

Climate Change, Upwelling, and Ecosystem Dynamics in the Gulf of the Farallones, CA



William J. Sydeman* - Farallon Institute, Bodega Marine Lab/UCD

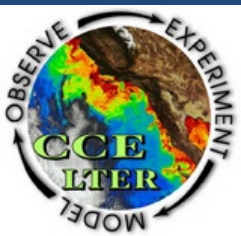
Robert M. Suryan - Oregon State University

Russell W Bradley, Pete Warzybok, Julie A Thayer – PRBO Conservation Science

John Largier, Marisol Garcia - Bodega Marine Lab/UCD

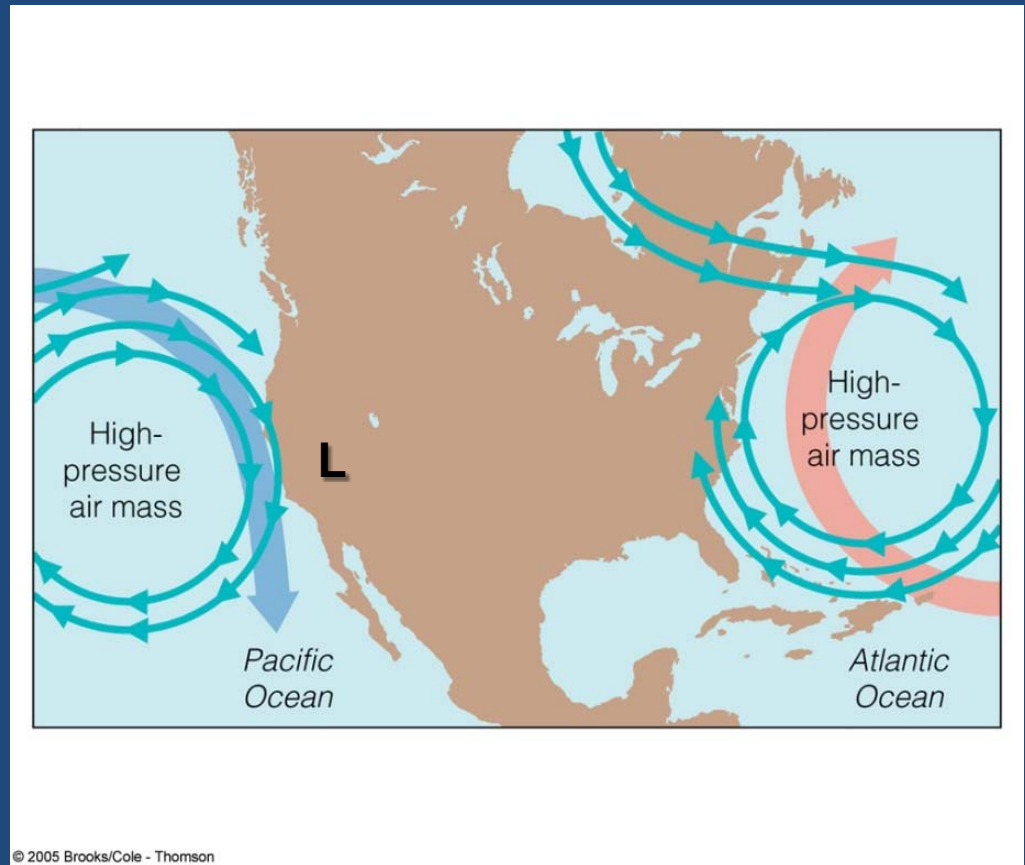
Steve Ralston - NOAA-NMFS, Southwest Fisheries

Joelle Buffa – U.S. Fish and Wildlife Service



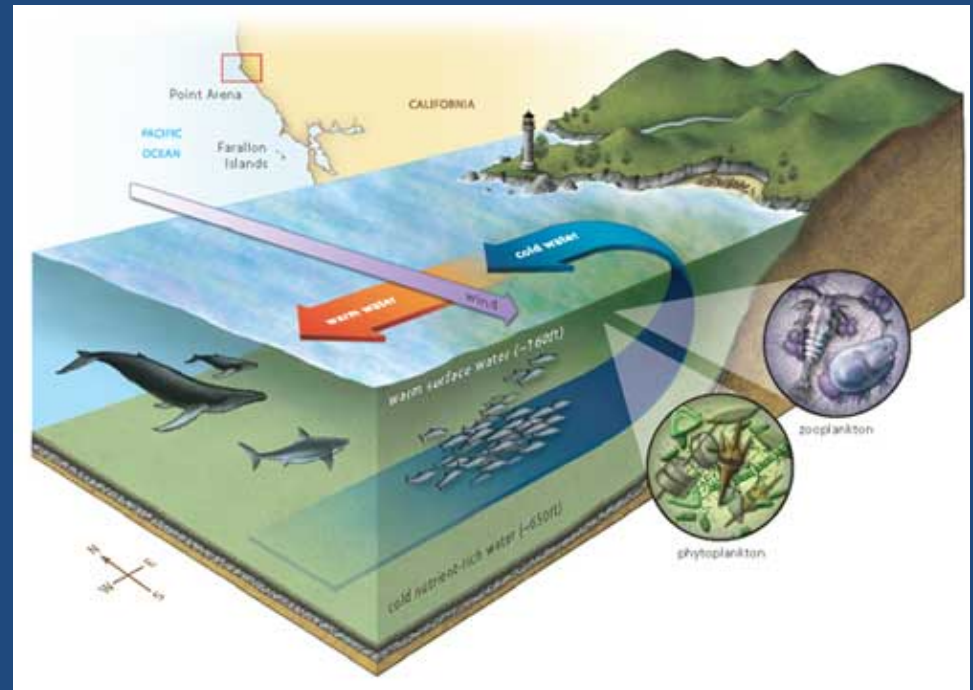
NSF Grant No. 0417616; www.faralloninstitute.org

- Bakun (1990, Science) - EBCS, upwelling intensification, global warming.
- For CA Current LME, this would involve strengthening of the Great Basin Low relative to North Pacific High.
- Climate modeling has confirmed (Synder et al. 2003, Diffenbaugh et al. 2004).
- Observations: increasing winds, decreasing SST (Schwing and Mendelssohn 1997; Mendelssohn and Schwing 2001, Breaker 2004, 2005)



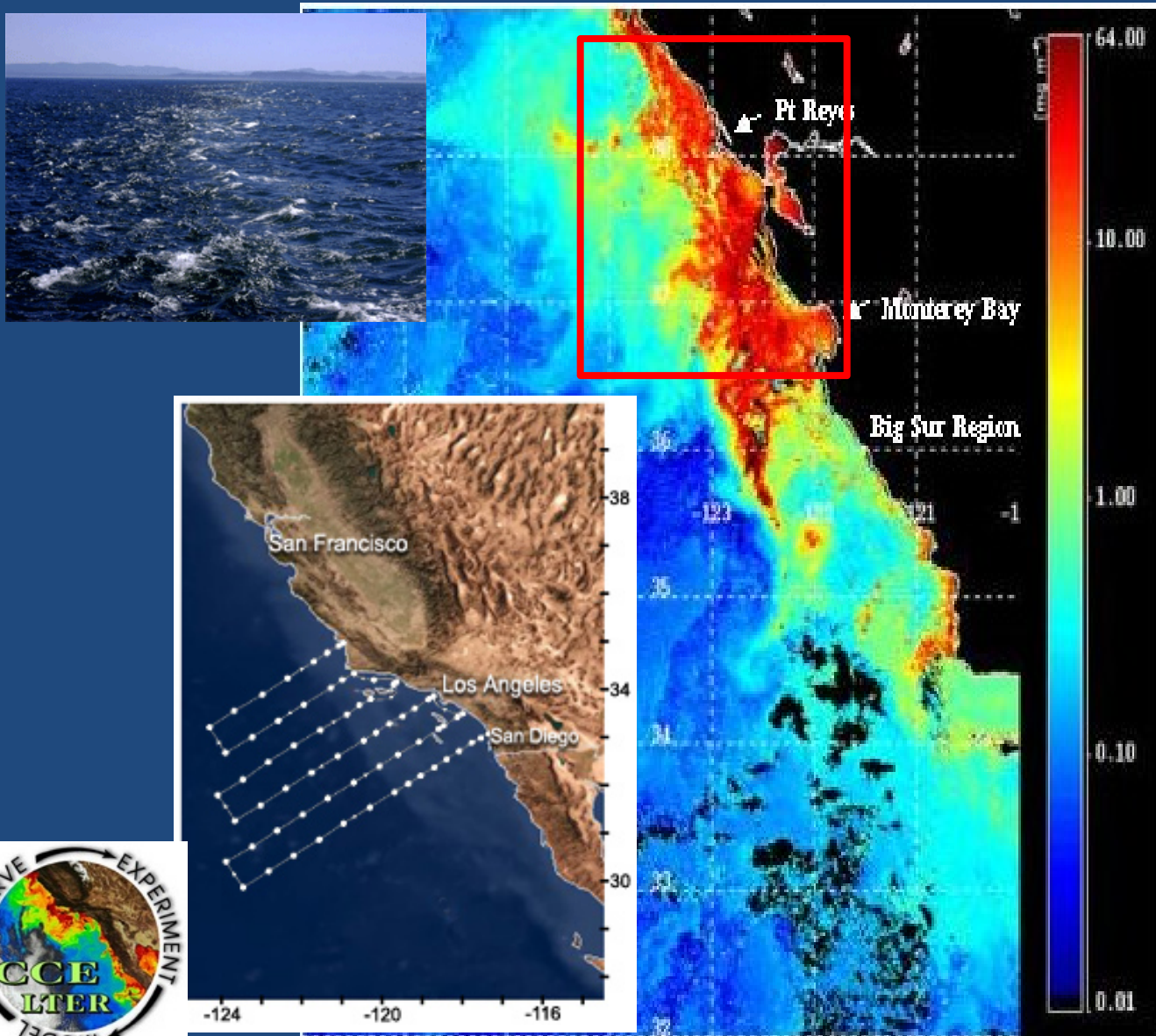
....will changes in upwelling be consistent from intertidal to offshore domains; neritic to oceanic habitats?

Hypothesis



- Global warming has differential effects on ocean habitats in EBCS
 - Upwelling and ecosystem dynamics nearshore is enhanced
 - Upwelling and ecosystem dynamics offshore is diminished
 -reality....continuum in responses

Coastal Study Area off Northern California

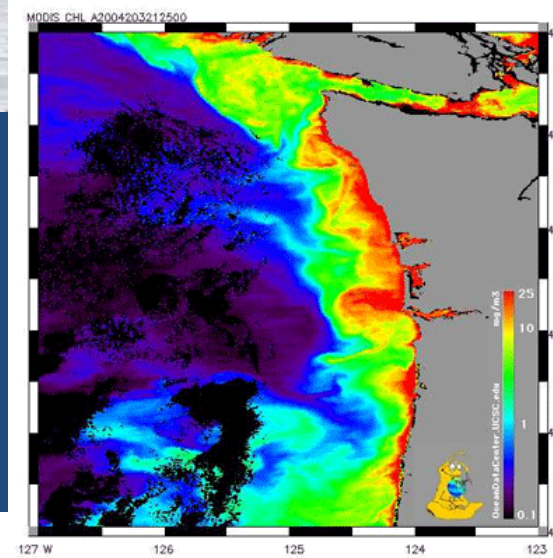
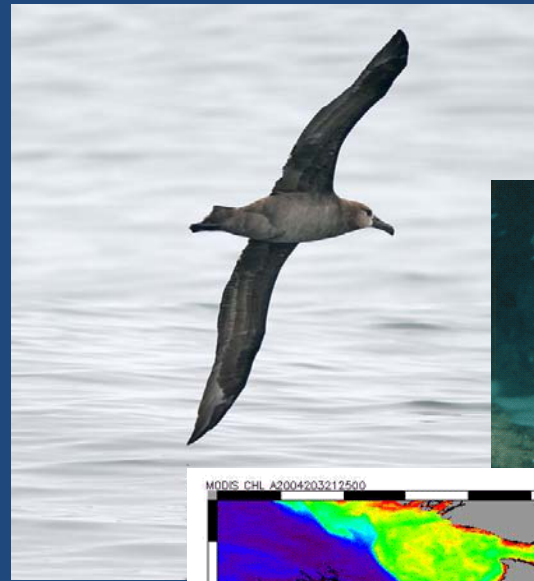


- Wide shelf
- SF Estuary
- Monterey Bay
- Upwelling
Pt. Arena
Pt. Reyes
Davenport
Pt. Sur

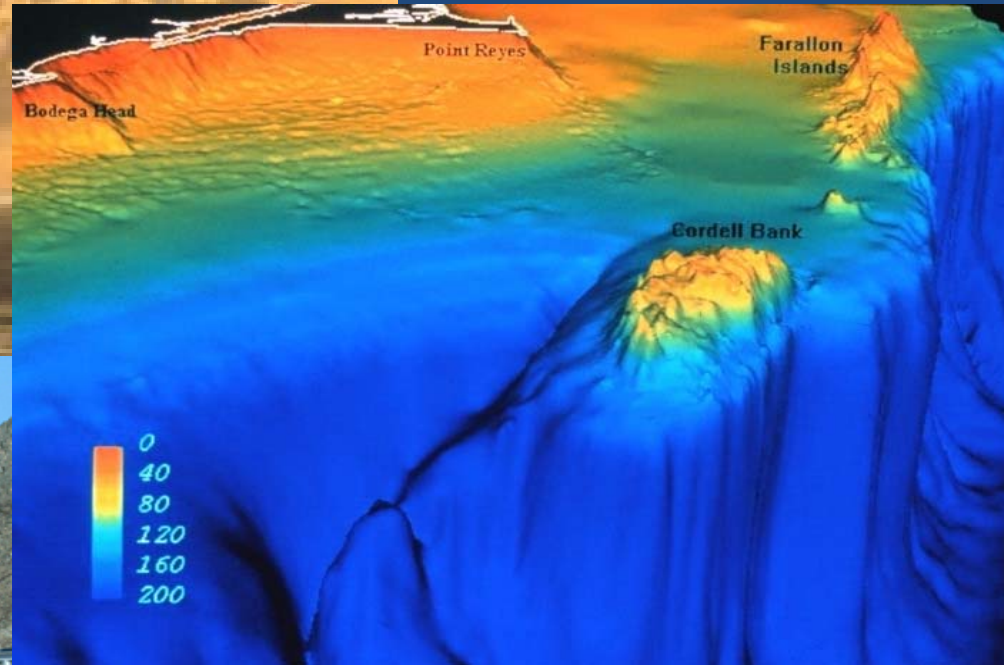


Outline

- (1) Upper trophic level predators (seabirds)
- (2) Primary production (SeaWiFS)
- (3) Mid trophic level prey (juvenile Sebastes)
- (4) Buoy Winds and SST



Seabirds, Farallon NWR (USFWS & PRBO)



➤ 12 species

➤ varying foraging and life history strategies

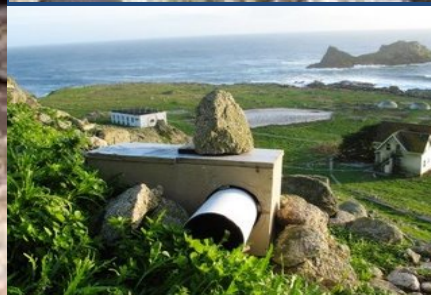
➤ 37 year time-series

➤ 3 spp. selected

Brandt's Cormorant,
Piscivorous, NO KRILL

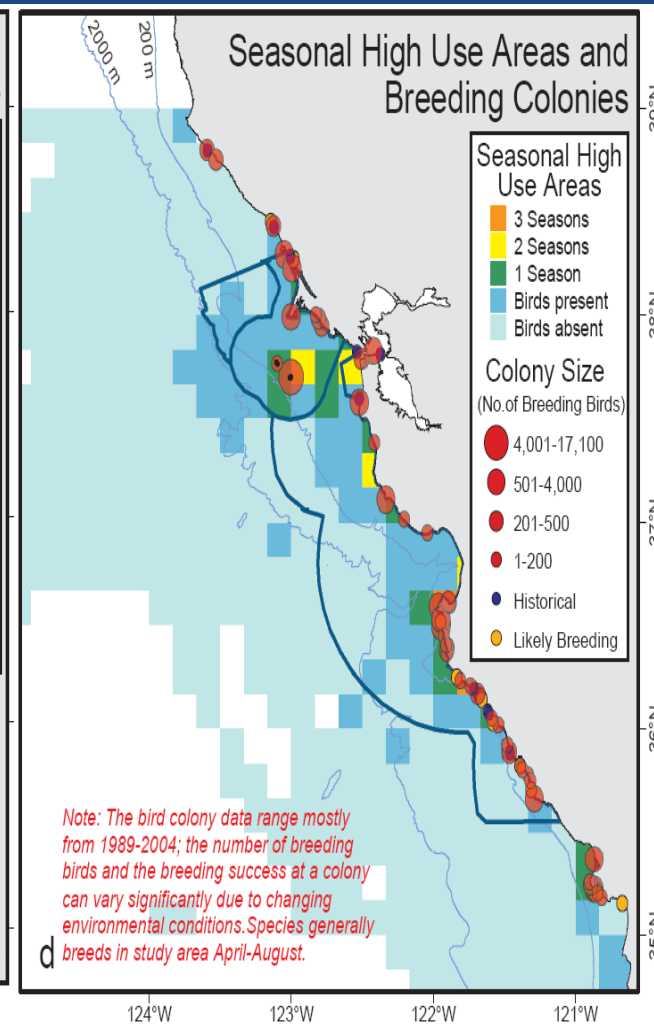
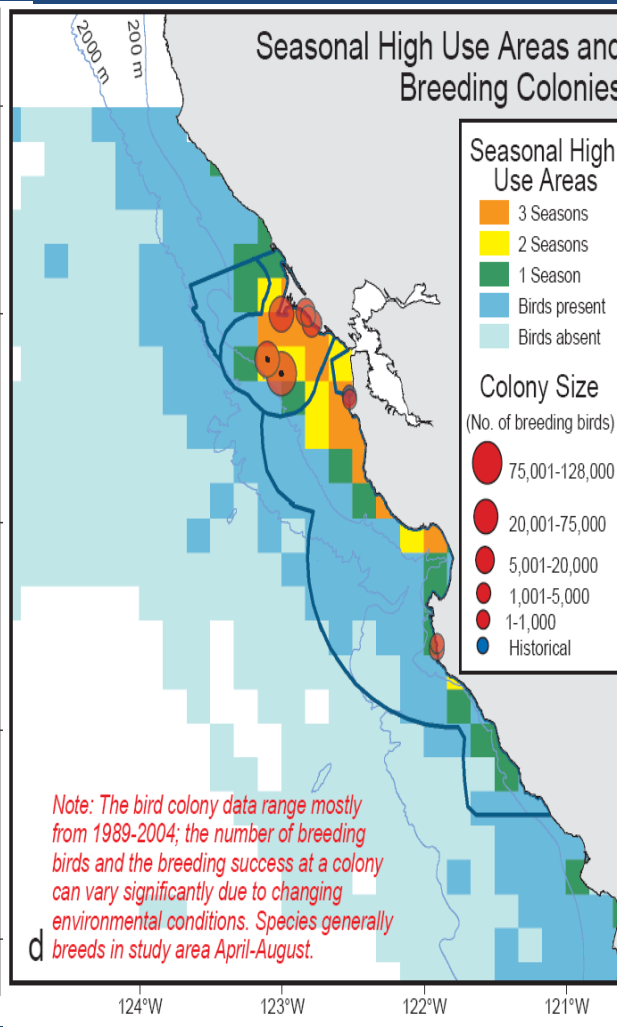
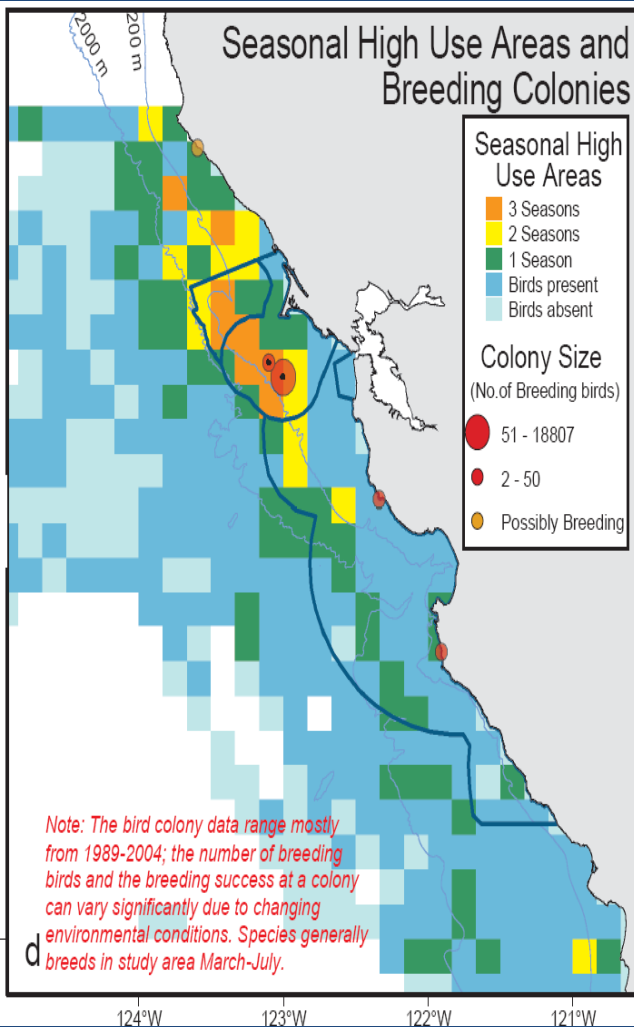


Common Murre, Omnivore,
Krill, Juv. *Sebastes*, *Engraulis*,
Merluccius, *Loligo*



Cassin's Auklet, Planktivore, ~80% Krill, *Epac* and *Tspin*

Seabird Foraging Domains (NCOOS 2007)



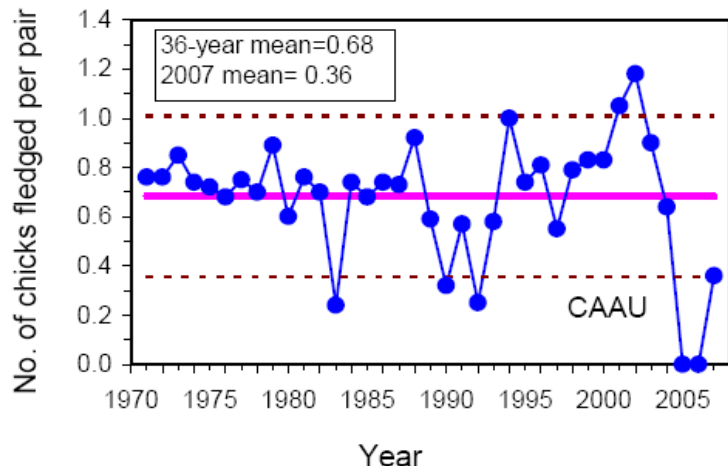
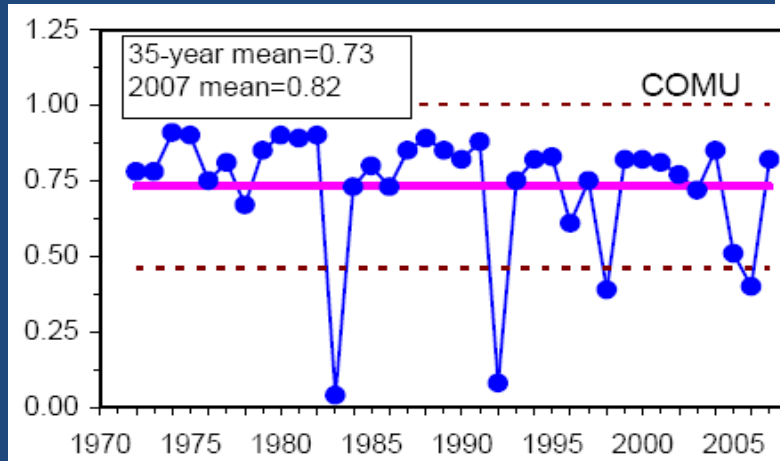
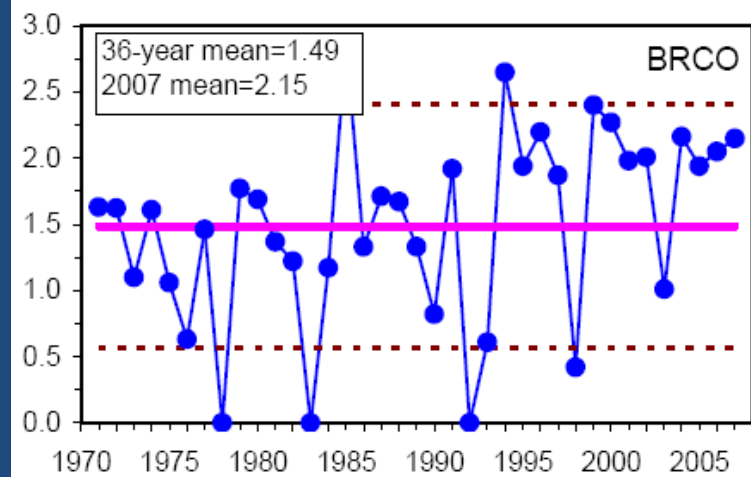
Auklet – outer shelf

Murre – inner shelf

Cormorant – neritic

Productivity (1971-2007)

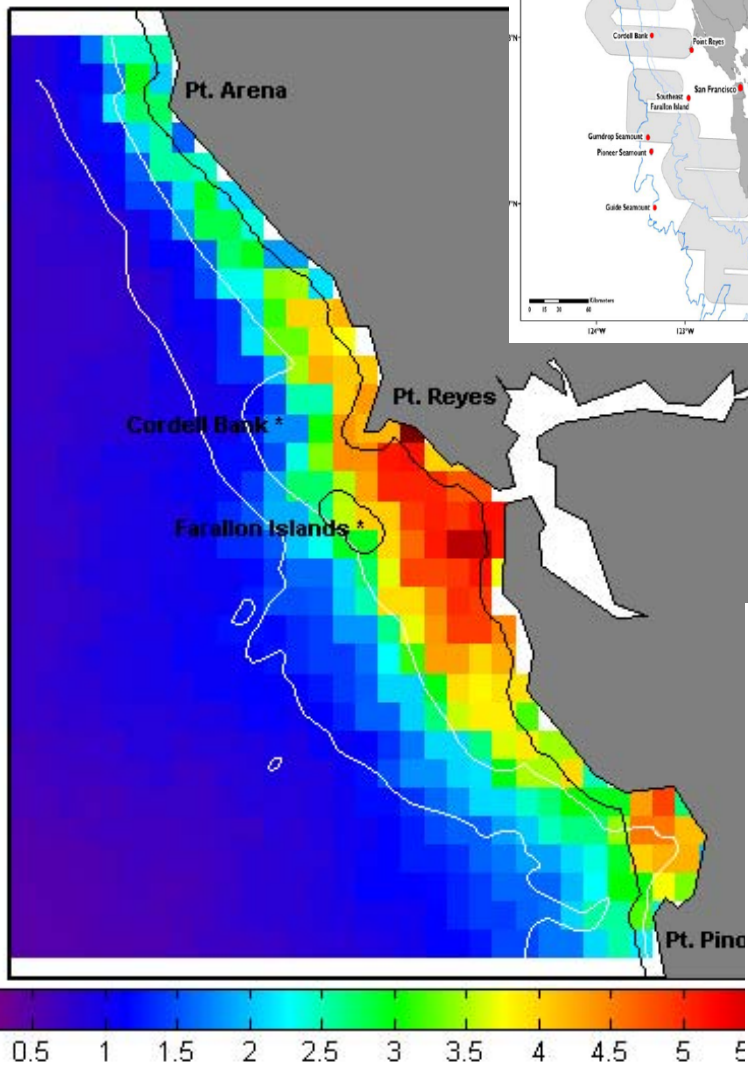
- individual nest monitoring
- long-term mean \pm 80% CI



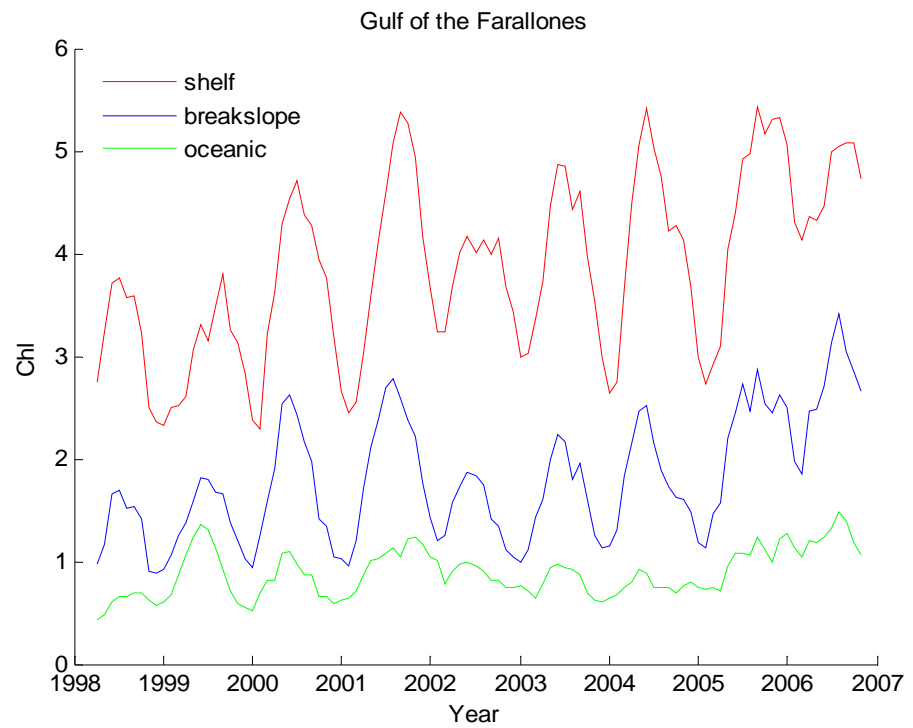
➤ **Piscivore**: Increasing trend; decreasing variance

➤ **Omnivore**: Slight decreasing trend, no consistent change variance.

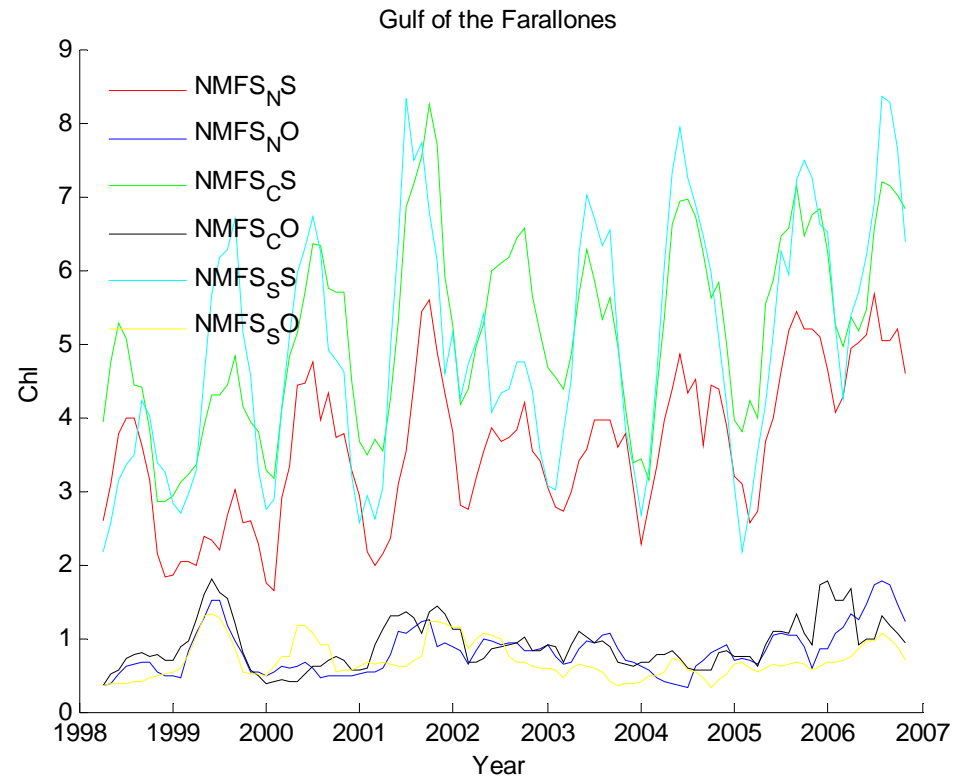
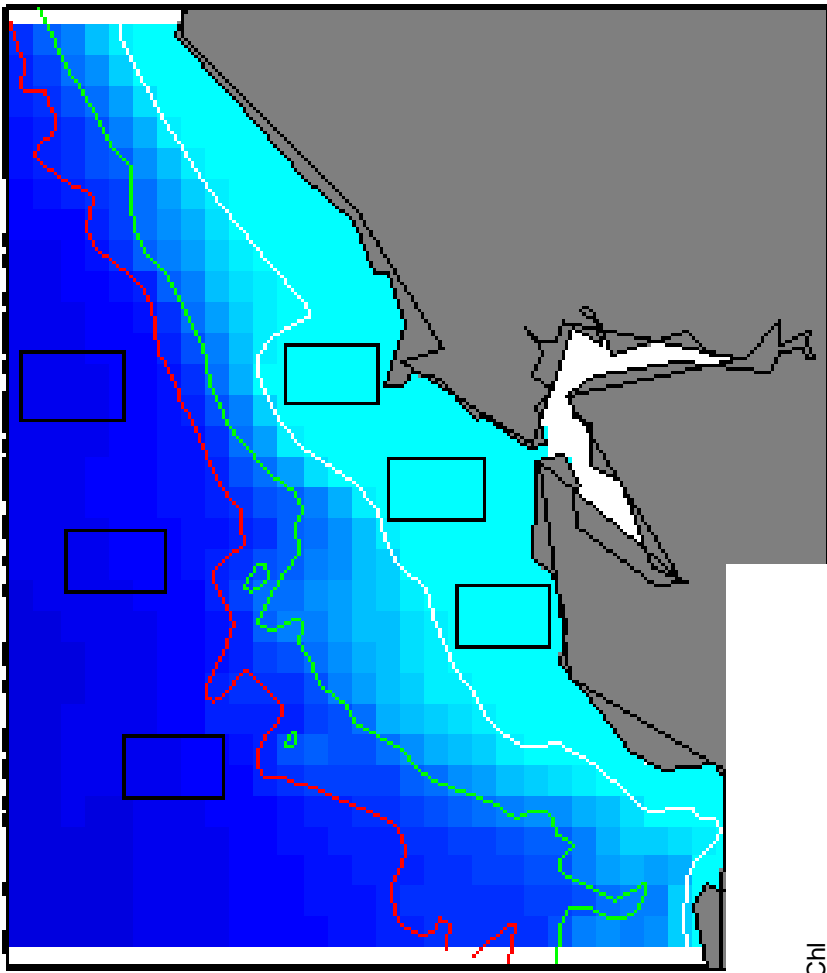
➤ **Planktivore**: Decreasing trend; increasing variance (CV by decade: 20, 40, 60, 80%).



- **SeaWIFS Chl-a**
- **Greater Gulf of the Farallones, Pt. Arena to Pt. Sur**
- **Unequal Areas (shelf largest)**
- **Greening on shelf**
- **No change in oceanic**



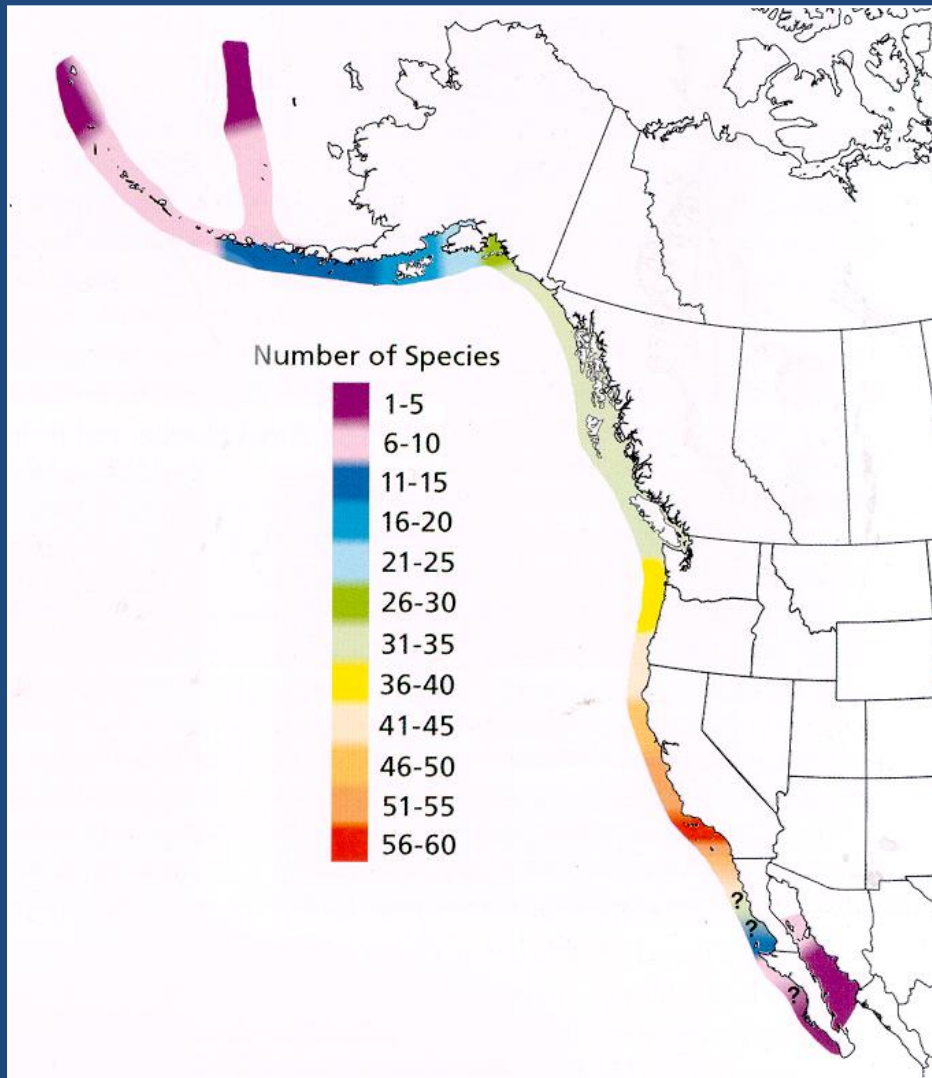
- SeaWIFS (97-07)
- Equal Weighting of Area (~400 km²)
- No change offshore
- Greening trend inner shelf



Caveats on Primary Productivity

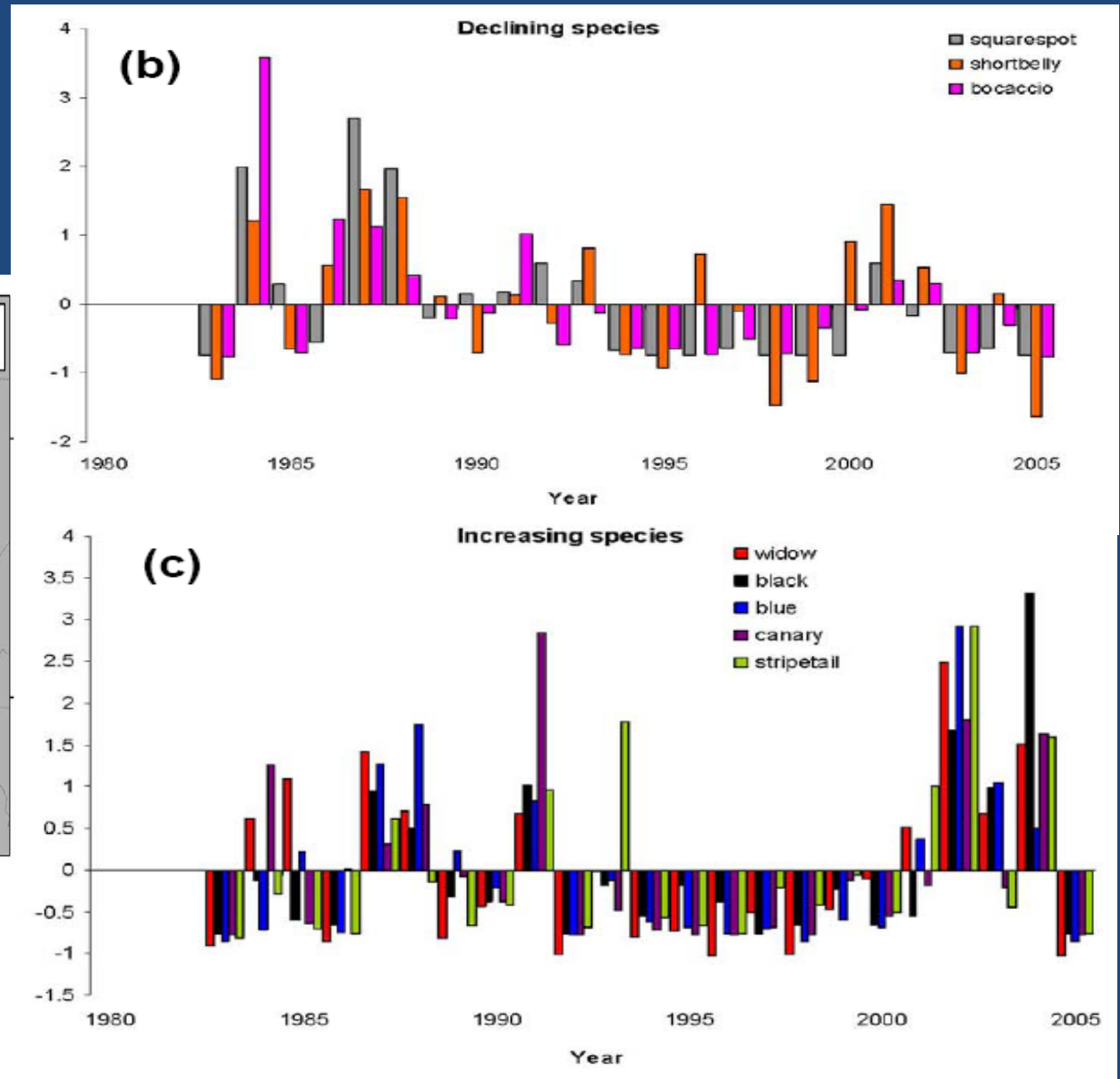
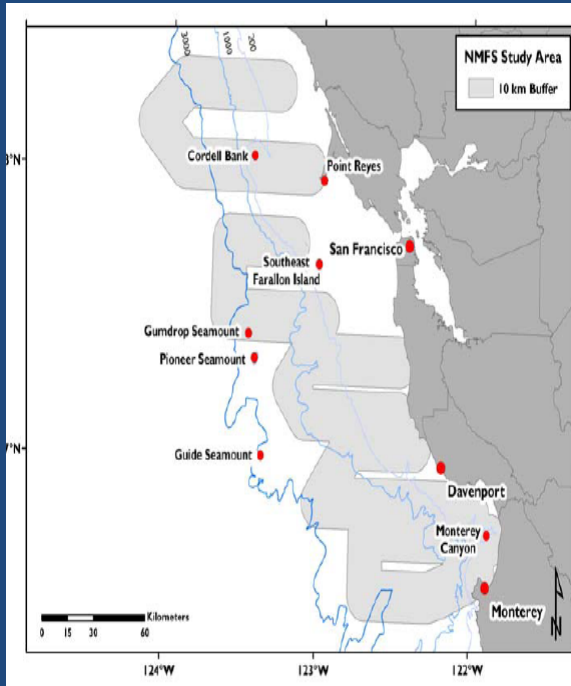
- ❖ Time series is too short
- ❖ End points are overly influential, especially starting with late 1997- early 1998 (darn ENSO events!)
- ❖ SF Bay Plume – sediments may be mistaken for CHL(?)
- ❖ But, standardizing by area results in similar patterns, maybe more striking...fairly compelling

Rockfish (*Sebastes* spp.) Diversity

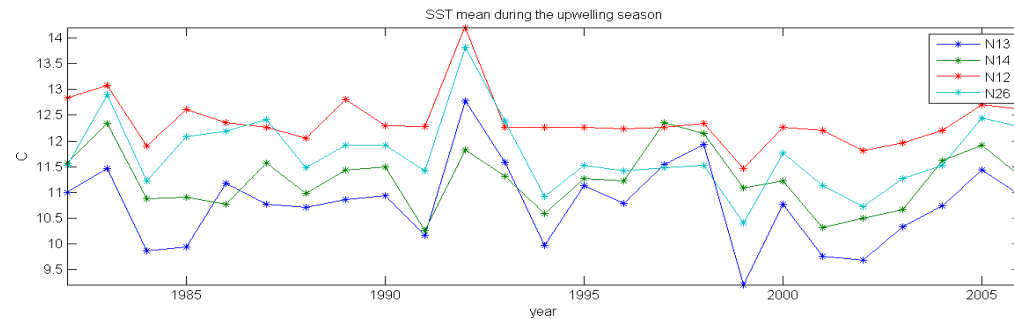
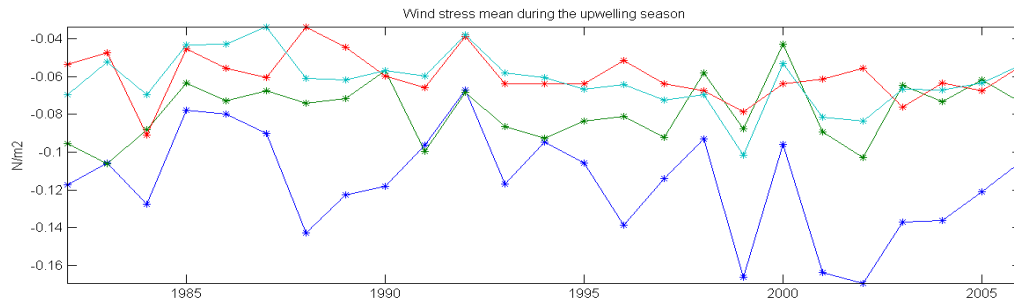


Love et al. 2002

Prey: age-0 *Sebastes* Relative Abundance (log CPUE)



Buoy Winds and SST



- Nearshore
- 1982-present
- March-Aug.

<u>Buoy</u>	<u>Wind Stress</u>	<u>SST (C)</u>
Point Arena	0.0003	-0.0054
Bodega Bay	-0.0014	-0.0081
San Francisco	-0.0004	-0.0149
Half Moon Bay	-0.0007	-0.0198

Summary

1. Initial analyses suggest differences in productivity trends between nearshore and offshore foraging seabirds (and salmon).
2. Changes in primary productivity and some prey appear to mirror seabird/salmonid patterns
3. Atmospheric-oceanographic (winds, SST) coupling supports the hypothesis, but no offshore data yet analyzed

Conclusions

- I. Varying life history strategists reveal varying responses to climate change
- II. Habitat-specific variability in climate change-ecosystem change should be examined
- III. Top predators integrate and thereby demonstrate key system variability
- IV. Implications for management and conservation – winners and losers.

Implications for Bio-diversity

Sardines, krill, anchovy

Seabird diversity (H')

