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In a Changing Antarctica, Some Penguins Thrive as Others Suffer

By ANDY ISAACSON

ROSS ISLAND, Antarctica — Cape Royds, home to the southernmost colony of penguins in the world, is a rocky promontory overlaid with dirty ice and the stench of pinkish guano. Beyond the croaking din of chicks pestering parents for regurgitated krill lies the Ross Sea, a southern extension of the Pacific Ocean that harbors more than one-third of the world's Adélie penguin population and a quarter of all emperor penguins, and which may be the last remaining intact marine ecosystem on Earth.

The penguin colony is one of the longest-studied in the world. Data on its resident Adélie penguins was first acquired during the 1907-9 expedition of Ernest Shackleton, the eminent British explorer, whose wooden hut stands preserved nearby.

"This is penguin nirvana," David Ainley, an ecologist with the consulting firm H. T. Harvey and Associates who has been studying Ross Sea penguins for 40 years, said on a morning in January. "This is where you want to be if you're a pack ice penguin."

Of the species that stand to be most affected by global warming, the most obvious are the ones that rely on ice to live. Adélie penguins are a bellwether of climate change, and at the northern fringe of Antarctica, in the Antarctic Peninsula, their colonies have collapsed as an intrusion of warmer seawater shortens the annual winter sea ice season.

In the past three decades, the Adélie population on the peninsula, northeast of the Ross Sea, has fallen by almost 90 percent. The peninsula's only emperor colony is now extinct. The mean winter air temperature of the Western Antarctic Peninsula, one of the most rapidly warming areas on the planet, has risen 10.8 degrees Fahrenheit in the past half-century, delivering more snowfall that buries the rocks the Adélie penguins return to each spring to nest — and favoring penguins that can survive without ice and breed later, like gentoos, whose numbers have surged by 14,000 percent.

The warmer climate on the Antarctic Peninsula has also upended the food chain, killing off the phytoplankton that grow under ice floes and the krill, a staple of the penguin diet, that eat them, by as much as 80 percent, according to a new study published this month

in The Proceedings of the National Academy of Sciences.

But in the Ross Sea a reverse trend is occurring: Winter sea ice cover is growing, and Adélie populations are actually thriving. The Cape Royds colony grew more than 10 percent every year, until 2001, when an iceberg roughly the size of Jamaica calved off the Ross Sea ice shelf and forced residents to move 70 kilometers north to find open water. (The iceberg broke up in 2006, and the colony of 1,400 breeding pairs is now recovering robustly.) Across Ross Island, the Adélie colony at Cape Crozier — one of the largest known, with an estimated 230,000 breeding pairs — has increased by about 20 percent.

Climate change has created a paradise for some pack ice penguin colonies and a purgatory for others, but the long-term fate of all Adélie and emperor penguins seems sealed, as relentless warming eventually pulls their rug of sea ice out from under them. Some scientists attribute the recent sea ice growth in the Ross Sea to the persistent ozone hole, a legacy of the human use of chlorofluorocarbons that cools the upper atmosphere over the continent, increasing the temperature difference with the lower atmosphere and equator, and over the last 30 years has delivered significantly brisker westerly winds in the summer and autumn. The warming of Earth's middle latitudes is having a similar effect, increasing that temperature difference and sending stronger winds that push sea ice off the coast and expose pockets of open water, called polynyas, that give nesting Adélie penguins easier access to food.

Meanwhile, consumers' appetite for Chilean sea bass (Antarctic and Patagonian toothfish) may also be benefiting Ross Sea penguins, as fishing fleets from southern nations converge on one of the last remaining refuges of the fish (Dissostichus mawsoni). A fishery in the Ross Sea that opened in 1996 and was certified sustainable in December by the Marine Stewardship Council, could ultimately serve Adélie penguins by reducing competition for Antarctic silverfish (Pleuragramma antarcticum), a sardine-size fish that the penguins and toothfish enjoy. Dr. Ainley and colleagues have reported seeing fewer killer whales in the southern Ross Sea since 2002. The whales feed on toothfish, and fewer sightings suggest that the fishery is already altering the ecosystem.

Researchers witnessed Ross Sea penguin colonies thrive during the 1970s when commercial whaling removed 20,000 Antarctic minke whales, also a food competitor of Adélies, from the penguins' wintering area. Adélie populations eventually leveled off after 1986, after an international moratorium on whaling began (and remained static until the more recent influences of climate change). Japanese whaling of minkes resumed right after the moratorium was instituted, purportedly for science, a claim that conservation groups dispute and that has incited a confrontation in the Ross Sea between the Japanese fleet and the Sea Shepherd Conservation Society, an antiwhaling

vigilante group.

“It has become difficult to separate whether the increase is due to climate change or fewer toothfish,” Dr. Ainley said. “Both factors seem to be working at the same time.”

On a chilly morning in January, the Cape Royds colony was clustered across the dark volcanic rock in crèches: month-old chicks, furry and pear-shaped with tummies full of krill, huddled near their parents as adolescent penguins, still too young to breed, acted “like teenagers trying to figure out the social scene,” in Dr. Ainley’s assessment. Their cuddly appearance is misleading, it turns out, a projection of human sentiment. “They’re really nasty to one another,” Dr. Ainley said, “and if you try to pick one up you’ll have your hands full.”

Climate models predict that the winds and sea ice will continue to increase in the Ross Sea for the next 30 to 40 years, at which time the region is expected to experience a tipping point, as rising temperatures and the waning effect of the ozone hole, now getting smaller, transform the climate into the kind now seen in the Antarctic Peninsula.

Already, that process is under way. The average summer temperature at McMurdo Station, the American research base on Ross Island, has inched up 2.7 degrees Fahrenheit in the past 30 years, records show, more than the global average. Scientists conducting long-term studies of lakes in the McMurdo Dry Valleys, Antarctica’s largest ice-free area, report that after a decade of cooling, some lakes in the Taylor Valley are now gaining heat. During this past research season the scientists recorded unprecedented lake levels caused by higher glacial runoff.

On Beaufort Island, north of Ross Island, glaciers have retreated over the rocky coastline farther than they have in 30,000 years, scientists estimate, a time before the last ice age. The receding ice has opened up more nesting habitat for the resident Adélie penguin colony, which has expanded to 55,000 breeding pairs from 40,000 in the last decade.

As the sea ice retreats, researchers expect that Adélie penguins living in the Ross Sea will be forced to shift their range farther south toward the pole. In a study between 2003 and 2005, Dr. Ainley and colleagues from PRBO Conservation Science, Stanford University, NASA and the British Antarctic Survey used geolocation sensor tags to track penguins from Cape Royds and Cape Crozier to better understand their migration patterns. Published last year in the journal Ecology, the study revealed how the penguins depart their nesting grounds in February, at the end of the austral summer, and head north on foot and ice floes to flee the protracted darkness of the Antarctic winter. They appear to stop on the sea ice about 300 miles from the boundary with open water, where they stay to forage and fatten before doubling back south to their island breeding sites ahead of the

creeping northern night — an 8,000-mile journey.

By carbon-dating mummified penguin remains, researchers have been able to construct a long-term history of the Adélie in Antarctica, indicating that throughout the last ice age penguins changed their migration routes and colony locations in response to advances and retreats of the sea ice. However, their range appears to have never extended farther south of where it is currently, for the simple reason that Adélie penguins appear to need light — if only twilight — to forage and navigate, and as comfort against predators.

“Emperor and Adélie penguins have an obligatory association with sea ice,” Dr. Ainley said. “As the sea ice goes, these species will go.”

The Ross Sea is projected to be the last place on Earth where sea ice will endure. But as the annual winter sea ice boundary retreats farther south, pack ice penguins may ultimately find themselves trapped behind a curtain of polar night for which they have no hardwired strategy.

Indeed, Dr. Ainley speculates, Adélie penguins face possible extinction not merely by a loss of habitat — but by an unshakable fear of darkness.