Point Blue Publication Brief

Trophic cascades in the western Ross Sea

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The importance of "top-down" processes in structuring marine ecosystems remains under-appreciated, in part because there are so few opportunities to assess them. One example from the terrestrial realm is the wolves in Yellowstone National Park, which have been shown to indirectly encourage re-generation of vegetation because they keep grazer (elk) abundance lower than it would be in the absence of wolves.

Despite comprising just 2% of the Southern Ocean, The Ross Sea contributes nearly 30% of the Southern Ocean's total primary production (phytoplankton), and is thus a mysteriously significant carbon sink of global importance.

We have previously shown that large predator populations in the Ross Sea have a measurable effect on the availability of krill and small fish, which are in lower numbers than comparable ecosystems elsewhere on the planet.

We evaluated the hypothesis that the high productivity in the Ross Sea is the result of a "trophic cascade" in which predators reduce the abundance of krill and small fish, resulting in much of the phytoplankton biomass remaining ungrazed.

To do this, we used an autonomous underwater vehicle (sea glider) equipped to assess productivity and prey abundance at the same time and place that we also instrumented Adélie penguins with satellite transmitters and time-depth recorders, making detailed recordings of their behavior while they were acquiring food for their chicks.

We found that the penguin foraging distance, depth, and duration increased during the study, in correspondence with a reduction and deepening of prey in their foraging area (as determined by the sea glider). At the same time, krill depth increased when there was less phytoplankton available, suggesting an uncoupling between krill food and krill distribution.

These results support the idea that the Ross Sea food web has a "wasp-waist" structure, in which middle-trophic levels are controlled top-down, whereas phytoplankton production is regulated bottom-up, largely independent of grazer control. The study adds another important reason to conserve top ocean predators.

Main Points

We used a sea glider to assess phytoplankton, krill, and fish availability at the same time that we recorded penguin foraging behavior.

We found that penguins probably reduced availability of krill and fish, independent of phytoplankton availability.

We propose that the Ross Sea food web has a "wasp-waist" structure that ultimately could explain the large carbon sequestration capability of the Ross Sea.

Ainley, D.G., G. Ballard, R. M. Jones, D. Jongsomjit, S. D. Pierce, W. O. Smith Jr., S. Veloz. 2015. Trophic cascades in the western Ross Sea, Antarctica: revisited. Marine Ecology Progress Series 534:1-16 (open access).