Whales Recycle Bioavailable Iron and Copper to Marine Phytoplankton

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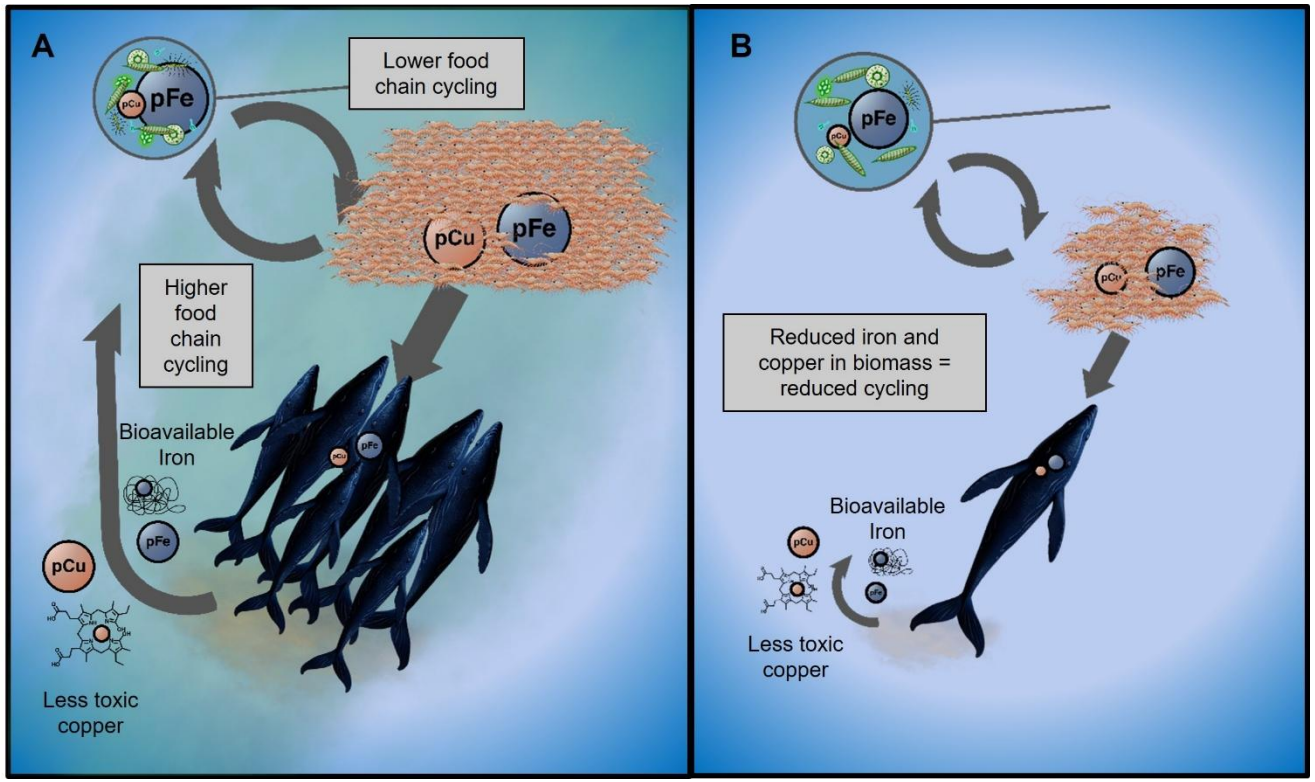
Whales are nutrient recyclers in our oceans. By eating krill and releasing metal-rich fecal plumes at the surface, baleen whales may have played a major role in sustaining phytoplankton growth in the iron-limited Southern Ocean. However, many questions remained about how accessible this metal is to phytoplankton, which depends on the organic molecules bound to the metal.

To investigate these metal-organic complexes, biologists collected rare fecal samples from whales, and chemists analyzed the metal and organic content. Electrochemical techniques revealed the iron was loosely bound to organic compounds, making it readily available. By contrast, copper (toxic at high levels) was found to be tightly bound. The MagLab 21 T Fourier Transform Ion Cyclotron Resonance mass spectrometer was used to identify the copper-binding compounds, many of which were novel and appear to be produced within the whale gut. These ligands play an important role in reducing the toxicity of copper.

The findings reveal that whales recycle iron in a form that boosts phytoplankton growth while simultaneously detoxifying copper, underscoring their role as ecosystem engineers. Thus, the loss of 1.5 million whales from industrial whaling may have disrupted ecosystem dynamics in unprecedented ways. The identification of copper-binding ligands enabled by the MagLab also highlights how animal microbiomes can shape ocean chemistry, with implications for microbial communities throughout the global ocean.



An illustration of the interactions between whales, krill, and phytoplankton in the Southern Ocean under (**A**) pre-whaling and (**B**) post-whaling conditions.

Facilities and instrumentation used: 21 T FT-ICR MS in the ICR Facility

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