Scientific Committee on Antarctic Research

Proposal for a New *SCAR KRILL Action Group*

Name of the Proposed Group:

SCAR Krill Action Group (SKAG)

Name(s) of the lead proponent(s)

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Sponsoring Science Group(s) or Standing Committee(s):

Life Sciences

Summary of SCAR Krill Action Group

Recent findings on Antarctic krill, *Euphausia superba* 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 dynamics, and the environmental mechanisms that drive variability of its lifecycle throughout the Southern Ocean (SO). At the 3rd International Krill Symposium (3IKS; St. Andrews, UK, June 2017) it was identified that, despite recent scientific advances in this field, the scientific community and the public still hold on to many out-dated perceptions about krill from the 1980s, or earlier. This is impeding the development of new directions in krill research. Given the multiple changes occurring to Southern Ocean ecosystems, and because of the prominent role of Antarctic krill in the Southern Ocean, it is crucial to highlight the areas where knowledge is lacking, reconsider the current methods used, and develop new approaches to krill research.

Currently CCAMLR is the Antarctic body with the most focus on krill, but there is no longer a krill working group within CCAMLR. The CCAMLR Scientific Committee have emphasised that we need a mechanism to better incorporate the relevant science being done on krill into CCAMLR, and thus the SCAR Krill Action Group (SKAG) aims to become the prime conduit between CCAMLR and the wider krill science community. SKAG will provide a forum to guide research directions, promote collaboration, improve understanding of krill biology and ecology, and thus assist in providing critical scientific information relevant to krill fishery management. Furthermore, since ship time for krill fieldwork is becoming more scarce, the group will provide a forum for an information exchange on upcoming cruises and funding opportunities, as well as lab facilities for experimental krill work, and will serve as a platform for the development of future international collaborative research proposals and programs. SKAG will interact with, and provide input to, the existing SCAR groups. Because krill are so central to the SO ecosystem, knowledge about krill is essential to answering many of the fundamental questions of groups such as: Integrating Climate and Ecosystem Dynamics in the Southern Ocean - ICED; Expert Group on Birds and Marine Mammals – EGBAMM; Biogeochemical Exchange Processes at the Sea-Ice Interfaces – BEPSII; and the Southern Ocean Continuous Plankton Recorder - SO-CPR.

Proposal for the Creation of a Action group "KRILL"

1. Introduction and Background

The BIOMASS Program, one of the major SCAR initiatives of the 1970s and 1980s, focussed on Antarctic krill and its role in the Southern Ocean ecosystem. Following the program's fieldwork phase, the SCAR Krill Working Group was formed. The Krill Working Group was extremely productive for a number of years in the late 1980s to early 1990s, forming an important foundation for future krill research. Krill research has been central to CCAMLR's ecosystem-based management approach since its early days. In 1987, an *ad hoc* Working Group on Krill was formed and tasked with providing an in-depth review of research on krill biology and ecology. The CCAMLR Working Group on Krill was formally constituted in 1988, holding its first meeting in 1989. The primary objective of the CCAMLR Working Group on Krill was to address issues relating to the management of the krill fishery. The SCAR Krill Working Group subsequently disbanded. In 1995, the CCAMLR Working Group on Krill was amalgamated into a Working Group with a wider remit, the Working Group on Ecosystem Monitoring and Management (WG-EMM), and this Working Group continues to this day. The scope of the work undertaken by WG-EMM has expanded and there has been a dilution of the focus on krill biology and ecology. Although there are a number of leading krill scientists who still attend WG-EMM, CCAMLR has recognised the need for increased access to the most up-to-date information on krill biology and ecology that is required for CCAMLR's management.

The recent 3rd International Krill Symposium (3IKS) emphasised that there is a large international group of krill scientists who operate outside the CCAMLR system, and whose research has been less frequently considered by the WG-EMM with regards to management-related issues of the krill fishery. During the 3IKS, there was considerable discussion on how this body of expertise could be tapped by CCAMLR. One proposed solution was to establish a working group outside of CCAMLR that could synthesise developments in the field of Antarctic krill biology. This group would be led by a krill scientist who also attends WG-EMM meetings, whose remit would be to report the findings of the SKAG to WG-EMM. WG-EMM would in turn also indicate topics of high priority that could be addressed by researchers in the wider krill community. Such two-way information flow will enhance CCAMLR's knowledge on krill and could also stimulate academic research 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 legitimacy, while at the same time enhancing the relevance of SCAR to CCAMLR, which is a long-standing aim of both bodies.

Many of the key questions identified in the SCAR Horizon Scan require knowledge of krill biology and ecology. The SCAR-supported publication, *Challenges to the Future Conservation of the Antarctic* (2012), suggested "The most immediate conservation threats to species, ecosystems, and resources around the Antarctic margin are consequences of regional warming, ocean acidification, and changes in sea-ice distribution". SCAR currently has groups that address regional warming, ocean acidification, and changes in sea-ice distribution, but there is no SCAR forum for discussing the biological effects of resource extraction, particularly from the largest Southern Ocean fishery - krill. Marine resource extraction may exacerbate the threats associated with warming, ocean acidification and changes in sea-ice

distribution, and it is critical that we understand how. Although climate change is an important component identified by CCAMLR, the additive effects of marine resource extraction on climate change in Southern Ocean ecosystems have not yet been addressed.

Recent publications on the long-term and seasonal population dynamics of krill (Atkinson et al. 2004, Steinberg et al. 2015, Loeb & Santora 2015, Reiss et al. 2017, Ryabov et al. 2017), krill's link to sea ice (Meyer et al. 2017), as well as their depth distribution (Schmidt et al. 2011), and observed threat from environmental changes (Fuentes et al. 2016) have demonstrated that, even after almost 100 years of krill research, crucial knowledge gaps remain with regards to krill 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 the comprehensive understanding of variability in krill life history and spatial dynamics, and the response of the species to climate change, information that is urgently needed to effectively manage the fishery.

Until the 1980s, krill research focused mainly on their abundance and distribution, and on deriving a more accurate quantitative estimate of their biomass. Since the 1980s, this research has continued, but the focus has shifted towards studies on krill in relation to the environment. More recently, research has focussed on the mechanisms by which physical and biological factors influence krill's annual cycle, taking all life stages into account (Summary of krill research from past to present in Meyer 2012 and Siegel 2016). Despite advances in our understanding of krill biology and ecology, there are still numerous out-dated perceptions currently circulating both within the broader scientific community and also the public realm. This is stalling our progress, preventing new directions in krill research. Given the climate-related changes occurring in Southern Ocean ecosystems and krill's prominent role in the Southern Ocean, it is crucial that we identify current gaps in our knowledge, as well as flaws and/or limitations in our current methods, and that we develop new lines of thought in krill research. Most of the publications listed below were published after the last major synthesis of krill and climate change (Flores et al. 2012). This highlights the importance of this topic and the urgent need to synthesise the plethora of emerging information into a digestible form to help management.

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2. Aims, Goals and Objectives

SKAG has two broad aims. The first is to become the prime forum for the discussion of Antarctic krill biology and ecology, where research directions are "guided" and collaborations are promoted. The second is to become the major conduit for two—way information flow between CCAMLR and the wider krill science community to assist in providing critical scientific information that matters to krill fishery management.

Advancing our current knowledge on krill will require research in the field, either on ships or at Antarctic field stations. 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 begin to coordinate international research efforts and resources. SKAG will provide a forum for information exchange on upcoming cruises and opportunities to encourage international collaboration and cooperation in the broader krill science community. In addition, there are now several sophisticated research aquaria where experimental work on krill can be conducted both in Antarctica and in more temperate zones. SKAG will provide a forum for developing collaborative research programs to best utilize these valuable facilities and to share information on krill husbandry to assist the further development of new facilities. Finally, the link to CCAMLR would allow the wider krill community to access opportunities for research that are becoming available through collaboration with the commercial krill fishing operators. The krill fishing fleet operates throughout most of the year, offering unprecedented scope for high-resolution sampling in all seasons, but few researchers outside CCAMLR are aware of these opportunities.

Numerous existing SCAR groups, including Integrating Climate and Ecosystem Dynamics (ICED), Expert Group on Birds and Marine Mammals (EGBAMM), Biogeochemical Exchange Processes at the Sea-Ice Interfaces (BEPSII), and Southern Ocean Continuous Plankton Recorder (SO-CPR), depend on information about krill. SKAG will interact with and provide valuable input to these groups.

3. Capacity Building, Education and Outreach Plans

There is a need to enhance capacity building in the krill research community. Although the recent krill symposium indicated that there is a vibrant krill research community, there is still a need to encourage students, post-docs and existing researchers into developing areas of krill research. SKAG would be 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. There is also a need for a co-ordinated outreach program on krill. There is little quality-controlled information on krill available to the general public and there is a considerable volume of material produced by bodies with an agenda, such as the krill fishing industry and conservation NGOs. SKAG would become a trusted source of unbiased information about krill that could be accessed by journalists and by the general public. Within SKAG we will work on a program to implement these aims in the future (see Task 3).

4. Proposed Milestone Activities with Timeline

In the next four years SKAG will work on the following major tasks:

1. Identify gaps in current krill research according to existing literature (Task 1).
2. Identify and prioritise new directions for krill research based on the results of Task 1 (above) (Task 2).
3. Develop and maintain a webpage, which mirrors our aims, research results, and developments in capacity building, education and outreach plans (Task 3).
4. Summarize information from Tasks 1 and 2 (above) in a publication in an international peer reviewed journal (Task 4).
5. Develop a proposal to move from a SCAR Krill Action Group to a Krill Expert Group to build a platform for coordinating krill research between CCAMLR and krill scientists outside of CCAMLR into the future (Task 5).

Milestones

2018	• Present SKAG proposal at the SCAR OSC in Davos, 18th June. • Initial meeting of SKAG after WG-EMM in Cambridge, UK, 16 and 17 July 2018. Working on Tasks 1 and 2, distribution of working tasks between group members to fulfill Tasks 1 and 2. • SKAG meeting at the CAMLR-SC (October 2018), summarizing first results from the executive group members. • Develop the SKAG webpage, to be completed by the end of the year, taking capacity building, education and outreach into account (Task 3) • Quarterly SKYPE meetings to discuss our tasks and progress. • Prepare progress report to CCAMLR WG-EMM.
2019	• SKAG meeting after WG-EMM 2019 (TBD). Summarize the data generated from Tasks 1 and 2, discuss and plan the structure of our publication, and begin writing (Task 4) as well as discuss Task 3. • SKAG meeting at the CAMLR-SC (October 2019), presenting first publication draft. • Submit the manuscript by the end of 2019 (Task 4). • Based on external reviews, revise webpage incorporating new results from SKAG (Task 3). • Quarterly SKYPE meetings to discuss our tasks and progress. • Prepare progress reports to CCAMLR WG-EMM and SCAR on the 1st year activity.
2020	• SKAG meeting after WG-EMM (TBD). Work on Tasks 3 and 5, distribution of working tasks between group members. • SKAG meeting at the CAMLR-SC (October 2020), summarizing first results from the group members and discussion of Task 5. • Produce first draft of proposal (Task 5) by the end of the year.

	• Revise the webpage, incorporating new results from SKAG, to be completed by the end of the year (Task 3). • Quarterly SKYPE meetings to discuss our tasks and progress. • Prepare progress reports to CCAMLR WG-EMM and SCAR on the 2nd year activity.
2021	• Submit proposal to SCAR (Task 5). • Quarterly SKYPE meetings to discuss our tasks and progress. • Prepare reports to CCAMLR WG-EMM and SCAR of the progress made during the 3-year period.

5. Data Management Plans

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

6. Terms of Reference

We propose that our Action Group will last from 2018 to 2021. The Action Group will have a chair who will be elected at the first meeting. The chair will have a term for the entire working period of SKAG. Should a need arise to replace the chair, the group will decide on someone to fill the post. Group activities will be steered by the executive group, taking into consideration the comments and advices by the members from the consultative group.

SCAR Krill Action Group (SKAG) will:

1) Assist and inform CCAMLR of the latest scientific knowledge on krill biology and ecology to improve management decisions for the krill fishery.

2) Identify fundamental gaps and possible new research directions for krill research.

3) Function as a conduit for the wider krill community outside CCAMLR to access opportunities for research and collaboration, including that with the commercial krill fishing operators.

4) Interact with, and provide input to, the existing SCAR groups to improve our understanding of Southern Ocean ecosystems and the impacts of climate change thereon.

5) Develop a proposal to move towards a SCAR Krill Expert Group.

7. Budget and Justification

Due to institutional circumstances it would not be possible for Angus Atkinson (UK), Kim Bernard (USA), Andrew Brierley (UK), and Steven Nicol (AU) to cover the costs to attend our meetings. Since most of the WG-EMM meetings are held in Europe, we are requesting a budget to accommodate travel costs for these executive members. According to information from a travel agency, inner European return flights costs max. 400€, Return flights from the US to Europe max. 1500€, and from Australia to Europe max. 1800€. For a full two days meeting we calculate hotel costs for 4 days.

Hotel costs per day per person will be max, 120€ (1920€ Hotel costs in total). Therefore, we would require a yearly budget of 6020€ = $7500 USD.

8. Confirmed (*) and/or Potential Members

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9. Webpages and Communication Plans

We are pleased SCAR will provide our group with a webpage and will send information upon approval. We would also like to have a mailing list set up and would like advice on communicating our activities via social media and other channels.

10. Other notes and comments

One of the prime tasks for SKAG is to develop an education program to encourage students and young scientists to start or continue working on krill. Instead of including early career scientists in the executive group, we believe it will be more effective to get input from as wide a range of young researchers as possible by holding open discussion regularly online to get their feedback for an education program on krill research.