MARINE ENVIRONMENTS

Editors comments

These two articles, originally published in The Conversation, provide some valuable insights into changes impacting on marine environments.

The first, *'Climate change could alter ocean food chains, leading to far fewer fish in the sea'*, looks at the impact of climate change on important marine environmental processes.

The second, '*Seagrass is a marine powerhouse, so why isn't it on the world's conservation agenda?*' explains the global loss of marine seagrass ecosystems and the need for greater management.

Further reading

'Loss of marine habitats is threatening the global fishing industry – new research', examines the interconnection between healthy marine environments, particularly seagrasses, and global food security. This article can be found at https://theconversation.com/loss-of-marine-habitats-is-threatening-the-global-fishing-industry-new-research-96561

THE CONVERSATION

CLIMATE CHANGE COULD ALTER OCEAN FOOD CHAINS, LEADING TO FAR FEWER FISH IN THE SEA

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Source: This article was originally published on April 19, 2018 http://theconversation.com, https://theconversation.com/climate-change-could-alter-ocean-food-chains-leading-to-far-fewer-fish-in-the-sea-93114

Climate change is rapidly warming the Earth and altering ecosystems on land and at sea that produce our food. In the oceans, most added heat from climate warming is still near the surface and will take centuries to work down into deeper waters. But as this happens, it will change ocean circulation patterns and make ocean food chains less productive.

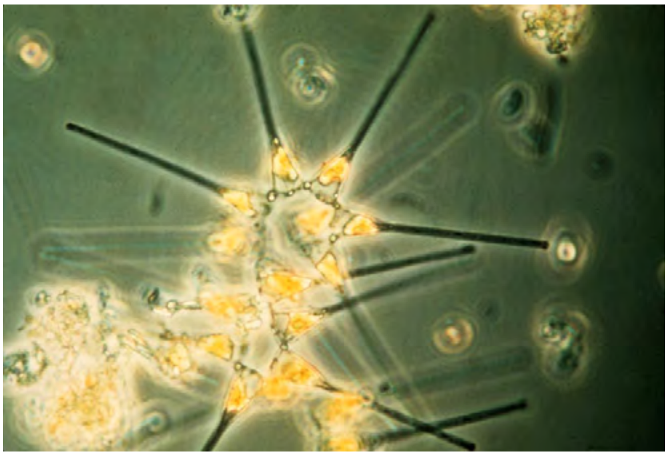
In a recent study, I worked with colleagues from five universities and laboratories to examine how climate warming out to the year 2300 could affect marine ecosystems and global fisheries. We wanted to know how sustained warming would change the supply of key nutrients that support tiny plankton, which in turn are food for fish.

We found that warming on this scale would alter key factors that drive marine ecosystems, including winds, water temperatures, sea ice cover and ocean circulation. The resulting disruptions would transfer nutrients from surface waters down into the deep ocean, leaving less at the surface to support plankton growth.

As marine ecosystems become increasingly nutrient-starved over time, we estimate global fish catch could be reduced 20 percent by 2300, and by nearly 60 percent across the North Atlantic. This would be an enormous reduction in a key food source for millions of people.

Ocean food production and the biological pump

Marine food production starts when the sun shines on the ocean's surface. Single-celled, mostly microscopic organisms called phytoplankton – the plants of the oceans – use sunlight to photosynthesize and grow in a process called net primary production. They can only do this in the sunlit surface layer of the ocean, down to about 100 meters (330 feet). But they also need nutrients to grow, particularly nitrogen and phosphorus, which can be scarce in surface waters.



Phytoplankton, the plants of the ocean. NOAA

Phytoplankton are consumed by zooplankton (tiny animals), which in turn provide food for small fish, and so on all the way up the food chain to top predators like dolphins and sharks. Unconsumed phytoplankton and other organic matter, such as dead zooplankton and fish, decompose in surface waters, releasing nutrients that support new phytoplankton growth.

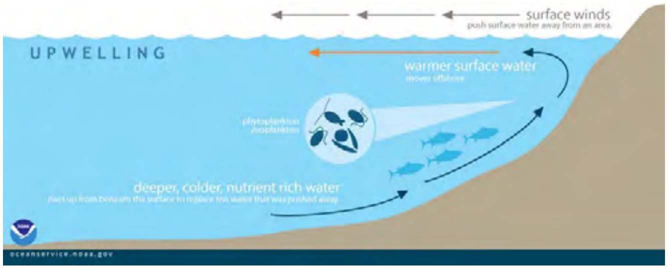
Some of this material sinks down into the deeper ocean, providing food for deep sea ecosystems. Carbon, nitrogen, phosphorus and other nutrients in this sinking organic matter ultimately are decomposed and released at depth.

This process, which is known as the biological pump, continually removes nutrients from surface waters and transfers them to the deeper ocean. Under normal conditions, winds and currents cause mixing that eventually brings nutrients back up to the sunlit surface waters. If this did not happen, the phytoplankton eventually would completely run out of nutrients, which would affect the entire ocean food chain.

Sea ice, winds and nutrient upwelling

Nutrients that sink to the deep ocean eventually return to the surface mainly in the Southern Ocean around Antarctica. North of Antarctica, strong westerly winds push surface waters away from Antarctica. As this happens, deep ocean waters that are rich in nutrients rise up to the surface all around Antarctica, replacing the waters that are being pushed away. The zone where this upwelling occurs is called the Antarctic Divergence.

Today there isn't a lot of phytoplankton growth in the Southern Ocean. Heavy sea ice cover prevents much sunlight from reaching the oceans. Concentrations of iron (another key nutrient) in the water are low, and cold water temperatures limit plankton growth rates. As a result, most nitrogen and phosphorus that upwells in this area flows northwards in surface waters. Eventually, when these nutrients reach warmer waters throughout the lower latitudes, they support plankton growth over most of the Pacific, Indian and Atlantic oceans.



When winds displace surface ocean waters, nutrient-rich colder waters well up from below. NOAA

Trapping nutrients in the deep ocean

Our study demonstrated that sustained, multicentury global warming could short-circuit this process, leaving all ocean areas to the north of this Antarctic zone increasingly starved for nitrogen and phosphorus.

We used a climate model simulation that assumed nations continued to use fossil fuels until global reserves were exhausted. This climate path would raise mean surface air temperature by 9.6 degrees Celsius (17.2 degrees Fahrenheit) by 2300 – nearly 10 times the warming beyond pre-industrial levels recorded up to the present. Scientists already know that the poles are warming faster than the rest of the planet, and in this scenario, that pattern continues. Eventually the oceans would no longer freeze over near the poles, even in winter.

Warmer ocean waters without sea ice, aided by shifts in winds that are also driven by strong climate warming, would greatly improve growth conditions around Antarctica for phytoplankton. This increased growth would trap nutrients that well up near Antarctica, preventing them from flowing northwards and supporting low-latitude ecosystems worldwide.

In our simulation, these trapped nutrients eventually mix back to the deep ocean and accumulate there. Nitrogen and phosphorus concentrations in the upper 1,000 meters (3,300 feet) of the ocean steadily decrease. In the deep ocean, below 2,000 meters, they steadily increase.

Far fewer fish

As marine ecosystems become increasingly nutrient-starved, phytoplankton growth and net primary production throughout most of the world's oceans would decline. We estimate that as these impacts ripple up the food chain, global fish catches could be reduced 20 percent by 2300, with decreases of more than 50 percent across the North Atlantic and several other regions. Moreover, at the end of our simulation net transfer of nutrients to the deep ocean was still taking place, which suggests that ecosystem productivity and potential fisheries catch would decline even further beyond 2300.

Eventually, after more than a thousand years, most of the carbon dioxide that human activities have added to the atmosphere will be absorbed by the oceans, and the Earth's climate will cool back down. Sea ice will return to polar oceans, suppressing phytoplankton growth around Antarctica and allowing more upwelled nutrients to flow north once again to lower latitudes. But even then, it will take centuries more for ocean circulation to fully replenish nutrients in the upper ocean.

Ocean resources are already stressed today. About 90 percent of the world's marine fisheries are fully fished or overfished. World population is projected to increase from 7.3 billion in 2015 to 11 billion in 2100. The impacts that we found in our study would have serious implications for global food security. Expanding aquaculture, or even more drastic steps such as directly fertilizing the oceans to spur plankton growth, would not even come close to making up for the loss of nutrients to the deep ocean driven by sustained global warming.

Our simulation was based on a strong climate warming scenario. More research is needed to explore just how warm the climate has to get to melt sea ice and initiate Southern Ocean nutrient trapping. But clearly this is a tipping point that we don't want to cross.

Source: https://www.youtube.com/watch?v=H7sACT0Dx0Q

Phytoplankton are critical to life on Earth. Climate change is interfering with ocean mixing processes that promote phytoplankton growth.

THE CONVERSATION

SEAGRASS IS A MARINE POWERHOUSE, SO WHY ISN'T IT ON THE WORLD'S CONSERVATION AGENDA?

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Source: This article was originally published in http://theconversation.com on October 11, 2016
https://theconversation.com/seagrass-is-a-marine-powerhouse-so-why-isnt-it-on-the-worlds-conservation-agenda-66503

Seagrass meadows are often overlooked by the public but vital to the ocean ecosystem. Source: Ben Jones, Author provided

Seagrass has been around since dinosaurs roamed the earth, it is responsible for keeping the world's coastlines clean and healthy, and supports many different species of animal, including humans. And yet, it is often overlooked, regarded as merely an innocuous feature of the ocean.

But the fact is that this plant is vital – and it is for that reason that the World Seagrass Association has issued a consensus statement, signed by 115 scientists from 25 countries, stating that these important ecosystems can no longer be ignored on the conservation agenda. Seagrass is part of a marginalised ecosystem that must be increasingly managed, protected and monitored – and needs urgent attention now.

Seagrass meadows are of fundamental importance to human life. They exist on the coastal fringes of almost every continent on earth, where seagrass and its associated biodiversity supports fisheries' productivity. These flowering plants are the powerhouses of the sea, creating life in otherwise unproductive muddy environments. The meadows they form stabilise sediments, filter vast quantities of nutrients and provide one of the planet's most efficient oceanic stores of carbon.

But the habitat seagrasses create is suffering due to the impact of humans: poor water quality, coastal development, boating and destructive fishing are all resulting in seagrass loss and degradation. This leads in turn to the loss of most of the fish and invertebrate populations that the meadows support. The green turtle, dugong and species of seahorse, for example, all rely on seagrass for food and shelter, and loss endangers their viability. The plants are important fish nurseries and key fishing grounds. Losing them puts the livelihoods of hundreds of millions of people at risk too, and exposes them to increasing levels of poverty.

Rapid loss

There is clear, extensive evidence of the rapid loss of seagrass. Growing historic, recent and current records show degradation and fragmentation of the plant around the world. In Biscayne Bay, Florida, for example, 2.6km^2 of seagrass disappeared between 1938 and 2009. Up to 38% of the seagrass in a lagoon in the south of France may have been lost since the 1920s. The nearshore waters of Singapore has lost some 45% over the past 50 years. Similar examples have been reported in Canada, the British Isles and the Caribbean too.

Even the Great Barrier Reef Marine Park has suffered periods of widespread decline and loss of seagrass over the past decade, particularly along its central and southern developed coasts; a consequence of multiple years of above average rainfall, poor water quality, and climate-related impacts followed by extreme weather events. The most recent published monitoring surveys show that the majority of inshore seagrass meadows across the reef – which cover some 3,063 km^2 – remain in a vulnerable state, with weak resistance, low abundance and a low capacity to recover.

Human impact

As the human population grows and the world economy expands, there will be increasing pressure on our coastal zone. And it must be ensured that this doesn't negatively influence seagrass meadows. It is already recognised that poor water quality, specifically elevated nutrients, is the biggest threat to seagrasses; these problems are particularly acute in many developing nations with rapidly growing economies, such as Indonesia, where municipal infrastructure is often limited and environmental legislation is largely weak.

Coastal development is a competition for finite space: boating, tourism, aquaculture, ports, energy projects and housing are all placing pressures on seagrass survival. These threats exist with a backdrop of the impacts of environmental change and sea level rise too. Humans must reduce their local-scale impact on seagrass so that it can remain resilient to longer term environmental stressors.

There can be a bright future for this oceanic plant, however. Across the world, communities, NGOs and governments are beginning to embrace the monitoring of meadows. As knowledge of the plants' ecology improves, conservationists are learning more about how to successfully restore seagrass meadows: Tampa Bay in Florida and Virginia's bays, for example, have seen genuine large scale recovery. We also now have greater appreciation for the value of seagrass in the global carbon cycle, and governments are more willing to include its conservation in ways to mitigate carbon emissions. Though commendable, these are just the first steps on a course of targeted strategic action.

As the WSA statement calls, seagrass meadows must be put at the forefront of marine conservation today. We need to increase its resilience by improving coastal water quality, prevent damage from destructive fishing practices and boating, include seagrasses in Marine Protected Areas and ensure that fisheries aren't over exploited. Seagrasses also need to be managed effectively during coastal developments, and steps taken to ensure recovery and restoration in areas where losses have occurred.

The scientific community must be more united, not only in its work, but in engaging more actively with the general public, coastal managers and conservation agencies too. Seagrass ecosystems must fully pervade policy around the globe too, as well as the consciousness of our global coastal communities. For the sake of future generations we need to work together to ensure the survival of the world's seagrass meadows now.