Antarctic sea-ice and macrozooplankton distribution as determinants of top predator community structure in winter

Max Czapanskiy[1,2], Jarrod Santora[1], Kim Dietrich[3], Megan Cimino[1,2], Elliott Hazen[1], Christian Reiss[1]

[1]NOAA Soutwhest Fisheries Science Center
[2]University of California Santa Cruz, Ocean Sciences Department
[3]Ocean Associates, Incorporated

Background

The marine ecosystem surrounding the Antarctic Peninsula is both highly productive and rapidly changing.

Abundance and distribution of Antarctic plankton and predators are controlled, in part, by physical and biogeochemical processes during the preceding winter (Hinke & Trivelpiece, 2011; Meyer et al., 2017).

Winter ecosystem surveys are limited by adverse weather conditions, leaving a key information gap. This season also has the most rapid warming and greatest increase in fisheries pressure (Ducklow et al., 2013; Nicol & Foster, 2016).

The Antarctic Peninsual predator community is a mix of seabirds and marine mammals, including ecologically and culturally important species such as Adélie penguins (*Pygoscelis adeliae*), snow petrels (*Pagodroma nivea*), and Antarctic fur seals (*Arctocephalus gazella*).

Methods

During the Austral winters of 2012-2016, we conducted ecosystem surveys of the northern Antarctic Peninsula, including the South Shetland Islands and Elephant Island. We collected hydrology, sea ice, zooplankton, and predator observations.

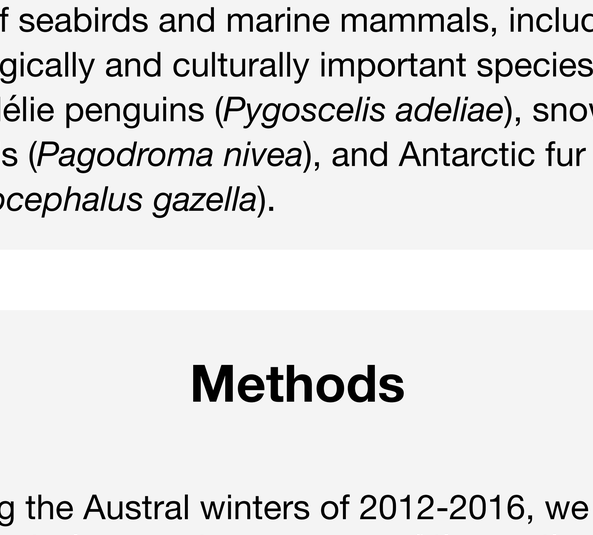

Figure 1: BS – Bellinghausen Sea; WS – Weddell Sea; EI – Elephant Island; JI – Joinville Island. Reproduced with permission from Dietrich et al. (2021)

We identified predator communities using hierarchical cluster analysis, and examined environmental determinants of community structure with NMDS and multiple regression.

Results

Predators formed three communities along a sea ice concentration gradient.

- **Open water** incl. southern fulmars (*genus species*), Antarctic petrels (*genus species*), and snow petrels.
- **Marginal ice** incl. Antarctic fur seals, snow petrels, kelp gulls (*genus species*), and Southern giant petrels (*genus species*).
- **Pack ice** incl. Adélie penguins and crabeater seals (*genus species*).

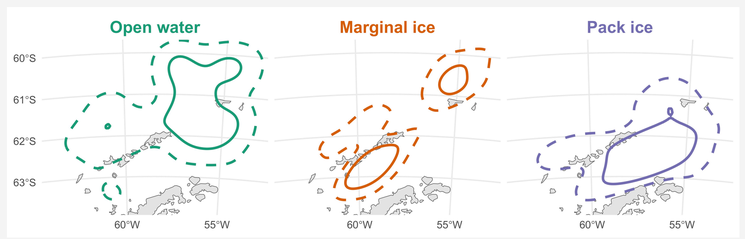

Figure 2: Distributions of three winter predator communities. Solid and dashed lines indicate 50% and 95% utilization distributions, respectively.

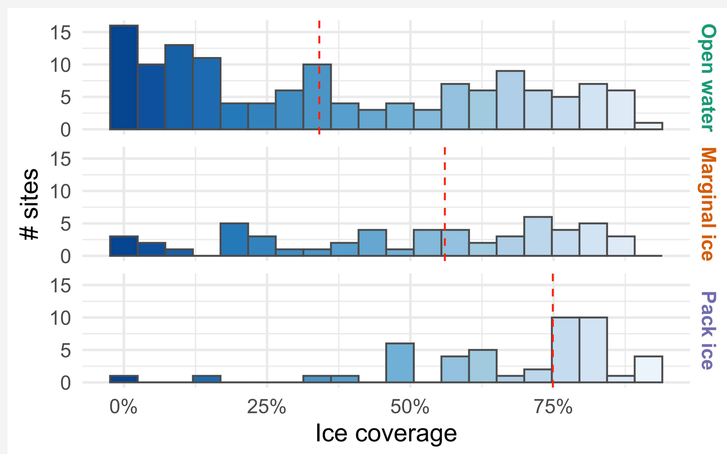

Figure 3: The median sea ice coverage (red dashed lines) increased from the **Open water** (34.1%) to **Marginal ice** (56.0%) to **Pack ice** (74.9%) communities.

Each predator community was significantly associated different macrozooplankton communities.

- **Open water** with a small-bodied euphausid community incl. *Thysanoessa macrura*
- **Marginal ice** with a large-bodied euphausid community incl. *Euphausia superba* and *E. crystallorophias*.
- **Pack ice** with an extremely diverse zooplankton community with an apparent mesopelagic signature, incl. chaetognaths, siphonophores, and *Calanoides acutus*.

Conclusions

Our results confirm the mesoscale organization of marine predator communities in the Antarctic Peninsula is largely driven by sea ice dynamics.

This five-year winter ecosystem synthesis is unlikely to be replicated due to increasing ship costs and the difficult logistics of winter Antarctic research. These observations represent a critical snapshot of winter community habitat associations. Therefore we will be publishing our full dataset in accordance with open science principles to support future research and conservation for this region.

It remains unclear how the expanding krill fishery and long-term reductions in sea-ice will affect the marine ecosystem of the Antarctic Peninsula. Our results will support projections for both individual species and entire communities.

Acknowledgements

We are grateful for the diligent work by the field personnel who made these surveys possible, including the captains, crew, and support personnel of the RVIB *Nathaniel B Palmer*. The surveys were conducted by a partnership of NOAA Fisheries Antarctic Ecosystem Research Division and the NSF US Antarctic Program.

We thank Dr Jack Conroy for his contributions and feedback on matters related to zooplankton communities.

References

Dietrich, K. S., Santora, J. A., & Reiss, C. S. (2021). Winter and summer biogeography of macrozooplankton community structure in the northern Antarctic Peninsula ecosystem. Progress in Oceanography, 196, 102610.

Ducklow, H. W., Fraser, W. R., Meredith, M. P., Stammerjohn, S. E., Doney, S. C., Martinson, D. G., Sailley, S. F., Schofield, O. M., Steinberg, D. K., Venables, H. J., & others. (2013). West Antarctic Peninsula: An ice-dependent coastal marine ecosystem in transition. Oceanography, 26(3), 190–203.

Hinke, J. T., & Trivelpiece, W. Z. (2011). Daily activity and minimum food requirements during winter for gentoo penguins (*Pygoscelis papua*) in the South Shetland Islands, Antarctica. Polar Biology, 34(10), 1579–1590.

Meyer, B., Freier, U., Grimm, V., Groeneveld, J., Hunt, B. P. V., Kerwath, S., King, R., Klaas, C., Pakhomov, E., Meiners, K. M., Melbourne-Thomas, J., Murphy, E. J., Thorpe, S. E., Stammerjohn, S., Wolf-Gladrow, D., Auerswald, L., Götz, A., Halbach, L., Jarman, S., … Yilmaz, N. I. (2017). The winter pack-ice zone provides a sheltered but food-poor habitat for larval Antarctic krill. Nature Ecology & Evolution, 1(12), Article 12.

Nicol, S., & Foster, J. (2016). The fishery for Antarctic krill: Its current status and management regime. Biology and Ecology of Antarctic Krill, 387–421.