Assessing the biogeographic origin and toxicity of Alexandrium species in the pan-Arctic region

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Dramatic changes are occurring in the Arctic, including rapid melting of glaciers, sea ice, and permafrost, resulting in ice-free summer conditions as early as 2040. The geographic range of a broad variety of marine species will be greatly impacted, particularly in ice-free, shallow waters. We hypothesize that another climate-related change will be the expansion of toxic or harmful algal bloom (HAB) species into or within the Arctic. HABs or "red tides" are characterized by the proliferation and occasional dominance of a particular species of toxic or harmful algae. Paralytic Shellfish Poisoning (PSP) is the most widespread HAB syndrome and is often associated with the marine microalga *Alexandrium tamarense.* The potent neurotoxins produced by these organisms are accumulated by filter-feeding shellfish, fish, and other grazers and are passed on to humans, seabirds, walruses, whales, and other animals at higher trophic levels, leading to illness, incapacitation, and death. With support from the James M. and Ruth P. Clark Arctic Research Initiative, we investigated the presence of *Alexandrium* in the pan-Arctic region to obtain preliminary data on their origin and physiology. The data collected from these studies will help to assess the future potential for a climate-driven range extension of HABs in the Arctic and associated risks to humans and the fisheries and ecosystems on which they depend.

The field work for this effort was carried out in part through the ARCHEMHAB program, an international research program for the study of HAB populations in the North Sea and

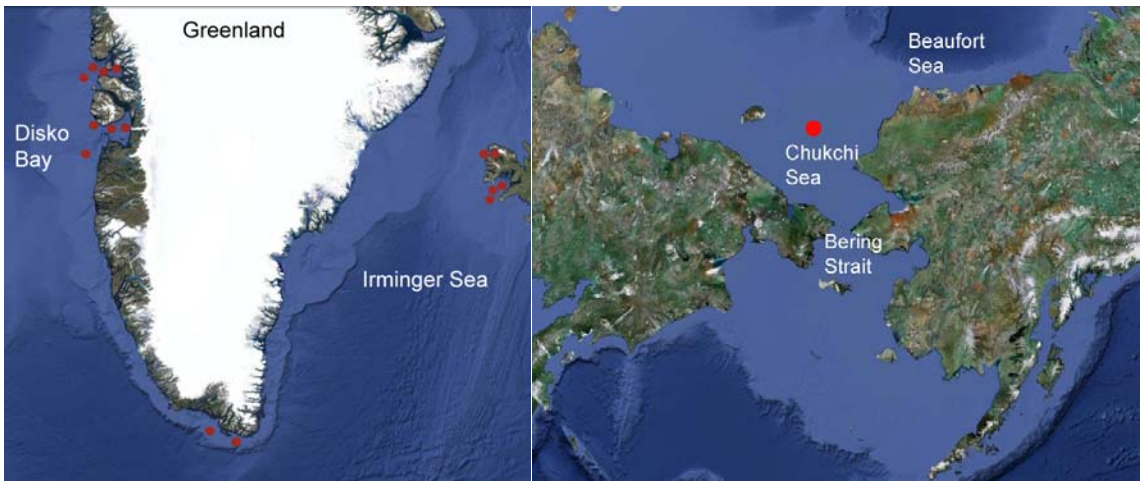

Fig 1. Locations of sample collections (red dots) from Greenland, Iceland, and the Chukchi Sea. Left: Cruise track of R/V Maria S. Merian (summer 2012) included intensive sampling in Disko Bay on the western coast of Greenland and in northwestern Iceland. Right: Sediment samples were collected from the Chukchi Sea in 2010, and used to establish cultures of *Alexandrium tamarense*.

the Arctic. Sampling in Greenland and Iceland took place in 2012 during an oceanographic cruise that departed from Nuuk, Greenland, transited north to Disko Bay, back around the southern tip of Greenland, and across the Irmiger Sea to western Iceland (Fig 1, left panel). Sediment and seawater samples were collected throughout the cruise (Fig 2), and examined for the presence of *Alexandrium* cells as well as their cysts (the dormant resting stage in their life cycle). Analysis of sediment samples showed that *Alexandrium* cysts were present at low to moderate densities in all areas surveyed in Greenland and Iceland, with the exception of two stations located at the southern tip of Greenland (where cysts were absent). In addition to the samples collected during this cruise, we were able to obtain sediment samples from a different area of the Arctic – the Chukchi Sea (Fig 1, right panel). These samples were kindly provided by a colleague, and contained very high densities of *Alexandrium* cysts.

Fig 2. Deploying a Van Veen sediment sampler near Disko Bay, Greenland.

Live cultures were established from all locations (Greenland, Iceland, and Chukchi) by isolating individual cysts and incubating them in culture media (Fig 3). We subsequently established a total of 163 cultures: 134 from the Chukchi Sea and 29 from western Greenland (Disko Bay) and Iceland. We commenced physiological experiments using these cultures to examine the effects of temperature and light on their growth rates and toxicity. Preliminary data suggest that the temperature tolerances of Arctic isolates are similar to those from temperate regions, which may be informative in assessing dispersal pathways in Arctic waters. In addition to the growth experiments, we are using molecular tools to determine the origin of *Alexandrium* populations from Greenland, Iceland, and the Chukchi Sea, and to assess their connectivity with populations from temperate waters.

This research has provided the first assessment of the distribution and abundance of *Alexandrium* cysts in the Disko Bay region in Greenland and in western Iceland. These studies are also yielding valuable data regarding the physiology and connectivity of *Alexandrium* from the areas sampled with populations from temperate waters. We are grateful to the Clark Arctic Research Initiative for providing the support needed to launch this research program, and are pursuing funding from the National Science Foundation to carry out an expanded study.

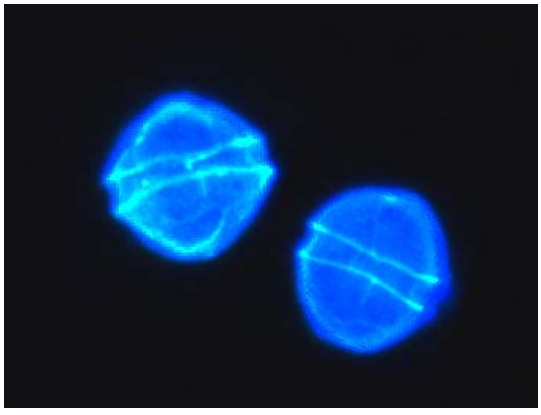

Fig 3. Epifluorescence image of *A. tamarense* cells from the Chukchi Sea.