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Oceanography, HABs, and how it's all changing

David W. Townsend

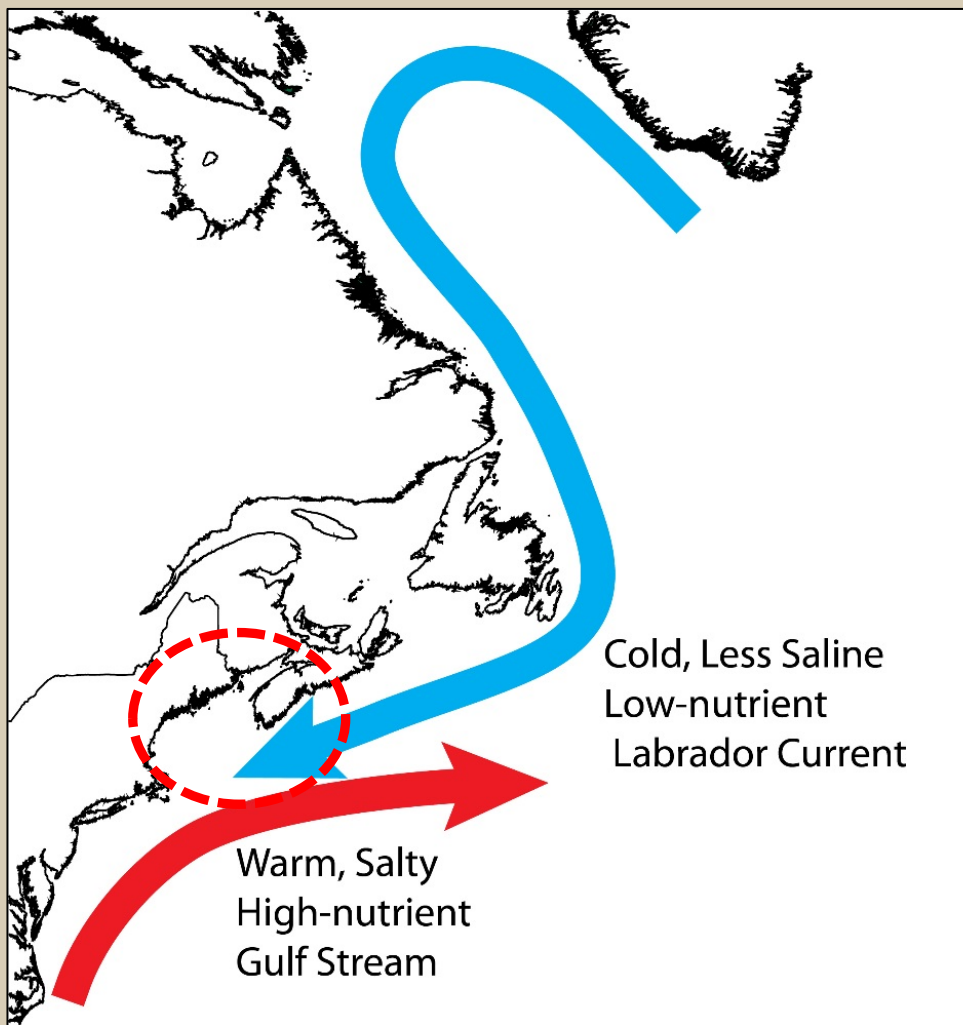
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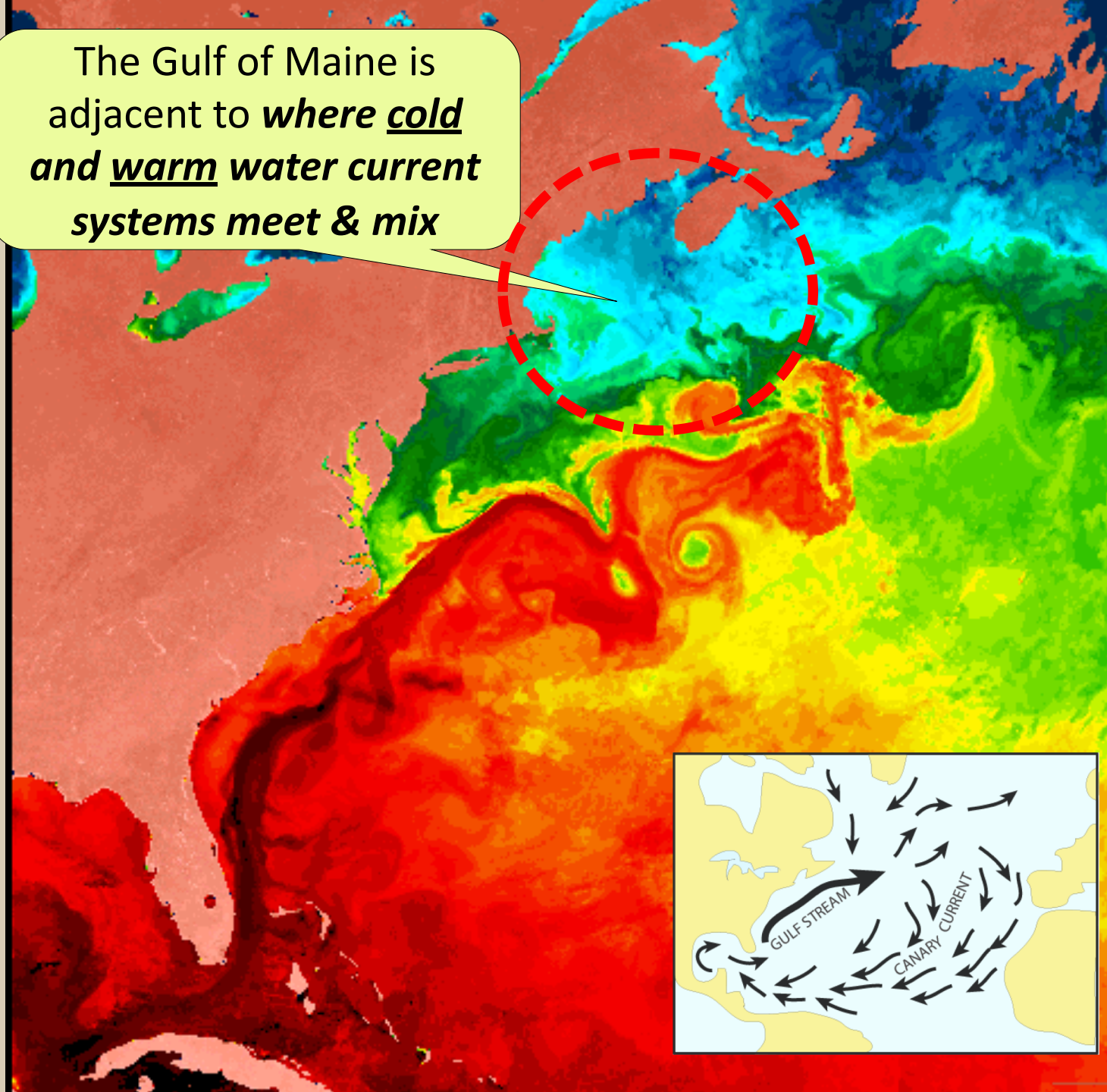
David W. Townsend

University of Maine

*Oceanography, HABs, and
How it's all changing*



The Gulf of Maine is adjacent to ***where cold and warm water current systems meet & mix***

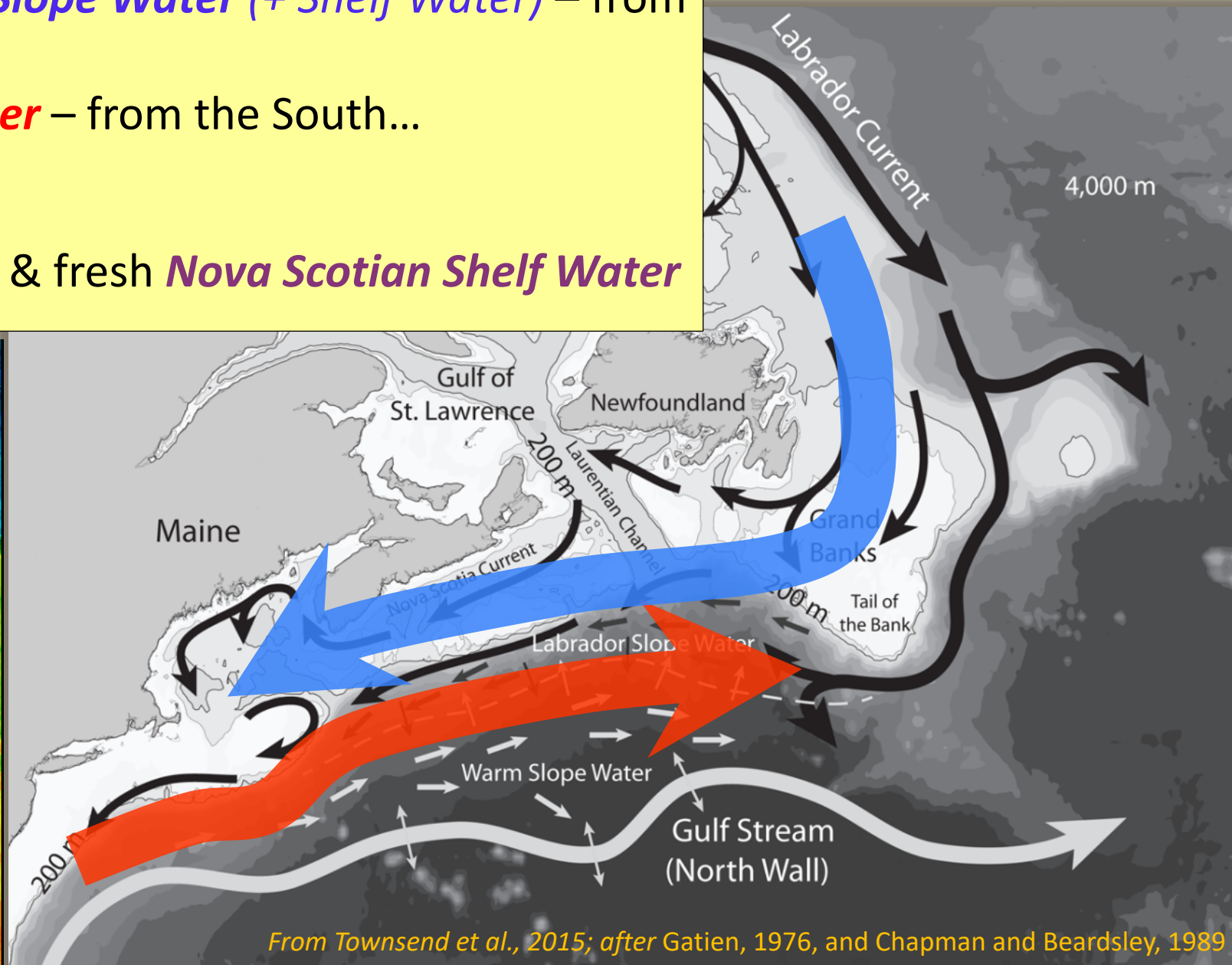
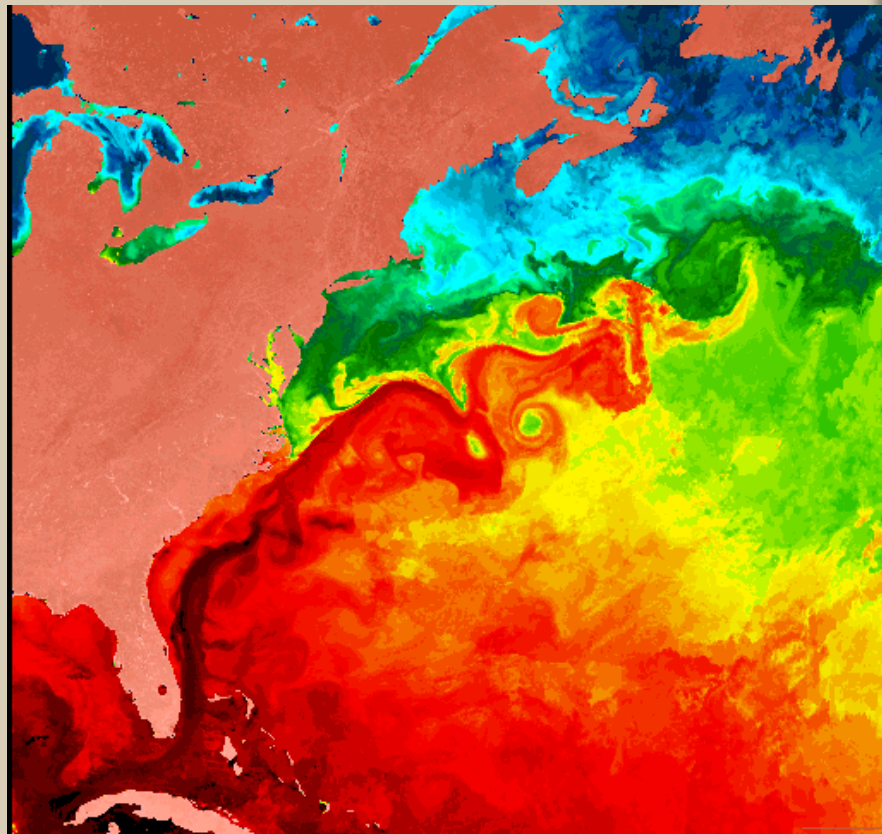


The GoM's waters enter from outside the Gulf as **Deep Slope Water:**

- ✓ Cold, relatively fresh **Labrador Slope Water (+ Shelf Water)** – from the North,
- ✓ Warm & salty **Warm Slope Water** – from the South...

And as:

- ✓ **Surface Shelf Waters**, esp. Cold & fresh **Nova Scotian Shelf Water**



From Townsend et al., 2015; after Gatién, 1976, and Chapman and Beardsley, 1989

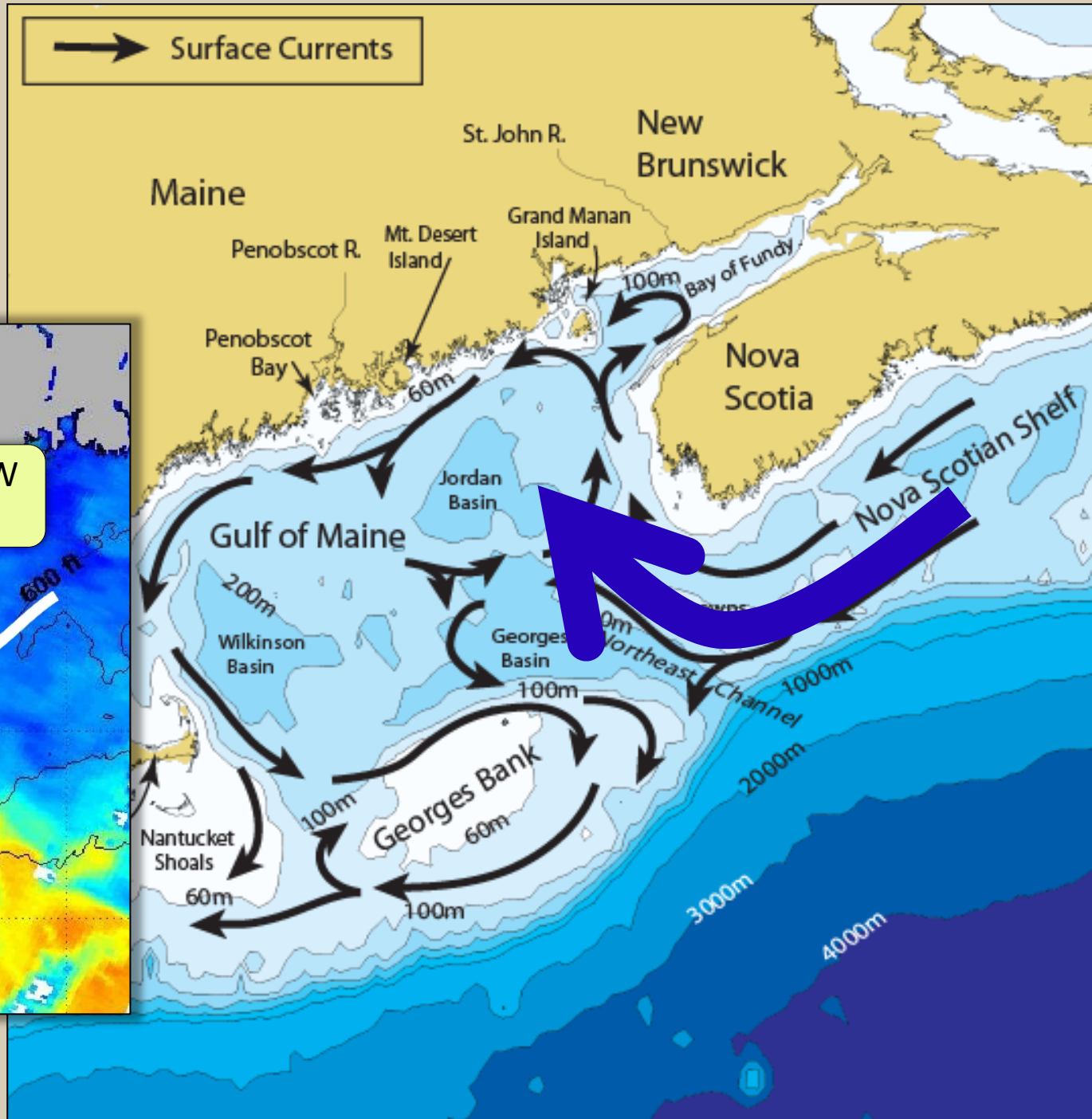
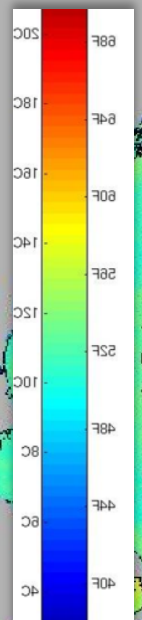
1. Surface Flows:

... a Surface Layer of cold and fresh Scotian Shelf Water

Scotian Shelf Water

Cold/fresh SSW at Surface

SST June 7, 2015
(Rutgers Univ)



2. Deep & Bottom Flows:

... *Slope Waters* enter at depth via the Northeast Channel



H.B. Bigelow
1927

Slope Water

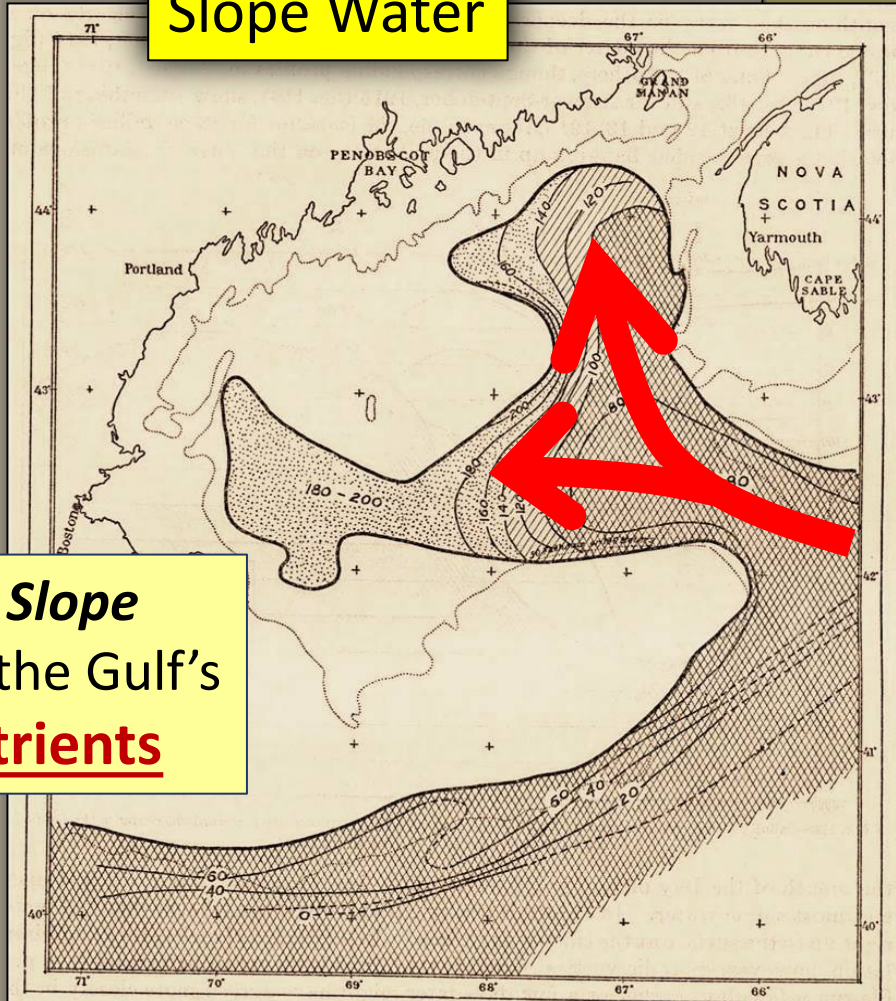
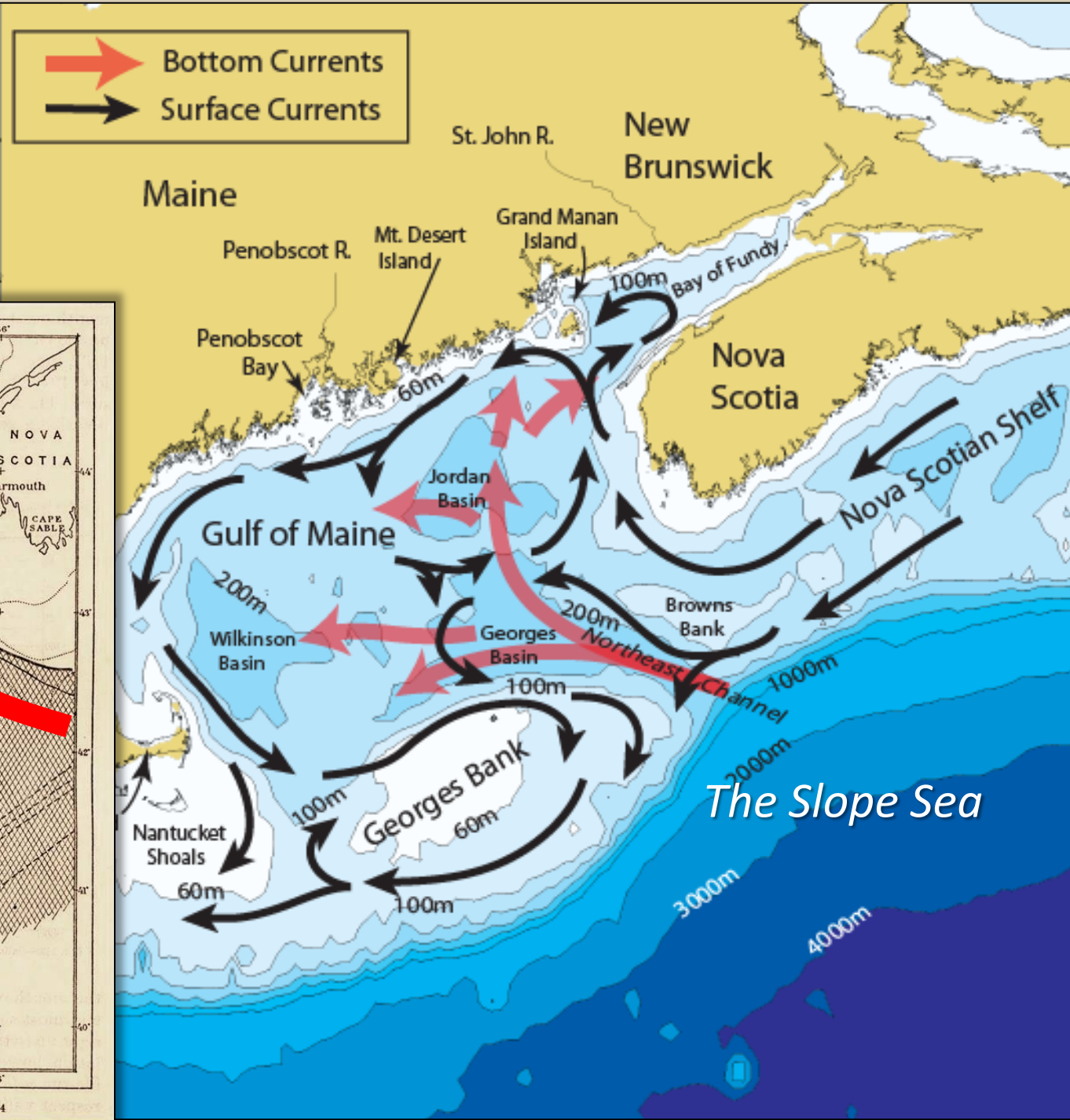
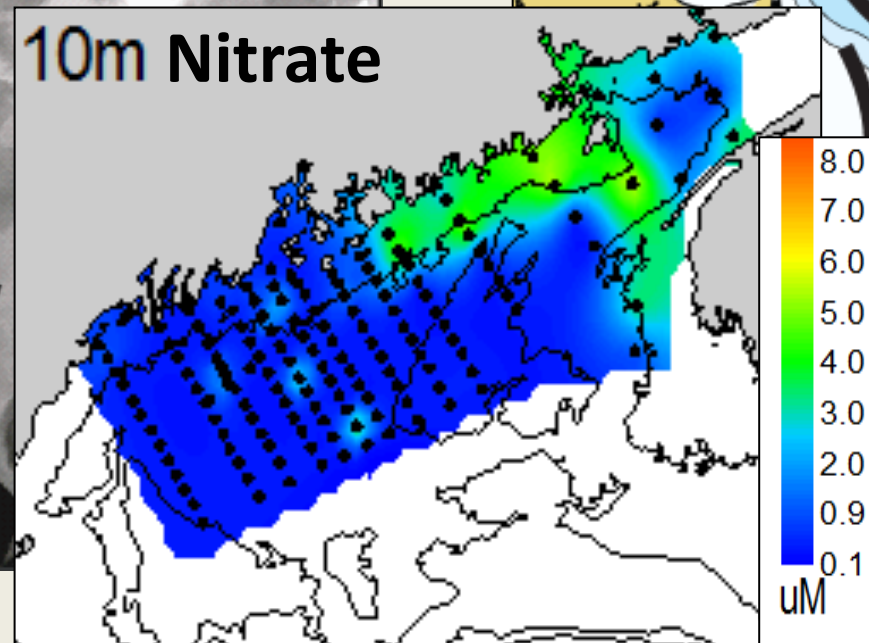
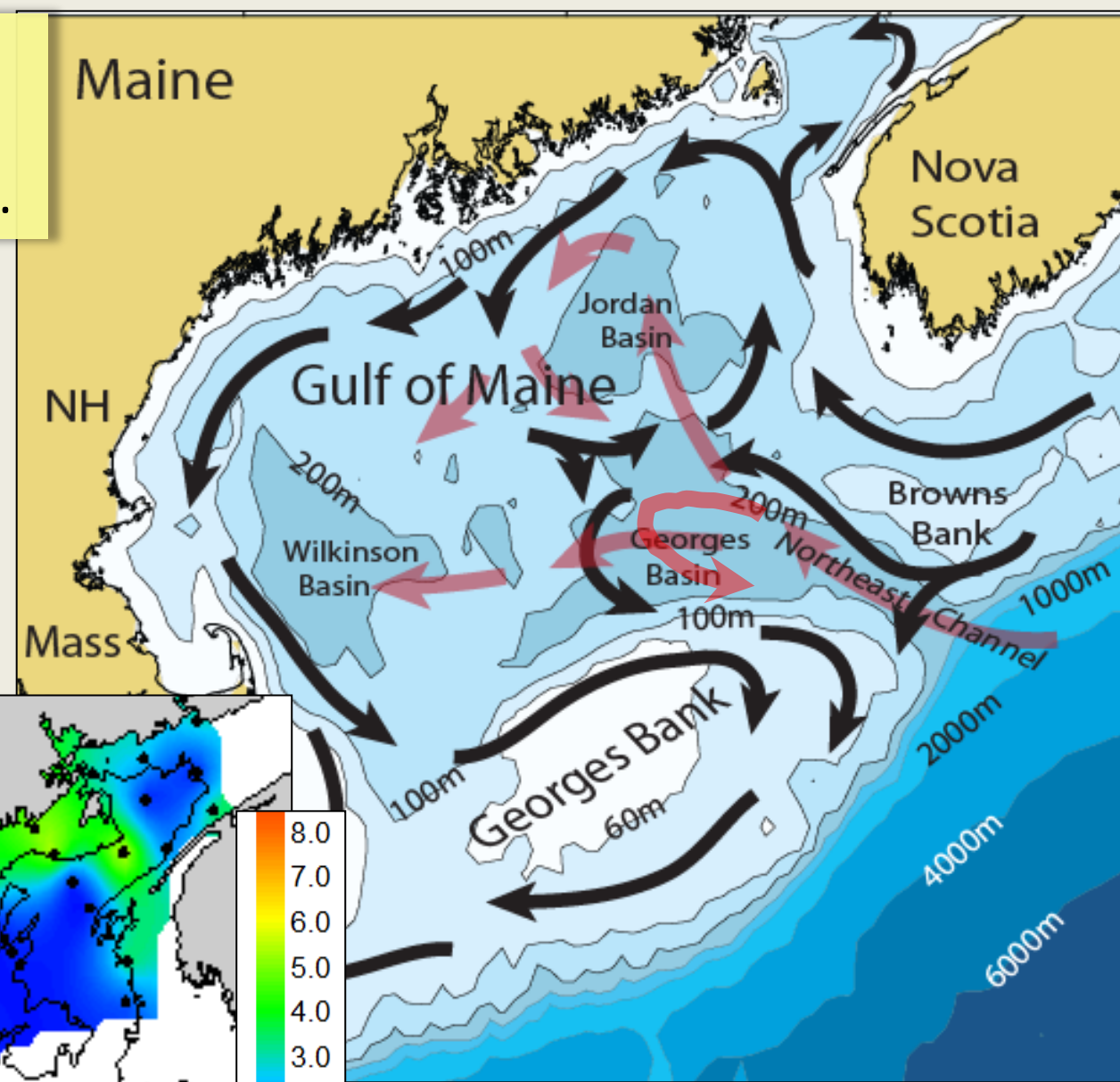
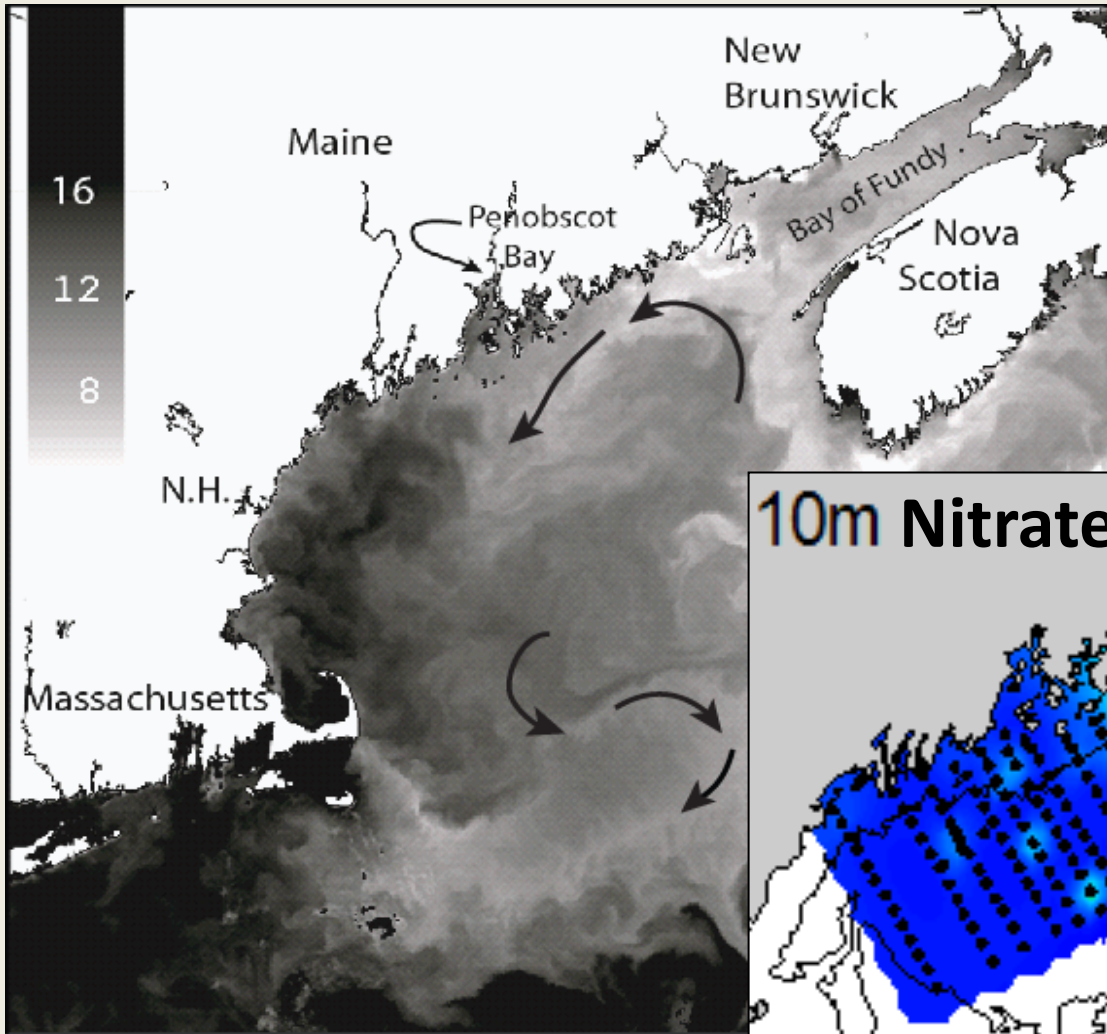


FIG. 152.—Depth below the surface of the isohalobath for 34 per mille, July to August, 1914

These deep *Slope Waters* supply the Gulf's Salt and Nutrients



✓ Once in the Gulf the deep nutrients (and salt) mix and circulate throughout the interior, thus driving biological productivity...

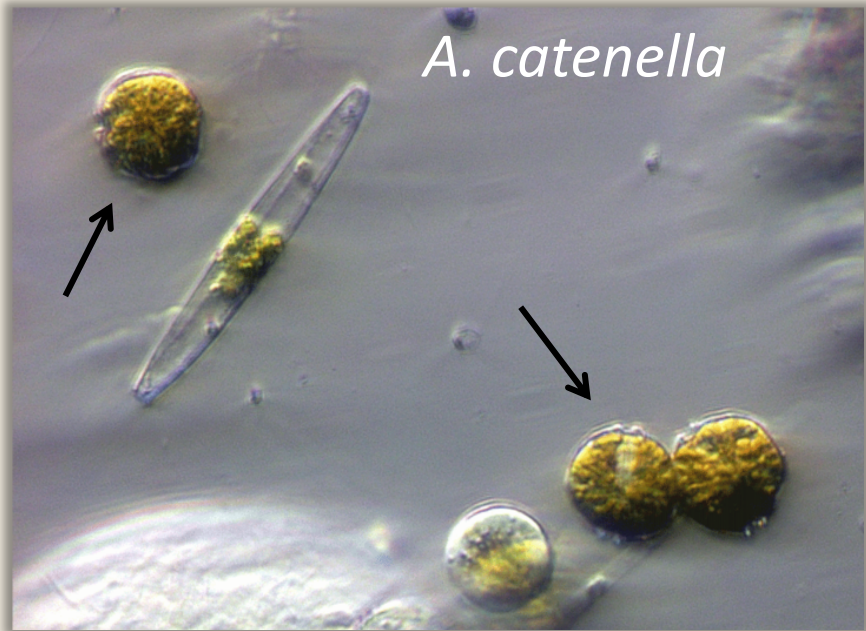


- **What about HABs?**

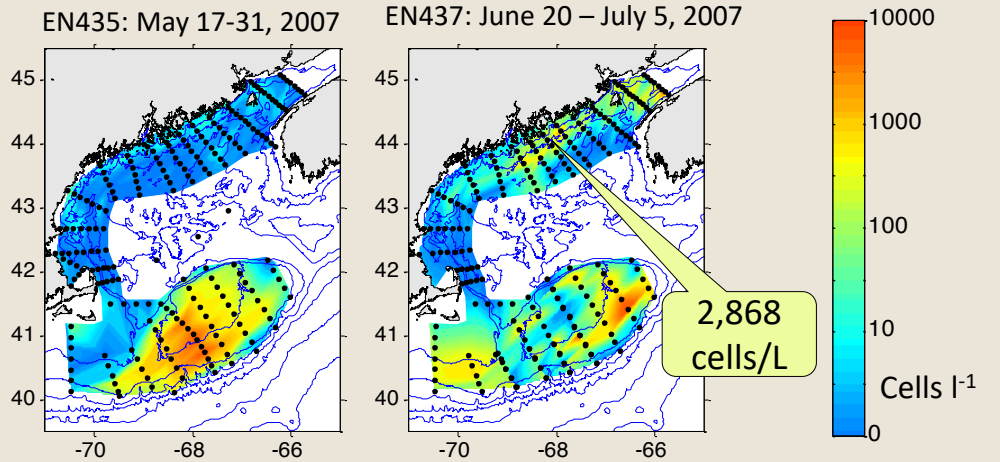
1. *Pseudo-Nitzschia australis* (ASP)
2. *Alexandrium catenella* (PSP)

- **And how is it all changing?**

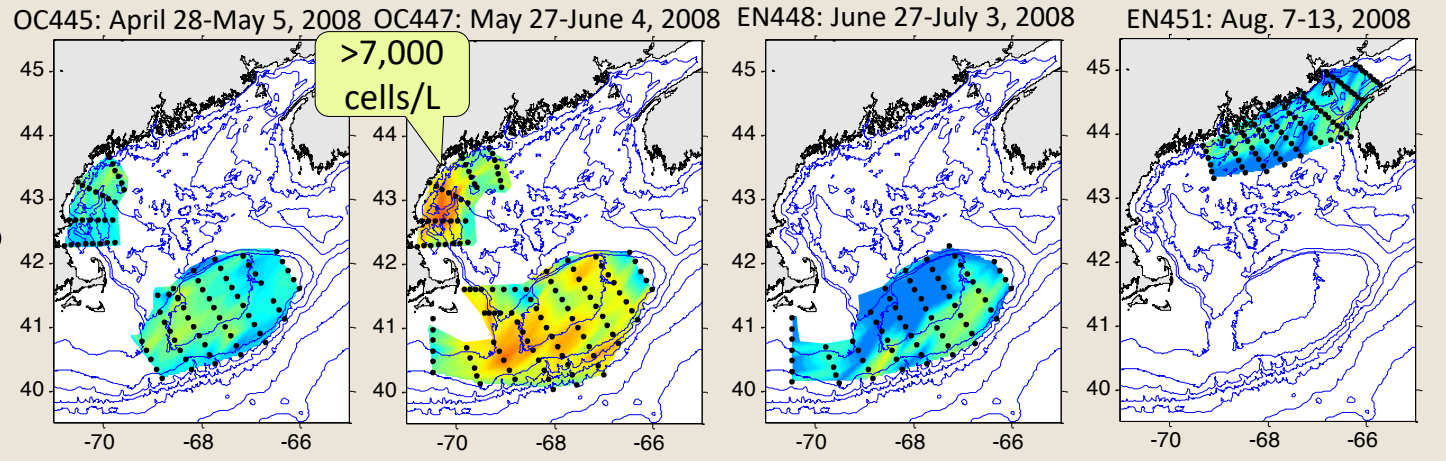
✓ Examples of earlier survey results:
Alexandrium (cells/L)



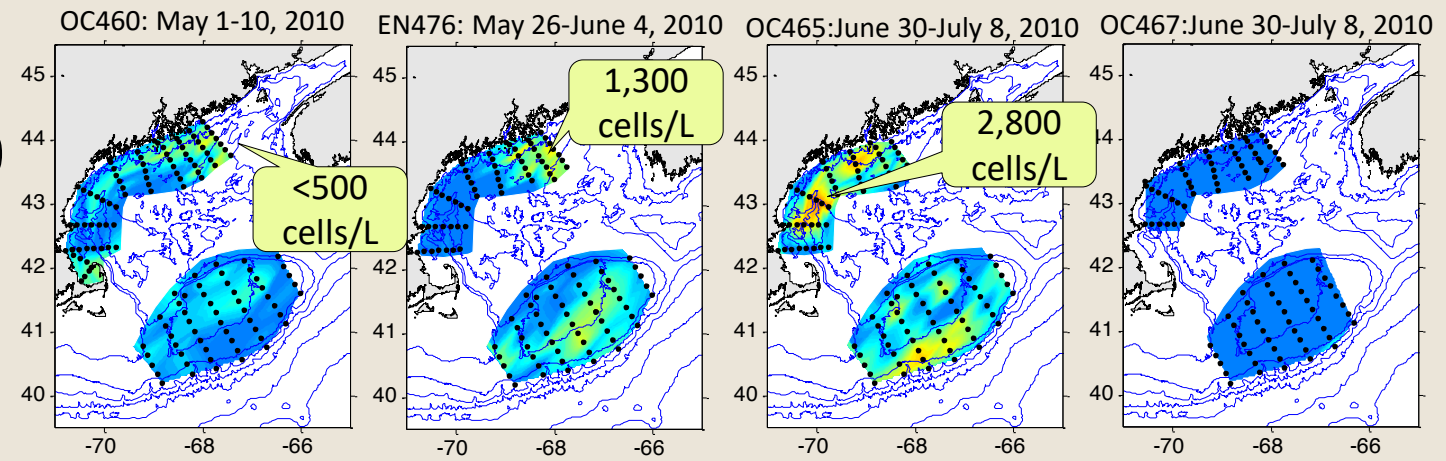
2007



2008



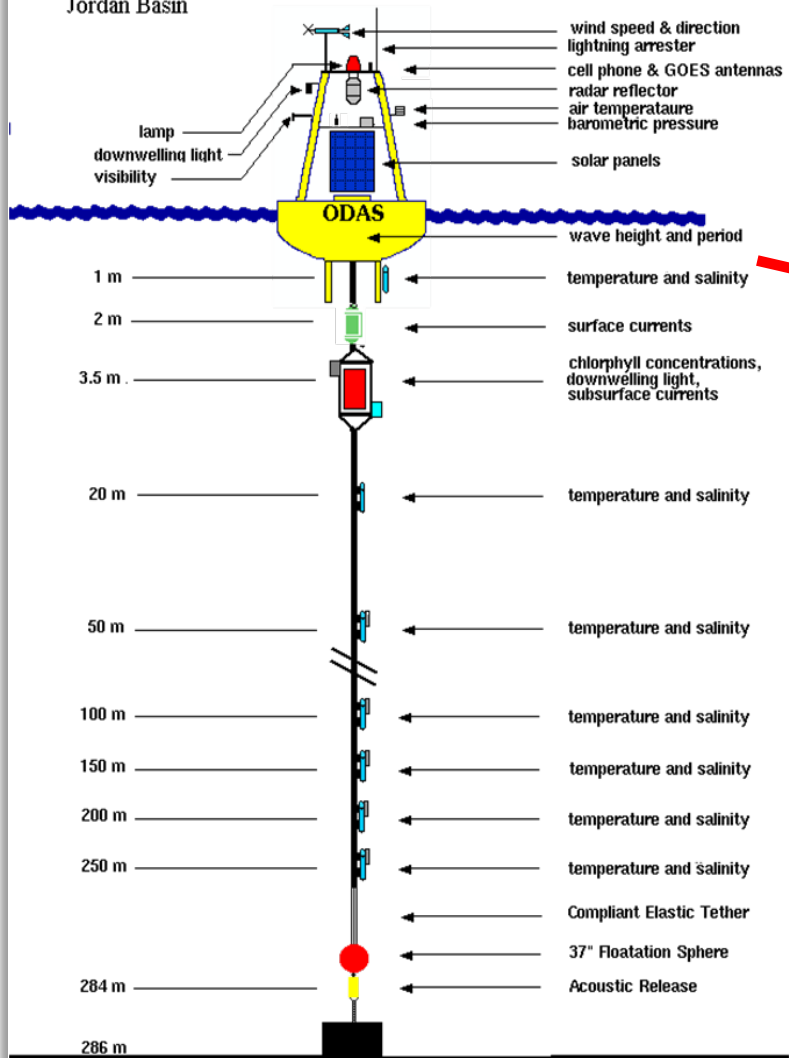
2010



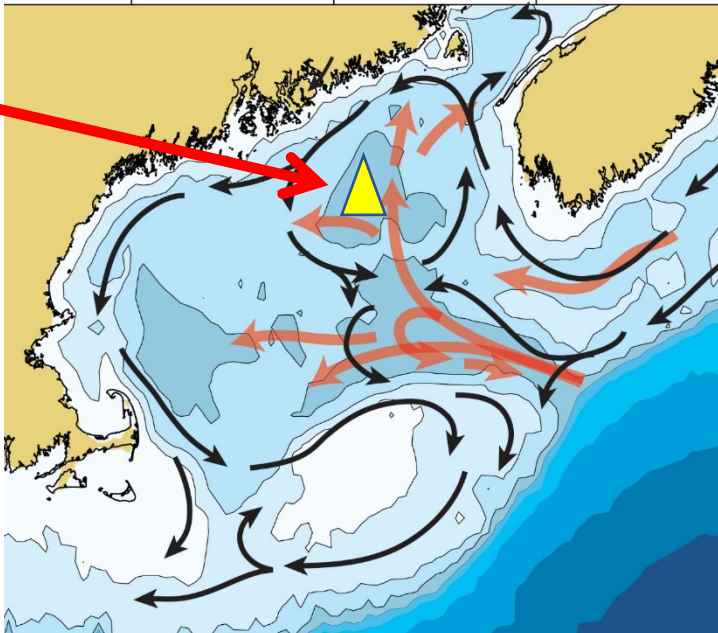
1. *Pseudo-Nitzschia* blooms in eastern Maine in 2016 and 2017: What happened?

MOORING M

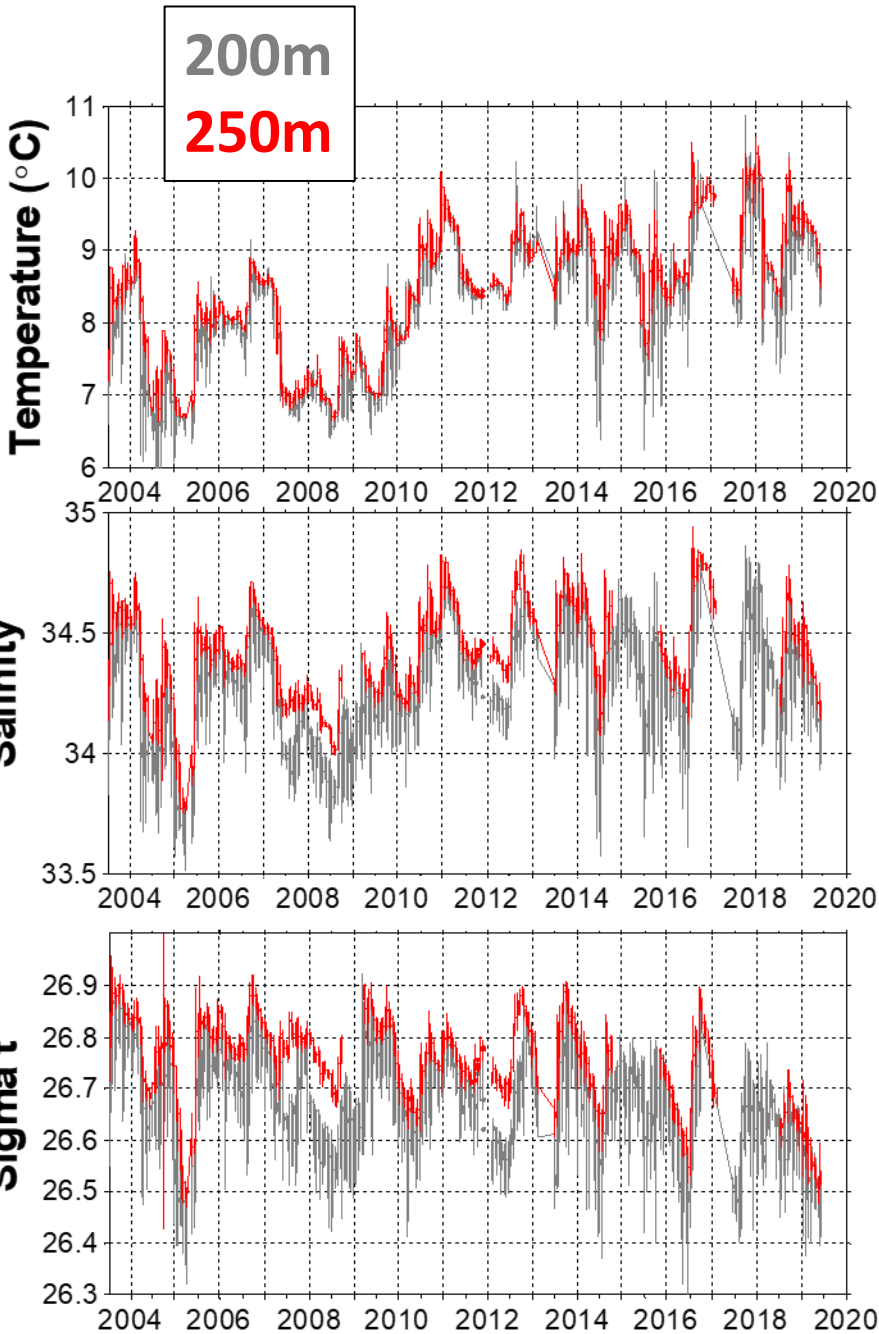
Jordan Basin



Jordan Basin
July 2003 to July 2019



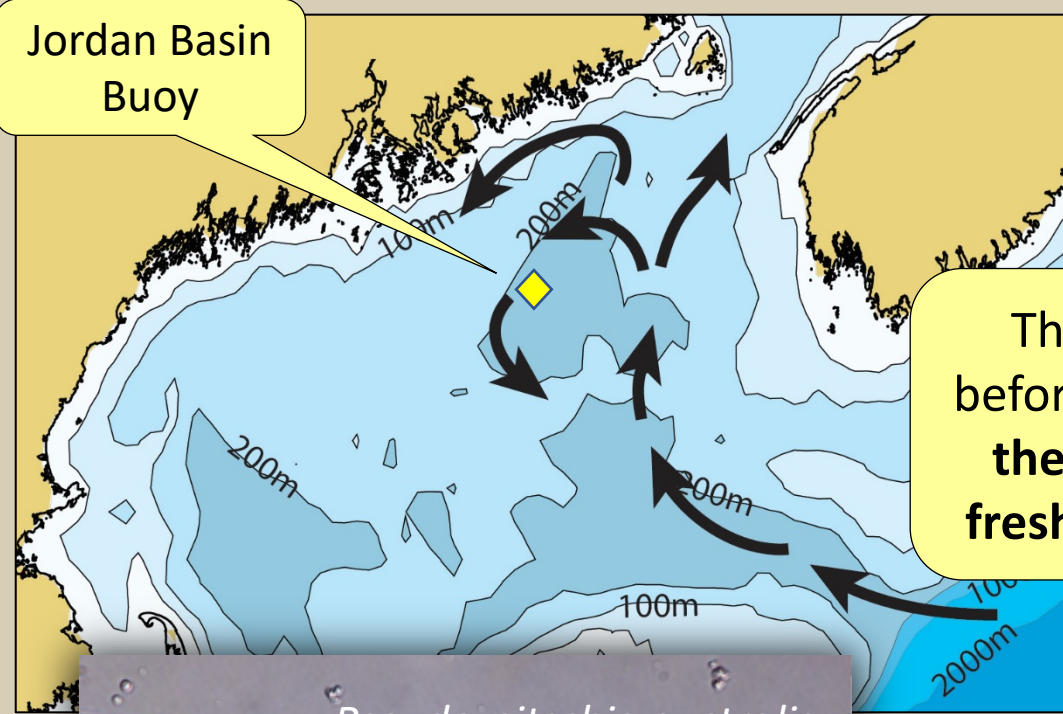
Deep and Bottom Water T, S and σ_t *All highly variable*



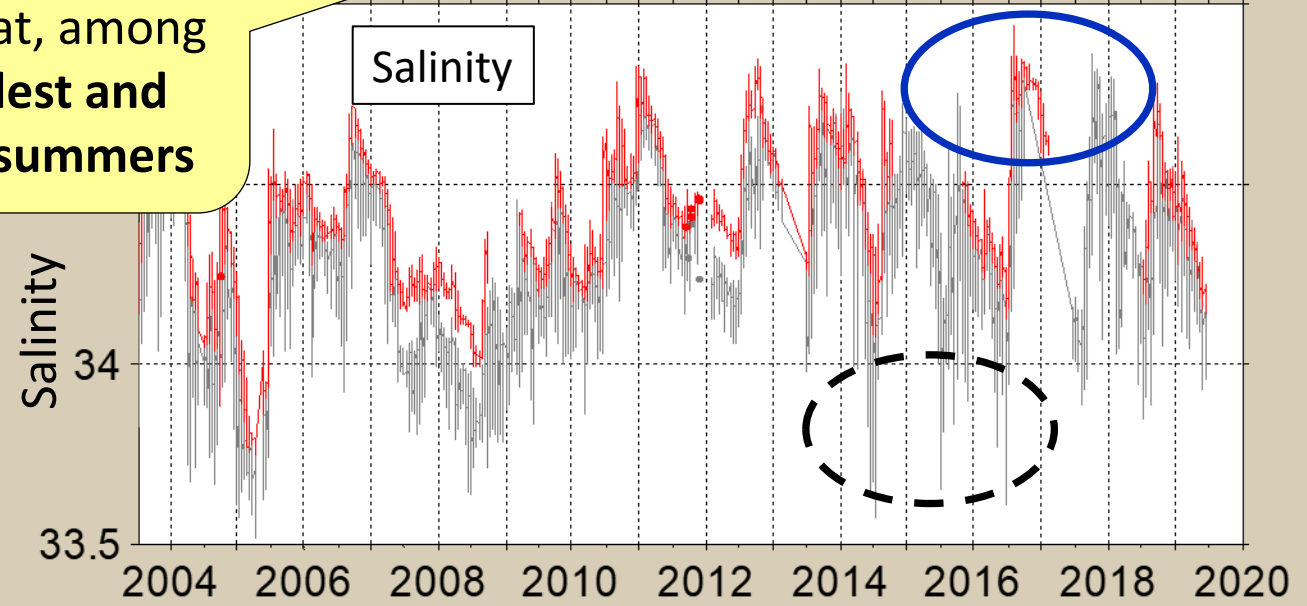
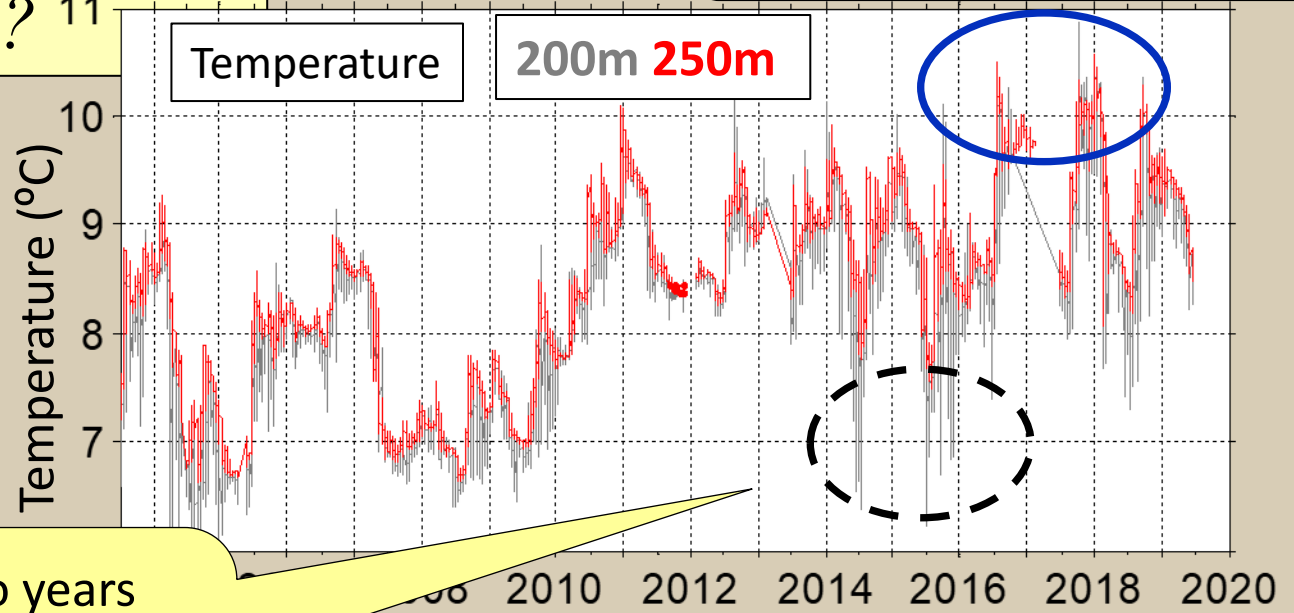
1. *Pseudo-Nitzschia* blooms in eastern Maine in 2016 and 2017: What happened?

Fall 2016 & 2017: warmest and saltiest on record

Buoy data: July 2013 to July 2019



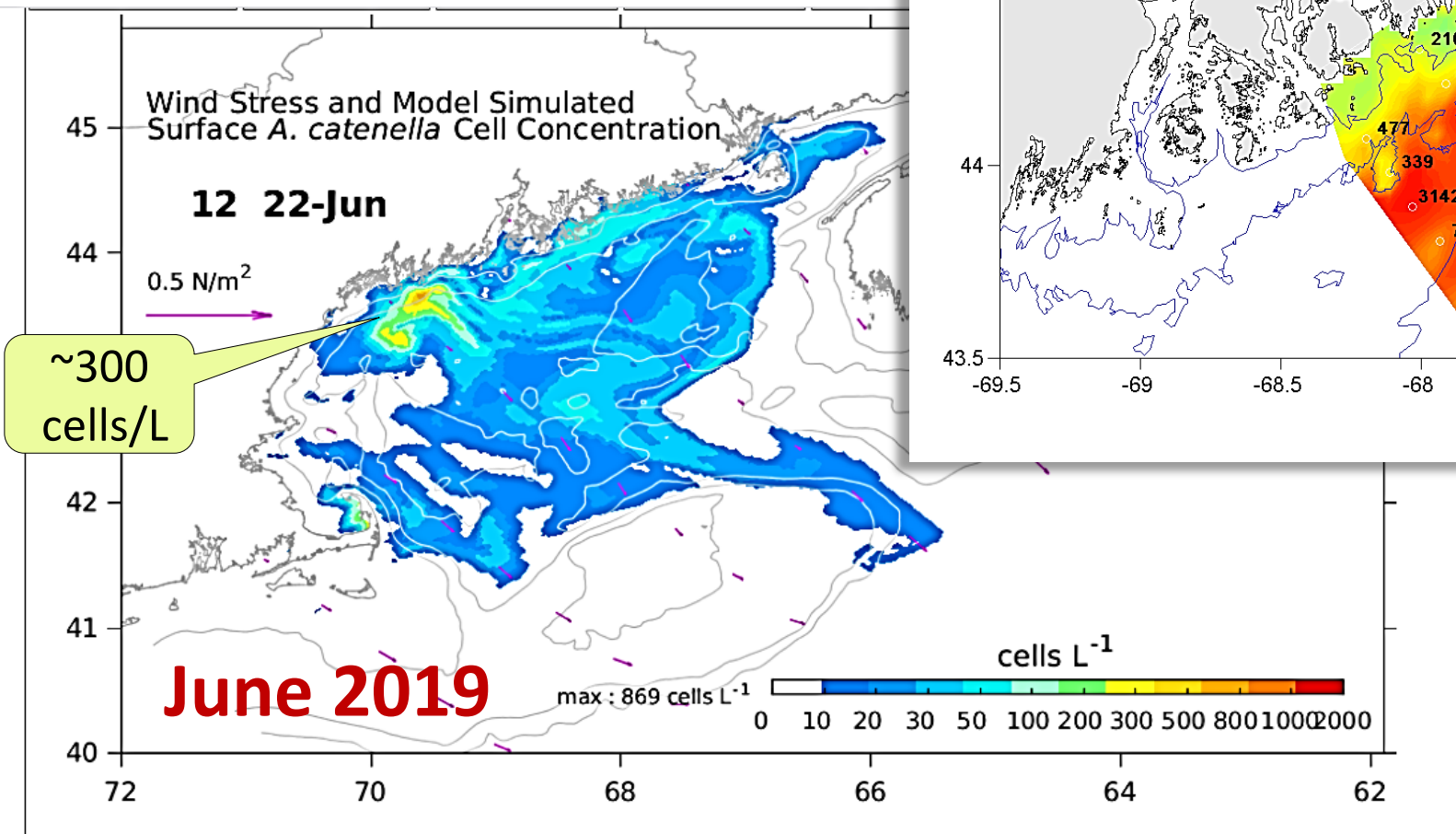
The two years before that, among the coldest and freshest summers



2. *Alexandrium catenella* bloom last summer: What happened?

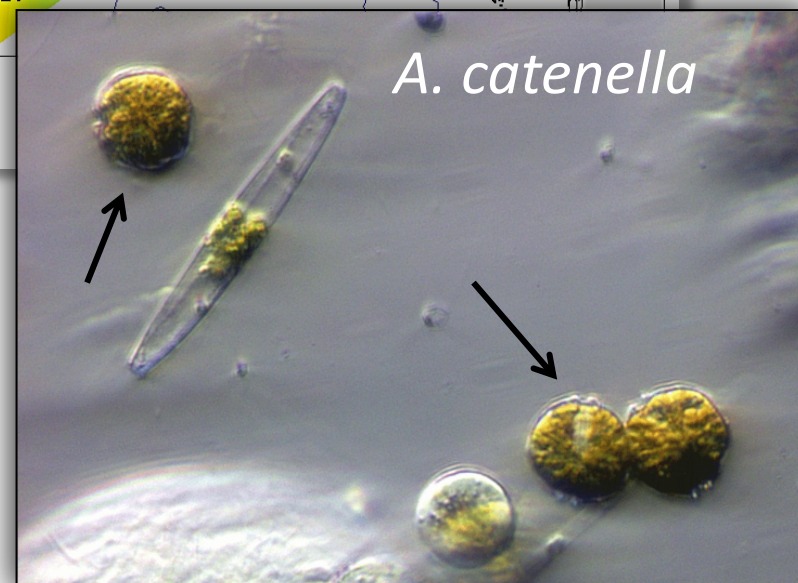
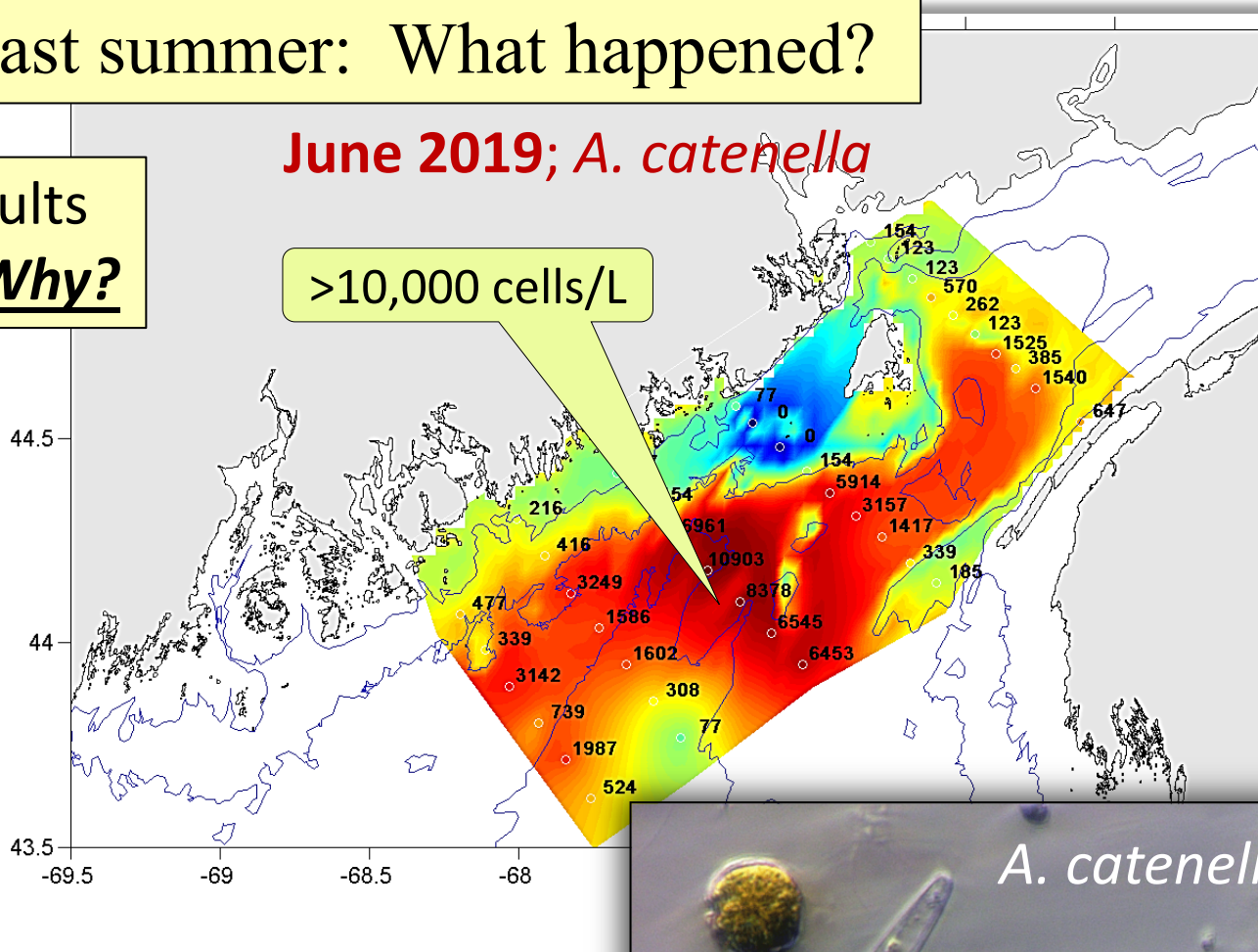
The NOAA "Operational Model" and results from last summer: ***The model failed. Why?***

 **NCCOS** NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE



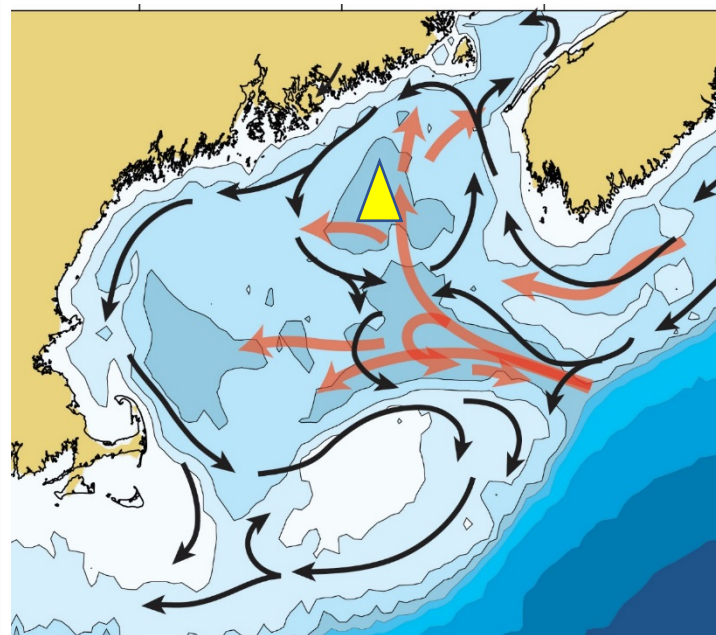
June 2019; *A. catenella*

>10,000 cells/L

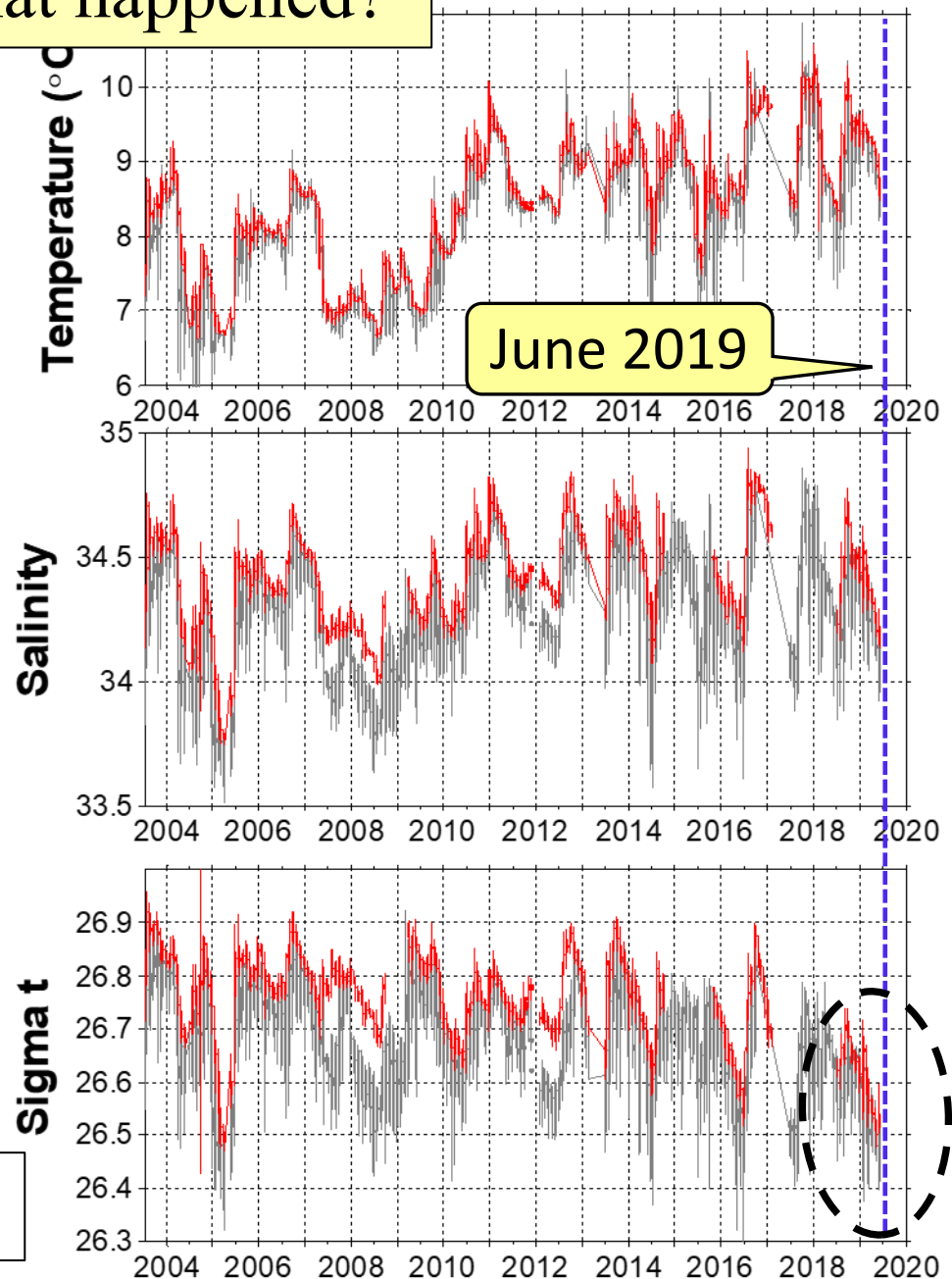
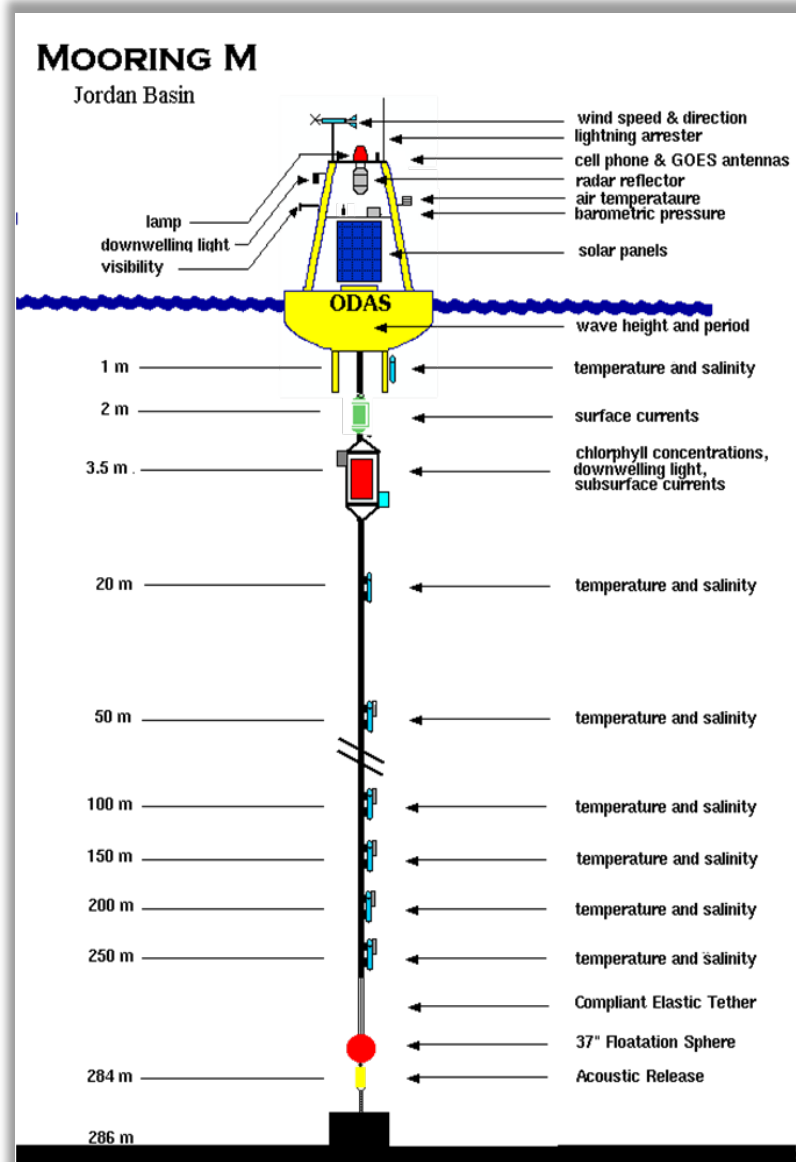


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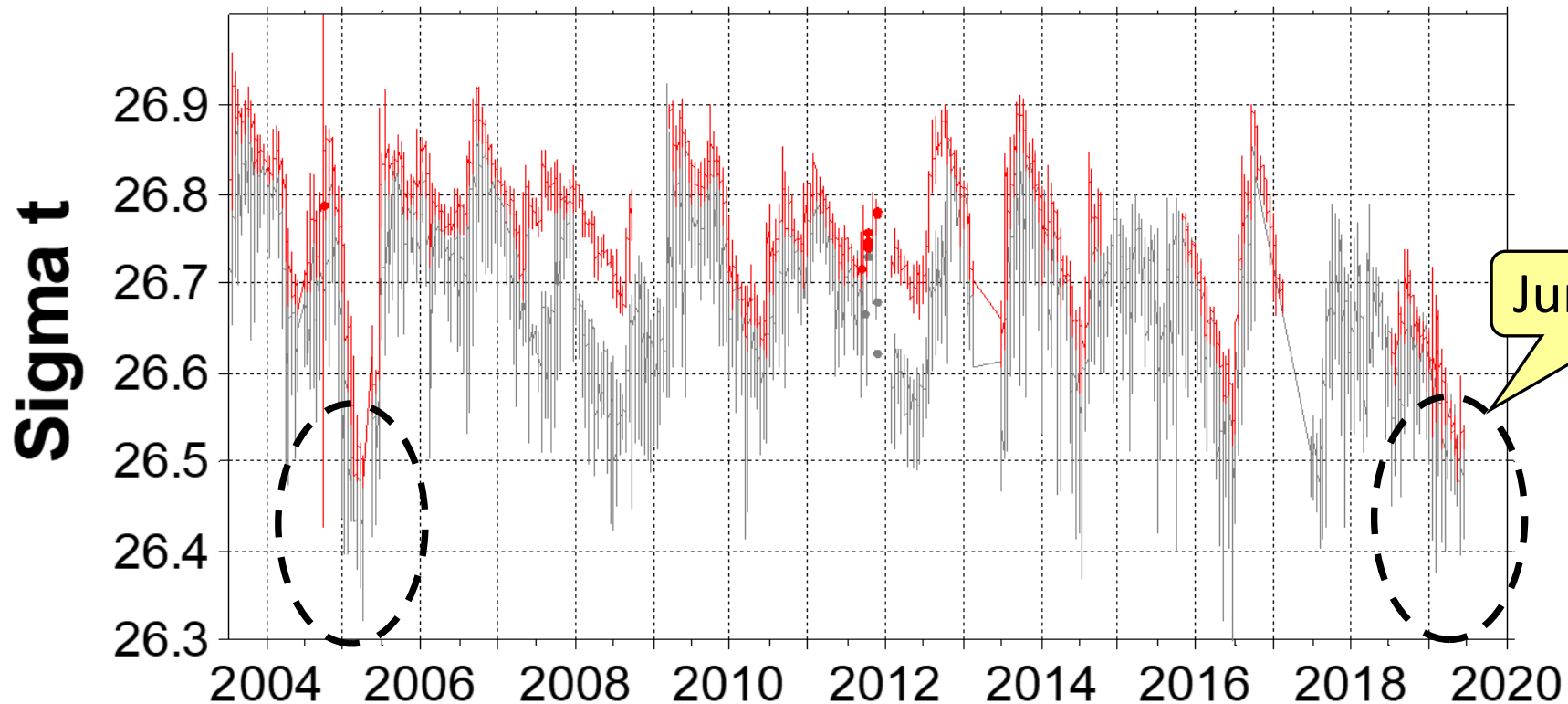
Deep water properties (T, S & σ_t) in Jordan Basin were very different, which affected vertical nutrient fluxes ...



200m, 250m



2. *Alexandrium catenella* bloom last summer: What happened?



Summer 2019 had **lowest density** deep & bottom water since summer of 2005...
Which was the last time we had a major bloom!

200m, 250m

MOORING M
Jordan Basin

lamp
downwelling light
visibility

1 m

2 m

3.5 m

20 m

50 m

100 m

284 m

286 m

← 37" Floatation Sphere
← Acoustic Release

26.9
26.8
26.7
26.6
26.5
26.4
26.3

2004 2006 2008 2010 2012 2014 2016 2018 2020