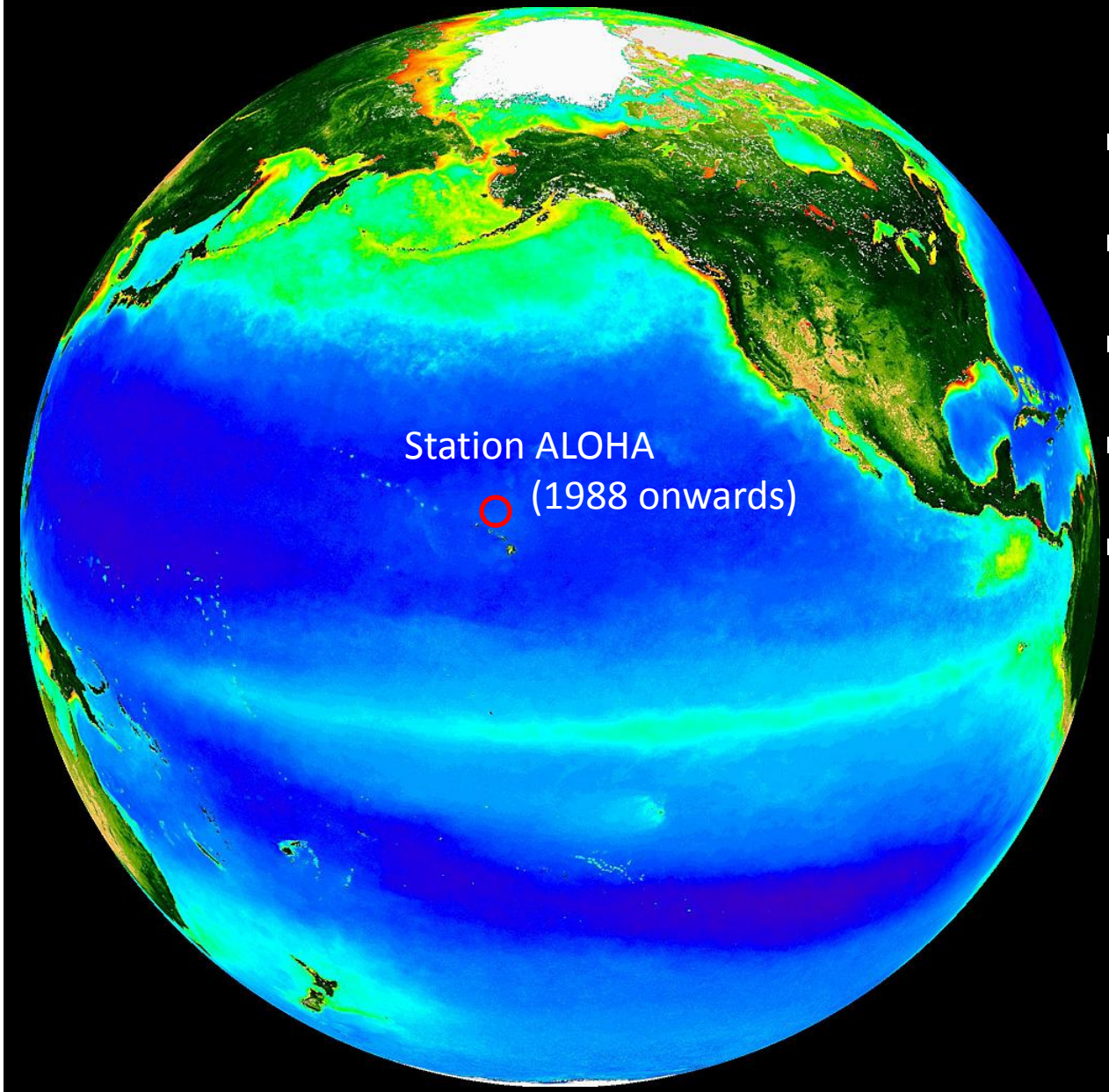
PHYTOPLANKTON BLOOMS IN THE NPSG

1. Introduction to the region
2. Types of blooms (enhanced biomass/growth… emphasis on the mixed layer)
3. Drivers of variability
4. Beyond biomass towards productivity

angelicque white, oregon state university

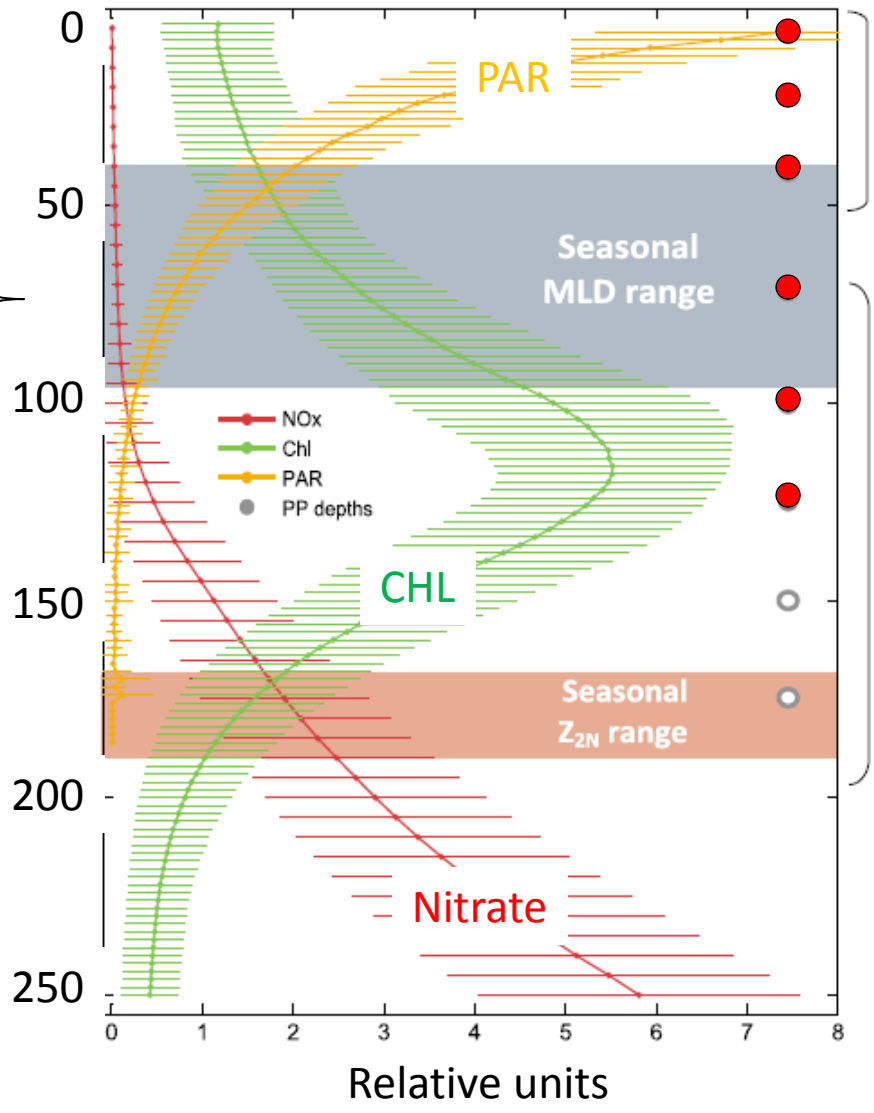
A sense of place



- 15-35°N, 135-145°W
- LNLC region
- ‘two layered system’
- < 50m mixed layer
- ~125 m euphotic zone/nutricline

Anatomy of the water column

45-100m seasonal mixed layer



Nutrient deplete surface (45-50m)

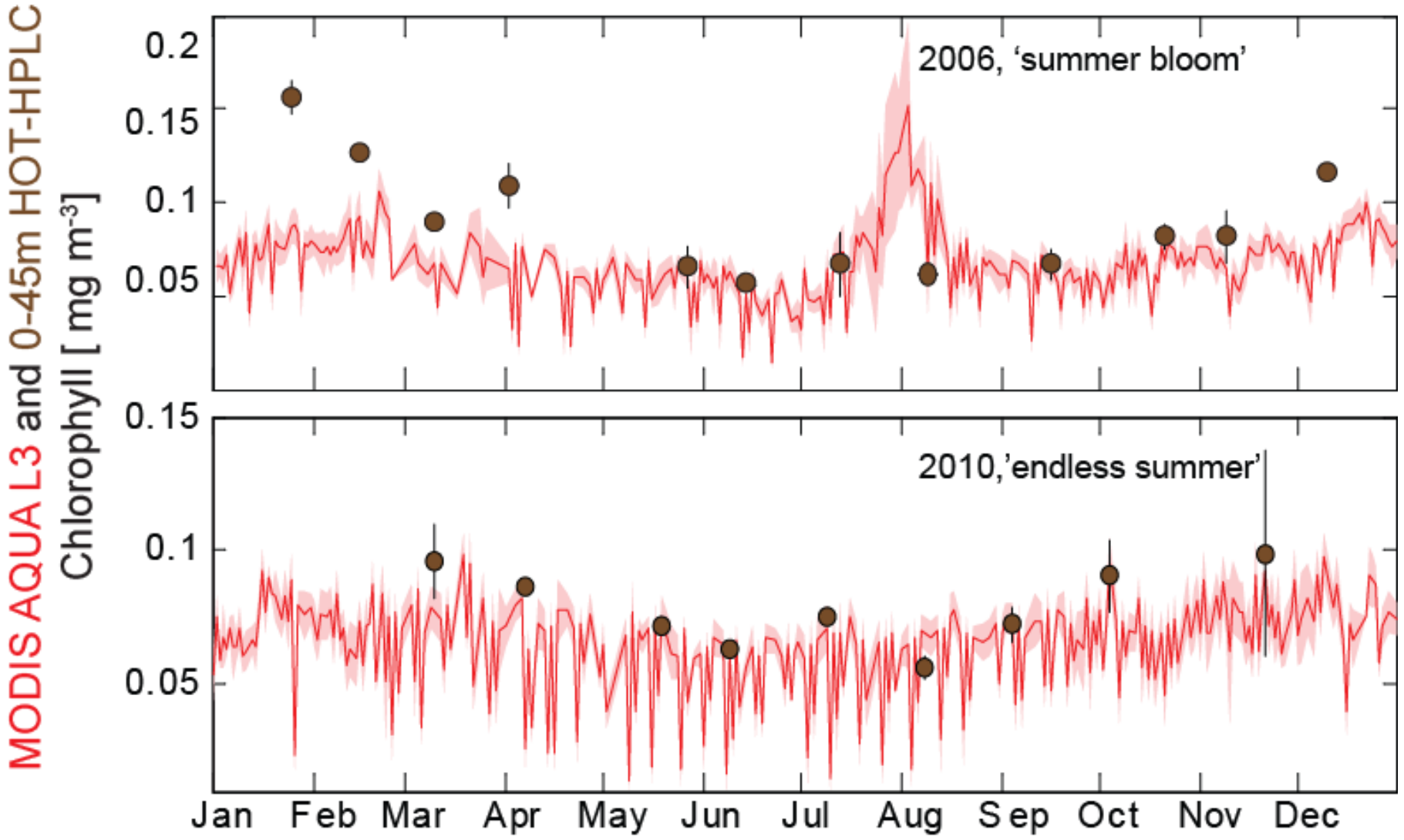
~125m chl max (not associated with particles)

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 115, C12032, doi:10.1029/2010JC006507, 2010

Apurva C. Dave[1] and M. Susan Lozier[1]

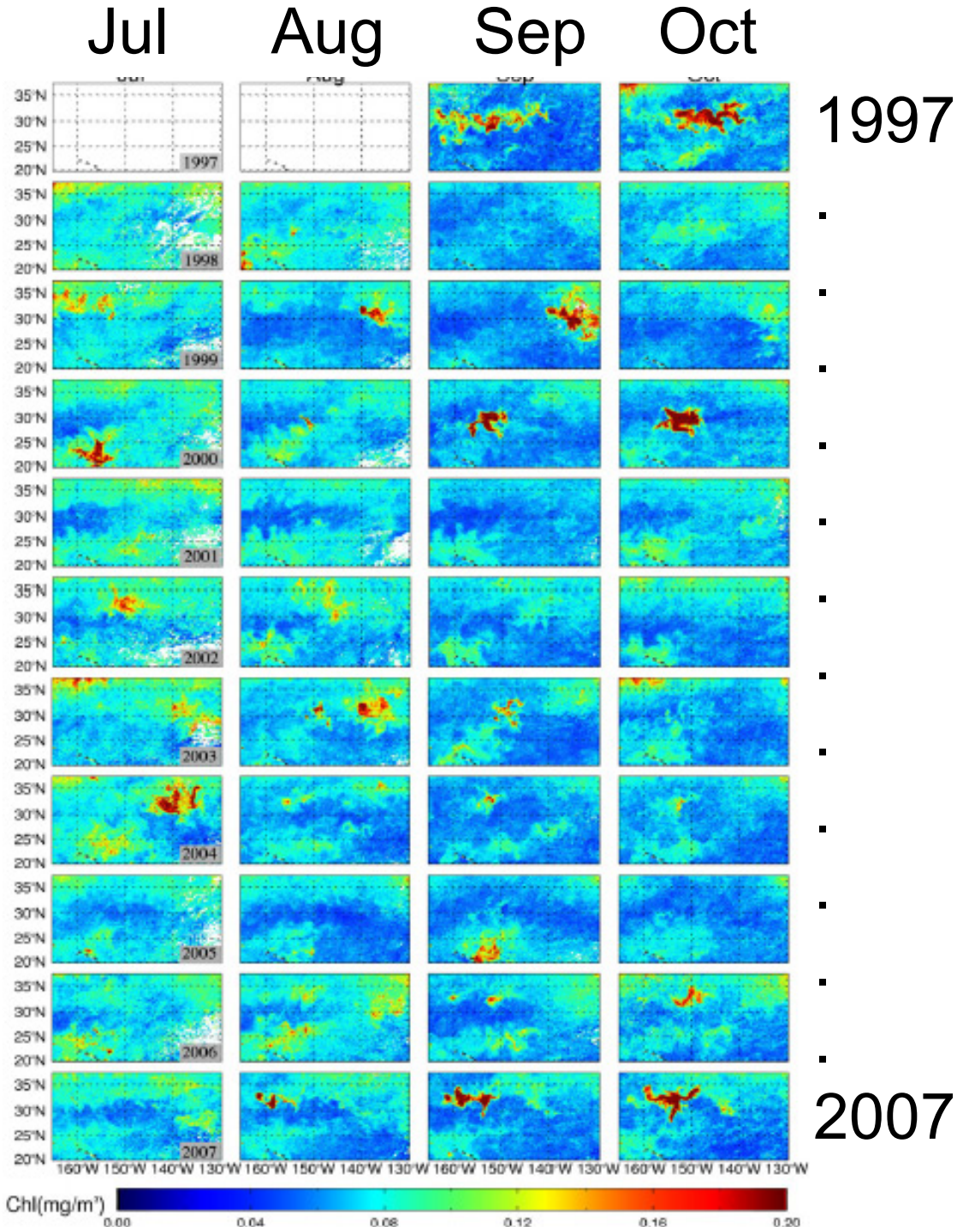
The NPSG “is very old, very large and relatively homogeneous, with minimal advective influence and low seasonality.…epipelagic populations are stable” ….. (Venrick 1974, 1990)

Station ALOHA CHL (MODIS & HPLC)



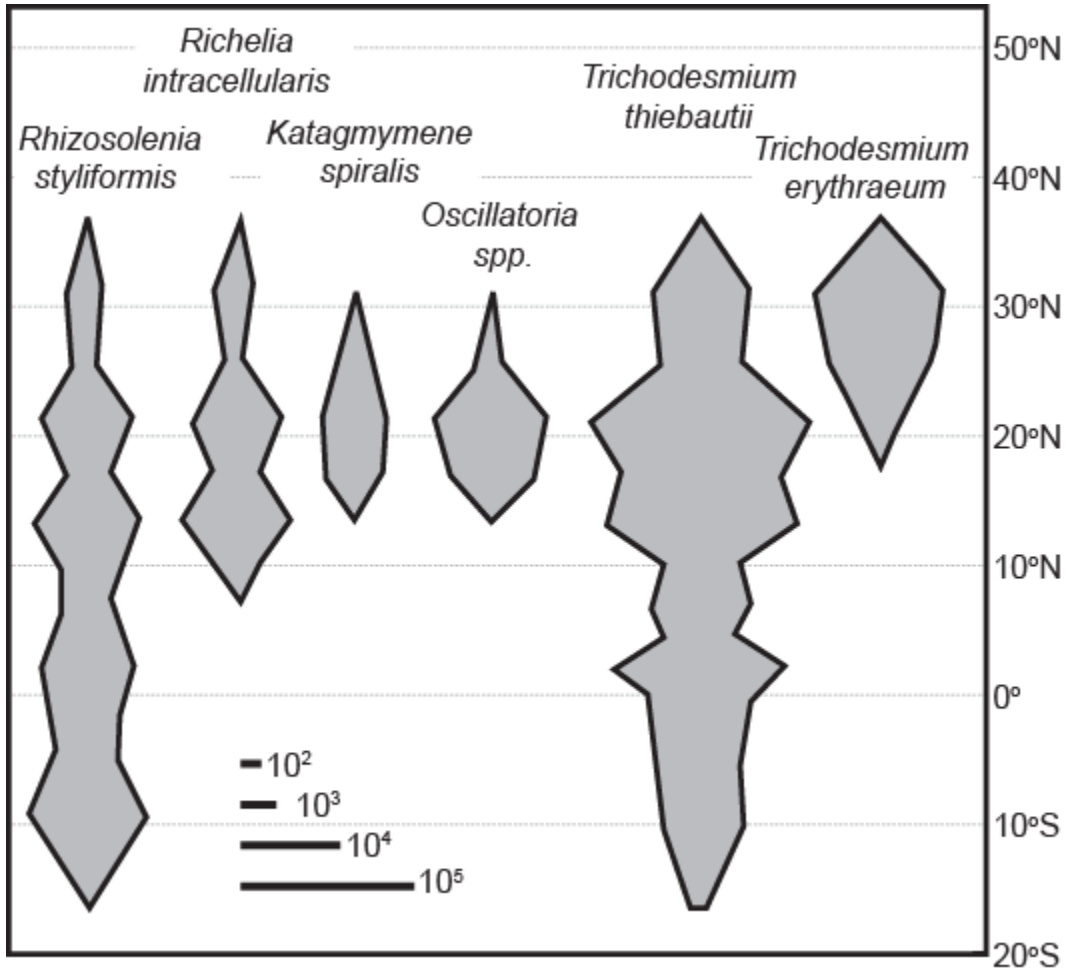
Wilson & Qui, 2008

- Bloom ~ Surface Chlorophyll > 0.15 mg m^{-3}
- Occurs 8/11 yr in summer
- 27-32°N, near the subtropical front
- N_2 fixers or echo blooms

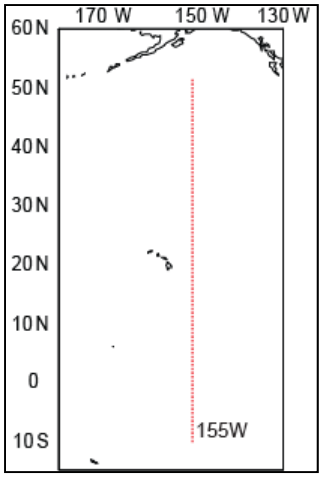


Why Blooms of N_2 Fixing Organisms?

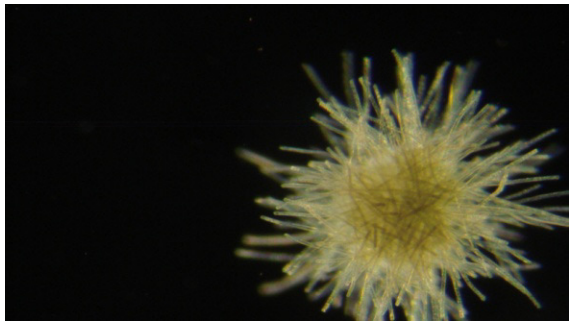
Marumo & Asaoka (1974) – 10°N Boundary

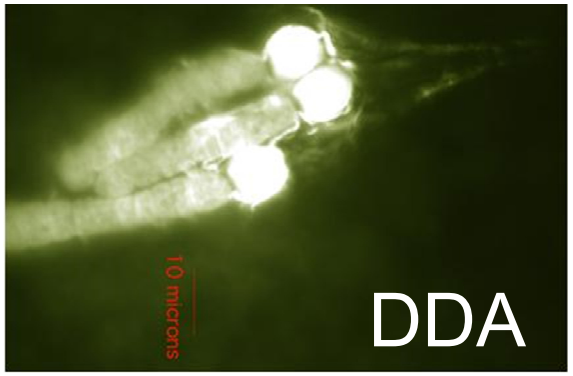


redrawn from Marumo & Asaoka (1974) Figure 2



Large, buoyant cells





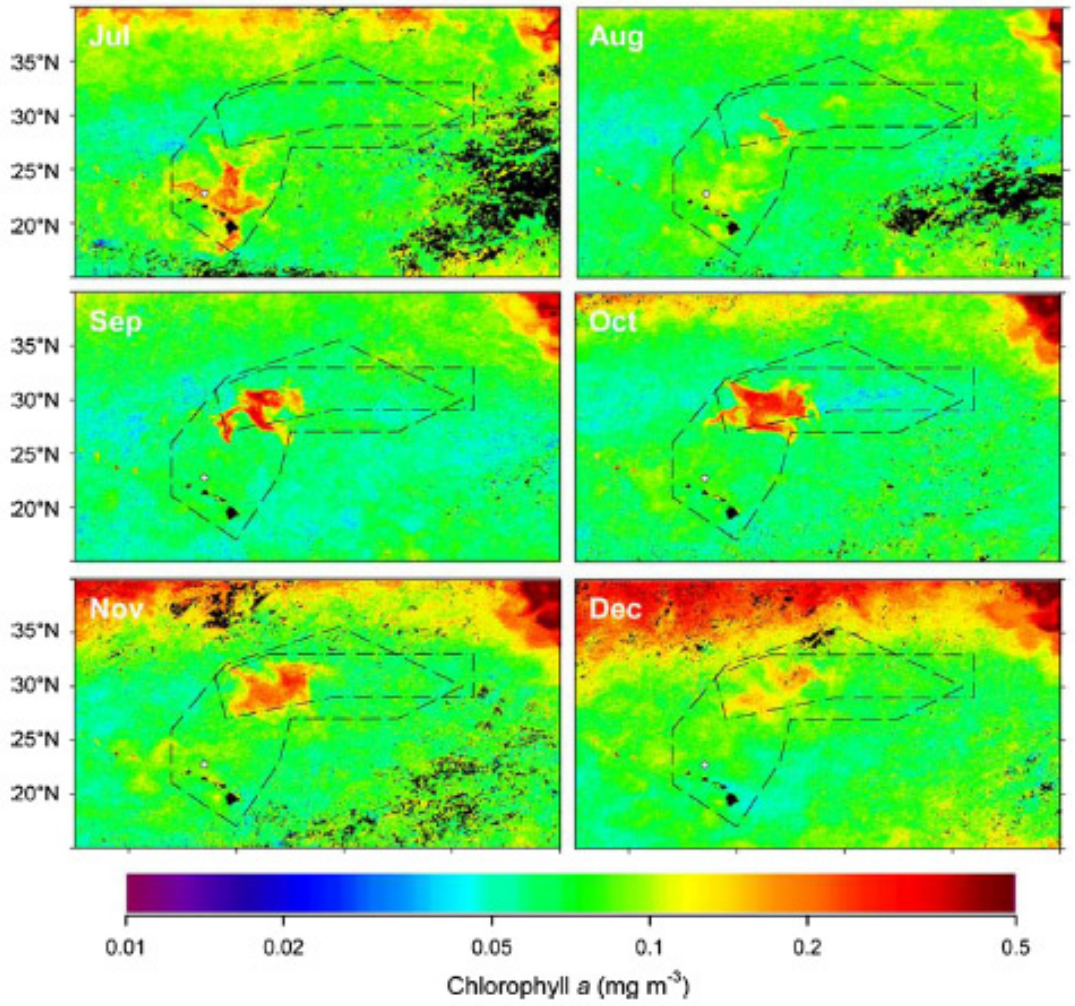
Summer phytoplankton blooms in the oligotrophic North Pacific Subtropical Gyre: Historical perspective and recent observations

John E. Dore [a,*], Ricardo M. Letelier [b], Matthew J. Church [a], Roger Lukas [a], David M. Karl [a]

2000

Bloom ~ rapid (days-weeks) increase in phytoplankton biomass (<60m)

What does HOT tell us?



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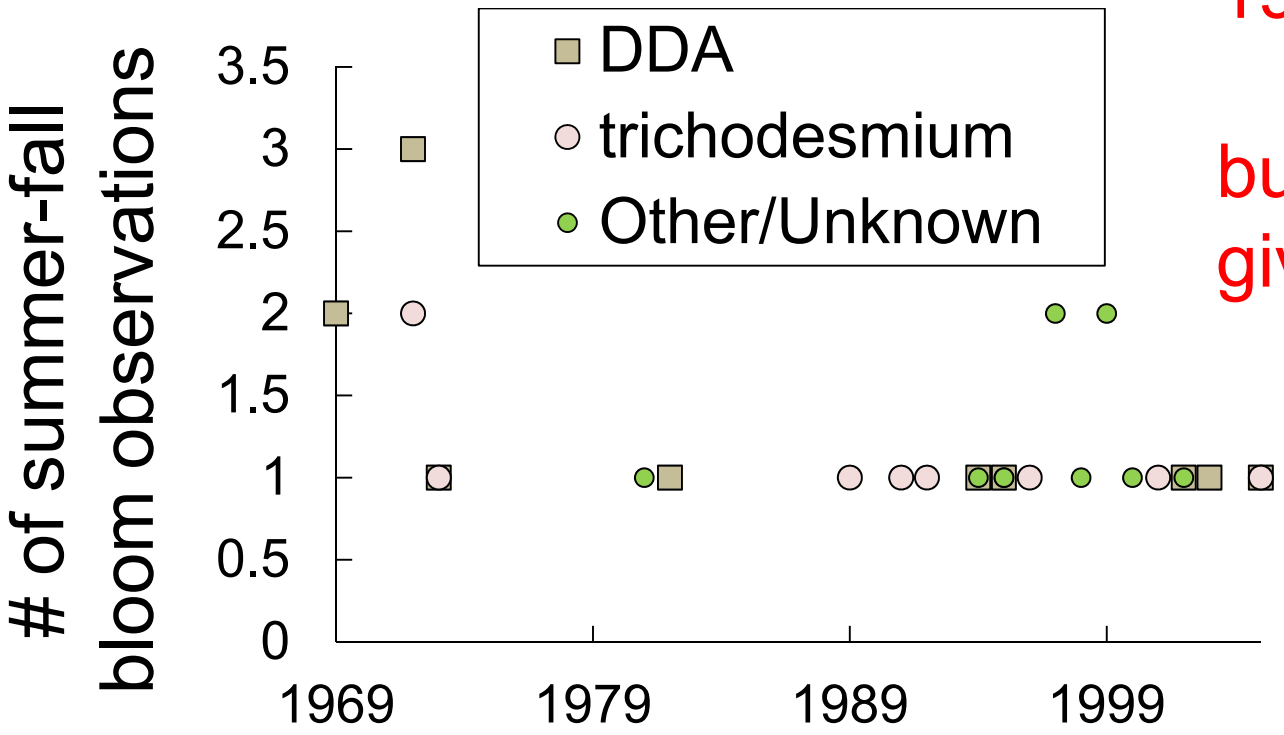
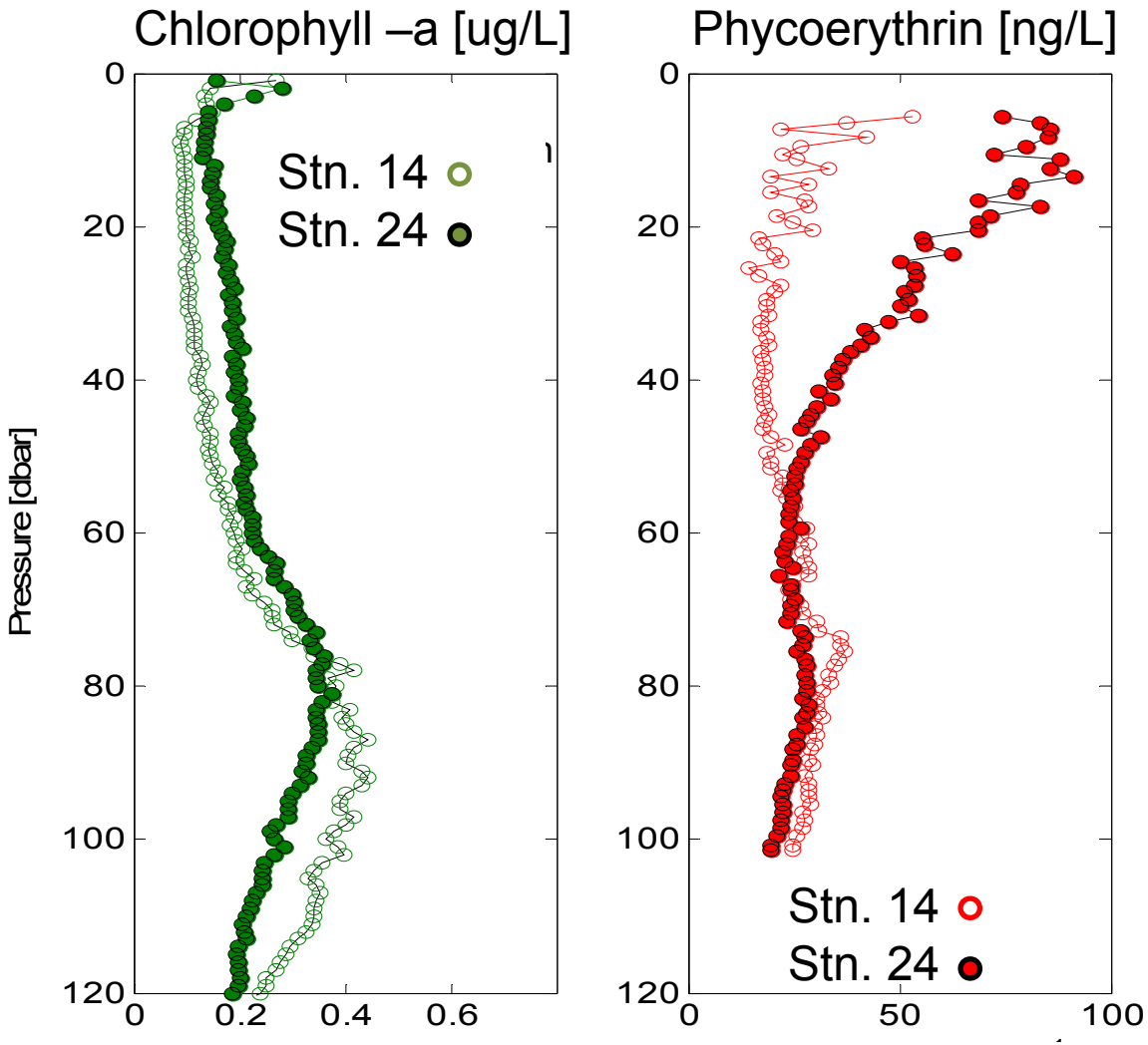


10 of 17 yrs from 1989-2005

but HOT just gives snapshots

N_2 Fixation in Summer – It's Trichy



Station 24

Ocean color (chl) and ship based observations of cells indicate ‘regular’ summer blooms linked to N_2 fixing organisms

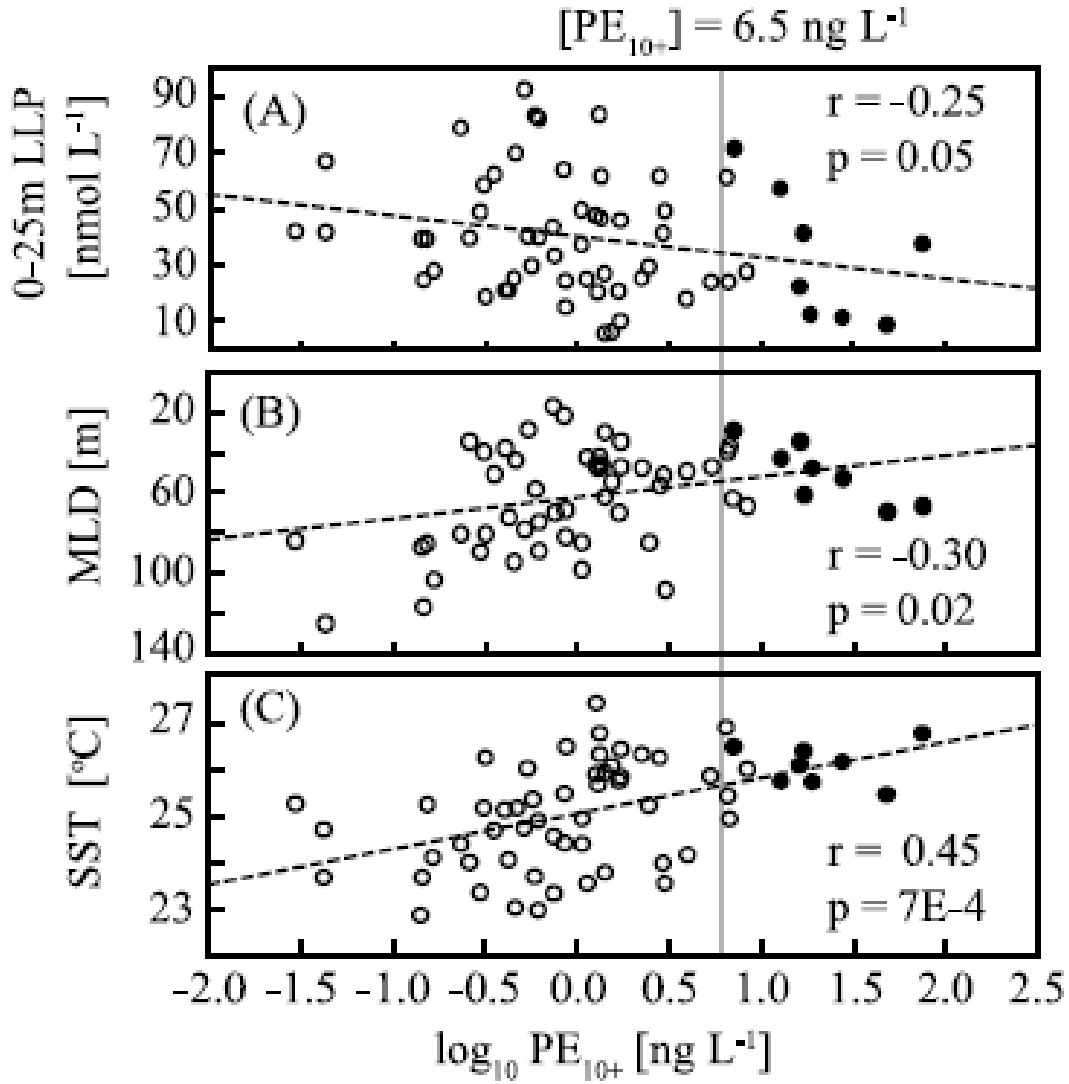
What causes them?

Shallow mixed layer depths lead to enhanced Phycoerythrin in the > 10 μm size class (proxy for *Trichodesmium)* - White et al. (2007)

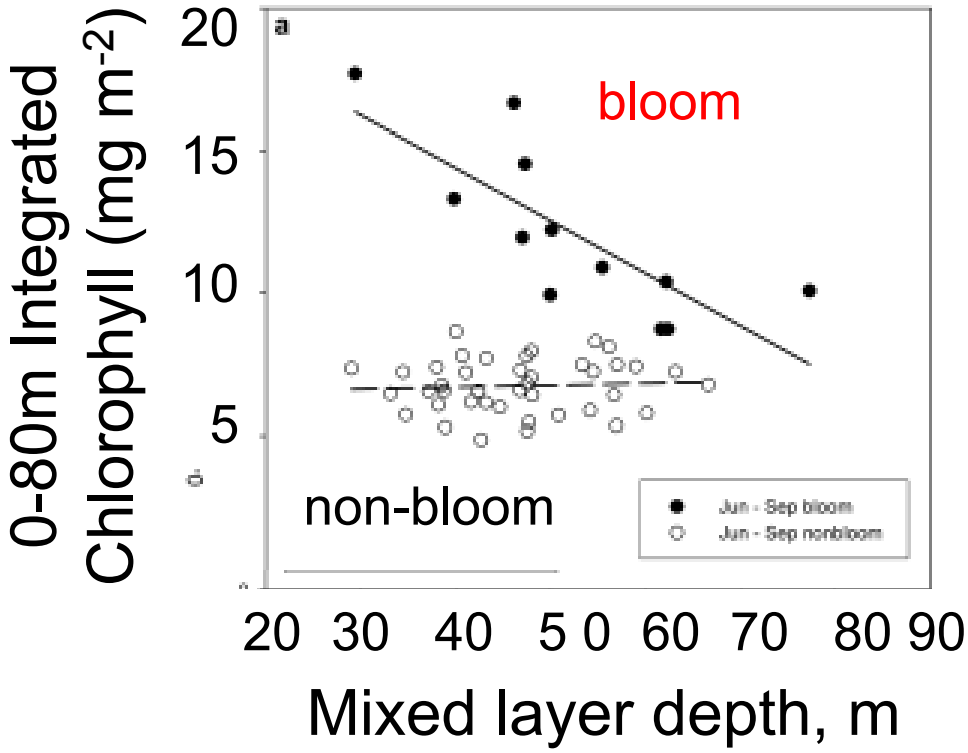
Phosphate

Mixed layer depth

SST



"N_2 Critical depth" (Energy for N_2 Fixation > Losses)…. a shallow mixed layer (= a high energy supply) is a necessary but not sufficient condition for bloom initiation" - Dore et al. (2008)

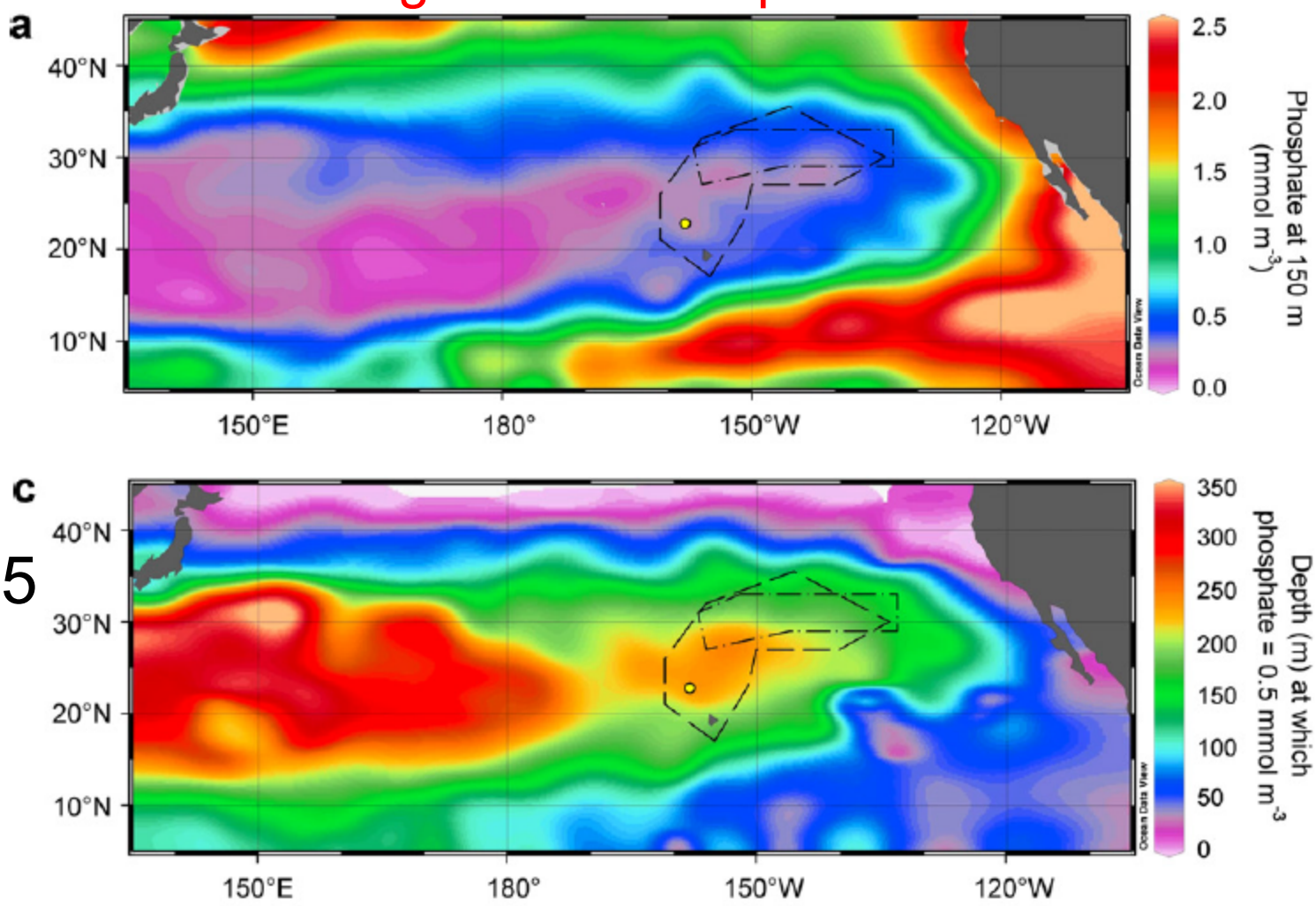


Basin Scale Variability

P(W-NPSG) < P (E-NPSG); deeper mixing would be required in W

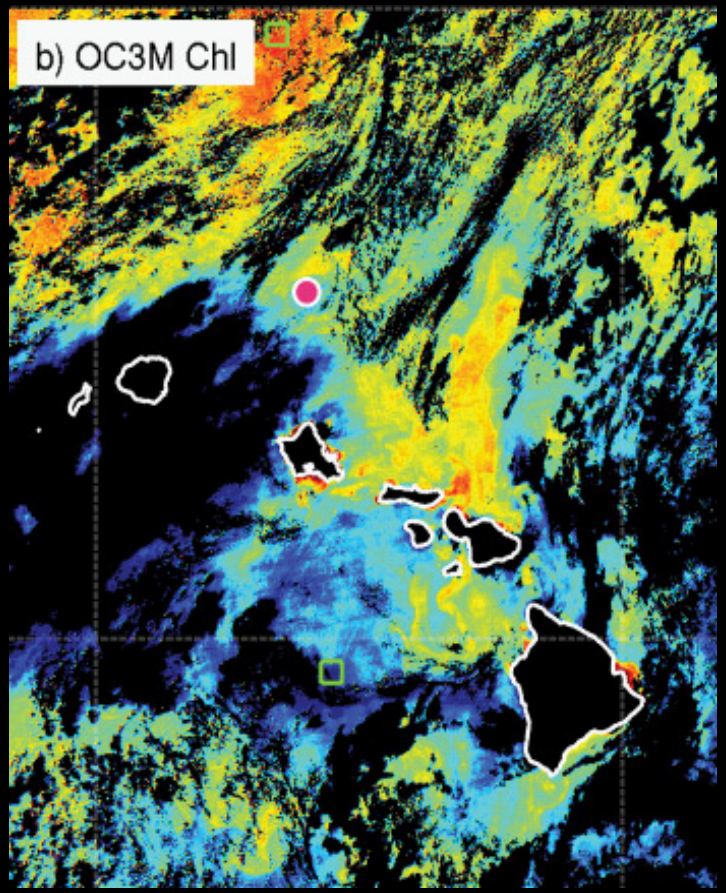
PO_4 at 150m

Z (PO_4 = 0.5 nmol L^{-1})



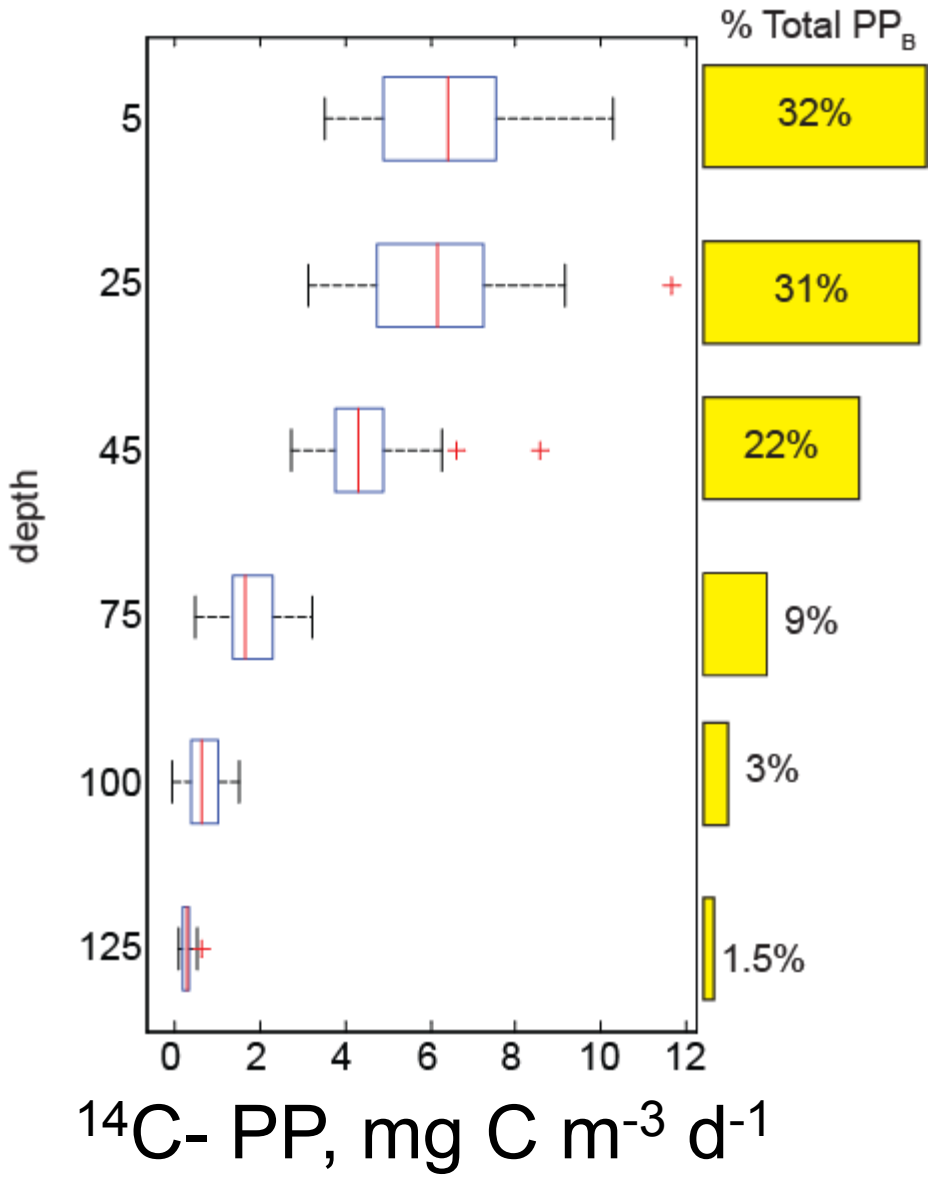
Ocean color (chl) and ship based observations of cells indicate ‘regular’ summer blooms linked to N_2 fixing organisms… driven by shallowing of the mixed layer (more energy) or availability of P pools ?

Do these ‘blooms’ enhance productivity?

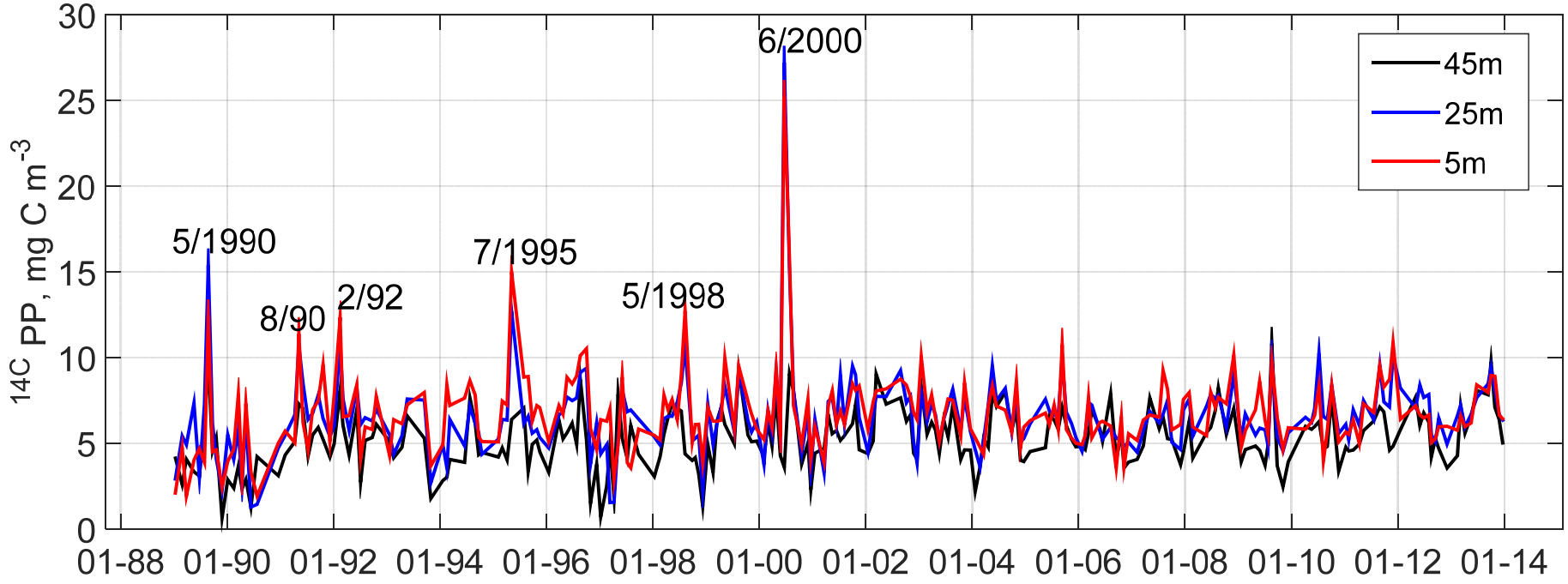


In situ Primary Productivity (^{14}C-PP)

- 1989-2012
- <3 fold variation at any depth
- 85% of ^{14}C-PP takes place in upper 45m

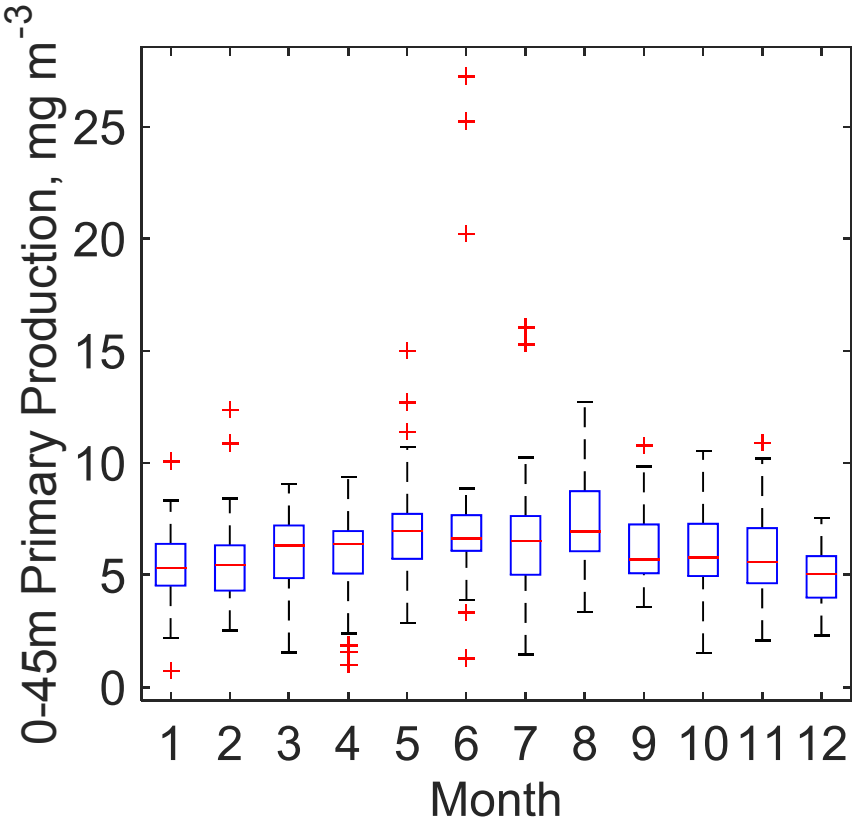


Summer ‘blooms’ are not as apparent in ^{14}C- productivity (1989-2013) and pulses > 10 mg m^{-3} end in 2000

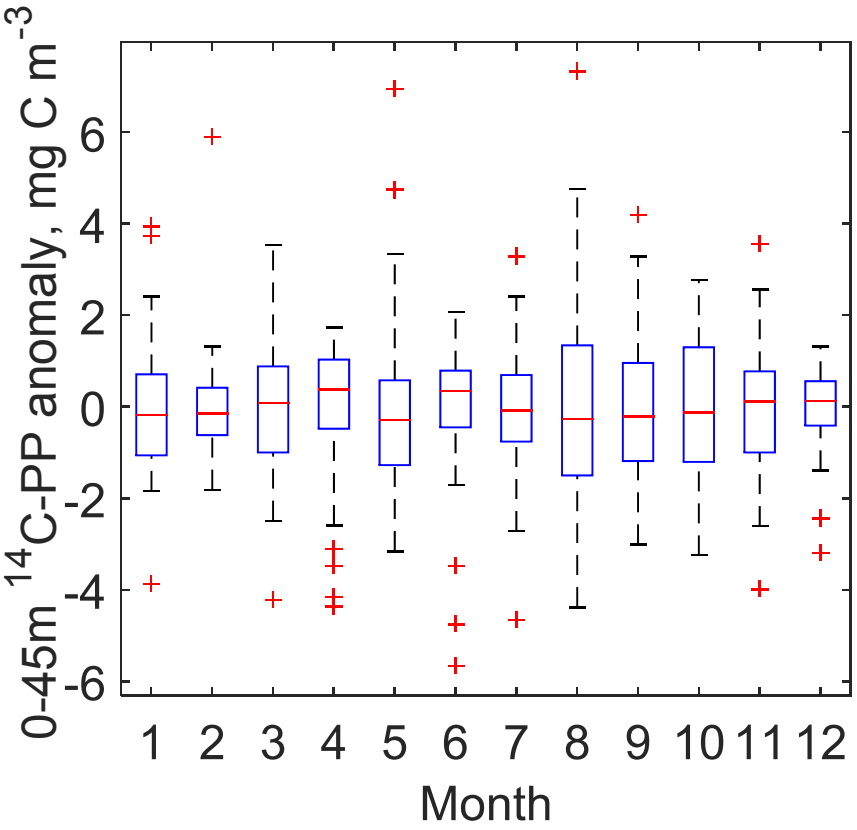


Summer ‘blooms’ are not as apparent in ^{14}C- productivity (1989-2013)… again HOT gives snapshots

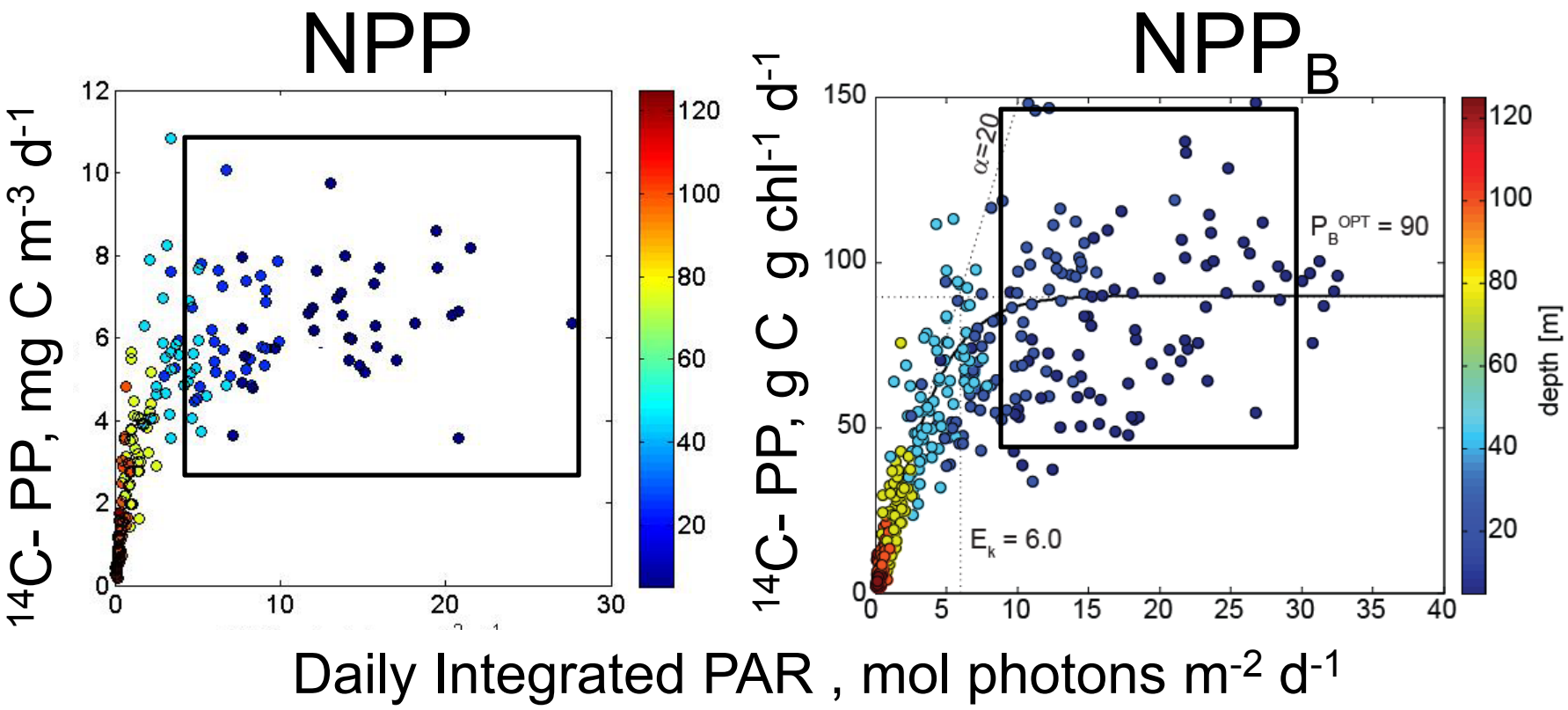
0-45m ^{14}C-PP



0-45m ^{14}C-PP anomaly

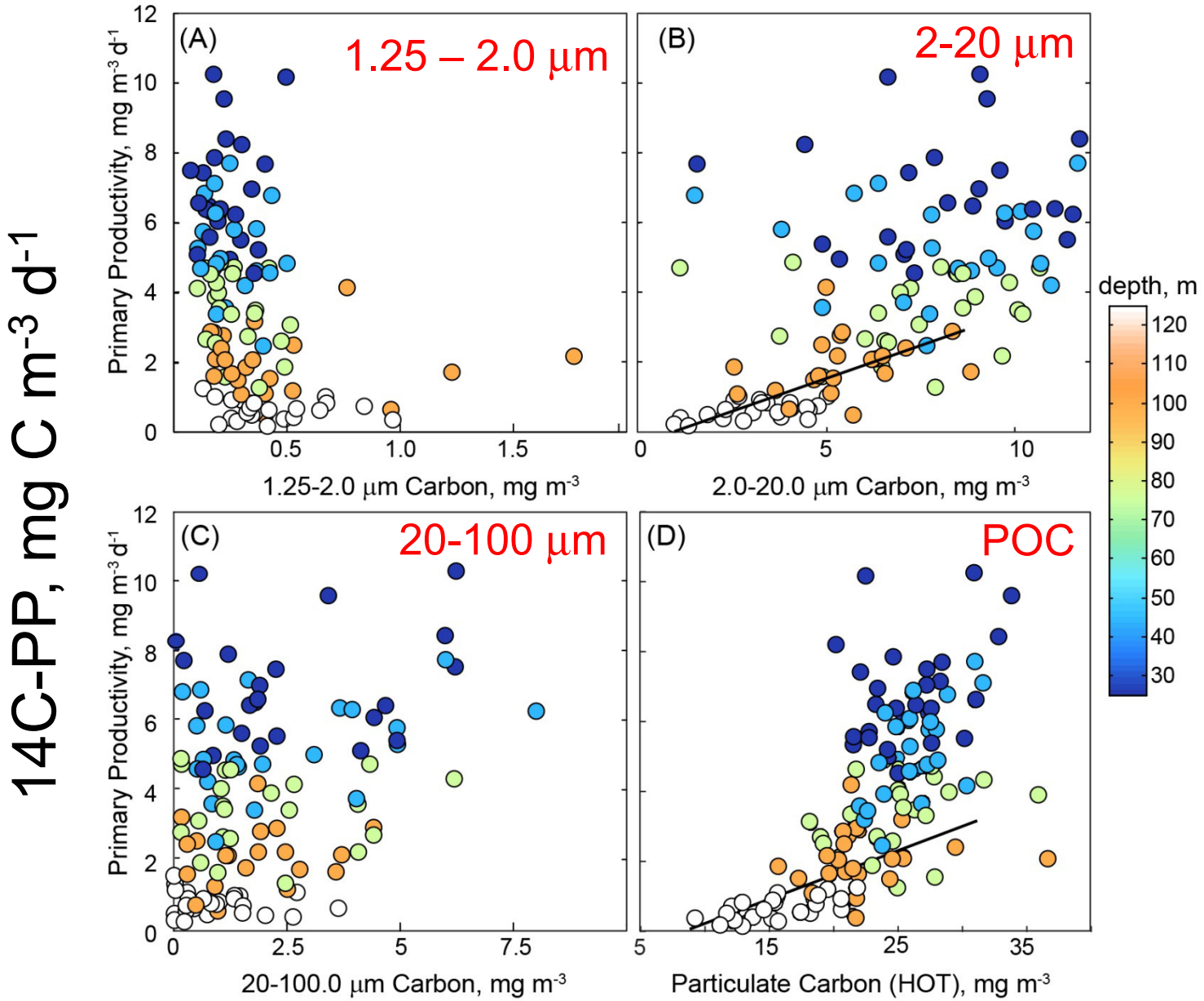


Primary Productivity: ALOHA Variability



The variability in the surface mixed layer PP appears largely light-independent and not constrained by shifts in total biomass (chl)

Primary Productivity: It's not about size



White et al. (2015)

Productivity trends at Station ALOHA

- Regular summer pulses in ^{14}C-PP are not as apparent in the HOT record as CHL_{sat} blooms
- Neither PAR, CHL, Carbon or carbon size classes appear to explain variability in ^{14}C-PP in the upper 45m
- Is this a sampling issue (limited scale)? Or are we looking at the wrong terms (e.g. NPP v. NCP?)

Predictable and efficient carbon sequestration in the North Pacific Ocean supported by symbiotic nitrogen fixation

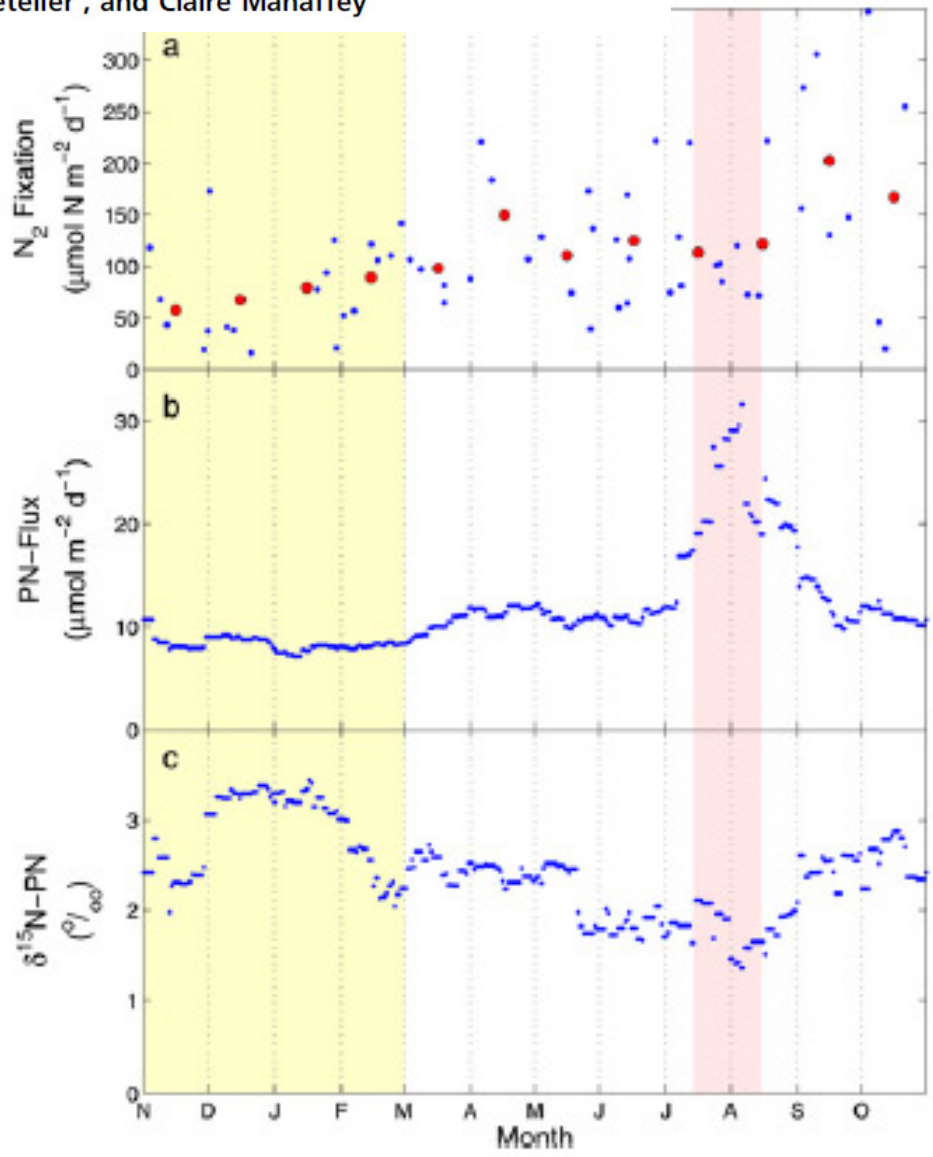
David M. Karl[a,1], Matthew J. Church[a], John E. Dore[b], Ricardo M. Letelier[c], and Claire Mahaffey[d]

J J A

N_2 Fixation (0-125m)

Particulate N Flux to 4000m (1992-2004)

δ^{15}N-PN at 4000m (1992-2004)



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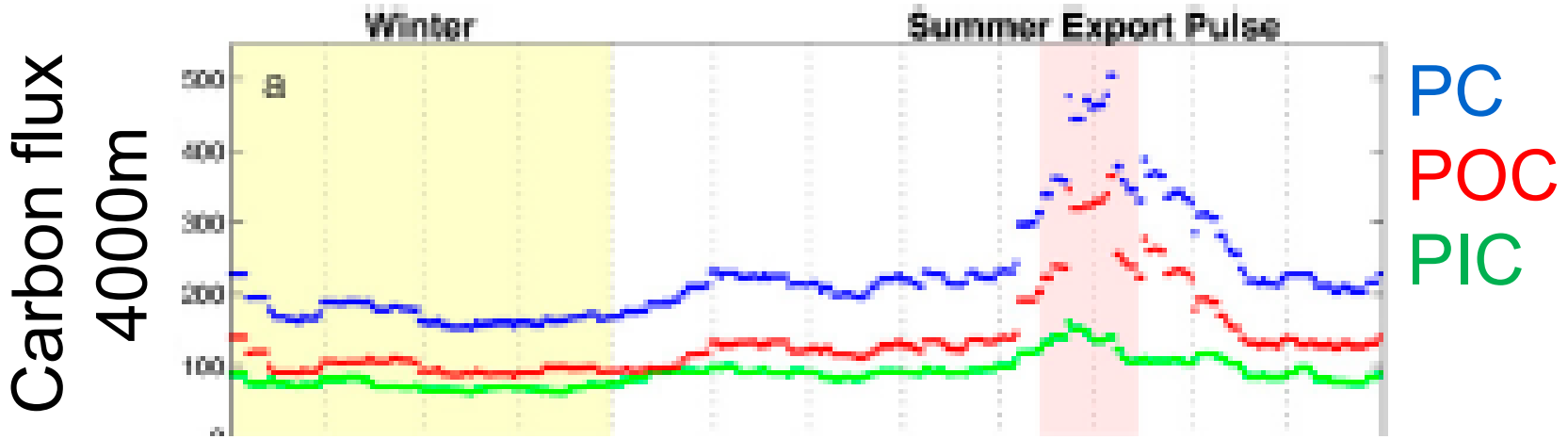


"We hypothesize that daylength may be a trigger for recurrent summer export pulses"… are we missing pulses of NCP in the surface?

Reconciliation of biomass and productivity

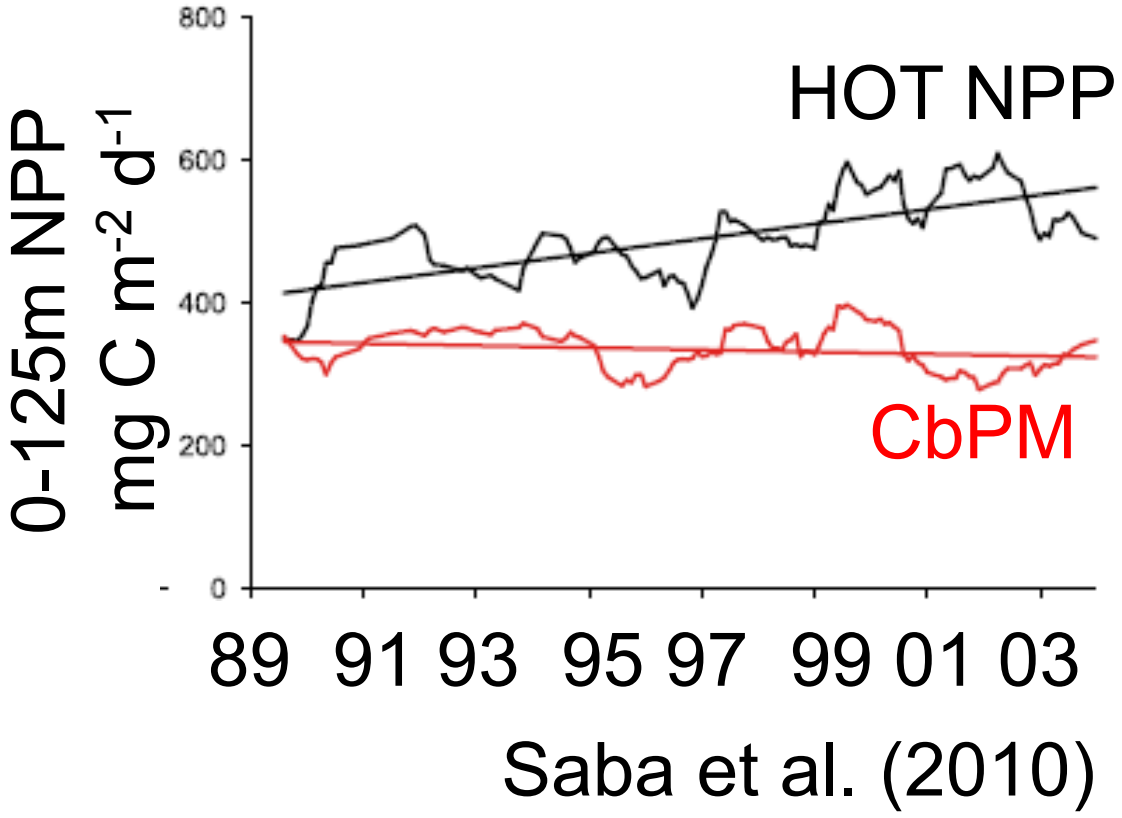
Small increase in biomass (of specific groups albeit not necessarily bulk pools) may lead to seasonal increase in net community production/export

Lack of detectable peaks in ^{14}C-PP… are we missing pulses of + NCP?

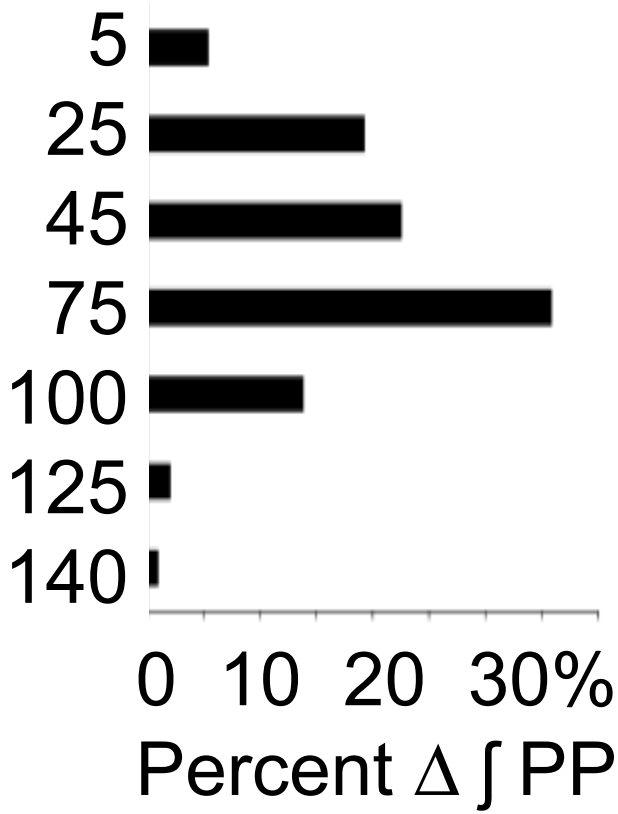
The temporal scales may require higher resolution monitoring… NCP is a razors edge value at HOT

A GRAND CHALLENGE

How do we detect high resolution change in NPP/NCP?

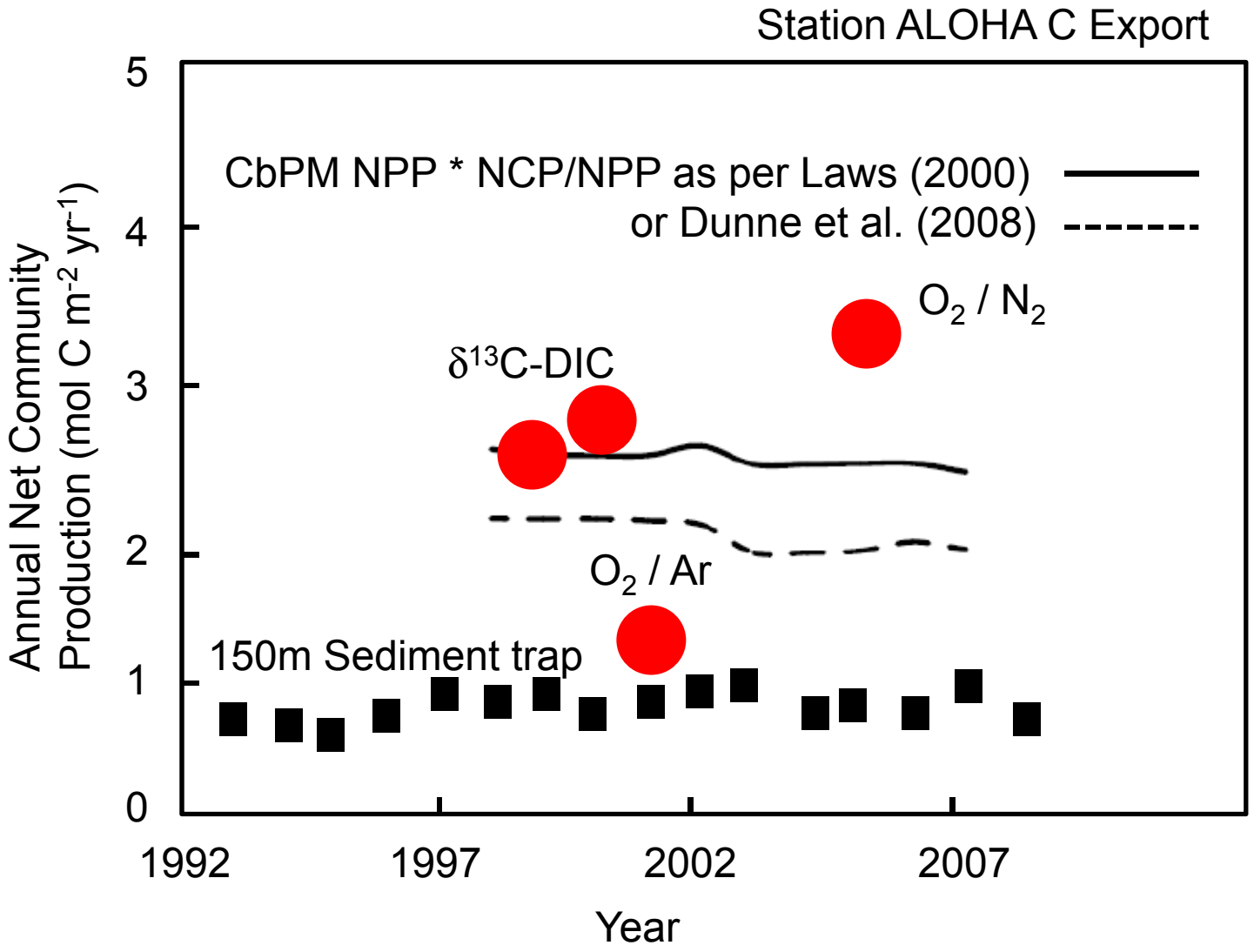


Saba et al. (2010)



1989-2007, Increasing integrated NPP linked to deepening MLD and PDO/ENSO (Corno et al. 2007, Saba et al. 2010).
Satellite models miss mean/trend/variability

A GRAND CHALLENGE



From Emerson (2014)

A GRAND CHALLENGE

- Carbon based satellite models miss the variability of NPP at HOT

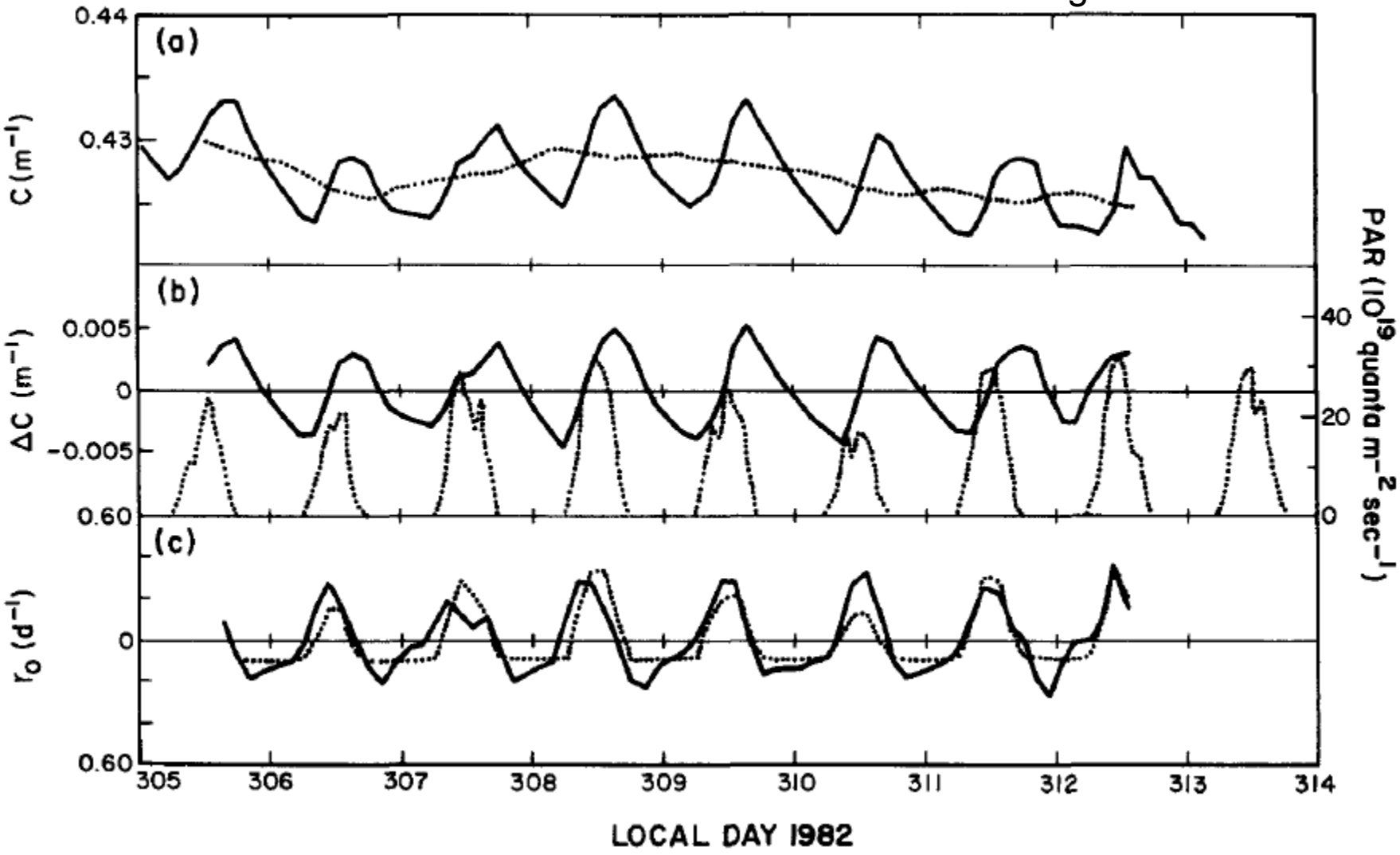
- Annual NCP determined from mass balances at HOT is 3-4 times POC fluxes measured in sediment traps. NCP:NPP relationships are not well constrained.

- **This uncertainty obscures our understanding of the drivers of ocean productivity (divergence from mean conditions)**

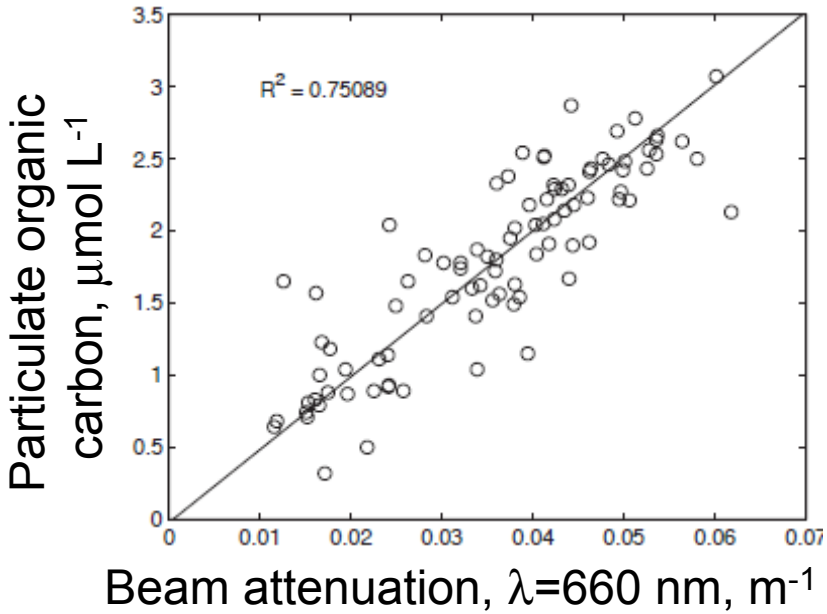
- **High resolution/ accurate in situ measurements** are necessary for estimation of NPP/NCP to match rates to forcing.

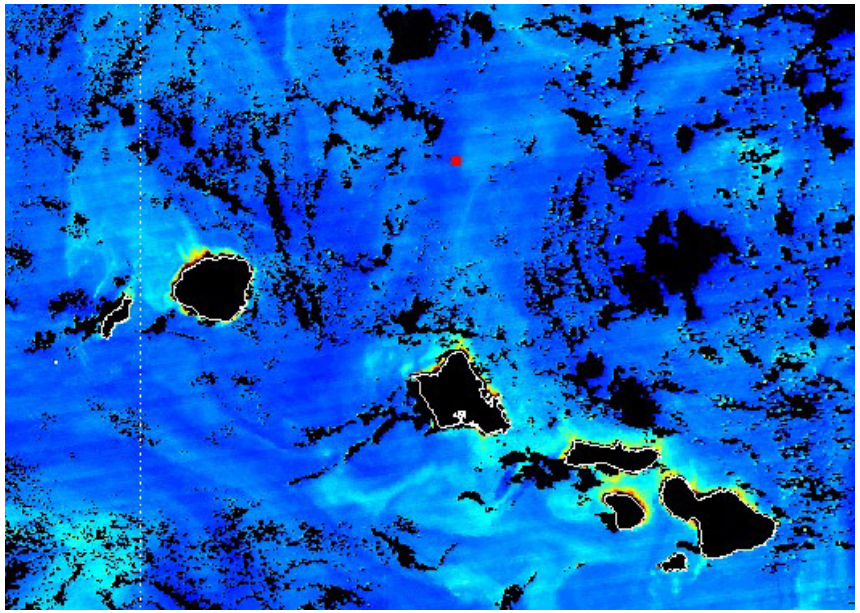
we can use optics to ‘see’ the daily rise and fall of carbon

Siegel et al. 1989



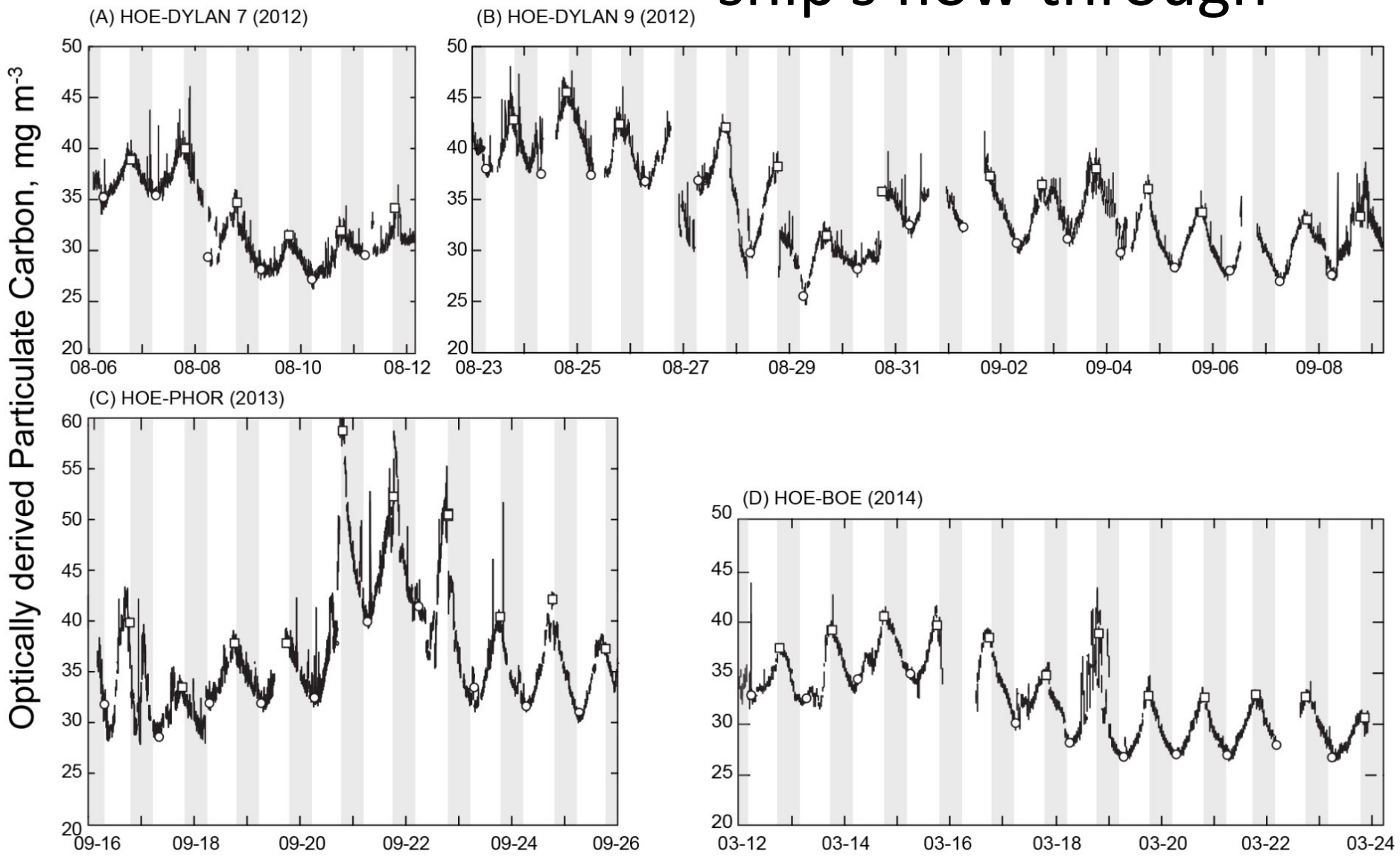
…calibrate beam attenuation at 660 nm to particulate organic carbon



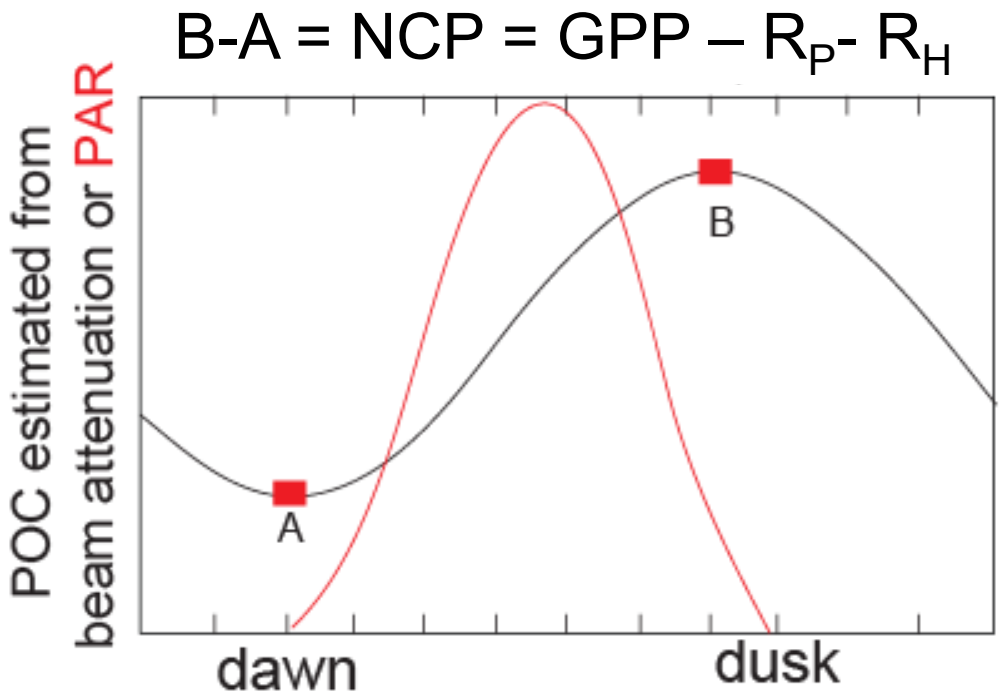


Station ALOHA

… the amplitude of daily change in POC via ship's flow through



… and then the amplitude of daily change in POC ≈ NCP_D …. oscillates +/-



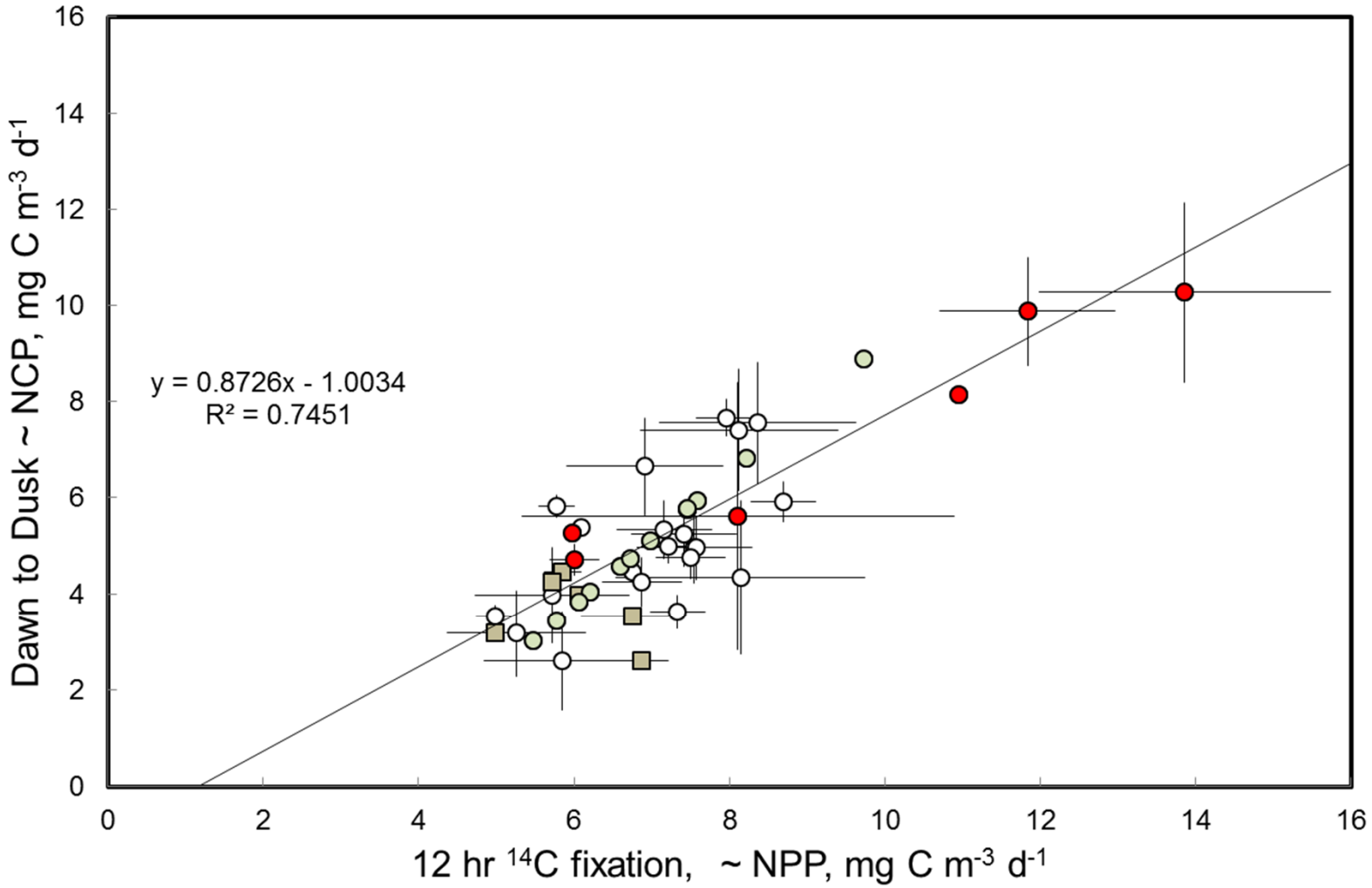
GPP = Gross primary productivity

- Autotrophic respiration (R_P)
- Heterotrophic respiration (R_H)

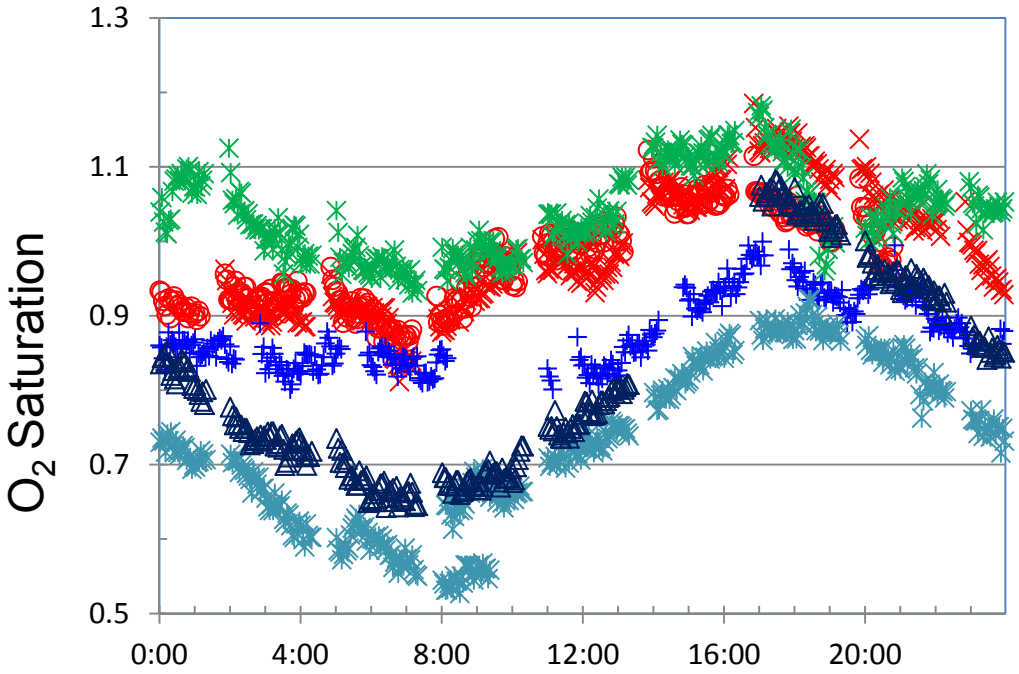
= NCP ,net community production

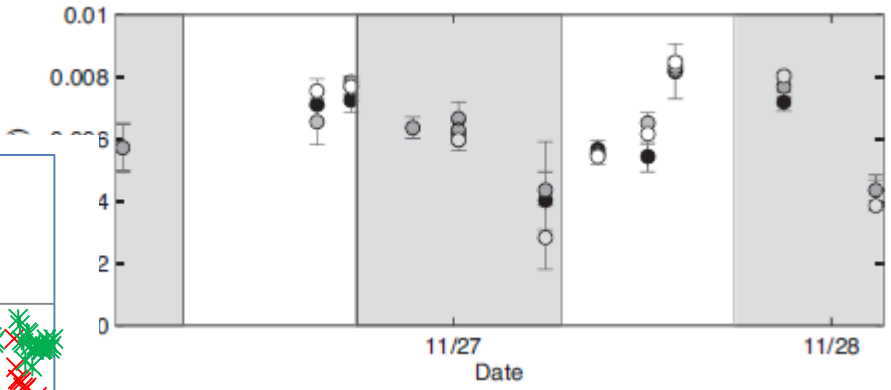
Caveats are advection and no robust cross-comparisons to NPP, NCP (O_2), GPP (O_2)

… the amplitude of daily change in POC closely tracks ^{14}C-NPP



… comparisons can now also be made to in situ estimates of *NCP, GOP* from diel cycling of O_2/Ar



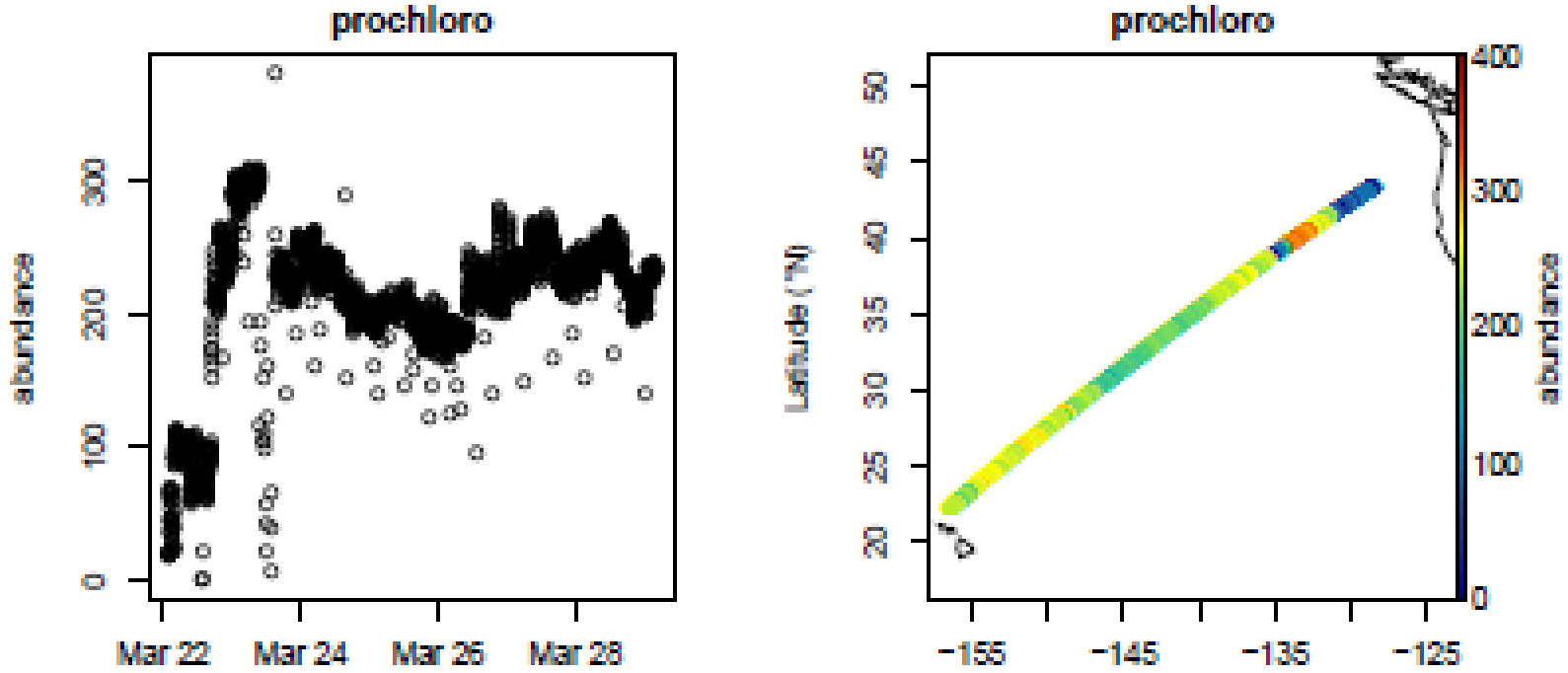


data from P. Quay

Ferron, Nicholson, Quay et al. (gliders and boats)

… comparisons can now also be made to cell specific growth (SeaFLow, Armbrust)

http://uwescience.github.io/seaflow-viz/

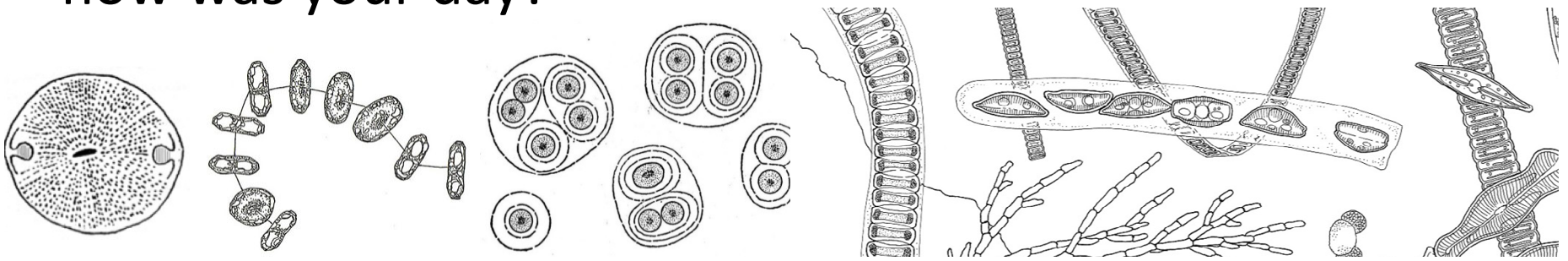


Light-driven synchrony of *Prochlorococcus* cell growth and mortality in the subtropical Pacific gyre PNAS, in press

VISION

calibrated eulerian/lagrangian optical approaches may allow for a robust and necessary comparison of in situ metrics of ocean productivity (C, O_2, cells) at higher spatial/temporal scales than previously achievable – paired to satellite imagery/HOT productivity

This will open doors to understanding microbial lives at the scale of their generation time. Essentially asking – how was your day?



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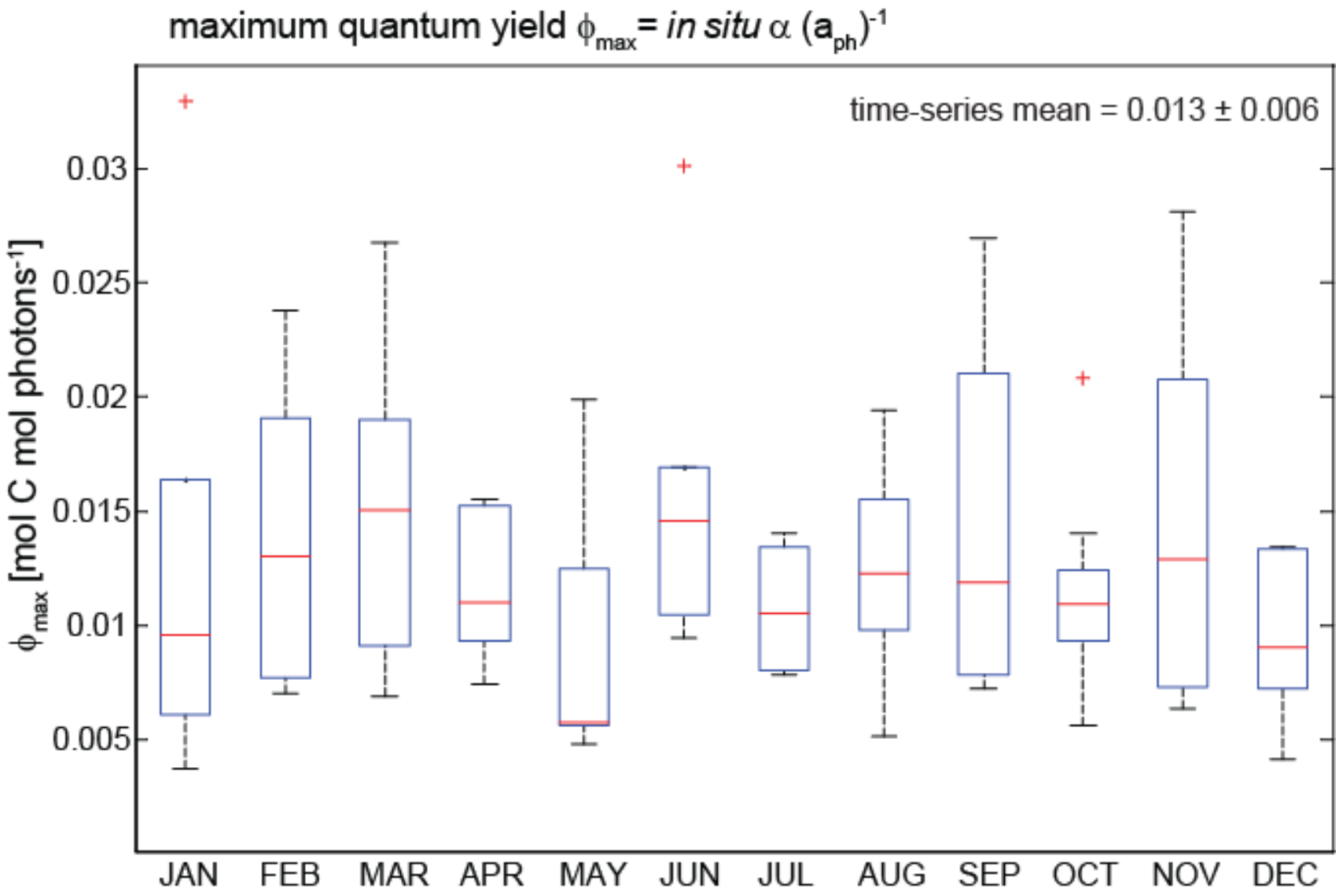
Collaborations: OSU, U. Hawaii

CEOAS
College of Earth, Ocean, and Atmospheric Sciences

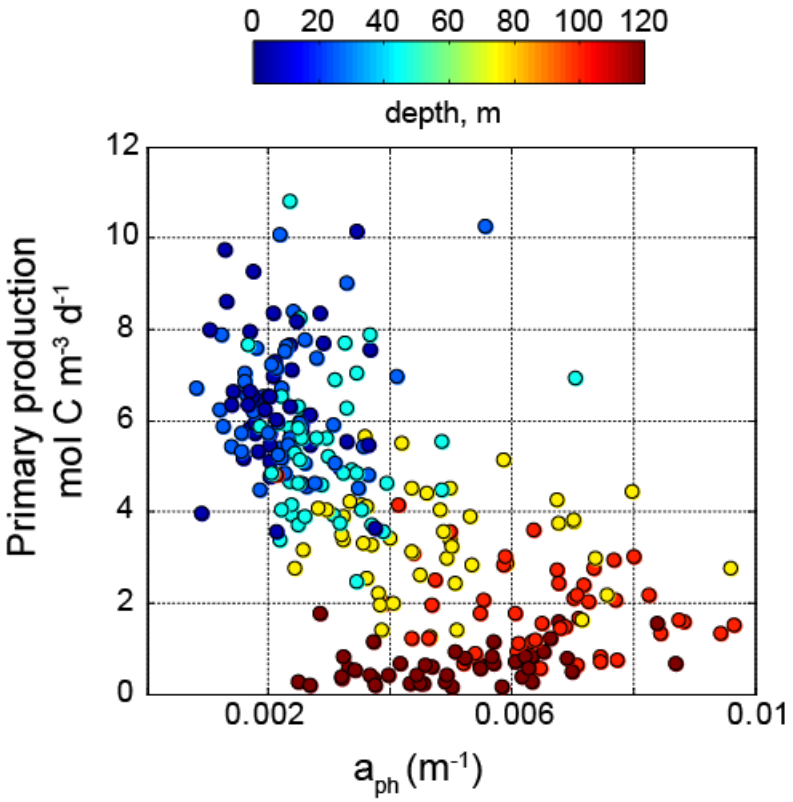
soest
SCHOOL OF OCEAN AND EARTH SCIENCE AND TECHNOLOGY
UNIVERSITY OF HAWAI'I AT MĀNOA

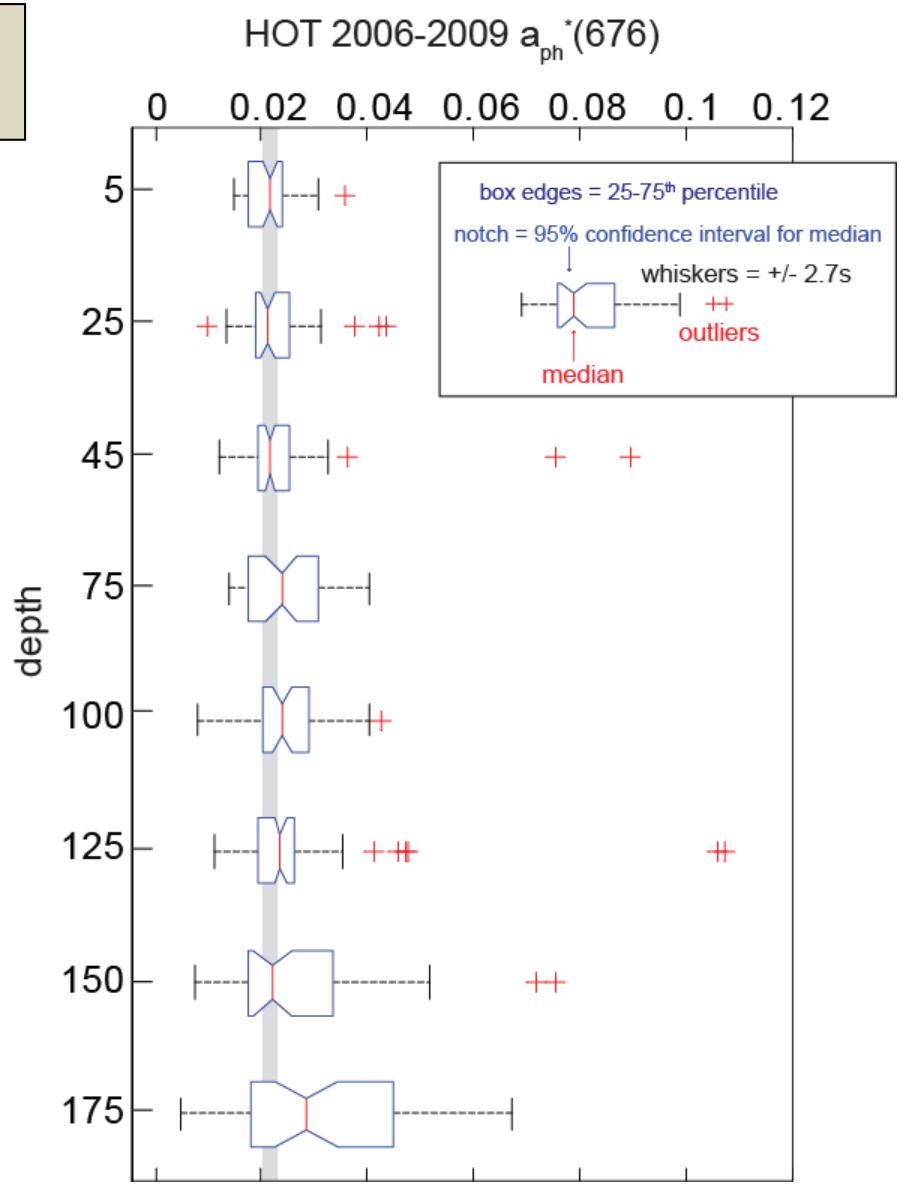
Photophysiology (ϕ_{max} 1998-2008)



Photophysiology (absorption)

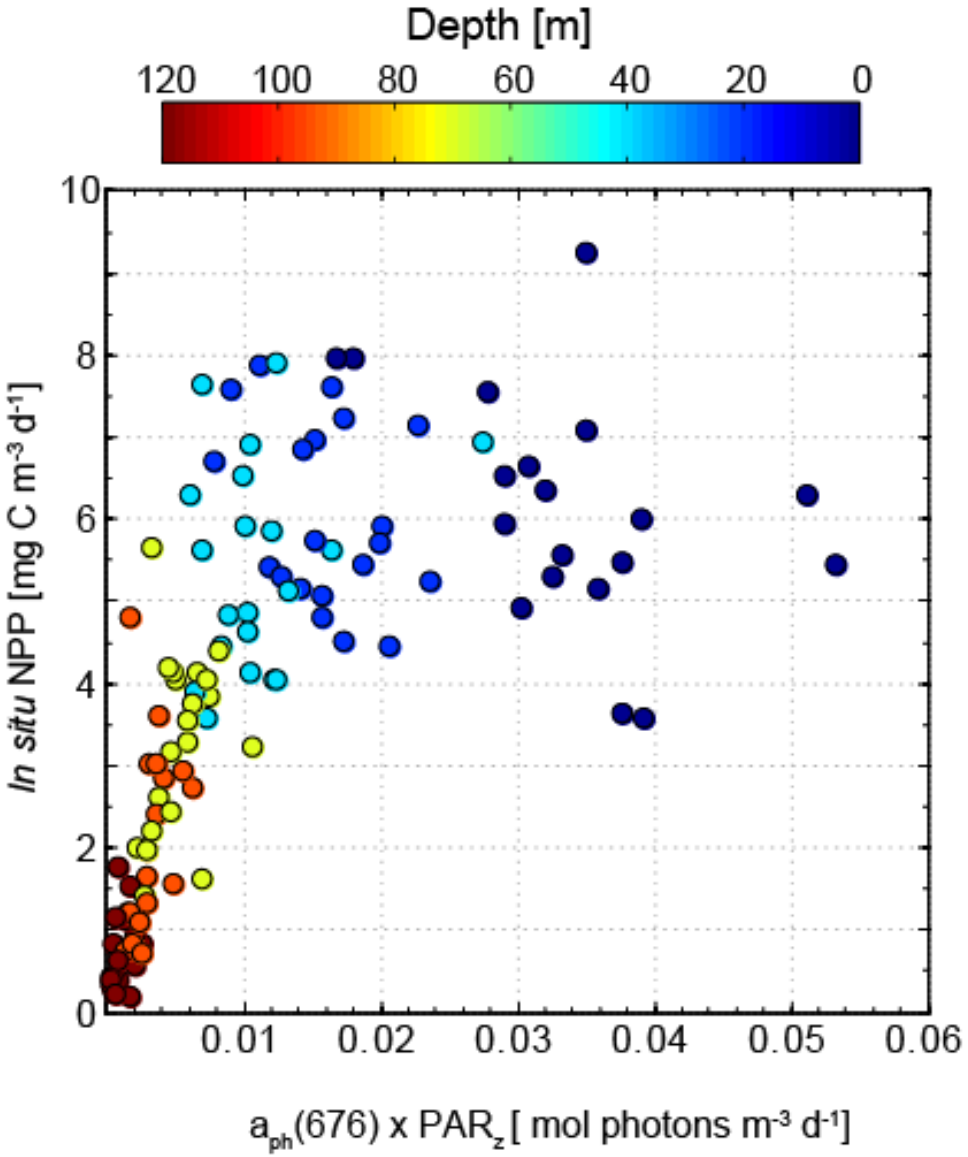
a_{ph} inversely correlated with PP over the water column, *as is chl*

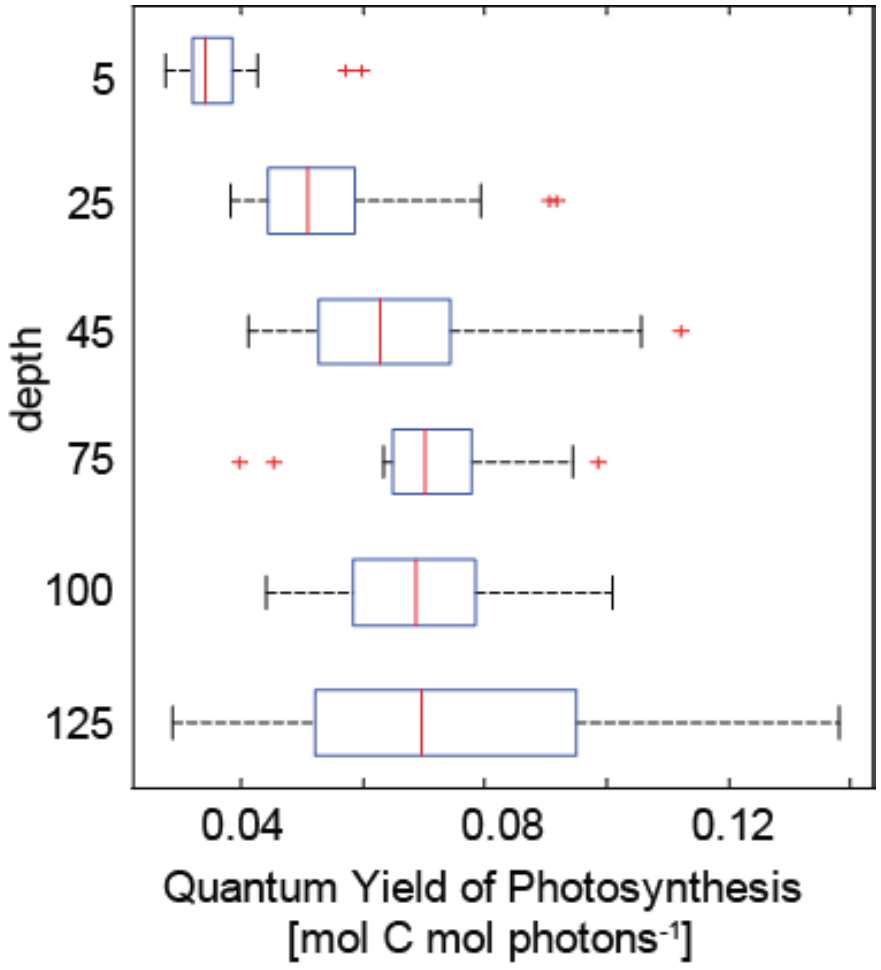




Photophysiology (absorption)

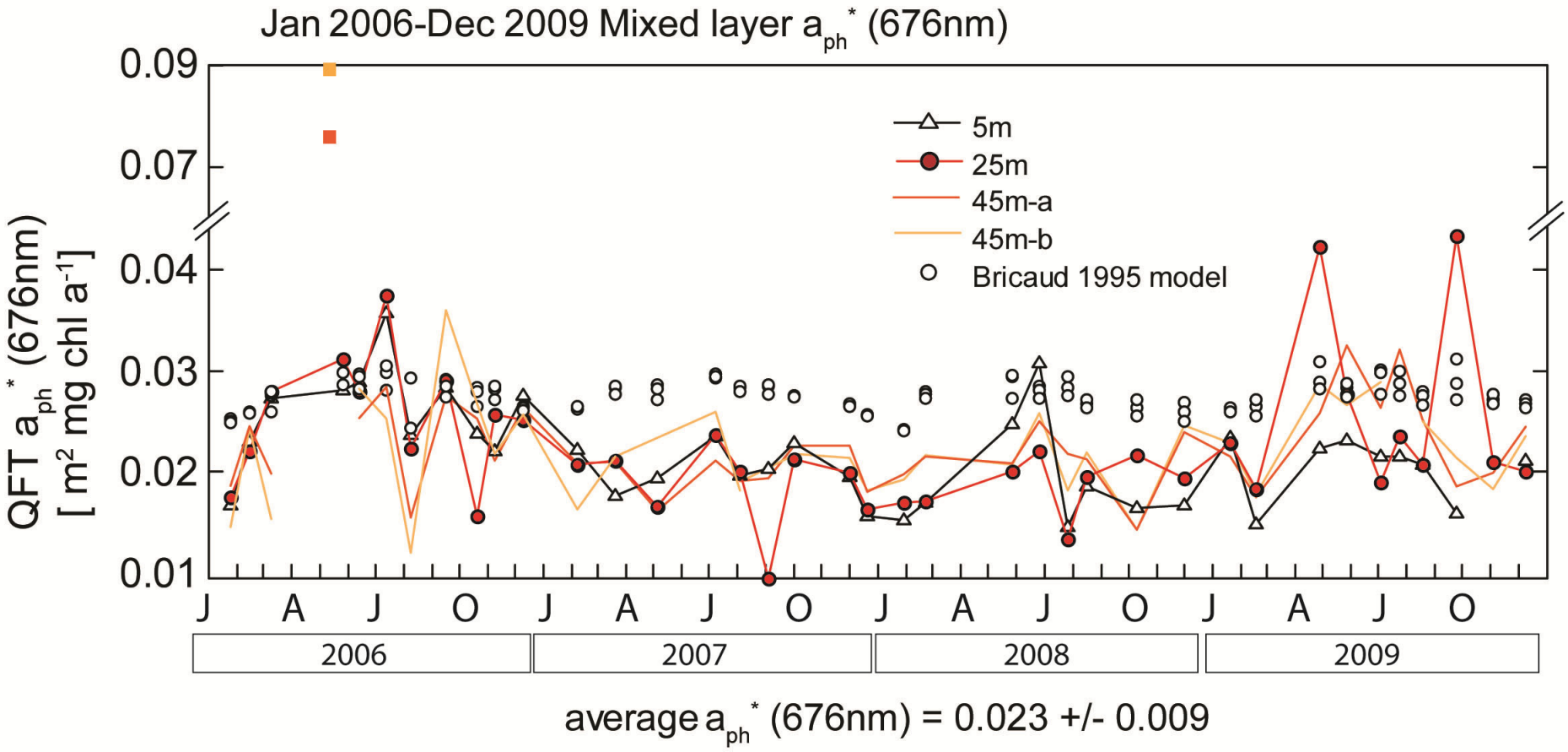
Neither a_{ph} PUR or ϕ_C (quantum yield) explain light-independent PP





Photophysiology (absorption)

a* shows low seasonality in surface layer at Station ALOHA



Models do not capture variability

Integrated Primary Production (mg m^{-2} d^{-1})