OCB Theme II : Carbon uptake and storage

"Recent observational and modeling findings quantifying the magnitude and trends in ocean carbon fluxes and storage"

Autonomous measurements of the subpolar North Atlantic spring bloom: early results from the NAB08 experiment

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and NAB08 Colleagues

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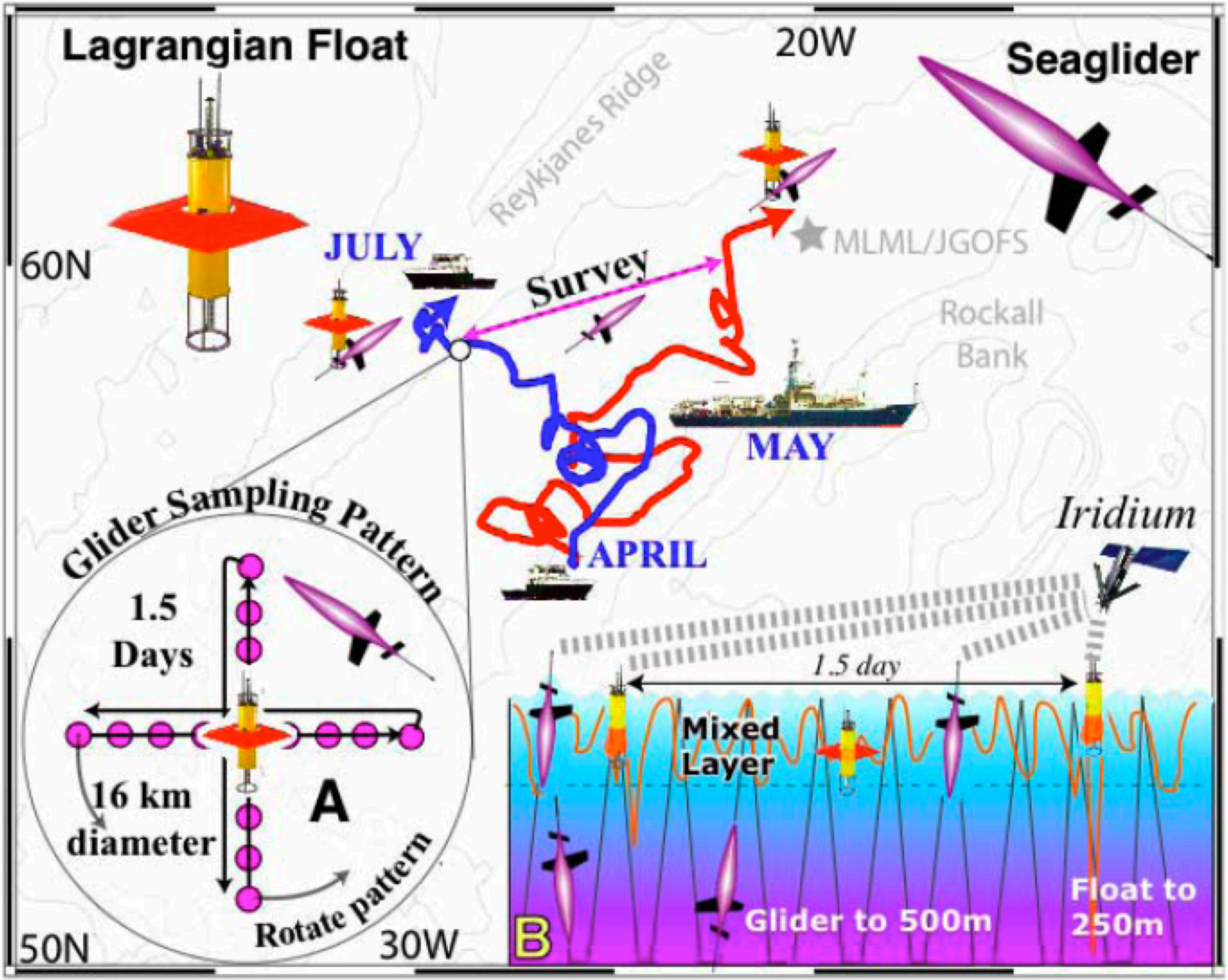
US (with support from NSF and NASA):

UW, UMaine, Dalhousie, URI, Scripps, MBARI, OSU

International:

Canada, Iceland, Denmark, UK (3 institutions)

Thanks to UW APL float and Seaglider groups for great jobs on floats 47, 48 and Seagliders 140, 141, 142, 143



Lagrangian Float
20W
Seaglider
Reykjanes Ridge
JULY
60N
Survey
MLML/JGOFS
Rockall
Bank
MAY
APRIL
Glider Sampling Pattern
Iridium
1.5
Days
1.5 day
Mixed
Layer
16 km
diameter
A
Rotate pattern
Float to
250m
Glider to 500m
50N
30W
B

So, why the subpolar North Atlantic ?

Carbon uptake:

One of largest CO_2 draw-downs on the planet occurs during NA spring bloom –> photosynthetic uptake of carbon

Carbon Removal: 3 mechanisms

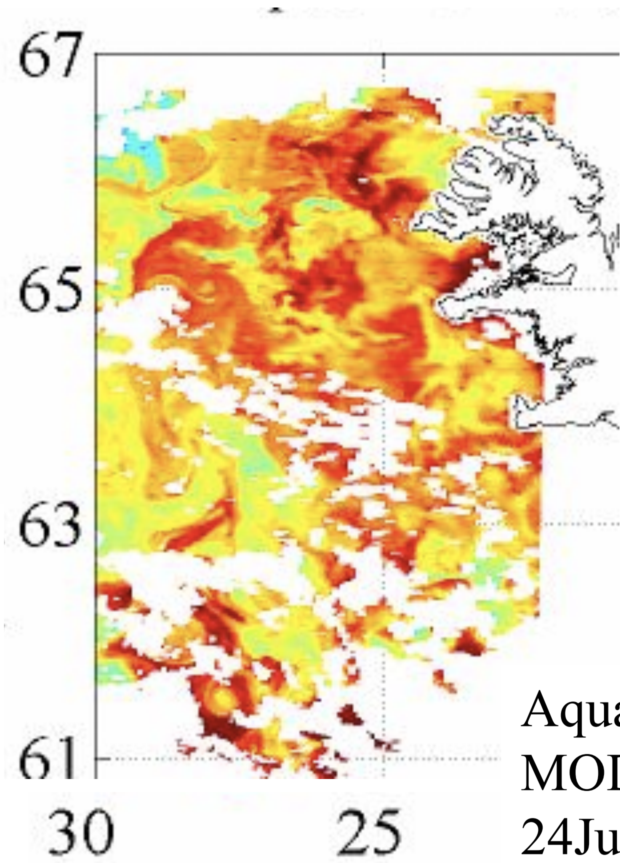
* mixed-layer pump (stratification/destratification)
* sinking of aggregates (diatoms, etc.)
* subduction of water mass

Carbon Storage:

depends on – how much gets down, how fast, and what happens next . . .

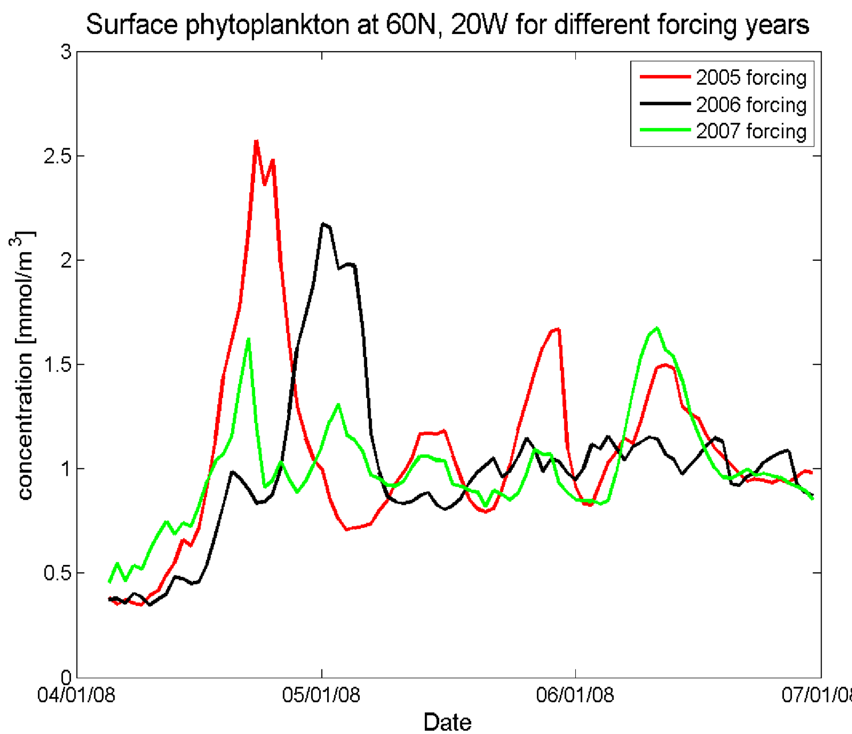
Challenges to studying NA bloom (and other regions)

High spatial variability on mesoscale and submesoscale (~ km)



Aqua MODIS 24June08

Inter-annual variability in timing of bloom (1D model, similar to SeaWiFS data)



Fennel and Bagniewski

Key OCB questions:

1) how much carbon is taken up ?
2) how much carbon is removed ?
3) how much carbon is stored ?
4) how will carbon uptake, removal and storage in the N. Atlantic, and other key regions, respond to **climate change or increased variability in forcings** ?
5) how can one **document change – in light of large temporal and spatial variability** ?

Challenges to assessing carbon uptake and removal:

Ships –
operate on fixed schedules (match or mismatch with timing of the bloom and major removal events)

Moorings –
single locations, how to interpret submesocale variability ?

Satellites –
can't see through (persistent) clouds; lack depth resolution

Models –
depend on quality of input data and understanding of processes

The Project: "NSF-Collaborative Research: Autonomous Measurements of Carbon Fluxes in the North Atlantic Bloom"

New approach to studying the evolution and demise of the subpolar North Atlantic spring bloom near 60˚N JGOFS site using floats and gliders, ship-based observations, satellites and models, and collaboratory.

The Motivation:

1) JGOFS NABE synthesis and modeling activities clearly identified a need for **more complete temporal / spatial coverage of the bloom** and **improved resolution of mixed-layer dynamics and lateral processes**.

2) **Autonomous platforms now sufficiently mature** to carry out a three-month, open-ocean experiment.

Core PIs, students and responsibilities

Eric D’Asaro, Eric Rehm	Lagrangian bio-floats
Katja Fennel, Witold Bagniewski (collaboration through student)	ecosystem models
Craig Lee, Amanda Gray	Seagliders
Mary Jane Perry, N. Briggs, E. Kallin	ship optics & samples
Michael Sieracki, Nicole Poulton	phytoplankton species
Annette deCharon	education and outreach

Process cruise collaborators

Approach:

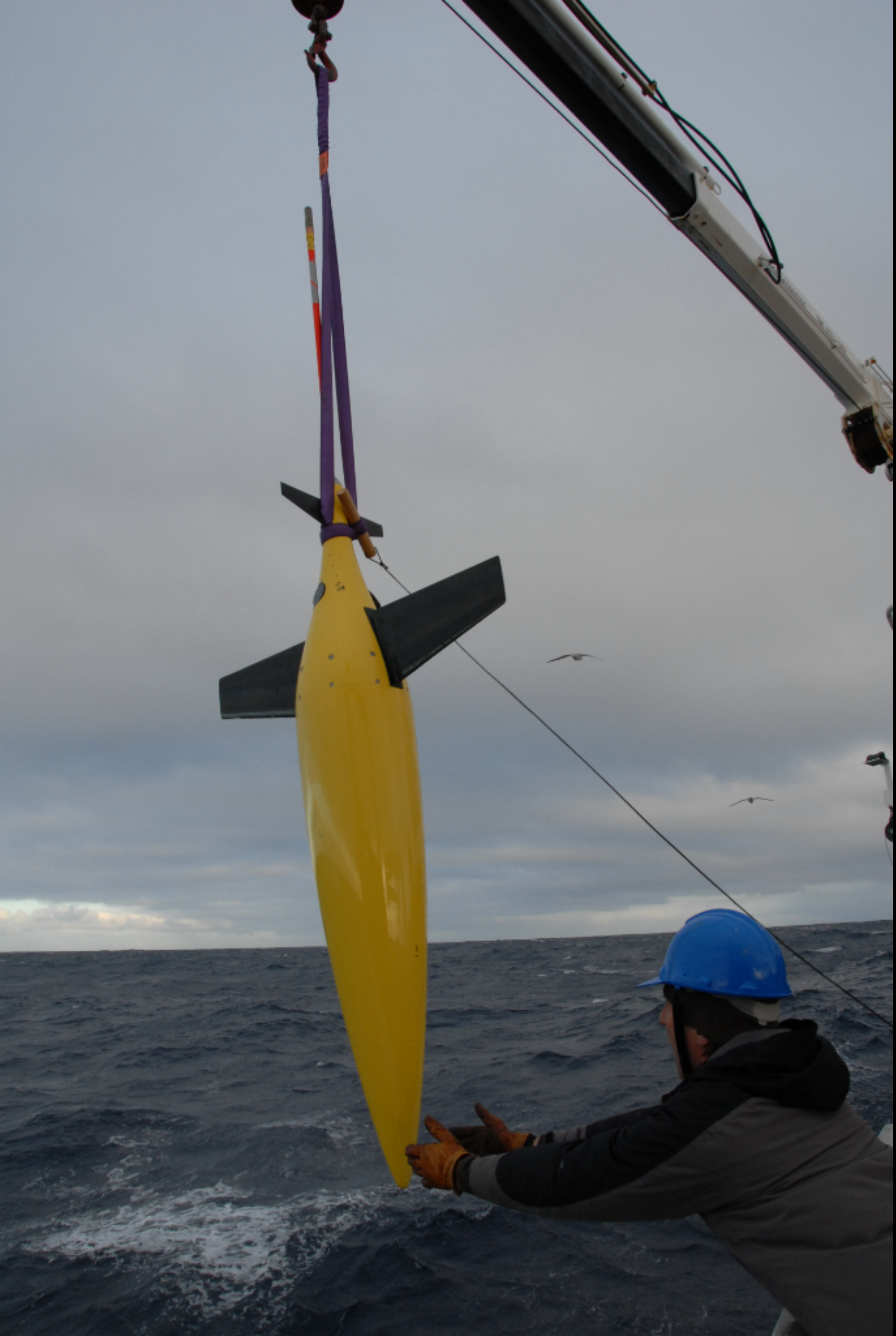
* autonomous 4-D sampling for 3 month, April–June
* 2 heavily-instrumented floats and 4 Seagliders
* proxy sensors for carbon-cycle components
* deploy all before spring bloom starts
* retrieve after spring bloom
* ship visits to help interpret data
  ** ancillary measurements on 3-week process cruise with great input from collaborators (*e.g.,* R. Lampitt's floating sediment traps)
* satellite data
* ecosystem model

Deployment cruise: 1-6 April 2008


Typical early April seas in North Atlantic

Two Lagrangian bio-heavy floats

- water-following
- T, C (2 each)
- O_2 (2 types)
- Transmission (c)
- Chl fluorescence
- Backscatter (2λ)
- Ed (λ) and Lu (λ)
- PAR
- ISUS NO_3^-



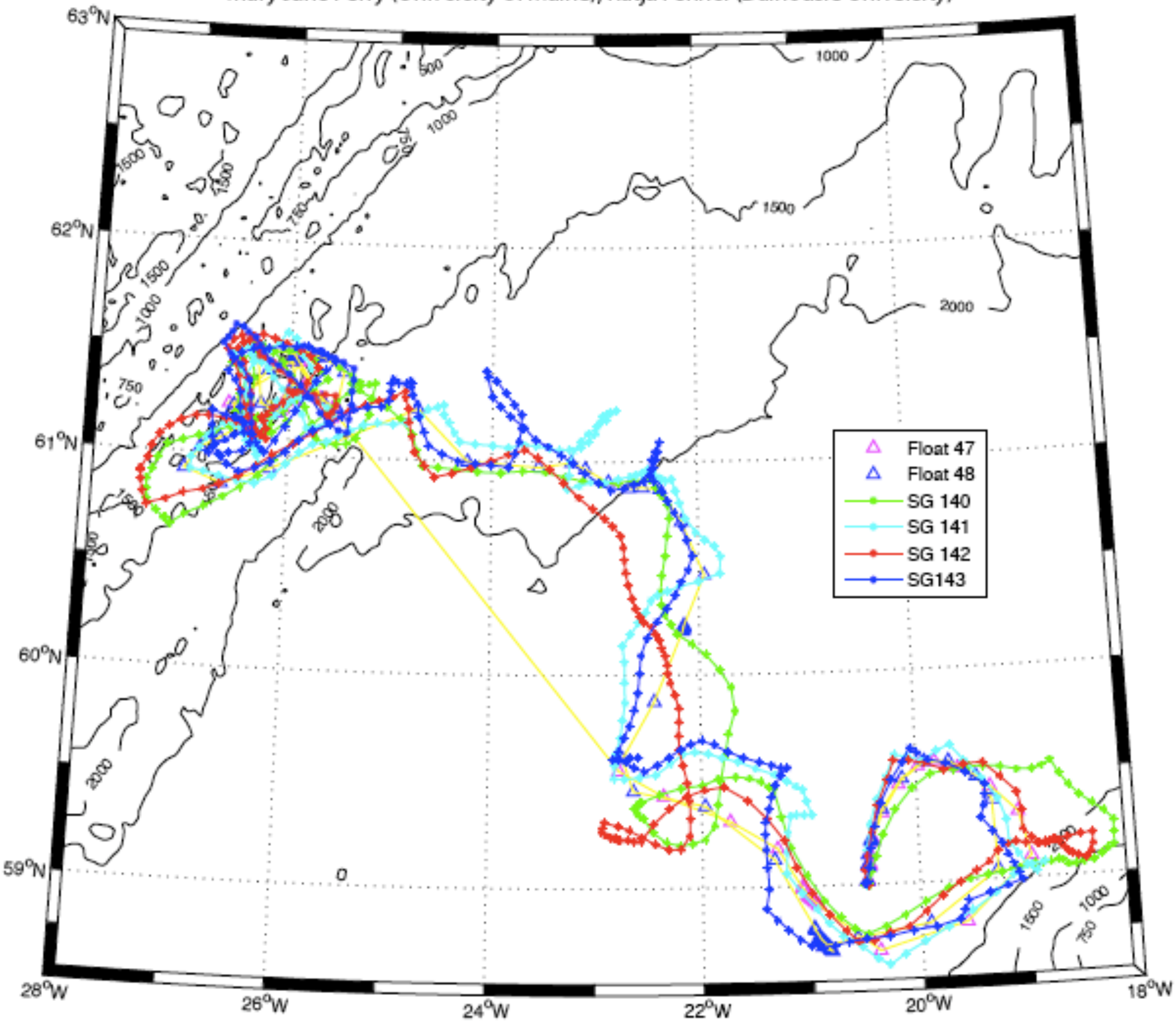
Four Seagliders

- float-following
- T, C
- O_2 (2 types)
- Chl fluorescence (2)
- Backscatter (3λ)
- CDOM fluorescence

North Atlantic Bloom 2008: 4 April - 22 May 2008

Locations of Lagrangian Floats and Seagliders

PIs: Eric D'Asaro and Craig Lee (University of Washington - Applied Physics Lab),
Mary Jane Perry (University of Maine), Katja Fennel (Dalhousie University)



3 months of data, 4 Seagliders - deployed before bloom

May 2, ship arrived on station after beginning of bloom

Panels with backscattering, chlorophyll from fluorescence, dissolved oxygen, chloropyll/backscattering

Value of process cruise

(some limited activities on deployment/rescue/pickup cruises)

Sensor **calibration** (vicarious)

Validation of ‘proxy’ relationships

Enhanced interpretation
of proxies and processes

"Calibration"
Has the sensor drifted or fouled?

Aggressive CTD calibration program

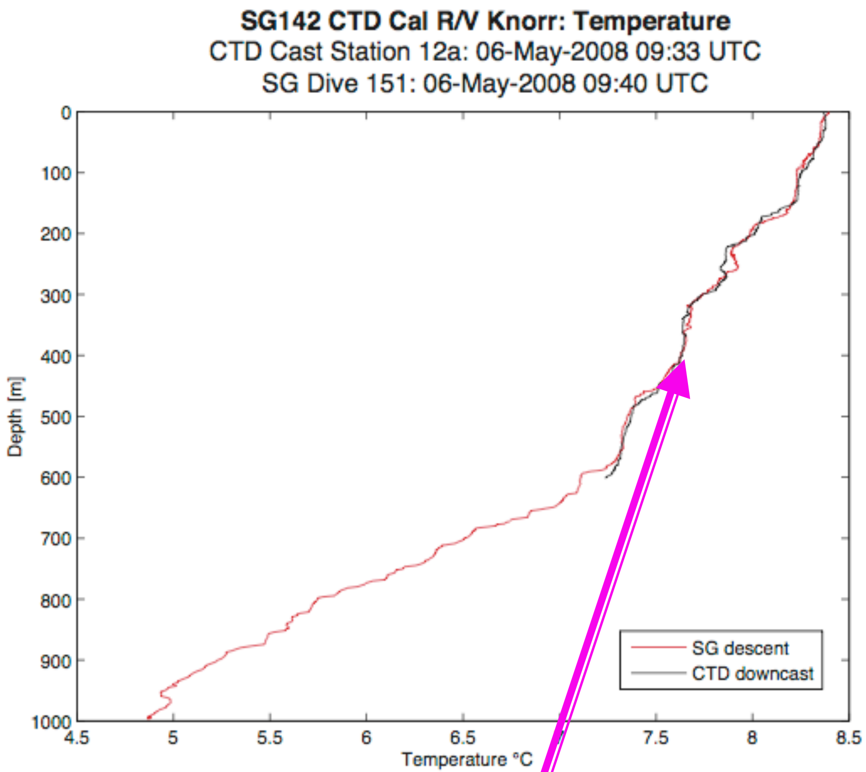
Cross-platform, vicarious sensor calibrations for:

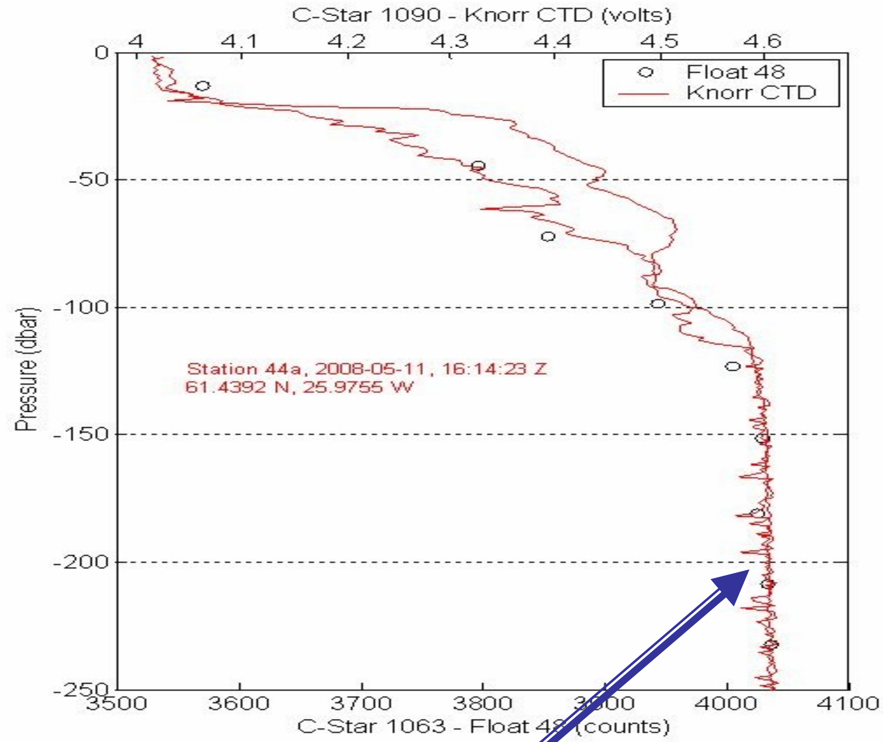
- temperature and transmission
- conductivity
- oxygen
- chlorophyll fluorescence
- backscattering
- PAR and spectral (ir)radiance

Float 48 calibration operation


Seaglider calibration operation

"Calibration"
Has the sensor drifted or fouled?

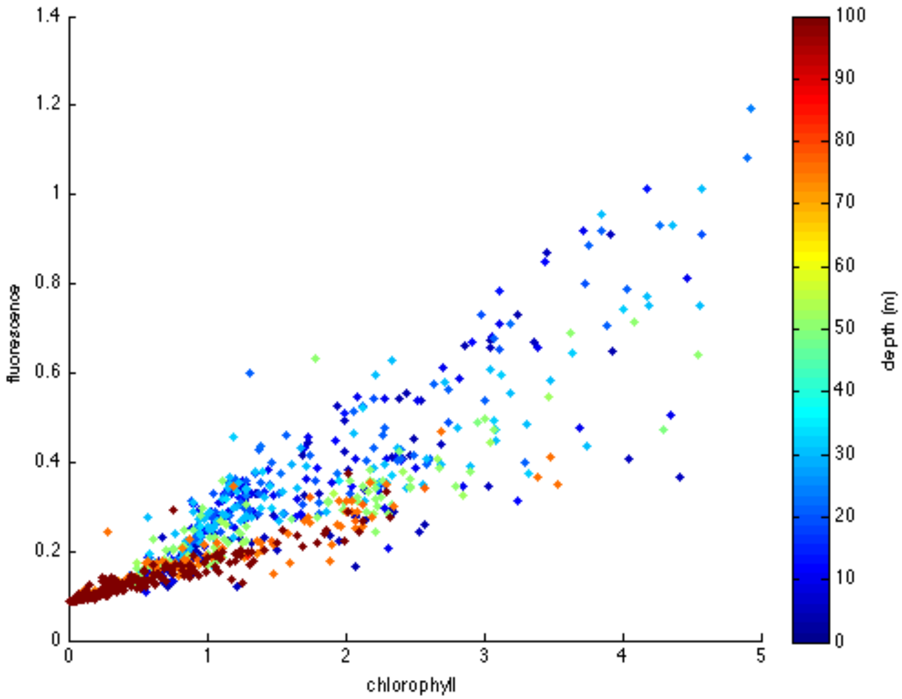




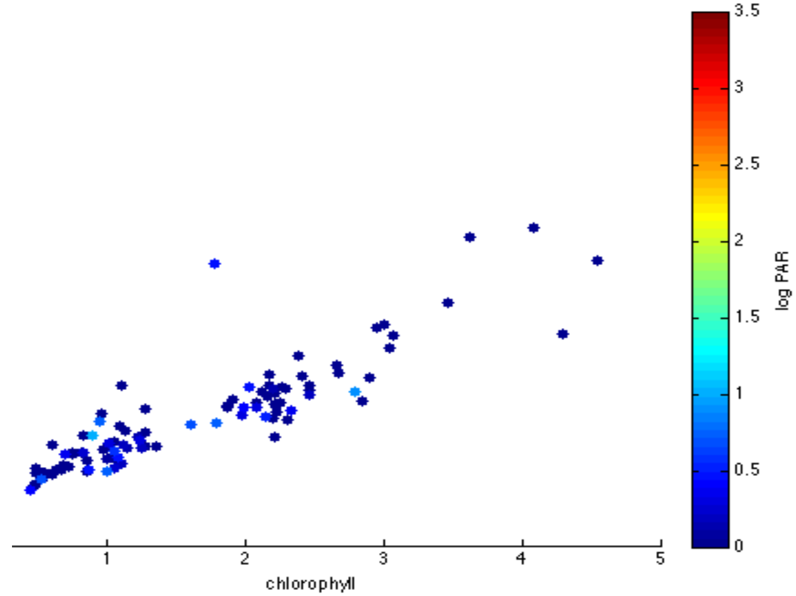
Temperature **Transmission**

“Validation of Proxies”

chlorophyll fluorescence vs. extracted chlorophyll:
fluorescence —> chlorophyll



all data (1,000 points)
colored by depth



50-m data
colored by PAR

"Validation of Proxies"

Other proxies remaining to be examined:

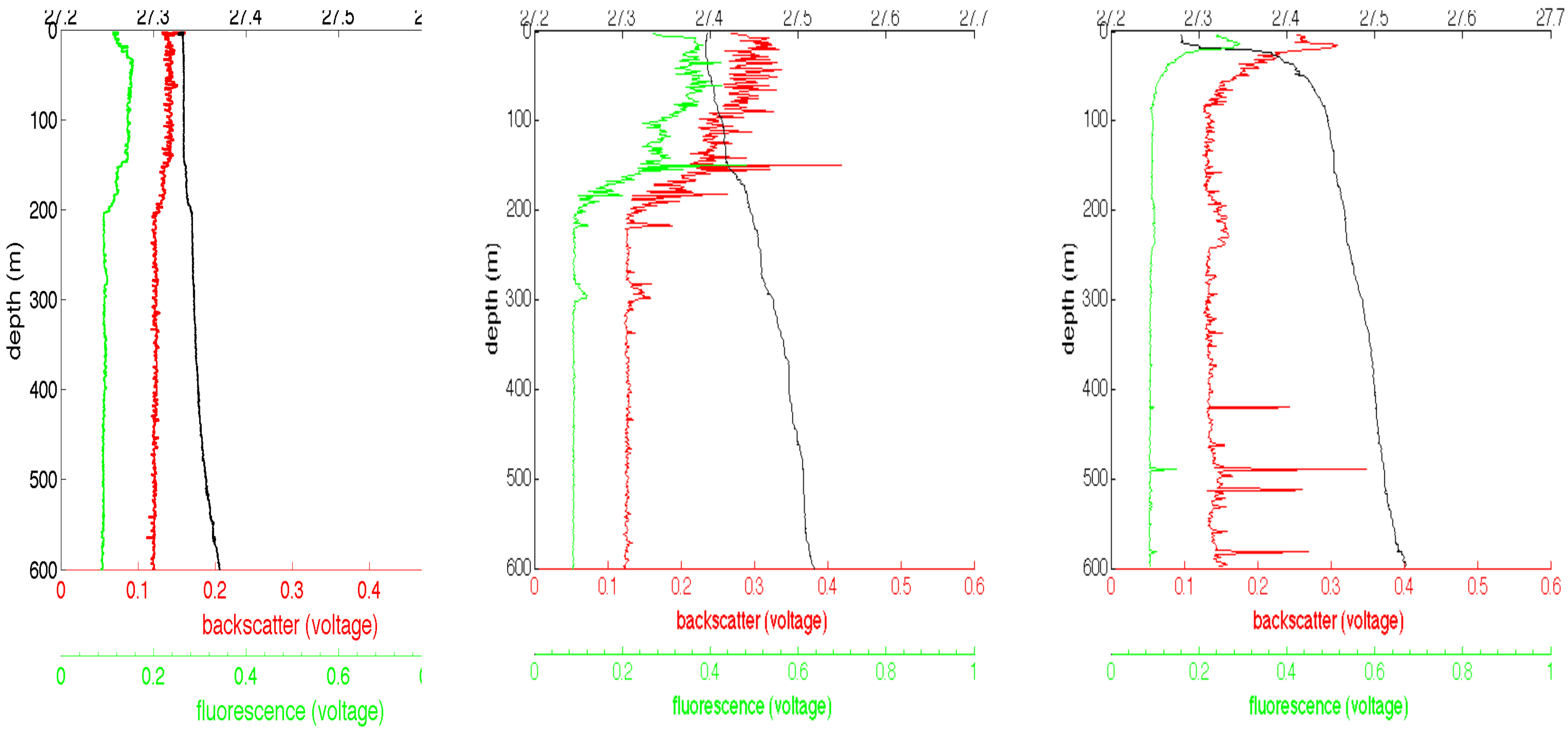
attenuation (c) and b_b	vs.	**POC** (~1,000 samples & blanks)
ISUS **nitrate**	vs.	chemical measurement ~1,000 samples)
chlorophyll	vs.	**phyto carbon** from FCM, FlowCAM
Lu (λ) / Ed (λ)	vs.	**phytoplankton "groups"** from HPLC pigments & FCM, FlowCAM

"Enhanced interpretation of optical & other signals"

1) Shift in phytoplankton community structure

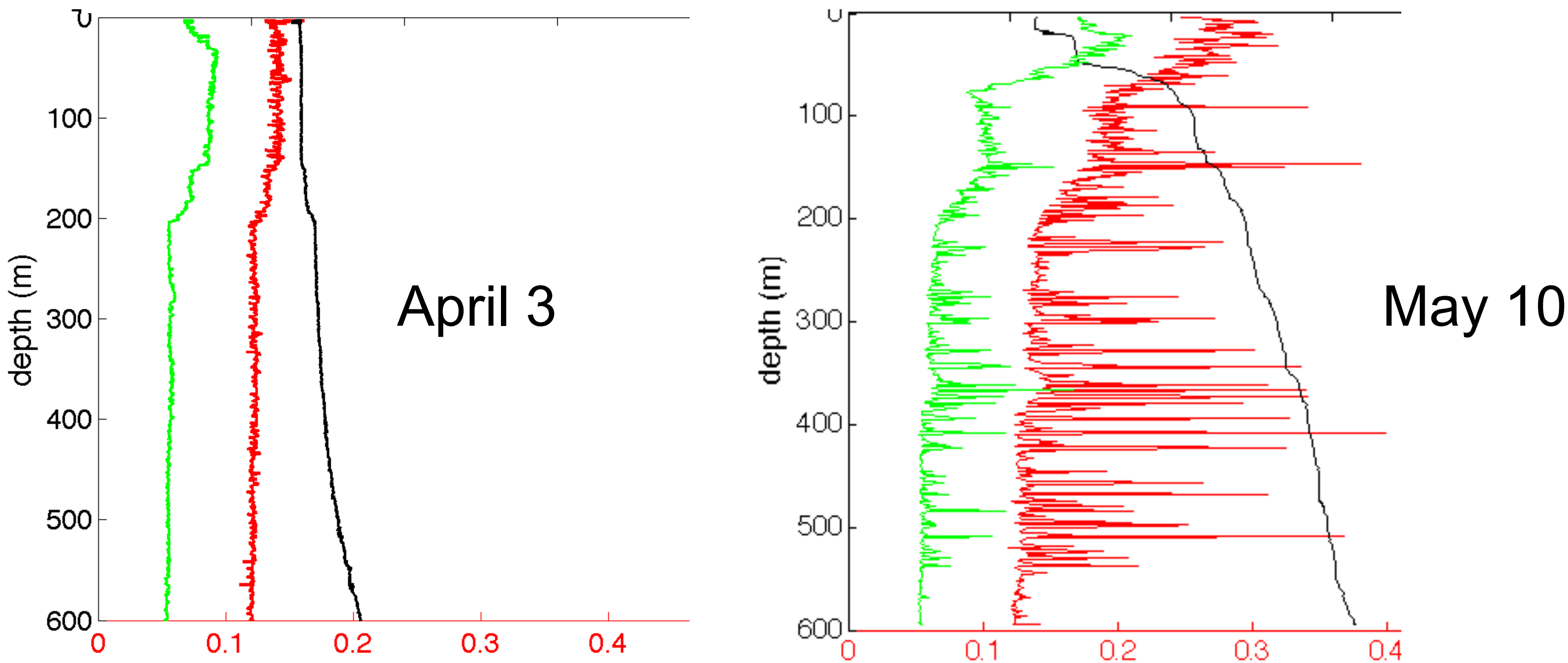
Large diatoms chains produce high-frequency variability in surface chl fluorescence

early April early May mid May



“Enhanced interpretation of optical & other signals”

2) Carbon flux:
high-frequency variability in deep chlorophyll fluorescence and backscatter, AKA “spikes”



red = bb; green = chl F; black = density

Seaglider 142 backscatter, deepening horizon of particle spikes ~ 50 m d^{-1}

Large PELAGRA trap catches at ~ 600 - 700 m coincide with backscatter events

What initiated the flux? Why so rapid? Probably silicate (not yet analyzed). ISUS data on float suggests nitrate was not depleted.

What comprised the sink? Large chain forming diatoms.