Water Masses & their Nutrients

A seasonal predictor of HABs?

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Maine DMR
W. Boothbay Harbor
April 10, 2018
Source waters to the Gulf of Maine:

- Relatively *fresh & cold* *Scotian Shelf Water* at shallower depths; and
- Relatively *warm & salty* *Slope Waters* at deeper depths and along the bottom; = *Source of Salt & Nutrients*.
- *(Plus some FW from rivers...)*
SST June 7, 2015
(Rutgers Univ)

Scotian Shelf Water

Cold/fresh SSW at Surface

“Shallow” Scotian Shelf Water

“Deep” Slope Water
Cold/fresh SSW at Surface

Scotian Shelf Water

Deep and Bottom Influx of warm/salty “Slope Water”, $S > 34\%$

“Shallow” Scotian Shelf Water

“Deep” Slope Water
As for the deep slope waters: There are two different Slope Water masses:

From Townsend et al., 2015; after Gatien, 1976, and Chapman and Beardsley, 1989
✓ Warm & salty *Warm Slope Water*, and
✓ Cold, relatively fresh, but denser, *Labrador Slope Water*

Cold & fresh water from the north, over the Nova Scotian Shelf and Slope

Warm & salty Slope Waters residing shoreward of the Gulf Stream

*From Townsend et al., 2015; after Gatien, 1976, and Chapman and Beardsley, 1989*
Each has different **Nutrient Loads**: Labrador Slope Water *Cold, Fresh, Low Nutr.*

From Townsend *et al.*, 2015; after Gatien, 1976, and Chapman and Beardsley, 1989
Each has different **Nutrient Loads:**

1. **WSW** has about 7 µM more N;
2. Both **WSW** and **LSW** have more N than Si.

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From Townsend et al., 2015; after Gatien, 1976, and Chapman and Beardsley, 1989
Once in the Gulf, deep *slope waters and their nutrients* are circulated and mixed upward by *winter convection* & by *tidal mixing* throughout the year.

**Example:** *Summer Nitrate at 10m; highest in tidally-mixed NE Gulf & carried with the residual circulation*...

*After:* Brooks, 1984; and Xue, Chai, Pettigrew, 2000.
Generalized schematic of flows & locations of Buoys (Univ. Maine / NERACOOS):

Allows **tracking of water mass fluxes**: 

- Surface Flows
- Deep & Bottom Flows
Jordan Basin: **Fall-Winter, 2016-2017:** *(Oct. 9, 2016 to Feb. 14, 2017)*

Scotian Shelf Water replacing warm surface layer, Nov-Dec

**Temp (°C)**

**Salinity**

**Sigma-t**

**Nitrate (μM)**

Very High Salinity > 34.8 *Gulf Stream Ring Water*
Jordan Basin: **Fall-Winter, 2016-2017:** *(Oct. 9, 2016 to Feb. 14, 2017)*

Nitrate concentrations at 1m and 20m are greater than at 50m; Scotian Shelf Water with 10-11 uM is *capping off low nitrate layer beneath.*
Dec. 25, 2016

Scotian Shelf Water penetrating interior Gulf at the surface
That *Scotian Shelf Water* spreads westward across the Gulf in winter...
Initial salinity 34.8 at 250m, then decreases

Initial nitrate 19 μM, then increases by 1.5 μM

An increase in bottom salinity usually indicates nutrient-rich slope water entering the Gulf, and so nitrate concentrations should increase, not decrease... This is evidence of Gulf Stream Ring water.
The next year: **Summer 2017 to Spring 2018 (June 29, 2017 to March 2018)**

- **Temp (°C):**
  - July: 0 to 100
  - August: 0 to 100
  - September: 0 to 100
  - October: 0 to 100
  - November: 0 to 100
  - December: 0 to 100
  - January: 0 to 100
  - February: 0 to 100
  - March: 0 to 200
  - April: 0 to 200
  - May: 0 to 200

- **Salinity:**
  - July: 30 to 35
  - August: 30 to 35
  - September: 30 to 35
  - October: 30 to 35
  - November: 30 to 35
  - December: 30 to 35
  - January: 30 to 35
  - February: 30 to 35
  - March: 30 to 50
  - April: 30 to 50
  - May: 30 to 50

- **Sigma t:**
  - July: 24 to 27
  - August: 24 to 27
  - September: 24 to 27
  - October: 24 to 27
  - November: 24 to 27
  - December: 24 to 27
  - January: 24 to 27
  - February: 24 to 27
  - March: 24 to 27
  - April: 24 to 27
  - May: 24 to 27

- **Nitrate (µM):**
  - July: 0 to 200
  - August: 0 to 200
  - September: 0 to 200
  - October: 0 to 200
  - November: 0 to 200
  - December: 0 to 200
  - January: 0 to 200
  - February: 0 to 200
  - March: 0 to 200
  - April: 0 to 200
  - May: 0 to 200

- **Notes:**
  - Again, **High Salinity > 34.8**
  - **Gulf Stream Ring Water**
  - Again, Scotian Shelf Water in 2017-2018
The next year: **Summer 2017 to Spring 2018 (June 29, 2017 to March 2018)**

- **Temperature at 200m & 250m** increases from 8 to 10 °C
- **Nitrate at 250m** decreases, from ca. 20 μM to 18 μM

(250m salinity sensor failure & SUNA 20m failure, Aug.15, 2017)
Buoy M: Full Record
*July 2013 to March 2018*

Buoy M
Jordan Basin

**Temperature (°C)**
- 200m
- 250m

**Salinity**
- 200m
- 250m

[Graph showing temperature and salinity trends from 2004 to 2016]
Buoy M: Full Record
*July 2013 to March 2018*

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

Last two *winters*, warmest and saltiest on record
Warm-Core Gulf Stream Ring, Summer 2017 (June 4) at entrance to the Northeast Channel...
HB1701: February 12 to 22, 2017

Warm, Salty, Low Nutrient Gulf Stream Ring Water?
Nitrate and Silicate in the Two Slope Water Types:

**Labrador Slope Water**
(June 1997)

\[ \text{NO}_3 = 17.3 \, \mu\text{M} \]
\[ \text{Si(OH)}_4 = 10.2 \, \mu\text{M} \]
\( \Delta \approx 7 \, \mu\text{M} \)

**Warm Slope Water**
(August 1997)

\[ \text{NO}_3 = 24.6 \, \mu\text{M} \]
\[ \text{Si(OH)}_4 = 14.7 \, \mu\text{M} \]
\( \Delta \approx 10 \, \mu\text{M} \)
“Snapshots” from the past:

Station Profiles of N and Si in Jordan Basin in the Interior Gulf:

By 2006, no difference between $[\text{NO}_3]$ and $[\text{Si(OH)}_4]$!

*Which is impossible if those deep waters are Slope Waters...*

Q. Have deep-water nutrients in offshore waters been changing over the past few decades?

Townsend et al. 2010