Back in time

Palmer LTER scientists monitor climate change across Antarctic Peninsula

By Peter Rejcek, *Antarctic Sun* Editor
Posted June 18, 2010

Hugh Ducklow and his colleagues aboard the ARSV *Laurence M. Gould* travel back in time every January.

The PhD from the Marine Biological Laboratory (MBL) in Woods Hole, Mass., isn't exactly Dr. Who, spinning through space and time in a malfunctioning machine shaped like a 1960s London police box.

His time machine is an ice-strengthened research vessel. The space is a 700-kilometer-long stretch of ocean along the western edge of the Antarctic Peninsula. The northern extreme of the region has warmed as quickly as anywhere in the world, ushering in a subantarctic climate and the types of critters that favor such conditions.

At the southern end — near an island called Charcot, named after the father of a French explorer — Antarctica still exists. Sea ice persists throughout the summer, thick enough to slow the *Gould* down to 1 knot with its engines pumping at full power. The surface ocean is a frigid minus 1.8 degrees Celsius, kept from freezing only by the high salinity in the water.

Once upon a time, the northern end around Palmer Station, a small research base of the U.S. Antarctic Program, must have existed in much the same way. But since the 1950s, the average winter temperature has spiked by 6 degrees centigrade, reducing the duration of sea ice in the area by three months.

"Going farther south we think of as going back in time, and trying to find conditions of what this region was like before it started to warm very much," explained Ducklow, director of The Ecosystems Center at MBL and principal investigator for the Palmer Longer Term Ecological Research (PAL LTER) program.

"We want a reference area where we can see where the ecosystem may be like before sea ice loss became so extensive," added Ducklow, seated in the ship's chief scientist office, with a little time to kill as the *Gould* makes the four-day trip from Punta Arenas, Chile, to Palmer Station on Anvers Island. After a brief port call to offload cargo and exchange passengers, the ship will begin a 28-day study of the region.

It's a journey that PAL LTER scientists have made 17 previous times since 1993. The peninsula is one of 26 long-term research sites funded by the National Science Foundation (NSF), most of them located in and around the United States. A second site in Antarctica centers on the McMurdo Dry Valleys, one of the few ice-free areas on a continent entombed in 98 percent ice.

Nearly 20 years ago, when the PAL LTER was first conceived, the big question in polar oceanography was how the marine ecosystem responds to the rhythm and changes in sea ice from year to year, according to Ducklow, a biological oceanographer. Sea ice is relatively thin ice that forms on the ocean surface, nearly doubling the size of the continent every winter and shrinking back each austral summer.

The researchers were interested in answering basic questions about what role the ice played throughout the food web, from top predators like penguins, to small marine critters like krill, to the algae that bloom and float through the upper levels of the ocean.

But by 1993, the cold and dry conditions that once dominated the northern end of the peninsula had been pushed aside by a warmer, more humid climate. Climate change was already under way.

"It is fortuitous — it is completely fortuitous — that Palmer Station, in the middle of the peninsula, and currently the *Gould*, happen to be studying this area, at this time, in this century, when it's one of the hotspots of global change on the planet," Ducklow said.

The penguin poster child

The poster child for climate change around the Antarctic Peninsula has been the Adélie penguin, one of three brushtail penguin species in the world. Its population has dropped from about 15,000 to 2,500 breeding pairs — spread out across about 20 islands near Palmer Station — over the last 30 years.

"We're using seabirds as monitors of change in the environment," said Donna Patterson-Fraser, who has worked on the seabird component of the PAL LTER since the early 1990s and has watched the Adélie colonies decline. The islands, once stained pink from the krill-centric diet of the Adélies, are home to ever-dwindling pockets of the birds.

"Something is going to have to change for them to bounce back. I don't see them bouncing back in my lifetime. It's depressing," she added.

Most of the "birders," led by Bill Fraser with Polar Oceans Research Group out of Montana, work from Palmer Station for the summer season, which lasts from about October to March, a relatively balmy time of the year with nearly 24 hours of daylight at its peak. It's a long stretch of time over which the various bird species return to the islands to nest, lay eggs, and fledge chicks.

The biologists pilot inflatable boats to the rock-strewn islands nearly every day, weather allowing, counting and monitoring the Adélies, gentoo and chinstrap penguins, brown and south polar skuas, giant petrels and other polar-loving seabirds.

Not all are facing local extinction like the Adélies. For example, the gentoo, a larger, deeper-diving penguin, isn't dependent on sea ice. Its flexibility in breeding and diet has helped it out-compete its smaller cousin.

For instance, 20 years ago, there were no gentoos at Biscoe Point, a spit of land on an island once thought to be a peninsula of Anvers Island until the glacier retreated. Today, there are 2,500 breeding pairs on Biscoe.

"They're all dancing to a different beat," Patterson-Fraser said of the seabirds.

The Adélie decline is well known by now, a cautionary tale, the so-called canary in the coalmine. But the apparent ascendancy of subantarctic gentoos and chinstraps over Adélies is only one story of how the migration of a subantarctic climate along the peninsula is dramatically changing the ecosystem.

Paucity of productivity

PAL LTER scientists reported last year in the journal *Science* that phytoplankton are also responding to climate change.

Phytoplankton are single-celled plants that float near the surface of the ocean, obtaining energy through photosynthesis. They not only provide food for other organisms in the food web, such as the shrimplike krill and squishy salps, but also draw down carbon dioxide already dissolved in the ocean and release oxygen.

Using satellite and field data from the last 30 years on ocean color, temperature, sea ice and winds, the PAL LTER researchers suggest the decline in sea ice and increase in wind speed cause greater mixing of the surface ocean waters. That forces phytoplankton deeper into the ocean, where there is less light, hurting productivity.

It's also forcing a shift from relatively large and juicy diatoms to smaller phytoplankton cells, which affect the food web and the cycling of carbon, according to Alex Kahl, a postdoctoral researcher with the PAL LTER who works on the phytoplankton group under Oscar Schofield at Rutgers University.

"Now you're selecting for a type of phytoplankton that can do well with less light compared to another one," explained Kahl, a tall, trim man with a Wyatt Earp mustache.

The smaller cells are not only less nutritious but also less effective in transporting carbon to the deep ocean after they die. The bigger cells, like diatoms, fall faster, with a better chance of burying carbon.

"That's good because that's isolating the carbon from the atmosphere on a long geological time scale," Kahl explained. The more carbon buried in the ocean, the less of it is available to return to the atmosphere as carbon dioxide, a heat-trapping gas.

Noted Michael Garzio, a graduate student with Schofield's group, "The system is becoming more like an open ocean system, which has tiny phytoplankton and less of the nutritious diatoms that drive the coastal system."

Attack of the killer salps

Another once-dominant, sea-ice dependent species decreasing in the north end of the peninsula is krill. In particular, the keystone species *Euphausia superba* is declining and appears to be moving closer inshore, while *Salpa thompsoni* are growing in numbers.

Salpa thompsoni is a species of salp, a gelatinous, voracious tunicate that indiscriminately filters its food — a sort of free-floating, transparent water pump. While numerous and as large as krill, salps have little nutritional value, like the difference between eating popcorn versus prime rib.

"We're seeing shifts in the community structure in just the past 15 years or so. There's definitely something going on," said Joe Cope, a wild-haired technician in Debbie Steinberg's lab at the Virginia Institute of Marine Science. Steinberg's team tracks and studies the most common species of zooplankton found in the Southern Ocean for the PAL LTER.

"That's probably attributable to the loss of sea ice on the shelf," Cope said, referring to areas on the PAL LTER study grid over the continental shelf. "We're starting to see larger and larger concentrations of salps over time in deep water off the shelf, and they may be expanding some onto the shelf."

Changing with the times

The PAL LTER program is also changing with the times.

For many years, the PAL LTER project followed the same script: Scientists would sail along a grid pattern, sampling the same 55 "stations" north to south and east to west — predetermined spots they would revisit each year by ship.

They collect water samples to study the health, abundance and composition of bacteria and phytoplankton. Another group tows nets at each station to capture and characterize zooplankton, which includes larger animals like krill and salps.

These “snapshots in time,” as Ducklow calls them, are important for the long-term records the program has collected over the last two decades. But they have their limitations, and over the last few years, the group has added new instruments to make year-round observations, and recruited new team members who offer different scientific techniques and equipment.

“It’s taken us five to 10 years to come to grips with what’s happening here,” said Ducklow, a silver-haired scientist who speaks in a deep monotone. He joined the PAL LTER in 2001. “To really understand a system like this you probably need a century. The system is also changing as we’re studying it, and that makes it challenging as well.”

Steinberg and Schofield are among the newest members of the PAL LTER team. In particular, Schofield’s lab employs autonomous underwater gliders that “fly” through the ocean on pre-programmed missions that can collect information about the ocean, such as temperature, salinity and optical properties. They can cover vast areas but with what scientists call high resolution. It’s another way of saying they have a dense collection of data over the area.

“In just the first few weeks that we had the glider out last year, we collected as much data as the cruises had collected since 1993,” Ducklow noted.

Hitting the spot

The torpedo-shaped robots have been particularly useful at the new “process” stations that the PAL LTER scientists have introduced to get away from the “snapshot” approach. Instead of just a hit-and-run at each grid station, the researchers spend at least three days at three different locations along their survey area, devoting about a third of their field season to these more in-depth studies.

Each spot — one in the far north close to Palmer Station, a second in the middle at a place called Marguerite Bay and a third at the end of the line near Charcot Island — focuses on a deep depression cut into the continental shelf. The scientists have found these canyons are hotspots for wildlife, particularly Adélie penguin colonies.

“There are ocean processes funneling nutrients and slightly warmer ocean water up these canyons,” Ducklow said. “We really want to find out the mechanisms that connect these canyons, ocean circulation, productivity and penguins.”

For instance, on Avian Island in Marguerite Bay, home to more than 60,000 breeding pairs of Adélie penguins, two members of Fraser’s team put satellite transmitters on several of the birds, which track their movements while foraging in the water. Schofield’s team then release one of their gliders to learn more about the ocean properties in the area favored by the penguins.

“We’re now able to take oceanographic measurements and team it with penguin measurements and get a bigger picture of why the penguins doing what they’re doing,” noted Tina Haskins, a marine research technician with the Rutgers group.

Next year, one glider will be outfitted with acoustic sensors to see if the canyons are also hotspots for krill and other zooplankton, according to Steinberg.

“That’s one great thing about the LTER: There’s all these different components.

The things you can't do yourself, there are people on board who know how to do it," Steinberg said. "I like working in these big, interdisciplinary programs for that reason."

In addition, the PAL LTER team recruited a group from Woods Hole Oceanographic Institution, led by Ken Buesseler, to look more closely at the carbon cycle in the Southern Ocean. And Rob Sherrell, from Rutgers University, is lending his expertise in trace metals, particularly iron, a naturally occurring nutrient involved in phytoplankton blooms.

"Nobody has made those trace metal measurements before in this region, so that's a nice addition for us as well," Ducklow noted.

Pushing south

Marguerite Bay, in the middle of the PAL LTER ocean grid, used to be the endgame for the long-term science program. But even there the climate has changed, and the thriving Adélie community on Avian could start feeling the effects in the next decade or so. The scientists needed a sort of polar equivalent of Eden — Antarctica before the fall of sea ice — to appreciate how far the northern extremity has changed.

The ecological time travel now ends at Charcot Island, where the *Gould* first ventured during the 2008-09 field season and returned this past year, despite even thicker sea ice. That first visit a year ago excited both veteran and rookies on the expedition when the vast field of sea ice appeared. "We were on the bridge almost cheering, 'Look there is sea ice, there really is sea ice here,'" Ducklow recalled.

The team believed there would be a canyon near Charcot Island as there was near Palmer and Avian. If so, that meant there might be an Adélie penguin colony, too. Both hunches proved to be true. In 2009, the scientists found a "bedraggled" colony with a few chicks clinging to a steep rock face on Charcot. This year, the *Gould* mapped the extent of the canyon for about 25 kilometers.

"It's a completely new canyon. It wasn't on any of the other bathymetric charts. It really was a lot of fun," Ducklow said following the end of the cruise, en route back to Punta Arenas. "Mapping that out for the first time lent a discovery aspect to the cruise — an exploration flavor to the cruise."

Of course, each new discovery leads to new questions. What are the different ocean processes at work in these canyons? How much heat is coming up from the deep ocean? Is more carbon being sequestered in the south of the peninsula versus the north? Why was the greatest amount of biological activity — from microbial to phytoplankton — near the sea ice edge at Charcot?

These are hard questions to answer. Ducklow knows that it will take an increasingly complex science program to answer them. Going back in time is only the first step in understanding the future of the Antarctic Peninsula.

"Palmer LTER is a really big, complicated thing. It takes a lot of choreography to do it well. And it takes a group that is committed to working together," he said. "People need to be able to compromise their own specific aims to make the program work. We have a nice group of people who are just really doing a great job of that."

NSF-funded research in this story: Hugh Ducklow, Marine Biological Laboratory, Award No. 0823101 (includes Bill Fraser, Deborah Steinberg and Oscar Schofield); and Ken Buesseler and James Valdes, Woods Hole Oceanographic Institution, Award No. 0838866.

Site Curator: Peter Rejcek, Raytheon Polar Services | **NSF Official:** Winifred Reuning, OPP | **Last Updated:** Friday - 3/18/2011