

Results from the
RAPID-MOCHA-WBTS
program of observations at 26°N

Observing the Atlantic Meridional Overturning Circulation at 26°N: new perspectives after the first decade of observations

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Outline

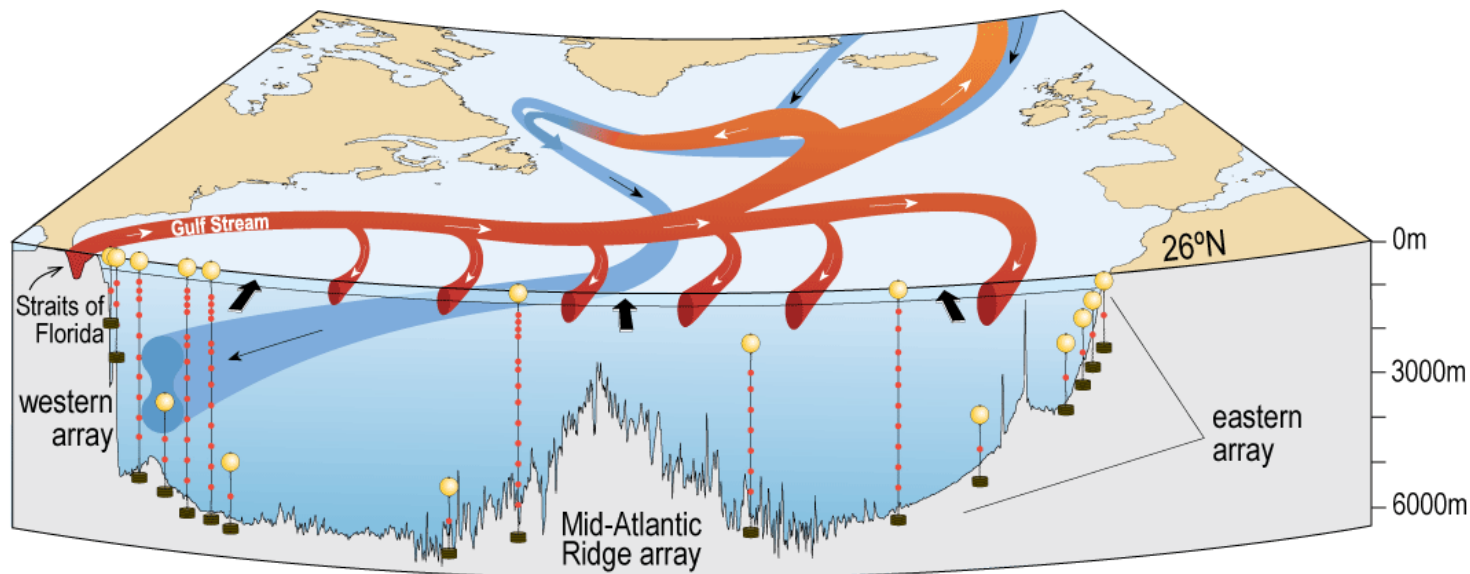


- Introduction
- The first decade of measurements of the MOC
- Multi-year trends in the MOC
- Selecting data for a real-time array
- Carbon transport
- Summary

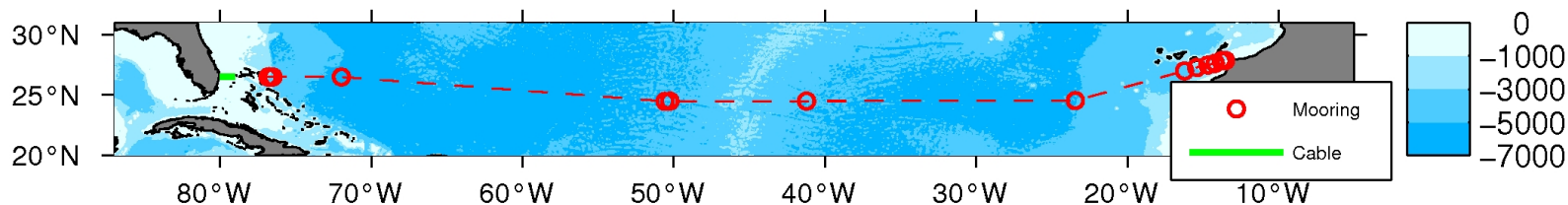
How is the MOC measured?



$$T_{MOC}(z) = T_{EKM}(z) + T_{FS}(z) + T_{MO}(z)$$



McCarthy, G and Coauthors: Measuring the Atlantic Meridional Overturning Circulation at 26°N. Prog Oceanography submitted



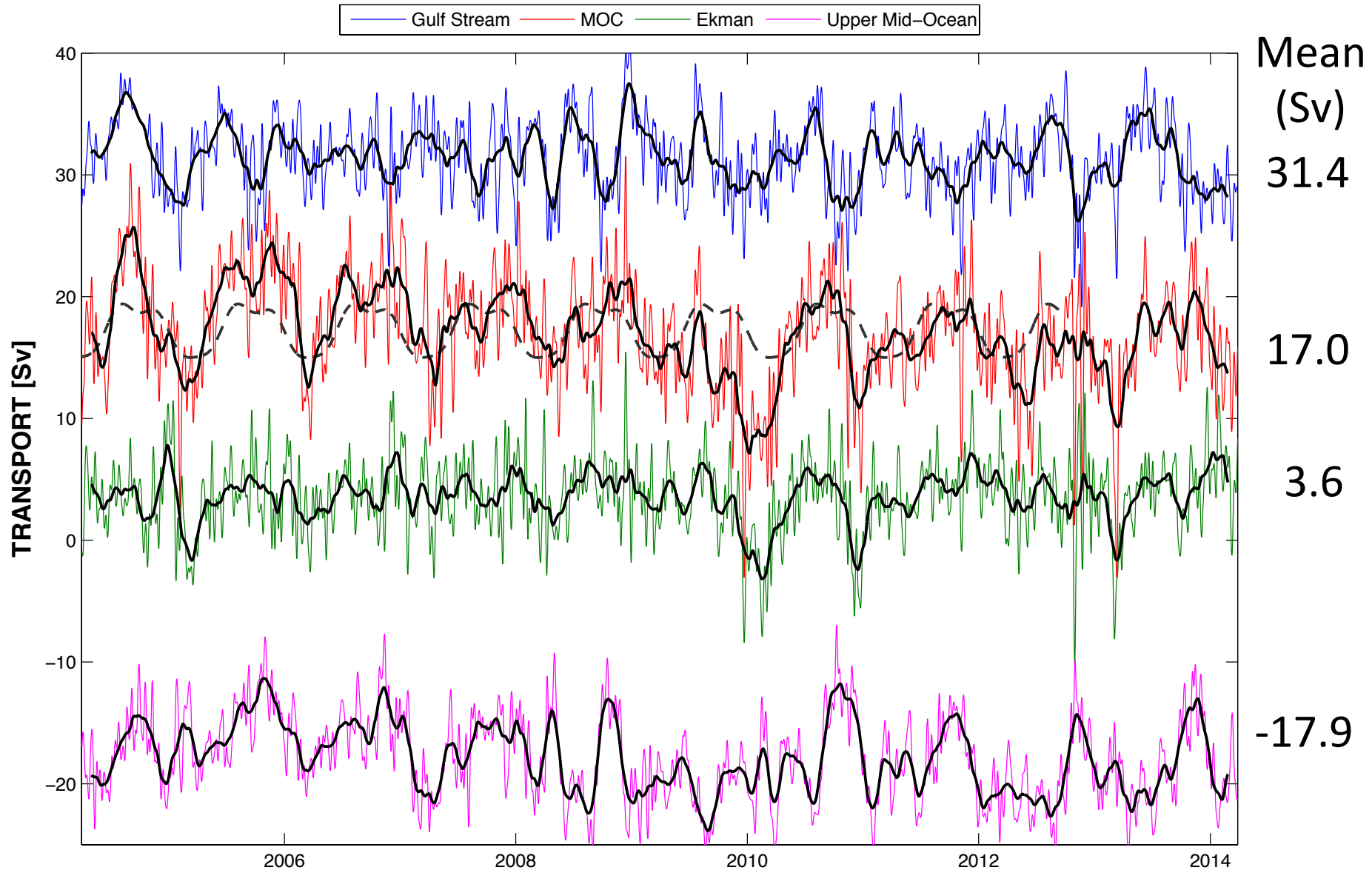
A decade of measurement at 26°N



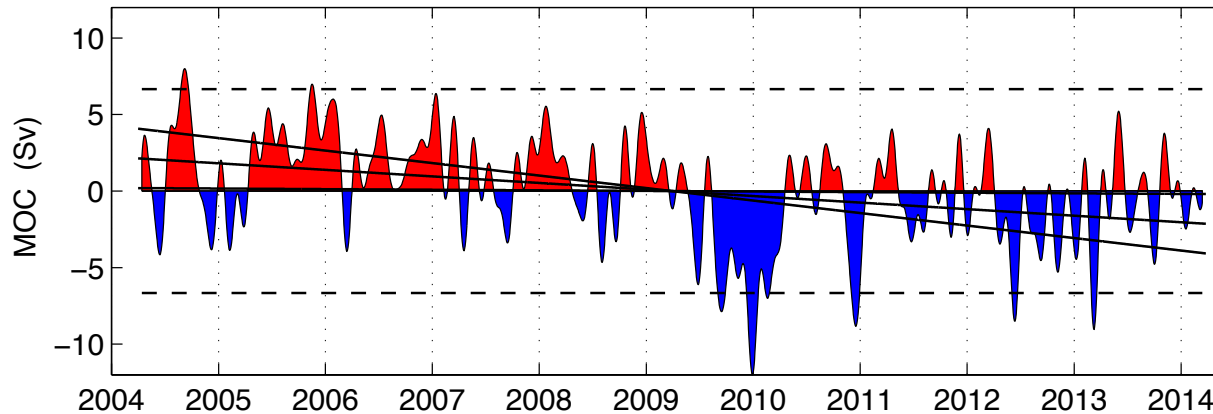
- Time series from 2nd April 2004 to 28th March 2014
- The current array has:
 - 32 moorings and landers
 - 197 instruments
- To date there have been 28 cruises (c. 593 days at sea)
- 88 scientists and students and 152 officers and crew have taken part in UK RAPID cruises



RAPID MOC time series: since 2004



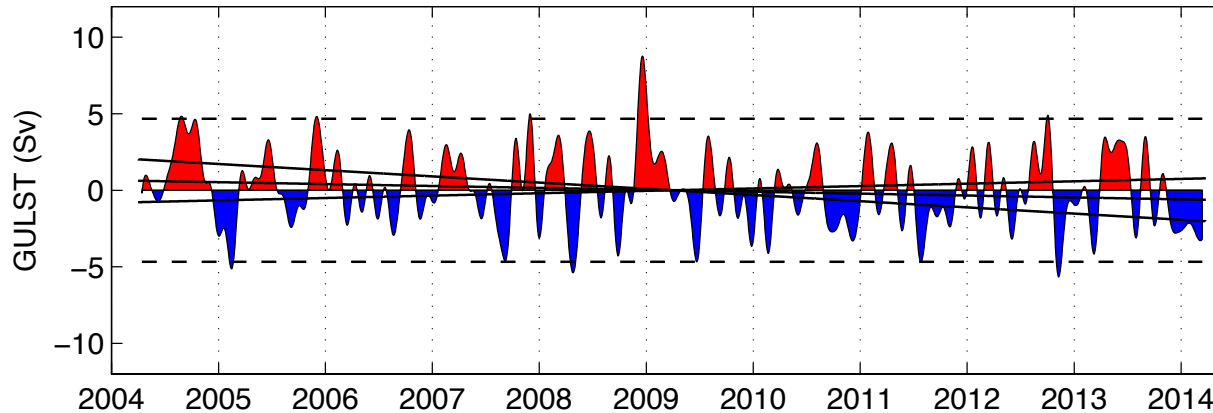
Trends in transports



MOC

Transport trend (Sv/yr)

5%	50%	95%
-0.82	-0.43	-0.04

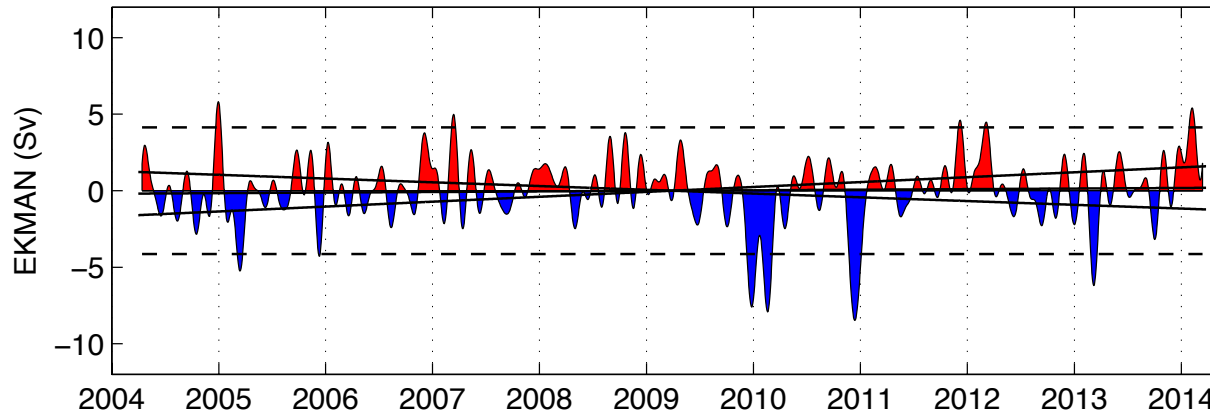


Gulf Stream

Transport trend (Sv/yr)

5%	50%	95%
-0.40	-0.12	0.16

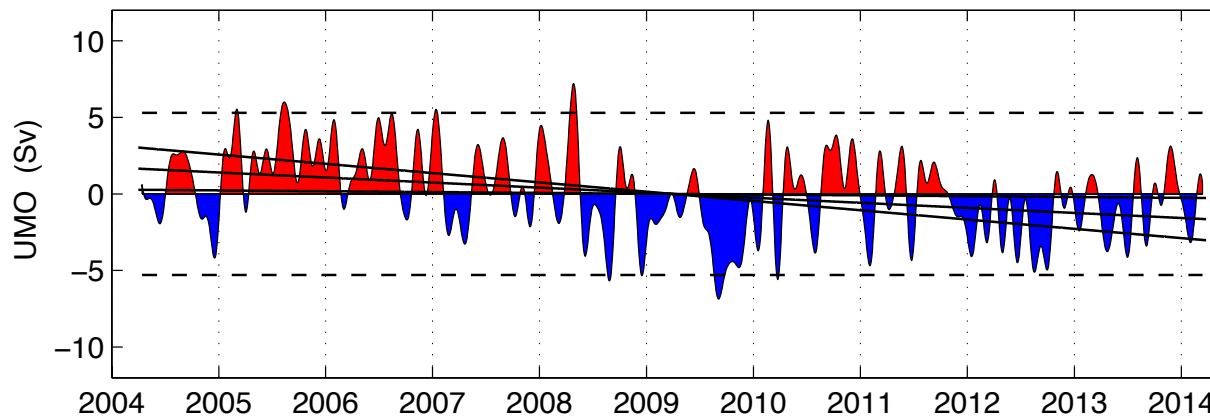
Trends in transports



Ekman

Transport trend (Sv/yr)

5%	50%	95%
-0.24	0.04	0.32

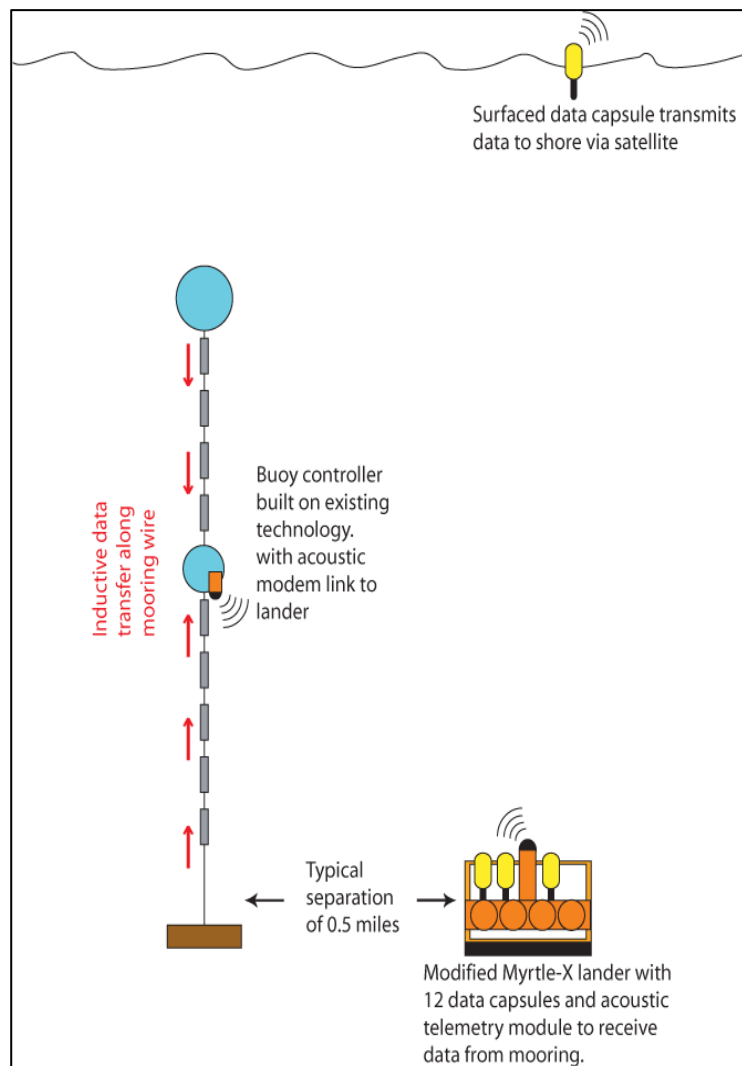


UMO

Transport trend (Sv/yr)

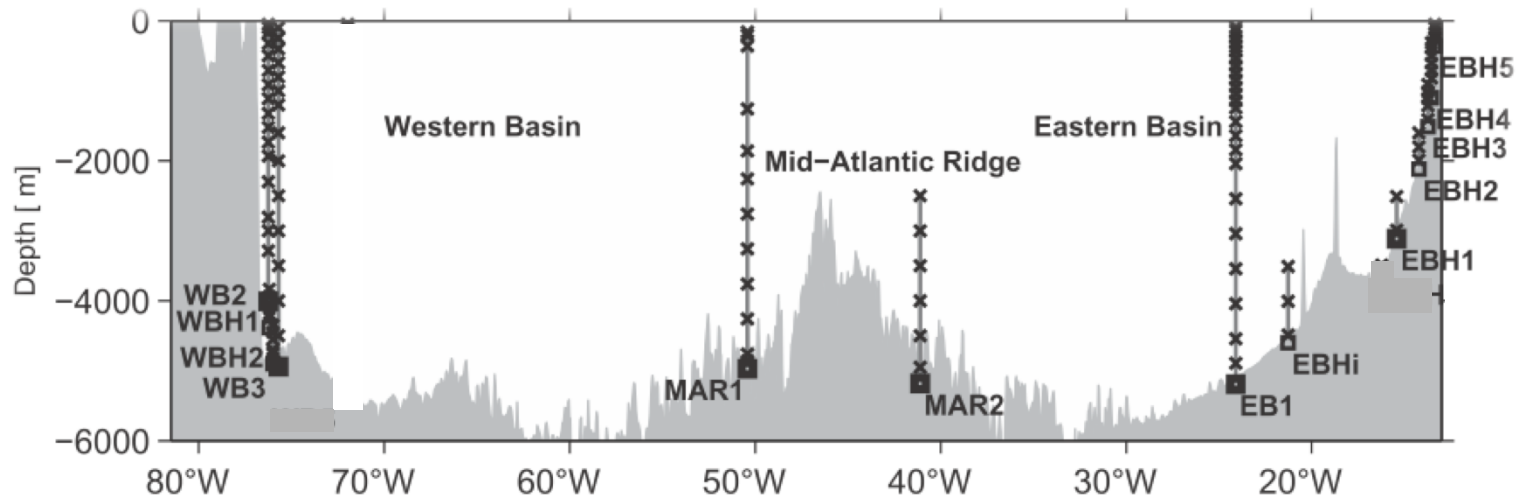
5%	50%	95%
-0.61	-0.33	0.05

Telemetry – and real-time data



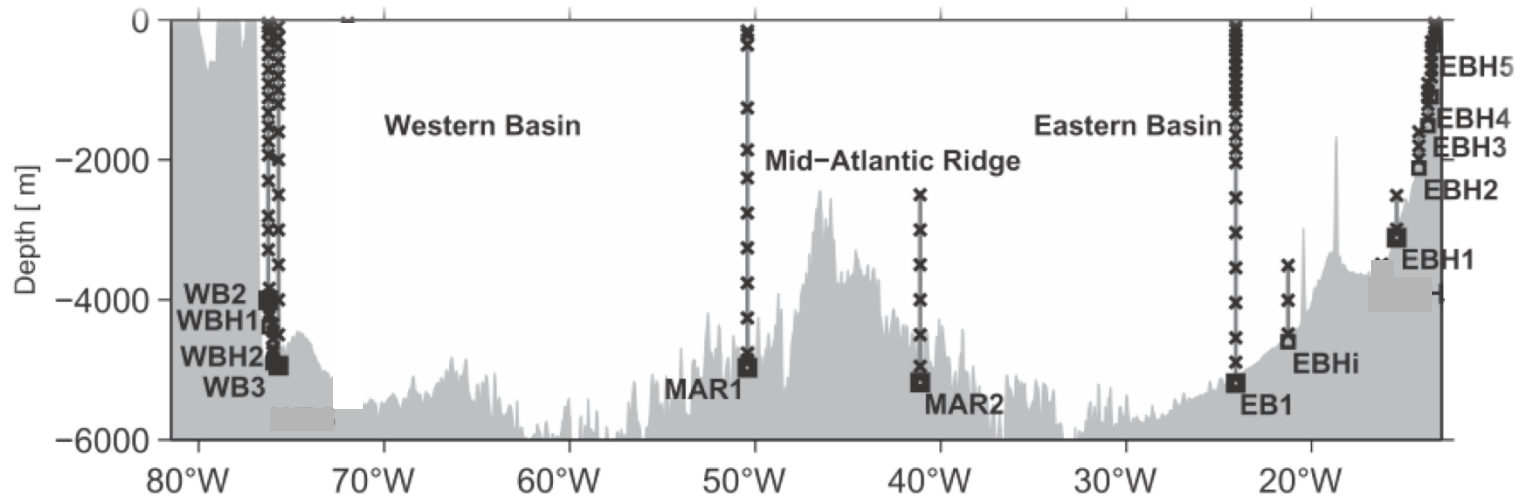
- To enable more frequent data retrieval
- Use acoustic communication to lander and release of Iridium data pods
- Shallow water trials complete. Deep water trials to be followed by deployment on RAPID array in 2017
- How much of the array data is needed in real time?

Observations for a real-time array



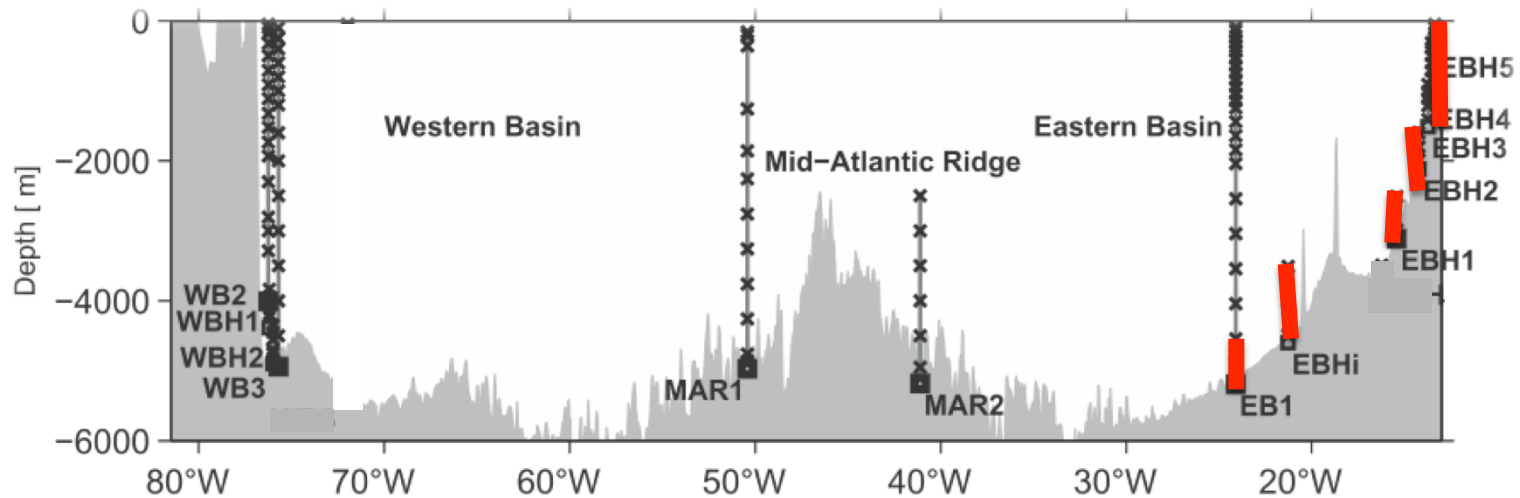
$$T_{MOC}(z) = T_{EKM}(z) + T_{FS}(z) + T_{MO}(z)$$

Observations for a real-time array



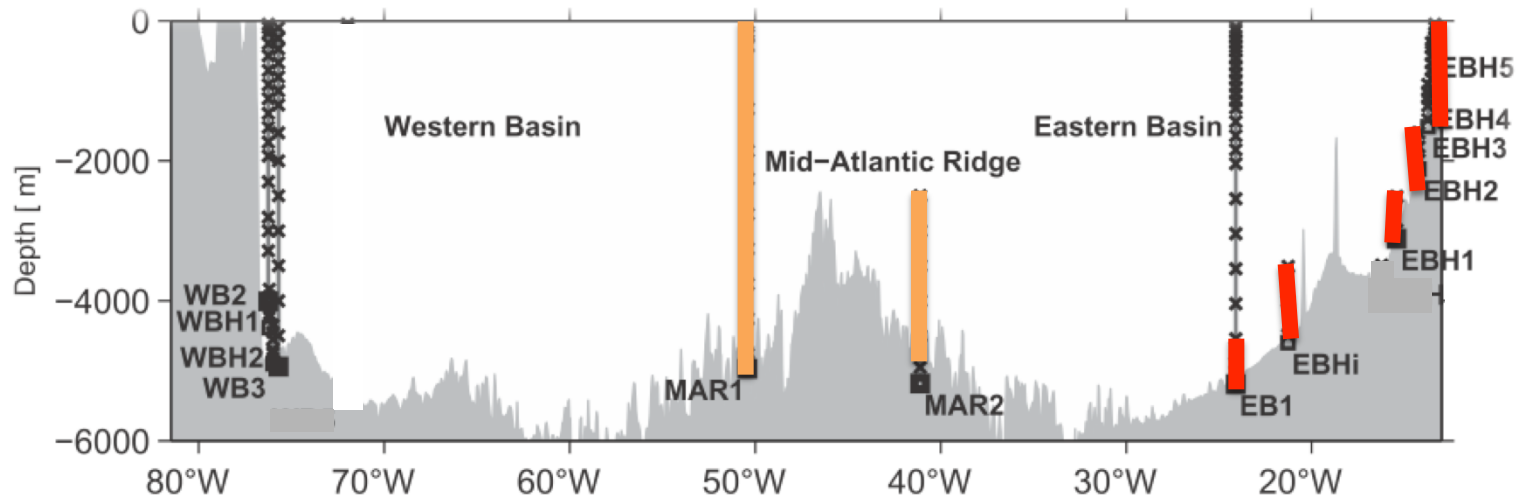
$$T_{MOC}(z) = T_{EKM}(z) + T_{FS}(z) + T_{MO}(z)$$

Observations for a real-time array



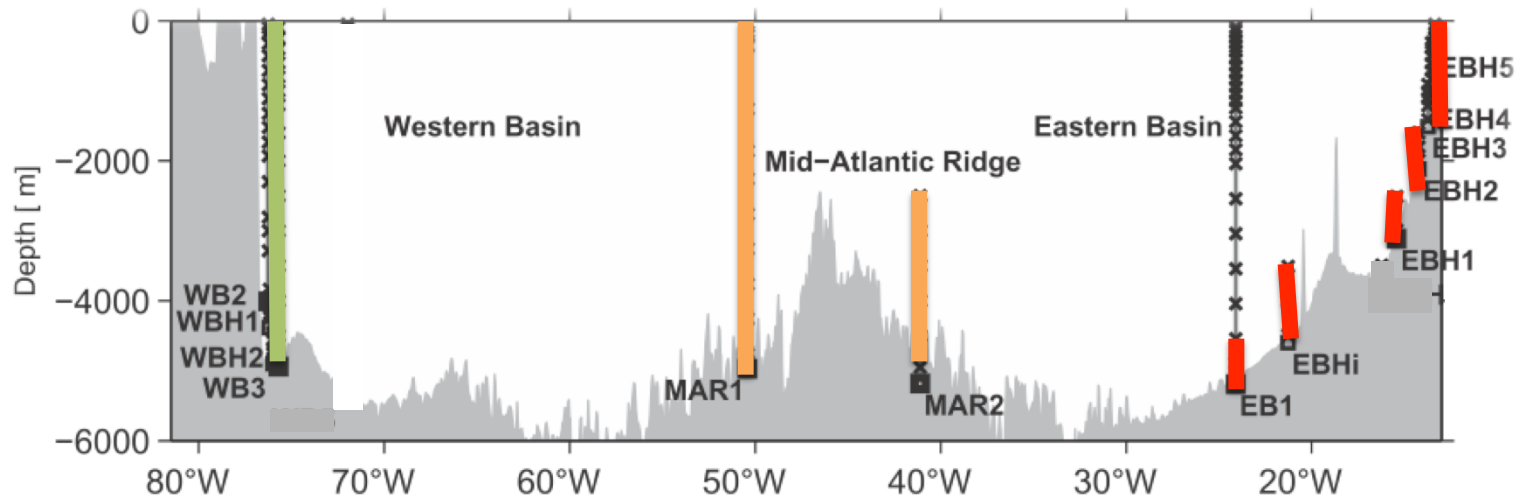
$$T_{MO}(z) = T_E(z) + T_{MAR}(z) + T_W(z) + T_{WBW}(z)$$

Observations for a real-time array



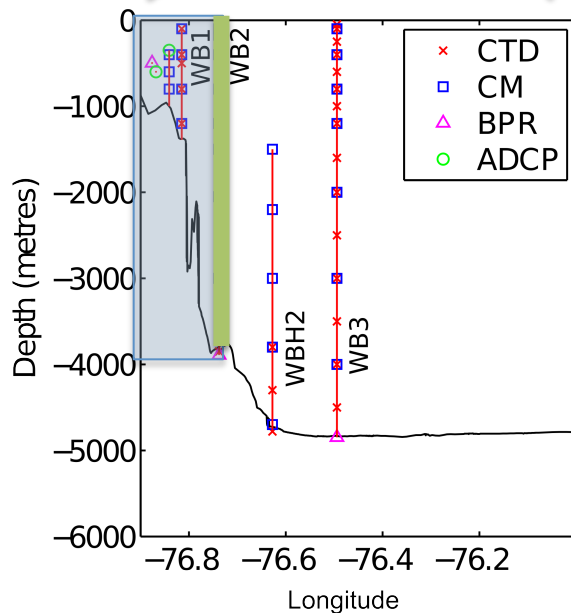
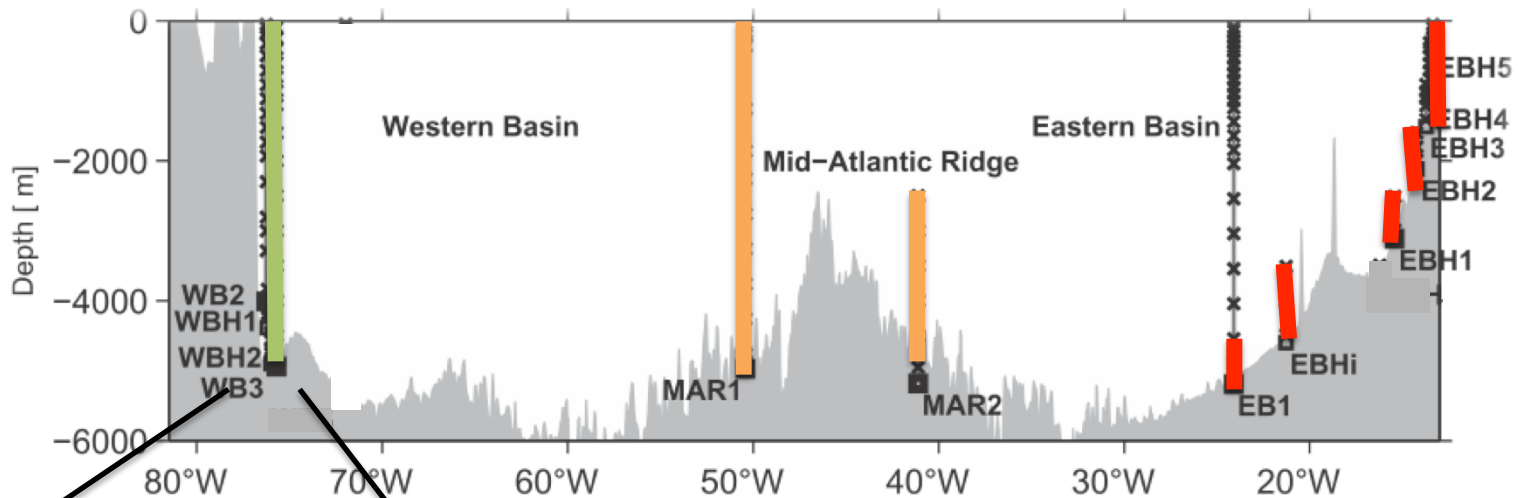
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Observations for a real-time array



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Observations for a real-time array



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Observations for a real-time array



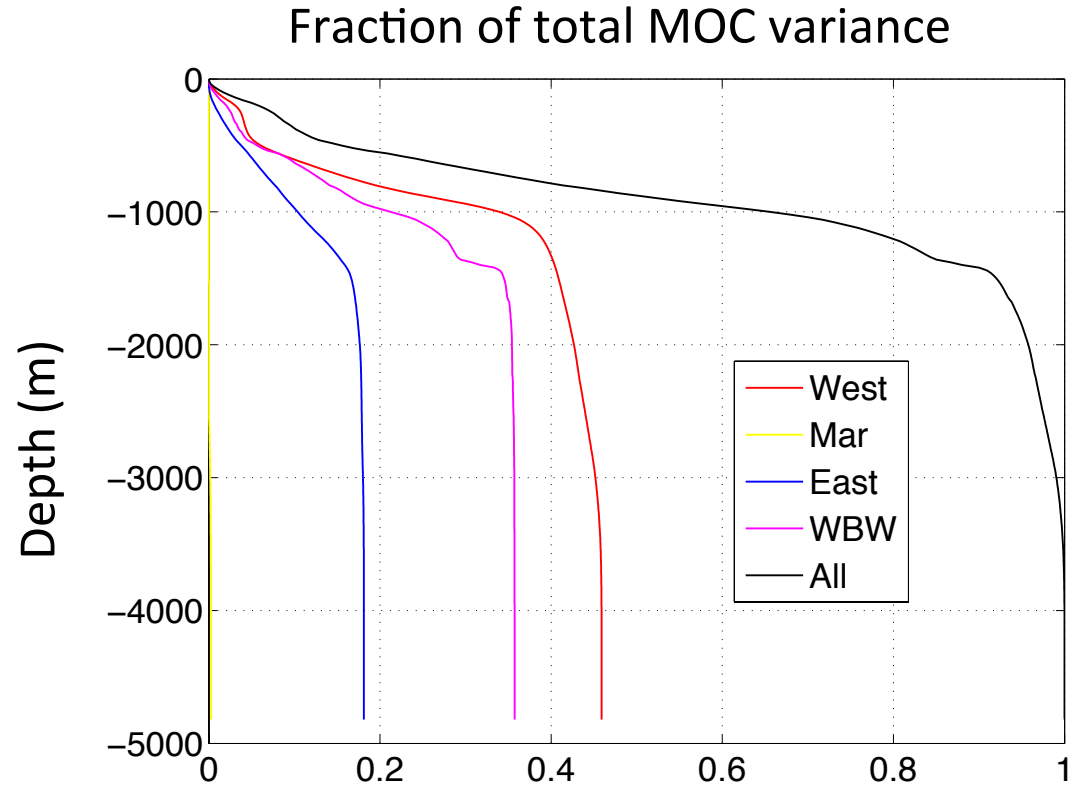
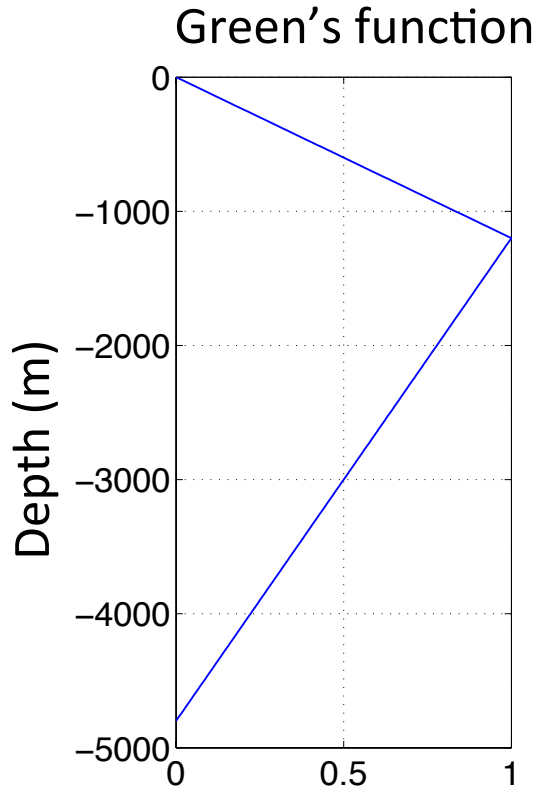
Data	West d.h.	WBW	West d.h. + WBW	East d.h.	MAR
Variance (Sv^2)	7.6	2.7	4.9	2.9	0.1

Error in estimating the upper mid-ocean (UMO) transport when various components are held constant. The table shows the variance of the difference between each time series and the full UMO time series.

	West d.h.	WBW	East d.h.	West d.h. + WBW
West d.h.	1	-0.56	0.12	0.78
WBW	-0.56	1	-0.17	0.06
East d.h.	0.12	-0.17	1	0.02
West d.h. + WBW	0.78	0.06	0.02	1

Error correlations for the different components

Observations for a real-time array

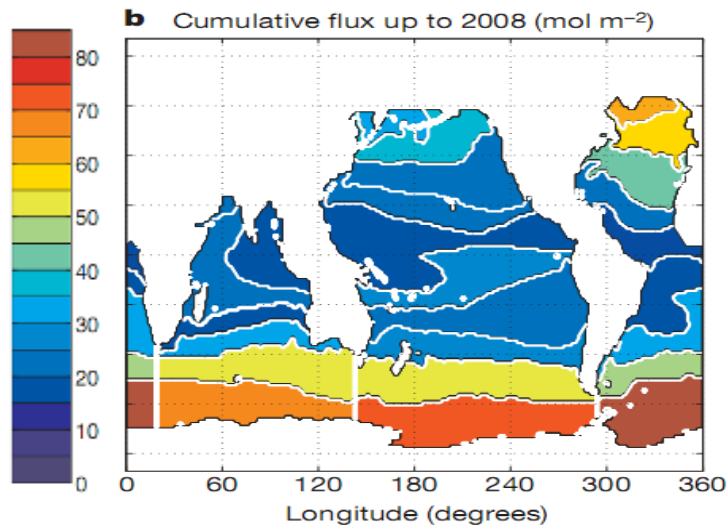


$$\Delta\Psi(z) = \frac{g}{\rho_0 f} \int_{z_b}^z dz'' G_\Psi(z, z'') [\Delta\rho_w(z'') - \Delta\rho_e(z'')]$$

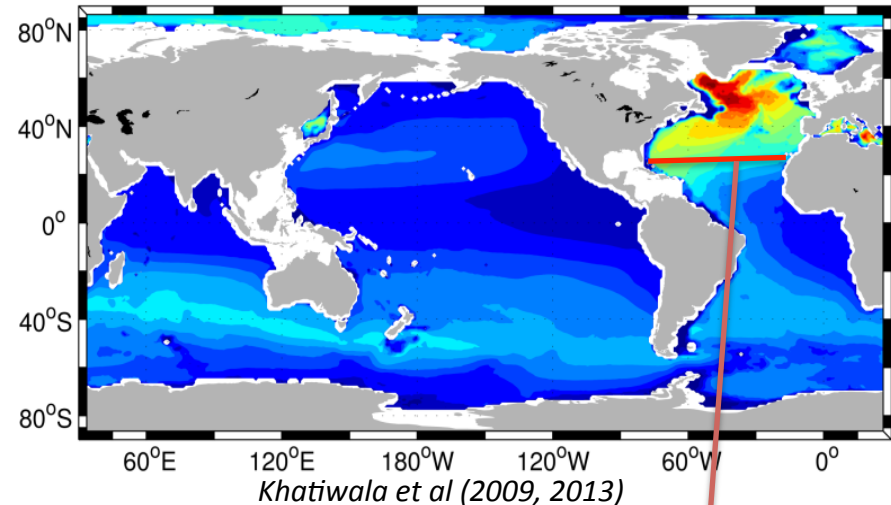
Carbon transport and the AMOC



C_{anth} uptake



C_{anth} storage – column inventory



Storage is determined by uptake and circulation

RAPID line well positioned to sample the oceanic transport into the North Atlantic

ABC - Atlantic BiogeoChemical fluxes



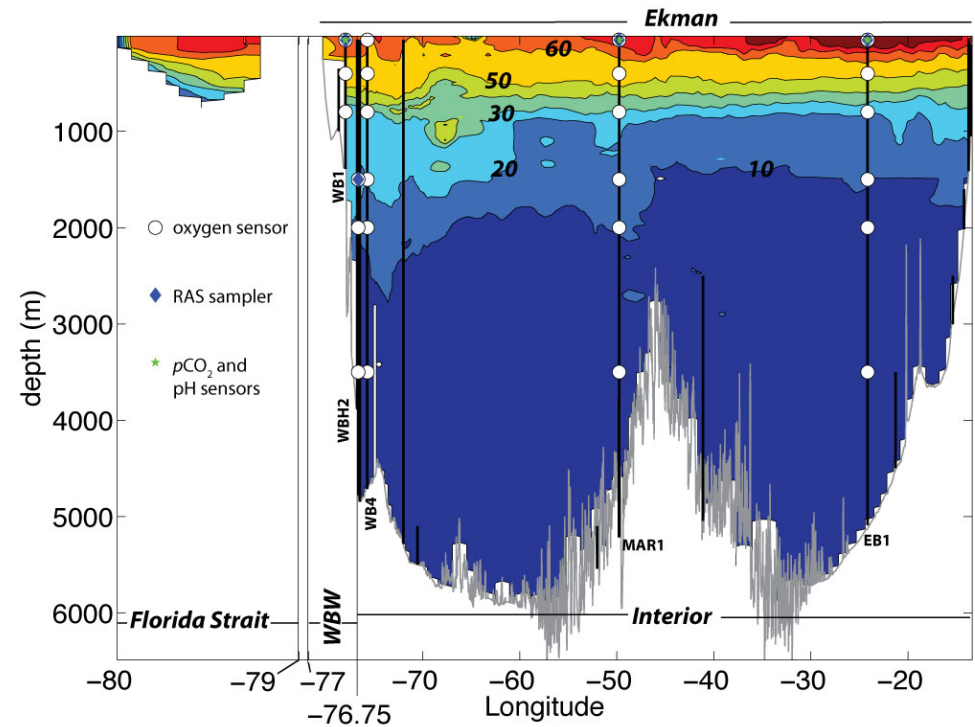
On the array: Oxygen, pH and $p\text{CO}_2$ sensors, water samplers for nutrient TA and DIC analysis

Florida Straits: quarterly cruises sampling for nutrient and carbon analysis

Floats: oxygen enabled deep- and bio-Argo floats

PI: Elaine McDonagh
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New observations
on the RAPID 26°N array



Summary



So far

- RAPID-MOC has completed one decade of measurements
- Updated time series show that reduction in the MOC persisted in 2013

Future

- Telemetry of data will enable real time estimates of MOC (2017-)
- ABC Fluxes project will instrument 26°N array for carbon
- Continuation of RAPID 26°N array as core of network of Atlantic monitoring programs

