Influence of the Alaska Coastal Current on seasonal patterns of near-bottom chlorophyll fluorescence in the eastern Chukchi Sea

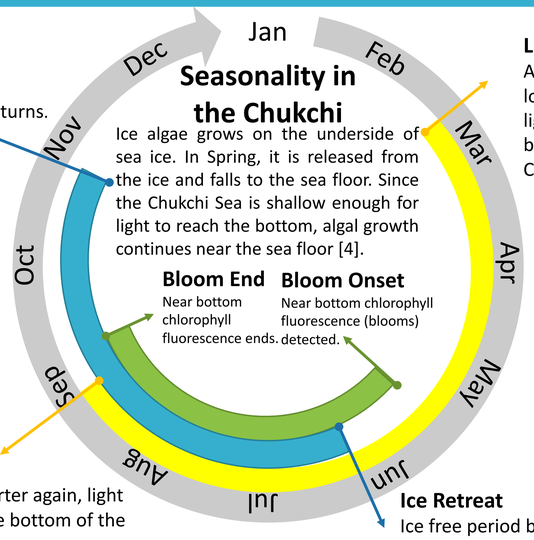
Yasamin Bayley[1,2], Dr. Mike Sigler[2], Dr. Phyllis Stabeno[3]

[1]Cornell University, [2]Shoals Marine Laboratory, [3]NOAA Pacific Marine Environmental Laboratory

PROBLEM

The Pacific Arctic waters are warming more quickly than the global ocean [2]. The Chukchi Sea is a largely benthic driven, ecosystem which is threatened by this warming which may lead to lack of sea ice [3]. In particular, near-bottom ice algae blooms may be threatened, thus so is the rest of the ecosystem.

BACKGROUND



Alaska Coastal Current (ACC)

- Important northward flowing water mass [5]
- Warmer than other flowing waters
- Lower salinity
- Lower nutrient [1]

Stabeno et al., 2020 [4]:

- Previous work on near bottom ice algae
- Data from moorings in the eastern Chukchi

We defined the moorings from Stabeno et al., 2020 (Fig. 1) as coastal and offshore, and compares seasonal events geographically:

- Coastal moorings = within ACC
- Offshore moorings = outside ACC

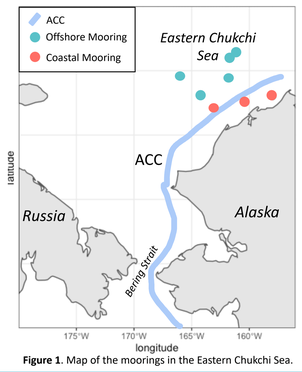


Figure 1. Map of the moorings in the Eastern Chukchi Sea.

METHODS

We used previously collected and analyzed mooring and satellite imagery data from 2010-2018 to compare **timing** of seasonal events: ice retreat and advance, bloom onset and end sufficient light onset (i.e. sufficient daylight) and end between coastal and offshore locations.

Moorings: 8 moorings were deployed and collected data on temperature, currents, salinity, chlorophyll fluorescence, nitrate and PAR (light intensity) from 2010 to 2018.

Sea ice: AMSR data was used. Ice coverage was determined (in percent) by the areal coverage in a 50km x 50 km box around each mooring.

Time Series Analysis: Limits were set for all the seasonal events:

- Ice retreat and advance day = ice cover passed 15% for the first and last time that year.
- Near surface bloom onset and end = chlorophyll concentration passed 1 ug l^{-1}.
- PAR onset and end = PAR value crossed 0.1uE m^{-2} s^{-1}.

Defining moorings within or outside ACC: Distance from the coast and spatial GAM's were used to define the moorings as either in or out of the ACC.

Statistical Analysis: The statistical significance of values for the variables in and out of the ACC was determined using Student's t-tests. ANOVA tests were performed to account for year and year-ACC interactions.

RESULTS

How do near-bottom seasonal bloom dynamics differ between coastal and offshore mooring locations?

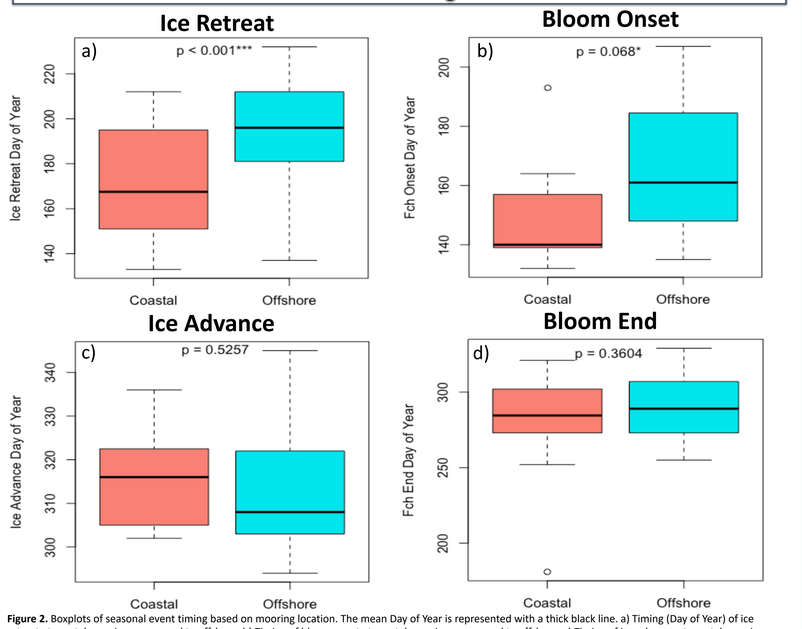


Figure 2. Boxplots of seasonal event timing based on mooring location. The mean Day of Year is represented with a thick black line. a) Timing (Day of Year) of ice retreat at coastal moorings compared to offshore. b) Timing of bloom onset at coastal moorings compared to offshore. c) Timing of ice advance at coastal moorings compared to offshore. d) the timing of bloom end at coastal moorings compared to offshore.

- Nearly significant earlier near-bottom bloom onset at coastal moorings (Fig. 2b), no significant difference in bloom end (Fig. 2d) → **longer bloom duration within ACC.**
- Significant earlier ice retreat at coastal moorings (Fig. 2a), no change in ice advance (Fig. 2c) → **longer ice free period within the ACC.**

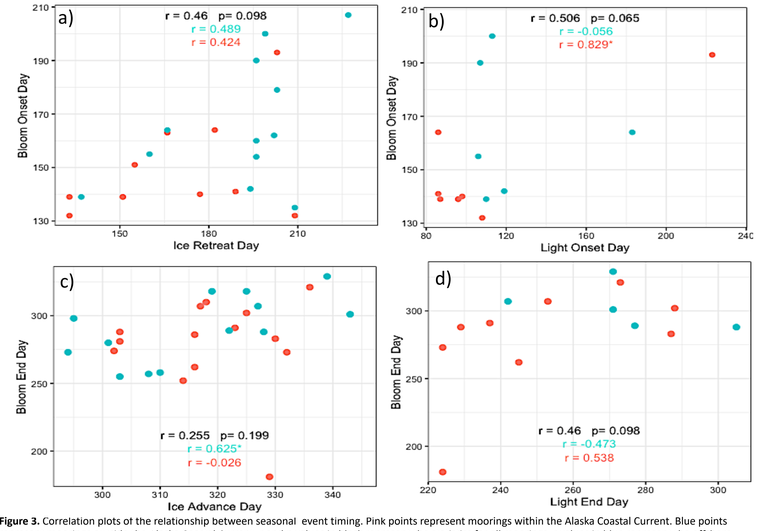


Figure 3. Correlation plots of the relationship between seasonal event timing. Pink points represent moorings within the Alaska Coastal Current. Blue points represent moorings outside the Alaska Coastal Current. r and p values in black represent the statistics for all moorings, r values in blue represent the offshore moorings, and r values in pink represent coastal moorings. a) the relationship between bloom onset and ice out retreat day of year. b) the relationship between bloom onset and light onset day of year. c) the relationship between bloom end and ice advance day of year. d) the relationship between bloom end and light end day of year.

- Timing of near-bottom algal blooms is highly correlated with timing of ice retreat, regardless of coastal/offshore location.
- Bloom onset in coastal locations is correlated with light onset.
- Light end correlated with near-bottom bloom end in both coastal/offshore locations.

DISCUSSION

Bloom Duration

- Coastal bloom onset ~20 days earlier than offshore
- Coastal ice retreat ~30 days earlier than offshore

Longer bloom duration within the ACC due to earlier ice retreat within the ACC.

Bloom and Light Relationship

Bloom onset is correlated with light onset when all moorings are considered, r = 0.506, but much more correlated for coastal locations, r = 0.829 (Fig. 3b). Why?

Earlier ice retreat → Earlier bloom onset → Blooms occur closer to light onset

Therefore, near-bottom coastal blooms are closer to upper limit of growing season.

Nutrient Availability

ACC has lower nutrients than other Chukchi Shelf Waters, but a longer growing season.

- Generally, an abundance of nutrients will lead to increased primary production.
- Within the ACC, can a longer ice algal growing season outweigh lower nutrients and have more primary production than offshore waters?

ACC or Wind?

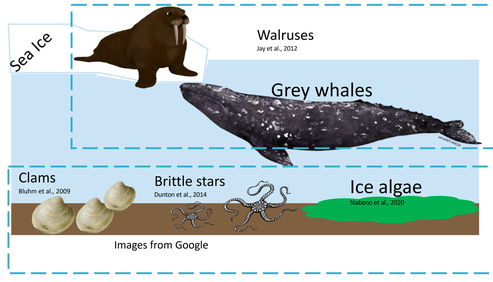
Environmental factors other than the ACC near the coast may impact ice cover, wind:

- Wind polynyas are persistent open water areas surrounded by sea ice
- Wind drives ice towards headlands or islands leaving open areas of water

We did not test for wind effect in this study but are currently investigating wind at mooring locations.

IMPLICATIONS

Cascading Effect:
→Rise in temperature
→Loss of sea ice
→Changes in ice algal bloom dynamics
→Changes for benthic organisms and feeders



Images from Google

Benthic Feeders

Walruses and grey whales feed on benthic organisms. Changes in ice algae at the benthos may impact these organisms.

Benthic organisms

Clams and brittle stars depend on lower trophic organisms such as ice algae.

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