Atlantic invaders

ZOË CORBYN

The melting of Arctic sea ice is blurring the biological boundaries between Pacific and Atlantic.

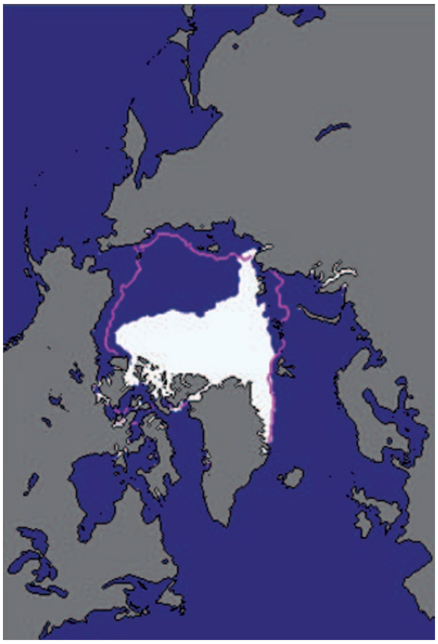
It was in May 1999, during routine monitoring, that the tiny diatom was first found drifting in the ocean currents. Not an unusual observation on a plankton survey, only the species was in the wrong ocean. The north-west Atlantic was thick with phytoplankton of a Pacific species on its first visit for 800,000 years.

"We were very familiar with the species in the Pacific," says Chris Reid, professor of oceanography at the Sir Alister Hardy Foundation for Ocean Science (SAFHOS) in Plymouth, UK, who led the survey. "But we had never seen it in the Atlantic before — it took a while for us to realise the significance."

Reid's explanation — based on analyses of sea ice coverage — is that *Neodenticula seminae* migrated from the Pacific to the Atlantic via the Arctic as a direct consequence of the Arctic's diminishing ice cover. Melting of ice is now opening up the Northwest Passage between the Arctic and Pacific Oceans during summer and could result in a seasonal ice-free state in the region as the climate continues to warm.

The threat is made all the more acute by recent satellite data which show the extent of Arctic sea ice at its lowest since satellite recording began in the early 1970s. With sea ice coverage reaching just 4.14 million km^2 in September[1], the route was more open this summer than in 1998 when *Neodenticula* slipped through. If Reid is correct, it is the first species to have become established via this trans-Arctic pathway for thousands of years and a sobering reminder of the extent to which our climate is changing.

Since its arrival, the diatom, commonly found in the most northerly reaches of the Pacific and the Bering Sea, has colonized the Labrador Sea between Greenland and Canada, as reported by Reid and colleagues in the September issue of *Global Change Biology*[2]. "An [ice] gate was opened in 1998 which has probably been closed for thousands of years and then it closed again immediately afterwards," he explains. "[The plankton] would have moved through the Bering Strait, through the [normally icy] Canadian archipelago and [south] into Baffin Bay." The completely open seawater in the summer months of that year — blown by winds accelerating the general east-west current flow — would have provided ideal conditions for the phytoplankton to grow and proliferate, he argues.



The extent of Arctic sea ice in September was at its lowest since satellite recording began in the early 1970s. Sea ice extent is 4.20 million square kilometers (1.61 million square miles). The magenta line shows the median September monthly extent based on data from 1979 to 2000.

BREACHED BARRIER

The true significance of the event lies not in the single species introduction but in a barrier being breached between the two oceans. Viable pathways through the Arctic ice mean that many more Pacific species could follow suit, posing a threat to northern north Atlantic species by competing for resources and potentially playing havoc with the ecosystem. Although phytoplankton are among the ocean's smallest denizens, their size belies their impact. The phytoplankton species *Coscinodiscus wailesii,* which invaded the North Sea from the Indian and Pacific Oceans, for example, displaces indigenous species given the right conditions. And as many native phytoplankton feeders find it unpalatable, its presence has knock-on effects throughout the entire food web. "This is the trickle before the flood," says Reid, describing plankton as a "tremendous indicator" of what is happening in the ocean. "We could well see a complete reorganization of the fauna of a large part of the northern north Atlantic."

Don Anderson, a Senior Biological Scientist and phytoplankton expert at the Woods Hole Oceanographic Institution (WHOI), who is unconnected with the paper, describes the work as "important" and agrees it reveals a worrying trend. "It addresses an issue that a lot of people have been talking about — the potential that this is going to happen — and here is an example that is really well documented," he says.

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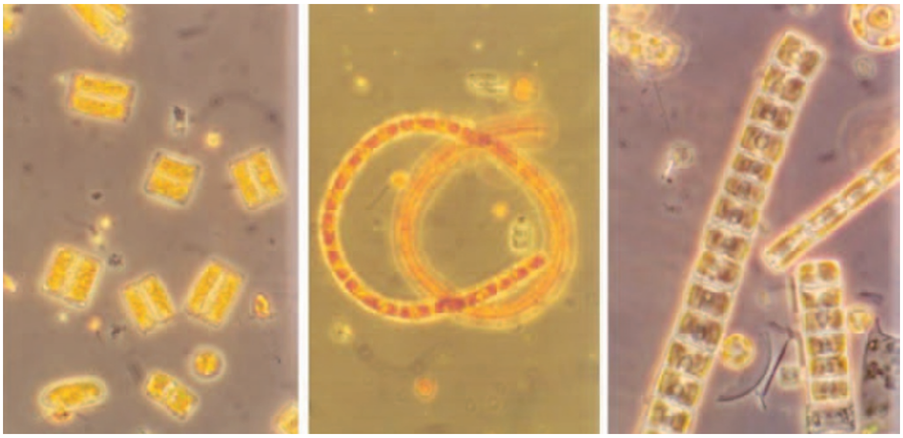
Chris Reid

Anderson stresses that the occurrence of species exchanges between the regions will be intermittent, but is also likely to increase as diminishing sea ice provides a more frequently accessible entry point. "It is a lot like opening the Panama Canal — but up north, and with Arctic boreal, rather than tropical, species exchanging back and forth." Phytoplankton, zooplankton, and fish and shellfish larvae could all take a one-way trip through the Northwest Passage, Anderson suggests. He notes that organisms with dormant resting stages such as eggs or cysts could get part way in one year and then push further the next. “It is open to anything that could survive the trip….though it could take quite a few invasions for something to really take hold,” he adds.

But there is another potential explanation for how *Neodenticula* made the trans-Arctic trip into Atlantic waters: as a stow away in a ship’s ballast water on a route that took the Zebra Mussel and many other invasive species to world domination.

Reid and colleagues are confident that this is not the case, though they cannot completely discount the route. They argue that few ships take the Northwest Passage and any ice breakers using the route are unlikely to risk exchanging their ballast water in transit or in the open waters of the Labrador Sea. The shortest alternative shipping route, about 18,000 km via the Panama Canal, would probably prove too tropical for the sub-polar species to survive. “I think they make a very good case,” says Anderson.



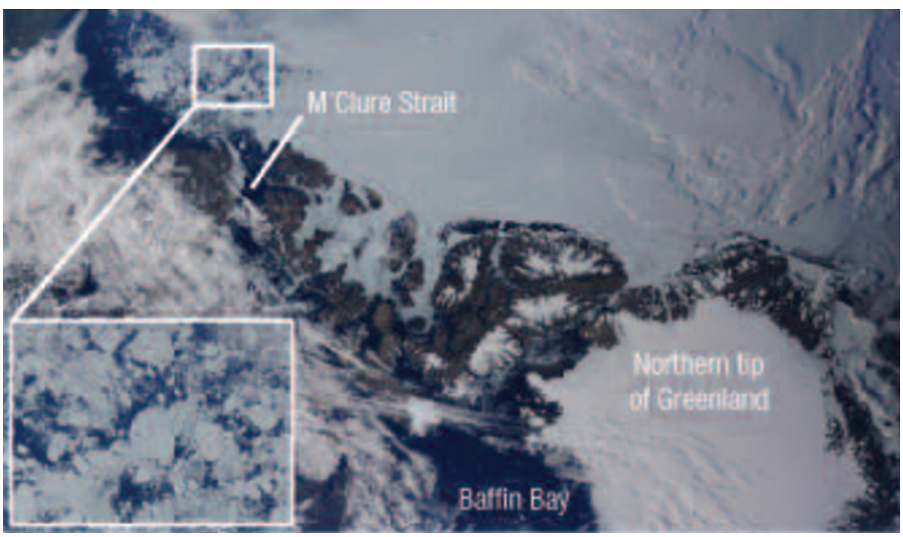
Neodenticula seminae may be the first species for thousands of years to become established in the Atlantic via the trans-Arctic pathway.

SOUTH BOUND

Hitched onto the back of helpful merchant ships, SAHFOS’s Continuous Plankton Recorder charted the species spread southward in the Labrador Sea between 1999 and 2004. Yet, the Atlantic’s newest resident hasn’t just taken refuge in the Labrador Sea. Other researchers have independently found *Neodenticula* elsewhere, providing valuable contributions to the paper. Samples have been found twice in Icelandic waters, and perhaps more significantly, the species has made a beeline for the Gulf of St Lawrence in Canada.

Michel Starr of Fisheries and Oceans Canada’s Maurice Lamontagne Institute, a collaborator on the paper says “there was a massive occurrence in the Gulf of St Lawrence in 2001 [compared with the lower concentrations in the Labrador Sea]. The low-salinity waters seem to have favoured the development of massive blooms after introductory seeding via the Labrador current”.

The Canadians have recently confirmed the genetic similarity between the Atlantic and Pacific species. Starr says the impacts on the ecosystem have yet to be determined but the discovery highlights the potential for substantial changes to plankton diversity from reducing Arctic Ocean ice. “Such effects would be likely to impact all ecosystem levels and fisheries,” he says. The Canadian government is continuing to monitor the invader.



Melting of Arctic sea ice has opened the Northwest Passage in summer, providing a route between the Atlantic and Pacific Oceans for invasive species.

FIRST PAST THE POST?

But *Neodenticula* might not be the first plankton species to have made the crossing in recent times, suggests Peter Weibe, also of WHOI, who points to an occurrence[3] of the Pacific zooplankton species *Calanus marshallae* off the Svalbard archipelago in 1994.

One possibility is that *Calanus* could have travelled underneath the ice to the Atlantic side of the Polar Ocean. Zooplankton, unlike phytoplankton, does not depend on light, although *Calanus marshallae* itself normally lives on continental shelves rather than in the deep ocean. *Calanus*’s seems to have been a one-off visit though. Unlike *Neodenticula*, which continues to be detected and seems to be well settled, the zooplankton has not been found in the region since.

One potential impact of *Neodenticula’s* arrival is a change in the ‘biological pump’ — the mechanism by which plankton transport carbon dioxide to the deep sea, enhancing the ocean’s storage of the greenhouse gas. In the Pacific, the species is an important component of the biological pump, which has led some to speculate that its invasion could contribute to carbon storage in Atlantic waters. Lack of silicate — a nutrient essential for *Neodenticula* — in the Atlantic compared to the Pacific, however, is likely to be a limiting factor. As the effects of the invader on planktonic life in the Atlantic are unknown, it seems equally plausible that the pump could be disrupted through competition with existing species.

Neodenticula's journey may also reveal new evidence for the unprecedented nature of today's warming climate. Fossil records show the only other time the species appeared in the north Atlantic was between 1.2 million and 800,000 years ago, introduced during an interglacial period. "It died out probably because of severe cooling," explains Reid, adding that oddly there is also no evidence of its presence in the north Atlantic during the Pliocene 'trans-Arctic interchange' of about 3.5 million years ago, when there was a huge extinction as Pacific species invaded the Atlantic.

Martin Head, a palaeoclimate expert from Brock University in Canada, points out that it hasn't appeared in the last 800,000 years despite plenty of interglacials during this time. The Eemian interglacial of about 130,000 years ago was thought to have been much warmer than today, for example. "It is telling us that something very unusual is happening during this [current] interglacial," says Head. "The reason could be those interglacials were not as warm as now."

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REFERENCES

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