Penguins and oceanographers work together

Penguins have helped oceanographers construct a picture of the structure and location of ocean fronts near Macquarie Island. The research will help improve our understanding of how climate-induced changes in the Antarctic Circumpolar Current, which connects oceans around the world, could impact on ocean productivity.

In the late 1990s, Australian Government Antarctic Division researchers were asked to provide information on king penguins that would assist in the preparation of a management plan for the Macquarie Island Marine Protected Area. An area east of the island was earmarked for the highest level of protection – was this part of the foraging area of king penguins, and would its protection benefit the birds?

To find out, we used satellites to track 21 king penguins on their foraging trips from Macquarie Island, during the incubation stage of their breeding cycle. Fifteen of these birds also carried sensors that collected pressure and temperature data. The pressure data tell researchers how frequently and how deep the penguins dive while hunting for food, while the temperature data help identify to what extent king penguins use ocean fronts (interfaces between water masses of different temperatures) at this time of year.

Fronts, such as the Subantarctic and the Polar fronts (both part of the Antarctic Circumpolar Current or ACC), can be highly productive areas, making them popular feeding grounds for marine mammals and seabirds. Penguins (and other marine animals) carrying electronic sensors that gather information on location and subsurface temperatures, provide large numbers of ocean profiles in a cost-effective manner. This is particularly important in areas where the ability to collect oceanographic measurements during scientific cruises is difficult or limited.

The data showed that over a three-week period the penguins performed nearly 83 000 individual dives. Most of those were 'travelling' dives, but on some 36 000 dives the penguins searched for food. Temperatures sampled during the dives helped to identify where the penguins were located relative to the Southern Ocean fronts. By combining the temperature data from the dive recorders and the penguin locations obtained via satellite, we established the structure and location of the fronts east of Macquarie Island. Together with our CSIRO colleague Steve Rintoul, we used these data to track changes in the frontal systems, and determine how the branches of the ACC form and differ in their temperature profiles. This knowledge is important for understanding changes in food production, which is heavily influenced by the ACC frontal system.

Using satellite measurements of sea surface height, CSIRO had previously discovered that Southern Ocean fronts, such as the Subantartic Front and Polar Front, could split into multiple branches, which can be tracked for many months before they merge again. With the help of the penguins, it was confirmed that the multiple frontal branches seen on the satellite maps are also apparent in the ocean's subsurface temperature data collected by the penguins.

Meanwhile, the foraging strategy of the penguins appeared to be greatly influenced by the regional currents. Upon leaving the island, the penguins consistently hitched a ride on one of the fastest flowing branches of the ACC – the southern branch of the Subantarctic Front. They travelled clockwise, first east and then south-east, reaching distances of up to 620 km from the island.

Most of their diving activity occurred close to the northern and southern branches of the Polar Front in an area of approximately 36 500 km^2 at the eastern border of the Marine Protected Area. Based on the satellite measurements of chlorophyll concentration, this area is more biologically productive than the Subantarctic Front zone located to the north. The king penguins chiefly explored the top 150 m of the water column.

When it was time to return to the colony, the penguins chose a southerly route across a region rich in eddies, where the currents were comparatively weak. Thus, the penguins utilise the currents in a most energy effective manner - they travel downstream when leaving the island and choose the path of least resistance when they return.

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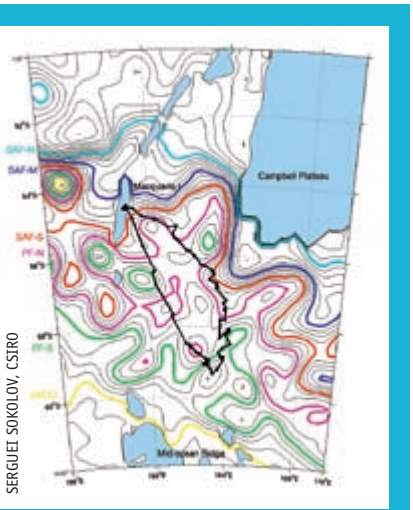

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This snapshot in time shows the approximate structure and location of the ocean fronts east of Macquarie Island, derived from the temperature data from the dive recorders and the penguin locations obtained via satellite. A typical foraging track of a king penguin can also be seen. When penguins leave the island, they catch a ride on the Subantarctic Front (red line), in a clockwise direction, and then return through areas of weaker current. Black dots indicate reliable satellite measurement points. Widely spaced contours on the map indicate areas of weaker, slow moving current, while closely spaced contours highlight areas of fast current.

SAF-N, SAF-S: Subantarctic Front, north and south branches of the current.
PF-N, PF-S: Polar Front, north and south.
sACCF: southern Antarctic Circumpolar Current Front