

## **Oceanographic mechanisms and penguin population increases during the Little Ice Age in the southern Ross Sea, Antarctica**

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Changes in the oceanic conditions associated with large-scale atmospheric forcing can exert substantial ecological impacts in the Southern Ocean, however, little is known on the coupling of atmospheric circulation, oceanic conditions, and marine ecology over a long time scale. Here, using ornithogenic sediments at Cape Bird, Ross Island, Antarctica, we inferred relative population changes of Adélie penguins in the southern Ross Sea over the past 500 years, and observed an increase in penguin populations during the Little Ice Age (LIA; 1500-1850 AD). We used cadmium content in ancient penguin guano as a proxy of ocean upwelling and identified a close linkage between penguin ecology and atmospheric/oceanic conditions. During the cold period of 1600-1825 AD, a deepened Amundsen Sea Low (ASL) led to stronger winds, intensified ocean upwelling, an enlarged Ross Sea and McMurdo Sound polynya, and thus higher food abundance and penguin populations. We propose a mechanism linking Antarctic marine ecology and atmospheric/oceanic dynamics which provides a new approach on understanding penguin ecological history that allows us to predict future changes with this species.