Phytoplankton and Zooplankton

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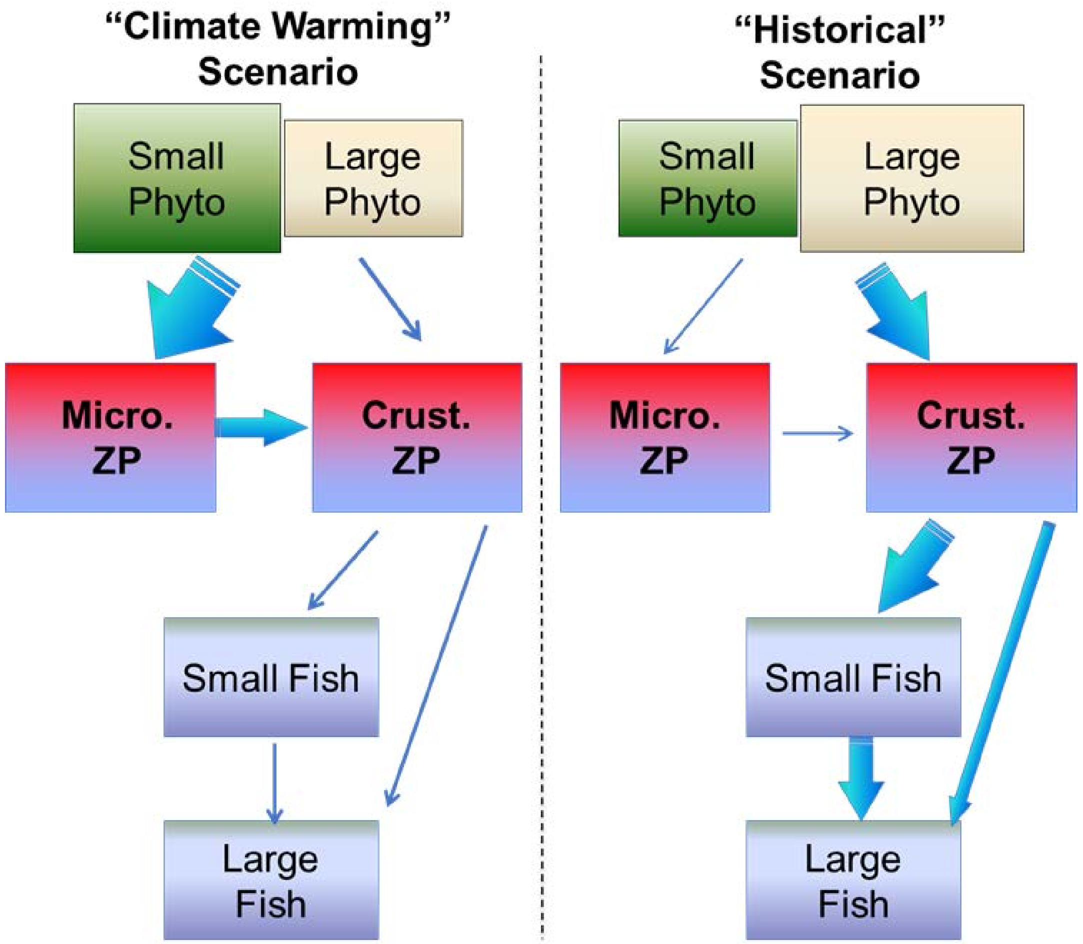
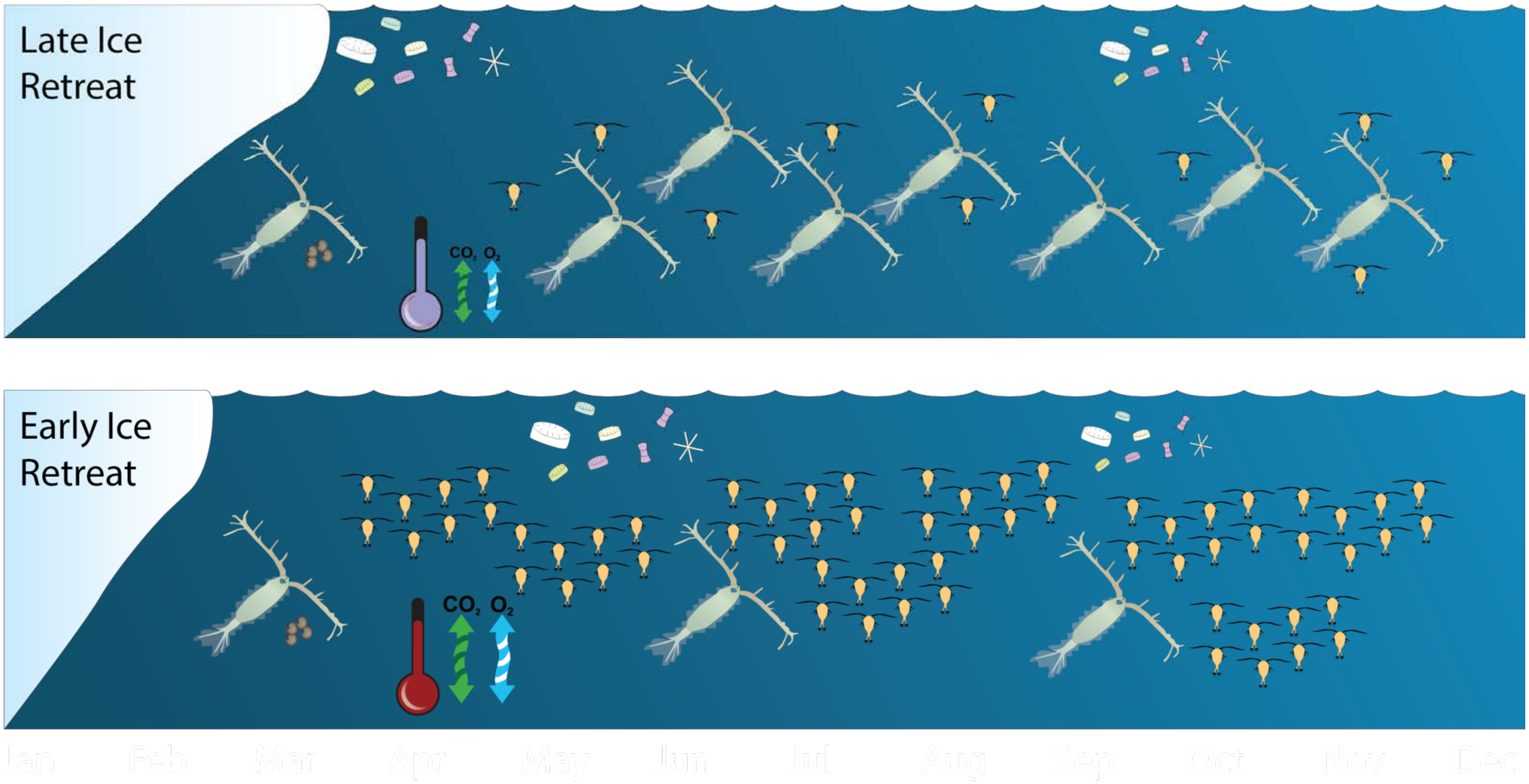
Potential climate-driven changes in ecosystems



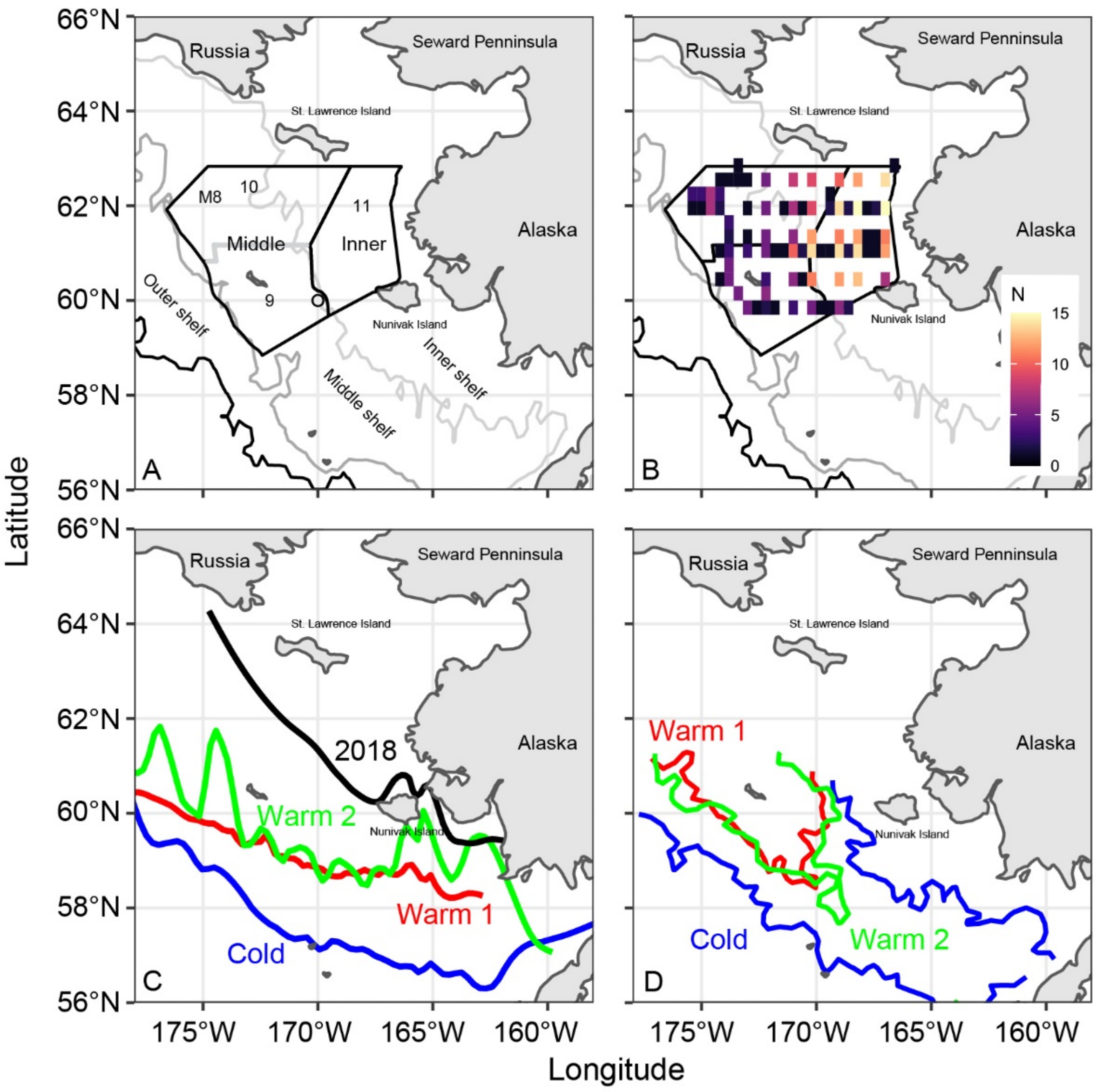
Schematic of the hypothesized changes in phytoplankton size structure and impact on flow of carbon and energy to different size classes of zooplankton, small microzooplankton (Micro. ZP) and large crustacean zooplankton (Crust. ZP), and ultimately fish under climate warming and historical scenarios

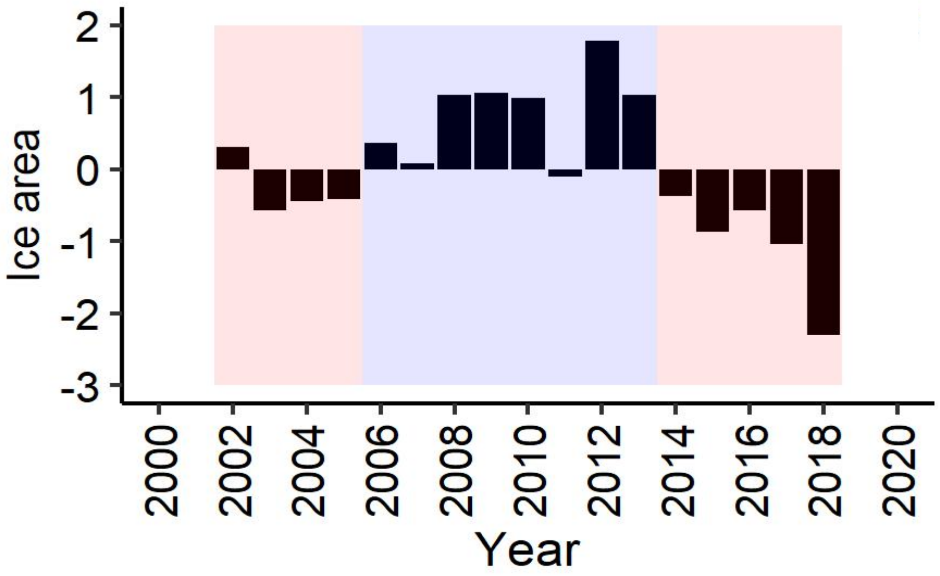
Conceptual model: southeastern Bering Sea

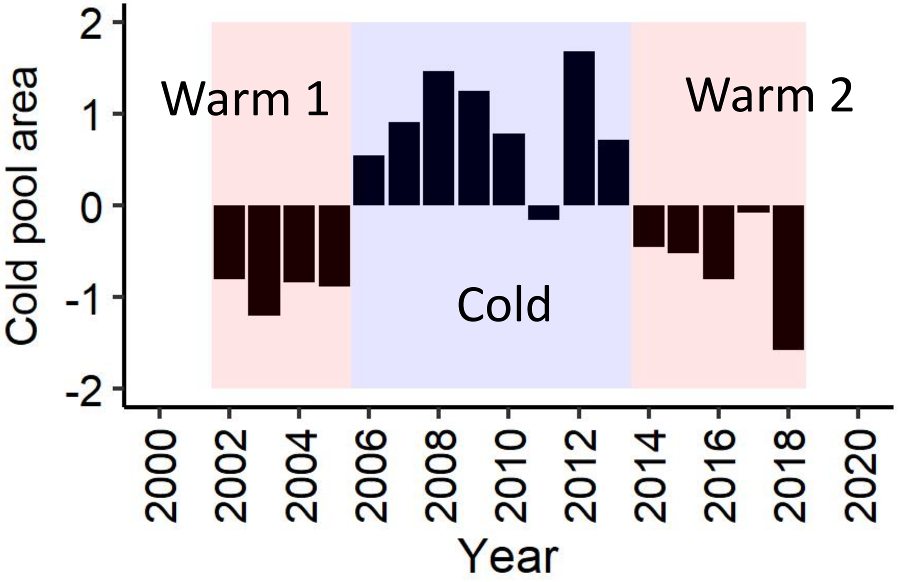


Hunt et al. 2002; Hunt et al. 2011; Sigler et al. 2016

Ice area and cold pool extent



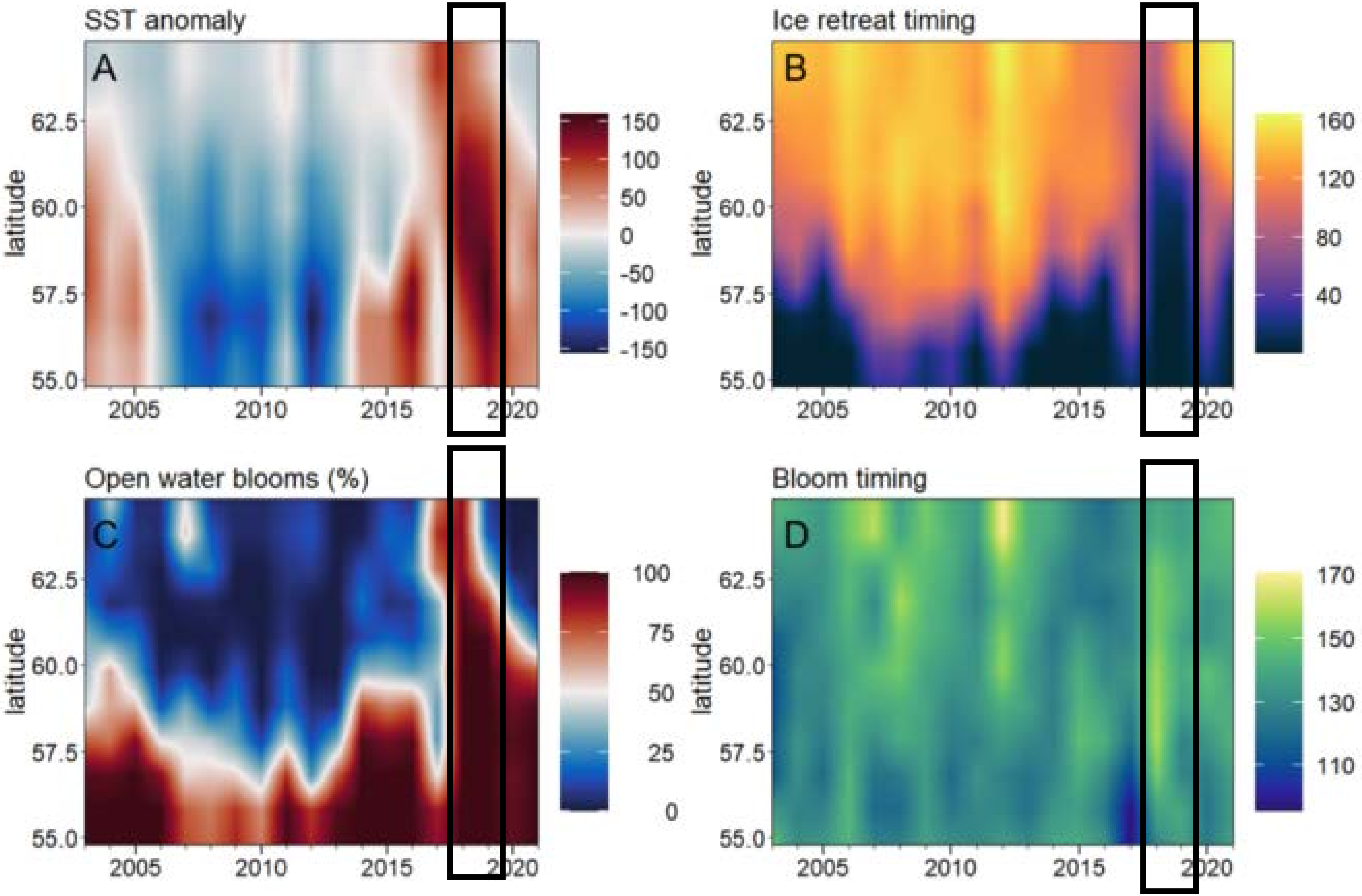




Kimmel et al. 2023

Phytoplankton response to warming

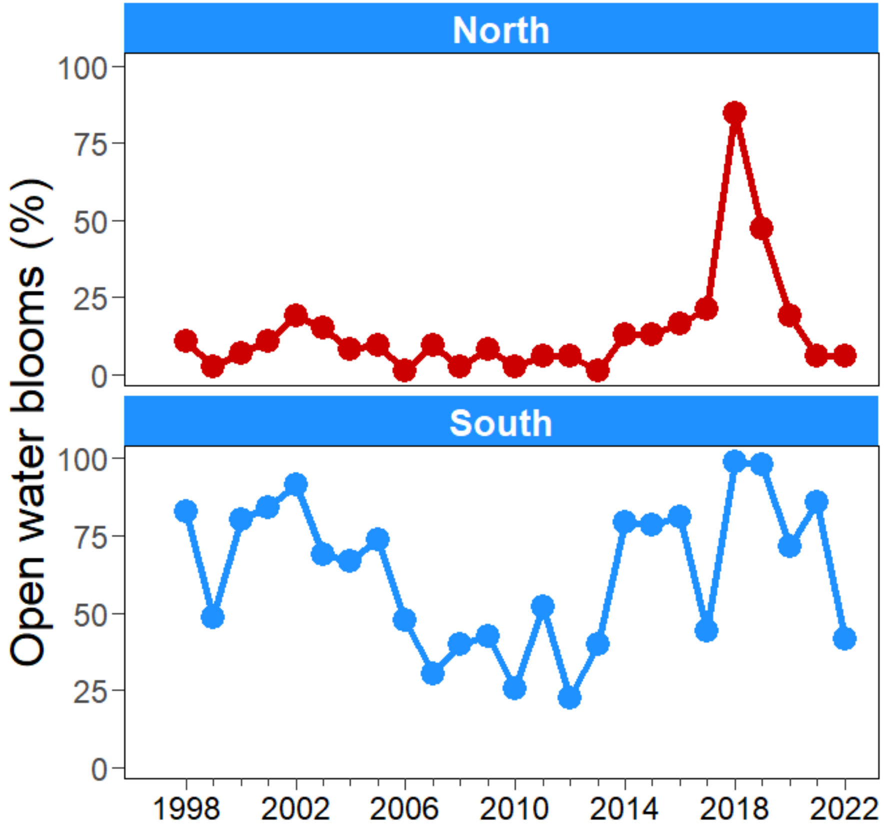
Hovmuller diagrams (year-latitude): data averaged across the middle and outer shelves



Nielsen et al. in prep

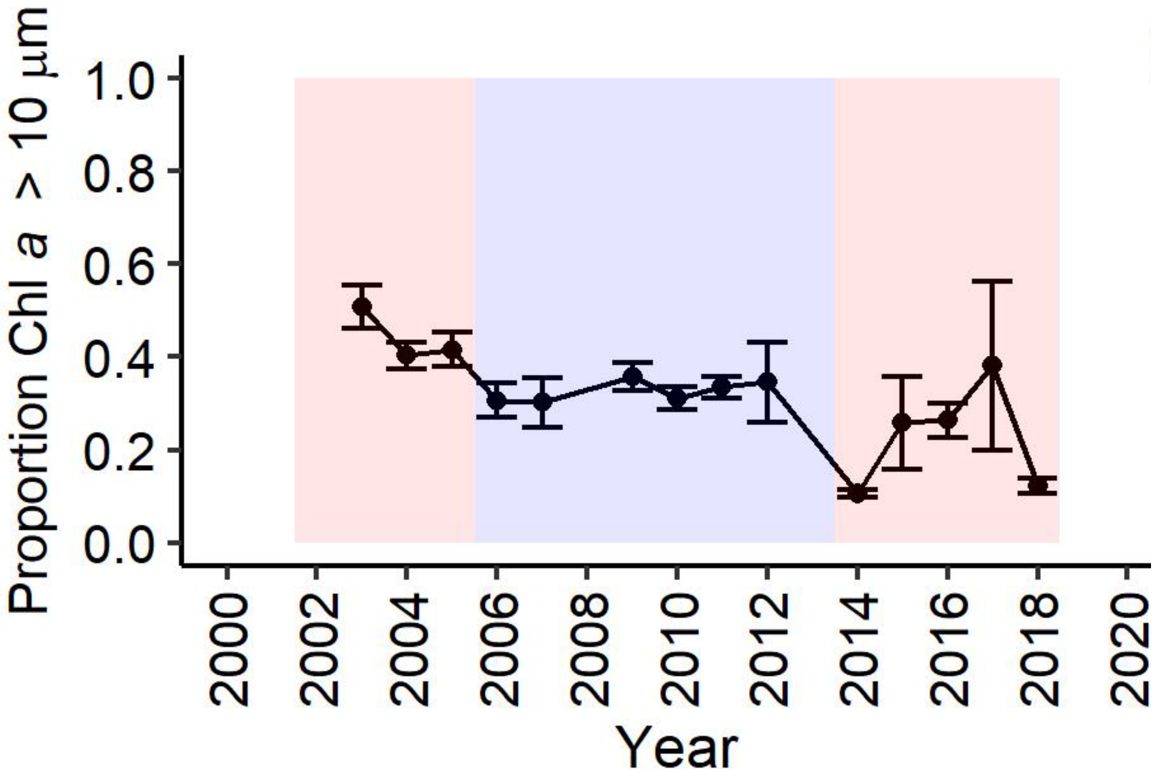
Phytoplankton response to warming

Percent of area with open water spring blooms in North (> 60°N) and South (< 60°N) Bering Shelf



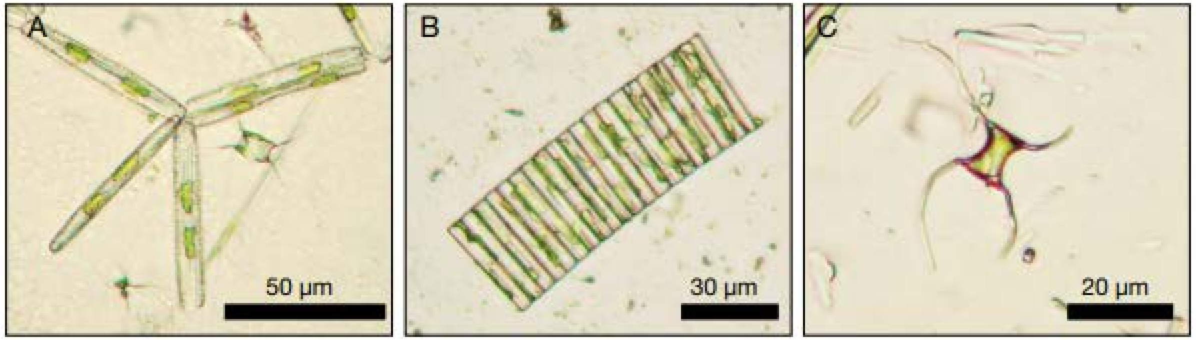
Nielsen et al. in prep

Late summer chlorophyll *a* on the NBS middle shelf

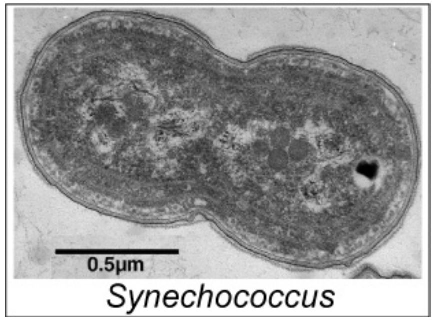


Kimmel et al. 2023

Phytoplankton community change – NBS/Chukchi Sea



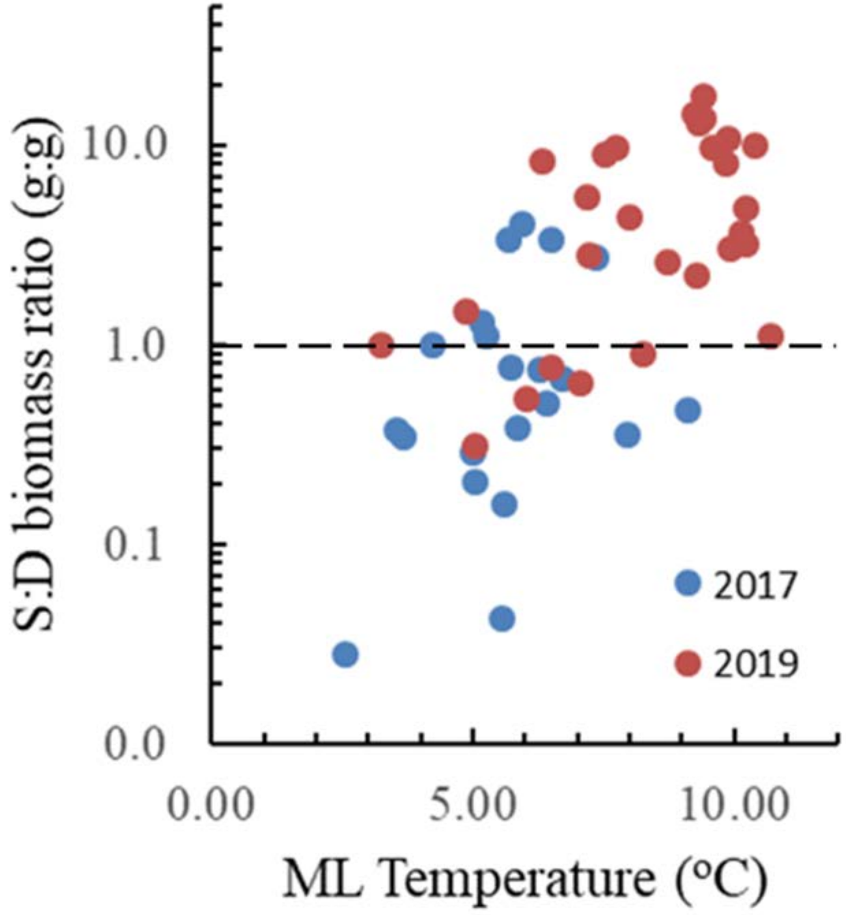
Diatoms



Synechococcus
1/100 the size of
many diatoms

- In the '***warm***' summer of 2017, diatom biomass exceeded *Synechococcus* biomass
- By the ***really warm*** summer of 2019, *Synechococcus* biomass exceeded diatom biomass

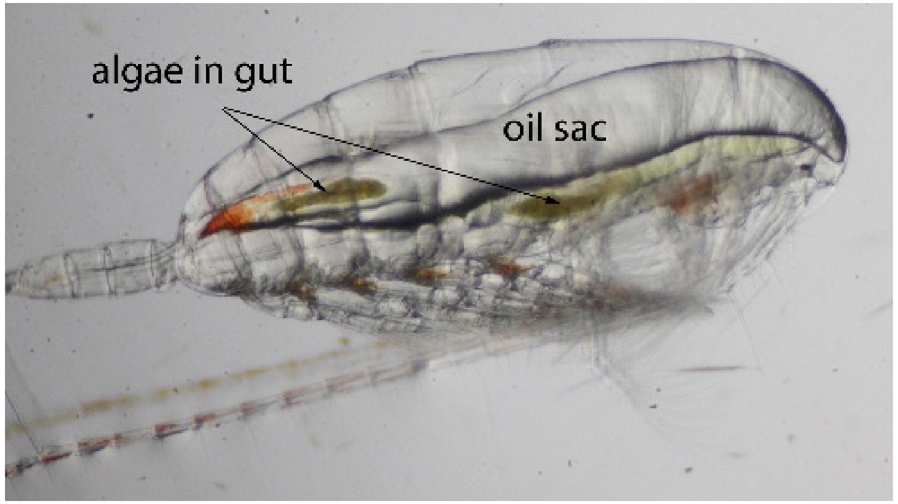
Synechococcus **to diatom biomass ratio (S:D) and mixed layer (ML) temperature**



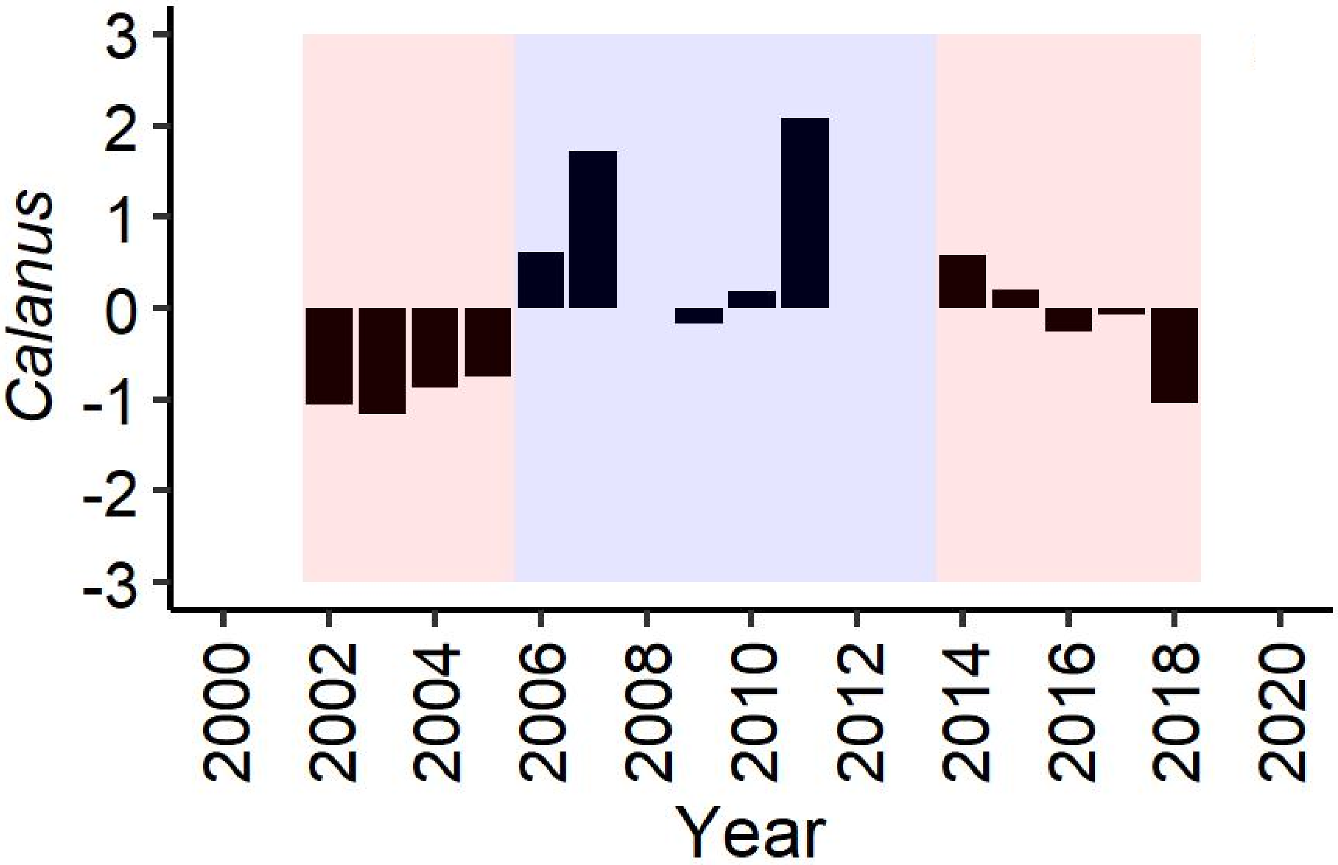
Porgorzelec et al. 2017. MEPS. 569: 77-88 (top photo); https://www.whoi.edu/science/b/people/ewebb/syne.html (bottom photo)

Lomas et al. in prep

Zooplankton: *Calanus glacialis*



Middle shelf in late summer



Tarrant (photo)

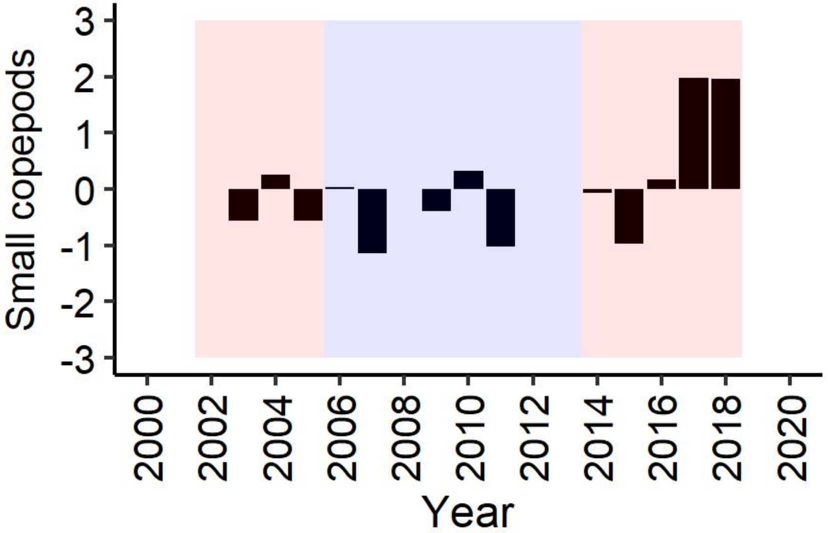
Kimmel et al. 2023

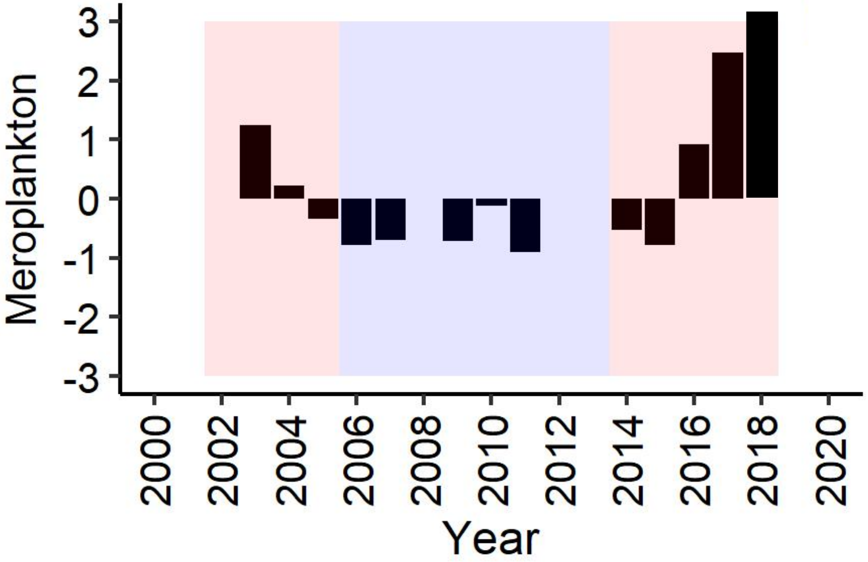
Zooplankton: small copepods and meroplankton

https://oceanexplorer.noaa.gov/explorations/18ccz/logs/may27/may27.html

https://www.theguardian.com/environment/2021/mar/09/tiny-copepod-unsung-climate-hero

Middle shelf in late summer





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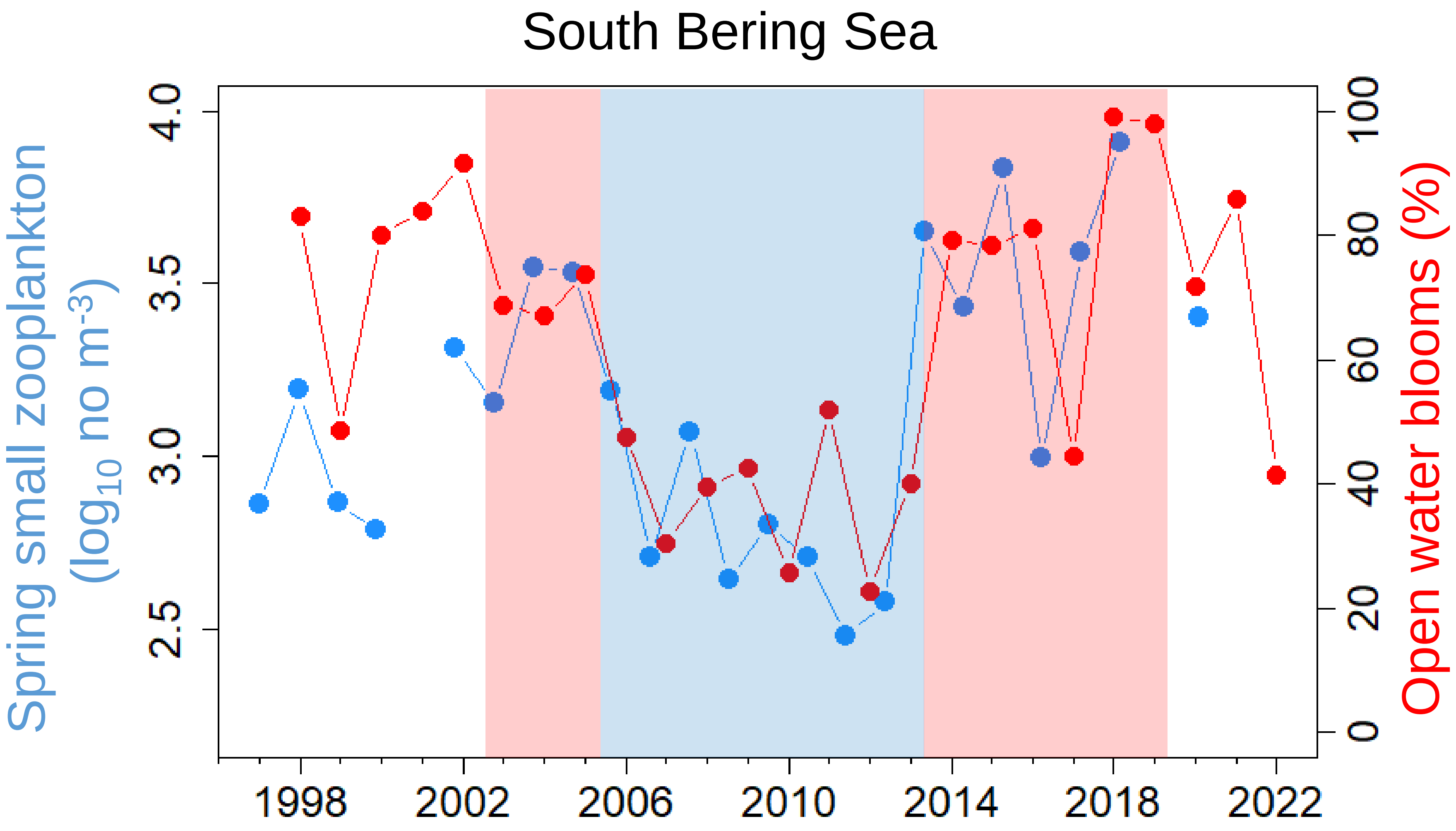
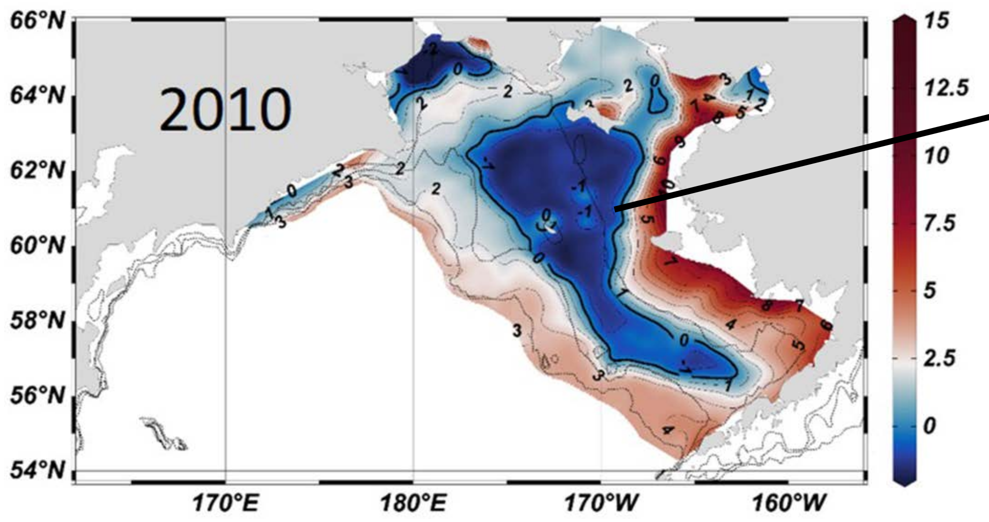
Small copepods and open water blooms

Will this pattern occur in a warming northern Bering Sea?

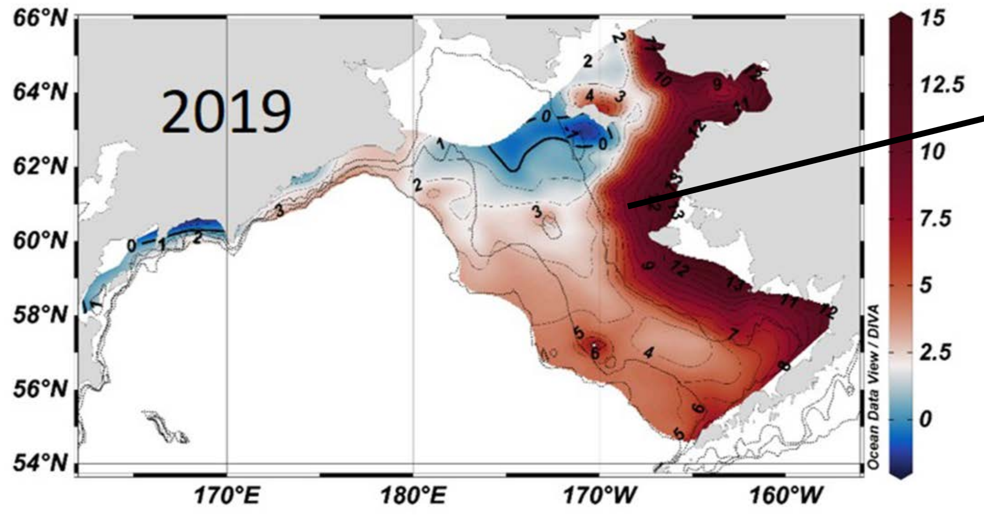


What happened? – a working hypothesis

Summer bottom temperature (°C)



- Cold: ice and late retreat creates cold pool. Neritic zooplankton community restricted in scope, little time to accumulate abundance



- Warm 2: little ice and early retreat eliminates cold pool. Neritic community spreads onto middle shelf, ample time to accumulate abundance with favorable temperatures for small, fast reproducing species

Eisner et al. 2020

Lower trophic level summary

- **Ice cover and cold pool extent show strong relationships with phytoplankton and zooplankton community structure**
- **We hypothesize reduced ice and cold pool extent will result in:**
  - As ice edge moves northward, ice edge bloom will move with it and the number of open water blooms will increase
  - Bloom timing may become decoupled from ice retreat timing in warmer years
  - The effect on phytoplankton biomass and total productivity remains an open question
  - The summer plankton community will consist of smaller phytoplankton cells and smaller zooplankton taxa leading to less efficient energy transfer to fish and reduced flux to benthos
  - The role of *Calanus* in the ecosystem will change, it may no longer accumulate in large numbers on the SE shelf in the absence of the cold pool

HAB:
Alexandrium

Data gap: Phytoplankton species info over the growing season (spring-fall)

Data gap – euphausiid abundance

- Difficult to sample
  - Wide size range
  - Net avoidance
  - Strong diel vertical migrators
- Abundance and biomass estimates vary widely depending on method used
- YOY pollock diets shift from *Calanus* in cold years to euphausiids in warm years

Estimates of mean euphausiid biomass (g C m^{-2}) in the middle shelf from different sources in 2008-2010 (Hunt et al. 2016)

Year	Net	NPZ model	Acoustic
2008	0.49	1.77	23.19
2009	0.26	1.83	34.41
2010	0.42		36.53