**Supplementary Table 3.** Future prognoses\* for Southern Ocean zooplankton in response to changes in key physical, chemical, and ecological drivers (based on information provided in Sections Euphausiids (Family Euphausiidae), Copepods (Subclass Copepoda), Salps (Order Salpida), Pteropods (Order Pteropoda), and Past Changes in Zooplankton: A modelled example using Continuous Plankton Recorder Data (including references cited therein)).Prognoses may vary across areas of the Southern Ocean, seasons, or life history stages. See Figure 1 for locations and key to MEASO areas.

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| --- | --- |
| **Taxa** | **Future prognoses**  |
| Antarctic krillA picture containing shape  Description automatically generated | Sea ice* Increased instability in sea ice may benefit krill by increasing availability of larval over wintering habitat and food
* Sea ice decline may reduce the availability of reproductive habitat and overwintering resources
* Sea ice decline may impact phytoplankton community structure (reducing diatoms), potentially reducing krill feeding efficiency
* Decline in sea ice extent may lead to poleward contraction of populations

Ocean warming* May reduce the availability of reproductive habitat
* May impact habitat quality, resulting in habitat contraction as temperatures at the northern fringes of their range exceed physiological limits
* Spatial variability in warming and localised increases in primary production could enhance habitat quality in some restricted regions, but these are unlikely to offset degradation elsewhere

Ocean acidification* Increased CO2 may negatively impact embryonic development and hatching

Primary productivity* Changes in primary productivity may alter the availability of reproductive habitat
* Changes in the seasonal primary productivity cycles may negatively impact krill population size across its current distributional range

Predators* Positive feedback loop generated by recovery of whale populations may support increased *E. superba* abundance

See Murphy et al. (2018+) for future prognoses in CCAMLR statistical Area 48, southwest Atlantic (Atlantic Sector, East Pacific Sector)Resilience* Observed phenotypic plasticity and high variability in life history strategies and behaviour may confer resilience and survival of the species
* *Future prognoses for E. superba are limited by uncertainties about vulnerabilities, resilience, and ecological interactions, particularly its relationship with sea ice and the mechanistic processes involved. Additive, synergistic, or antagonistic effects of multiple environmental drivers on these aspects poorly quantified*
* *Climate change is likely to increase physiological stress on early life stages and adults. These may be compounded by loss and fragmentation of spawning and over wintering habitat. May eventually become restricted to a limited number of locations suitable for successful spawning, survival and recruitment. Contraction of distributions and biomass will have consequences for the Antarctic krill fishery. They are also likely to impact krill predator populations, with consequences for finfish fisheries and wildlife tourism. Severity of impacts on E. superba and predators may increase with severity of climate change.*
* *Changes will also have consequences for spatial and temporal variations in biogeochemical cycling, particularly particulate organic matter export and remineralisation*
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| Other euphausiids**A picture containing shape  Description automatically generated** | Sea ice* Decline in sea ice concentration may result in the severe loss of spawning habitat and reproductive success of *E. crystallorophias*

Ocean warming* *E. crystallorophias* vulnerable due to narrow thermal habitat (≤2oC) and lower diversity of heat shock protein systems
* Growth rate, and hence potential biomass per recruit, of *T. macrura* may increase
* Surface warming (and deepening of mixed layer depth) may increase environmental stability between Antarctic Polar Front and northern annual limit of sea ice, and hence increase habitat availability for *T. macrura*
* Range extension into higher latitudes projected for *E. superba* and *T. macrura* under warmer conditions may also increase the potential for interactions with *E. crystallorophias*, the impacts of which are unknown

MLD* Shallowing of mixed layer depth in the Pacific sectors (East Pacific Sector, West Pacific Sector) may increase environmental stability and habitat for *T. macrura*

Primary production* Changes in phytoplankton community structure favouring diatoms (particularly in the Ross Sea continental shelf area, West Pacific Sector) may enhance *E. crystallorophias* feeding efficiency, but may not be offset by impacts of sea ice loss on spawning habitat and reproductive success
* Changes in phytoplankton community structure favouring *Phaeocystis antarctica* may reduce *E. crystallorophias* feeding efficiency
* Elevated primary productivity north of the Antarctic Polar Front may increase habitat availability for *T. macrura*

Predators* Positive feedback loop generated by recovery of whale populations may support increased *E. crystallorophias* and *T. macrura* abundance

Resilience* *E. crystallorophias’* low capacity to move to other areas, limited thermal range and genetic adaptations to past periods of increased glaciation imply this species is unlikely to be resilient to future climate change. Areas of the high Antarctic (Antarctic Zone), in the Ross Sea (12), or southern most parts of Weddell Sea (7) may provide refugia for some populations
* Range of life history strategies (wide thermal tolerance, omnivorous diet etc.) and independence from spring bloom and sea ice for reproductive success may confer resilience of *T. macrura* to future change, however, impact of future predator populations unclear
* *Future prognoses limited by uncertainties about ecological interactions and responses to key drivers. Additive, synergistic, or antagonistic effects of multiple environmental drivers on these species (including resilience) unknown*
* *Future climate change is likely to cause a decline in E. crystallorophias abundance and contraction of its distribution to higher latitudes. T. macrura distribution and abundance may increase. T. macrura likely to be more resilient to future changes than E. crystallorophias. However, potential combined impact of multiple environmental drivers unknown*
* *Changes in* *distribution and abundance are likely to increase ecological interactions between E. crystallorophias, T. macrura and E. superba and also impact predator populations. These will have consequences for food web dynamics and spatial and temporal variations in biogeochemical cycling*
 |
| Copepods**A picture containing sitting, light  Description automatically generated** | Sea ice* Decrease in sea ice will reduce the amount of available habitat for sympagic genera such as *Drescheriella*, *Paralabidocera* and *Stephos* and reduced food availability of winter-active species such as *Calanoides propinquus*

Ocean acidification* Increased acidification may affect the grazing (phytoplankton) selectivity of some copepod species
* Copepods may be resilient to increased ocean acidification (at least up to levels projected by the end of the century) but this may be offset by local stressors

Primary production* Changes in phytoplankton biomass/concentration may impact egg production rates, carbon mass and abundance of copepod populations
* Food availability at the local scale may be more important in driving copepod abundances than changes in other physical drivers such as ocean temperatures

Resilience* Calanoid copepodsmay show resilience to warming by maintaining a fixed geographical distribution (on the basis of food availability and/or genetic or phenotypic adaptation)
* Copepods form a diverse group with varying habitat preferences so changing conditions may favour some species over others
* Copepods may show some degree of resilience to future increases in ocean acidification (as above)
* *Future prognoses are severely limited by basic knowledge of their phenotypic plasticity, life history traits and strategies, long-term changes in their distributions and abundance, and the mechanistic processes involved.* *Additive, synergistic, or antagonistic effects of multiple environmental drivers, including changing competition and predation, on these aspects (including resilience) are unknown*
* *Copepods may show some degree of resilience to increased ocean acidification (however, impact of multiple environmental drivers unknown)*
* *Any changes in* *distribution and abundance are likely to impact their predator populations, particularly those that rely on copepod or krill-dominated food webs. These will also have consequences for spatial and temporal variations in biogeochemical cycling, particularly particulate organic matter export and remineralisation*
 |
| A picture containing icon  Description automatically generatedSalps | Ocean warming* Increased warming will expand the range of *S. thompsoni* (see also ocean circulation)

Ocean circulation* Advection of warmer waters into high Antarctic regions may support higher occurrence of *S. thompsoni* in certain regions

Primary production* Increases in phytoplankton biomass/concentrations may support replacement of *E. superba* populations with salps in regions around the Antarctic Peninsula (Atlantic Sector, East Pacific Sector)

Resilience* May be resilient to abrupt shifts in the environment via fast-evolving genes and fast population turnover rates (during asexual reproduction), which may enhance chances of finding an environmental match
* *Future prognoses are limited by basic knowledge of their physiology, life history strategies, long-term changes in distribution and abundance, and the mechanistic processes involved, particularly interactions with E. superba. Additive, synergistic, or antagonistic effects of multiple environmental drivers on these aspects (including resilience) unknown*
* *Abundance and distributions are likely to expand*
* *Increased range expansion and biomass, and hence increased krill-salp interactions, will have major effects on the planktonic food web and the contributions of salps to carbon flux. Changes in* *distribution and abundance are also likely to impact predator populations, particularly those that rely on krill-dominated food webs, and fisheries. Changes will also have consequences for spatial and temporal variations in biogeochemical cycling*
 |
| PteropodsA picture containing arrow  Description automatically generated | Sea ice* Decline in sea ice may favour increased pteropod abundance

Ocean warming* May favour abundance of sub-Antarctic pteropods
* May result in a poleward shift in pteropods, resulting in range expansion for sub-Antarctic taxa and contraction for Antarctic species

Primary production* Expected to be an important driver of pteropod species composition and abundance
* Increased productivity may favour increased pteropod abundance

Ocean acidification * Thecosomes may be increasingly negatively impacted by aragonite undersaturation, which will affect higher latitude waters first

Resilience* The seasonal Ωar undersaturated conditions that Southern Ocean pteropods already experience, together with an ability to maintain shell integrity may be indicative of a level of resilience. This may come at a metabolic cost that is unlikely to be maintained over the longer-term
* *Future prognoses are limited by basic knowledge of their physiology, life history strategies, long-term changes in distribution and abundance, resilience and the mechanistic processes involved (particularly regarding ocean acidification and its interaction with other drivers). Additive, synergistic, or antagonistic effects of multiple environmental drivers on these aspects poorly quantified*
* *Sub-Antarctic species may expand their distributions and abundance in higher latitude waters*. *Thecosomes may be resilient to increasing aragonite undersaturation in the short-term. Potential combined impact of multiple environmental drivers not extensively explored*
* *Changes in* *distribution and abundance will have implications for food web dynamics and biogeochemical cycling*
 |

**\*** This assessment represents our expert consensus as explained in the Section Summaries and Assessments

CCAMLR = Commission for the Conservation of Antarctic Marine Living Resources

+ see main paper for reference details