Imperial College London

Natural Environment Research Council

2024_51_DoLS_EC: The consequences of climate change and fisheries on Antarctic krill carbon sequestration

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Climate change and fisheries can have detrimental impacts on marine ecosystems, altering population structure and ecosystem function. Human-induced change can also influence nutrient cycling by marine life, in particular their influence on biological stores of carbon. Antarctic krill (Euphausia superba) are an important vector in transporting carbon to the deep ocean and is subject to both climate change and fishing pressures. Antarctic krill are one of the most abundant organisms on Earth, occupying a large range of environmental conditions in the Southern Ocean and swarming, at times, in their trillions. They are well known for their role in sustaining Southern Ocean food-webs as essential prey for baleen whales, penguins, seals and seabirds. Their equally important role in carbon cycling has recently come to light. The high abundance of krill and their fast-sinking carbon-rich pellets result in pulses of carbon to the ocean interior. It's not just their faeces that can contribute though, their exoskeletons (moults), carcasses and daily migrations transport carbon deep enough to be sequestered (removed from the atmosphere for at least 100 years).

We know that Antarctic krill play a key role in sequestering carbon, yet our current knowledge is limited as we do not have comprehensive observations in all seasons and locations. We also have not yet developed a computational framework that is advanced enough to explore how human pressures may influence Antarctic krill's potential to sequester carbon. Climate change is forcing some krill populations to contract southwards, and decreasing the density of krill swarms. Ice regions are essential for the recruitment of krill and the ongoing loss of sea-ice will impact krill population structure. Krill are also fished for their rich lipid reserves, which provide omega-3 for fish-meal, human pharmaceuticals and pet feed. Whilst the catch of the fishery is a small fraction of the krill population, fishing is concentrated in space and time with the potential to disrupt the swarms that deliver carbon pulses, and catches may increase in future as other sources of fish meal and omega-3 become scarce.

This project will develop a novel computer model to represent the role of krill in carbon cycling and use it to explore the effects of fishing and climate change. There will also be opportunities to undertake laboratory work to determine parameter rates for less well-observed traits, and to work with the CASE partner NGO on translating the results into conservation action.

Key scenarios and their impact on krill carbon sequestration that could be explored using the model include:

- Climate-driven changes in krill distribution, abundance and swarming behaviour.
- Climate-driven changes in krill demographics and growth rate.
- Changes in the fishery catch.
- Changes in the spatial and seasonal patterns of fishing.
- Partial replacement of the krill population with other organisms such as salps