Role of the in water light field and water column structure on phytoplankton composition in the eastern Bering Sea

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Motivation
Colored dissolved organic matter (CDOM) is an important optical constituent in Arctic and sub-Arctic waters that can regulate the underwater light field, impact phytoplankton species composition, the degree of pigment packaging, and the presence of the sub-surface chlorophyll maximum. CDOM absorption ($a_{CDOM}$) and spectral slope ($S_{CDOM}$) have potential to provide utility for assessing phytoplankton composition and distribution by better characterizing the underwater light field, depth of the euphotic zone and source, bioavailability and diagenetic state of CDOM as indicated by $S_{CDOM}$. Here we seek to understand the impact CDOM has on phytoplankton composition within the context of variable nutrient and physical water column structure.

Results

Figure 1. (a-c) Sea ice extent for spring 2008, with March 31 the date of maximum sea ice extent. (d) Station locations for HPLC pigment, CDOM and particulate absorption observations during July 2008 binned by days since sea ice retreat. Sea ice retreat date was determined as the last day with a sea ice concentration above 15%.

Figure 2. Mean absolute absorption budget at 443 nm for stations (a) 0-55 days since sea ice retreat, (b) 55-110 days since sea ice retreat, and (c) >110 days since sea ice retreat. Data derived from total and filtered optical profiles and discrete absorption measurements.

Figure 3. Mean absorption budget from 400-700 nm for stations 0-55 days since sea ice retreat, 55-110 days since sea ice retreat, and >110 days since sea ice retreat for surface (0-10m), mid-depth (11-30m), and deep (>30m) layers. Data derived from total and filtered optical profiles and discrete absorption measurements.

Figure 4. (a) Mean phytoplankton community composition based on CHEMTAX size classes of pico-, nano-, and microplankton (Goes et al. 2013) for days since sea ice retreat for surface (0-10m), mid-depth (11-30m), and deep (>30m) layers. The light to dark gradient represents pico-plankton (light), nanoplankton (medium), and microplankton (dark). (b) Plots of phytoplankton size class composition on concentric circles, with light, medium, and dark circles overlaid to represent pico-, nano-, and microplankton. Circles are plotted relative to their relationship between sigma t (x-axis) and $(i)$ nutrients, $(ii)$ $a_{CDOM}(350)$, and $(iii)$ $S_{CDOM} (y-axis)$ for surface (0-10m), mid-depth (11-30m), and deep (>30m) layers.

Conclusions
1. Pico-plankton maintain a baseline population across days since sea ice retreat and depths. Surface and deep layer phytoplankton composition does not change significantly due to time since sea ice retreat. Mid-depth phytoplankton composition is dominated by microplankton within 55 days of sea ice retreat, but microplankton dominance progressively decreases as time since sea ice retreat increases.

2. Surface waters observe an increase in relative phytoplankton absorption as time since sea ice retreat increases, mid-depths observe little change, and the deep layer observes a decrease in relative phytoplankton absorption as time since sea ice retreat increases.

Future Directions
Freshwater inputs to sub-Arctic and Arctic environments are changing in volume, timing and composition (Spencer et al. 2009). This, coupled with variable sea ice extent and duration, significantly impacts CDOM spatial patterns as a function of source and photodegradation (Stedmon et al. 2011). The underwater light field in the eastern Bering Sea has been characterized in recent years (Naik et al. 2013), and links to phytoplankton distribution, pigment packaging, and community composition are beginning to emerge (D’Sa et al. 2014). However, much is yet to be understood about the role of specific IDPs and the spectral quality of the underwater light field on phytoplankton community structuring.

Specific areas to address include:
- Understand the impact of $a_{CDOM}$ and $S_{CDOM}$ on simulated, in situ, and satellite radiometry
- Account for the large impact of CDOM on $R_0(i)$ to accurately and reliably retrieve phytoplankton cell size from sub-Arctic and Arctic waters
- Further ecological understanding of the distribution of phytoplankton functional types derived from satellite imagery as it relates to spatial changes in sea ice extent and duration

References