Study: Growing potential for toxic algal blooms in the Alaskan Arctic

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A water sampler known as a conductivity, temperature, depth (CTD) rosette is deployed from the U.S. Coast Guard icebreaker Healy during a 2019 expedition to the Alaskan Arctic Ocean to study the presence of harmful algae and the conditions that promote their growth and spread. Credit: Woods Hole Oceanographic Institution

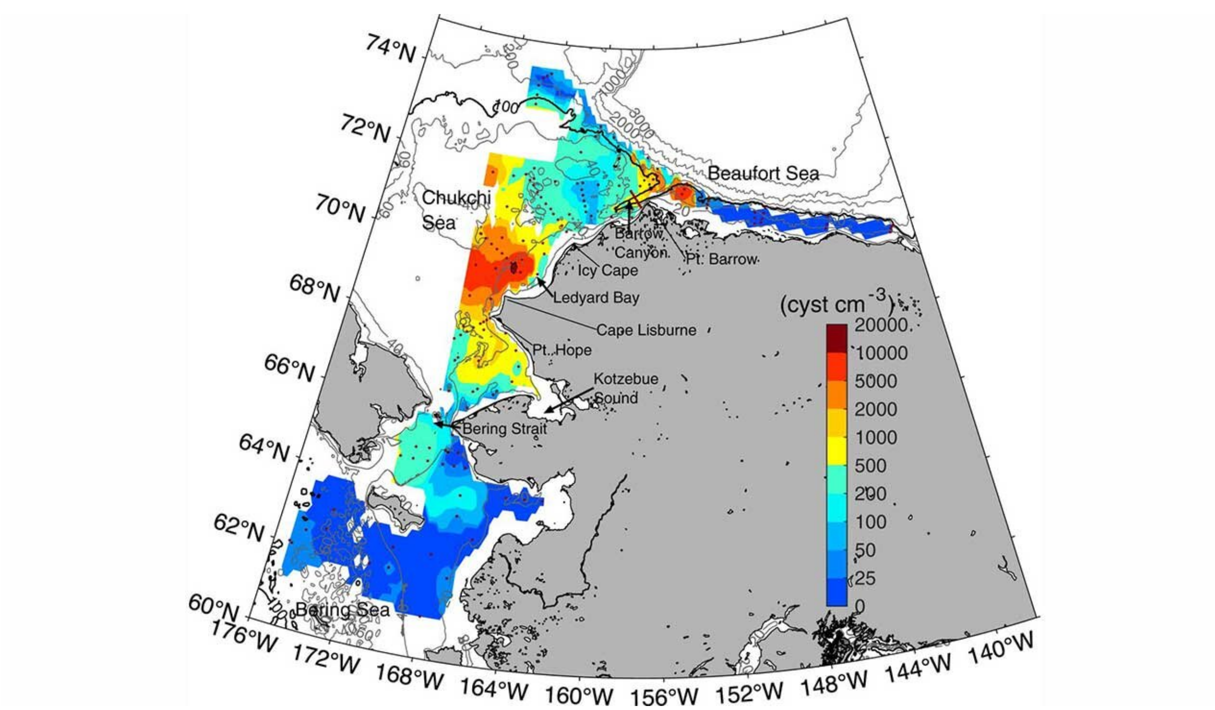
Changes in the northern Alaskan Arctic ocean environment have reached a point at which a previously rare phenomenon—widespread blooms of toxic algae—could become more commonplace, potentially threatening a wide range of marine wildlife and the people who rely on local marine resources for food. That is the conclusion of a new study about harmful algal blooms (HABs) of the toxic algae Alexandrium catenella being published in the journal *Proceedings of the National Academy of Science*.

The study, led by scientists at the Woods Hole Oceanographic Institution (WHOI) in collaboration with colleagues from the National Oceanic and Atmospheric Administration (NOAA) and other researchers in the U.S, Japan, and China, looked at samples from seafloor sediments and surface waters collected during 2018 and 2019 in the region extending from the Northern Bering Sea to the Chukchi and Beaufort Seas north of Alaska. The sediment samples allowed the researchers to count and map Alexandrium cysts—a seed-like resting stage that lies dormant in the seafloor for much of the year, germinating or hatching only when conditions are suitable. The newly germinated cells swim to the surface and multiply using the sun's energy, producing a "bloom" that can be dangerous due to the family of potent neurotoxins called saxitoxins that the free-swimming cells produce.

Although microscopic algae in the ocean are most often beneficial and serve as the base of the marine food web, some species produce potent neurotoxins that can directly and indirectly affect humans and wildlife. When the Alexandrium cells are consumed by shellfish and some fish, those toxins can accumulate to levels that can be dangerous to humans and wildlife, resulting in the human syndrome called paralytic shellfish poisoning, with symptoms ranging from tingling lips, to respiratory distress, to death. In fish, toxin levels can be highest in digestive and excretory organs, such as the stomach, kidney, liver, but are very low in muscle and roe. The toxin can also cause illness and mortality of marine wildlife such as larger fish, marine mammals, and seabirds. This is of particular concern for members of coastal communities in northern and western Alaska who rely on a variety of marine resources for food.

"We've known about human and marine wildlife health risks associated with Alexandrium and its toxins in Alaskan waters for a long time, including occasional events north of Bering Strait, but these results show increased potential for large and recurrent blooms of this species as a new hazard for Alaska's Arctic," said Don Anderson, WHOI senior scientist and Director of the U.S. National Office for Harmful Algal Blooms, who led the study. "The rapid warming that we're seeing all across the Arctic is setting the stage for dangerous bloom events in the waters of western and northern Alaska that we formerly thought were too cold for significant germination and growth."

Alexandrium are part of a group of single-celled organisms found in oceans and lakes worldwide known as dinoflagellates, named for their flagella—whip-like appendages that cells use to swim through the water. In their cyst stage, Alexandrium cells settle on the seafloor where they can remain inactive for decades, waiting for water temperatures to become favorable for them to germinate and take on their free-swimming form.



Location of dense beds of Alexandrium cysts (red) in the seafloor of Ledyard Bay and east of Pt. Barrow. Credit: Anderson, et al., 2021

"As the climate has warmed, the significant and ongoing reduction in extent and duration of seasonal ice cover along the coast of western and northern Alaska has resulted in dramatic changes" said Bob Pickart, a WHOI physical oceanographer and co-leader of the project with Anderson. "These include warming temperatures due to local heating of ice-free waters, as well as an increased influx of warmer, fresher water from the Pacific flowing north through the Bering Strait region into the Chukchi Sea."

In addition, atmospheric conditions and less seasonal sea ice means organisms that rely on sunlight to grow, including Alexandrium, are able to thrive and multiply. As a result of this and related changes, the authors write in their paper, the Arctic Ocean ecosystem is witnessing an "unprecedented regime shift."

Among these shifts is both the timing and favorability of ocean conditions that promote the germination of Alexandrium cysts on the seafloor in the Ledyard Bay area of the northeast Chukchi Sea. Previously, Alexandrium was known to exist in the Chukchi Sea as dormant cysts or as bloom cells thought to be carried north through the Bering Strait from populations that originated in southeastern Alaska, the Aleutian Islands, or the east coast of Russia. The fast north-flowing currents through the narrow Bering Strait slow near Ledyard Bay, allowing Alexandrium cysts to settle to the seafloor. Over time, exceptionally dense and large beds of Alexandrium cysts have formed. Formerly, water temperatures on the seafloor were thought to be too cold to allow significant germination to inoculate local blooms. However, the authors demonstrate that warming over the last two decades has increased bottom water temperatures in Ledyard Bay and nearby waters by nearly 2°C, sufficient to nearly double the flux of germinated cells from the seafloor and also speeding up the process, thereby advancing bloom initiation by almost three weeks and lengthening the window for favorable growth and bloom formation in surface waters. The swimming Alexandrium cells in surface waters can grow and multiply As a result, they find increased potential for large blooms of Alexandrium to produce dangerous levels of the PSP toxins that can enter the food web and threaten the people and wildlife of the Arctic ecosystem during warmer years.

"What we're seeing now are very different Arctic Ocean conditions than anyone in living memory has known," said Anderson. "We've learned from the Gulf of Maine in the Atlantic Ocean how to monitor and manage Alexandrium bloom events and how to sustain commercial and recreational fisheries in the face of HABs, but navigating this new Alaskan Arctic HAB problem is going to take a great deal of targeted research and far more attention to the food security of coastal residents and Alaska Natives and the health of Arctic wildlife than we've paid so far."

"The threat is clear, but we don't yet know the extent to which these toxins will ultimately lead to increased human exposure or to impacts on the health of wildlife at all levels of the food web," said Kathi Lefebvre, a research biologist at NOAA's Northwest Fisheries Science Center who, in partnership with Anderson, is leading a parallel study in close collaboration with Alaskan subsistence communities on the effects, concentrations, and movements of these toxins in food webs. "To complicate the challenge, this is a new stress on northern marine ecosystems that are already undergoing unprecedented change, adding yet another concern for the food security of coastal peoples for whom the ocean is a primary source of food and a central element of their identity. Alaskan coastal communities are now aware of this emerging issue and have been active partners in the research process to protect their subsistence life as well as advance our understanding of the changing Arctic and what it means for the future."

More information: Donald M. Anderson et al, Evidence for massive and recurrent toxic blooms of Alexandrium catenella in the Alaskan Arctic, *Proceedings of the National Academy of Sciences* (2021). DOI: 10.1073/pnas.2107387118

Provided by Woods Hole Oceanographic Institution

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