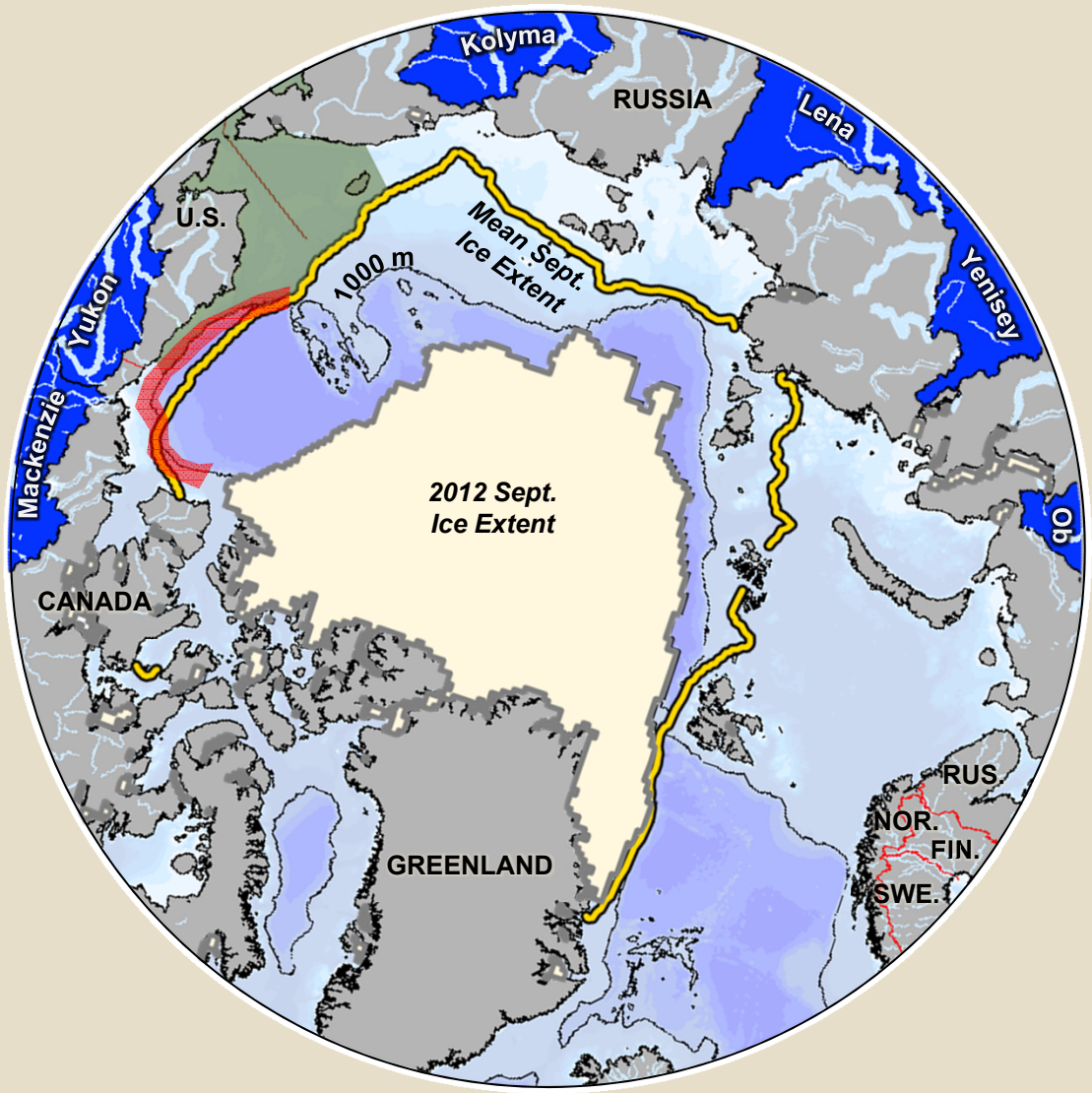
Formation and Transport of Corrosive Water in the Pacific Arctic Region

Jessica Cross, Wiley Evans, Jeremy Mathis, Nicholas Bates, Robert Pickart

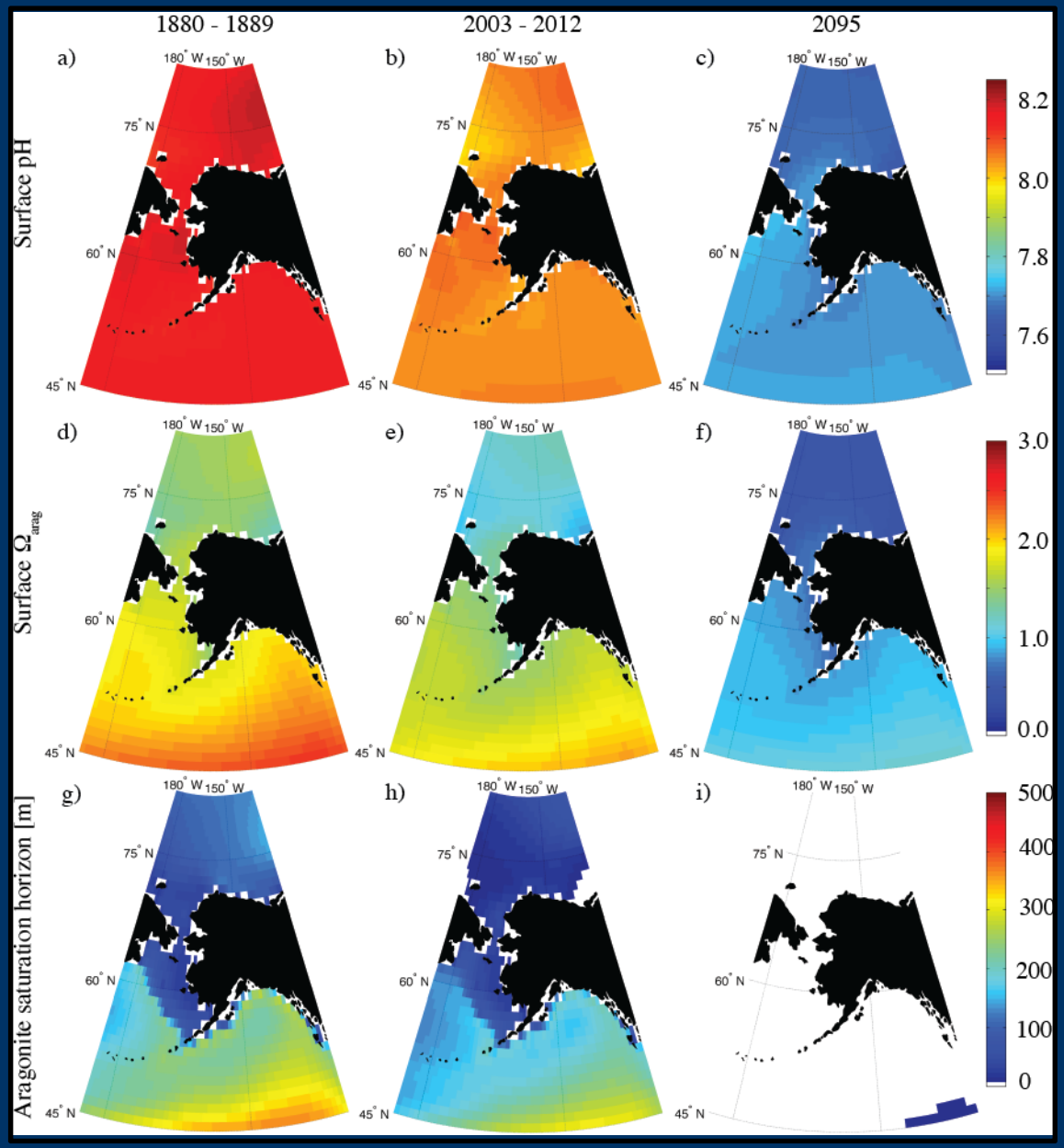
2014 OCB Summer Workshop

The Changing Pacific Arctic Carbon Cycle

- The western Arctic is undergoing dynamic change:
  - Warming temperatures
  - Sea ice loss
  - Changes in circulation and FW inputs
  - Timing, fate, and location of primary production
  - Ocean acidification

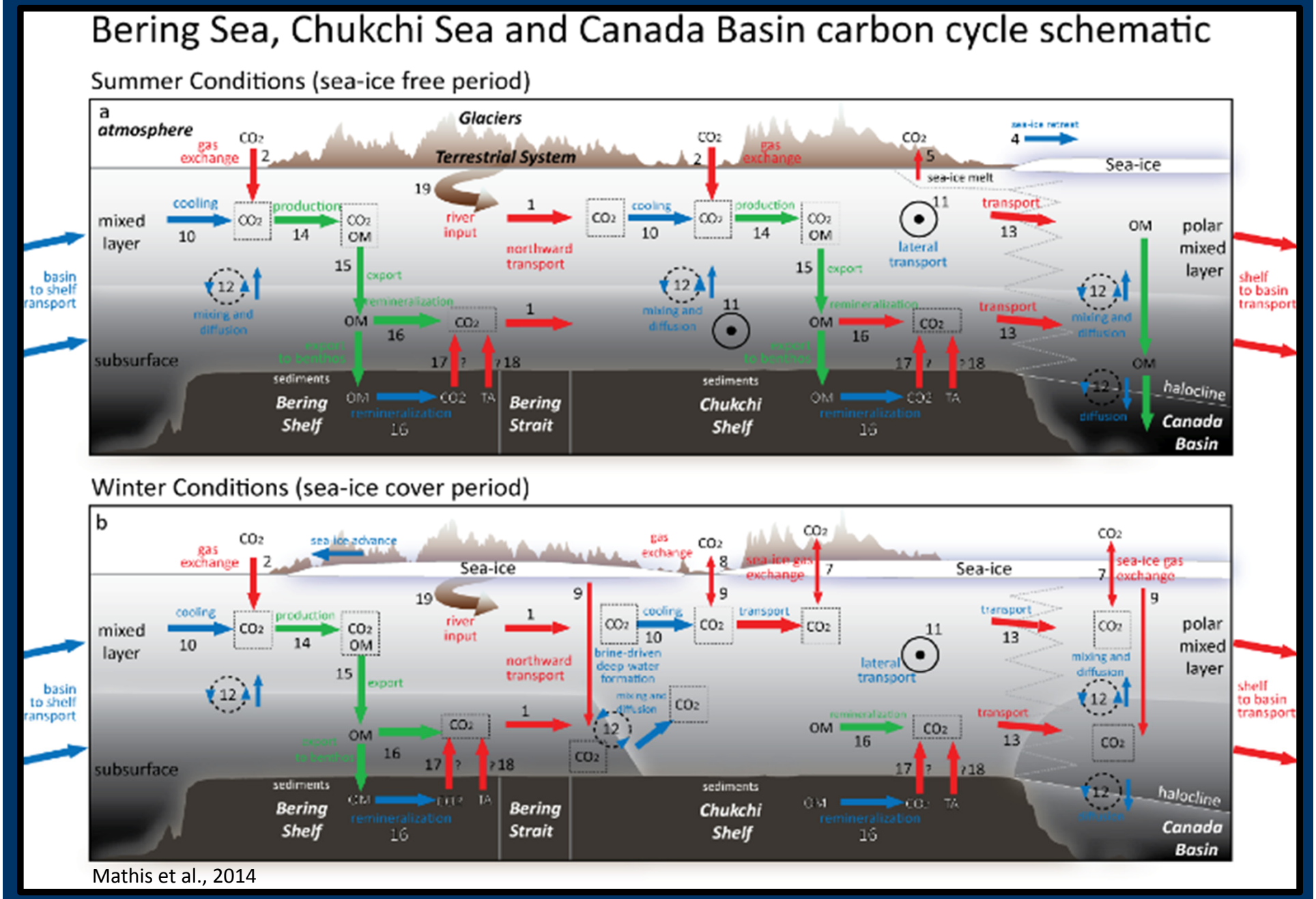


Rapid Onset of OA in the Arctic



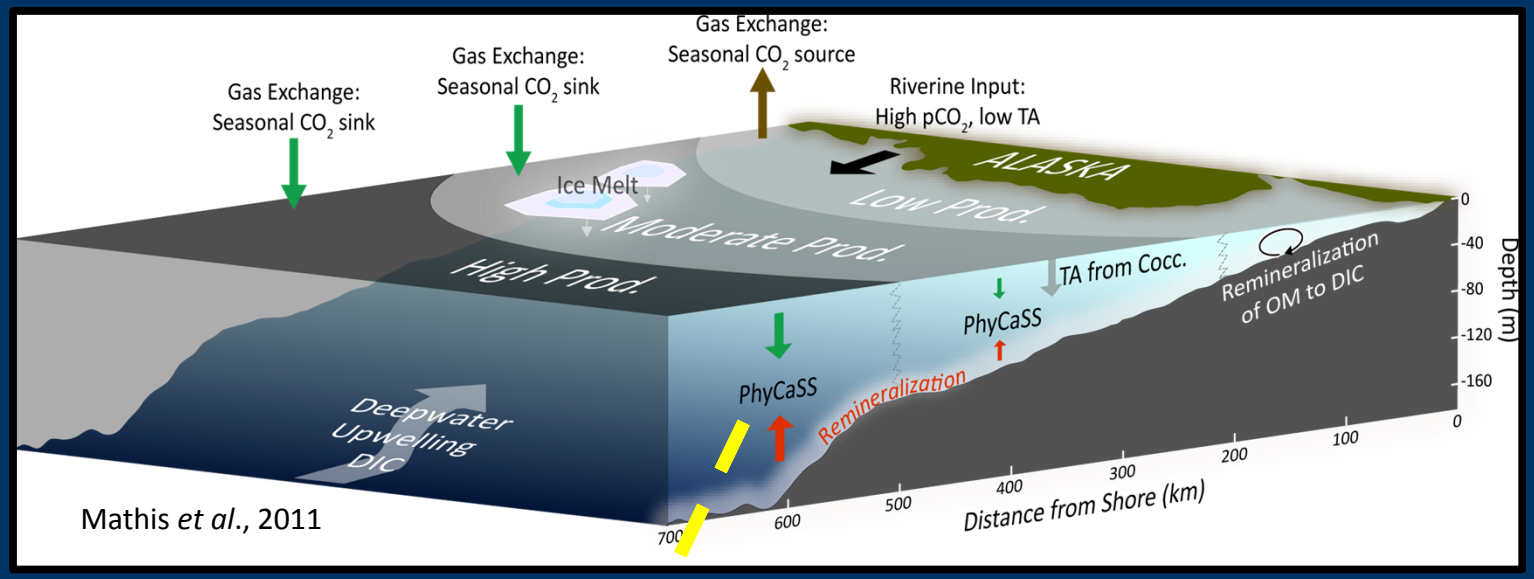
Mathis et al., In Press
Progress in Oceanography

Biogeochemical Modifications Over the Bering/Chukchi Shelf

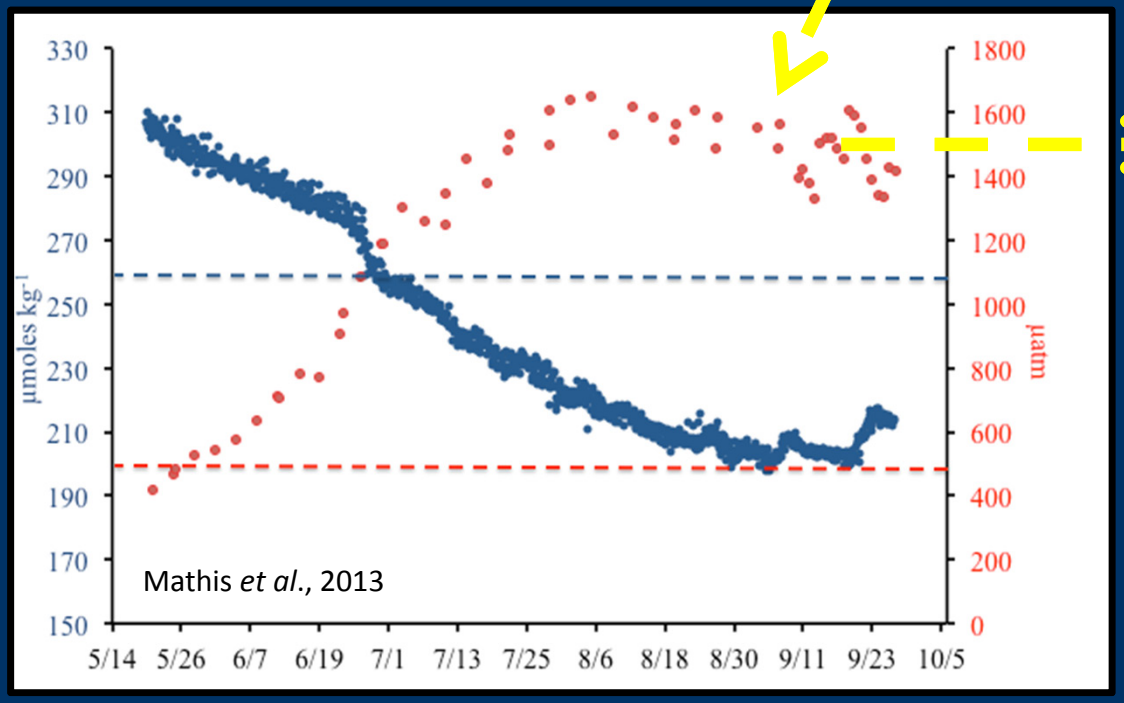


Mathis et al., 2014

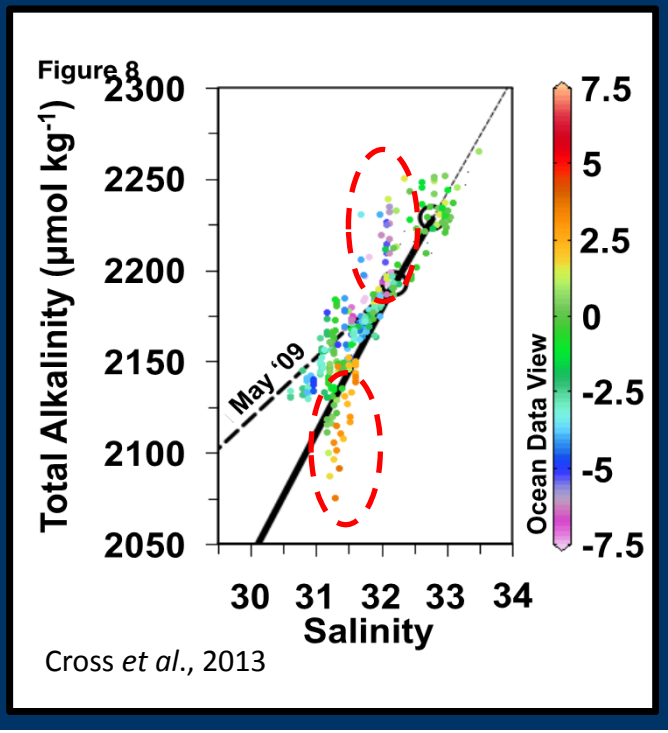
OA in the Bering Sea



Mathis *et al.*, 2011



Mathis *et al.*, 2013

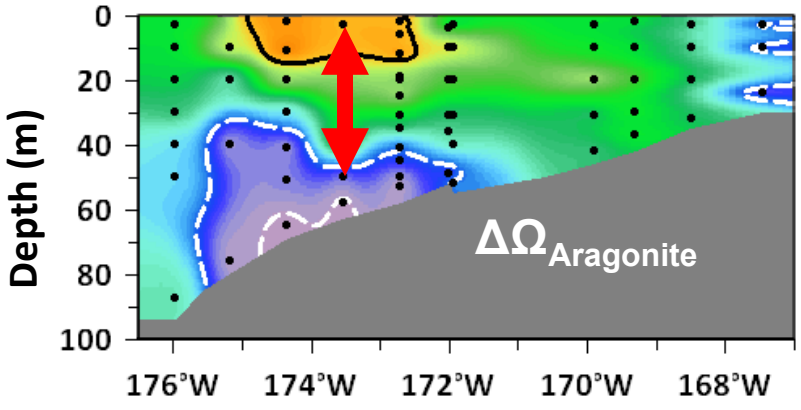


Cross *et al.*, 2013

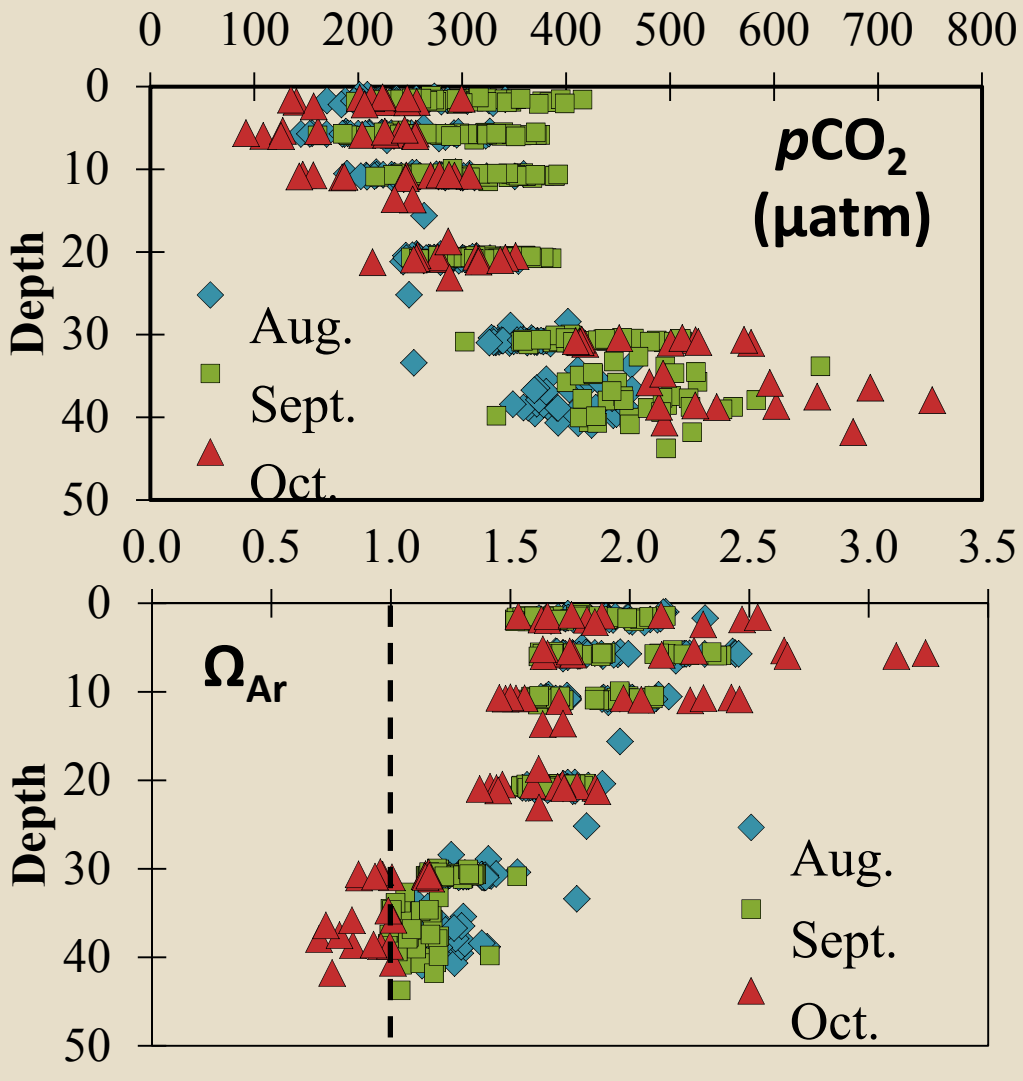
Preconditioning of Pacific Inflow

CO_2 accumulates seasonally from water column and sedimentary respiration over the shallow shelves of the Bering and Chukchi Seas during summer and fall.

Bering Sea

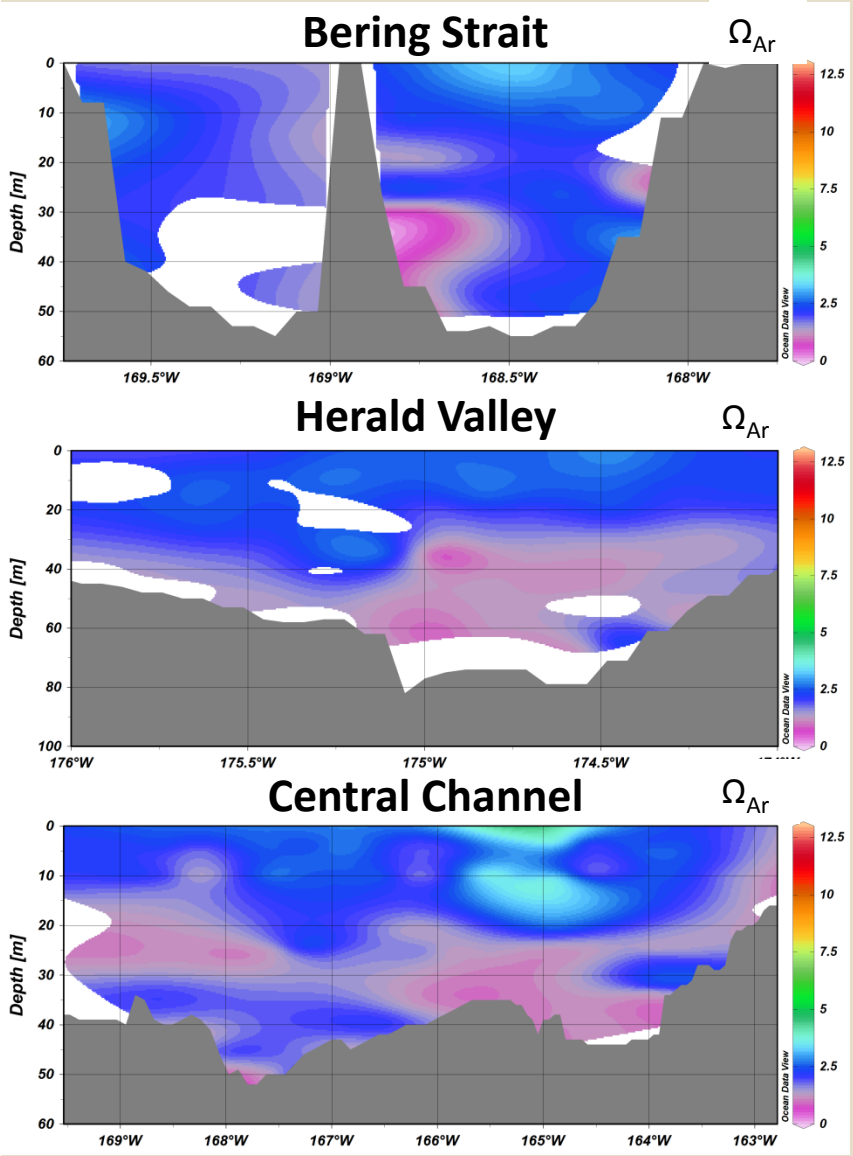


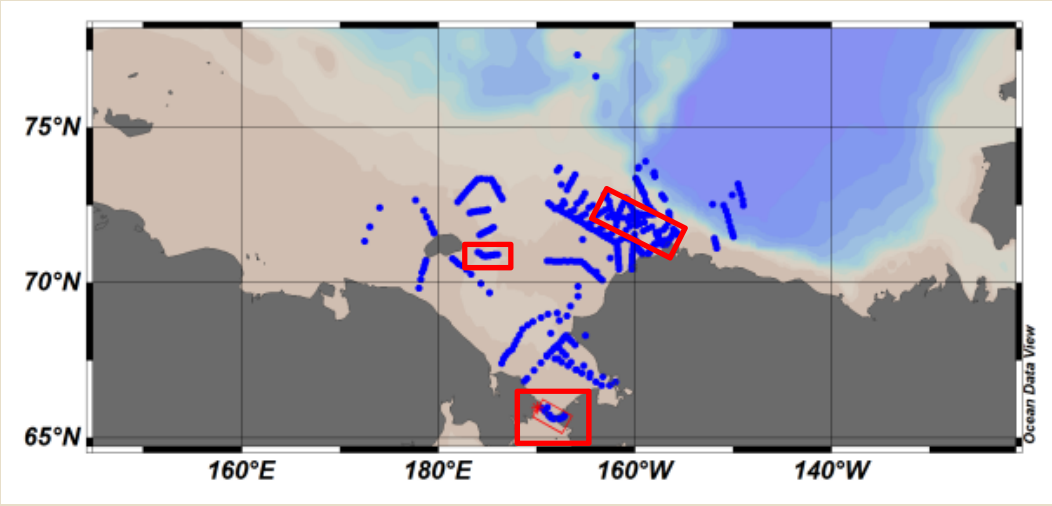
Chukchi Sea



Mathis, J.T., and Questel, J.M., 2013, CSR 67, 42-51

Widespread Undersaturations in the Chukchi Sea





Summertime calcium carbonate undersaturation in shelf waters of the western Arctic Ocean – how biological processes exacerbate the impact of ocean acidification

Biogeosciences Open Access

N. R. Bates[1], M. I. Orchowska[2], R. Garley[1], and J. T. Mathis[3]

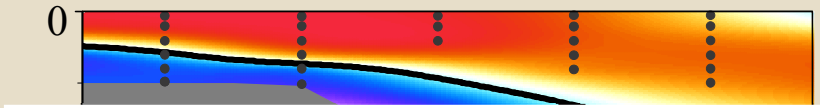
At least 40% of the Chukchi Sea benthos is exposed to bottom waters that are corrosive to $CaCO_3$ during summertime.

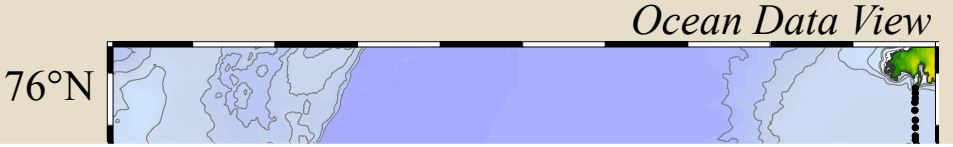
N. Bates, Pers. Comm.

Bates et al., unpublished data

RUSALCA data combined with 2010/2011 ICESCAPE data

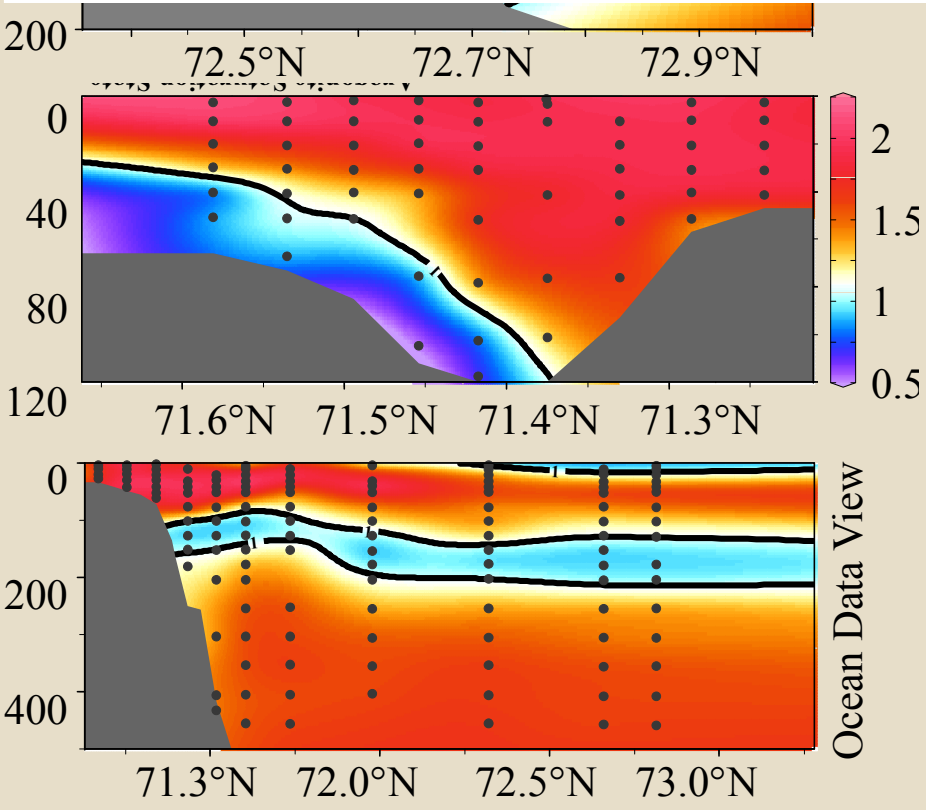
Undersaturation in the Pacific Inflow

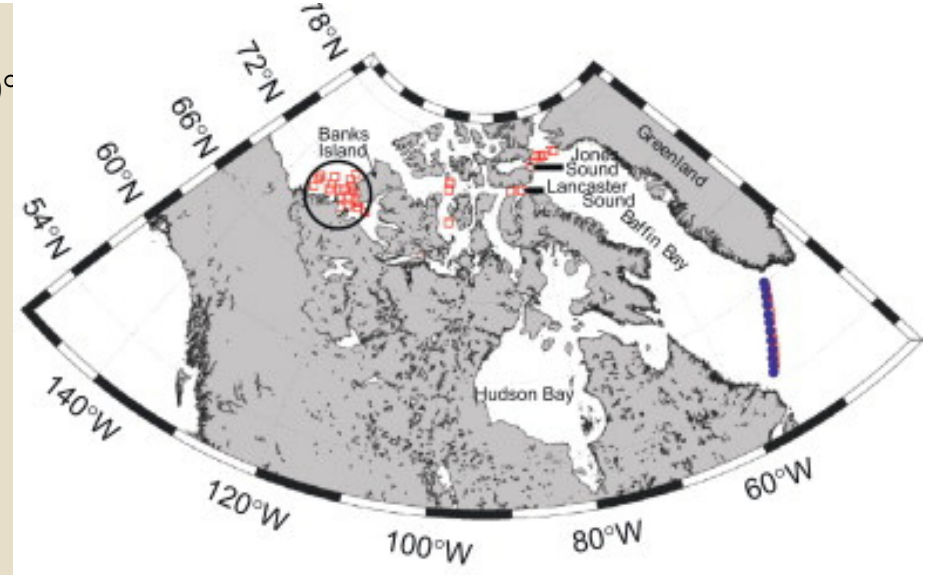




Export of Pacific carbon through the Arctic Archipelago to the North Atlantic

E.H. Shadwick [a,*], H. Thomas [a], Y. Gratton [b], D. Leong [a], S.A. Moore [a], T. Papakyriakou [c], A.E.F. Prowe [d]

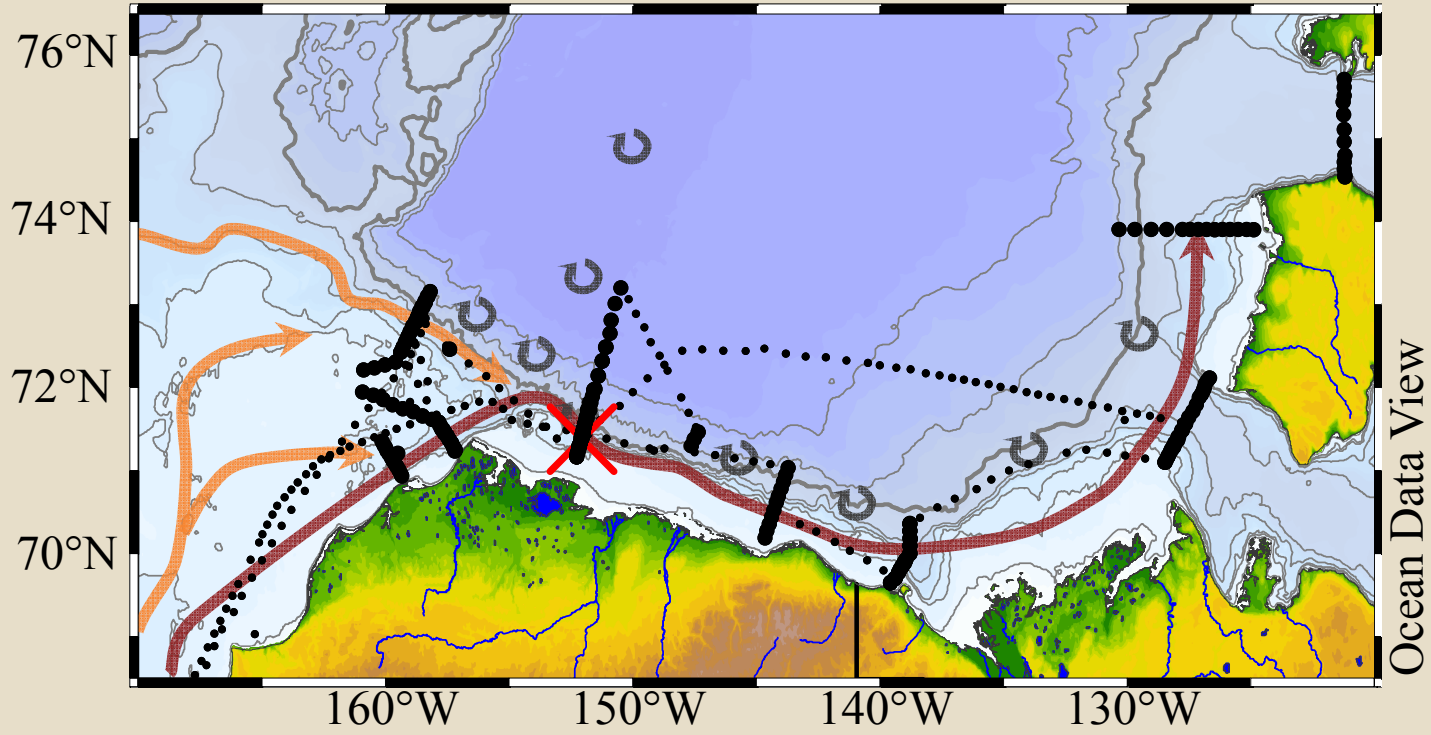




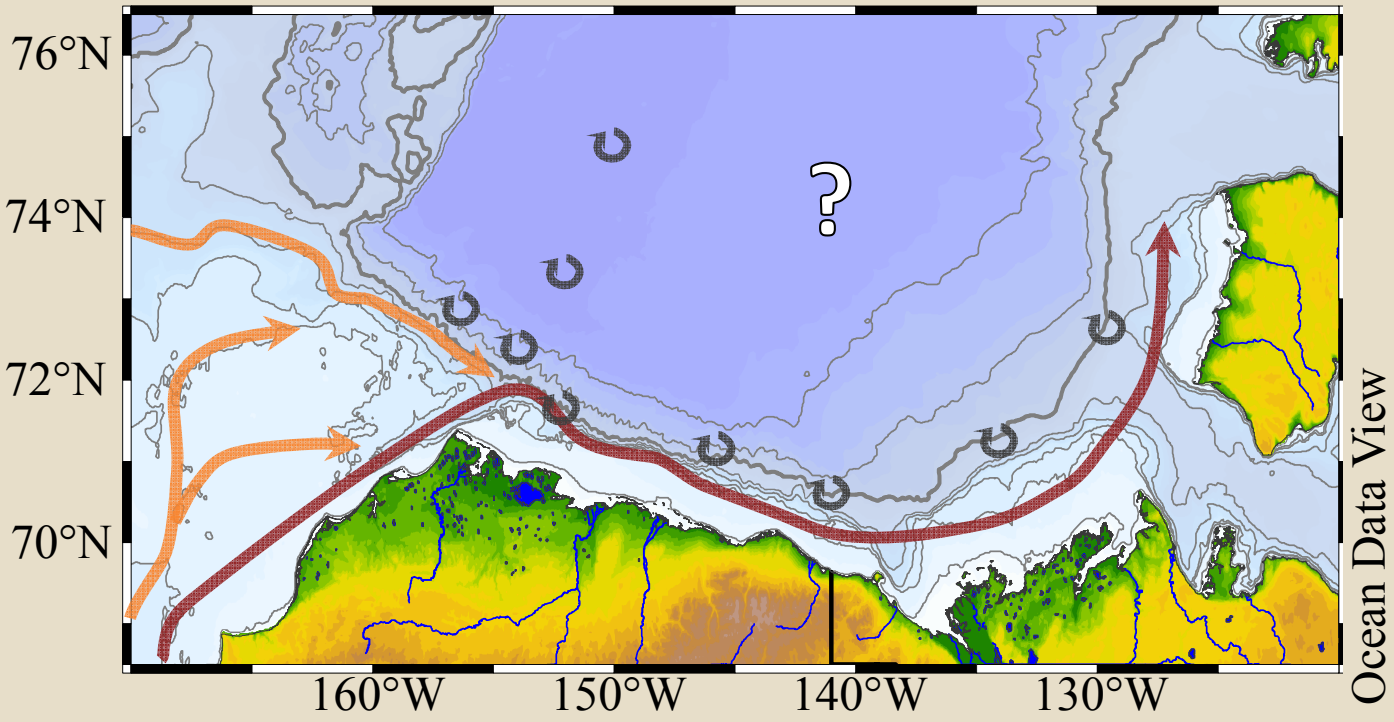
What is the fate of this undersaturated water?

The Beaufort Sea Boundary Current

- What is the fate of this undersaturated water?
  - **Canadian Archipelago.** *Flow eastward in a subsurface intensified shelf-break jet*
  - **The Basin.** *Unstable jet produces subsurface anticyclonic eddies that ventilate the upper halocline*



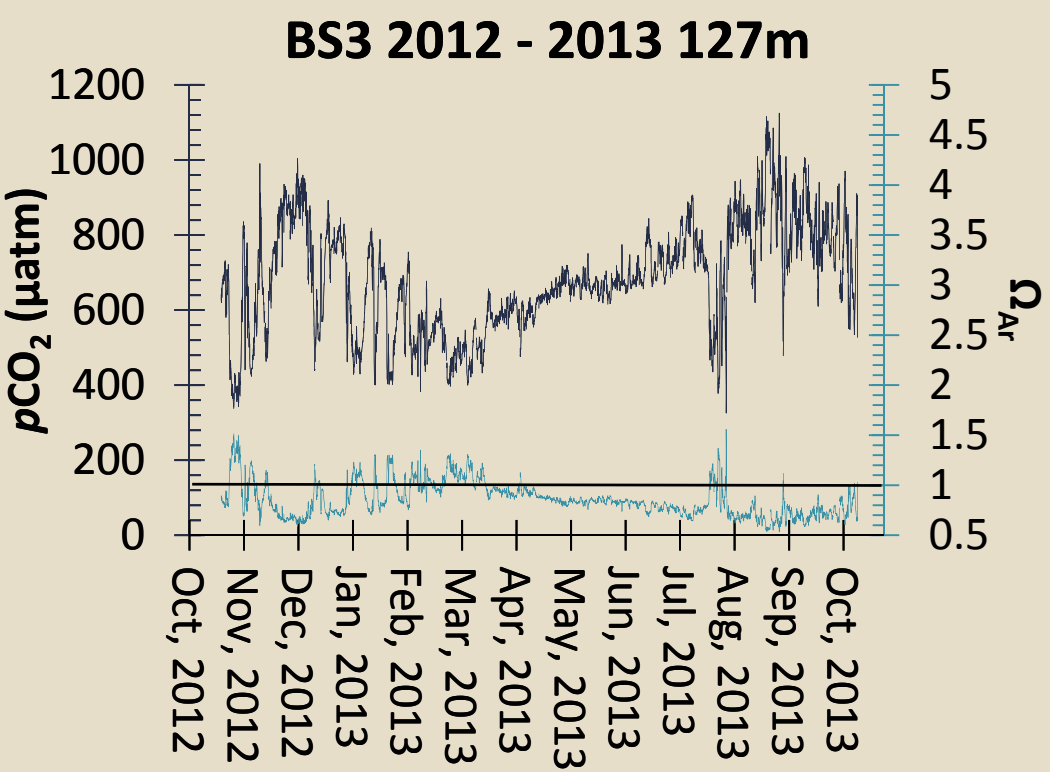
Estimating Basin Transport

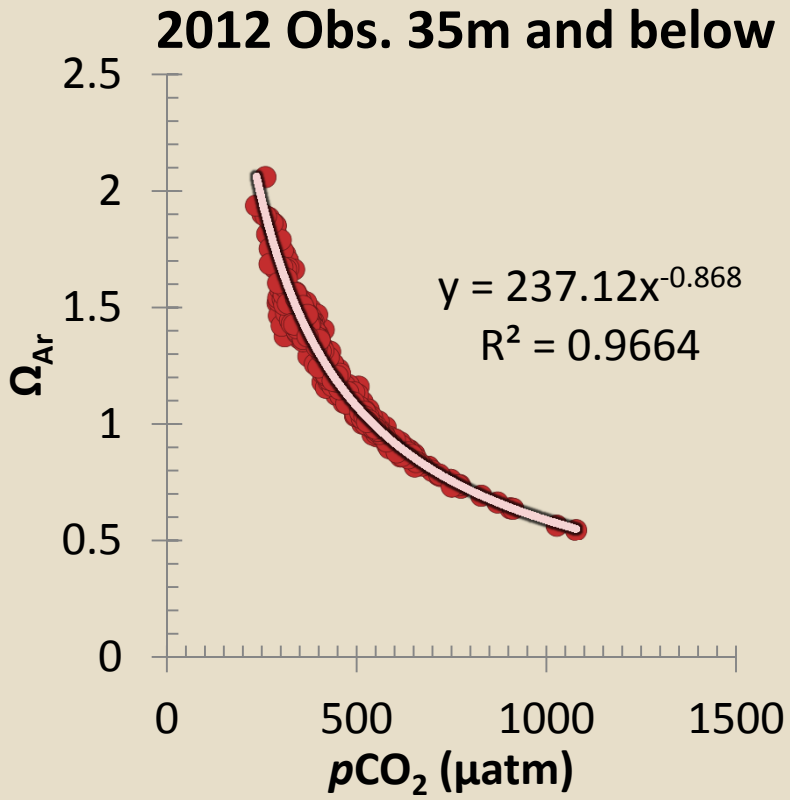


Eddy transport of organic carbon and nutrients from the Chukchi Shelf: Impact on the upper halocline of the western Arctic Ocean

Jeremy T. Mathis,[1] Robert S. Pickart,[2] Dennis A. Hansell,[1] David Kadko,[1] and Nicholas R. Bates[3]

How Much Undersaturated Water is There?



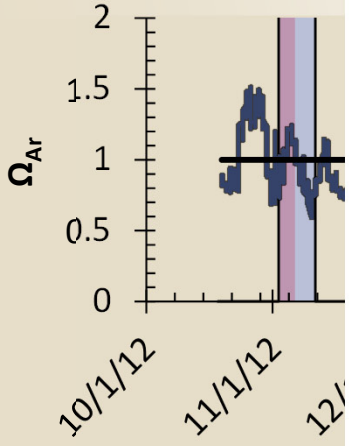


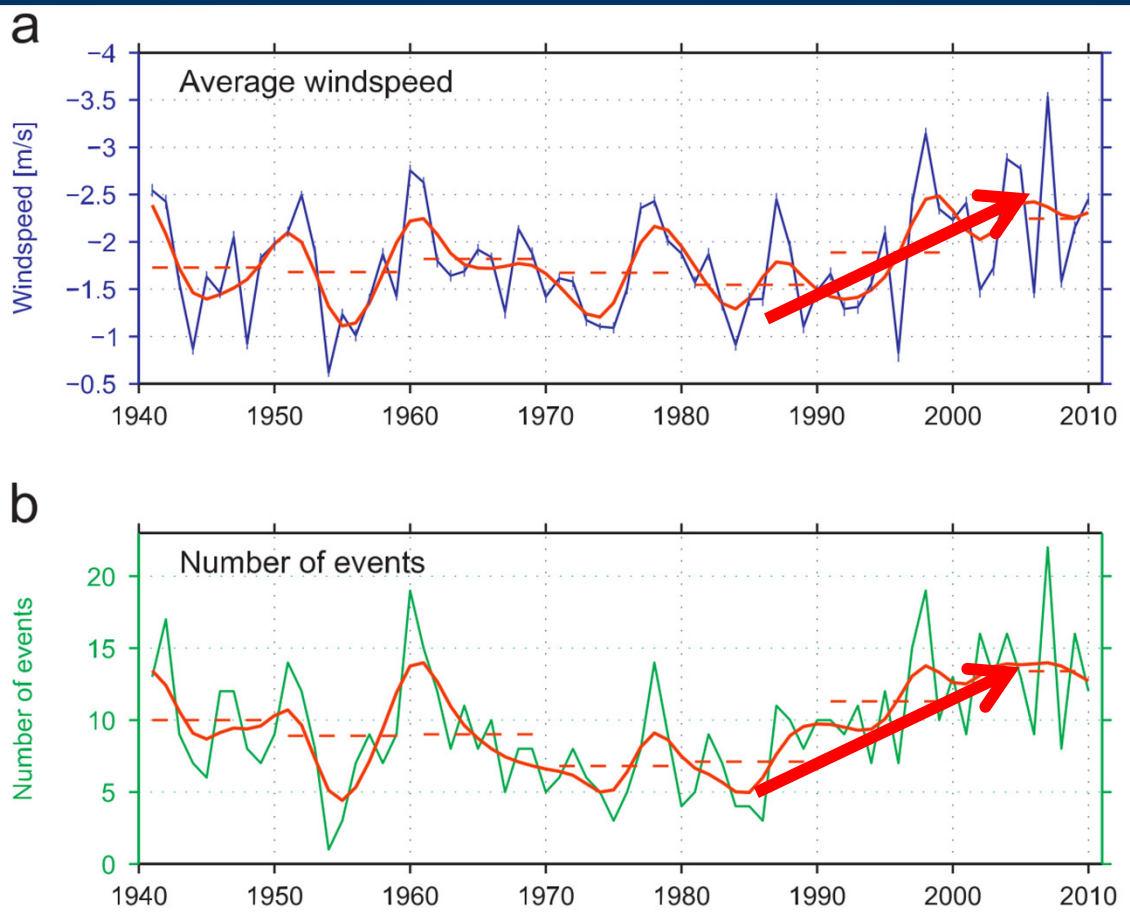
- Ω < 1 : 80% of the year
- Ω < 0.75 : 30% of the year

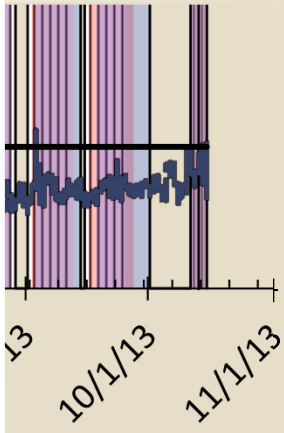
What is the fate of this undersaturated water?

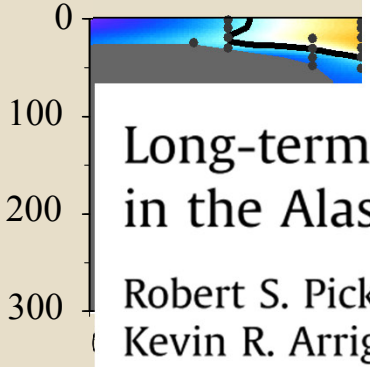
Upwelling

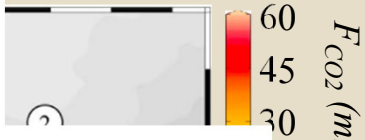
- **The atm** *eliminat* *vater will be* *here*
- 10 event
- 8-25% o *elling*









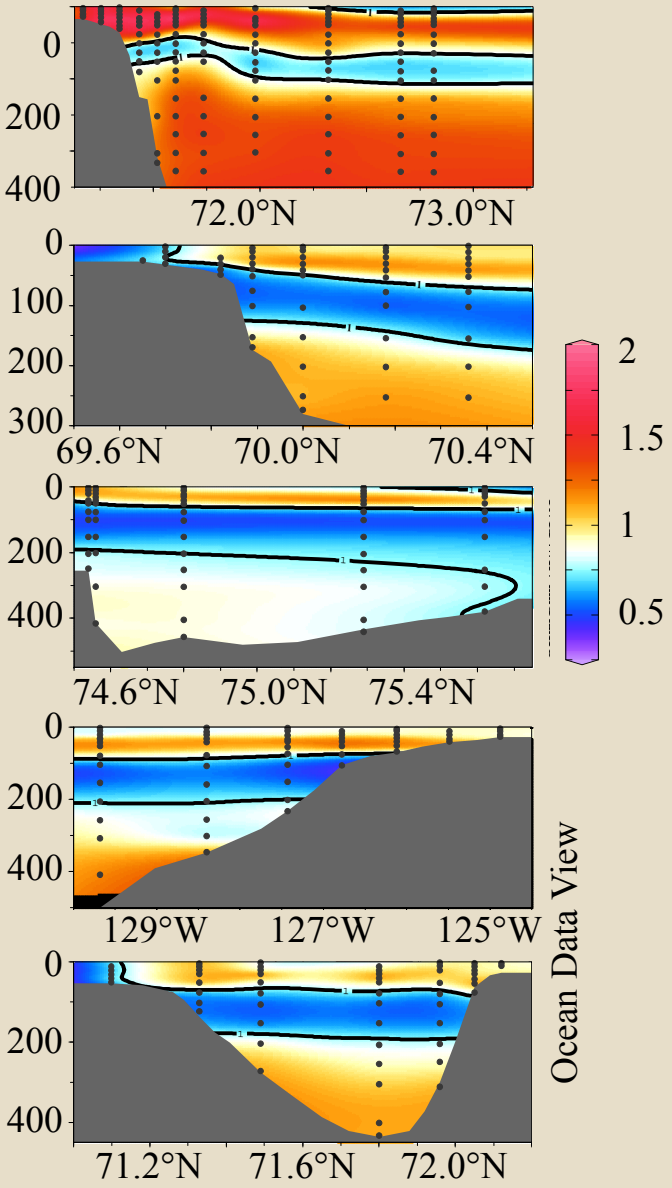


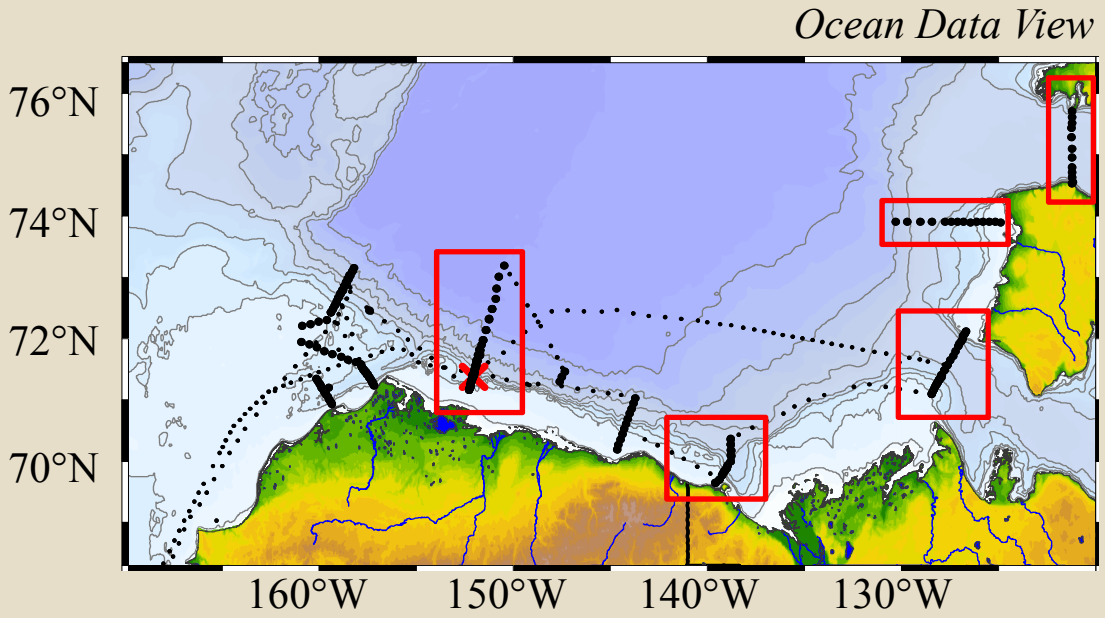
Long-term trends of upwelling and impacts on primary productivity in the Alaskan Beaufort Sea

Robert S. Pickart [a,*], Lena M. Schulze [a], G.W.K. Moore [b], Matthew A. Charette [a], Kevin R. Arrigo [c], Gert van Dijken [c], Seth L. Danielson [d]

Mathis, J.T., et al., 2012. GRL 39, L07606

The Canadian Archipelago

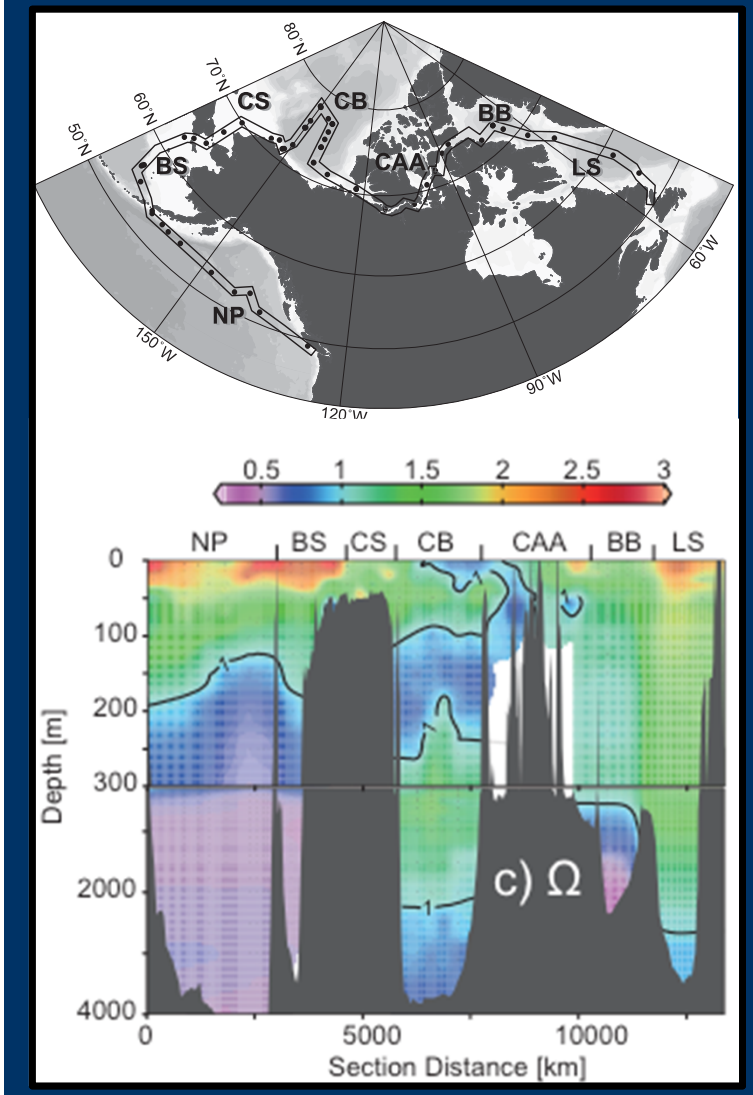




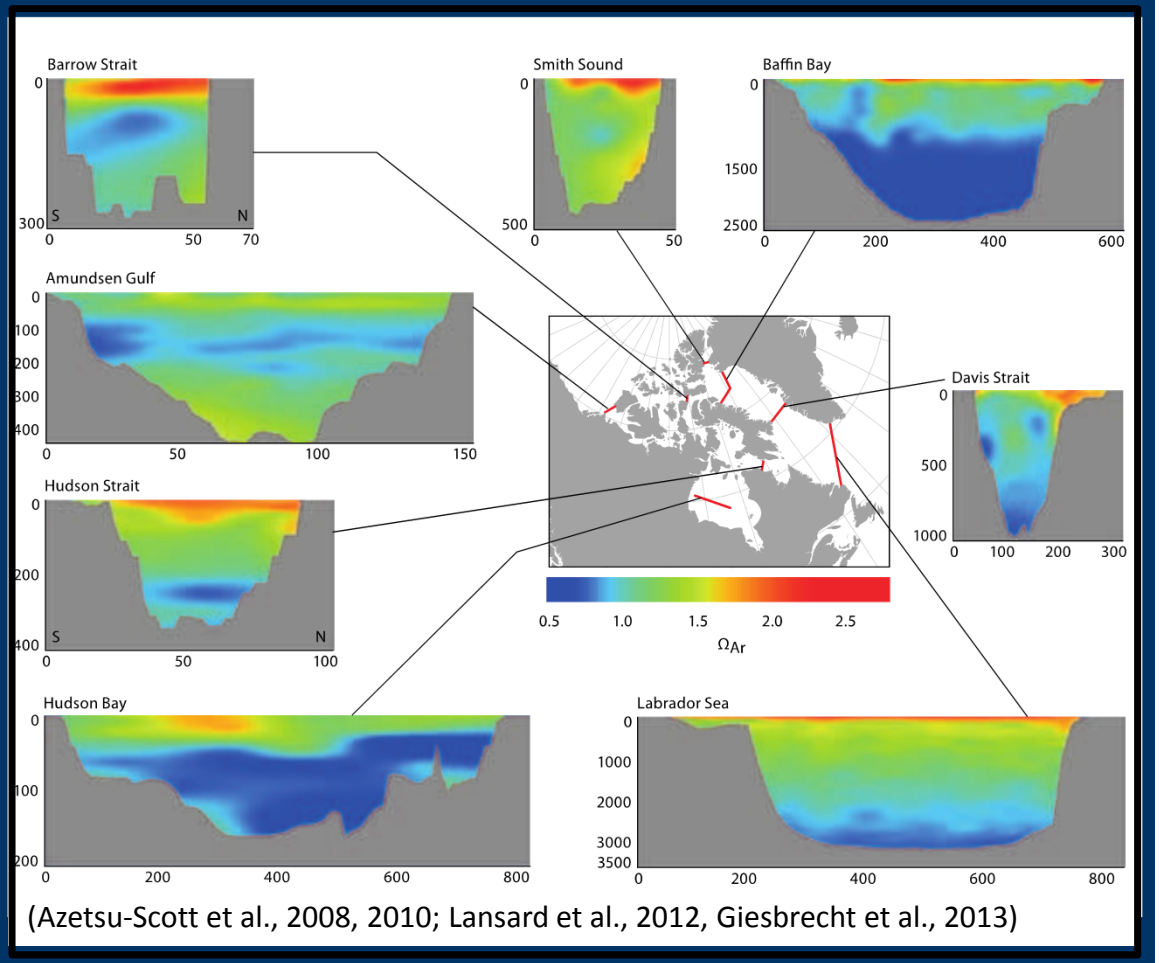
How much undersaturated water remains in the current?

- ~172 non-upwelling days of undersaturated water transport at BS3
- 58% of total volume of undersaturated water remains in the current at BS3
  - Likely a lower bound

The Fate of Shelf Modified Inflow Waters



Yamamoto-Kawai et al., 2013



(Azetsu-Scott et al., 2008, 2010; Lansard et al., 2012, Giesbrecht et al., 2013)

Conclusions

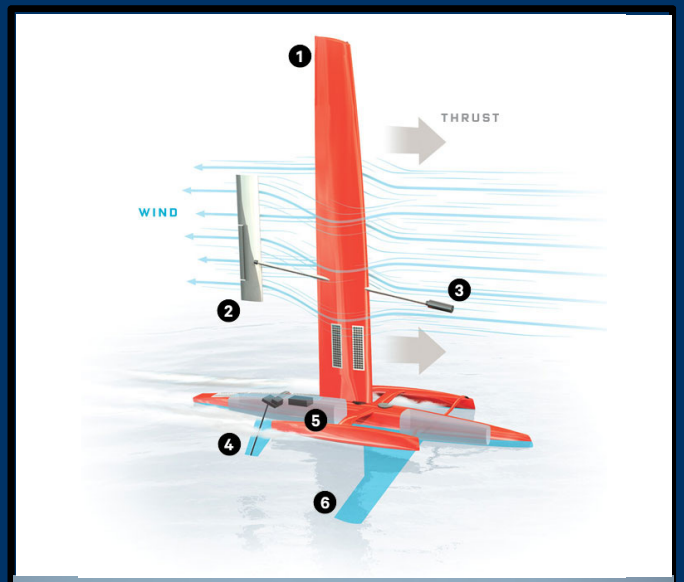
- **Natural biogeochemical preconditioning combined with anthropogenic CO_2 produces strong undersaturations in Pacific-Arctic inflow**
  - **$\Omega < 1$: 80%**
  - **$\Omega < 0.75$: 30%**
- **Three primary destinations for this undersaturated water:**
  - **The Atmosphere (8 – 25%)**
    - **May increase in the future**
  - **(The Canadian Archipelago + The Basin): 58%**
  - ***Still missing ~20%***
    - ***Conservative estimation of westward flow of undersaturated water at BS3***
    - ***Early shelf-basin exchange***

Enhancing and Expanding the Observations

Carbon Wave Glider

Autonomous platforms could increase our observational coverage by several orders of magnitude.

Sail Drone



OA and CO_2 in the North Atlantic