Phytoplankton dynamics

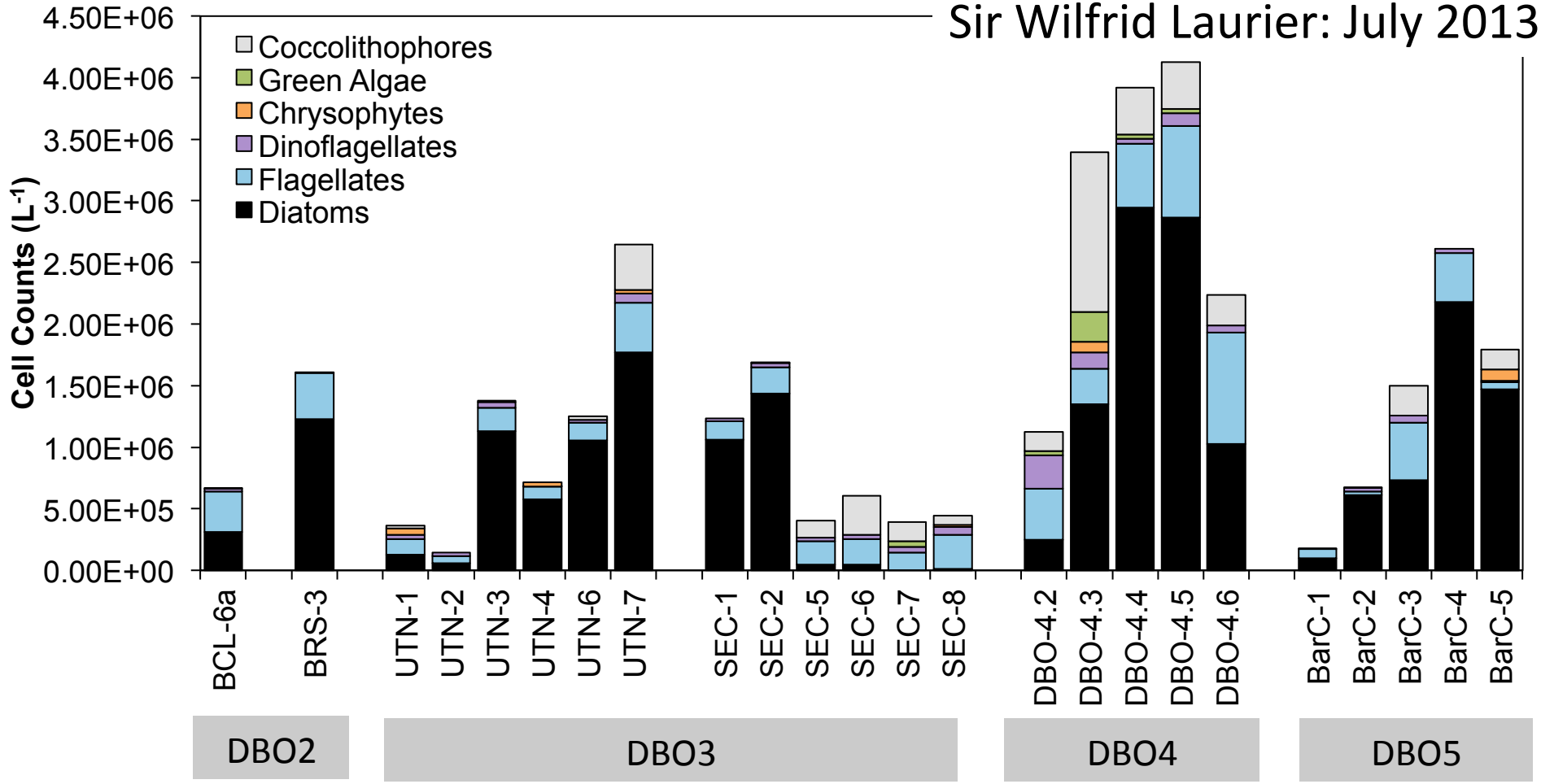
University of Victoria

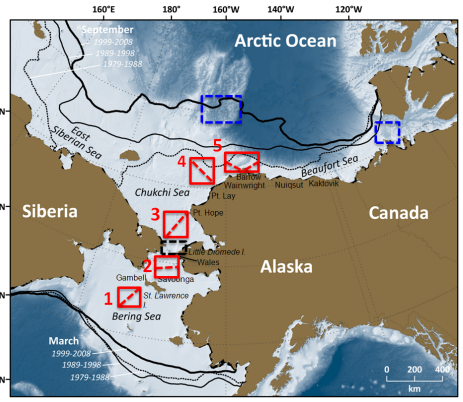
Euphotic-zone measurements during the DBO Laurier cruises:

- <u>Standing stock</u>:
  - Total Chlorophyll *a* concentrations
  - Size-fractionated Chlorophyll *a* concentrations
  - Biogenic silica (SiO_2) concentrations
  - Dissolved nutrient (NO_3, PO_4 and $Si(OH)_4$) concentrations
  - Phytoplankton identification (Józef Wiktor, Poland)
- <u>Rate processes</u>:
  - Primary productivity (^{13}C incorporation)
  - New production (^{15}N incorporation)
  - Biogenic silica production (^{32}Si incorporation & net $bSiO_2$ changes)

All DBO lines (as much as possible)

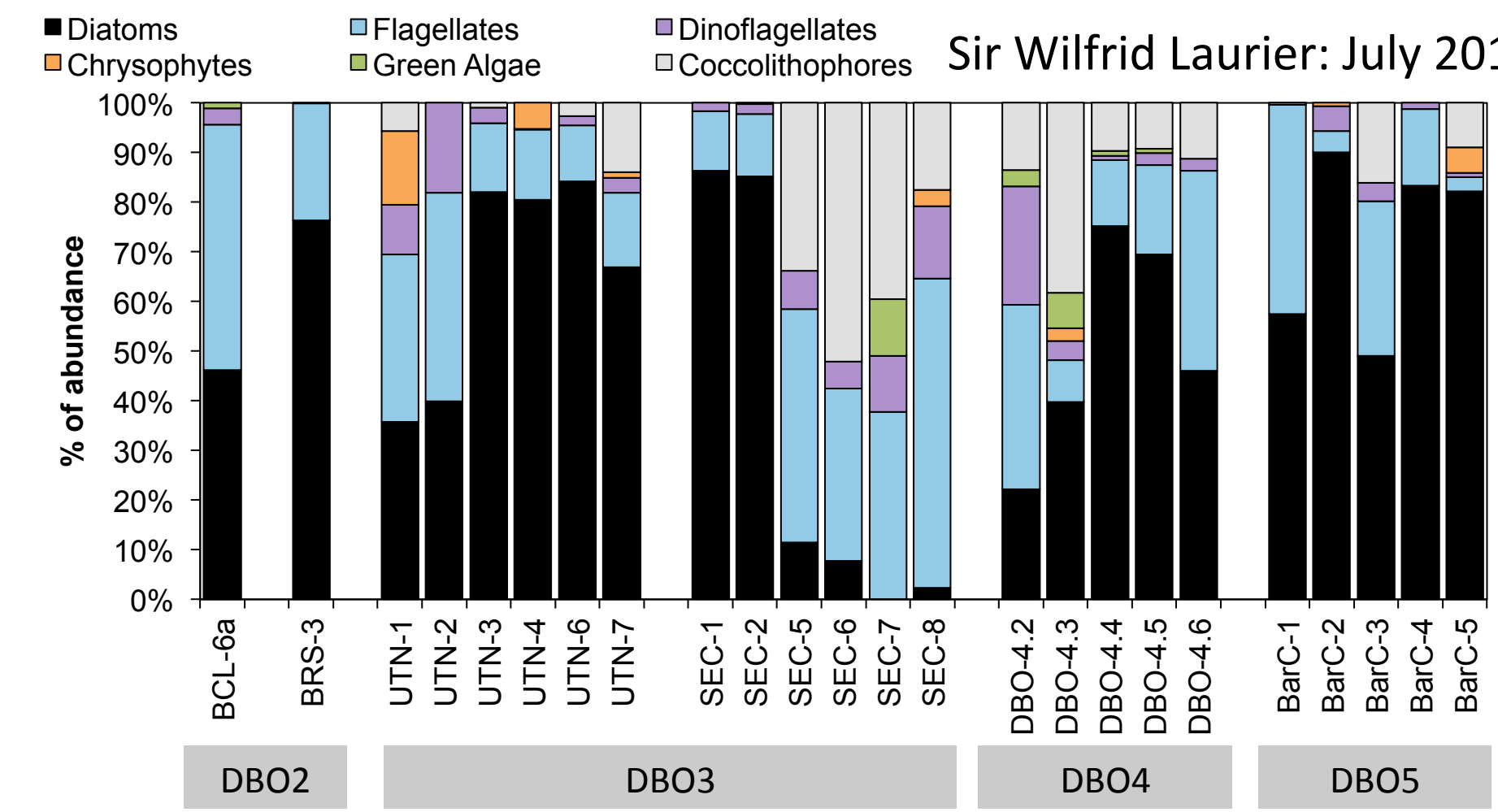
July of 2006, 2008, 2011, 2012, 2013 and 2014

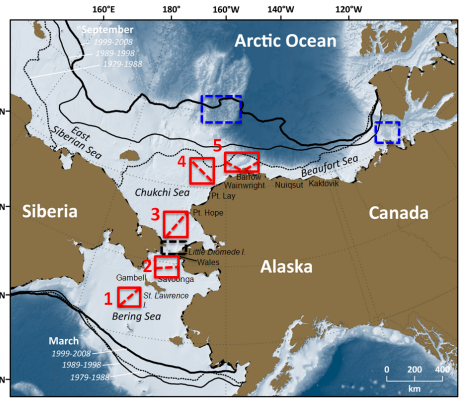




Phytoplankton community composition (Chlorophyll max)

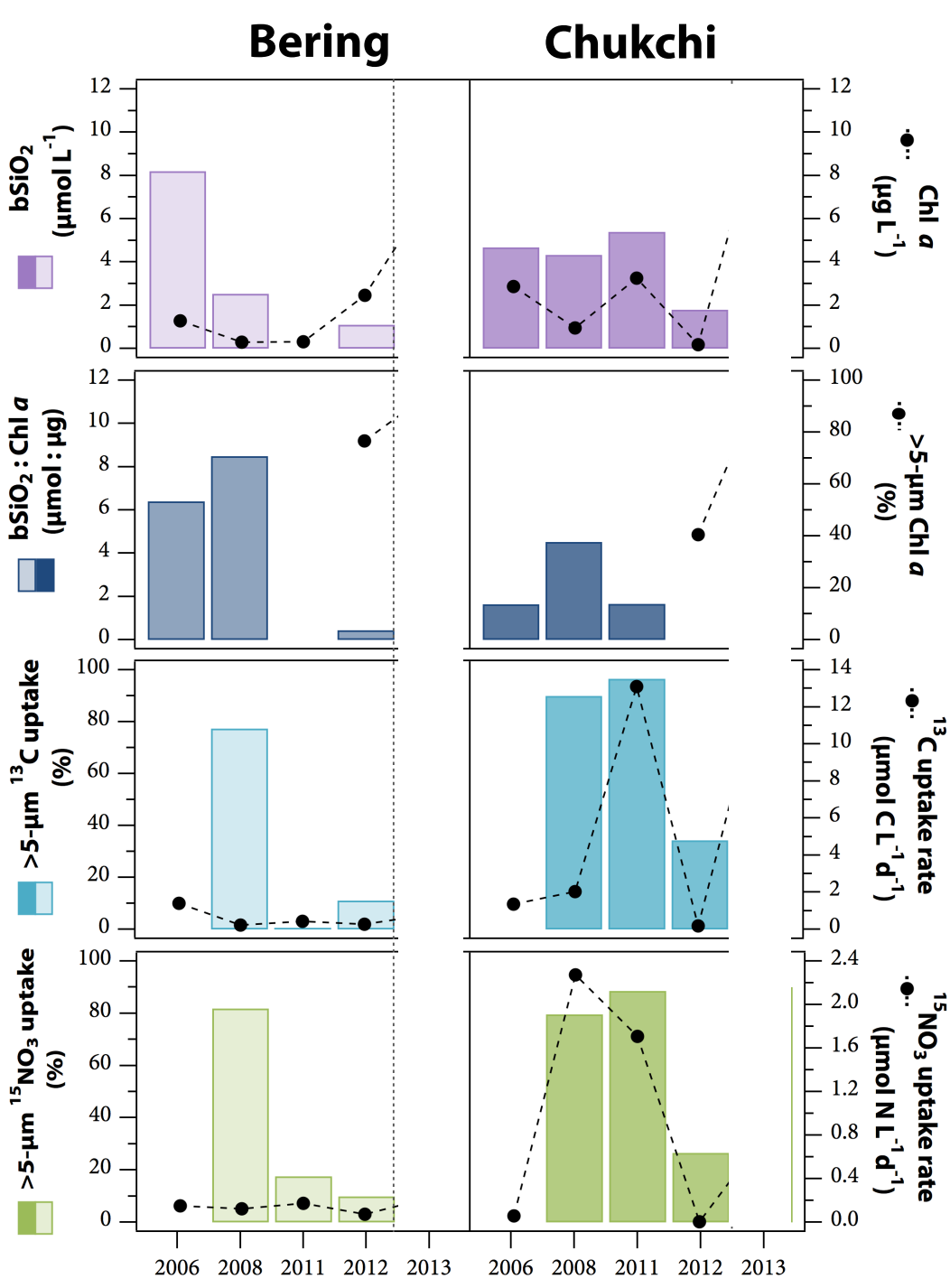
- Diatoms tend to be most abundant
- Notable abundance of coccolithophores on the DBO3 and DBO4 lines





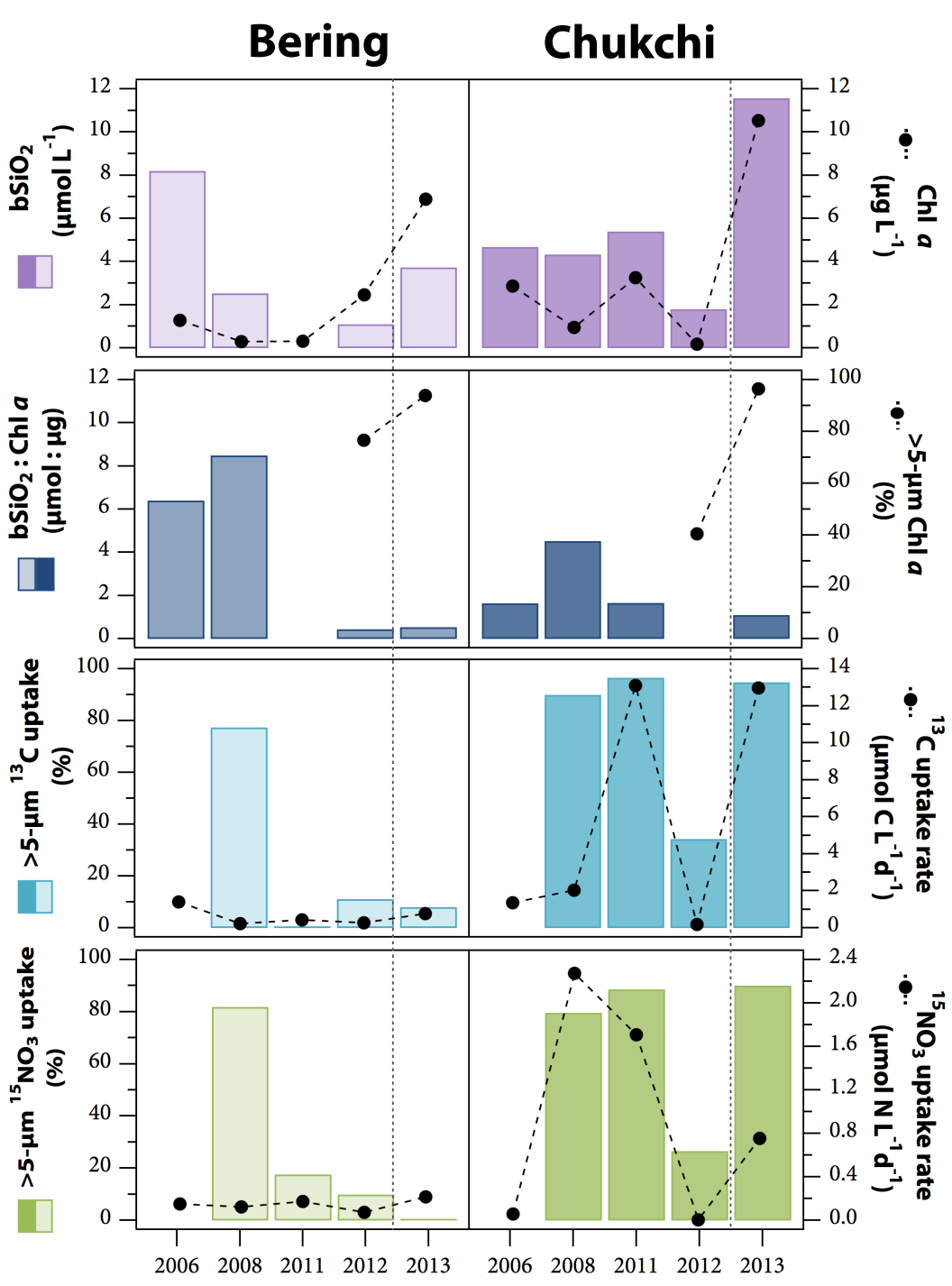
Phytoplankton community composition (Chlorophyll max)

- Small flagellates and coccolithophores are next most abundant after diatoms
- Diatoms decrease in abundance moving onshore on DBO3 line



Trends: 2006 - 2012

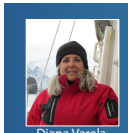
- Decreasing $bSiO_2$
- No clear trend for Chl *a*
- Decreasing $bSiO_2$:Chl *a* ratio
- Decreasing contribution of large (>5 µm) cells to productivity



Change in 2013

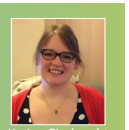
- $bSiO_2$ and Chl *a* increased
- $bSiO_2$:Chl *a* ratio remains low
- Dramatic increase in contribution of non-siliceous large cells to phytoplankton dynamics in the Chukchi Sea

Why chlorophyll doesn't tell the whole story: decreasing biogenic silica and microplankton productivity in the Bering and Chukchi Seas since 2006


Diana Varela
dvarela@uvic.ca

Diana E. Varela and Karina E. Giesbrecht

Department of Biology, and School of Earth and Ocean Sciences, University of Victoria, Victoria, BC, Canada.


Karina Giesbrecht
karinag@uvic.ca

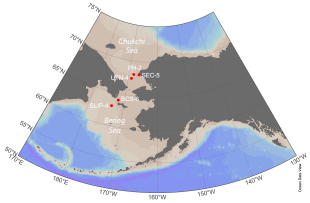
Introduction

The highly productive Bering and Chukchi Seas are undergoing rapid change due to shifts in climate forcing[1,2].

In response to these changes, an ecological monitoring program (Distributed Biological Observatory, DBO) was launched in 2010[3].

We compiled a time-series of summertime water column data of phytoplankton biomass and productivity, and the contribution of siliceous plankton (mainly diatoms) to phytoplankton dynamics through these regions measured as part of both DBO (2011 – 2013) and other previous Arctic programs[4].

Study Location



- Samples were obtained from stations in the Bering and Chukchi Seas during five July research cruises in 2006, 2008, 2011, 2012 and 2013.
- For comparison, stations were divided into two regions:

Region	Station	Year(s) sampled
Bering	BCS-6	2006
	SLIP-4	2008, 2011, 2012, 2013
Chukchi	PH-2	2006
	UTN-4	2008, 2011, 2013
	SEC-5	2012

- Sampling dates within regions were ± 4 days of each other from year to year (Bering: July 13-16; Chukchi: July 17-19).

Methods

- At each station, seawater samples were collected at depths corresponding to 100, 50, 30, 12, 1 and 0.1% of surface irradiance.
- Samples were taken for the measurement of biogenic silica ($bSiO_2$), chlorophyll *a* (Chl *a*), and uptake rates of carbon (C) and nitrate (NO_3^-) by phytoplankton.
- Experiments for C (^{13}C) and NO_3^- ($^{15}NO_3^-$) uptake rates were conducted by placing isotopically-enriched samples in temperature-controlled on-deck incubators for approximately 24 hours. The isotopic composition was measured by mass spectrometry.

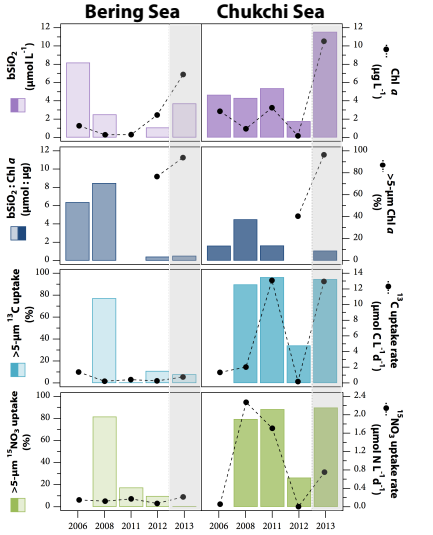
References

1. Grebmeier, J. M. *et al.* (2006). Science. **311**:1461-1464
2. Grebmeier, J. M. (2012). Annu. Rev. Mar. Sci. **4**:63–78
3. Grebmeier, J.M. *et al.* (2010). EOS. **91**(*18*): 161-162
4. Collaboration between Fisheries and Oceans Canada (DFO) and Western Arctic Shelf Basin Interactions (NSF-SBI) in 2006; and Canada's Three Oceans (C3O) in 2008
5. Li *et al.* (2009). Science. **326**: 539

Acknowledgements

- Brianne Kelly, Ian Wrohan, Eddy Carmack (PI: C3O), Jackie Grebmeier (PI: DBO), Sarah Zimmerman, Jane Eert, Svein Vagle, and other members of the Arctic group at the Institute of Ocean Sciences (Fisheries and Oceans Canada)
- Crew and officers of the the CCGS Sir Wilfrid Laurier
- Sea ice concentration ASI Algorithm AMSR-E data were retrieved from the Integrated Climate Date Center (ICDC, http://icdc.zmaw.de/), Hamburg, Germany, [February, 2014]

Evidence of shifting phytoplankton communities in the Bering and Chukchi Seas



The >5-μm C and NO_3 uptake rates were measured only at the 50% light depth. The remaining data presented are euphotic-zone averages calculated by normalizing integrated values (from 100 to 0.1% I_o) by the depth of integration.

Trends observed from 2006 – 2012

Decrease in the contribution of siliceous plankton to phytoplankton dynamics and in the total phytoplankton productivity in both regions. This is shown by:

- **Decreased $bSiO_2$**
- **Decreased $bSiO_2$:Chl *a* ratios**
- **Decreased contribution of >5-μm cells to total C and NO_3 uptake**
- **Decreased total C and NO_3 uptake**

Change in 2013

Contribution of siliceous plankton to phytoplankton biomass remains low in both regions. This is shown by:

- **Low $bSiO_2$:Chl *a* ratios**

Dramatic increase in the contribution of non-siliceous large-cells to phytoplankton dynamics and in the total phytoplankton productivity in the Chukchi Sea. This is shown by:

- **Increased contribution of >5-μm cells to biomass and total C and NO_3 uptake**
- **Increased total C and NO_3 uptake**

Changing physical oceanographic conditions and sea-ice dynamics

Physical oceanographic conditions

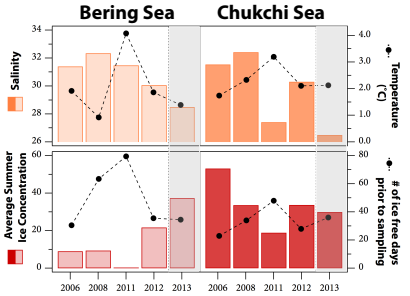
Decreasing salinity may be driving the observed community shift.

- Striking **salinity** decrease in both regions
- Variable **temperature** patterns in both regions

Sea-ice dynamics

Sea-ice conditions do not correlate with the observed trends in phytoplankton dynamics:

- Opposing trends in **summer sea-ice concentration** between regions
- Variable number of ice-free days prior to sampling in both regions



Temperature and Salinity measurements are euphotic-zone averages calculated by normalizing integrated values (from 100 to 0.1% I_o) by the depth of integration.

Summary and Conclusions

- We found that the contribution of siliceous plankton (mainly diatoms) to phytoplankton biomass in the Bering and Chukchi Seas has decreased by 75 – 93% since 2006, a trend which may be driven by the decreasing salinity observed in both regions and is similar to that observed in other regions of the Arctic[5].
- Our results show that other measurements in addition to total chlorophyll *a* concentrations are required to properly evaluate the status of a changing phytoplankton community. Shifting community composition may have a dramatic effect on both marine food webs and the climate.
- This dataset also highlights the importance of ecological monitoring programs such as DBO in understanding how climate-induced changes are affecting the highly sensitive sub-polar and polar regions.