Increased sea ice cover disrupts food web structure in coastal Antarctica

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Antarctica currently undergoes strong and contrasted impacts linked with climate change. While the West Antarctic Peninsula is one of the most rapidly warming regions in the world, resulting in sea ice cover decrease, the sea ice cover of East Antarctica unexpectedly tends to increase, possibly in relation with changes in atmospheric circulation. Sea ice is a major environmental driver in Antarctica, and changes in sea ice cover are likely to influence benthic food web structure through several processes (modifications of benthic-pelagic coupling, disruption of benthic production and/or modifications of benthic community structure and therefore resource availability for benthic consumers).

To date, regions where sea ice cover is decreasing have received more attention than regions where it is increasing. Here, on the other hand, we studied shallow (0-20 m) benthic food web structure on the coasts of Petrels Island (Adélie Land, East Antarctica) during an event of unusually high spatial and temporal (two successive austral summers without seasonal break-up) sea ice cover. Using time-tested integrative trophic markers (stable isotope ratios of carbon, nitrogen and sulfur) and state-of-the-art data analysis tools (bayesian ecological models), we studied the structure of the food web associated to benthic macroinvertebrates communities. In total, 28 macroinvertebrate taxa spanning most present animal groups (sponges, sea anemones, nemerteans, nematods, sipunculids, sessile and mobile polychaetes, gastropods, bivalves, pycnogonids, crustaceans, sea stars, sea urchins, brittle stars and sea cucumbers) and functional guilds (grazers, deposit feeders, filter feeders, predators, scavengers) were investigated.

Our results indicate that the absence of seasonal sea ice breakup deeply influences coastal benthic food webs in Antarctica. We recorded marked differences from literature data, both in terms of horizontal (i.e. primary producers and resources supporting animal populations) and vertical (i.e. trophic level of the studied consumers) structure of the food web. Overall, sympagic (sea-ice associated) algae dominated the diet of many important consumers, and the trophic levels of invertebrates were low, suggesting omnivore consumers relied less on predation and/or scavenging than in normal environmental conditions. Surprisingly, few animals seemed to feed on the extremely abundant benthic biofilm, whose exceptional development was also presumably linked with the peculiar sea ice conditions. Interpretation of data was complicated by the peculiar ecophysiological features of Antarctic invertebrates, whose very low metabolic rates could be associated to low tissue turnover. However, comparison of data obtained in the austral summers of 2013-2014 (first year without seasonal breakup) and 2014-2015 (second year without seasonal breakup) clearly showed that the observed trends were linked with actual temporal changes in invertebrate feeding habits rather than with other potential ecological drivers.

Our results provide insights about how Antarctic benthic consumers, which have evolved in an extremely stable environment, might adapt their feeding habits in response to sudden man-driven changes in environmental conditions and trophic resource availability. They also show that local and/or global trends of sea ice increase in Antarctica could cause strong changes in food web structure and therefore impact zoobenthic communities. This reinforces the view that, no matter their overall direction (i.e. increase or decrease), fluctuations in sea ice cover are likely to influence Antarctic benthic ecosystems' structure and functioning.

Keywords: Antarctica; sea ice; food webs; trophic ecology; global change, benthic invertebrates