

Improving Satellite Ocean Color Assessments of Arctic Coastal Ecosystems

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Most climate models predict drastic warming in the Arctic within this century. The ongoing loss of seasonal sea ice cover that is now being observed is expected to continue, and thawing and erosion of permafrost will increase nutrient levels in coastal Arctic seas. Both of these profound environmental changes have the potential to fundamentally alter Arctic coastal ecosystems by their effect on the local photosynthetic phytoplankton that form the base of marine food webs. Even small reductions in sea ice cover will greatly increase light levels in the ocean, which will give these phytoplankton additional energy for assimilating the dissolved nutrients that they may encounter. Therefore, phytoplankton biomass in coastal Arctic waters will increase. Moreover, it is also likely that such environmental changes will alter the types of species that dominate Arctic phytoplankton assemblages. Although either outcome is difficult to predict, both scenarios would impact Arctic food webs and fisheries dramatically.

Remote sensing techniques have considerable potential for monitoring and measuring the effects of such climate-driven changes in coastal phytoplankton assemblages, especially ocean color satellites. Such satellites are widely used at lower latitudes with great effectiveness, but their ability to assess coastal Arctic waters at higher latitudes is hindered by a lack of essential baseline data about the optical properties that affect ocean color in the coastal Arctic, and a lack of knowledge about how native Arctic phytoplankton species are represented in ocean color images. Support from the Clark Arctic Research Initiative has allowed us to develop a new research program at WHOI that focuses on ocean color and phytoplankton ecology in the Arctic. Our overall science goal has been to better understand the factors in coastal Arctic waters that critically affect satellite assessments of phytoplankton ecology.

We are pleased to report that our ocean color research program has grown considerably beyond the initial studies we proposed. We have created archives of historical ocean color imagery from Arctic regions on computer servers, and we have examined that historical information to gain insight into “problem areas” along coastal margins where current ocean color satellite approaches may not be robust. We have conducted a field program in the Bering and Chukchi Seas in which important measurements were collected of optical properties that affect ocean color in these waters and that had not previously received much attention (Figure 1, and Figure 2, next page). The study included over 50 stations in Alaskan Arctic coastal waters and along the shallow Chukchi shelf (Figure 3, next page). These *in situ* observations – using specialized optical instrumentation – have provided important baseline data regarding the current distribution of optical properties in a broad region of the coastal Alaskan Arctic.

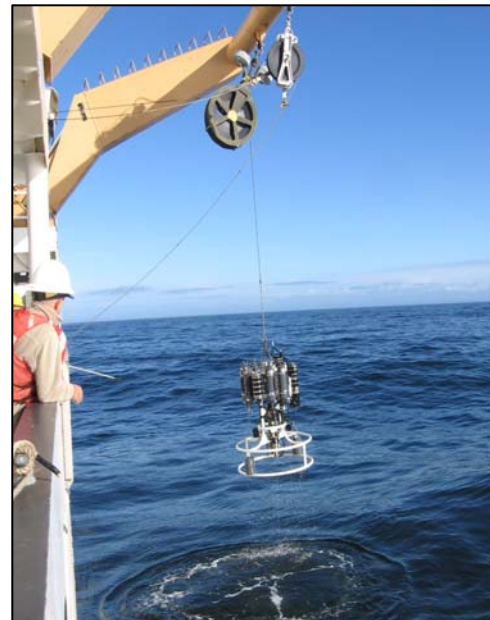


Figure 1: Deploying a specially instrumented profiling package to assess optical and phytoplankton properties in the surface layers of the Arctic Ocean.



Samples of phytoplankton that were collected on this cruise were returned to our laboratory in Woods Hole for further analysis using the automated underwater microscope, the Imaging FlowCytobot, which was developed at WHOI. This application of novel imaging technology represents an important advancement in understanding phytoplankton dynamics in the Alaskan coastal Arctic. We were also able to obtain additional phytoplankton samples through a smaller study in the Bering Sea. These baseline data represent an important body of information regarding the current distribution of phytoplankton species in these Arctic waters, against which any future changes (climate-driven or otherwise) in coastal Arctic ecosystems can be compared.

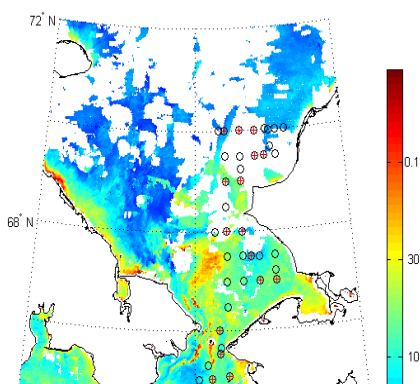


Figure 3: A satellite image of the region we studied in the Chukchi and Bering Seas in 2007. The Bering Strait is located in the center of this map. We conducted over 50 stations east of Russia in U.S. or international waters (circles). Colors indicate the abundance of phytoplankton as determined by satellite (red = high abundance, blue = low). White areas over ocean regions indicate clouds. The strong spatial variability in this single satellite image illustrates the complex optical and ecological nature of Arctic coastal waters.



Figure 2: Sam Laney holding a profiling radiometer package. This instrument descends through the water column, recording the amount and color of light entering and leaving the ocean. This information is then used to determine the “color” of the ocean that an orbiting satellite might see.

Our field work and these findings, both supported by the Clark Arctic Research Initiative award, have led to a larger outside grant from NASA to continue our optical and ecological assessments of satellite ocean color in the coastal Bering and Chukchi Seas. This NASA-sponsored research could not have been funded without leveraging the work we were able to complete with Clark Arctic Research Initiative support.

Our initial ocean color study has now grown into a much larger, externally funded research program that focuses not only in the Arctic but now on complementary regions in the Antarctic as well. Our ongoing efforts include improving the optical and automated approaches for assessing Arctic phytoplankton that we developed under our Clark Arctic Research Initiative award. We are currently in the process of training WHOI research technicians in these methods, so that they can be more widely used on cruises-of-opportunity that arise in other regions of the coastal Arctic. We are exceedingly grateful to the donors of the Clark Arctic Research Initiative for providing the support to make this research possible.

