

OCB summer workshop, Woods Hole, 2014

Autonomous sensors to quantify remineralization rates and the mesopelagic C flux

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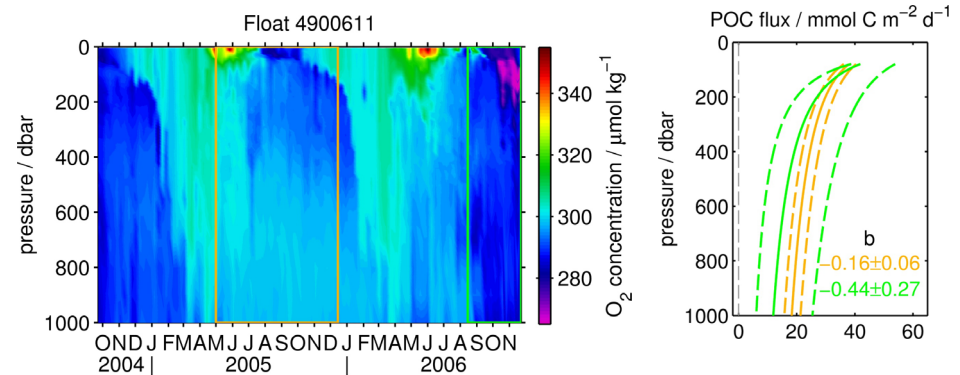
Antoine Poteau, Catherine Schmechtig,

Hervé Claustre (OAO-LOV)

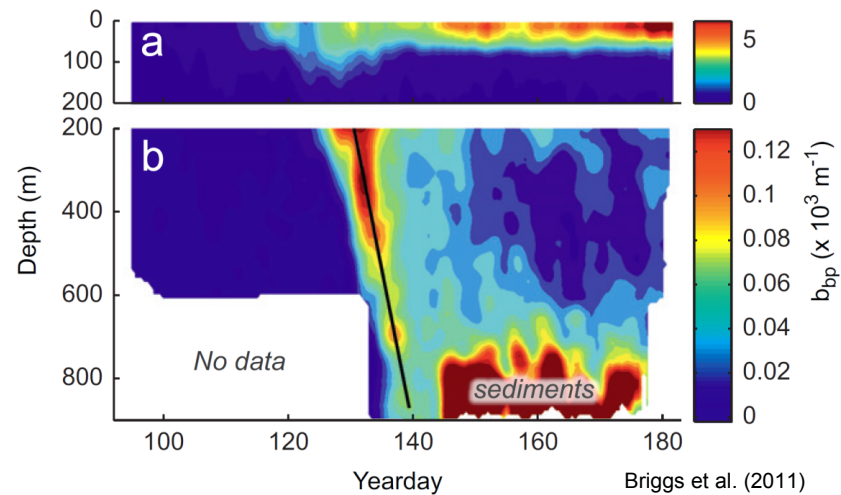
Ken Johnson (MBARI)



- Chemical approach



- Optical approach

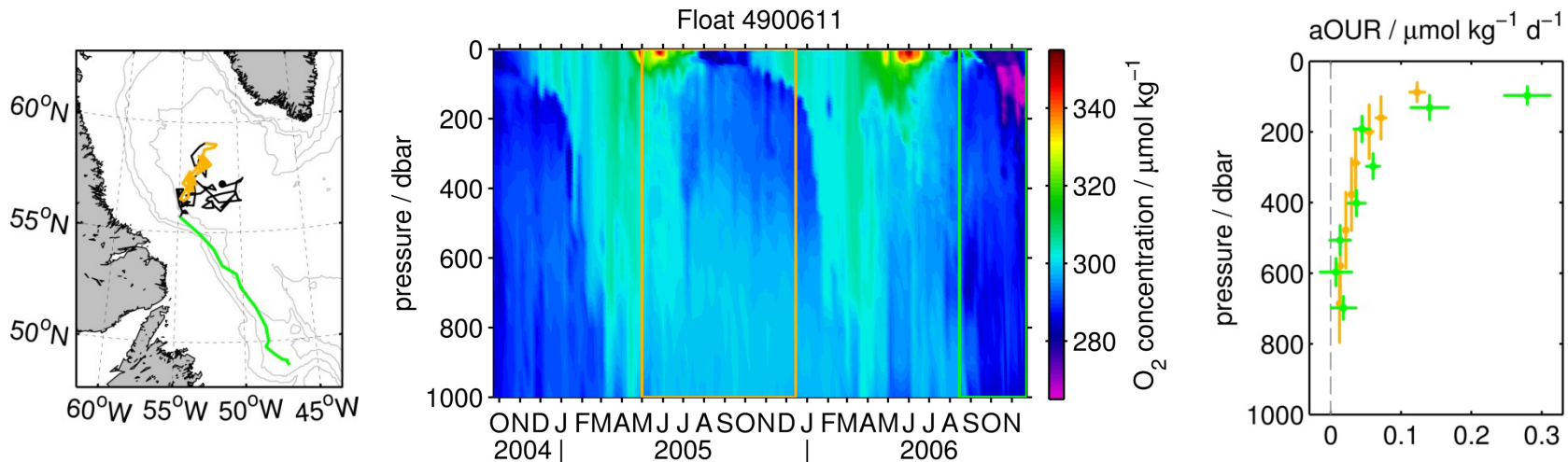


Chemical Approach: General Concept

Showcase 1: Labrador Sea Argo-O₂



Evolution of Tracer vs. Time → Respiration Signal



- Central Labrador Sea (April – December 2005)
- Boundary current (July – November 2006)
- Deeply mixed water column after deep convection (vertically homogenized)
- AADI optode 3830 calibrated against deployment CTD-O₂ cast

after C. Kihm, PhD thesis

Chemical Approach: General Concept

Showcase 1: Labrador Sea Argo-O₂

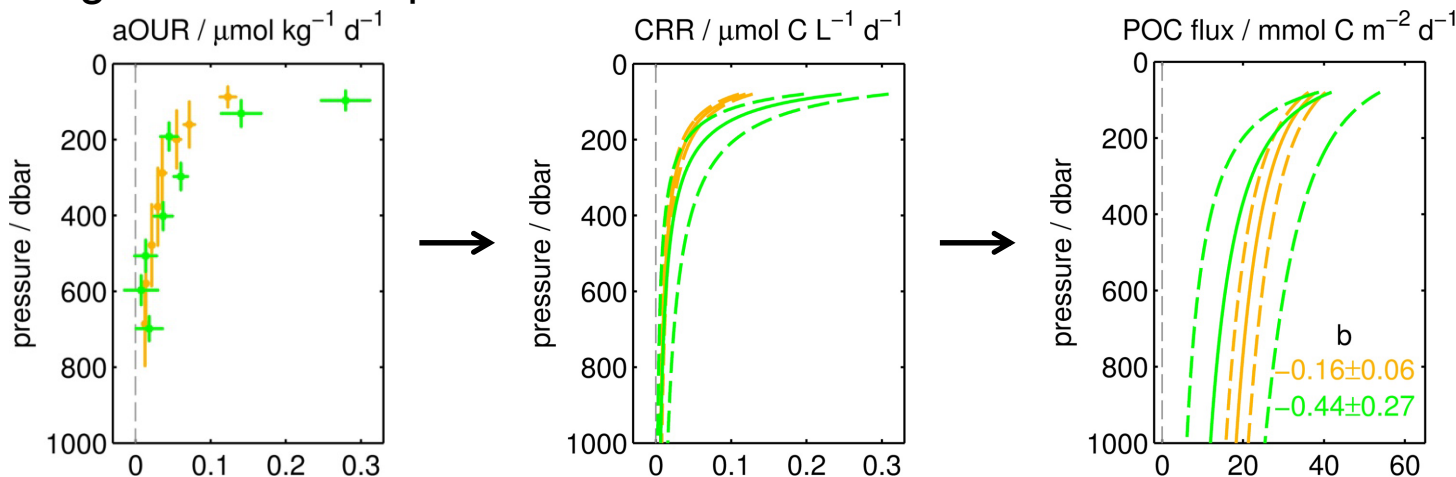


Respiration Signal



C Flux

- O₂ utilization along isopycnals
- Assumed O₂:C ratio (e.g., -1.34:1, Körtzinger et al., 2001)
- fit to (differentiated) Martin curve
- Integration of C respir. rate → C flux



- b exponent higher using OUR than other techniques (Martz et al. 2008)

after C. Kihm, PhD thesis

Available Sensors

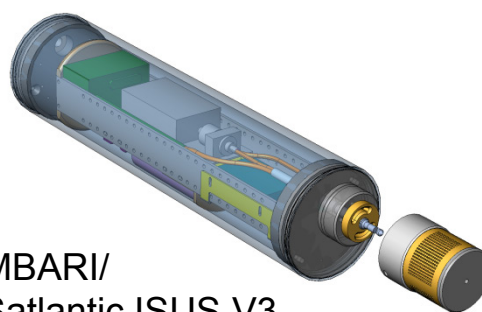
- Oxygen O_2 sensors most mature, air sea gas exchange
- Nitrogen ISUS/SUNA nitrate sensor
- Carbon pH, pCO_2 , indirectly: local $A_T - S$ relationship



Aanderaa (AADI)
Optode 4330



Sea-Bird
Optode SBE 63



MBARI/
Satlantic ISUS V3

CONTROS
HydroC



MBARI Deep-Sea DuraFET



Satlantic SUNA V2



Available Sensors

- Oxygen O_2 sensors most mature, air sea gas exchange
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Caveat

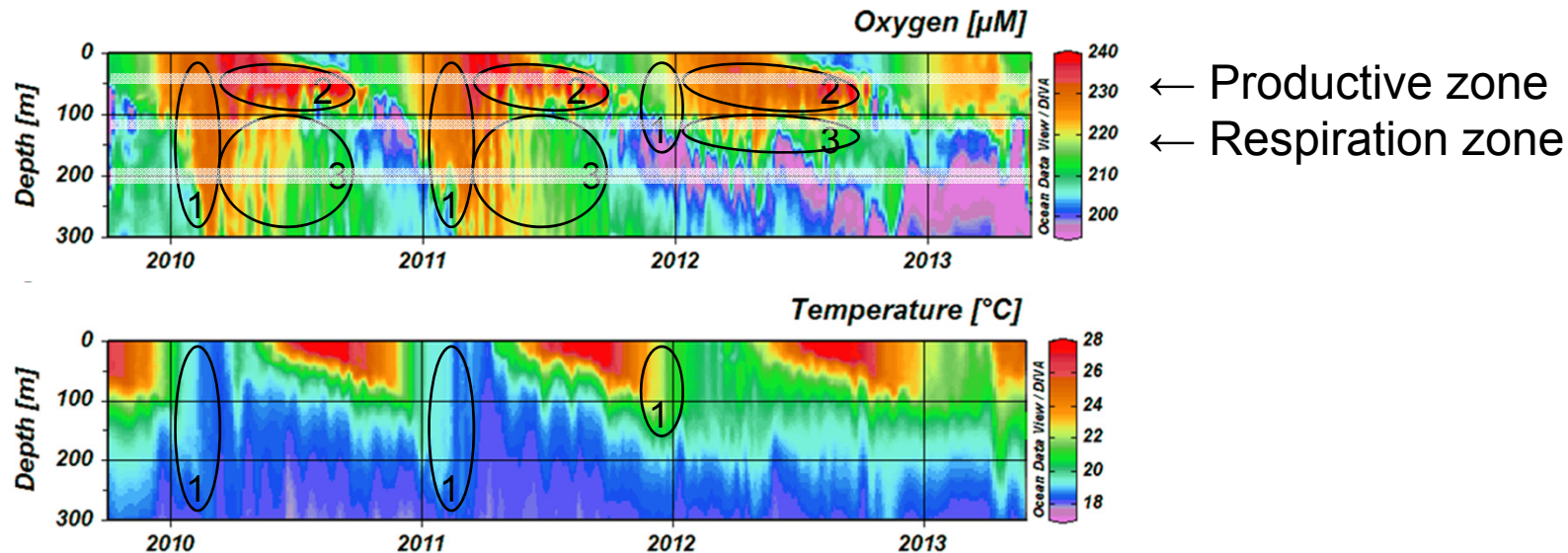
- Give only net biological signal → sum of production & respiration
- Affected by biology and ocean physics (advection, mixing, entrainment) !

Requirement: separate Ocean Physics

- Seasonal reset (deep mixing)
- „Simple“ hydrographic setting

Showcase 2a: Temporal Aspect North Atlantic Subtropical Gyre

- Bio-Argo Floats (MBARI/UW) @ 31°40' N / 064°10' W (BATS)

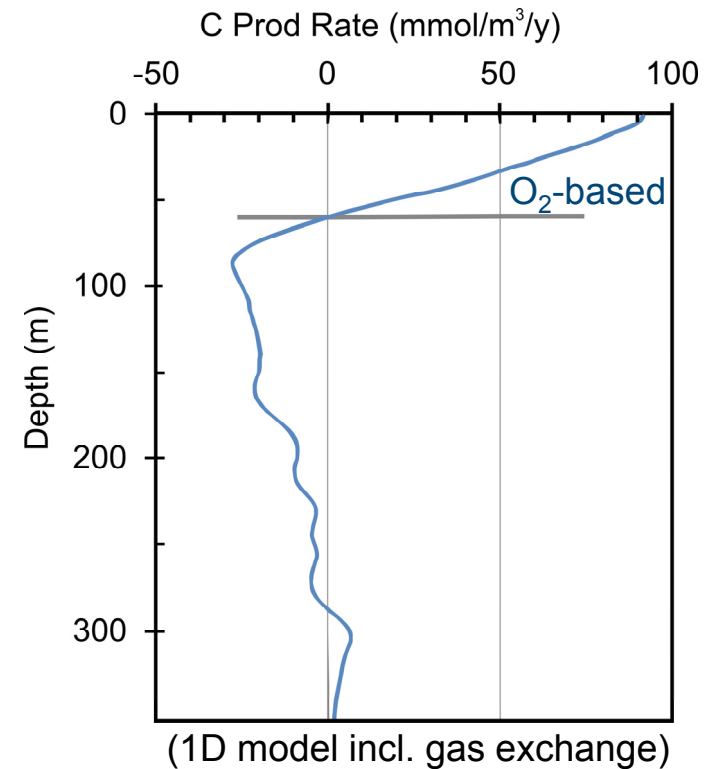
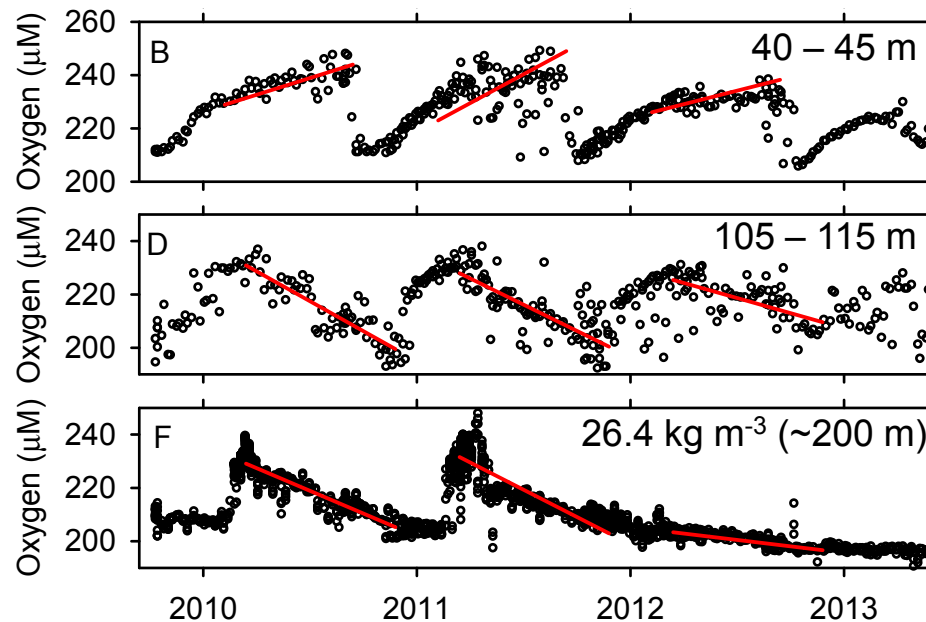


- 1 Convective overturn homogenizes water column
- 2 Seasonal net O_2 increase (SOM)
- 3 Seasonal net O_2 decrease

Johnson & Riser (2014), submitted.

Showcase 2a: Temporal Aspect North Atlantic Subtropical Gyre

- Bio-Argo Floats (MBARI/UW) @ 31°40' N / 064°10' W (BATS)
- Quantify both production & respiration

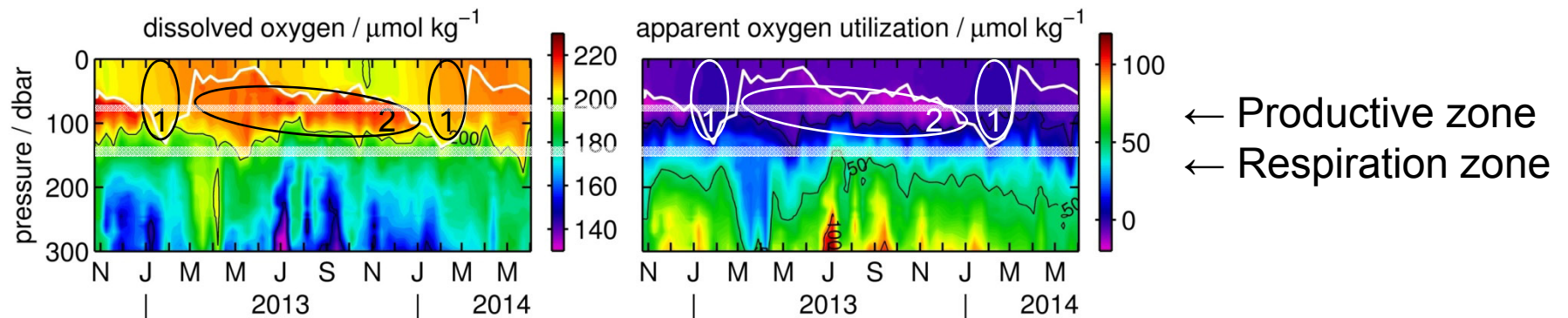


Johnson & Riser (2014), submitted.

Showcase 2b: Temporal Aspect North Atlantic Subtropical Gyre



- Bio-Argo Floats (remOcean) @ 20° N / 040° W
- Shallower mixing, deeper nitracline/productive zone



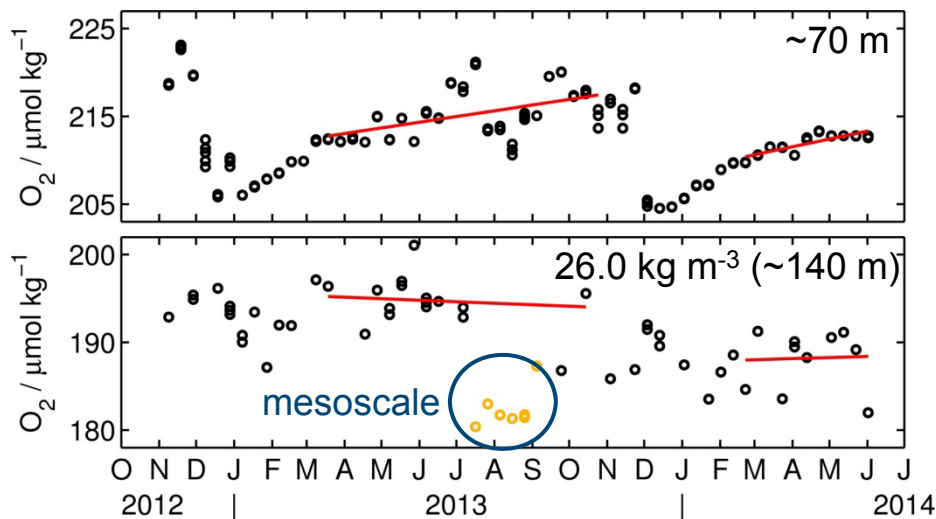
- 1 Convective overturn
 - 2 Seasonal net O_2 increase (SOM)
- No seasonal net O_2 decrease**

**“steady-state”
biological respiration
vs.
physical diffusion/mixing**

Showcase 2b: Temporal Aspect North Atlantic Subtropical Gyre



- Bio-Argo Floats (remOcean) @ 20° N / 040° W
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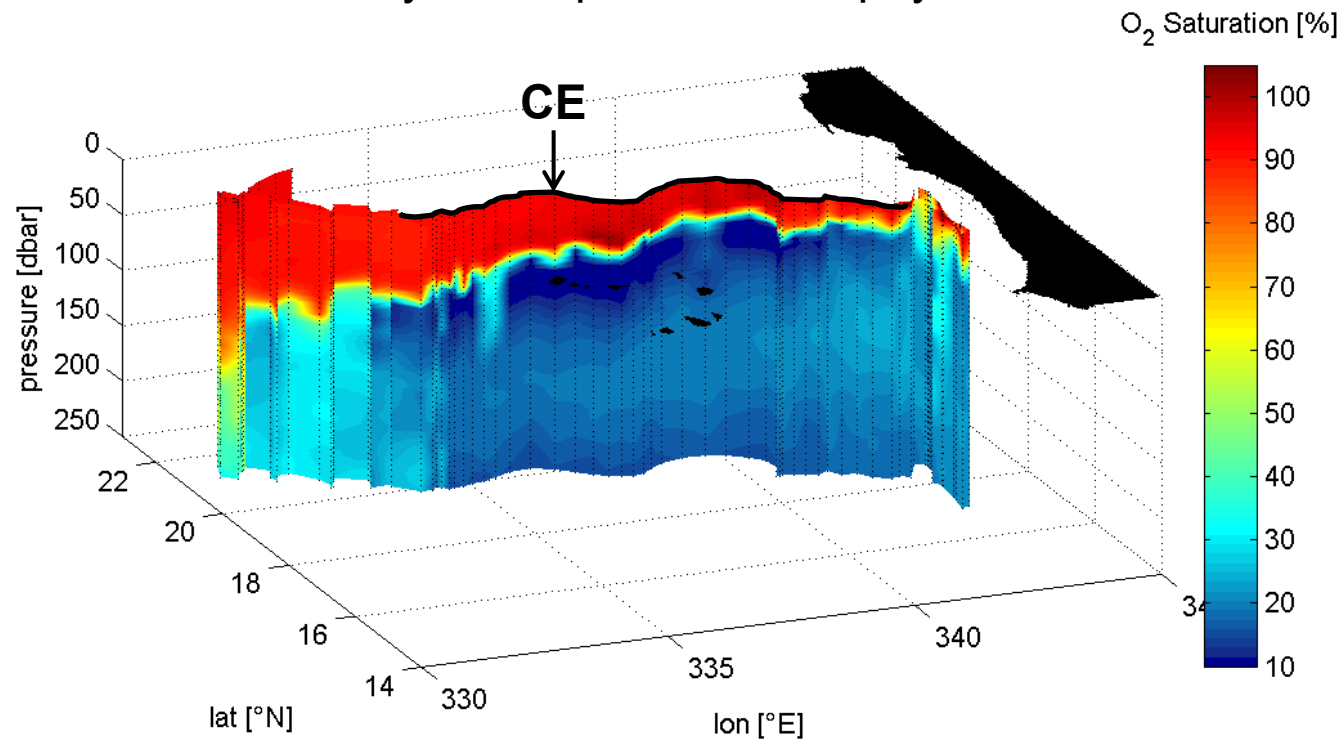
← Productive zone

← Respiration zone !

- Ocean physics superimposed to biological signal (continuously mixed)

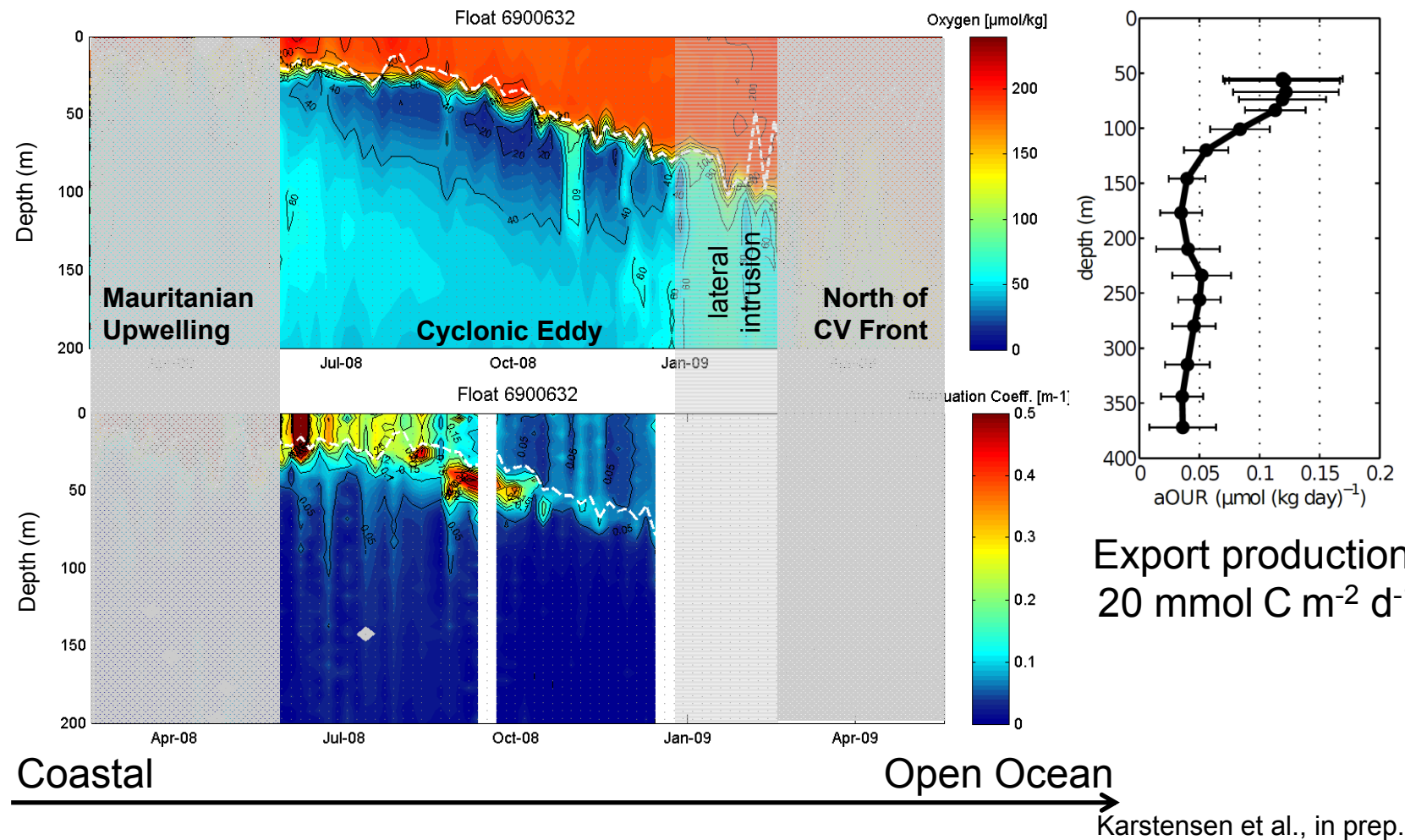
Showcase 3: Spatial Aspect Cyclonic Eddy (CE) off Mauritania

- Bio-Argo float (WMO ID 6900632; O_2 , c_p) trapped inside Cyclonic Eddy
- Isolated water body → simplified ocean physics

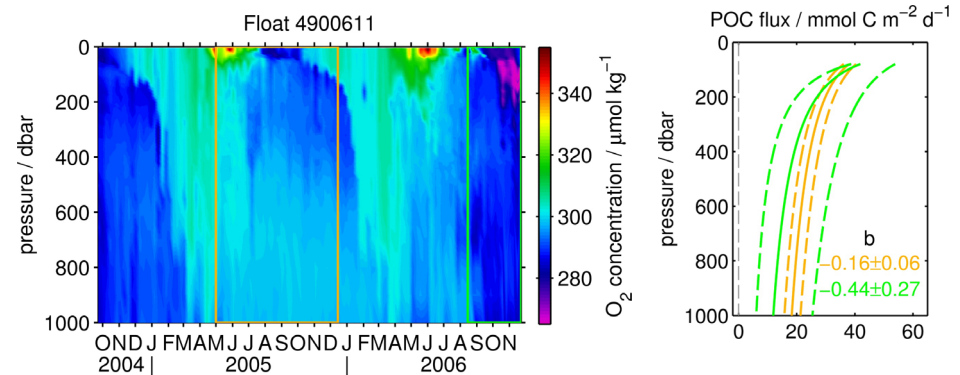


Fiedler, unpublished.

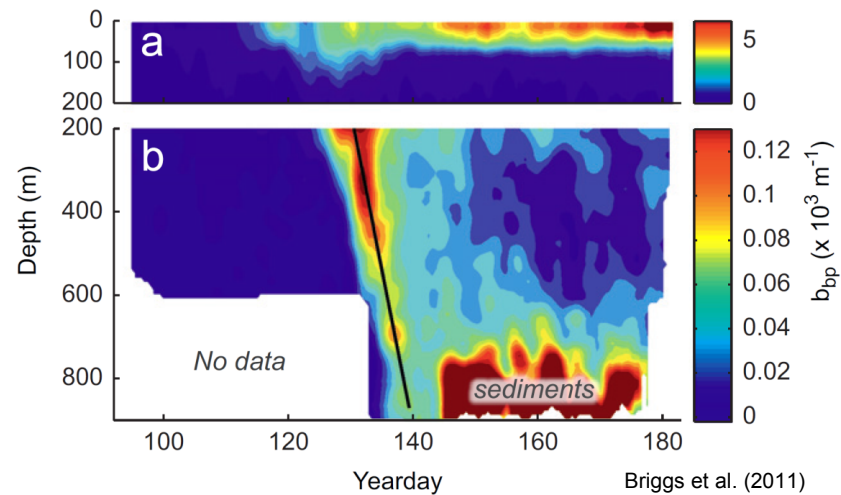
Showcase 3: Spatial Aspect Cyclonic Eddy (CE) off Mauritania



- Chemical approach



- Optical approach



General Concept

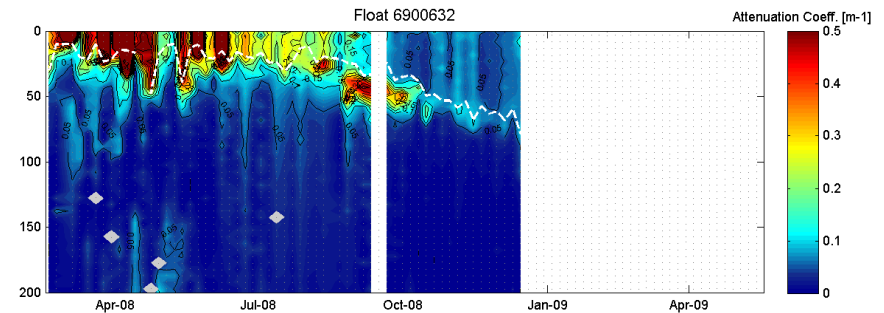
- Establish proxy for POC
→ Follow C directly

Available Sensors

- Beam attenuation $c_p(650)$
- Particle backscatter $b_{bp}(700)$

Requirements

- No seasonal system required
- *Sensitivity*



WET Labs
C-Rover

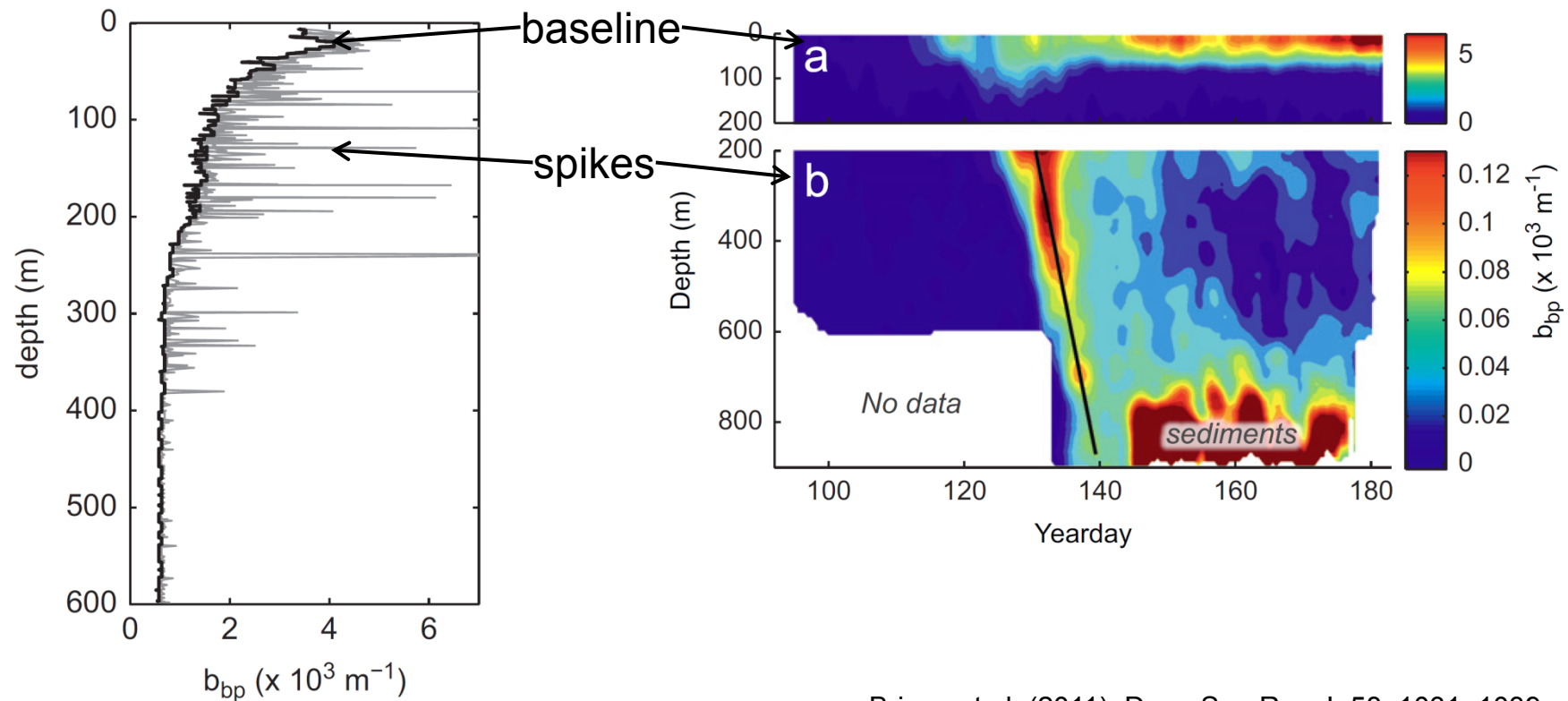


WET Labs
ECO triplet

Showcase 1: Profile Focus

Trace POC Export (NAB08 experiment)

- Separate profile data into baseline & spikes (Briggs et al., 2011)
- “Direct” POC observation



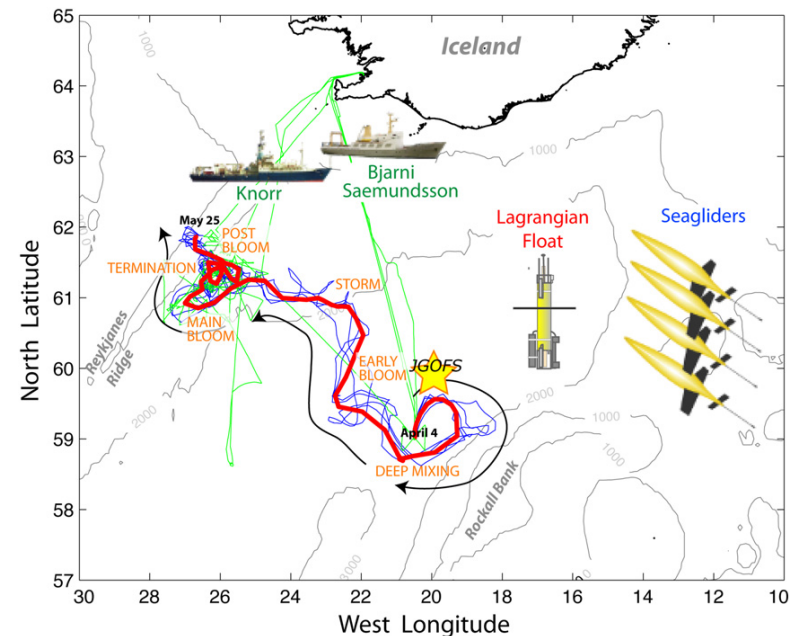
Briggs et al. (2011), Deep Sea Res. I, 58, 1031–1039.

Showcase 2: Mixed Layer Focus Use Budget Imbalance (NAB08 experiment)



- Use mixed layer C inventory changes (Alkire et al., 2012):
 - TOC (POC & DOC) ~ POC proxy
 - Production ~ O₂ budget / O₂-NCP
- Difference between production and POC accumulation (in mixed layer)
= Export (out of mixed layer)

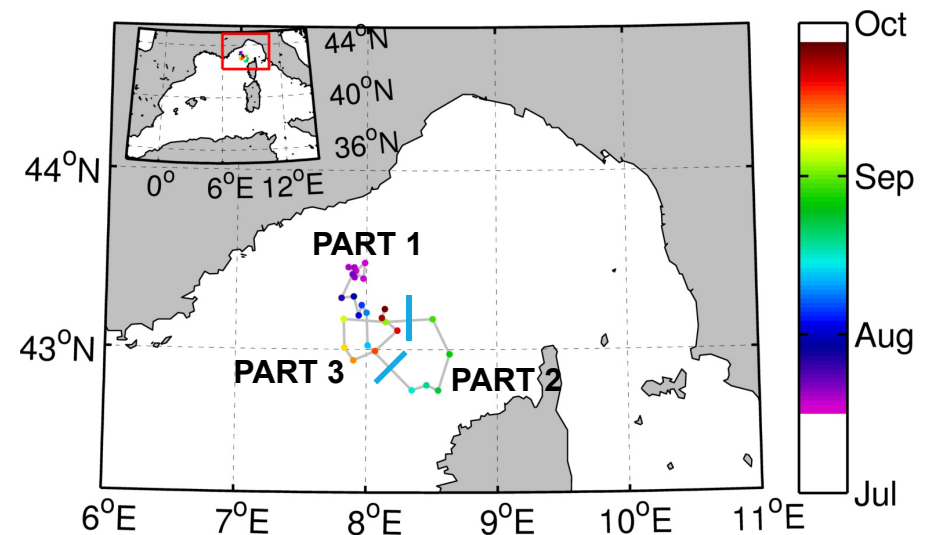
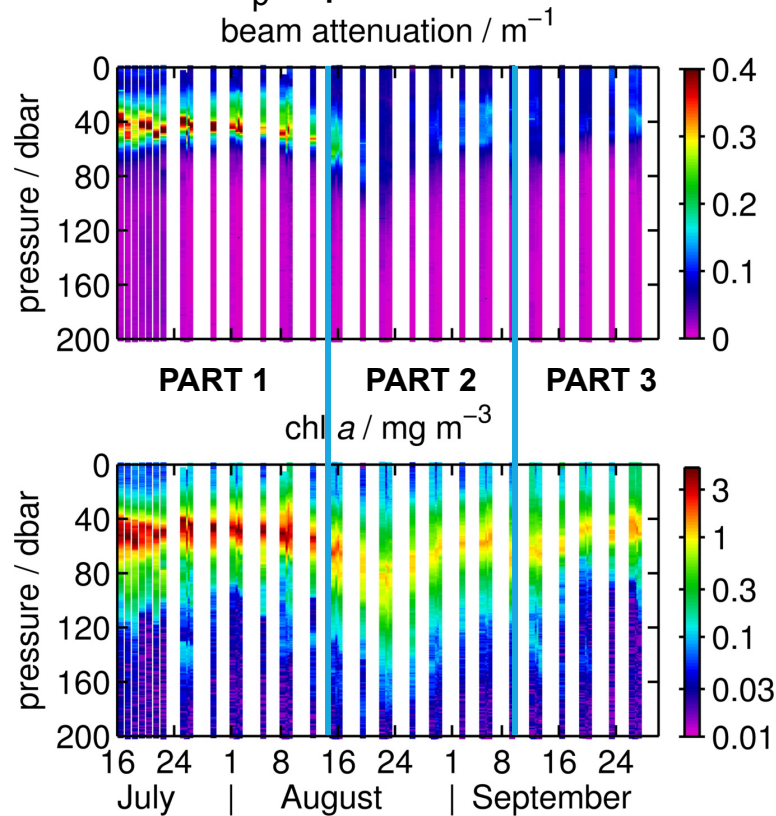
$$F_{\text{sink}} = F_{\text{NCP}} - \frac{d\text{POC}/dt}{b_{\text{bp}}} - \frac{d\text{DOC}/dt}{./}.$$



Alkire et al. (2012), Deep Sea Res. I, 64, 157–174.

Showcase 3: Float Drift Focus Sediment Accumulation during Drift

- Med Sea deep bloom → oligotrophic system
- Particles settle on transmissiometer: „in-situ sediment trap“
- Drift in $c_p \sim$ particle flux

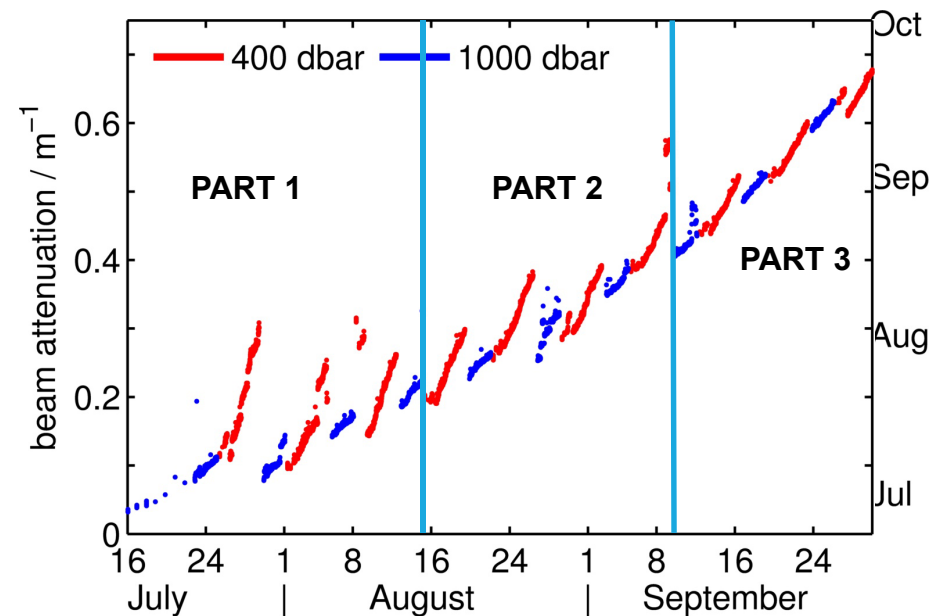
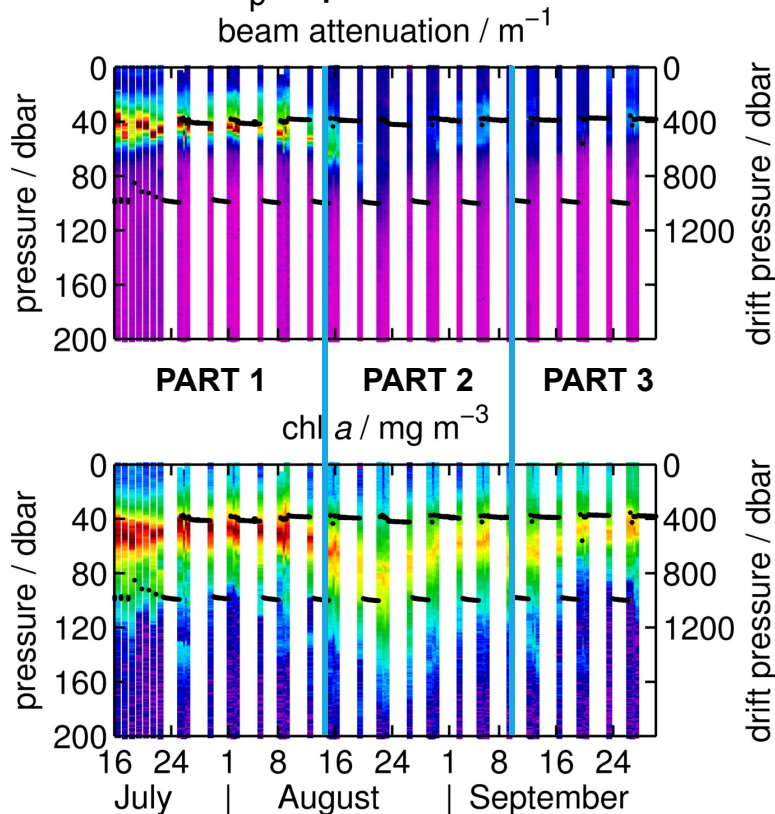


Claustre et al., in prep.

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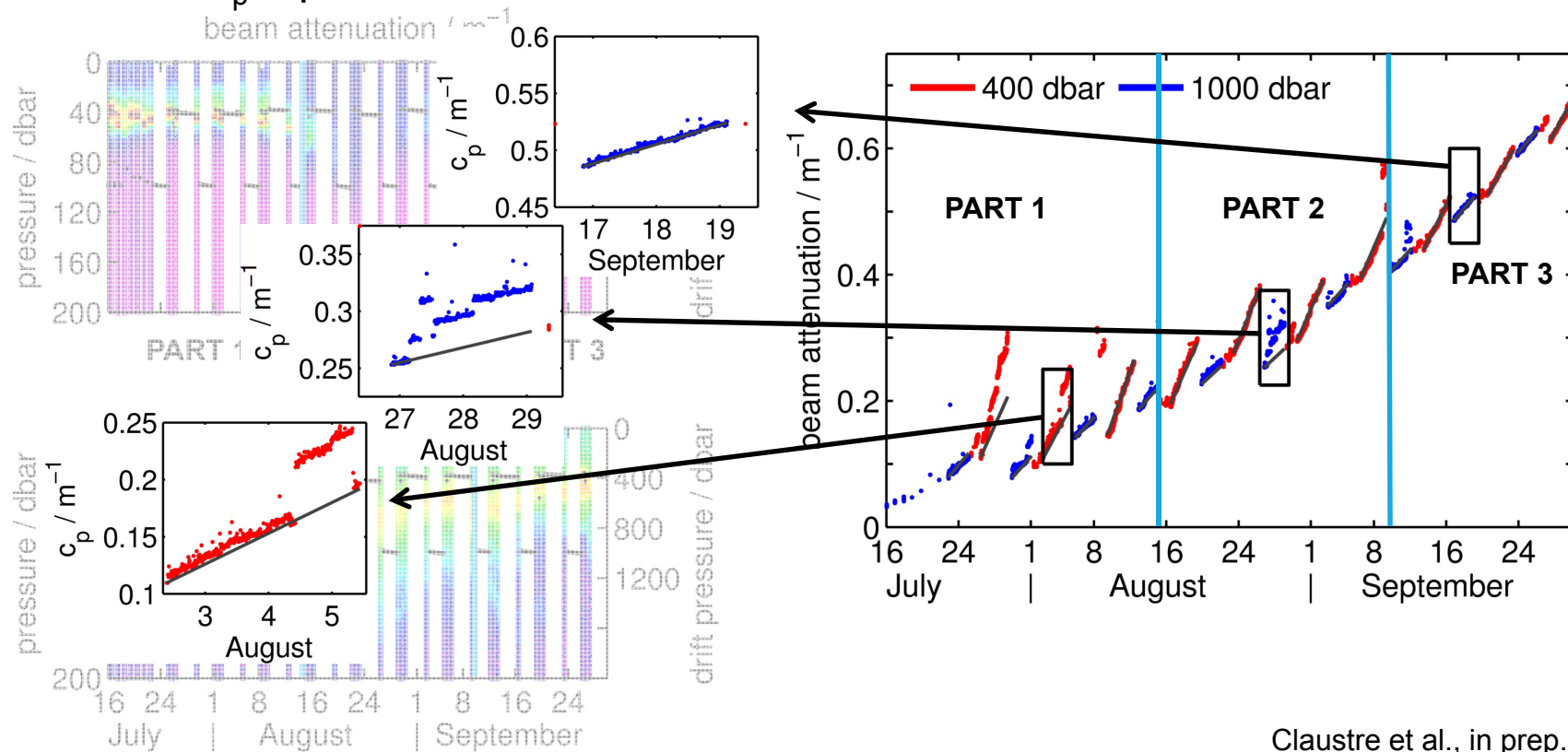
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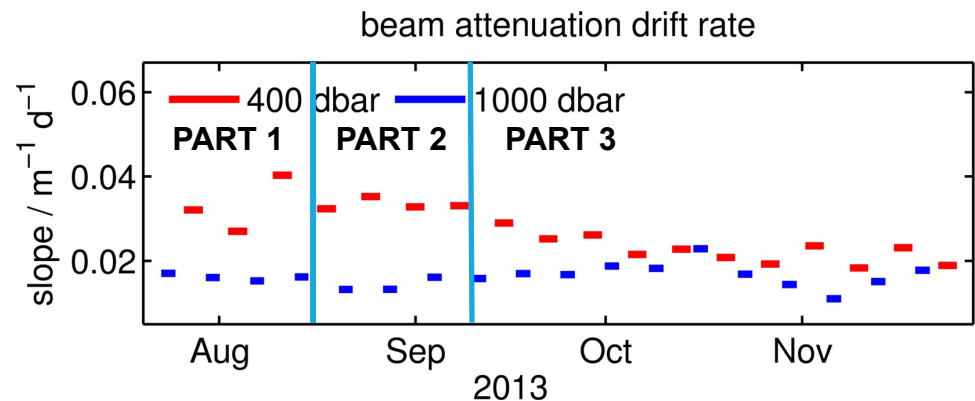
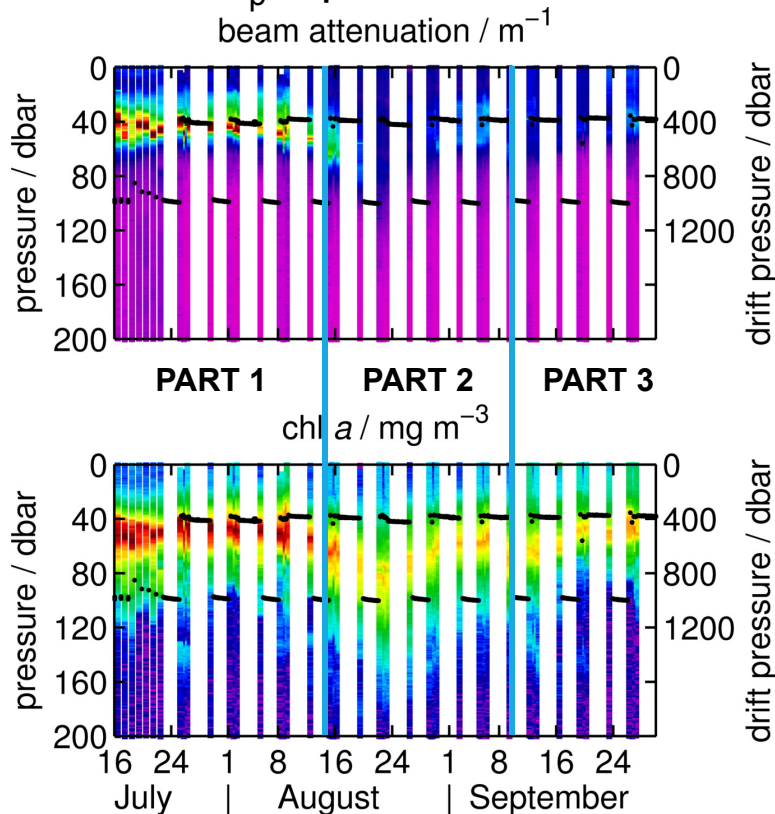


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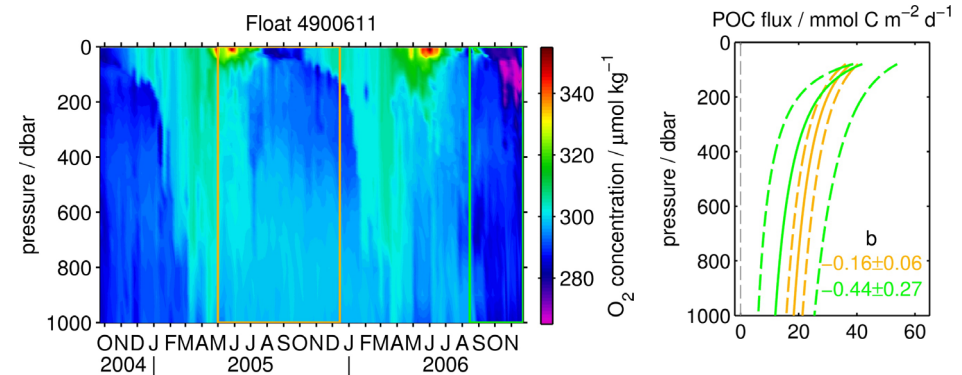


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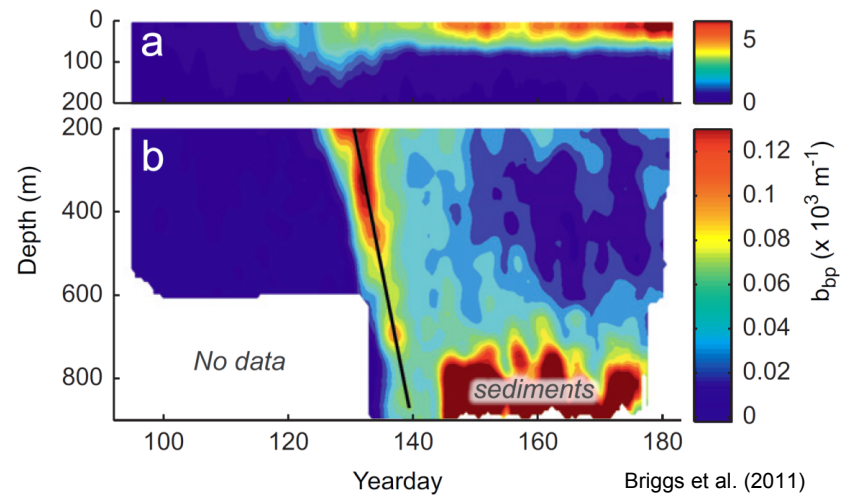


Claustre et al., in prep.

- Chemical approach



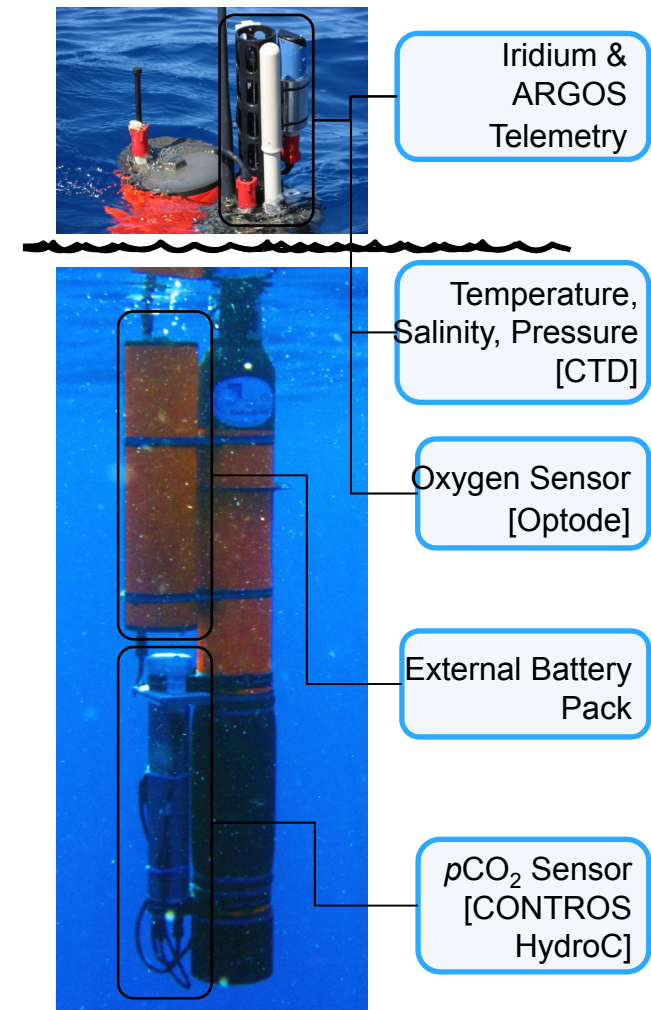
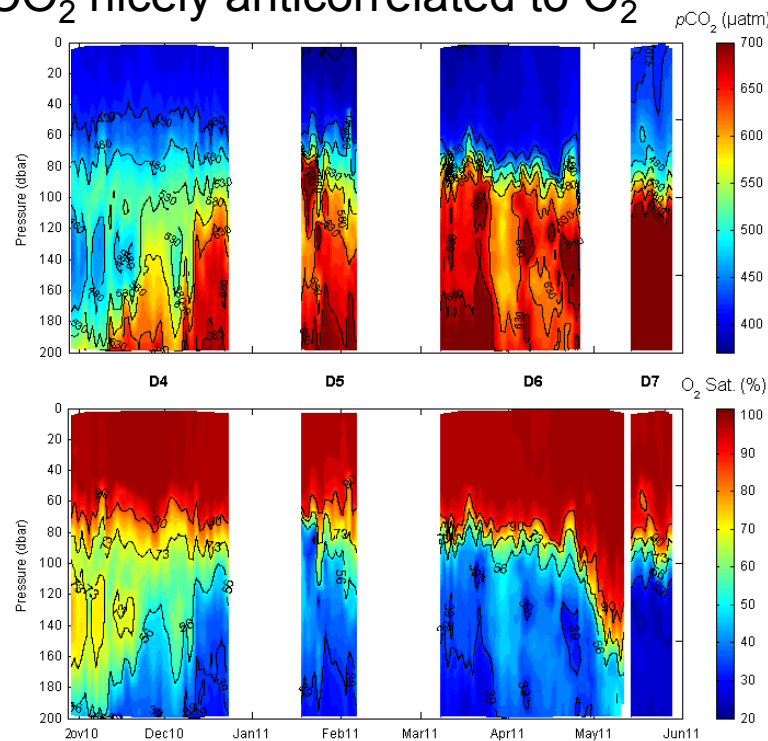
- Optical approach



Trends: Extended Chemical Capabilities: Inorganic C Float



- CO₂-system sensors ($p\text{CO}_2$, pH)
- Potential to reduce uncertainty in stoichiometric ratios ($\rightarrow$ C-overconsumption)
- $p\text{CO}_2$ nicely anticorrelated to O₂

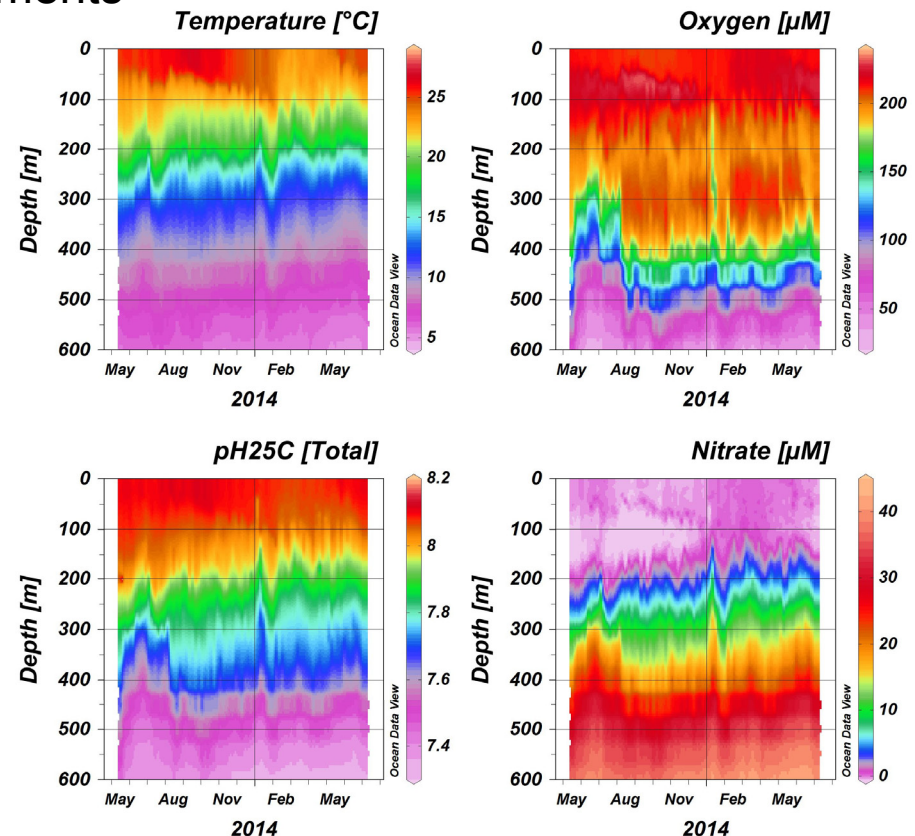
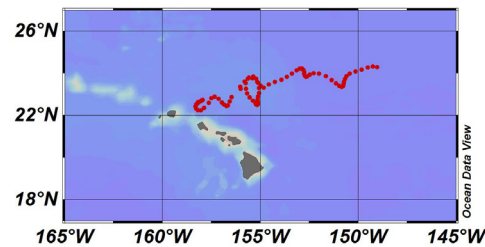


Fiedler et al. (2013), J. Atmos. Oceanic Technol., 30, 112–126.

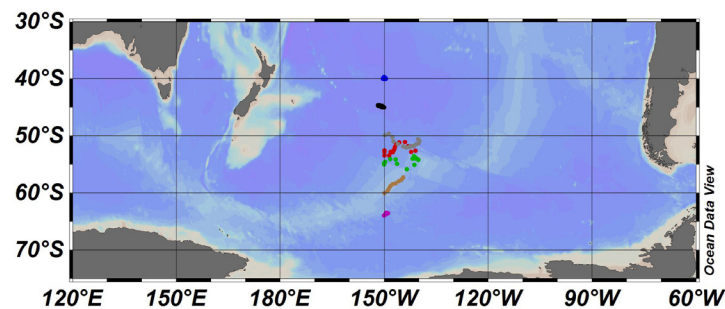
Trends: Extended Chemical Capabilities: C:N:O Float



- Technological potential for C:N:O Float: simultaneous C, N, and O measurements
- e.g., MBARI @ HOT:



- pre-SOCCOM:

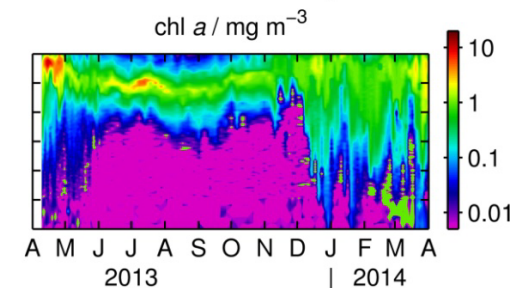
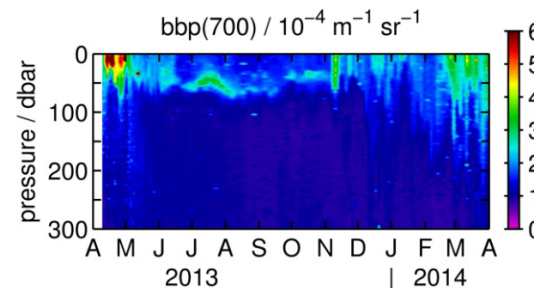
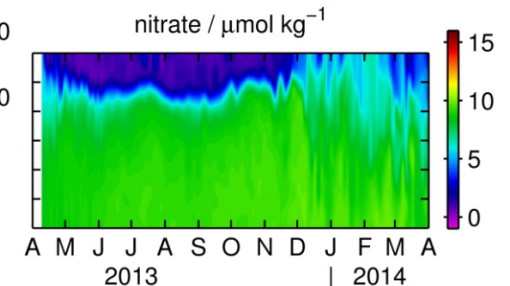
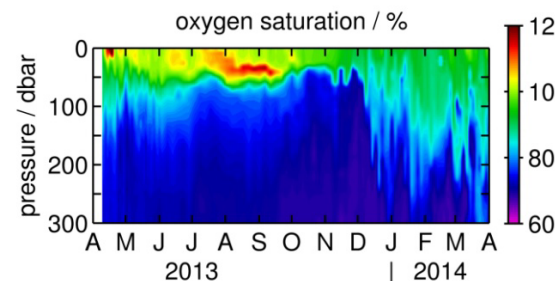
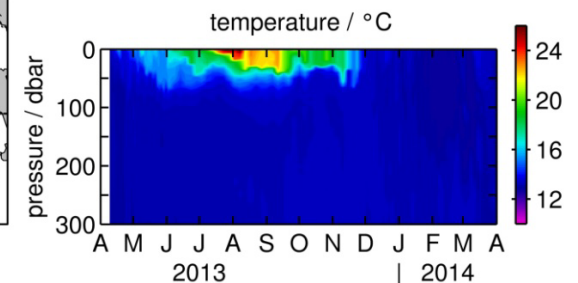
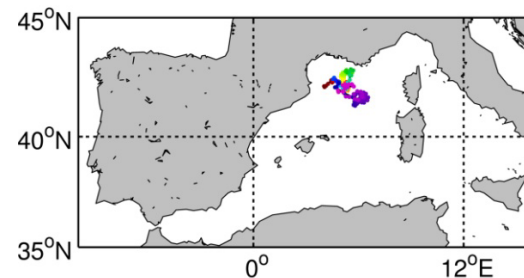
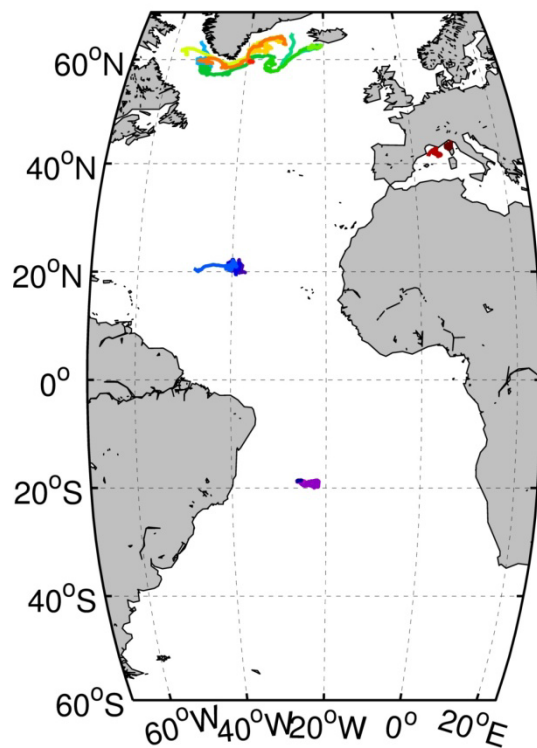


Johnson et al., <http://www.mbari.org/chemsensor/floatviz.htm>

Trends: Chemical & Optical Approaches combined



- e.g., lovbio floats (capable to carry heavy load of sensors)
- Multitude of information from autonomous platforms



Summary

- Chemistry:
 - sum of production & respiration
 - if physics can be separated
 - feasible with deep winter mixing / otherwise simplified system (CE)
- Optics:
 - complementary approach
 - requires in-situ data for calibration
- advent of new / more mature technology to extend capabilities
- possibly smart way to separate physics in complex systems (modeling complement)

