Seabird response to abrupt climate change 5,000 years ago transformed Falklands ecosystems: study

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A rookery of black-browed albatross (Thalassarche melanophris) nest at a windy, exposed tussac grassland on West Point Island, Falkland Islands. Credit: Dulcinea Groff

The Falkland Islands are a South Atlantic refuge for some of the world's most important seabird species, including five species of penguins, Great Shearwaters, and White-chinned Petrels. In recent years, their breeding grounds in the coastal tussac (*Poa flabellata*) grasslands have come under increasing pressure from sheep grazing and erosion. And unlike other regions of the globe, there has been no long-term monitoring of the responses of these burrowing and ground nesting seabirds to climate change.

A 14,000-year paleoecological reconstruction of the sub-Antarctic islands led by University of Maine researchers has found that seabird establishment occurred during a period of regional cooling 5,000 years ago. Their populations, in turn, shifted the Falkland Islands ecosystems through the deposit of high concentrations of guano that helped nourish tussac, produce peat and increase the incidence of fire.

This terrestrial-marine link is critical to the islands' grasslands conservation efforts going forward, says Dulcinea Groff, who led the research as a UMaine Ph.D. student in ecology and environmental sciences, and part of a National Science Foundation-funded Interdisciplinary Graduate Education Research Traineeship (IGERT) in Adaptation to Abrupt Climate Change (A2C2). The connection of nutrients originating in the marine ecosystem that are transferred to the terrestrial ecosystem enrich the islands' nutrient-poor soil, thereby making the Falkland Islands sensitive to changes in climate and land use.

The terrestrial-marine linkage in the Falkland Islands was the focus of Groff's dissertation in 2018.

"Our work emphasizes just how important the nutrients in seabird poop are for the ongoing efforts to restore and conserve their grassland habitats. It also raises the question about where seabirds will go as the climate continues to warm," says Groff, who conducted the research in

the Falkland Islands during expeditions in 2014 and 2016 led by Jacquelyn Gill, an associate professor of paleoecology and plant ecology in the UMaine Climate Change Institute.

A rookery Southern rockhopper penguins (Eudyptes chrysocome chrysocome) nest between a rocky slope and a tussac grassland and bring in nutrients from the ocean directly to the grasses at the Kidney Island National Nature Reserve, Falkland Islands. Credit: Dulcinea Groff.

"Our 14,000-year record shows that seabirds established at Surf Bay during cooler climates. Seabird conservation efforts in the South Atlantic

should be prepared for these species to move to new breeding grounds in a warmer world, and those locations may not be protected," says Groff, who is now a postdoctoral research scientist at the University of Wyoming.

The UMaine expedition team, which included Kit Hamley, then a master's student in Quaternary studies and a Climate Change Institute Fellow, collected a 476-centimeter peat column from Surf Bay, East Falkland. The 14,000-year record revealed in the undecomposed tussac leaves of the peat column "captures the development of a terrestrial-marine linkage that supports some of the most important breeding colonies of seabirds in the Southern Ocean today," according to the research team, which published its findings in the journal *Science Advances.*

The absence of seabirds at the East Falklands site prior to 5,000 years ago suggests that seabirds may be sensitive to warmer mediated sea surface temperatures, which can impact their food supply, according to the research team. With a warming South Atlantic today, the question is whether the Falkland Islands, about 300 miles east of South America, will continue to be a seabird breeding "hot spot."

"Our work suggests that as the Southern Ocean continues to warm in the coming decades, the Falkland Islands seabird communities may undergo abrupt turnover or collapse, which could happen on the order of decades," according to the research team, which, in addition to Groff, Hamley (now a UMaine doctoral student) and Gill, involved Trevor Lessard and Kayla Greenawalt of UMaine, Moriaki Yasuhara of the University of Hong Kong, and Paul Brickle of the South Atlantic Environmental Research Institute, all co-authors on the American Association for the Advancement of Science journal article.

The Falkland Islands are at the boundary of a number of potential

climate drivers, note the researchers. And *P. flabellata* peatlands have the world's highest accumulation rates, "providing an unusually high-resolution record capable of recording abrupt change"—preserved charcoal, seabird guano and pollen data that can be used to analyze fire history, seabird population abundance and vegetation composition, respectively.

At dusk thousands of seabirds called sooty shearwaters (Ardena grisea) return to their deep nesting burrows dug into the peat of the tussac grassland at the Kidney Island National Nature Reserve, Falkland Islands. Credit: Dulcinea Groff.

In the Falklands, where there are no native mammals or trees, settlers introduced sheep in the 17th century. Today, residents make their livelihoods from fishing, sheep farming and tourism.

The 14,000-year record from East Falkland revealed that for 9,000 years before the arrival of seabirds, the region was dominated by low levels of grasses, a heathland of ferns and dwarf Ericaceous shrubs. About 5,000 years ago, the researchers say, an "abrupt transition" appears to occur. Concentrations in bio-elements such as phosphorus and zinc increase. Grass pollen accumulation rates skyrocket, indicating the establishment of tussac grasslands within 200 years of the establishment of seabird colonies on the island. Also found in the core: increased accumulation rates of peat and charcoal.

It's clear that the addition of seabird populations bringing nutrients from the marine environment to the island drove changes in the terrestrial plant community structure, composition and function, according to the researchers, as well as increased fire activity and nutrient cycling.

What remains unclear is what drove the abrupt ecosystem shift, says Gill, one of the world's leading authorities on paleo-ecosystems, including the impacts of climate change and extinction, and the geographical distribution of living things through space and time.

"We know seabirds arrived at Surf Bay during a time when the climate was becoming cooler in the South Atlantic, though we still don't know for sure what it was they were tracking. We also don't know where these birds took refuge when climates were warmer, and that's concerning as the South Atlantic gets hotter into the future," says Gill, an NSF CAREER researcher who most recently was named a 2020 Friend of the Planet by the National Center for Science Education.

"Our study is also a powerful reminder of why we need to understand

how different ecosystems are connected as the world warms," says Gill. "We know that many seabirds in the South Atlantic rely on these unique coastal grasslands, but it turns out that the grasses also depend on the nutrients seabirds provide. Because they rely on ecosystems in the ocean and on land for their survival, seabirds are really good sentinels of global change. We just don't have good long-term monitoring data for most of these species, so we don't know enough about how sensitive they are to climate change. The fossil record can help us fill in the gaps."

More information: "Seabird establishment during regional cooling drove a terrestrial ecosystem shift 5000 years ago" *Science Advances* (2020). DOI: 10.1126/sciadv.abb2788

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