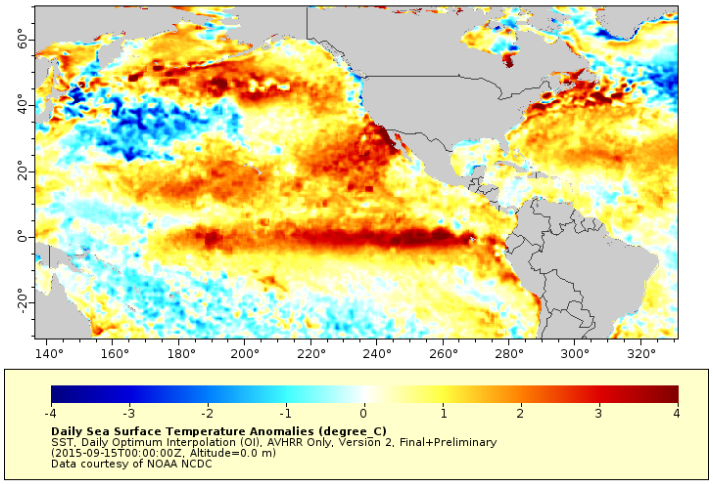
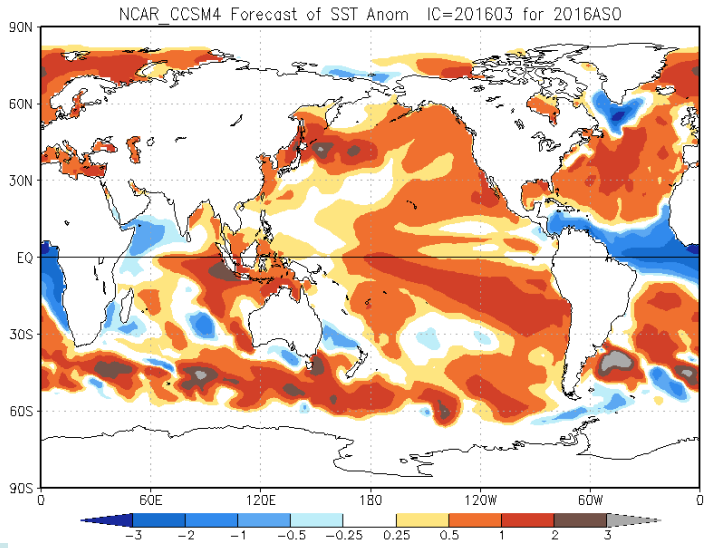
El Niño, the Blob, and Ocean Conditions

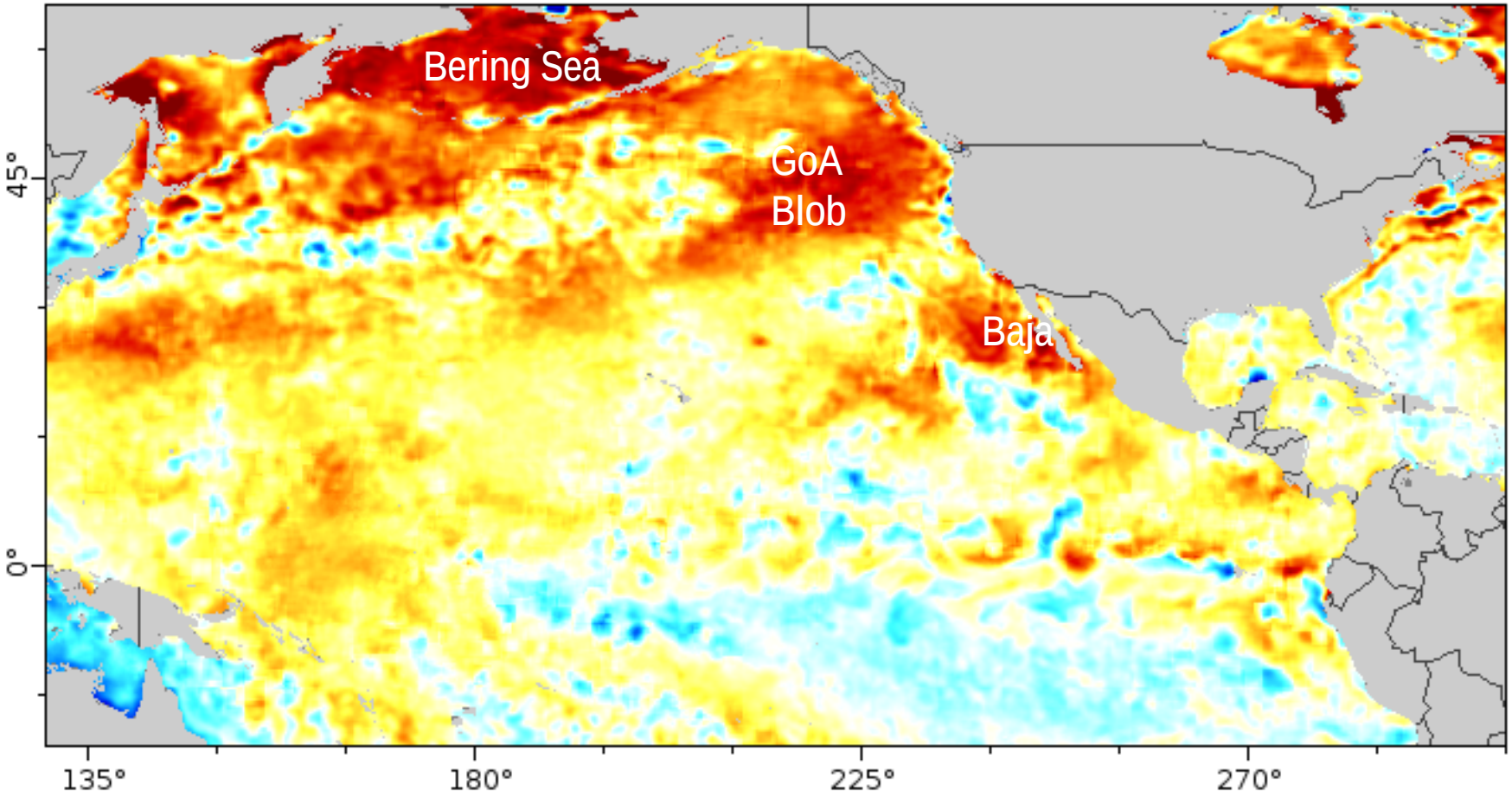
Nate Mantua, PhD

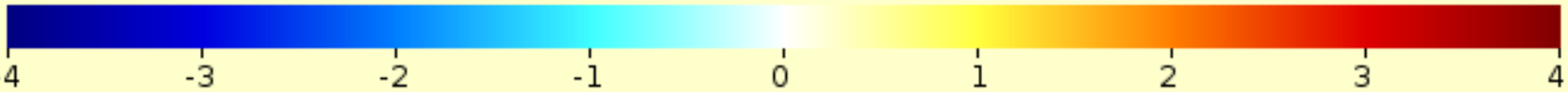
2016 Pacific Coast Steelhead Management Meeting
March 9, 2016
Asilomar, CA





OISST anomalies – August 31, 2014





Daily Sea Surface Temperature Anomalies (degree_C)
SST, Daily Optimum Interpolation (OI), AVHRR Only, Version 2, Final+Preliminary
(2014-08-31T00:00:00Z, Altitude=0.0 m)
Data courtesy of NOAA NCDC

Biological Impacts

Warming Pacific Makes for Increasingly Weird Ocean Life

A "blob" of warm water that's partly to blame for dead birds and stranded sea lions in the Pacific may share a cause with Boston's snows and California's drought.

Pacific Ocean 'blob' draws scrutiny of researchers

A huge swath of unusually warm water that has drawn tropical fish and turtles to the normally cool West Coast over the past year has grown to the biggest and longest-lasting ocean temperature anomaly on record, researchers now say, profoundly affecting climate and marine life from Baja California to Alaska.

Experts puzzled as 30 whales stranded in 'unusual mortality event' in Alaska

Scientists 'very concerned' and suspect toxic algae, though Noaa concedes 'bottom line is we don't know what's causing deaths'

Mysterious Sea Lion Die-Off Strikes Again on California Coast

Tiny sea lion pups are washing up on beaches in unusually high numbers—for the third winter in a row.

Record Algae Bloom Laced With Toxins is Flourishing in "The Blob" — and Spreading in the North Pacific

Unusual warm ocean conditions off California, West Coast bringing odd species

Striated Sea Butterfly (Hyalocylis striata): This species of pteropod has a delicate cone-shaped shell and its foot is modified into two wings that it flaps to swim through the water like a butterfly. This is typically a tropical/subtropical species known from Baja California, Mexico. The specimens collected in September and October 2014 may be the first definite records from California. The individual shown was collected on October 21, approximately 1 km offshore from Bodega Marine Laboratory. The shell of this sea butterfly was less than 1 millimeter long. Photo by Eric Sanford/UC Davis (Photo by Eric Sanford/UC Davis)

Unusual species in Alaska waters indicate parts of Pacific warming dramatically

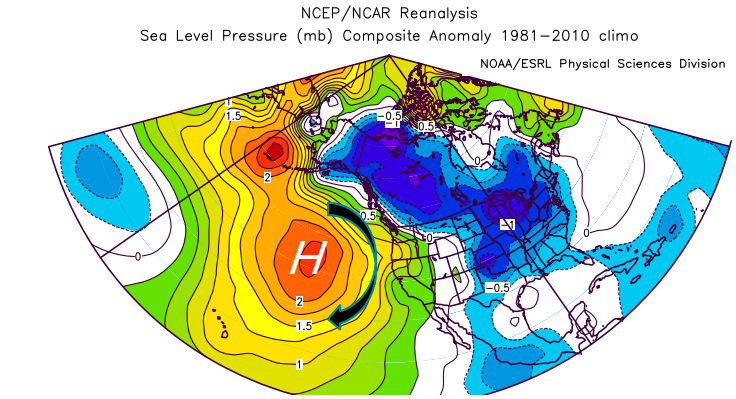
Why are so many whales dying on California's shores?

Huge Toxic Algal Bloom Shuts Down West Coast Fisheries

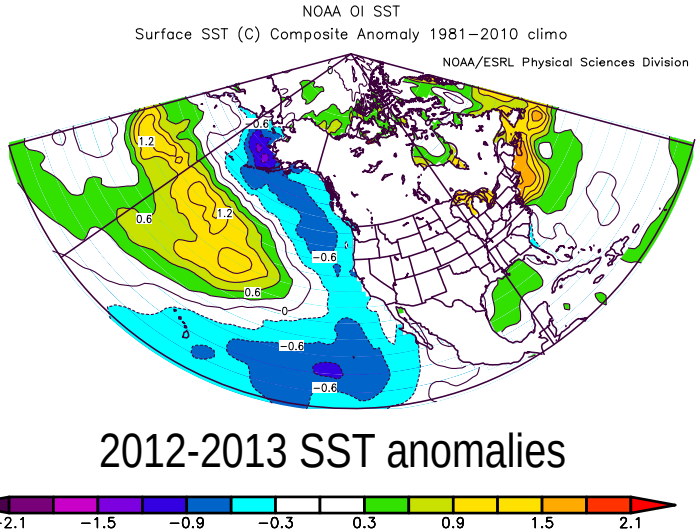
The Gulf of Alaska is unusually warm, and weird fish are showing up

In this Aug. 29 photo, a 7-foot ocean sunfish rarely seen in Washington waters washed ashore on a beach near Ilwaco, Wash., with June Mohler, a biological technician working as an interpretative assistant. (AP Photo/Cape Disappointment State Park, Eric Wall)

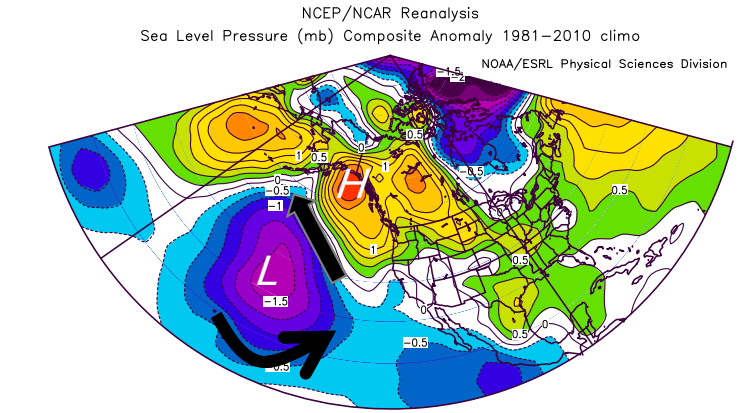
Origins of the Blob



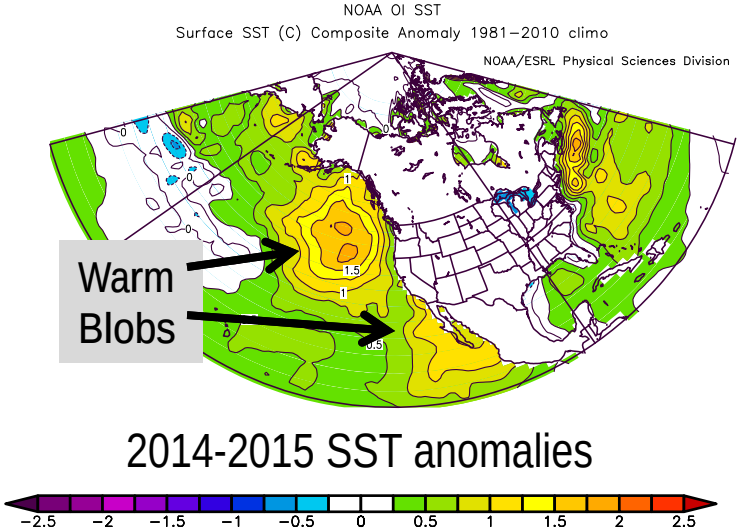
2012-2013 SLP anomalies



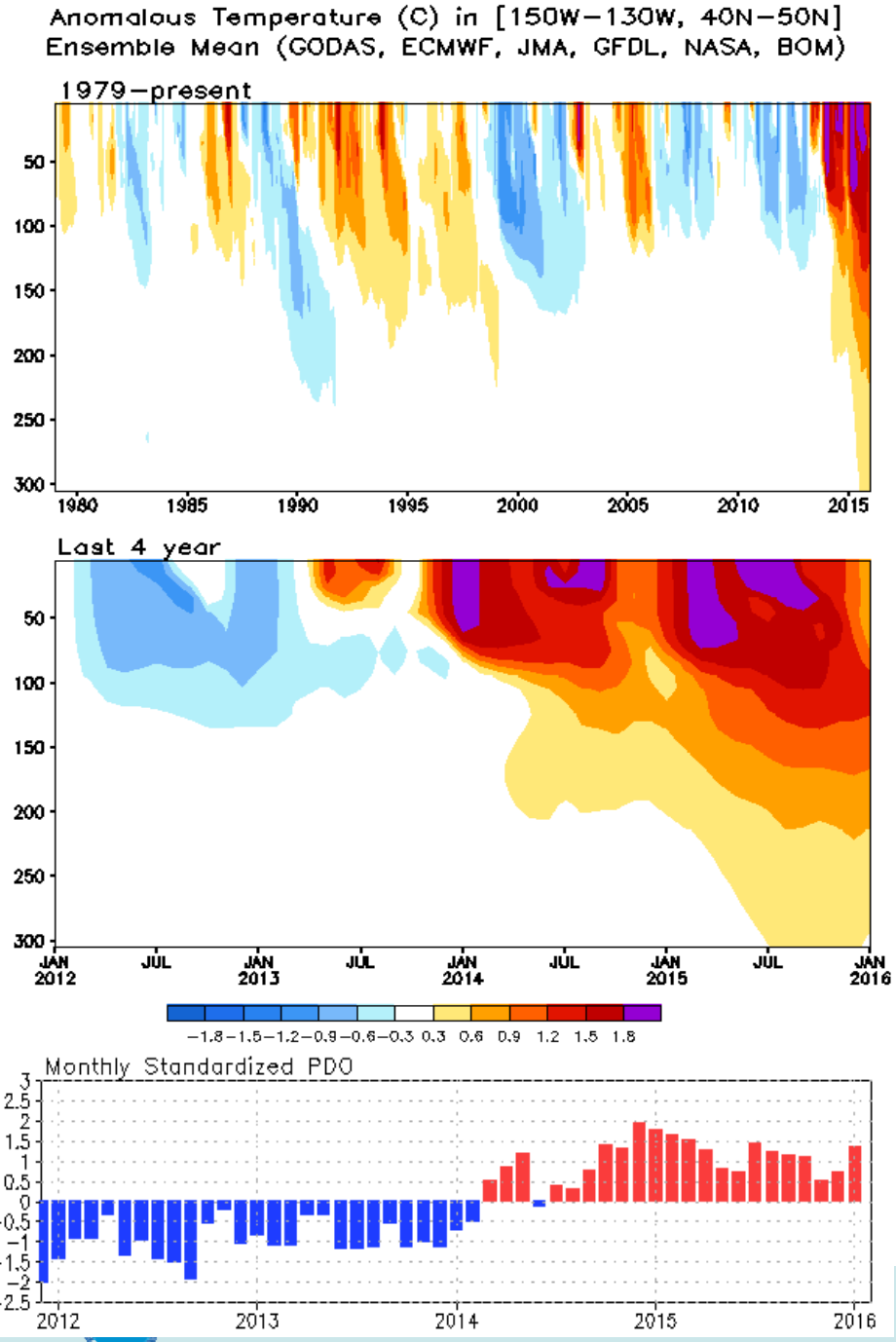
2012-2013 SST anomalies



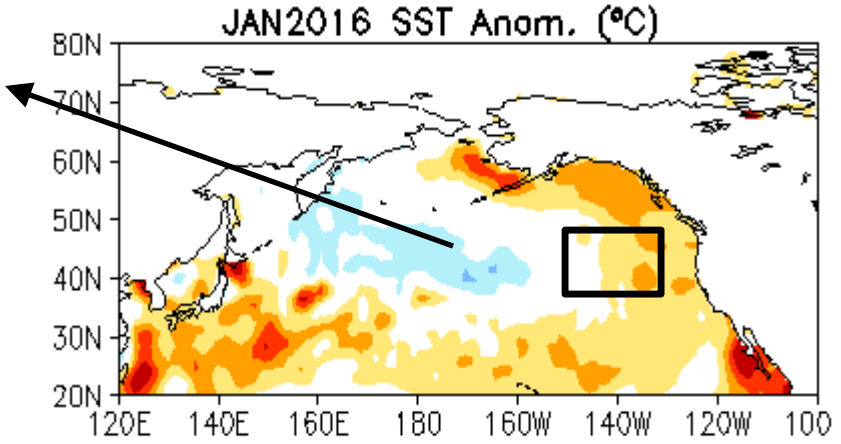
2014-2015 SLP anomalies



2014-2015 SST anomalies



"Blob" in North Pacific



- **Record SST warming appeared off shore near the west coast of North America in late 2013, referred to as "Blob" by Bond et al. (2015).**

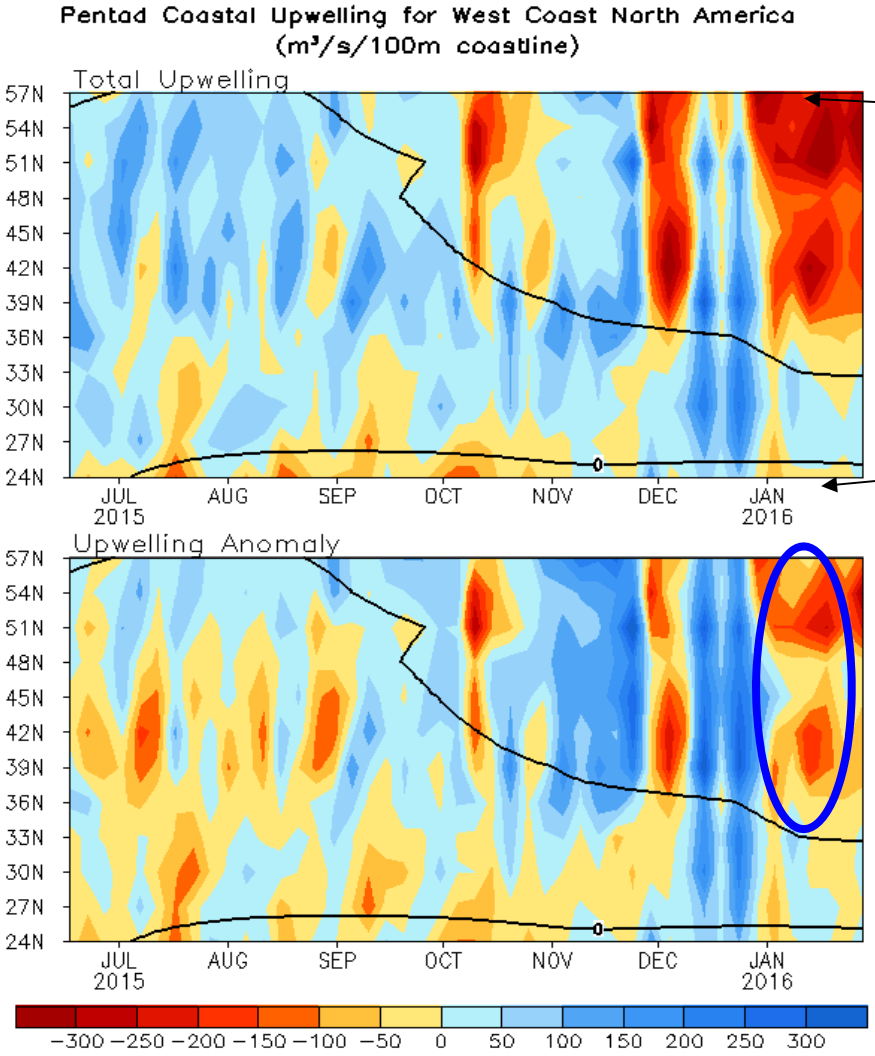
- **The warming in the NE Pacific box [150°W-130°W, 40°N-50°N] started near the surface in late 2013 and seems associated with the switch to positive PDO phase.**

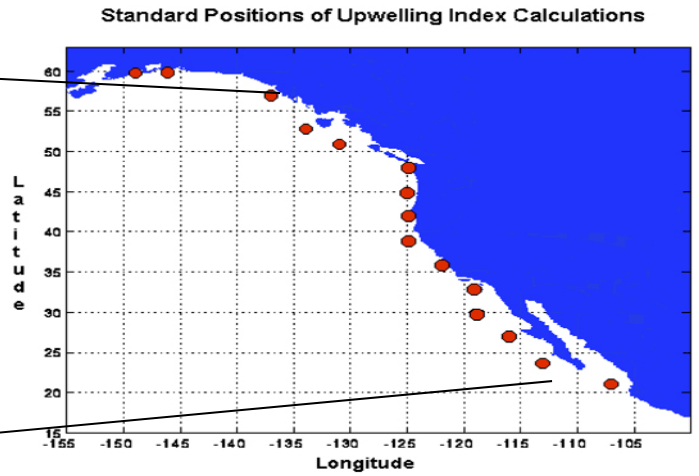
- **The warming in upper 100m depth dissipated rapidly in last two months, while the warming in the depth of 100-300m persisted.**

Blob: interior Gulf of Alaska

- Timeline: Late 2013 to summer 2014 in SST marked the beginning of multi-year warming; re-emerged in SST in summer 2015; also warm in spring/summer 2013, but that was a blip
  - Persistent warm temperature anomalies in the sub-surface ocean through all of 2014-15 to present; now especially between 100-300m depth
  - Clear role for persistent atmospheric forcing (a lack of wind and storms!) in the generation and evolution of Blob SST/mixed layer warming
  - Record high SST anomalies in 2014-15 back to at least 1920
  - Evidence for tropical-influences that favor a persistent high pressure ridge in the Gulf of Alaska

North America Western Coastal Upwelling





- Downwelling north of 36N was enhanced in Jan 2016, consistent with southerly wind anomalies near the shore.

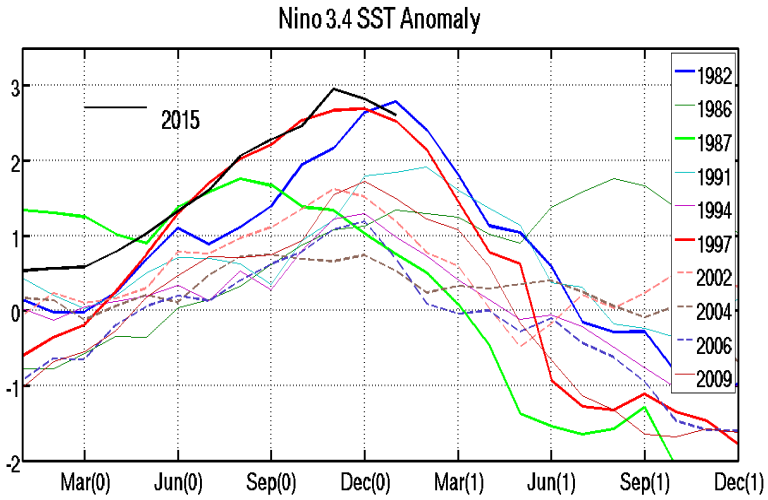
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport at 50 meter depth from each location to its nearest coast point (m³/s/100m coastline). Anomalies are departures from the 1981-2010 base period pentad means.

- **Area below (above) black line indicates climatological upwelling (downwelling) season.**
- **Climatologically upwelling season progresses from March to July along the west coast of North America from 36°N to 57°N.**

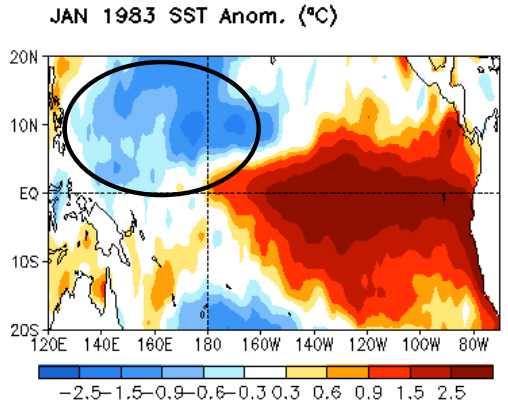
NOAA FISHERIES

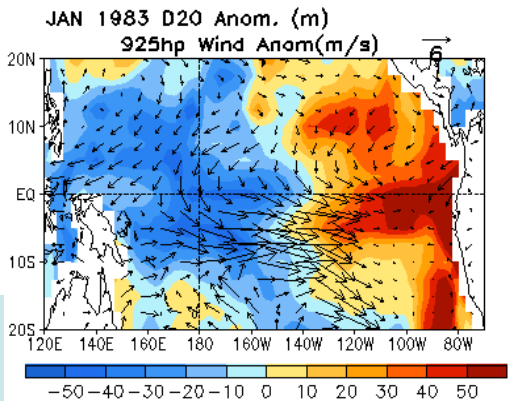
SST, D20 and 925hPa

Wind Anomalies

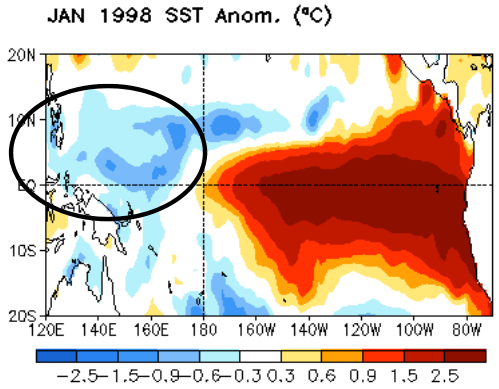


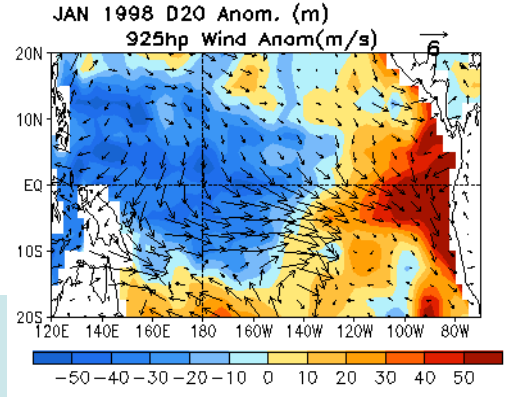
1983



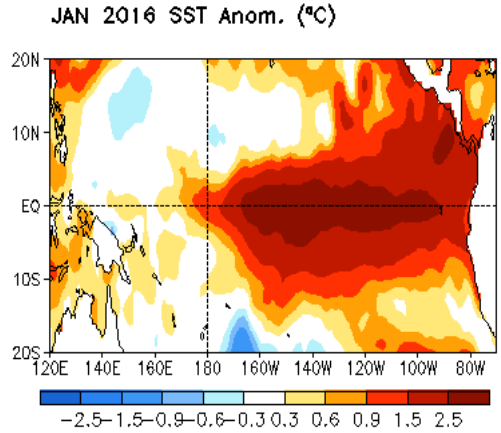


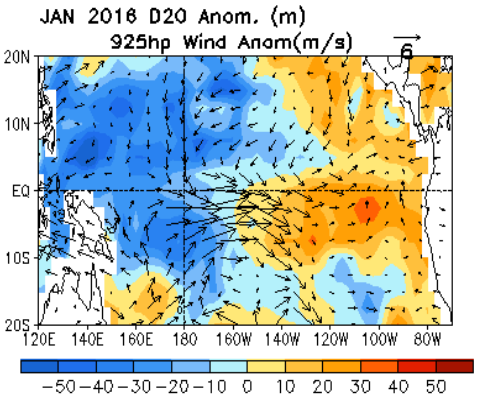
1998





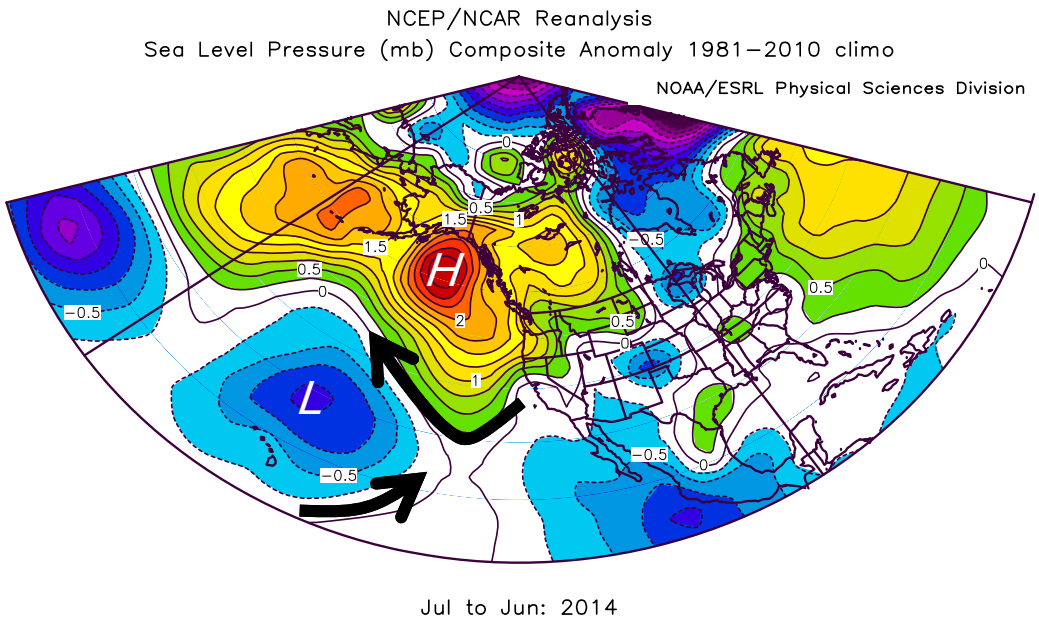
2016

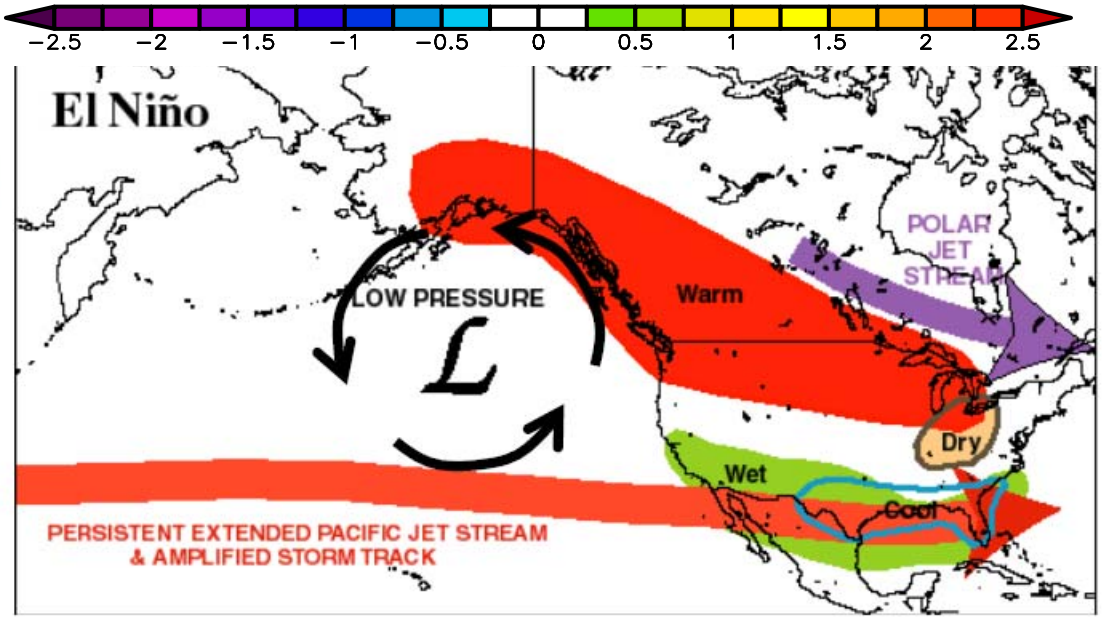




Atmospheric Forcing

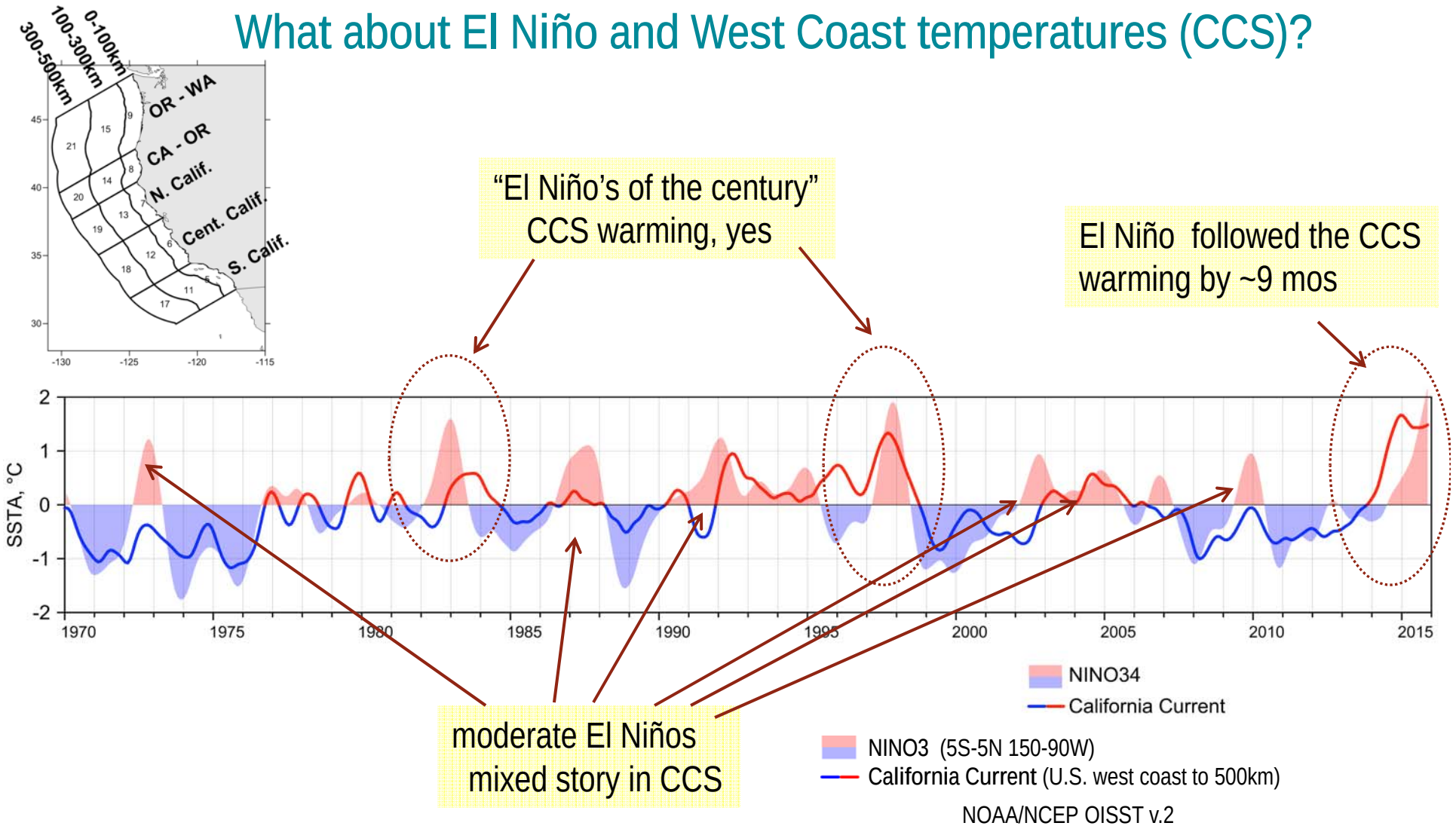
The *Ridiculously Resilient Ridge*: the proximate cause for California's extended drought and the "Blob" of exceptionally warm ocean temperatures in the NE Pacific (2013-15)





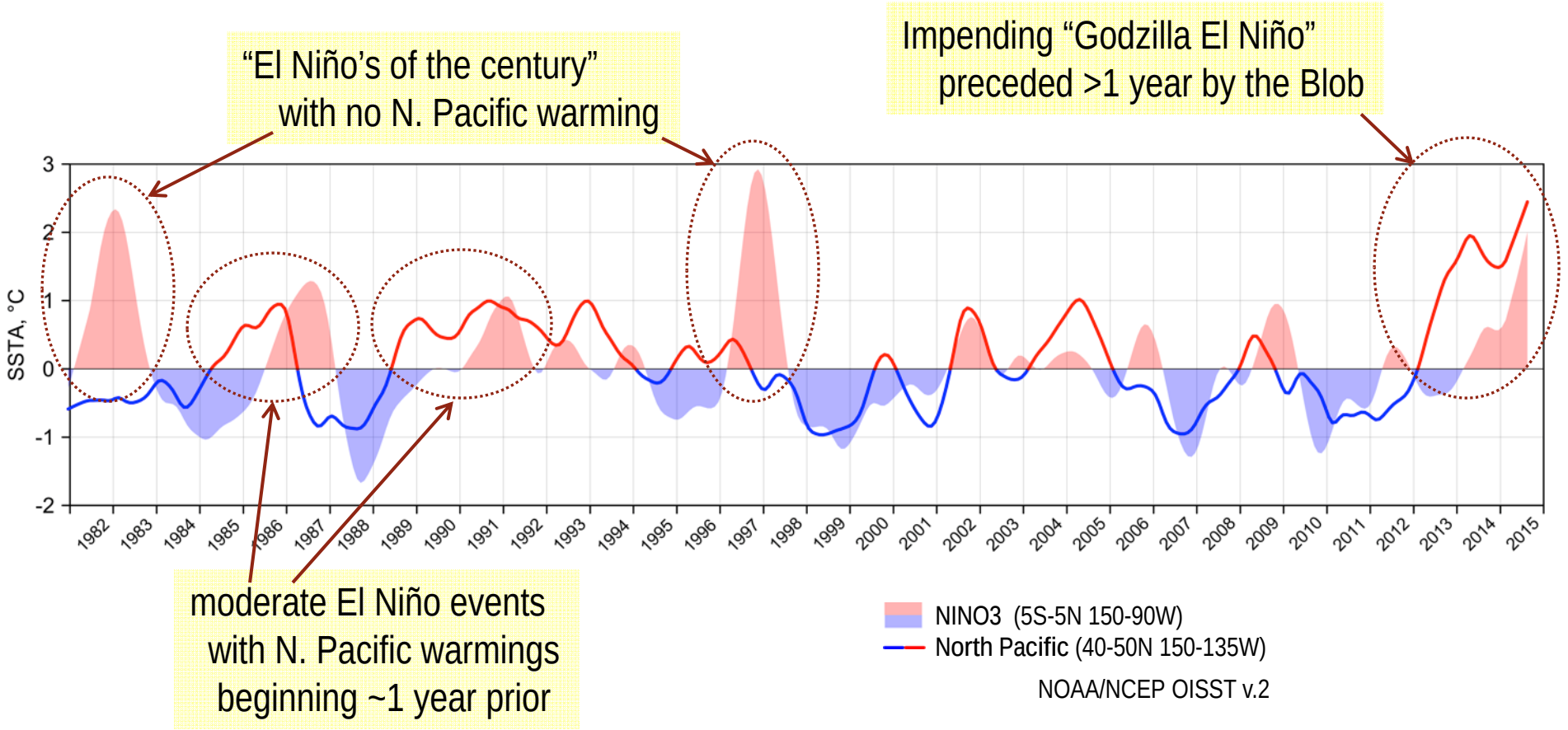
The typical El Niño winter pattern, featuring persistent and intense low pressure over the Gulf of Alaska and a very active jet stream and storm track just north of Hawaii extending over the southern US and northern Mexico.

What about El Niño and West Coast temperatures (CCS)?



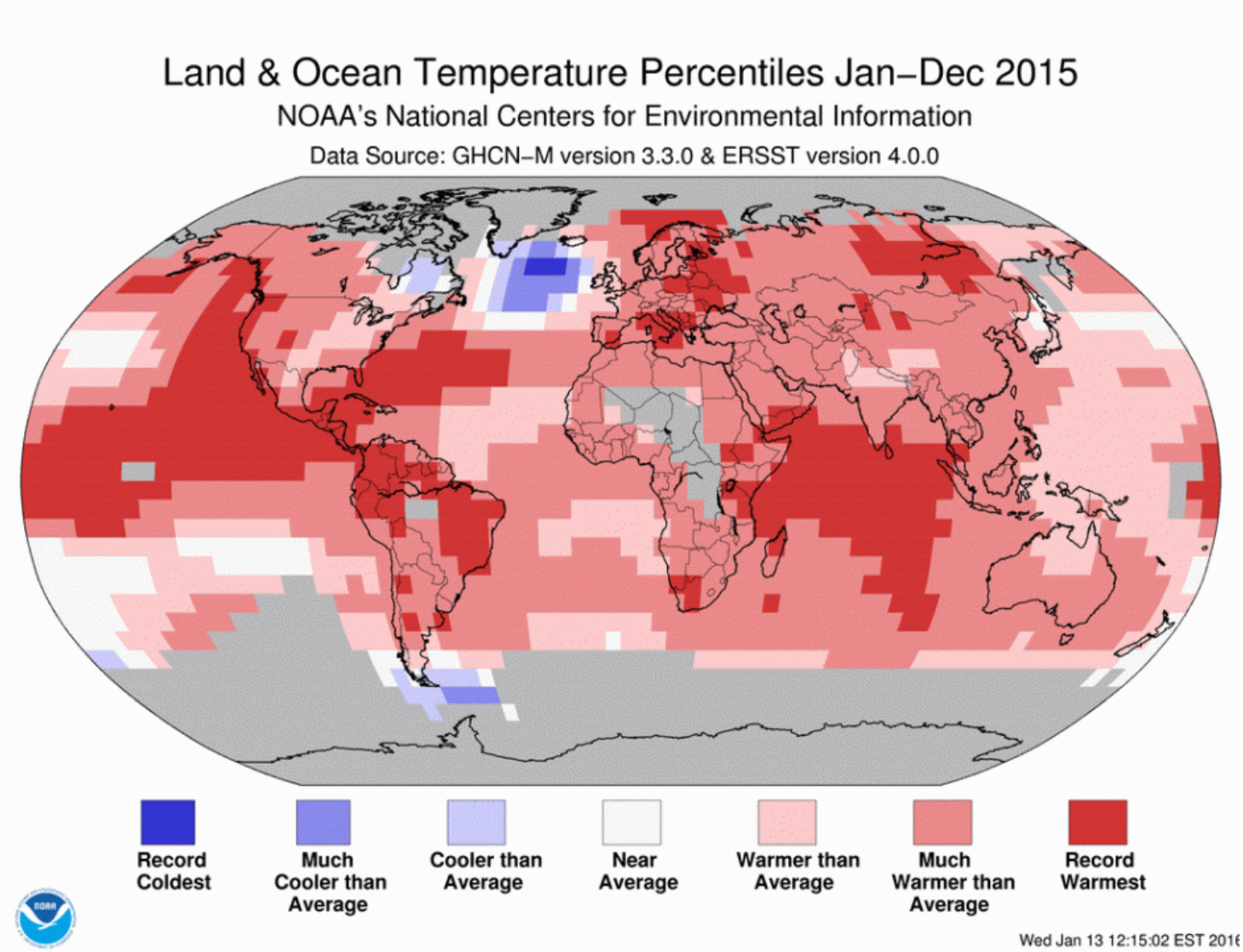
From Paul Fiedler, NOAA's SWFSC

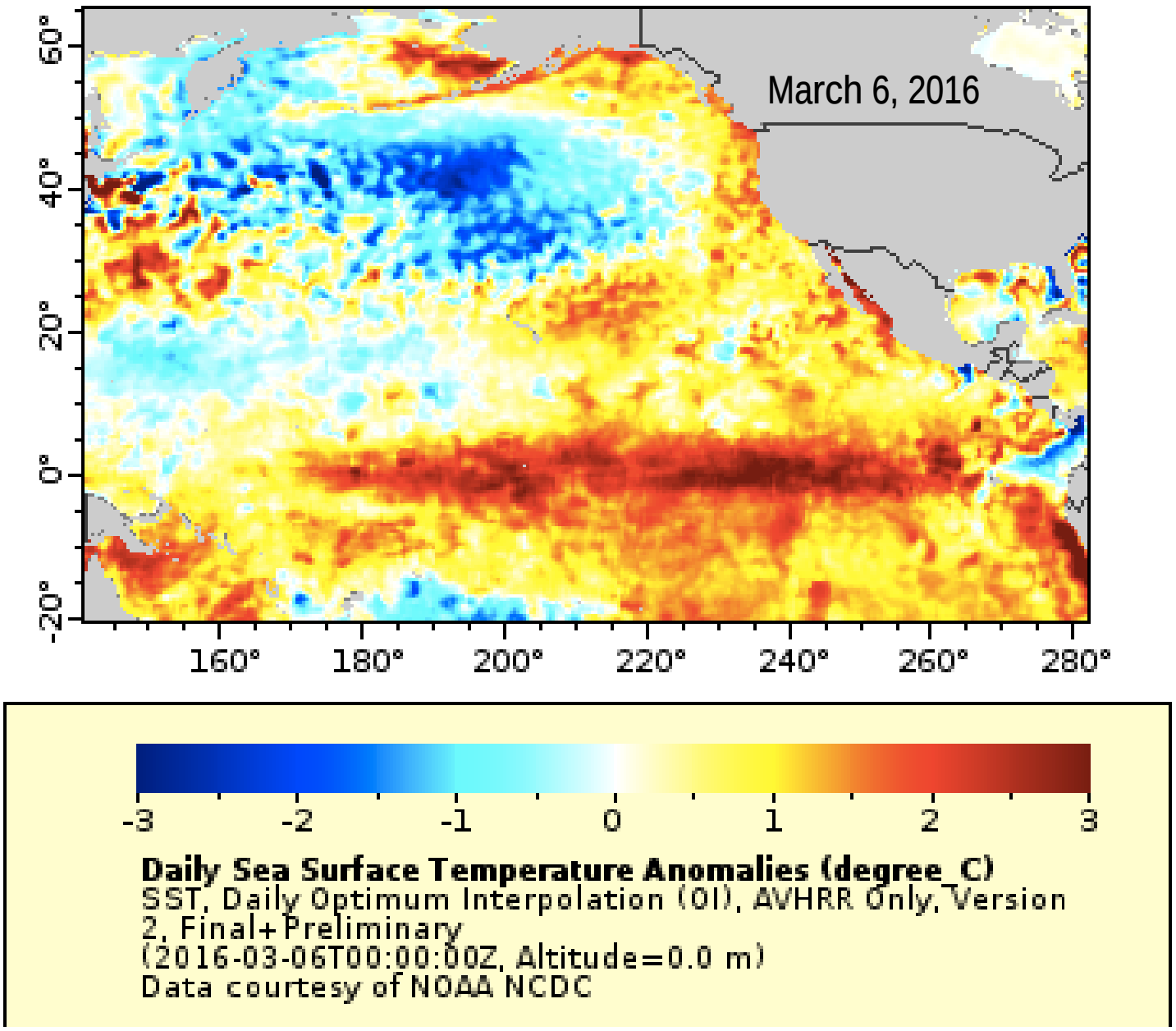
History of El Niño and North Pacific warmings (Blobs)

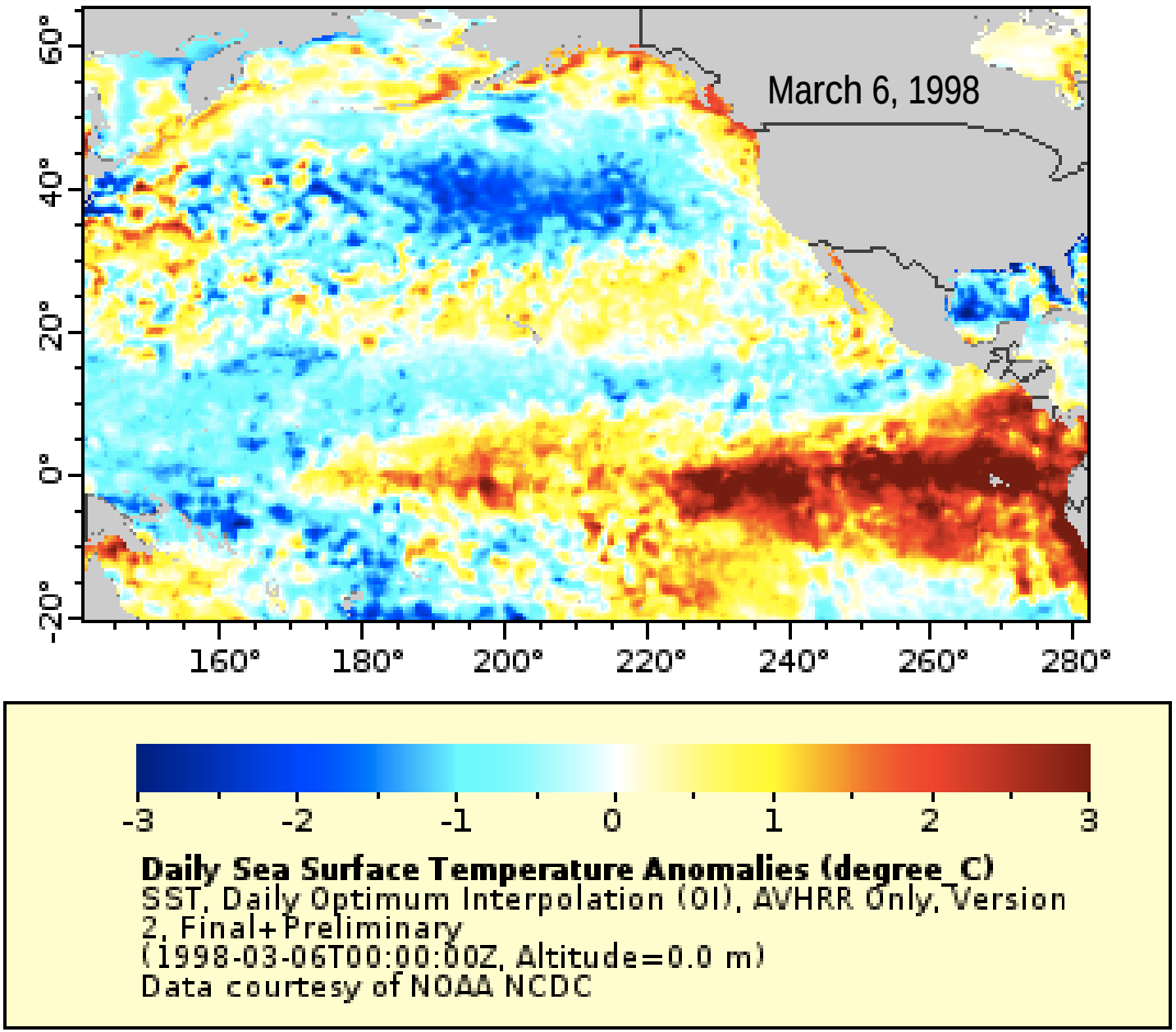


From Paul Fiedler, NOAA's SWFSC

2015 also had record high temperatures in coastal regions




March 6, 2016
60°
40°
20°
0°
-20°
160°
180°
200°
220°
240°
260°
280°
-3
-2
-1
0
1
2
3
Daily Sea Surface Temperature Anomalies (degree_C)
SST, Daily Optimum Interpolation (OI), AVHRR Only, Version 2, Final+Preliminary
(2016-03-06T00:00:00Z, Altitude=0.0 m)
Data courtesy of NOAA NCDC


March 6, 1998
60°
40°
20°
0°
-20°
160°
180°
200°
220°
240°
260°
280°
-3
-2
-1
0
1
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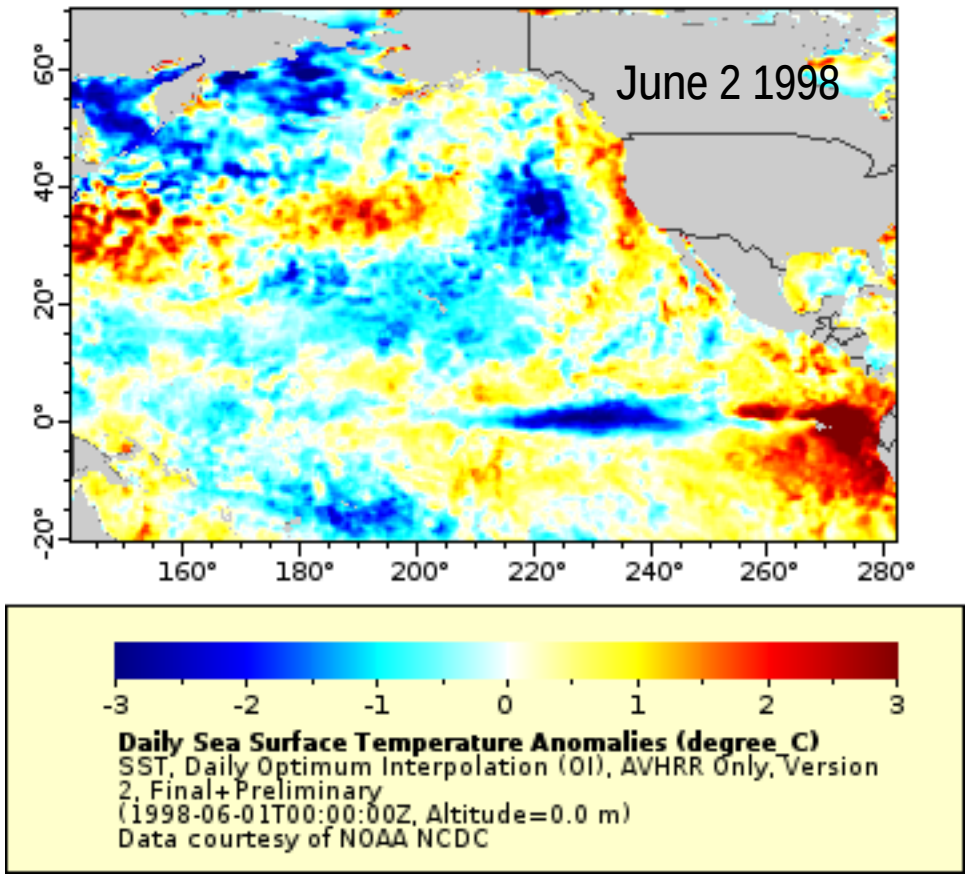
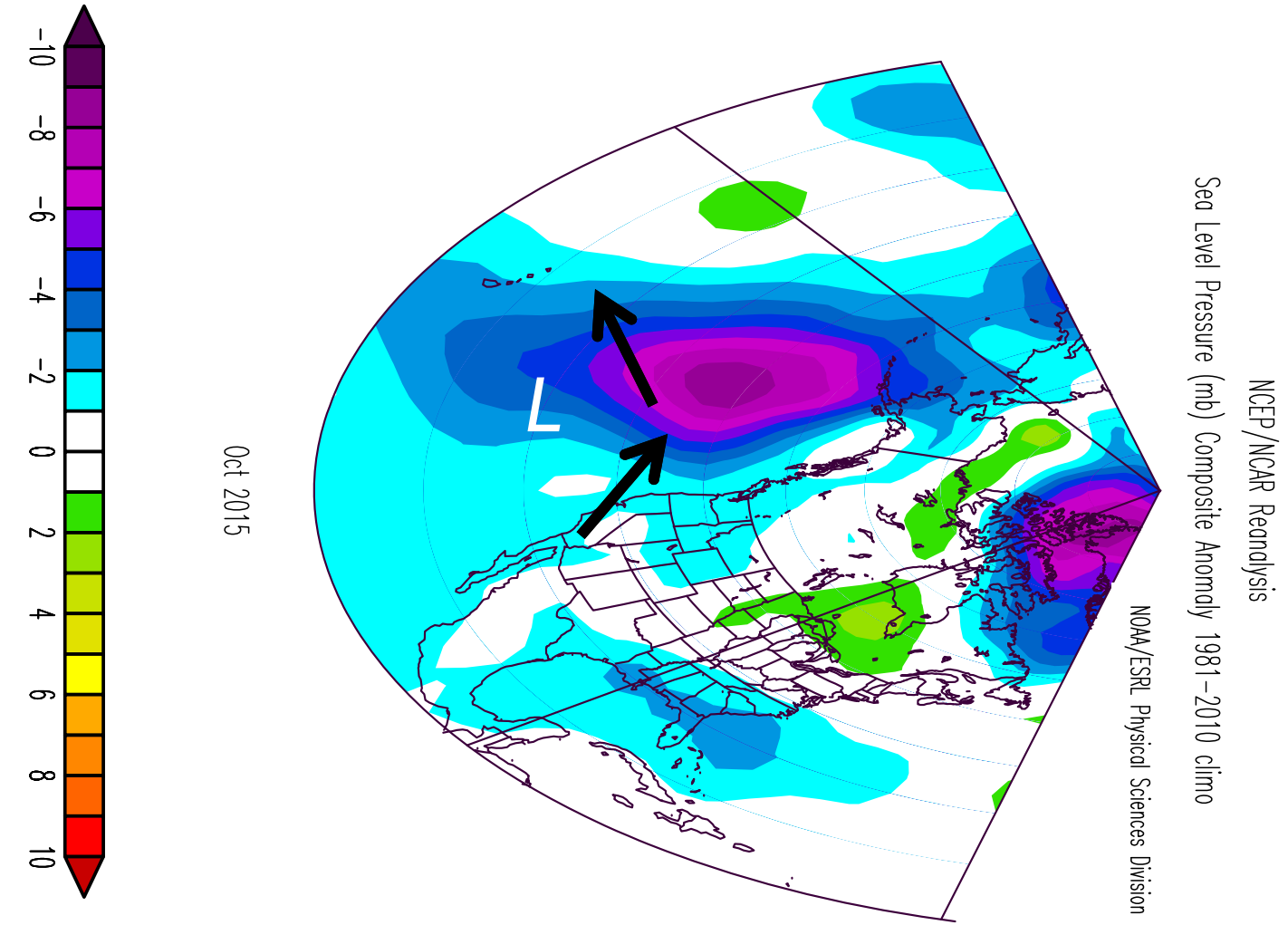
3
Daily Sea Surface Temperature Anomalies (degree_C)
SST, Daily Optimum Interpolation (OI), AVHRR Only, Version 2, Final+Preliminary
(1998-03-06T00:00:00Z, Altitude=0.0 m)
Data courtesy of NOAA NCDC

If the climate forecast is on the right track …

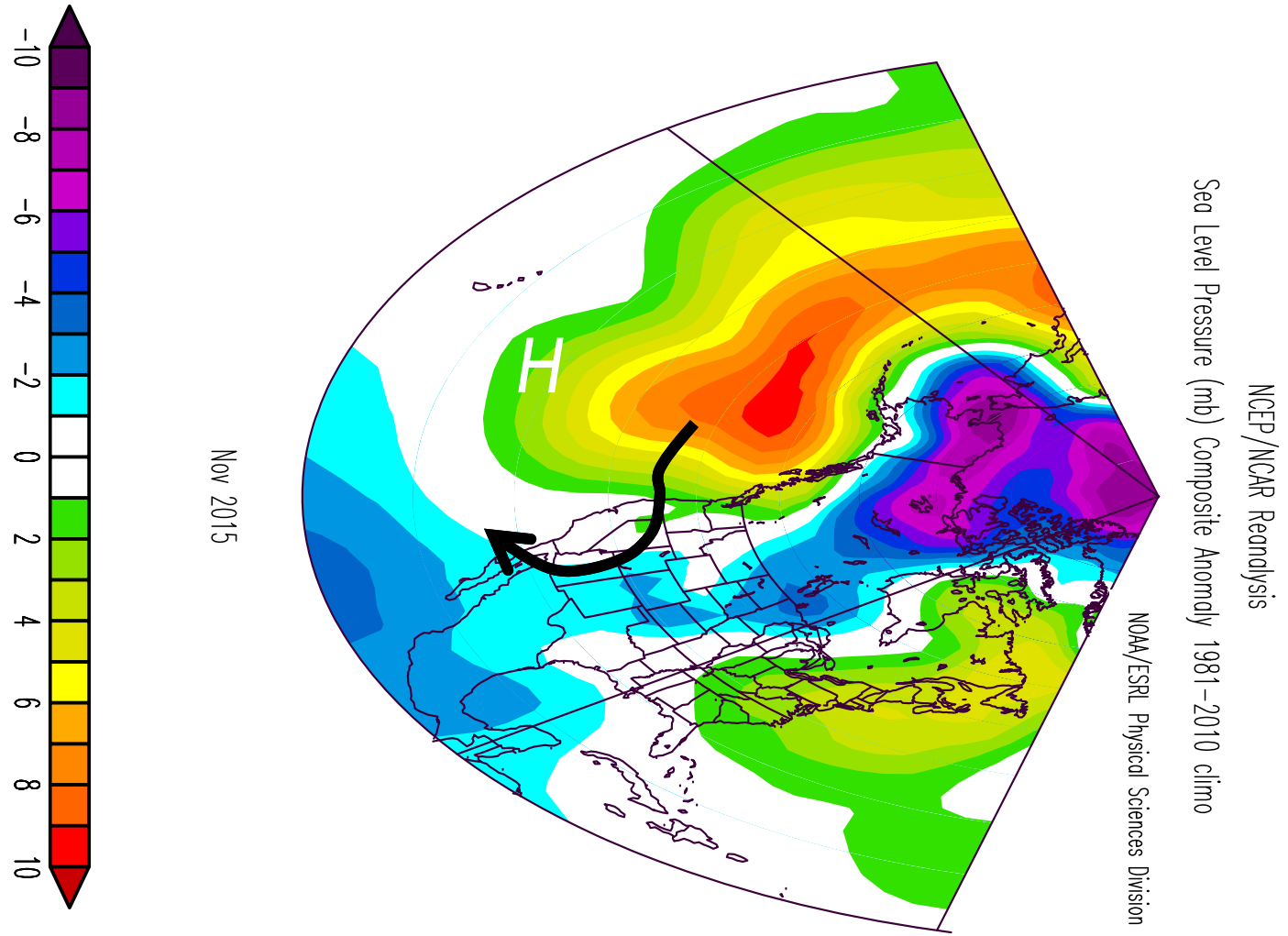
- Expect to see frequent California storms and low pressure off the West Coast, strong winds from the south, onshore advection, coastal downwelling, concentrated warming and deepening of the thermocline over the continental shelf, enhanced northward transport
- Continued tropical/subtropical influences along the Pacific coast for the next half year or so



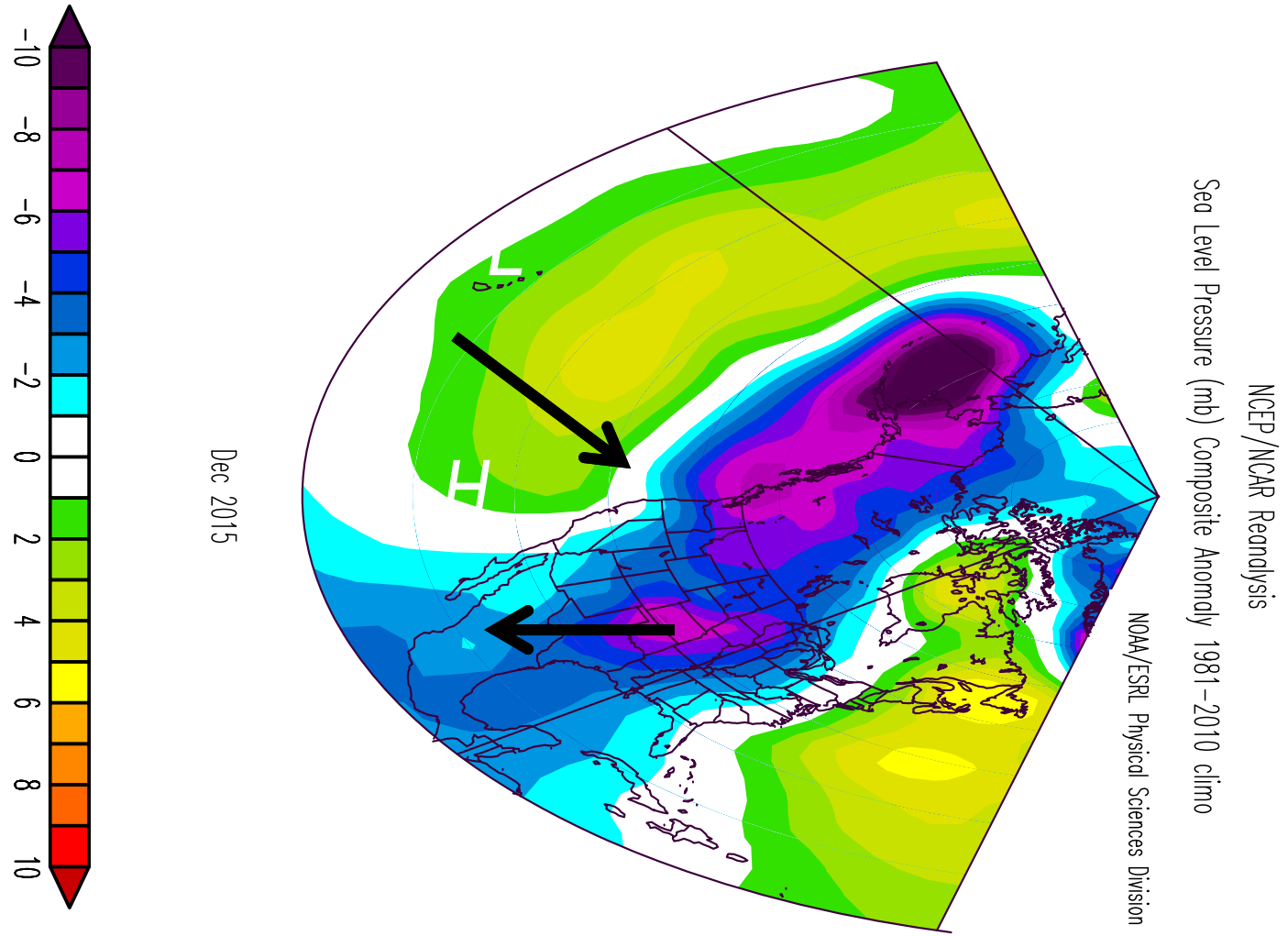
Observed sea level pressure anomalies: October 2015



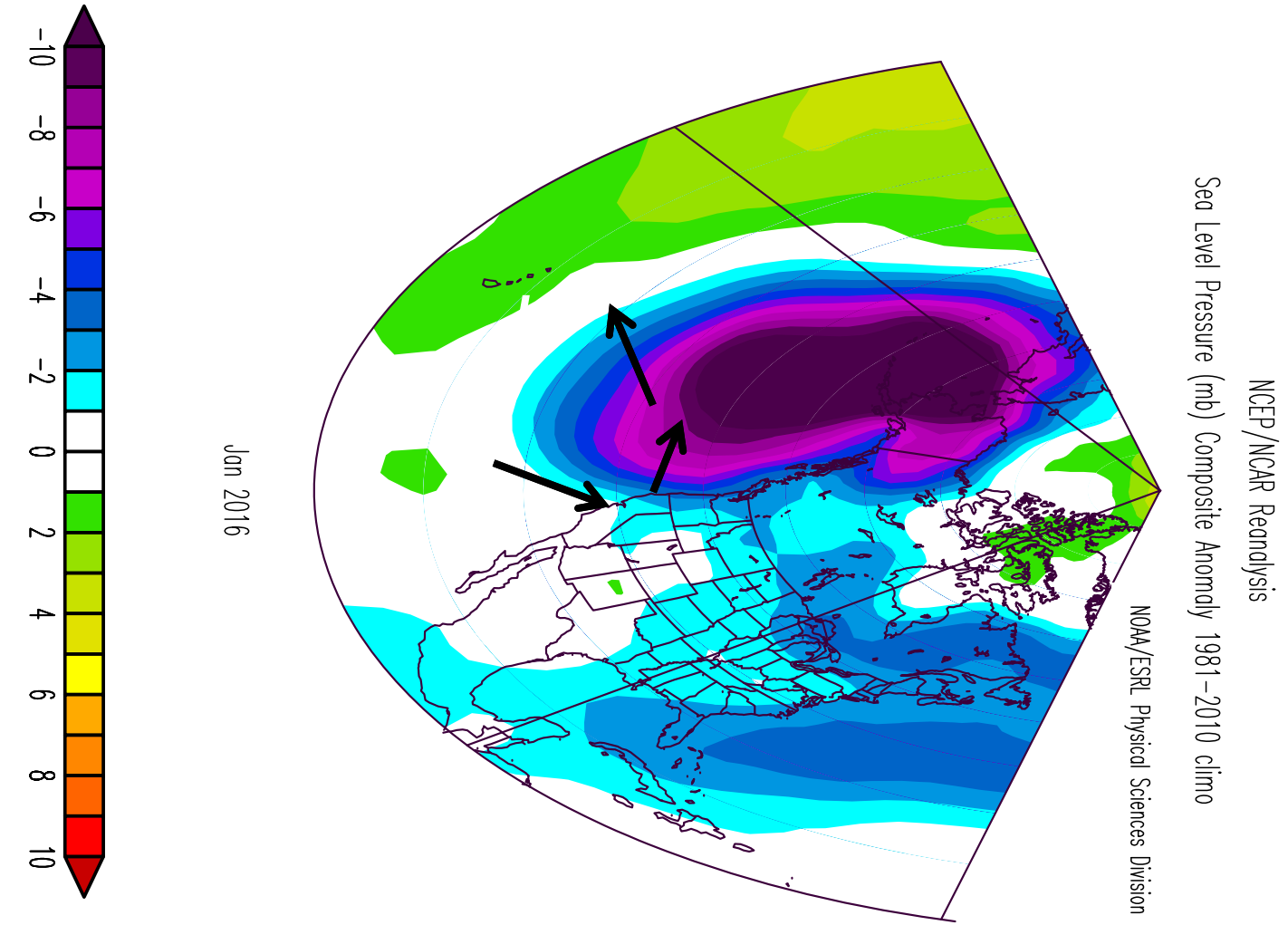
Observed sea level pressure anomalies: November 2015



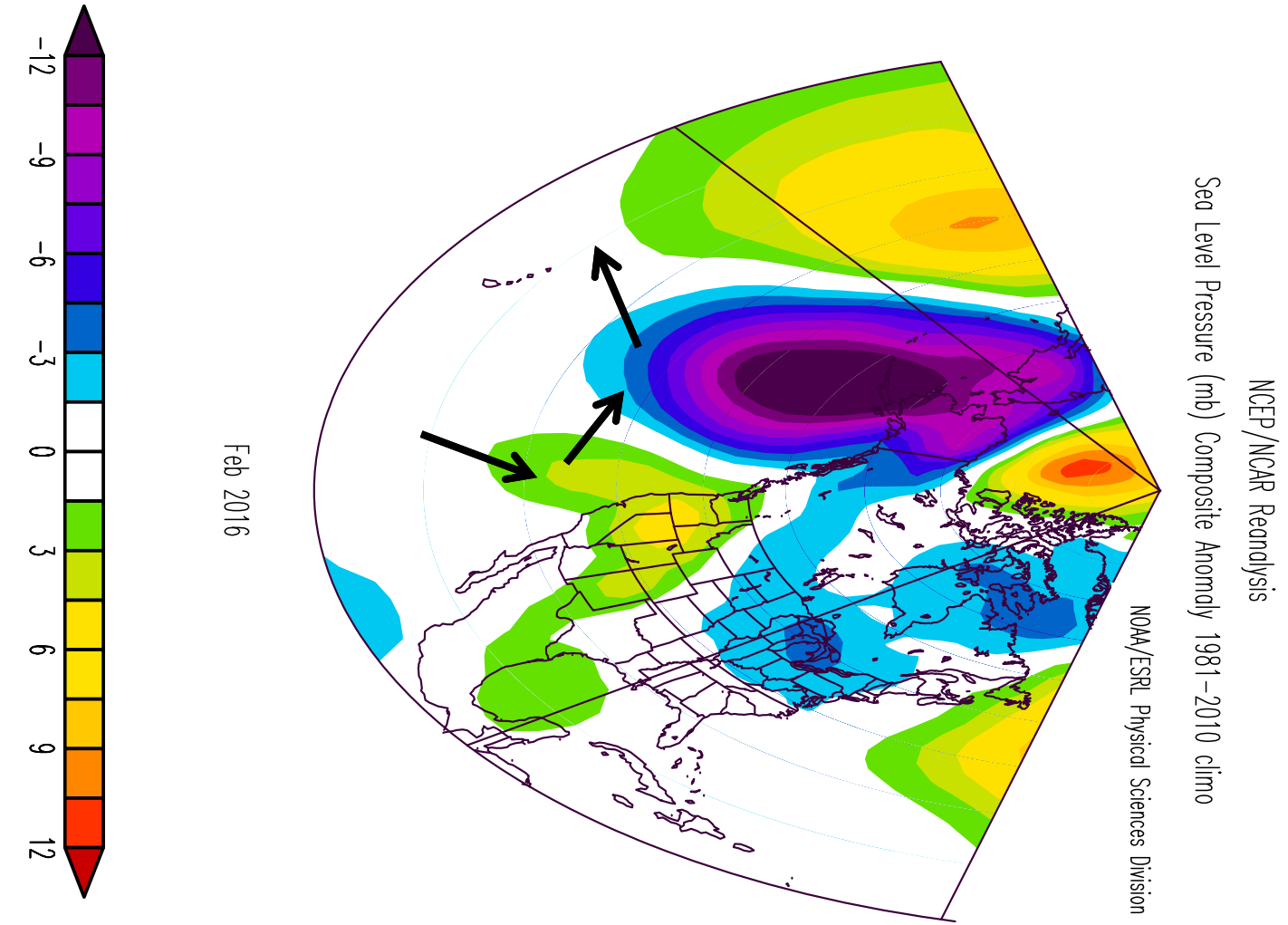
Observed sea level pressure anomalies: December 2015



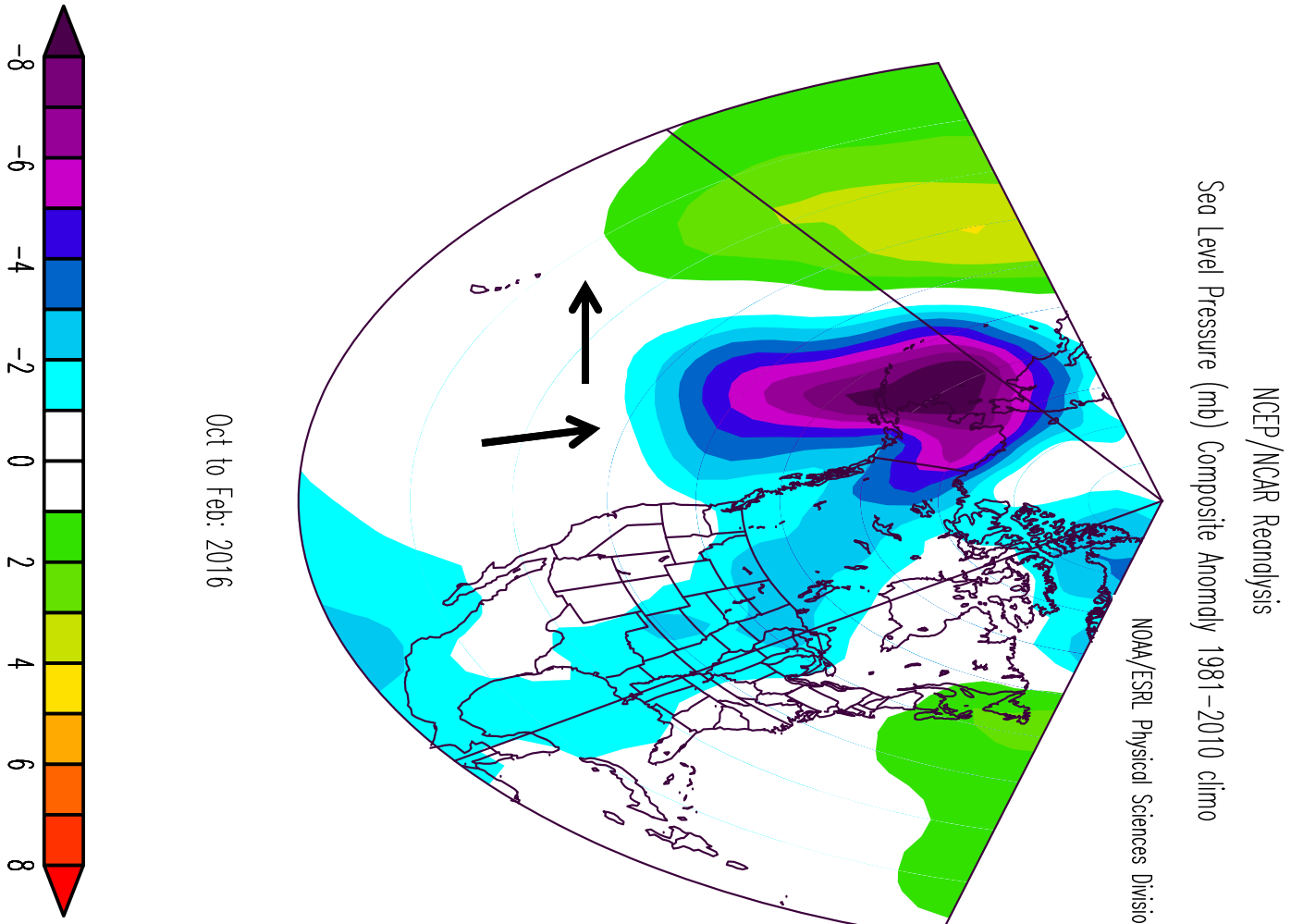
Observed sea level pressure anomalies: January 2016



Observed sea level pressure anomalies: February 2016

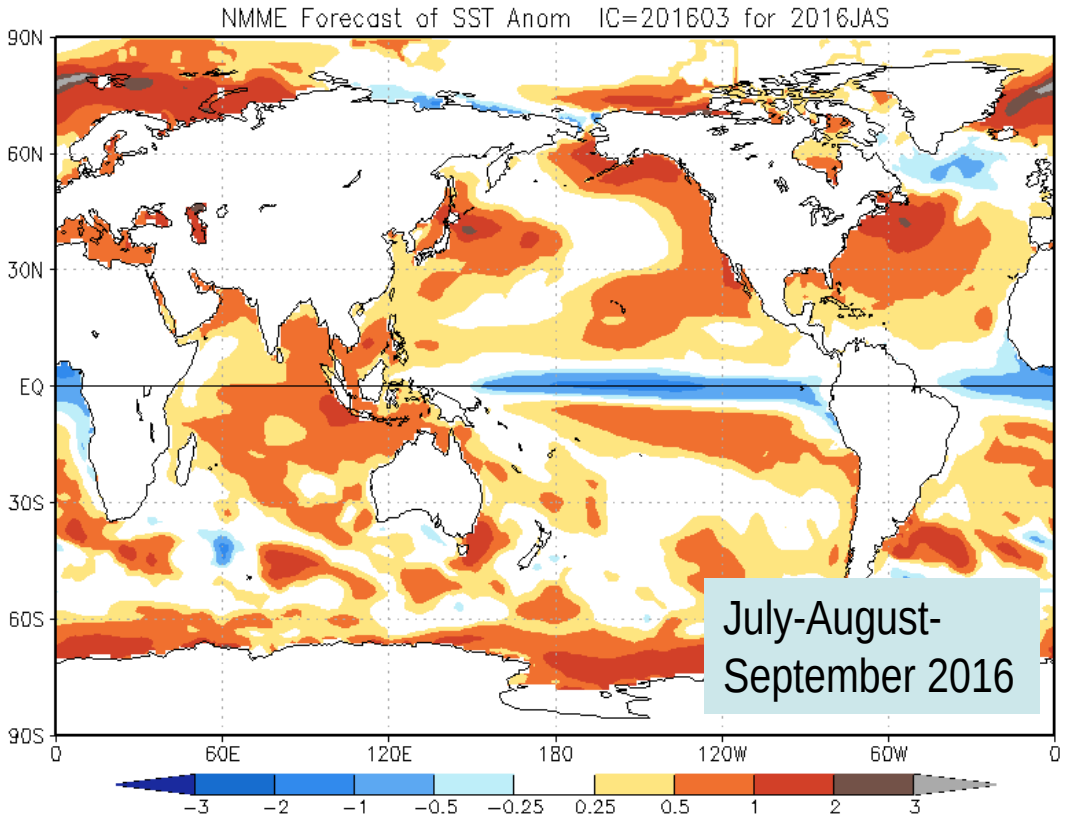


Observed sea level pressure anomalies: October - February 2016



Predictions for N. Pacific Ocean temperatures

- US climate forecast models predict a transition away from the offshore warm blobs toward a broad NE Pacific warming (a warm phase PDO pattern)
- They also predict the tropical El Niño will end mid-year



http://www.cpc.ncep.noaa.gov/products/NMME/current/CFSv2tmpsfcSeas.html

A climate timeline for West Coast salmon

2012	2013	2014	2015	2016
Year 1 CA drought, carryover storage in reservoirs	Year 2 CA drought, carryover storage in reservoirs	Year 3 CA drought, record warm winter, depleted reservoirs	West Coast "snow drought" and record high temperatures	Abundant snow pack and streamflow?
Cold productive NE Pacific	Cold productive NE Pacific	NE Pacific in transition from good to bad ocean conditions	Record warm temperatures in NE Pacific; many signs of stress on "subarctic" species off the West Coast	A still warm and unproductive NE Pacific?
BY 2012 coho	Freshwater rearing	Smolt migration, jack returns in fall	Ocean year 2, majority maturing	
BY 2012 winter steelhead	Freshwater rearing	Smolt migration, ocean year 0	Ocean year 1	majority maturing
	BY 2013 winter steelhead	Freshwater rearing	Smolt migration, ocean year 0	Ocean year 1

Take home messages

- The North Pacific Warm Blobs were established before the tropical El Niño intensified
- The proximate cause for the West Coast warming was unusual and persistent wind patterns (not obviously related to the tropical El Niño event in 2013/14, but moreso in 2014/15)
- Still warm in the NE Pacific, with subsurface warming down to depths >100m in Gulf of Alaska and off Baja
- This El Niño has been different – but still extreme
- El Niño influences on the West Coast are expected to remain strong through spring, and if they do we'll continue to see tropical/subtropical influences into spring/summer 2016, more storms, intense coastal downwelling, elevated coastal sea level, big ocean swell …