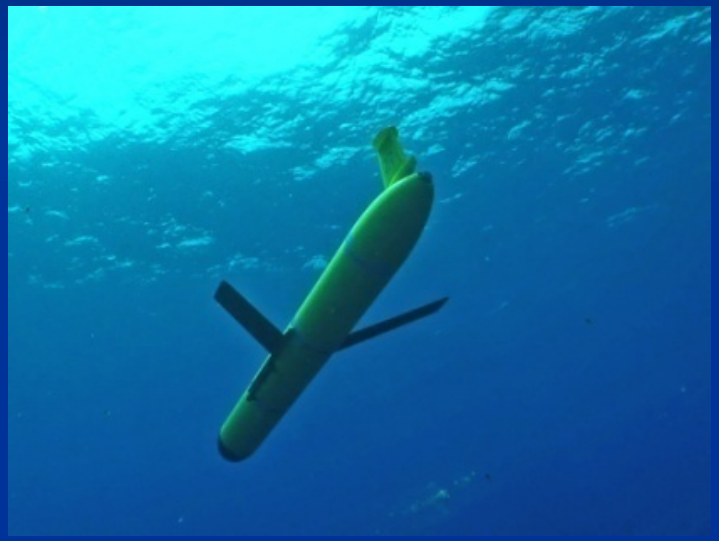
Ocean Glider Observations of the Mid-Atlantic Bight Cold Pool



Wendell Brown

University of Massachusetts Dartmouth
School for Marine Science & Technology

for

a large cast of MARACOOSIANS

Talk Outline

- Cold Pool Context
- Cold Pool Mapping
- Cold Pool Modeling

UG^2-EGO Presentation

22 May2019

UMASS DARTMOUTH

MARACOOS
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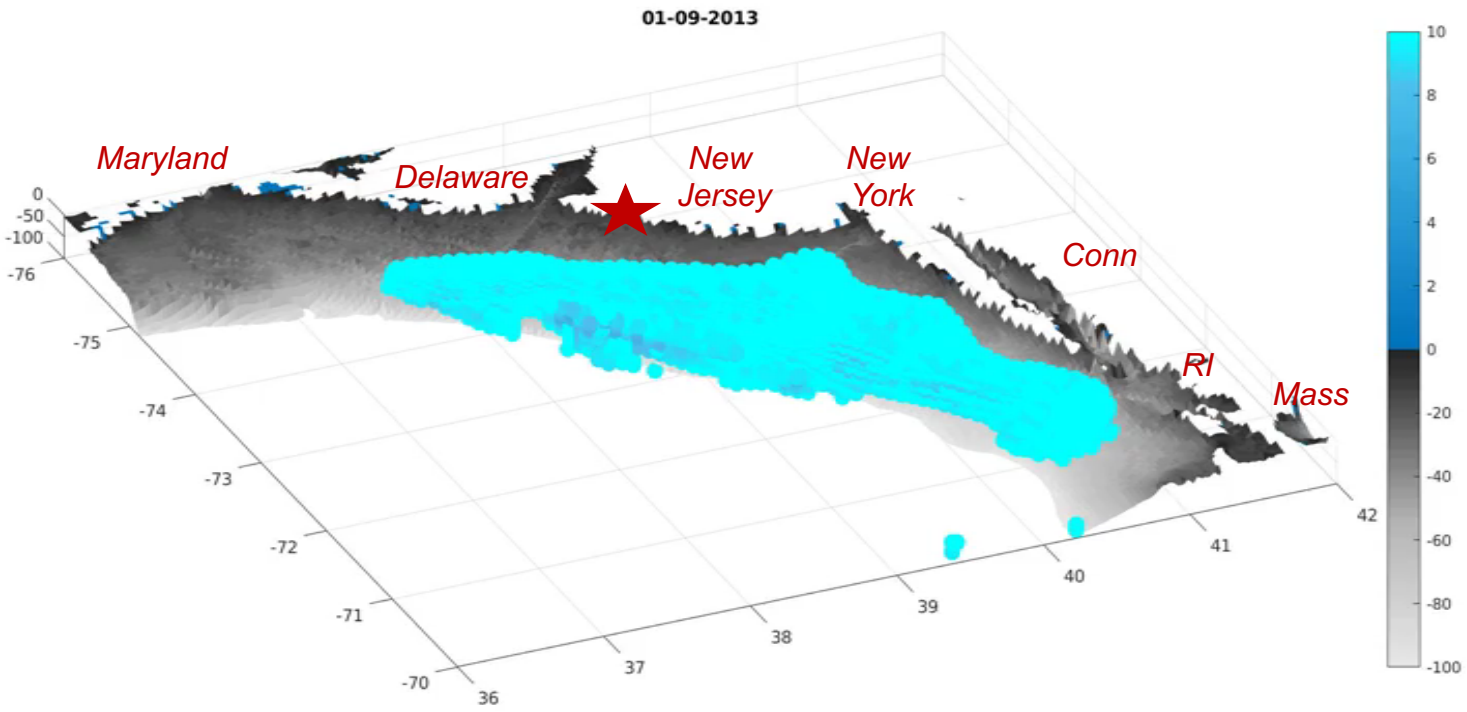
ESPRESSO Model Run: Sub-10°C Water

Daily Maps: September – October 2013



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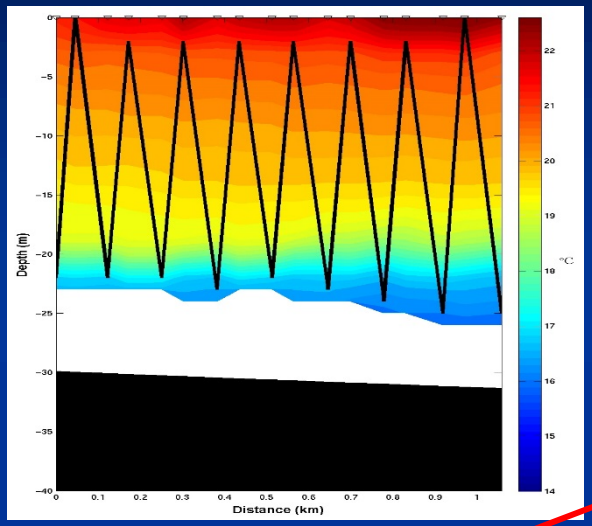
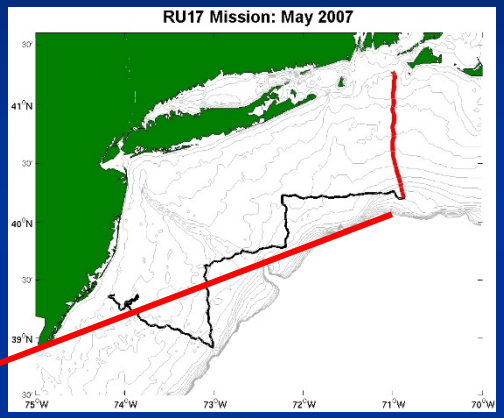
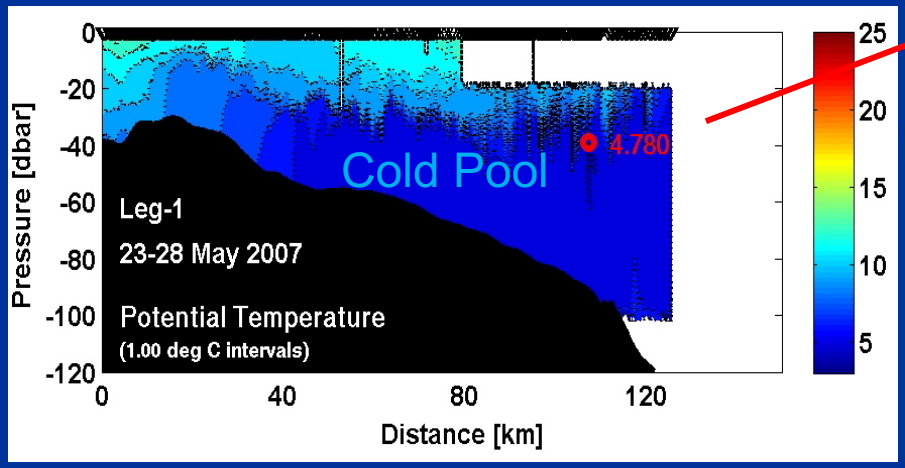
Measuring the MAB Cold Pool with Slocum Ocean Gliders







COLD POOL Established May 2007

Mapping the *2007 Coastal Ocean*
….with a ONE-GLIDER "Fleet "

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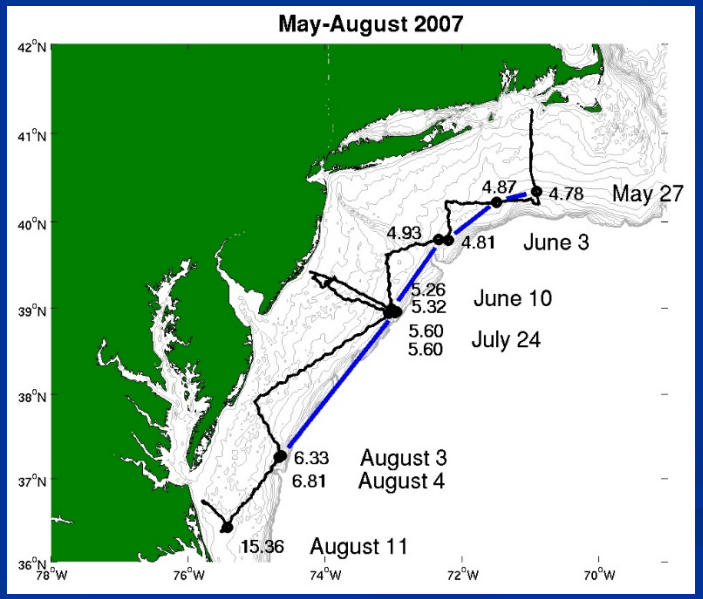
Summary

Mapping the *2007 Coastal Ocean* ….*with a ONE-GLIDER "Fleet "*

Section Minimum Temperatures

1
2
4
6
8



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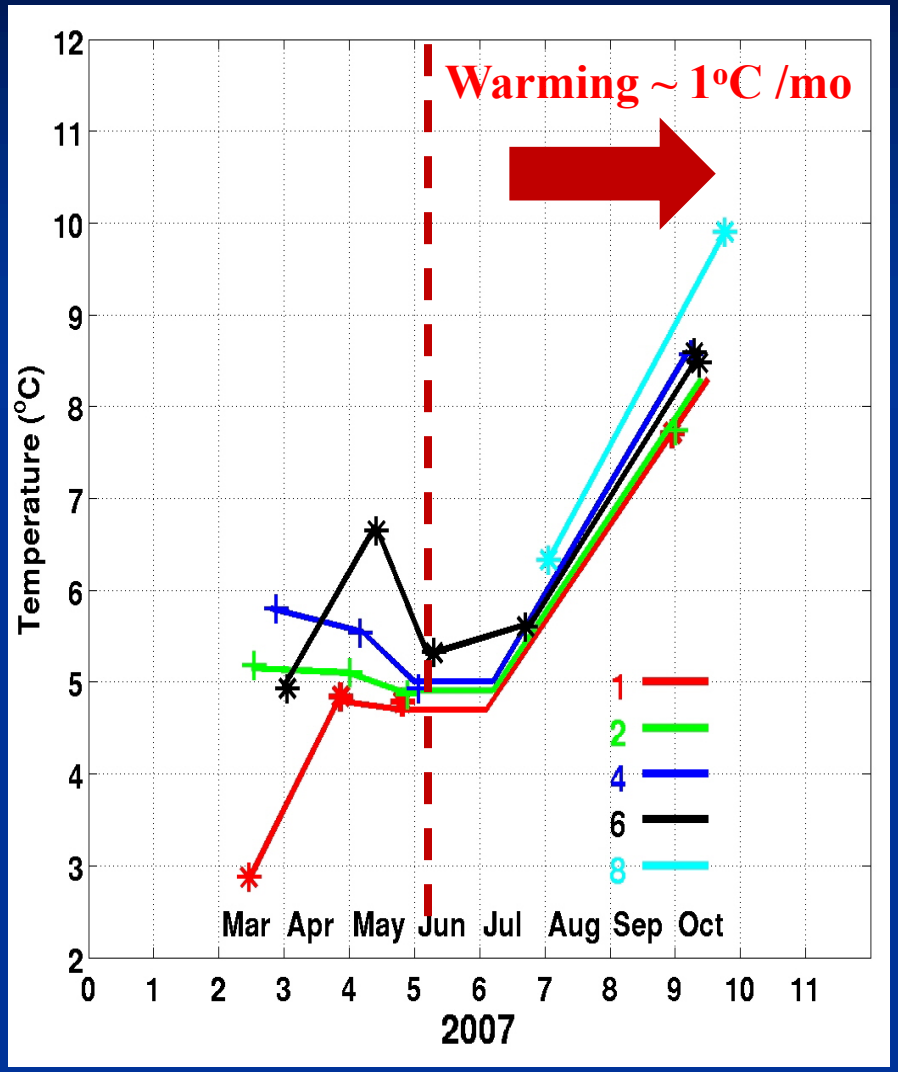
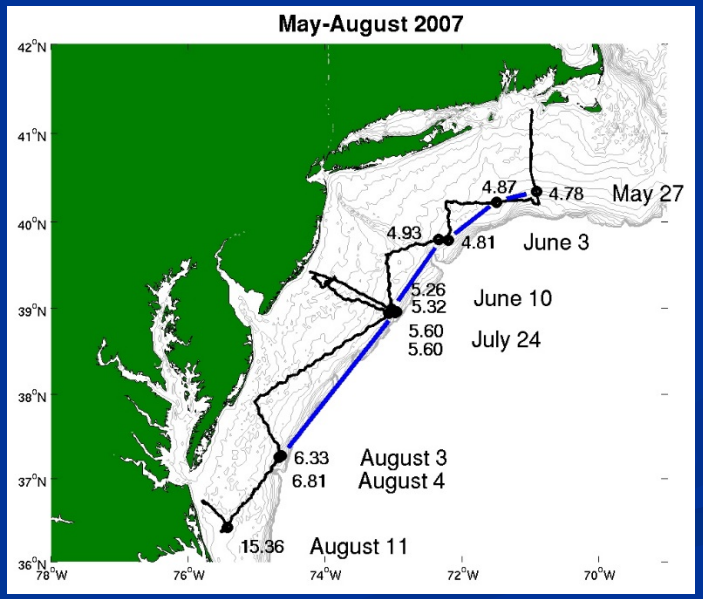
Summary

Mapping the *2007 Coastal Ocean* ….*with a ONE-GLIDER "Fleet "*



Warming Phase



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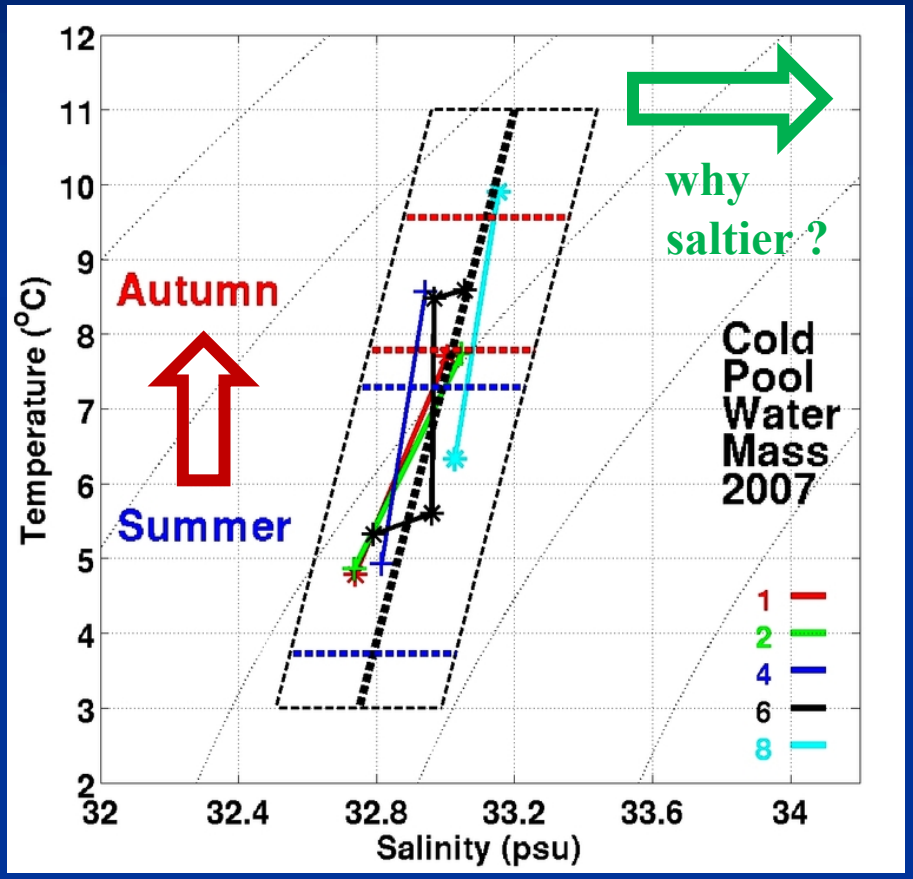
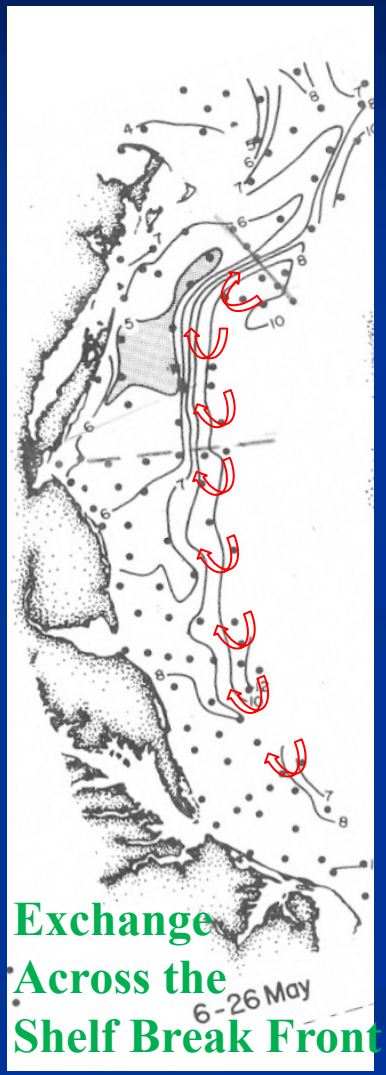
Defining Properties of COLD POOL WATER MASS





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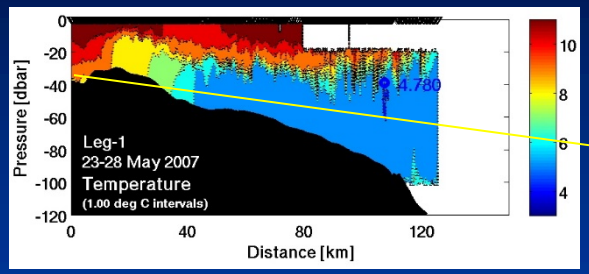
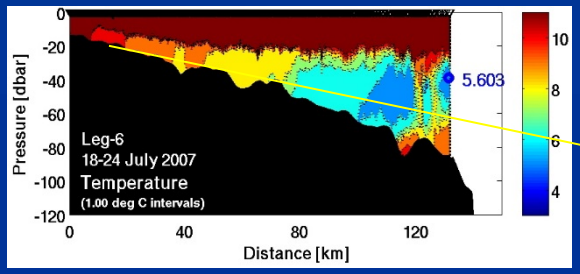
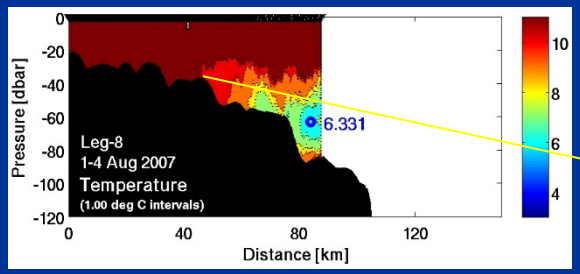
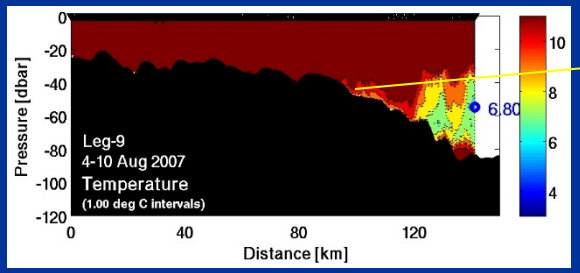
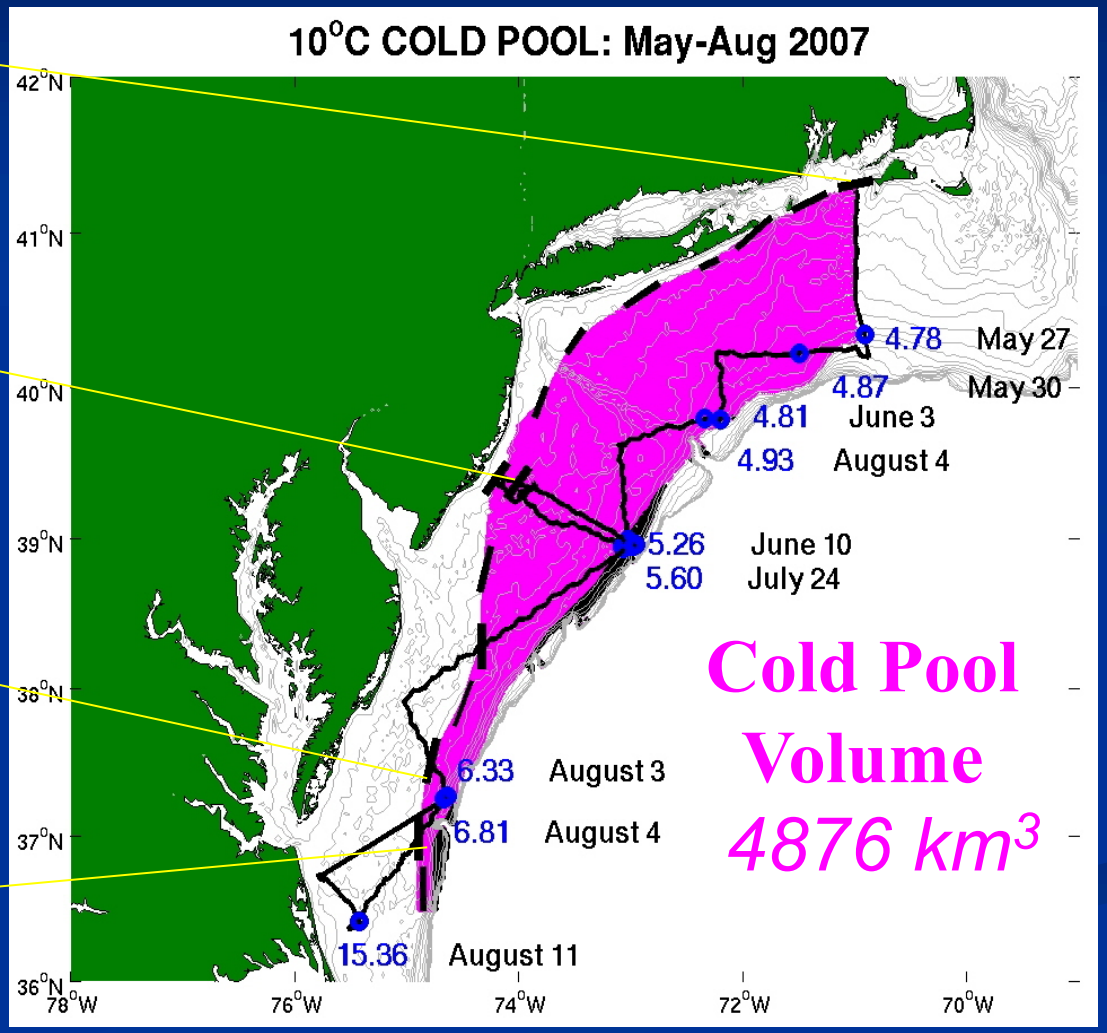
Mapping the *sub-10°C* COLD POOL : *May –Aug 2007*











PROBLEM!

How do you map an evolving Cold Pool?

=> Multi -Glider Ocean Information

+

=> Data Assimilation Ocean Modeling

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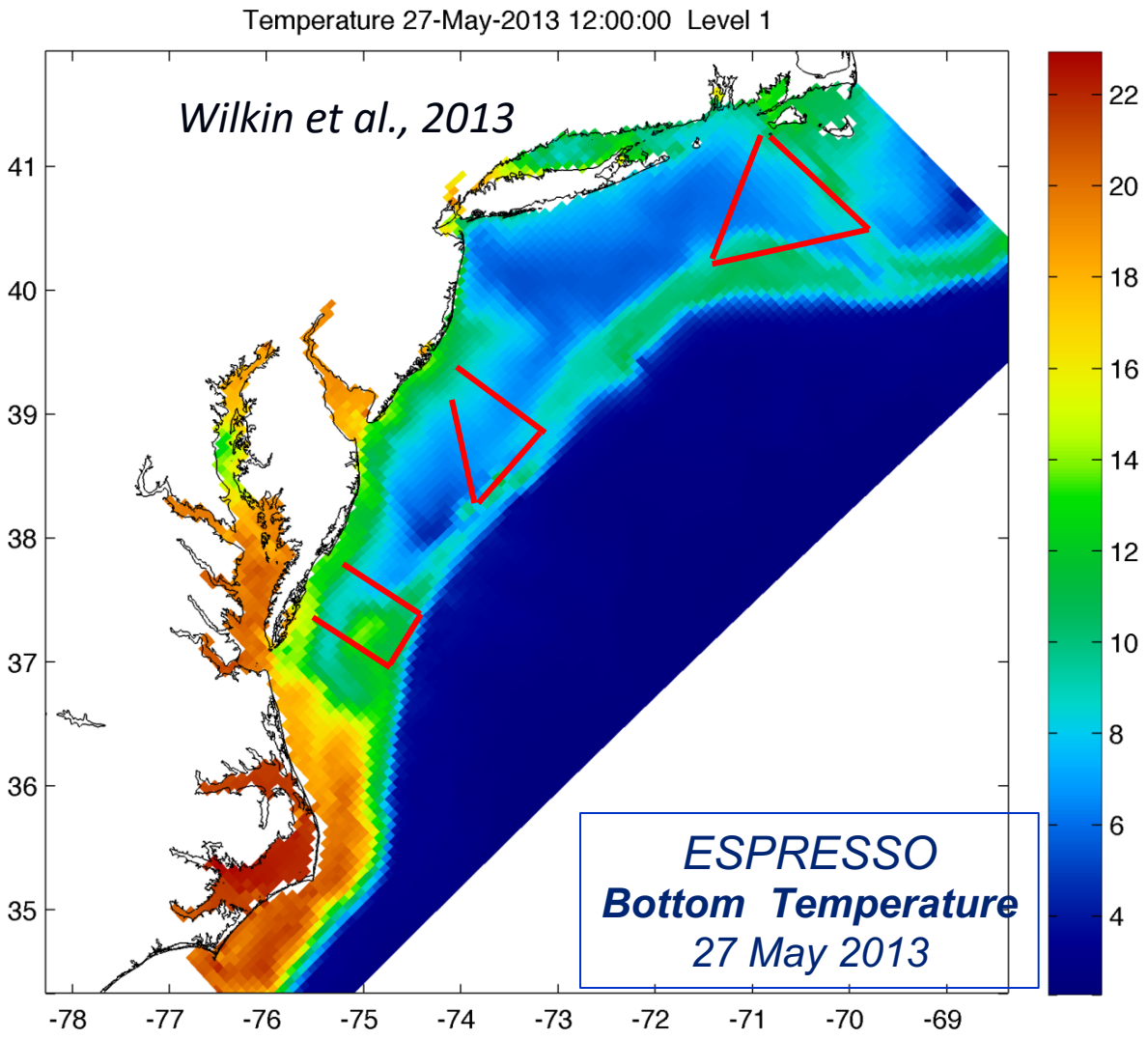
Cold Pool Glider Array Design: *Model Guidance*



One of the COLD POOL SCIENCE QUESTIONS

Relative importance of

top-down

vs.

cross-frontal exchange

vs.

convergence

Cold Pool *summer warming* ??

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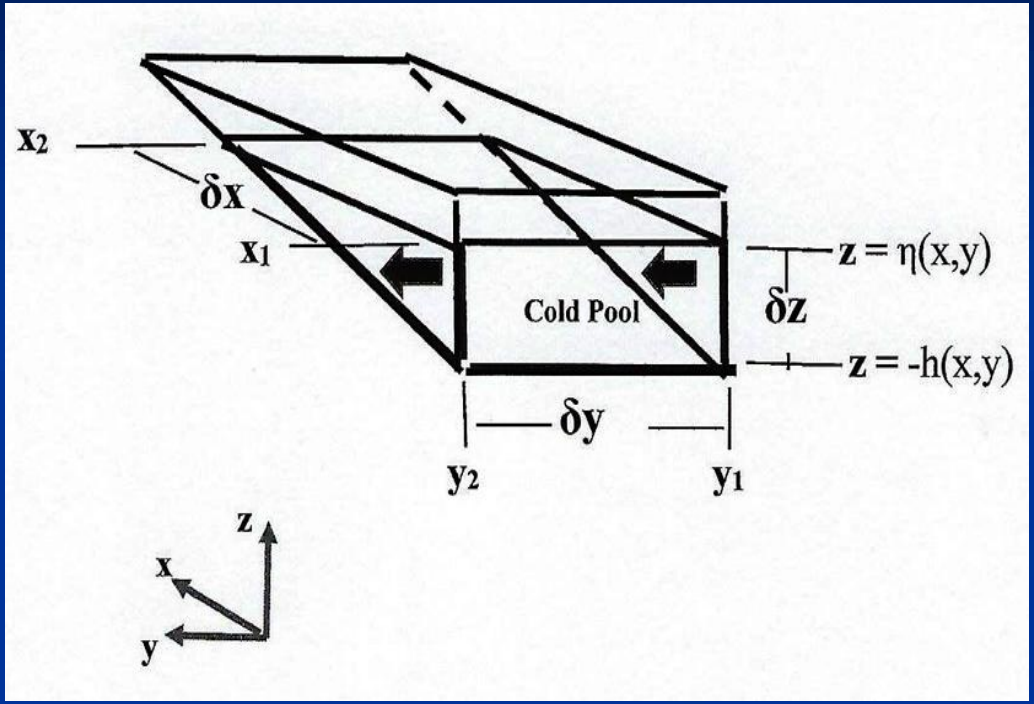
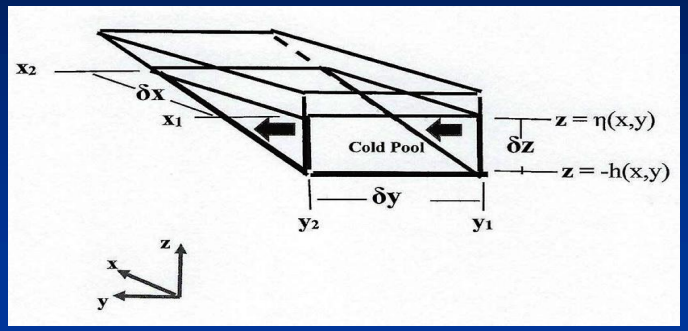
The COLD POOL Slice Model



FOCUS on the Warming Phase

COLD POOL Model: *September 2013*



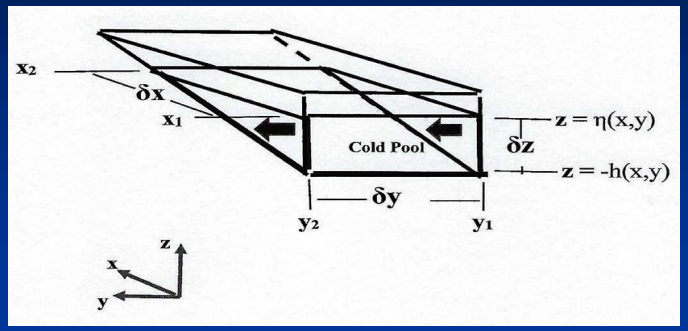
Integrate Temperature => Conservation

Cold Pool Slice Model Warming Rate

$$\left(\frac{\delta\left[\overline{T}\right]_{ave}}{\delta t}\right) = -\frac{K_x}{\delta x}\frac{\partial \overline{T}}{\partial x}(x_1) + \frac{\overline{uT}(x_1)}{\delta x} + \frac{1}{\delta y}\left(\left(\overline{vT}(y_1)\right) - \left(\overline{vT}(y_2)\right)\right) + \frac{K_z}{\delta z}\frac{\partial \overline{T}}{\partial z}\Big|^{\eta}$$

Term-1 = *Term-2* *Term-3* *Term-4* *Term-5*

COLD POOL Model: *September 2013*



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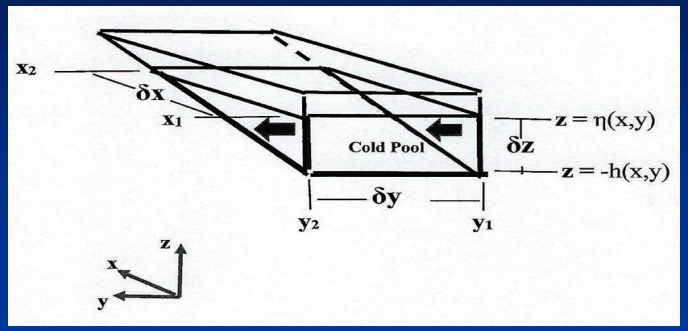
$$\left(\frac{\textbf{\textit{Cold Pool}}}{\textbf{\textit{Warming}}}\right) = \textbf{in}\text{eddy}_{OS}\,T(x_1) + \textbf{in}\text{flow}_{OS}\,T(x_1) + \textbf{\textit{in}}\text{flow}_{AS}\,T(y_1) - \textbf{\textit{outflow}}_{AS}\,T(y_2) + \textbf{\textit{in}}\text{eddy}_{DN}T(\eta_2)$$

COLD POOL Model: *September 2013*



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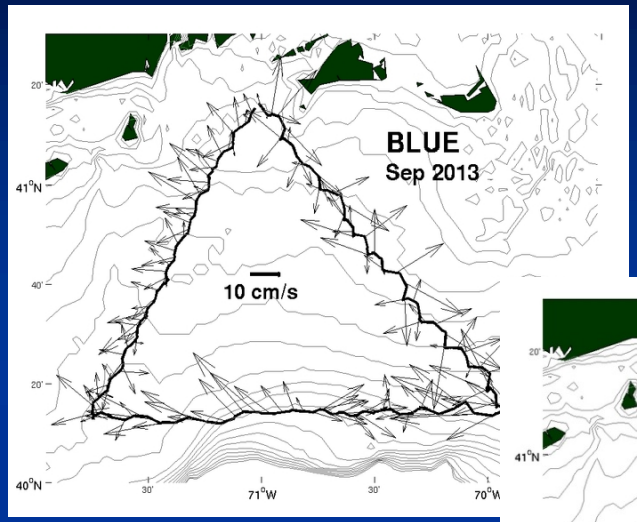
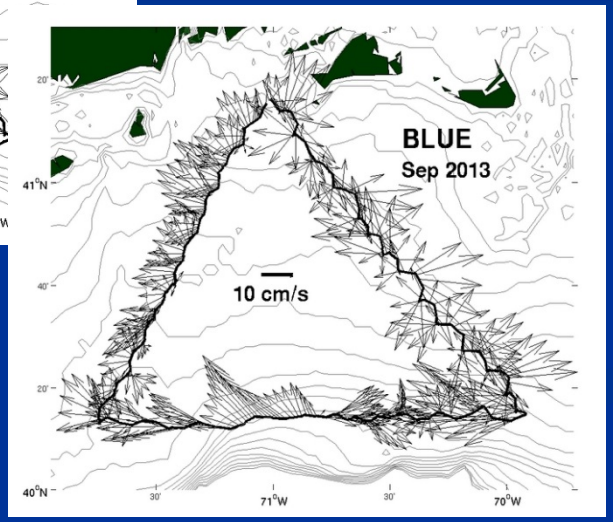
NEED TO ESTIMATE THESE TERMS

Glider Dead-Reckoned Velocity Processing

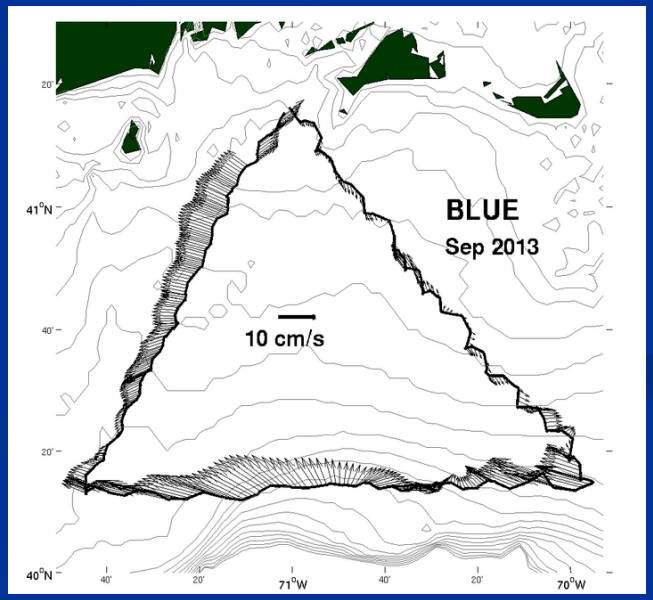


3-hourly



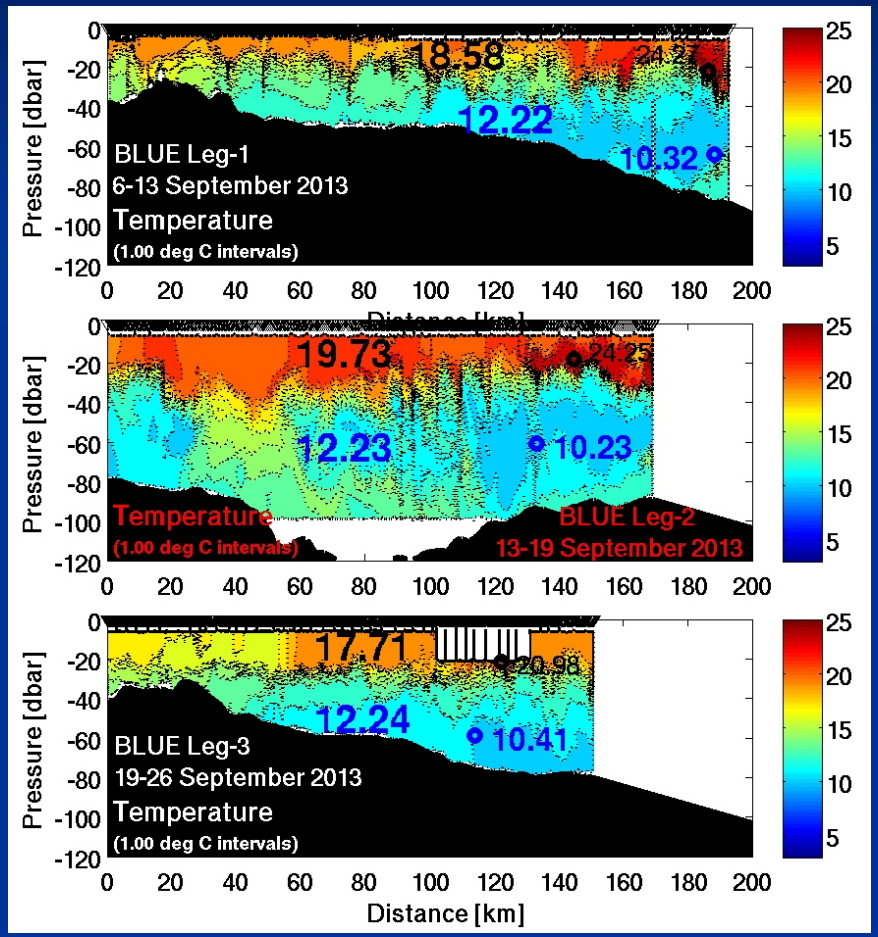
1-hourly

Detided
depth-independent
Currents

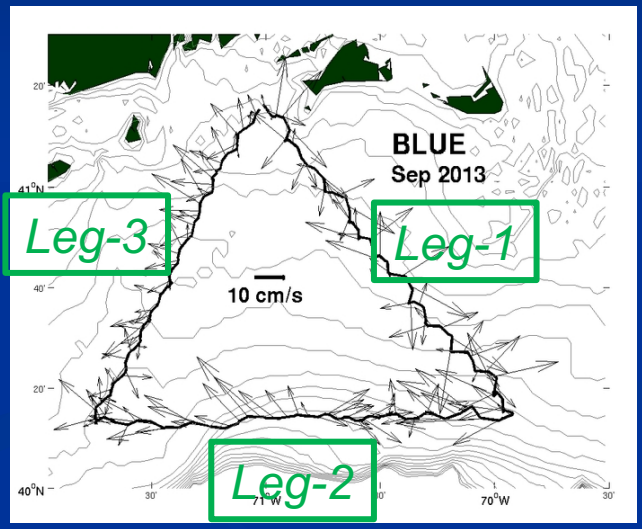


The DATA: *September 2013*

……the glider data



Temperatures



Velocities

COLD POOL Model: *September 2013*

Application Summary: Cold Pool Slice Model

$$\left(\frac{\delta\left[\overline{T}\right]_{ave}}{\delta t}\right) = -\frac{K_x}{\delta x}\frac{\partial \overline{T}}{\partial x}(x_1) + \frac{\overline{uT}(x_1)}{\delta x} + \frac{1}{\delta y}\left(\left(\overline{vT}(y_1)\right) - \left(\overline{vT}(y_2)\right)\right) + \frac{K_z}{\delta z}\frac{\partial \overline{T}}{\partial z}\Big|^{\eta}$$

Lentz, 2017

Survey ID	*Term 1* = (ºC/mo)	*Term 2* (ºC/mo)	*Term 3* (ºC/mo)	Term 4a (ºC/mo)	Term 4b = (ºC/mo)	*Term 4* (ºC/mo)	*Term 5* (ºC/mo)
SNEB	**0.58**	***-3.11***	**17.90**	3.74	-18.01	**-14.27**	**0.08**
BLUE	net warming	cooling	robust warming	warming	cooling	robust cooling	weak warming
NJ	**0.03**	***18.69***	**5.62**	-6.39	-17.91	**-24.31**	**0.03**
RU-23	net warming	robust warming	warming	cooling	cooling	robust cooling	weak warming
MD	**1.07**	***-21.12***	**-31.05**	147.81	-94.57	**53.24**	**0.03**
	net warming	robust cooling	robust cooling	warming	cooling	robust warming	weak warming

$$\left(\frac{\boldsymbol{Cold\ Pool}}{\boldsymbol{Warming}}\right) = \mathbf{ineddy}_{OS}\,T(x_1) + \mathbf{inflow}_{OS}\,T(x_1) + \boldsymbol{inflow}_{AS}\,T(y_1) - \boldsymbol{outflow}_{AS}\,T(y_2) + \boldsymbol{ineddy}_{DN}T(\eta_2)$$

COLD POOL Model: *September 2013*

Application Summary: Cold Pool Slice Model

$$\left(\frac{\delta\left[\overline{T}\right]_{ave}}{\delta t}\right) = -\frac{K_x}{\delta x}\frac{\partial \overline{T}}{\partial x}(x_1) + \frac{\overline{u}\overline{T}(x_1)}{\delta x} + \frac{1}{\delta y}\left(\left(\overline{v}\overline{T}(y_1)\right) - \left(\overline{v}\overline{T}(y_2)\right)\right) + \frac{K_z}{\delta z}\frac{\partial \overline{T}}{\partial z}\Big|^{\eta}$$

Onshore Eddy

Survey ID	*Term 1* = (°C/mo)	*Term 2* (°C/mo)	*Term 3* (°C/mo)	Term 4a (°C/mo)	Term 4b = (°C/mo)	*Term 4* (°C/mo)	*Term 5* (°C/mo)
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COLD POOL Model: *September 2013*

Eddy Temperature Transport Contribution

Term-2

$$-\frac{K_x}{\delta x}\frac{\partial \overline{T}}{\partial x}(x_1) = -\frac{\overline{u}\overline{T}(x_1)}{\delta x} - \frac{1}{\delta y}\left(\left(\overline{v}\overline{T}(y_1)\right) - \left(\overline{v}\overline{T}(y_2)\right)\right) - \frac{K_z}{\delta z}\frac{\partial \overline{T}}{\partial z}\Big|^{\eta} + \left(\frac{\delta\left[\overline{T}\right]_{ave}}{\delta t}\right.$$

Term-2 = *- Term-3* *- Term-4* *-Term-5* *+Term-1*

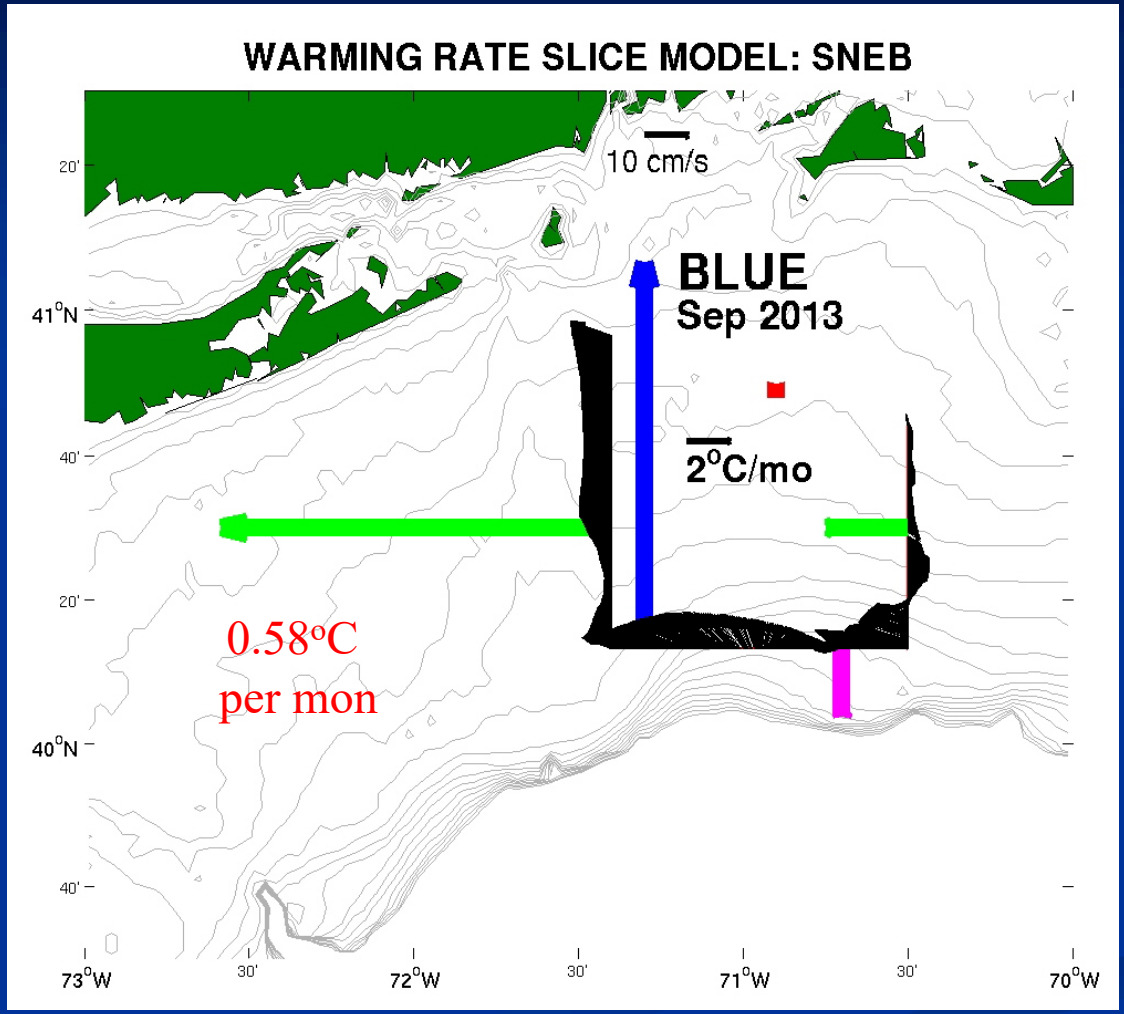
Onshore Eddy Term

= | *Terms estimated using GLIDER DATA* |

COLD POOL Model

SNEB

MODEL TERM ESTIMATES

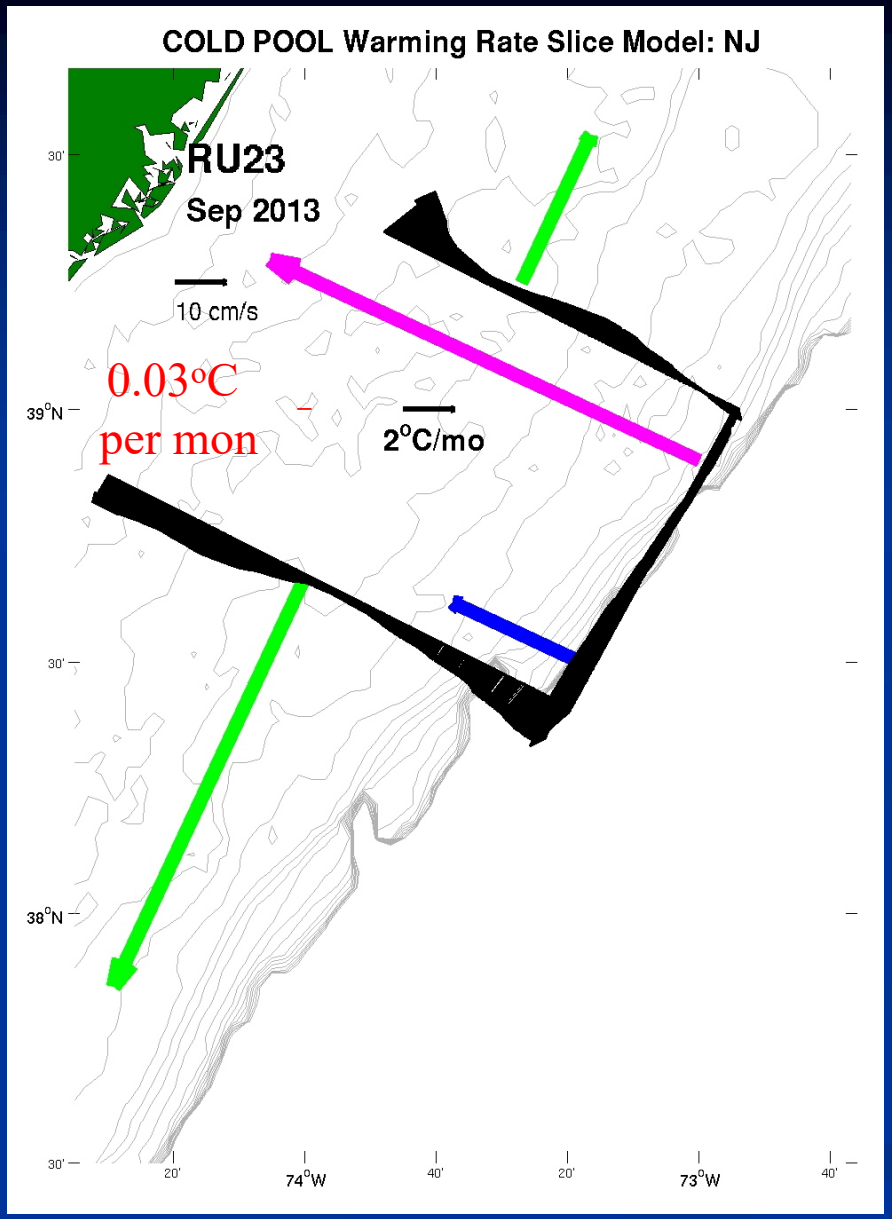


$$\left(\frac{Ocean}{Warming}\right) = \mathrm{ineddy}_{OS}\,\mathrm{T} + \mathrm{inflow}_{OS}\,\mathrm{T} + \mathit{inflow}_{AS}\,\mathrm{T} - \mathit{outflow}_{AS}\;T$$

COLD POOL Model

NJ

MODEL TERM ESTIMATES

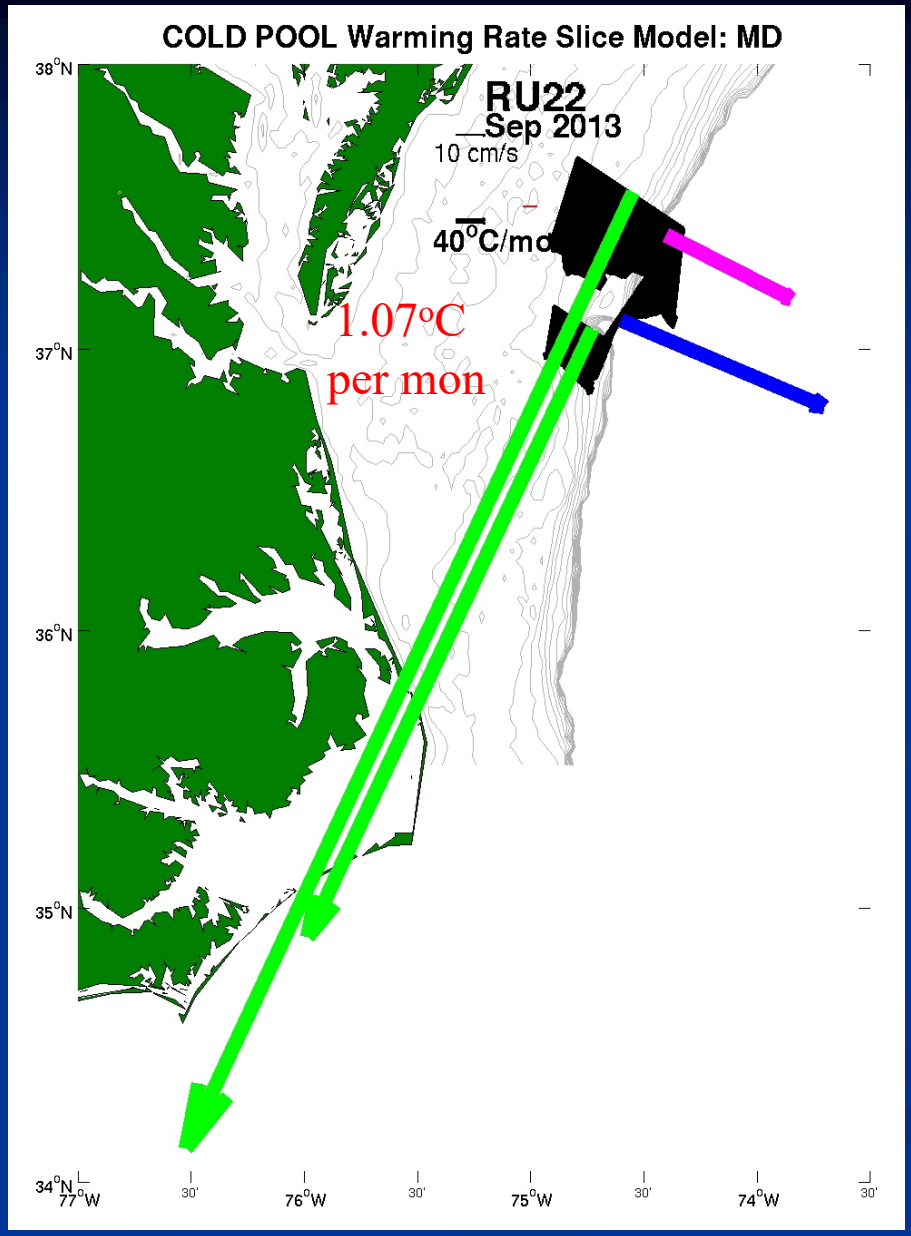


$$\left(\frac{Ocean}{Warming}\right) = \mathrm{ineddy}_{OS}\,T + \mathrm{inflow}_{OS}\,T + inflow_{AS}\,T - outflow_{AS}\,T$$

COLD POOL Model

MD

MODEL TERM ESTIMATES



$$\left(\frac{Ocean}{Warming}\right) = \mathrm{ineddy}_{OS}\,T + \mathrm{inflow}_{OS}\,T + inflow_{AS}\,T - outflow_{AS}\,T$$

Summary

Cold Pool Model Warming Rates?

..consistent with OBSERVATIONS

Cold Pool Exchange Rates at Shelf Break Front (SBF)?

…. glider data is necessary complement to model estimates

Cold Pool Exchange Rates very different along SBF

Timely Maps of the Cold Pool?

…. *require glider data – assimilation ocean modeling*

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