latimes.com

Altered Oceans: Part One: A Primeval Tide of Toxins

By Kenneth R. Weiss July 30, 2006 12 AM PT | Jul. 30th, 2006

Reporting from MORETON BAY, AUSTRALIA — The fireweed began each spring as tufts of hairy growth and spread across the seafloor fast enough to cover a football field in an hour.

When fishermen touched it, their skin broke out in searing welts. Their lips blistered and peeled. Their eyes burned and swelled shut. Water that splashed from their nets spread the inflammation to their legs and torsos.

"It comes up like little boils," said Randolph Van Dyk, a fisherman whose powerful legs are pocked with scars. "At nighttime, you can feel them burning. I tried everything to get rid of them. Nothing worked."

As the weed blanketed miles of the bay over the last decade, it stained fishing nets a dark purple and left them coated with a powdery residue. When fishermen tried to shake it off the webbing, their throats constricted and they gasped for air.

After one man bit a fishing line in two, his mouth and tongue swelled so badly that he couldn't eat solid food for a week. Others made an even more painful mistake, neglecting to wash the residue from their hands before relieving themselves over the sides of their boats.

For a time, embarrassment kept them from talking publicly about their condition. When they finally did speak up, authorities dismissed their complaints — until a bucket of the hairy weed made it to the University of Queensland's marine botany lab.

Samples placed in a drying oven gave off fumes so strong that professors and students ran out of the building and into the street, choking and coughing.

Scientist Judith O'Neil put a tiny sample under a microscope and peered at the long black filaments. Consulting a botanical reference, she identified the weed as a strain of cyanobacteria, an ancestor of modern-day bacteria and algae that flourished 2.7 billion years ago.

O'Neil, a biological oceanographer, was familiar with these ancient life forms, but had never seen this particular kind before. What was it doing in Moreton Bay? Why was it so toxic? Why was it growing so fast?

The venomous weed, known to scientists as *Lyngbya majuscula,* has appeared in at least a dozen other places around the globe. It is one of many symptoms of a virulent pox on the world's oceans.

In many places — the atolls of the Pacific, the shrimp beds of the Eastern Seaboard, the fiords of Norway — some of the most advanced forms of ocean life are struggling to survive while the most primitive are thriving and spreading. Fish, corals and marine mammals are dying while algae, bacteria and jellyfish are growing unchecked. Where this pattern is most pronounced, scientists evoke a scenario of evolution running in reverse, returning to the primeval seas of hundreds of millions of years ago.

Jeremy B.C. Jackson, a marine ecologist and paleontologist at the Scripps Institution of Oceanography in La Jolla, says we are witnessing "the rise of slime."

For many years, it was assumed that the oceans were too vast for humanity to damage in any lasting way. "Man marks the Earth with ruin," wrote the 19th century poet Lord Byron. "His control stops with the shore."

Even in modern times, when oil spills, chemical discharges and other industrial accidents heightened awareness of man's capacity to injure sea life, the damage was often regarded as temporary.

But over time, the accumulation of environmental pressures has altered the basic chemistry of the seas.

The causes are varied, but collectively they have made the ocean more hospitable to primitive organisms by putting too much food into the water.

Industrial society is overdosing the oceans with basic nutrients — the nitrogen, carbon, iron and phosphorous compounds that curl out of smokestacks and tailpipes, wash into the sea from fertilized lawns and cropland, seep out of septic tanks and gush from sewer pipes.

Modern industry and agriculture produce more fixed nitrogen — fertilizer, essentially — than all natural processes on land. Millions of tons of carbon dioxide and nitrogen oxide, produced by burning fossil fuels, enter the ocean every day.

These pollutants feed excessive growth of harmful algae and bacteria.

At the same time, overfishing and destruction of wetlands have diminished the competing sea life and natural buffers that once held the microbes and weeds in check.

The consequences are evident worldwide.

Off the coast of Sweden each summer, blooms of cyanobacteria turn the Baltic Sea into a stinking, yellow-brown slush that locals call “rhubarb soup.” Dead fish bob in the surf. If people get too close, their eyes burn and they have trouble breathing.

On the southern coast of Maui in the Hawaiian Islands, high tide leaves piles of green-brown algae that smell so foul condominium owners have hired a tractor driver to scrape them off the beach every morning.

On Florida’s Gulf Coast, residents complain that harmful algae blooms have become bigger, more frequent and longer-lasting. Toxins from these red tides have killed hundreds of sea mammals and caused emergency rooms to fill up with coastal residents suffering respiratory distress.

North of Venice, Italy, a sticky mixture of algae and bacteria collects on the Adriatic Sea in spring and summer. This white mucus washes ashore, fouling beaches, or congeals into submerged blobs, some bigger than a person.

Along the Spanish coast, jellyfish swarm so thick that nets are strung to protect swimmers from their sting.

Organisms such as the fireweed that torments the fishermen of Moreton Bay have been around for eons. They emerged from the primordial ooze and came to dominate ancient oceans that were mostly lifeless. Over time, higher forms of life gained supremacy. Now they are under siege.

Like other scientists, Jeremy Jackson, 63, was slow to perceive this latest shift in the biological order. He has spent a good part of his professional life underwater. Though he had seen firsthand that ocean habitats were deteriorating, he believed in the resilience of the seas, in their inexhaustible capacity to heal themselves.

Then came the hurricane season of 1980. A Category 5 storm ripped through waters off the north coast of Jamaica, where Jackson had been studying corals since the late

1960s. A majestic stand of staghorn corals, known as "the Haystacks," was turned into rubble.

Scientists gathered from around the world to examine the damage. They wrote a paper predicting that the corals would rebound quickly, as they had for thousands of years.

"We were the best ecologists, working on what was the best-studied coral reef in the world, and we got it 100% wrong," Jackson recalled.

The vividly colored reef, which had nurtured a wealth of fish species, never recovered.

"Why did I get it wrong?" Jackson asked. He now sees that the quiet creep of environmental decay, occurring largely unnoticed over many years, had drastically altered the ocean.

As tourist resorts sprouted along the Jamaican coast, sewage, fertilizer and other nutrients washed into the sea. Overfishing removed most of the grazing fish that kept algae under control. Warmer waters encouraged bacterial growth and further stressed the corals.

For a time, these changes were masked by algae-eating sea urchins. But when disease greatly reduced their numbers, the reef was left defenseless. The corals were soon smothered by a carpet of algae and bacteria. Today, the reef is largely a boneyard of coral skeletons.

Many of the same forces have wiped out 80% of the corals in the Caribbean, despoiled two-thirds of the estuaries in the United States and destroyed 75% of

California's kelp forests, once prime habitat for fish.

Jackson uses a homespun analogy to illustrate what is happening. The world's 6 billion inhabitants, he says, have failed to follow a homeowner's rule of thumb: Be careful what you dump in the swimming pool, and make sure the filter is working.

"We're pushing the oceans back to the dawn of evolution," Jackson said, "a half-billion years ago when the oceans were ruled by jellyfish and bacteria."

The 55-foot commercial trawler working the Georgia coast sagged under the burden of a hefty catch. The cables pinged and groaned as if about to snap.

Working the power winch, ropes and pulleys, Grovea Simpson hoisted the net and its dripping catch over the rear deck. With a tug on the trip-rope, the bulging sack unleashed its massive load.

Plop. Splat. Whoosh. About 2,000 pounds of cannonball jellyfish slopped onto the deck. The jiggling, cantaloupe-size blobs ricocheted around the stern and slid down an opening into the boat's ice-filled hold.

The deck was streaked with purple-brown contrails of slimy residue; a stinging, ammonia-like odor filled the air.

"That's the smell of money," Simpson said, all smiles at the haul. "Jellyballs are thick today. Seven cents a pound. Yes, sir, we're making money."

Simpson would never eat a jellyfish. But shrimp have grown scarce in these waters after decades of intensive trawling. So during the winter months when jellyfish swarm, he makes his living catching what he used to consider a messy nuisance clogging his nets.

It's simple math. He can spend a week at sea scraping the ocean bottom for shrimp and be lucky to pocket $600 after paying for fuel, food, wages for crew and the boat owner's cut.

Or, in a few hours of trawling for jellyfish, he can fill up the hold, be back in port the same day and clear twice as much. The jellyfish are processed at the dock in Darien, Ga., and exported to

China and Japan, where spicy jellyfish salad and soup are delicacies.

"Easy money," Simpson said. "They get so thick you can walk on them."

Jellyfish populations are growing because they can. The fish that used to compete with them for food have become scarce because of overfishing. The sea turtles that once preyed on them are nearly gone. And the plankton they love to eat are growing explosively.

As their traditional catch declines, fishermen around the world now haul in 450,000 tons of jellyfish per year, more than twice as much as a decade ago.

This is a logical step in a process that Daniel Pauly, a fisheries scientist at the University of British Columbia, calls "fishing down the food web." Fishermen first went after the largest and most popular fish, such as tuna, swordfish, cod and grouper. When those stocks were depleted, they pursued other prey, often smaller and lower on the food chain.

“We are eating bait and moving on to jellyfish and plankton,” Pauly said.

In California waters, for instance, three of the top five commercial catches are not even fish. They are squid, crabs and sea urchins.

This is what remains of California’s historic fishing industry, once known for the sardine fishery attached to Monterey’s Cannery Row and the world’s largest tuna fleet, based in San Diego, which brought American kitchens StarKist, Bumble Bee and Chicken of the Sea.

Overfishing began centuries ago but accelerated dramatically after World War II, when new technologies armed industrial fleets with sonar, satellite data and global positioning systems, allowing them to track schools of fish and find their most remote habitats.

The result is that the population of big fish has declined by 90% over the last 50 years.

It’s reached the point that the world’s fishermen, though more numerous, working harder and sailing farther than ever, are catching fewer fish. The global catch has been declining since the late 1980s, an analysis by Pauly and colleague Reg Watson showed.

The reduction isn’t readily apparent in the fish markets of wealthy countries, where people are willing to pay high prices for exotic fare from distant oceans — slimeheads caught off New Zealand and marketed as orange roughy, or Patagonian toothfish, renamed Chilean sea bass. Now, both of those fish are becoming scarce.

Fish farming also exacts a toll. To feed the farmed stocks, menhaden, sardines and anchovies are harvested in great quantities, ground up and processed into pellets.

Dense schools of these small fish once swam the world’s estuaries and coastal waters, inhaling plankton like swarming clouds of silvery vacuum cleaners.

Maryland’s Chesapeake Bay, the nation’s largest estuary, used to be clear, its waters filtered every three days by piles of oysters so numerous that their reefs posed a hazard to navigation. All this has changed.

There and in many other places, bacteria and algae run wild in the absence of the many mouths that once ate them. As the depletion of fish allows the lowest forms of life to run rampant, said Pauly, it is “transforming the oceans into a microbial soup.”

Jellyfish are flourishing in the soup, demonstrating their ability to adapt to wholesale changes — including the growing human appetite for them. Jellyfish have been around, after all, at least 500 million years, longer than most marine animals.

In the Black Sea, an Atlantic comb jelly carried in the ballast water of a ship from the East Coast of the United States took over waters saturated with farm runoff. Free of predators, the jellies gorged on plankton and fish larvae, depleting the fisheries on which the Russian and Turkish fleets depend. The plague subsided only with the accidental importation of another predatory jellyfish that ate the comb jellies.

Federal scientists tallied a tenfold increase in jellies in the Bering Sea in the 1990s. They were so thick off the Alaskan Peninsula that fishermen nicknamed it the Slime Bank. Researchers have found teeming swarms of jellyfish off Georges Bank in New England and the coast of Namibia, in the fiords of Norway and in the Gulf of Mexico. Also proliferating is the giant nomurai found off Japan, a jellyfish the size of a washing machine.

Most jellies are smaller than a fist, but their sheer numbers have gummed up fishing nets, forced the shutdown of power plants by clogging intake pipes, stranded cruise liners and disrupted operations of the world’s largest aircraft carrier, the Ronald Reagan.

Of the 2,000 or so identified jellyfish species, only about 10 are commercially harvested. The largest fisheries are off China and other Asian nations. New ones are springing up in Australia, the United States, England, Namibia, Turkey and Canada as fishermen look for ways to stay in business.

Pauly, 60, predicts that future generations will see nothing odd or unappetizing about a plateful of these gelatinous blobs.

“My kids,” Pauly said, “will tell their children: Eat your jellyfish.”

The dark water spun to the surface like an undersea cyclone. From 80 feet below, the swirling mixture of partially treated sewage spewed from a 5-foot-wide pipe off the coast of Hollywood, Fla., dubbed the “poop chute” by divers and fishermen.

Fish swarmed at the mouth — blue tangs and chubs competing for particles in the wastewater.

Marine ecologist Brian Lapointe and research assistant Rex “Chip” Baumberger, wearing wetsuits and breathing air from scuba tanks, swam to the base of the murky funnel cloud to collect samples. The effluent meets state and federal standards but is still rich in nitrogen, phosphorous and other nutrients.

By Lapointe’s calculations, every day about a billion gallons of sewage in South Florida are pumped offshore or into underground aquifers that seep into the ocean. The wastewater feeds a green tide of algae and bacteria that is helping to wipe out the remnants of Florida’s 220 miles of coral, the world’s third largest barrier reef.

In addition, fertilizer washes off sugar cane fields, livestock compounds and citrus farms into Florida Bay.

“You can see the murky green water, the green pea soup loaded with organic matter,” said Lapointe, a marine biologist at Harbor Branch Oceanographic Institution in Fort Pierce, Fla. “All that stuff feeds the algae and bacterial diseases that are attacking corals.”

Government officials thought they were helping in the early 1990s when they released fresh water that had been held back by dikes and pumps for years. They were responding to the recommendations of scientists who, at the time, blamed the decline of ocean habitats on hypersalinity — excessively salty seawater.

The fresh water, laced with farm runoff rich in nitrogen and other nutrients, turned Florida’s gin-clear waters cloudy. Seaweed grew fat and bushy.

It was a fatal blow for many struggling corals, delicate animals that evolved to thrive in clear, nutrient-poor saltwater. So many have been lost that federal officials in May added what were once the two most dominant types — elkhorn and staghorn corals — to the list of species threatened with extinction. Officials estimate that 97% of them are gone.

Sewage and farm runoff kill corals in various ways.

Algae blooms deny them sunlight essential for their survival.

The nutrients in sewage and fertilizer make bacteria grow wildly atop corals, consuming oxygen and suffocating the animals within.

A strain of bacteria found in human intestines, *Serratia marcescens*, has been linked to white pox disease, one of a host of infectious ailments that have swept through coral reefs in the Florida Keys and elsewhere.

The germ appears to come from leaky septic tanks, cesspits and other sources of sewage that have multiplied as the Keys have grown from a collection of fishing villages to a stretch of bustling communities with 80,000 year-round residents and 4 million visitors a year.

Scientists discovered the link by knocking on doors of Keys residents, asking to use their bathrooms. They flushed bacteria marked with tracers down toilets and found them in nearby ocean waters in as little as three hours.

Nearly everything in the Keys seems to be sprouting green growths, even an underwater sculpture known as Christ of the Abyss, placed in the waters off Key Largo in the mid-1960s as an attraction for divers and snorkelers. Dive-shop operators scrub the bronze statue with wire brushes from time to time, but they have trouble keeping up with the growth.

Lapointe began monitoring algae at Looe Key in 1982. He picked the spot, a 90-minute drive south of Key Largo, because its clear waters, colorful reef and abundance of fish made it a favorite site for scuba divers. Today, the corals are in ruins, smothered by mats of algae.

Although coral reefs cover less than 1% of the ocean floor, they are home to at least 2 million species, or about 25% of all marine life. They provide nurseries for fish and protect oceanfront homes from waves and storm surges.

Looe Key was once a sandy shoal fringed by coral. The Key has now slipped below the water's surface, a disappearing act likely to be repeated elsewhere in these waters as pounding waves breach dying reefs. Scientists predict that the Keys ultimately will have to be surrounded by sea walls as ocean levels rise.

With a gentle kick of his fins through murky green water, Lapointe maneuvered around a coral mound that resembled the intricate, folded pattern of a brain. Except that this brain was being eroded by the coralline equivalent of flesh-eating disease.

"It rips my heart out," Lapointe said. "It's like coming home and seeing burglars have ransacked your house, and everything you cherished is gone."

The ancient seas contained large areas with little or no oxygen — anoxic and hypoxic zones that could never have supported sea life as we know it. It was a time when bacteria and jellyfish ruled.

Nancy Rabalais, executive director of the Louisiana Universities Marine Consortium, has spent most of her career peering into waters that resemble those of the distant past.

On research dives off the Louisiana coast, she has seen cottony white bacteria coating the seafloor. The sulfurous smell of rotten eggs, from a gas produced by the microbes, has seeped into her mask. The bottom is littered with the ghostly silhouettes of dead crabs, sea stars and other animals.

The cause of death is decaying algae. Fed by millions of tons of fertilizer, human and animal waste, and other farm runoff racing down the Mississippi River, tiny marine plants run riot, die and drift to the bottom. Bacteria then take over. In the process of breaking down the plant matter, they suck the oxygen out of seawater, leaving little or none for fish or other marine life.

Years ago, Rabalais popularized a term for this broad area off the Louisiana coast: the "dead zone." In fact, dead zones aren't really dead. They are teeming with life — most of it bacteria and other ancient creatures that evolved in an ocean without oxygen and that need little to survive.

"There are tons and tons of bacteria that live in dead zones," Rabalais said. "You see this white snot-looking stuff all over the bottom."

Other primitive life thrives too. A few worms do well, and jellyfish feast on the banquet of algae and microbes.

The dead zone off Louisiana, the second largest after one in the Baltic Sea, is a testament to the unintended consequences of manufacturing nitrogen fertilizer on a giant scale to support American agriculture. The runoff from Midwestern farms is part of a slurry of wastewater that flows down the Mississippi, which drains 40% of the continental United States.

The same forces at work in the mouth of the Mississippi have helped create 150 dead zones around the world, including parts of the Chesapeake Bay and waters off the Oregon and Washington coasts.

About half of the Earth's landscape has been altered by deforestation, farming and development, which has increased the volume of runoff and nutrient-rich sediment.

Most of the planet's salt marshes and mangrove forests, which serve as a filter between land and sea, have vanished with coastal development. Half of the world's population lives in coastal regions, which add an average of 2,000 homes each day.

Global warming adds to the stress. A reduced snowpack from higher temperatures is accelerating river discharges and thus plankton blooms. The oceans have warmed slightly — 1 degree on average in the last century. Warmer waters speed microbial growth.

Robert Diaz, a professor at the Virginia Institute of Marine Science, has been tracking the spread of low-oxygen zones. He has determined that the number is nearly doubling every decade, fed by a worldwide cascade of nutrients — or as he puts it, energy. We stoke the ocean with energy streaming off the land, he said, and with no clear pathways up the food chain, this energy fuels an explosion of microbial growth.

These microbes have been barely noticeable for millions of years, tucked away like the pilot light on a gas stove.

"Now," Diaz said, "the stove has been turned on."

In Australia, fishermen noticed the fireweed around the time much of Moreton Bay started turning a dirty, tea-water brown after every rain. The wild growth smothered the bay's northern sea-grass beds, once full of fish and shellfish, under a blanket a yard thick.

The older, bottom layers of weed turned grayish-white and started to decay. Bacteria, feeding on the rot, sucked all of the oxygen from beneath this woolly layer at night. Most sea life swam or scuttled away; some suffocated. Fishermen's catches plummeted.

Most disturbing were the rashes, an outbreak often met with scoffs from local authorities.

After suffering painful skin lesions, fisherman Greg Savige took a sealed bag of the weed in 2000 to Barry Carbon, then director-general of the Queensland Environmental Protection Agency. He warned Carbon to be careful with it, as it was “toxic stuff.” Carbon replied that he knew all about cyanobacteria from western Australian waters and that there was nothing to worry about.

Then he opened the bag and held it close to his face for a sniff.

“It was like smearing hot mustard on the lips,” the chastened official recalled.

Aboriginal fishermen had spotted the weed in small patches years earlier, but it had moved into new parts of the bay and was growing like never before.

Each spring, *Lyngbya* bursts forth from spores on the seafloor and spreads in dark green-and-black dreadlocks. It flourishes for months before retreating into the muck. Scientists say it produces more than 100 toxins, probably as a defense mechanism.

At its peak in summer, the weed now covers as much as 30 square miles of Moreton Bay, an estuary roughly the size of San Francisco Bay. In one seven-week period, its expansion was measured at about 100 square meters a minute — a football field in an hour.

William Dennison, then director of the University of Queensland botany lab, couldn’t believe it at first.

“We checked this 20 times. It was mind-boggling. It was like ‘The Blob,’ ” Dennison said, recalling the 1950s horror movie about an alien life form that consumed everything in its path.

Suspecting that nutrients from partially treated sewage might be the culprit, another Queensland University scientist, Peter Bell, collected some wastewater and put it in a beaker with a pinch of *Lyngbya*. The weed bloomed happily.

As Brisbane and the surrounding area became the fastest growing region in Australia, millions of gallons of partially treated sewage gushed from 30 wastewater treatment plants into the bay and its tributary rivers.

Officials upgraded the sewage plants to remove nitrogen from the wastewater, but it did not stop the growth of the infernal weed.

Researchers began looking for other sources of *Lyngbya’s* nutrients, and are now investigating whether iron and possibly phosphorous are being freed from soil as forests of eucalyptus and other native trees are cleared for farming and development.

“We know the human factor is responsible. We just have to figure out what it is,” Dennison said.

Recently, *Lyngbya* has appeared up the coast from Moreton Bay, on the Great Barrier Reef, where helicopters bring tourists to a heart-shaped coral outcropping. When the helicopters depart, seabirds roost on the landing platform, fertilizing the reef with their droppings.

Lyngbya now beards the surrounding corals.

“*Lyngbya* has lots of tricks,” said scientist Judith O’Neil. “That’s why it’s been around for 3 billion years.”

It can pull nitrogen out of the air and make its own fertilizer. It uses a different spectrum of sunlight than algae do, so it can thrive even in murky waters. Perhaps its most diabolical trick is its ability to feed on itself. When it dies and decays, it releases its own nitrogen and phosphorous into the water, spurring another generation of growth.

“Once it gets going, it’s able to sustain itself,” O’Neil said.

Ron Johnstone, a University of Queensland researcher, recently experienced *Lyngbya’s* fire. He was studying whether iron and phosphorous in bay sediments contribute to the blooms, and he accidentally came in contact with bits of the weed. He broke out in rashes and boils, and needed a cortisone shot to ease the inflammation.

“It covered my whole chest and neck,” he said. “We’ve just ordered complete containment suits so we can roll in it.”

Fishermen say they cannot afford such pricey equipment. Nor would it be practical. For some, the only solution is to turn away from the sea.

Lifelong fisherman Mike Tanner, 50, stays off the water at least four months each year to avoid contact with the weed. It’s an agreement he struck with his wife, who was appalled by his blisters and worried about the long-term health consequences.

“When he came home with rash all over his body,” Sandra Tanner said, “I said, ‘No, you are not going.’ We didn’t know what was happening to him.”

Tanner, a burly, bearded man, is frustrated that he cannot help provide for his family. Gloves and other waterproof gear failed to protect him.

"It's like acid," Tanner said. "I couldn't believe it. It kept pulling the skin off."

Before the *Lyngbya* outbreak, 40 commercial shrimp trawlers and crab boats worked these waters. Now there are six, and several of them sit idle during fireweed blooms.

"It's the only thing that can beat us," Greg Savige said. "Wind is nothing. Waves, nothing. It's the only thing that can make us stop work. When you've got sores and the skin peels away, what are you going to do?"

Times staff writer Usha Lee McFarling contributed to this report.

Next: Altered Oceans, Part Two: Sentinels Under Attack

Full coverage: Altered Oceans
