Scientific Committee on Antarctic Research

Proposal for a *SCAR Krill Expert Group*

Name of the Proposed Group:
SCAR Krill Expert Group (SKEG)

Name(s) of the lead proponent(s)
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Summary
Recent findings on Antarctic krill, *Euphausia superba,* the central prey in the Southern Ocean food web, have demonstrated that even after almost 100 years of research on this species, there remain crucial gaps in our understanding of its life history, response to climate variability, spatial population dynamics, and the environmental mechanisms that drive its life cycle throughout the Southern Ocean. Increasing commercial interest in Antarctic krill resources in the 1970s followed over-exploitation of other marine resources in the Southern Ocean. Concerns about the potential ecosystem impacts of krill fishing led to the establishment of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), an international organization responsible for managing Southern Ocean fisheries and conservation of the wider ecosystem that depends on fished species. The krill fishery grew rapidly in the 1980s and remains responsible for over 90% of the fishery catch in the Southern Ocean. Historically CCAMLR has received scientific advice on Antarctic krill only from the official delegations of CCAMLR member countries, representing a small subset of the overall community of krill researchers. CCAMLR's Scientific Committee has emphasized the need for a mechanism to better incorporate the results of relevant krill research into fishery management decisions. Thus, the SCAR Krill Action Group (SKAG) was initiated in 2018 to become a prime conduit between CCAMLR and the wider krill science community in SCAR and beyond.

SKAG now provides a forum to (1) guide the direction of krill-related research; (2) promote international collaboration among both senior krill scientists and early career researchers (ECRs); (3) improve understanding of krill biology and ecology; (4) serve as a conduit between scientists and the krill fishing industry; and (5) through the SCAR Standing Committee on the Antarctic Treaty System, assist in providing critical scientific information to CCAMLR that are relevant to krill fishery management. Furthermore, the group provides a forum for information exchange on upcoming cruises and funding opportunities, including fishing vessels, as well as lab facilities for experimental krill work, and serves as a platform for the development of future international collaborative research proposals and programs. Since 2020, SKAG has cemented its position as a voice of Antarctic krill researchers. Through publications, reports, website and well-attended annual workshops, SKAG has developed into the central node for transferring relevant krill science to CCAMLR and other organisations, such as the newly established Science-Industry Forum (SIF) and Non-Governmental Organisations (NGOs) like the World Wide Fund For Nature (WWF) and the Pew Charitable Trust (PEW). In addition, SKAG is well integrated with the existing SCAR group "Integrating Climate and Ecosystem Dynamics in the Southern Ocean" (ICED). SKAG's joint workshops and papers have greatly enhanced the opportunities for ECRs to connect with peers and experts internationally and to nurture collaboration. We are currently at a crucial juncture in the management of the krill fishery. As the climate warms and the krill fishery continues to develop, CCAMLR is developing a new krill management approach that relies heavily on new survey and life history information. The role of SKAG in providing policy-relevant information on krill and in serving as a conduit for collaboration is a key legacy that we wish to continue. We, therefore, propose that SKAG becomes a SCAR Krill Expert Group (SKEG) in 2023 for an initial period of 6 years. An application is submitted to the heads of the Life Science Group.

Proposal for the Creation of a Krill Expert Group

1. Introduction and Background

The CCAMLR Scientific Committee recognised in 2017 the need for increased access to the most up-to-date information on krill biology and ecology to improve CCAMLR's management of the Antarctic krill fishery.

One proposed solution was to establish a working group outside of CCAMLR that could synthesise developments in Antarctic krill biology. This group would report its activities and findings to the CCAMLR working group on Ecosystem Monitoring and Management (WG-EMM). WG-EMM would in turn indicate topics of high priority that could be addressed by researchers in the broader community of krill researchers. Such two-way information flow was recognised as a way forward for broadening and accelerating the CCAMLR community's knowledge on krill and for stimulating policy-relevant academic collaboration on krill more widely. Such a krill working group would most logically be formed under the auspices of SCAR, providing it with the appropriate level of independence and legitimacy, while at the same time enhancing the relevance of SCAR to CCAMLR. This led to the submission of a proposal to SCAR to initiate a SCAR krill action group (SKAG), which was approved by SCAR in 2018. The SCAR Standing Committee on the Antarctic Treaty System (ATS), which has responsibility for the provision of SCAR advice to the ATS, including CCAMLR, contributed to these proposals. Since its inception, SKAG has led on coordination of the krill research community and the transfer of krill science to CCAMLR and beyond (e.g. Science Industry Forum: SIF and NGOs: e.g. WWF, PEW).

Many key questions identified in the SCAR Horizon Scan require knowledge on krill biology and ecology. Fishing may exacerbate the threats associated with warming, ocean acidification and changes in sea-ice distribution. However, the cumulative effects of fishing and climate change in Southern Ocean ecosystems have received little attention. SCAR currently has groups that address regional warming and changes in sea-ice distribution. We suggest that a group is also needed to address the science needed to manage the largest Southern Ocean fishery.

Recent publications on the long-term and seasonal population dynamics of krill (Atkinson et al. 2019, 2022, Steinberg et al. 2015, Loeb & Santora 2015, Reiss et al. 2017, Ryabov et al. 2017), their ecological links to sea ice (Meyer et al. 2017), as well as their depth distribution, and threats from environmental changes (Fuentes et al. 2016) have demonstrated that even after almost 100 years of krill research, there are critical gaps in our knowledge of this species. These concern some basic aspects such as life history, responses to climate change, spatial dynamics, and the environmental mechanisms that drive population variability. Currently, no single group within either SCAR or CCAMLR has responsibility for developing a comprehensive understanding of variability in krill life history and spatial dynamics, and the likely response of the species to climate change. This information is urgently needed to effectively manage Antarctic krill fishery. There is also a need to synthesize emerging information into a digestible form targeted at developing management advice.

In 2022 the CCAMLR Scientific Committee held a symposium to identify the scientific information requirements necessary to progress management and conservation of Southern Ocean marine resources. This symposium identified the following opportunities for SKAG (and any successor group) to contribute to the Scientific Committee's krill work program:

- Estimating krill biomass based on acoustic surveys: Advice on design, technology and sources of bias for surveys, including using fishing vessels as research platforms.
- Assesment of the relative ecological risk of potential spatial catch distributions: Contribution or refinement of spatial data of krill life stages outside of Area 48.1.
- Characterizing the functional relationships between krill, their predators and the fishery in space and time.

Here we propose that, due to the ongoing nature and relevance of a SCAR Krill Group to transfer krill research to CCAMLR, SKAG should evolve into a SCAR Krill **Expert** Group with a duration of 6 years. If this proposal is not approved by SCAR Life Science Delegates, our contingency proposal is that SKAG should be extended.

References

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2. Aims, Goals and Objectives

The proposed SCAR Krill Expert Group (SKEG) has five broad aims. **The first** is to be the prime forum for discussing Antarctic krill biology and ecology, where research directions are "guided" and collaborations and early career opportunities are promoted. **The second** is, through close collaboration with the SCAR Standing Committee on the Antarctic Treaty System, to be the major conduit of information and collaboration among CCAMLR, the fishing industry and the wider krill science community on providing policy-relevant information and knowledge about krill. **The third** is to strengthen connections between the krill modelling community within ICED and the broader krill research community to identify priority research needs for the development of models of krill. **The fourth** aim is to establish links between SKEG and SCAR's Antarctic Biodiversity Informatics Expert Group (EG-ABI), to promote the development of an overarching data repository. The former would provide links to already established databases such as KRILLBASE, and expand to consider how krill data other than abundance (e.g. physiological, genetic and behavioural data) can be combined in a repository, available and visible through SCAR under the FAIR principles (Findability, Accessibility, Interoperability and Reusability). **The fith** aim is to implement a vision paper on Krill stock hypothesis for Southwest Atlantic Sector of the Southern Ocean, by looking to this topic from different angles, environmental parameters such as sea ice, currents, climatology but also krill distribution, physiology, and behaviour. The 2020 policy paper generated by the SCAR Krill Action group identified knowledge gap in krill biology and how we can close it. As following up on this paper, in the last couple of years it became obvious that we do not have a common stock hypothesis for krill in southwest Atlantic sector. However, this is quite important since this will form the basis for coming up with a sensible approach in krill fishery management in the area as well as provide a framework for designing future surveys. How many sources areas does CCAMLR Area 48 krill population have? If so where and what is the dependencies. What is the relation with Bellingshausen sea and Weddell Sea population, e.g. in terms of krill flux and recruitment?

Advancing our current knowledge on krill will require research in the field and the lab, on ships, at Antarctic field stations, and in-home institutions. Ship time is becoming increasingly difficult to obtain, and space at field stations is limited and often prohibitively costly for funding agencies. It is therefore essential that we foster and coordinate international research efforts and resources. SKEG will provide an ongoing forum for information exchange on upcoming cruises, including onboard fishing vessels through the Science-Industry Forum (SIF), and opportunities to encourage international collaboration and cooperation in the broader krill science community. The SCAR Krill Action Group has already provided the basis to realize these plans.

3. Capacity Building, Education and Outreach Plans

There is a need to enhance capacity in the krill research community. SKEG will function as an excellent forum for the advertisement of research opportunities and for scientists to collaborate to develop new initiatives that could grow the krill research community, especially on critical topics. One such opportunity is to support ECR and industry participation in the science underpinning the data collection needs from the krill fishery through participation in upcoming CCAMLR workshops in 2023 and 2024 (in development at WG-EMM-2022). There is also a need for a coordinated outreach program on krill. There is an enormous amount of information on krill available to the

general public, including a considerable volume of material produced by bodies such as the krill fishing industry and environmental NGOs with their viewpoints. SKEG would be a trusted independent source of scientific information on krill that could be accessed by journalists and the general public. SKEG will build on the excellent achievements on this front made by the SCAR Krill Action Group (SKAG) to realize these plans.

4. Proposed Milestone Activities with Timeline

4.1. What have we achieved so far in the SCAR Krill Action Group (SKAG)

Outcomes/Achievements Summary

	Outcome/Achievement
SKAG	Policy paper Meyer et al. 2020, Communications Earth & Environment:https://doi.org/10.1038/s43247-020-00026-1 22 Web of Science citations and 6290 article accesses in the 20 months since publication.
SKAG	SKAG online workshop in cooperation with the WWF 26-30 April 2021: Evaluating change within the krill-based food web and developing solutions for the future sampling of krill: https https://doi.org/10.5281/zenodo.4776335 Workshop attended by 127 participants from 19 countries, of whom 46 were ECR's.
SKAG and ICED	Joint ERC modeling workshop with the SCAR Group Integrating Climate and Ecosystem Dynamics of the Southern Ocean (ICED), 17-20 May 2021: Using models to improve our understanding of Antarctic krill and their ecological role in the Southern Ocean, https://doi.org/10.5281/zenodo.6780069 Joint ICED-SKAG online Session in AGU Open Sciences Meeting, 2-4 March 2022. 'The role of Southern Ocean ecology in the Earth system: Integrating across scales, disciplines, and methods'.
SKAG	SKAG online workshop in March 2022, https://doi.org/10.5281/zenodo.6780075
SKAG	Comment CCAMLR Scientific Committee Chair, Dr. Dirk Welsford: While many of the world's krill experts participate in CCAMLR, it is also a fact that significant expertise and knowledge exists outside of the regular attendees to CCAMLR meetings. SKAG performs an important bridge between CCAMLR and this broader scientific community to ensure CCAMLR bases its decisions on the best available science.

4.2. Proposed Milestone Activities with Timeline

We propose that our SKEG will work for an initial period of six years, from the start of 2022/23 to the end of 2028.

Year	Milestone Activities
2023	• Annual workshop • Writing the semi-annual Newsletter, papers related to the annual workshop and the krill research in SKEG that are related to CCAMLR issues • Reporting to SCAR, ATCM and CCAMLR working groups • Development of the SKEG vision paper on Krill stock hypothesis for Southwest Atlantic Sector of the Southern Ocean, to be implemented during the SKEG phase • Development of an ECR education program. • Support early career scientist and industry participation in CCAMLR krill data collection workshop • Developing of a specific SKEG webpage as known from other Expert Groups (Identification of key topics requiring information for the public and the media, and development of information materials to be hosted on the SKEG web page) • Active participation in the Science-Industry Forum annual board meeting
2024	• Annual workshop • Writing the semi-annual Newsletter, papers related to the annual workshop, the krill research in SKEG that are related to CCAMLR issues. • Reporting to SCAR, ATCM and CCAMLR working groups • Development of an ECR education program. • Refinement maintenance of SKEG webpage • Active participation in the Science-Industry Forum annual board meeting and collaboration on *ad-hoc* program(s) • Establish a link between SKEG and SCAR's EG-ABI
2025	• Annual workshop • Writing the semi-annual Newsletter, papers related to the annual workshop and the krill research in SKEG that are related to CCAMLR issues • Reporting to SCAR, ATCM and CCAMLR working groups • Maintenance of SKEG webpage • Organisation of the 4th International Krill Symposium for 2026 • Active participation in the Science-Industry Forum annual board meeting and collaboration on *ad-hoc* program(s)
2026	• Annual workshop • Writing the semi-annual Newsletter, papers related to the annual workshop and the krill research in SKEG that are related to CCAMLR issues • Reporting to SCAR, ATCM and CCAMLR working groups • Maintenance of SKEG webpage • The 4th International Krill Symposium • Active participation in the Science-Industry Forum annual board meeting and collaboration on *ad-hoc* program(s)
2027	• Annual workshop • Evaluation of SKEG and potential Application writing to continue as Expert Group • Writing the semi-annual Newsletter, papers related to the annual workshop, krill symposium and krill research in SKEG that are related to CCAMLR issues

	• Finalising the vision paper on krill stock hypothesis for Southwest Atlantic Sector of the Southern Ocean, identified by the SKEG group at the beginning of the SKEG period • Reporting to SCAR, ATCM and CCAMLR working groups • Maintenance of SKEG webpage • Active participation in the Science-Industry Forum annual board meeting and collaboration on *ad-hoc* program(s)
2028	• Annual workshop • Writing the semi-annual Newsletter, paper related to the annual workshop • Reporting to SCAR, ATCM and CCAMLR working groups • Maintenance of SKEG webpage • Active participation in the Science-Industry Forum annual board meeting and collaboration on *ad-hoc* program(s)

5. Data Management Plans

The results generated from our tasks will be made public on our webpage.

Where SKEG plays a major role in developing a coordinated international research activity, the planning phase of that activity will include the development of a data management plan to follow best practices (i.e, FAIR principles), using established institutional data repositories such as KRILLBASE at the Britsih Antarctic Survey, PANGAEA at the Alfred Wegener Institute Helmholz Centre for Polar and Marine Research, SOOS-DueSouth, among others. In this context, we also plan to establish a link between SKEG and SCAR's Antarctic Biodiversity Informatics Expert Group (EG-ABI) to promote the development of an overarching data repository, providing links to already established databases such as KRILLBASE, but also to consider how krill data other than abundance (e.g. physiological, genetic and behavioural data) can be combined in a data repository so that these data are available and visible through SCAR.

6. Terms of Reference

The SCAR Krill Expert Group will:

1) Inform CCAMLR of the latest scientific knowledge on krill biology and ecology to further develop its krill management approach and to improve krill fishery management decisions.
2) Identify fundamental knowledge gaps and critical new topics for krill research.
3) Facilitate and guide the development of research initiatives aiming to reduce these knowledge gaps and address these new topics.
4) Organise workshops involving members of the CCAMLR scientific community, the wider krill research community, and representatives from the krill fishing companies, with the specific aim of reducing gaps in scientific knowledge about Antrarctic krill relevant to current and future fishery management.
5) Function as a conduit for the wider krill community outside of CCAMLR to facilitate opportunities for research and collaboration, including with commercial krill fishing companies.

6) Develop an education program to encourage more ECRs from a broader representation of countries with Antarctic programs to study Antarctic krill.
7) Interact with, and provide input to, existing SCAR groups such as ICED to improve our understanding of Southern Ocean ecosystems and the impacts of climate change.
8) Identify key topics related to Antarctic krill of interest to the public and the media. Facilitate the preparation of information on these topics in plain language by suitably qualified researchers and make this information available via the SKEG website.

7. Budget and Justification

We apply for a budget of p.a. 5000$ which we plan to spend on the following activities:

In 2023 and 2024

- Developing an education program for students and young scientists on krill research for the SKEG webpage, in close cooperation with ECRs
- Refinement and maintenance of SKEG webpage
- Travel expenses for ECRs and some board members to attend SCAR meetings and workshops
- Travel expenses for ECRs to participate in CCAMLR krill data collection workshops (2023, 2024)

In 2025 and 2026

- Organisation of the 4th International Krill Symposium
- Travel expenses for ECRs and some board members to attend the 4th International Krill Symposium
- Maintenance and update of SKEG webpage

In 2027 and 2028

- Travel expenses for ECRs and some board members to attend SCAR meetings and workshops
- Maintenance and update of SKEG webpage

8. Current SKAG Members

In total 78 members and 40 of them are ECRs, marked with *

Leadership

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9. Webpages and Communication Plans

We would like to improve our webpage with more information for early career researchers (ECR) and work closely with these members to meet their requirements.

We will also develop material providing the media and general public with relevant and up-to-date information on krill.

10. Other notes and comments

Through collaboration and consultation with the ECR members in our Executive Member group, SKEG will develop an education program to encourage ECRs from a broad representation of countries with Antarctic programs to study Antarctic krill.

SCAR Krill Action Group are currently involved in the Science-Industry Forum (SIF) board. This parallel organization aims to bring scientists onboard fishing vessels, develop protocols for fishing vessels to follow, and collect valuable information required to improve the management of the kill fishery. Their participation will continue through SKEG.