

Trends of ocean-bay connectivity

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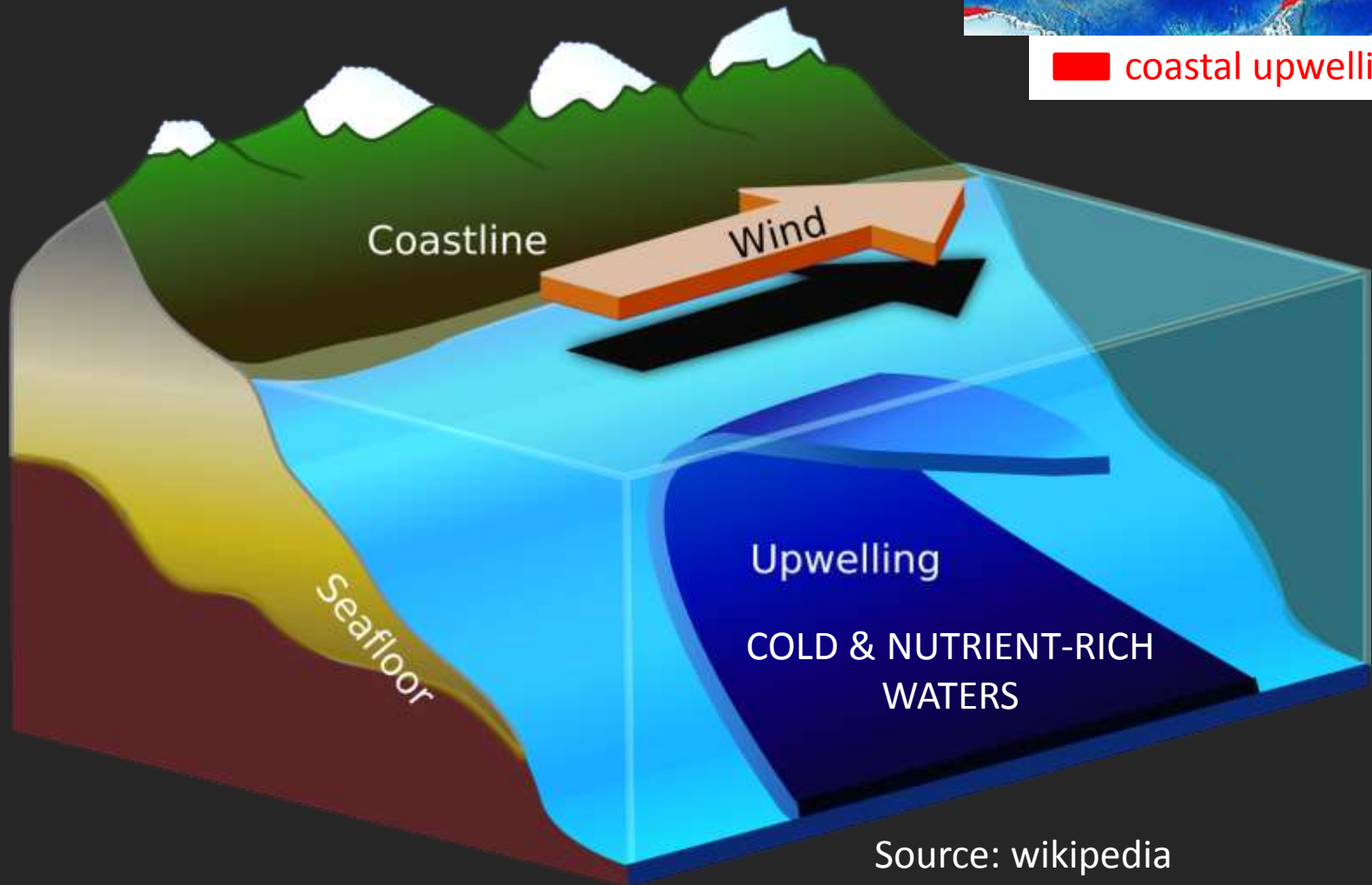
Delta-Bay Science Conference – Sacramento
October 29th, 2014



California coastal upwelling

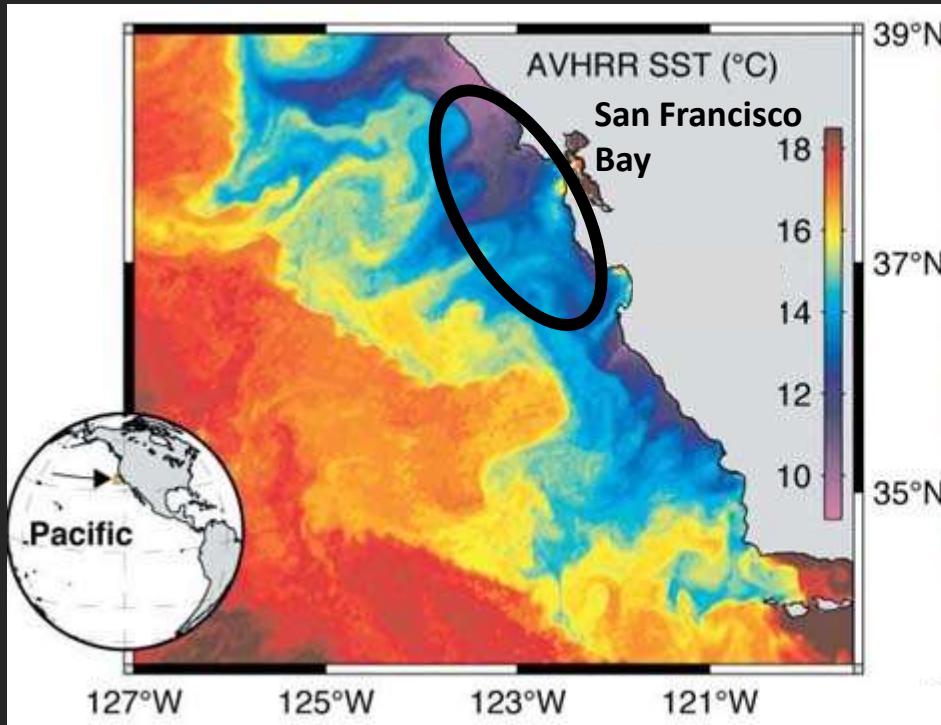


coastal upwelling



Source: wikipedia

TEMPERATURE



Source: Ryan et al. (2005)

**Cold waters
(and nutrient-rich)**



Phytoplankton

Two indicators of upwelling activity

Questions

- ❑ Is there a signal of oceanic change over time?
- ❑ How does this oceanic signal propagate into the Bay?
 - Central Bay
 - South Bay

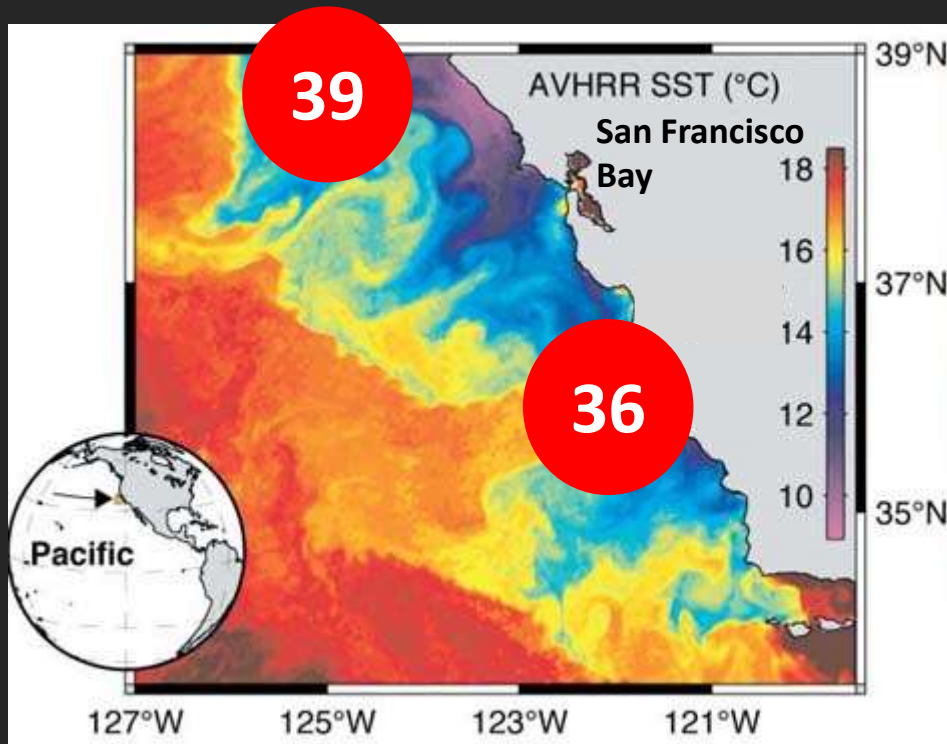
Methods

Daily Upwelling Index 1967-2013 (Bakun, 1973; Schwing et al., 1996)

⇒ **based on surface atmospheric pressure fields**

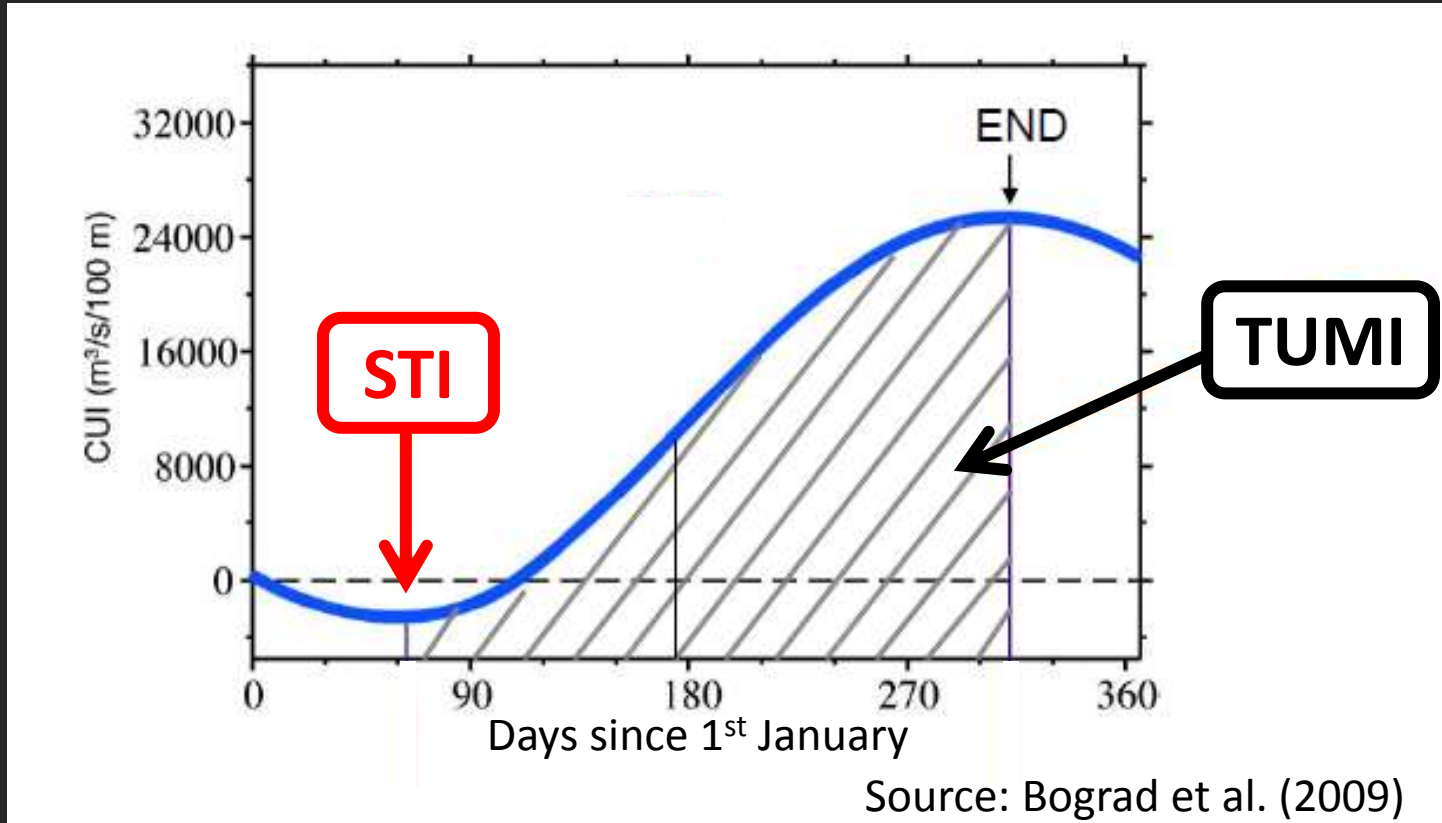
⇒ **amount of water upwelled ($\text{m}^3/\text{s}/100\text{m}$ of coastline)**

Source: NOAA/NMFS/PFEG



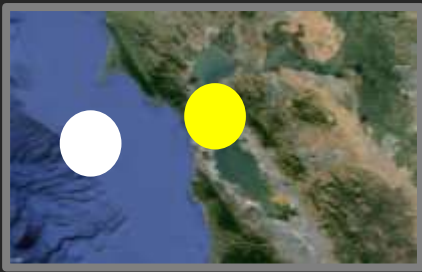
**Daily average
of 36 and 39°N**

Cumulative Upwelling Index (CUI)



**Spring Transition Index
(days)**

**Total Upwelling Magnitude Index
($\text{m}^3/\text{s}/100\text{m}$ of coastline)**



Temperature

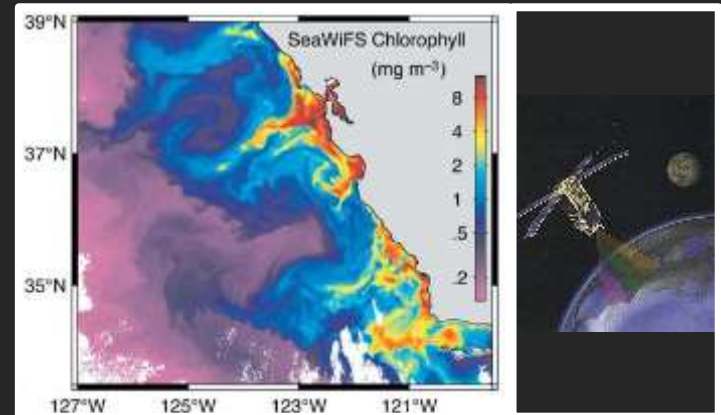
Chlorophyll

Farallon islands

Daily surface water sampling
Farallon shore station
1991-2013



Monthly: Garcia-Reyes et al. (2014)
Satellite images Kahru et al. (2012)
1997-2013



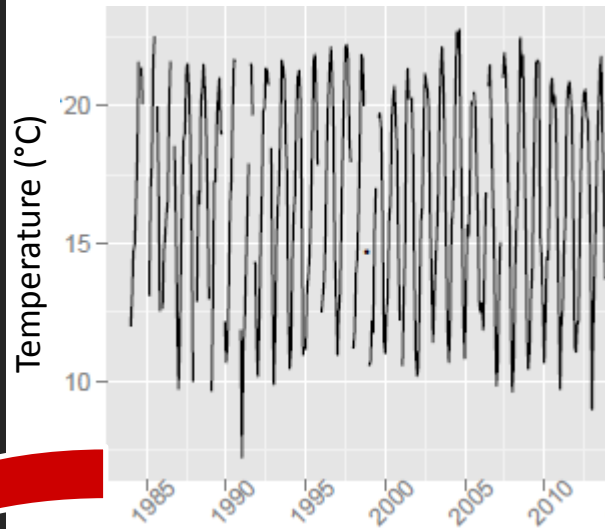
San Francisco Bay

Weekly/monthly sampling
Bottom/surface
USGS dataset
1984-2013

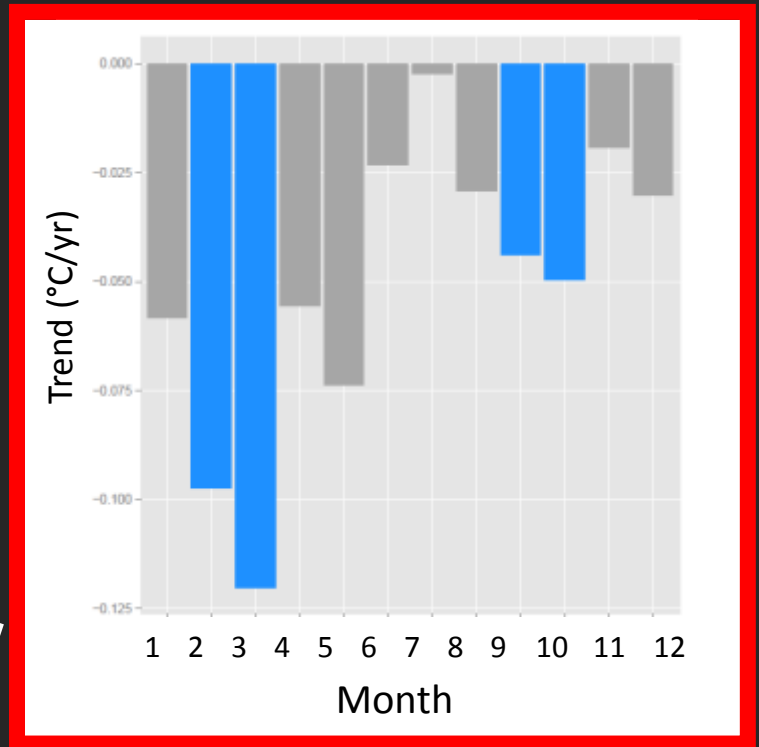


Investigating trends

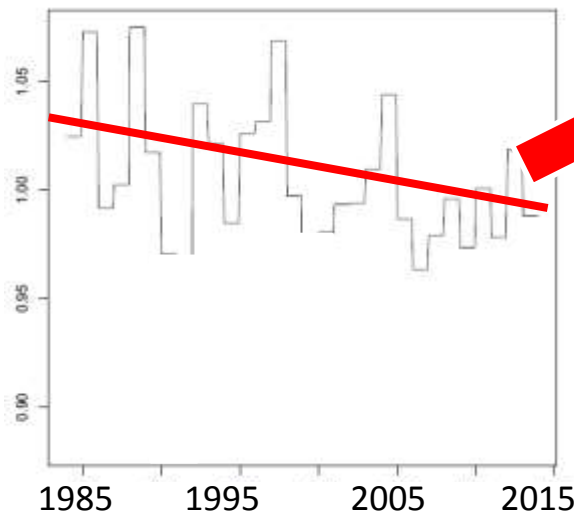
Time series



**Annual trend for each month
over a time period (e.g. 1984-2013)**



Trend for each month



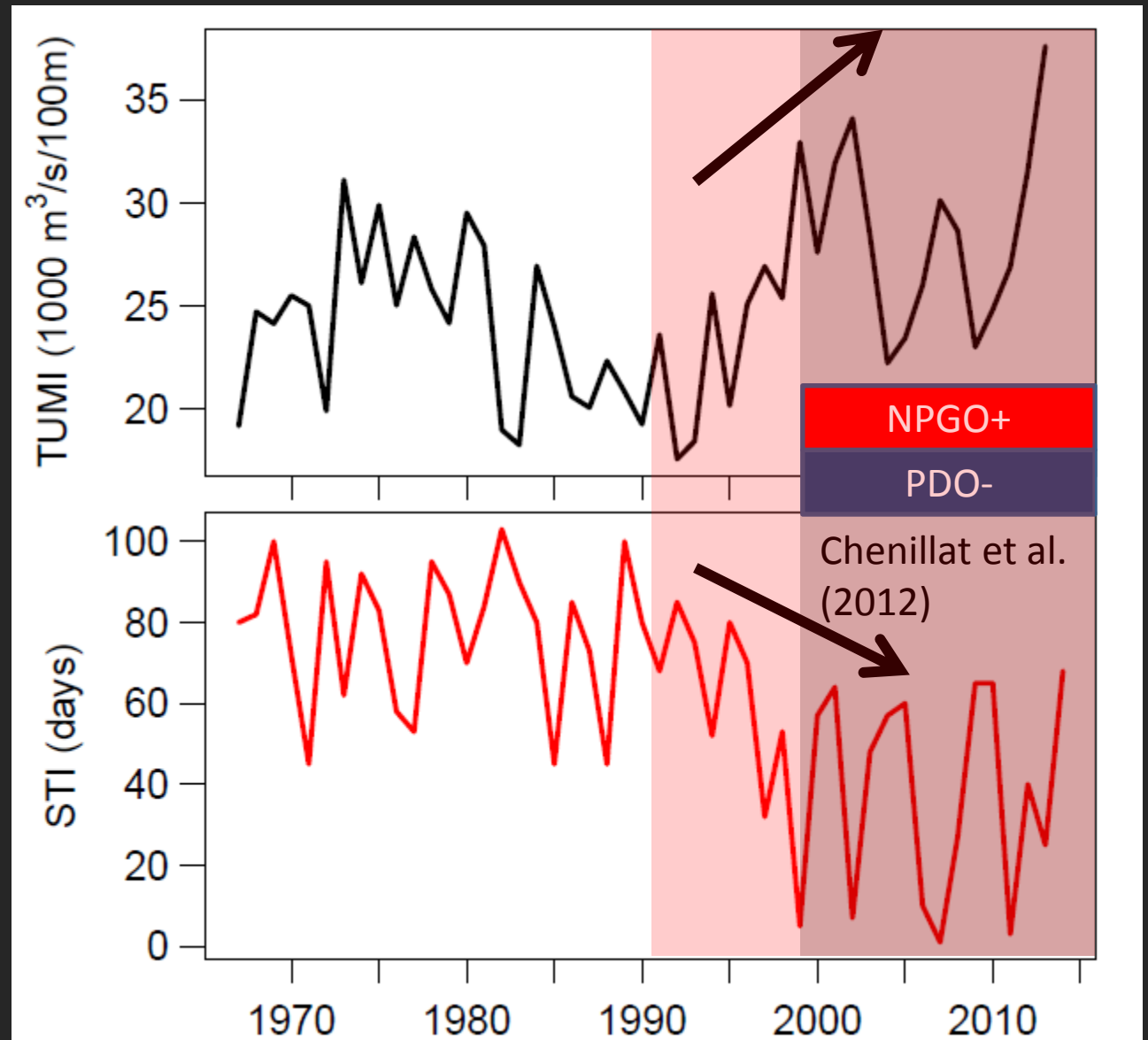
**statistically
significant**

wq R package (Jassby and Cloern, 2014)

□ Is there a signal of oceanic change
over time?

**Total Upwelling
Magnitude Index**

**Spring Transition
Index**



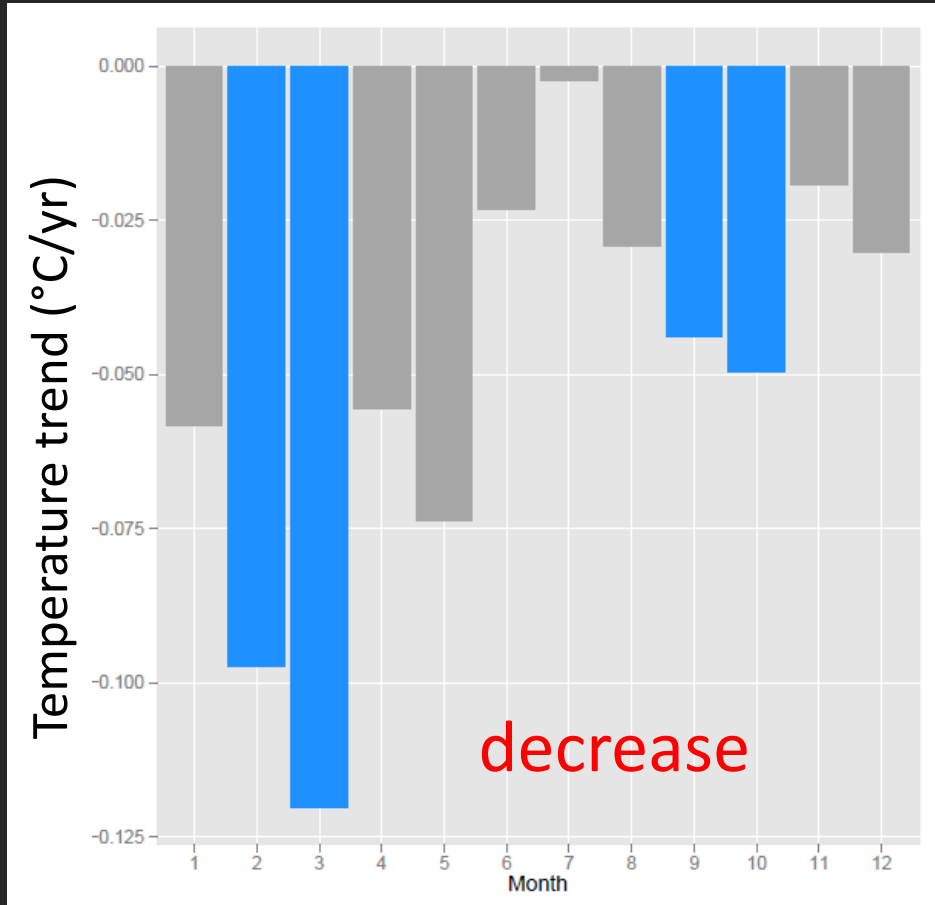
Stronger and earlier upwelling since 1999

⇒ Temperature decrease and chlorophyll increase?

Trends at Farallon islands

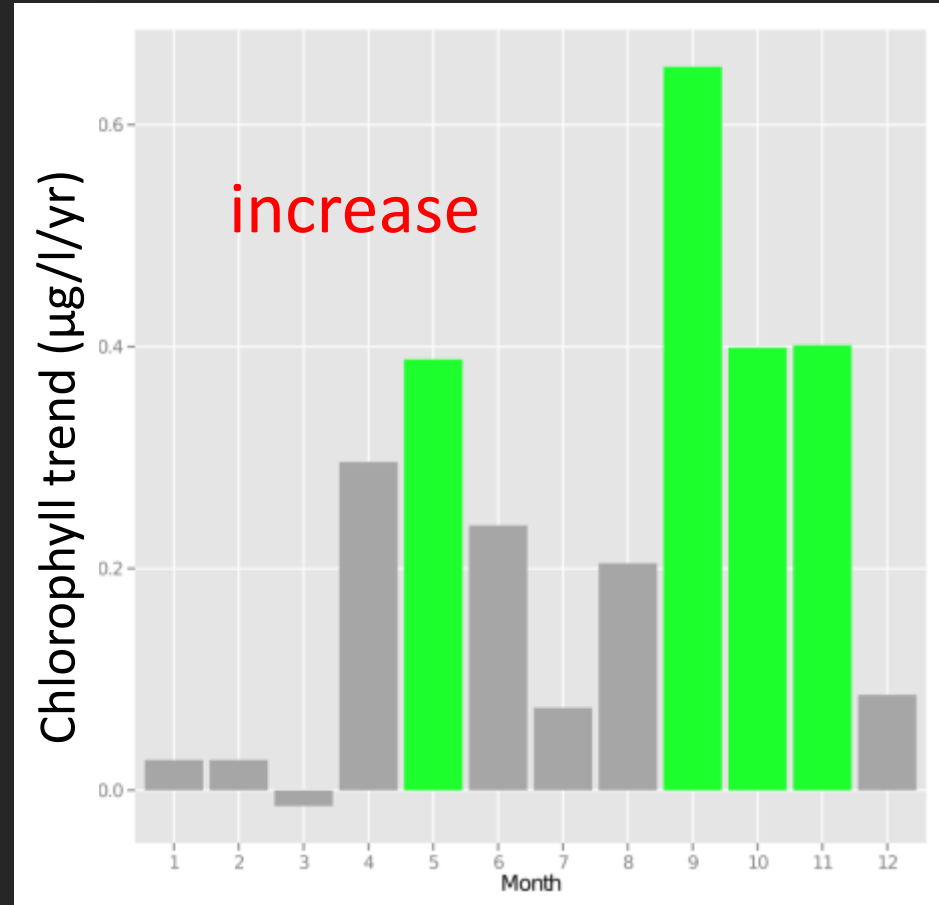


Temperature



■ significant

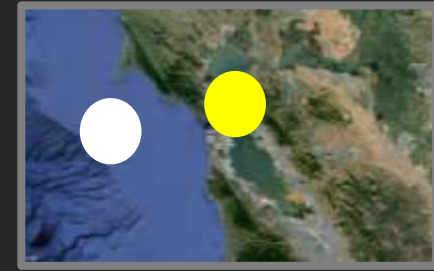
Chlorophyll



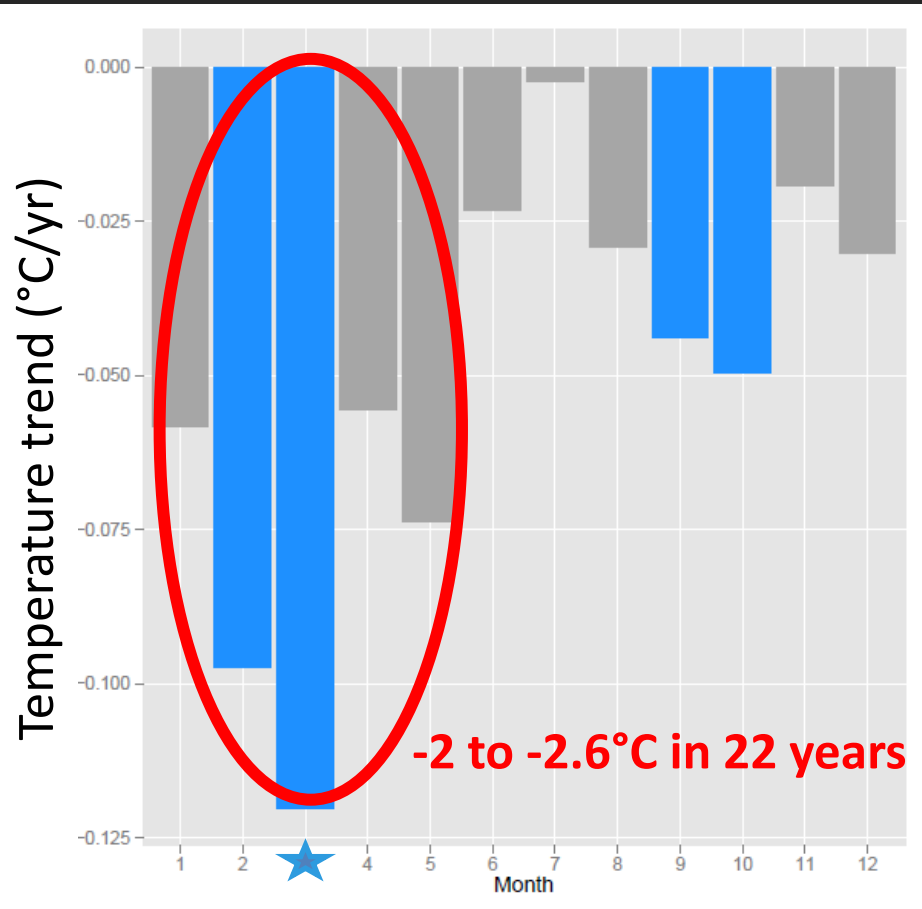
■ significant

□ How does this oceanic signal propagate into Central Bay?

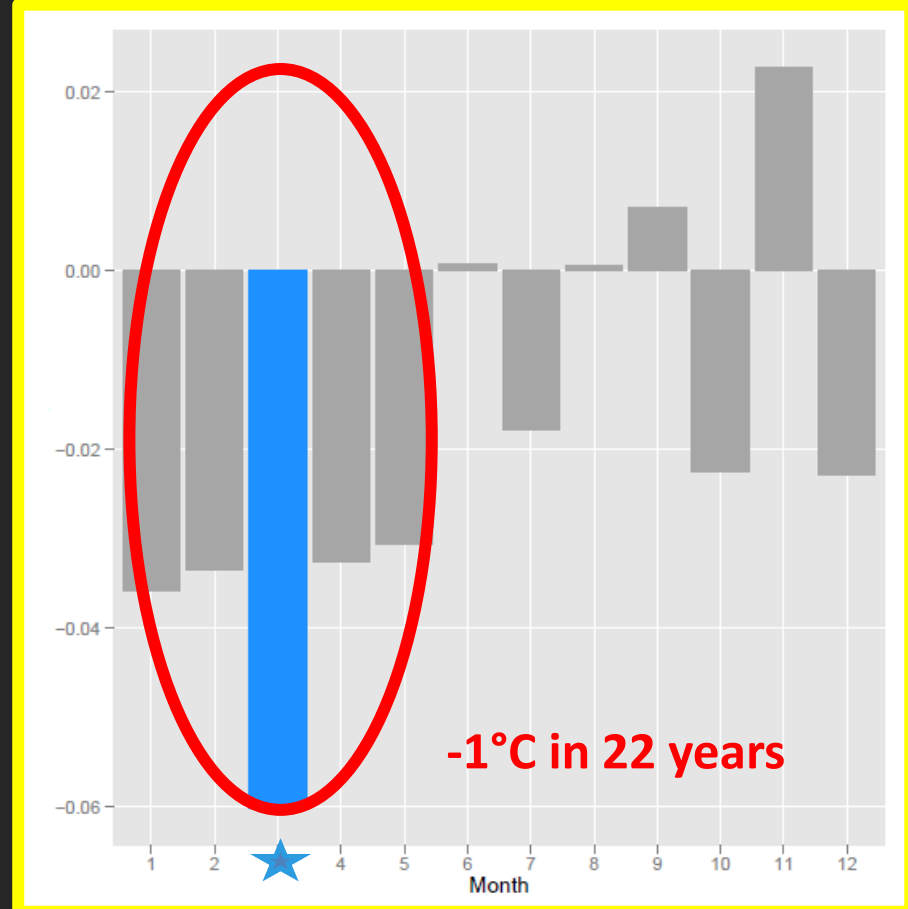
Temperature trends in Central Bay



Farallon (surface)



Central Bay (bottom)



■ significant

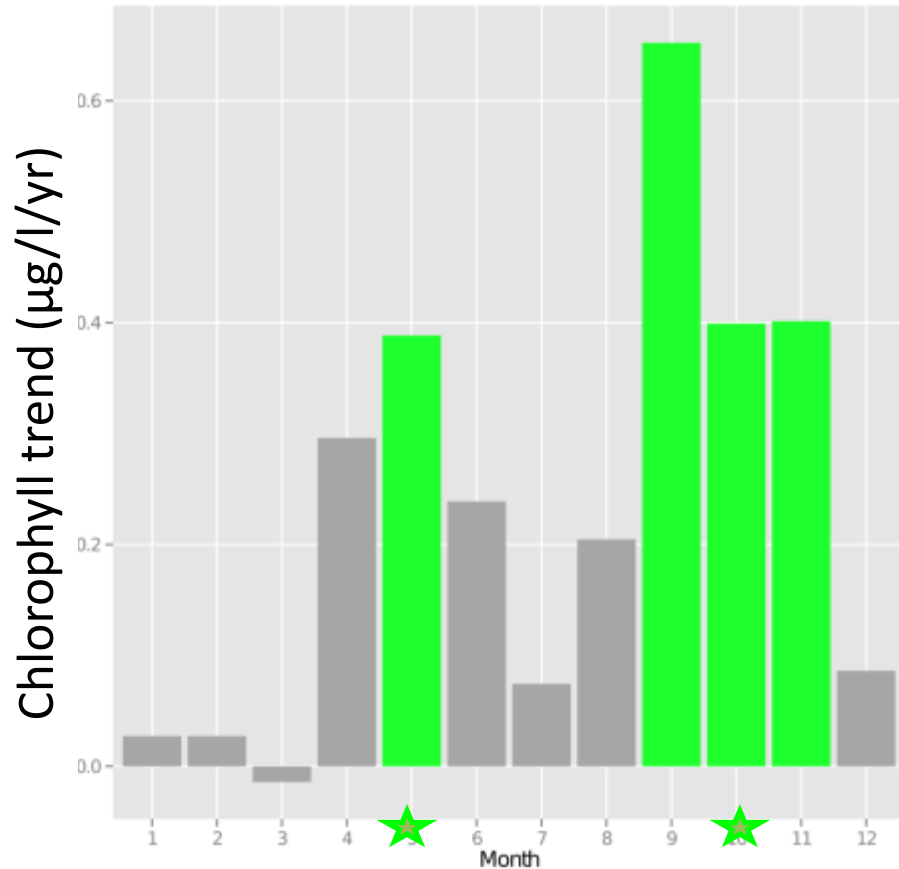
★ common trend

Similar cooling trend significant in March, but less strong

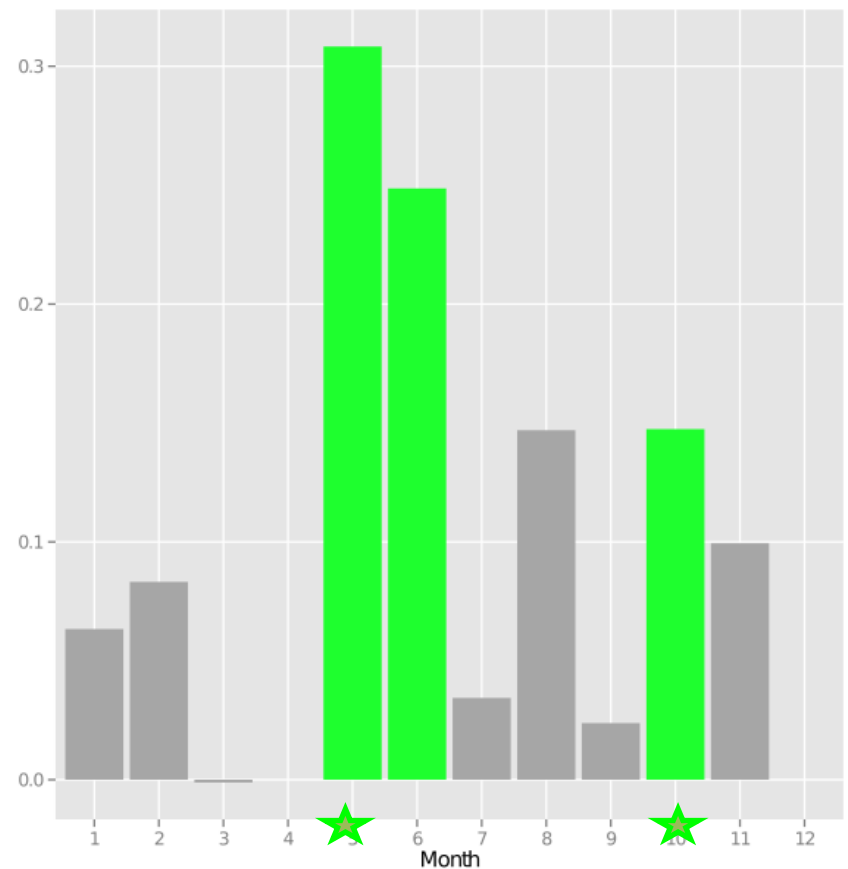
Chlorophyll trends In Central Bay



Farallon (surface)



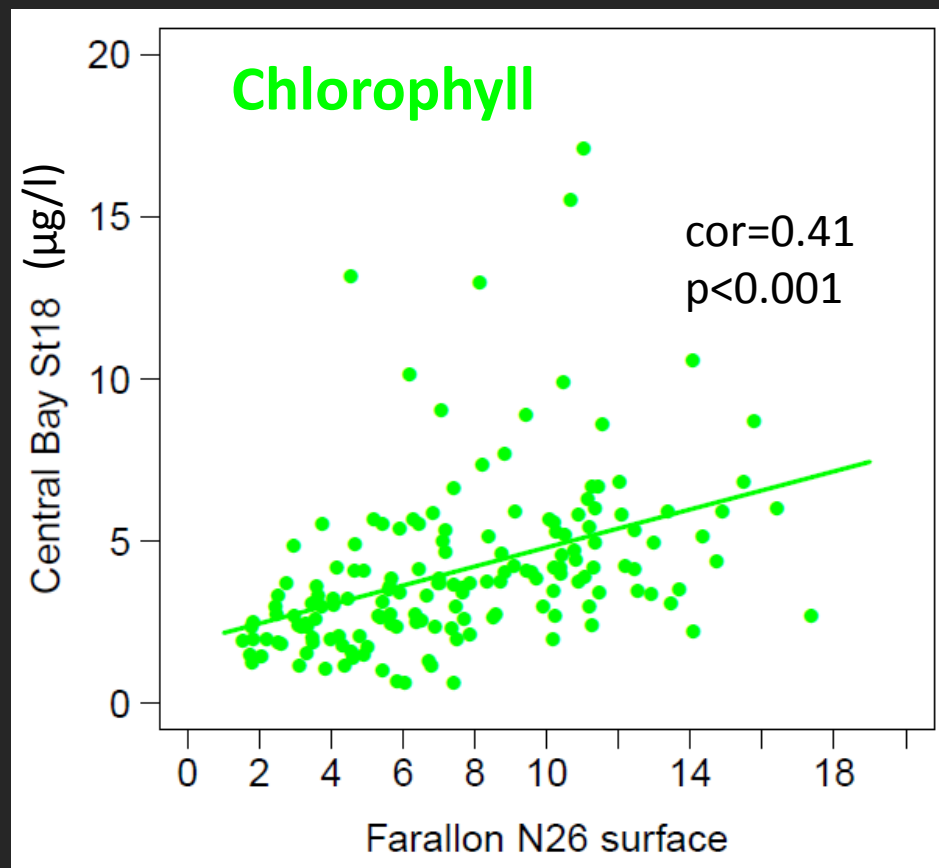
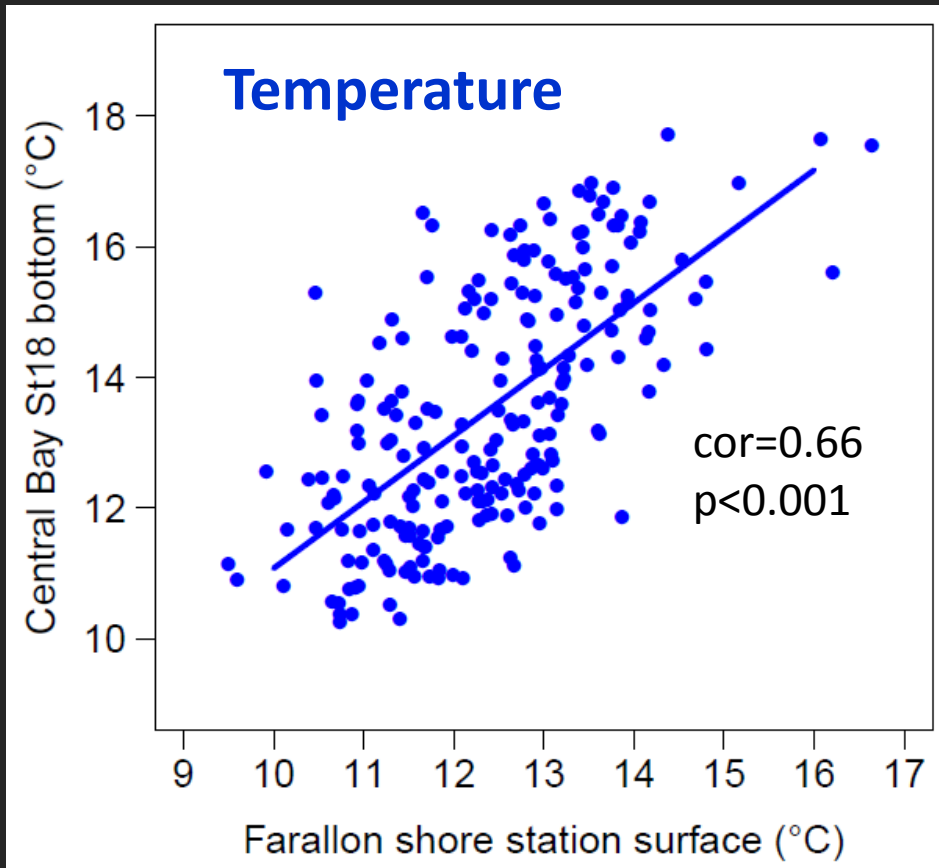
Central Bay (surface)



■ significant ★ common trend

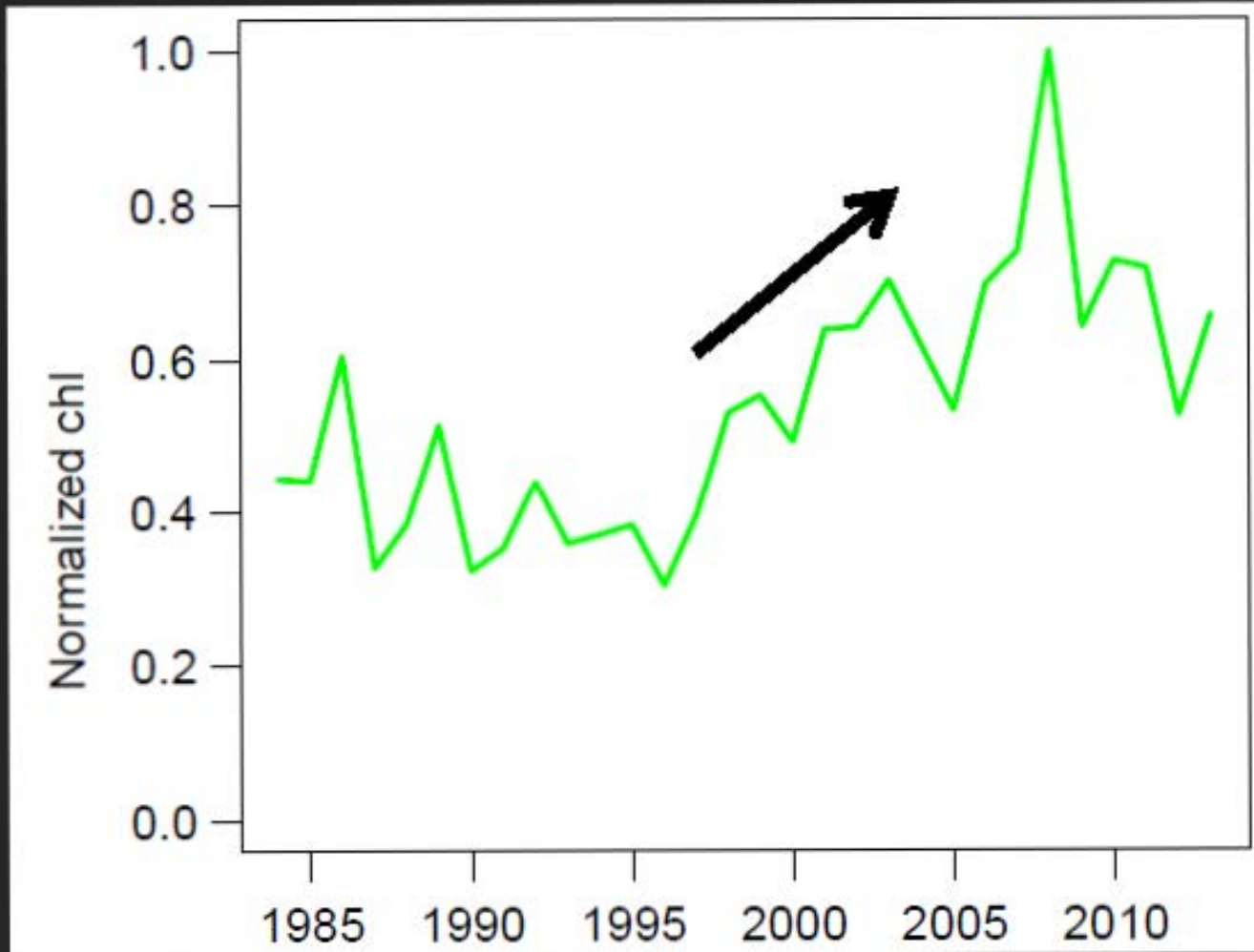
Same significant increase at both sites: May & October

Central Bay *versus* Farallon datasets

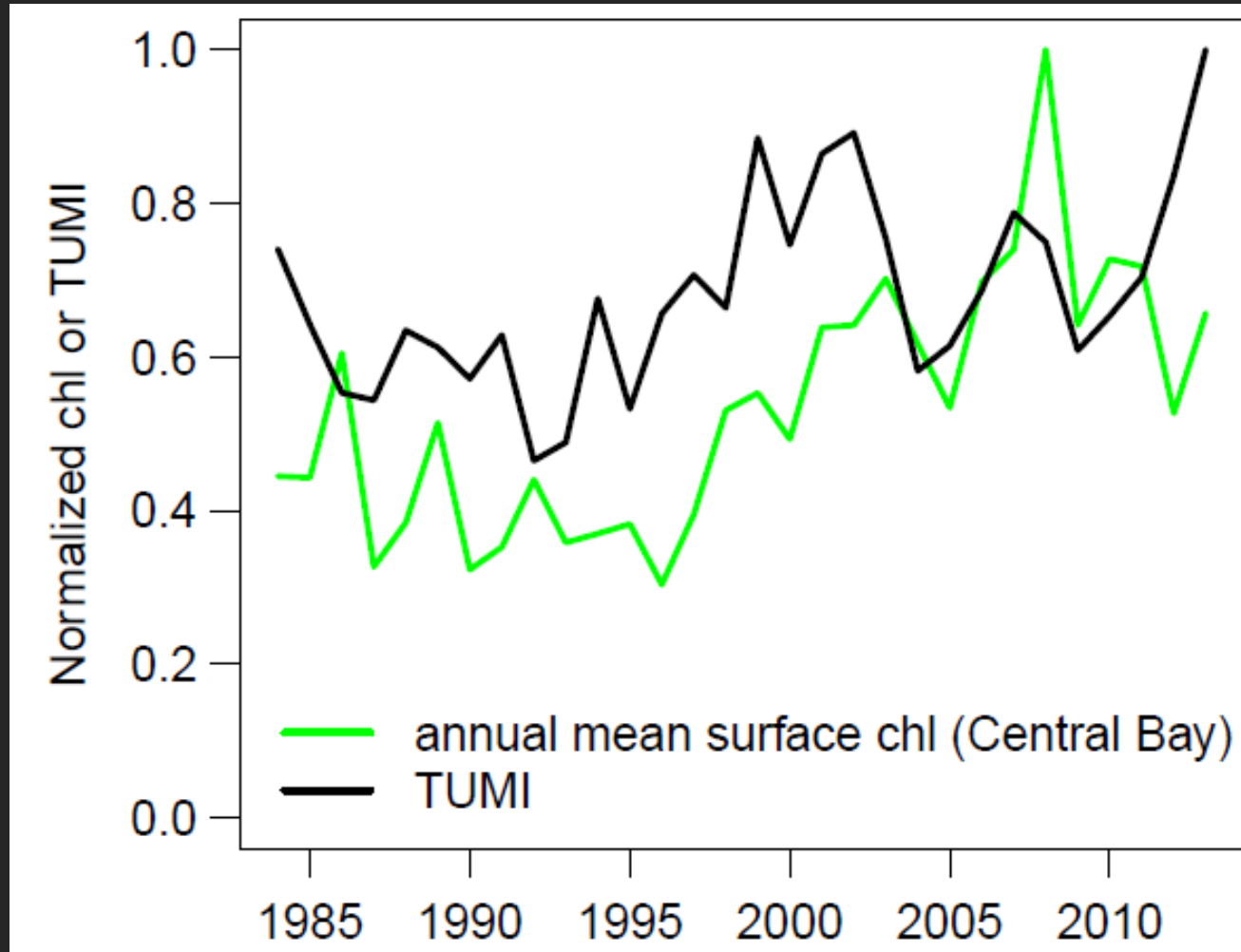


Significant correlations between Central Bay and Farallon
for both **temperature** and **chlorophyll**

Annual mean surface **chlorophyll** in Central Bay



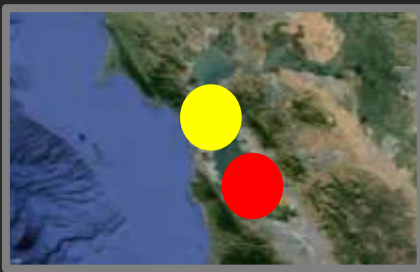
Annual mean surface **chlorophyll** in Central Bay



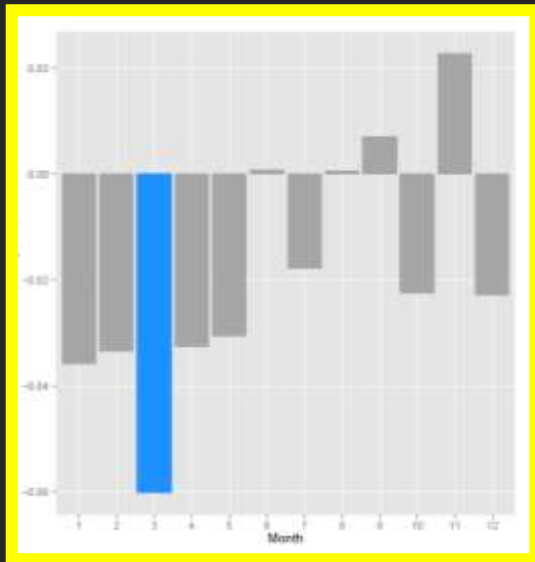
**Spearman
rho=0.52
p<0.01**

Surface Chl in Central Bay significantly correlated with TUMI

□ How does this oceanic signal propagate into South Bay?

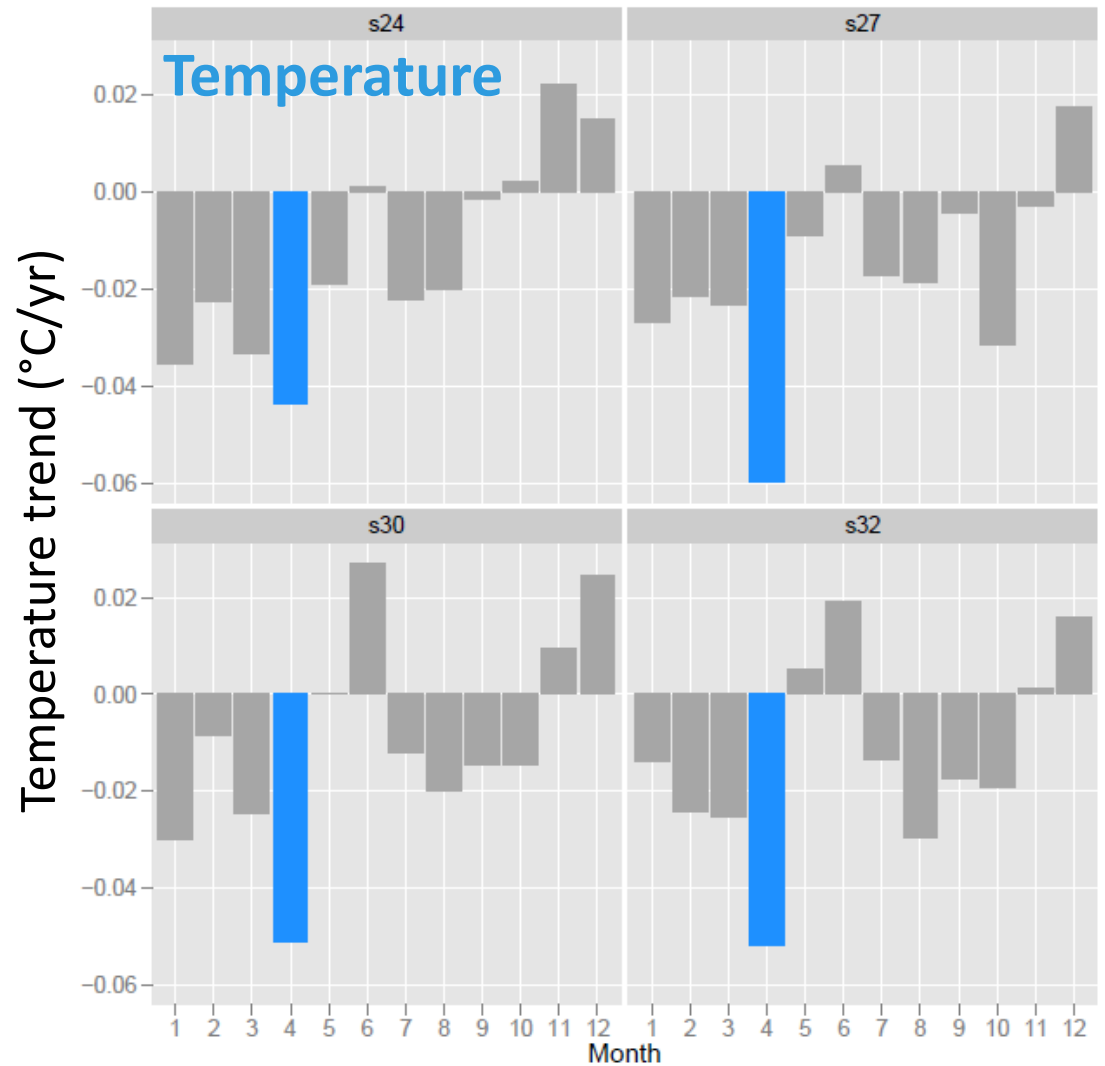


Central Bay

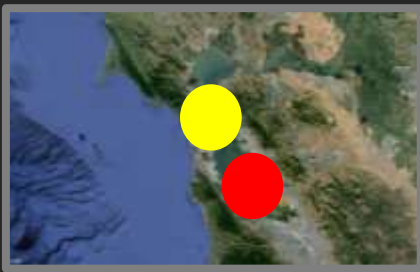


Bottom water 1991-2013

South Bay



Temperature decrease in April **in SB** => 1 month lag **with CB**



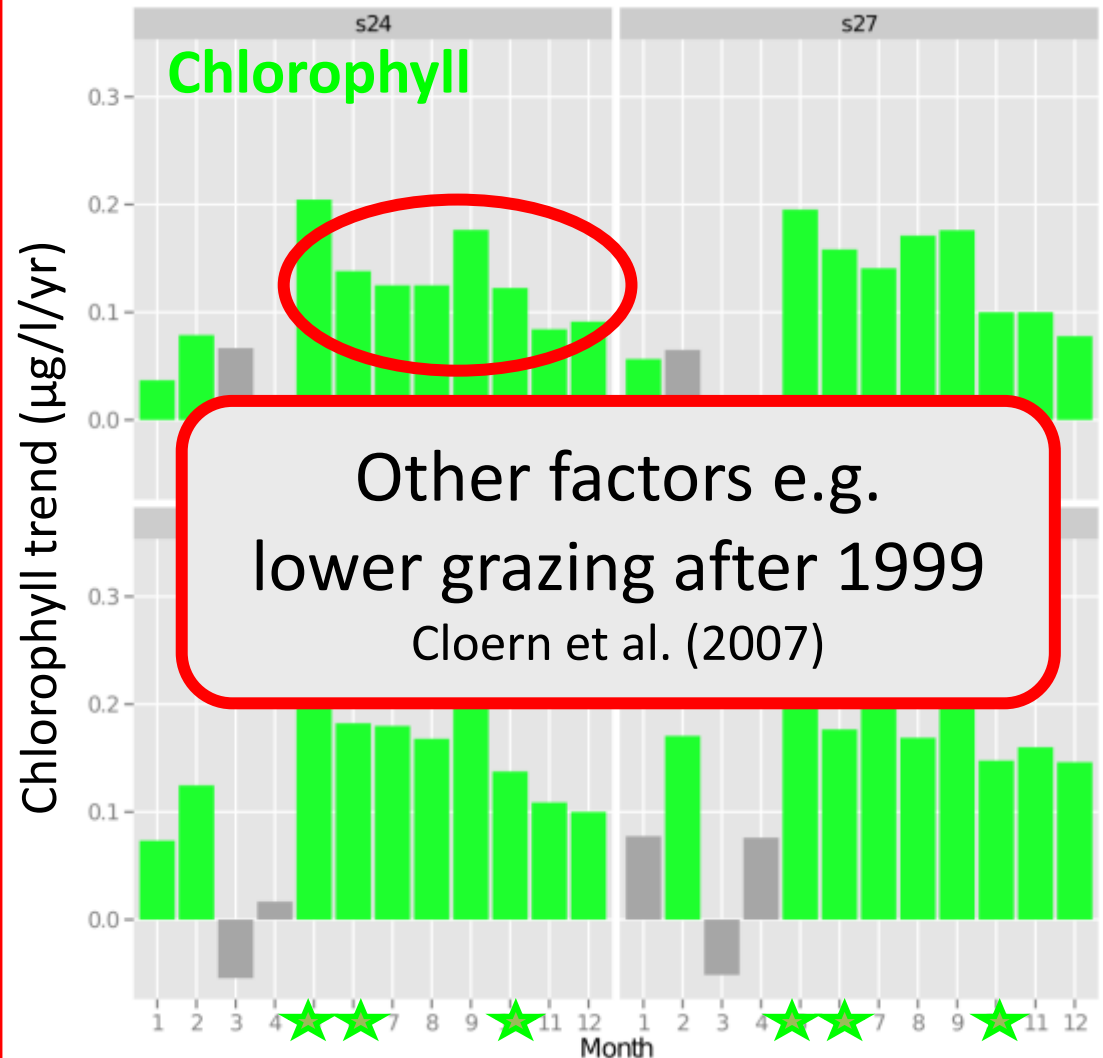
Central Bay



Surface water 1991-2013

★ common trend

South Bay




Chl increase in May/Jun/Oct like CB, but also until Dec

Take home messages

- Stronger and earlier upwelling since 1999
- Colder temperature and higher chlorophyll in Farallon
- Colder temperature propagates into Central and South Bay
- Higher chlorophyll in the Central and South Bay too (due to upwelling and other factors e.g. grazing, turbidity...)

To manage water quality and determine baselines:

We cannot forget that the ocean is influenced by climate and that the Bay is influenced by the ocean!



Thank you for your attention

Special thanks to:

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