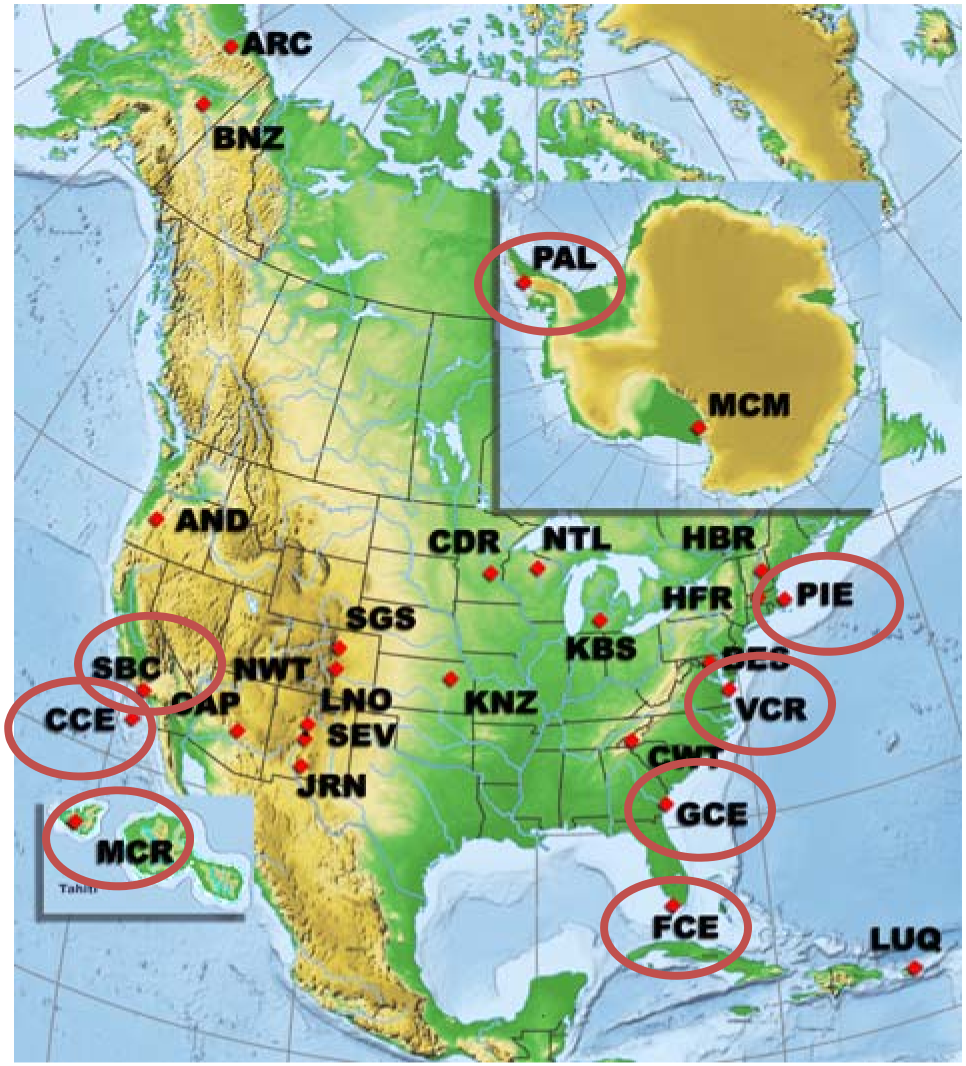
Competition for 1-2 new coastal marine LTER's

(marine or estuarine, currently N=8 sites of 24)



A.O. expected in 2015

<u>Open meeting:</u>

LTER **All-Scientists Meeting**

Estes Park, CO

30 Aug. – 2 Sept. 2015

http://asm2015.lternet.edu/

U.S. LTER Network

www.lternet.edu

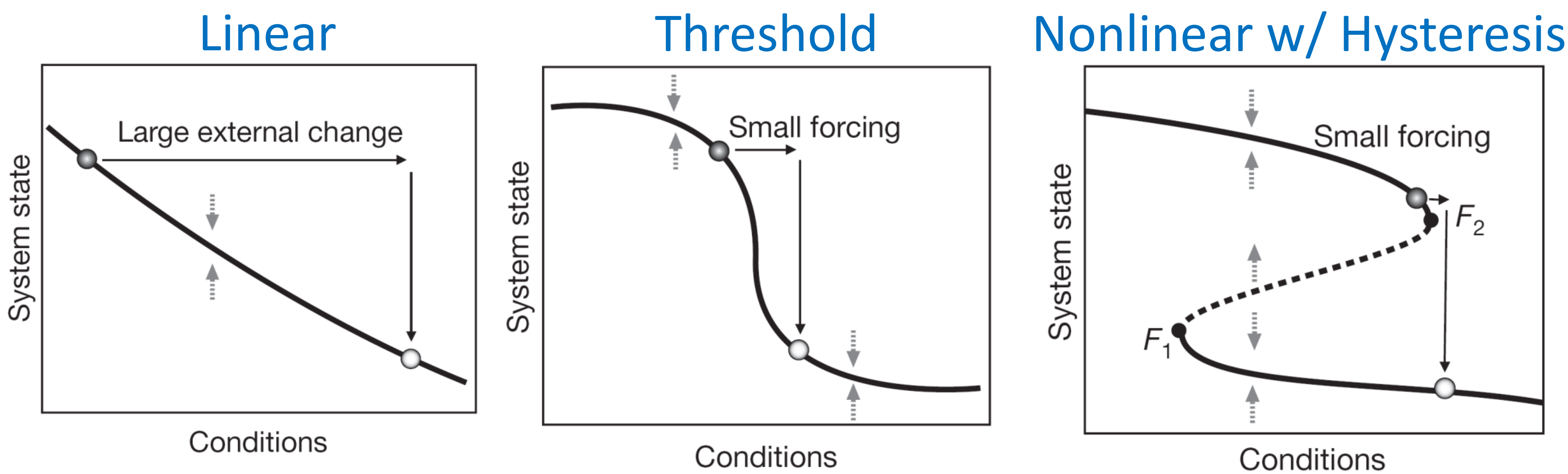
Integration of measurement methods in the *California Current Ecosystem*

Mark D. Ohman

Scripps Institution of Oceanography

California Current Ecosystem LTER site

Conceptual Models for Ecosystem Change



Scheffer et al. 2009, Nature

see: Double integration hypothesis

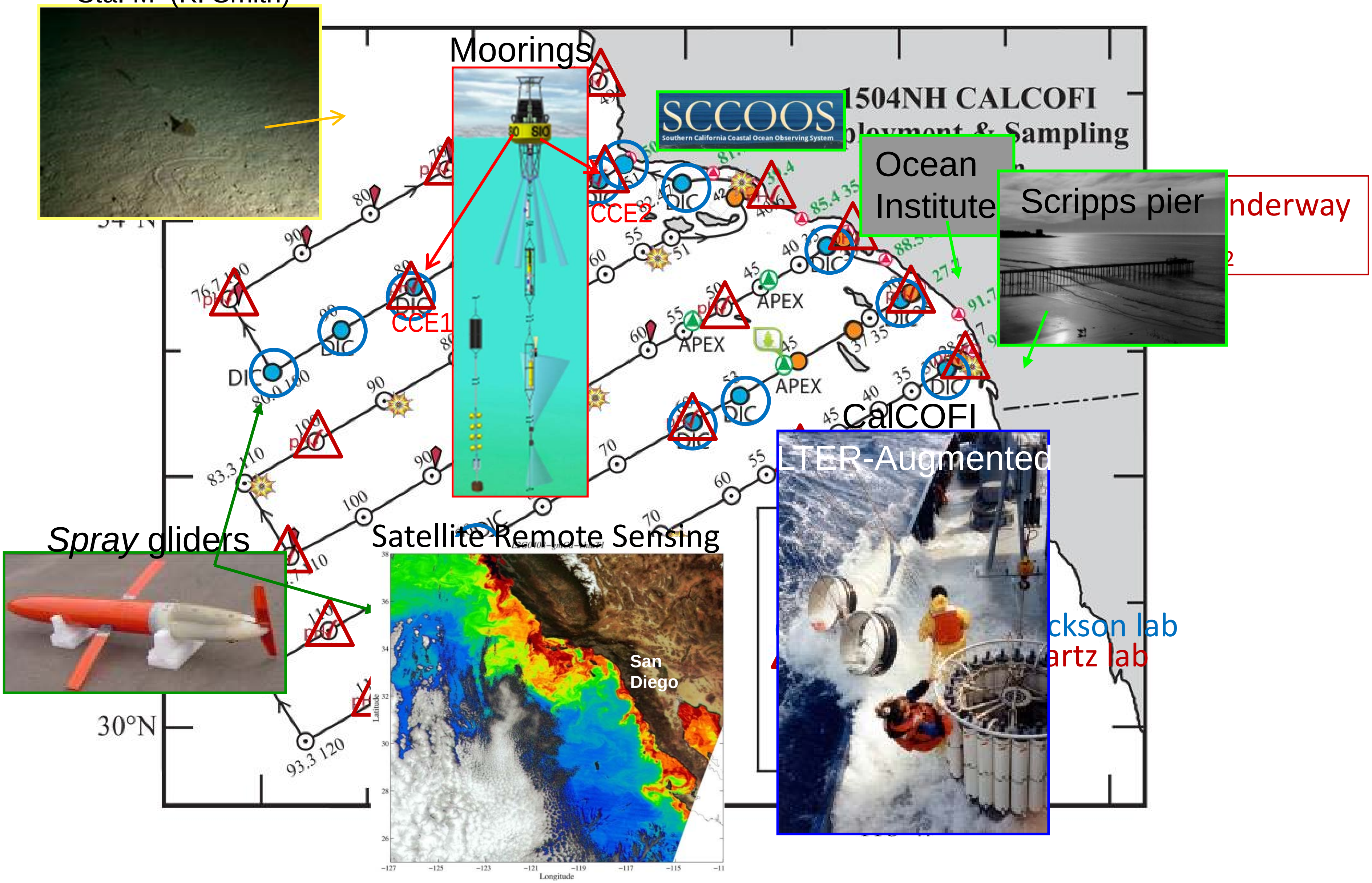
Di Lorenzo and Ohman 2013, PNAS

Southern Sector of the California Current System

- CCE-LTER (*Long-Term Ecological Research* site)
- CalCOFI (a *space-resolving* time series)
- pCO_2 (C. Sabine, D. Feely)
- *Spray* gliders (D. Rudnick)
- CCE moorings (U. Send, M. Ohman)
- Satellite remote sensing (M. Kahru)
- Modeling (P. Franks, A. Miller, E. DiLorenzo, C. Edwards)
- Santa Barbara Basin sediment traps (C. Benitez-Nelson)
- Sta. M abyssal benthic time series (K. Smith)
- C explorer (J. Bishop)

CalCOFI shipboard, 4X yr^{-1}

Deep-sea benthos
Sta. M (K. Smith)



Brief vignettes, illustrating the importance of integration of:

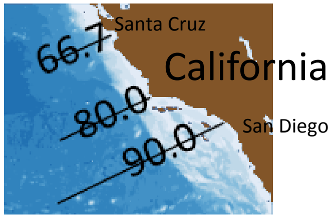
Autonomous

Semi-autonomous

Attended Shipboard measurements

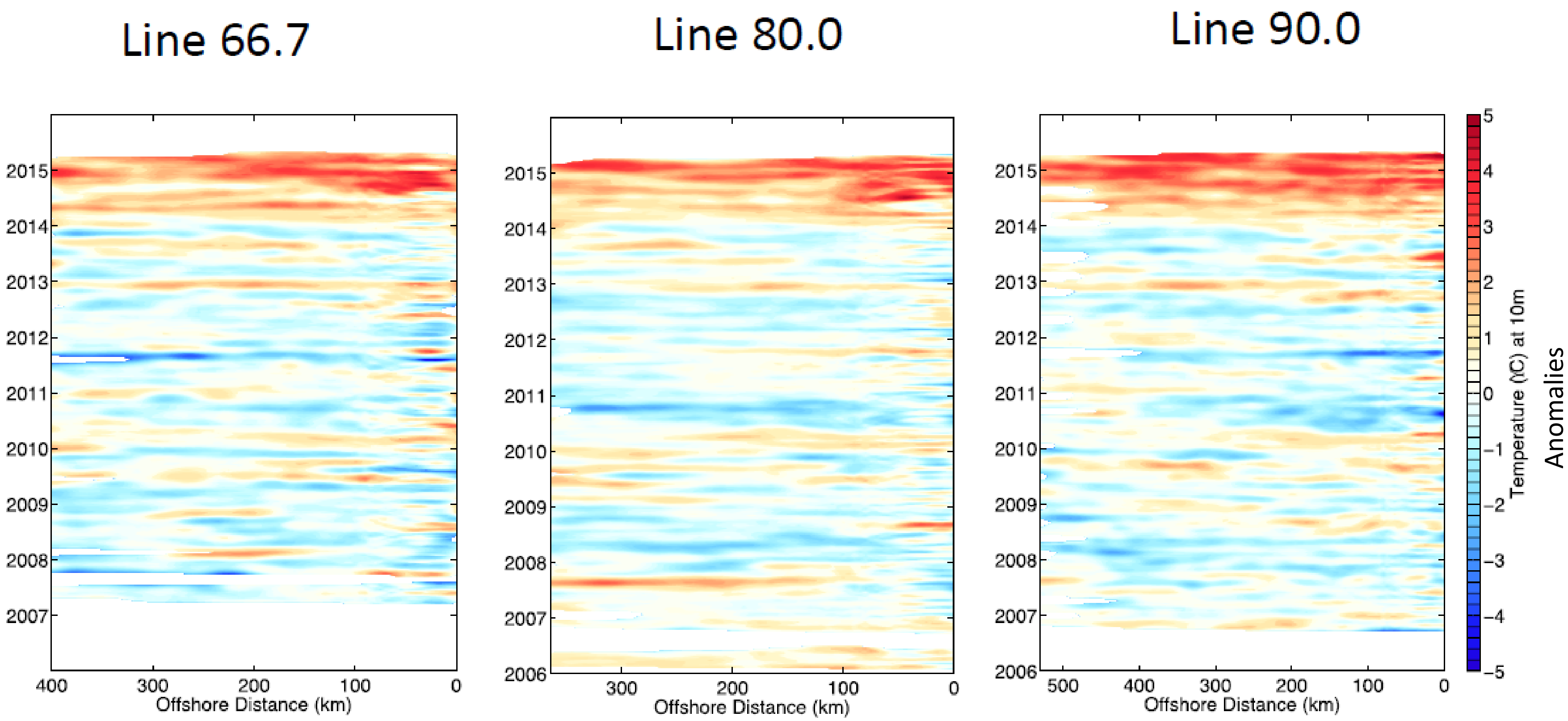
Katherine Zaba and Dan Rudnick, SIO
Pacific Anomalies Workshop, SIO, May 2015

Interannual Anomalies



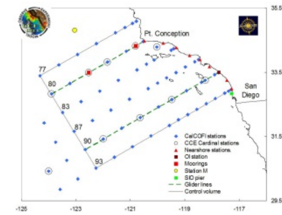
Spray gliders

10 m Temperature (º C)

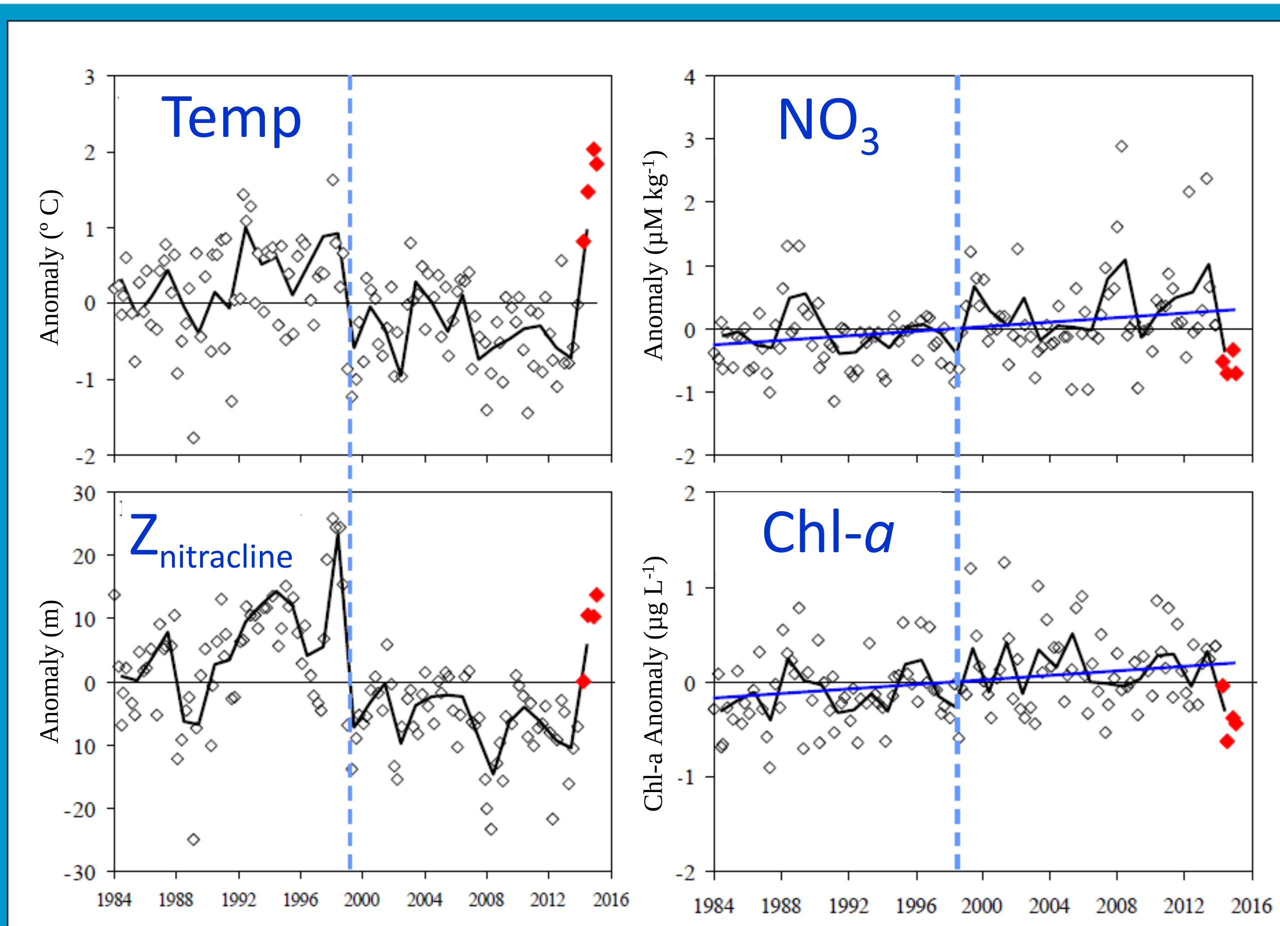


Ralf Goericke, SIO
Pacific Anomalies Workshop, SIO, May 2015

CalCOFI



Phytoplankton and Nutrients



Mixed layer anomalies

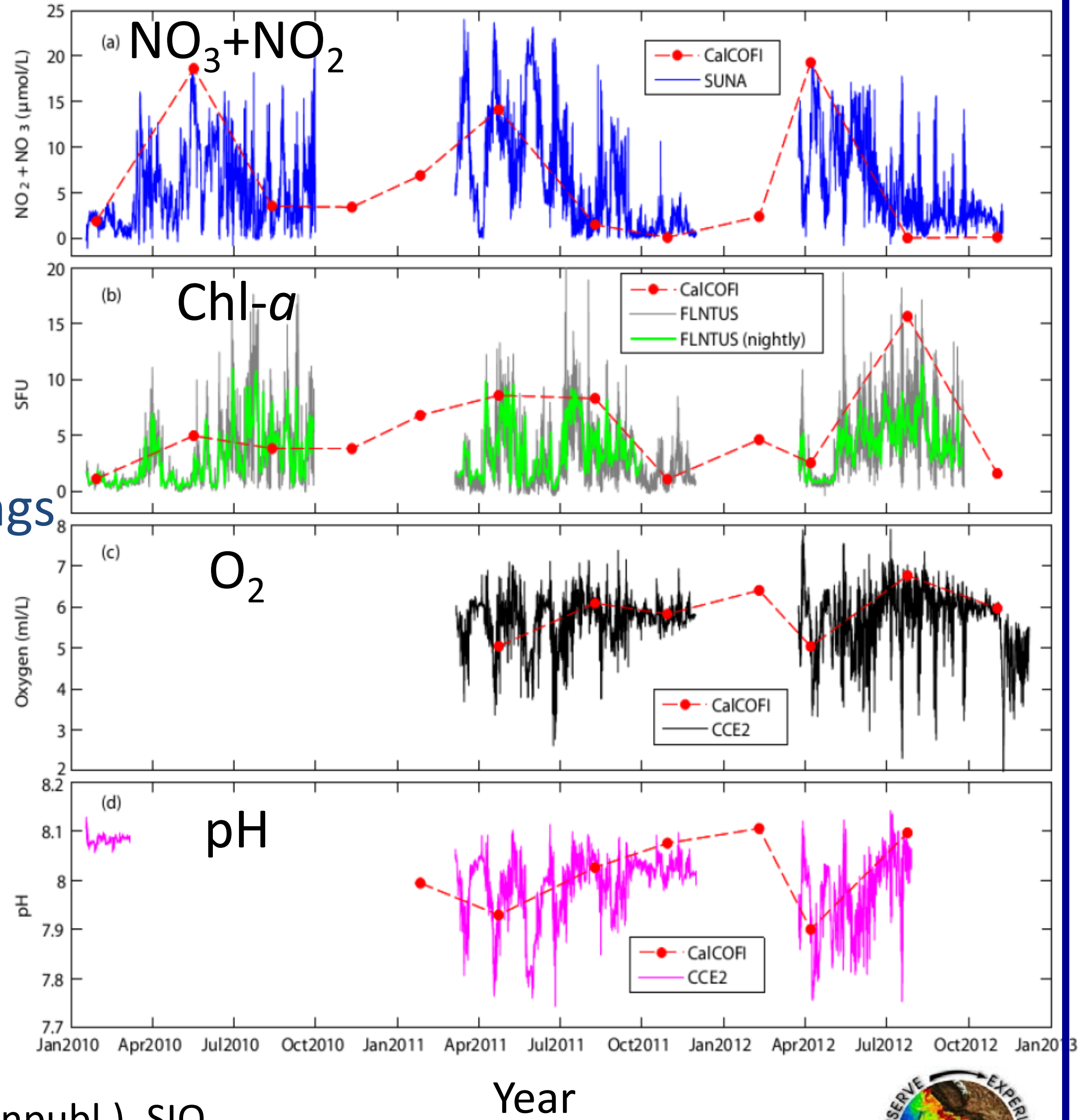
Phytoplankton biomass was controlled by the availability of inorganic nitrogen

'Seasonal' variations
shipboard sampling

(CalCOFI, 4 times year^{-1})

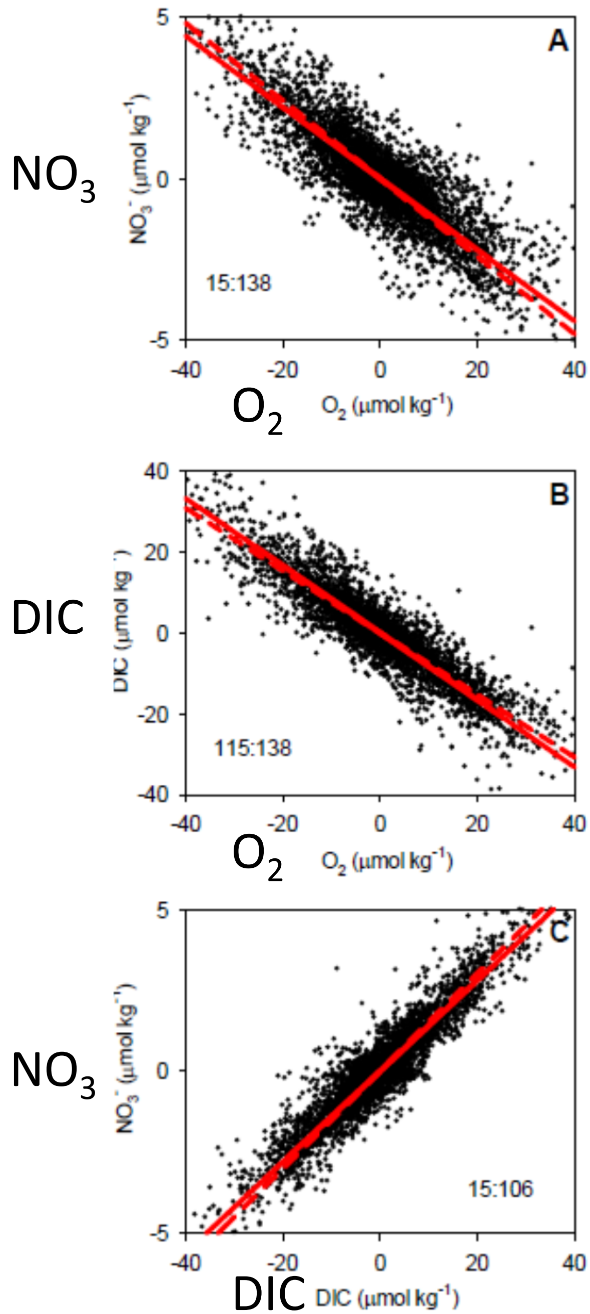
'Event-scale' variations
multi-disciplinary moorings

(continuous)



CCE2 mooring

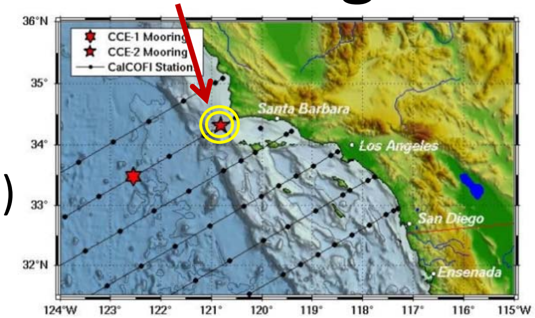
U. Send, M. Ohman, T. Martz (unpubl.), SIO



Data (Model II regression)

Redfield ratio

CCE2 mooring



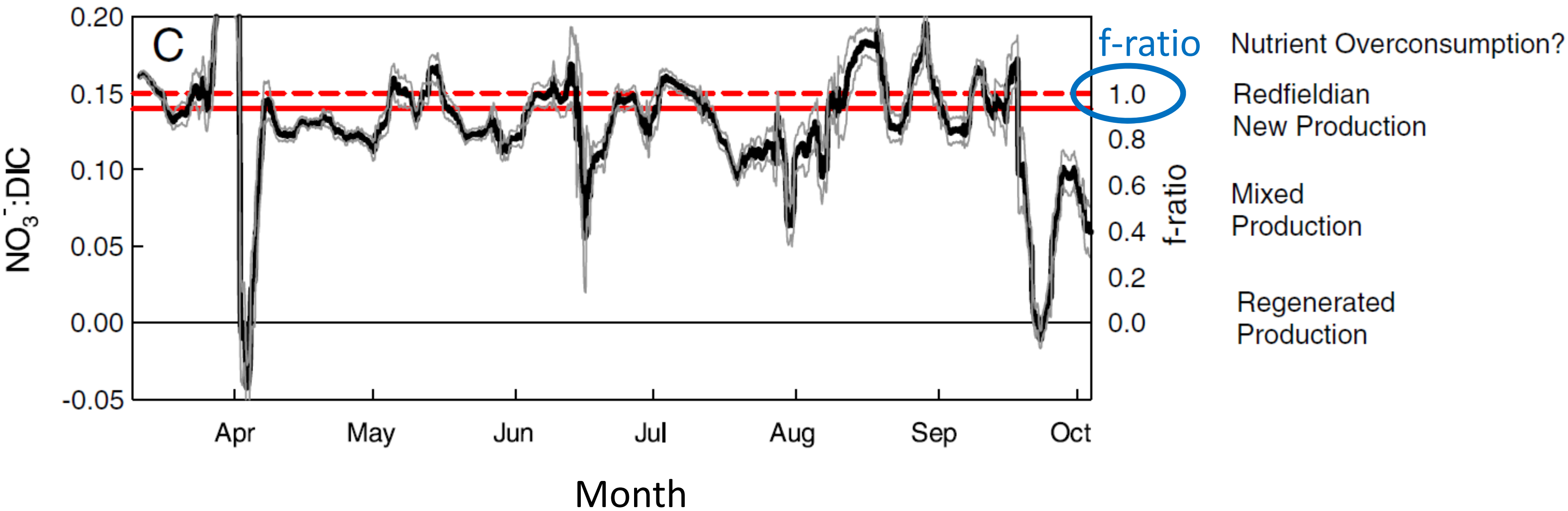
Excellent agreement of mean values w/ Redfield Ratio

Martz et al. (2014) GRL

33 h high pass filter

Dynamic variability of f-ratio

CCE2 mooring



mean 8 mo. ratio

Redfield ratio
mean 8 mo. ratio

Redfiled Ratio

Martz et al. (2014) GRL

33 h high pass filter

Extending autonomous (and semi-autonomous) measurement capabilites using proxy relationships

Proxy relationships for Carbonate System Variables

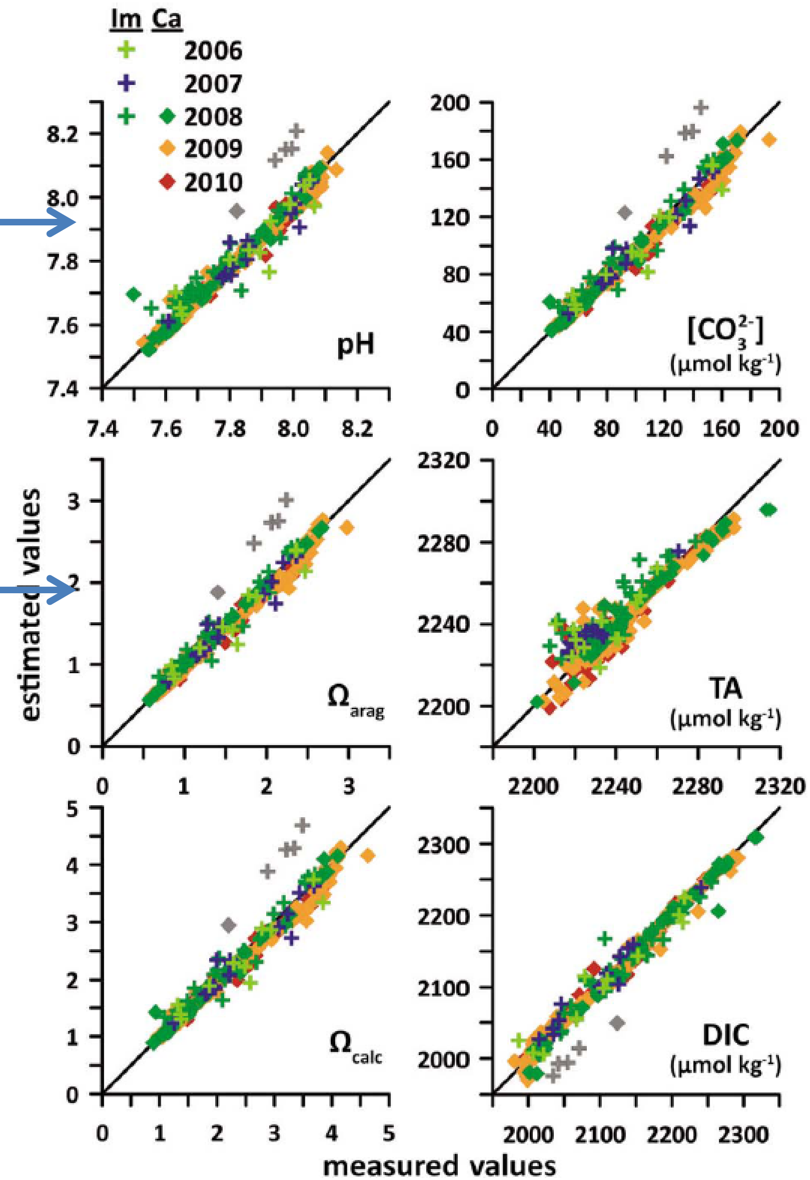
from ship samples, Southern and Baja CA regions

Alin et al. (2012)

pH = $f(Temp, O_2)$

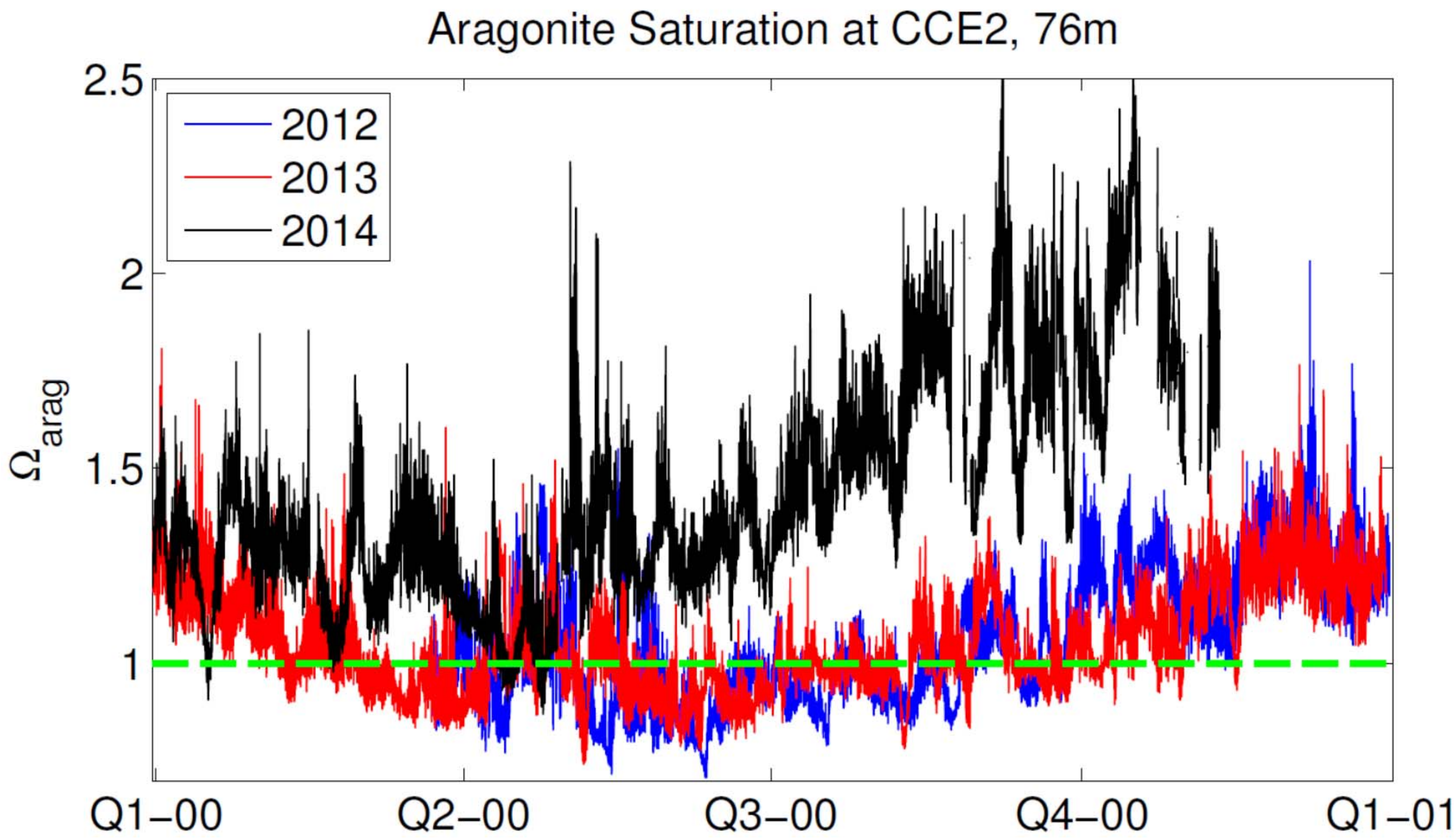
Ω_{arag} = $f(Temp, O_2)$

Applicable to autonomous sensors
> 15 m depth



Resolving Interannual Variability

CCE2 mooring-based measurements combined with Alin et al. proxy



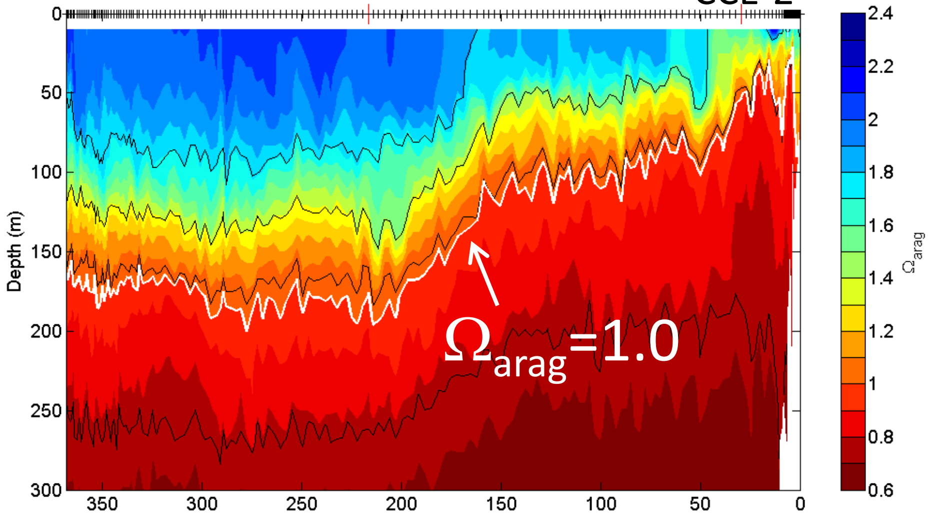
U. Send, M. Ohman (unpubl.), SIO

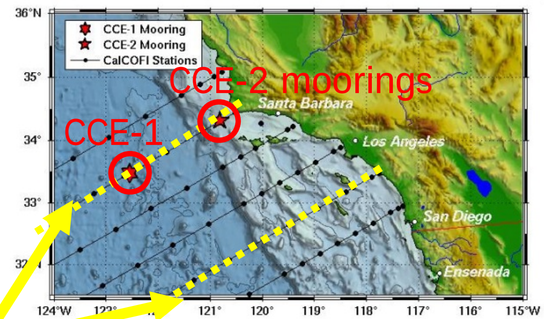
Combining Gliders and Moorings resolve

both Space and Time

Resolving Undersaturation Events

Spray gliders (spatial variations)



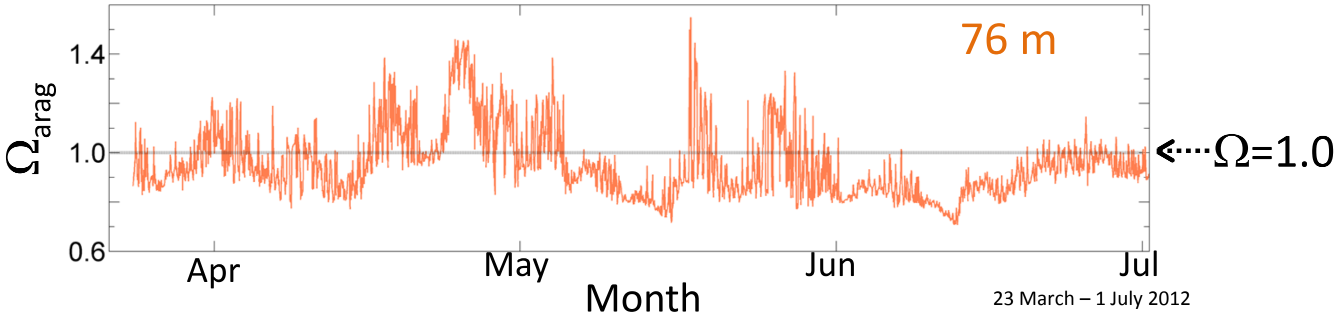


Spray

Ohman et al. (2013) *Oceanography*

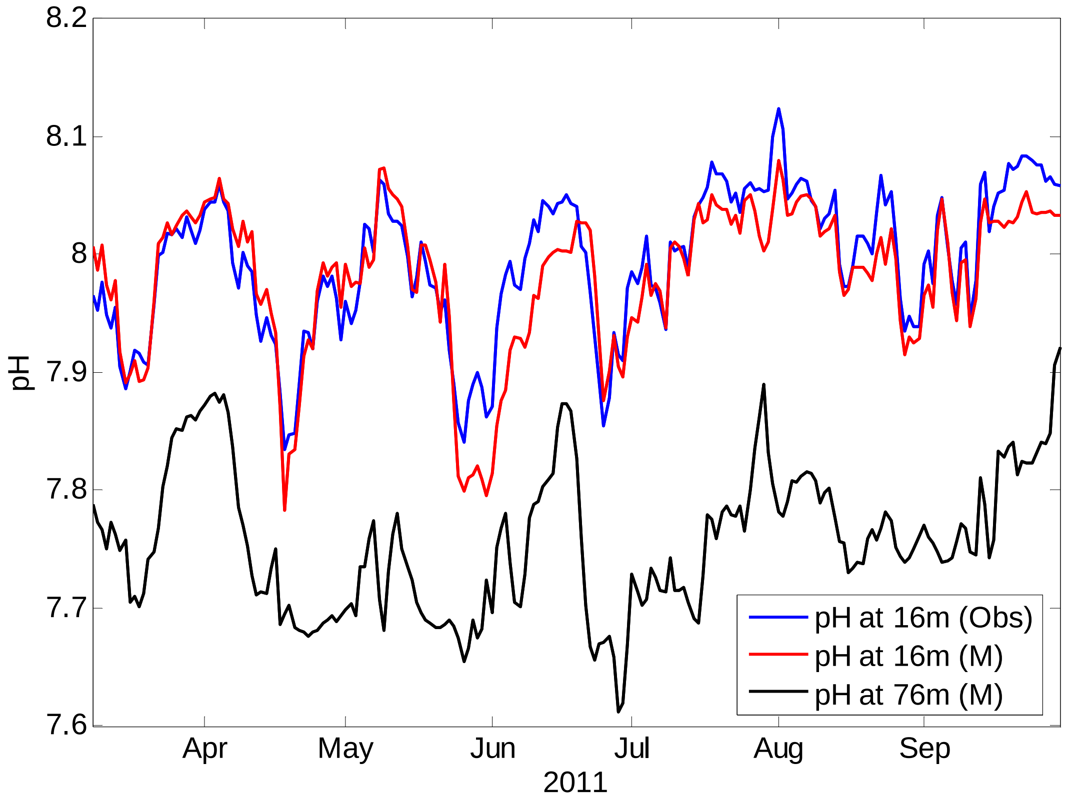
(using Alin et al. 2012 proxy)

Moorings (temporal variations)



Independent Validation

in situ measurements compared w/ proxies



16 m - Measured pH (SeapHOx)

16 m - Proxy estimate of pH

(from Alin et al. 2012)

76 m – Proxy estimate of pH

Todd Martz (unpubl.)

SIO

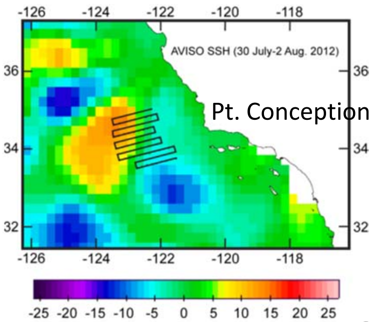
Use of autonomous and semi-autonomous measurements

to situate process studies

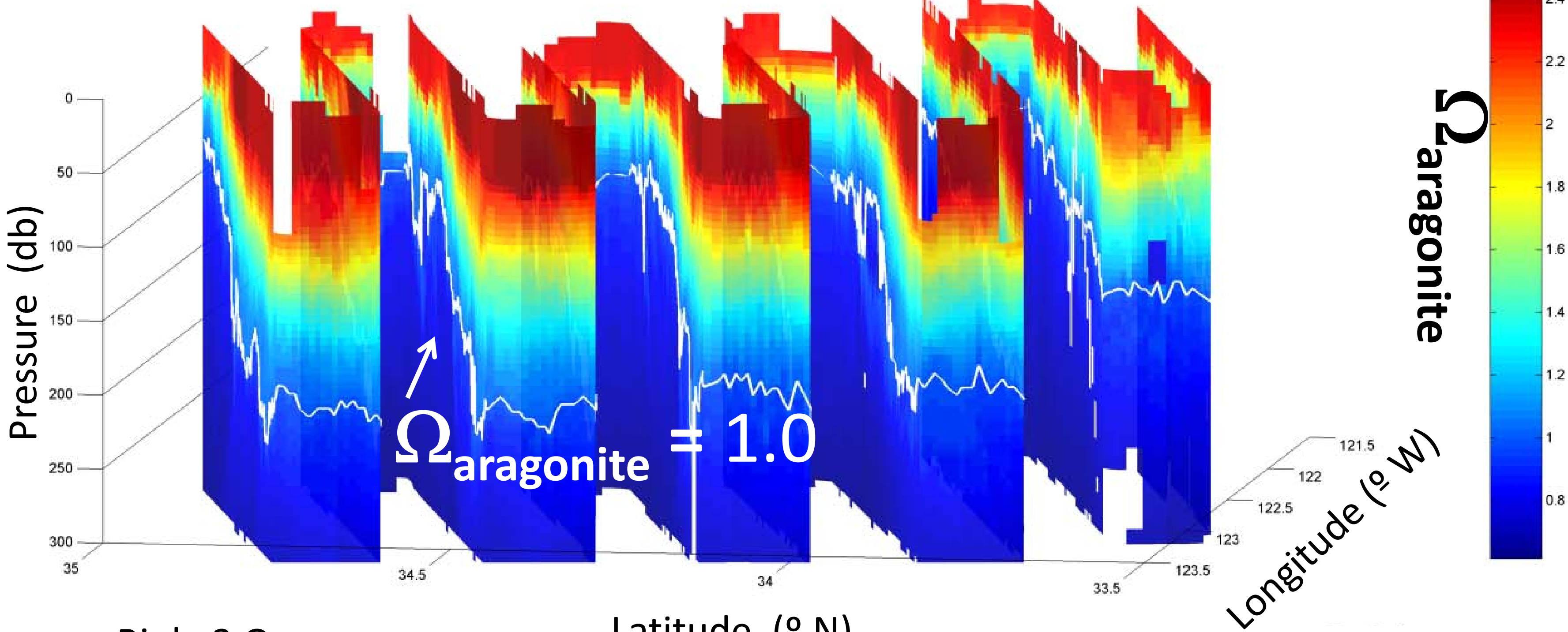
in the CCE-LTER/CalCOFI region

3-D spatial structure of Ω_{arag}

(SeaSoar combined w/ Alin et al. 2012 proxy)



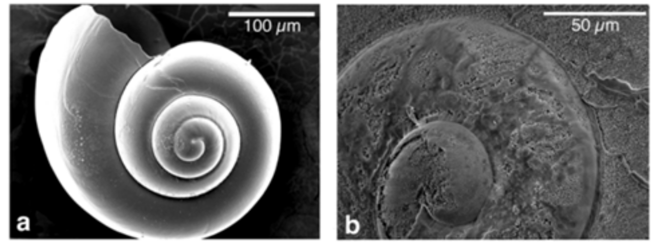
Cross-frontal shoaling of Ω_{arag}



Bednaršek and Ohman (2015) *Marine Ecology Progress Series*

Potential effects of ocean acidification

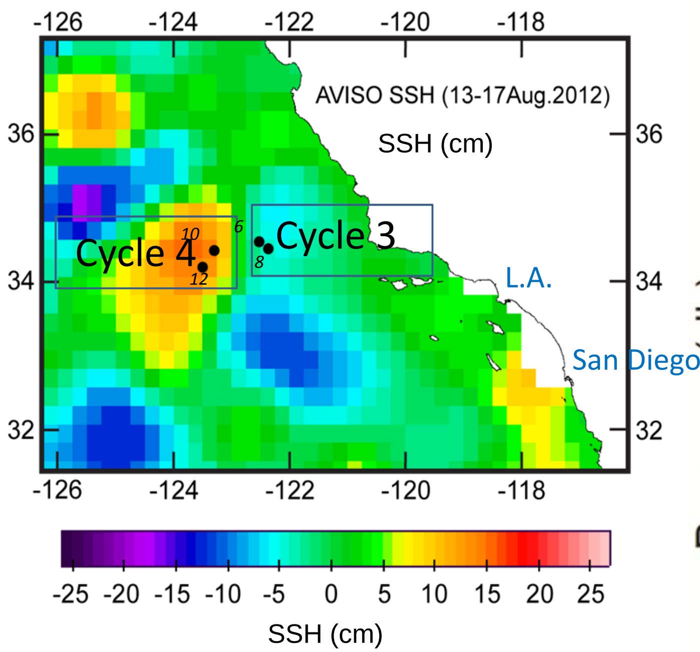
Shell dissolution of
Limacina helicina

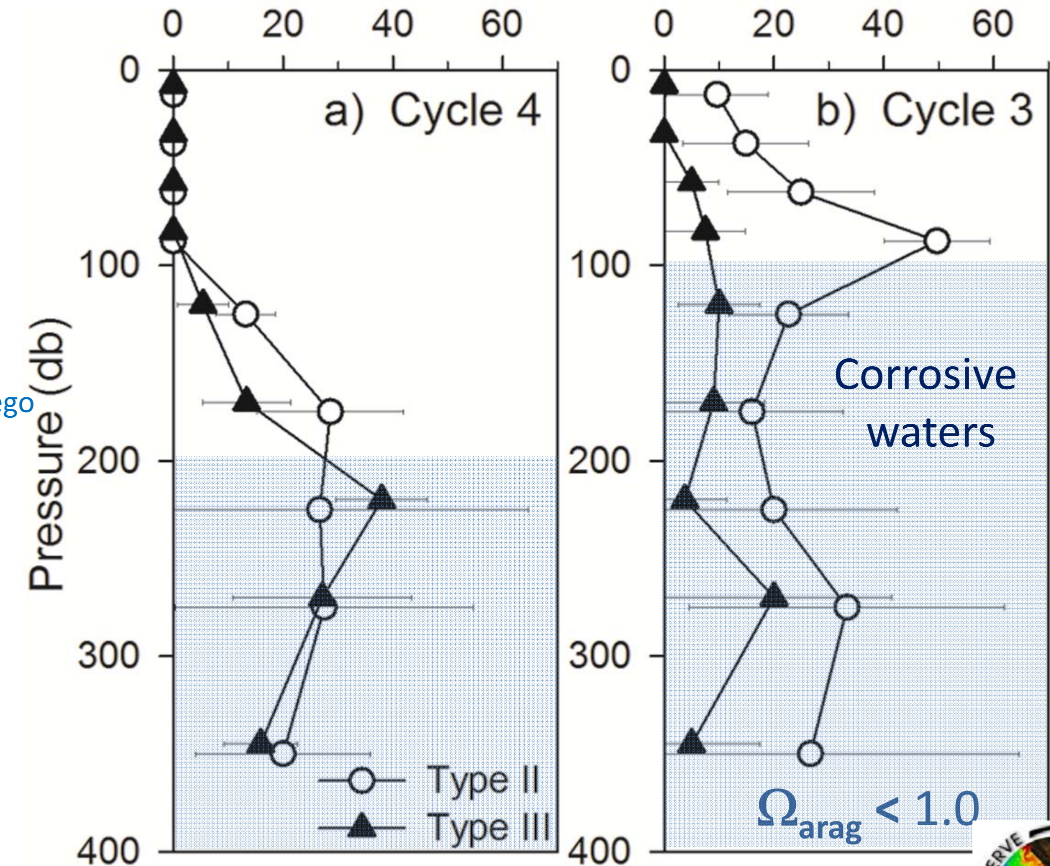


Offshore of front

% Shell Dissolution

Inshore of front





Bednaršek and Ohman (2015) *Marine Ecology Progress Series*

The power of sustained observations/replication

Spray glider time series

Covariability of Physical and Biological Fronts at sub(mesoscale)

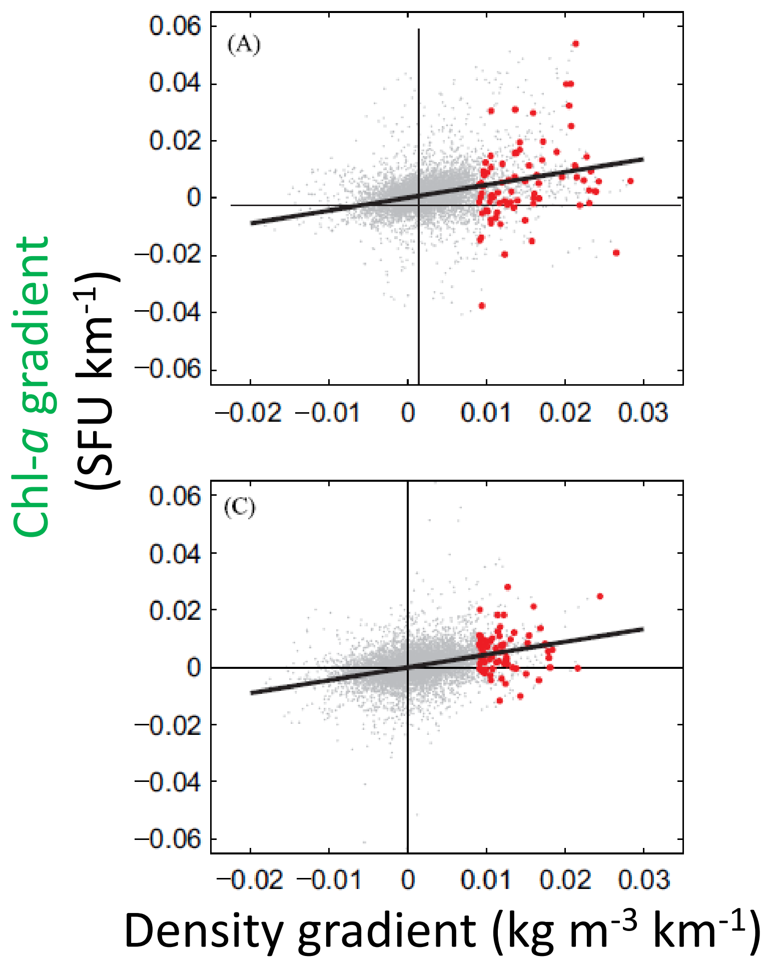
22,942 glider dives over 6 years
N = 154 fronts

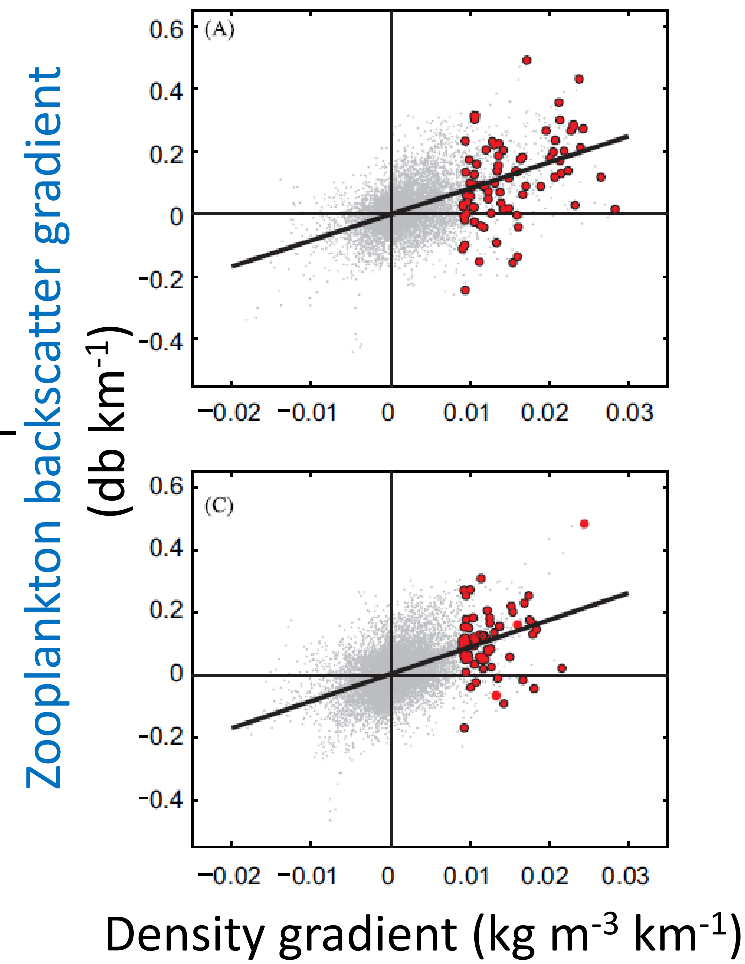
Chl-*a* gradients

Zooplankton backscatter gradients 750 kHz

Line 80

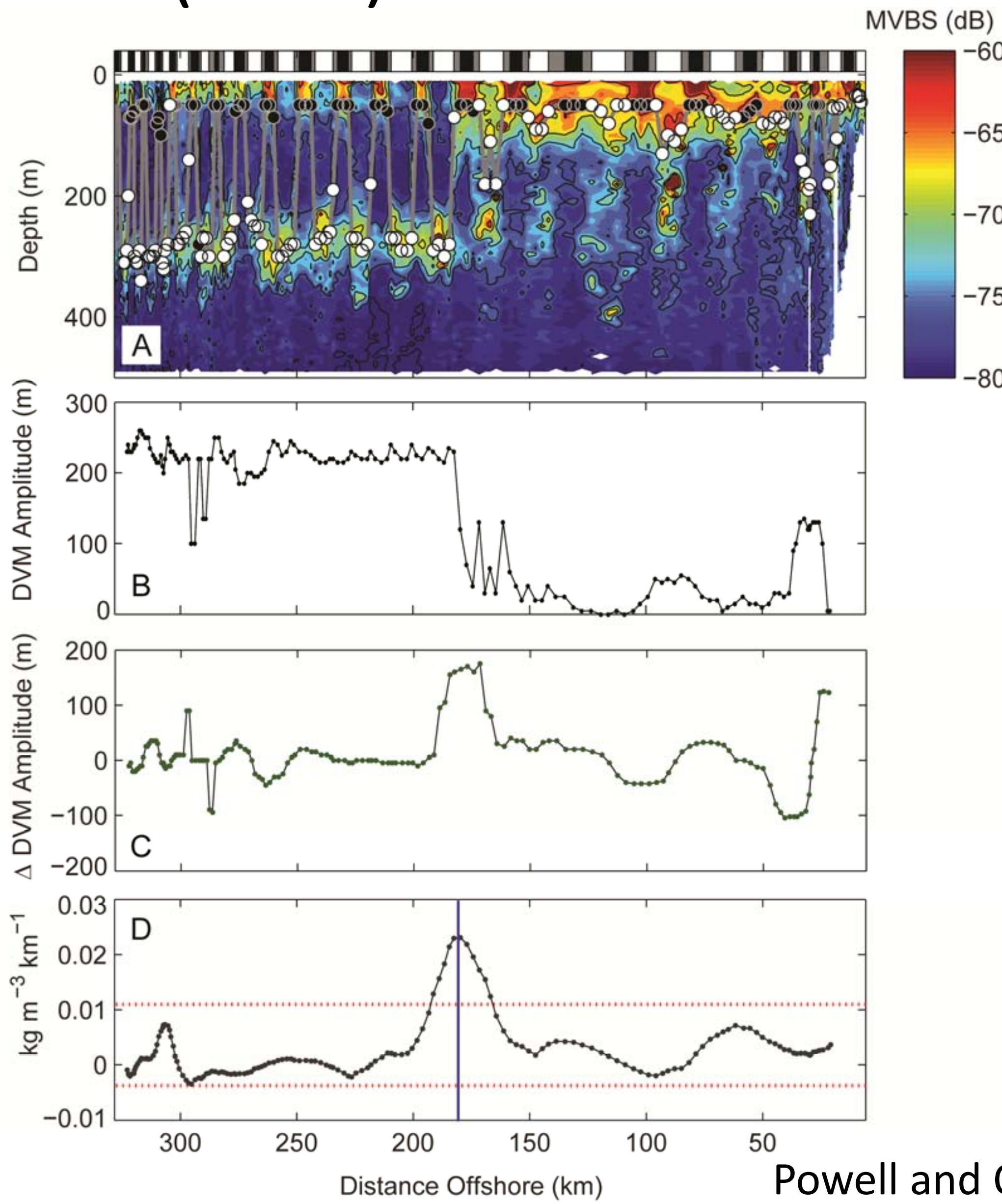
Line 90





Powell and Ohman (2015a) *DSR II*

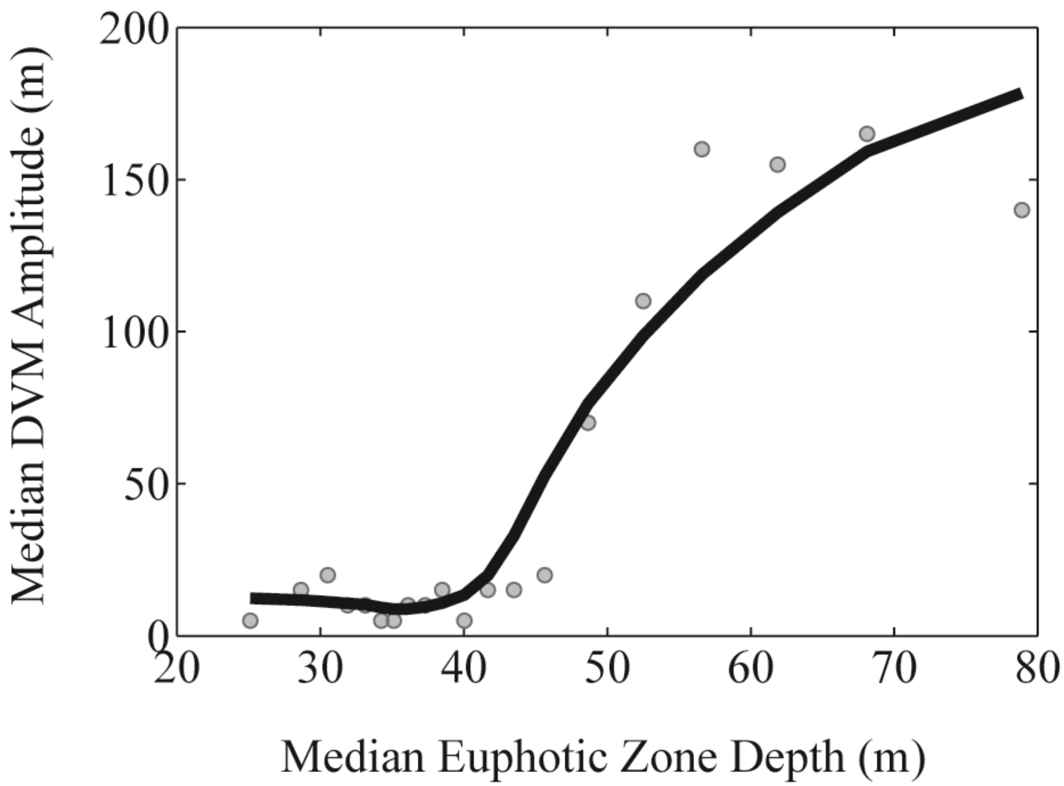
Changes in Zooplankton Diel Vertical Migration (DVM) across fronts



Acoustic backscatter @ 750 kHz

Powell and Ohman (2015b, *PinO*)

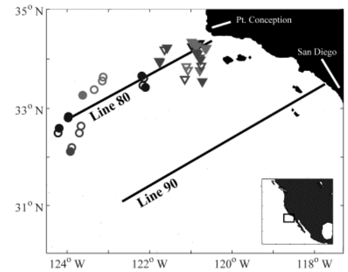
Amplitude of Zooplankton Diel Vertical Migration varies with Euphotic Zone Depth



Powell and Ohman (2015b) *PinO*

Validation by MOCNESS sampling

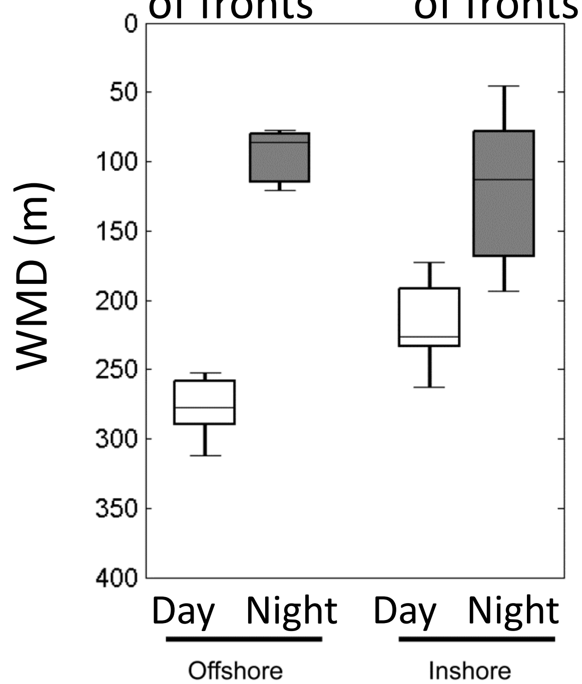
(N=39 MOCNESS tows)



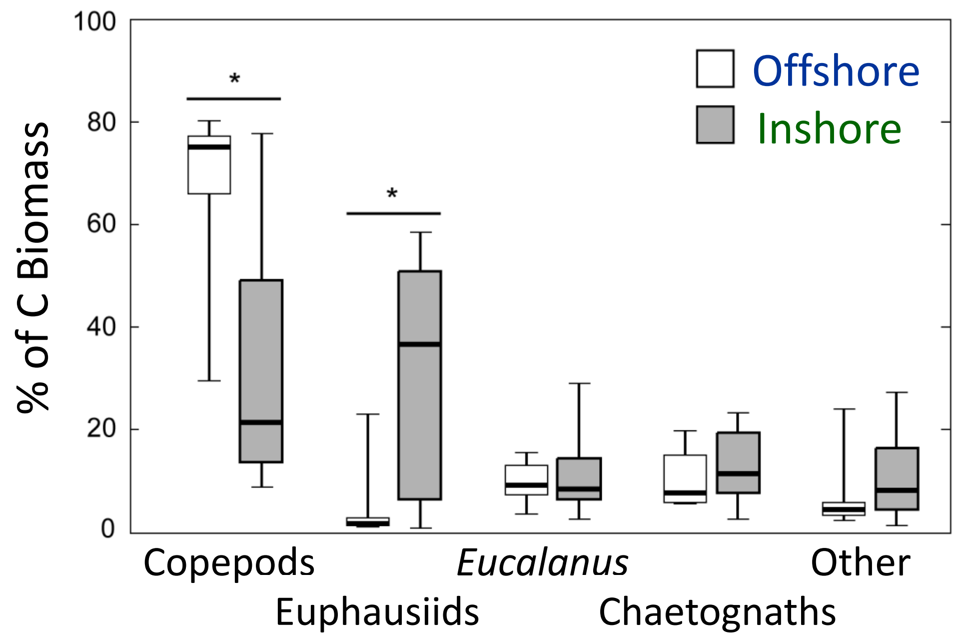
● = offshore of front
▼ = inshore of front

Weighted mean depth

Offshore of fronts   Inshore of fronts

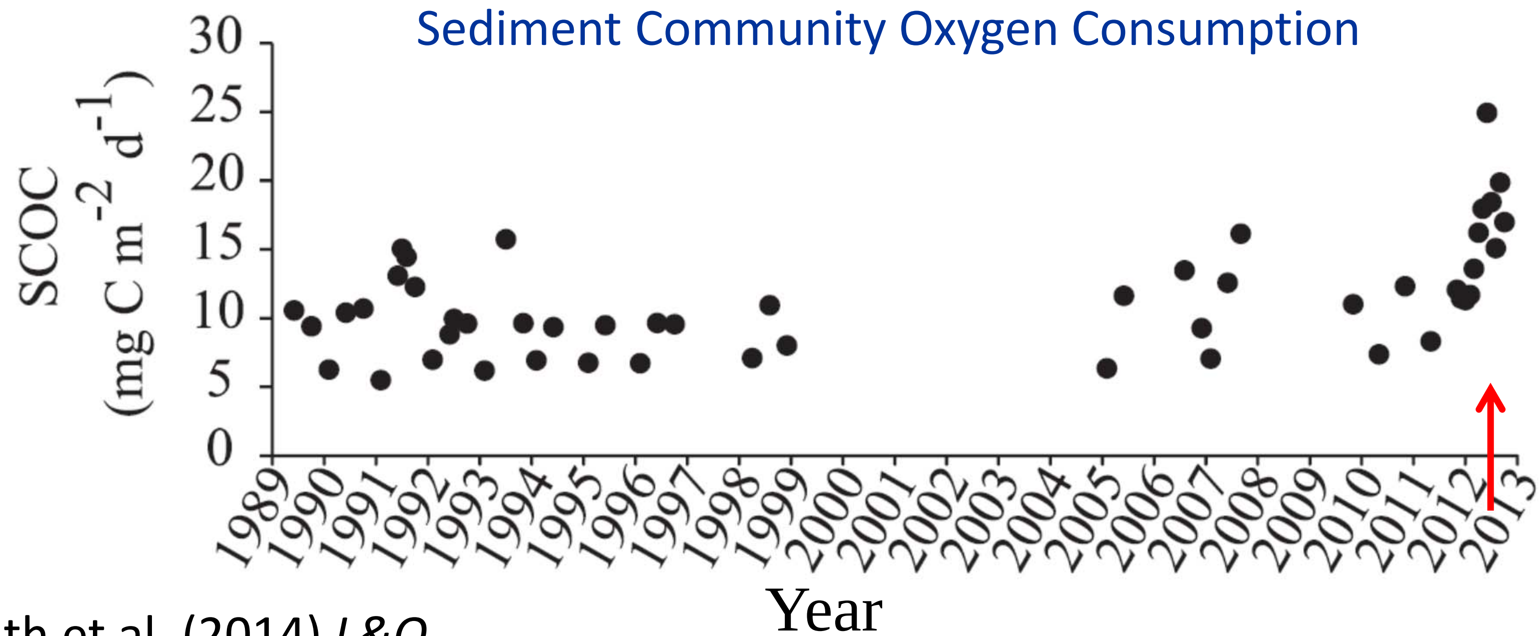


Taxonomic Composition

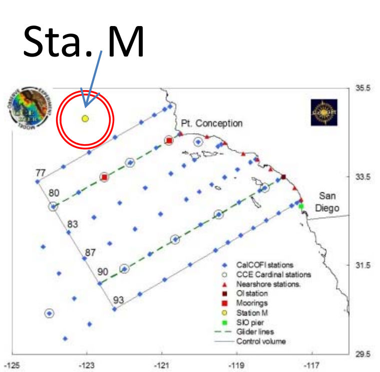


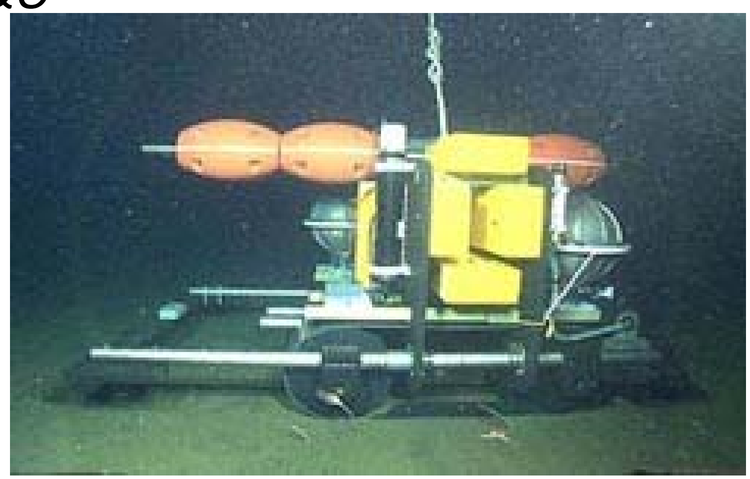
Powell and Ohman (2015b) *PinO*

24-year record Carbon demand by Deep Sea Benthos
4,000 m Sta. M (Ken Smith)



Smith et al. (2014) *L&O*





Benthic Rover

Ken Smith, MBARI

SCOC

Sediment fluorescence

Acoustic Scanners

Episodic food 'pulses' to the Deep Sea Benthos

(Sta. M)

Abyssal plain
~4,000 m depth

Chl-*a*

Net Primary Production

Zooplankton Biomass

Salp biomass

POC flux

% Seafloor Cover

SCOC

Smith et al. (2014) *L&O*

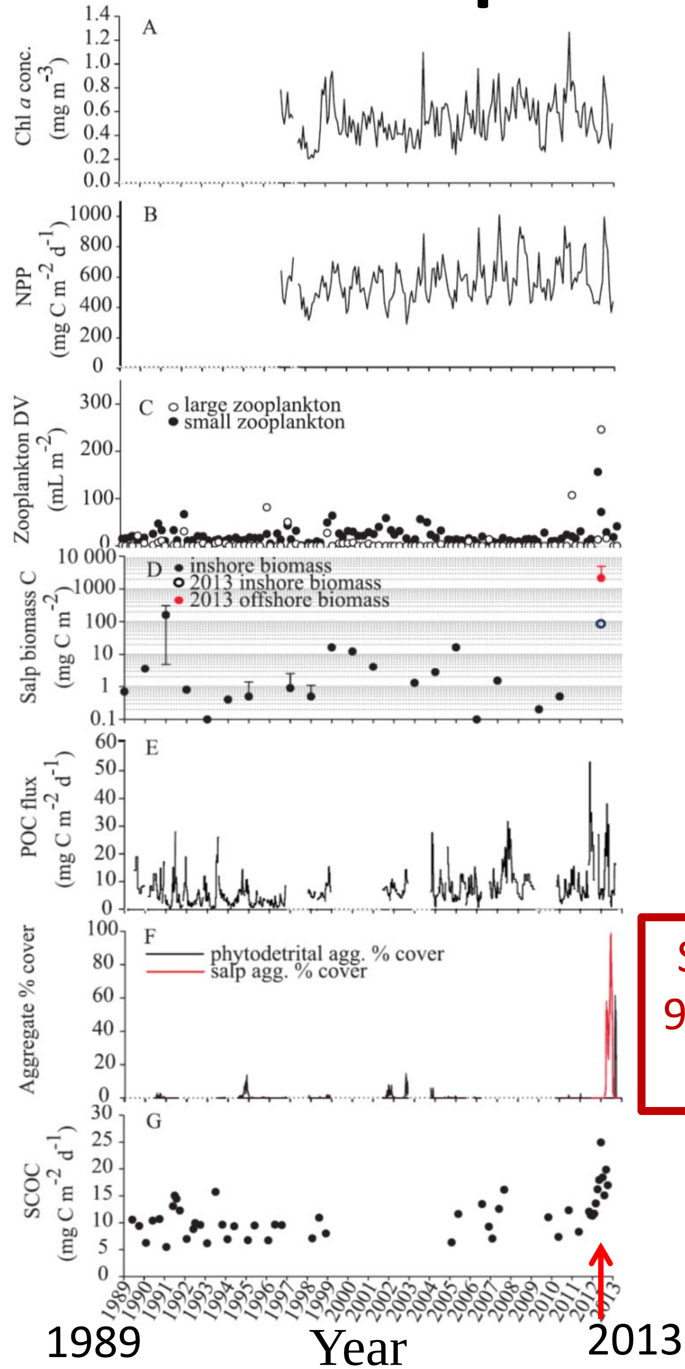


photo: D.Wrobel

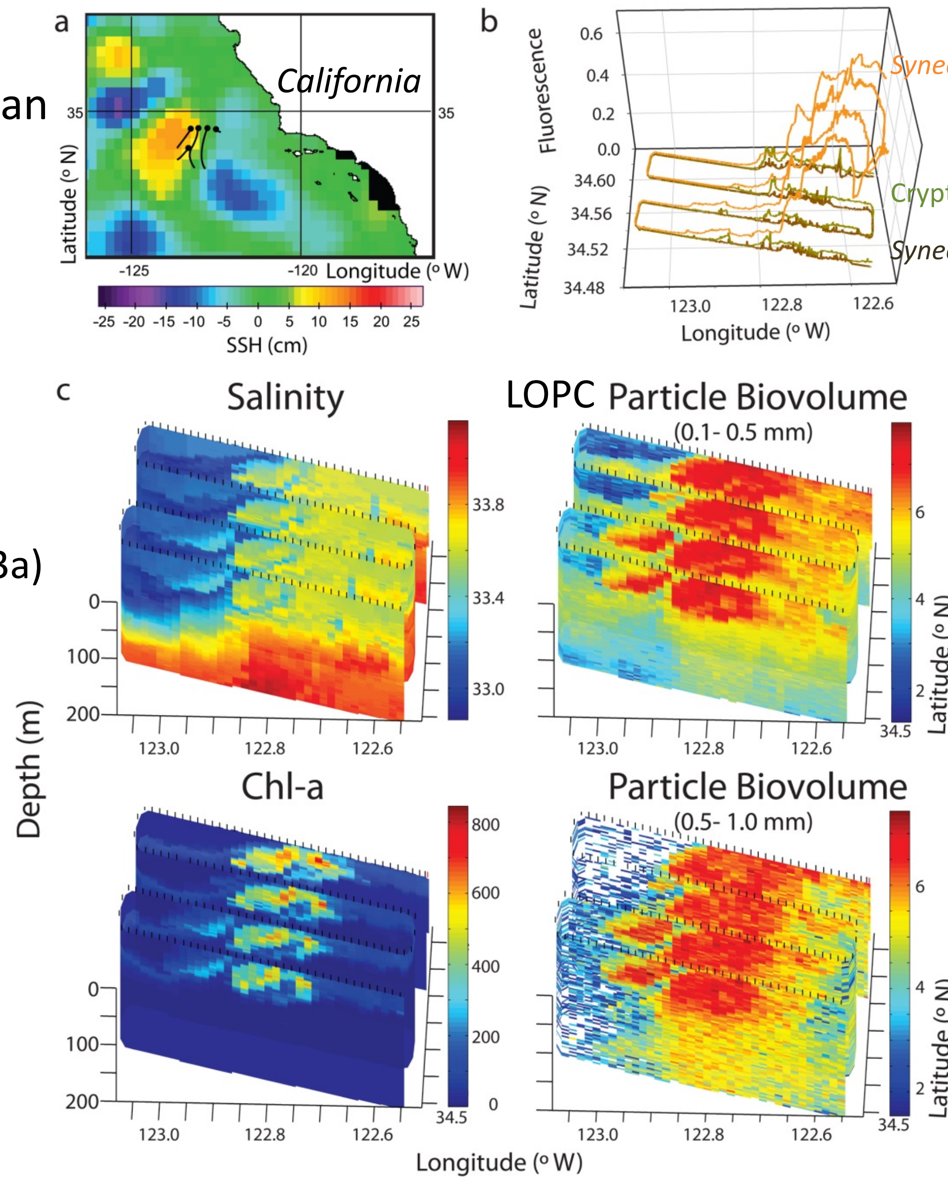
Salp pulse supplied 97-327 % of benthic C demand

Semi-autonomous shipboard measurements

Localization of Submesoscale Fronts

(Quasi-) Lagrangian
Drift array

Ohman et al. (2013a)
Oceanography



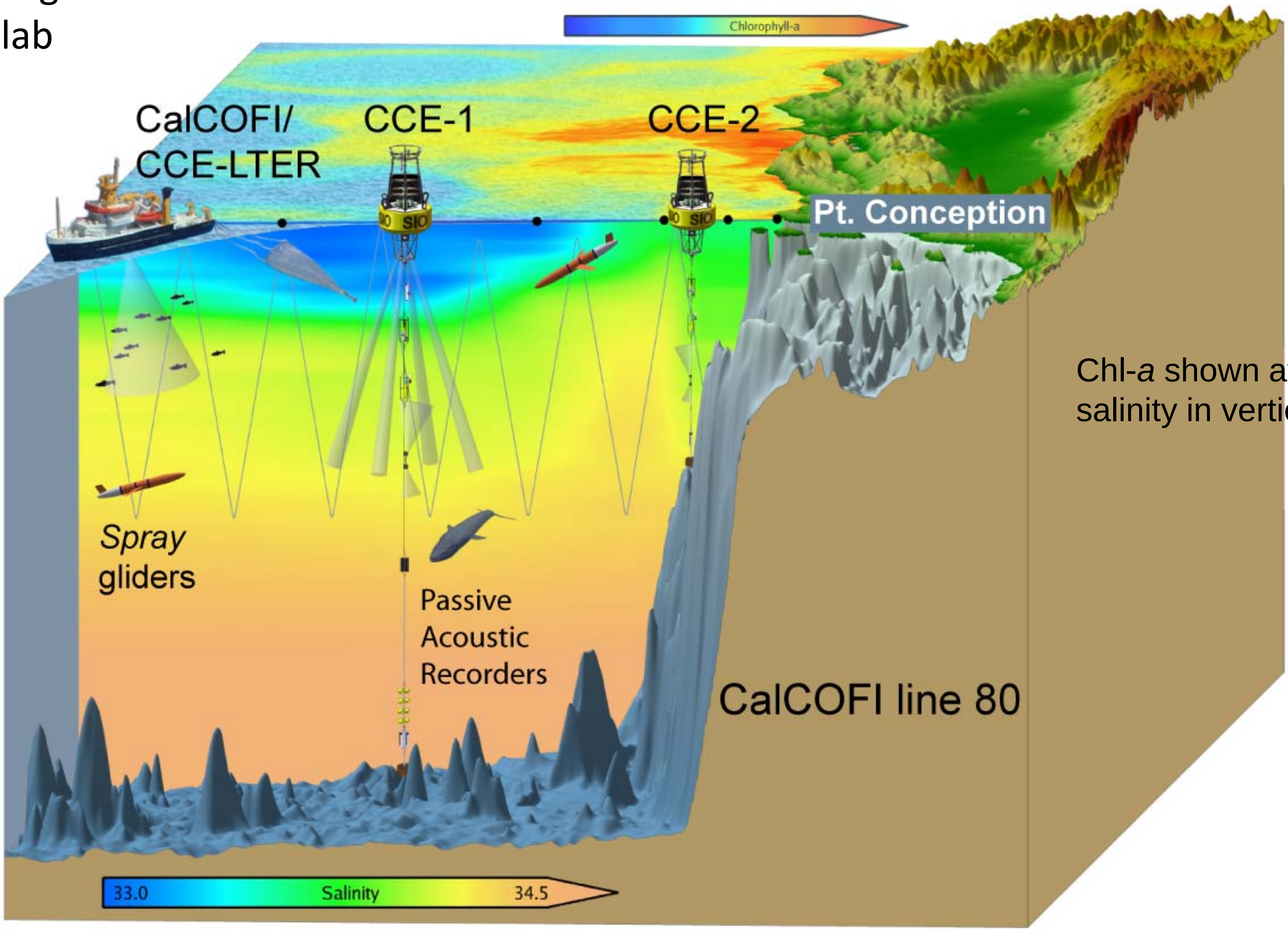
ALF
Advanced Laser Fluorescence
(Alex Chekalyuk)

Moving Vessel Profiler
Free-fall vehicle
Computer controlled

End-to-end Observing System

pCO_2 to marine mammals, integrated with 4D ocean modeling

figure design:
U. Send lab



Chl-*a* shown at surface;
salinity in vertical section

Ohman et al. (2013) *Oceanography*

Summary

- Power of integration of autonomous (e.g., gliders, moorings, floats, remote sensing), semi-autonomous (e.g., MVP, ALF, SeaSoar, u/w pCO_2), and attended shipboard measurements (e.g., CalCOFI)

- Importance of independent validation of autonomous instrumentation

- New model? Research vessels for more sophisticated attended measurements, w/ larger teams; autonomous instruments for survey activities

⇒ *Need for global class, technologically advanced vessels*