NICK HIGGINS

Q&A Paul Falkowski

A slow-motion crisis

Nature Outlook *talks to Rutgers University environmental scientist Paul Falkowski about the effects of human activity and climate change on communities of life-sustaining oceanic microorganisms.*

How did you first recognize the importance of phytoplankton to oceanic health?

When I was at the Brookhaven National Laboratory, I was involved in developing algorithms enabling satellites to estimate photosynthetic productivity — the amount of organic matter that phytoplankton incorporate into their bodies through photosynthesis — from space. I started to put together maps that were really surprising. Half the productivity in the world was being done by organisms that account for less than 1% of the photosynthetic biomass on the planet. That was an eye-opener.

Is their increased productivity due primarily to their rapid rate of reproduction?

Exactly. It's mind-boggling. They have to replicate themselves by doubling every three or four days in order for at least one daughter cell to remain alive and replicate before the other daughter cells are eaten or die. They don't produce huge numbers of seeds like trees or grasses. These organisms have a very simple, but very successful, life strategy.

Beyond the impact of industrialization on rising oceanic temperatures and the resulting reduction in phytoplankton growth, how else are human activities affecting phytoplankton populations?

One of the other big problems is eutrophication of the coastal oceans, that is, the addition of huge amounts of nutrients to the water. You can see this resulting in massive phytoplankton blooms, which trigger processes that deplete the water of oxygen. The one most familiar to Americans would be the so-called 'dead zone' in the Gulf of Mexico. These blooms can be phenomenally large, tens of thousands of square kilometres.

Are there any examples of such sites being successfully restored?

The most successful case in the United States is probably the Hudson River. New York City finally established tertiary treatment plants for sewage, and far fewer nutrients flow out of the Hudson River into the mid-Atlantic than was the case 20 or 30 years ago. But these are expensive solutions, and many communities don't want to pay for these kinds of treatments. As a whole, we're going the other way. The Chesapeake Bay on the US east coast, for example, receives massive amounts of nutrients from chicken farms. It's very difficult to reduce these nutrient flows because they're so widely distributed. The Mississippi River is particular tough to deal with because it carries run-offs from farms throughout the entire Mississippi drainage basin, which is enormous.

Does the climate science community as a whole recognize the importance of oceanic life as a factor?

Most people working on climate are physicists, who don't generally think much about biological processes, and who tend to think that ocean productivity is irrelevant. On short time scales of a decade or so that's true, but on longer time scales that's not true. What's going to happen, though, is that the changes in the climate over the next 100 or 200 years will alter the productivity of the planet, and I'm afraid it's not going to be for the better.

Are you seeing more opportunities for interdisciplinary communication and collaboration in the climate field?

There is a nascent field that we call 'Earth systems science', which attempts to integrate biological effects with the physical processes of the planet. But progress in this area has been slow because the physics of the planet is still not completely understood. Physicists spend an awful lot of time designing complex climate-change models, and to some extent they incorporate feedbacks from biological systems, but they focus mainly on terrestrial ecosystems. There is a failure to integrate this vitally important component of the Earth into climate feedbacks.

For areas of the ocean that are losing phytoplankton, what sort of impacts can we anticipate?

We're looking at a slow, long-term decline in photosynthetic productivity – we're already seeing this in satellite images of the open Atlantic and Pacific oceans. What this means for humans is that large open-sea fisheries, such as those for tuna, will be hard hit in the coming years.

Given their rapid turnover rate, might phytoplankton adapt in ways that could delay this decline?

No, they can't adapt on this timescale. There have been five major extinction events that naturally occurred and that we can see in the geological record. We are going through a sixth extinction event, and this one is entirely due to humans.

How severe do you believe the environmental damage is?

I think that in the best case, it would take a long time — probably about 1,000 years — for the current damage to be reversed. The phytoplankton will survive, but humans are going to pay the price. I find it very discouraging that a large segment of US society is not accepting conclusions that are based on objective science. It's distressing because everybody seems to be their own climate expert. I don't think humans realize that we're a vulnerable species. ■

Interview by **Michael Eisenstein**, *a freelance writer based in Philadelphia, Pennsylvania.*