Project CLAMER
Climate Change and European Marine Ecosystem Research
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Prodigal Plankton Species Makes First Known Migration from Pacific to Atlantic via Pole

Microscopic plant disappeared from North Atlantic 800, 000 years ago; unwanted return one of several climate change symptoms , already apparent throughout European oceans

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Some 800,000 years ago - about the time early human tribes were learning to make fire - a tiny species of plankton called *Neodenticula seminae* went extinct in the North Atlantic.

Today, that microscopic plant has become an Atlantic resident again, having drifted from the Pacific through the Arctic Ocean thanks to dramatically reduced polar ice, scientists report.

The melting Arctic has opened a Northwest Passage across the Pole for the tiny algae. And while it's a food source, it isn't being welcomed back by experts, who say any changes at the base of the marine food web could, like an earthquake, shake or even topple the pillars of existing Atlantic ocean life.

The discovery represents "the first evidence of a trans-Arctic migration in modern times" related to plankton, according to the UK-based Sir Alister Hardy Foundation for Ocean Science, whose researchers warn that "such a geographical shift could transform the biodiversity and functioning of the Arctic and North Atlantic marine ecosystems."

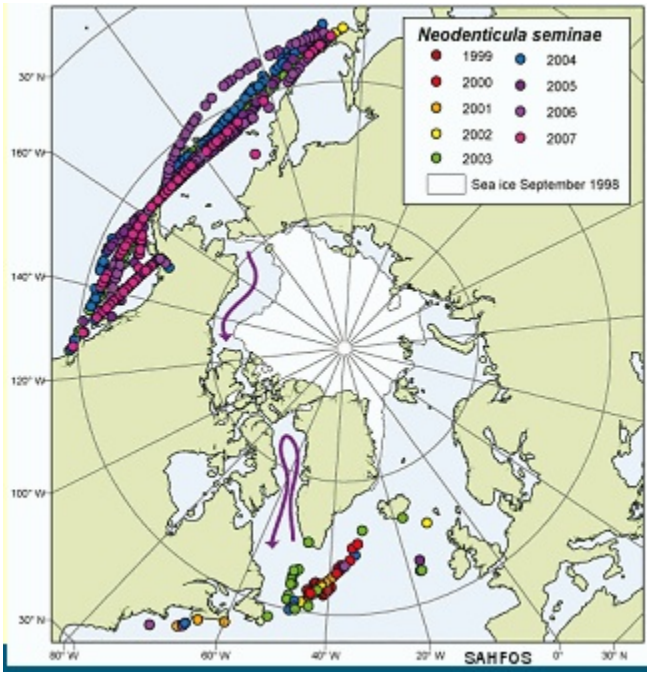
The tiny marine plant's migration parallels, near the extreme opposite end of the ecological weigh scale, the arrival last year of a Pacific gray whale spotted off the coasts of Spain and Israel, a species that vanished from the Atlantic three centuries ago, likely because of over-hunting. Scientists believe the ice-reduced Arctic allowed the whale to cross into the North Atlantic, from where it wandered its way to the Mediterranean Sea.

These are among a number of reports about the marine life upheaval underway in the North Atlantic due to climate change, findings being captured and cataloged by project CLAMER, a collaboration of 17 marine institutes in 10 European countries.

The project is synthesizing the results of almost 300 EU-funded climate change-related research projects over 13 years in Europe's oceans and near-shore waters, as well as the Mediterranean, Baltic and Black Seas.

"The migrations are an example of how changing climate conditions cause species to move or change their behaviour, leading to shifts in ecosystems that are clearly visible today," says Carlo Heip, Director General of the Royal Netherlands Institute for Sea Research, which leads the CLAMER project.

The Alister Hardy Foundation for Ocean Science (SAHFOS) is documenting the change in plankton through the Continuous Plankton Recorder Survey, the longest and most geographically extensive marine biological survey in the world.



SAHFOS scientists say that, in addition to the return of *Neodenticula seminae*, populations of tiny animals called copepods are changing too, threatening the food supply of fish such as cod, herring and mackerel, as well the many marine mammals that, in turn, prey on fish.

As the waters of the Atlantic and the North Sea warm, a valuable member of the copepod family known as *Calanus finmarchicus*, a rich and crucial source of oil, is being replaced by varieties that are smaller and less nutritious.

The consequences are already evident. The changes in plankton life have "been related to the collapse of some fish stocks" as well as declines in fish-eating North Sea birds, the researchers report. Harbour porpoises migrated from the northern North Sea when sand eels, a mainstay of their diet, moved poleward with the nutritious copepods.

Overall, studies show that re-arrangements of marine life composition is likely to be mixed - some species could, in fact, thrive and parts of the ocean gain in biodiversity and

productivity.

"But most of the impacts are so clearly negative, and the scope of change so potentially huge that, taken together, they constitute brightly flashing warning signals," says Dr. Heip.

Other findings from the project:

* A form of phytoplankton, known as *dinoflagellates*, is rising in abundance and moving steadily eastward across the Atlantic toward Scandinavia. Many *dinoflagellates* are harmful because their bloom and death absorbs dissolved oxygen in the water, which affects other marine creatures. Some also produce toxic compounds that make shellfish flesh poisonous to humans and other organisms. Researchers believe the marine conditions forecast due to climate change favour their growth.

* Jellyfish are increasing in the northeast Atlantic, often forming massive blooms. A venomous warm-water species, *Pelagia noctiluca*, dominates in many areas and outbreaks have become an annual event, forcing the closing of beaches. This form of jellyfish is a gluttonous predator of juvenile fish, so researchers consider its spread a harmful trend. Recently, the highly venomous Portuguese Man-of-War *(Physalia physalis*), a jellyfish-like subtropical creature, were found more regularly in northern Atlantic waters.

* Changes in temperature and other conditions mean some prey species are no longer available when their predators need them. Off Northwest Europe, the warming trend has led to earlier spawning of cod, while phytoplankton have kept their traditional biological schedule. The result is a timing mismatch between the cod's larval production and its food supply.

Says the Marine Board of the European Science Foundation: "In the North Sea, seasonal changes in the timing of biological events for plankton as a response to warming are leading to a mismatch between phytoplankton and zooplankton, between zooplankton and fish, between bivalve larvae and shrimp, and between fish and seabirds."

* The cod population has plummeted throughout the North Atlantic, largely, so far, due to over-fishing. But a team led by researchers with Norway's Institute of Marine Research warn that cod can't tolerate higher temperatures, and "if warming continues at the rate projected by the United Nations' Intergovernmental Panel on Climate Change, it will considerably limit larval cod survival and thereby recruitment, making the reconstitution of the stock difficult."
Young cod rely on the copepod *Calanus finmarchicus*, the migration of which 1,000 kilometres to the north inhibits the cod from re-establishing in the southern North Sea.

* Warmer temperatures and stratification of the water are allowing living and dead microscopic organic matter to form massive, mucous-like blobs of marine mucilage in the Mediterranean Sea. This noxious material harbours bacteria and viruses that could kill fish.

* In the North Sea, several fish species, including sea bass, mullet, solenette and scaldfish,

are moving northward and increasing in numbers as the water warms, according to experts at the Royal Netherlands Institute for Sea Research and the Netherlands Institute for Ecology (NIOO).

"The predictions of higher average temperatures and milder winters in the North Sea make it likely that these species will increase further in abundance and move northward," say NIOO scientists. This "will affect the North Sea food web and therefore commercial species by predation on juveniles and competition for food resources."

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The impacts of some observed changes remain difficult to assess because the web of life in the oceans, and the forces that shape it, are so complex, and so little is known about them. Some impacts will combine to magnify their effects on ocean life; others might neutralize each other.

In the Baltic Sea, for example, warmer temperatures should improve biodiversity. But the sea is also expected to become less salty, which would reduce the number of fish species. If, as forecast, sea levels rise, newly flooded coastal areas in Europe will provide more fish habitat. On the other hand, studies suggest a combination of rising temperature and decreasing oxygen could degrade the coastal habitats for bottom-living fish species such as cod and flatfish, particularly in areas that already receive high levels of nutrients. These species will become less abundant if coastal areas experience longer and more frequent periods with low or no oxygen.

Different species will respond in varying ways to a particular change and that, in turn, could alter how they interact with each other.

Fishing, pollution and the erosion of soil and nutrients into the water will combine with the climate impacts. For example, fish harvests rising in tandem with world population reduces the age, size and geographical diversity of fish populations, making them more sensitive to climate stress.

Marine species are tending to migrate toward the poles, but they're doing so at varying speeds, again, making it difficult to predict how they'll interact.

In enclosed seas, species that require cooler conditions might have nowhere to go when the waters warm. Researchers predict that by 2060, as the Mediterranean warms, one-third of its 75 fish species will be threatened and six will be extinct.

On the other hand, in the almost equally enclosed Black Sea, where "new Mediterranean species are arriving and establishing new niches," warming air and seawater are expected to result in increased diversity, with adverse effects limited to declines or loss of a small number of native species, according to Temel Oguz of the Institute of Marine Sciences at

Turkey's Middle East Technical University.

Other researchers including Manuel Barange, director of science at the UK's Plymouth Marine Laboratory, point out that linear change isn't likely. Marine life might alter abruptly as new conditions push a species beyond a tipping point. "Gradual changes in future climate may provoke sudden and perhaps unpredictable biological responses as ecosystems shift from one state to another," he says.

Typical of the uncertainty is a study by scientists from the Institute for Marine Resources & Ecosystem Studies, in the Netherlands, which found that warming water led to more species in the North and Celtic Seas, mostly migrants from the south, and, unexpectedly, fewer in the ocean west of Scotland.

This change "will undoubtedly have implications for commercial fisheries and on the implementation of effective conservation and environmental monitoring strategies," they write.

"We need to learn much more about what's happening in Europe's seas, but the signs already point to far more trouble than benefit from climate change," says Dr. Heip.

"Despite the many unknowns, it's obvious that we can expect damaging upheaval as we overturn the workings of a system that's so complex and important."

Project CLAMER concludes with an international conference at the Royal Flemish Academy of Belgium, Brussels, Sept. 14-15.

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Project CLAMER
(Climate Change and European Marine Ecosystem Research)

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