Tropical plankton invade Arctic waters

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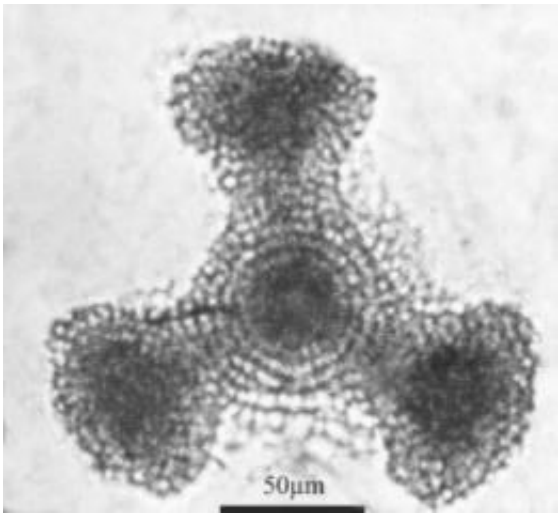

Dictyocoryne truncatum, normally found near the equator, was one of nearly 100 species of protozoa found living in the arctic ocean in 2010. Credit: Bjorklund et al., Jnl of Micropalaeontology, 2012

For the first time, scientists have identified tropical and subtropical species of marine protozoa living in the Arctic Ocean. Apparently, they traveled thousands of miles on Atlantic currents and ended up above Norway with an unusual—but naturally cyclic—pulse of warm water, not as a direct result of overall warming climate, say the researchers. On the other hand: arctic waters are warming rapidly, and such pulses are predicted to grow as global climate change causes shifts in long-distance currents. Thus, colleagues wonder if the exotic creatures offers a preview of climate-induced changes already overtaking the oceans and land, causing redistributions of species and shifts in ecology. The study,

by a team from the United States, Norway and Russia, was just published in the *British Journal of Micropalaeontology*.

The creatures in question are radiolaria—microscopic one-celled plankton that envelop themselves in ornate glassy shells and graze on marine algae, bacteria and other tiny prey. Different species inhabit characteristic temperature ranges, and their shells coat much of the world's ocean bottoms in a deep ooze going back millions of years; thus climate scientists routinely analyze layers of them to plot swings in ocean temperatures in the past. The new study looks at where radiolarians are living now.

In 2010, a ship operated by the Norwegian Polar Institute netted plankton samples northwest of the Norwegian archipelago of Svalbard, about midway between the European mainland and the North Pole. When the coauthors analyzed the samples, they were startled to find that of the 145 taxa they spotted, 98 had come from much farther south—some as far as the tropics. Furthermore, the southern radiolaria were in different sizes and apparently different stages of growth for each species, indicating they were reproducing, despite the harsh conditions. It was the first time since modern arctic oceanographic research began in the early 20th century that researchers had spotted a living population of such creatures in the northern ocean.

Coauthor O. Roger Anderson, a specialist in one-celled organisms at Columbia University's Lamont-Doherty Earth Observatory, said, "When we suddenly find tropical plankton in the arctic, the issue of global warming comes right up, and possible inferences about it can become very charged. So, it's important to examine critically the evidence to account for the observations." He said the invaders were apparently swept up in the warm Gulf Stream, which travels from the Caribbean into the north Atlantic, but usually peters out somewhere between Greenland and Europe. Oceanographers have previously shown that

sometimes pulses of warm water penetrate along the Norwegian coast and into the arctic basin; such pulses have occurred in the 1920s, 1930s and 1950s. Further, the authors say that well-dated fossils of foraminifera—protozoans closely related to radiolaria—found on the arctic seafloor suggest that warm-water plankton may have temporarily established themselves at least several times before—around 4200 and 4100 BC, and again around 220, 370 and 1100 AD. "All the evidence is that this isn't necessarily immediate evidence of global warming of the ocean," said Anderson. Lead author Kjell Bjørklund, of the University of Oslo Natural History Museum said of the invaders, "This doesn't happen continuously—but it happens."

That said, oceanographers have noted that such pulses seem to be coming more often and penetrating further—"exactly what one would expect from global warming," said Rainer Froese, an oceanographer at the Helmholtz Centre for Ocean Research who tracks fish global populations. Could this be the start of a switch in currents predicted by climate models? The most recent pulse began in the early 1980s, and has lasted more or less to the present. Even without that, the arctic ocean itself is warming rapidly; with progressive loss of summer sea ice over past decades, average surface temperature has gone up as much as 5 degrees centigrade (9 degrees Fahrenheit) since 1950 in some patches.

Researchers lower plankton nets over the side during a scientific expedition in northern waters. Credit: Beth Stauffer/Lamont-Doherty Earth Observatory

Physical oceanographers have different ideas on the mechanics of how more southerly water--and the things living in it--may arrive in the arctic. However, most agree that it will happen if climate keeps warming, said Arnold Gordon, head of Lamont's division of ocean and climate physics, who was not involved in the research. For one, a countercurrent running near Greenland, the North Atlantic Polar Gyre, normally wards off the Gulf Stream; but that gyre is predicted to slow with warming. Atlantic currents might also respond to changing wind patterns, or to the increasing fresh water now pouring into the northern ocean from melting sea ice and glaciers. Either way, this could draw more southerly water into the north, said Gordon.

Louis Fortier, an arctic oceanographer at Laval University in Quebec, said of the recent injections of southerly waters, "Whether or not [such] intrusions are signs of this predicted increased advection in response to climate change, nobody can tell yet, I believe. But for me, the observations so far certainly support the models." Paul Snelgrove, a specialist in cold-ocean studies at Memorial University of Newfoundland, agreed. "The question is, are these kinds of incursions becoming more frequent and stronger? If it continues, the case would become more persuasive. Right now, this study is not a definitive test, but it seems like an intriguing teaser as to what might happen."

Whatever the answer, this is the first time a living population of southern radiolaria has been found so far north. Radiolaria live only about a month, so it must have taken 80-some generations for some species to make the five- to seven-year trip, say the authors. On the way, successive generations could have adapted to colder waters. In 2009, the surface

water in the sample area measured an extraordinary 7.5 degrees C (about 45.5F). A year later, when the samples were taken, it was down to a more normal level of 3.5C (38F), and yet the radiolarians were still there. However, the fast-changing nature of the ocean makes their presence in the arctic hard to interpret, said Paul Wassman, an arctic biologist at the University of Tromsø in Norway. Marine creatures routinely travel vast distances on currents. Water temperatures may vary widely in the same latitude. Populations of some creatures may live for a while in a narrow tongue of temperate water, then wink out once that gets too diluted, he said. Bjørklund, Anderson and their coauthor Svetlana Kruglikova of the P.P. Shirshov Institute of Oceanography in Moscow note that it is uncertain whether the southern invaders are still there; they have not gotten any new samples since 2010.

In any case, changes in global ocean ecology are already being detected in many places. Warmer-water species are marching poleward, much as creatures are on land, where butterflies have been shifting ranges northward about 6 kilometers per decade, and amphibians and migratory birds are breeding an average of two days earlier. A 2011 global study on the impact of climate change on fisheries says that many marine species are moving poleward or into deeper, cooler waters in response to warming--among other places, along the U.S. east coast, the Bering Sea, and off Australia. The North Sea, off Scandinavia and the United Kingdom, has warmed about 2 degrees F in the last 50 to 100 years; there, 15 of 36 fish species studied have moved northward; fish more common nearer the Mediterranean—anchovy, red mullet, sea bass—are being caught by commercial fishermen, while cod, which prefer colder waters, are moving out. There is also evidence that zooplankton similar to the radiolaria are shifting northward in the North Atlantic. In the Pacific, poisonous algal blooms harmful to the shellfish industry are being detected farther north, into Alaskan waters.

In the arctic itself, earlier and faster melting of sea ice in the summer

appears to be shifting plankton species assemblages toward smaller types. This could ultimately damage the food web that feeds much larger creatures, including seals, walruses and whales, said Jody Deming, a biologist at the University of Washington who studies arctic microbes. In an email, Deming said the new paper "presents an intriguing observation (warmer species making it into Arctic waters and surviving at least on the short term), but without more knowledge of how living radiolarians fit into the larger ecosystem, as both prey and predator, potential impacts on the whole ecosystem cannot be predicted reliably or at all really."

The big question, said Bjørklund, is what happens next. In the future, radiolaria may serve as useful indicators of how currents, and ecology, are changing. There are at least 60-some radiolaria species peculiar to the arctic; they may be quite different from the new arrivals, but too little is known about the life cycles of either group to say how either will react if they meet on a long-term basis, and how this might affect arctic ecosystems. Of the southerly radiolaria, Bjørklund said, "Will they adapt? Will they perish? Will they mix with the native fauna?" He said that he and his colleagues are anxious to receive new samples to find out.

More information: "Modern incursions of tropical Radiolaria in the Arctic Ocean" *British Journal of Micropalaeontology*.

Provided by Columbia University