Formation and Persistence of Benthic Biological Hotspots in the Pacific Arctic

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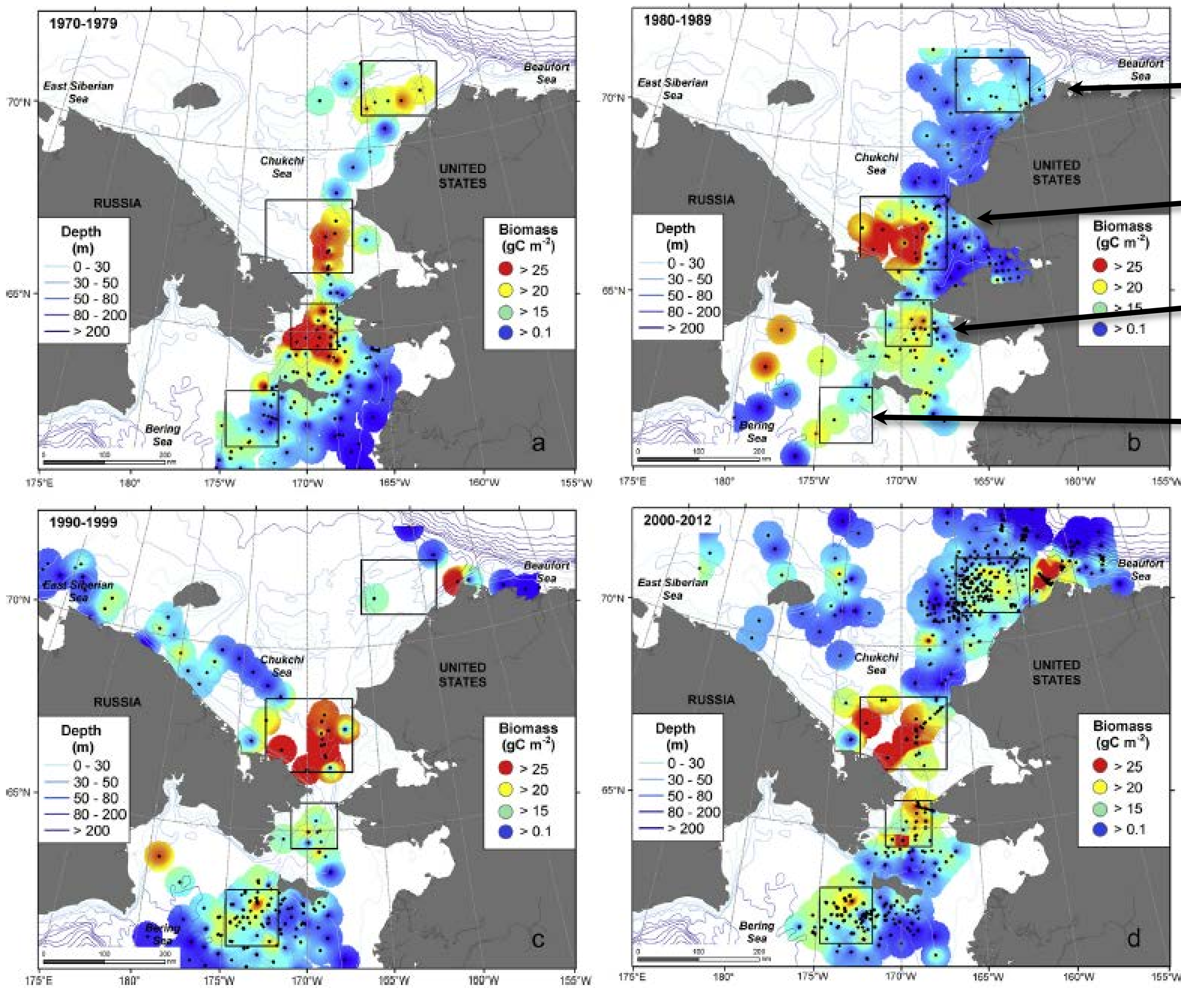
Benthic biological hotspots have been observed in the shallow northern Bering and Chukchi continental shelves for more than four decades.



NE Chuchi Sea (NECS)

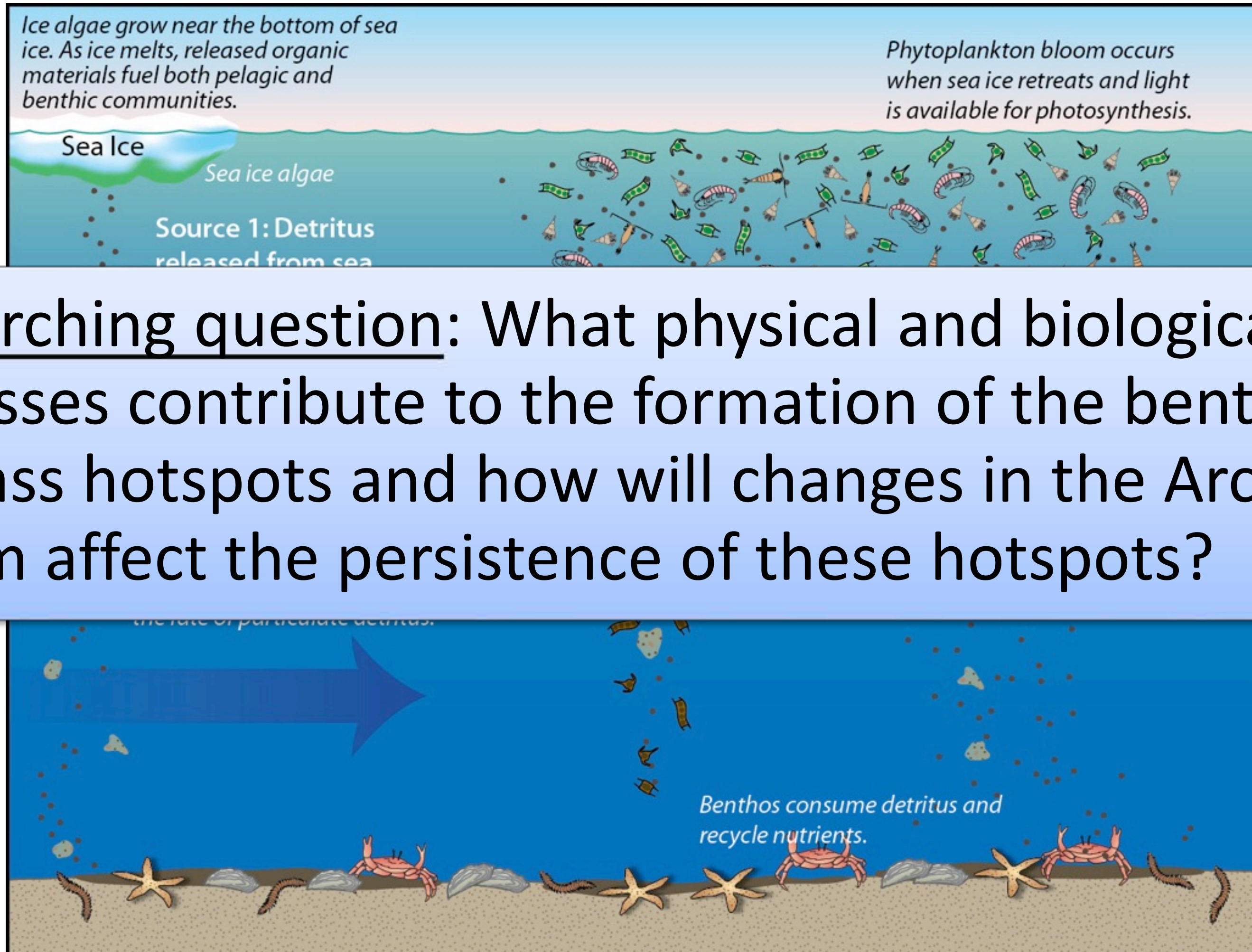
SE Chuchi Sea

Chirikov Basin

St. Lawrence Island Polynya (SLIP)

Grebmeier et al. 2015 Prog. Oceanogr.

Our study explores the sympagic-pelagic-benthic coupling and delivery of organic carbon to the benthos under the changing environmental conditions (export vs. retention).



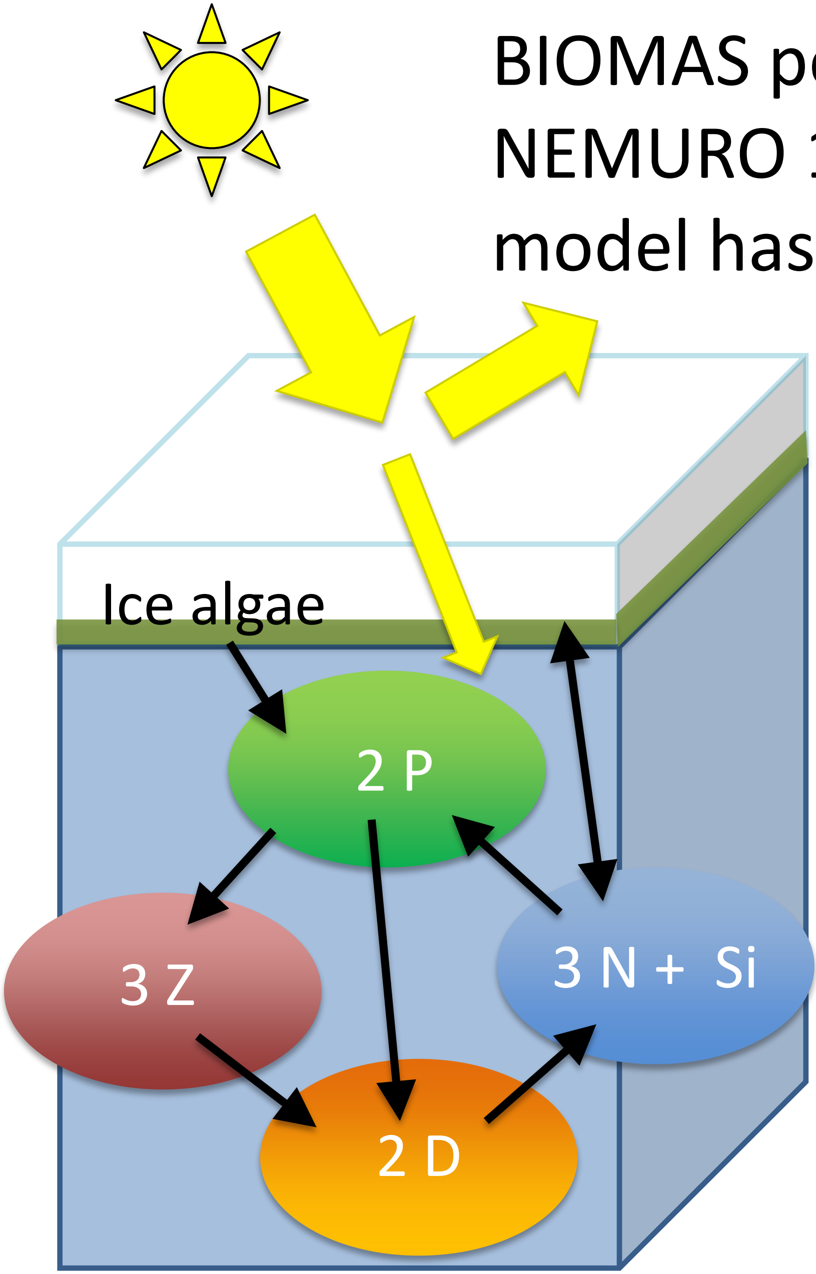
<u>Overarching question</u>: What physical and biological processes contribute to the formation of the benthic biomass hotspots and how will changes in the Arctic system affect the persistence of these hotspots?

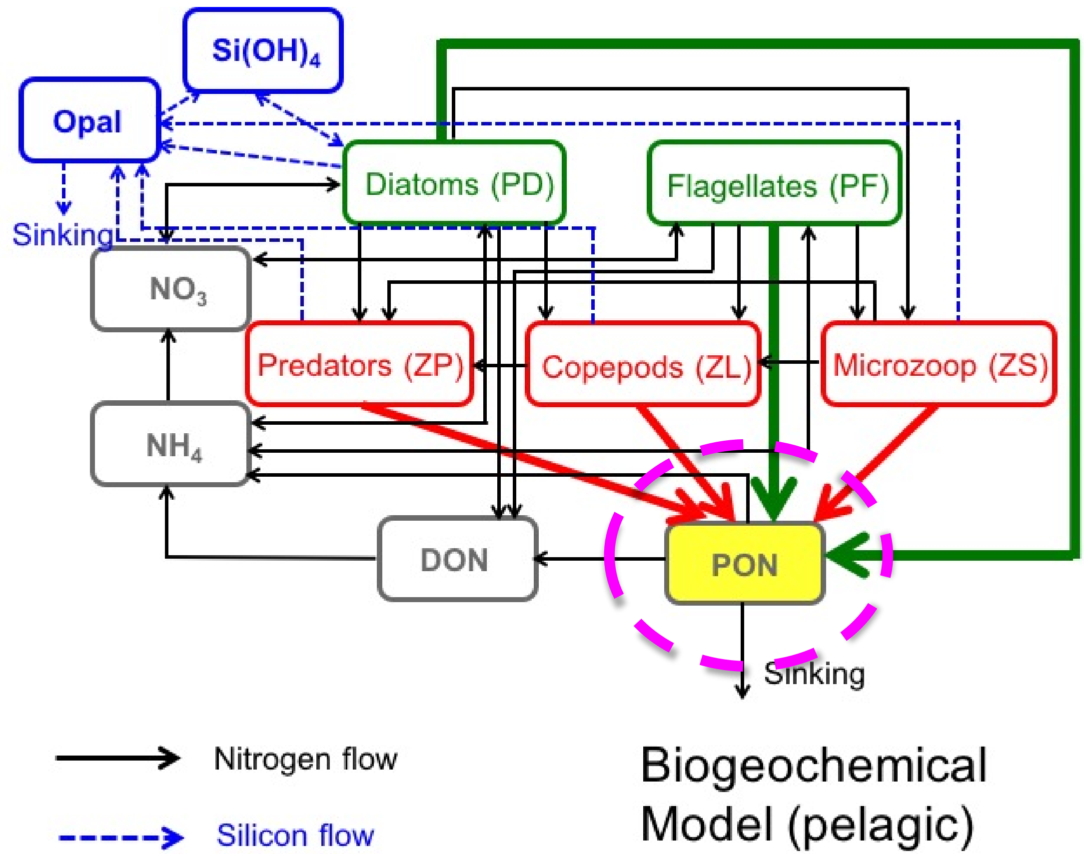
Courtesy of Jack Cook (WHOI Graphics)

Two Approaches

- Diagnosing physical-biological model output to identify causes of hotspot formation
- Particle tracking using physical model and particle sinking rates to identify sources of OM at hotspots

BIOMAS pelagic ecosystem model: NEMURO 11-component lower trophic level model has been adapted to the Arctic Ocean

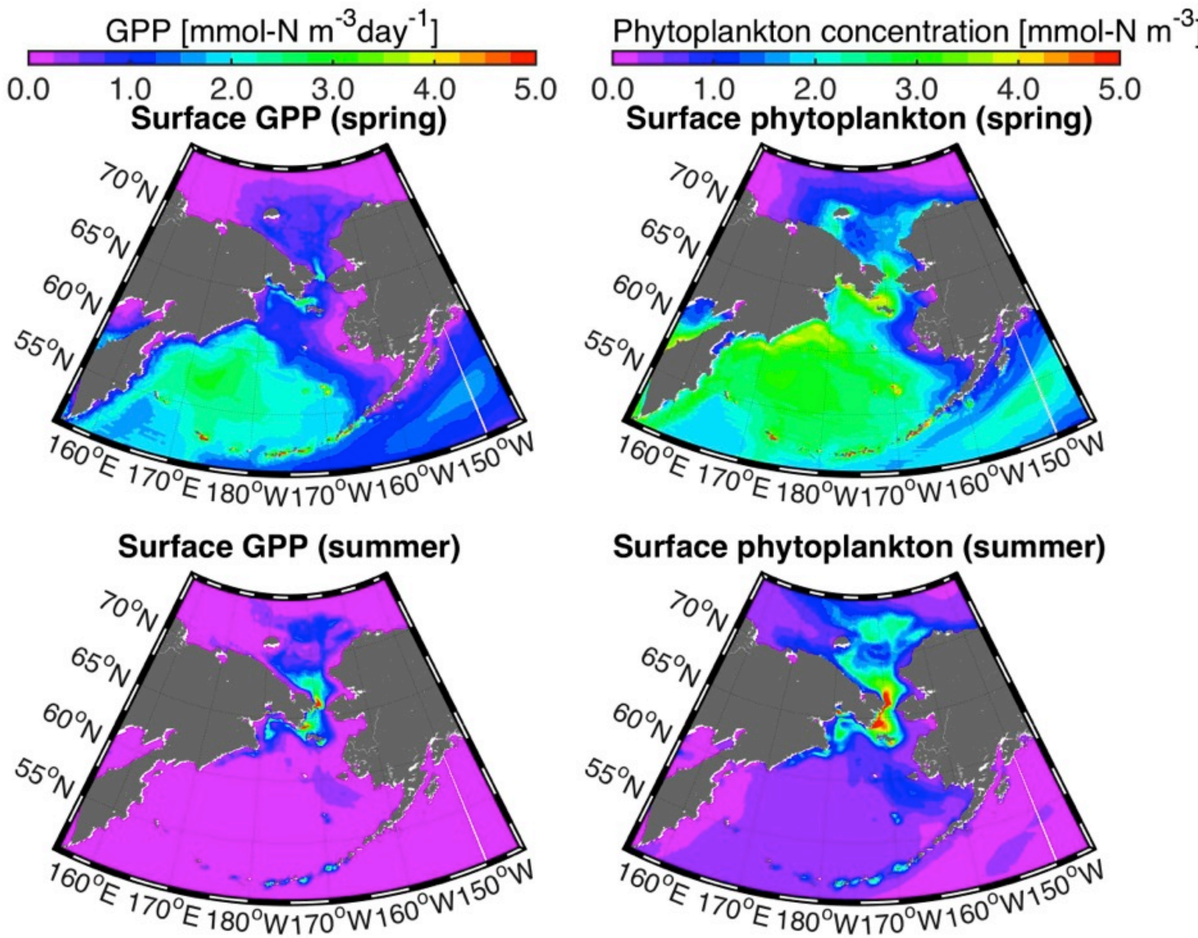




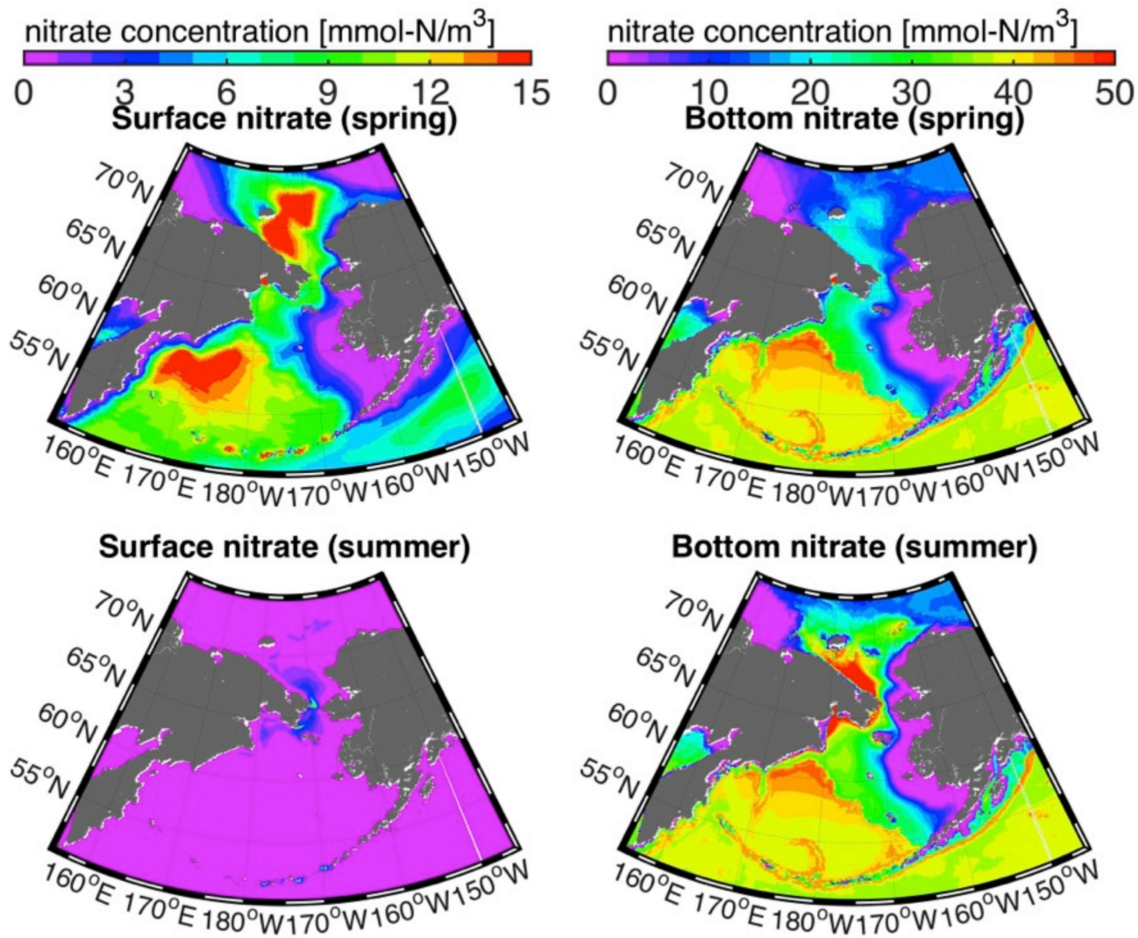
Biogeochemical Model (pelagic)

Kishi et al. 2007; Zhang et al. 2010; 2015

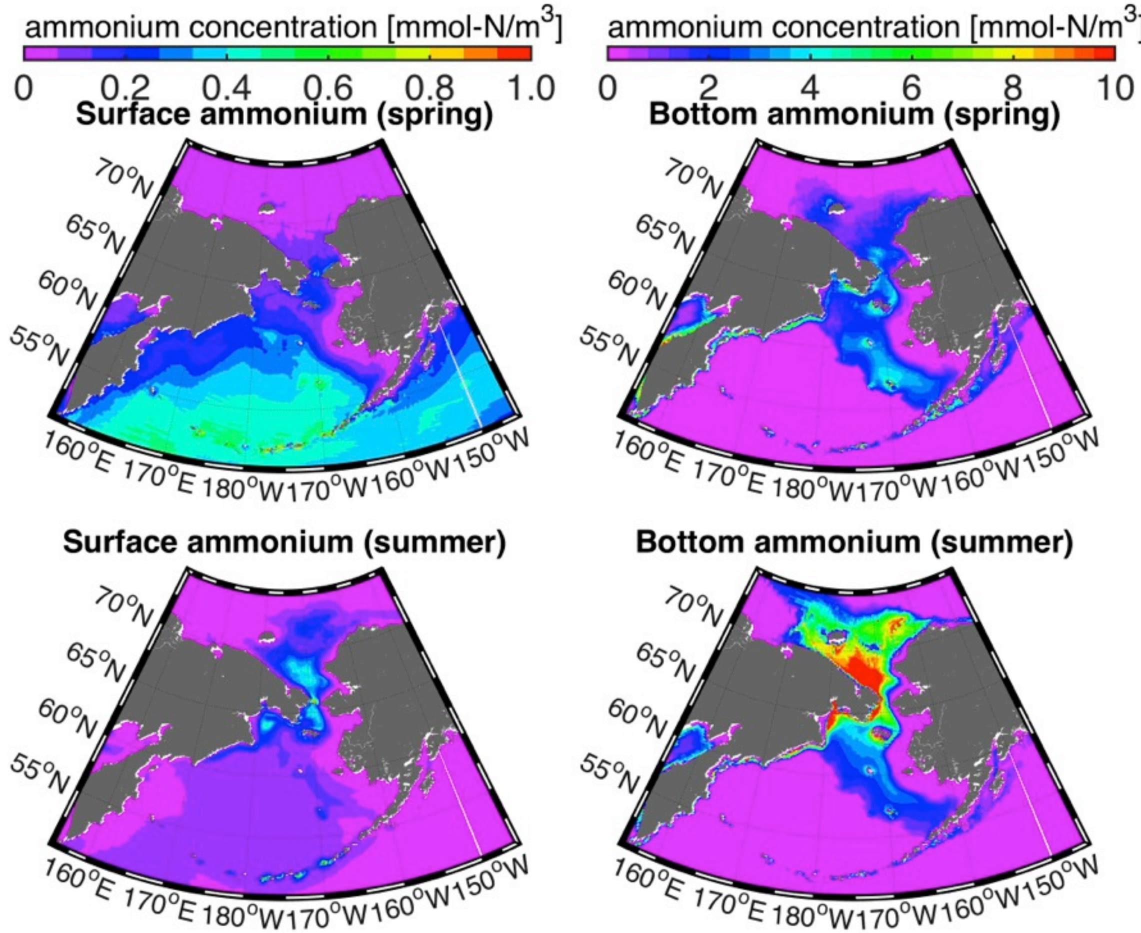
Gross primary production and phytoplankton standing stock



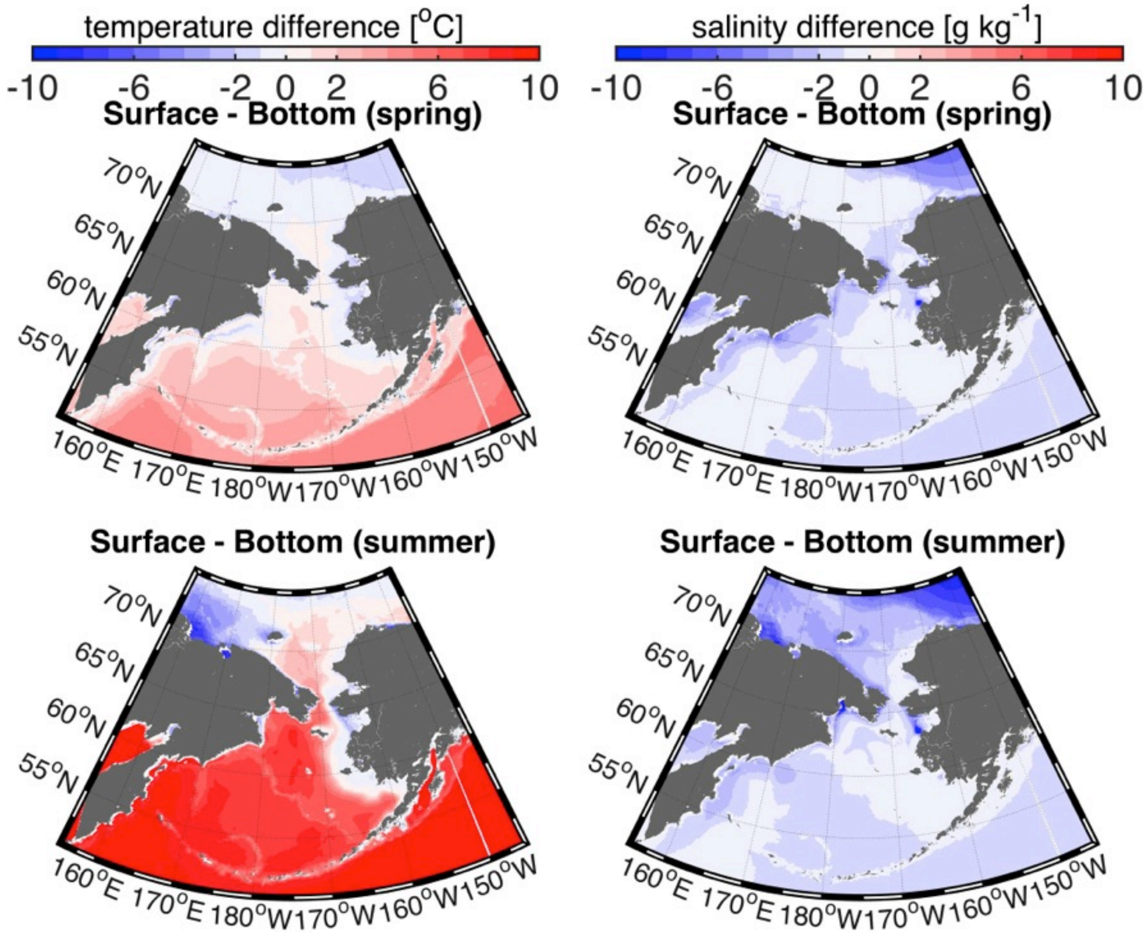
BIOMAS-simulated nitrate



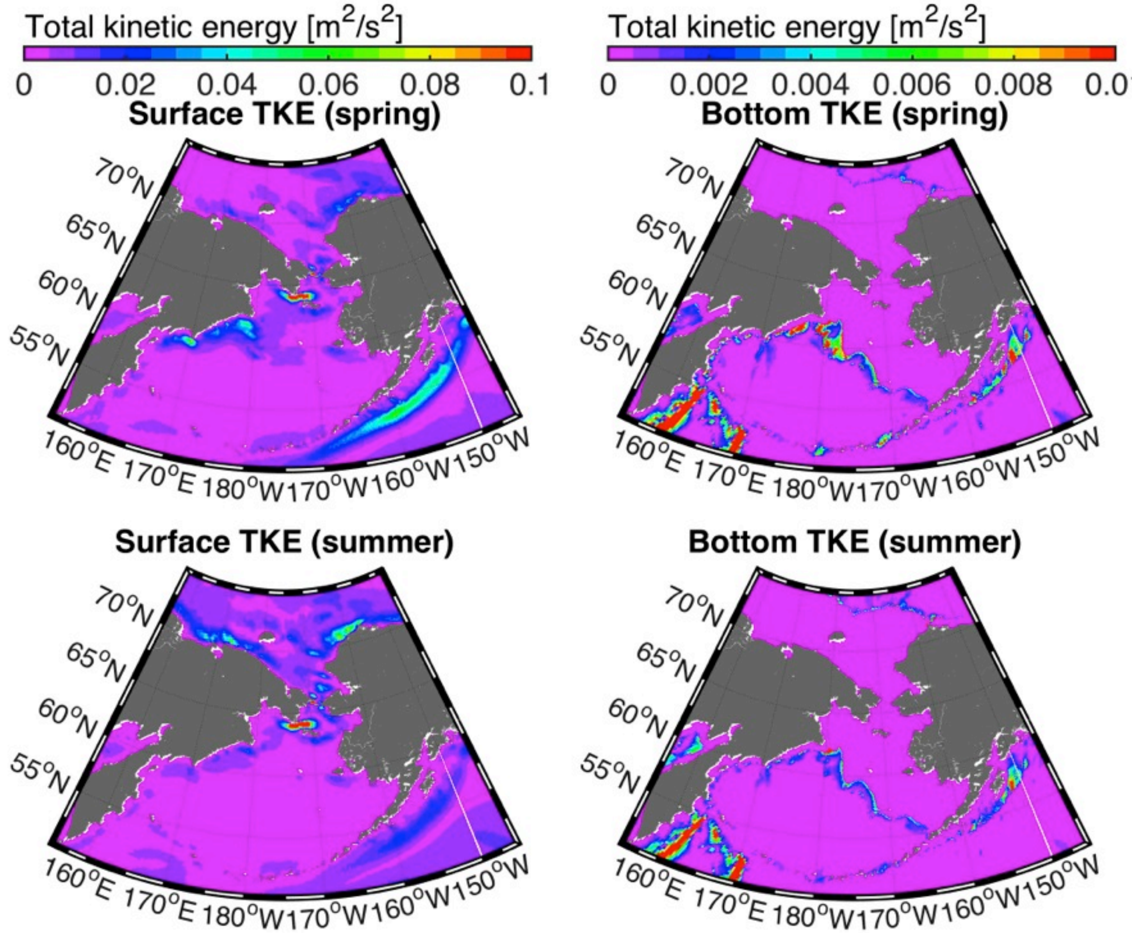
BIOMAS-simulated ammonium



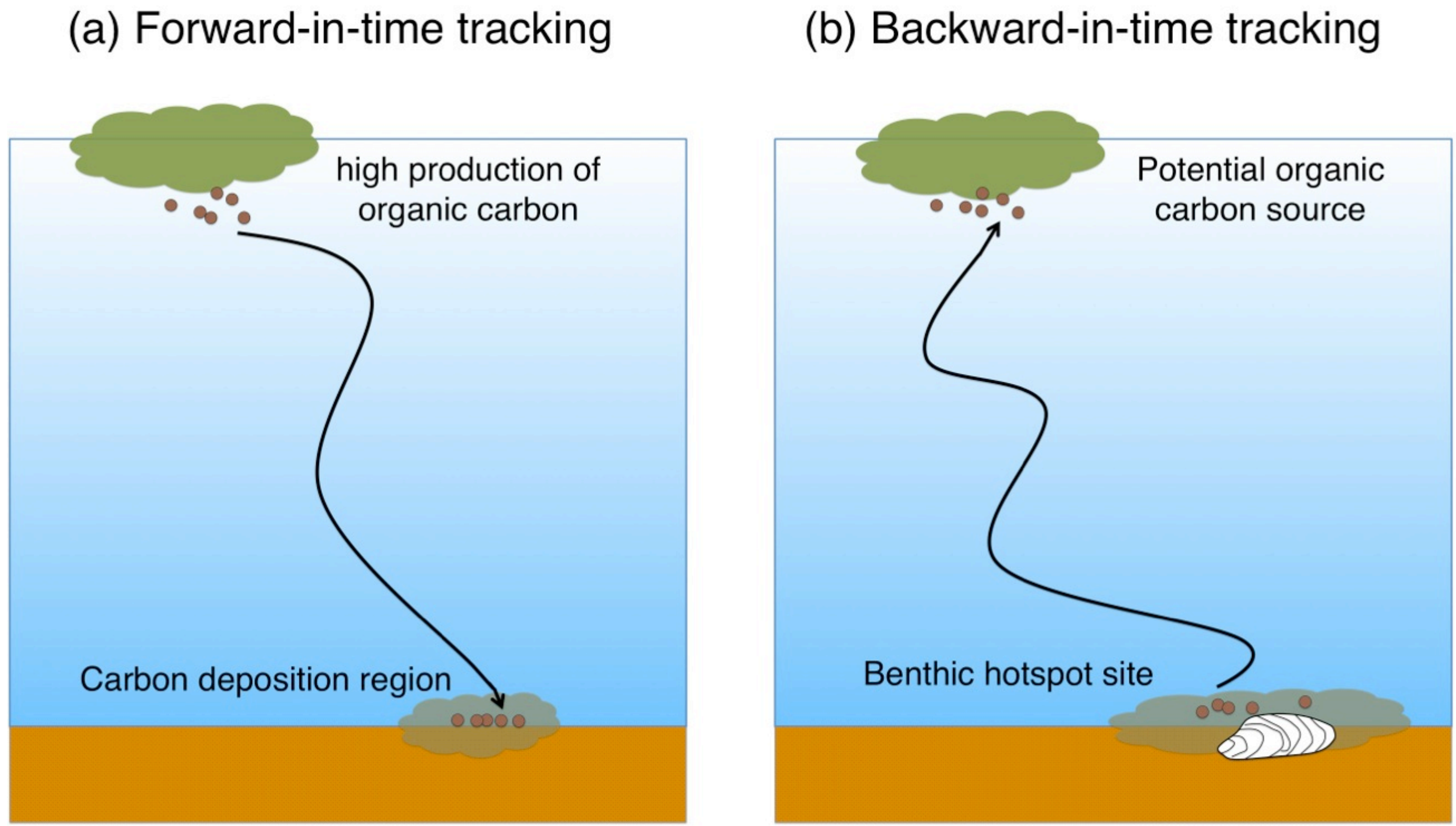
Surface vs bottom T/S difference



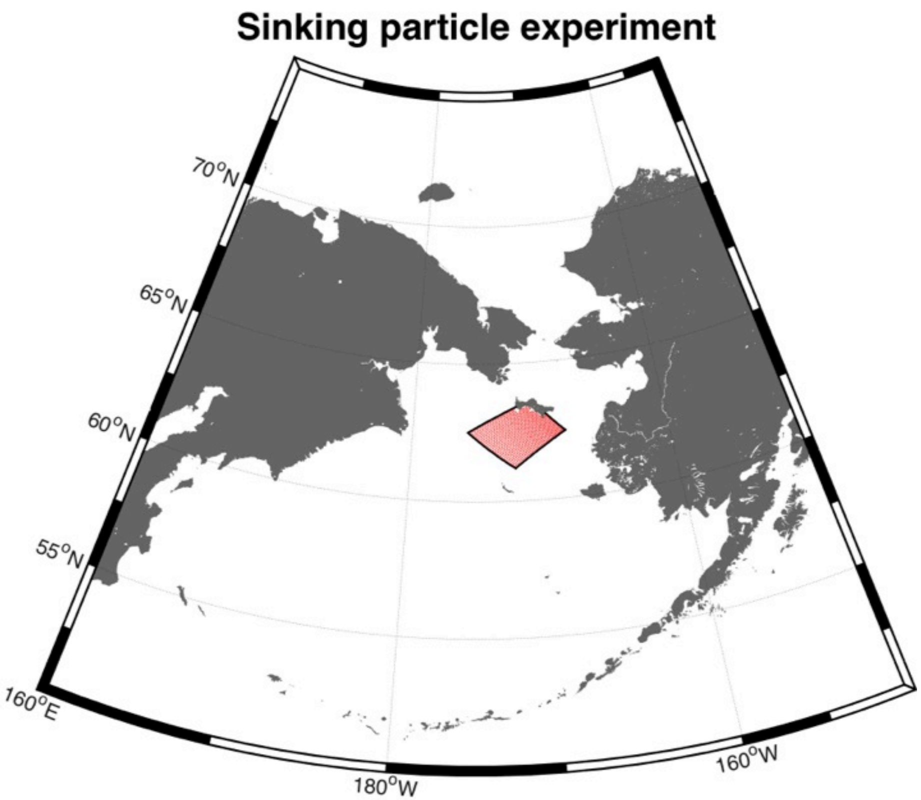
BIOMAS-simulated total kinetic energy



Conceptual diagrams of forward-in-time and backward-in-time tracking

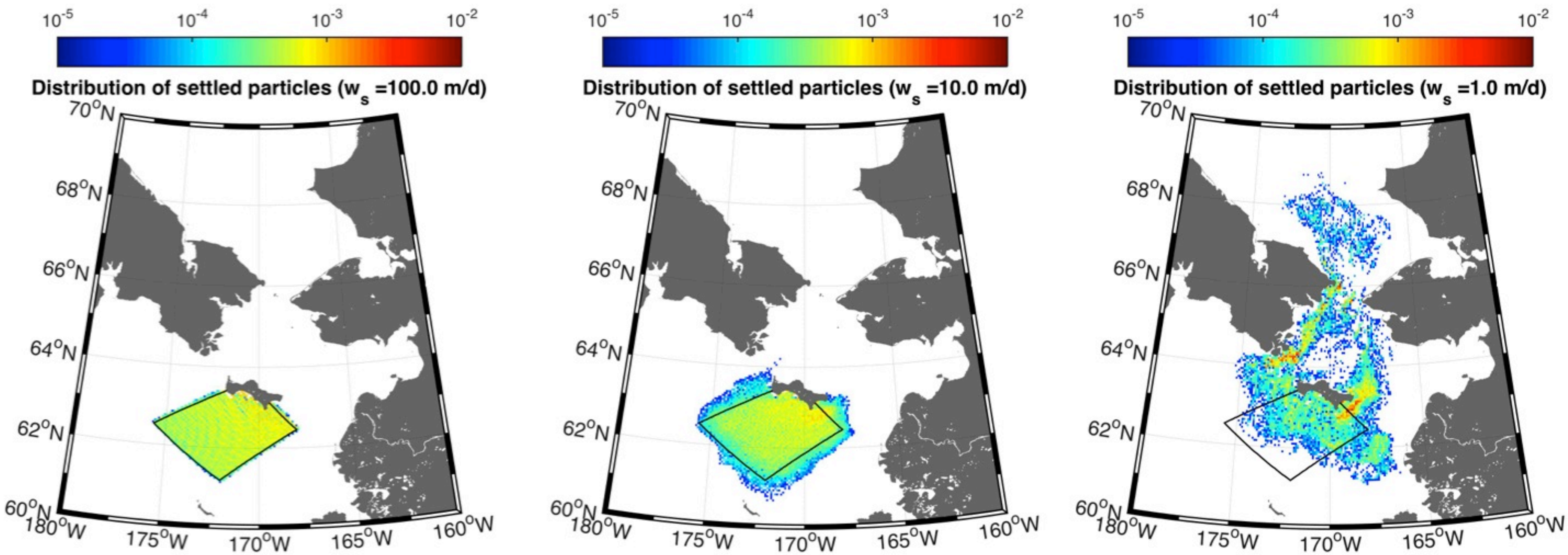


Lagrangian tracking for sinking particles



- ❑ Particles (n = 1065) are released daily from the region south of St. Lawrence Island.
- ❑ Experiment Day-100 and -129 to mimic spring bloom timing.
- ❑ Constant sinking velocities are added to background flow velocities:
  - ➢ 1.0 m/d (small cells);
  - ➢ 10.0 m/d (large cells);
  - ➢ 100.0 m/d (marine snow).
- All particles are tracked for a total of 60 days.
- ArcIBM code is modified to allow particles sink and settle to the seafloor.

Particle settling of different size groups



What determines the range of organisms and how might climate change change this?

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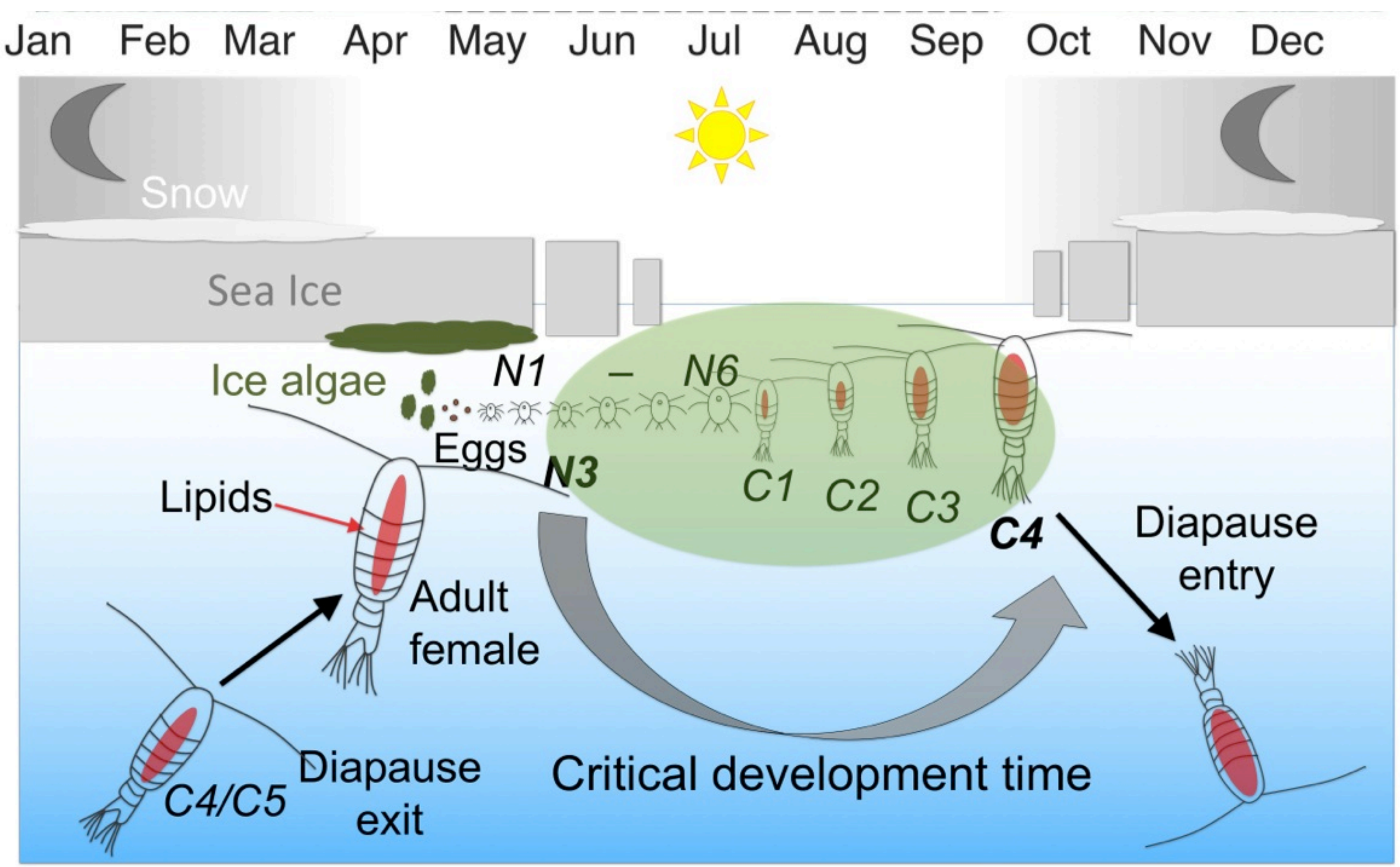
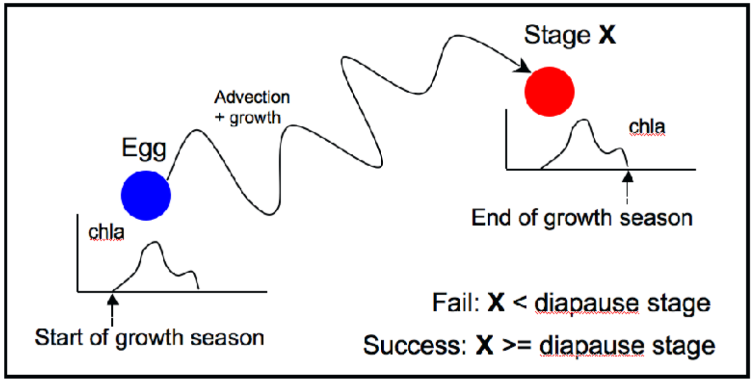
To persist, Calanus has to develop from egg to diapausing stage during the available growth season (food available for the copepod)



Modified from Varpe 2012 J. Plankton Res.

Modeling *Calanus* spp.

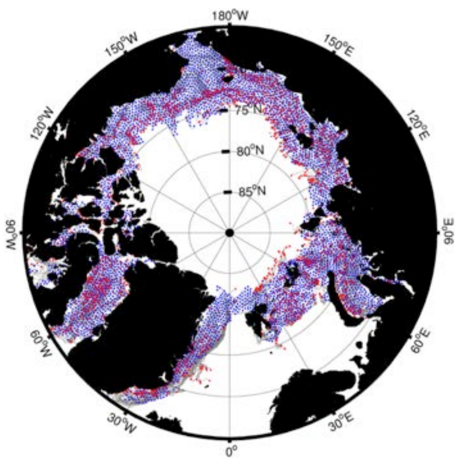


GOAL: Identify locations to which animals could be transported and successfully achieve an overwintering stage and thus persist

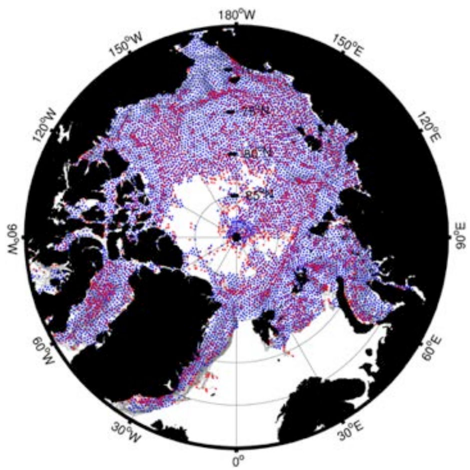
- Individual based modeling study
- Temperature and food dependent development rates
- Modeled circulation and water temperature
- Growth season length for each node point from satellite ocean color or from snow melt/radiation levels

Arctic Copepod *Calanus glacialis*

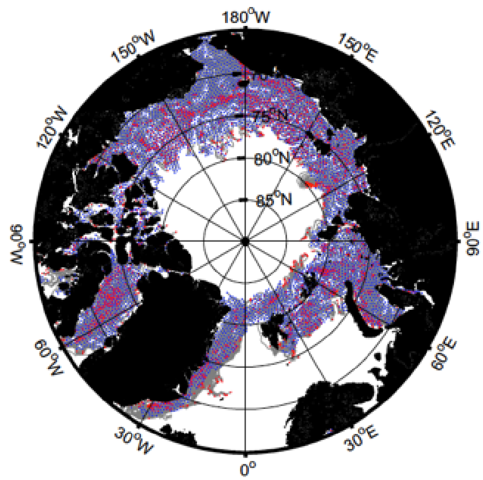
Present Temperature and Growth Season Length



Temperature Increased 2° C



Growth Season Lengthened 2 Weeks

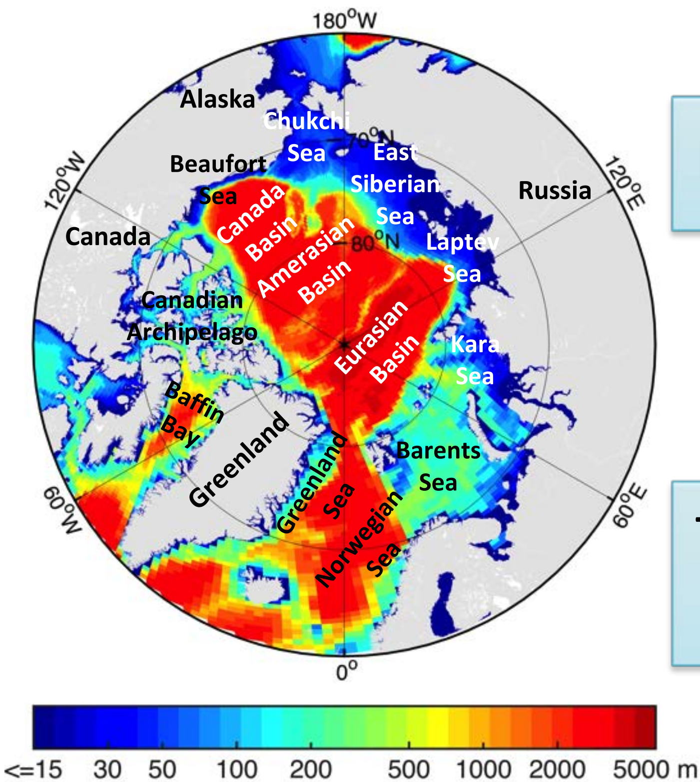


- A 2° C temperature increase greatly expands the potential range over which this species can persist. Lengthening of the growth season has a somewhat lesser effect

Ji, Ashjian, Campbell, et al. 2012. Progress in Oceanography 96: 40-56.

Individual-based modeling approach

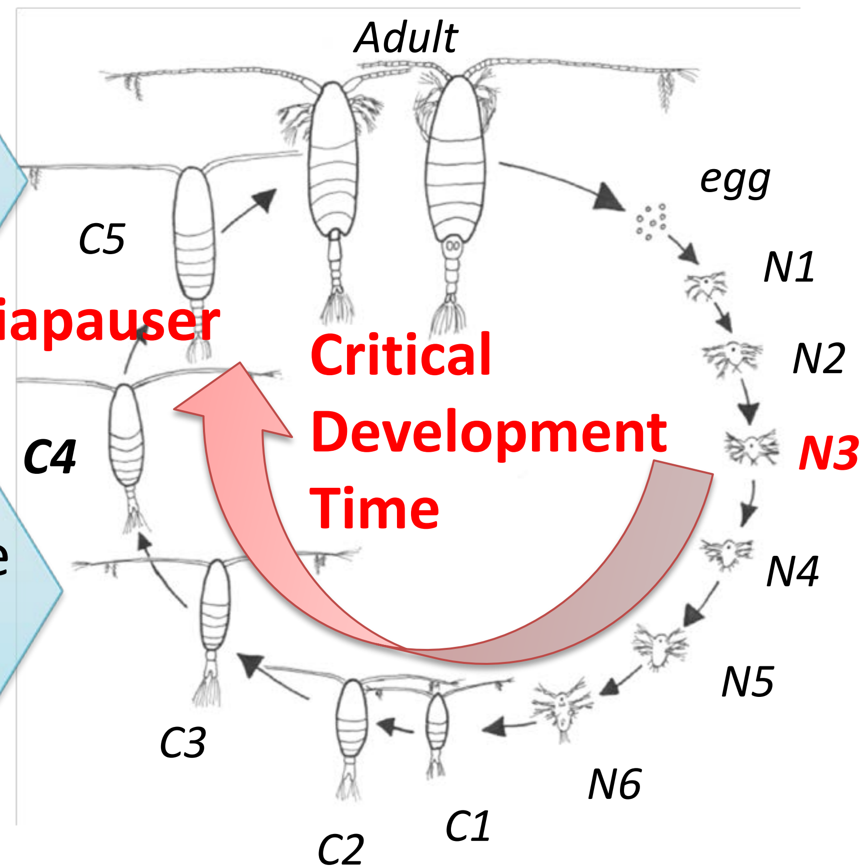
BIOMAS (forcing)



Flow fields

Temperature & Food

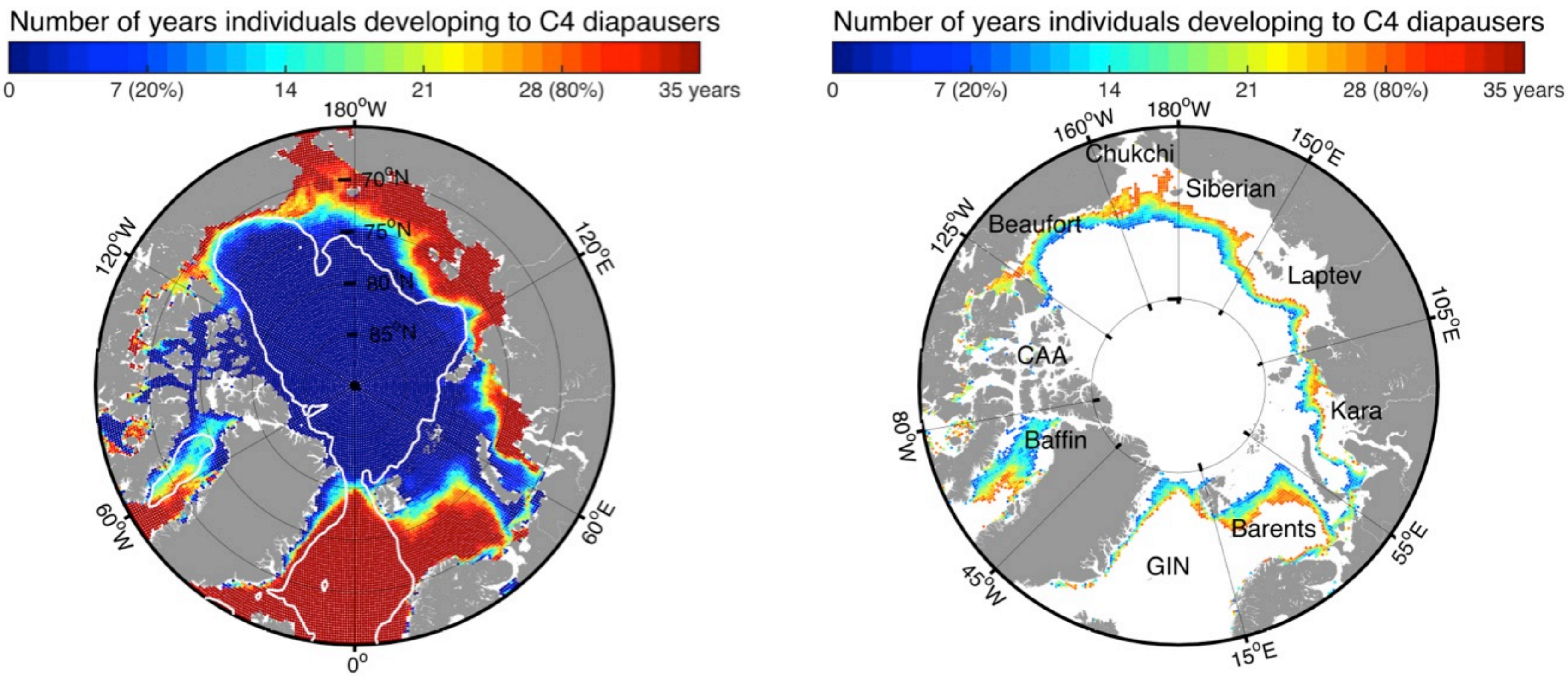
ArcIBM



BIOMAS, Biology/**I**ce/**O**cean **M**odeling & **A**ssimilation **S**ystem (Zhang et al. 2010), is one of the ecosystem models in FAMOS intercomparison study (Jin et al. 2016).

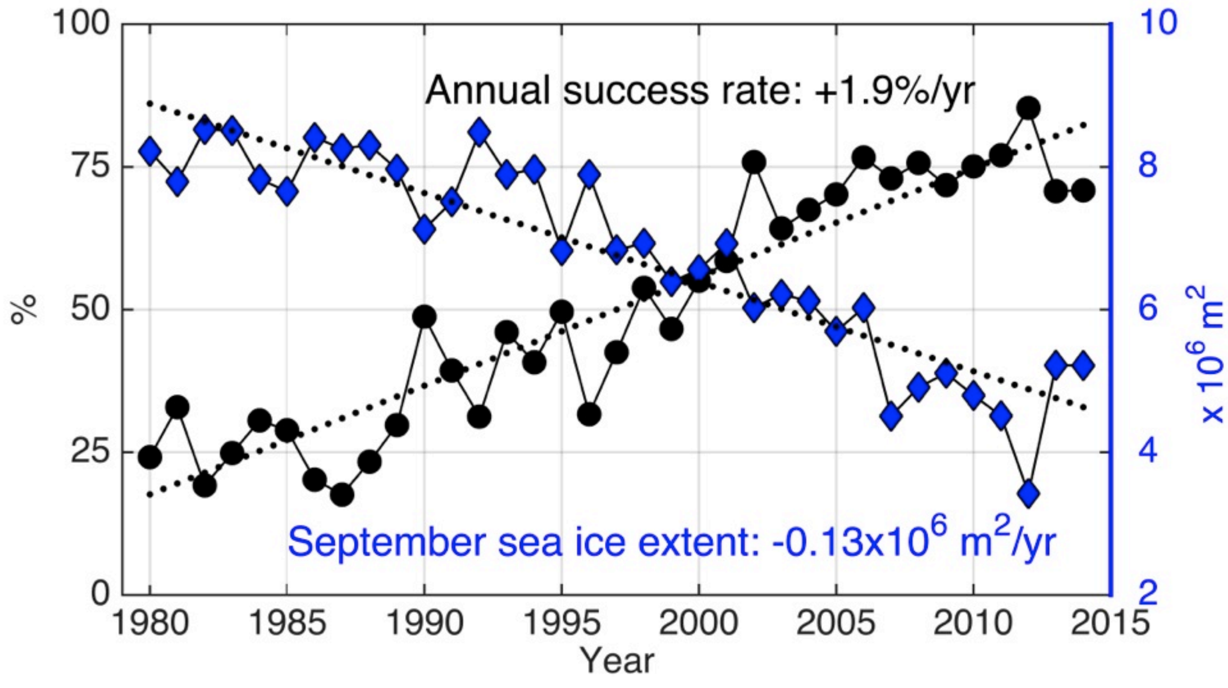
ArcIBM: **Ar**ctic **c**opepod **I**ndividual-**B**ased **M**odel (Ji et al., 2012; Feng et al. 2016, 2017).

Pan-Arctic distribution of diapausers: 1980-2014



Feng et al. 2017

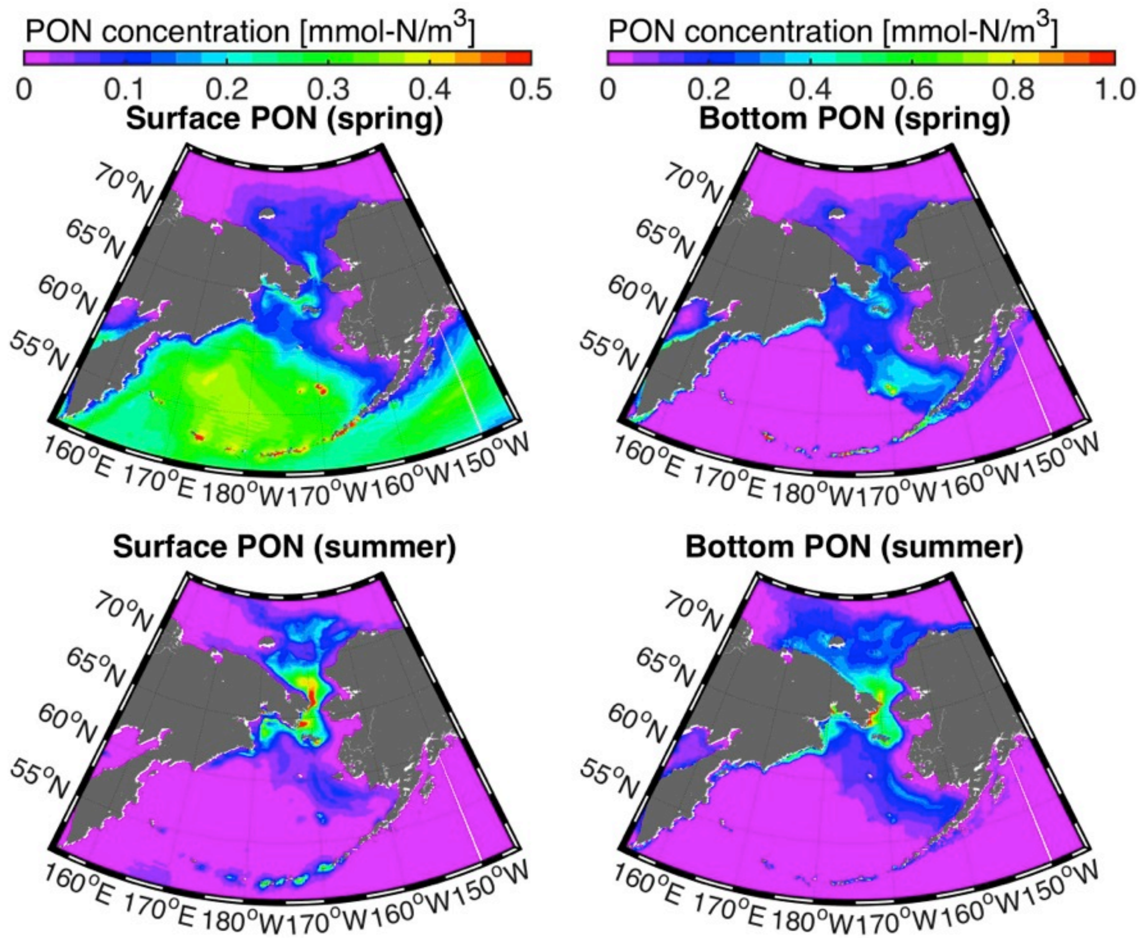
Decrease in sea ice extent -> Increase of annual success rate of the transition-zone individuals.



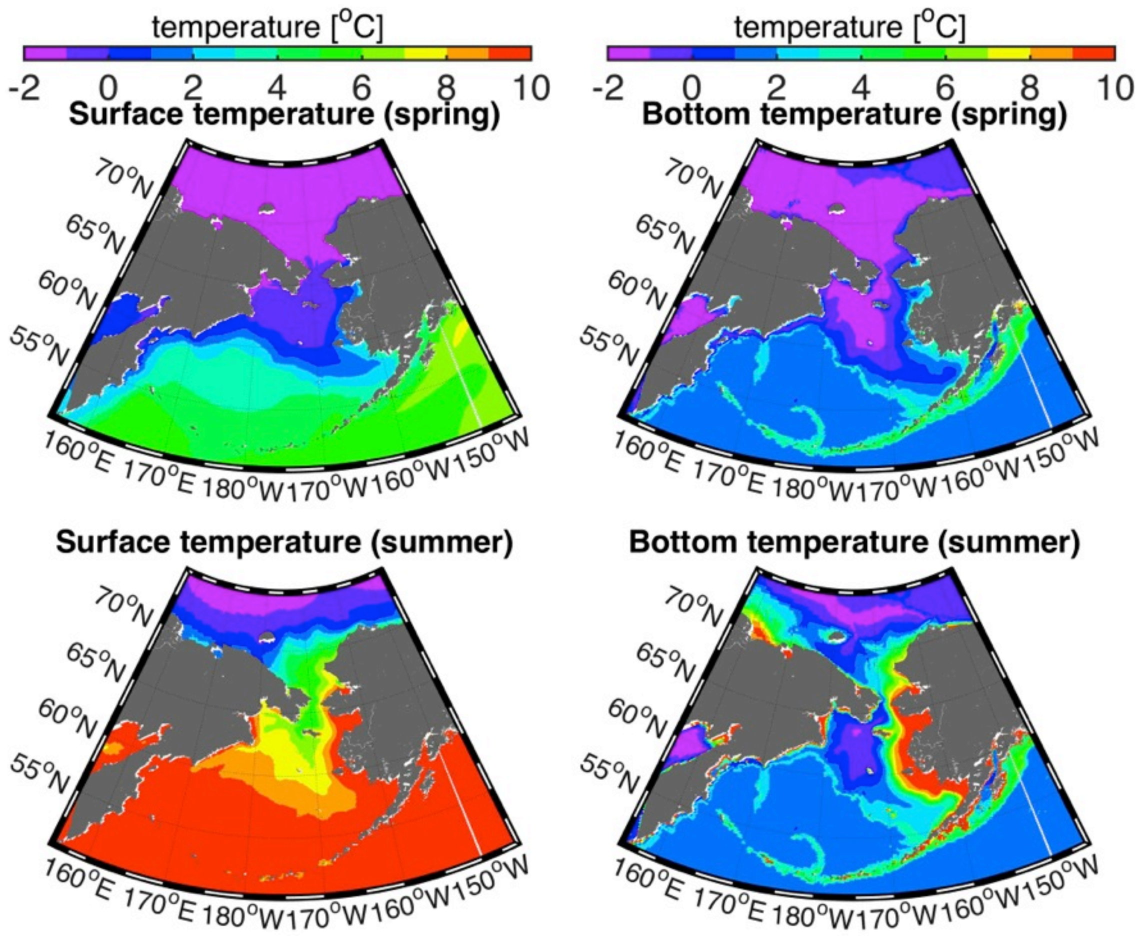
A surprisingly high correlation:

r = -0.94; $p < 0.01$

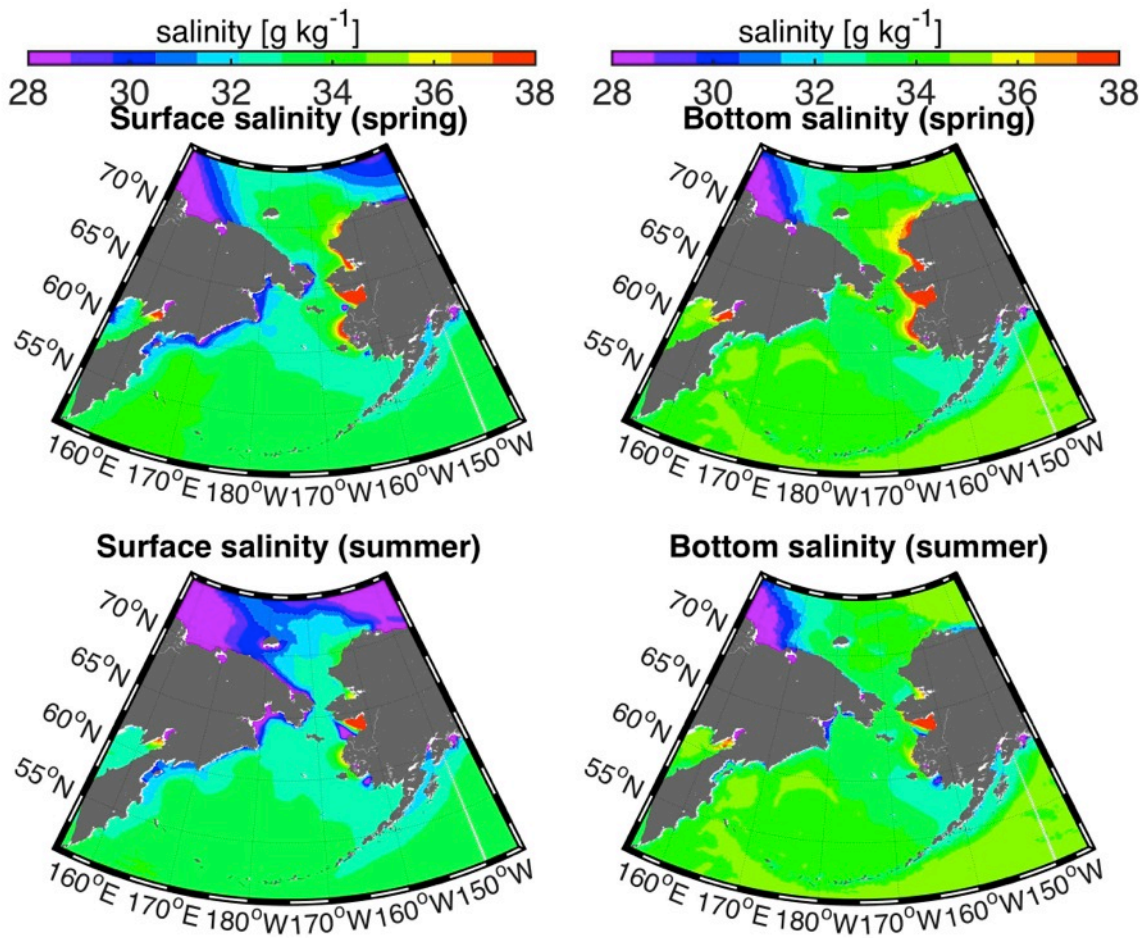
BIOMAS-simulated PON



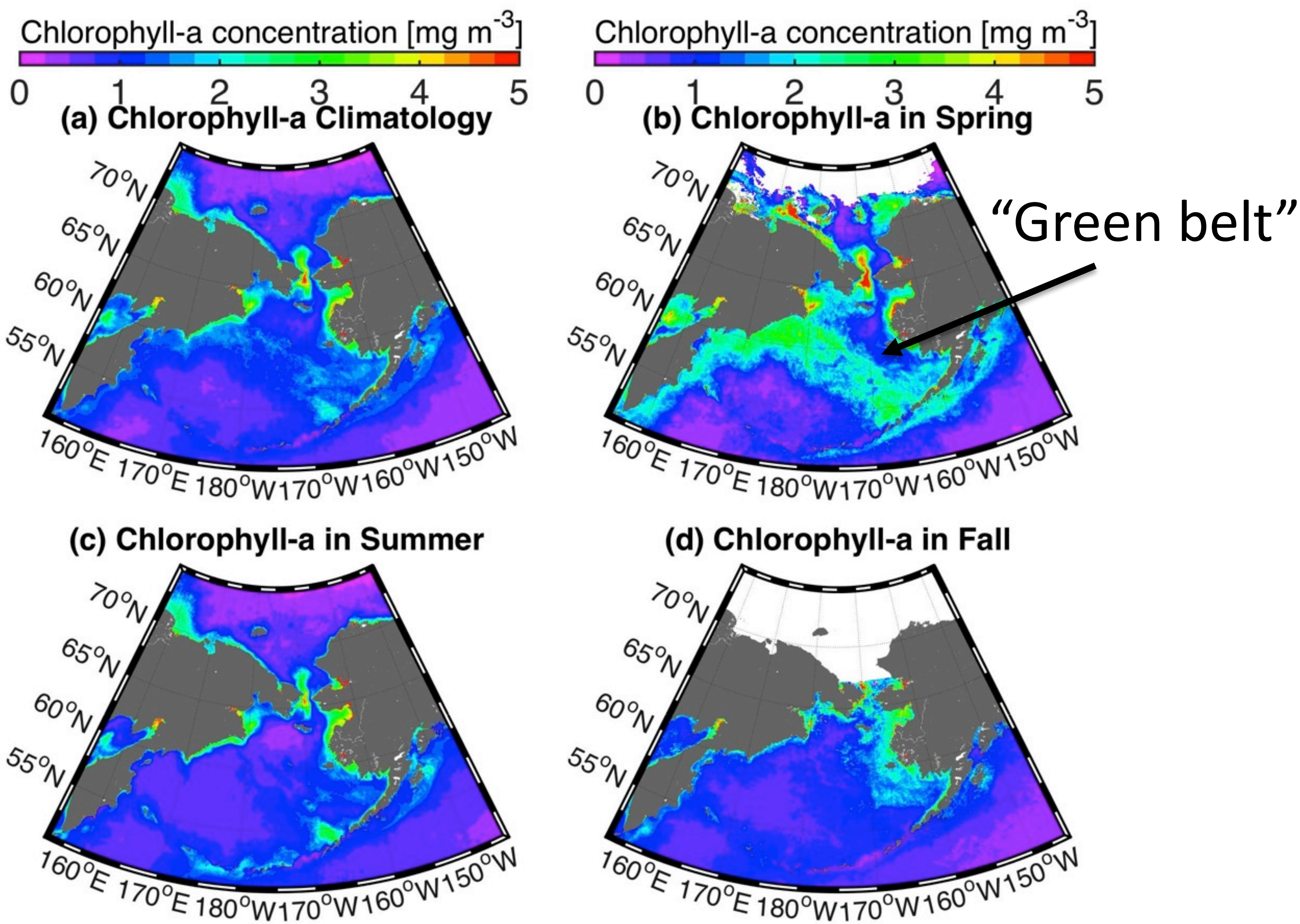
BIOMAS-simulated temperature



BIOMAS-simulated salinity



GlobColour satellite product: Ocean chlorophyll-a climatology (1998-2014)



Interannual variability of chlorophyll-a (1998-2014)

High chl-a regions in the Gulf of Anadyr and Bering Strait