What did we learn from the unusual North Pacific 2012-2016 oceanic conditions? How did we respond and what can we expect next?

Cisco Werner — *SWFSC*

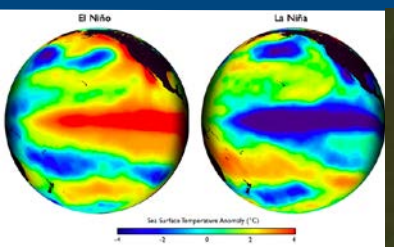
John Stein — *NWFSC*

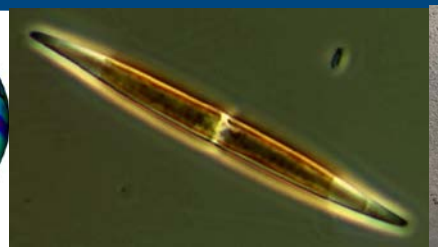
Doug DeMaster — *AFSC*

NOAA FISHERIES

Alaska
Northwest
Southwest
Fisheries Science Centers

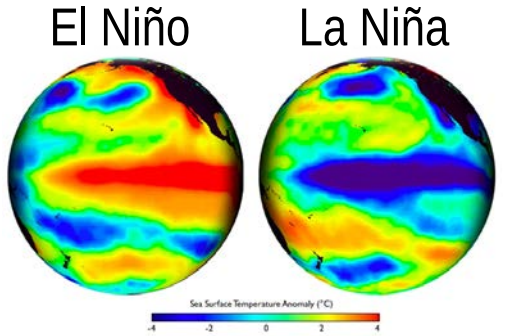
69th PSMFC Annual Meeting
26 Sept 2016; Portland, OR







Outline

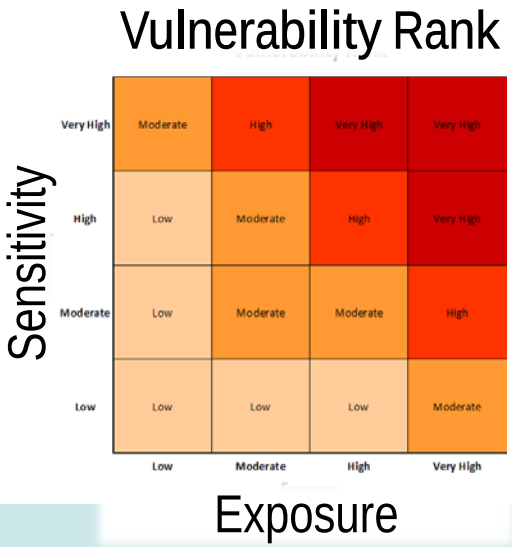


1. Brief recap of observed conditions in the North Pacific (Cisco)

The conditions we witnessed *ecosystem-wide* were unprecedented, and they gave us the opportunity to take a peek into what may be either a new baseline or a preview of a warmer future.

2. The need for more comprehensive measurements (John)

There is a need for developing observational capabilities that can consider multiple environmental components simultaneously, and to operationalize these.

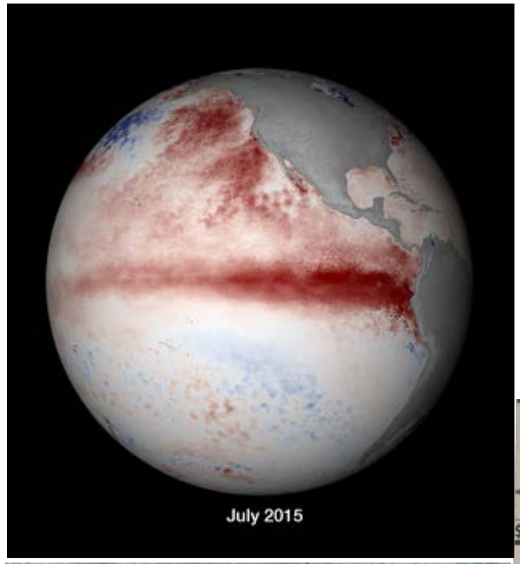


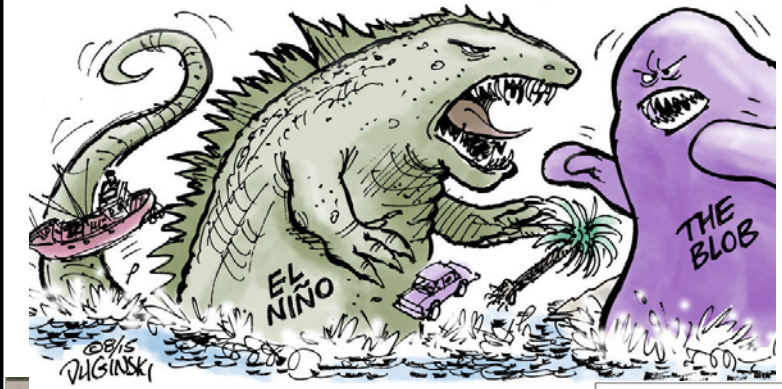
3. Next steps in ecosystem management considerations (Doug)

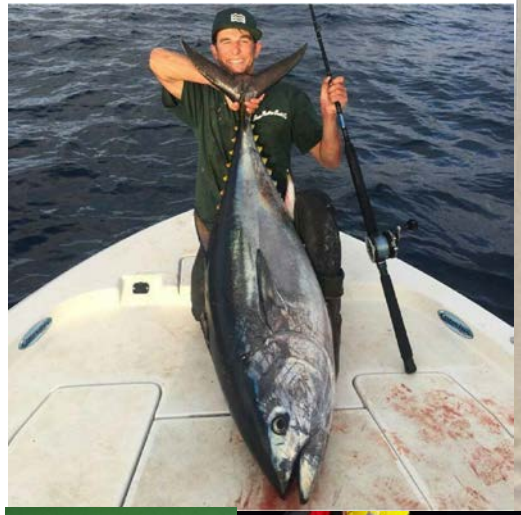
Successful management will have to incorporate impacts of climate change into management strategies. In collaboration with the Councils, Commissions, and States, we will have to take deliberate steps to include ecosystem and climate change considerations to best serve the US public over the next 20 years.

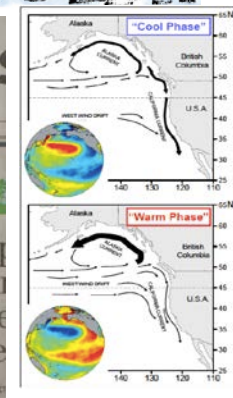
Last year's summary (Girdwood, 24 Aug 2015)

- Present conditions in the N. Pacific are anomalous and record warm SSTs, but are not all related to an El Niño (EN)
- Signals of a positive (warm) PDO evolving
- Models are predicting a "strong" EN in the Fall and Winter of 2015-2016.
- Ocean Acidification impacts the North Pacific in different ways
- HABs…
- The possible El Niño/La Niña seesaw offers an important window to learn how our ecosystems and trust species will respond.

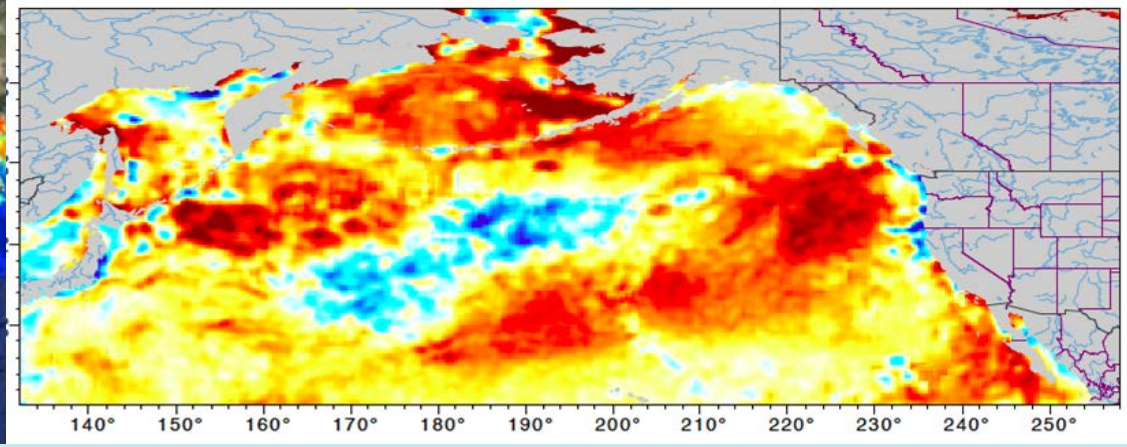








Climate Change "Stress Test": From 2012 to 2015, the Western US and northeast Pacific Ocean experienced climate extremes *(a sustained marine heatwave?)* that in many ways represent a climate change stress test on our marine habitats.



Example ecosystem stresses/stressors:

- What happens if temperatures rise and remain 2-3°C above normal for prolonged periods?
- What happens if stratification increases for prolonged times?
- What biogeochemical changes occur under prolonged exposure to unusual physical conditions?
- What changes occur in the food web?
- What happens to vital rates of native species?
- What happens when non-native species enter the geographic domain?
- What happens to species that shift outside their "normal" domain? Do they return?

Marine heatwaves

Progress in Oceanography 141 (2016) 227–238

Contents lists available at ScienceDirect

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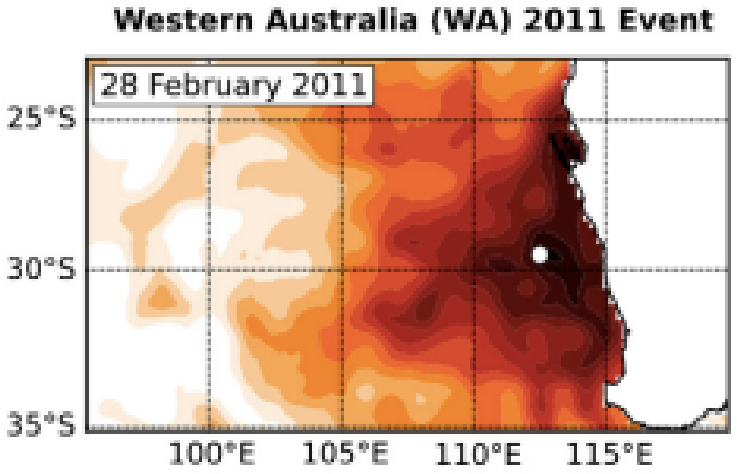
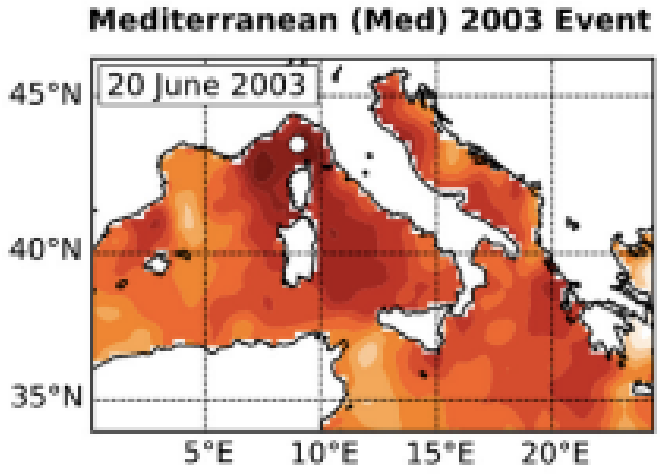
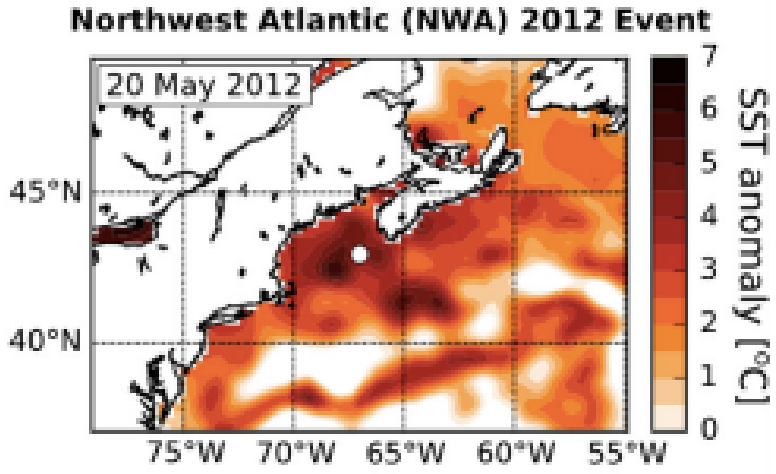
A hierarchical approach to defining marine heatwaves

Alistair J. Hobday [a,*], Lisa V. Alexander [b,c], Sarah E. Perkins [b,c], Dan A. Smale [d,e], Sandra C. Straub [e], Eric C.J. Oliver [b,f], Jessica A. Benthuysen [g], Michael T. Burrows [h], Markus G. Donat [b,c], Ming Feng [i], Neil J. Holbrook [b,f], Pippa J. Moore [j], Hillary A. Scannell [k,l], Alex Sen Gupta [b,c], Thomas Wernberg [e]







theguardian

August 2016

'The blob': how marine heatwaves are causing unprecedented climate chaos

Wide-scale disruption from warming oceans is increasing, but they could change our understanding of the climate

https://www.theguardian.com/science/2016/aug/15/the-blob-how-marine-heatwaves-are-causing-unprecedented-climate-chaos?CMP=twt_a-science_b-gdnscience

Australia's vast kelp forests devastated by marine heatwave, study reveals

Coral on reefs around Lizard Island, on the Great Barrier Reef in Australia in July 2016, after the worst mass bleaching event in recorded history. Photograph: Justin Marshall/University of Queensland

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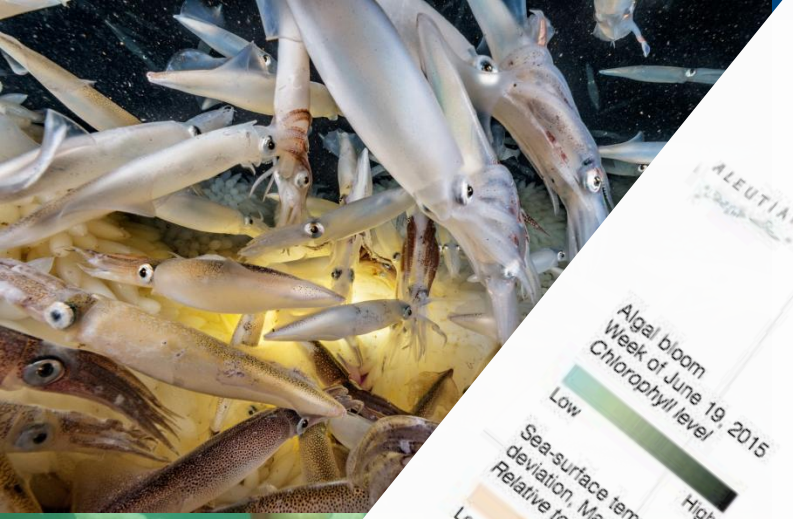
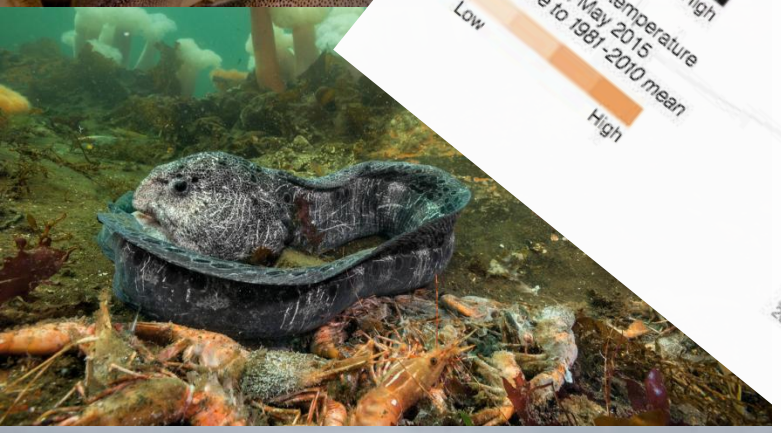
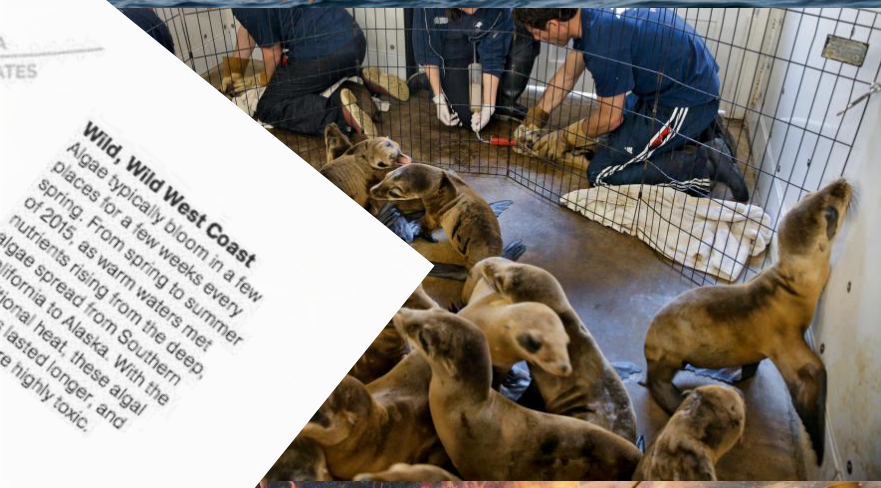






NATIONAL GEOGRAPHIC

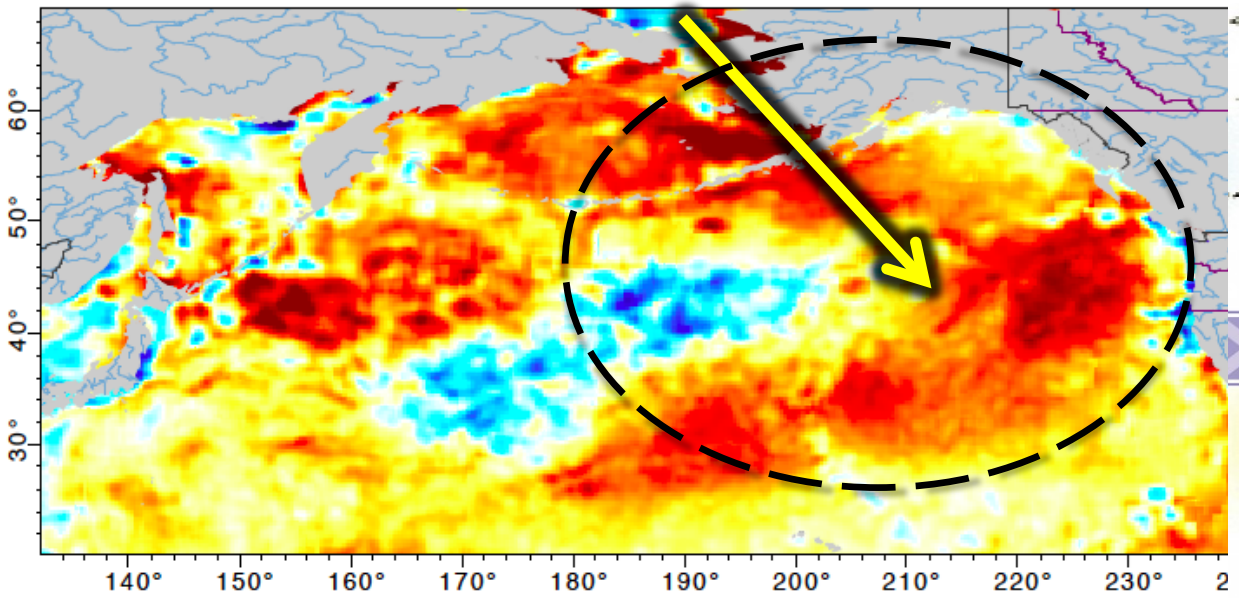
(September 2016)

Wild, Wild West Coast

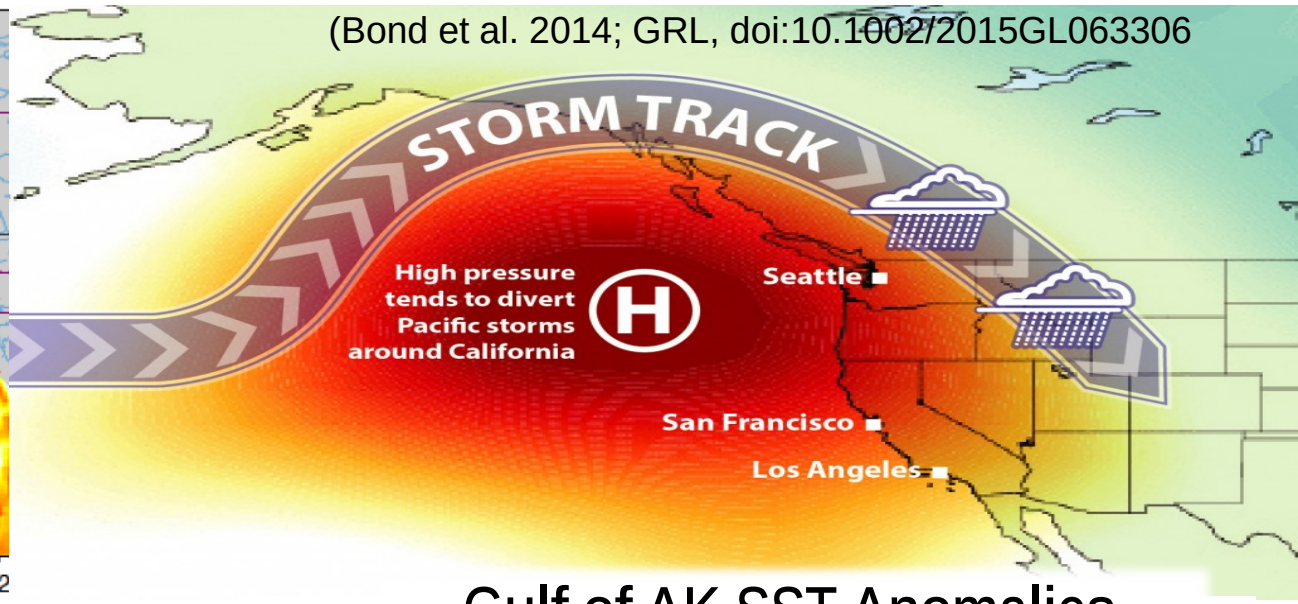
Algae typically bloom in a few places for a few weeks every spring. From spring to summer of 2015, as warm waters met nutrients rising from the deep, algae spread from Southern California to Alaska. With the additional heat, these algal blooms lasted longer, and many were highly toxic.

http://www.nationalgeographic.com/magazine/2016/09/warm-water-pacific-coast-algae-nino/#/AP_390543457600.ngsversion.1470954342760.jpg

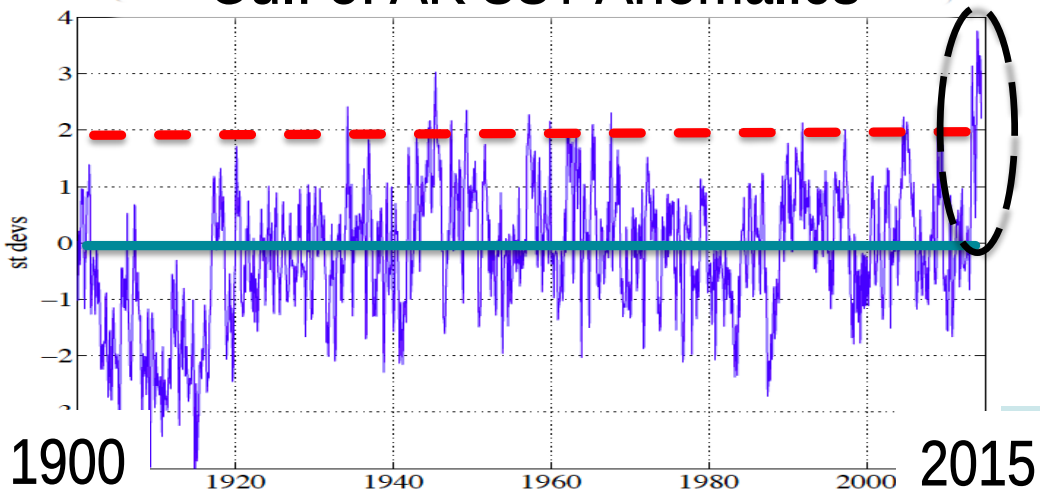
The Blob (2013-2015): A mass of positive temperature anomalies developed in the NE Pacific Ocean during winter of 2013–2015. This development can be attributed to strongly positive anomalies in SLP (the *Ridiculously Resilient Ridge*), which served to suppress the loss of heat from the ocean to the atmosphere. The extra Mixed Layer heat persisted through the summer of 2015.



SST anomaly (18 Aug 2014) relative to the 30-year (1982-2010) climatology



Gulf of AK SST Anomalies



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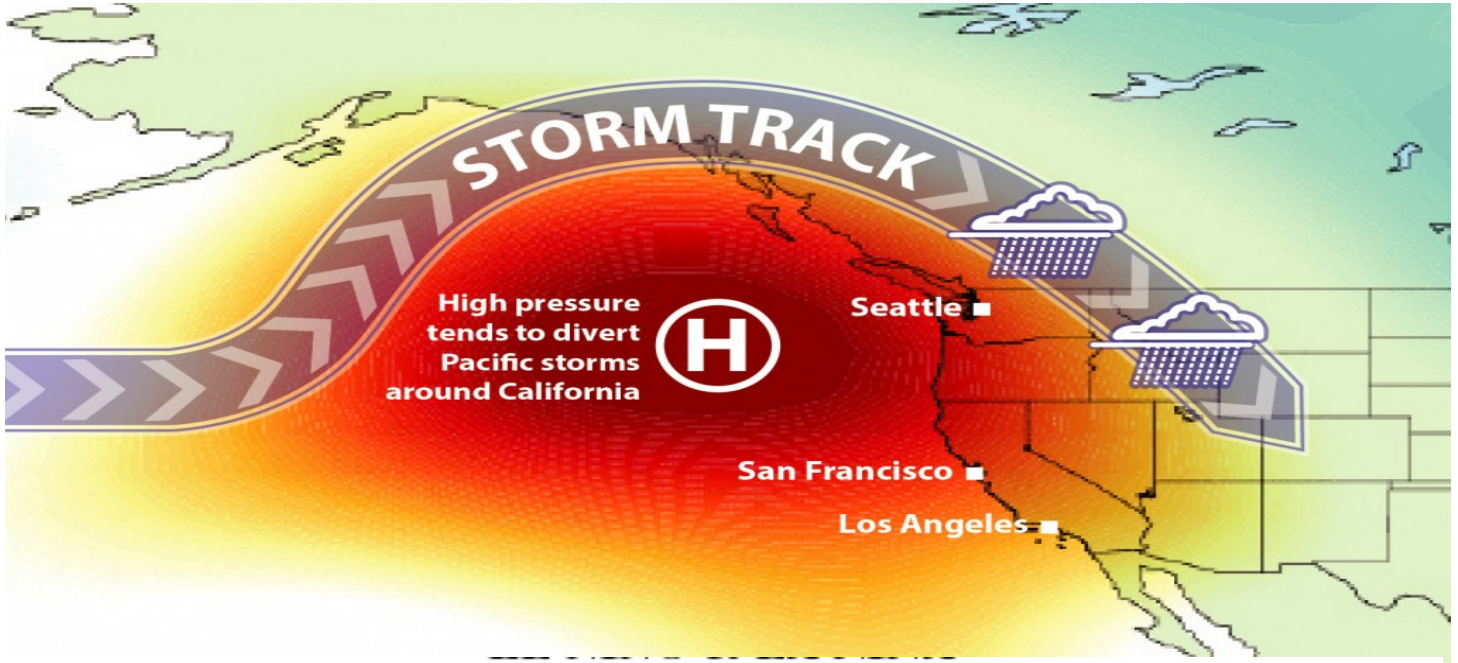
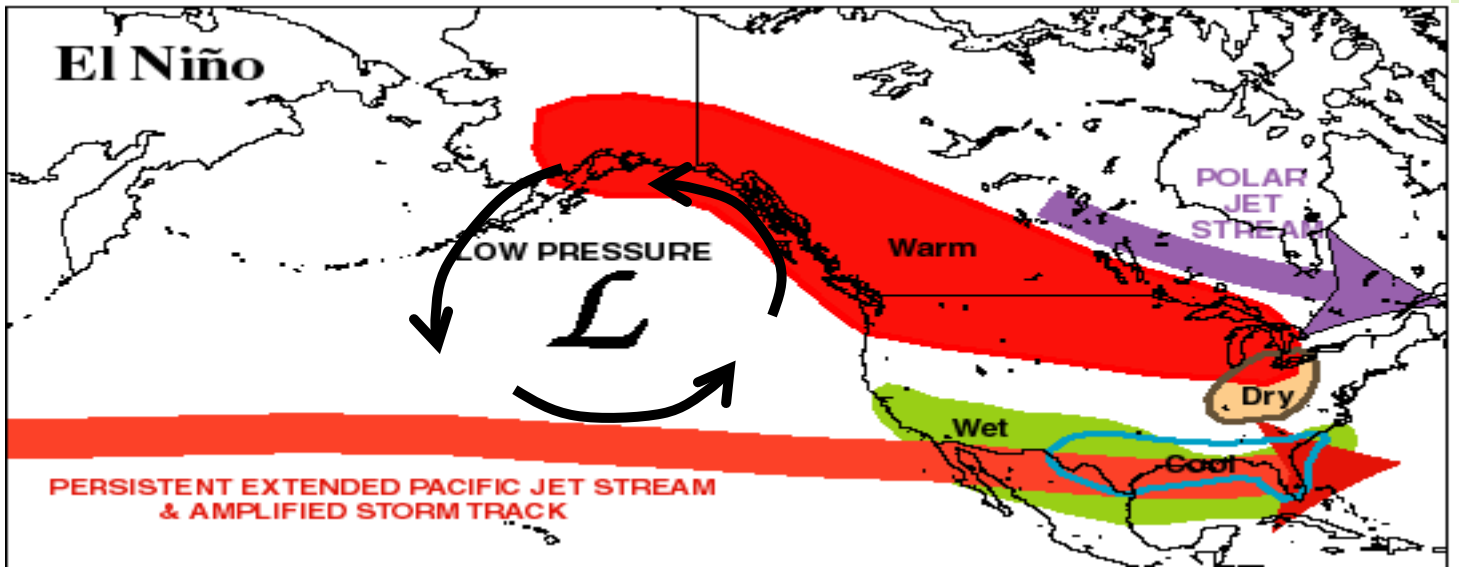
Blob vs. El Niño

- The *Ridiculously Resilient Ridge*: the proximate cause for California's extended drought and the "Blob" of exceptionally warm ocean temperatures in the NE Pacific (2013-15)
- The typical El Niño winter pattern, featuring persistent and intense low pressure over the Gulf of AK and a very active jet stream and storm track just north of Hawaii extending over the southern US and northern MX.

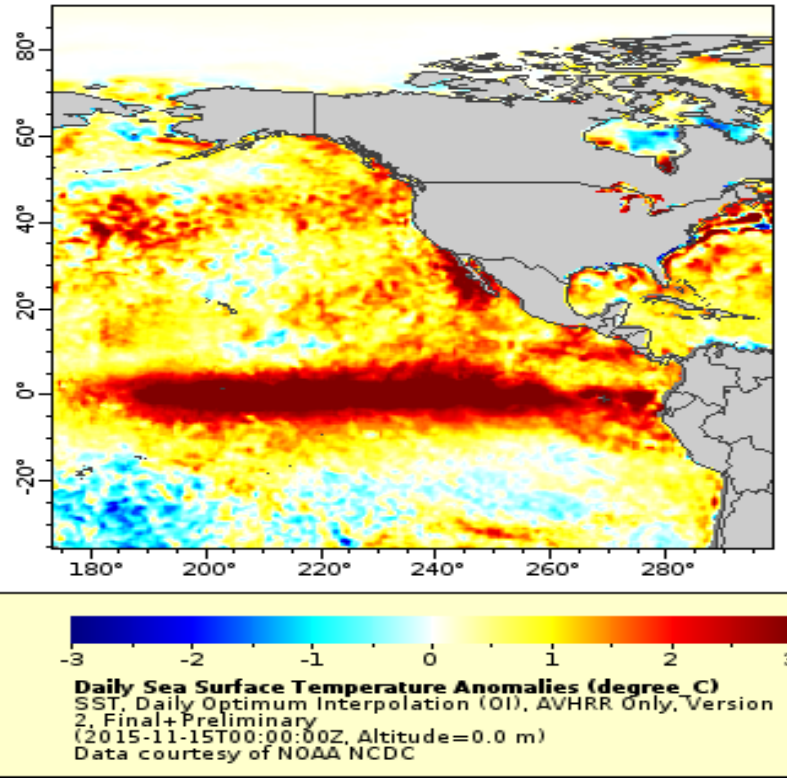




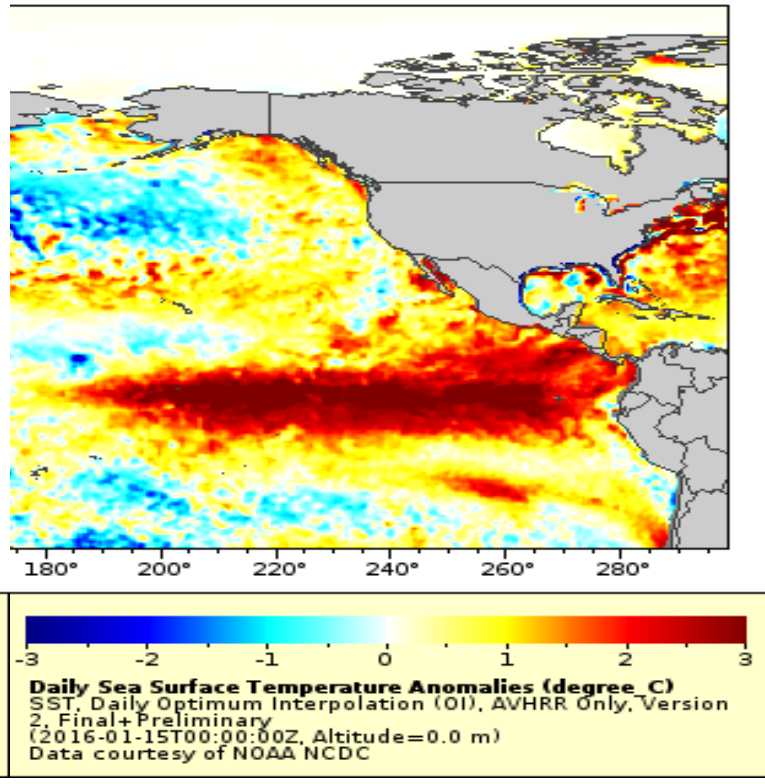
http://www.latimes.com/local/lanow/la-me-ln-what-a-godzilla-el-nino-winter-looks--001-photo.html

The end(?) of the North Pacific warm anomaly: the blob gave way to El Niño during winter 2015/2016

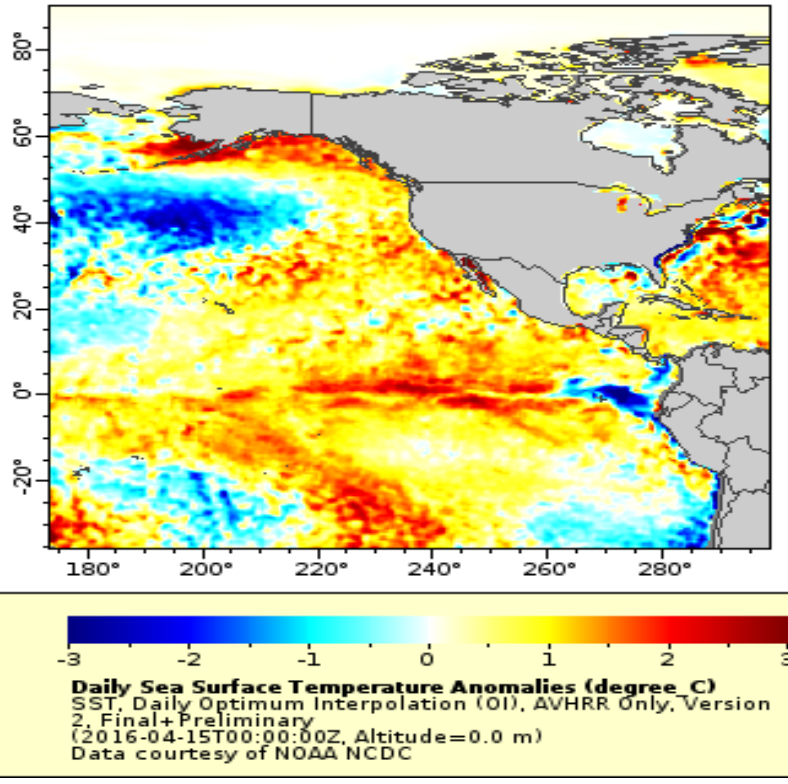
Nov 2015



Jan 2016



April 2016

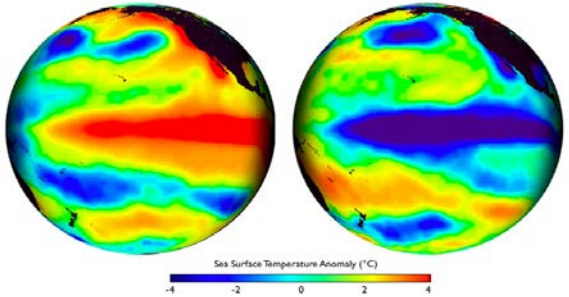


Sea Surface Temperature anomalies based on daily optimal interpolated field

2015-2016 El Niño "post-mortem" and what next?

- The 2015–2016 El Niño was by some measures one of the strongest
- But impacts on the physical state of the CCS appear weaker than expected

El Niño La Niña



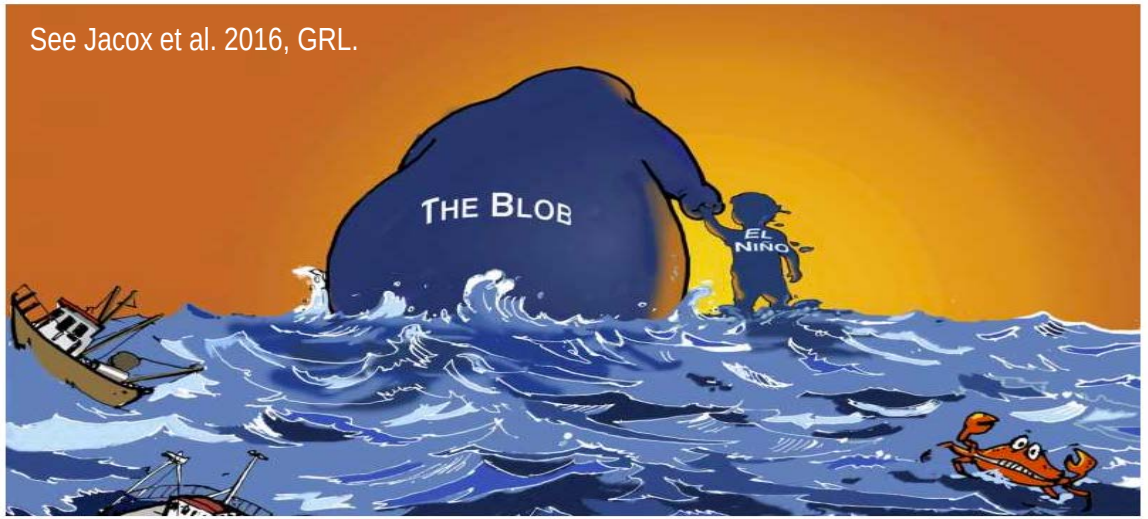
Six "strong" and eight "moderate" *El Niños*

And five "strong" and four "moderate" *La Niñas*.

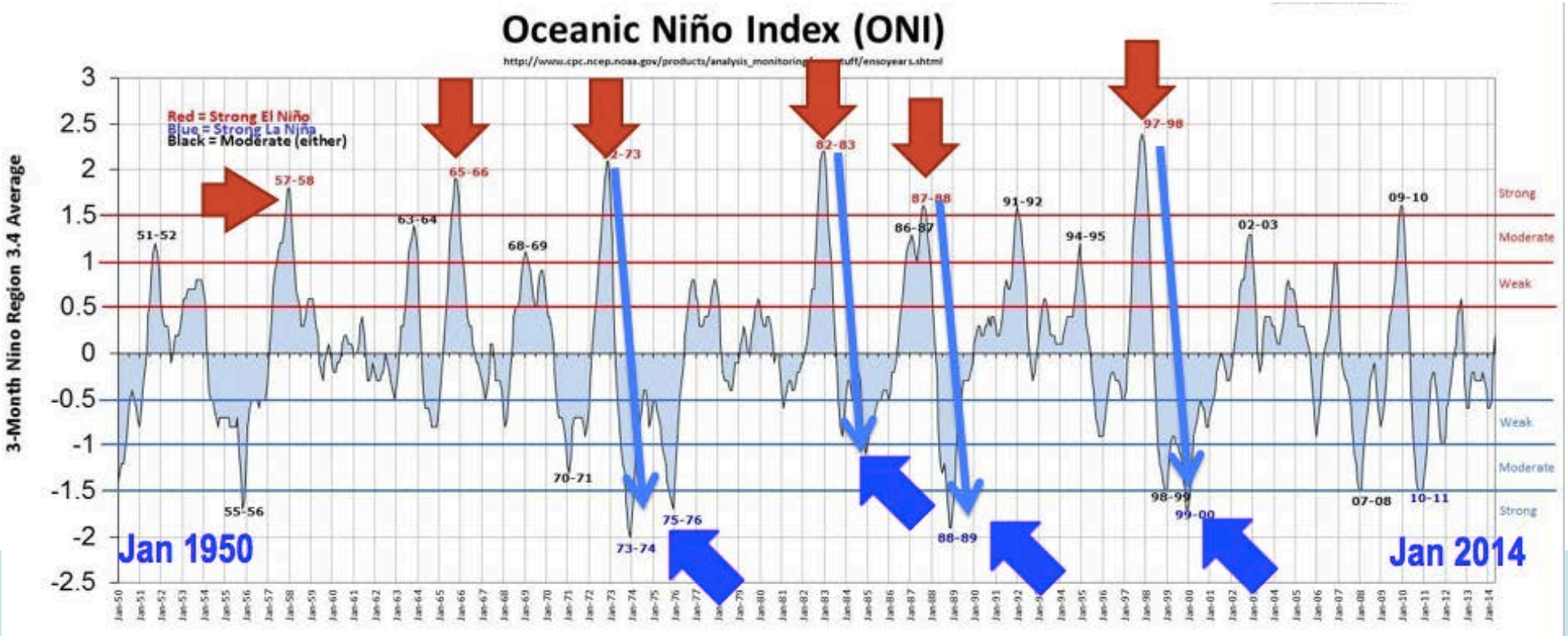
'The Blob' overshadows El Nino

July 6, 2016

See Jacox et al. 2016, GRL.



'The Blob' and El Niño are on their way out, leaving a disrupted marine ecosystem behind. Credit: Michael Jacox



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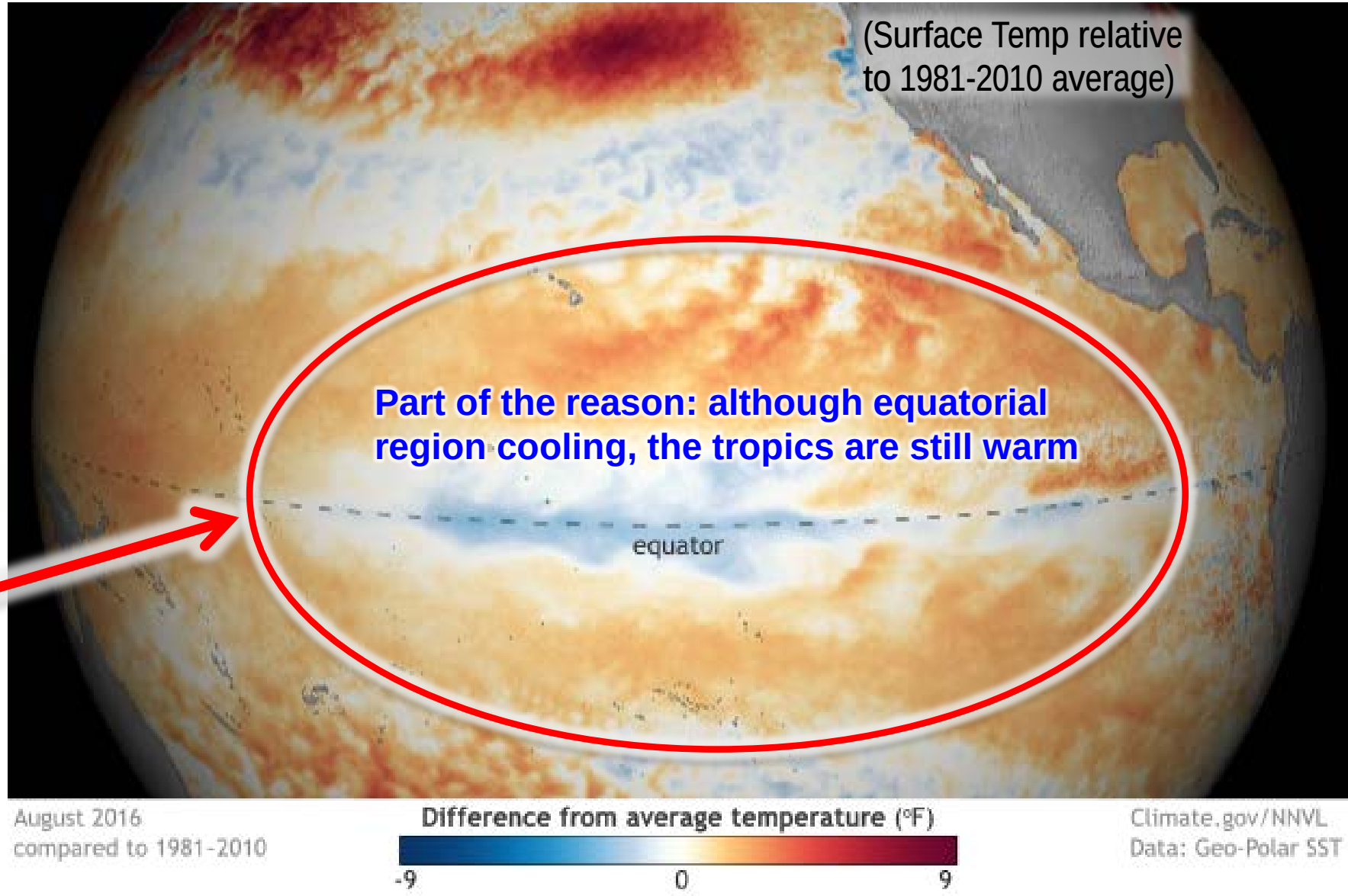
El Niño to a La Niña? Or to a "La Nada"?

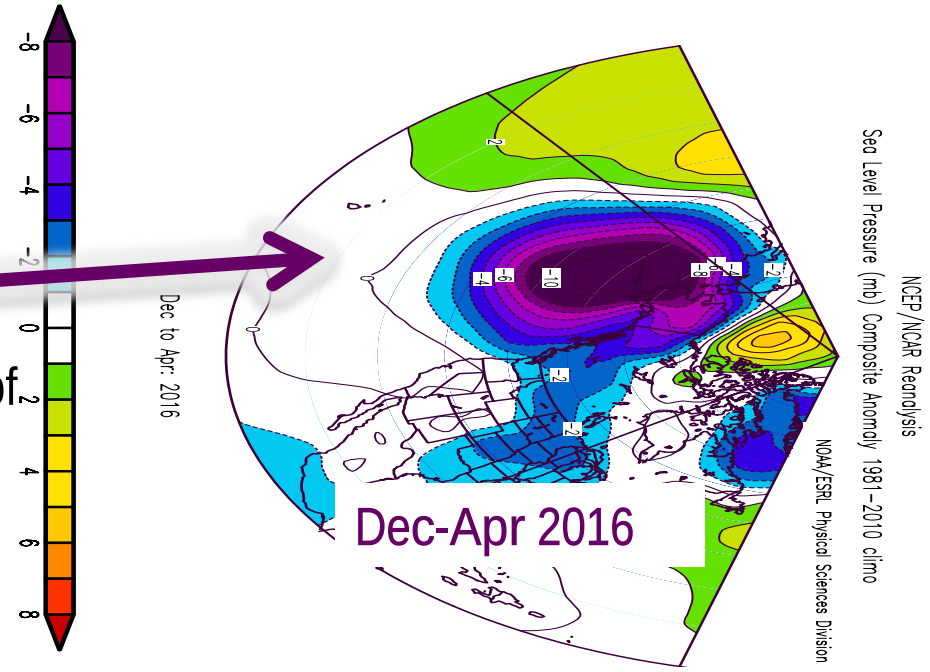
Since the end of the 2015-16 El Niño in April, the tropical Pacific has been loitering in neutral… and it's likely to stay that way through the winter.

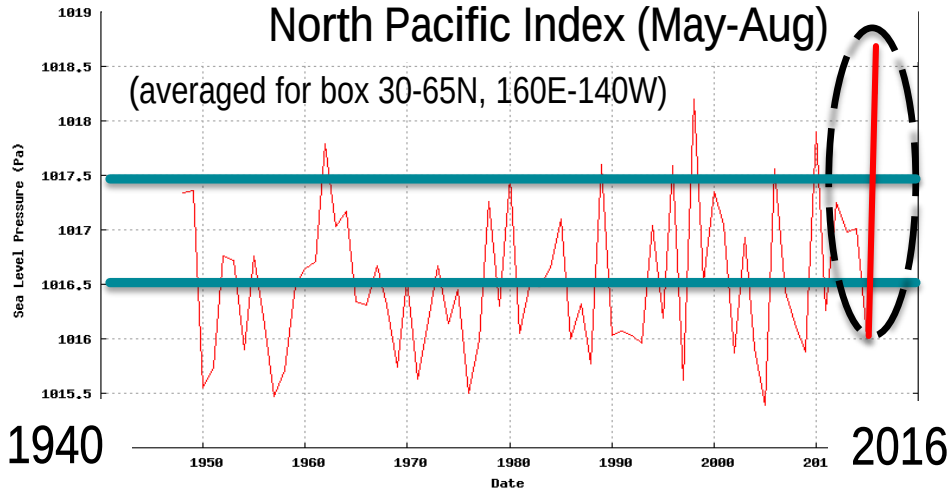
For now, the "*La Niña Watch*" is on hold, since it does not look likely for La Niña conditions to develop within the next six months.

August 2016

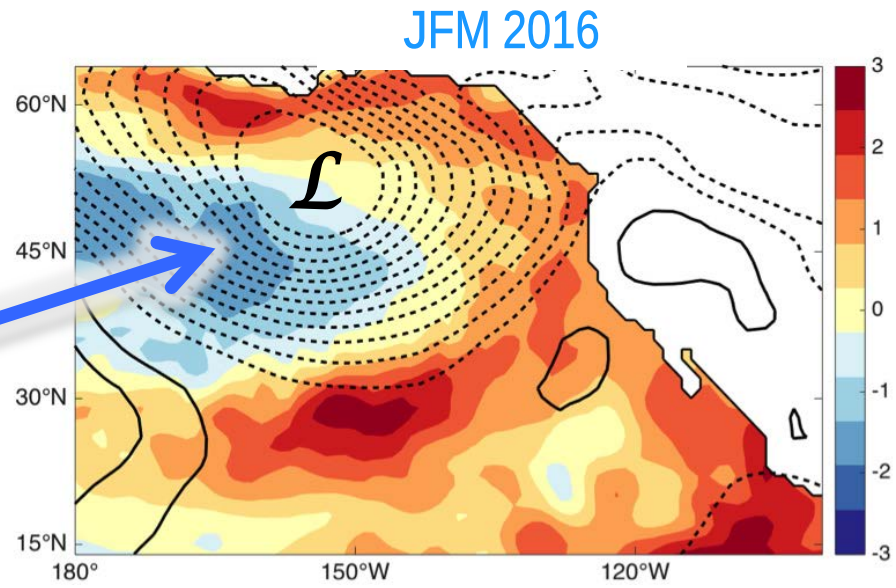


Past year: the N. Pacific shifted between Dec-May to Aug, from the El Niño that fueled an intense Aleutian Low (Dec-Apr) ... and drove the decline of the N. Pacific warming features.

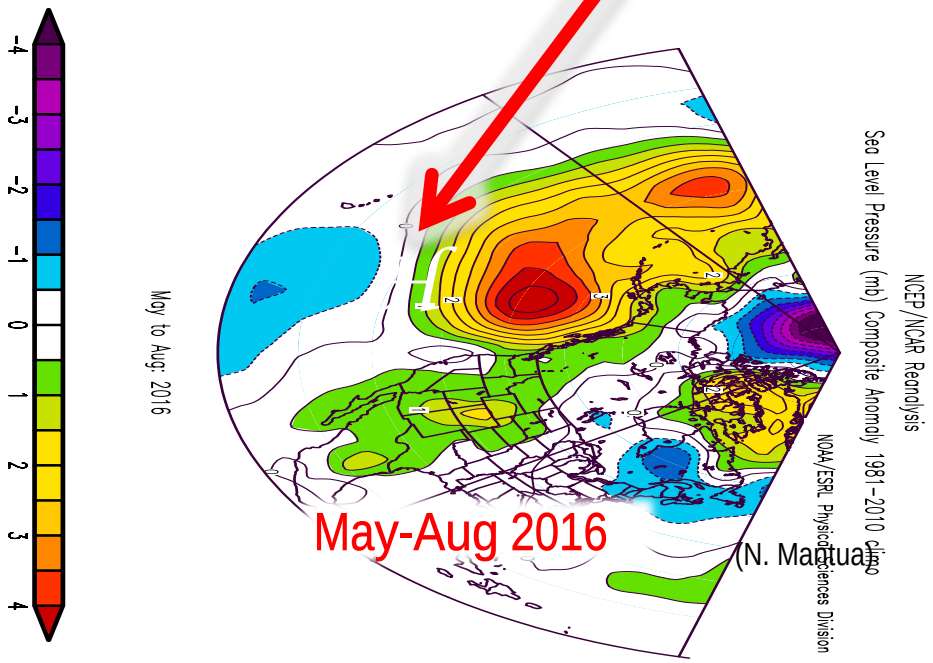




Hence, the average JFM 2016 N. Pacific SST and SLP anomalies show a PDO-like pattern of SST anomalies, with cold anomalies in the central North Pacific and a warm "arc".



Recently (May-Aug) we have had months with weak Aleutian Low and a strong N. Pac. High



(N. Mantua)

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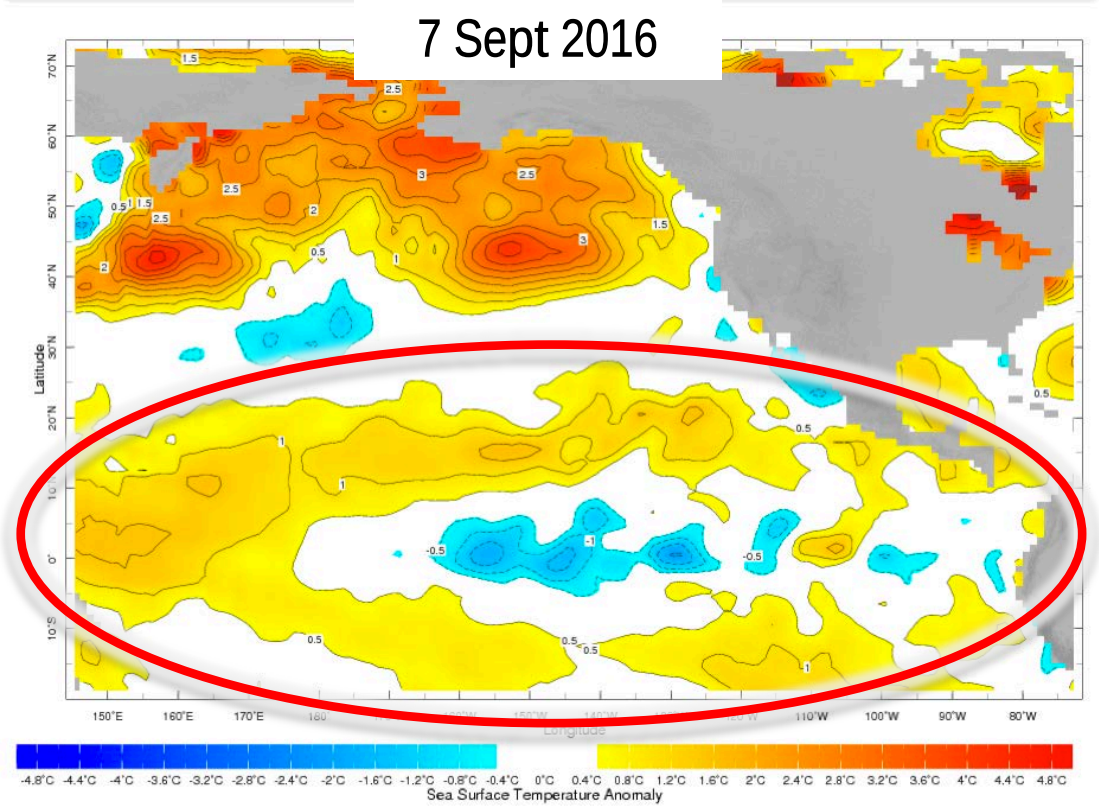
The evolution and known atmospheric forcing mechanisms behind the 2013-2015 North Pacific warm anomalies. (Amaya et al., 2016)



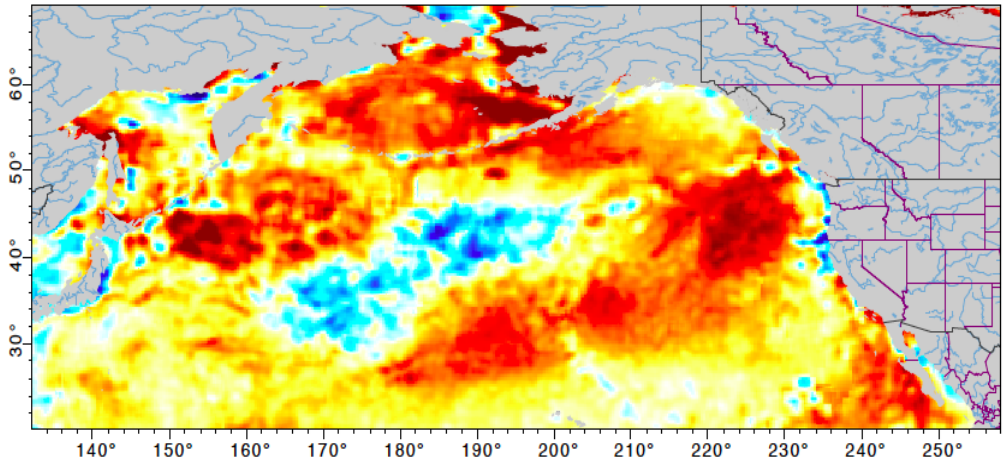
Present: The tropical Pacific appears will remain neutral with respect to ENSO. We do not have much to go on from that perspective towards forecasting the upcoming seasons.

A quick peek forward: models agree that there will be warmer than normal water in the classic arc along the west coast of N. America (associated with a positive PDO) but the western N. Pacific is not necessarily going to be colder than normal. The bottom line is that the NE Pacific marine heat wave is not over.

Fisheries and biological considerations

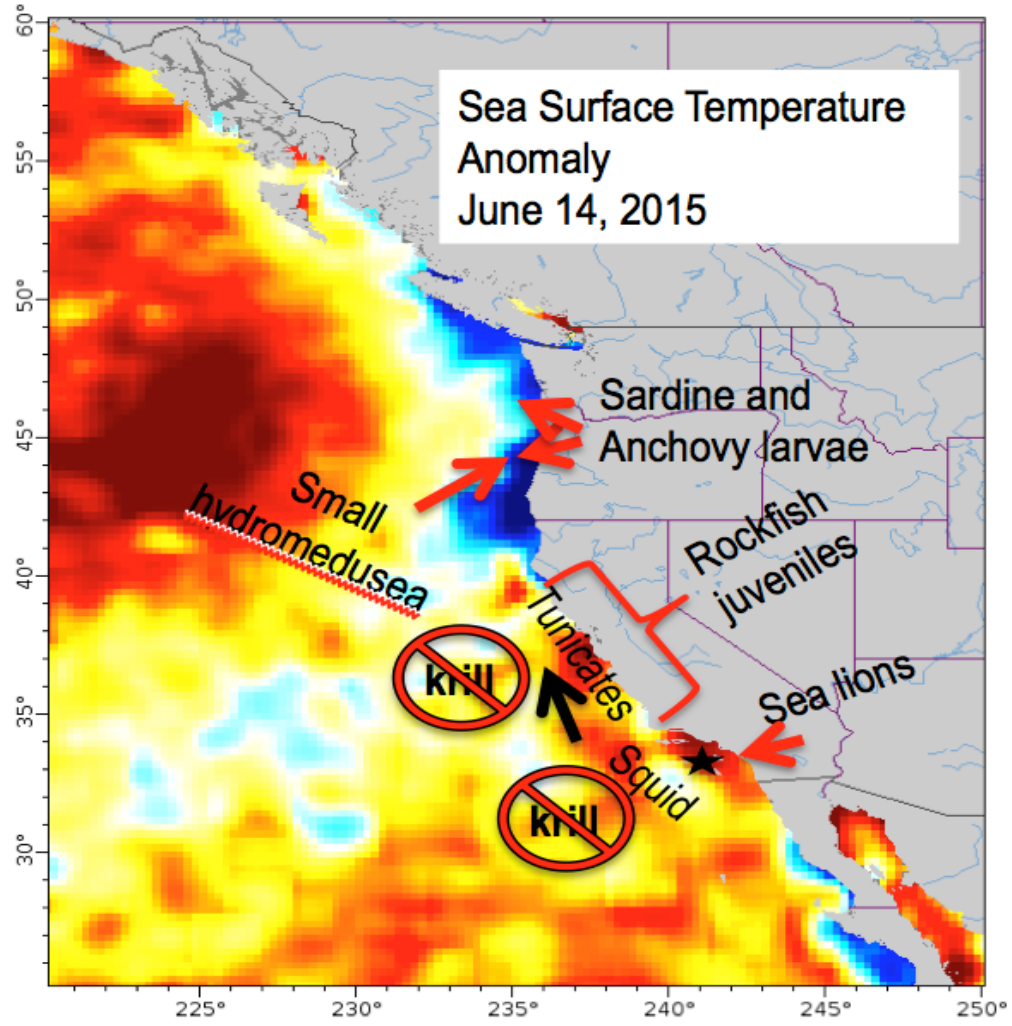
Anchovy school forms a dark band off Scripps on July 8, 2014. Credit: Douglas Alden.

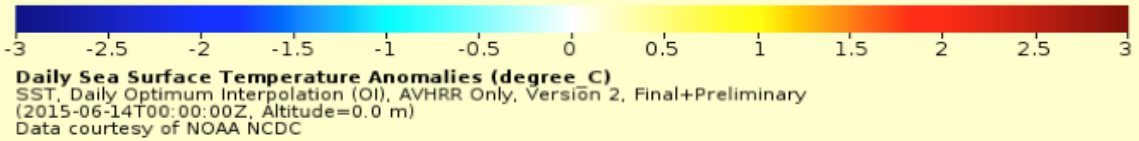
Synthesis: 2015 impacts along the west coast of N. America



Most warming was due to Blob and not El Niño

- Phytoplankton was patchy and lower than previous years
- Sardine and anchovy went north
- Market squid shifted north and numbers decreased
- Krill decreased
- Rockfish juveniles did OK on central CA coast
- Seabirds… depending on location (e.g., the mass mortality of Cassin's Auklets)
- Sea lions did poorly
- "New" (oceanic) species along the coast

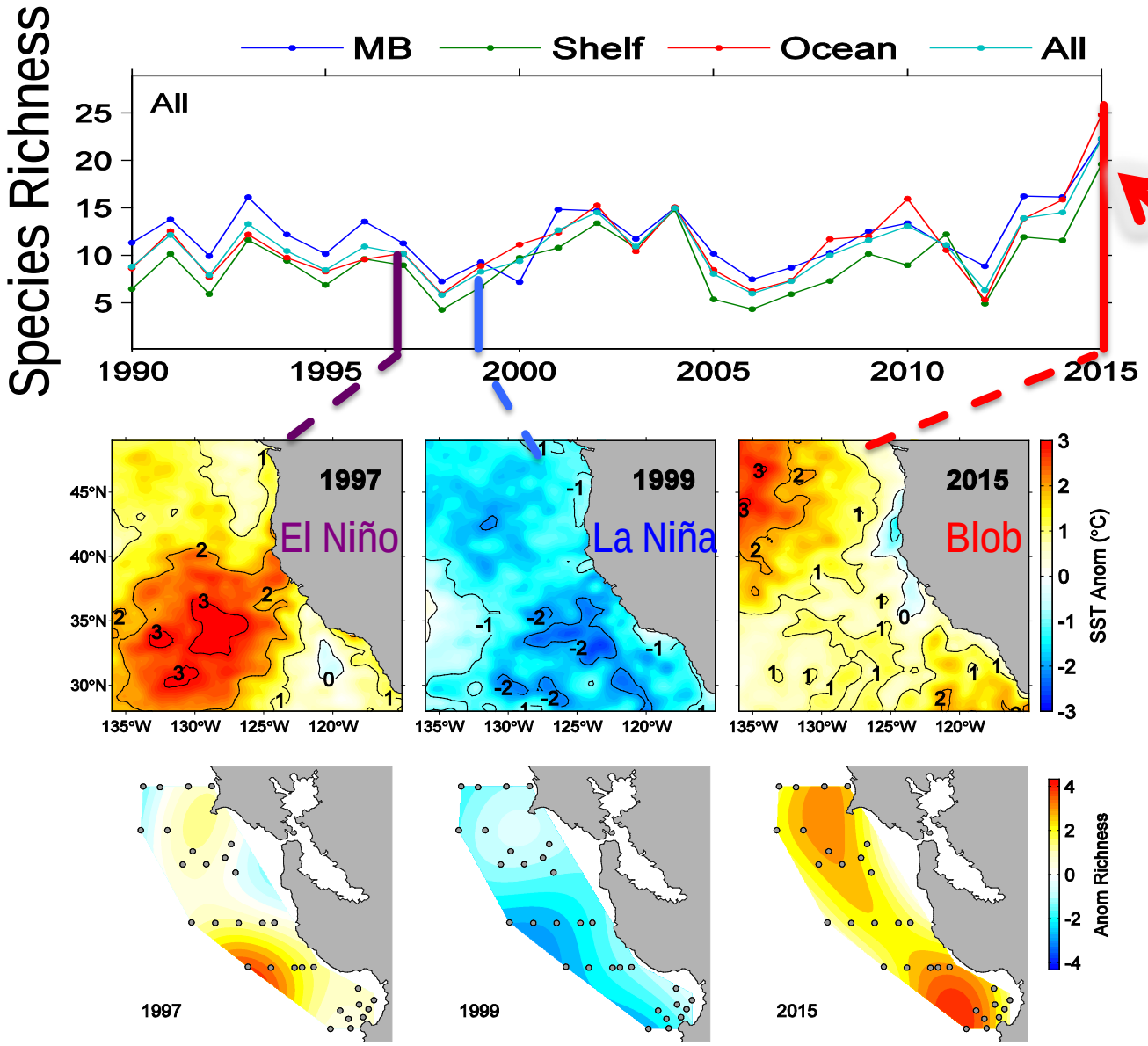




2015 Rockfish recruitment survey catches were unusual in that there were record catches of YOY rockfish and some other YOY groundfish, very high gelatinous organisms (salps, pyrosomes, etc.), and record catches of what have previously considered to be “El Niño” or subtropical water mass species (pelagic red crabs, California lizardfish, lobster phyllosoma), and finally a suite of never observed before were collected such as the slender snipefish and the greater argonaut.

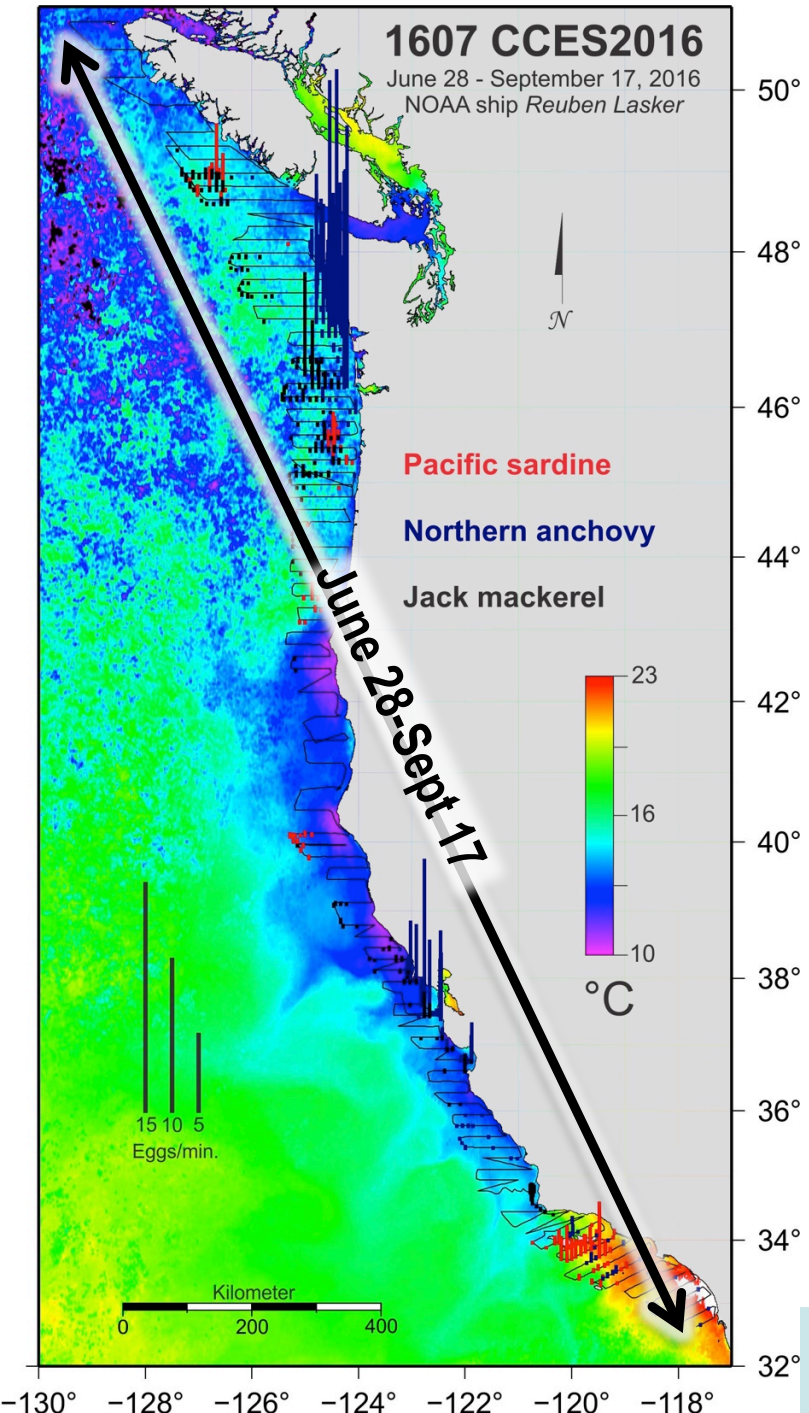
https://swfsc.noaa.gov/publications/CR/2015/2015Sakuma.pdf

NOAA-NMFS Rockfish Recruitment and Ecosystem Assessment Surveys



- Baseline record of Rockfish/Groundfish and Forage species (e.g., CPS, mesopelagics, squid) diversity indices
- Record biodiversity levels observed during the 2015 Blob Event. Attributed to convergence of northern, southern and offshore water masses and species assemblages.
- 2016 was a lot like 2015 – still strong YOY rockfish catches. Lots of salps and pyrosomes, and pelagic red crabs and lizardfish – a few less oddballs (such as argonauts and snipefish) but in general very similar patterns

Santora et al., in prep.



2016: Lasker returned from 3 months surveying the CPS complex (sardine, anchovy, Pacific mackerel, jack mackerel, market squid) in the California Current, from north Vancouver Island to San Diego

- 4500 nautical miles of east-west transects.
- 6.8 million gallons of water filtered through CUFES
- 260 CTD casts
- 119 trawls, 1000's of fish measured and weighed
- 28/120 catches did not have any of the 5 target CPS
- 2500 otoliths and 700 ovaries collected for age and maturity

The data collected on this survey will be used for the assessment of CPS fishes, including Pacific sardine and Northern anchovy.

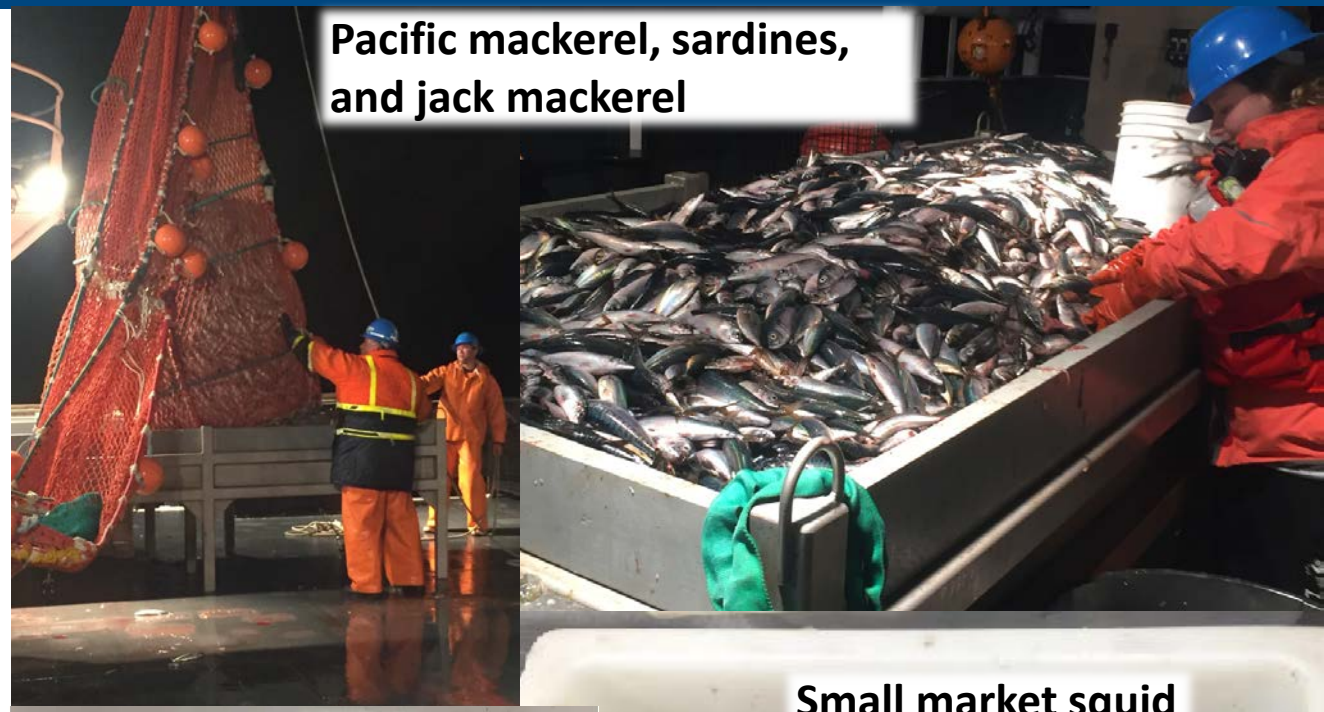
(D. Griffith and J. Zwolinski, 2016)

Of the 120 trawls completed, the number of trawls for which each of the listed species:

Species	# Positive Hauls
Sardine	22
Anchovy	46
Pacific mackerel	34
Jack mackerel	42
Market squid	57

Composition of catch in some of the trawls:

(N. Bowlin, J. DiNardo and J. Zwolinski, 2016)



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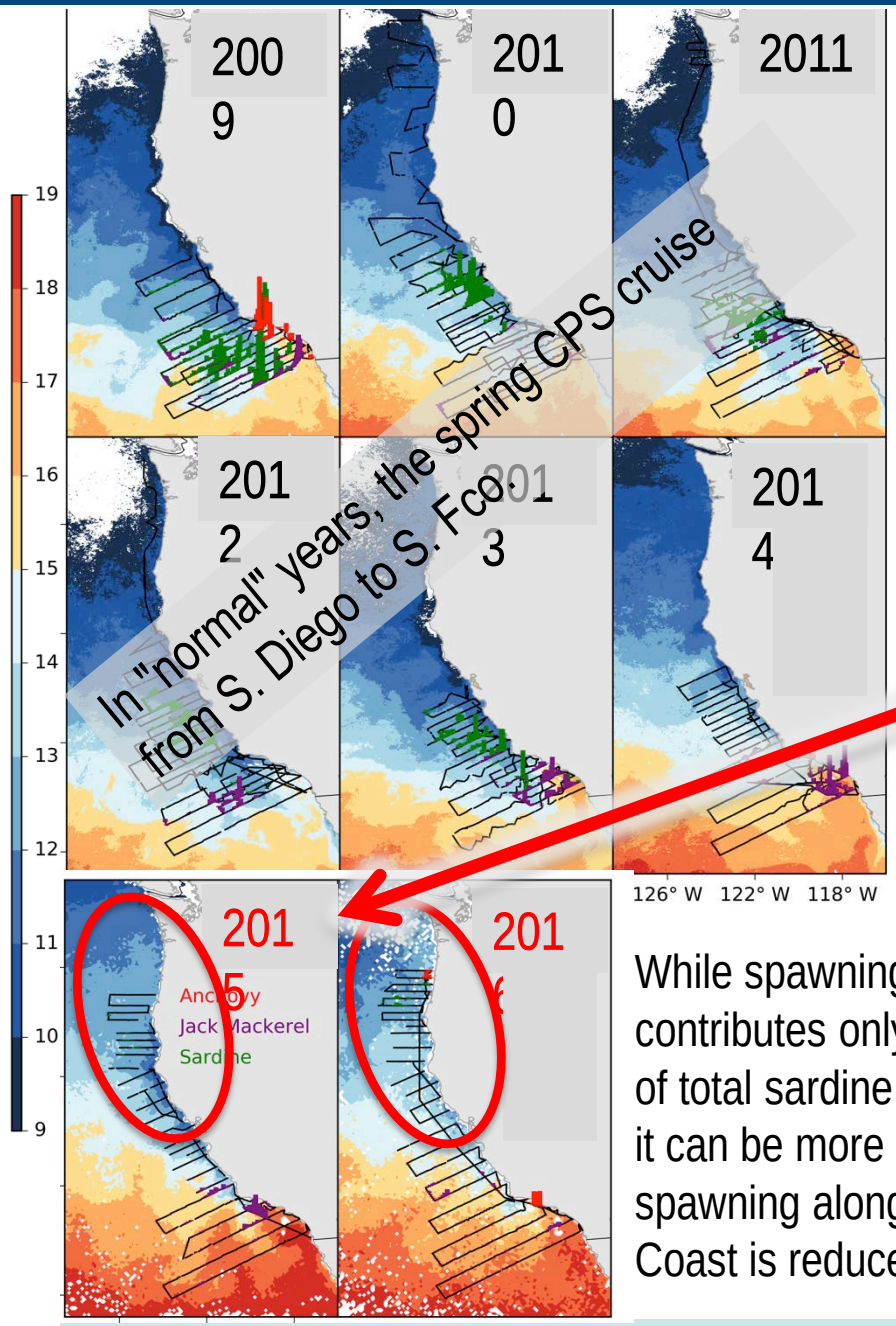
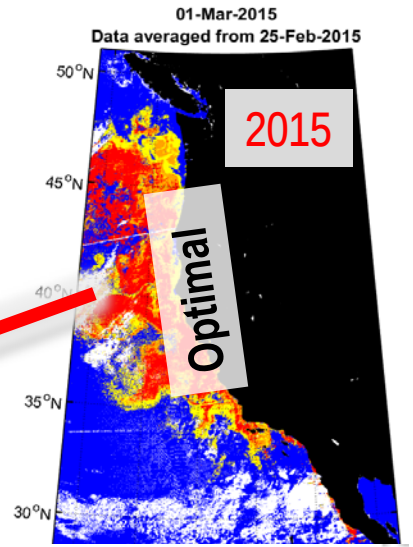
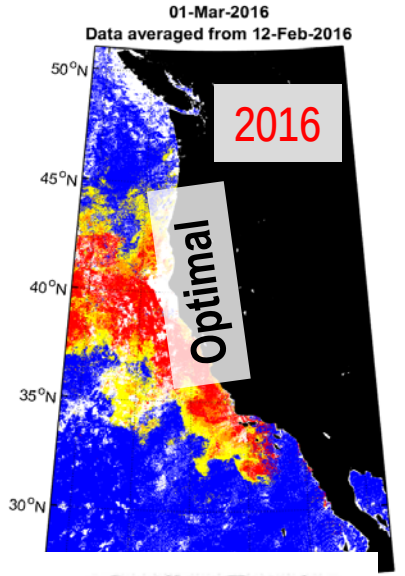
A large group of Bigeye trevallies (bigeye jack) at Cabo Pulmo National Park, Mexico.

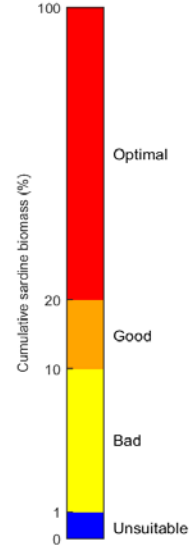
Fishing in 2015 confirmed presence of sardine off Oregon before the spring survey. This was supported by habitat maps. As a result, the northern limit of the survey was extended to north of Newport, OR in 2015 and 2016.



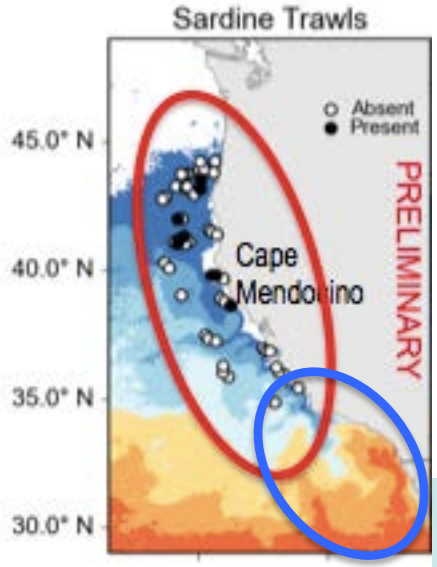
While spawning off OR generally contributes only a small fraction of total sardine egg production, it can be more significant when spawning along the U.S. West Coast is reduced.

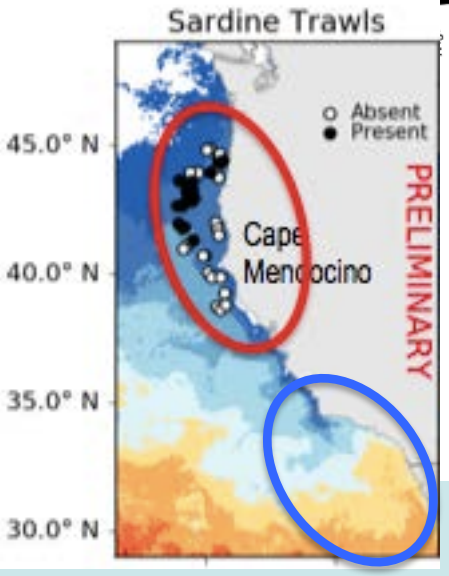






Potential habitat





Not adjusting northern bounds would have missed the northern spawning.

(E. Weber, S. McClatchie)

- In addition to the unusual conditions, the ESA and MMPA's success … increasing abundance of protected spp. can result in:

  a) increased interaction/conflict with human activities; see Penny Ruvela's talk this afternoon;
  b) increased mortality (in absolute numbers) associated with environmental change (e.g., California Sea Lion and Alaska whale Unusual Mortality Events).

- Lessons learned/changes in our future approach:

  a) help decision-makers become better prepared to deal with surprises, e.g., better communicate the range of environmental variability that can be expected.
  b) Doing more MSEs with robustness to climate shocks could be more of a focus.

Species composition of the California Current (CC) is changing, species are returning, species appearing that have never been recorded and range limits are changing.

Example: increasing abundance of loggerhead turtles in the SCB, triggered fishery closures by a SST threshold. The rule requires revision.

Concluding remarks

- The *ecosystem-wide* conditions we witnessed were unprecedented, and they gave us the opportunity to take a peek into what may be either recurrent conditions or a “new baseline”.

- We need greater nimbleness to capture sudden or unexpected changes: either rapid response or sustained ship and in-water capabilities – leading to time series that are the baselines for tomorrow’s surprises. John

- Decision-makers need to be ready and better prepared to deal with surprises. Doing more MSEs with robustness to climate shocks could provide a focus. Doug

Questions?

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