The distribution, phenology and fate of ice-algal blooms in the Arctic Ocean

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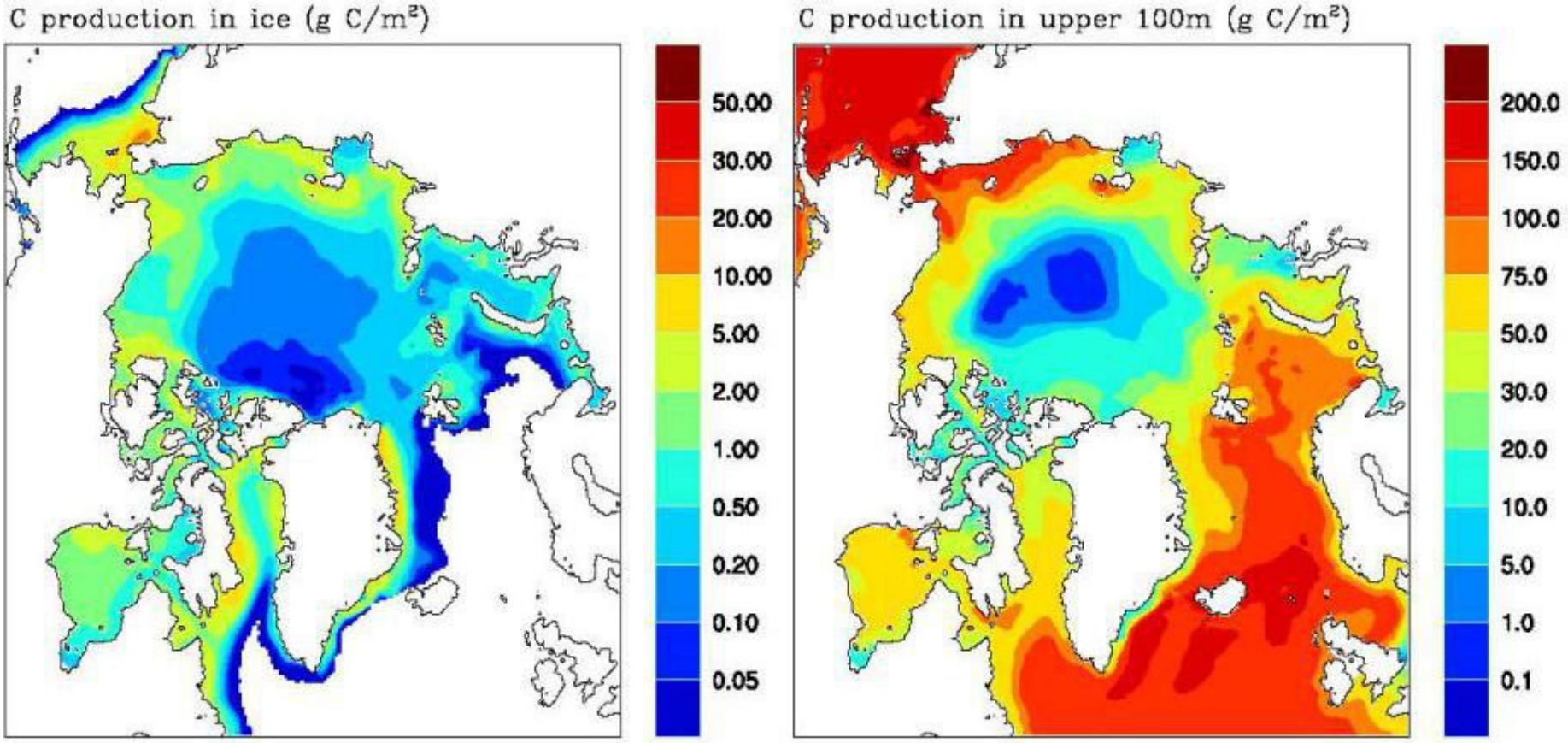
Arctic primary production is partitioned between ice algae and phytoplankton



Model: 21.3 Tg C yr^{-1}

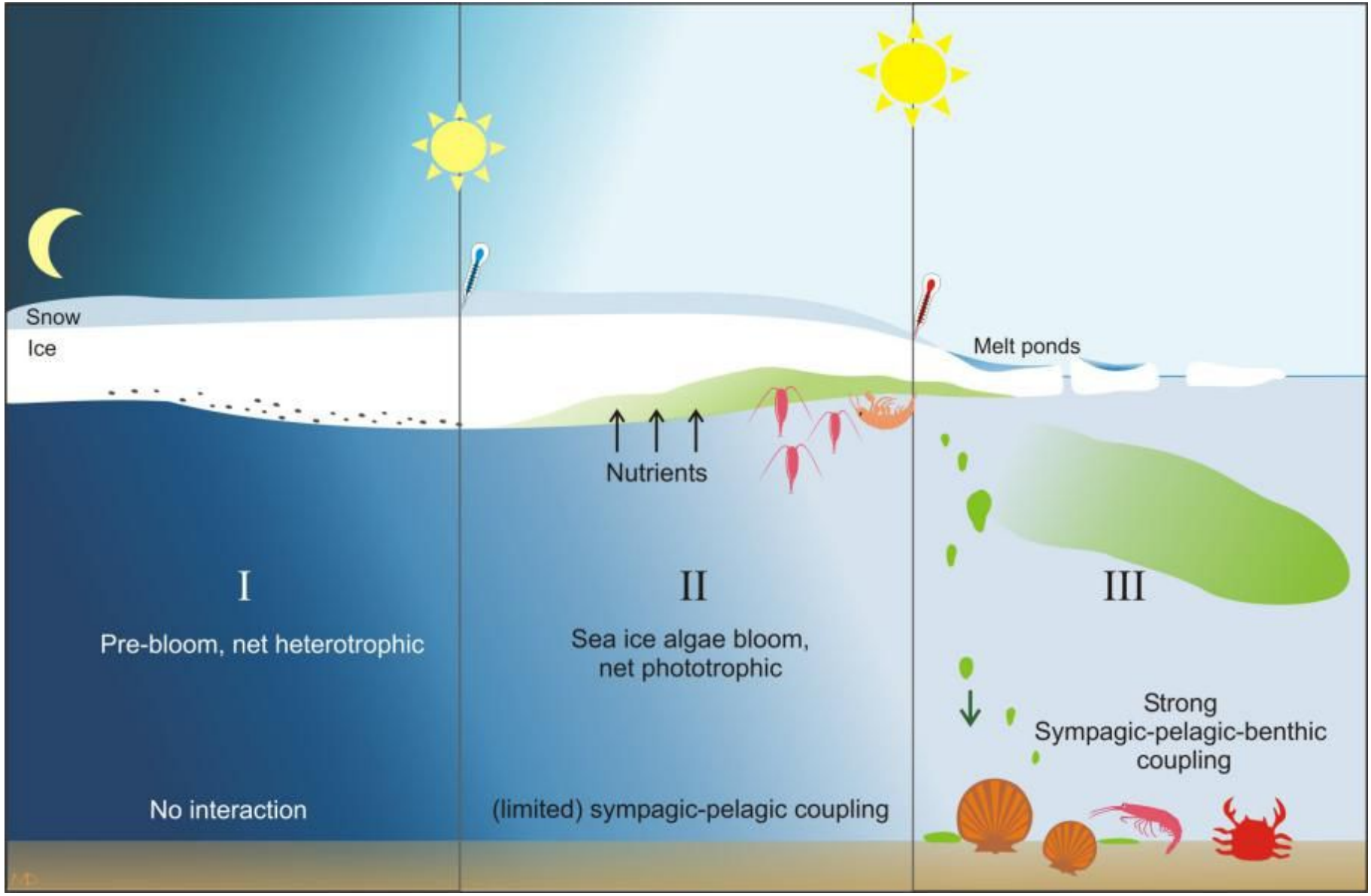
Multi-observational: 9-73 Tg C yr^{-1}

Model: 413±88 Tg C yr^{-1}

Satellite derived: 419±33 Tg C yr^{-1}

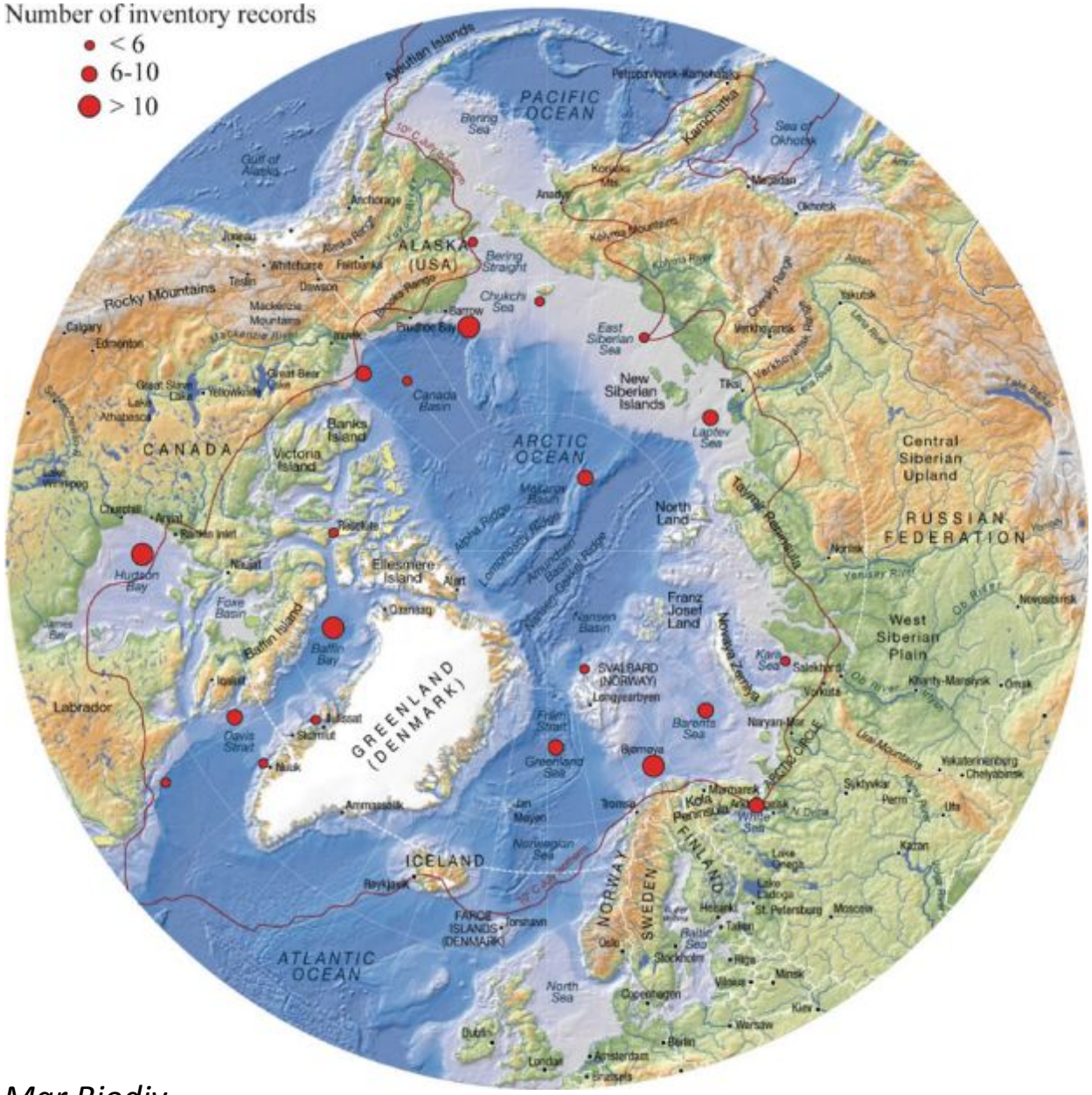
Jin et al. 2011 *DSR II*

Ice-associated ecosystem



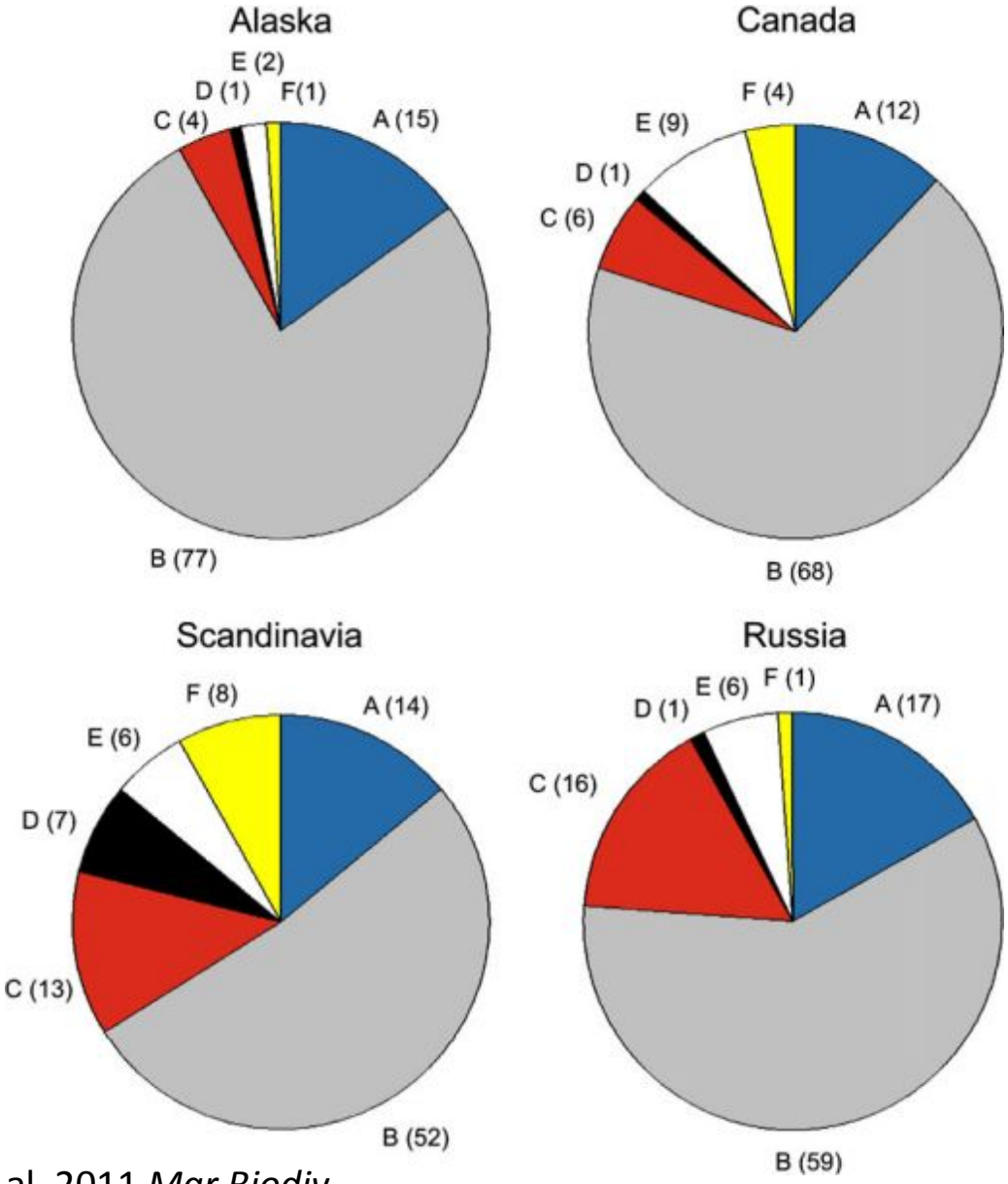
Leu et al. accepted *Prog. Oceanogr.*

Number of sea-ice eukaryote inventory records throughout the Arctic



Poulin et al. 2011 *Mar Biodiv*

Relative proportion (%) of marine sea-ice eukaryote taxa recorded from different Arctic regions:



- A centric diatoms
- B pennate diatoms
- C dinoflagellates
- D other stramenopiles
- E remaining groups
- F incertae sedis + choanoflagellates

Total of 1,027 sympagic single celled eukaryote (protist) taxa

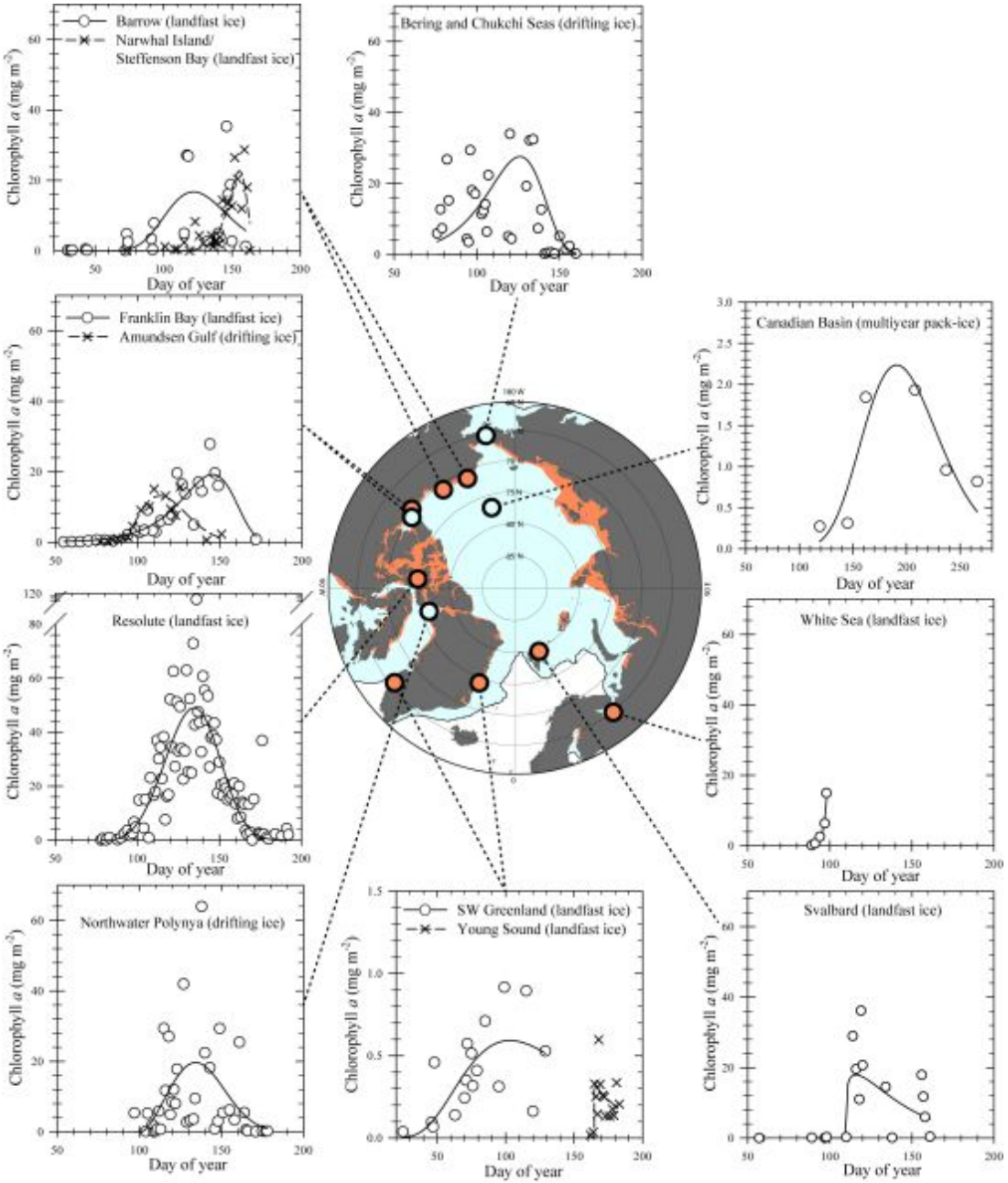
Poulin et al. 2011 *Mar Biodiv*

Ice-algal standing stocks for different Arctic areas

Geographic area n = number of studies	Chl *a* standing stock (mg m^{-2})	Dominant algae (in terms of biomass)
Pacific sector n = 5	**0.2 - 304**	**<u>Pennate diatoms</u>** • ***Nitzschia frigida*** • *N. neofrigida* • *N. promare* • *N. polaris* • *N. grunowii* • *Navicula* directa • *N. pelagica* • *N. septentrionalis* • *N. transitans* • *N. kariana* • *N. quadripedis* • *Fragilariopsis cylindrus & F. oceanica* • *Synedropsis hyperborea* • *Fossula arctica* • *Cylindrotheca closterium* • *Amphiprora palludosa* • *Pseudo-nitzschia delicatissima* • *Pauliella taeniata* • *Entomoneis kjelmanii & E. paludosa* • *Hantzschia weyprechtii* and the centric diatoms ***Melosira arctica*** and *Attheya septentrionalis*
Canadian Arctic Archipelago n = 20	**0.01 - 711**	
Baffin and Hudson Bay n = 8	**0.1 - 800**	
Barents and Kara Seas n = 6	**0.01 – 48**	
Greenland Sea and Fram Strait n = 5	**0.1 – 3.3**	
Central Arctic Ocean n = 3	**<0.01 - 14**	

Leu et al. accepted *Prog. Oceanogr.*

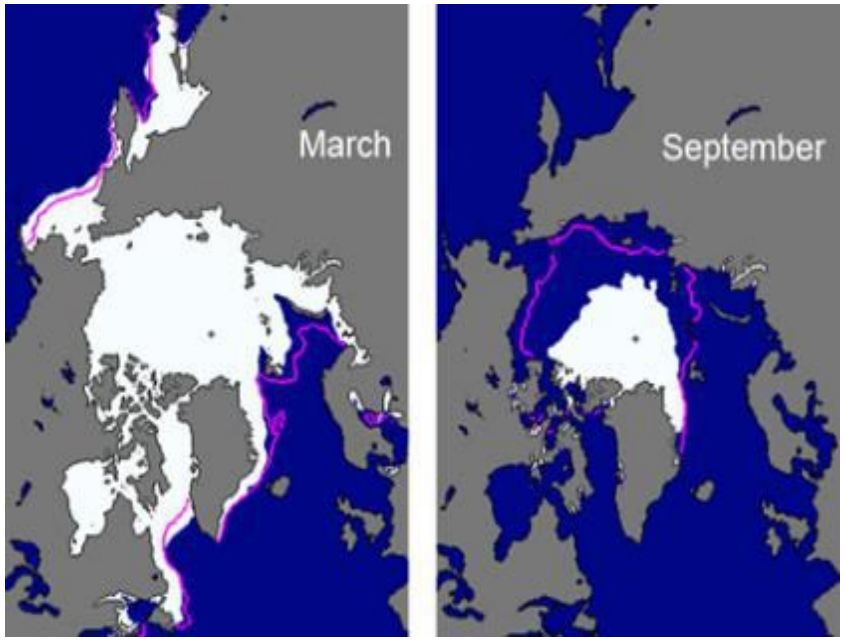
Ice-algal time-series around the Arctic



Leu et al. accepted *Prog. Oceanogr.*

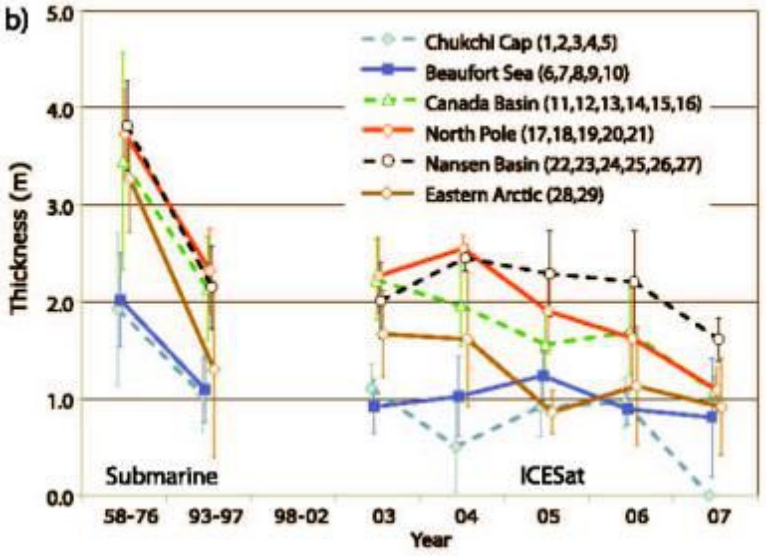
No significant correlation between bloom start, peak, and end dates and latitude, ice freeze-up and ice break-up dates.

Decline and thinning of sea ice habitat

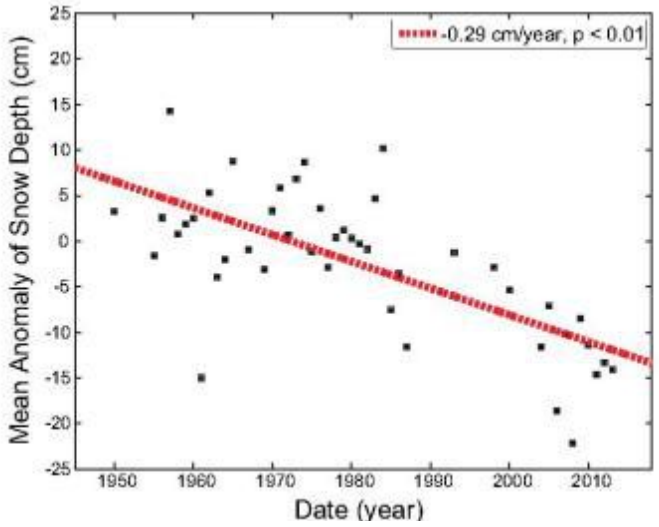


Sea ice extent in March 2012 (left) and September 2012 (right). The magenta line indicates the median maximum and minimum ice extents during the period 1979-2000.

Perovich et al. 2012 *Arctic Report Card*

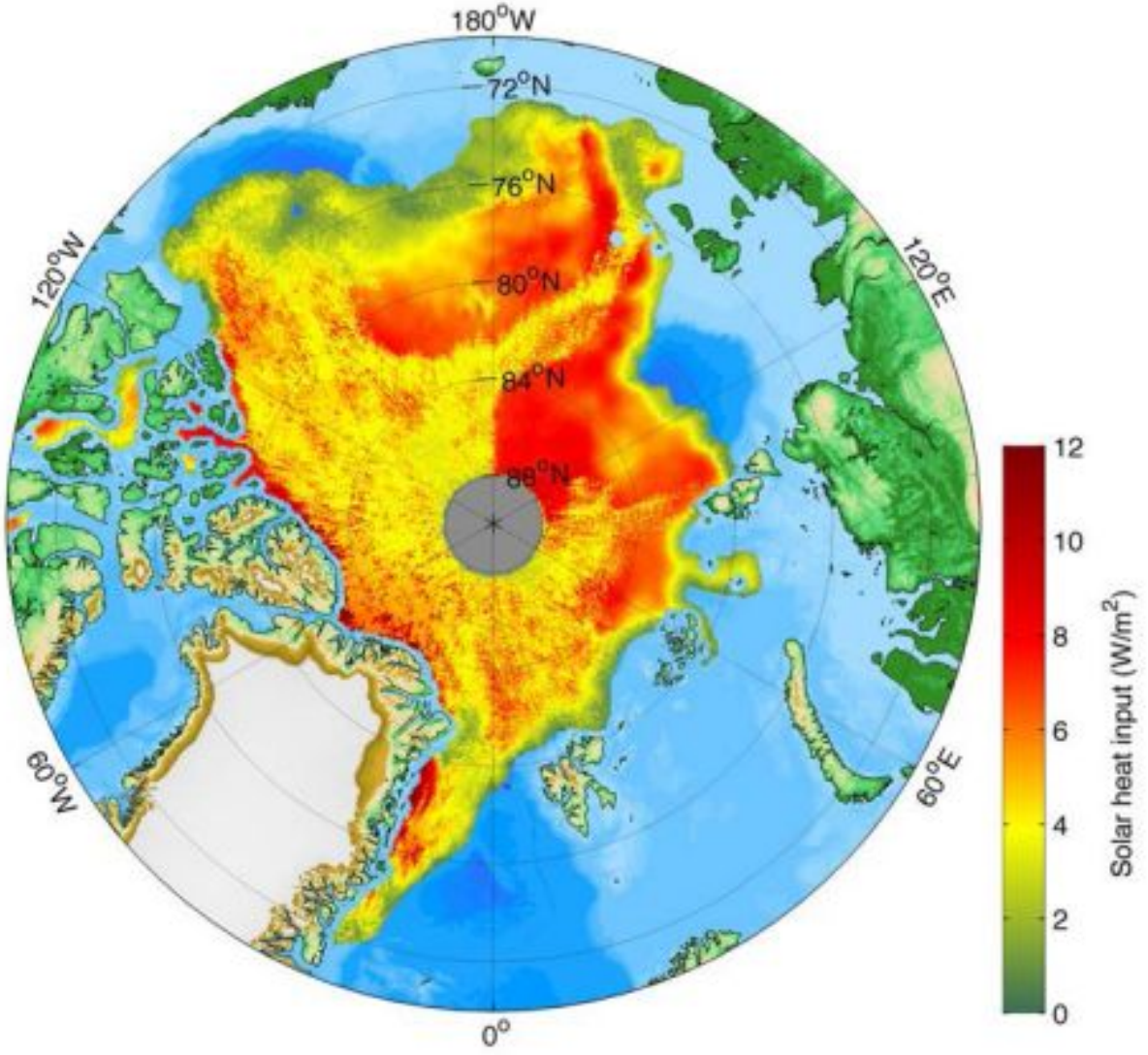


Long-term trend in ice thickness
Kwok & Rothrock 2009 *GRL*



Decadal change in snow depth in spring
Webster et al. 2014 *JGR*

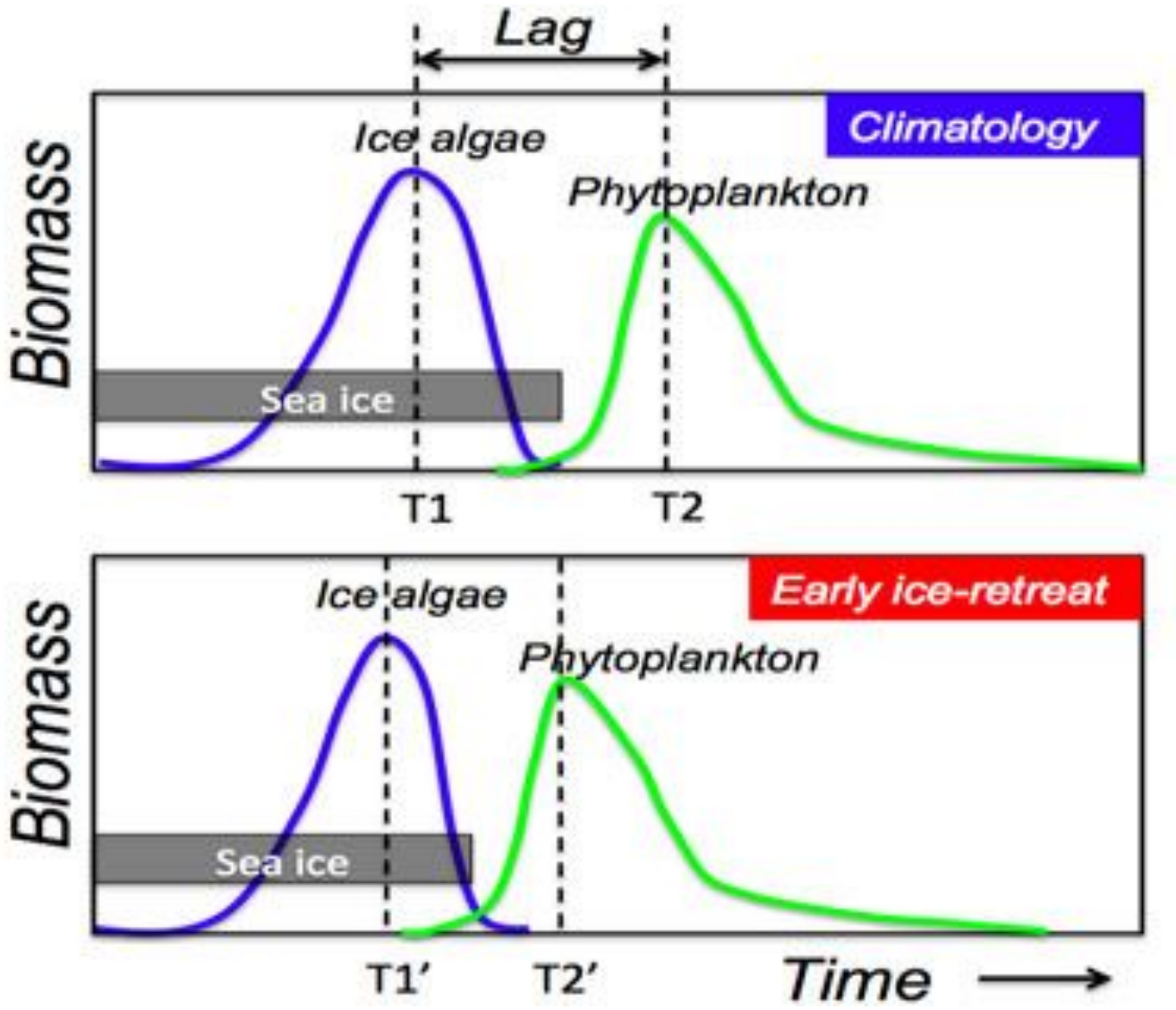
“Enlightening” of the Arctic Ocean



Solar heat input into the Arctic Ocean through sea ice in August 2011. This map only considers fluxes through sea ice, excluding fluxes through open water

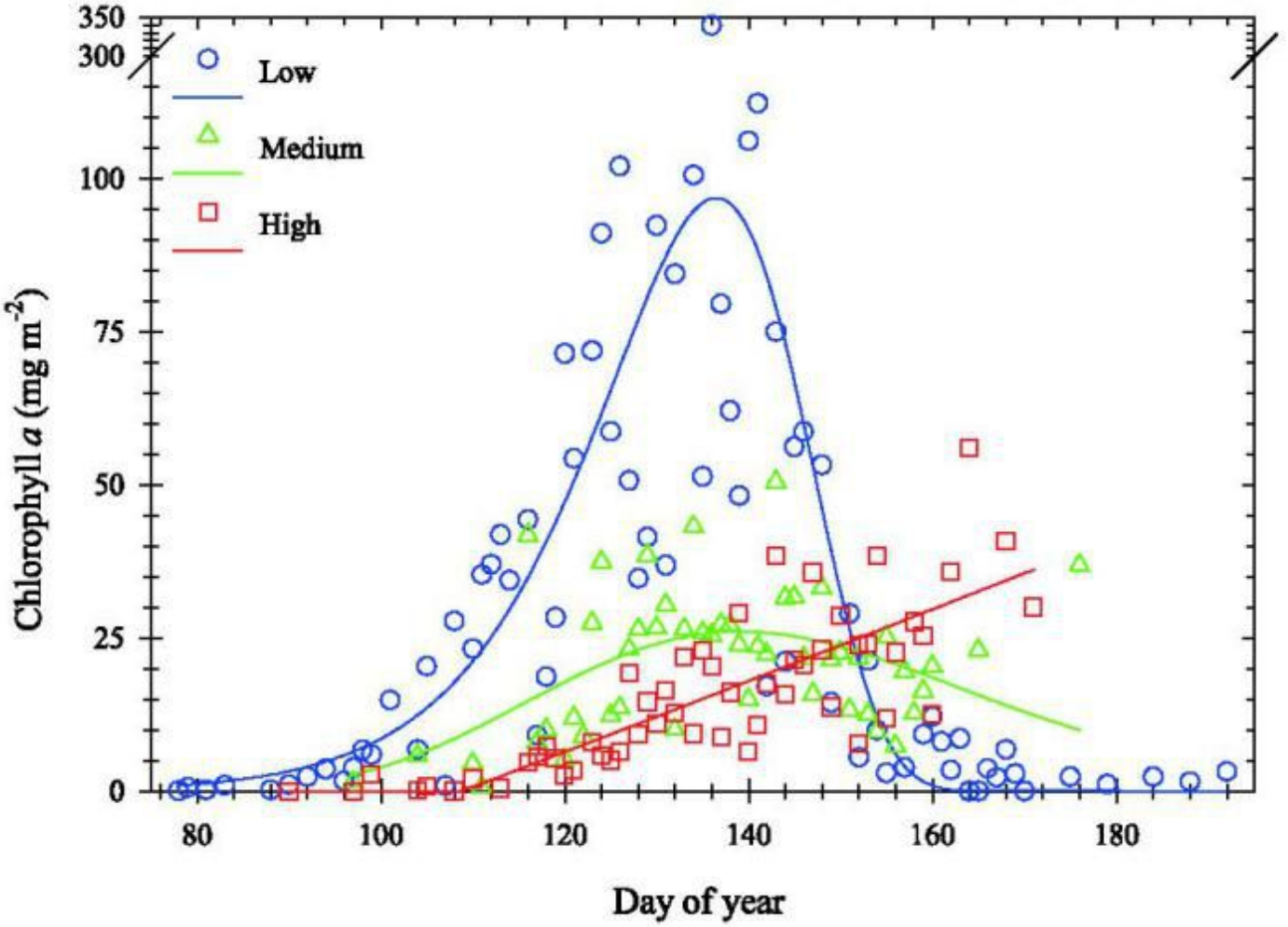
Nicolaus et al. 2012 *GRL*

Timing of the ice algal and phytoplankton bloom



Ji et al. 2013 *Global Change Biology*

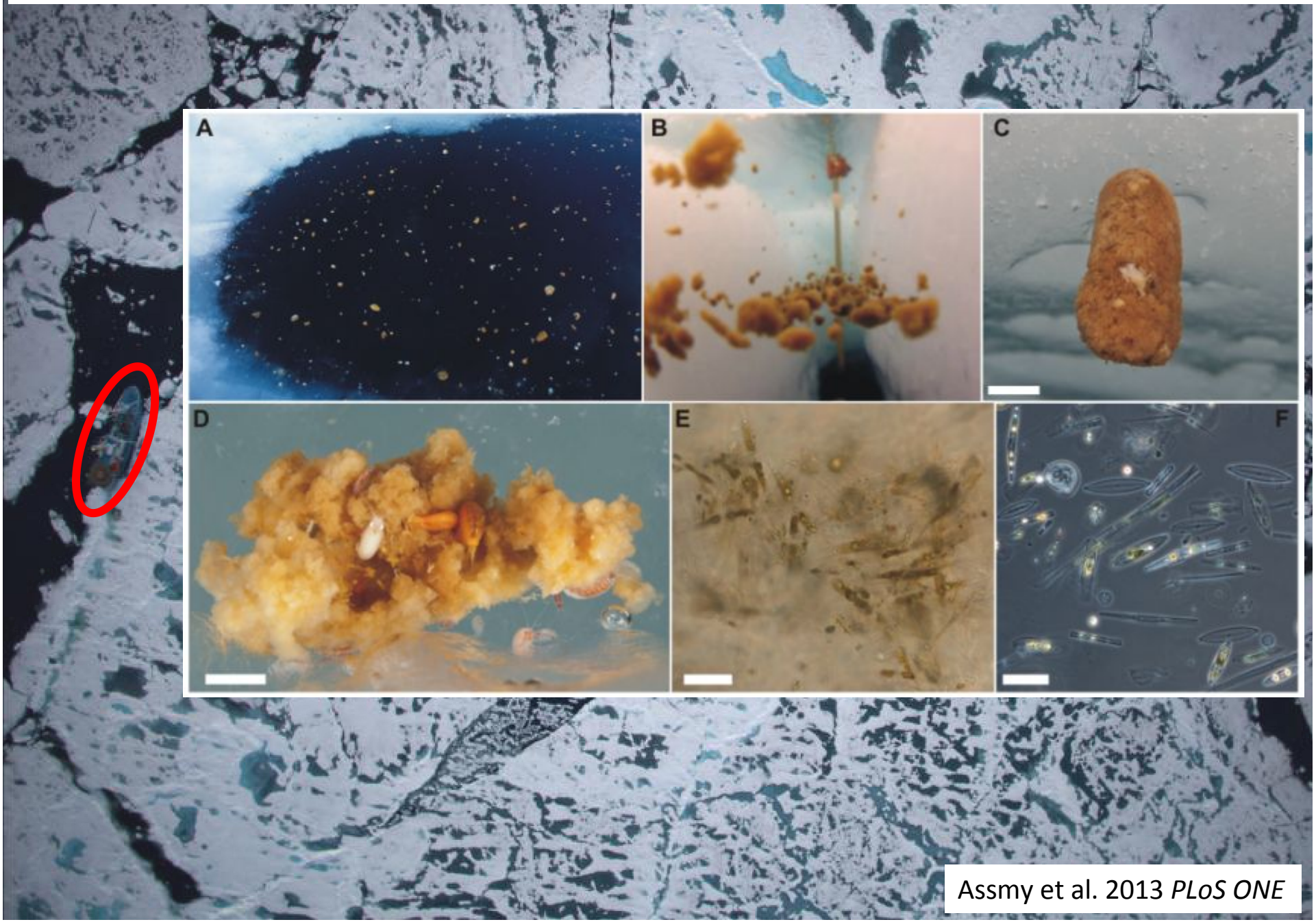
Snow cover: the single most important predictor of ice-algal biomass



Seasonal development of ice-algal chlorophyll concentrations at Resolute Bay, Canadian Arctic under low (blue), medium (green) and high (red) snow cover.

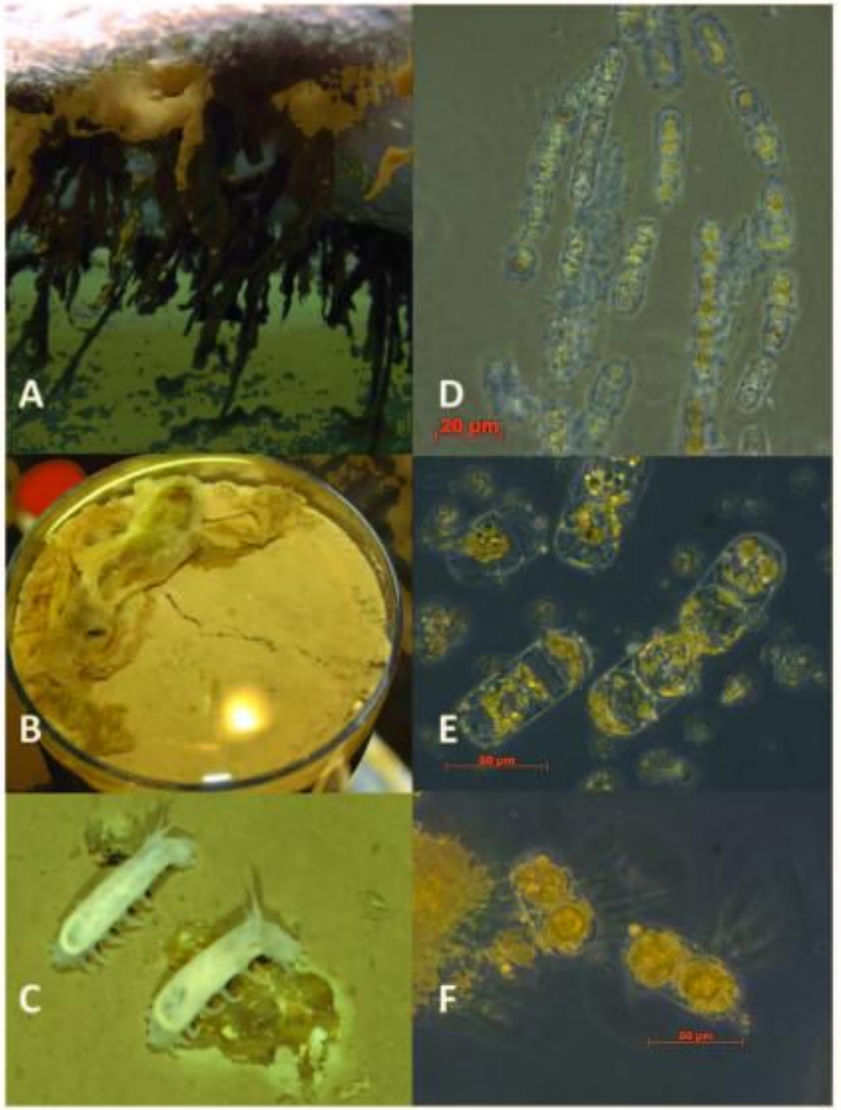
Leu et al. accepted *Prog. Oceanogr.*

Floating ice-algal aggregates below melting Arctic sea ice



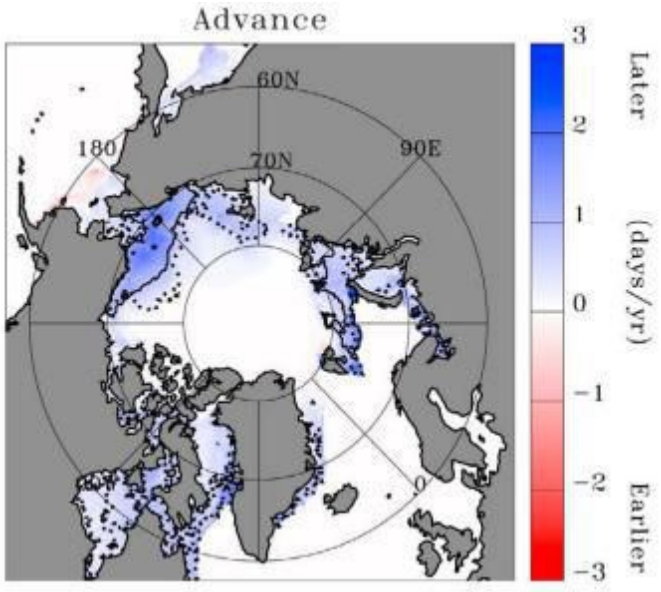
Assmy et al. 2013 *PLoS ONE*

Melosira arctica drives cryo-pelagic-benthic coupling in the central Arctic Ocean

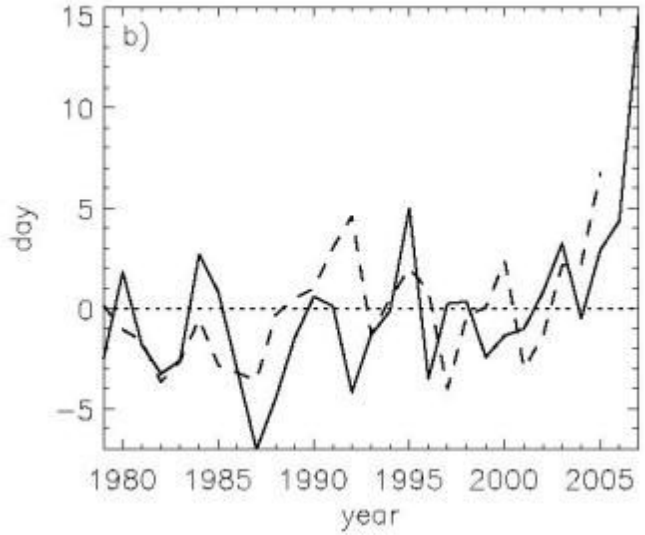


Boetius et al. 2013 *Science*

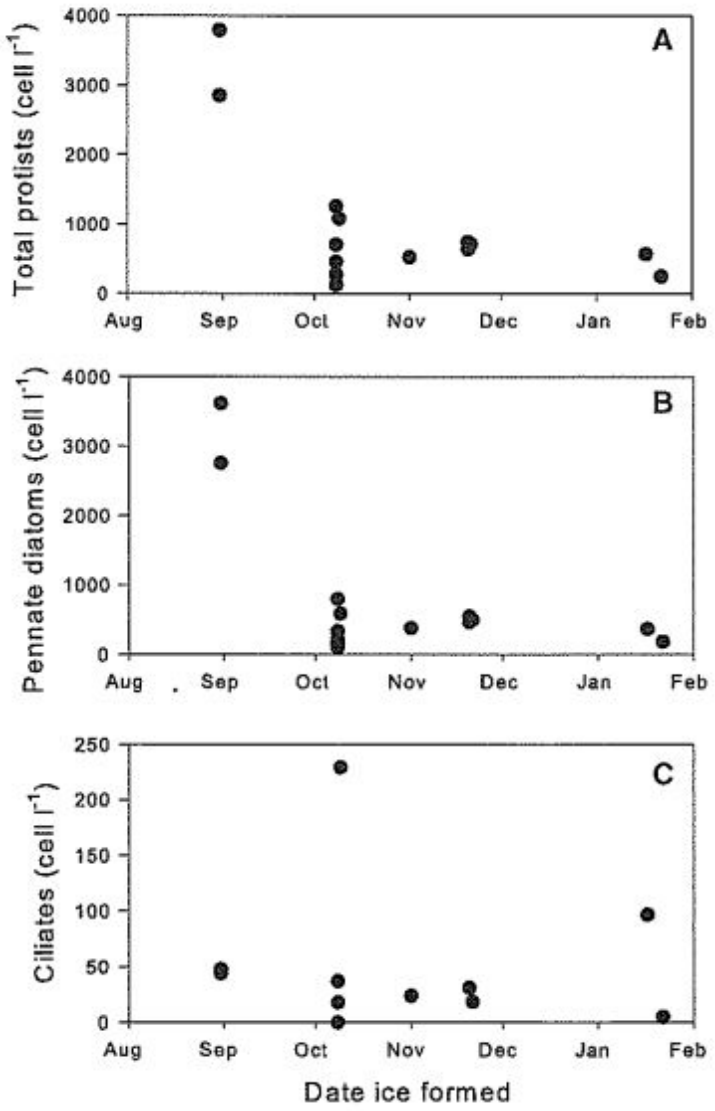
The date of ice formation and seeding of the ice-algal spring bloom



Trend (days/year) over 1979/80 to 2010/11 in sea ice advance. Stammerjohn et al. 2012 *GRL*



Freeze-up anomalies for the entire Arctic. Markus et al. 2009 *JGR*



Total protist, pennate diatom, and ciliate abundance in the bottom 3 cm of sea ice versus estimated date of ice formation in the Cape Bathurst flaw lead study area

Niemi et al. 2011 *Polar Biol*

Conclusions

- Caveat: under-sampling and very limited time-series
- Dominant ice-algal species seem to be widely distributed (limited risk of extinction)
- Snow depth seems to be the single most important predictor of ice-algal biomass
- Future thinning of ice and snow is likely to boost ice-algal biomass, with slightly earlier bloom start but at the expense of an earlier bloom decline
- Earlier and rapid bloom decline might stimulate cryo-pelagic-benthic coupling
- A later freeze-up date might negatively effect the seeding of the spring bloom

Thank you for your attention!