TIDEPOOL News for Salmon Nation

Tidepool Originals: **FEATURES**

California's Coast Feels the Heat, Pt. 2

In this excerpt from "Feeling the Heat: Dispatches from the Frontlines of Climate Change," Tidepool associate editor Orna Izakson shows how global warming may fuel a collapse of the ocean's food chain

by ORNA IZAKSON | posted 12.21.04

To read Part 1 of this excerpt from "Feeling the Heat," click here

The findings at Hopkins were remarkable in themselves, but also significant because the changes had been under way for decades and no one noticed. The first sunburst anemones appeared in 1947. Seaweeds that once covered the rocks -- not just Gilman's Endocladia -- completely disappeared. "The astounding thing is that we didn't know it was going on," Baxter says with a growl. "This is a marine biological station!"

If not for Baxter's tenure and tenacity, the changes might still be going unnoticed. Those slow shifts are easy to miss or to write off as a temporary change. Without a basis for comparison or long personal experience, population shifts in small ecosystems are nearly invisible. The best way to avoid missing those changes is to track small details over long periods. But in the world of scientific research, there is a simple fact: Monitoring -- the kind of meticulous counting that Sagarin and Gilman did, repeated over time -- simply is not glamorous.

It is not quick, it generally does not attract money, and it does not interest top researchers who can more easily find funding and fame with other kinds of studies. Even dramatic findings such as those at Hopkins and elsewhere do not often inspire funding agencies such as the National Science Foundation.

But when trying to understand how a warming climate evolves -- and the effects of such warming on all natural processes -- monitoring is the best and possibly the only way to document reactions to a phenomenon that every year becomes more obvious and less theoretical.

Researchers examining what long-term data are available have uncovered alarming and portentous evidence of a changing world. One area where monitoring has been funded is in the southern portion of the California Current, a 600-mile-wide swath of southward-flowing water running along the western U.S. coastline, roughly from Oregon down through California. Part of a great subtropical gyre of currents in the northern Pacific Ocean, the California Current is the eastern end of a swirling seawater highway that circles from Japan to Oregon, south past California just into Mexico, across to the Philippines, and back up to Japan to begin again.

Along the way the water changes. As it crosses the Pacific toward North America, more water comes in through rain than leaves through evaporation, so the overall current becomes less salty. As it comes down the U.S. coastline, it meets cold, salty water heading north on another current, mixing in great meanders and eddies that can be up to 300 miles wide. The current turns west again south of California to start the process again.

In 1949, a combination of state and federal organizations began monitoring physical, chemical, biological, and meteorological facets of the California Current under the auspices of the California Cooperative Oceanic and Fisheries Investigations program, known as CalCOFI. It was designed in part to track many factors affecting commercially important fish species such as mackerel and sardines. The data gathered under CalCOFI include air temperatures, wind speeds, nutrient levels, salinity, water temperature on the surface and deep below the surface, and the abundance of larval fish and zooplankton -- the smallest marine animals.

The early monitoring cruises brought researchers as far north as the Oregon border, but the surveys were scaled down to meet budget demands in 1970. But those first 20 years of data were enough to show that what happens in the south and what happens in the north tend to be the same. The data since 1970 cover the area between San Diego and Santa Barbara. It is the largest, longest-term data set of its kind on the West Coast.

What happens if you watch those data change over the years? Your findings might echo those of John McGowan, an oceanography professor at the Scripps Institution of Oceanography in San Diego: As water temperatures have risen, the base of the marine food chain off the coast of California has crashed. And one by one, the fish and birds farther up that food chain are crashing, too.

Life in the ocean begins with tiny plants known as phytoplankton. Like all plants, phytoplankton need light to drive photosynthesis and nutrients to feed the process. Although it is somewhat counterintuitive, the richest and most nutritive ocean waters are the coldest and heaviest. Strong winds do the work of stirring the system and pulling the nutrient-rich waters up toward the light.

The first problems showed up in conjunction with El Niños, shortterm changes in ocean temperatures that tend to increase the warm water along the western U.S. coastline, reducing the food that boosts the phytoplankton. But researchers like McGowan noticed a difference between early El Niños and the later ones. Numbers of zooplankton -- the tiniest animals in the food chain, which depend on the phytoplankton -- dropped during the El Niño of 1957 to 1959 and then quickly rebounded. But after subsequent El Niños during the 1983 to 1984 and 1997 to 1998 seasons, the zooplankton did not come back.

In 1995, going back through the accumulated years of data, McGowan reported a staggering finding in Science: Zooplankton numbers in the California Current had dropped by 70 percent. The CalCOFI data show a sharp increase in California Current water temperatures in 1977 -- at the same time the zooplankton numbers crashed.

"It's the largest change ever measured in plankton productivity in the ocean," McGowan says. "This enormous change in the zooplankton in the California Current could not be detected from year to year. It several decades before we discovered this big drop, by at least 70 percent or even up to 80 percent."

If you pull out the bottom stone in a pyramid, you expect the structure to come tumbling down. With that huge loss at the base of the food chain, reverberations throughout the system that depended on it were inevitable. Since McGowan's study came out, declines of species throughout the area have been attributed to the loss of zooplankton and the warming water.

The crash showed up in fish, although it is often tough to tell if such declines come from too many nets or too little fish food. But even when researchers look at species for which human markets have no appetite, they find precipitous declines. The larvae of Leuroglossus stilbius -- a fish of so little market value that it does not even have a name in English -- historically are the third most abundant in the California Current. Counts of its larvae dropped 50 percent after 1977. Another similarly ignored species with no common name, Stenobranchus leucopsarus, saw its larvae drop 42 percent after the sharp temperature rise. Its larvae are typically the sixth most abundant in those waters.

In 1967, aerial surveys found 70 square miles of kelp forests along the long California coastline. In 1989, that number dropped 42 percent. By 1999, the most recent year for which data are available, the total plummeted to just 17.8 square miles, down 75 percent from the 1967 survey.

But the most dramatic decline came to the sooty shearwater, a predatory seabird at the top of the marine food chain.

"In the 1960s and 1970s they were present in the tens of millions," McGowan says, "the largest population of pelagic [marine] seabirds in the entire California Current. They dominated it. Millions and millions of them." The birds feed on juvenile fish and larger zooplankton.

Researchers began looking at the birds regularly in 1987. By the 1990s, the population of sooty shearwaters -- like the guillemots in Alaska -- had crashed, with numbers down 90 percent.

"The decline of the sooty shearwater is very dramatic," McGowan says. "And that clearly is not due to man harvesting it, or at least not directly."

As of 2003, water temperatures in the California Current are back down to their long-term average, but zooplankton numbers have not changed. In fact, McGowan says, samples taken in February 2003 showed the lowest abundance ever recorded. Eight years after first reporting the zooplankton die-off, McGowan thinks he knows why it occurred: The warm surface layer of the ocean got so deep that the nutrient-rich waters below could not get close enough to the light to help the phytoplankton grow.

McGowan compares that oceanic phenomenon to the familiar warm layer on a lake or swimming pool. When you go in, he explains, "Sometimes your feet are cold and your upper body's warm. Warm water floats on top of cold because it's less dense. And because there's this sharp layer between the warm upper water and the cold lower water, it makes it difficult to stir."

In the California Current, McGowan and his colleagues have found that the line between warm surface water and cooler, nutrientrich water became substantially deeper in 1977, when everything heated up. The deeper that line goes, the harder winds need to blow to mix up the nutrients. And the winds have not changed. That means the basic driver of ocean life is on an extremely low setting. "Less productivity, less plankton and birds and squid and fish," he says.

Although McGowan's work is limited to southern California, the earliest CalCOFI data showed that what happened on the south end of the California Current was very similar to what happened further north. That means the die-offs he has documented could be repeated all the way up the West Coast.

"The whole system pumps up and down and up and down," he says. "It's one system, in spite of all of the eddies, in spite of all the meanders, in spite of all the species that are involved. We know that the temperature change is still synchronous, all up and down the coast. That has been extensively tested."

And that is perhaps the most important implication of McGowan's research: The ecosystem crash documented in southern California could happen along with warming in any part of any ocean anywhere. Some British studies are turning up evidence of deepening surface layers of warm, nutrient-poor water, McGowan says. U.S. agencies and the Intergovernmental Panel on Climate Change have documented higher ocean surface temperatures around the world.

"This 1977 regime shift that we thought was something that happened in the North Pacific, there's evidence globally that temperatures took a big jump up," McGowan says. "It wasn't just California, the West Coast, the North Pacific or the Gulf of Alaska. It was everywhere."

"It's a very, very serious problem," he adds. "And the seriousness comes from the fact that we really don't know what the consequences will be." The crashes McGowan has seen "could be a generalized response of the whole ocean -- all the world's oceans -- to heating. It might look something like what we see in the California Current."

As with Gilman and Sagarin's research, McGowan cannot definitively prove that increased carbon in the atmosphere caused heating that was the direct and sole cause of the changes he has seen. But his research continues to suggest temperature increases as the most likely driver for his observations.

Climate change appears to be making big-picture changes to transcontinental currents and the rocky interface of shore and ocean, but rising sea levels also combine with runaway development to devastate local environments. In the last remaining salt marshes ringing San Francisco Bay, a bird and a secretive mouse are steeling to fight their own battles with climate change. The problem there is not that the water is getting too warm, but that it is getting too high.

As glaciers melt and oceans rise, so too will the waters of the famous bay. That would not necessarily be a problem, since the marshland plants and animals in theory could simply move upslope, in much the same way Sarah Gilman's seaweed moved down toward cooler water. But two endangered species -- the California clapper rail, a secretive bird that does not much like to fly, and the salt marsh harvest mouse, which lives without drinking fresh water -- are stuck between rising water and asphalt, the latter covered by multimillion-dollar development. If or when the water rises, they will not be able to afford the new rents.

Marge Kolar, who manages the Don Edwards San Francisco Bay National Wildlife Refuge, says that 150 years ago the water was ringed by 50,000 acres of muddy tidal flats and 190,000 acres of lush tidal marsh. Today only three-fifths of the tidal flats remain, and a mere onefifth of the marshland. The clapper rail and harvest mouse live nowhere else on earth, and need the marshes to live, hide from predators, and feed. The clapper rail was one of the first birds put on the federal list of endangered species, and only about six hundred individual birds are still alive to perpetuate the species. No one knows how many of the mice there are. Their population is assumed to have declined as much as their habitat has: 79 percent.

From the hill above the refuge's visitor center, the marshes look like geometric farm plots outlined by sandy dirt roads. Here, however, the fields are ponds used by Cargill Salt to evaporate water and harvest salt, and the roads are earthen levees 5 to 6 feet tall that keep the waters of the bay out.

Before those walls went up, cordgrass grew out of the mud ringing the bay at low tide. As it eased away from the water's edge, the cordgrass gave way to salty, bitter pickleweed, whose round, segmented stems grow like anemone arms, historically feeding the native Ohlone Indians and still the major source of water for the harvest mouse. Further above the tide line, the pickleweed in turn gives way to the shrubby, yellow-flowered gumplant that the clapper rail runs to when it is hiding from predators.

It is possible to reverse time and turn salt ponds back into marshland, Kolar says. It just takes breaching the levees and letting the bay waters go to work. As an example, she points just east of the refuge's visitor center. The refuge bought the land from Cargill and, in 1985, breached the levees, and let tide water flow back in. Although it did not have the complexity of the more mature marsh nearby, by 2000 harvest mice were in it, munching the new pickleweed and making themselves at home.

But the busy commuter street just behind the recovering marsh, Thornton Road, is a sharp dividing line between the ecological reality of the harvest mouse and the economic reality of the area's famed computer industry. Just behind it rise the shiny offices of Sun Microsystems, which paid Cargill $477,000 per acre for the old salt pond at the peak of the Silicon Valley boom. Kolar is quick to say that the refuge did not pay anything like that amount of money when it bought the land for restoration.

In the spring of 2003, Kolar's refuge and the state of California joined forces to buy another 16,500 acres of salt pond from Cargill at bargain, nondevelopment prices in a bad economy -- slightly above $6,000 per acre. The purchase nearly doubles the total protected area around the bay, bringing it up to 38,500 acres of total refuge land. Kolar says the U.S. Fish and Wildlife Service and two state agencies are beginning to plan for restoration, and they will take rising water into account.

Nevertheless, the purchase became controversial because details about pollution and the true value of the land were kept from the public. Newspaper reports say the $100 million deal was based on outdated economic assumptions -- especially prickly given the collapse of the Silicon Valley economy -- costing taxpayers unnecessary millions.

And while it may be physically easy to turn salt ponds back into marsh, factors other than development and rising sea levels are complicating restoration. Especially in the south part of the bay, near San Jose, the land ringing the bay is slowly subsiding. Between the dropping land and the rising water, the native endangered species are getting further squeezed. For them, the simple solution is to break the salt-pond levees. But doing so now carries another political cost: Those levees currently protect the city of San Jose from encroaching bay water.

The new land purchase will do the clapper rail and the harvest mouse little good if it is inundated and there is nothing but asphalt when the cordgrass, pickleweed, gumplant, and assorted species that depend on them try to move upward away from the rising water.

But exactly what is happening on the edges of the bay is still murky. At the same time as the water is rising and the land subsiding, development and erosion are constantly spilling more sediment into the bay. Those sediments fill in the very areas where the mouse and the rail live, with the possible effect of creating a new ring of habitat.

The big question is which will come first: rising water pushing these endangered creatures onto asphalt or rising sediments building them new homes. "Will [sediment deposition] keep up with sea-level rise?" Kolar asks. "That's a question people haven't answered yet."

In the world of science, nothing is ever proven. Researchers say their findings "show" a certain thing, and may discredit some previously held notions. McGowan, Sagarin, Gilman, and Baxter cannot say that the crashing food chain or the migration of intertidal species they documented is "caused" by a warming world, although they all seem to believe that is the case. But all the pieces together begin to form a picture.

If it is not a picture of global warming, it is certainly a picture of what global warming could bring.