Continuous Multidisciplinary Observations in the Southern California Current Elucidate Events in Climate, the Ecosystem, and Fisheries

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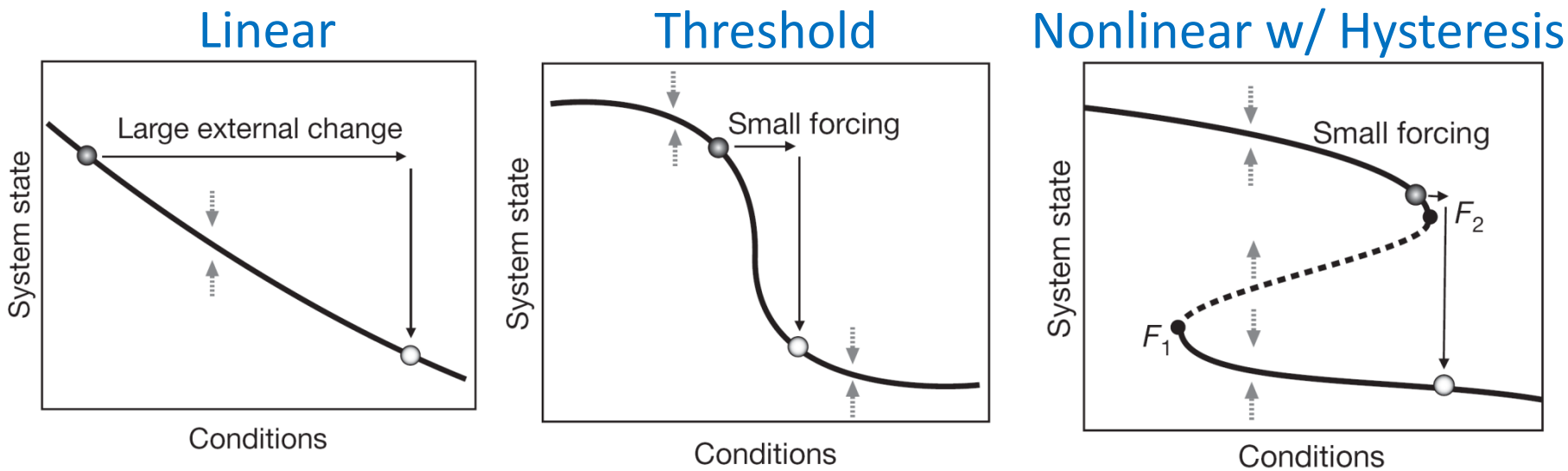
Conceptual Models for Ecosystem Change

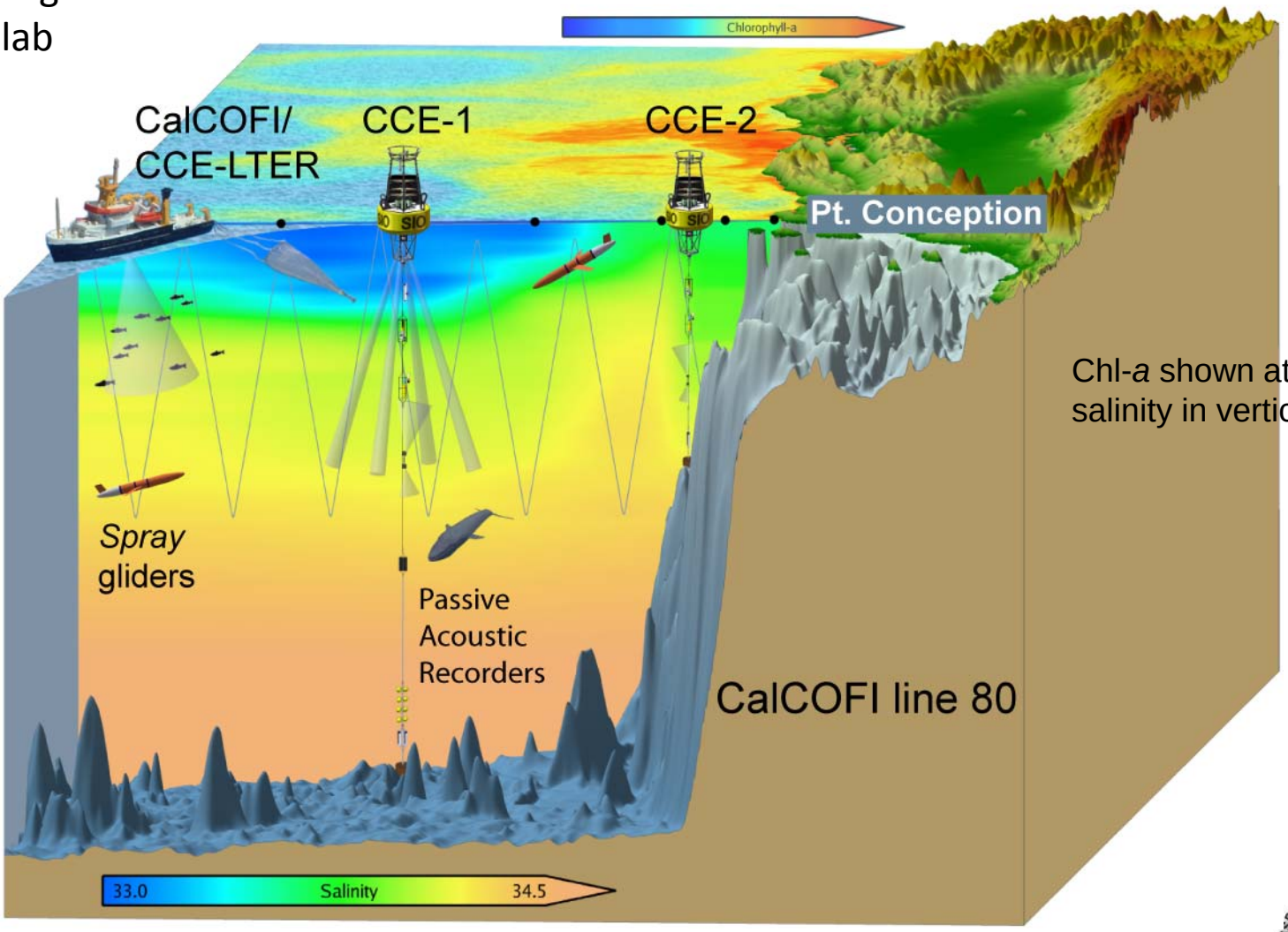


Scheffer et al. 2009, Nature

End-to-end Observing System

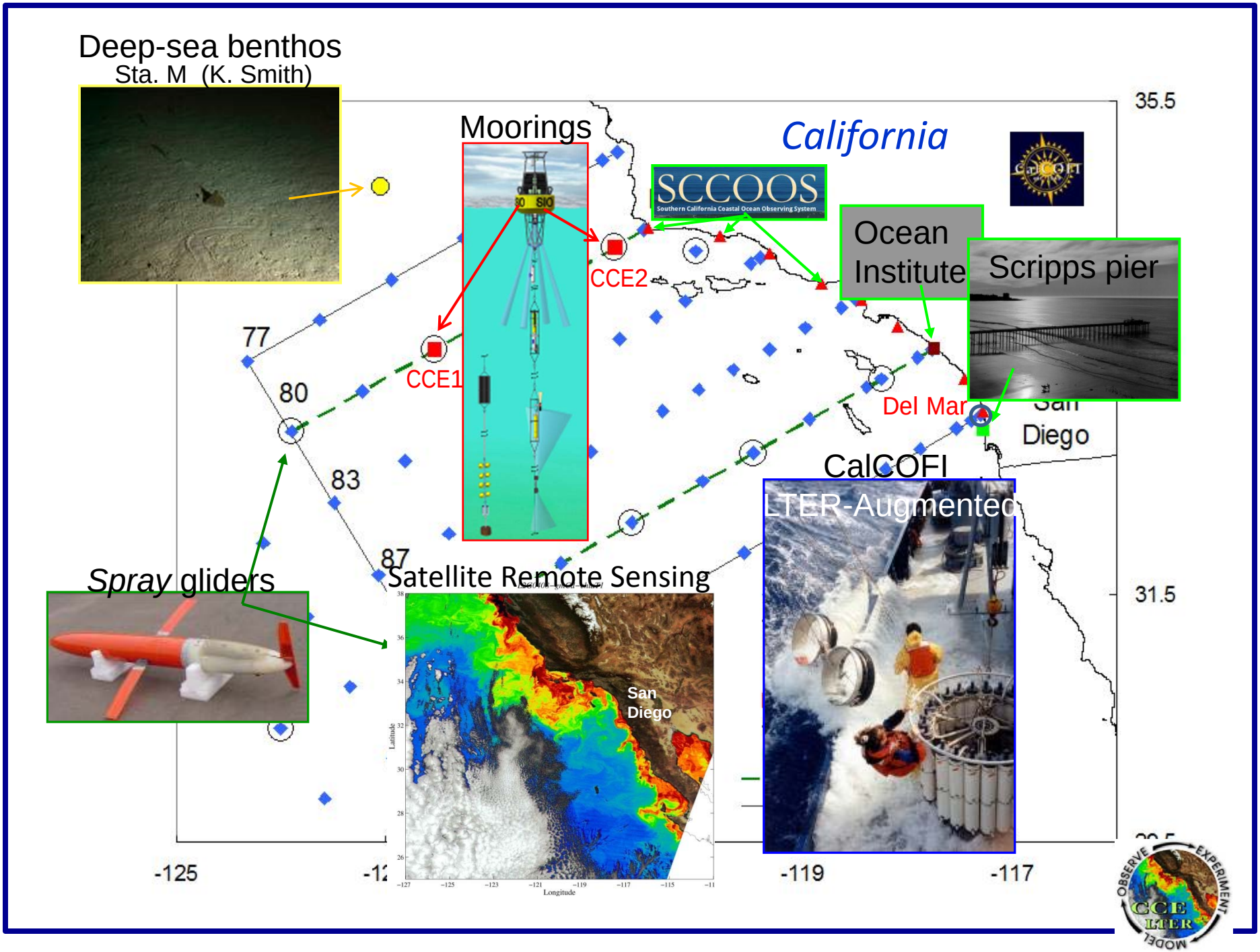
pCO_2 to marine mammals, integrated with 4D ocean modeling

figure design:
U. Send lab



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

Ohman et al. (2013) *Oceanography*


Deep-sea benthos
Sta. M (K. Smith)
Moorings
California
SCCOOS
Southern California Coastal Ocean Observing System
Ocean Institute
Scripps pier
CCE2
CCE1
Del Mar
San Diego
CalCOFI
LTER-Augmented
Spray gliders
Satellite Remote Sensing
San Diego
Latitude
Longitude
77
80
83
87
35.5
31.5
-125
-119
-117
OBSERVE
EXPERIMENT
MODEL
CCE
LTER

'Seasonal' variations

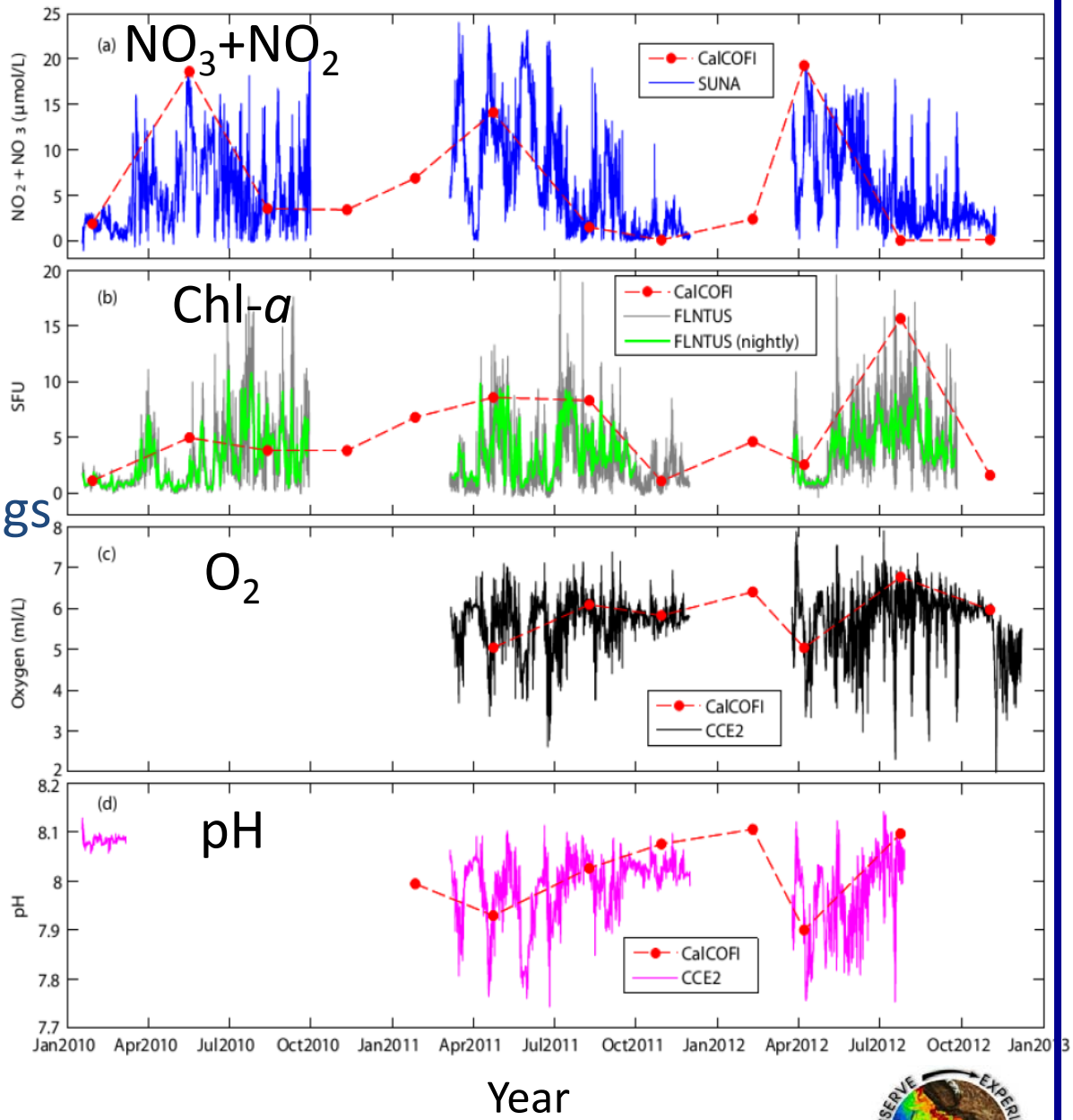
shipboard sampling

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

'Event-scale' variations

multi-disciplinary moorings

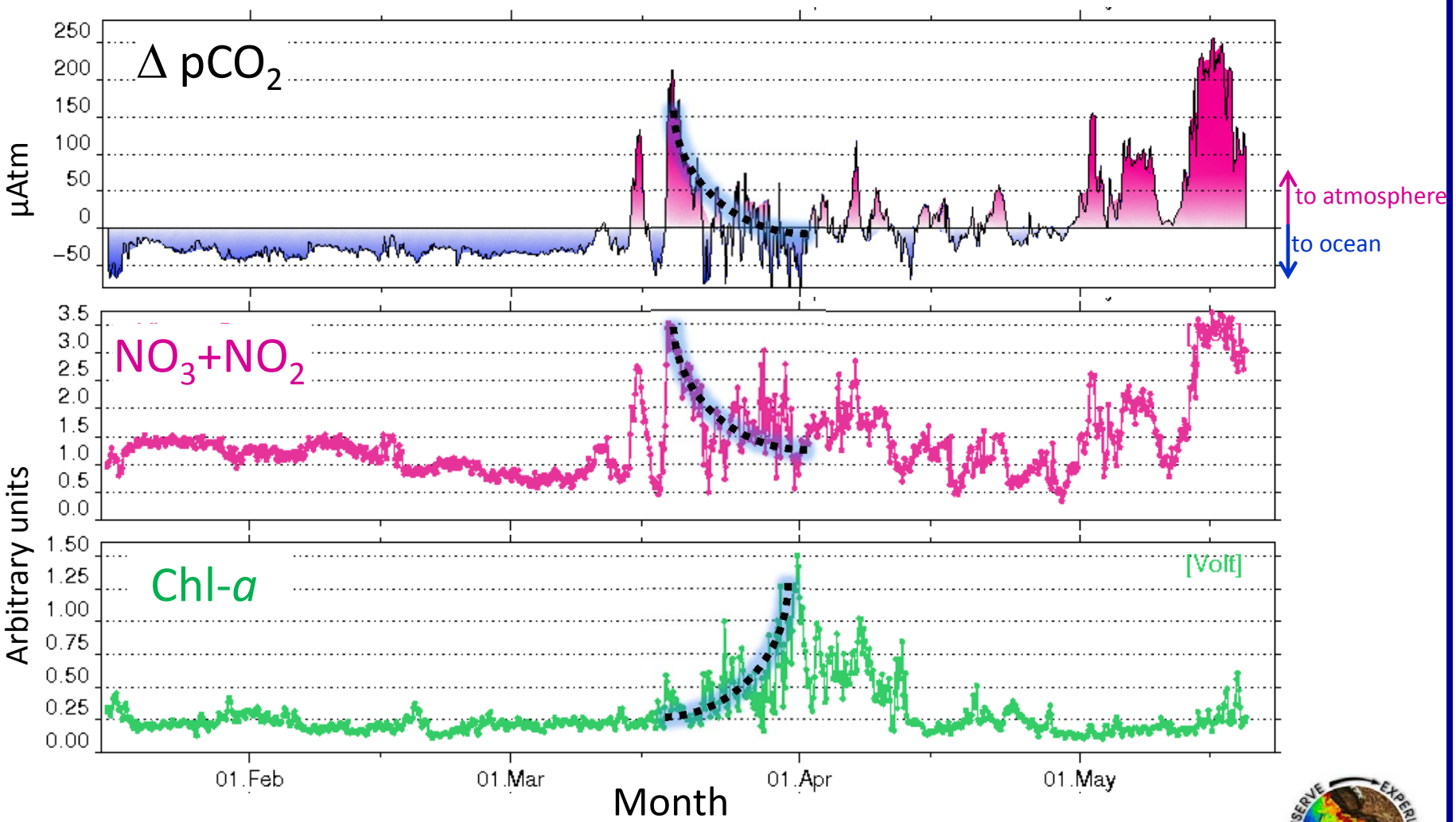
(continuous)



Send, Ohman, Martz (unpubl.)

Upwelling events

High-resolution time series reveal detailed timing of responses



Send, Ohman, Feely (unpubl.)

The CCE moorings are highly leveraged

- CalCOFI
- CCE-LTER (Long-Term Ecological Research) site
- pCO_2
- *Spray* gliders
- Satellite remote sensing
- Modeling programs

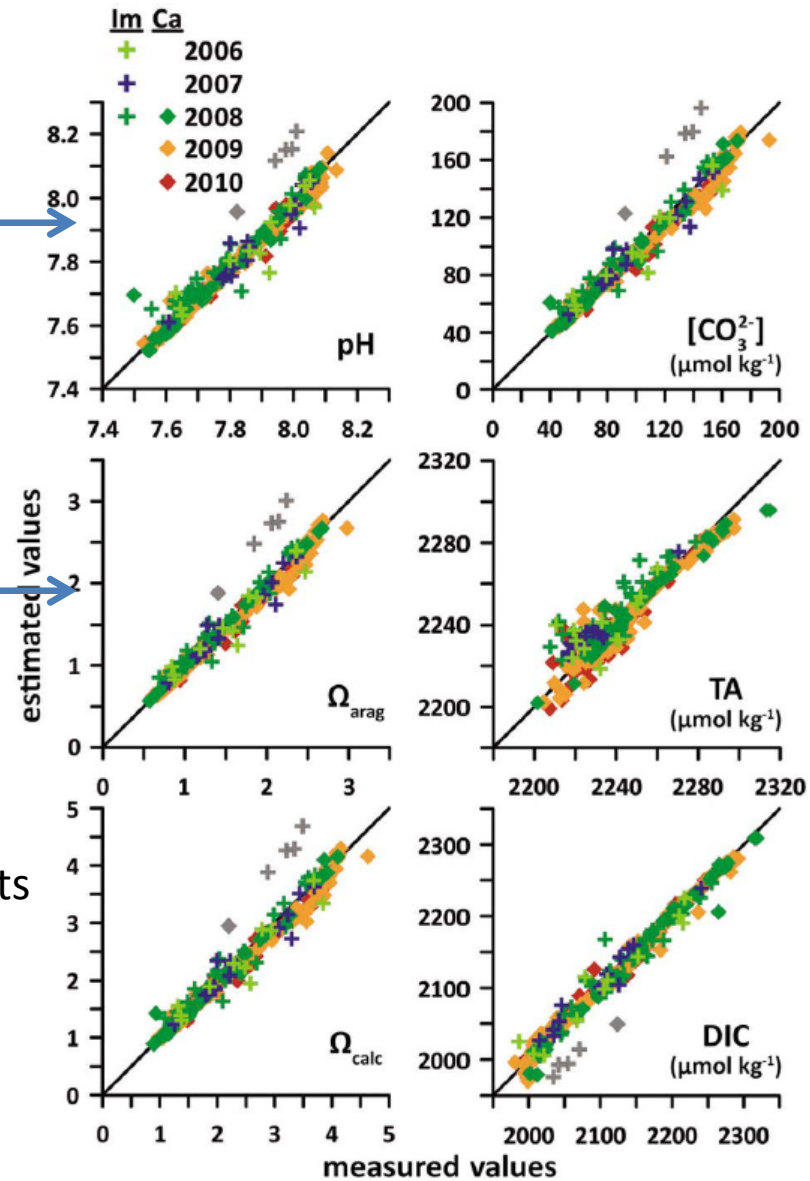
Proxy relationships for Carbonate System Variables

from CalCOFI/CCE mooring region

Alin et al. (2012)

$pH = f(Temp, O_2)$

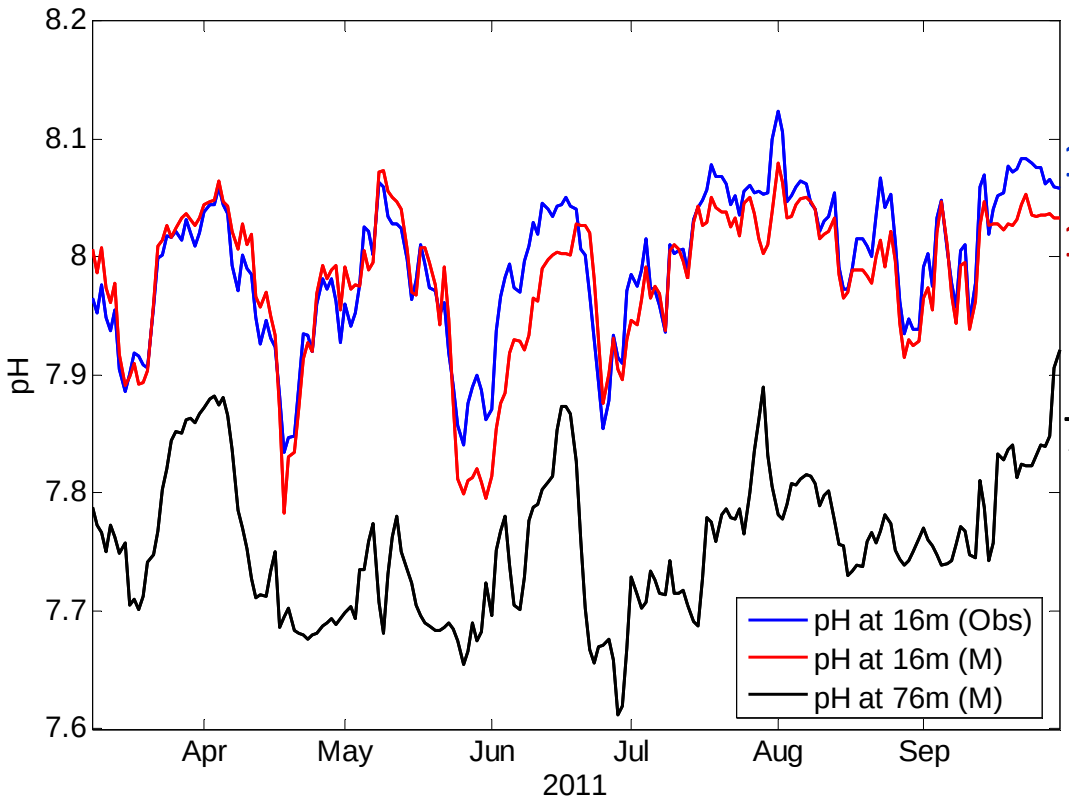
$\Omega_{arag} = f(Temp, O_2)$



Based largely on CalCOFI measurements

Applied to autonomous sensors

Independent Validation



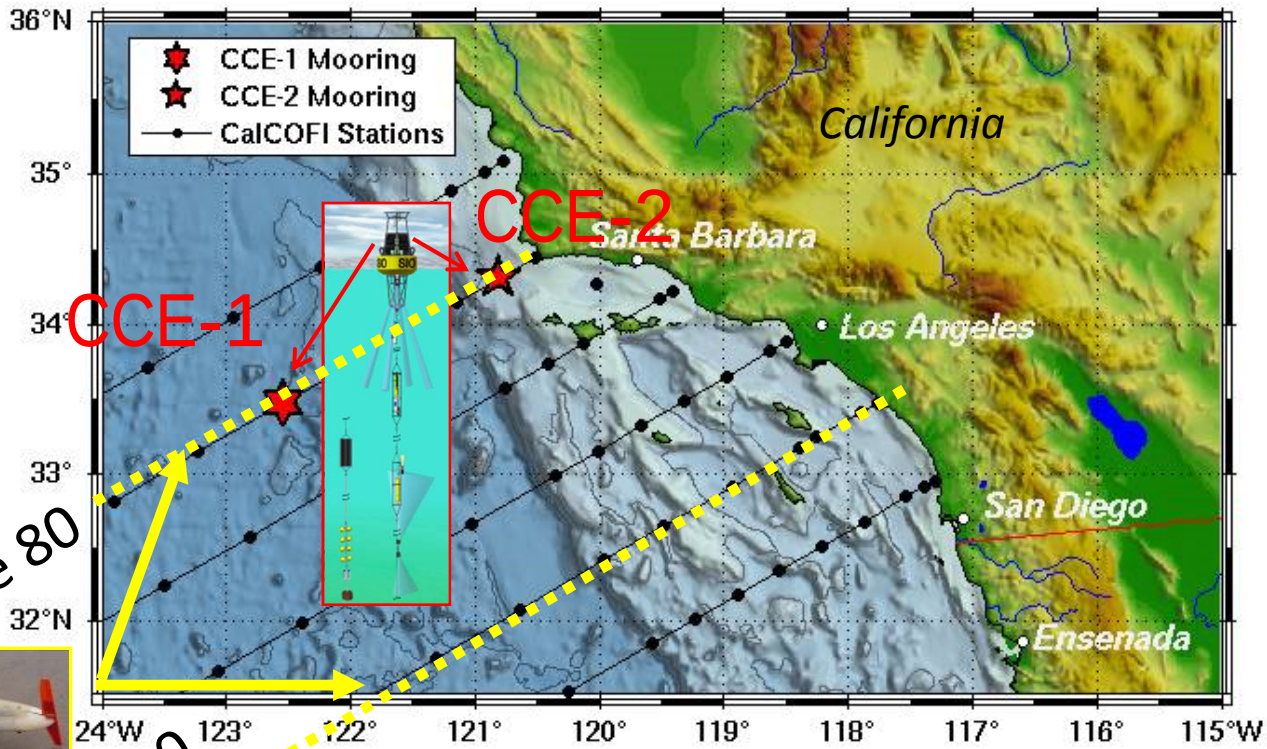
16 m – pH (Measured) (SeapHOx)

16 m – pH (Proxy estimate)

76 m – pH (Proxy estimate)

Todd Martz (unpubl.)
Scripps

Moorings + Gliders

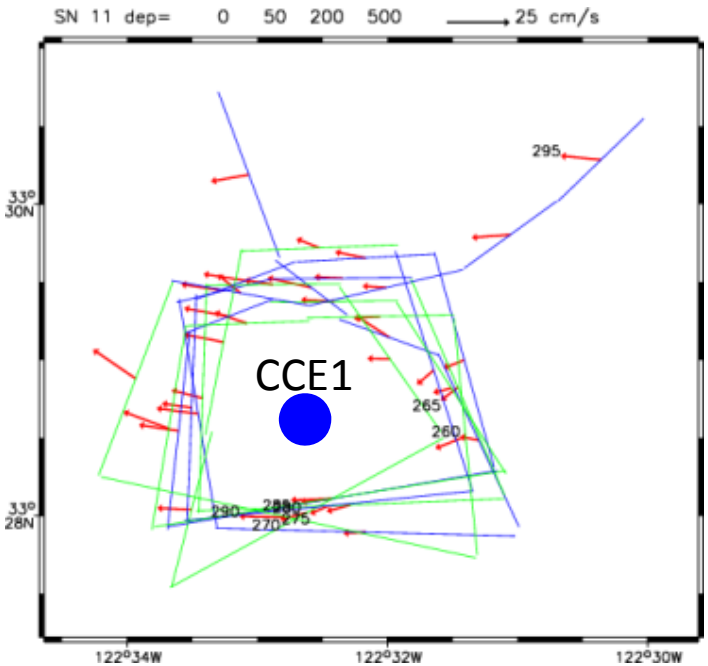


Line 80

Line 90

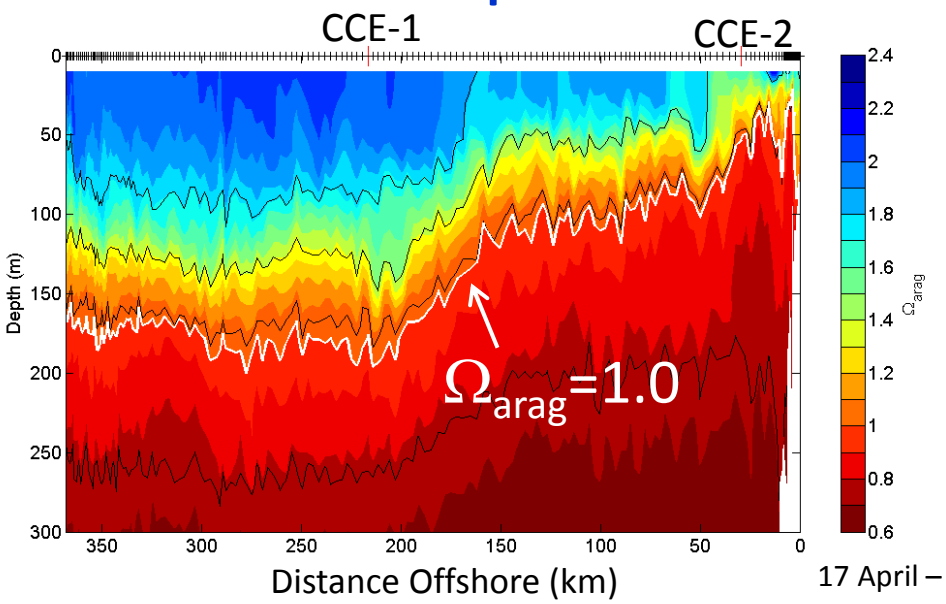
Spray gliders

Mooring vs. Glider comparisons



Upwelling/Acidification Events

Spatial variations

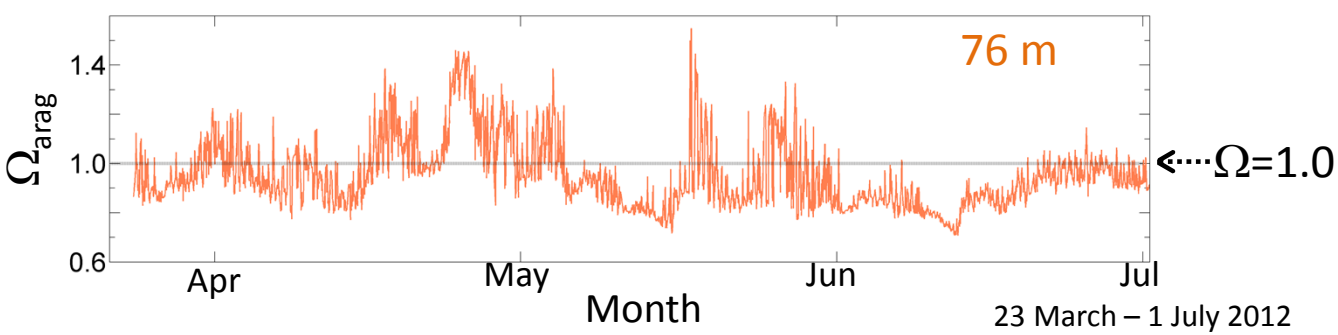


17 April – 9 May 2012

Ohman et al. (2013)

Temporal variations

CCE-2 Mooring



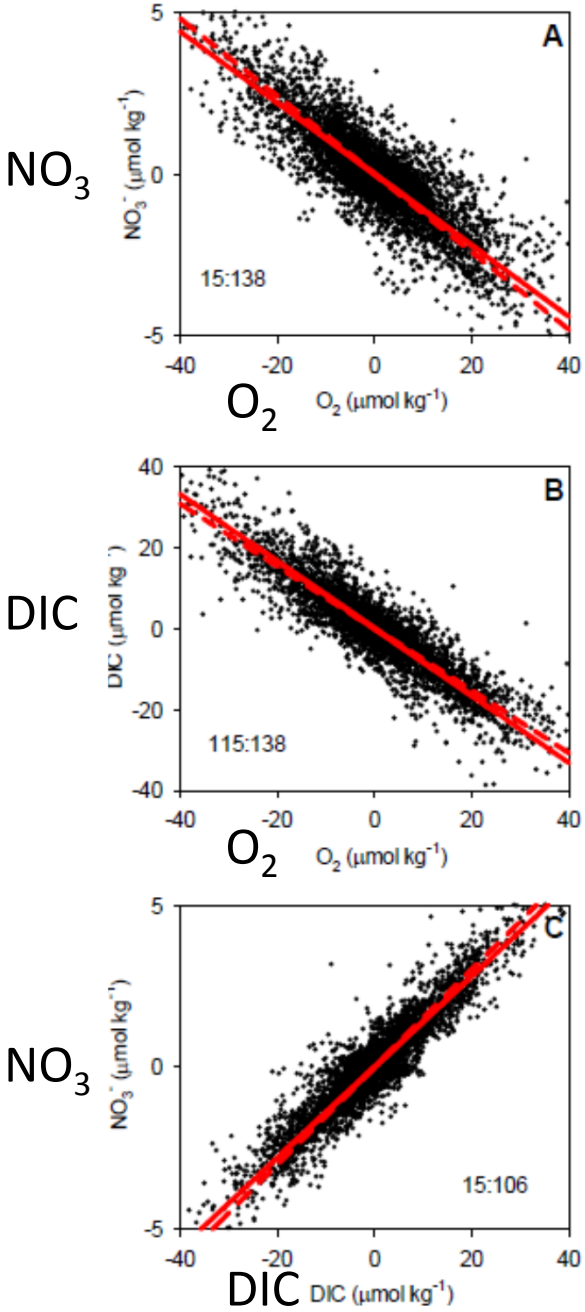
23 March – 1 July 2012

Ability of primary production to sustain fisheries (i.e., high f-ratios) ?

$$f = \frac{New\ Production}{New + Regenerated\ Production}$$

(assuming export production α new production)

CCE2 mooring



Data (Model II regression)
Redfield ratio

Excellent agreement of mean values w/ Redfield Ratio

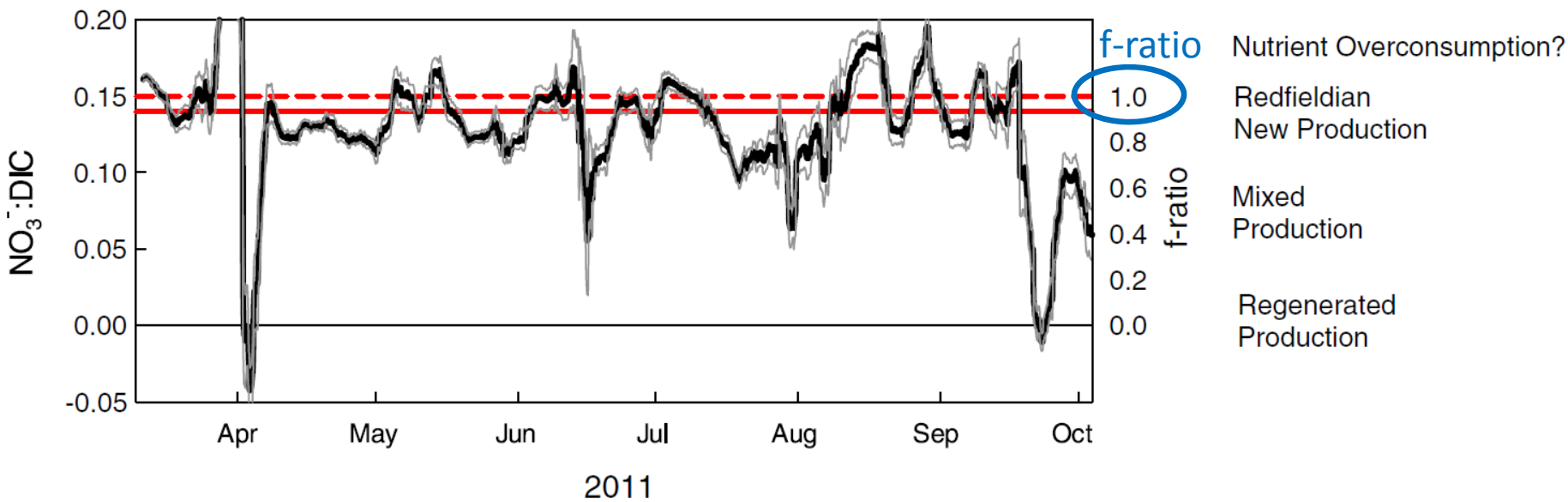
Martz et al. (2014) GRL

33 h high pass filter

Dynamic variability of f-ratio

What part of primary production can sustain fisheries ?

CCE2 mooring



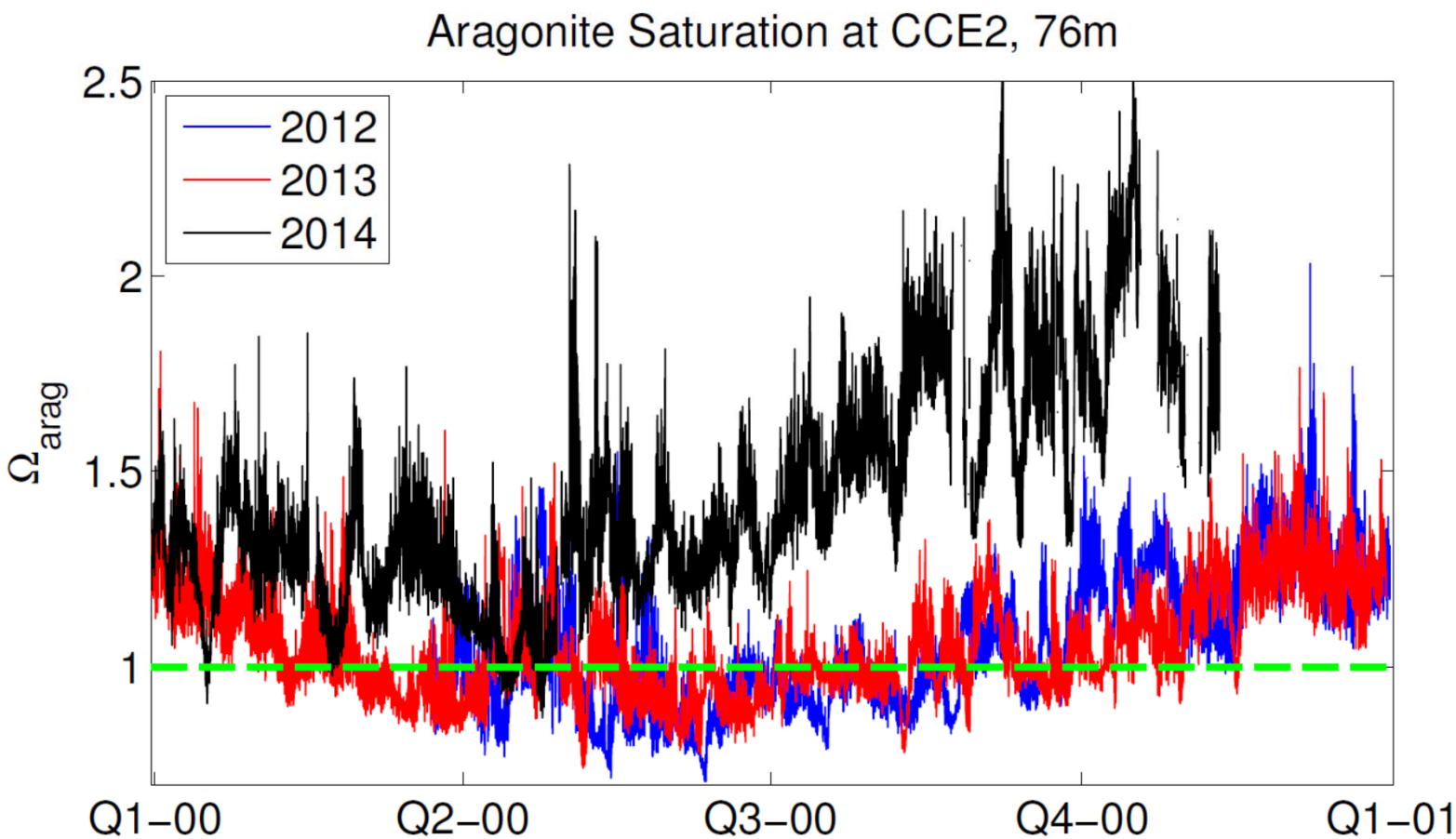
mean 8 mo. ratio

Redfield ratio

Martz et al. (2014) GRL

33 h high pass filter

Resolving Interannual Variability



Send, Ohman, et al. (unpubl.)

Summary

- CCE moorings have revealed key '**event-scale**' processes in the California Current Ecosystem

  (e.g., upwelling; aragonite undersaturation; f-ratio events)

- Characterization of the **statistical distributions** (i.e., **magnitude, frequency, duration**) of such events is essential for assessing biotic impacts:

  - guidelines for experimental design (e.g., OA, hypoxia)
  - process studies
  - building the next generation of ecosystem models
  - assessing climate change

- Sustained autonomous measurements need to be **integrated** with:

  - shipboard validation
  - rigorous sensor calibrations
  - QA/QC