NICK HIGGINS

Q&A John P. Smol

Regime change

A freshwater ecologist at Queen's University in Kingston, Ontario, Canada, Smol studies lake sediments to understand climatic and environmental change. Nature Outlook *asks him to share his experience.*

What can we learn from lake sediments?

One of the biggest challenges in environmental science is the lack of long-term data, so we have to use indirect proxies. All over the planet, lakes act as passive samplers of the environment, recording information 24 hours a day. They contain biological, chemical and physical information. The deeper you go in the sediment, the older it gets. Typically, in North America you can go back 12,000 years to the last Ice Age. In ponds near the Arctic Ocean, it's closer to 5,000 years, because before that those areas were below sea level. We focus on the changes that have occurred in the past few hundred years and compare them with the long-term record. So we can ask: is there anything peculiar going on now, or is this just part of a long-term cycle?

What have these remote ponds told us about climate change?

We chose shallow ponds because they would be the most sensitive. They're the bellwethers. The palaeo-data show that some very striking ecological changes started happening since the 1800s. The most plausible interpretation is that it was climate change and that it was human related. This conclusion was very controversial when we published it in 1994 (ref. 1).

We started going to these ponds on Cape Herschel in far northern Canada in 1983. We were going up every two or three years, and we could see they were getting shallower. We thought they could eventually disappear, but none of us thought it could happen in our lifetime. By 2006, many of the ponds had gone dry. It was stunning. We wondered if it was a one-off event, but we checked the 2005 data from the probes that we had left in some of the ponds in 2004 and saw that they were dry even then. We could tell that the ponds were evaporating, not draining, because the water's conductivity — which is proportional to the concentration of dissolved ions — had steadily been increasing. Nothing like this had ever happened before, although the drying trend has occurred since. We called it crossing the final ecological threshold.

Lakes and ponds across the Arctic region are shrinking and disappearing, while others are expanding. What effect will these changes have on the ecosystems?

We're entering all sorts of new ecological modes. There will be winners and losers. Some of the ponds have completely dried up and are covered in plants. If you're an aquatic invertebrate that is dependent on the pond — say, a fairy shrimp — you're gone. One of the large ponds on Cape Herschel had little rock islands in the middle that birds nested on. But when the water is low, those islands become peninsulas and the foxes just trot across to them and eat the eggs.

As you go farther south, the deeper lakes show other changes. They're still there, but they have less ice cover. There may be more algae. Lakes that once constantly mixed can become thermally stratified, so that many lake characteristics may change, such as the distribution of oxygen to the deeper layers. The reduced deep-water oxygen levels that might result can stress the fish in that habitat. Extended thermal stratification can also promote the growth of cyanobacteria, which are the least preferred food for aquatic organisms and can crowd out other foods and disrupt the entire food chain. Cyanobacteria growth can also degrade water quality.

What questions are you trying to answer with your current research?

One of the main difficulties is to sort out the roles of multiple stressors. We live in a complex world and the climate is changing, but a lot of other things are changing too. How do we tease apart the climate signal from everything else? It's a little naive to think that what we're seeing is just the effect of A and not the effect of B. The Arctic is a good place to start with new ideas. It is almost a clean slate. There are no farms, forest fires or highways to confuse the issue. Having said that, there are a lot of other things going on in the Arctic, and many of these are climate related too. We are finding new mechanisms for contaminant transport to the Arctic (and other regions). For example, Arctic seabirds can accumulate contaminants from the ocean and take them to the land. If we can show this happening in the Arctic, it is happening elsewhere as well.

Humans have left a large footprint on the world's aquatic ecosystems. How does climate change stack up against agricultural run-off, industrial pollutants and acid rain?

We have committed a multitude of sins on this planet, but I would have to say that climate change is the big one. A lot of the other problems can be solved at the source: you can treat material coming out of a pipe, stop the run-off, and add scrubbers to smoke stacks. But there's no simple, localized 'off switch' for climate change.

What can be done about this looming problem?

We have to stop releasing greenhouse gases and wean ourselves off our fossil fuel addiction. We also have to increase research into what effects are coming and how to mitigate them. Unfortunately, there seems to be very little will to embrace the problem. The lack of leadership is horrifying. ■

Interview by **Hannah Hoag**, *a science journalist based in Toronto, Canada.*

1. Douglas, M. *et al. Science* **266**, 416–419 (1994).