Biogeochemistry - Lab / field instruments for carbon stocks and rates

In situ measurement protocol revision for cal/val
IOCS 2013, Darmstadt, Germany
H.M. Sosik, WHOI

Biogeochemistry - Lab / field instruments for carbon stocks and rates

- Stocks
  - Particulate organic carbon (POC)
  - Particulate inorganic carbon (PIC)
  - Dissolved organic carbon (DOC)
  - Phytoplankton carbon
- Rates
  - Primary production
  - Export production / Sinking flux

Biogeochemistry - Lab / field instruments for carbon stocks and rates

Existing Protocols

NASA/TM-2003

Ocean Optics Protocols For Satellite Ocean Color Sensor Validation, Revision 5, Volume V: Biogeochemical and Bio-Optical Measurements and Data Analysis Protocols

Chapter 1 (Mueller) Overview of Biogeochemical Measurements and Data Analysis in Ocean Color Research

Addresses **POC** measurement protocol → JGOFS

Protocols for the Joint Global Ocean Flux Study (JGOFS) Core Measurements. JGOFS Report Nr. 19, UNESCO 1994. Knapp et al.

Chapter 4 (Balch and Drapeau) Backscattering by Coccolithophorids and Coccoliths: Sample Preparation, Measurement and Analysis Protocols

Includes **PIC** measurement protocol

Biogeochemistry - Lab / field instruments for carbon stocks and rates

Existing Protocols

Dissolved organic carbon

Consensus literature (e.g., Sharp et al.) ; use of common standard (Consensus Reference Material, CRM, from Hansell, RSMAS)

PICES Special Publication 3, Guide to Best Practices for Ocean CO_2 Measurements, IOCC Report No. 8, Dickson et al., 2007. (Section on Determination of DOC / DON in sea water)

Primary, new, export production

Incubation methods (C-14, N-15, etc.): JGOFS protocols

Sediment trap methods: JGOFS protocols

Isotope methods (Thorium, Oxygen/Argon, etc.): GEO-TRACES protocols

Sampling and Sample-handling Protocols for GEOTRACES Cruises, GEOTRACES Standards and Intercalibration Committee, 2010.

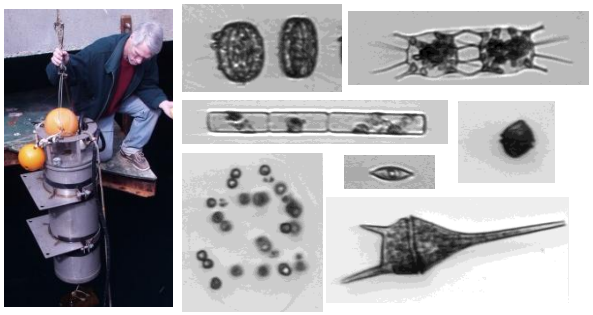
Phytoplankton carbon

- Microscopy

  Cell dimensions → cell volume → cell C

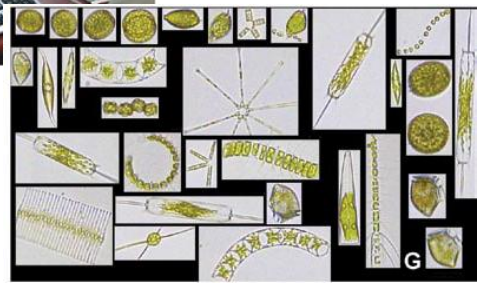
  Relies on standard shape assumptions; Literature-based C:volume relationships

- Automated cell imaging, Flow cytometry



Imaging FlowCytobot
Olson and Sosik 2007

FlowCam
Sieracki et al. 1998



In situ and laboratory

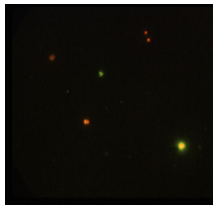
Phytoplankton Carbon – Single cells to biomass

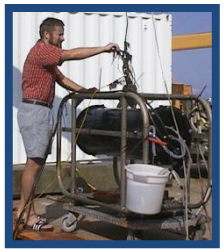
$$\text{Carbon} = \sum_i C_i$$

$$C_i = f(V_i)$$

Menden-Deuer
and Lessard 2000

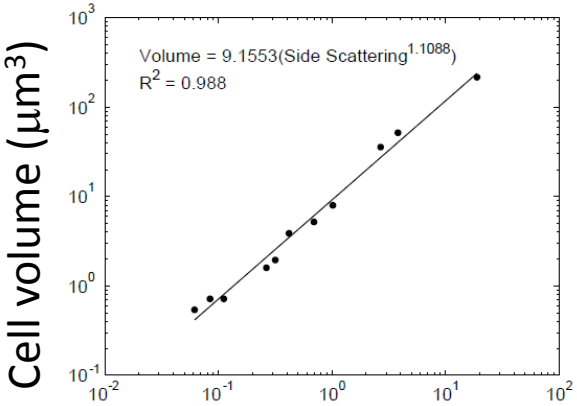
Picoplankton





FlowCytobot

Volume from laser scattering

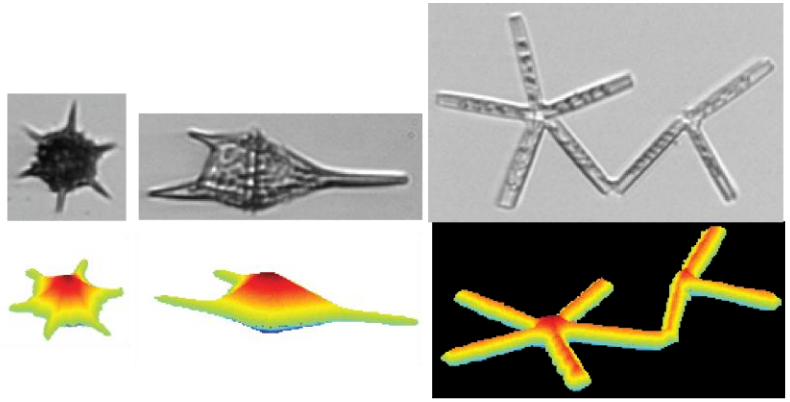


Light scattering

Olson et al. 2003

Microplankton

Imaging
FlowCytobot

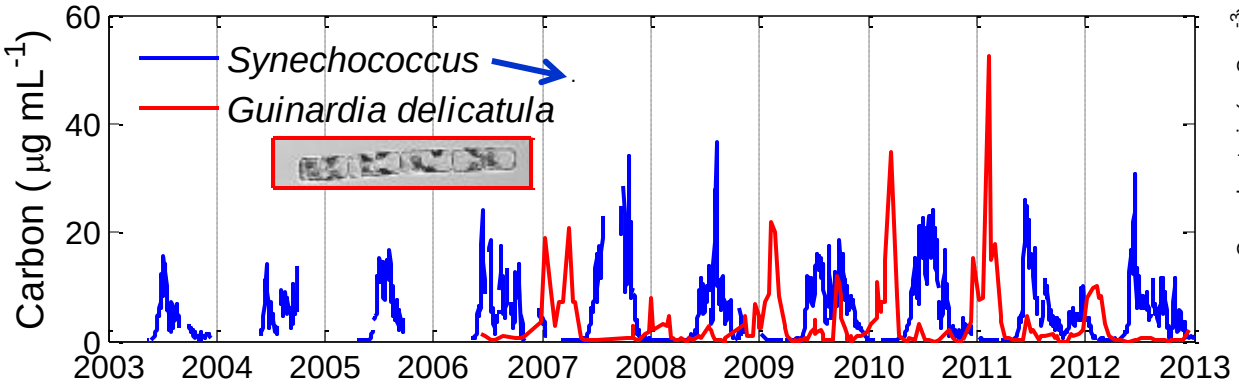


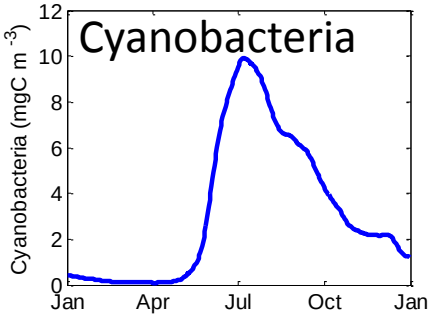
Volume from image analysis
"distance map" approach

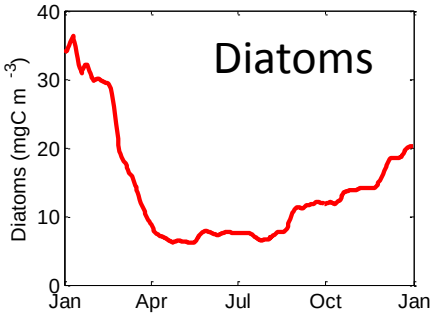
Sosik and Olson 2007
Moberg & Sosik 2012

Phytoplankton Carbon – Single cells to biomass

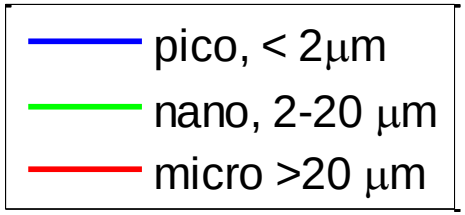
Individual cells → Taxa → Communities

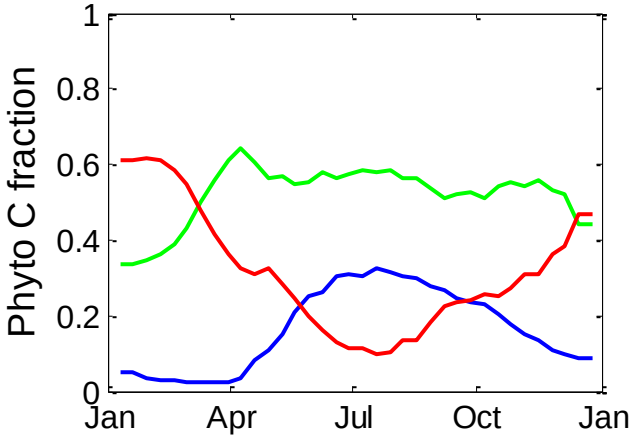






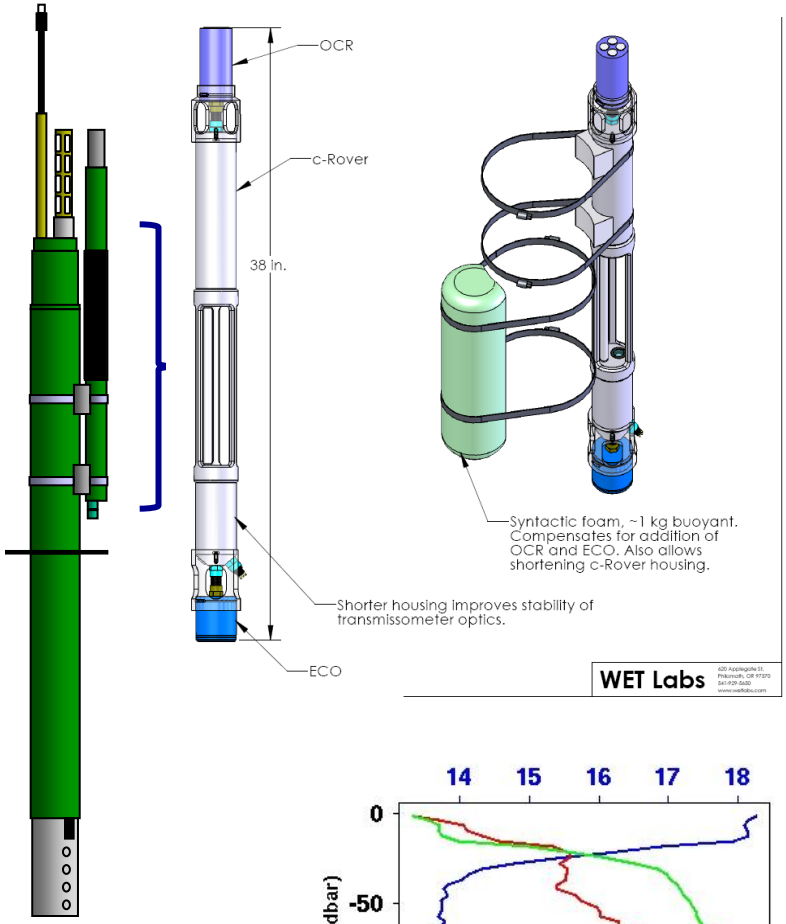
Individual cells → Size-classes → Communities



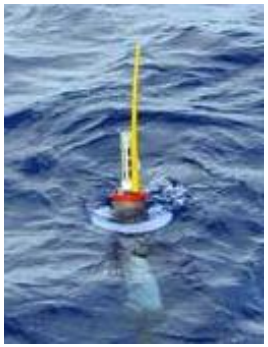


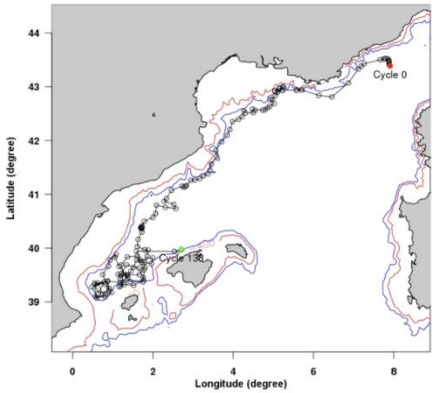
Optical-Biogeochemical Observations on Floats

ARGO-PROVBIO : PROVOR + c(660) + b_b(555) + Chl*a* Fluor + CDOM Fluor + $E_d(3\lambda)$ + Iridium

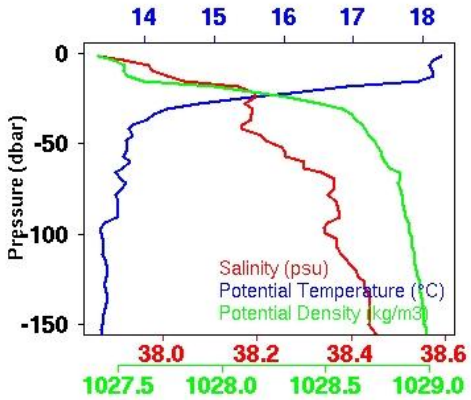


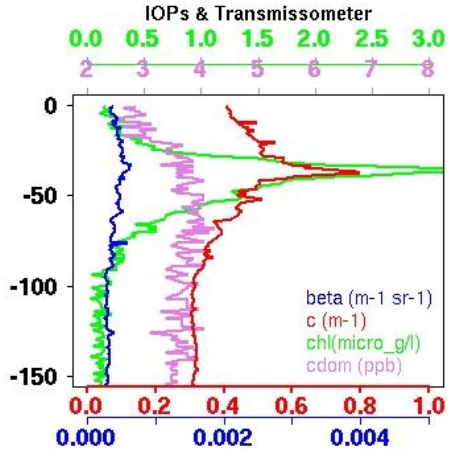
IOCCG Report Number 11
Bio-Optical Sensors on Argo Floats
Claustre et al. 2011

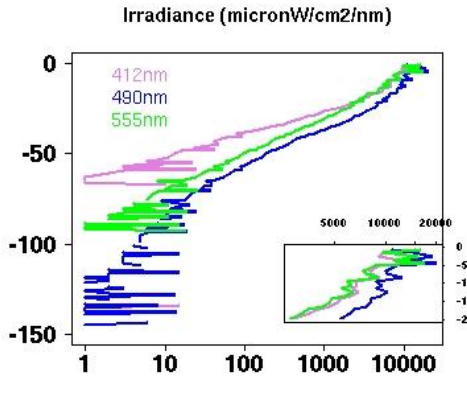




MED_NW_B02_6900677 Mediterraneen_sea (Lat: 43.33 Lon: 7.12)
22 May 08 10:51 GMT

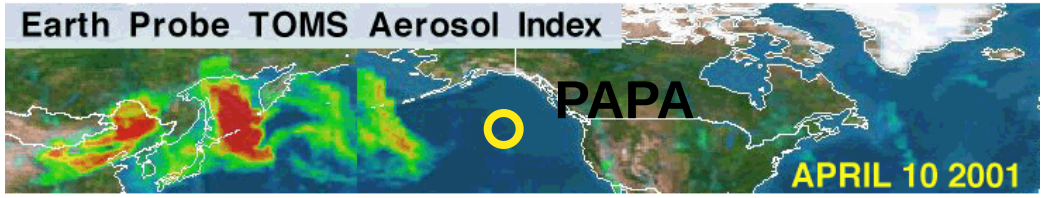






1000 m profiles

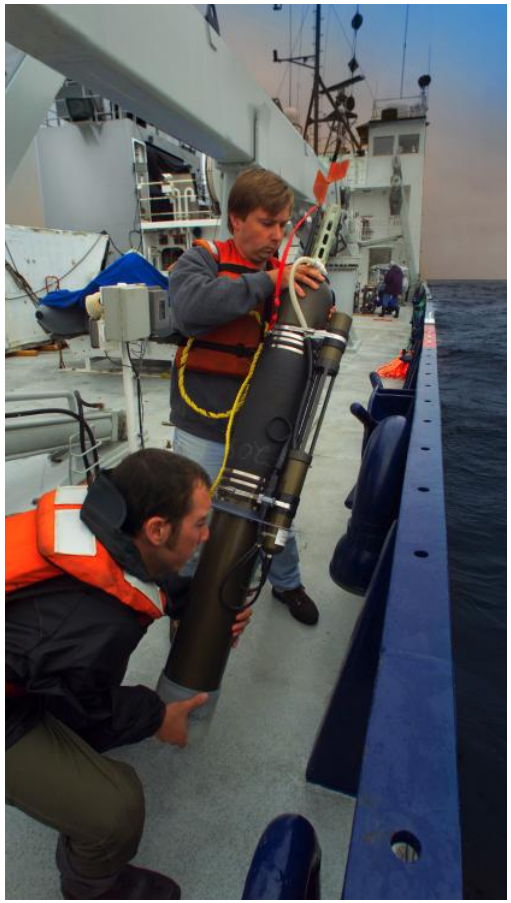
Optical Carbon Explorers

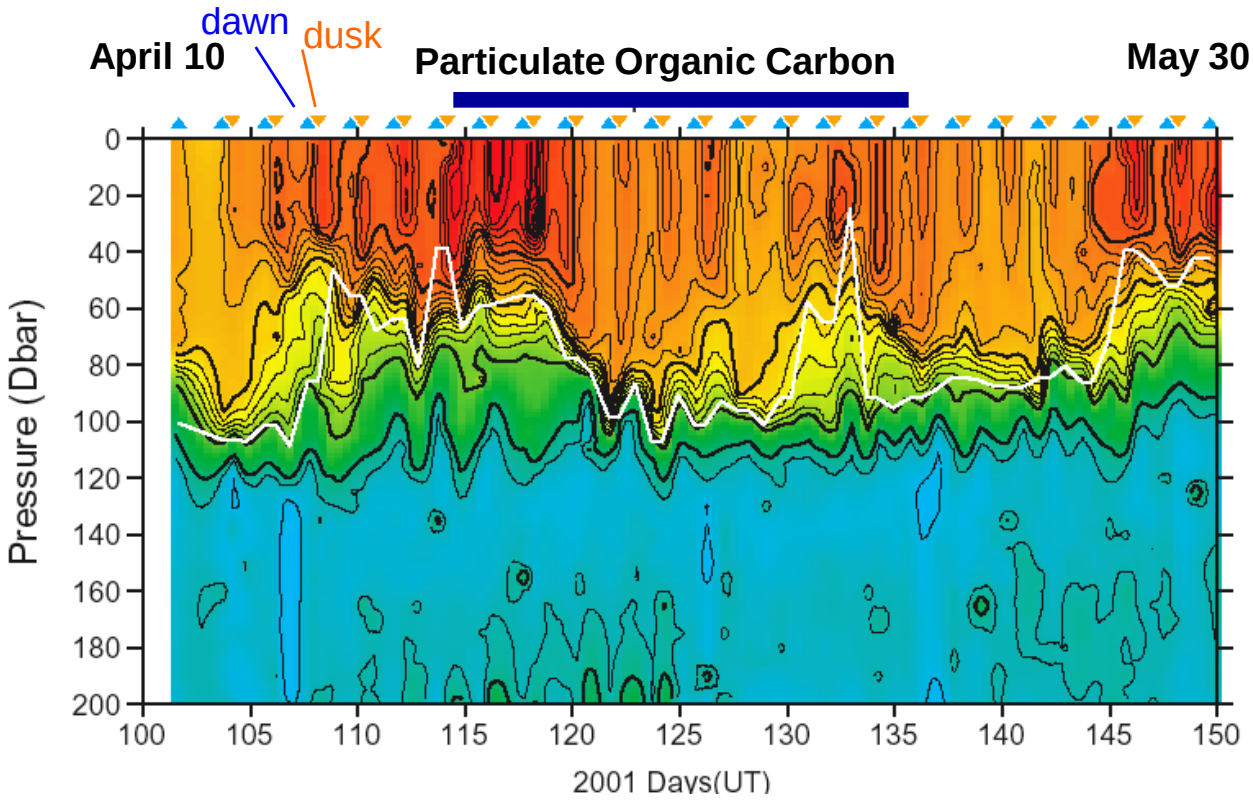


Response to dust input

Gobi Desert Dust Crosses Pacific

April 10-14, 2001



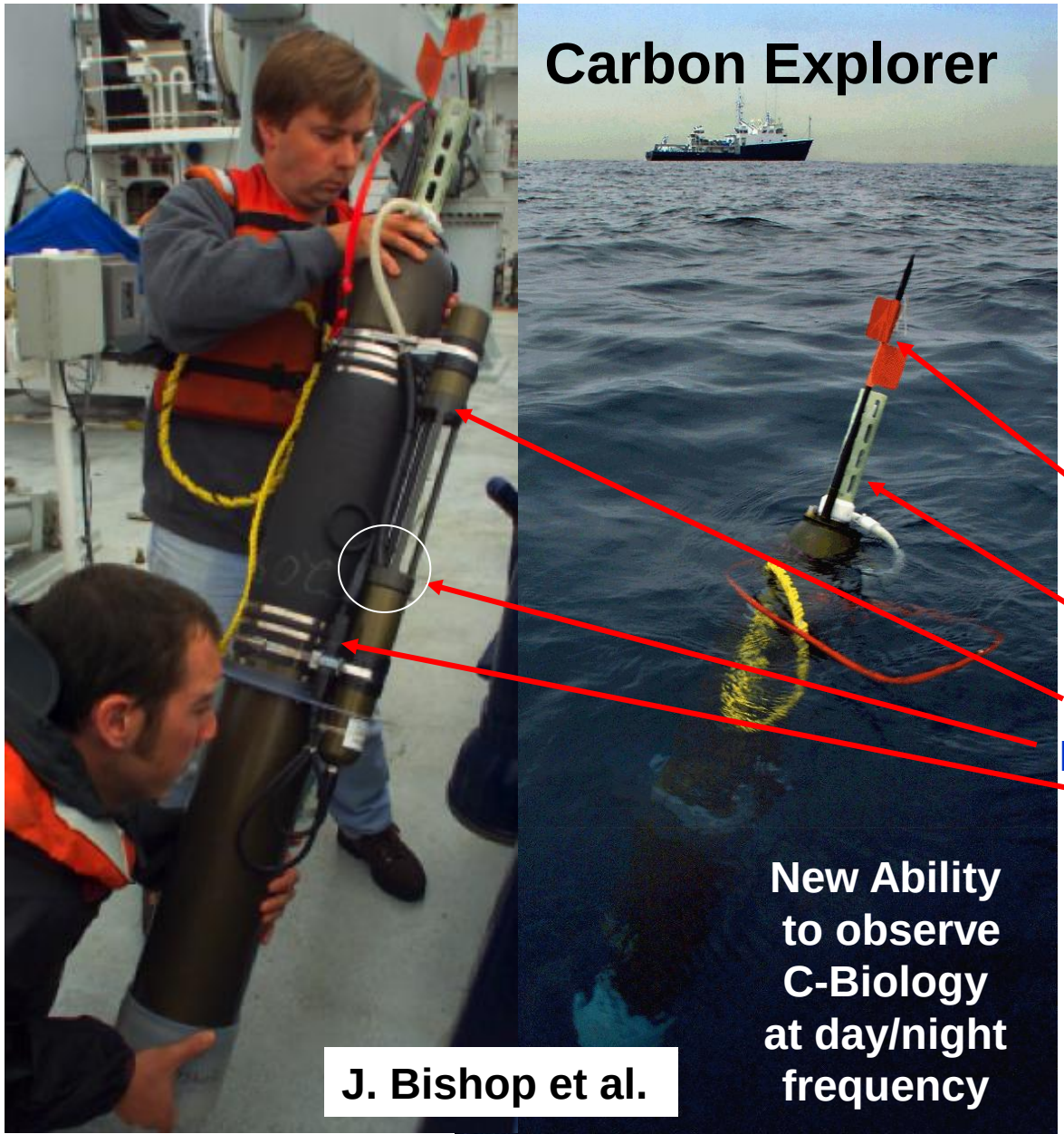


POC vs. transmissometer (c_p) relationship is robust

Diurnal profiles → productivity

J. Bishop et al. 2002, Science

Optical Carbon Explorers



Modified SOLO [ARGO] float

Fast Profiling (diurnal profiles to 1000m)

Long Lived ~1 year (battery limited)

Real Time Bi-directional Satellite Telemetry

Temperature, Salinity
Particulate Organic Carbon
Particulate Carbon Flux Index
Scattering

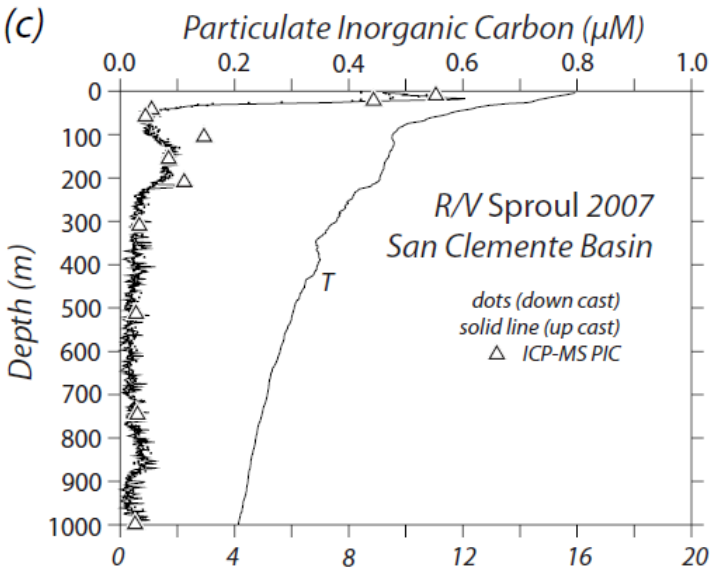
Particulate Inorganic Carbon

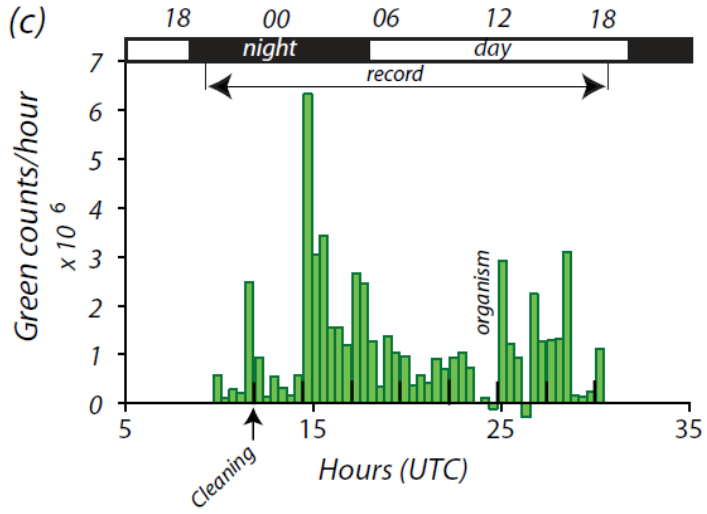
$30k per enhanced explorer = 1 ship day

Optical Carbon Explorers

Particulate Inorganic Carbon

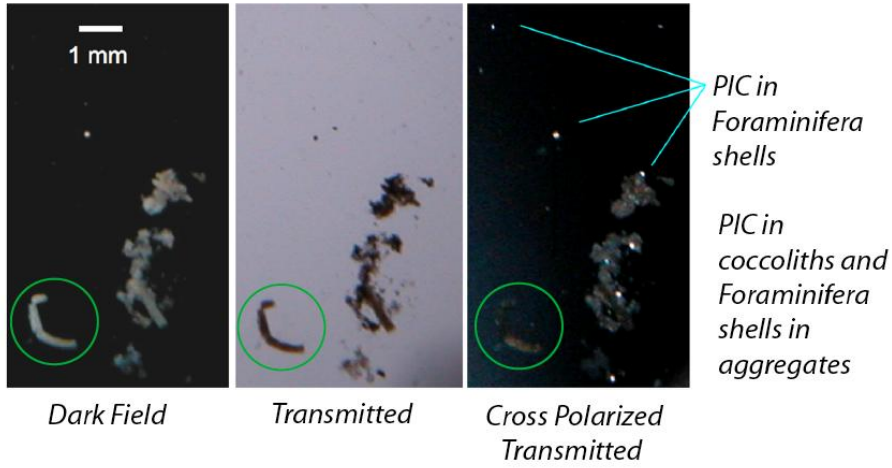
- Cross polarized transmission





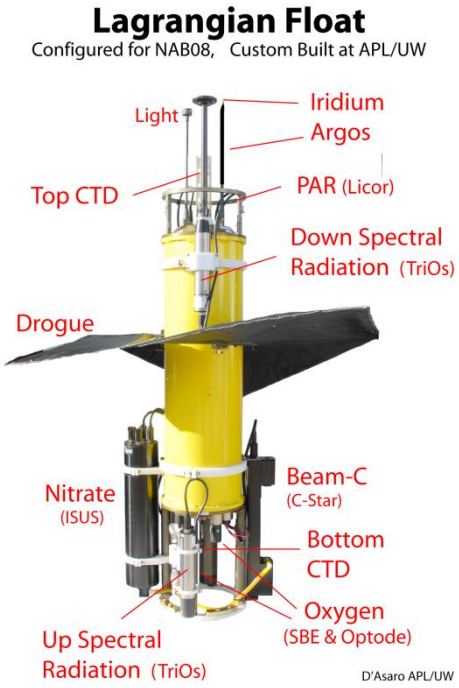
Carbon Flux Index

- settling and imaging



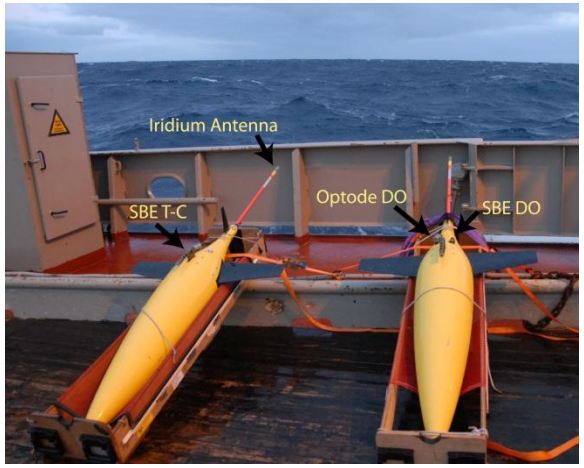
J. Bishop 2009, Oceanography

North Atlantic Spring Bloom Experiment 2008

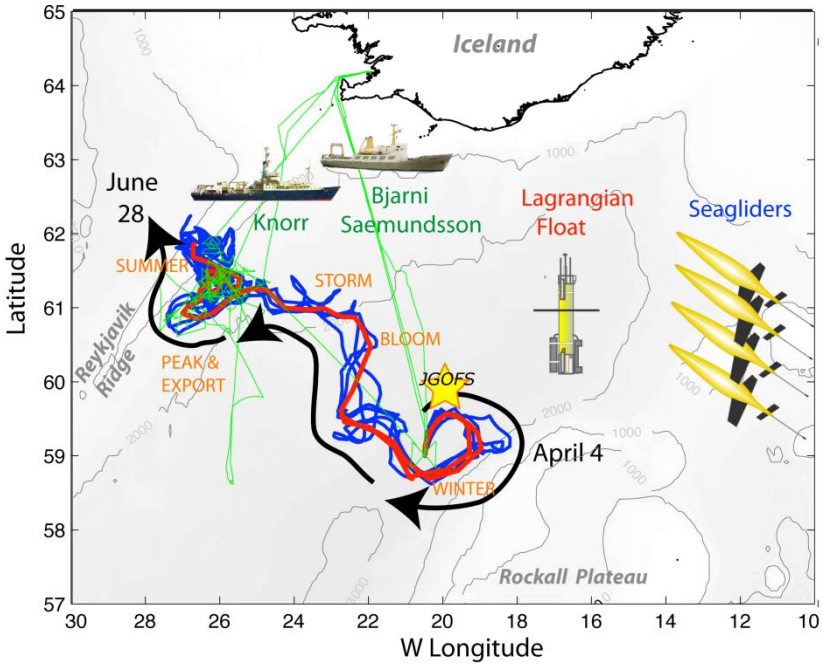


Floats-Define Lagrangian Frame, vertical fluxes. Profile to 250 m every 24-36 h.

~ 2 month multi-platform, multi-sensor approach



Gliders-Spatial context around floats. Profile to 1000 m every 4-5 h.



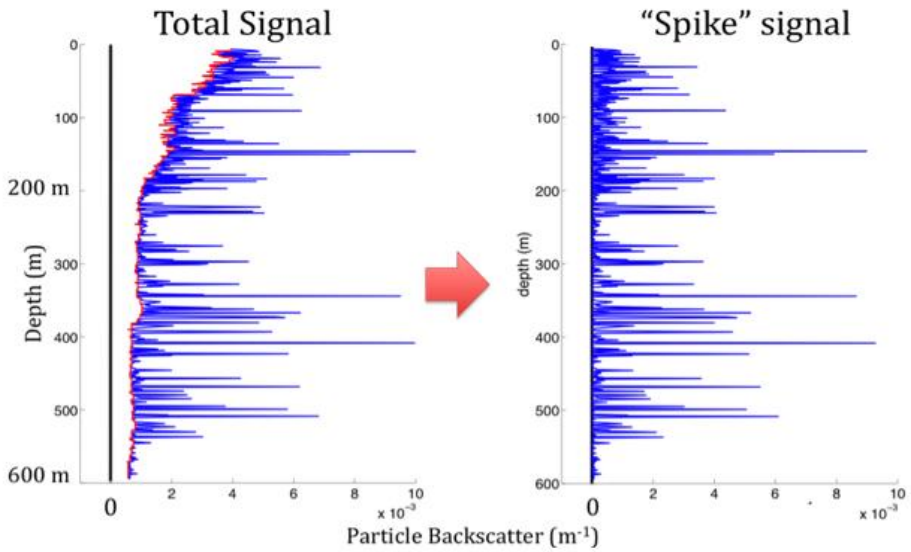
R/V Knorr, R/V Sæmundsson

Extensive biological and chemical Calibration data, Build proxies

D'Asaro, Lee, Perry, Fennel et al.

North Atlantic Spring Bloom Experiment 2008

Deep optical spikes → sinking diatom aggregates



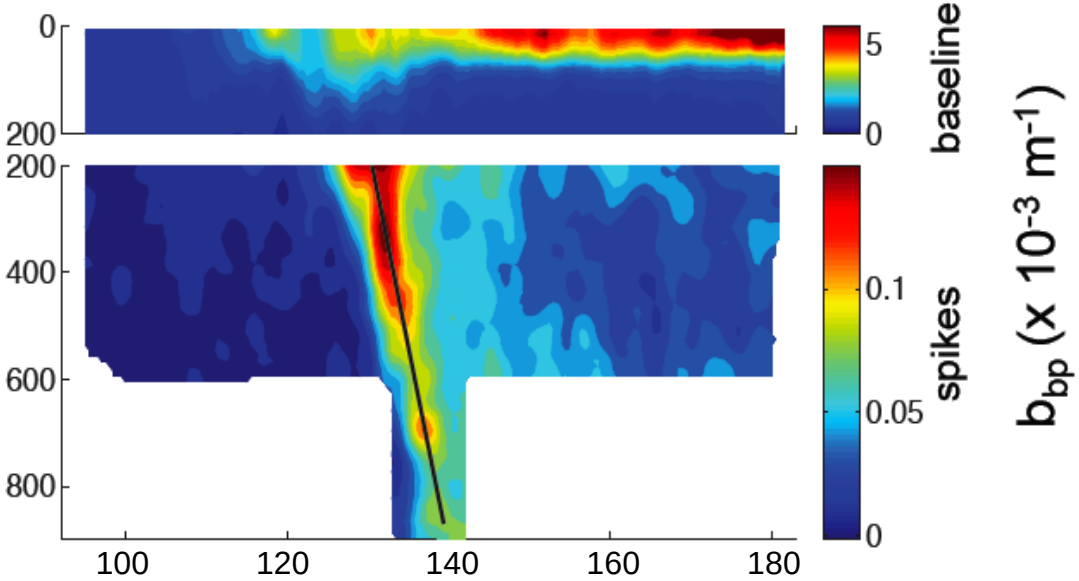
Carbon Flux Index

- Optical spikes

Separation of backscattering spikes from total signal; profile to 600 m

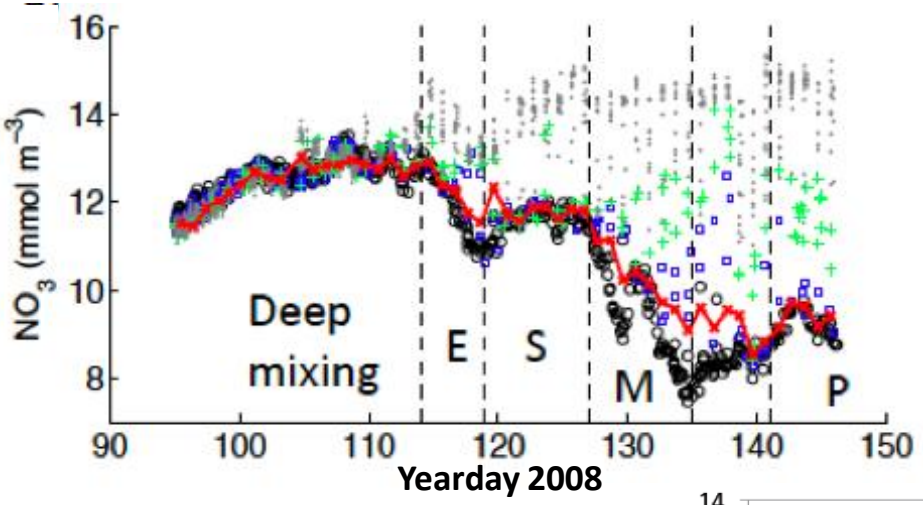
Optical spike data from gliders suggests sinking rate ~ 75 m d^{-1}

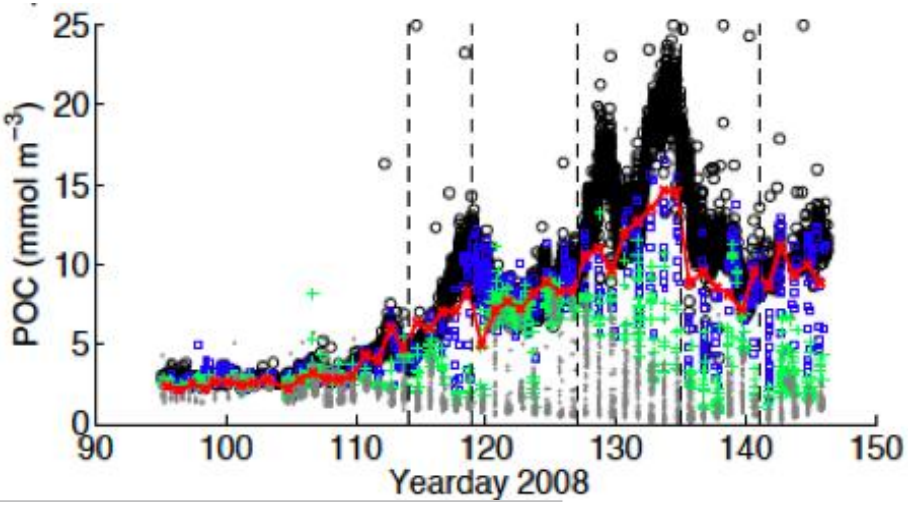
Briggs et al., 2011 DSR



North Atlantic Spring Bloom Experiment 2008

NO_3 drawdown, O_2 evolution, and POC production

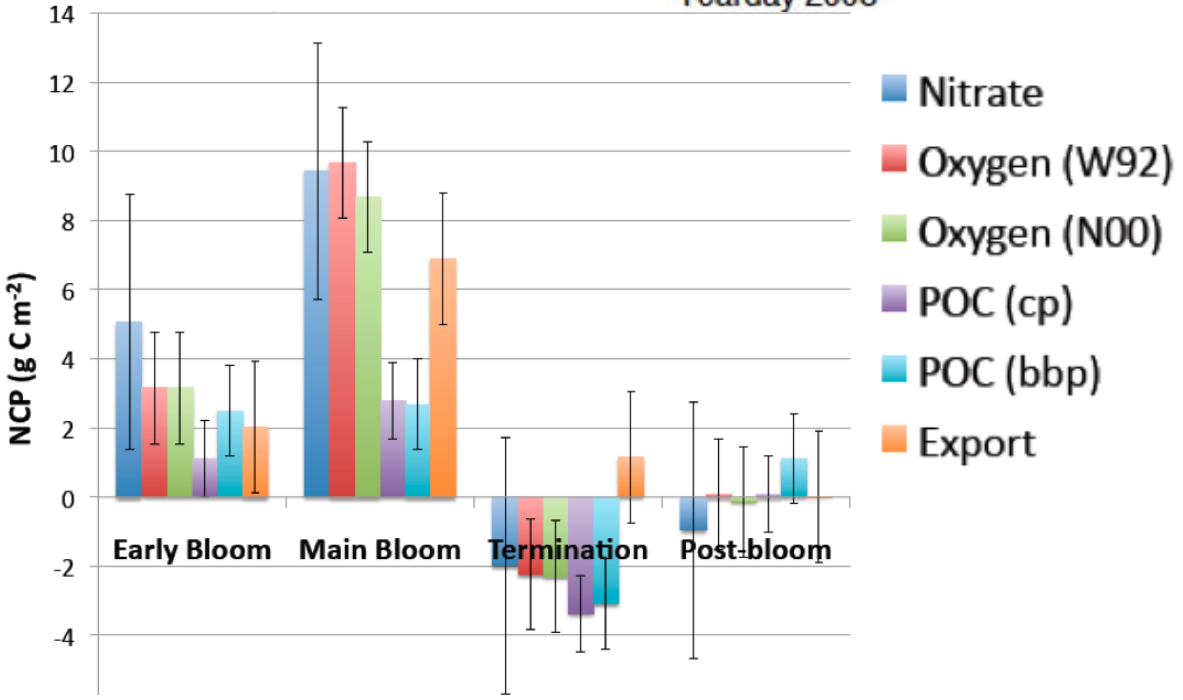




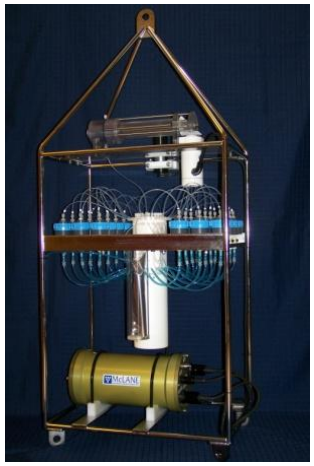
Net Community Production

- multiple methods

Alkire et al., 2012 DSR



Primary production - instruments



IPS

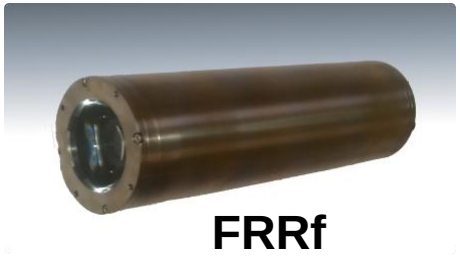
Incubating Productivity System

Taylor et al. 1993

PHORCYS

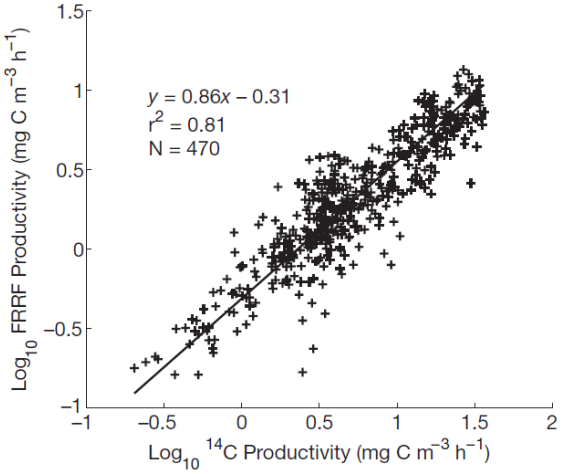
*PHO*tosynthesis,
*R*espiration, and
*C*arbon-balance
*Y*ielding *S*ystem

Collins et al. 2013



FRRf

Fast Repetition Rate fluorometry



Melrose et al. 2006

PAM

Pulse-Amplitude-Modulation fluorometry

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What is missing?

Is there a need for protocol development or revision?

What are the priority topics?