Climate variability and change: time series observations from a coastal ocean

Francisco Chavez and collaborators

Monterey Bay Aquarium Research Institute

Two things never to do with a time series:

1) Start one; 2) End one

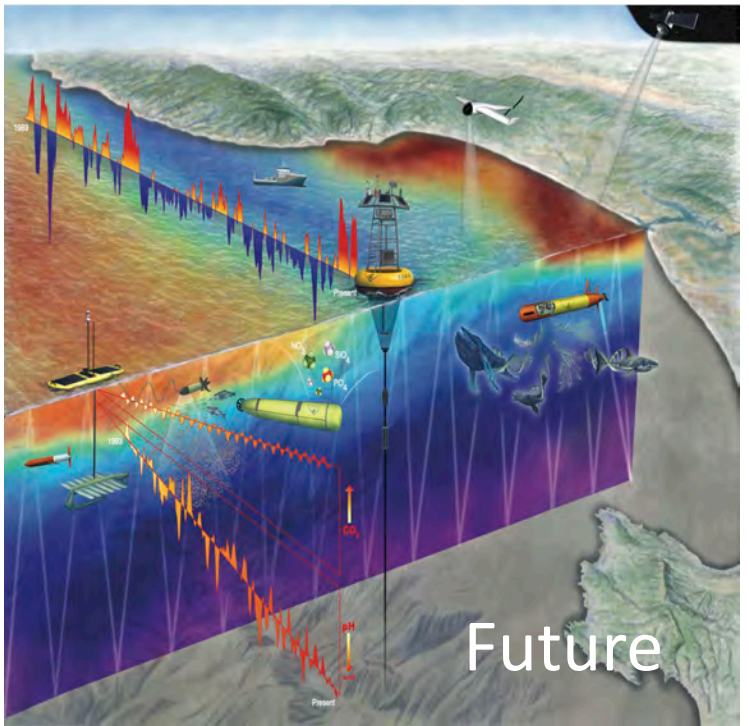
Climate variability and change: time series observations from a coastal ocean

Francisco Chavez and collaborators

Monterey Bay Aquarium Research Institute

Two things never to do with a time series:
1) Start one; 2) End one

Past

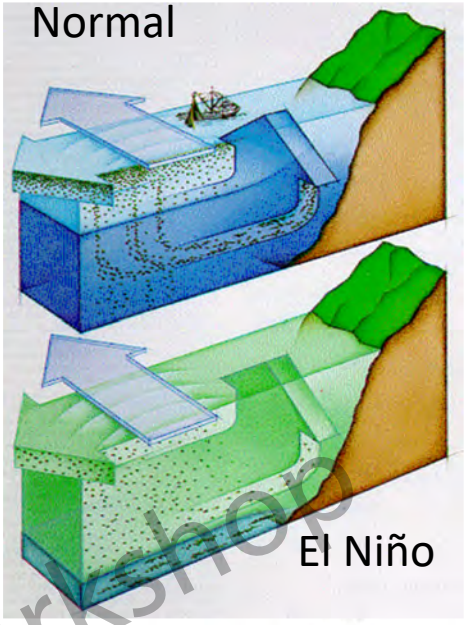


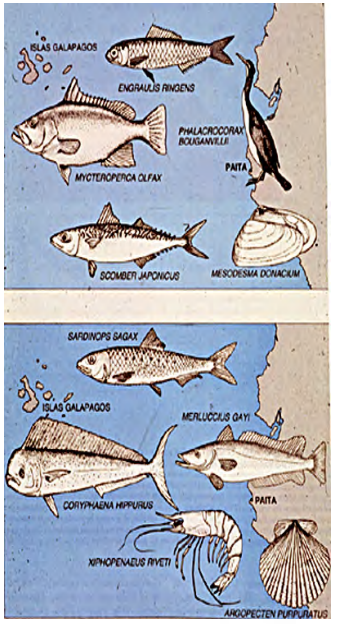
Future

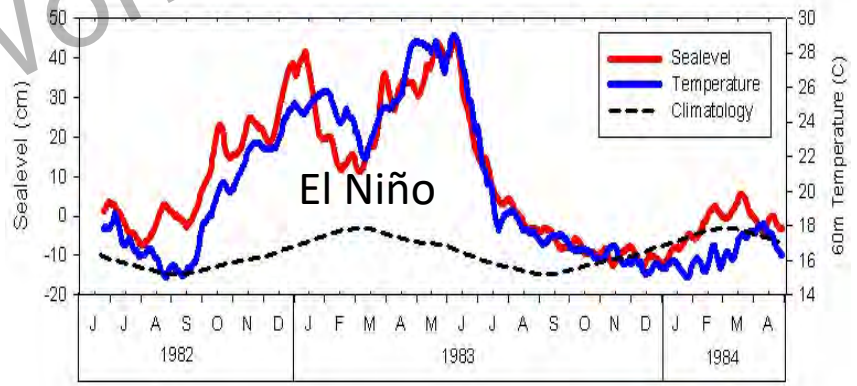
The concept of "process" time series

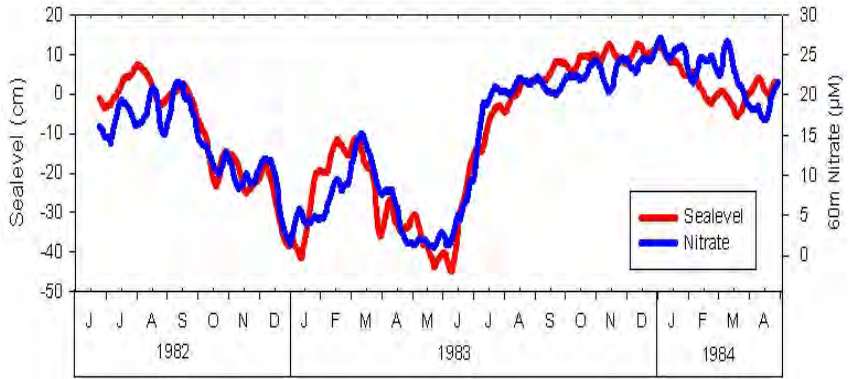
Galapagos

Paita



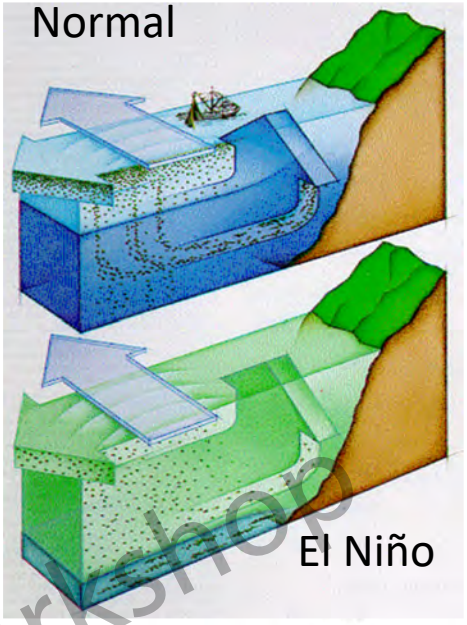


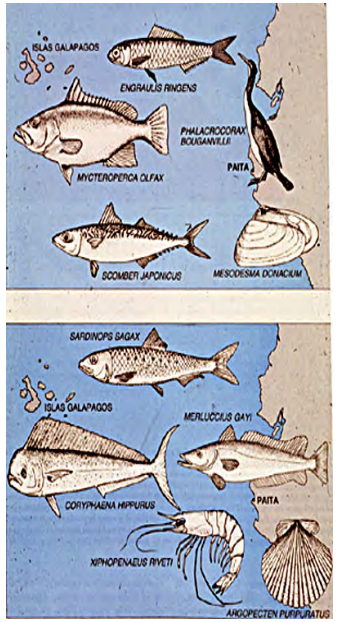


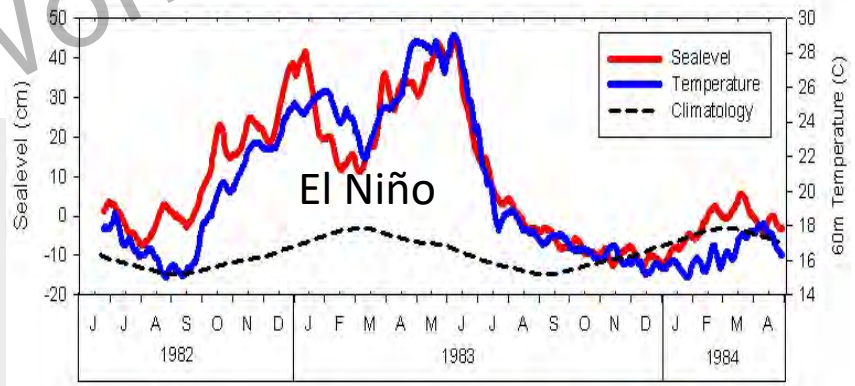


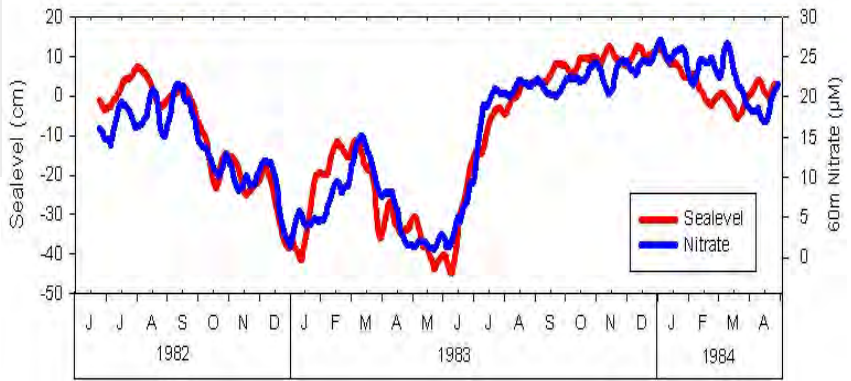
Process: Propagating disturbances observed in sea level have biological impacts that can be measured

The concept of "process" time series









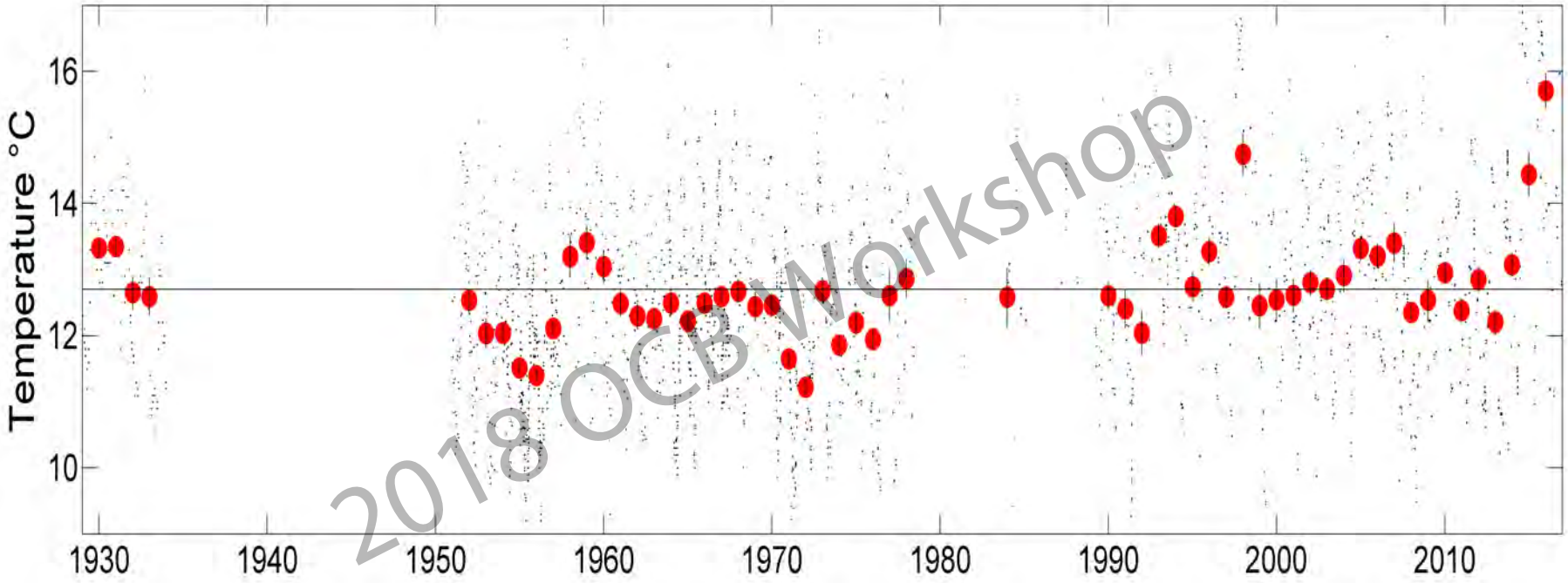
Depth of thermocline/nutricline a fundamental property in upwelling ecosystems and globally

Process: Propagating disturbances observed in sea level have biological impacts that can be measured

Monterey Bay Time Series

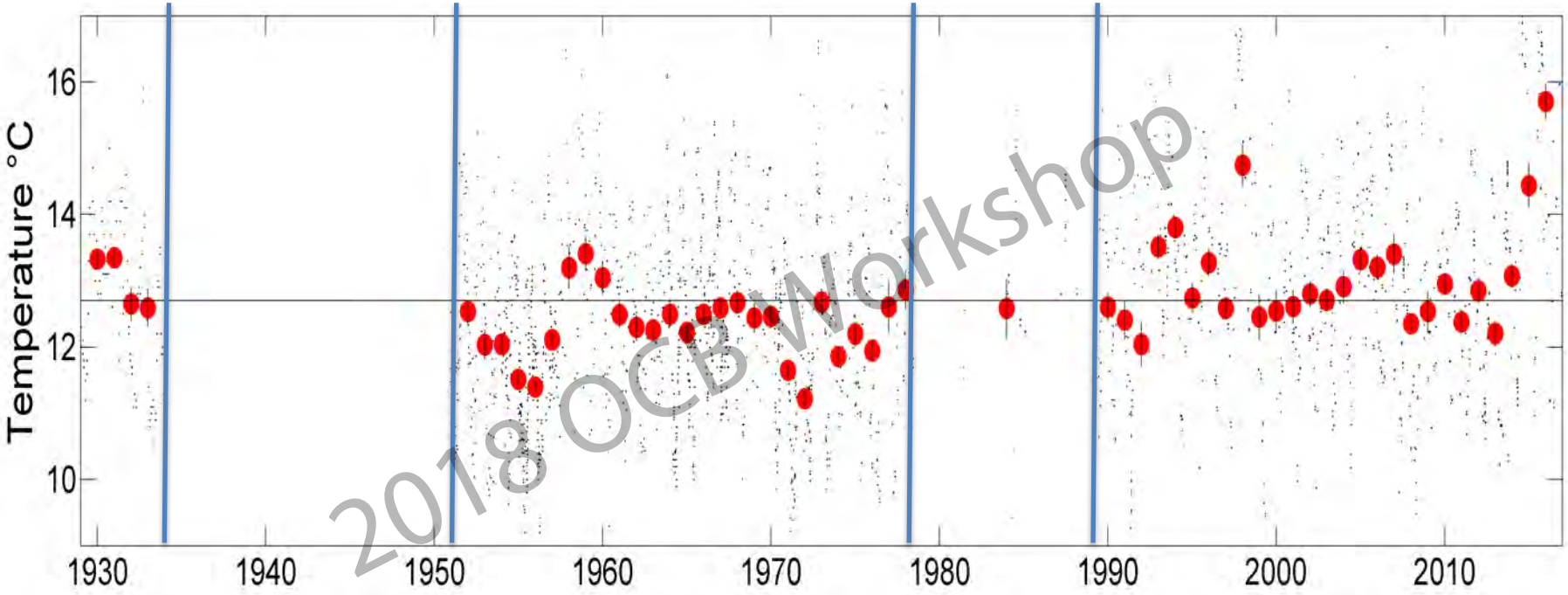
- Since 1989 combines ship, mooring, AUVs/gliders, satellite and modeling
- Resulted in over 300 publications
- Generates new ideas and process studies
- Provides a natural laboratory for technology development
- Studies biological response to climate variability and global change

Station M1/H3 observed in situ since early 1920s



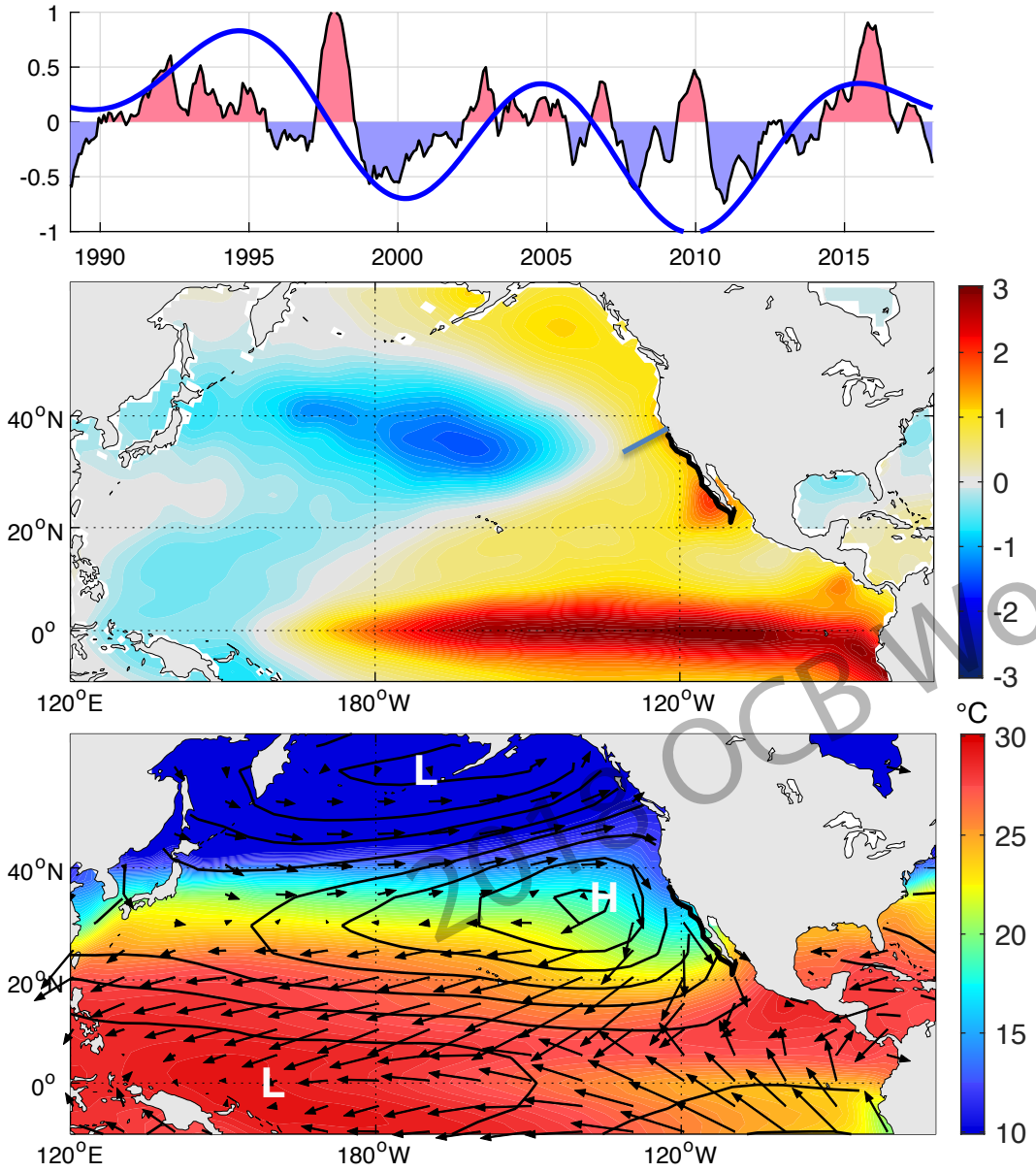
Chavez et al., 2017, Oceanography

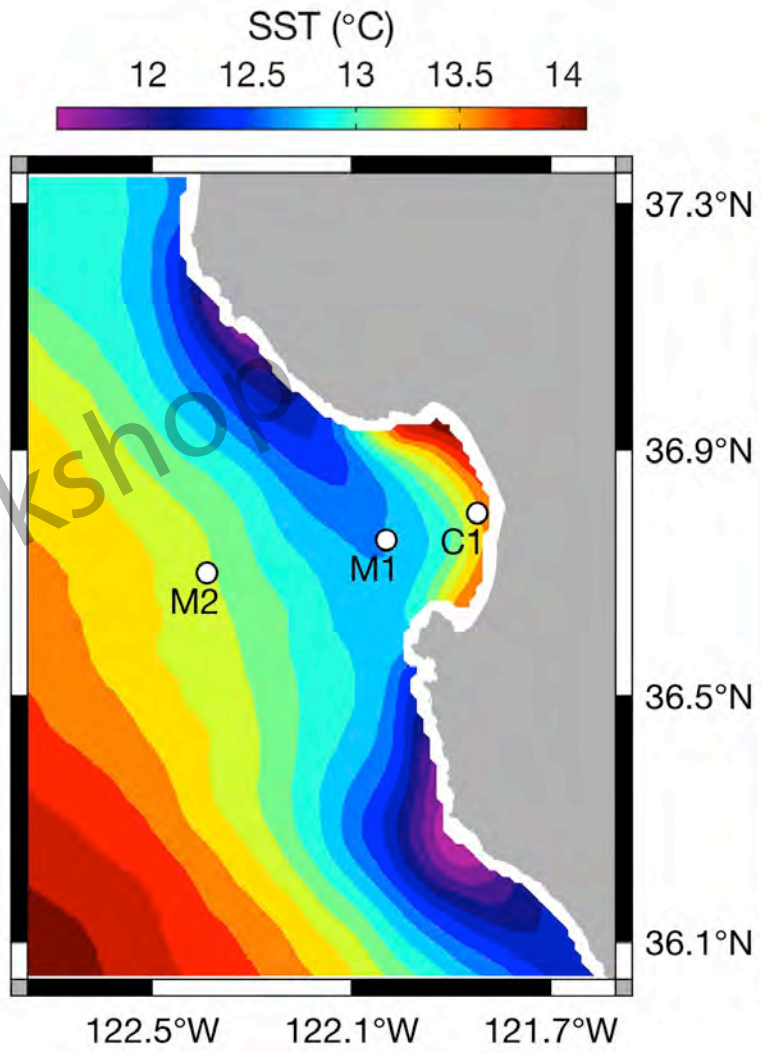
Station M1/H3 observed in situ since early 1920s



Hopkins CalCOFI MLML MBARI

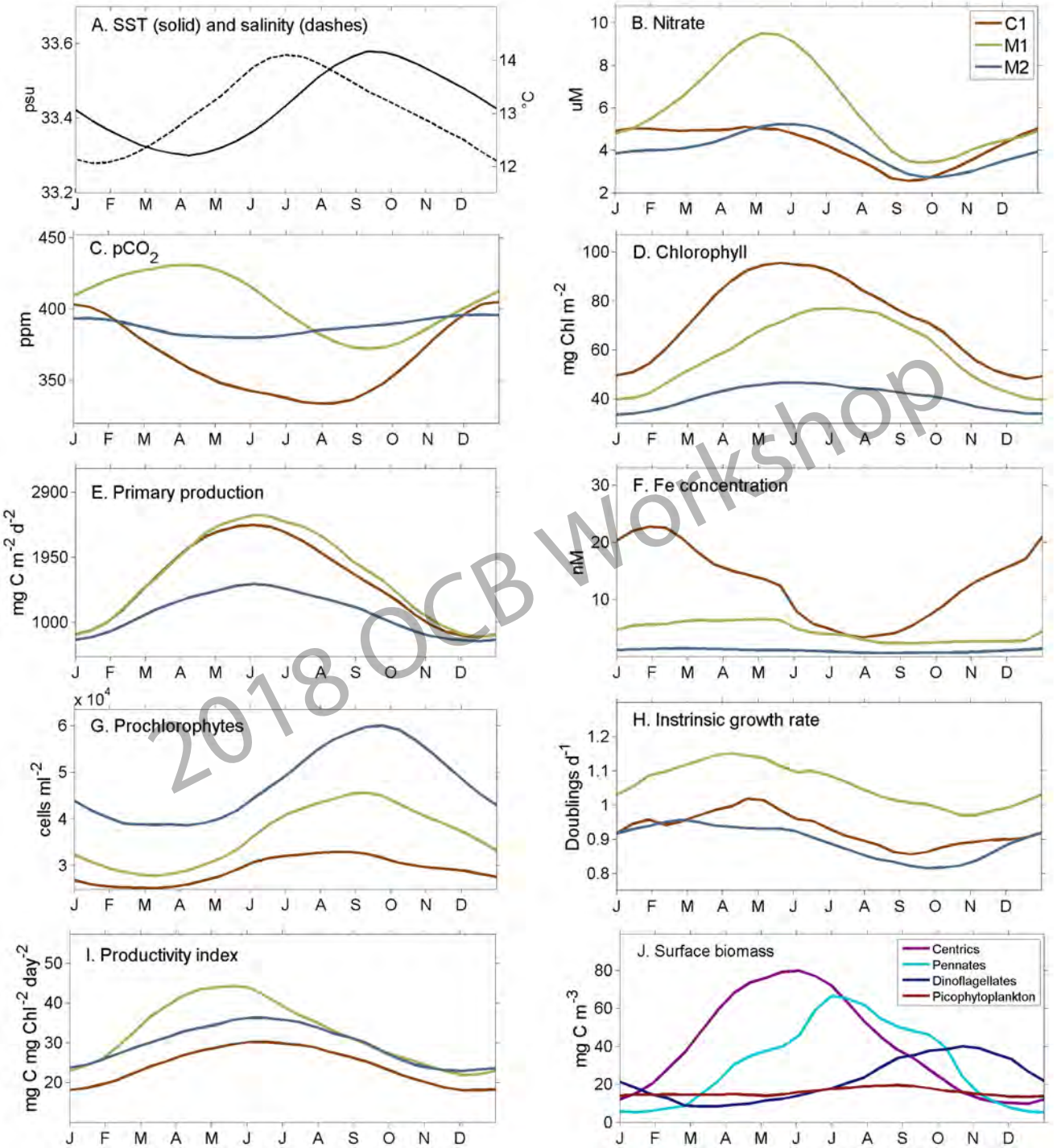
Chavez et al., 2017, Oceanography



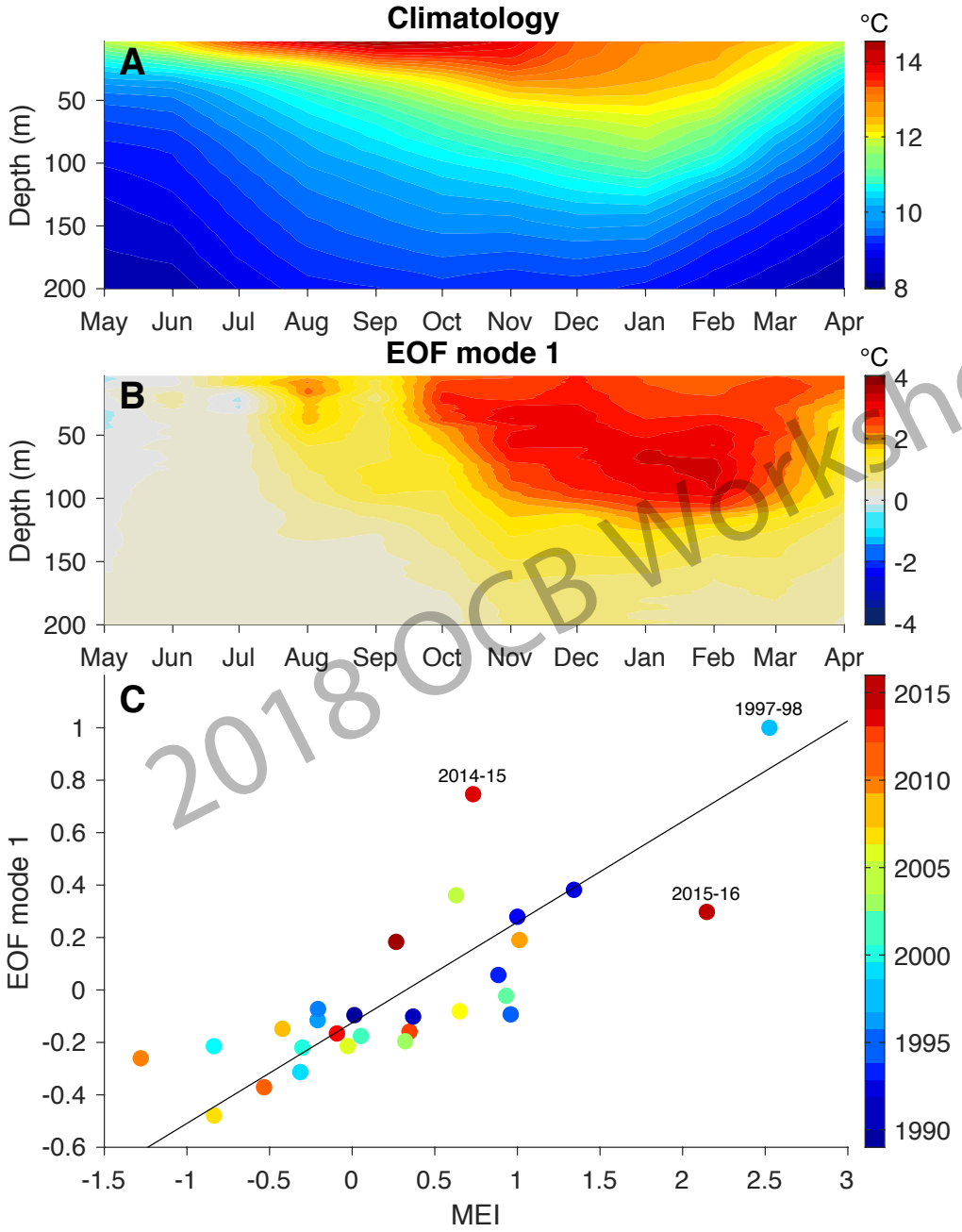


Space and time are intertwined especially for biology

Chavez et al., 2017, Oceanography

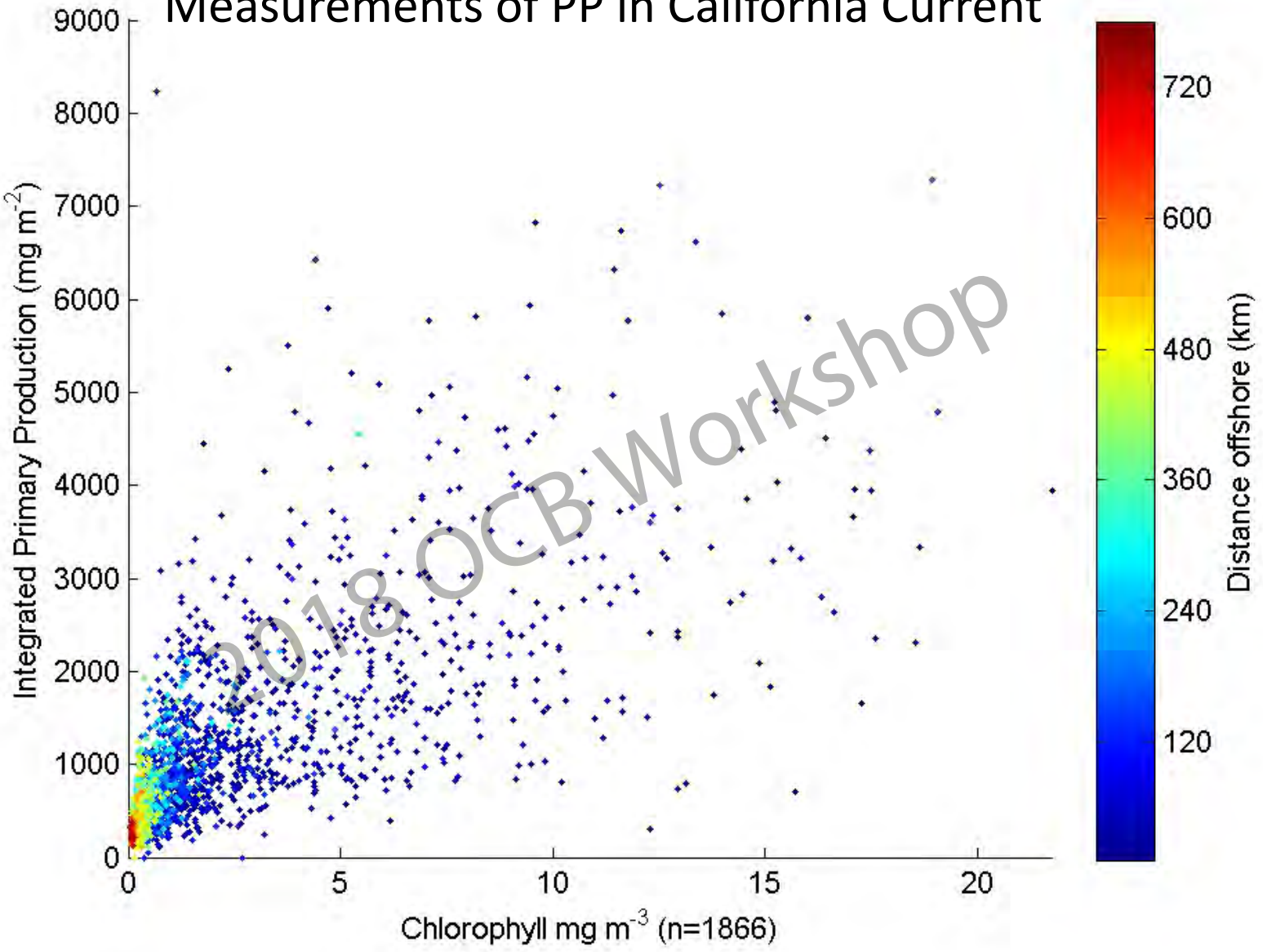


Strong relations between T and climate, less so for biology



El Niño impacts low productivity winter season

Measurements of PP in California Current

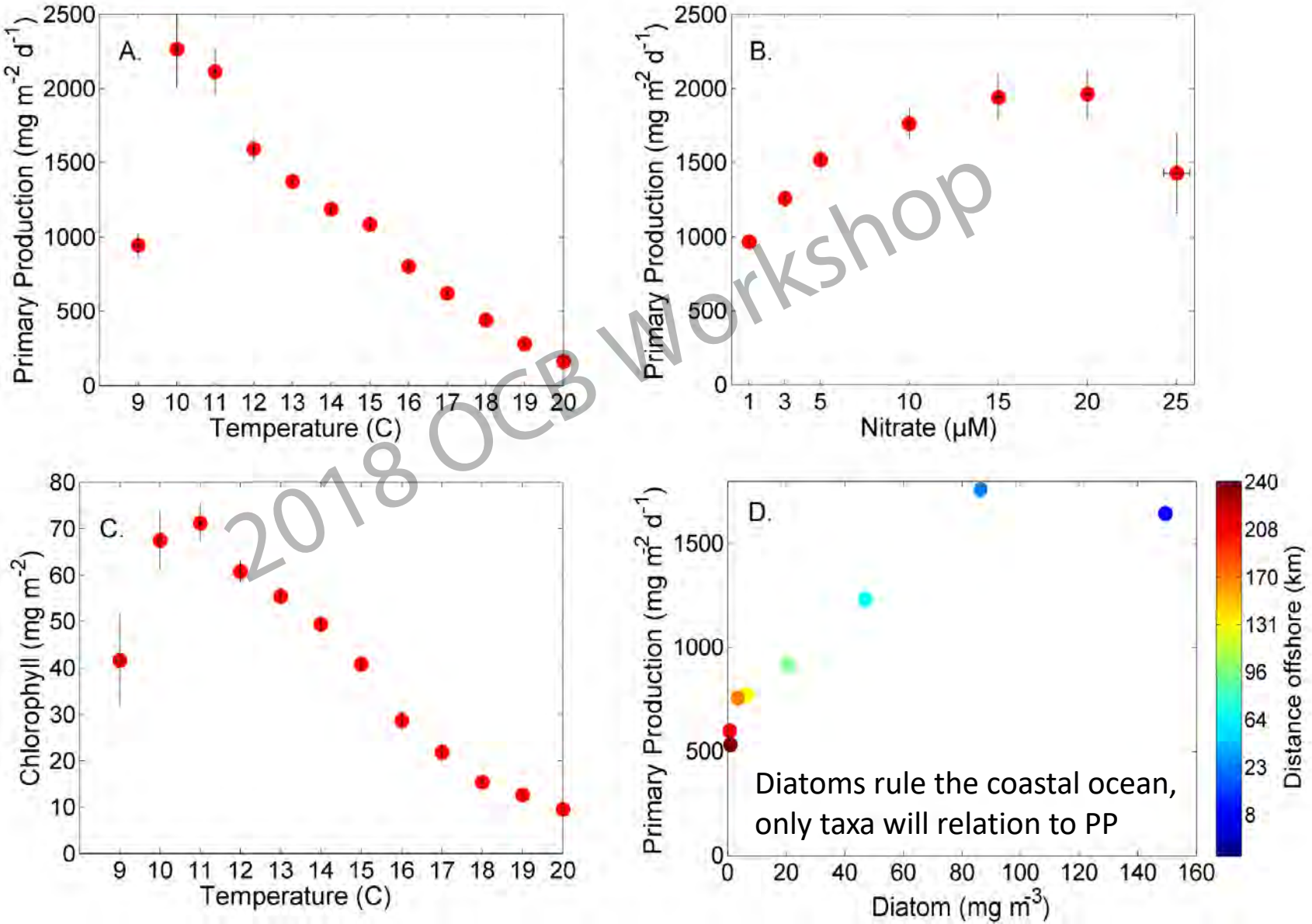


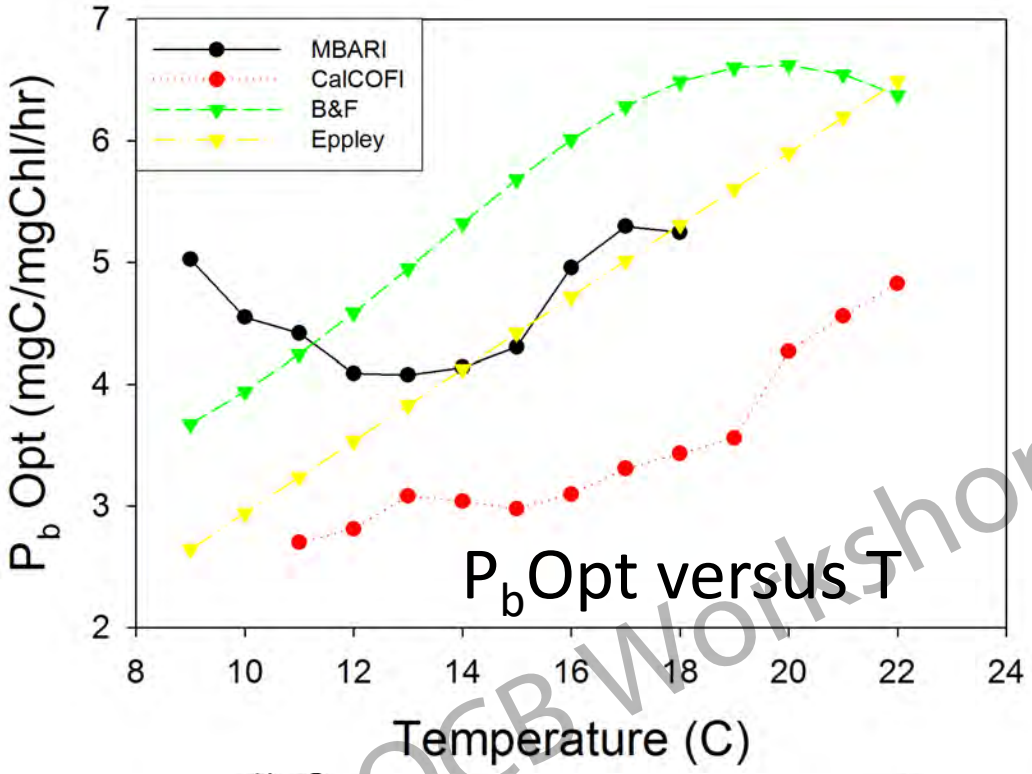
700

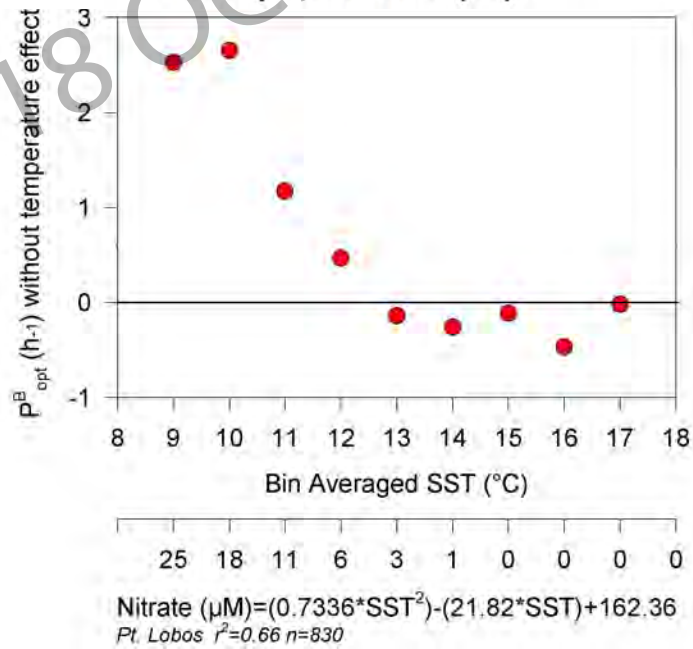
mmole C/m2/day

0

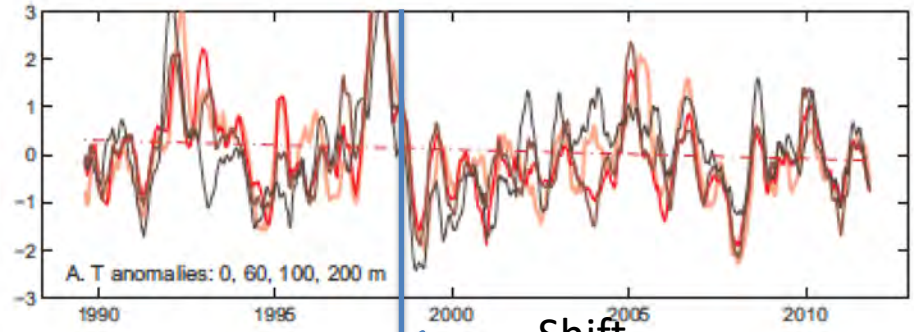
Space and time lead to nonlinear relations, and low correlations between physics/chemistry and biology







Temp

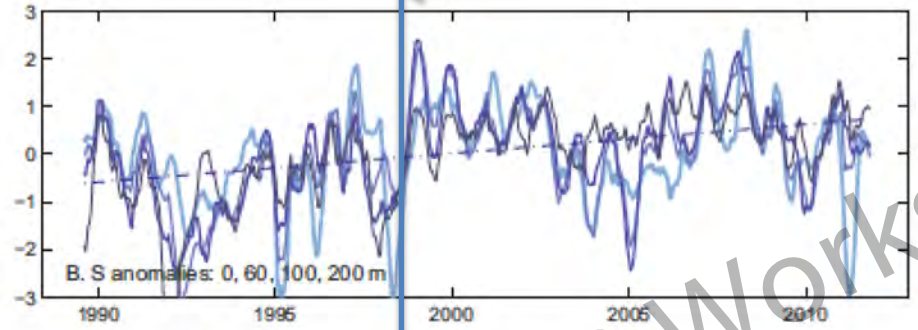


1988 to 2013

Temperature decreasing

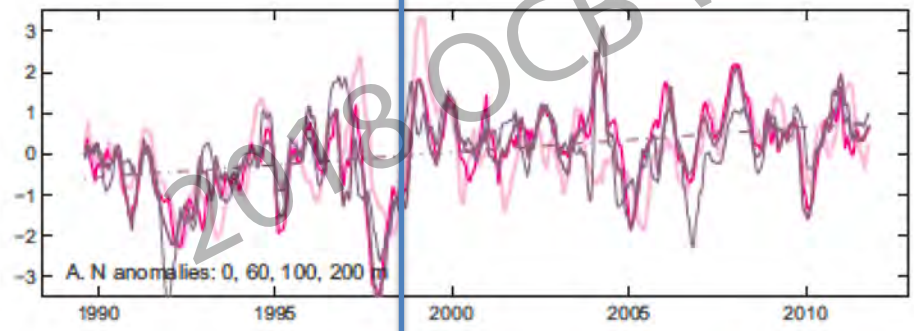
Shift

Salinity



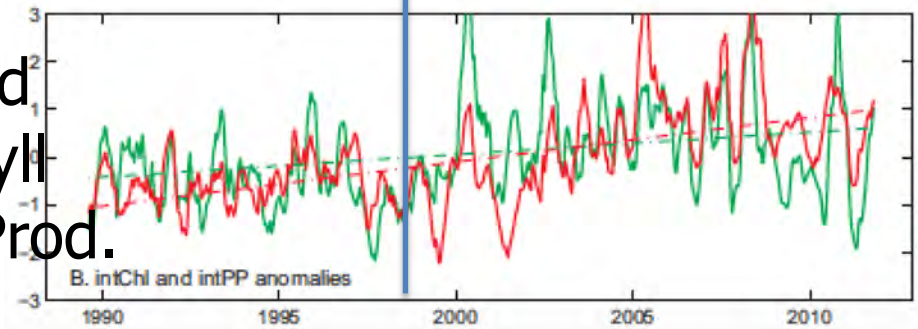
Salinity increasing

Nitrate



Nitrate increasing

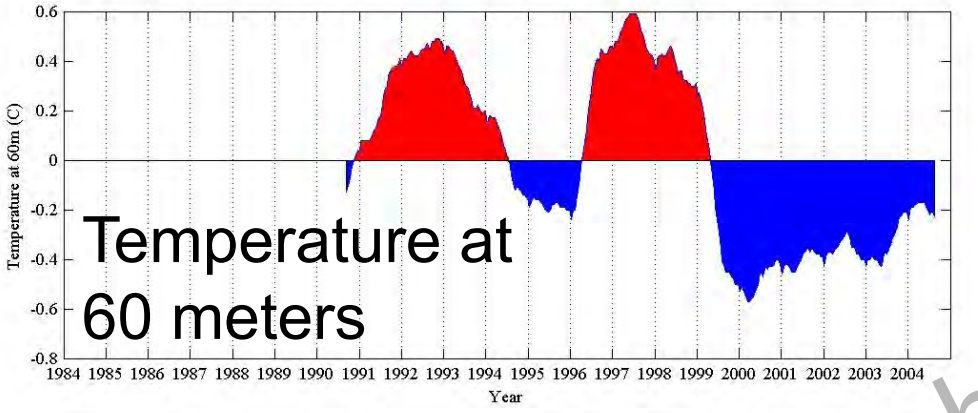
Integrated Chlorophyll Primary Prod.



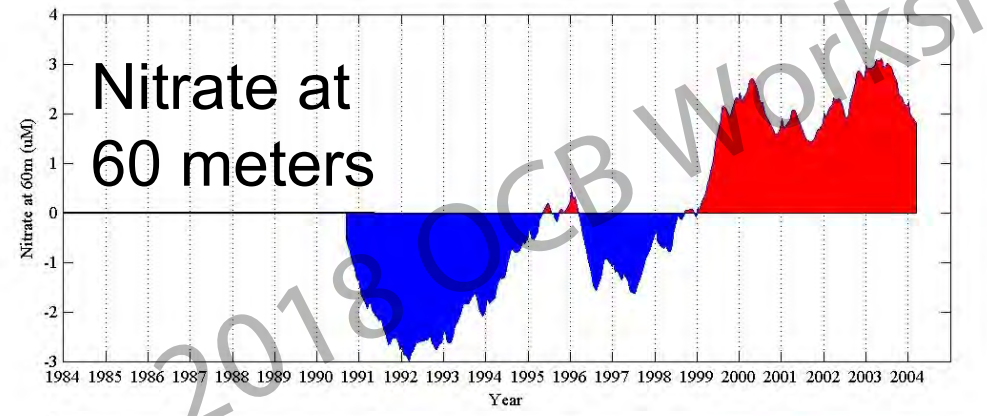
Primary productivity Chlorophyll increasing, PP faster than Chl and P biomass, faster growth

Pennington and Chavez, 2017

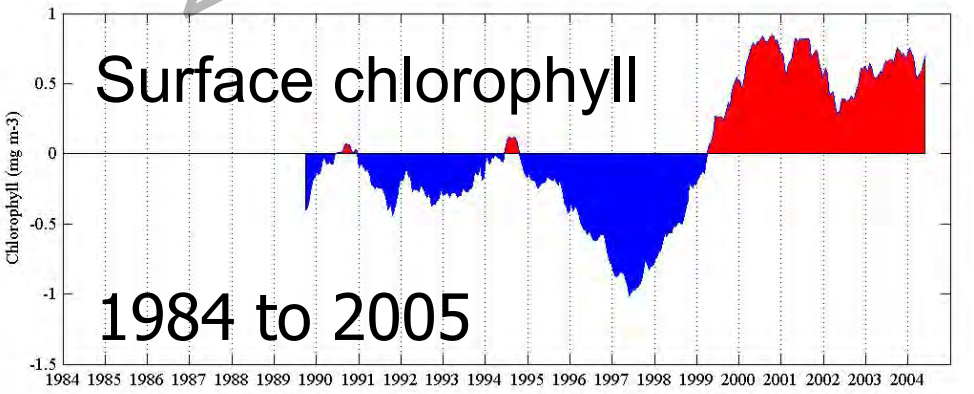
Greening correlated with cooling and increase of nutrients at depth



Monterey Bay
Temperature
at Depth



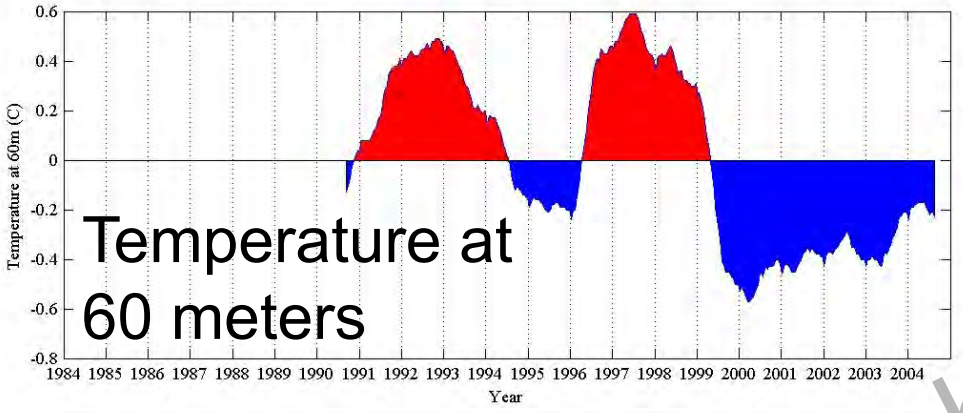
Monterey Bay
Nitrate at Depth



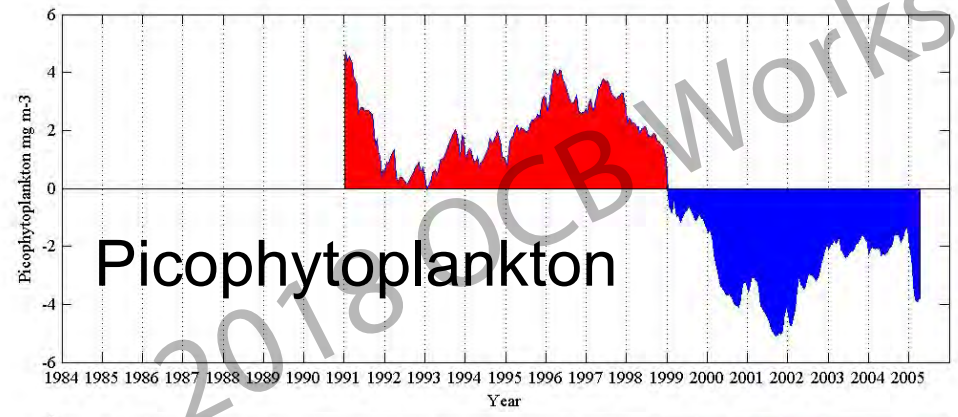
Monterey Bay
Surface
Chlorophyll

1985 1990 1995 2000 2005

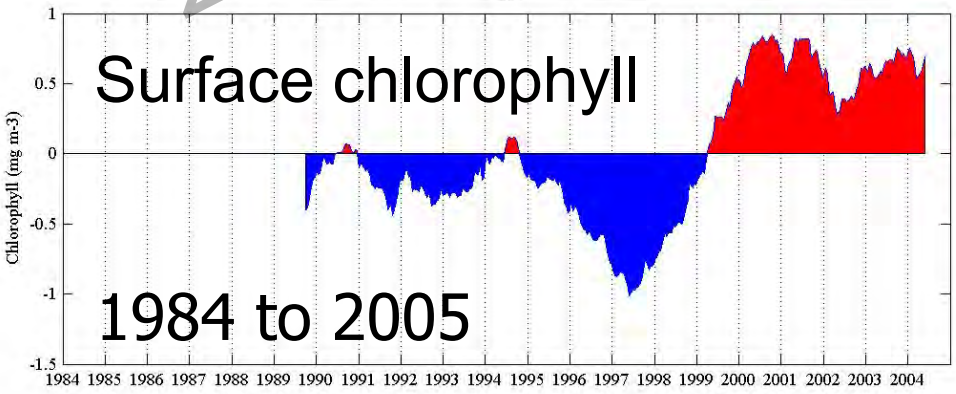
Greening correlated with cooling and increase of nutrients at depth



Monterey Bay
Temperature
at Depth

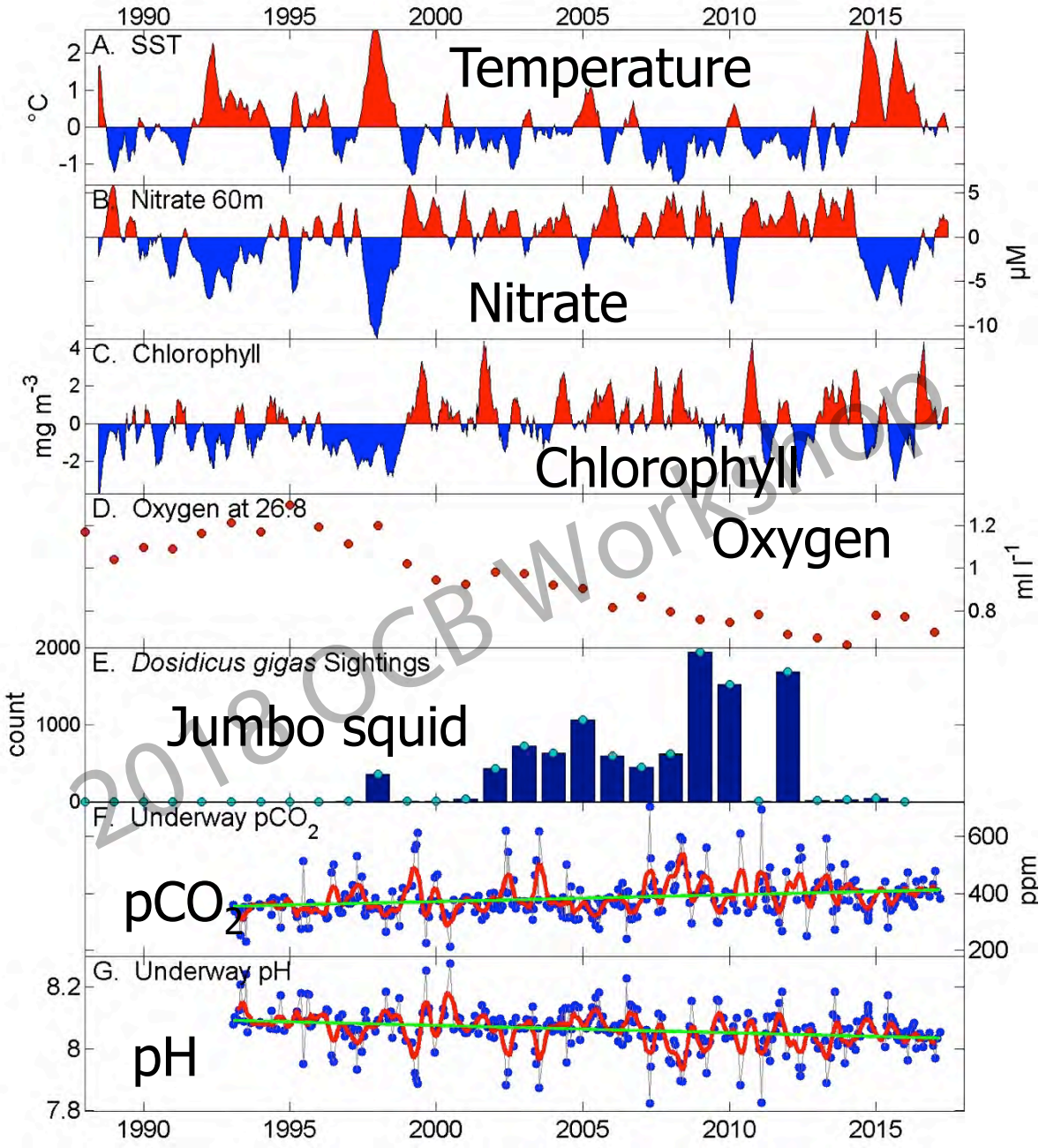


Monterey Bay
Nitrate at Depth

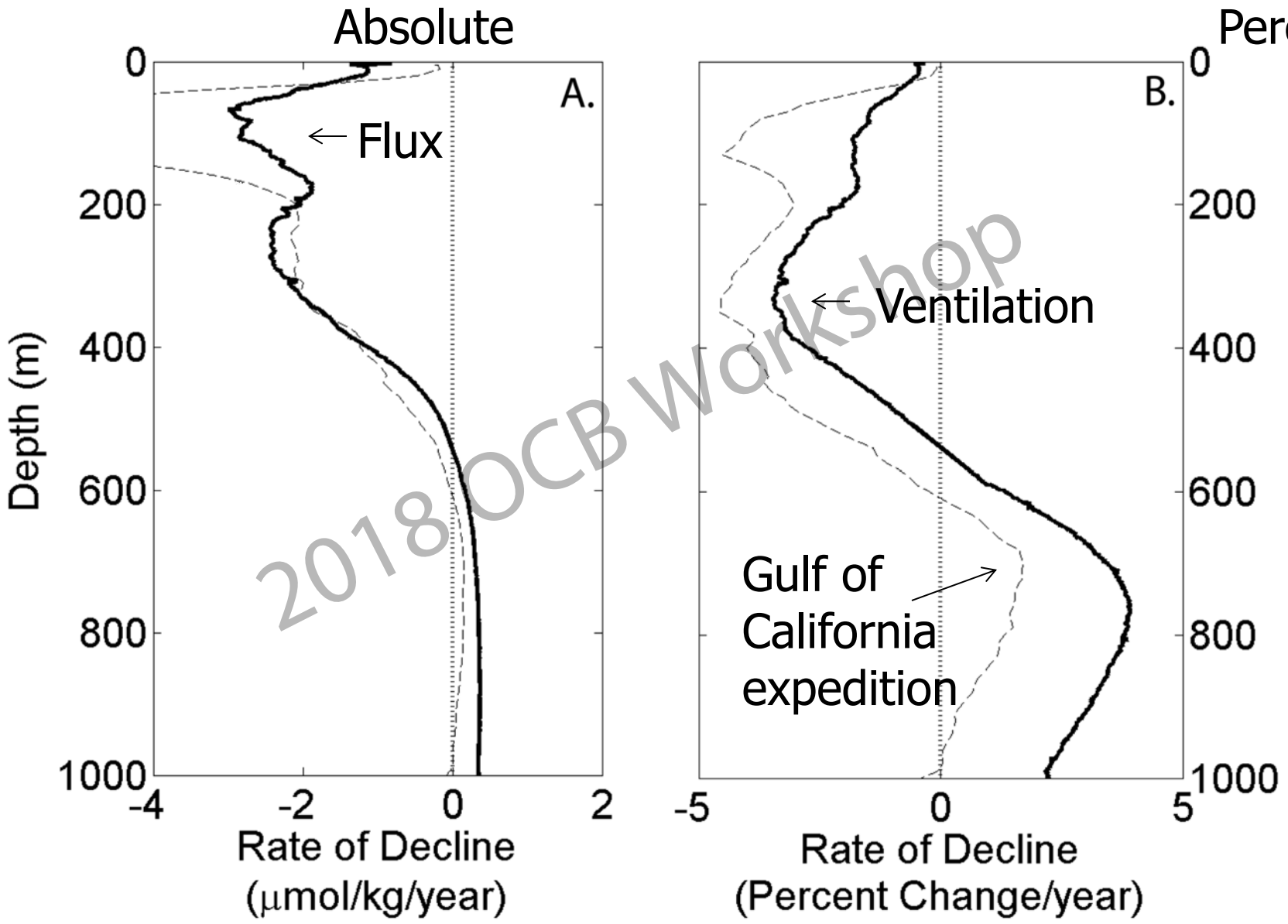


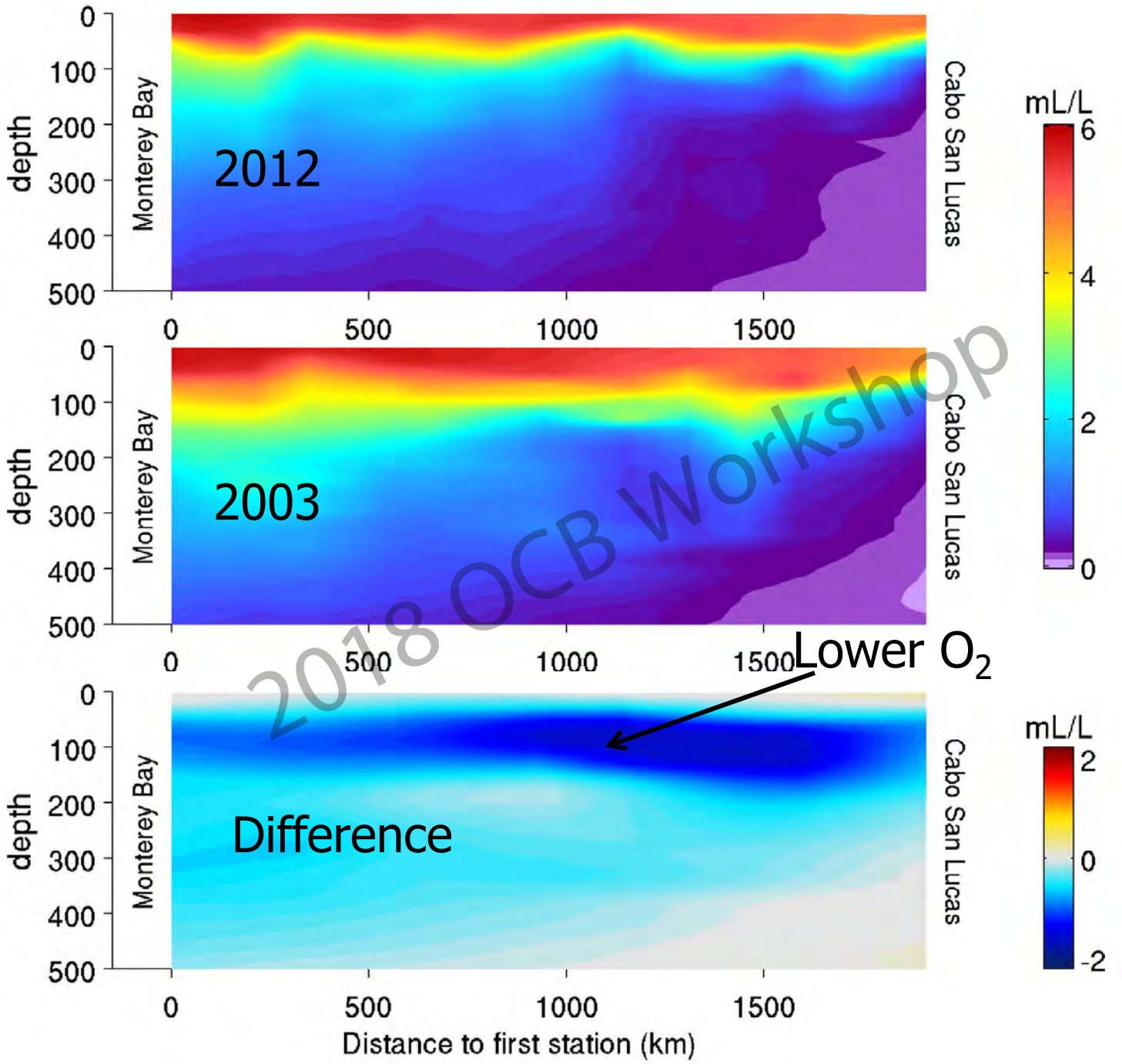
Monterey Bay
Surface
Chlorophyll

1985 1990 1995 2000 2005

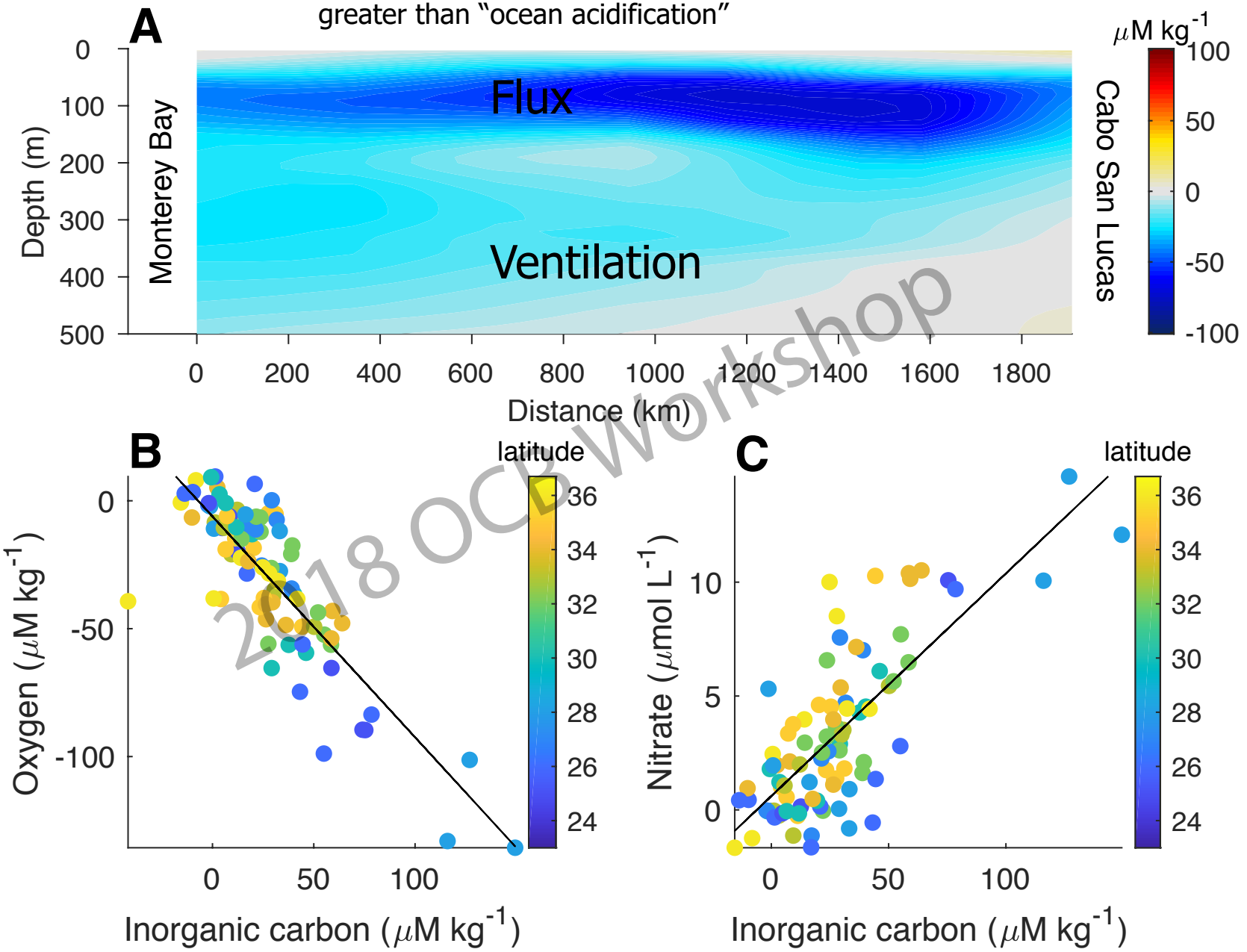


Rate of oxygen decline off central California, shallow maxima at 75 m (25.5 isopycnal), deep maxima at 300 m (26.7-26.8 isopycnal)

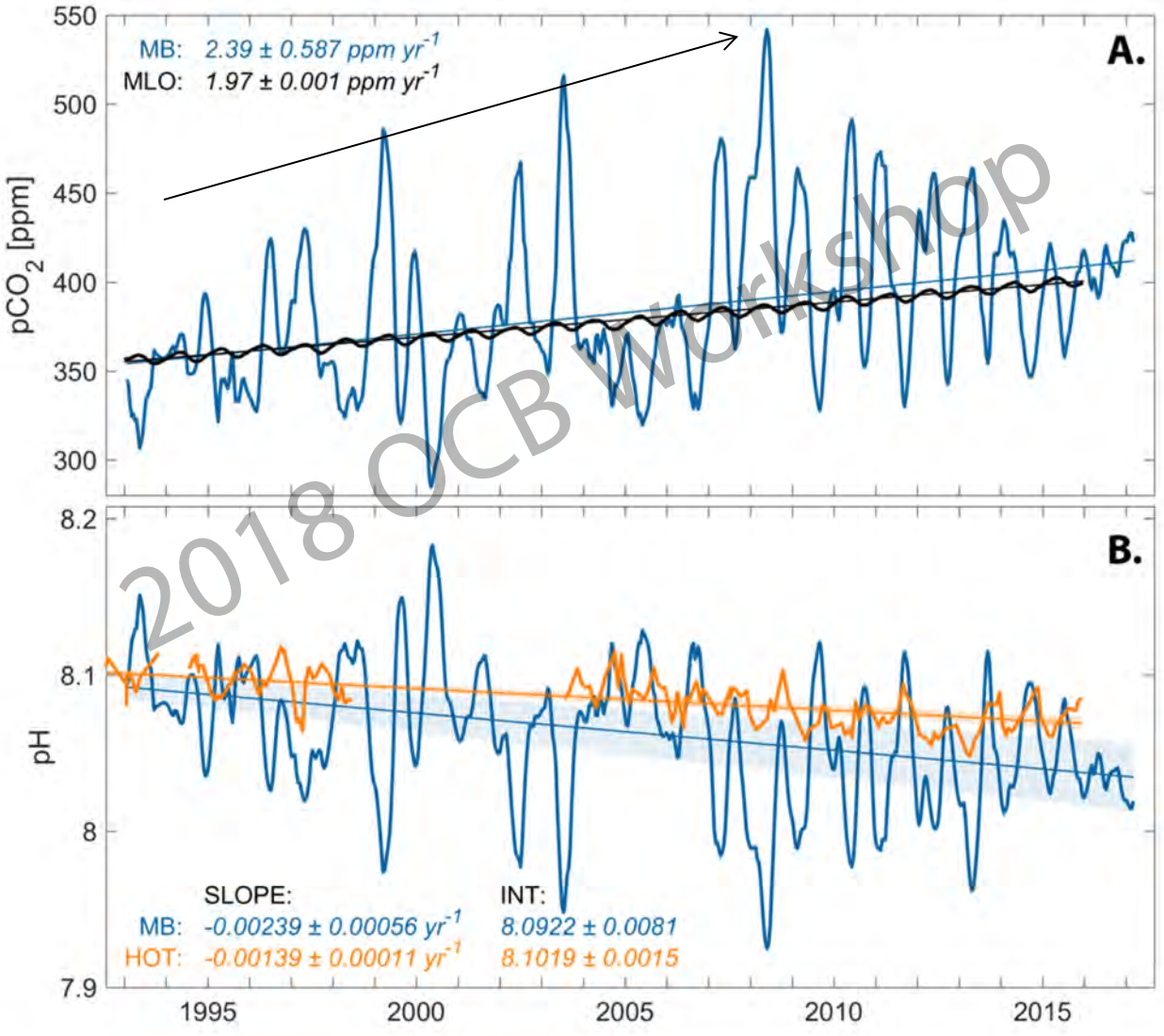




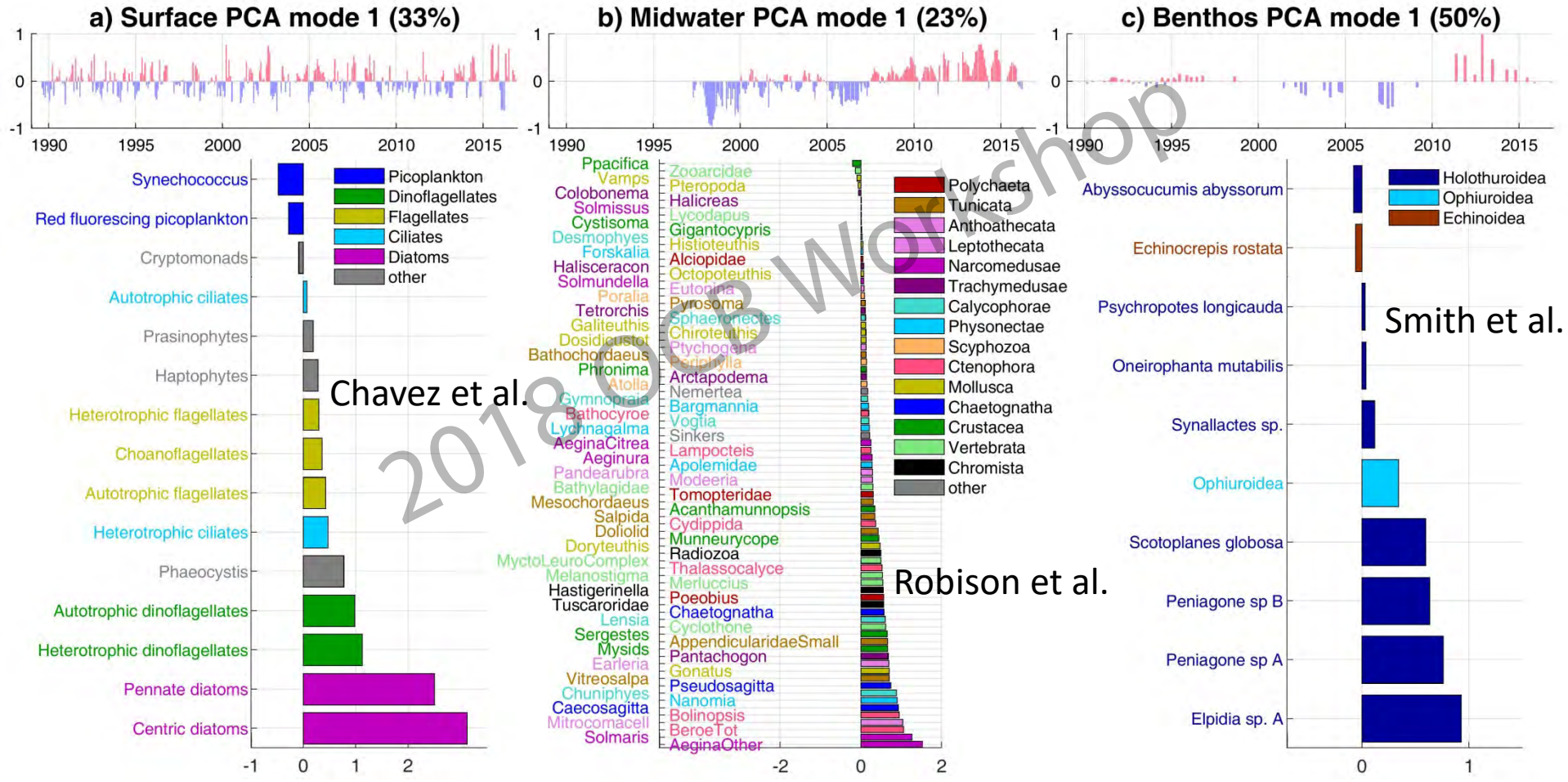
A 4 umol (Redfield) increase in TCO_2 (at 12 C) increases pCO_2 by 8 ppm per year, 4 times greater than "ocean acidification"



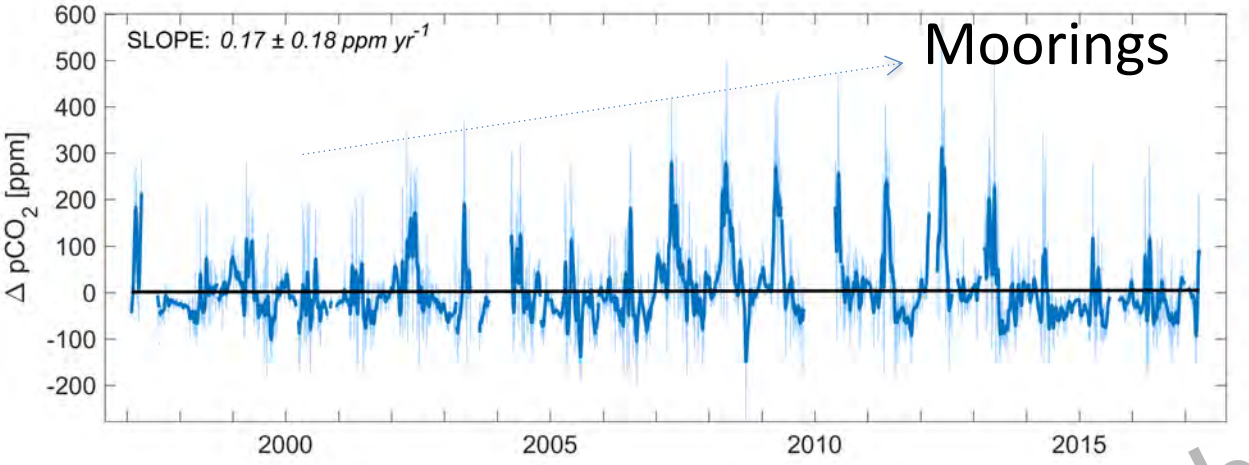
A 4 umol (Redfield) increase in TCO_2 (at 12 C) driven by respiration increases pCO_2 by 8 ppm per year, 4 times greater than "ocean acidification". Because nitrate also increasing (stimulating PP) effect felt mostly inshore during strong upwelling

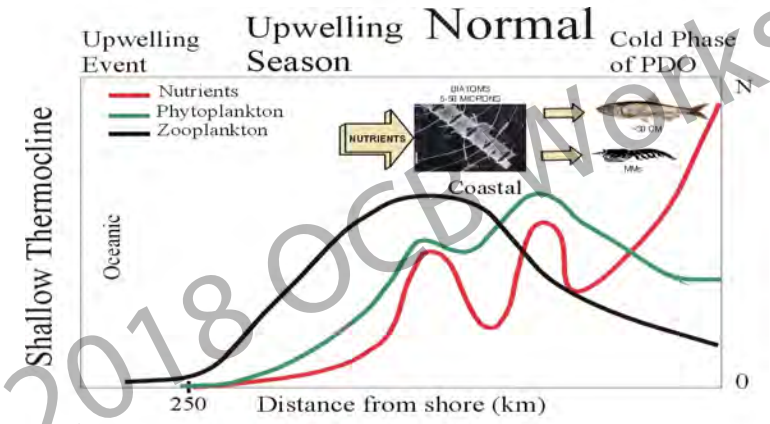


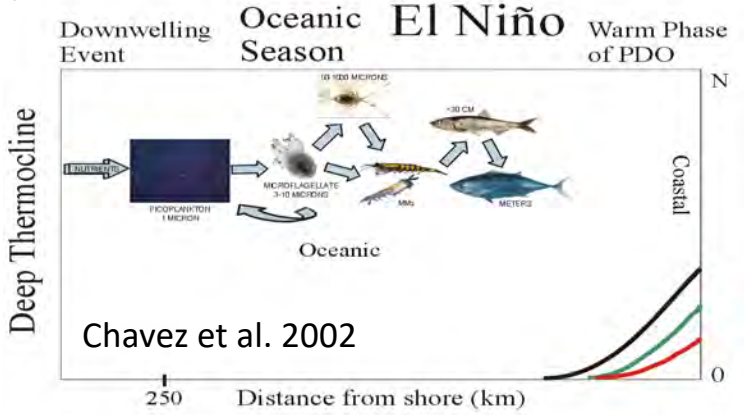
Integrating surface, midwater and benthic time series (Messie et al. in prep) – relating community composition to climate/upwelling



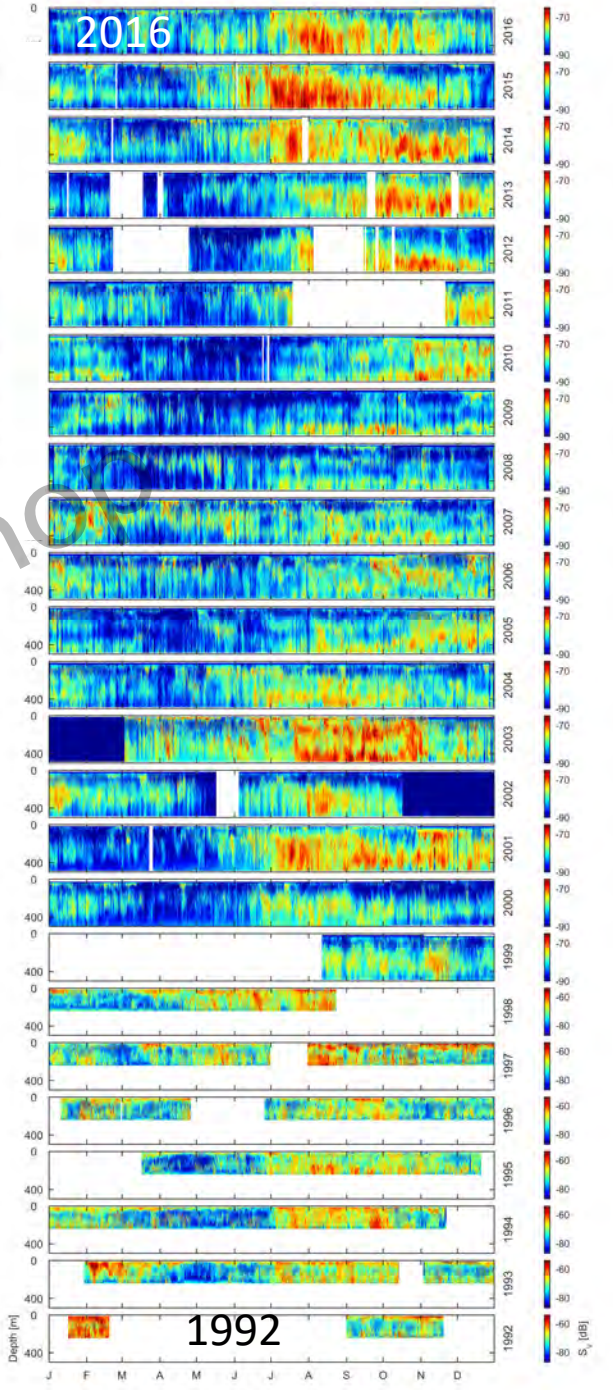
PCA mode 1 = changes in biomass/density



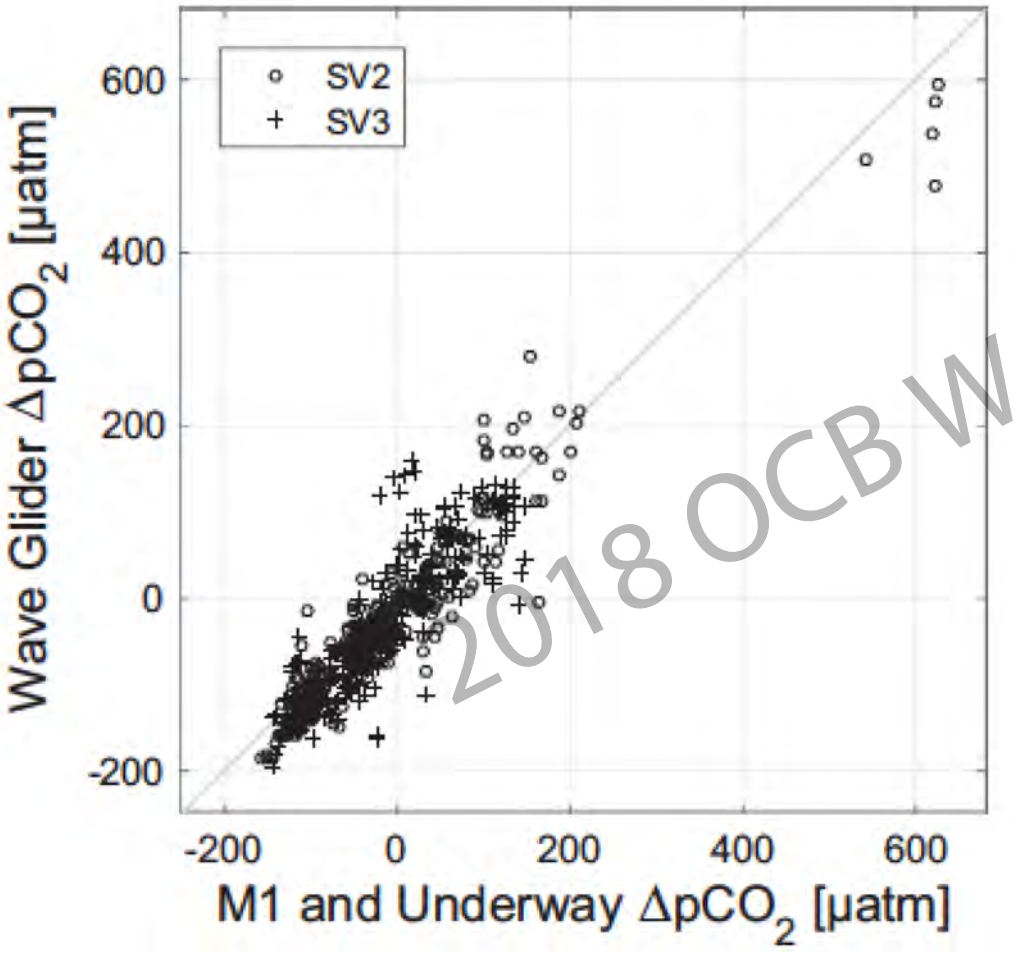




Chavez et al. 2002

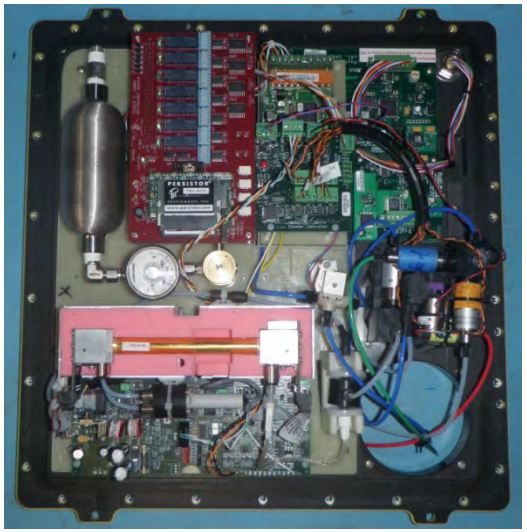


Autonomous surface vehicle measurements of pCO_2 and pH



Chavez et al., 2018 DSRII

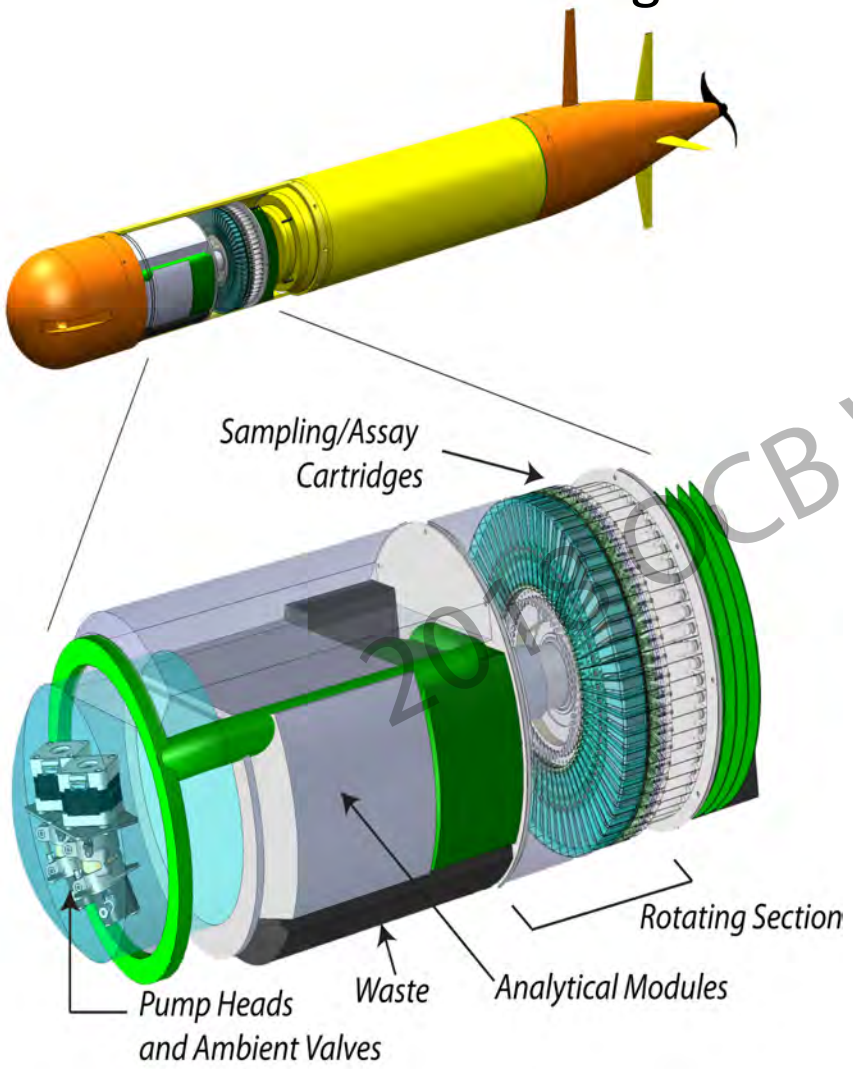
Wave Glider equipped with the same mooring sensors



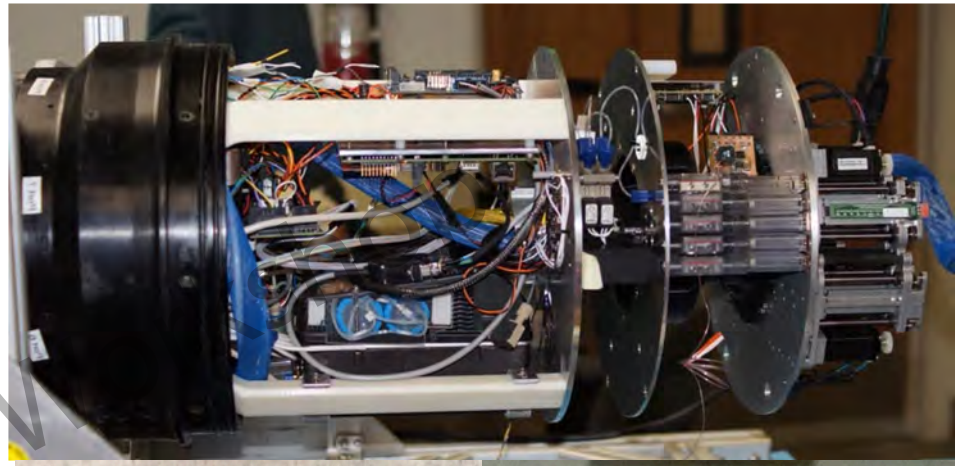
Fleets of Long Range AUVs with ESPs

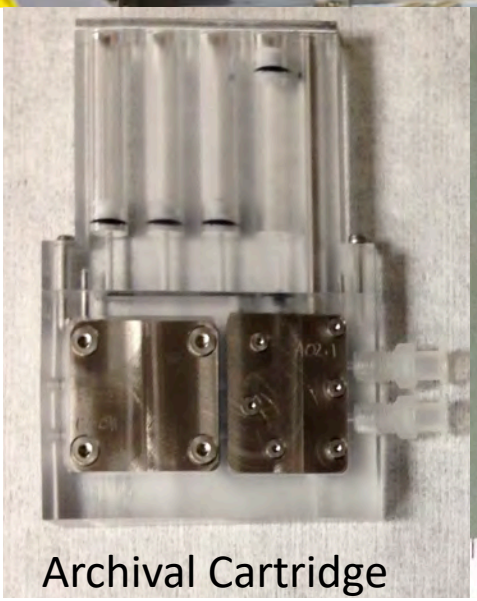
(and other samplers, instruments)

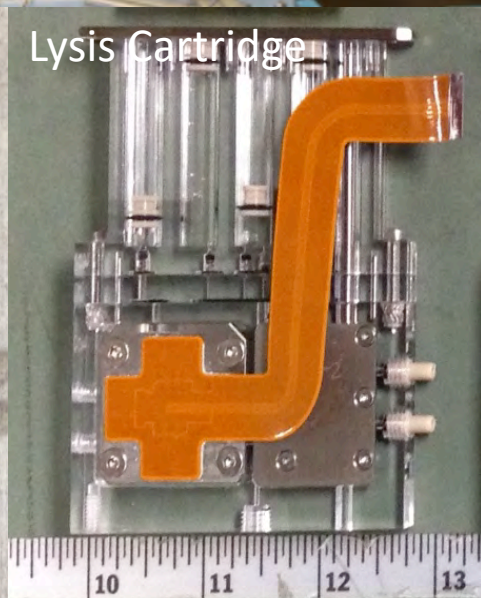
A new window for observing the sea



5 Cartridge Prototype



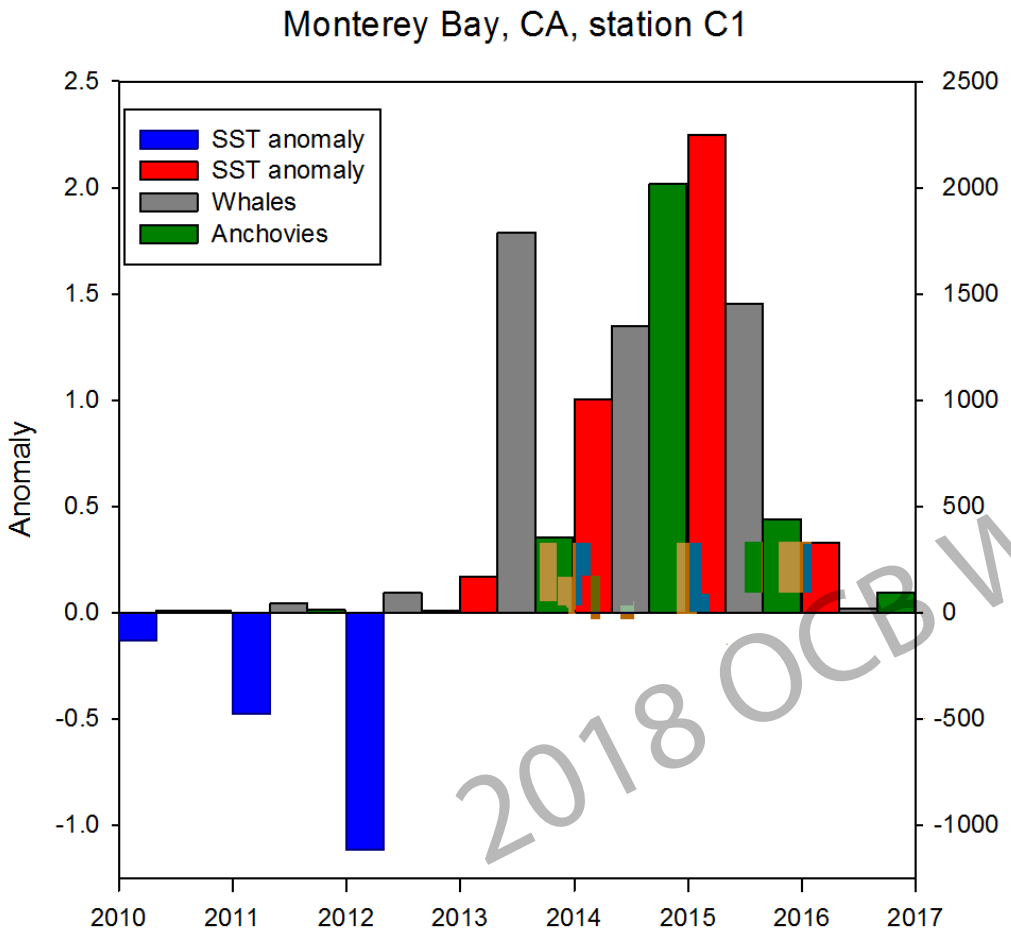




ESP AND LRAUV TEAMS

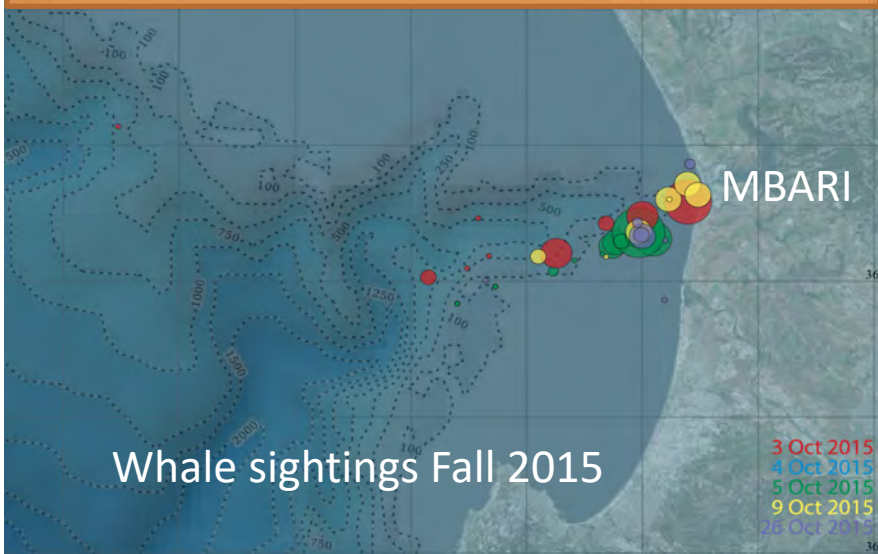
Sequence onboard in the future

eDNA detection of increased anchovy abundance



Comparison of anchovy eDNA detection from archived samples, whale watching boat sightings, and SST anomaly. Consequence – increased whale entanglements with crab pots

Preserved DNA samples allow the eDNA analysis of long time series – where other methods of analysis may be unavailable.



Automating the Monterey Bay Time Series

A future of "process" time series?