

Where do Adélie Penguins go in the winter?

Migration in many organisms enables them to take advantage of seasonal changes in their environment and food sources; in many cases, leaving the location where they spend the spring-summer, go to another location for the winter and then return to the summer location year after year.

Adélie penguins live only where the ocean for much of the year is covered by sea ice within a range. Too much ice prevents access to the water and their food, not enough ice and they have no place to rest and have to swim more than they want to. They also require at least a low level of sunlight as they are visual predators, and believe it or not they are afraid of the dark. These penguins won't dive into the ocean unless there is enough light to see that no predators are present!



Figure 1 Adélie Penguins on an ice floe. This is where they live.

Adélie penguins move to places on the coast as far south as $S77.5^{\circ}$ latitude to breed (Nov-Feb). They look for ice- and snow-free land that also provides a supply of small rocks to build their nests, however they still require the closeness of open water and sea ice for foraging trips. In the winter the ocean near their breeding grounds becomes covered with a continuous solid sheet of ice with no access to the ocean and continuous darkness, so these birds must move north. It also gets very, very cold.

Where do they go?

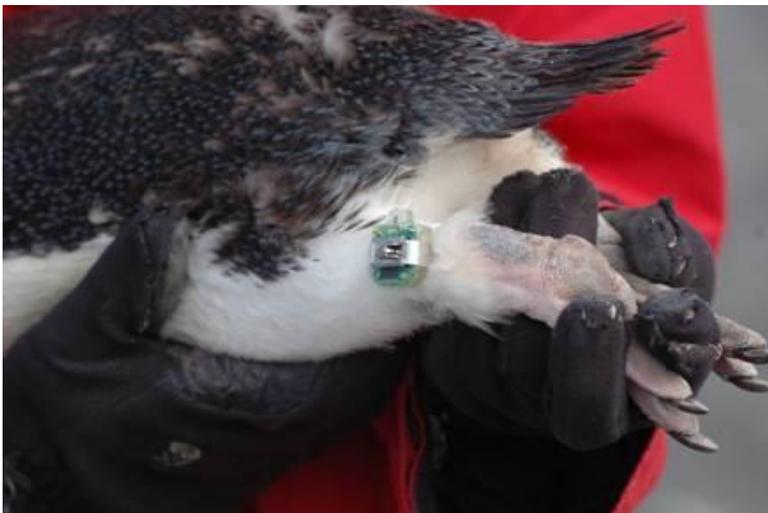


Figure 2 A GLS tag on an Adélie Penguin. He will wear it for a full winter season, and will need to bring it back to us next year so we can collect the data.

Where the Adélie Penguins go in the winter has long been a mystery as the logistics for researchers to make winter pack ice observations are very difficult and expensive. To find out, our team attached GLS (geolocation sensor) tags to a few dozen birds at the end of the breeding season during a three year study in the hopes they would return to Cape Royds and Cape Crozier the following season with the tag still attached to their leg. The tag then had to be removed --- a 30 second procedure --- and the data that were stored in the tag was retrieved.

What did the tags tell us?

The distance the penguins traveled during the winter averaged 1276 km (780 miles) with the longest being 1760 km (1100miles).

The quality of Adélie Penguin wintering habitat, or what they prefer, is determined by several conditions.



Figure 3 Open ocean in Antarctica, not enough ice for the penguins. No place to rest or get away from predators

prefer ocean with about 15-20% coverage of ice, but no more than 75%. In other words they do not like open water, nor continuous ice. More ice and they do not have good access to their food; less ice and there are not enough places (large ice floes) to rest nor are their prey very abundant. In parts of Antarctica where sea ice cover has become reduced, Adélie Penguins have moved away, i.e. emigrated farther south never to return.

Besides the ideal amount of sea ice and at least some daylight, another important condition is the presence of food. Not all ocean areas have equal amounts. Adélie penguins in large numbers need to be in areas of plenty of food for everyone. Look at the map below and notice the white line marked Edge of Antarctic current. This is the Southern Boundary of the Antarctic Circumpolar Current. This large ocean current flows in a ring around the Antarctic continent. In the Current, food resources are less abundant than waters to the south. This nearer-to-the coast zone of ocean has colder water that holds more nutrients and oxygen. Therefore, the food web is much richer. The tag data showed that Adélie penguins stayed close or southward of this Boundary

How do they get there?

After raising their chicks, Adélie penguins need to get really fat and then go someplace for about three weeks to molt. During this time they can not swim so need to be on ice or land. Some will molt at Cape Royds, but these will be delayed in the migration movement out to the wintering grounds and may have to walk great distances over the growing solid ice. Others will swim away

One condition that does not vary over time is the seasonal day length cycle --- long days in summer, short days in winter. Where these penguins nest it is 24 hours of daylight in mid-summer shifting to 24 hours darkness in mid-winter. The penguins want to escape the winter darkness. Even though Adélie Penguins can hunt in deep water with low light visibility, they won't dive into the water when it is dark. From the data on the tags we learned that they have moved themselves far enough north during winter to be able to see at least part of each day. But why not go further north?

Another condition of suitable winter habitat is the amount of ocean covered by sea ice. Adélie's



Figure 4 Solid sea ice, penguins have to walk over this to get to where they can find food. This is too much ice.



Figure 5 Sea ice broken up and just right for penguins, lots of places to rest and easy access to their food in the ocean

from Ross Island to where there is still pack ice that has large floes that won't break up before their molting is complete. Sitting on those ice floes, the winds and currents will take them to the west and north. These floes become part of a very large circular movement of sea ice, called a gyre.

During and following the molting period the tags showed the penguins move at a rate and direction consistent with the movement of the pack ice. Moving about 5.5 km/day and in a clockwise motion as part of the Ross Gyre. Therefore, jumping from the ice floe for a couple hours each day then climbing back onto another ice floe, much of the time they are simply traveling where the ice takes them.

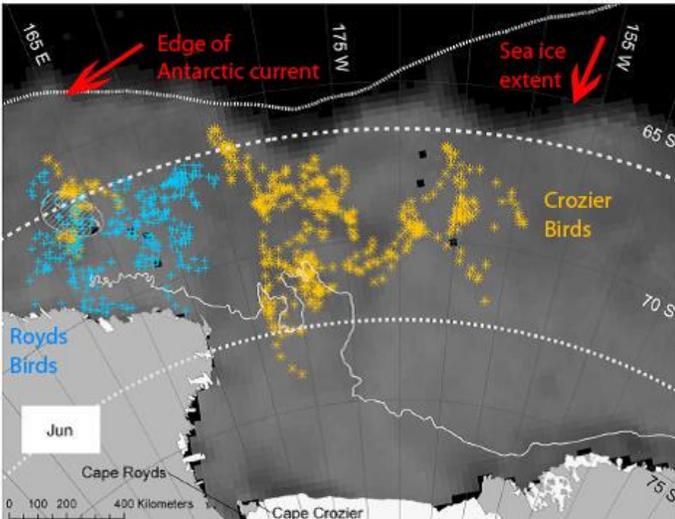


Figure 6 Here you see a map of the Ross Sea area and the location of the Ross Island penguins at the maximum extent of their trip north during winter.

the ice as they head back to Ross Island. The sun is up now for longer periods of time so they are able to navigate as they swim. Yes, Adélie penguins use the sun to navigate, just as do bees and other creatures. Total round trip for many of these birds is about 12 800 km with a total movement from their breeding ground of about 22°Lat (2100 km, 1300miles). Some reach Ross Island by the end of Oct. with Cape Crozier birds returning about a week earlier than Royds birds, which have farther to go.

They have to arrive as early as they can, because the summer ahead is very short. Then they do the trip year after year.

The tags indicated that Adélie Penguins reach the farthest point from their Ross Island breeding colonies around the middle of June, continuing to move with the ice until the end of Sept and early Oct. Fortunately, the Ross Gyre is like a very large merry-go round and they eventually return to where they started (where they had molted).

Once they return to their starting point, in late Sept and Oct, the tags showed that the Adélie penguins moved at a faster rate indicating they are swimming, at least partially rather than floating on



Figure 7 Penguins doing what they do best, swimming.

