Ocean physics as a driver of N_2 fixation at the shelf-break

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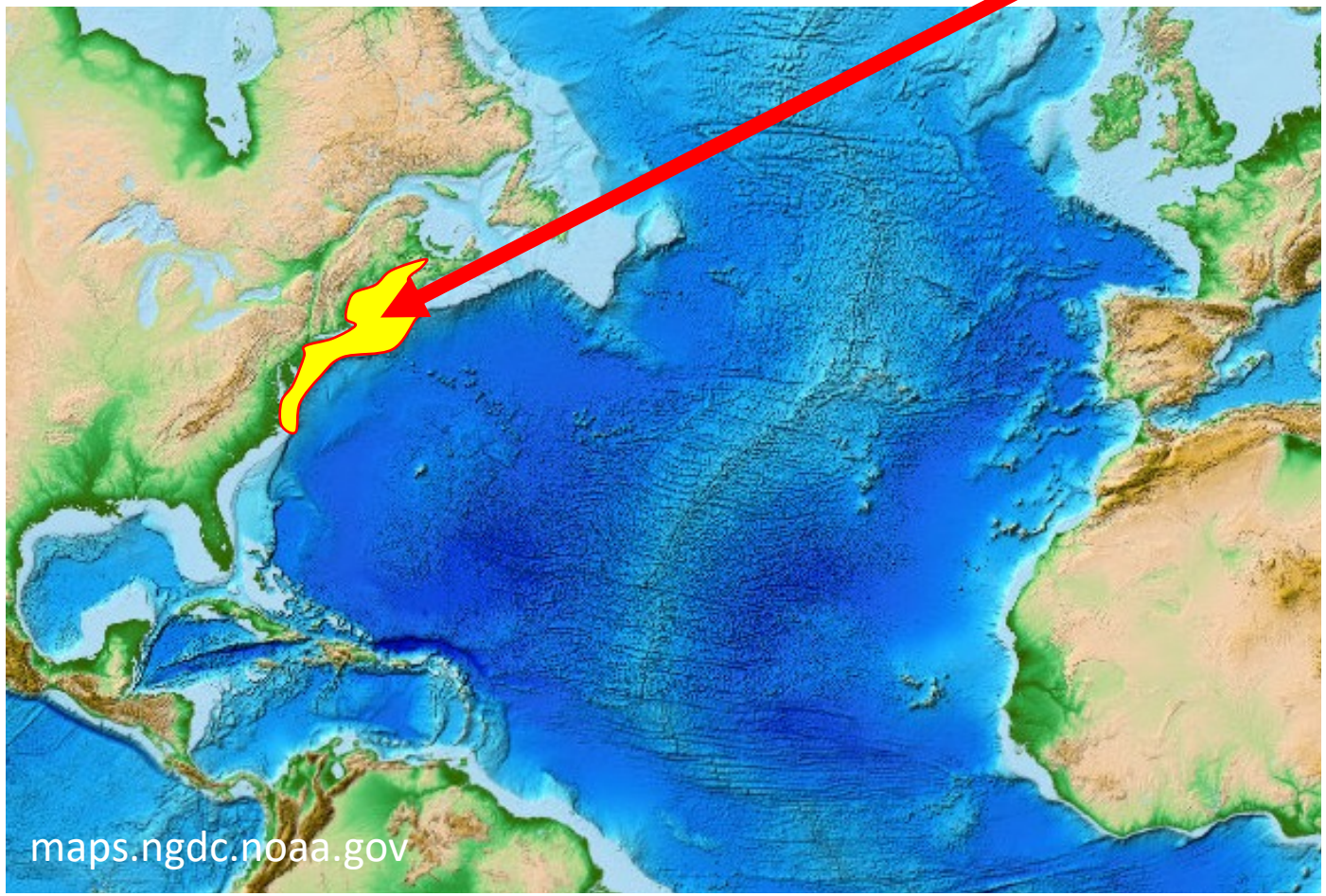
Ocean physics as a driver of N_2 fixation at the shelf-break

- A significant proportion of marine N_2 fixation likely occurs on continental shelves where diazotrophy can facilitate drawdown of terrestrial nutrients once N is exhausted.
- Coastal diazotrophy influenced by shelf-break frontal dynamics e.g.,
  - mixing
  - eddies
  - upwelling

  which are likely to change as the planet warms.

A significant proportion of marine N_2 fixation likely occurs on continental shelves.



Estimate for MAB – GoM shelf (6.4% total North Atlantic shelf area):

~0.02 Tmol N yr $^{-1}$

(Mulholland, Bernhardt, Widner, **Selden** et al. 2019 *GBC*)

Extrapolation of above estimate to entire shelf:

~0.31 Tmol N yr^{-1}

Relative contribution of NA shelf to basin:

3.6 – 5.7%

Geochemical mass balance:
Capone et al. 2005 *GBC*

12.4 – 63%

Computational models:
Tang et al. 2020 *JGR Biogeosci.;* Landolfi et al. 2015 *GRL*

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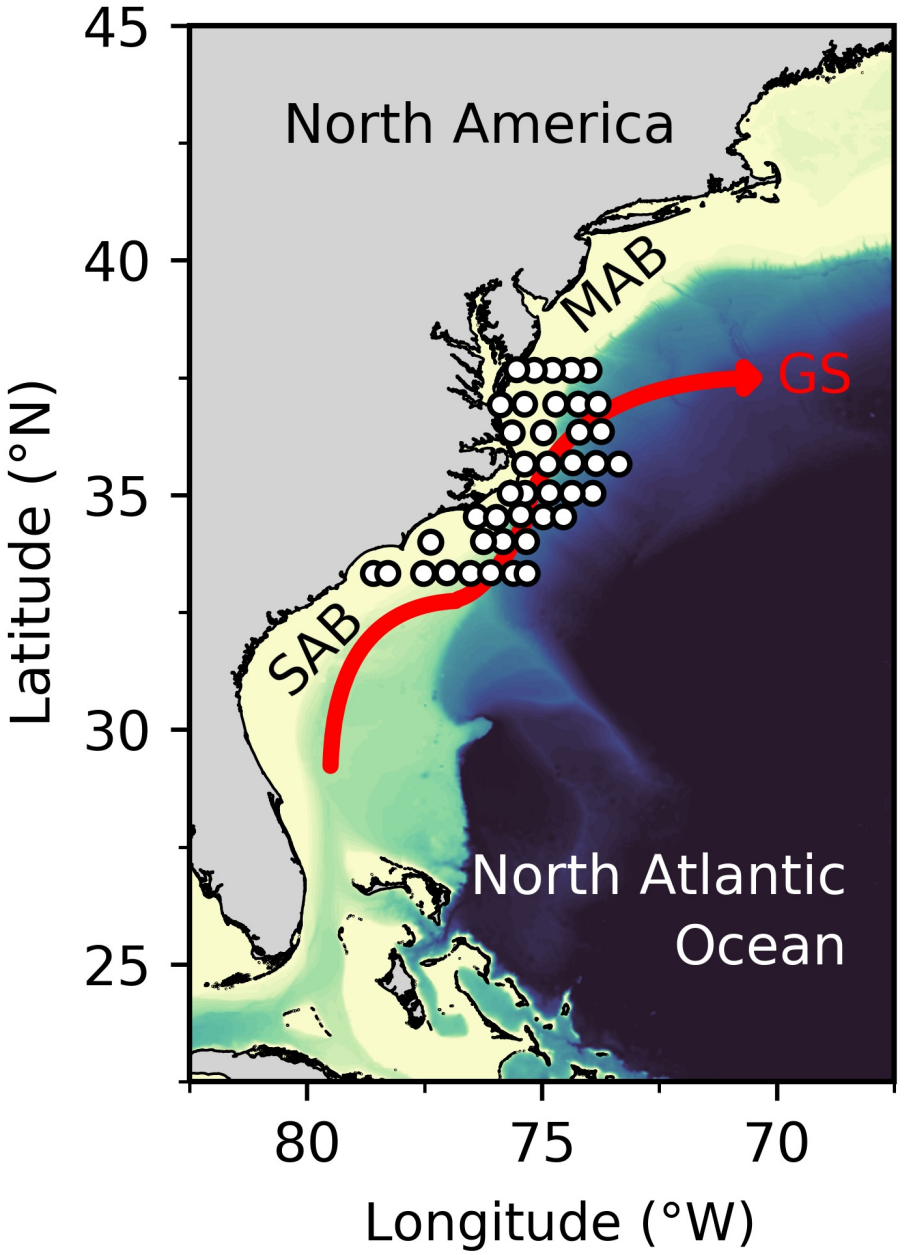


A significant proportion of marine N_2 fixation likely occurs on continental shelves *where diazotrophy facilitates drawdown of terrestrial nutrients once N is exhausted.*

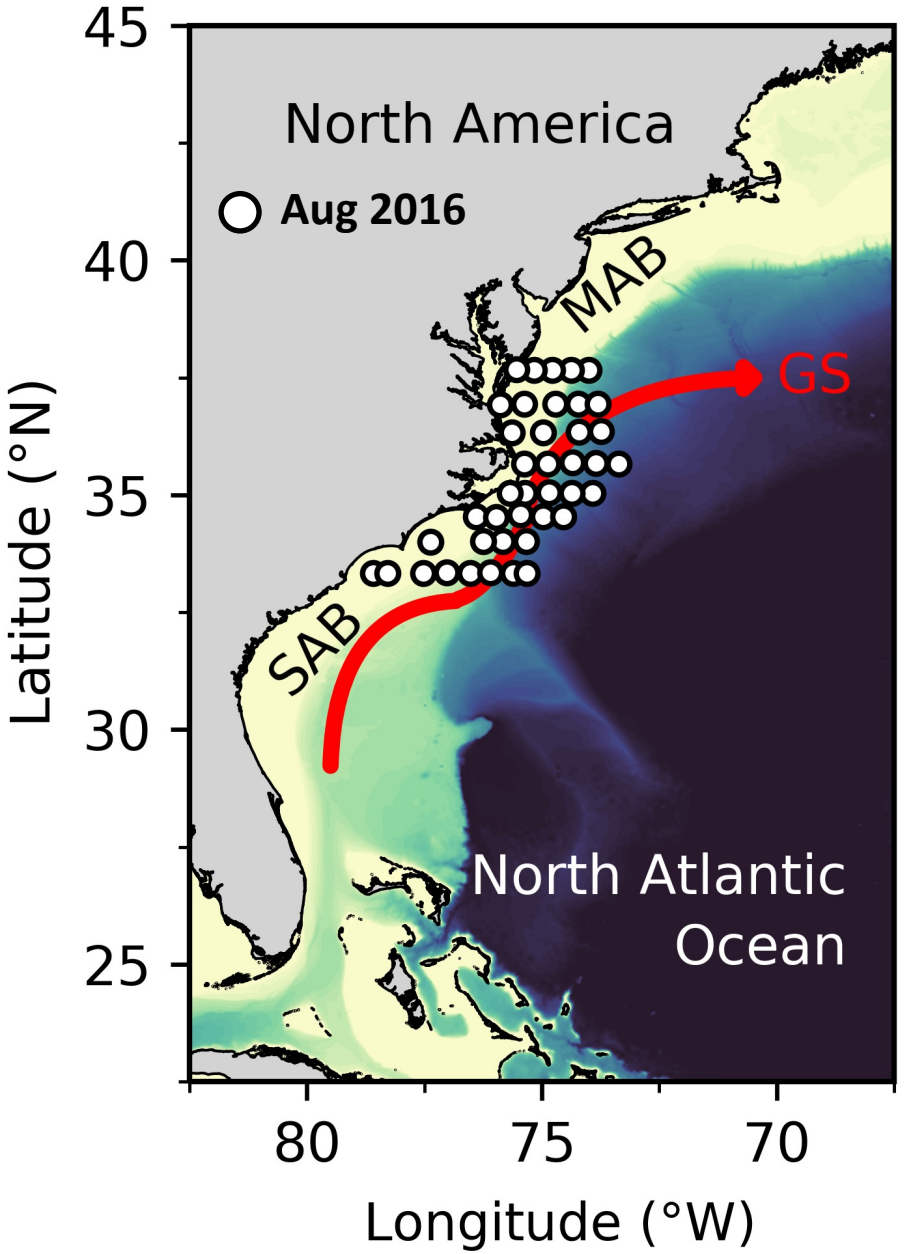
- August 2016 - R/V Hugh R. Sharp

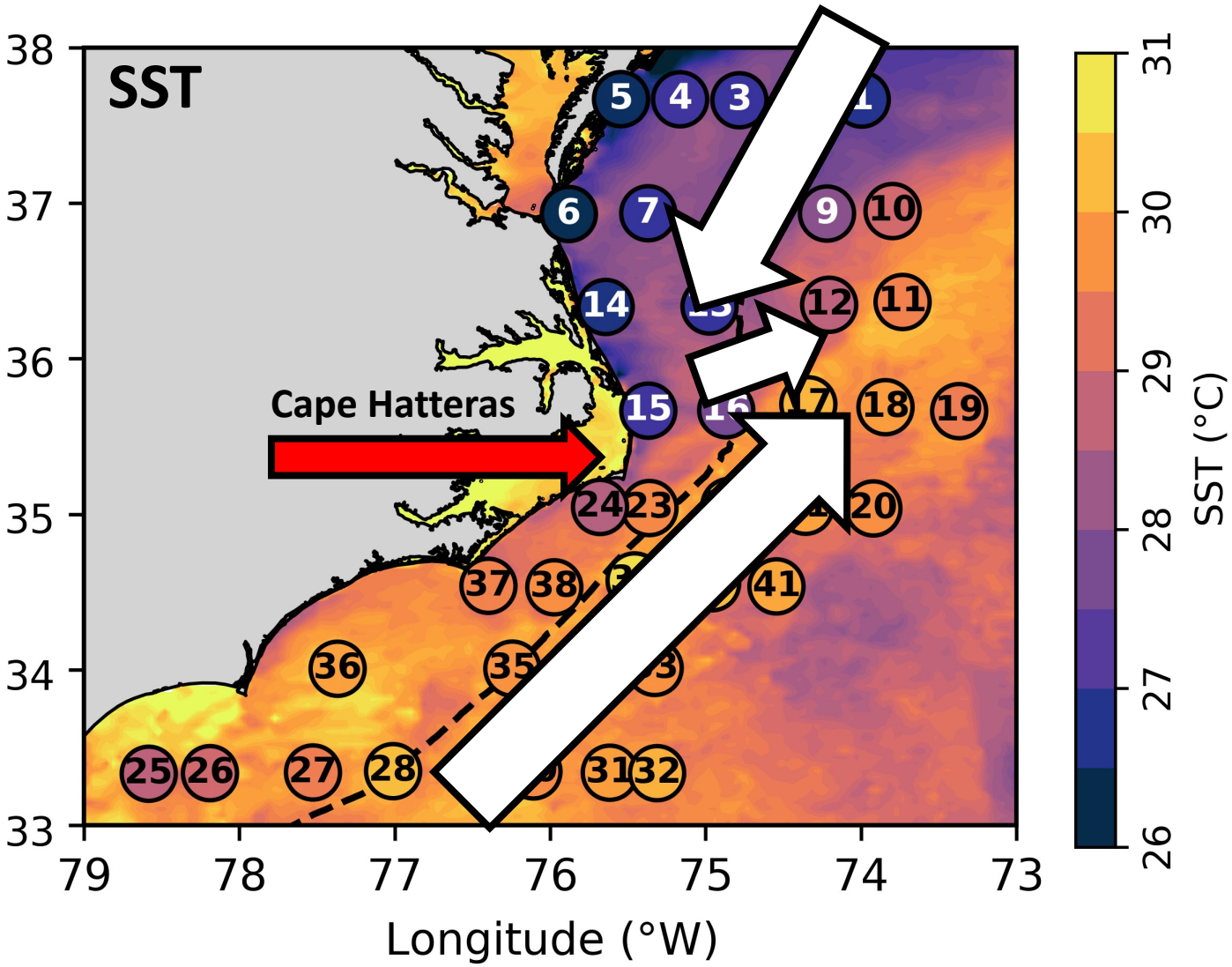
  Collaborators: ODU - Dreux Chappell, Sophie Clayton, Alfonso Macías Tapia, Pete Bernhardt, Margie Mulholland

  Publication: **Selden** et al. 2021 *L&O*

On $^{15}N_2$ tracer methods…
White, Granger, **Selden** et al. 2020 *L&O Methods*

The study site captured the convergence of Mid- and South Atlantic Bight shelf waters and the Gulf Stream.

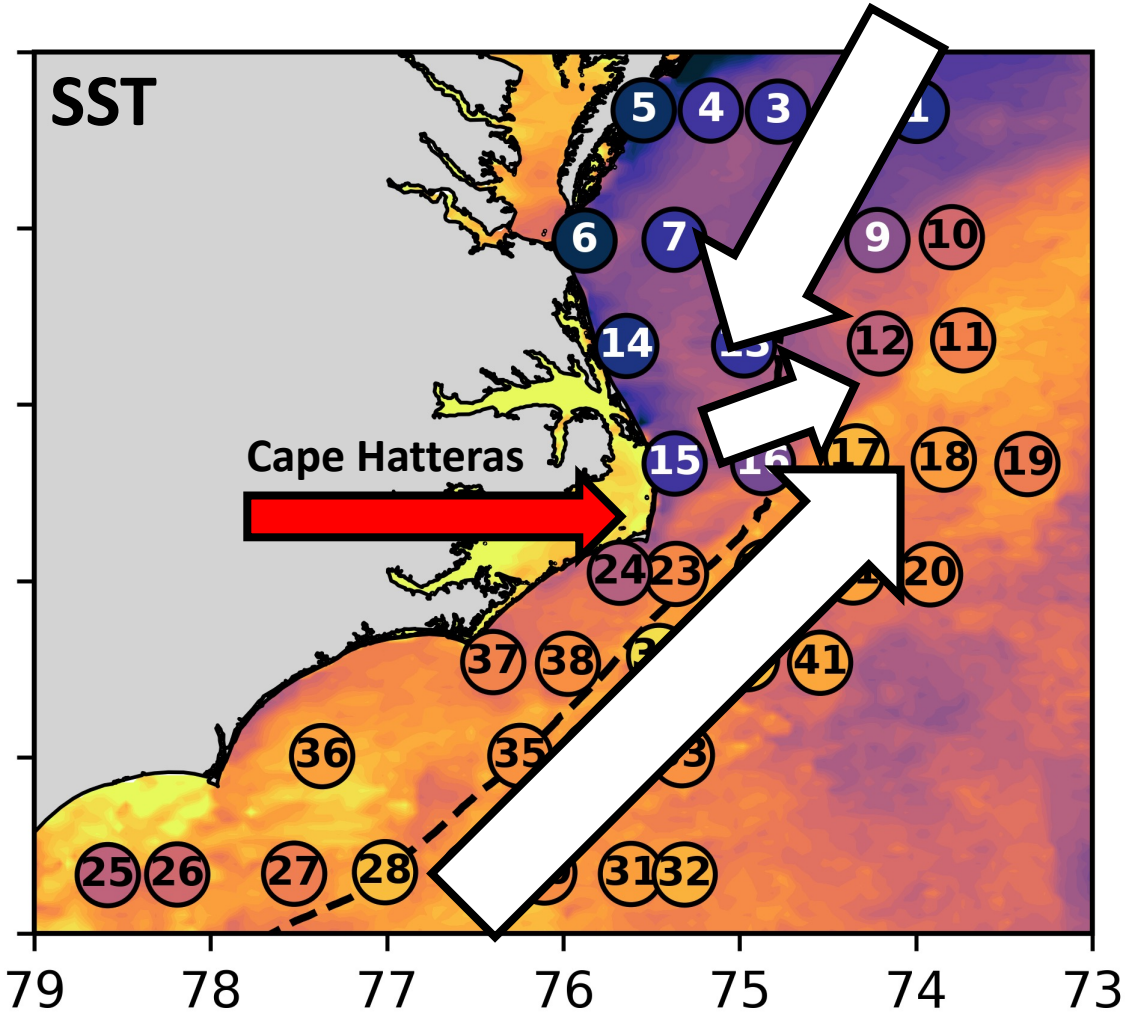


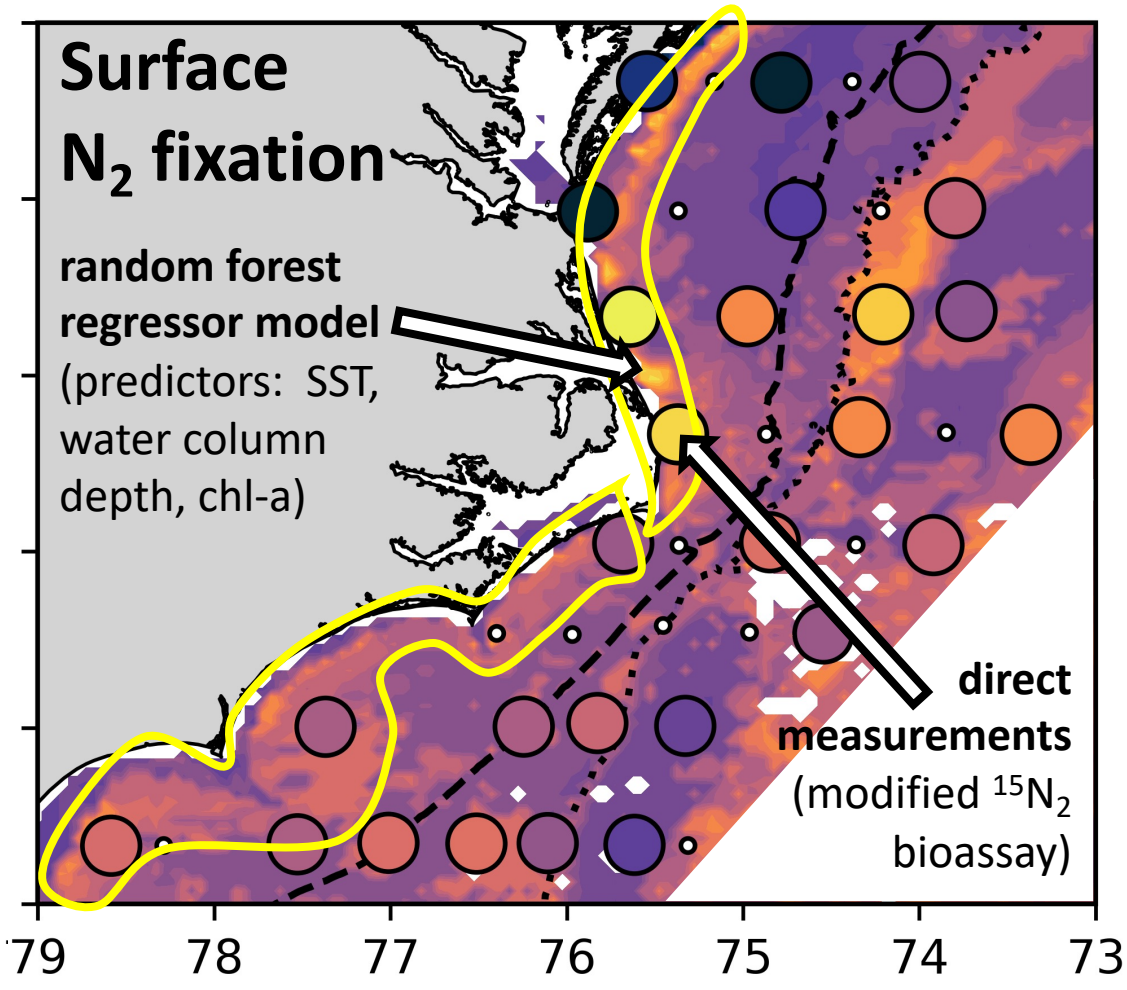


MODIS 8-day mean SST for sampling period

ETOPO 1 Arc-minute bathymetry (NOAA)

N_2 fixation is enhanced along the inner shelf.

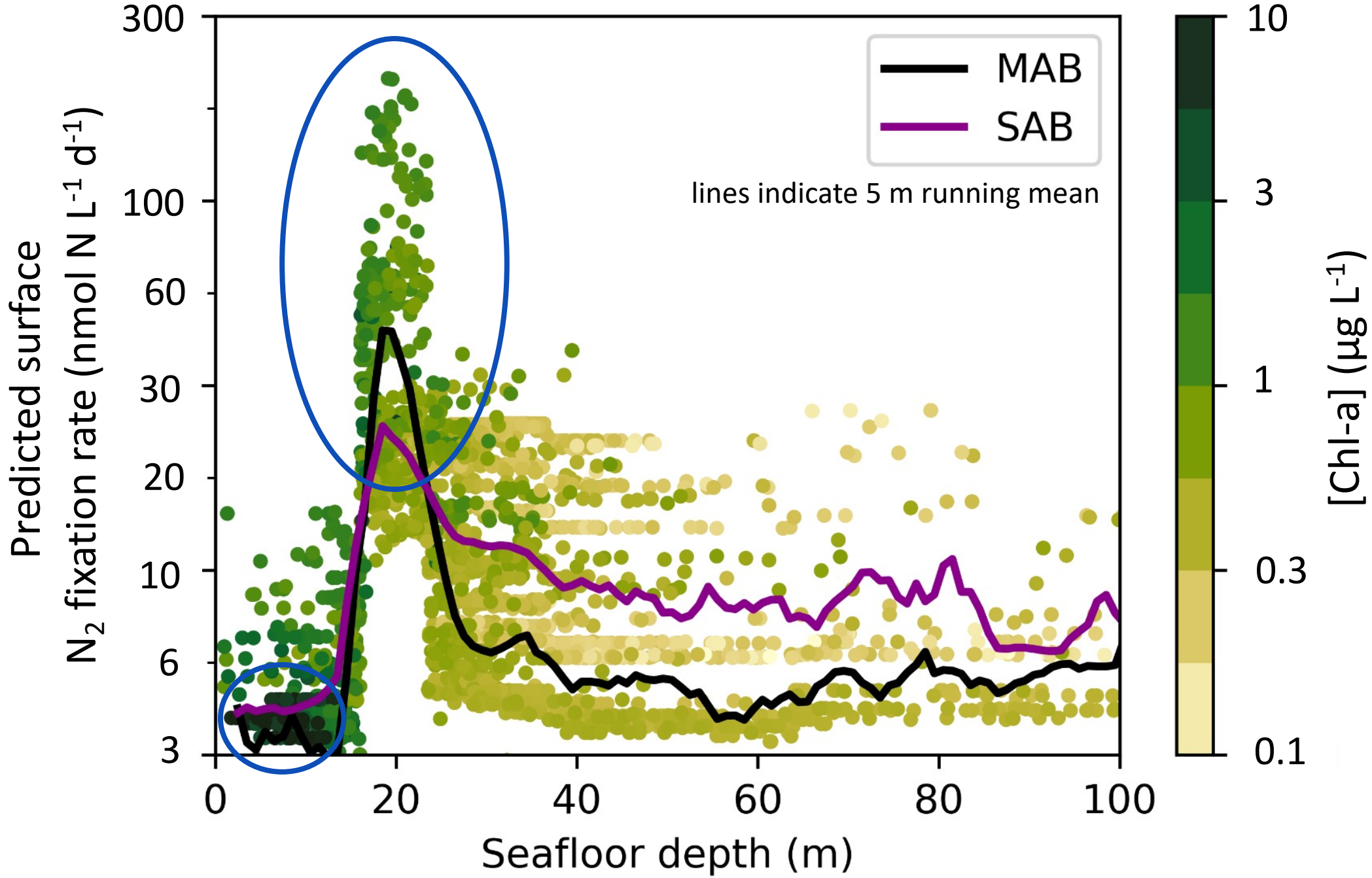




79 78 77 76 75 74 73

Longitude (°W)

N_2 fixation is enhanced seaward of the chl-a maximum along the inner shelf.



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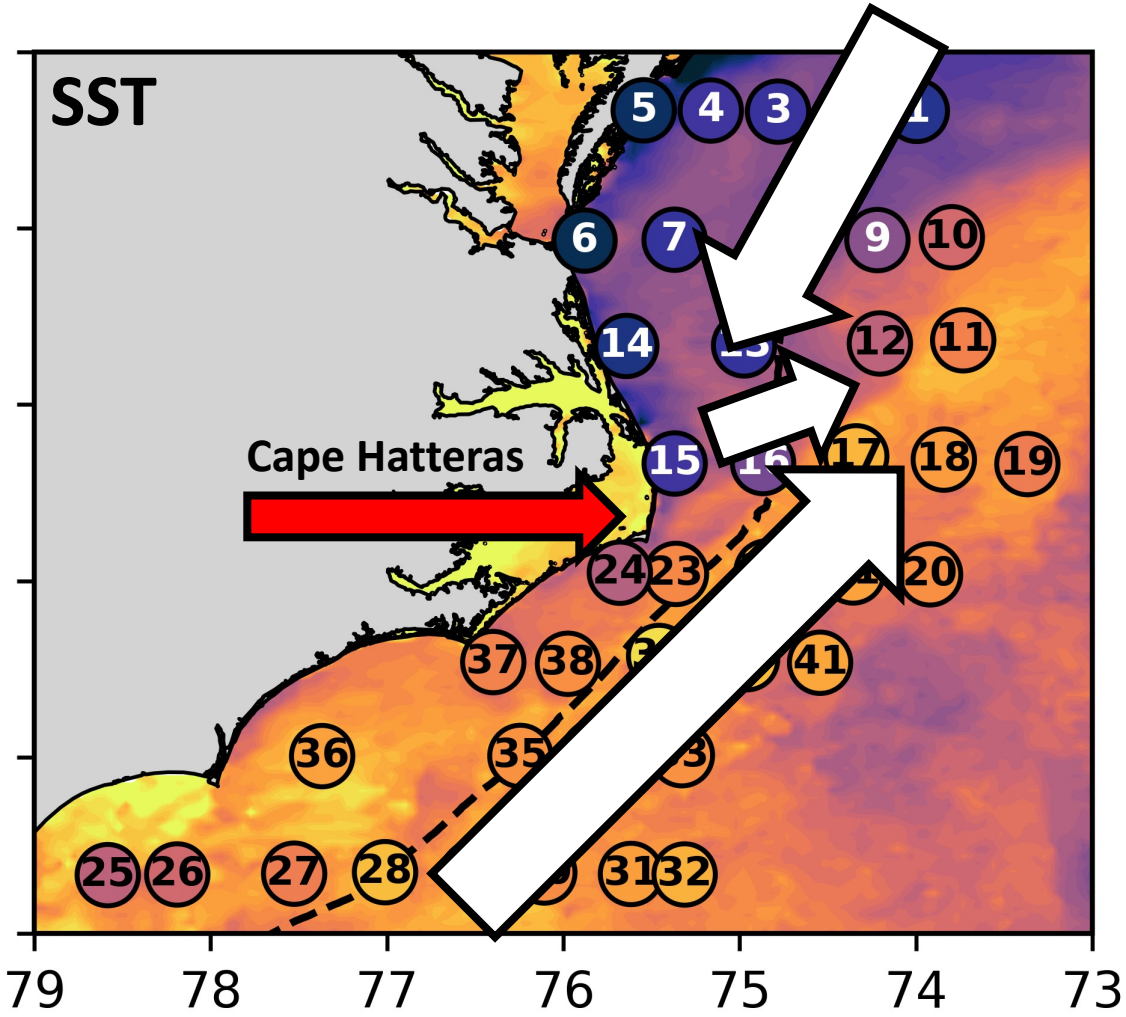
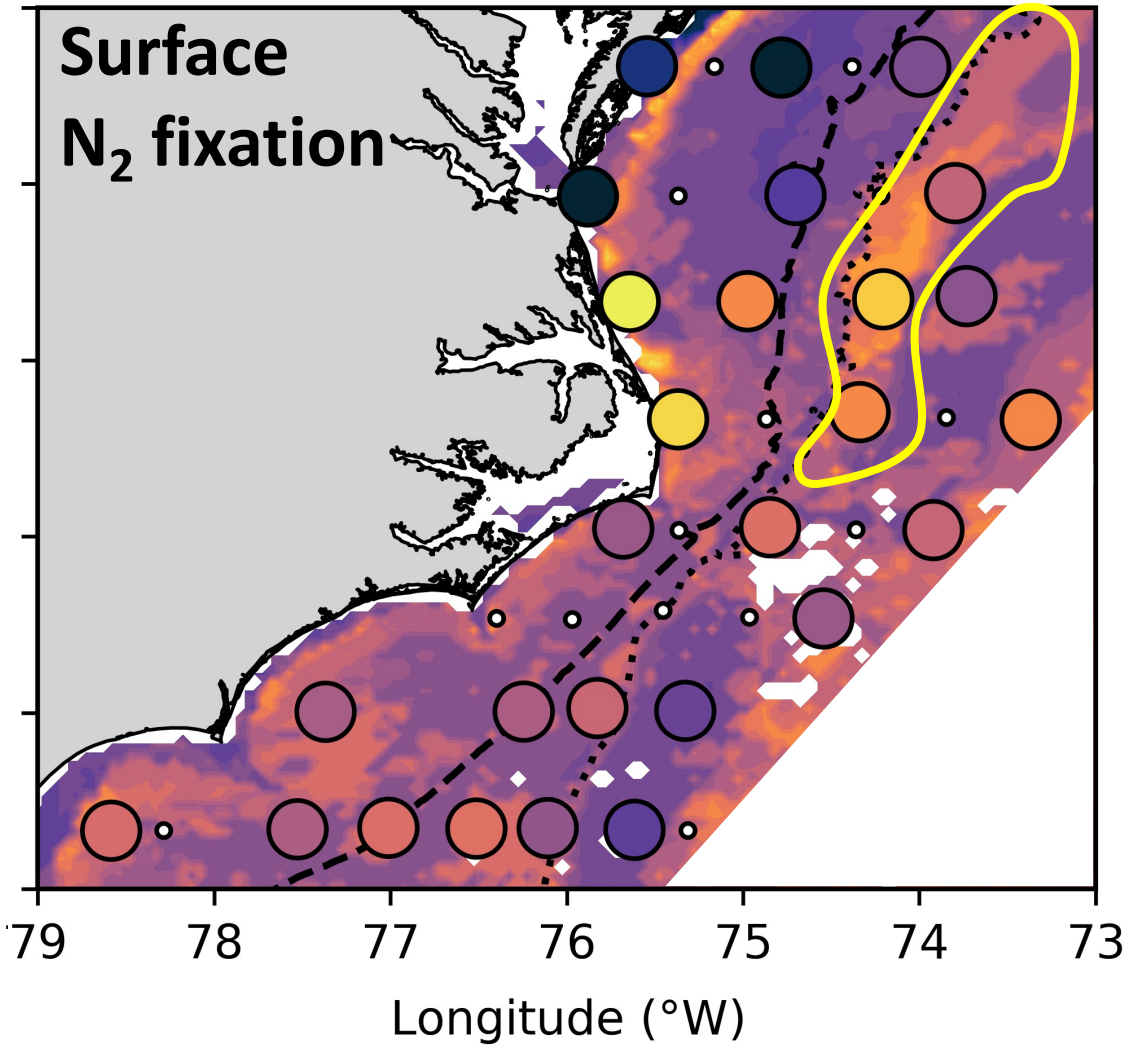
  which are likely to change as the planet warms.

N_2 fixation is enhanced in coastal waters entrained by the Gulf Stream.





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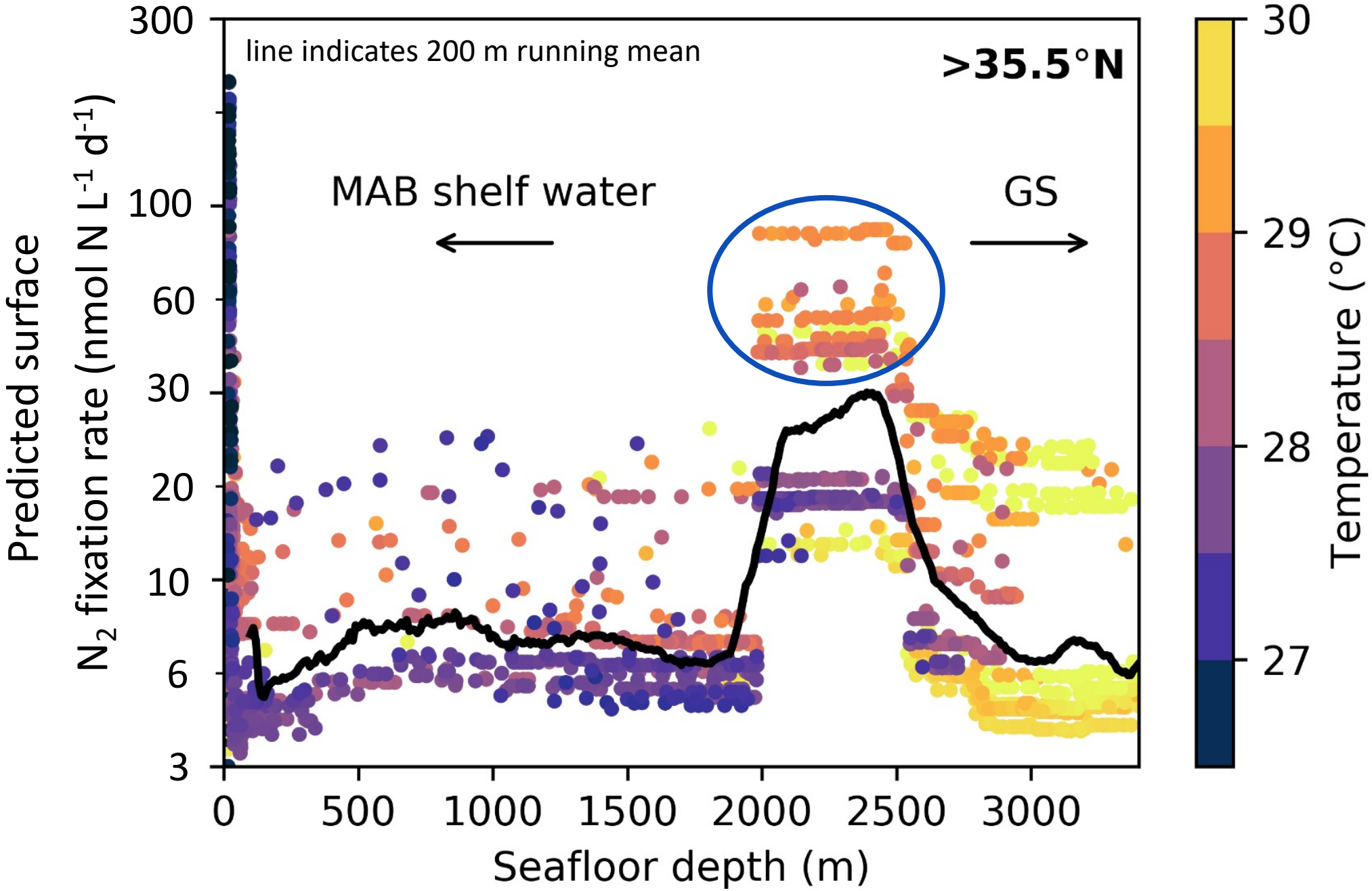
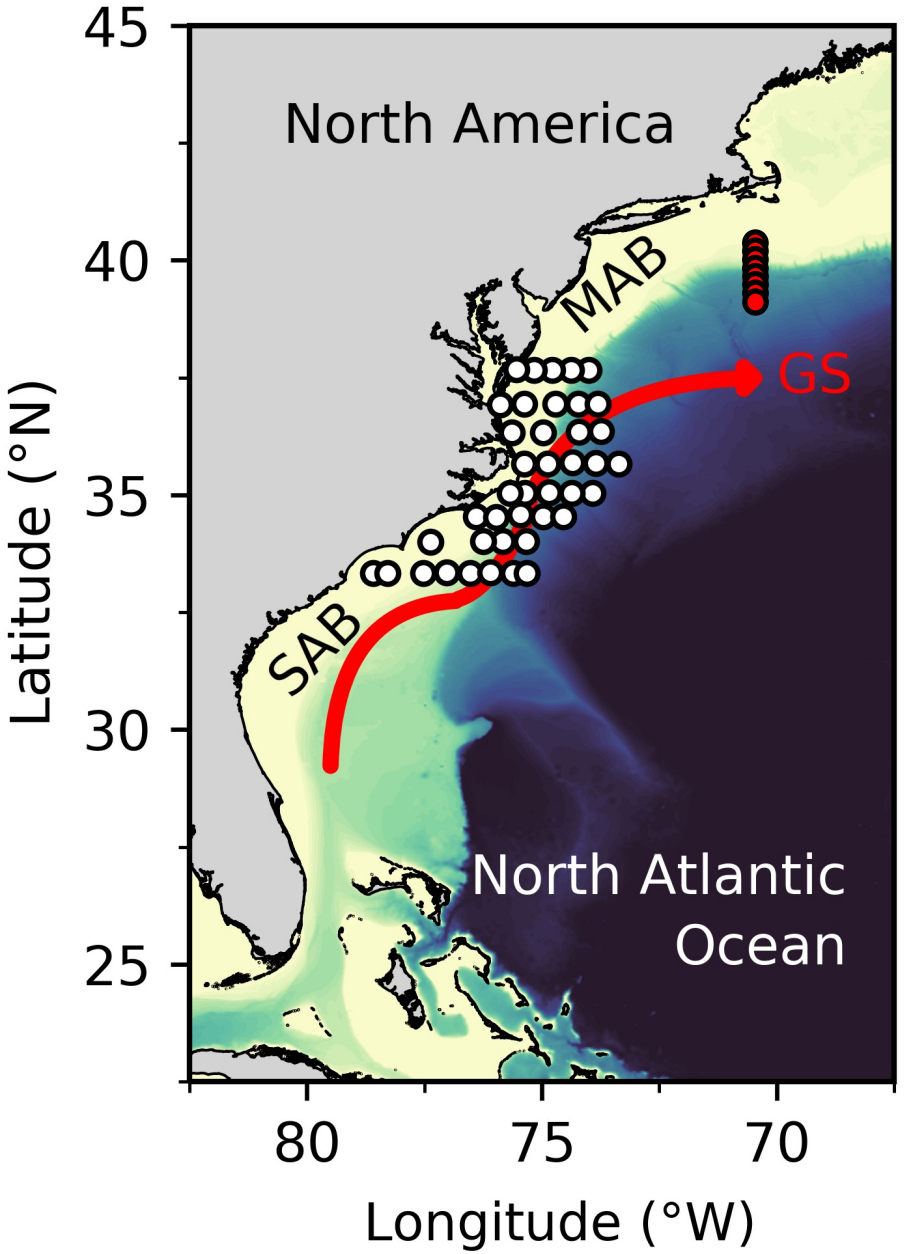




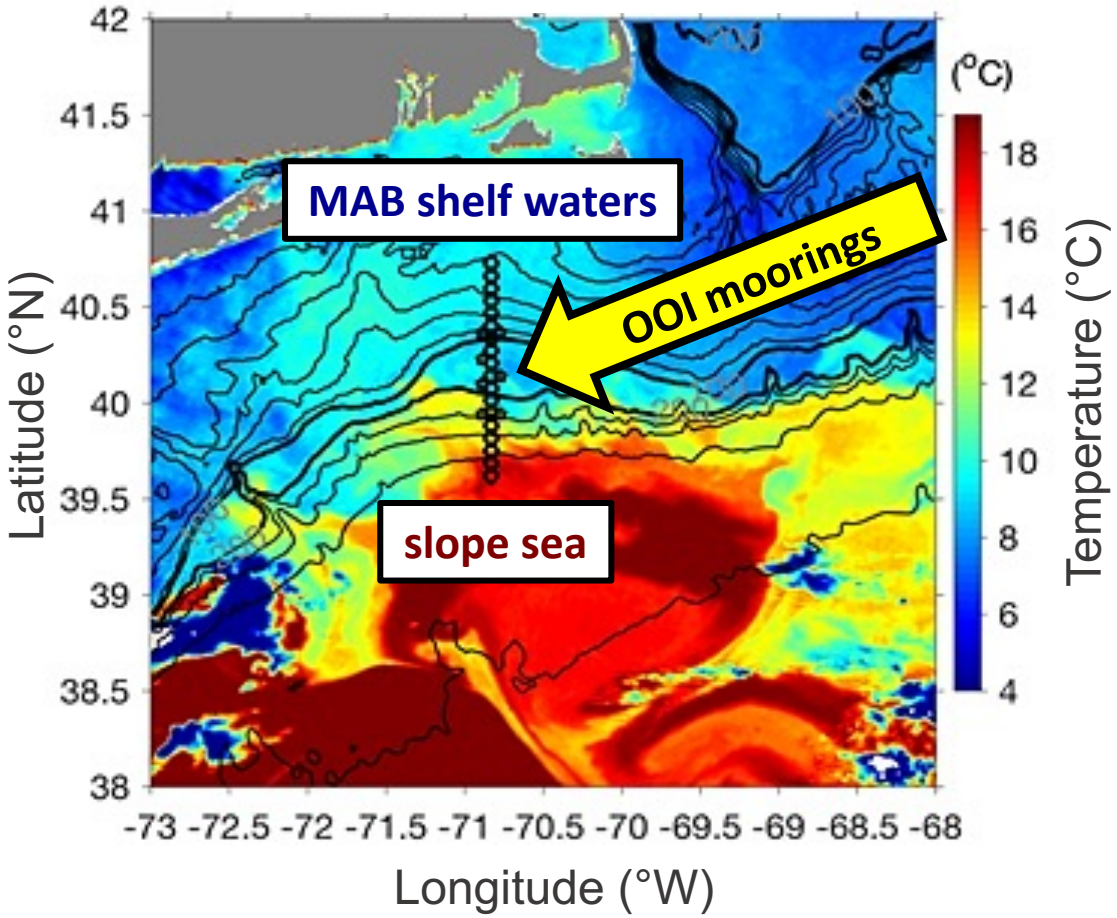
Coastal diazotrophy is influenced by shelf-break frontal dynamics: *mixing.*

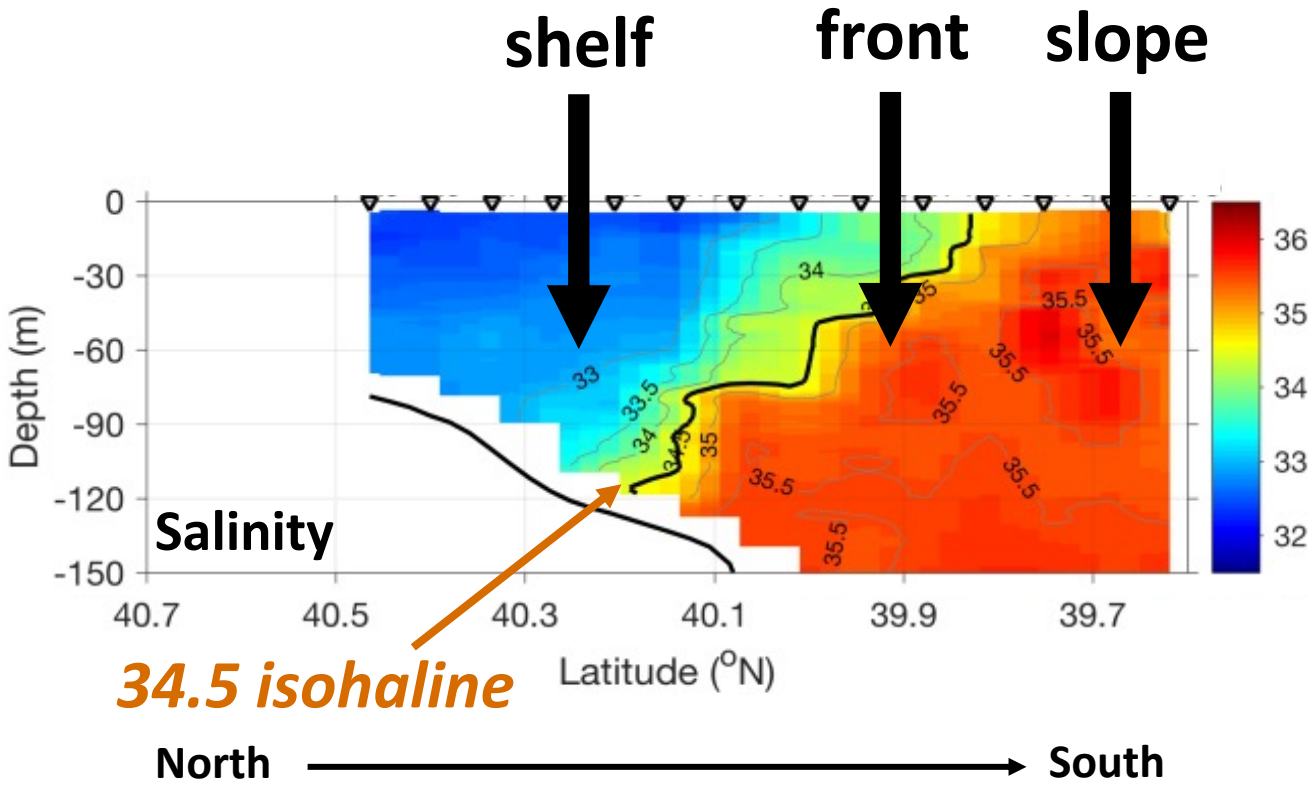
- ○ August 2016 (**Selden** et al. 2021 *L&O*)
- ● July 2019 - R/V Thomas G. Thompson (**Selden** et al. in prep.)

Collaborators: ODU - Dreux Chappell, Sophie Clayton, Alfonso Macías Tapia, Pete Bernhardt, Margie Mulholland
WHOI –Dennis McGillicuddy, Weifang Zhang

The transect surveyed captured shelf and slope water mixing at the New England shelf-break front.

NOAA-19 SST, Rutgers Coastal Ocean Observation Lab; courtesy of W. Zhang (WHOI)

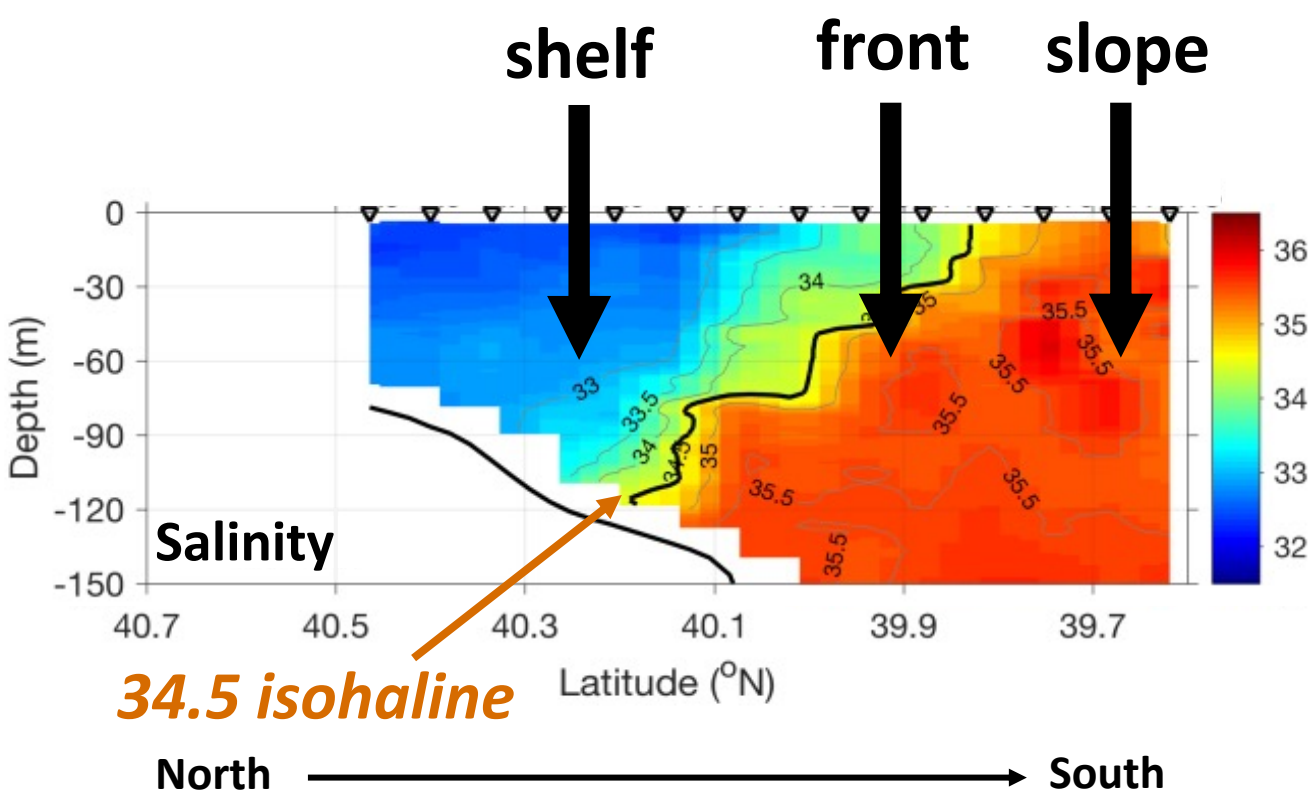




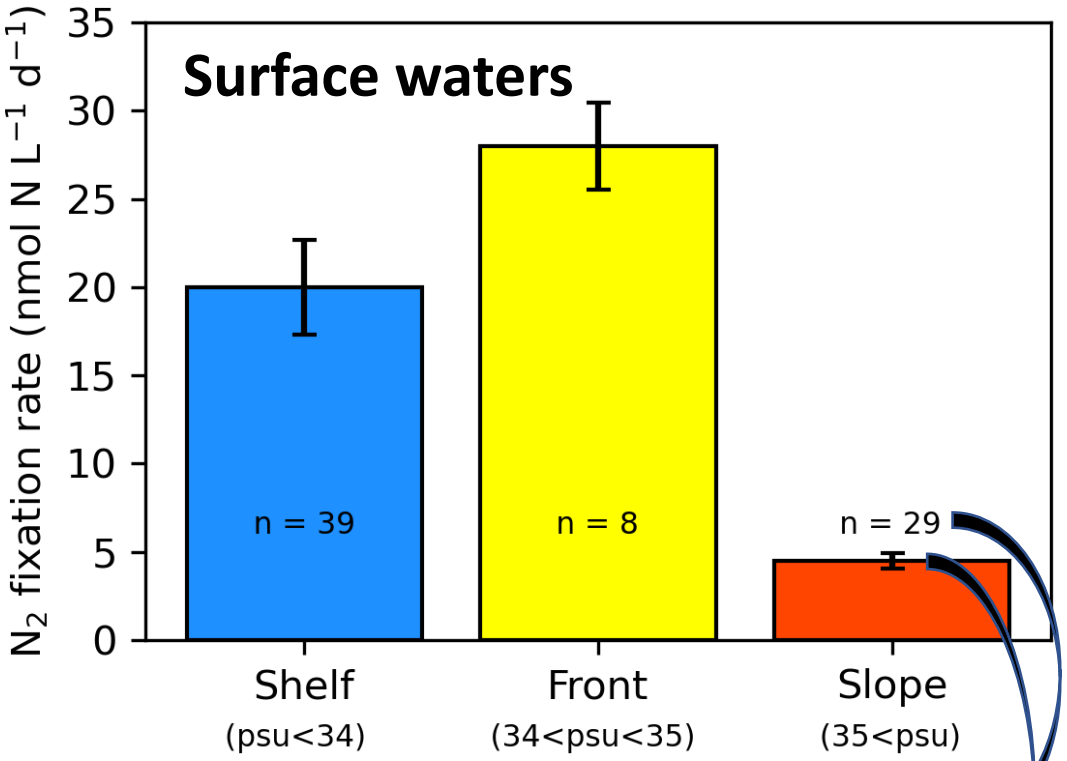
North → **South**

repeatedly occupied stations in end-member and mixing waters to constrain characteristic N_2 fixation rates across the three regimes

N_2 fixation rates in surface waters were enhanced near the front.



repeatedly occupied stations in end-member and mixing waters to constrain characteristic N_2 fixation rates across the three regimes



"n" represents the number of triplicated rate measurements made in each group

Error bars depict propagation of standard deviation of triplicated measurements

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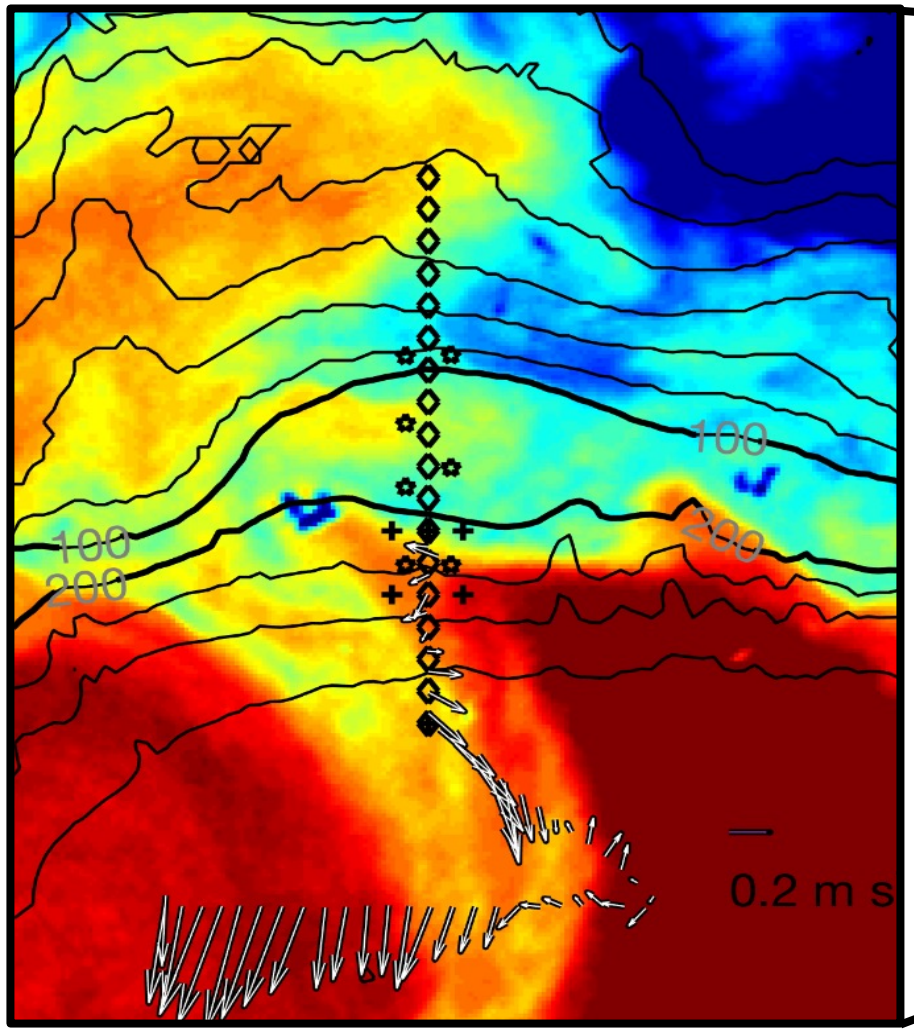
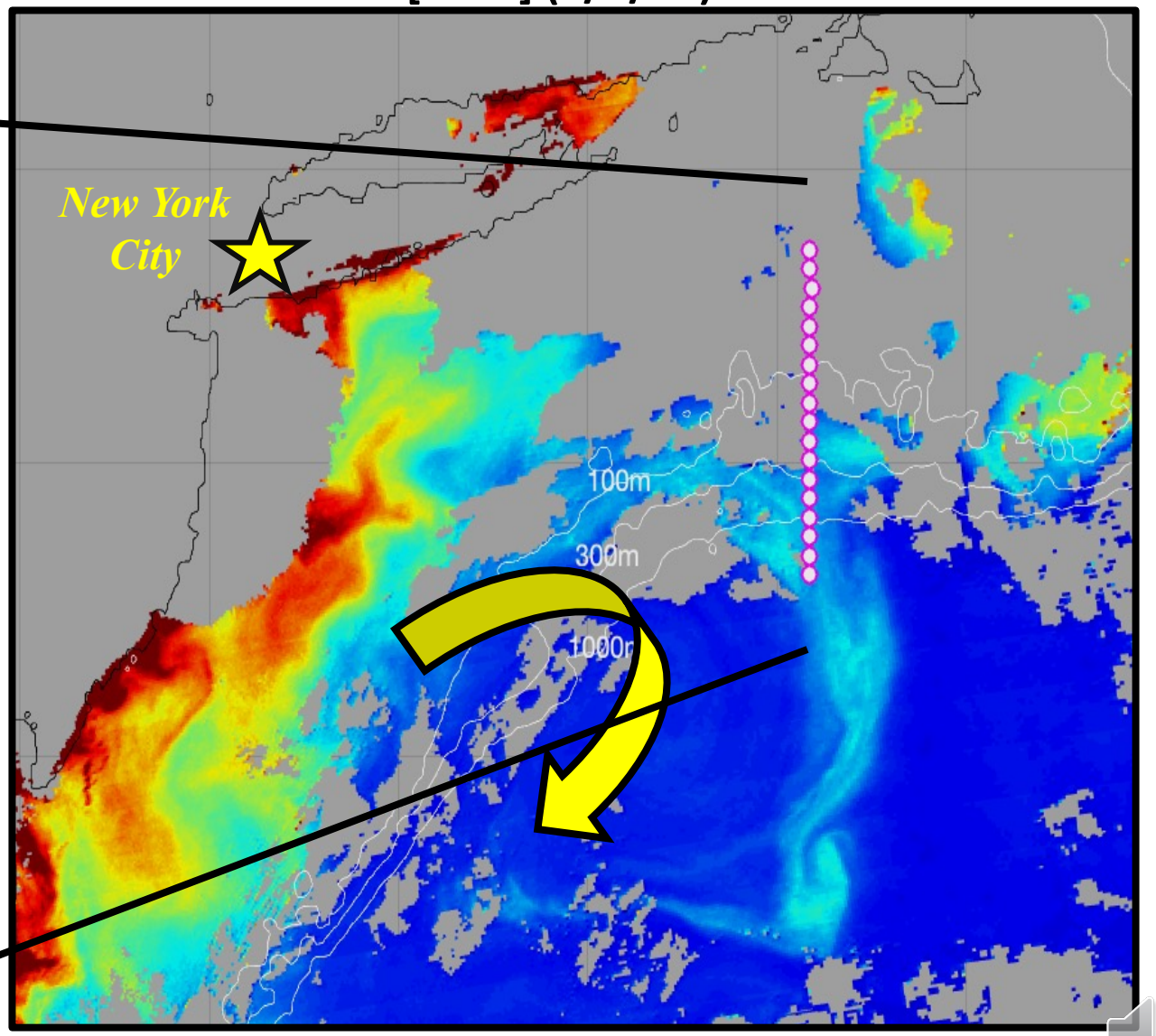
An eddy near our transect resulted in a shelf water streamer.

MODIS sea surface temp. (7/8/19)

Arrows indicate surface current direction and magnitude



MODIS sea surface [chl-a] (7/6/19)

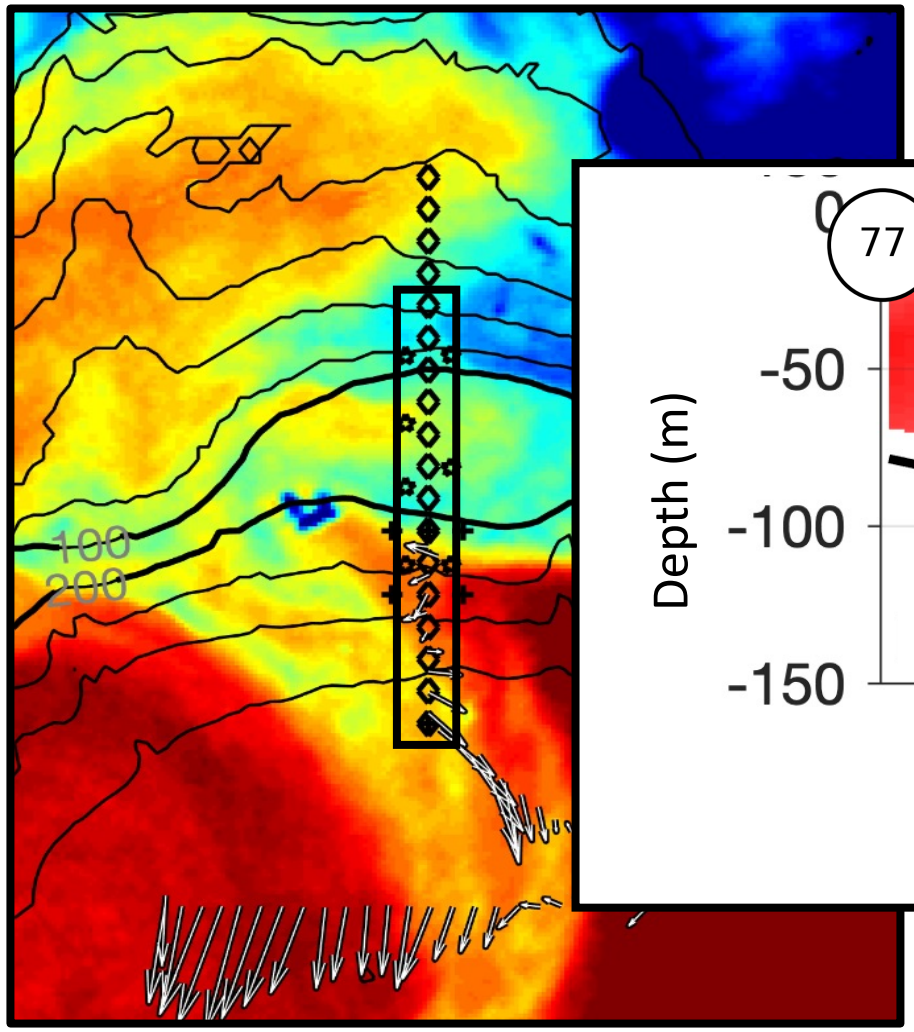


Figures courtesy of W. Zhang (WHOI)

N_2 fixation rates enhanced in shelf waters during offshore transport, particularly where PO_4^{3-} anomaly is high.

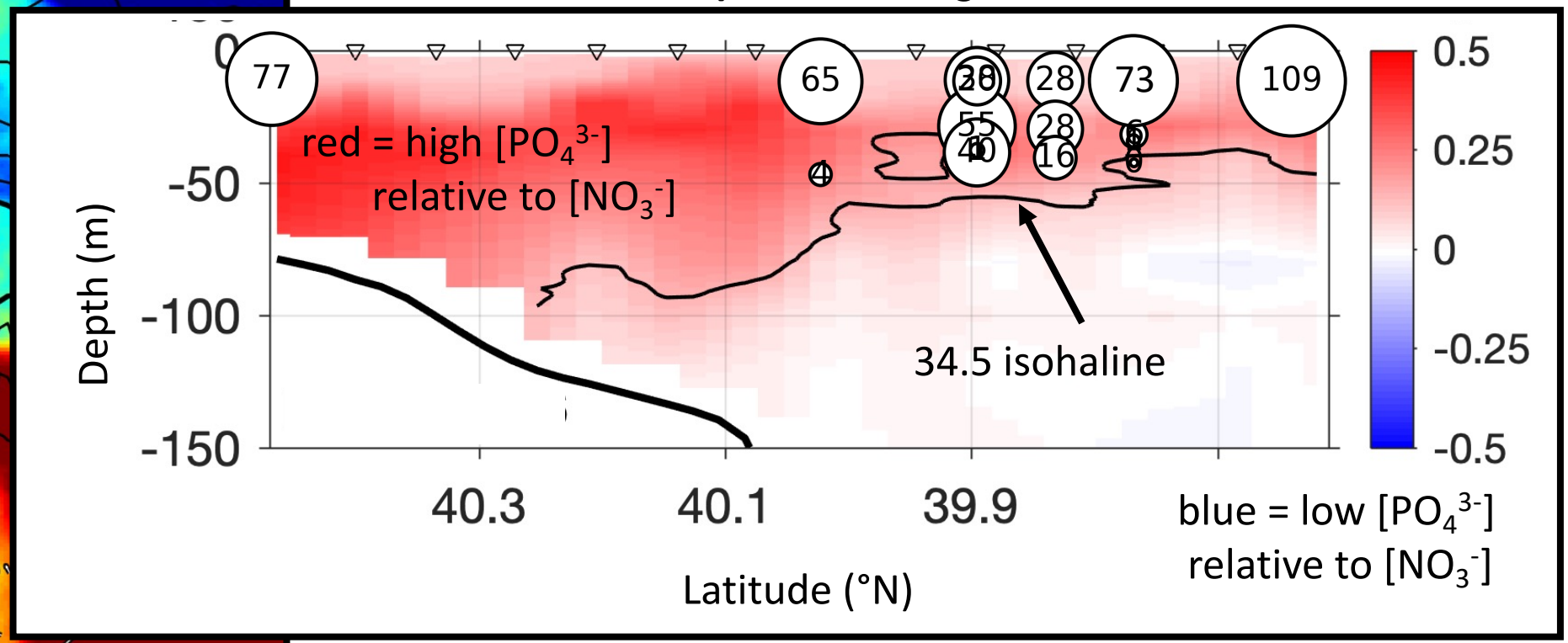
MODIS sea surface temp. (7/8/19)

Arrows indicate surface current direction and magnitude



N_2 fixation rates (nmol N L^{-1} d^{-1}) shown as sized dots shelf median (non-streamer conditions) during July:
27 nmol N L^{-1} d^{-1}

$P^* = [PO_4^{3-}] - ([NO_3^-]/16)$



North → South

SST and P* figures courtesy of W. Zhang (WHOI)

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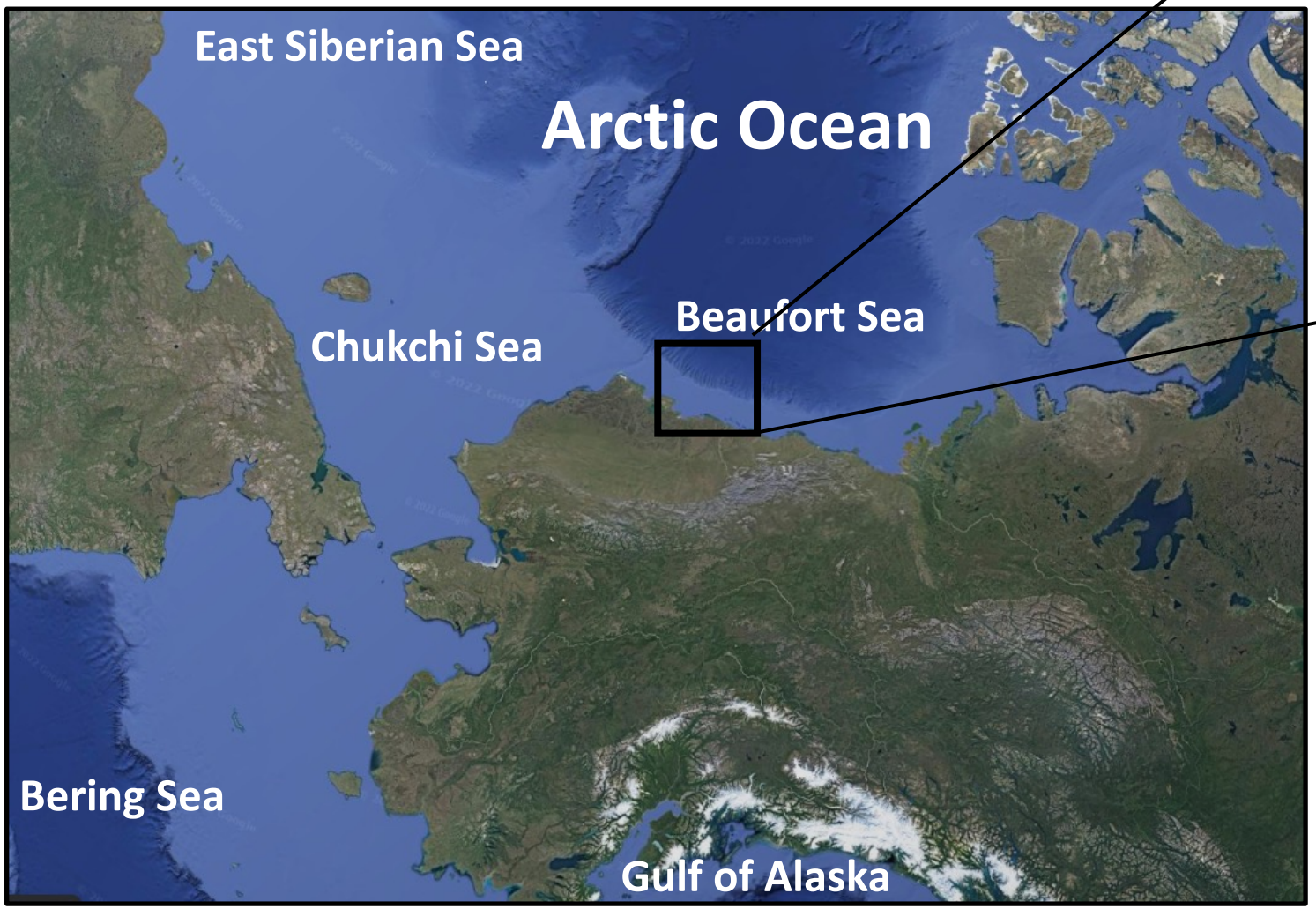
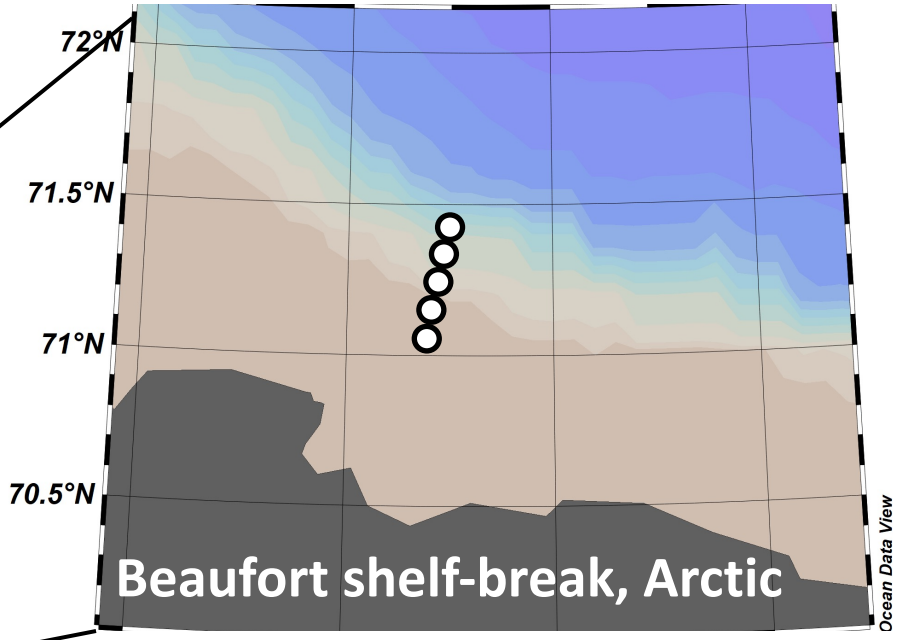
Coastal diazotrophy is influenced by shelf-break frontal dynamics: *upwelling.*





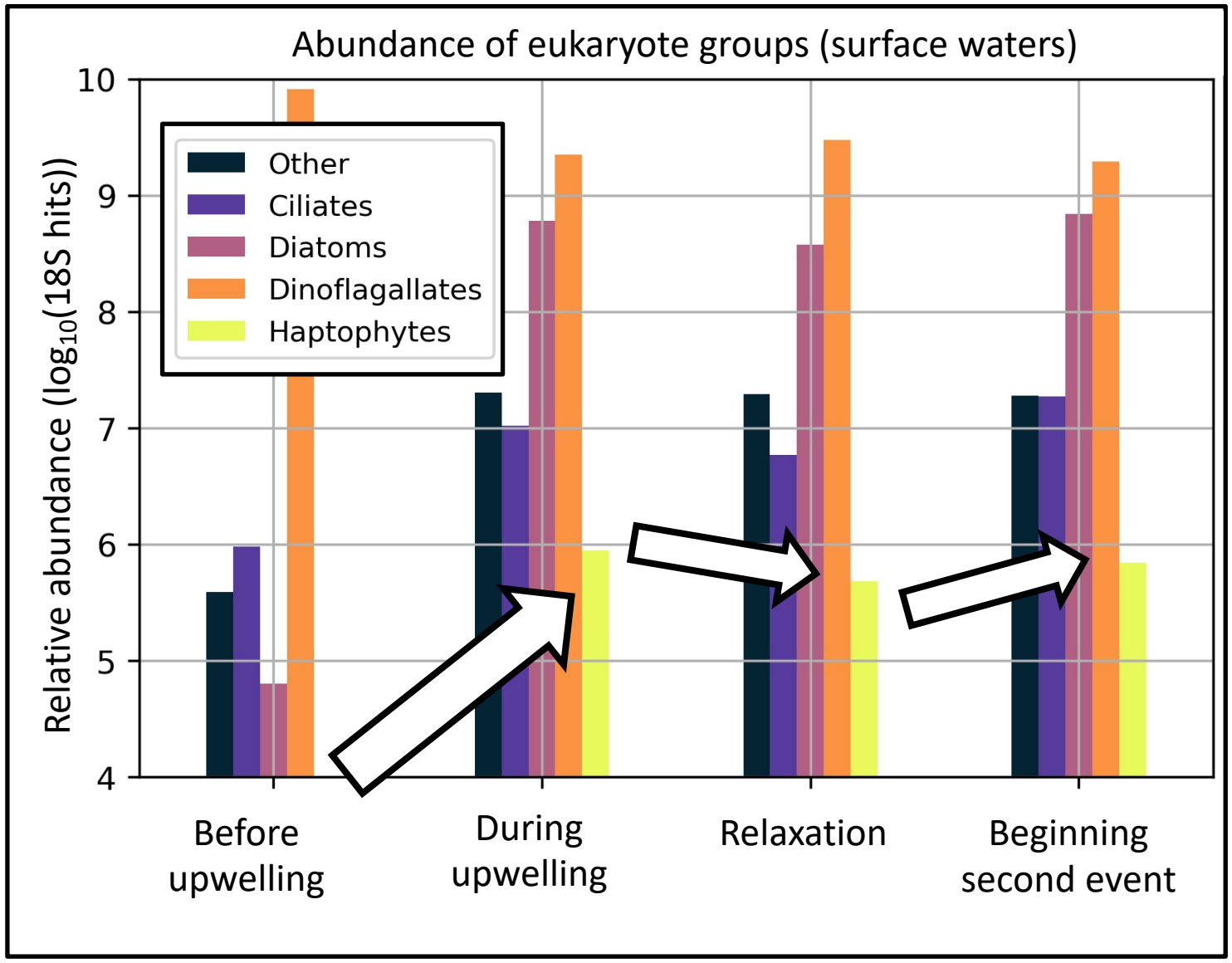
○ Sep. 2017 - R/V Sikuliaq

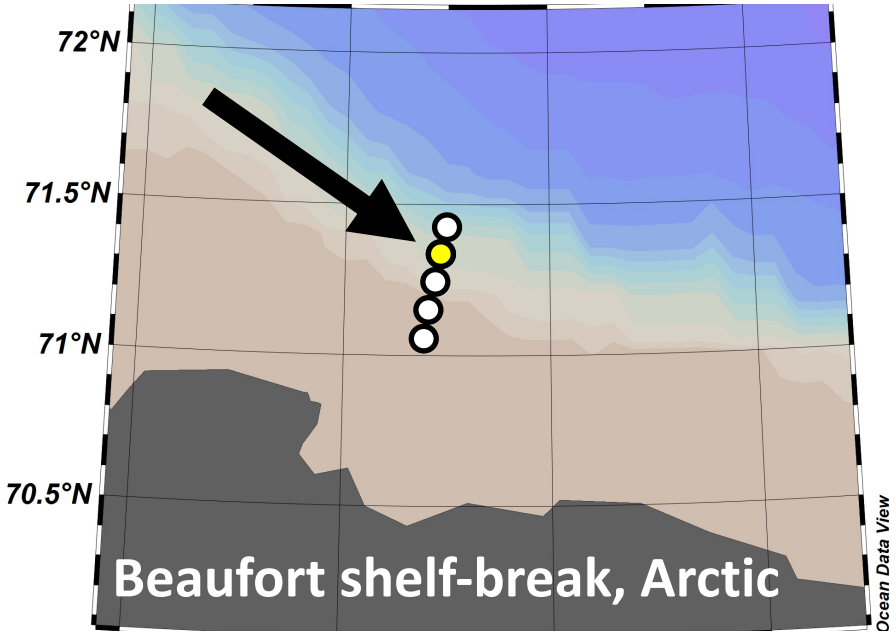
Denni (Sveinn) Einarsson
Chappell lab
ODU

currently at Univ. of Florida

Upwelling favors haptophytes among eukaryotic phytoplankton.

18S amplicons (totals normalized across samples)





Sep. 2017 - R/V Sikuliaq

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Chappell lab
ODU

currently at Univ. of Florida

The diazotrophic UCYN-A/B. bigelowii symbiosis increased in abundance following upwelling.

K. Crider

S. Einarsson

UCYN-A2 (*nifH*) and host (18S) abundance measured via quantitative polymerase chain reactions

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increased open-ocean/shelf mixing events across Mid-Atlantic Bight

Geophysical Research Letters

RESEARCH LETTER
10.1002/2016GL069966

On the recent destabilization of the Gulf Stream path downstream of Cape Hatteras

M. Andres[1]

[1]Physical Oceanography Department, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA

Key Points:
- The location where the detached Gulf Stream's meanders initiate varies by 1500 km and has shifted west (upstream) at ~25 km yr^{-1}
- Gulf Stream troughs and deep cyclones that stir the Deep Western Boundary Current into the deep interior have become more common since 2008
- The detached Gulf Stream's stability may reflect the system's intrinsic variability controlled at the DWBC cross-over near Cape Hatteras

Abstract Mapped satellite altimetry reveals interannual variability in the position of initiation of Gulf Stream meanders downstream of Cape Hatteras. The longitude where the Gulf Stream begins meandering varies by 1500 km. There has been a general trend for the destabilization point to shift west, and 5 of the last 6 years had a Gulf Stream destabilization point upstream of the New England Seamounts. Independent in situ data suggest that this shift has increased both upper-ocean/deep-ocean interaction events at Line W and open-ocean/shelf interactions across the Middle Atlantic Bight (MAB) shelf break. Mooring data and along-track altimetry indicate a recent increase in the number of deep cyclones that stir Deep Western

The Changing Nature of Shelf-Break Exchange Revealed by the OOI Pioneer Array

By Glen Gawarkiewicz, Robert E. Todd, Weifeng Zhang, Jacob Partida, Avijit Gangopadhyay, Mahmud-Ul-Hasan Monim, Paula Fratantoni, Anna Malek Mercer, and Margaret Dent

THE OFFICIAL MAGAZINE OF THE OCEANOGRAPHY SOCIETY
Oceanography

number and intensity of upwelling events increasing…

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journal homepage: www.elsevier.com/locate/dsri

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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]

…exacerbated by ice loss

GEOPHYSICAL RESEARCH LETTERS, VOL. 30, NO. 14, 1778, doi:10.1029/2003GL017526, 2003

Wind-driven shelf/basin exchange on an Arctic shelf: The joint roles of ice cover extent and shelf-break bathymetry

Eddy Carmack
Institute of Ocean Sciences, Sidney, BC, Canada

David C. Chapman
Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA