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EDITED AND REVIEWED BY
Stelios Katsanevakis,
University of the Aegean, Greece

*CORRESPONDENCE
So Kawaguchi
So.Kawaguchi@aad.gov.au

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Editorial: Antarctic krill and interactions in the East Antarctic ecosystem

So Kawaguchi[1,2]*, Elanor Bell[1], Sophie Bestley[2,3], Martin J. Cox[1,2] and Kerrie M. Swadling[2,3]

[1]Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water, Kingston, TAS, Australia, [2]Australian Antarctic Program Partnership, Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, TAS, Australia, [3]Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, TAS, Australia

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Editorial on the Research Topic
Antarctic krill and interactions in the East Antarctic ecosystem

Collectively, the seventeen articles comprising this Research Topic represent a significant advancement in understanding the ecological role, spatial variability, and trophic significance of Antarctic krill (*Euphausia superba*) across East Antarctica and the broader Southern Ocean. Eight papers in this multidisciplinary research initiative were based on data collected between February and March 2021, within 62°S to 68°S and 55°E to 80°E during the TEMPO (Trends in Euphausiids off Mawson, Predators, and Oceanography) voyage. Data from two more contemporary voyages were also used: Japan's 2018/19 (KY1804; 80°E to 150°E) and Australia's 2018/19 ENRICH (Euphausiids and Nutrient Recycling in Cetacean Hotspots). Other articles used historical data (Liang et al., Tan and Bai), and data collected using a variety of sampling platforms, from ship-based surveys (Schaafsma et al.; Abe et al., 2023) to autonomous moorings (de Castro et al.; Smith et al., 2025), remotely sensed satellite observations (Foppert et al.; Tan and Bai), animal trackers (Riaz et al.), and remotely piloted aircraft (Andrews-Goff et al.).

The datasets compiled encompass physical oceanography, passive and active acoustic measurements, biogeochemical analyses, and environmental DNA (eDNA) sampling (Suter et al.), necessitating the development of novel technologies and analytical methods (Bairstow et al., 2021, 2022; Smith et al.). These comprehensive efforts have unveiled rapid changes in krill habitats, leading to a possible redistribution of krill populations throughout East Antarctica, as evidenced by variations in krill density and distribution observed from fine (Cox et al., 2022) to basin scales (Green et al.). Beyond krill, the taxa studied span from phytoplankton (Heidemann et al.), to zooplankton (Weldrick et al.) to whales (de Castro et al.; Miller et al.), with investigations into physical processes ranging from surface sea observations to the characterization of entire water masses, discerned from Conductivity Temperature Depth (CTD) profiles (Foppert et al.). In sum, these fieldwork endeavors and analyses reflect a sustained commitment to krill research and is high-relevant to improving our understanding of marine ecosystem function and the management of krill.

The influence of environmental variability on krill habitats across the Southern Ocean was investigated. Habitat suitability modeling—employing satellite remote sensing data, sea-ice phenology, and phytoplankton bloom timing—has documented both long-term habitat degradation and spatial redistributions of krill populations in response to climate forcing (Foppert et al.; Heidemann et al.; Liang et al.; Tan and Bai). These studies are particularly valuable in projecting how krill may shift their range under changing sea-ice dynamics and altered primary production regimes. Importantly, they provide a bridge between physical forcing and krill availability to higher predators, creating synergies with both biomass modeling and predator-prey interaction studies.

In parallel, physical oceanography and biogeochemistry studies have provided context for interpreting habitat models. However, the picture is complex, with many potential explanatory variables, operating at a variety of spatial scales influencing krill behaviour and distribution. For example, a slight deepening of the mixed layer depth was found towards the northern limits of the TEMPO survey area (Foppert et al.), along with changes in the number and structure of krill swarms (Cox et al., 2022). However, spatial heterogeneity of phytoplankton communities, partly shaped by regional light availability (Vives et al., 2022), may also influence krill distribution.

The ecological importance of Antarctic krill is further underscored by its role in structuring the behavior and distribution of higher predators. Studies on Adélie penguins (*Pygoscelis adeliae*), Snow Petrels (*Pagodroma nivea*), and baleen whales have demonstrated that predator foraging activity is closely aligned with krill swarm frequency, structure, and vertical accessibility, rather than simple measures of biomass (Cox et al., 2023; Miller et al.; Riaz et al.; Viola et al.). These relationships highlight the value of integrating multiple scales of predator movement data with concurrent acoustic and environmental observations.

Recent advances in technology and modeling frameworks have expanded our capacity to monitor Antarctic krill and their interactions with the environment. Mechanistic models like KRILLPODYM simulate krill life-cycle stages in response to oceanographic conditions and fisheries pressure (Green et al.). Meanwhile, shipborne drones, and multi-frequency acoustics have greatly enhanced spatial and vertical resolution of swarm structure (Andrews-Goff et al.; Cox et al., 2023). These tools not only improve biomass estimation but also enable direct comparisons with predator movement data and carbon flux models and should be coupled with time-series observations from fixed locations (Smith et al., 2025) enabling observation of seasonal variability in krill distribution.

The long-term sustainable management of krill requires estimates of the standing stock of krill (biomass) calculated from acoustic-trawl surveys (Abe et al., 2023), recruitment, demographics and the requirements of krill-dependent predators, such as Adélie penguin (Riaz et al.). Balancing the competing needs of fishers and krill-dependent predators is a focus of several studies and is a driver of Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR's) precautionary approach to krill fisheries. Maschette et al., based on information from the recent surveys (Cox et al., 2022; Murase, 2025) updates estimates of precautionary catch limits across longitudinal range between 50 to 140 degrees east in East Antarctica. Krill swarms become sparse away from the continent, and the bioenergetic content of krill varies by swarm composition (swarms of gravid females containing the most energy) (Cataldo-Mendez et al.). This illustrates the importance of considering both recruitment (Maschette et al.) and stage-specific maturity representations of krill (Green et al.; Schaafsma et al.).

The collective insights from recent Antarctic krill research have direct relevance for ecosystem-based fisheries management strategies employed by CCAMLR. Improved demographic and energetic characterization of krill enhances the precision of yield models and supports spatially differentiated catch limits (Cataldo-Mendez et al.; Maschette et al.). Furthermore, simulation frameworks like KRILLPODYM enable scenario testing under varying environmental and harvest regimes (Green et al.), and they rely heavily on empirical observations of habitat use and predator interaction.

Crucially, the use of predator foraging metrics and spatial fidelity as monitoring proxies offers a practical means to assess krill availability across trophic levels (Calderan et al.; Viola et al.). These integrative approaches support CCAMLR's precautionary harvest framework by emphasizing ecological roles and the importance of krill for dependent species. Recent studies collectively encourage a shift toward adaptive, spatial management informed by feedback from coupled ecological indicators and biomass models.

Several knowledge gaps remain that are critical for advancing the science and stewardship of Antarctic krill dominated ecosystems. High priorities include empirical studies of under-ice and winter ecology, energy-based metrics in trophic models, and improved seasonal resolution in predator-prey data collection (Cataldo-Mendez et al.; Weldrick et al.). The incorporation of autonomous platforms—such as gliders, drones, and moored acoustic arrays—can provide continuous, high-resolution coverage of krill habitats (Andrews-Goff et al.; Miller et al.).

Additionally, modeling efforts should further integrate machine learning techniques and coupled physical-biogeochemical frameworks to improve predictions of krill dynamics under future climate and fishery scenarios (Green et al.; Tan and Bai). Cross-study synergies, such as integrating habitat models with predator telemetry (Riaz et al.) and biomass estimates (Cox et al., 2022, represent a fertile area for synthesis and inter-disciplinary collaboration. Long-term, multinational research collaborations will be indispensable in filling observational gaps and ensuring robust, dynamic, and ecologically coherent management strategies for krill-based ecosystems.

Author contributions

SK: Writing – review & editing, Conceptualization, Project administration. EB: Writing – review & editing. SB: Writing –

review & editing. MC: Conceptualization, Writing – original draft. KS: Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The author(s) declare that no Generative AI was used in the creation of this manuscript.

Publisher's note

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