The rise of slime

The run-off from modern life is feeding an explosion of primitive organisms. Kenneth R Weiss finds evolution running in reverse.

In 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 fishers 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 fisher whose powerful legs are pocked with scars. 'At night-time 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 past decade, it stained fishing nets a dark purple and left them coated with a powdery residue. When fishers tried to shake it off the webbing, their throats constricted and they gasped for air.

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. 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 US Seaboard, the fjords 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.

Overdosing the ocean

Jeremy BC Jackson, a marine ecologist and palaeontologist at the Scripps Institution of Oceanography in La Jolla, California, 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. Even in modern times, when oil spills, chemical discharges and other industrial accidents heightened awareness of people's capacity to injure sea life, the damage was 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.

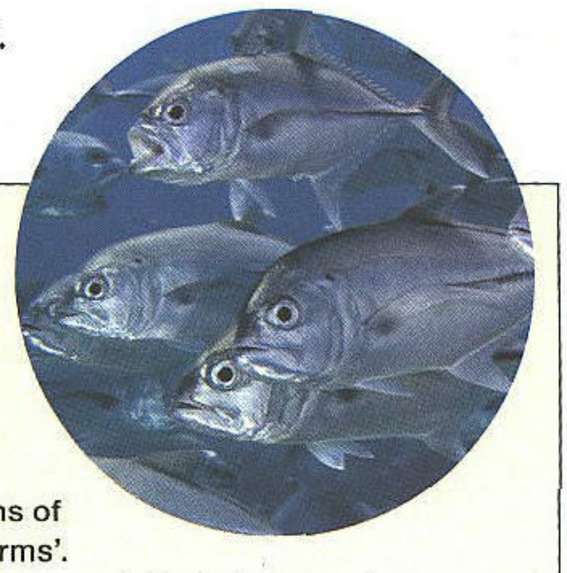
Modern industry and agriculture produce more fixed nitrogen – fertilizer, essentially – than all natural processes on land. Millions of tons of carbon dioxide *and nitrogen oxide, produced by burning fossil fuels,* enter the ocean every day. These pollutants feed excessive growth of harmful algae and bacteria. At the same time, overfishing and the destruction of wetlands have diminished the competing sea life and natural buffers that once held 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'.

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.

Organisms such as the fireweed that torments the fishers 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 was slow to perceive this latest shift in the biological order. He has spent a good part of his professional life underwater. 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



CURRENTS

PERPETUAL MOTION

Ocean water is always on the move, sometimes in subtle but powerful ways that are little understood, absorbing or releasing vast amounts of energy.

THE TURMOIL OF the atmosphere and winds, powered by solar energy, keeps surface ocean water in constant motion. The forces involved are huge. The amount of water transported every minute by the Gulf Stream in the western North Atlantic, for example, is around 1,000 times the amount discharged every minute by the world's 20 biggest rivers put together.

Although wind is mainly responsible for driving surface currents, their patterns reflect complex interactions with other forces as well.

Twice daily, tides driven by the gravitational pull of the Sun and Moon cause the ocean to 'bulge' and then fall back.

Far from being flat, the ocean surface is warped. Converging currents tend to pile water up, while diverging currents draw water down. Travelling from New York to Africa involves a steady uphill climb for the first 1,000 kilometres, then a gentle descent. The difference is only about a metre, but that is enough to set up a pressure gradient, down which water molecules tend to fall.

The Coriolis effect – which happens because a point on the equator rotates around the Earth's axis at a higher speed than a point near the poles – bends currents of water or air to the right in the northern hemisphere and to the left in the southern. So circulation patterns or 'gyres' – like water draining from a bathtub – move in opposing directions between the continents north and south *of the equator. The Coriolis effect* also constrains deep water against the margins of ocean basins and generates abyssal 'storms'.

Below the surface there are other, very powerful but slow-moving currents. Linked with the surface gyres, they form a network of circulating water that transfers energy, nutrients and sediments around the world. They are still poorly understood.

During the long polar winters, seawater at the surface becomes extremely cold, making it denser. The winter expansion of sea ice incorporates only fresh water, making the underlying water more saline and adding to its density. This water sinks and spreads out across the ocean floor. Nearer the surface, warmer currents from the equator replace the cold water and in their turn sink, in an apparently endless cycle, rather like a giant conveyor belt.

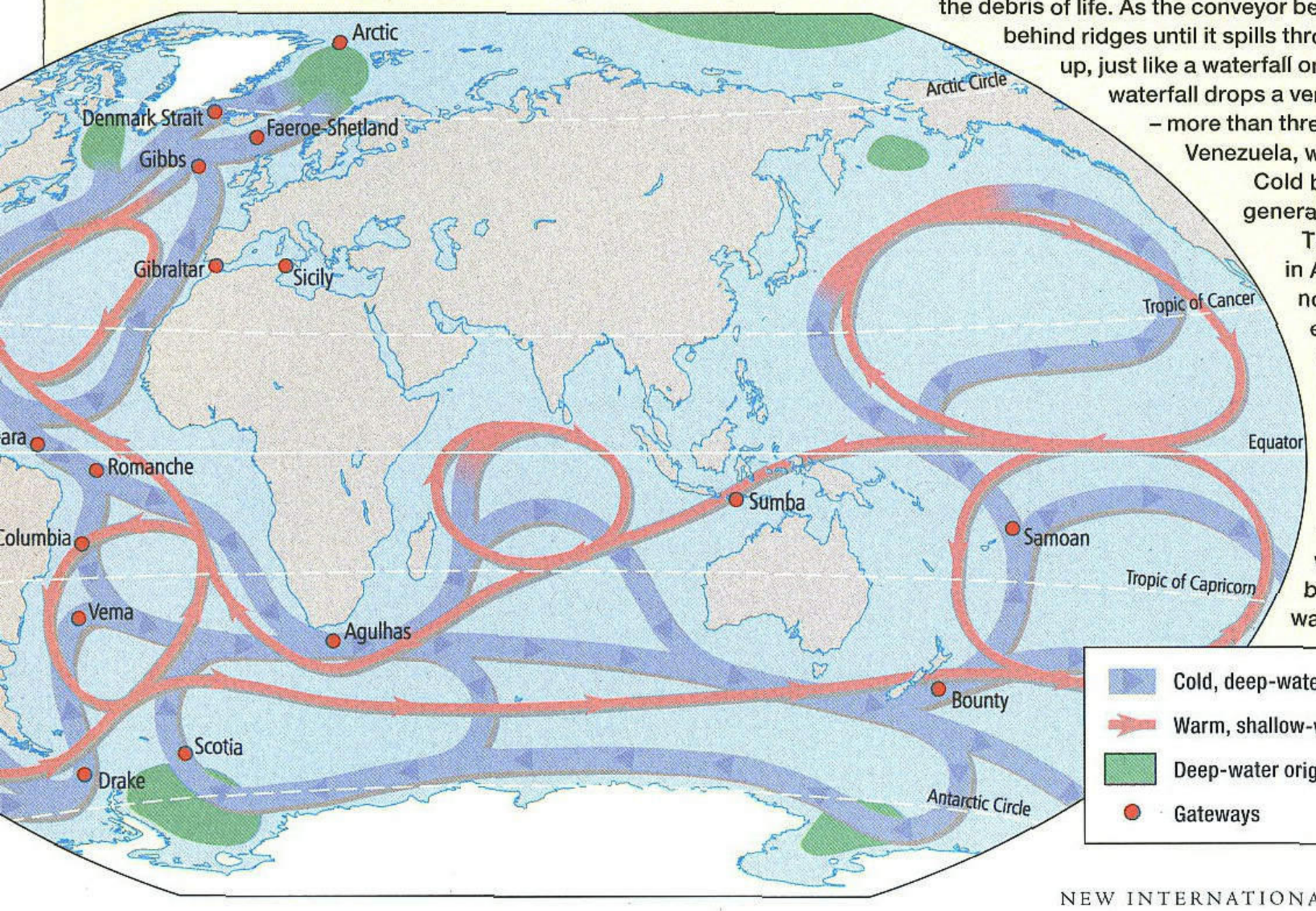
These currents carry oxygen from the surface to the deep sea, allowing life to exist at all depths. The nutrients they recycle to the surface feed the phytoplankton that underpin the whole of ocean life. The currents also carry carbon dioxide to the deeper layers of the ocean where it helps to dissolve the debris of life. As the conveyor belt grinds on, cold 'bottom water' piles up behind ridges until it spills through passes or 'gateways' and speeds up, just like a waterfall on land. The Denmark Strait submarine waterfall drops a vertical distance of 3.5 kilometres – more than three times the height of the Angel Falls in Venezuela, which are the tallest on land.

Cold bottom water that sinks to the abyss is generated only in a few places.

The Weddell Sea is the principal source in Antarctica, and the coldest. It flows north through the Atlantic and across the equator, *mixing upwards until it finally* loses its identity somewhere east of Newfoundland.

In the northern hemisphere bottom water comes largely from the Norwegian and Greenland seas. It spills south until, somewhere in the Antarctic, it blends with water from intermediate levels – as well as some Antarctic bottom-water – to become what's known simply as 'common water'. This water dominates the deep Indian Ocean and much of the Pacific as well.

The whole cycle takes about 1,000 years to complete.



SOURCE: DORRICK STOW, ENCYCLOPEDIA OF THE OCEANS, OXFORD UNIVERSITY PRESS, 2004; ILLUSTRATION: THE BROWN REFERENCE GROUP

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-per-cent wrong,' Jackson recalled.

The vividly coloured 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. Over-fishing removed most of the grazing fish that kept algae under control. Warmer waters encouraged bacterial growth and further stressed the corals.

Over time, the accumulation of environmental pressures has altered the basic chemistry of the seas

Today, the reef is largely a boneyard of coral skeletons.

Many of the same forces have wiped out 80 per cent of the corals in the Caribbean, despoiled two-thirds of the estuaries in the US and destroyed 75 per cent of California's kelp forests, once prime habitat for fish.

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

Jellyballs and slimeheads

The 17-metre 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, Grover 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 1,000 kilos of cannonball jellyfish slopped on to the deck. A stinging, ammonia-like odour 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.

He can spend a week at sea scraping the ocean bottom for shrimp and be lucky to pocket $600. 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 and exported to China and Japan, where spicy jellyfish salad and soup are delicacies.

Jellyfish populations are growing because they can. The fish that used to compete with them for food have become scarce because of over-fishing. 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, fishers around the world now haul in 450,000 tons of jellyfish a 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'. Fishers 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.

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.

Over-fishing began centuries ago but accelerated dramatically after World War Two, 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 per cent over the past 50 years.

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, 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 largest estuary in the US, 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.

As the depletion of fish allows the lowest forms of life to run rampant, says Pauly, it is 'transforming the oceans into a microbial soup'.

'My kids,' he added, 'will tell their children: eat your jellyfish!' ✦

Kenneth R Weiss is a staff writer for the *Los Angeles Times*, where this article originally appeared. This is an edited extract, reprinted with permission.