



The Physical Oceanographic Environment of the Southern California Current During the Past Decade: Changes in Climate and Concepts

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PICES FUTURE Open Science Meeting

Session 5

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The Physical Oceanographic Environment of the Southern California Current During the Past Decade: Changes in Climate and Concepts

California Current Ecosystem –
Long-Term Ecological Research Program

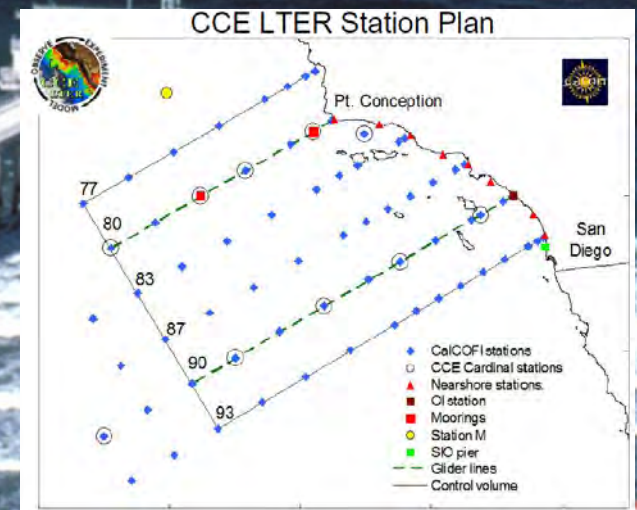
Instigation for today's talk:

CCE-LTER founded in 2004

- Long-term CCE observational time series

- Augmented CalCOFI

- Process Cruises



The Physical Oceanographic Environment of the Southern California Current During the Past Decade: Changes in Climate and Concepts

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Outline:

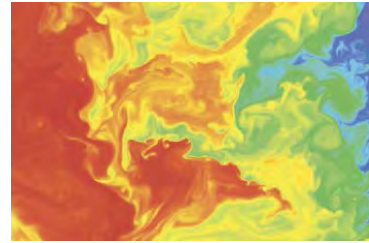
- 1) Changes in perspective of CCS physical processes since 2004
- 2) CCS physical variations during the CCE-LTER era
- 3) CCE Process Cruises: Data assimilation and climate context

Miller, Song and Subramanian: *Deep-Sea Research II*, 2014
(Special issue on Long-Term Observations of CCE-LTER)

Changes in perspective of CCS physical processes (1)

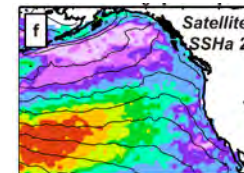
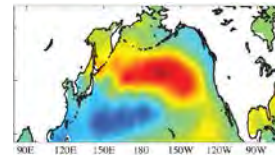
* Identification of Submesoscale Eddies as important mixing processes

- Capet et al. (2008)
- Bocalletti et al. (2007)
- Fox-Kemper et al. (2009)



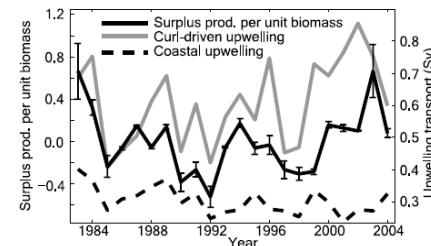
* Identification of the North Pacific Gyre Oscillation (NPGO) as an important large-scale controlling feature of upwelling, currents and ecosystem response

- Di Lorenzo et al. (2008, 2009)



* Recognition that offshore open-ocean Ekman pumping can be as important coastal upwelling in fluxing nutrients to the photic zone

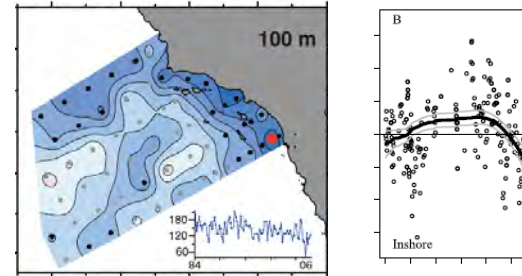
- Rykaczewski and Checkley (2008)



Changes in perspective of CCS physical processes (2)

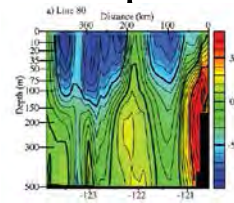
* Long-term decreases in dissolved oxygen below the thermocline threaten numerous species

- Bograd et al. (2008)
- McClatchie et al. (2010)



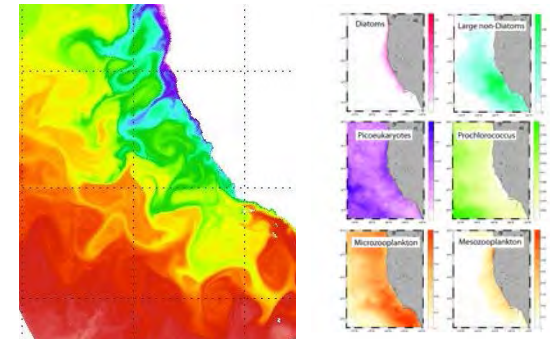
* Gliders reveal subsurface persistent poleward flows offshore of the undercurrent

- Davis et al. (2008)



* New modeling capabilities, finely resolved and over decadal timescales, reveal forced response, intrinsic variations, coupled O-A interactions and ecosystem response

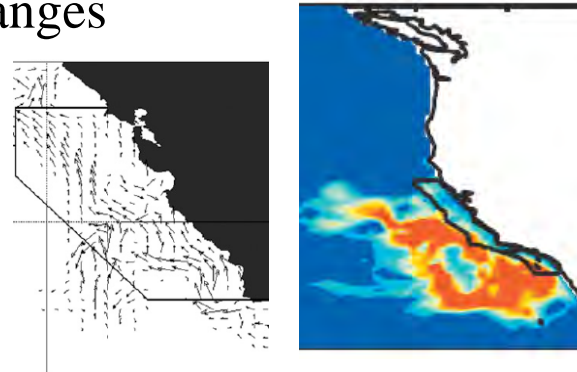
- Di Lorenzo et al. (2005), Seo et al. (2007)
- Capet et al. (2008)
- Centurioni et al. (2008)
- Gruber et al. (2010), Goebel et al. (2010)



Changes in perspective of CCS physical processes (3)

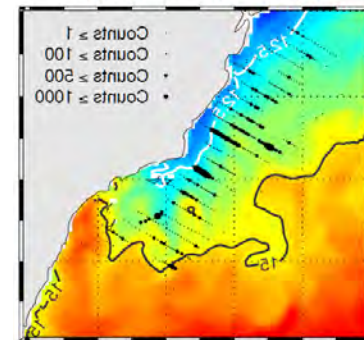
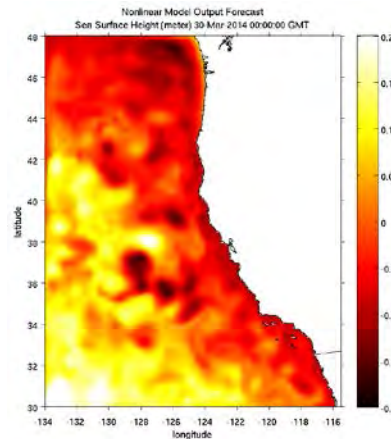
* New computational diagnostic tools (Generalized Stability Analysis, tangent linear and adjoint models) provide metrics of sensitivity to forcing and explanations of upwelling source water changes

- Moore et al. (2004, 2011)
- Chhak and Di Lorenzo (2007)



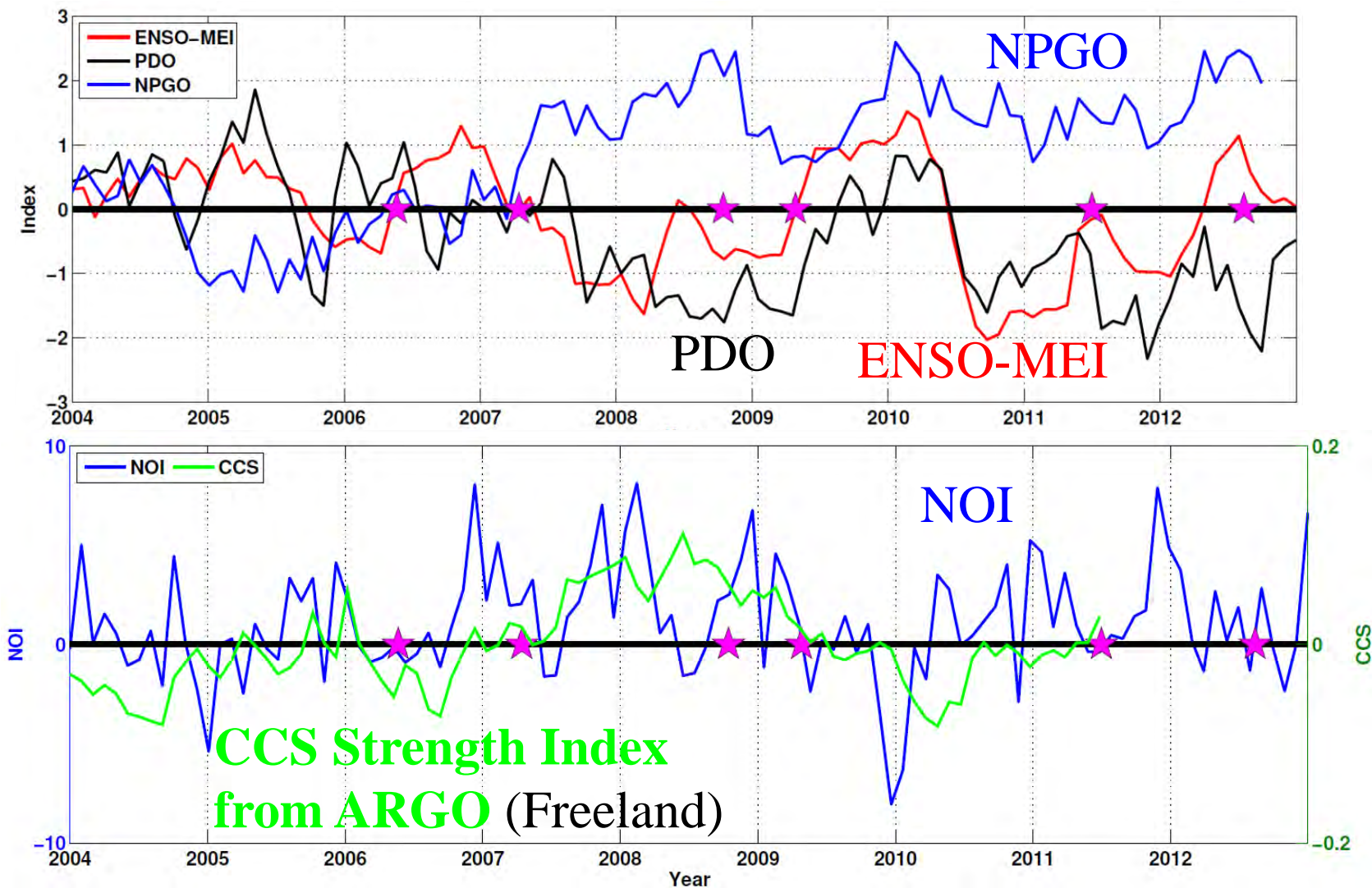
* Ocean data assimilation tools developed and applied to create ocean analysis products and diagnostic information for biology

- Moore et al. (2011)
- Broquet et al. (2009)
- Song et al. (2012)



CCS physical variations during the CCE-LTER era

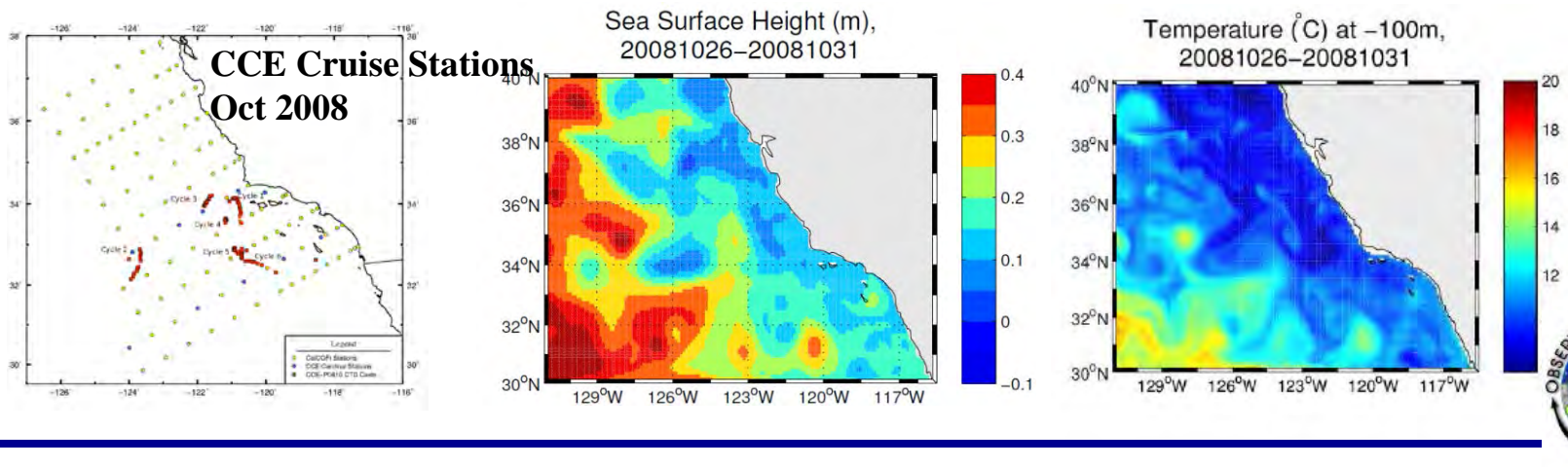
Climate indices in the CCS (2004-2012) and Process Cruises (Starred)



(Miller, Song and Subramanian, 2014, DSR)

CCE Process Cruises: Data assimilation and climate context

- CCE-LTER Process Cruises measured various fluxes of biological variables in new ways
- Multi-class 1D ecosystem models were developed to interpret CalCOFI and CCE
- Fits of the physics for the Process Cruises are now completed giving 4D representation of the flows
- Optimize ways to use them, modify them diagnose them to interpret the limited sampling of biological response

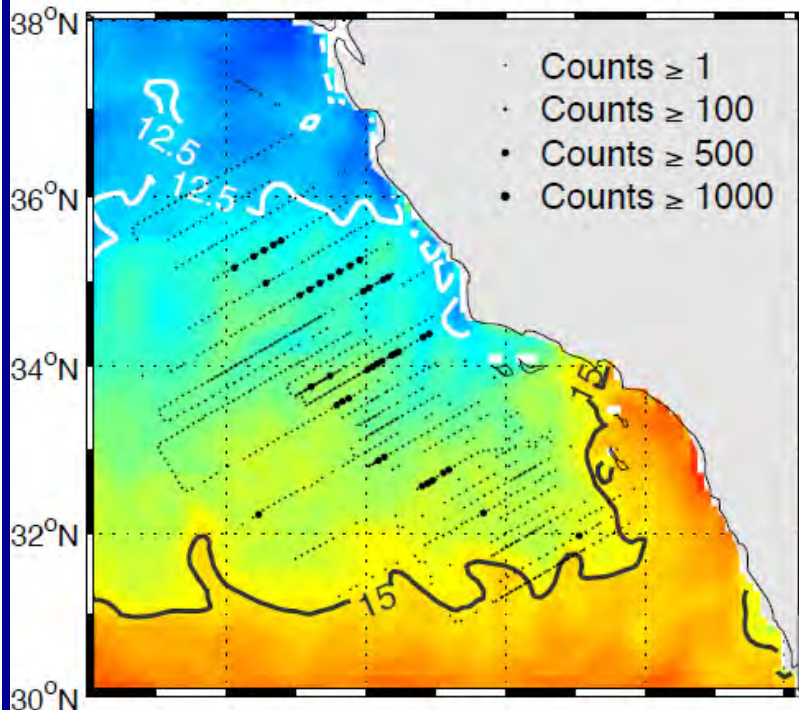


Using Data Assimilation Fits to diagnose Sardine Spawning Habitat changes

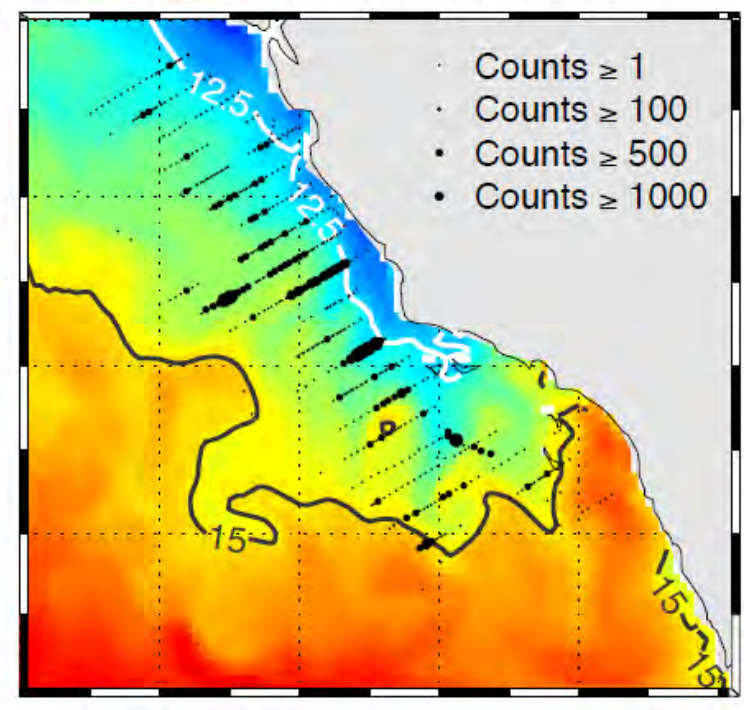
-Strong constraint fits over 30-day periods in April 2002 and 2003
Allows diagnosis of 4D physical processes that help
explain the large disparity in sardine spawning

Song et al., JGR, 2012

(a) SST from model, 2002



(b) SST from model, 2003



Offshore spawning, fewer eggs: **La Nina** Nearshore spawning, many eggs: **El Nino**

Data includes: T-S (CalCOFI, Argo, CUFES), SLH (AVISO), SST (AVHRR)

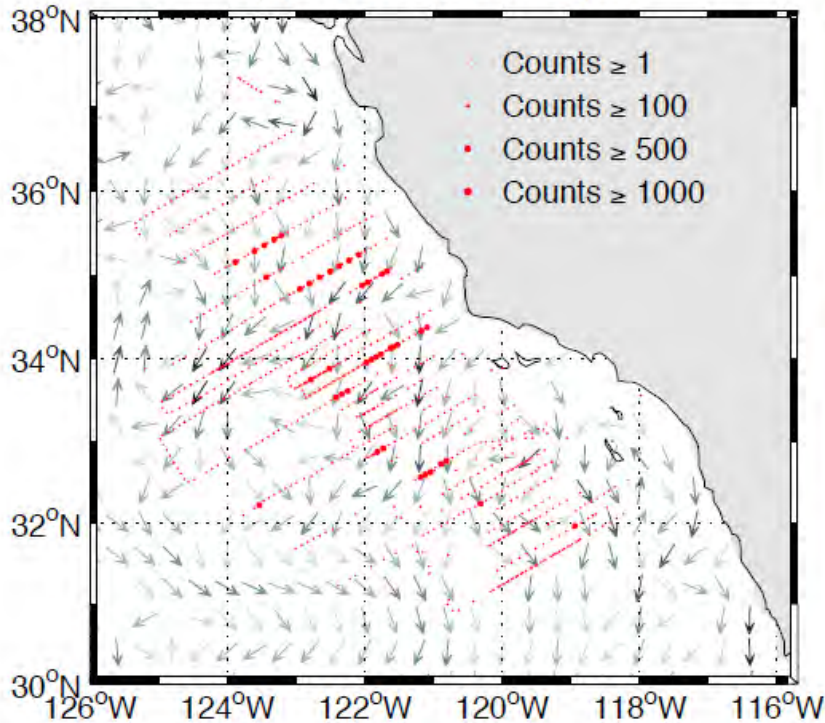
Data Assimilation Model Fits: Quantifying Transport

Stronger offshore transport and upwelling in 2002

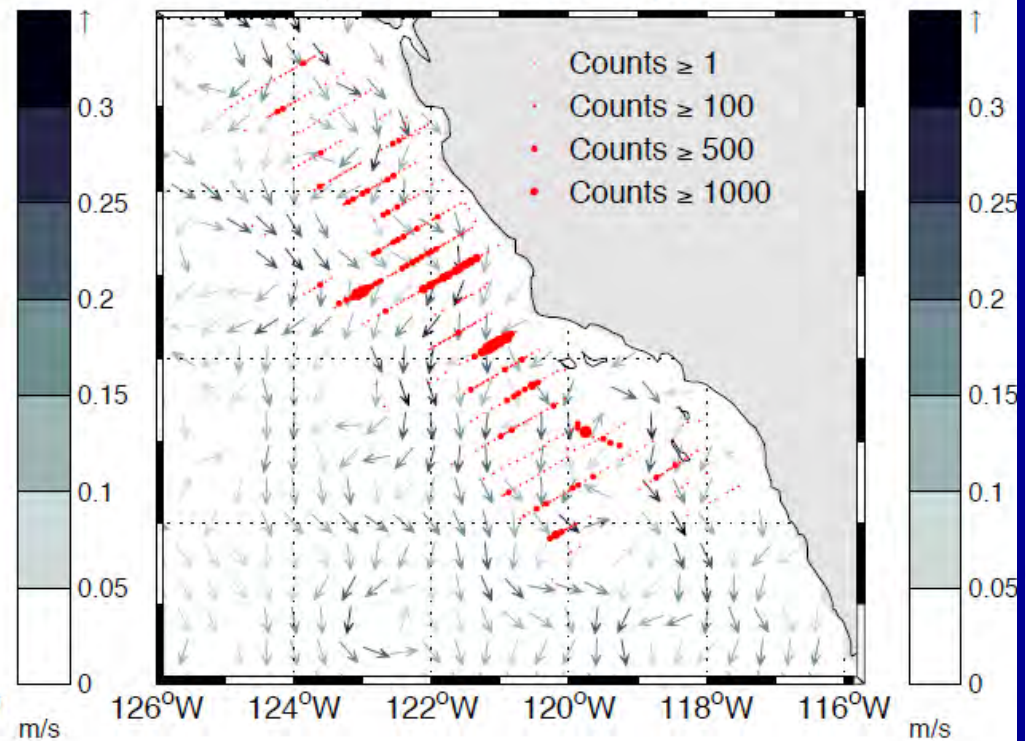
Weaker offshore transport and stronger convergence in 2003

Song et al., JGR, 2012

(a) Current, 2002 April



(b) Current, 2003 April

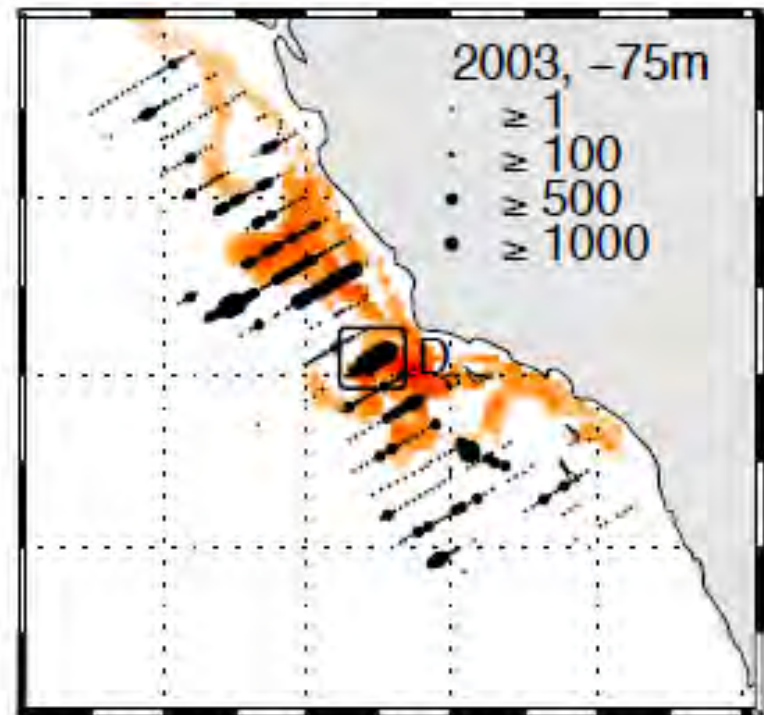
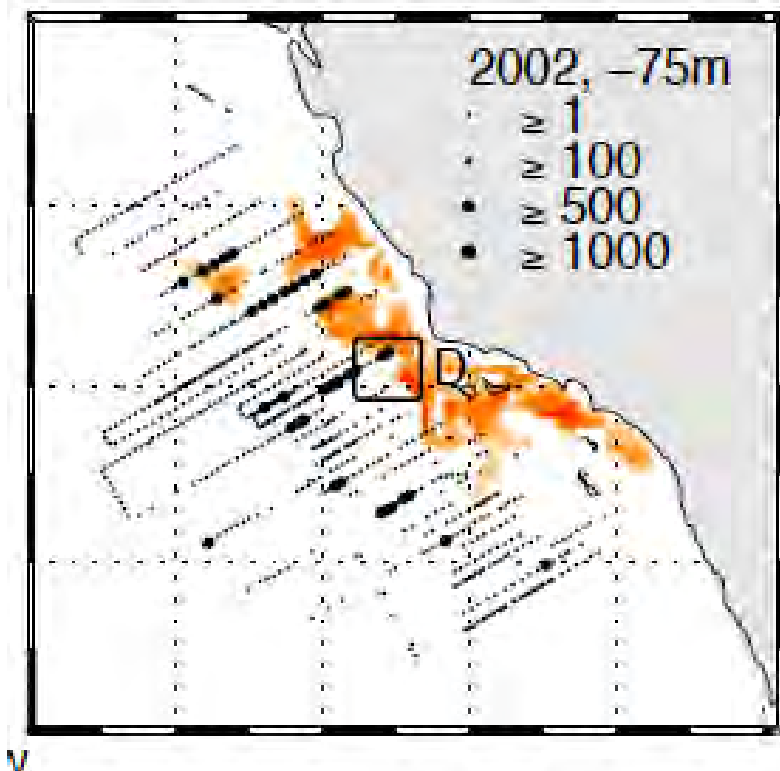


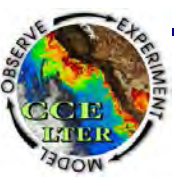
Red: Egg density **Grey Scale Arrows: Surface Currents**

Data Assimilation Model Fits: Quantifying Upwelling Sources

Adjoint tracer model (run backwards) for source waters (boxes) of surface ocean

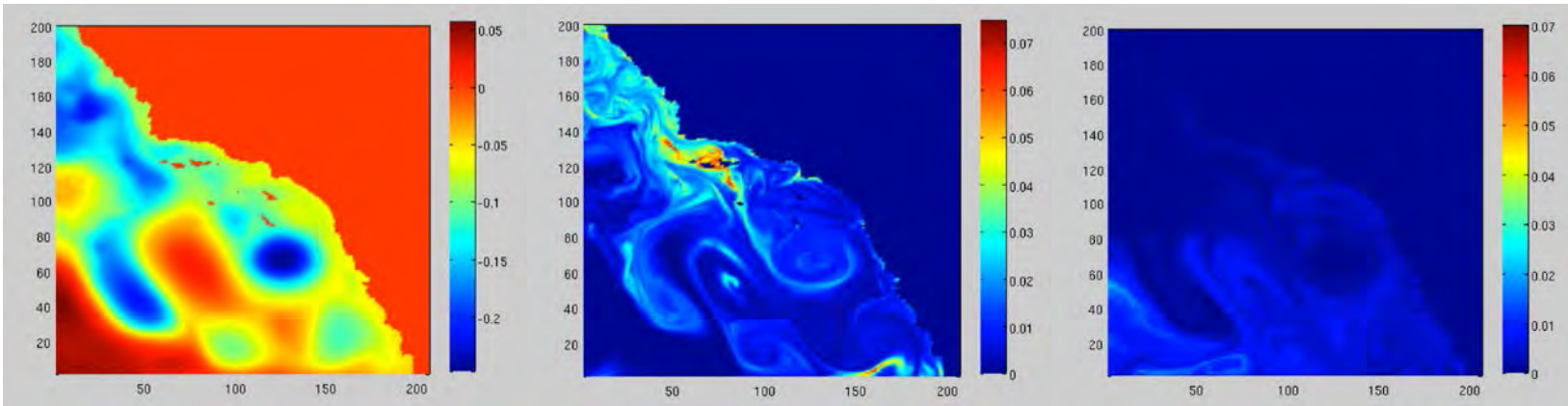
2003 source waters in **nearshore spawning** area transported from more productive **deep water in the central California Current**
Orange indicates location of water 30 days before arriving in BOX





Related work

- Study space-time structural relations between physics and phytoplankton in “Darwin Model” runs, by Chris Edwards (UCSC), which include many types of phyto’s (and zoop.)
- Determine if emergent biological features exhibit similar cross-frontal transitions as observed by CCE

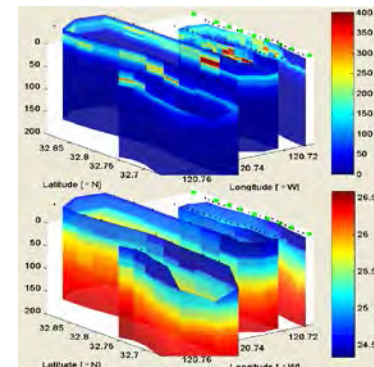


Sea-Surface height

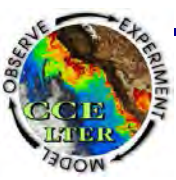
Diatom-1

Dino-2

..... with Ana Lopez (SDSU undergrad)

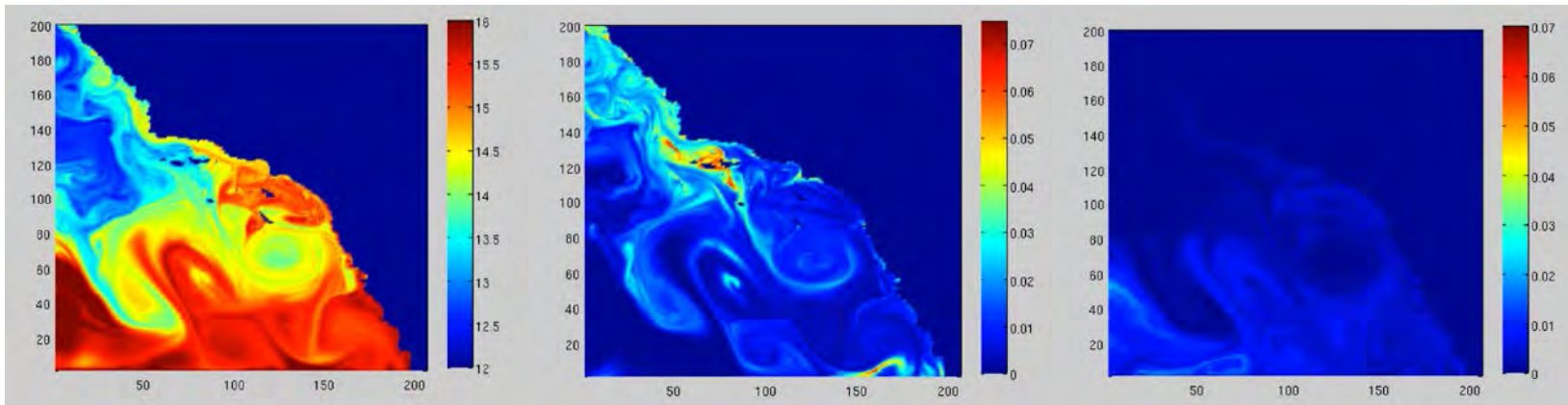


Example CCE survey



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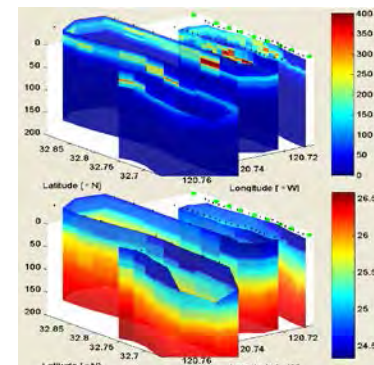


SST

Diatom-1

Dino-2

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Example CCE survey

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Thanks!

