Marginal Ice Zone: Biogeochemical Sampling with Gliders

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LONG-TERM GOALS

The long-term goal is to understand the feedback between ice melt and phytoplankton optical properties under Arctic ice. The project specific goals are to build collaboration with Arctic biogeochemists at KOPRI, to develop biogeochemical and optical proxies for glider optics, to use the proxies to project ship biogeochemical and optical measurements from the ship to the larger spatial scales sampled by the gliders, and to estimate the contribution of phytoplankton to heating in the water column under the ice.

OBJECTIVES

The scientific objectives are to:

1. Calibrate the biogeochemical sensors on the MIZ (Marginal Ice Zone DRI) Seagliders with from shipboard measurements taken on the *R/V Araon* and develop optical proxies for phytoplankton concentration, pigment spectral absorption coefficient, mean phytoplankton size, and particulate organic carbon.
2. Characterize the development and spatial extent of blooms of phytoplankton under full ice cover, in the MIZ, and in open ice-free water through analysis of calibrated glider data and other shipboard data.

3. Determine how upper ocean vertical structure and turbulent mixing rates affect development of blooms in the MIZ and open ice-free water, and the role of entrainment of nutrient rich waters into the euphotic zone in supporting these blooms.
4. Evaluate the potential role of phytoplankton pigment absorption on the vertical gradient of heating under the ice and apply a light and chlorophyll primary productivity model to estimate and compare phytoplankton productivity under full ice cover, in the MIZ, and in open ice-free water.

APPROACH

This work relies on autonomous measurements collected by Seagliders deployed Dr. Craig Lee and colleagues as part of the Marginal Ice Zone DRI (MIZ) and on shipboard sampling to be carried out by the PI from the Korean ice breaker, the *R/V Araon*, during its transit across the Arctic. A minimum of one berth has been committed to biogeochemical measurements. The data will be analyzed by Perry and Cetinic (UMaine) in collaboration with Dr. Craig Lee of the University of Washington and Korean scientist Dr. EunJin Yang and her colleagues from KOPRI.

Calibration of glider biogeochemical sensors and development of optical proxies

Protocols for calibrating glider sensors will be based on those developed during the 2008 North Atlantic bloom program, and will be modified for local conditions. The specific protocols for each sensor – backscatter and chlorophyll fluorescence – are described in sensor specific calibration reports available at the BCO DMO website <http://osprey.bcodmo.org/dataset.cfm?id=13820&flag=view>. The general protocol entails putting an individual glider into a shallow pre-calibration dive sequence, bringing the ship to the projected surfacing site, and navigating to within 100 m of the surfaced glider. A ship CTD profile is made simultaneously with a glider dive. Sensor data from the ship's CTD downcast is interpolated in density coordinate space to align with the glider profile. Water samples for chlorophyll concentration, HPLC pigments, particulate and phytoplankton absorption coefficients, and particulate organic carbon are taken on the CTD upcast. The ship's downcast optical data is paired with upcast water samples, again using density to align measurements.

Characterization of phytoplankton blooms under the ice, in the MIZ and open water

The repeat occupation of Seaglider survey lines will allow us to characterize the distribution of phytoplankton and the development of blooms under full ice cover, in the MIZ, and in open ice-free water. Glider measurements of spectral irradiance and turbulent dissipation rates will help in understanding the controlling mechanisms of phytoplankton abundance in the various regimes. Irradiance under the ice primarily depends on ice thickness and presence of melt ponds and leads, and hence will be expected to vary spatially. The variable nature of light transmission under the ice may give rise to patchy blooms. In the Chukchi Sea continental shelf, Arrigo et al. (2012) observed the presence of large phytoplankton blooms under the ice, which they attributed to higher light transmission through the relatively thinner (0.5 – 1.8 m) one-year ice. However, their measurements under the ice were sufficiently sparse to prevent them from assessing spatial patchiness. We will be able to determine patchiness of phytoplankton and particulate organic carbon concentrations on the ~ 4 – 5 km scale from the repeat surveys.

WORK COMPLETED

The project was funded in August 2013. The only work conducted to date has been planning discussions with other MIZ scientists and Dr. Yang at KOPRI.

RESULTS

The project was funded in August 2013 and no results are available at this time.

IMPACT/APPLICATIONS

The results of this project will provide improved knowledge of the distribution, magnitude and productivity of phytoplankton under the ice, in the MIZ, and in open water through collection of data with well calibrated and validated autonomous sensors. These data will also provide an estimate of the contribution of under-ice phytoplankton to localized vertical heating, with potential amplification of melting from below the ice. A new collaboration with Korean scientists at KOPRI will enhance the potential use of the icebreaker *R/V Araon* for future ONR Arctic studies.

RELATED PROJECTS

This project is a component of the Marginal Ice Zone DRI (MIZ) and is most closely aligned with the project entitled *Evolution of the Marginal Ice Zone: Adaptive Sampling with Autonomous Gliders*, PIs C. Lee, L. Rainville, and J. Gobat. http://www.apl.washington.edu/project/project.php?id=miz . This work will also rely on collaboration with with Korean scientists at KOPRI and with other DRI team members collecting irradiance measurements and measuring entrainment of deeper (nutrient rich) water into the euphotic zone.

REFERENCES

Arrigo, K. R., and thirty others, 2012. Massive phytoplankton blooms under Arctic sea ice. Science 336: 1408. doi: 10.1126/science.1215065.