



Parks That Can Move When the Animals Do

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When scientist Dee Boersma first arrived to Punta Tombo, Argentina, in the early 1980s, the colony of Magellanic penguins there was 300,000 breeding pairs strong. Since then, they've declined by more than 20 percent. Dr. Boersma faults competition from fishermen, pollution in the form of oil dumped at sea, and climate change for the decline.

But while the Punta Tombo colony is shrinking, others farther north are growing. The penguins' shifting range underscores how climate change isn't always a drop-dead-from-the-heat affair. And it raises questions about how to protect threatened - and mobile - marine species as they adjust.

Changing weather patterns have shifted upwelling currents, the productive areas that support large anchovy schools, northward. On average, Punta Tombo penguins must now swim 25 miles farther for a meal - 50 miles total - compared with a decade ago. Some penguins have simply established new colonies closer to their food source, welcome evidence of their ability to adapt.

But the move also worries Boersma: At Punta Tombo, the penguins are protected. In their new colonies farther north, on private land, they're not.

The aquatic birds' exodus from a safe haven highlights a quandary presented by a changing world: How do people, with their landlubber bias, protect and manage marine ecosystems that, by definition, go with the flow?

"We set aside parts of the world as if it's going to be static," says

Boersma, at the University of Washington, Seattle. "But the one thing that's constant is change."

So far, few - and maybe none - of the more than 4,500 marine protected areas (MPAs) established worldwide have been explicitly designed to cope with climate change and the issues exemplified by the Magellanic penguins, say experts. Getting protected areas drawn on a map is hard enough, they note. Establishing one that moves or adjusts with changing conditions - a roving MPA - will be harder still.

But some are already thinking about how to design MPAs that still function as climates change. Maybe they're bigger, say scientists, or spaced like stepping stones so species can hopscotch to higher latitudes. Perhaps they're not tied to a geographic location at all, but follow conditions scientists know are important.

New technologies for tracking marine species and people, and more sensors to monitor conditions at sea now make what was once impossible at least theoretically possible. Questions of governance and human bureaucracy are the greater challenge, scientists say.

"It's really sort of a fundamental challenge to how we've been doing conservation until now," says Emily Pidgeon, lead adviser for Conservation International's Marine Climate Change Program in Arlington, Va. "But it's not a completely hopeless story. This requires us to change ideas and go to Version 2.0. But we can do that."

As human impact on the world's oceans has become more readily apparent, scientists have pushed harder for the creation of marine protected areas. Ecosystems that are allowed to function relatively unperturbed will be a kind of insurance policy against species extinction and ecosystem collapse, the thinking goes.

Governments Have Heeded the Warning Somewhat

To some degree, governments have heeded the warning. Former President George W. Bush created two large MPAs in the Pacific at the end of his tenure. Island nations in the Pacific and Caribbean, among others, have also established MPAs in recent years. California is creating an MPA network that may, when complete, protect some 20 percent of state waters. Currently, just 0.7 percent of the world's oceans enjoy even nominal protection, a far cry from the "20 to 30 percent protected by 2012" goal declared at the fifth World Parks Congress in 2003. Yearly, protected ocean

increases by about 5 percent.

Already, scientists are observing shifts in species distribution around the world. After an 800,000-year absence, a species of Pacific diatom, a shell-encased alga, has recently appeared in the North Atlantic. Scientists are unsure of its impact, but they take its arrival as evidence that certain conditions absent for nearly a million years - lack of sea ice, prevailing winds - are reemerging.

Northern countries like Norway and Iceland have seen an influx of more southerly fish species. They're not complaining, because they're likely to catch more fish. Blue mussels, once found only as far north as Norway's coast, meanwhile, have colonized the Svalbard archipelago, more than 400 miles from Scandinavia.

Salmon spawn in ever more northerly Alaskan rivers. And walleye pollock, the largest US fishery by volume, appear to be shifting into Russian waters. This development has implications for both US fishermen and stock health, says Daniel Pauly, a fisheries professor at the University of British Columbia, Vancouver. In US waters, pollock is carefully managed, he says - but not in Russian waters.

If a fish stock moves out of a particular area, he says, it takes much more time to work out new international fishing treaties than it does to fish down the stock.

Indeed, unsure about how much fishing newly accessible Arctic waters can sustain, in February, the US North Pacific Fishery Management Council approved a moratorium on fishing in the US Arctic pending more studies.

A recent study in the journal *Fish and Fisheries* concluded that, broadly speaking, these trends will continue during this century. Higher latitude waters will continue to see an influx of lower-latitude species, and, most likely, a corresponding increase in catches. Lower-latitude developing countries, on the other hand, where many people still subsist on fish, will lose species. Semienclosed oceans like the Mediterranean and the Gulf of Mexico are likely to see local extinctions.

"For people who are doing conservation or fishery management, they should not think of the ocean as static or unchanging," says William Cheung, a researcher with the University of British Columbia and lead author on the *Fish and Fisheries* study. "They should think of it as

changing."

But local changes due to a changing global climate can be unpredictable. Cornell University scientist Charles Greene has found that waters off the Northeastern US paradoxically cooled during the 1990s, for example. Melting permafrost, sea ice, and more precipitation at higher latitudes - all attributable to a warming climate - increased freshwater influx into the Arctic. That cold, low-salinity water then flowed south along the Eastern Seaboard, perhaps impeding the recovery of overfished cod stocks and affecting marine ecosystems as far south as North Carolina.

Greater extremes of wet, hot, and dry are "the dirty secret behind climate change," says Pidgeon. El Niño, a periodic warming of surface waters in the eastern Pacific that scientists think will become more frequent in a warmer world, halts the upwelling that fuels many marine ecosystems. On the Atlantic side, Boersma has noted that heavier and more frequent rainfall, which can flood penguin nests, lowers their reproductive success.

What Needs to Be Done?

Preparations for a changing marine environment include making reserves bigger in anticipation of a general shift toward the poles, say scientists. Better yet, design marine reserves as networks, like California's, so critters can hop poleward on "what you might think of as steppingstones," says Dennis Heinemann, a senior scientist with the Ocean Conservancy in Washington, D.C.

Protecting habitat critical to keystone species will also help. California kelp, for example, needs a hard substrate. To aid its migration, rocky areas along the way should be protected.

Another strategy: Protect places known to be important at crucial stages of critters' life cycles. The ice's edge in the Arctic, for example: Marine mammals use it as a staging area for hunting and foraging. The long-ranging bluefin tuna could be protected while it spawns in the Gulf of Mexico.

That might mean shutting down or restricting fishing in an area during a certain period of the year. Migrating species like whales and sea turtles ride currents. Removing shipping traffic and fishing from these sea highways during migration periods would lessen mortality.

There are some precedents for these approaches. Some migrating birds

enjoy protected nesting grounds and wintering grounds, but nothing in between, and that suffices, says Pauly.

New Technologies Will Play Pivotal Role

But as these protected areas will be pegged to ocean conditions rather than geographic locations, new technologies will necessarily play a pivotal role.

Satellites can see high concentrations of chlorophyll - blooms of algae - and help scientists infer where upwelling is occurring and where feeding grounds are likely to be.

Endeavors like the National Science Foundation's Ocean Observatories Initiative, which scientists will soon begin putting in place, will increase the number of sensors at sea and vastly improve humans' ability to see what's happening where and adjust accordingly.

New smaller fish tags, meanwhile, have already revealed a lot about when, where, and why fish migrate.

"We're sort of getting a fish's eye view of the undersea world," says Cornell's Greene. "The biology gives us a really strong signal that enables us to look for things that sometimes slip past the physical oceanographers."

GPS-enabled Vehicle Monitoring Systems, common on boats, will play an important role both in enforcement, and in helping boats navigate around MPAs of complex shape of shifting location. (They've historically been mostly square-shaped, though ecosystems typically aren't, partly to make them easier to avoid.)

But the more difficult question is political. Where will plans for species that cross national borders be hammered out? How will nations manage the high seas where, currently, there's little governance beyond a nation's 200-mile wide exclusive economic zone?

One model: The 25-nation Commission for the Conservation of Antarctic Marine Living Resources governs fishing, especially that of krill, in the Southern Ocean. Another model: Colombia, Ecuador, Costa Rica, and Panama have agreed under the San José Declaration to manage jointly the marine species that migrate among the nations' waters together.

"Those sorts of approaches are going to have to become more common," says Pidgeon.

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