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
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Finer-scale krill fishery management, enhanced monitoring and additional measures to protect the krill-based ecosystem

Submitted by ASOC

EN

Finer Scale Krill Fishery Management, Enhanced Monitoring and Additional Measures to Protect the Krill-Based Ecosystem
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Abstract

Given the tremendous uncertainties facing the krill-based ecosystem, ASOC recommends the following to ensure precautionary management of the krill fishery:

1) SC-CAMLR should complete the krill work plan agreed in 2019, and CCAMLR should agree on a new precautionary conservation measure to replace CM 51-07.
2) CCAMLR should renew CM 51-07 if a new CM cannot be agreed in 2022, and formulate a new CM in a later year.
3) CCAMLR should maintain precaution in management. Any increase in catch limits should be incremental and should only happen if supported by science that shows that a new measure improves the protection of predators, and if all the following elements are agreed and implemented by CCAMLR and SC-CAMLR:
    - Regular science-based revisions of catch limits at least every five years
    - Regular testing and evaluation of the gRym if it is used to set catch limits
    - Regular monitoring of the impacts of fishing on krill and predators, and a revision of the CCAMLR Ecosystem Monitoring Program
    - 100% international observer coverage[1]
    - Designation of the D1MPA to provide resilience for the fishery and to the ecosystem and to be used as climate change reference areas
    - Improvement of the transshipment conservation measure to increase transparency, monitoring, and reporting of transshipments
    - Collaboration with ACAP, IWC and relevant experts, including through IMAF, to mitigate all marine mammal and seabird bycatch.

Introduction

In the context of climate change, growing fishing pressure and political stasis in CCAMLR (ASOC 2022, ASOC and COLTO 2022), what would effective international management of the krill fishery look like to ensure protection of the krill-based Antarctic ecosystem? In this paper ASOC reviews recent developments and proposals concerning the krill fishery and makes a range of suggestions to improve krill management including in connection with the proposed Domain 1 MPA.

In 2019, CCAMLR committed to a scientific work program that was designed to lead to a new approach to managing the Antarctic krill (*Euphausia superba*) fishery (CCAMLR-38 - para 5.17-5.19) and to replace the existing Conservation Measure (CM) 51-07, which subdivides the catch limit in 51-01 to avoid potential ecosystem impacts of fishing. In 2021, significant progress had been made on the three major elements of that scientific work program, which included a revised krill biomass estimate, an

[1]Conservation Measure 51-06 sets 100% observer coverage for Antarctic krill fisheries but does not specify the requirement for international observers managed under SISO. https://cm.ccamlr.org/en/measure-51-06-2019. Finer details can be found in https://www.ccamlr.org/en/system/files/e-pt10_4.pdf

update to the generalized R yield model (stock assessment model) to set precautionary catch rates, and a risk assessment to space out catch to reduce the impact on predators. Interactive explanations of these scientific tools are available online (The Pew Charitable Trusts, 2021). However, due to the global pandemic, the work plan was not completed and CCAMLR extended CM 51-07 for an additional year, committing to revise the measure in 2022, with a focus on Subarea 48.1 where the science was most developed (CCAMLR-38, paragraphs 6.11 - 6.12).

Since the October 2021 CCAMLR meeting, the fishery has continued to expand. For the fishing season (2022/23), five Members notified their intention to fish for krill with a total of 14 vessels (one more vessel compared to the previous season). Seasonal catches in Area 48 in 2022 reached 411,544 tonnes as of September 16th (Fishery Notice 57) which represents the second largest catch ever in Area 48 since systematic recording began - with a previous record of ca. 450,000 tonnes in 2020 (see Figure 1). The fishery in Subarea 48.1 was closed prior to the end of the fishing season (on June 27th) due to the catch reaching the seasonal limit for that subarea, which represents the tenth time this has occurred since 2010.

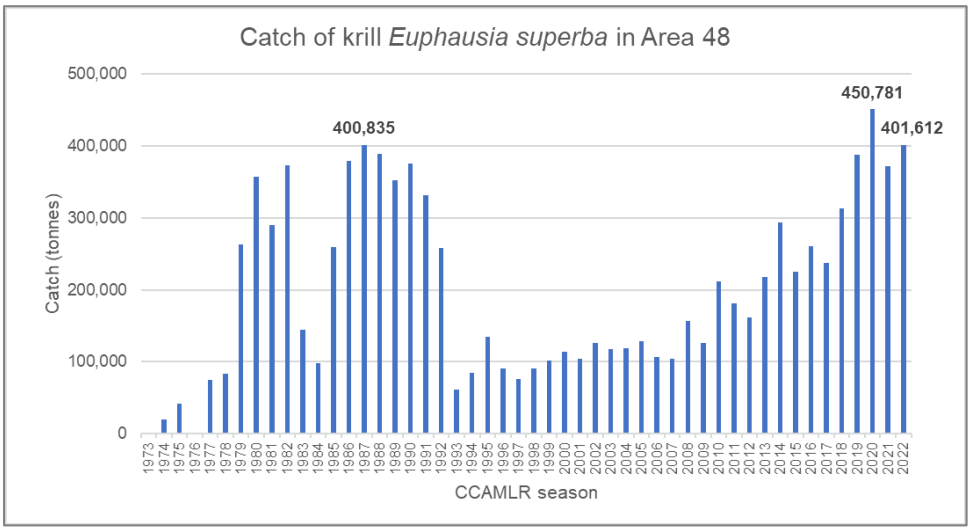

Figure 1. Catch of krill *Euphausia superba* in Area 48. Source: https://www.ccamlr.org/en/fisheries/krill-fisheries accessed September 2021 and Fishery Notice 57.

Based on scientific progress made since the 2021 CCAMLR meeting, some Members have provided illustrative examples of how the krill biomass estimate, stock assessment and risk assessment could be brought together to provide management advice for Subarea 48.1 (WG-EMM-2022/05, WG-EMM-2022/25 Rev. 1). Both scenarios subdivide Subarea 48.1 into smaller management units for which WG-ASAM 2022 has provided biomass estimates (see Figure 2).

CCAMLR 41 could decide a new conservation measure for Subarea 48.1. However, many scientific and management uncertainties remain. While it is desirable to move forward with a new conservation measure that offers greater protection for predators by spreading out the catch, any increase in the overall catch limit within Subarea 48.1 should only be allowed to proceed in a manner that allows for effective precautionary management and the monitoring of potential impacts. In addition, CCAMLR should ensure that any outcome from the new krill fisheries management approach should be no less precautionary than the current CM 51-07 in place. This will help CCAMLR achieve the objective of Article II[2] of the CAMLR Convention.

[2]Article II, paragraph 3b and c require, *"Any harvesting and associated activities in the area to which this Convention applies shall be conducted in accordance with the provisions of this Convention and with the following principles of conservation:*

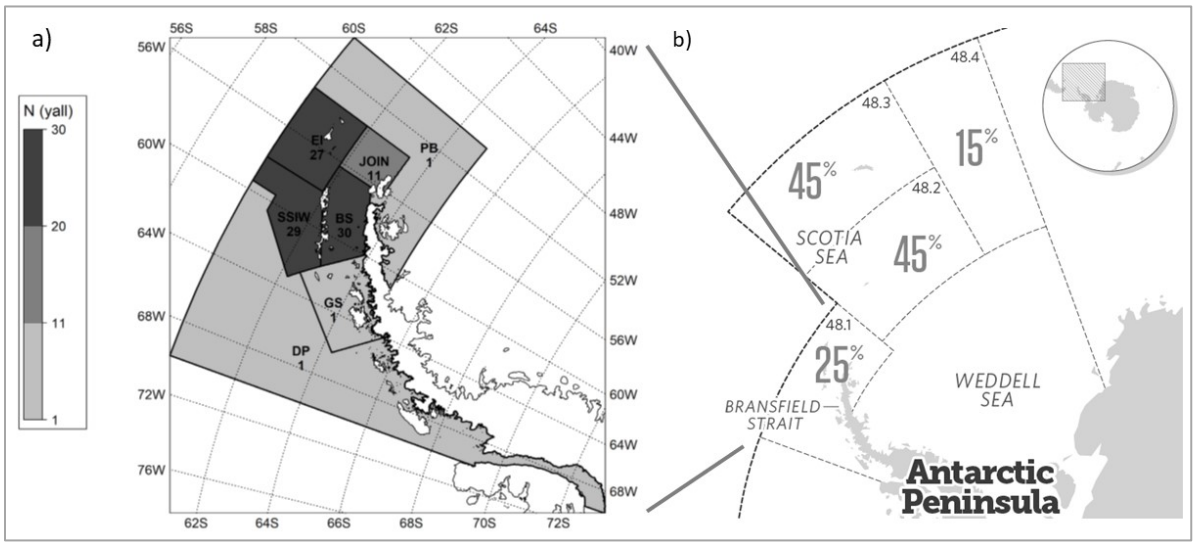

Figure 2. This graphic represents one scenario for subdividing the catch within Subarea 48.1 for which biomass estimates have been provided by WG-ASAM. Shading indicates the number of surveys (N) conducted in each stratum 1996-2020. For this scenario, stratum names are: EI— Elephant Island, JOIN – Joinville, BS – Bransfield Strait, SSIW – South Shetland Islands West, GS – Gerlache Strait, DP – Drake Passage, PB – Powell Basin. (Source WG-ASAM 2022, Figure 1a). b) Conservation Measure 51-07 allows 25% of the precautionary trigger limit of 620,000 metric tons to be taken from anywhere in Subarea 48.1. (Source: The Pew Charitable Trusts).

Ongoing changes to the Antarctic ecosystem

The vulnerability of the Southern Ocean and krill to climate change has been clearly established. The impacts of climate change and related ocean acidification (Kawaguchi et al. 2013) are having negative impacts on krill populations including loss of habitat (Atkinson et al. 2019), with habitat loss projected to continue (Sylvester et al. 2021, Veytia et al. 2020). It has recently been revealed that krill have abruptly undergone a range shift to southern spawning grounds (Atkinson et al. 2021). And while the fishery continues growing and increasing its concentration in space and time, evidence has mounted that the combined effects of climate change and fishing are having negative impacts on penguin colonies in the South Shetland Islands (Watters et al. 2020) and more broadly across the Antarctic Peninsula (Kruger et al. 2020).

New research (Santa Cruz et al. 2022) highlights that concentrated fishing is causing poor performance for the fishery. Based on an analysis of almost forty years of krill fishery data, they found that concentrations of krill fishing in both space and time are highest in the regions surrounding the Western Antarctic Peninsula and the nearby South Orkney Islands. This is related to higher seasonal catches being removed persistently from the same small areas during shorter fishing seasons, as well as changes in sea-ice which allow concentration of fishing efforts. In these areas catch per unit effort has decreased over time, indicating concentrated fishing is causing negative fishing performance which could be related to krill migration or habitat shift, reduction of krill abundance, or increasing consumption by recovering whale populations.

(b) maintenance of the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources and the restoration of depleted populations to the levels defined in sub-paragraph (a) above; and
(c) prevention of changes or minimisation of the risk of changes in the marine ecosystem which are not potentially reversible over two or three decades..."

Additional research indicates that between 2007 and 2020, in less than 1.5 generations, the South Sandwich Islands population of Antarctic fur seals *(Arctocephalus gazella)* has declined 86% (WG-EMM 2022/42). The last Working Group on Ecosystem Monitoring and Management (WG-EMM) meeting noted that this depleted population has fallen below a level which ensures greatest net annual increment and should be of concern to the Commission (WG-EMM 2022, Paragraph 2.80).

Fishery bycatch of seabirds and marine mammals (both seals and whales) in the krill fishery is a poorly addressed threat to the ecosystem; since the 2021 CCAMLR meeting, there has been an additional instance of a humpback whale being caught by the krill fishery (E24, 2022) following the first three that were reported to CCAMLR in 2021 (SC-CAMLR-40/BG/27). Recently SC-CAMLR and Secretariat representatives participated in whale bycatch discussions as part of the International Whaling Commission (IWC) Human Induced Mortality subgroup which provided opportunities for future collaboration on desk and field-based activities to address this important issue.

Finally, new research indicates that pollution is being found in krill in the form of organochlorine pesticides (Xie et al. 2022), heavy metals (Mirzoeva et al. 2022), and mercury (Matias et al. 2022).

Recovering whale populations – the elephant in the room

It is well-established that krill-eating baleen whales have experienced a significant population recovery in recent years/decades (Zerbini et al. 2019). For example, an atypically large gathering of fin whales (*Balaenoptera physalus*) ever was recently documented near the coast of Elephant Island, with estimates of almost 8,000 fin whales in the Antarctic area(Herr et al. 2022).

In the Southern Ocean alone, scientists have recently calculated that pre-whaling populations of baleen whales annually consumed 430 million tonnes of Antarctic krill (Savoca et al. 2021), approximately the current estimated total biomass of krill at the circumpolar scale. Furthermore, a new study by Warwick-Evans et al. (2022) estimates that humpback (*Megaptera novaeangliae*) and fin whales in Subarea 48.1 consume an estimated 2.1 million tonnes (likely an underestimate) of krill during a single Antarctic summer. Authors of the preceding papers highlight that such concentrated fishing demonstrates that there is a mismatch between the spatial and temporal scale at which krill fisheries are currently managed, and that at which fisheries operate and consumers forage. WG-EMM 2022 (para 3.22) also noted that blue whale (*Balaenoptera musculus)* populations in Area 48 have also been reported to be recovering, and that fin whales likely account for a substantial amount of krill removal in Subarea 48.2.

Additionally, new research by Reisinger et al. (2022) highlights the large degree of overlap in space and time of krill eating baleen (humpback and minke - *Balaenoptera acutorostrata*) whales and the fishery for Antarctic krill in the Bransfield Strait in April and May. Also, it has been found that there is a significant relationship between the reproductive success of humpback whales and the density of krill in the Western Antarctic Peninsula for humpback whale population breeding in the Southwest Pacific (Seyboth et al 2021). Therefore, authors of that study noted that if CCAMLR aims to effectively monitor the status of krill predators while managing the krill fishery, they may also need to consider data collected outside the Southern Ocean.

The potential large annual summer krill consumption by whales in the Antarctic Peninsula and Scotia Sea area highlights the importance of including baleen whales in the assessment and management of the krill fishery. Thus, there is an urgent need for a new evaluation of the abundance, distribution, and ecological role of fin whales in the Southern Ocean.

Uncertainties related to krill biology and fishing operations call for precautionary management

There are many scientific uncertainties remaining in SC-CAMLR's understanding of the dynamics of krill and krill predators, and how both will continue to change in the future. In addition, several questions also remain about how CCAMLR will effectively handle any change in the krill fisheries management system.

The greatest unknown amongst the tools being used by SC-CAMLR to provide advice to the Commission is in the recruitment parameters being used in the gRym (a generalized population yield model implemented through the programming language R). This special topic was taken up by the Scientific Committee on Antarctic Research Krill Action Group (SKAG) (WG-EMM-2022-07).The gRym is not a statistical model and therefore is very sensitive to parameterization. Recruitment is one of the three main parameters impacting the model results and the gRym recruitment parameter does not currently account for the extreme fluctuations observed in the krill population. Thus, minor changes in the choice of recruitment parameters can lead to major changes and inaccuracies in the output of the model - the catch rate set for krill to sustain a healthy krill population.

One key additional area of uncertainty is the population structure and movement dynamics of krill (i.e., "flux"). For example, a recent study of krill associated bacterial communities in East Antarctica showed strong geographical segregation in these communities, which negated the existing theory of a mixed krill population (WG-EMM-2022/P08). In response, WG-EMM noted that, "the study raised questions regarding the relationship between oceanographic processes and population dynamics of krill" (WG-EMM 2022, Paragraph 2.15), "a holistic approach to all subarea catch limits is required when considering any revision to CM 51-07" and "recommended the need for a krill stock hypothesis workshop" (WG-EMM 2022, Paragraph 2.89). Understanding the structure of a fished population is a key tenet in fisheries management and not adequately accounting for spatial structure or movement between components can lead to poor advice to managers (Van Beveren et al. 2019).

Differences between fishing gears remain among vessels in the krill fishery, which could lead to inaccuracies in catch reporting (referred to as "greenweight"[3]) as well as inaccuracies in biomass estimates due to variable gear selectivity[4] between vessels when fishing vessels are used for acoustic surveys (WG-EMM 2022-29). As such, WG-EMM has recommended all krill fishing operators submit details of net diagrams, configuration measurements, etc., to meet the standards required by Conservation Measure 21-03[5](WG-EMM 2022, paragraph 2.23).

Scientific uncertainties

The CCAMLR krill risk assessment framework is a significant tool for protecting krill predators; however, several uncertainties about the protection of predators remain. However, while the risk assessment framework provides an important tool to spread out the catch to minimize localized depletion of krill and minimize risk to predators, it does not explicitly allocate or account for the amount of krill to be consumed by predators, and neither does the stock assessment[6]. Serious implications result from not explicitly accounting for krill predators' growing needs. For example, new evidence shows that fin and humpback whales alone are eating more than 13 times the current catch limit in Subarea 48.1 under CM 51-07 (Warwick-Evans et al. 2022).

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[3]Greenweight means the unprocessed weight of caught krill

[4]Selectivity the capacity of any gear type to capture certain fractions of the krill population whether grouped by species, age, size, or behavior and to exclude others.

[5]Conservation Measure 21-03 specifies information Members notifying to fish for krill must submit for review by the Scientific Committee. https://cm.ccamlr.org/en/measure-21-03-2019

[6] The gRym model does not include as an input a natural mortality term which accounts for the consumption needs of predators.

Many data gaps exist for winter distributions of krill and krill-dependent predators which may bias estimates of relative risk (WG-EMM 2022, Paragraph 2.70). Major abundance and krill consumption estimate gaps remain for pack-ice seals, finfish, squid, and other baleen whale species not currently considered (Warwick-Evans et al. 2022).

The risk assessment approach only quantifies the relative risk of different spatial krill fishing regimes under a fixed catch amount. Therefore, CCAMLR does not currently have an agreed tool that would compare the absolute risk to predators of an increased catch to the risk under the current catch limits under CM 51-07. Consequently, the amount of krill consumed by predators is something SC-CAMLR should account for explicitly in management or use as the basis to maintain precautionary management measures. Without fully accounting for krill consumption, use of the risk assessment approach may produce catch limits that are not sufficiently precautionary.

Key questions remain about CCAMLR's capacity to handle the existing fishery as well as one with changes to the management system:

- How will SC-CAMLR ensure that any increases in krill catch aren't negatively affecting krill populations or their predators?
- How often will catch setting measures be revised based on newly available data?
- How will the CCAMLR Secretariat handle the additional data collection and communication requirements of potentially smaller spatial management units?

The growing monitoring requirements of the CCAMLR krill fishery

Monitoring is critical to ensuring the krill fishery is not having negative impacts on krill or their predators. CCAMLR has referred to its aspirations of adaptive management as "feedback management" which requires monitoring to allow management to be adjusted as relevant information becomes available to maintain krill populations at a healthy level providing the necessary foraging conditions for krill dependent predators. At WG-EMM 2022, it was recommended that if CM 51-07 is revised, data reporting and collection, including from the fishery, need to be reviewed and increased as necessary to assess the possible effects of the revised measure consistent with CM 23-06[7], (WG-EMM 2022, paragraph 2.90).

Adaptive management for the krill population could be ensured through regular acoustic surveys, which would provide krill biomass information on a regular basis. This is particularly important for the Gerlache Strait region where estimated krill biomass is based on only one year of data. The acoustic biomass data needed for adaptive management could be achieved by making surveys mandatory for krill fishing vessels, like the tagging required for participation in CCAMLR toothfish fisheries.

Monitoring of key indicator species is central to a feedback management system that can be used to detect impact of the fishery on krill predators, and this is the purpose of the CCAMLR ecosystem monitoring program (CEMP). Whales are not currently included as a CEMP indicator species and WG-EMM 2022 suggested that the strong overlap between whales and fishing operations should be considered in the enhancement of the CEMP for krill fishery management. In addition, climate change is inducing rapid changes within the ecosystem, impacting the way indices generated by CEMP may be used to detect fisheries impacts. Consequently, a review of CEMP, including the requirements for its monitoring reference sites and species, is urgently needed and could be achieved through a dedicated workshop.

[7]Conservation Measure 23-06 sets requirements for reporting catch and effort data for krill fisheries. https://cm.ccamlr.org/en/measure-23-06-2019

Discussions over recent years by CCAMLR scientists and the SKAG have concluded that krill fishing vessels could be a great research platform to address knowledge gaps in krill biology for supporting krill fisheries management. The proposed krill observer workshop is a necessary step in discussing opportunities to address the data requirements of an improved management system.

Detection of climate change and fisheries impacts is possible through comparing adjacent areas open and closed to fishing that have similar ecological features. In that sense the proposed D1MPA could provide a unique opportunity since it would allow fishing to occur in a large area of the domain but include no take areas that could be used as reference areas. Existing and potentially revised CEMP indices will play an important role in monitoring the impacts of fishing and the effectiveness of the MPA once established.

Conclusions and Recommendations

ASOC recommends that:

1. SC-CAMLR completes the krill work plan agreed in 2019 – including the biomass estimate, stock assessment, and risk assessment – and CCAMLR subsequently agrees on a new conservation measure to replace CM 51-07 that uses the risk assessment to space out the krill catch in Subarea 48.1 for predator protection, and commits to progress scientific work in Subareas 48.2, 48.3, and 48.4.

2. CCAMLR should renew CM 51-07 if a new CM cannot be agreed in 2022, so that the SC can complete the agreed krill work plan and formulate a new CM in a later year.

3. CCAMLR should maintain precaution in management, given numerous existing uncertainties. Any increase in catch limits should be incremental and should only happen if supported by science that shows that a new measure improves the protection of predators, and if all the following elements are agreed and implemented by CCAMLR and SC-CAMLR:

    - Regular science-based revisions of catch limits at least every five years
    - Regular testing and evaluation of the gRym if it is used to set catch limits
    - Regular monitoring of the impacts of fishing on krill and predators including regular survey transects, which should be made mandatory for fishing vessels, and a revision of the CCAMLR Ecosystem Monitoring Program
    - 100% international observer coverage[8]
    - Designation of the D1MPA to provide resilience for the fishery and to the ecosystem and to be used as climate change reference areas
    - Improvement of the transshipment conservation measure to increase transparency, monitoring, and reporting of transshipments
    - Collaboration with ACAP, IWC and relevant experts, including through IMAF, to quickly mitigate all marine mammal and seabird bycatch.

[8]Conservation Measure 51-06 sets 100% observer coverage for Antarctic krill fisheries but does not specify the requirement for international observers managed under SISO. https://cm.ccamlr.org/en/measure-51-06-2019. Finer details can be found in https://www.ccamlr.org/en/system/files/e-pt10_4.pdf

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