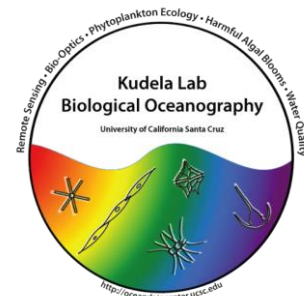


The Year of Crazy—Droughts, Blooms, Warm Blobs, and other Anomalies in the Eastern Pacific

Raphael Kudela

University of California Santa Cruz

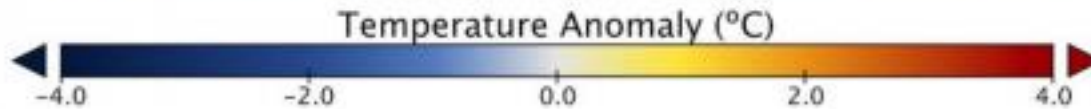
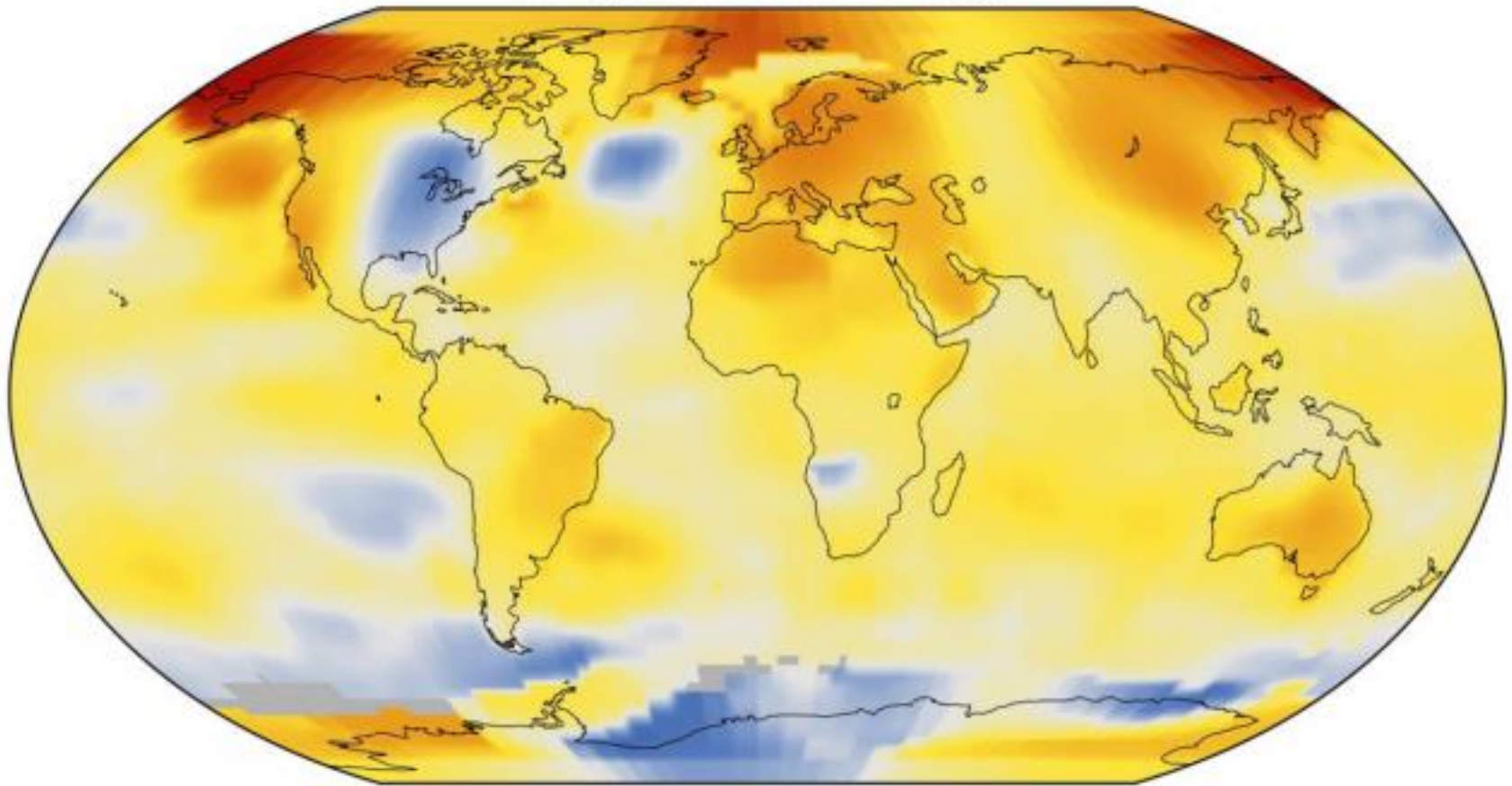
<http://oceandatacenter.ucsc.edu/>

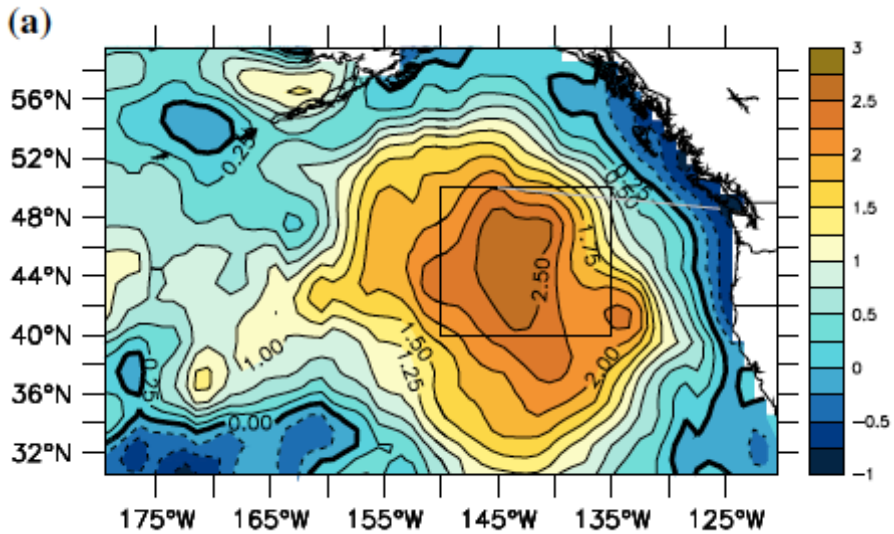


2014: The Warmest Year In the Modern Record

^
2015

GISTEMP 2014 Anomaly
with respect to 1951-1980 climatology

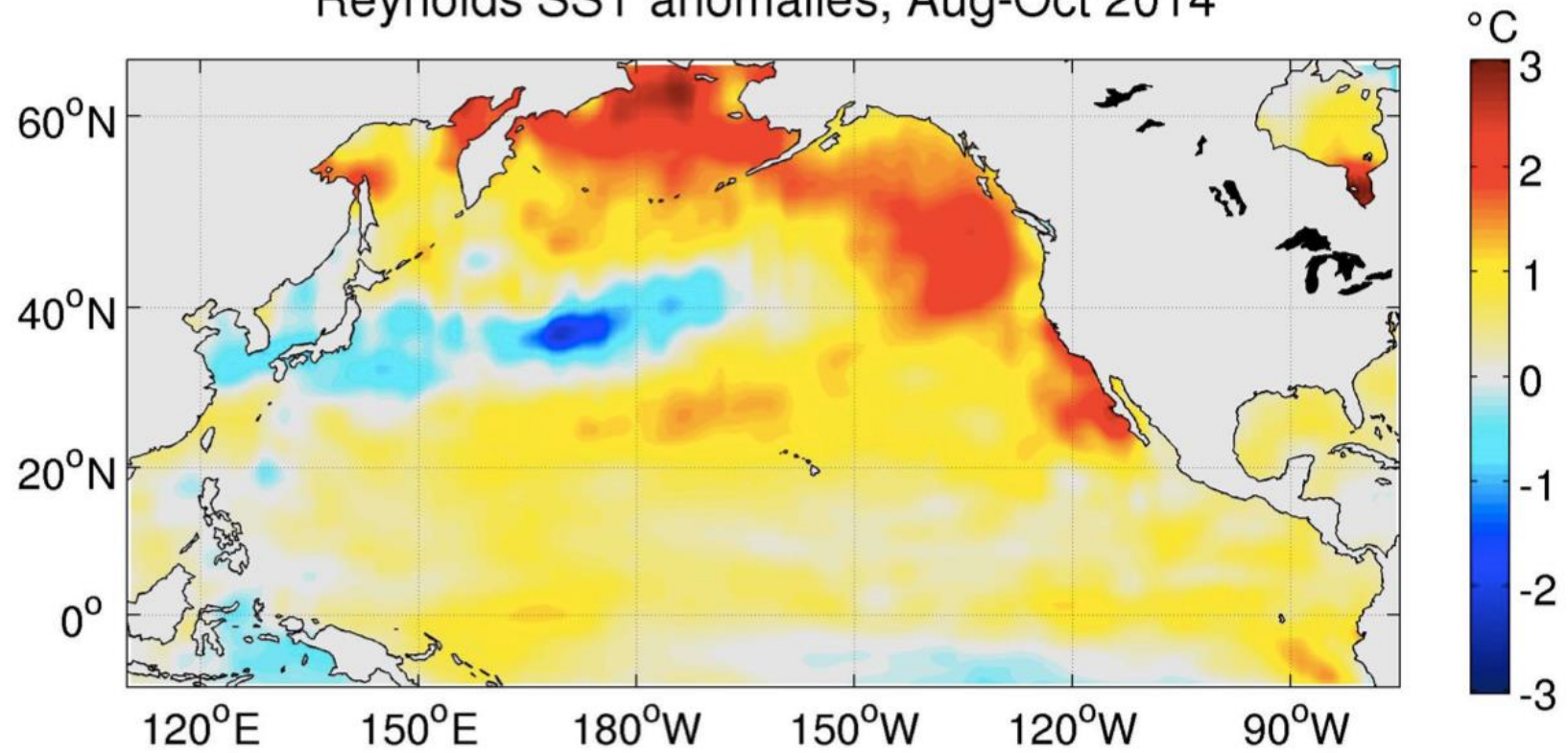




SST Anomaly, February 2014

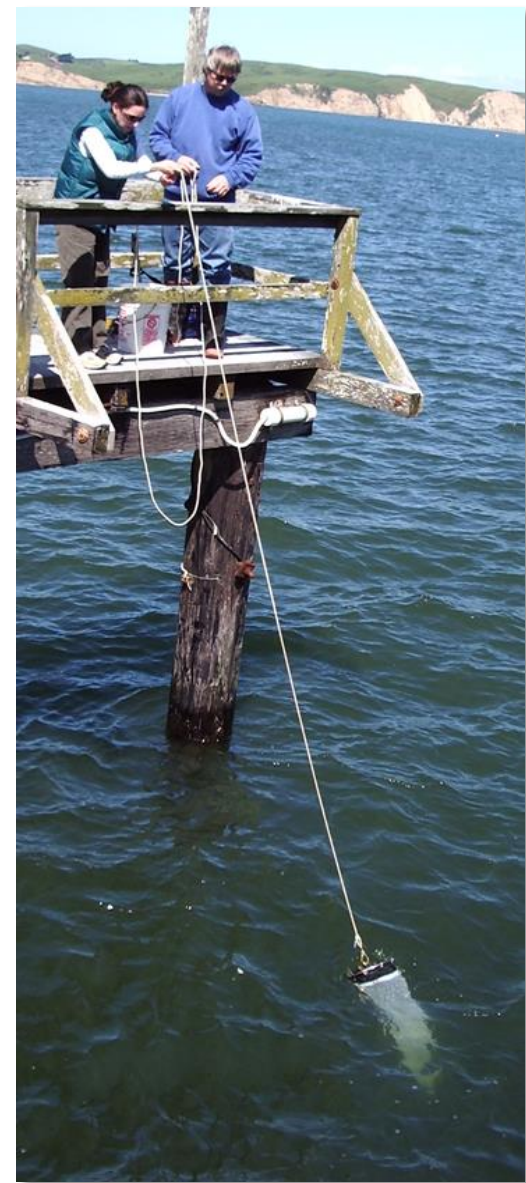
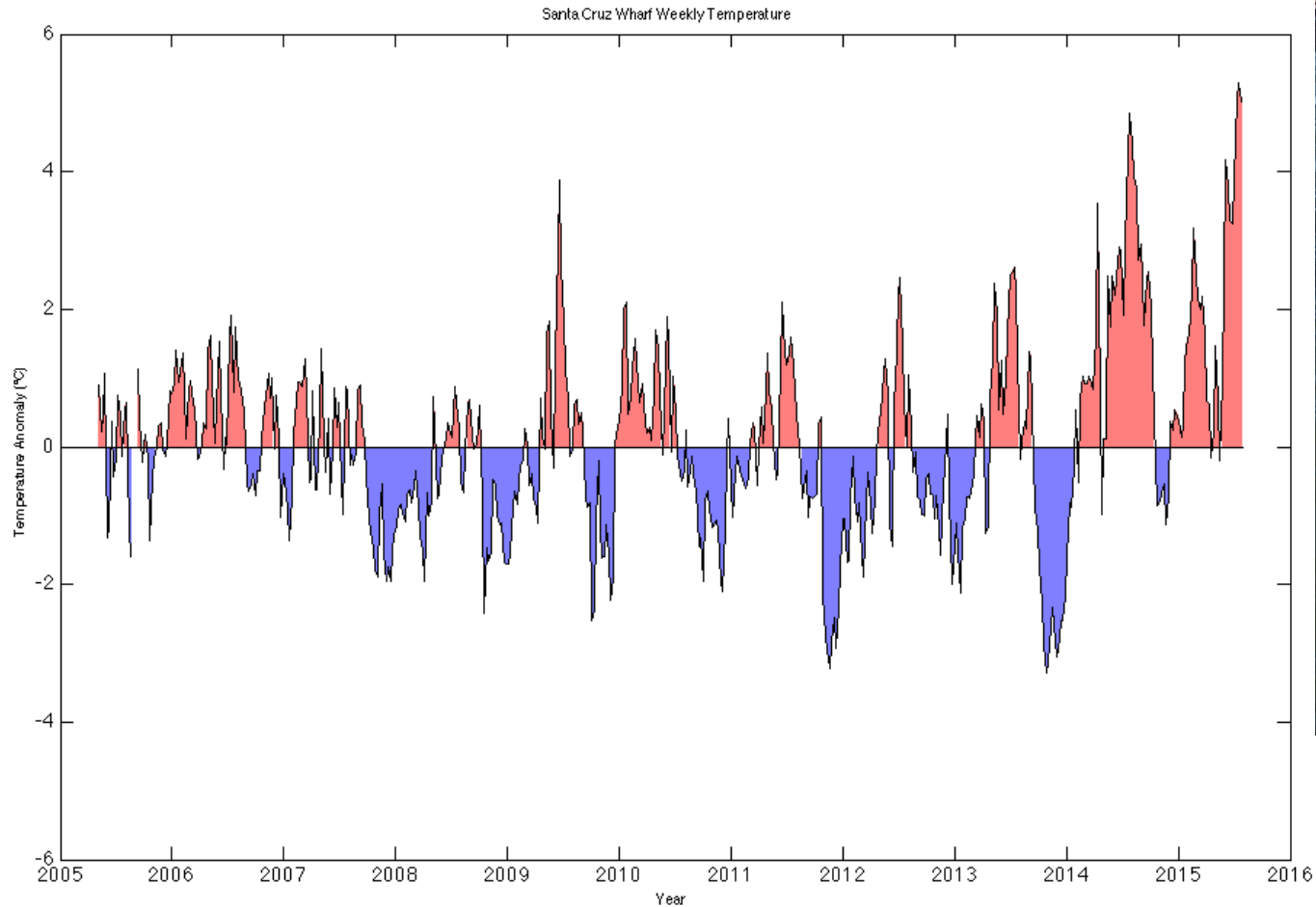
Bond et al. GRL 2015

Reynolds SST anomalies, Aug-Oct 2014



Santa Cruz Municipal Wharf Time Series

Weekly Observations Since 2002





HILLTROMPER SANTA CRUZ

the nature-worshipping, fun-loving adventurer's guide

BECOME A HILLTROMPER

LOG IN



PARKS & REC

EVENTS

GEAR

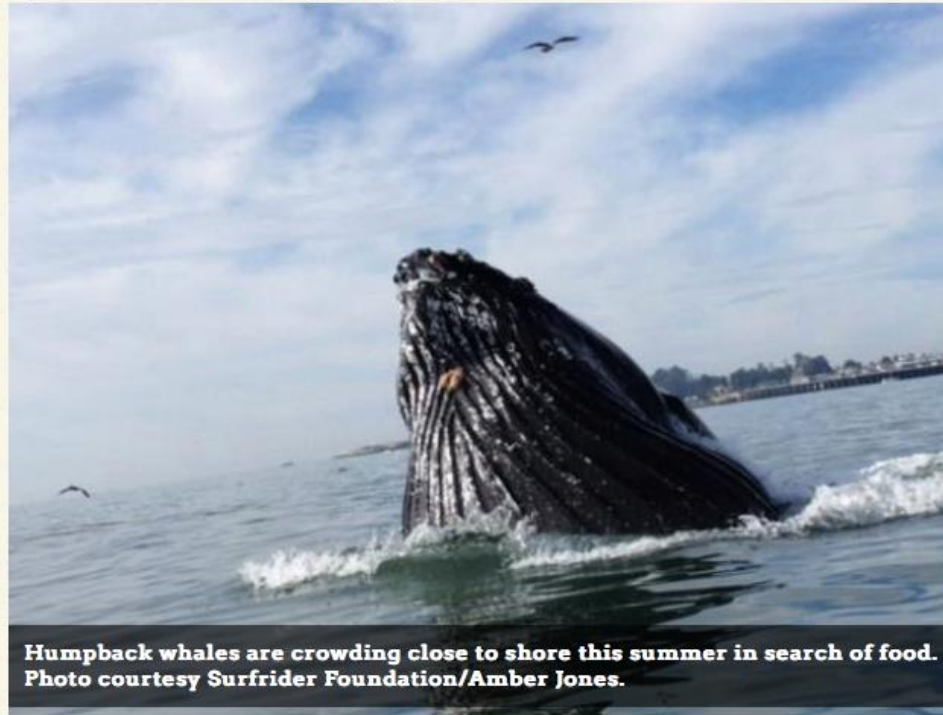
COMMUNITY

ECO NEWS

TROMP BLOG

The Summer of Crazy

Tags: *whales whale watching humpback anchovies domoic acid El Nino*



Humpback whales are crowding close to shore this summer in search of food. Photo courtesy Surfrider Foundation/Amber Jones.

<http://www.hilltromper.com/article/monterey-bay-weird-summer-2014-whales-anchovies-algae>



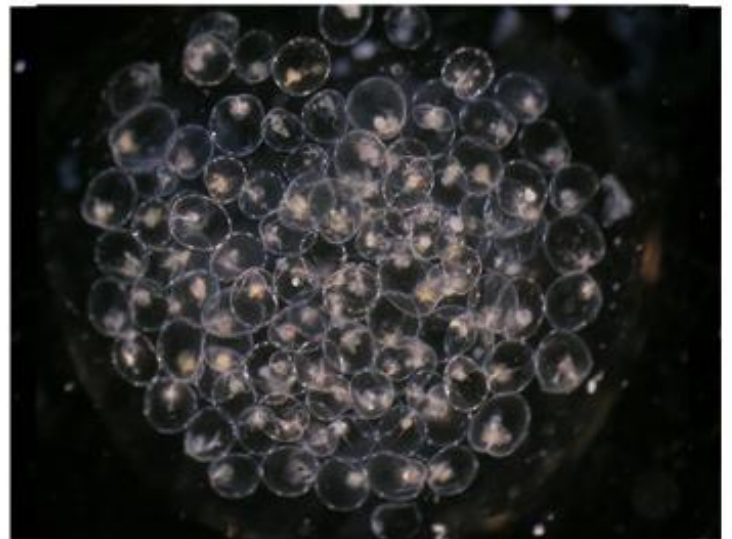
haddock@mbari.org



<http://lifesci.ucsb.edu/~biolum>



<http://jellywatch.org>



Beachings of exotic blue velella tied to wind patterns

Velella, probably carried by wind, a reminder of ocean's diversity

Hamed Aleaziz Updated 7:14 pm, Thursday, July 31, 2014



Green stuff on Seaside beach probably common marine algae

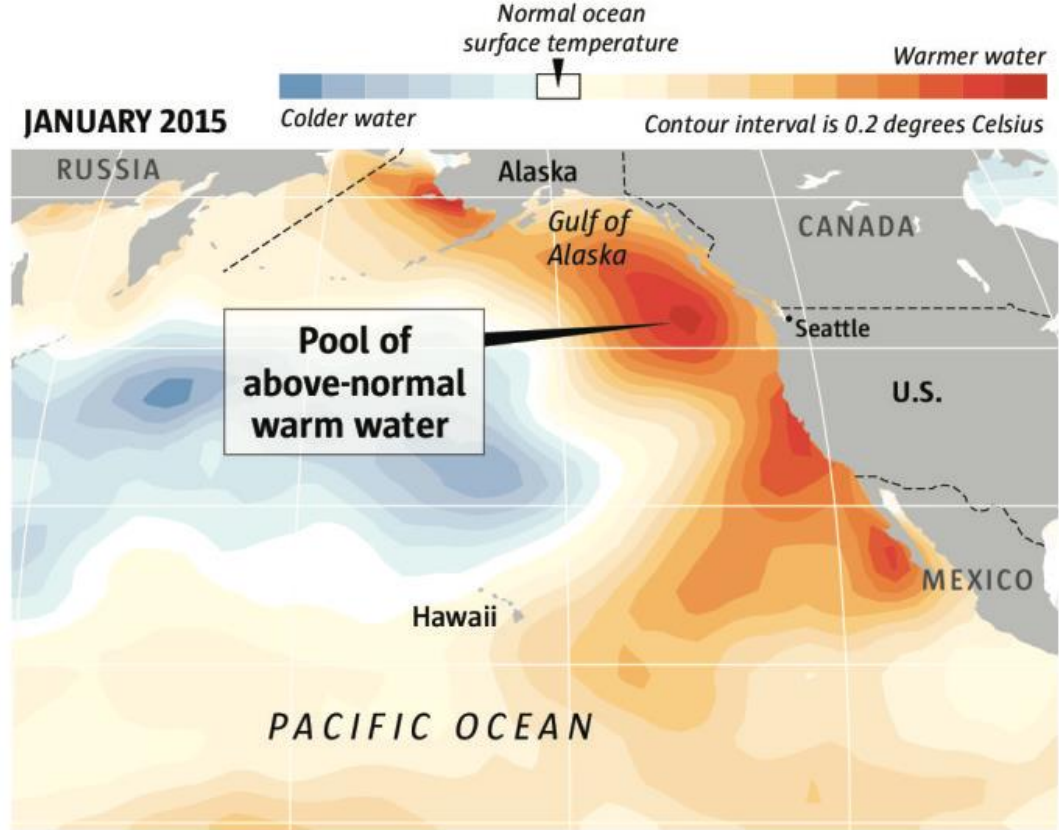


The blob off our coast

Scientists say a vast pool of warm water off our coast is affecting marine life and local weather, and is part of a bigger pattern that includes California's drought and East Coast blizzards.

Source: Department of Atmospheric Sciences, University of Washington

MARK NOWLIN / THE SEATTLE TIMES



≡ KQED Science

NEWS

PROGRAMS & BLOGS

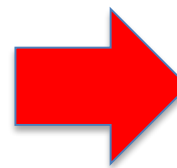
EDUCATION RESOURCES

DROUGHT WATCH 2015

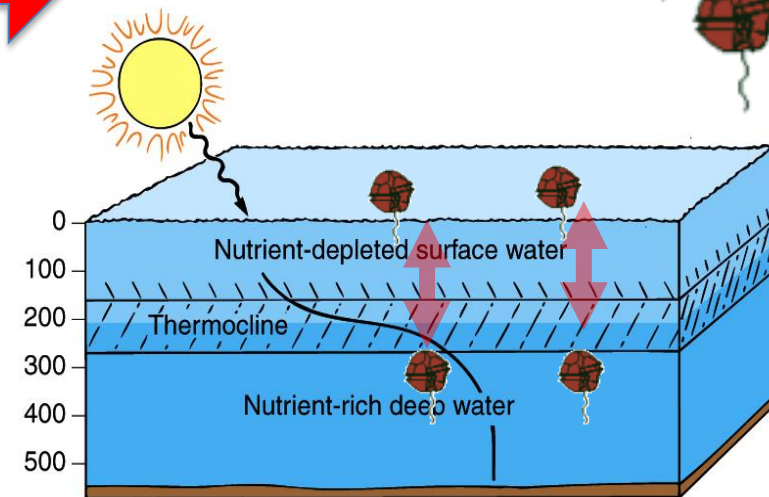
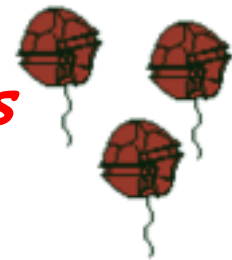
El Niño Update: California's 'Great Wet Hope' Continues to Build

Decadal Trends in the California Current:

- Mixed Layer Depth is shoaling
- Surface temperatures are increasing
- Stratification intensity is increasing
- Nutrient concentrations, ratios shifting

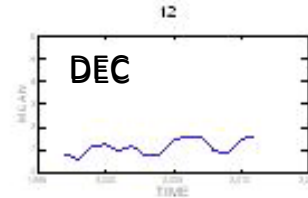
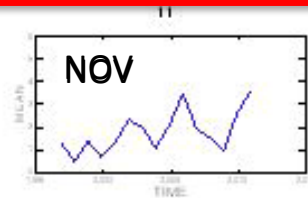
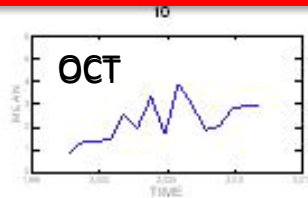
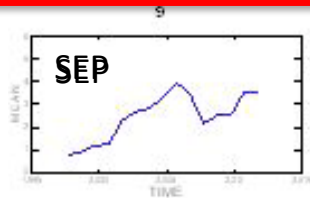
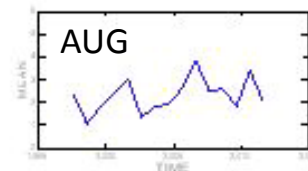
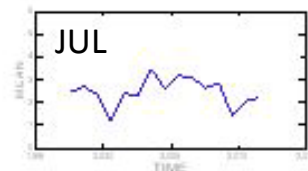
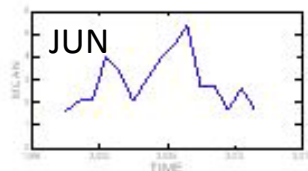
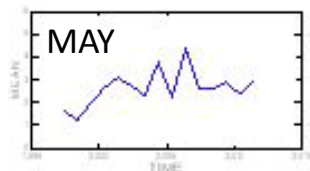
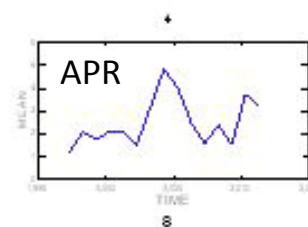
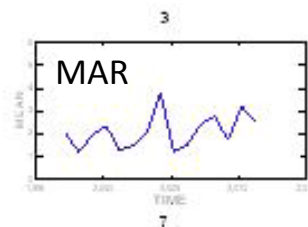
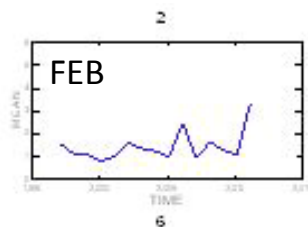
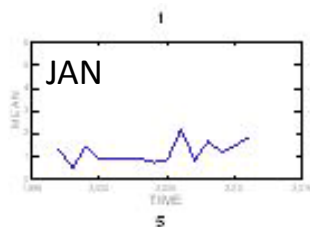


Dinoflagellates



Depth (m)

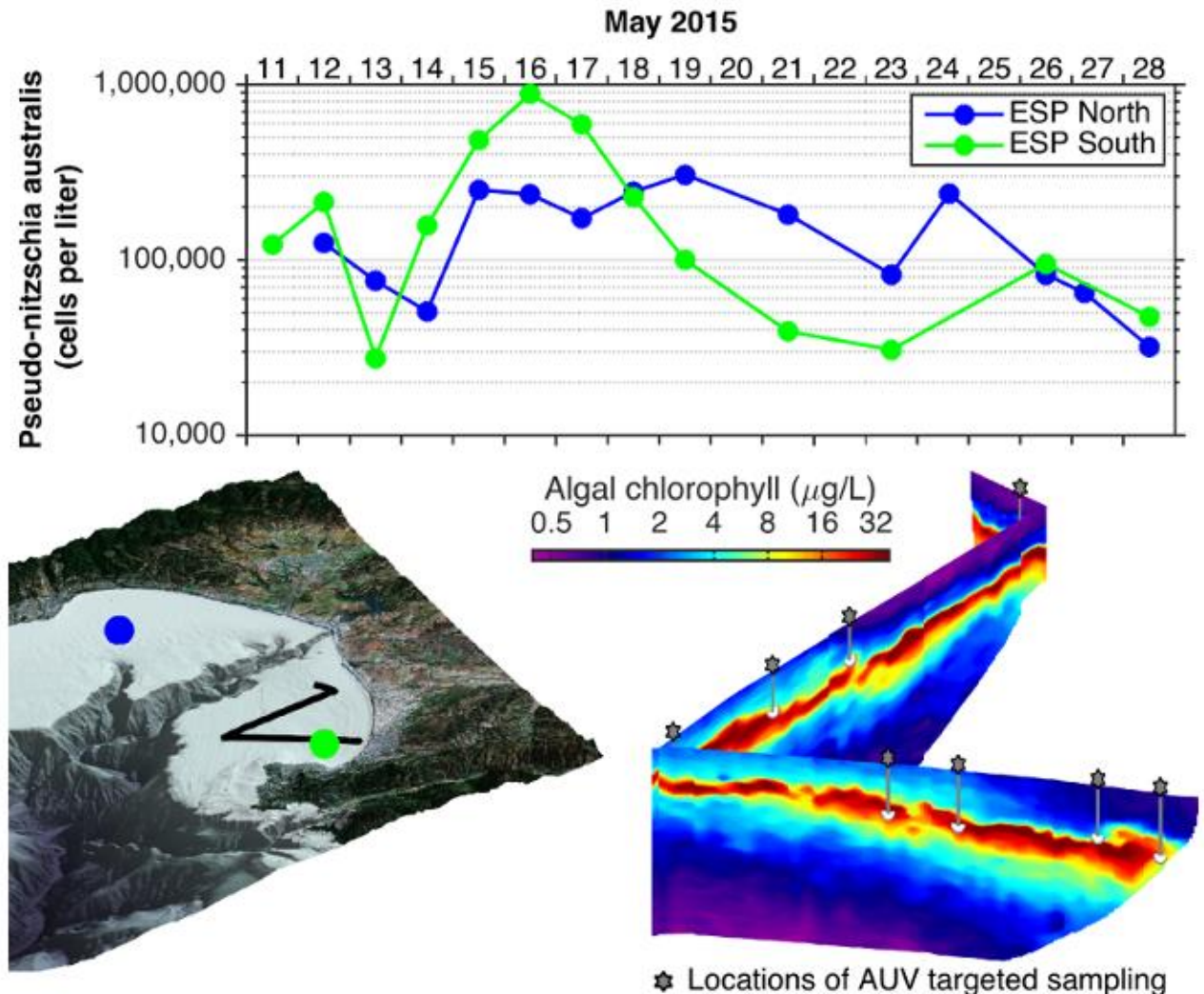
Mean Monthly Trends in Chlorophyll



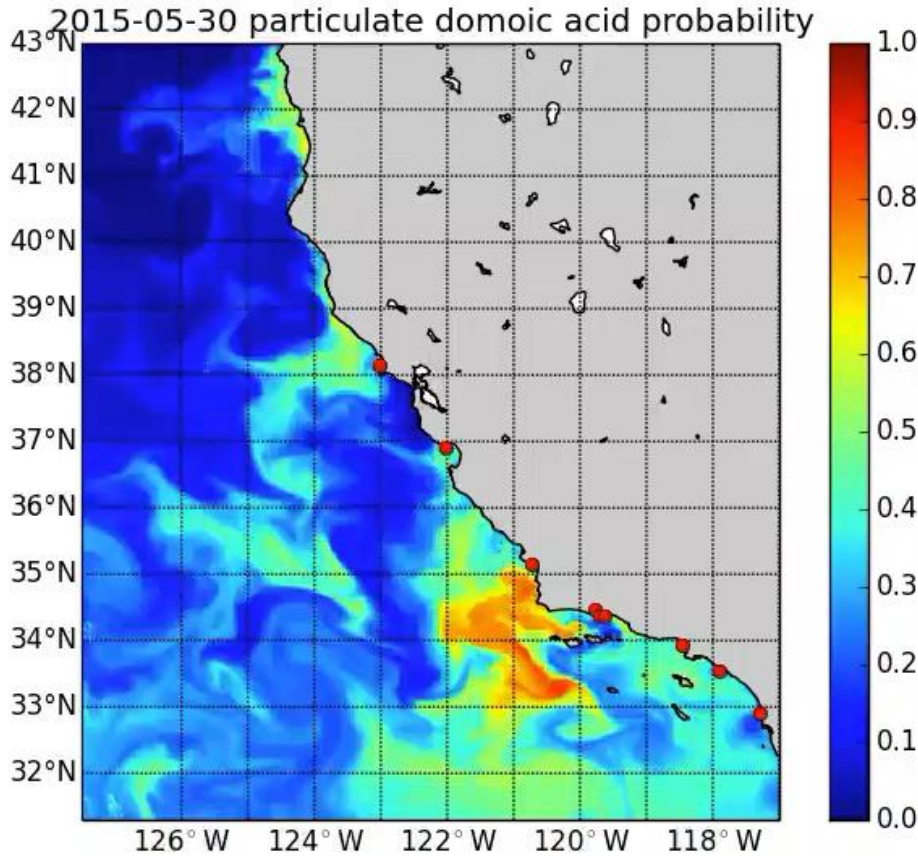
Pseudo-nitzschia has characteristics of a dinoflagellate:

- It prefers weak, pulsed upwelling/relaxation and WARM water
- It forms subsurface maxima
- It does well on anthropogenic nutrients and may be more toxic with urea
- It responds to “flush” rain events in autumn

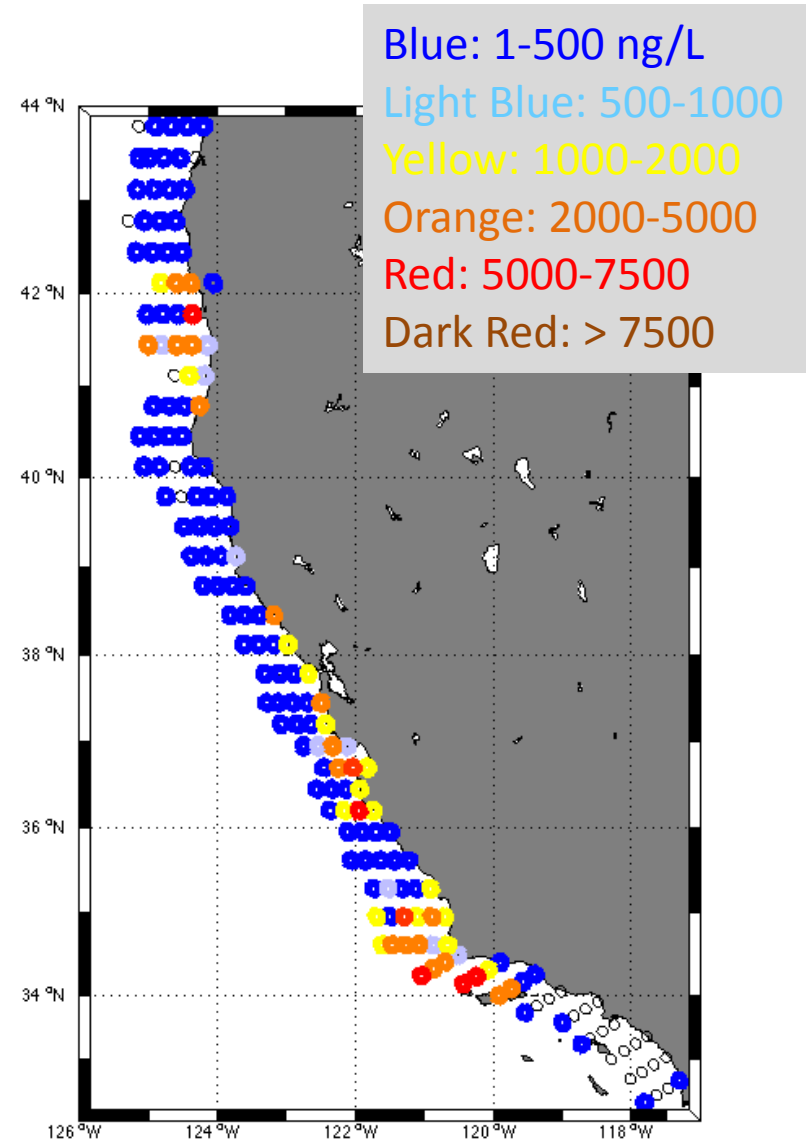
2015 data from Monterey showing the development of a subsurface layer of *Pseudo-nitzschia* (sitting on the nutricline). Previous studies show coupling with high-Fe waters from BBL feeding these layers.



Modeled Toxin Probability



Particulate Domoic Acid (ng/L)

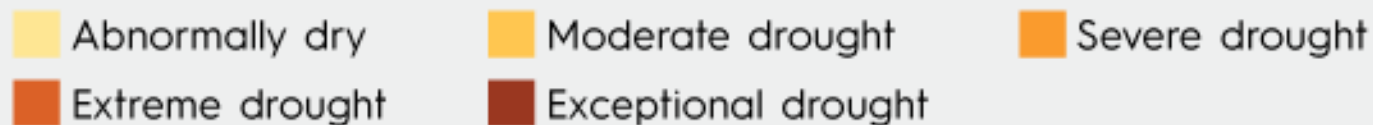


2015: An Unprecedented Year

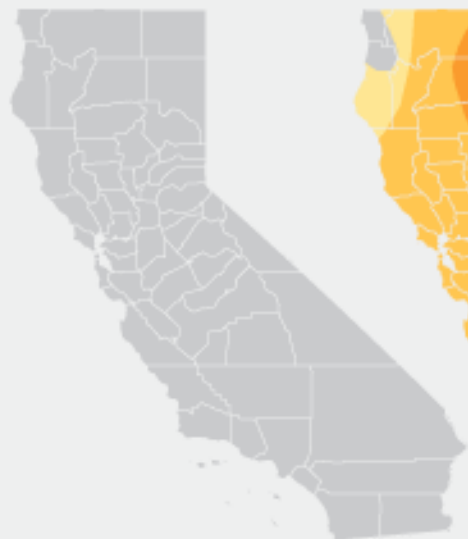
- The bloom appeared essentially simultaneously from Kodiak Alaska, to Santa Barbara (but not SoCal)
- Surface and subsurface (DCM)
- Peak toxin levels of ~110,000 ng/L (highest ever)
- ***Trophic Transfer:***
 - Mussels up to 200 ppm, Dungeness up to 120 ppm
 - Anchovy 100-600, viscera (new record) >3,000 ppm
 - Barnacles 100 ppm
 - Detectable in filet of halibut, salmon, ling cod, whole body of mackerel, squid, smelt
 - Acute poisoning in pelicans, sea lions
 - Contaminated Monterey Bay Aquarium tanks

A Record-Breaking Drought

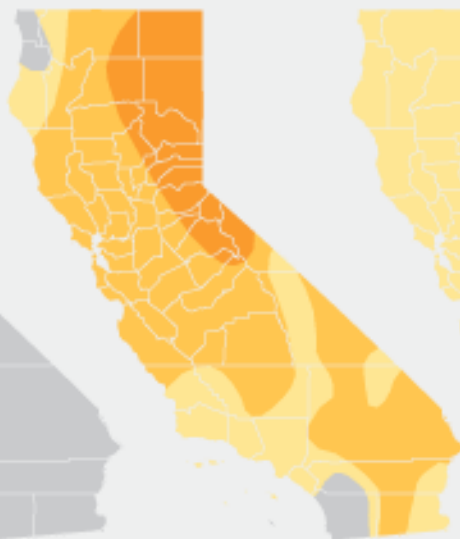
41% of the state is facing “exceptional drought” (the most severe kind).



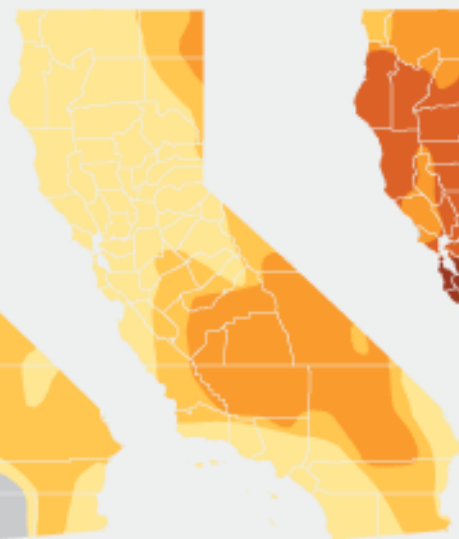
2011



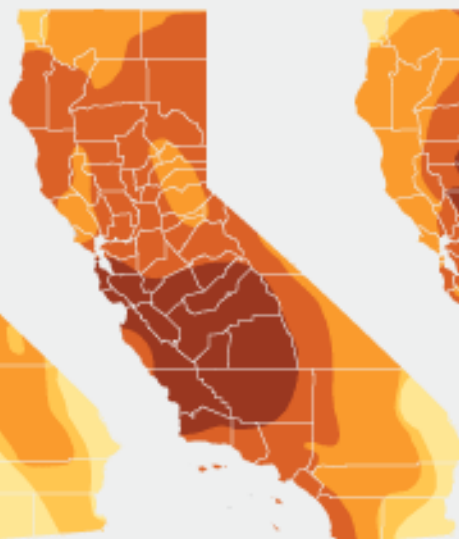
2012



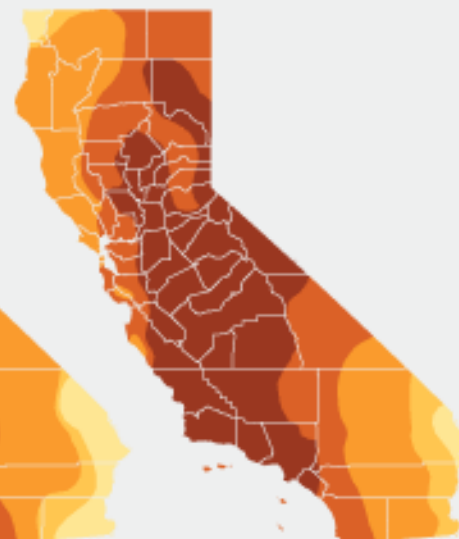
2013



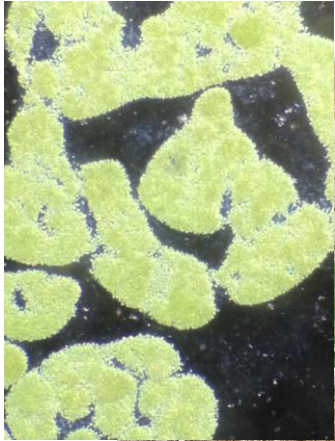
2014



2015



A Tour of California Hotspots



San Joaquin Marsh—33,500 $\mu\text{g/L}$

Lake Chabot—11,000 $\mu\text{g/L}$;
800,000 $\mu\text{g/L}$ scum

Pinto Lake—1,000 $\mu\text{g/L}$ annually;
2.9 million $\mu\text{g/L}$ scum



A Tour of California Hotspots



Wadeable Streams:

Microcystin—33%

Lyngbyatoxin—21%

Saxitoxin—7%

Anatoxin-a—3%

Eel River algal mats:

Anatoxin-a—42%

Microcystins—15%

Both—5%

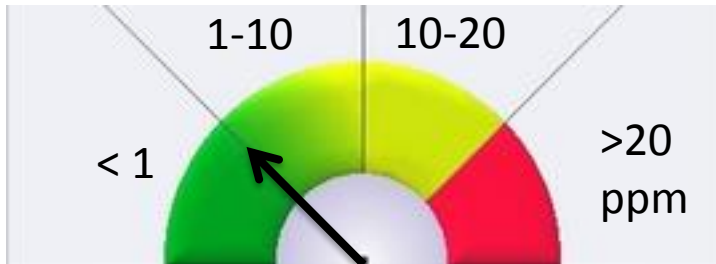
ATX ~ 10x > MCY

Data Sources: Fetscher et al. *Harmful Algae*, in press

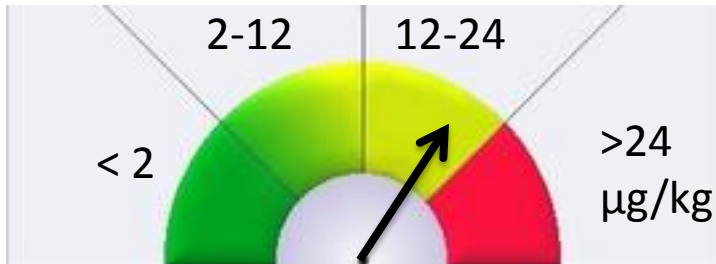
Bouma-Gregson & Higgins, Eel River Recovery Project Report 2015

San Francisco Bay: A mixing bowl for Toxins

Mussels 2012, 2014, 2015: 25% of sites have all three toxins



Domoic Acid
(100% of mussels contaminated)



Microcystins
(82% of mussels contaminated)

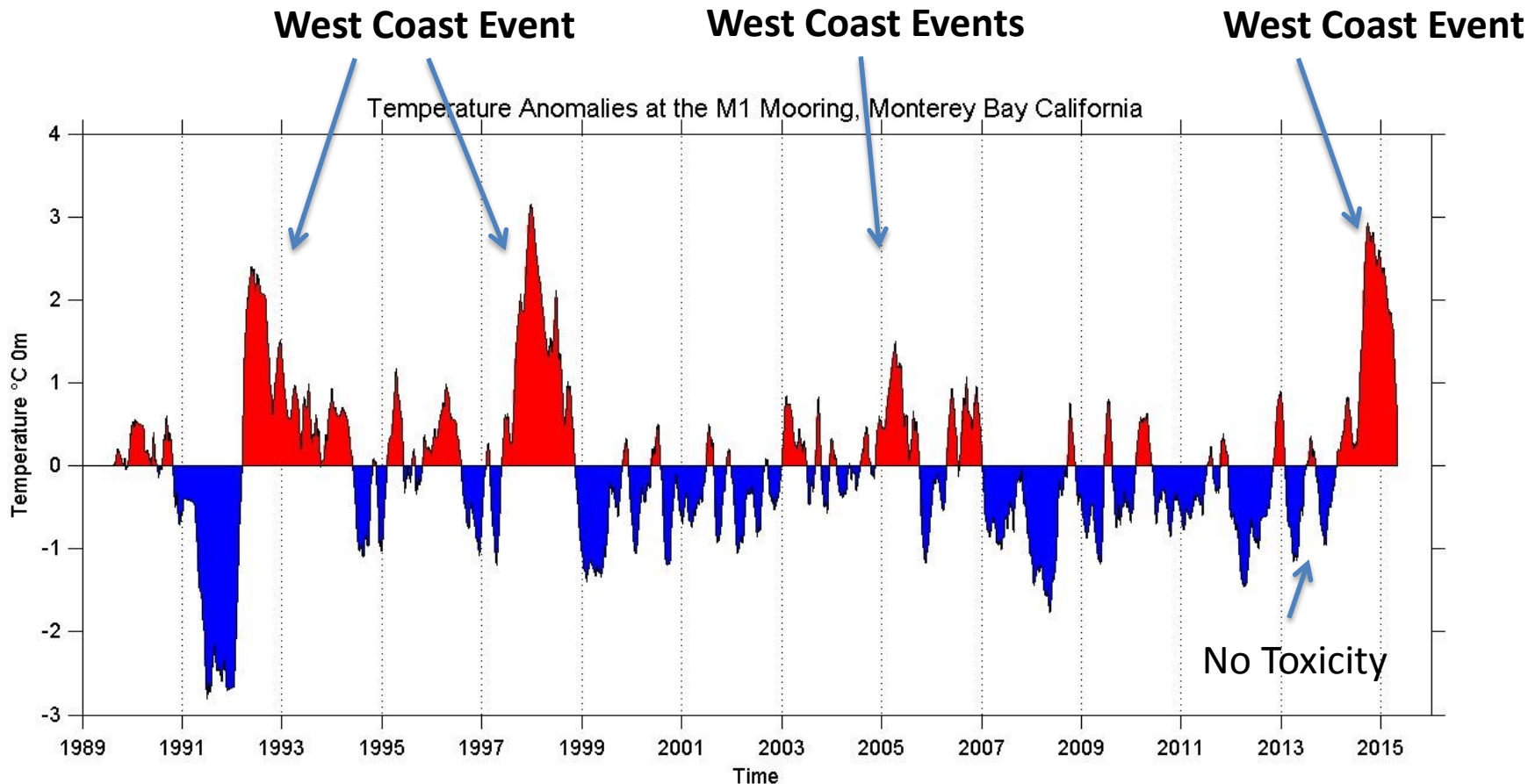


Paralytic Shellfish Toxins
(25% of mussels contaminated)

Blooms Like It Hot

Hans W. Paerl¹ and Jef Huisman²

A link exists between global warming and the worldwide proliferation of harmful cyanobacterial blooms.

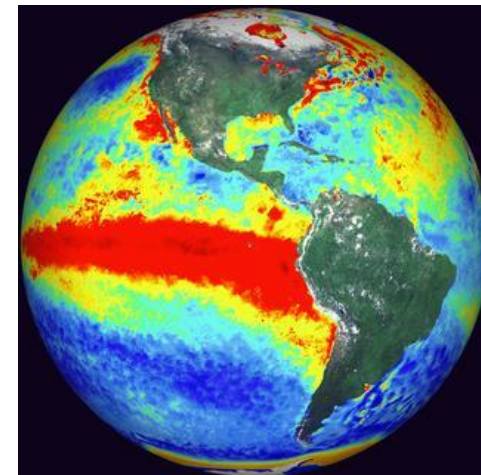


Note: 60 point moving average applied to daily averaged values.

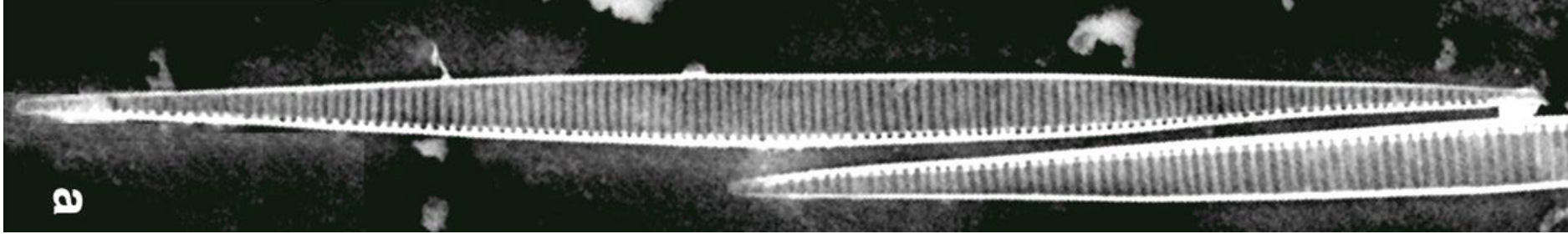
Monterey Bay Aquarium Research Institute

Updated: 20-Jul-2015

2014-2016: From Bad to Worse? Or Will El Niño Save Us?



- Historically, more toxic marine HABs during El Niño
- More rainfall may alleviate cyanobacterial problems...
...but rainfall may also flush everything into the ocean
- **Good News:** we have operational HAB forecasts, and greatly improved monitoring in both the watersheds and coastal ocean. Fantastic opportunity to test theories!



Acknowledgements

Project Funding

California Sea Grant and Ocean Protection Council (R/OPCCONT-12-A-10)
Central and Northern California Ocean Observing System (NOAA NA08NOS4730382)
NASA Grants NNX09AT01G, NNX13AL28G
NOAA ECOHAB Program, NA11NOS4780030)
NSF RAPID OCE1251573

Historical Data & Model Development

NOAA MERHAB Award (NA04NOS4780239)
NOAA California Sea Grant Award (NA04OAR4170038)

Data Access

Southern California Coastal Ocean Observing System
Central and Northern California Ocean Observing Systems
California Harmful Algal Bloom Monitoring and Alert Network (Cal-HABMAP)

