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July 29, 2014

MEMORANDUM

TO: Council members

FROM: Jim Ruff – Manager, Mainstem Passage and River Operations

SUBJECT: Panel discussion on possible El Niño effects on snowpack/precipitation, salmon and the ocean food web

At the August 5, 2014, Council meeting in Portland, Phil Mote (Director of Oregon Climate Change Research Institute at Oregon State University) and Bill Peterson (Oceanographer at NOAA's Northwest Fisheries Science Center in Newport, Oregon) will present information about the possible El Niño event developing in the Pacific Ocean this year. On July 28, 2014, NOAA's Climate Prediction Center (CPC) issued the current status and predictions for an El Niño event for 2014-15. The NOAA report states that "ENSO" (e.g., El Niño -Southern Oscillation) neutral conditions continue at present. However, sea surface temperatures have been above average across the western and eastern Pacific Ocean. NOAA predicts the likelihood of an El Niño condition in the Northern Hemisphere is about 70 percent this summer and close to 80 percent during the coming fall and winter.¹

Background and Current Conditions

Globally, the most important pattern of climate variability is called "El Niño" or, the term favored by climate scientists, "ENSO" (El Niño-Southern Oscillation). ENSO is a pattern of coupled atmosphere-ocean changes, known historically in the 16th century to South American fishermen who noticed that some years, fish were less abundant and the waters warmer - and this condition occurred usually around Christmas time, hence

¹ The NOAA-CPC considers El Niño or La Niña conditions to occur when the monthly sea surface temperature departures in the equatorial central Pacific Ocean (Niño 3.4 region) meet or exceed +/- 0.5° C, respectively, along with consistent atmospheric features. These temperature anomalies must also be forecasted to persist for three consecutive months.

"El Niño" or the Christ child. During an El Niño event, the normal patterns of wind and warm water are disrupted and shift eastward, affecting climate in the Northwest and other places. In the Northwest, the winter and spring climate during El Niño events are typically somewhat warmer and drier than usual, leading to somewhat lower snowpack, streamflow and other changes. The climatic and hydrologic effects of an event can vary considerably with the strength of the El Niño – and can differ from place to place.

Historically, El Niño events have had a profound effect on the physics and biology of the California Current Ecosystem (CCE), Gulf of Alaska (GoA), and Eastern Bering Sea. The response in the North Pacific is typically lagged from the tropical signal by several months, with maximum effects typically occurring in late summer (for the really big events) and late autumn and winter (for events of moderate-to-weak magnitude). At the time of the most recent alert (July 2014), the forecasters anticipate El Niño will peak at weak-to-moderate strength during the late fall and early winter.

While we have a good idea of what to expect during El Niño, no two El Niño events are the same. In some cases, the local response can be modified by existing conditions. For example, prior to the strong 1997-98 El Niño event, the Northeast Pacific had been in a prolonged warm 'regime', possibly compounding the effects of the El Niño. What is most interesting about the event that is developing now is the fact that ocean temperatures in the Gulf of Alaska and Eastern Bering Sea are exceptionally warm, a situation that may ultimately lead to poor survival of West Coast and Alaska salmon that grow and feed in this region. This is due to declines in prey production that are likely associated with the warmest waters in the Central Gulf of Alaska.

Another pattern of climate variability in the North Pacific is the Pacific Decadal Oscillation (PDO), identified by a pattern of sea surface temperature north of 20°N latitude. Although climate scientists are still investigating its causes and arguing about whether it can truly be called an oscillation, it appears to be linked to ENSO and has similar influences on the Northwest climate.

Effects of a Warm Ocean Condition on Salmon

The PDO has been in its positive (warm) phase since the first of the year. We know from our studies of ocean conditions over the past 20 years that when the PDO is in positive phase, regardless of the status of El Niño, the zooplankton community structure in the northern California Current becomes more sub-tropical in nature and becomes dominated by lipid-poor species. This bodes ill for West Coast salmon because their survival is usually relatively low when the PDO is in a positive (warm) phase. Thus, even if there is only a weak to moderate El Niño event in 2014/15, juvenile salmon entering the California Current Ecosystem in 2015 are likely to experience very low survival due in part to the "warm blob" that occupies the entire Gulf of Alaska as well as waters of the offshore California Current off Washington and Oregon. Other fished species are likely to be affected in a similar manner because the food chain upon which they depend will have lower bioenergetics content.

Finally, it should be noted that those Columbia/Snake River spring Chinook and steelhead stocks that entered the ocean this spring and traveled to the Gulf of Alaska to

feed may experience very poor survival this year due to the exceptionally warm conditions (and likely associated low productivity) in the Gulf of Alaska.

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El Niño or not El Niño: that is the question

Bill Peterson

Senior Scientist

NOAA-Northwest Fisheries Science Center

Hatfield Marine Science Center

Newport OR

With some help from Laurie Weitkamp –NOAA Fisheries



Dorado

Sightings from 1997/98 El Nino (Pearcy 2002)



Yellowfin tuna

Unusual sightings off Oregon

- Dorado, yellowtail, rosy rockfish, yellowfin tuna, Humboldt [jumbo] squid, striped marlin, lumptail searobin, popeye catalufa, California barracuda



Striped marlin

Warm water species in OR bays and estuaries

- Pacific mackerel, jack mackerel, Pacific sardines, albacore tuna



California barracuda



Popeye catalufa

Humboldt squid



Humboldt squid expansion

1997 **Strong El Niño**: Abundant in
Monterrey Bay, along Oregon coast

1998-2000 (- **PDO**): No sightings

2004 & 2005 (+ **PDO**): To Sitka, AK

2006-2008: Increasingly widespread on
West Coast

2009 **Weak El Niño**: Exploded!!!! to BC-
AK border

2010-2013 (- **PDO**): Few seen

2014 (+ **PDO**): ???

**Consistently
found in nets
since 2004**



Some other observations of note

- **Anchovy** stocks, market **squid** and CA sea lion populations in So. California decline
- **Whiting** and **sardines** migrate much farther north, into Canadian waters
- **Some winners...some losers:** Improved growth and recruitment for some species, such as sardines, but reduced recruitment for rockfish and anchovies and likely others (salmon in the PNW)
- **Tropical fishes** like mahimahi, swordfish, and marlin, and subtropical fish like Albacore and Pacific bonito, move north/onshore
- **Zooplankton** community transitions to a sub-tropical community of small species that are lipid-poor, replacing the 'normal' large lipid-rich community: think **popcorn** vs **cheeseburgers**.

However.....the news as of yesterday:

- "I think this year's El Nino has been a real enigma. Many of us were thinking that it would be a big event this year, but now the signal is pretty weak and a strong event seems quite unlikely." Matt Collins, Exeter University
- NOAA is now predicting a "weak-to-moderate" event
- The Australian Bureau of Meteorology has eased its projections for the next El Niño's potential strength too, saying: "If an El Niño were to occur, it is increasingly unlikely to be a strong event."

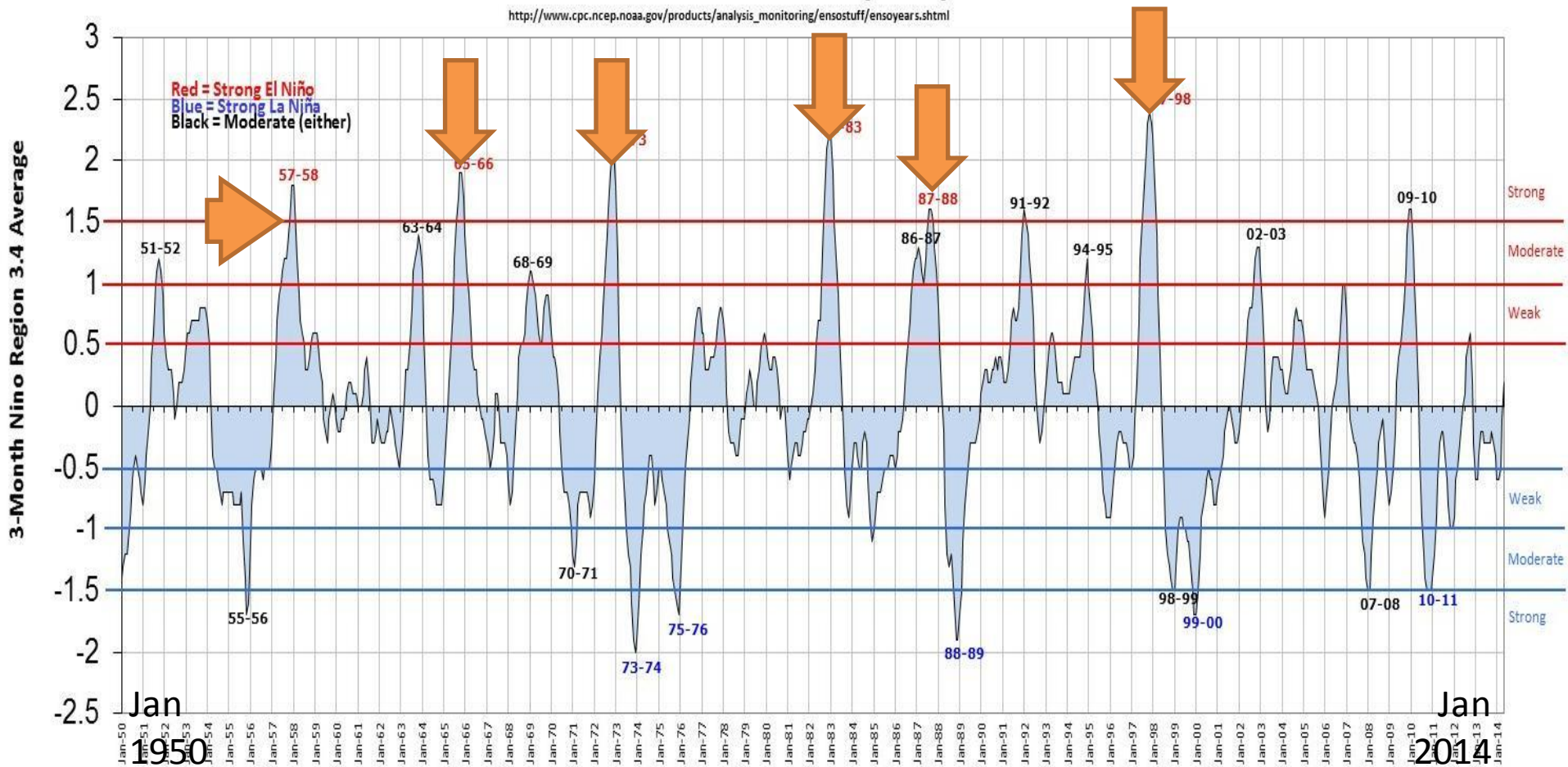
From "The Carbon Brief" blog

We are overdue for a big one

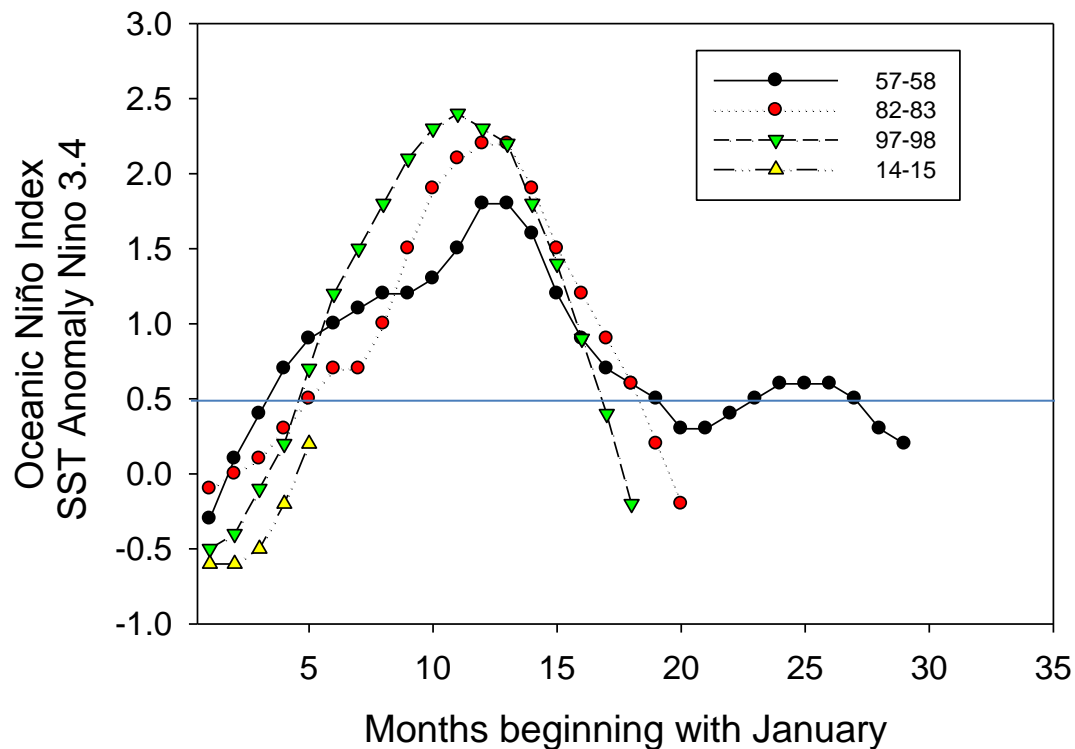
Since 1950 occurrences there have been **six “strong”**
and eight “moderate” El Niño events

Oceanic Niño Index (ONI)

http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml



SST Anomaly at Equator for the past three really big events

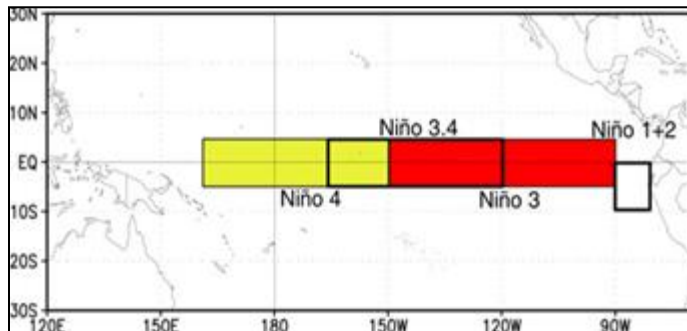


- The three big past events exceeded the 0.5 °C threshold by March or April;
- This event has not (and won't).

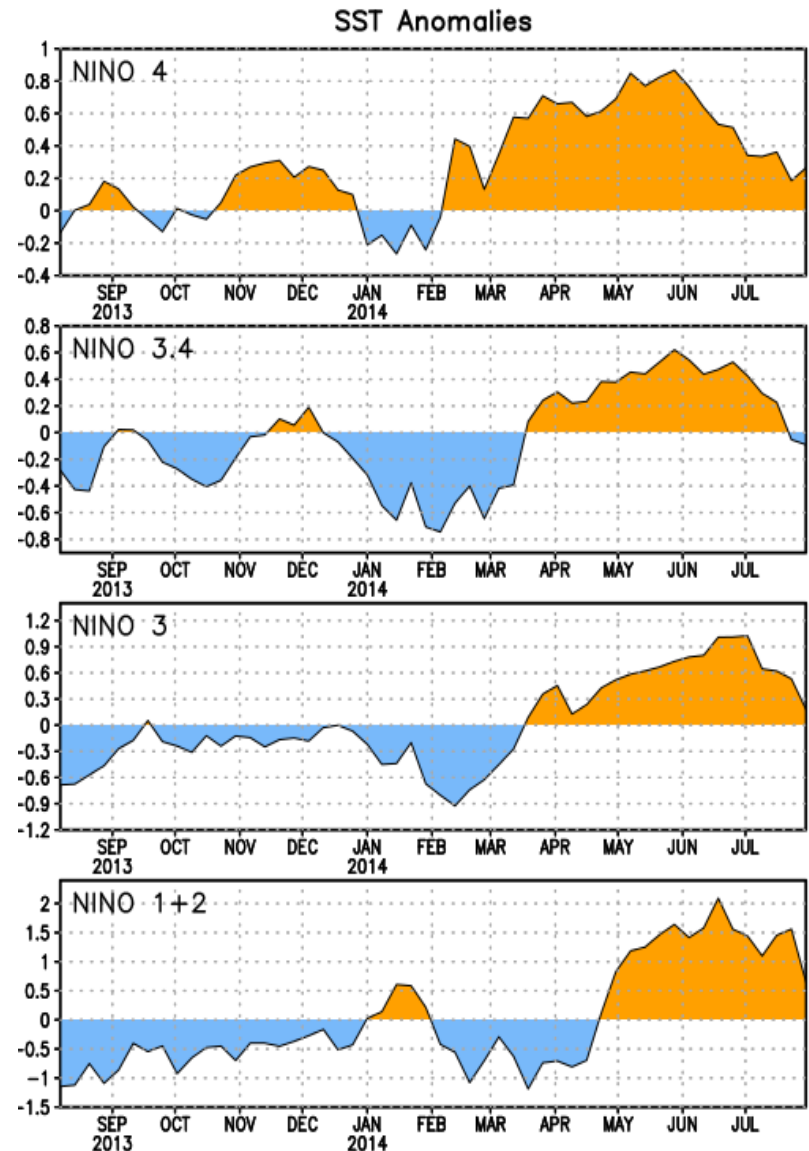
Niño Region SST Departures (°C) Recent Evolution

The latest weekly SST departures are:

Niño 4	0.3°C
Niño 3.4	-0.1°C
Niño 3	0.2°C
Niño 1+2	0.6°C



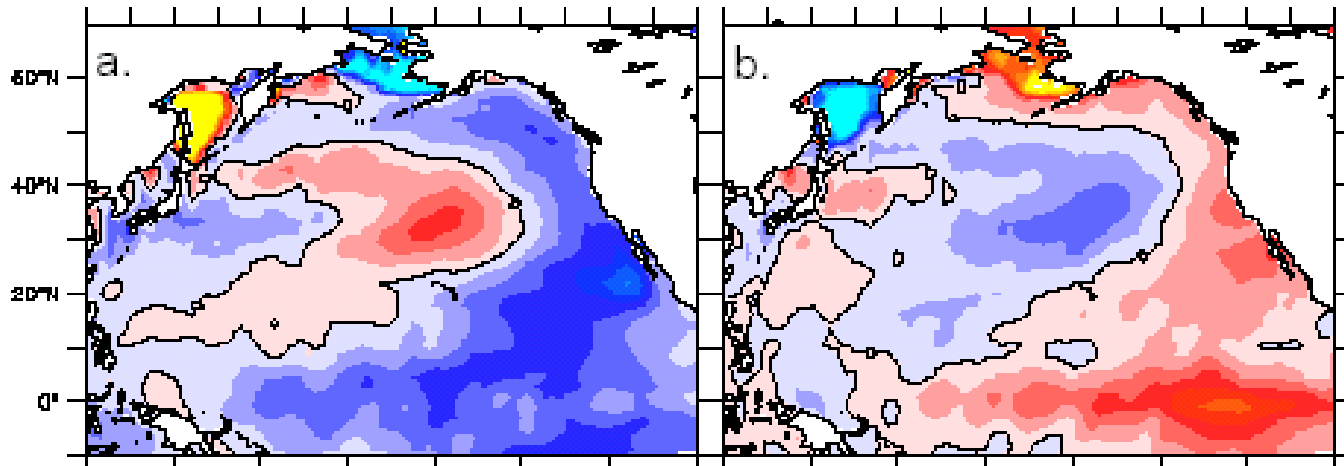
http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/



Other problems have not gone away

- Pacific Decadal Oscillation (PDO) is in positive (warm) phase
- Gulf of Alaska is still very warm
- Neither of these conditions are good for salmon, perhaps especially for the types that migrate to the Gulf of Alaska to feed (spring Chinook and steelhead; fall Chinook and coho to a much lesser extent).

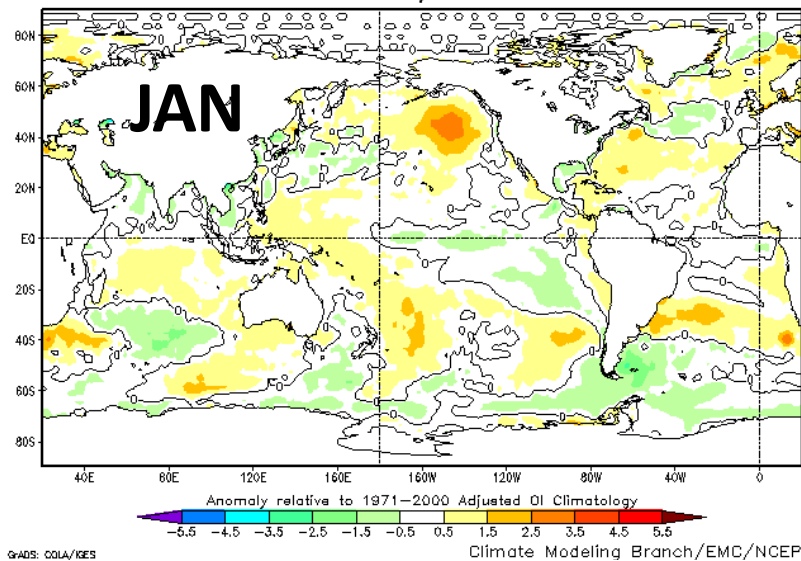
Winds over the North Pacific in winter are a big driver of ocean variability: e.g., the Pacific Decadal Oscillation)



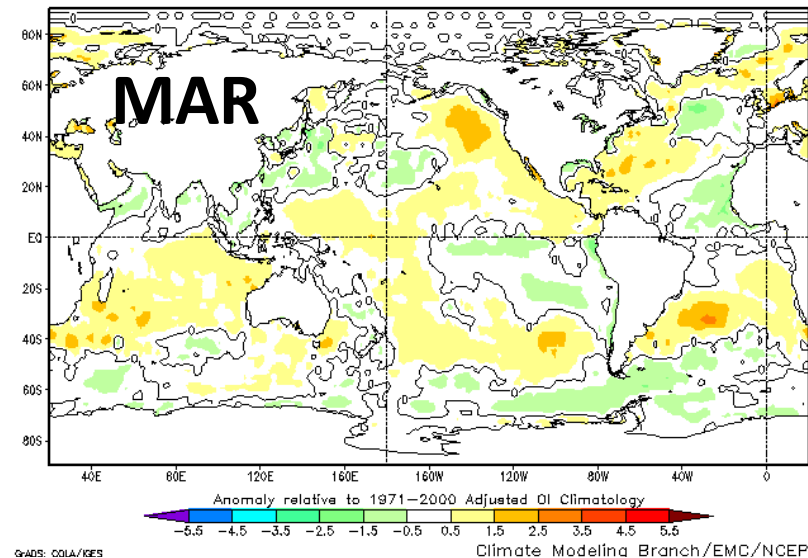
Blue is anomalously cold; Red is anomalously warm
La Niña at the equator El Niño at the equator

SST anomaly patterns result from basin scale winds: W'ly
and NW'ly [negative phase= cool regime] and SW'ly
[positive phase=warm regime].

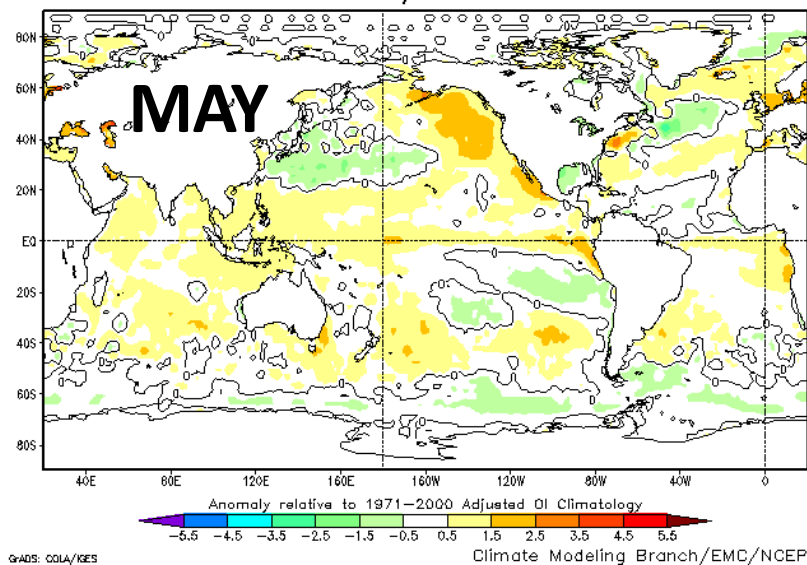
Olv2 Sea Surface Temperature Anomaly (°C)
January 2014



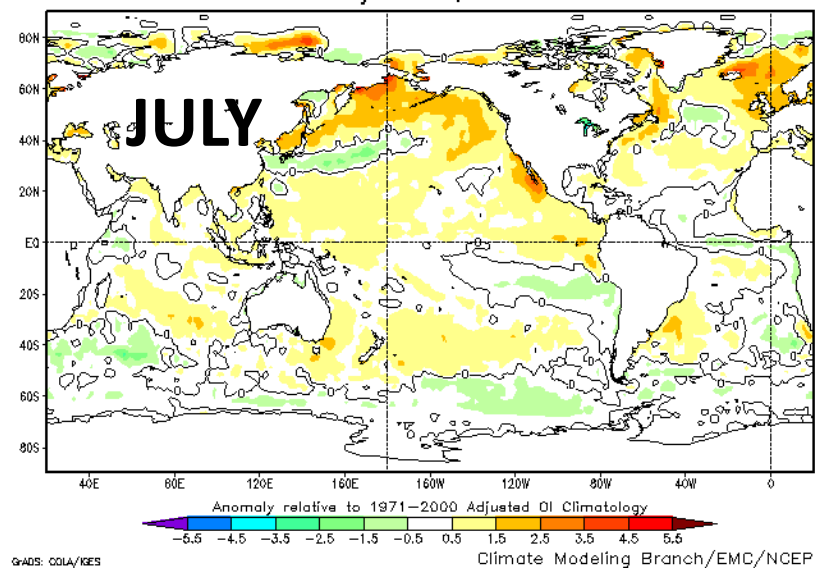
Olv2 Sea Surface Temperature Anomaly (°C)
March 01–26, 2014



Olv2 Sea Surface Temperature Anomaly (°C)
May 2014

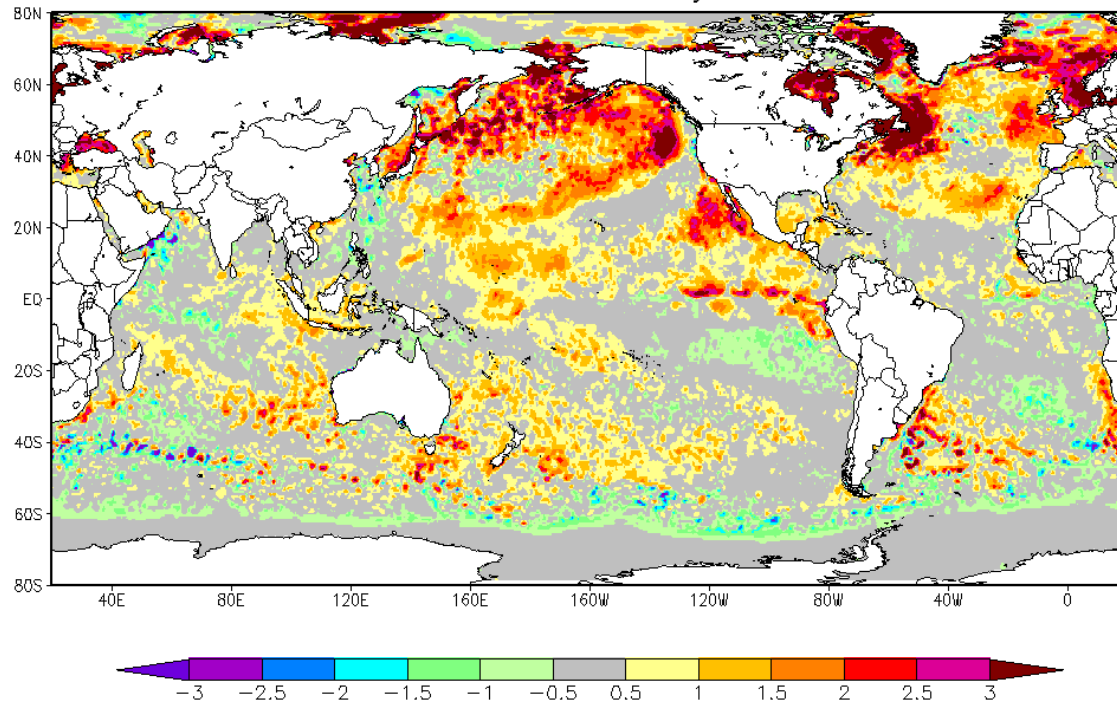


Olv2 Sea Surface Temperature Anomaly (°C)
July 01–30, 2014



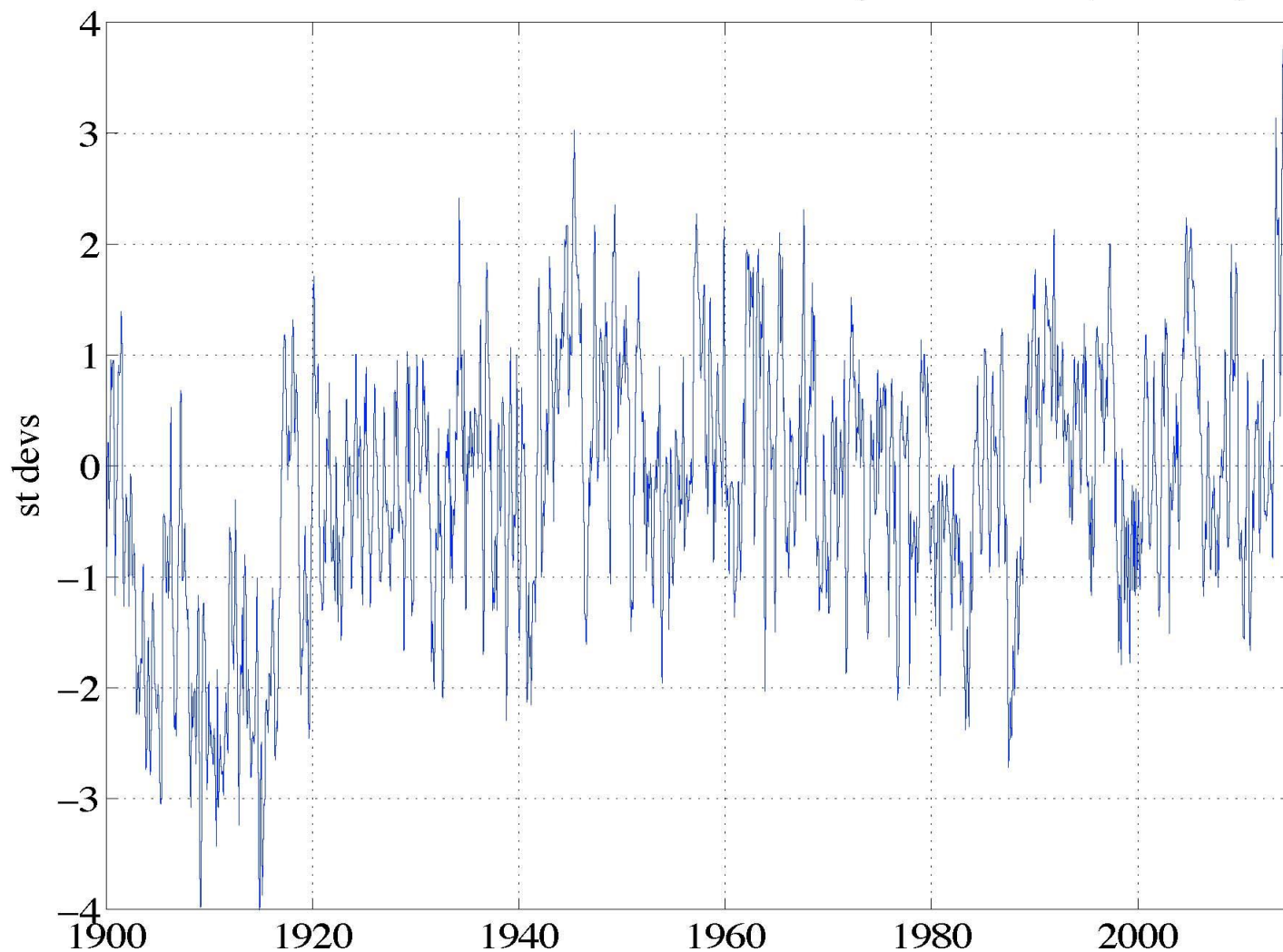
Conditions at present

Daily OISST Anomaly Intv2: 03AUG2014
AVHRR – only



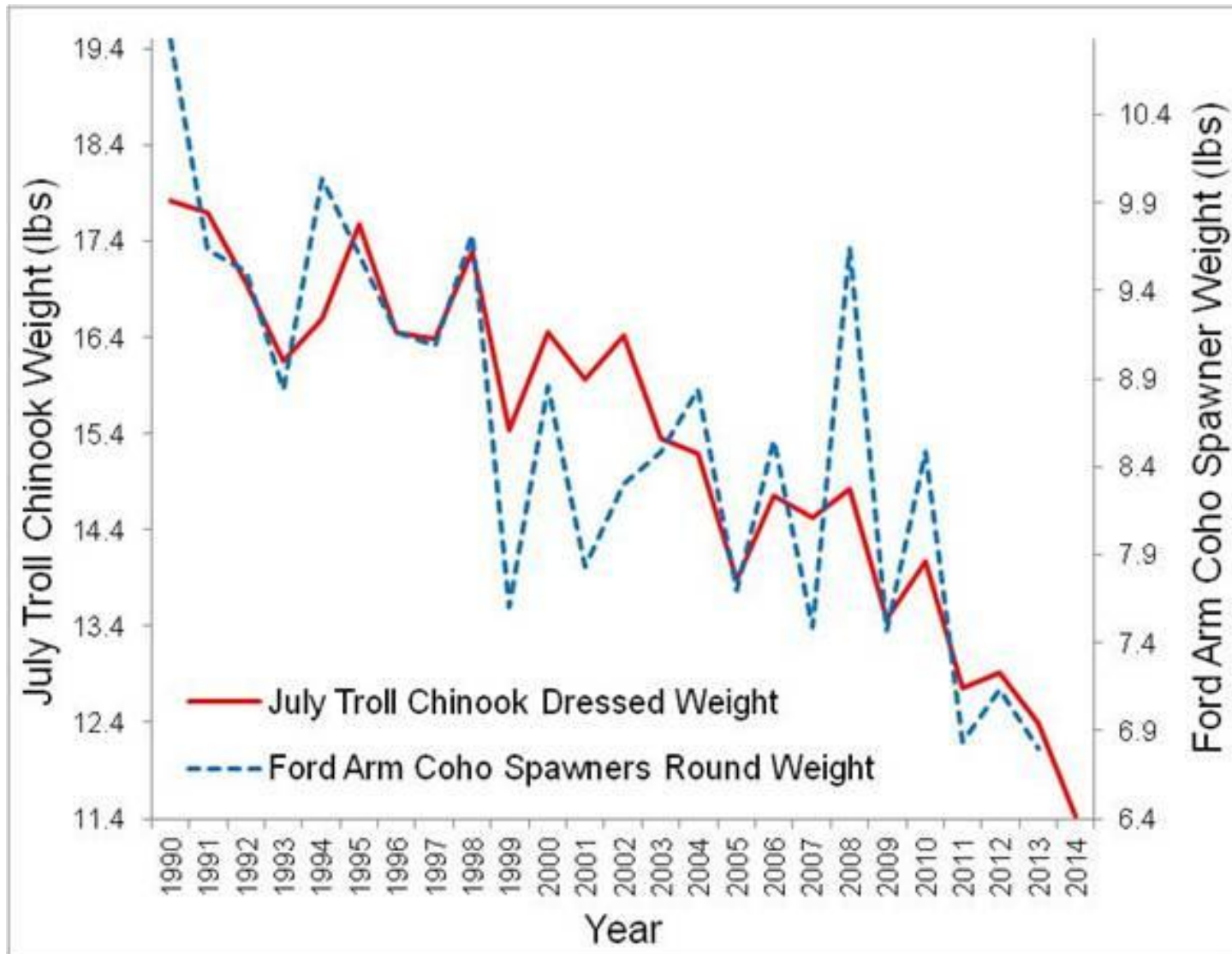
- Warming has spread into the Bering Sea, western GOA and Oyashio
- Cooling in the California Current
- Cooling off the coast of S. Peru

Gulf of Alaska normalized SST anomalies (160W–130W, 30–50N)



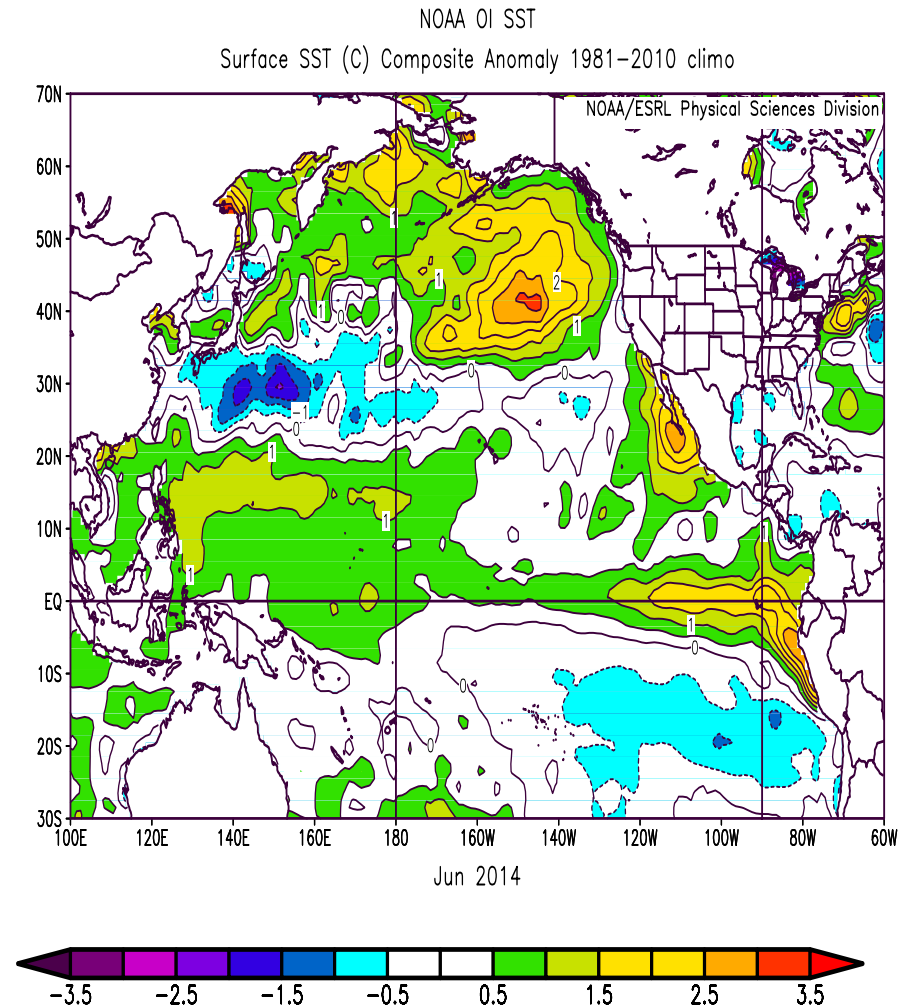
Courtesy of Nate Mantua, NMFS-Southwest Fisheries Science Center; Santa Cruz

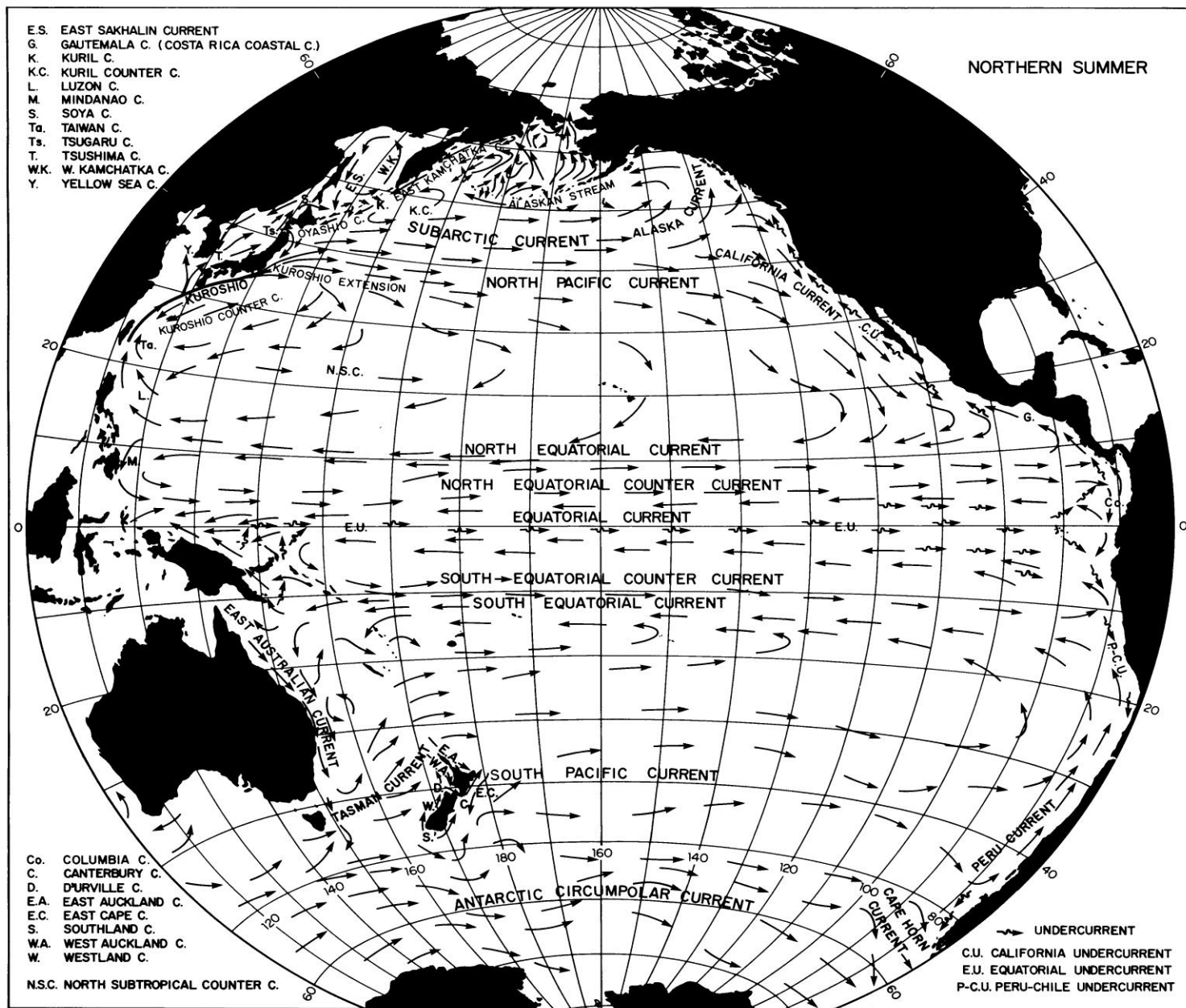
Southeast Alaska Chinook salmon weight (ADFG, unpubl. data)



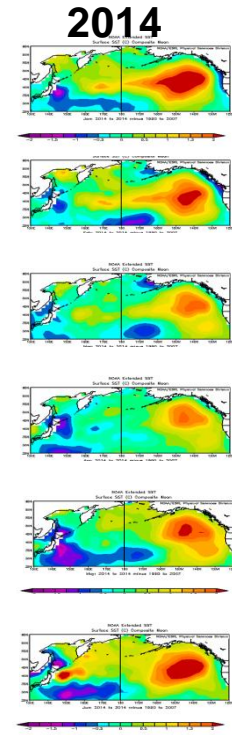
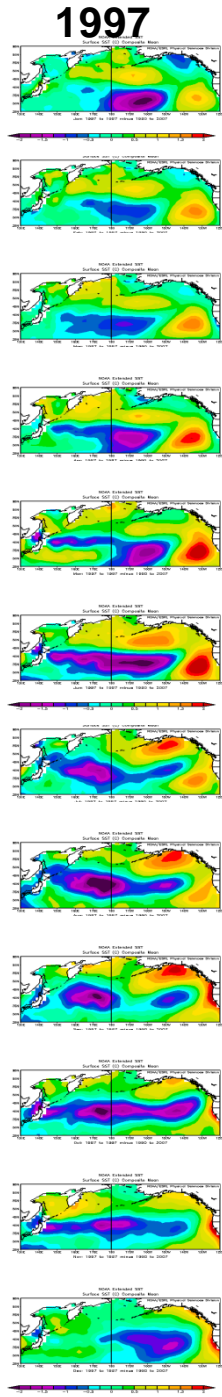
An unusual situation

- Northeast Pacific warmed before the Eastern Tropical Pacific warmed in May 2014
 - Gulf of Alaska has been extremely warm for the past year
 - Baja and S. California nearshore has been warm since January
 - PDO is now in its positive (warm) phase.





Jan
Feb
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Dec



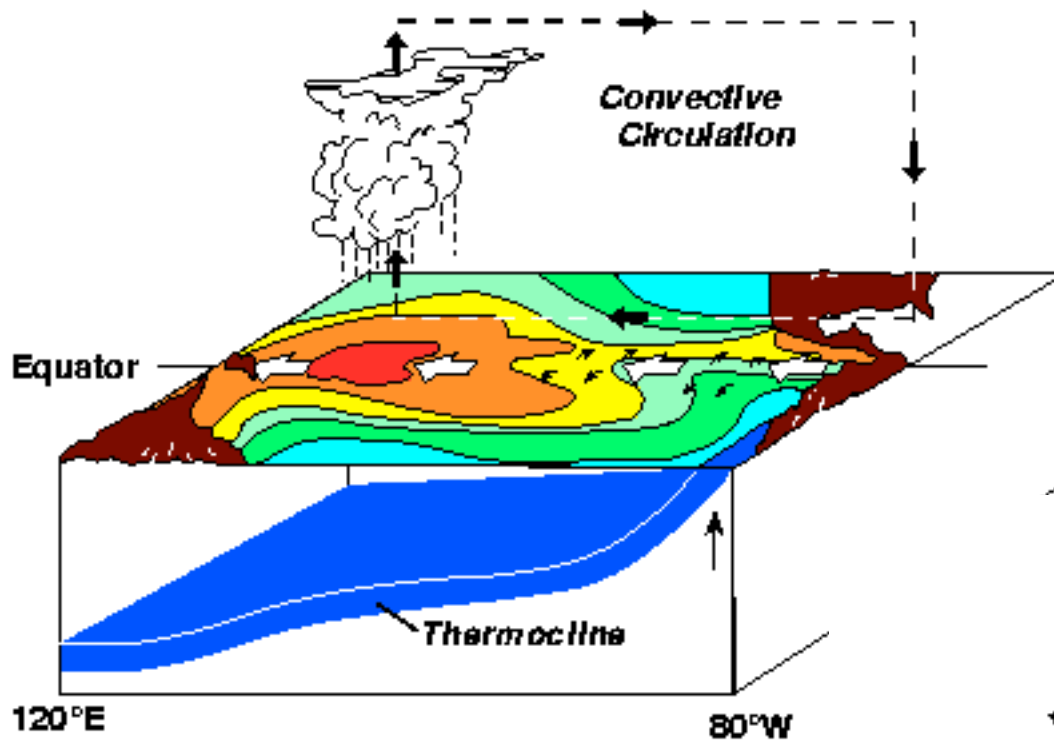
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El Niño 2014?

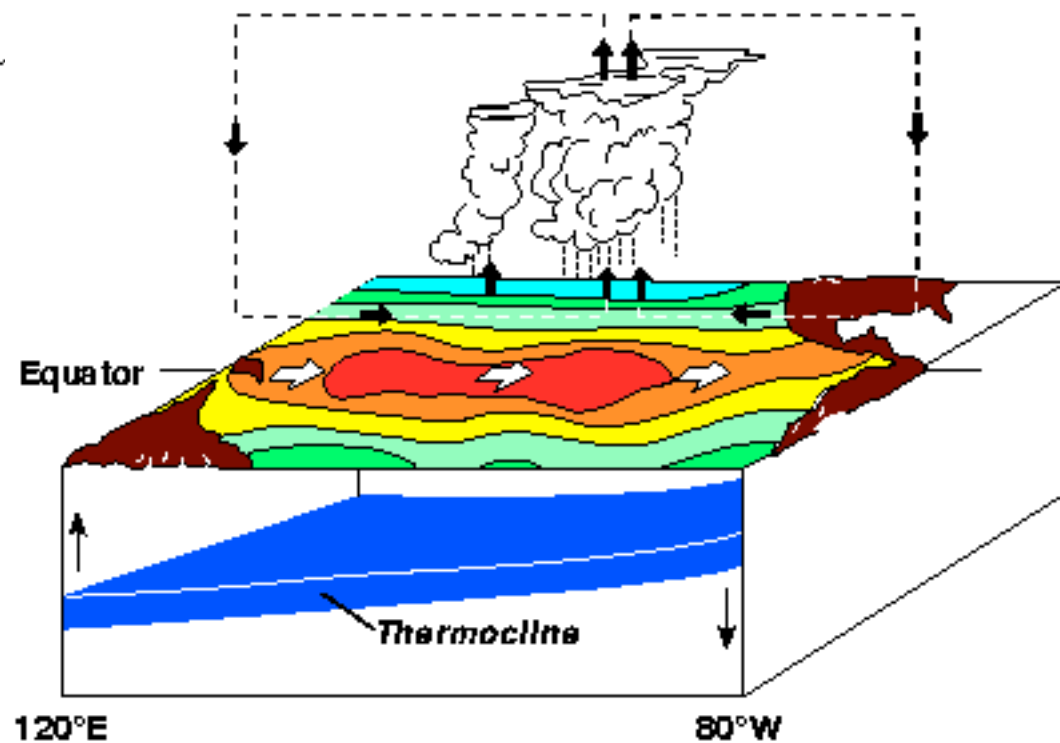
Philip Mote
Oregon Climate Change Research Institute/
Oregon Climate Services
Oregon State University
occri.net



Normal Conditions

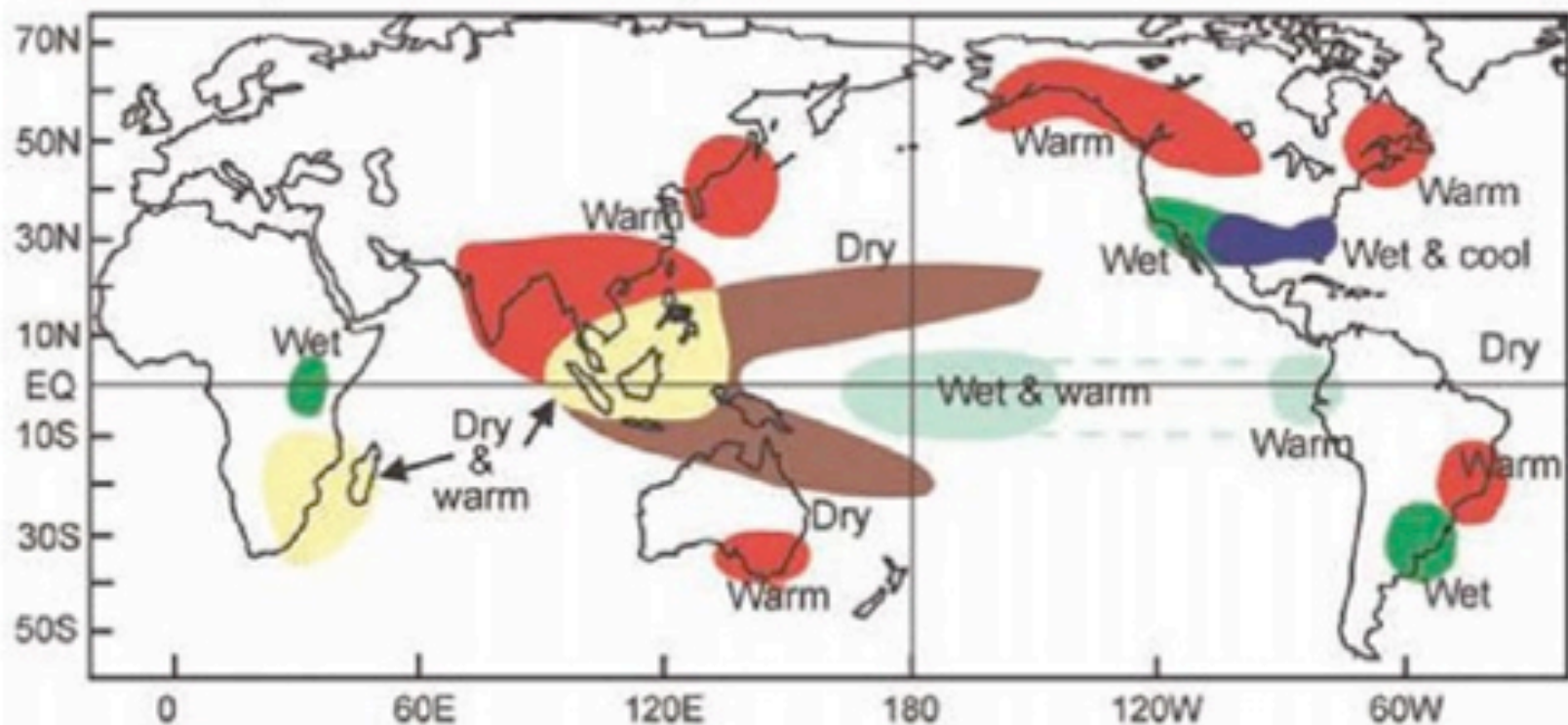


El Niño Conditions

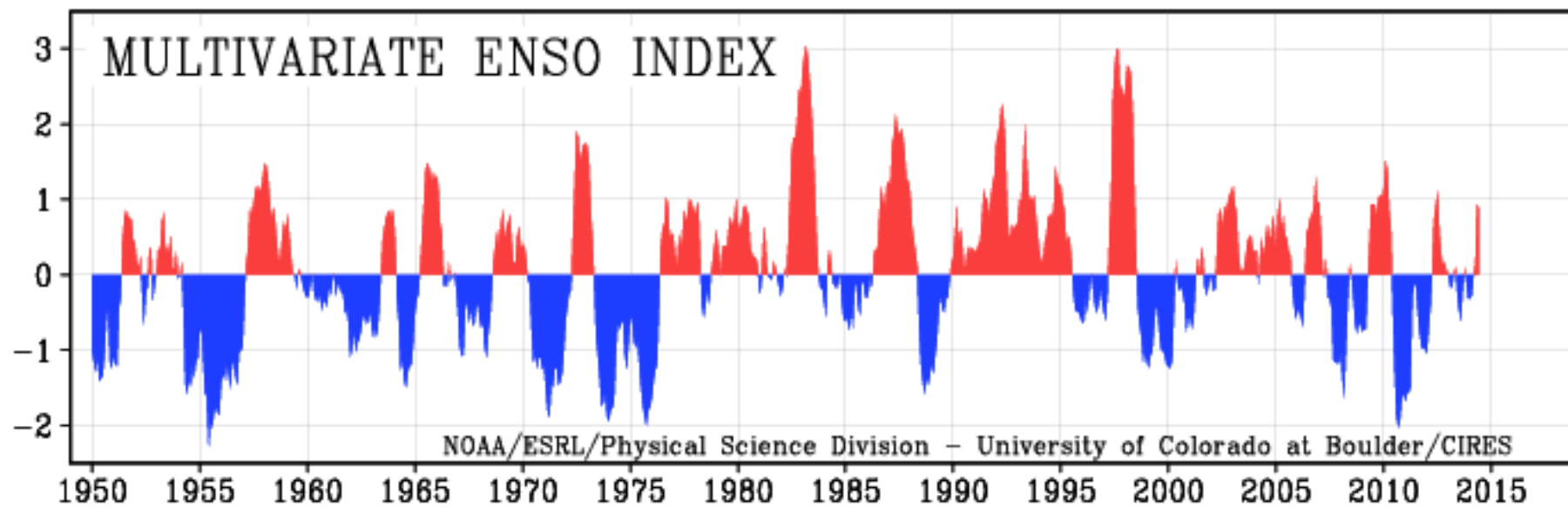


Warm episode relationship

December-February



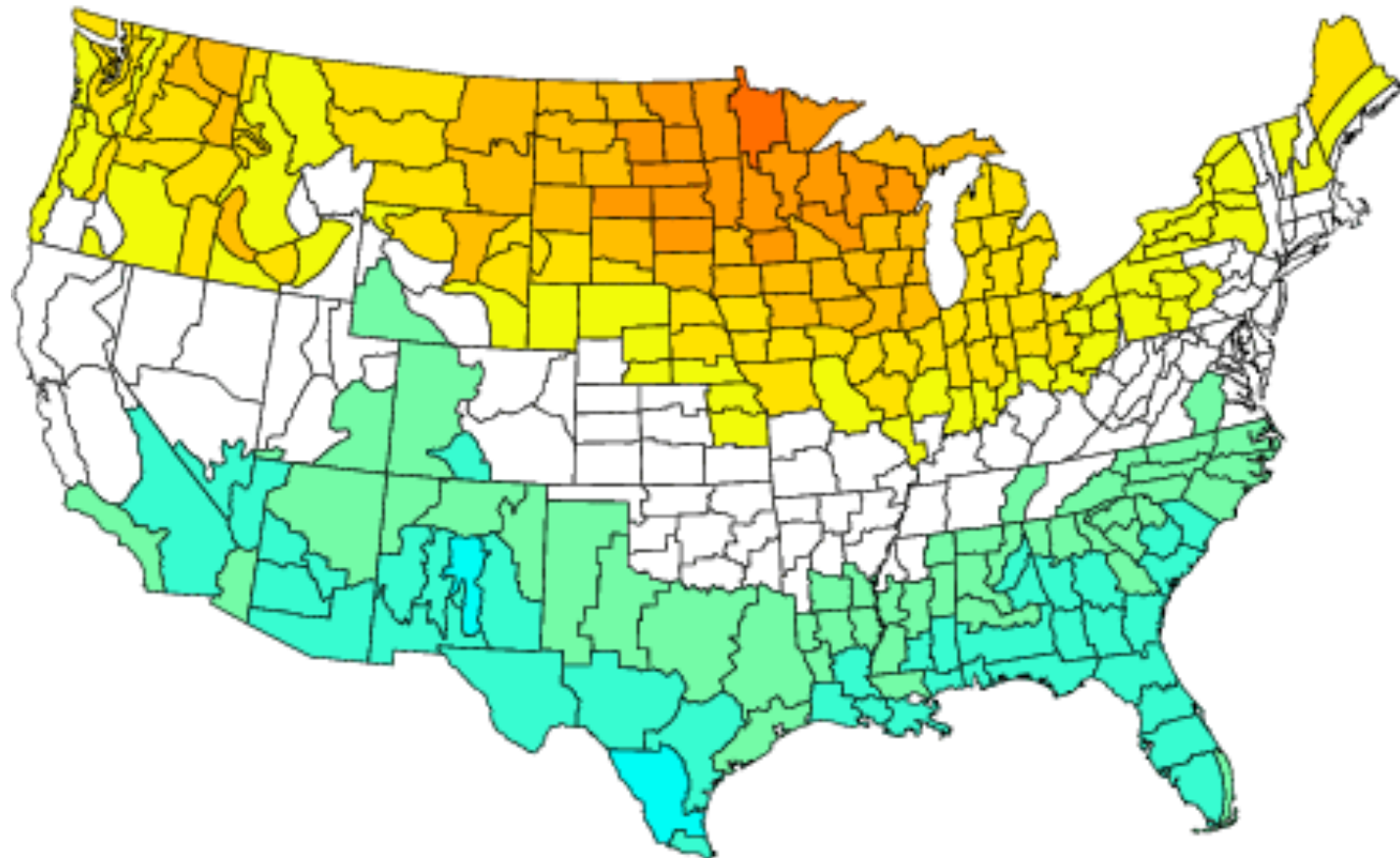
Standardized Departure



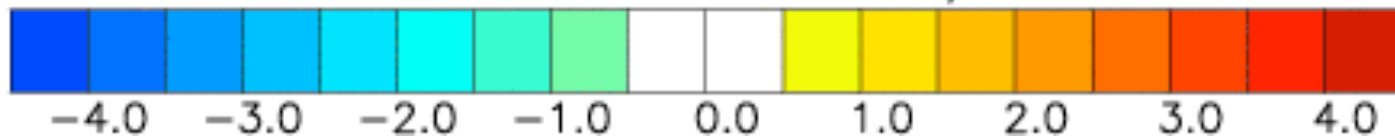
El Niño Nov-Mar average

Composite Temperature Anomalies (F)
Versus 1971–2000 Longterm Average

Nov to Mar 1982–83, 1972–73, 1957–58, 1965–66, 1986–87, 1991–92, 1968–69, 1997–98
2002–03,



NOAA/ESRL PSD and CIRES–CDC

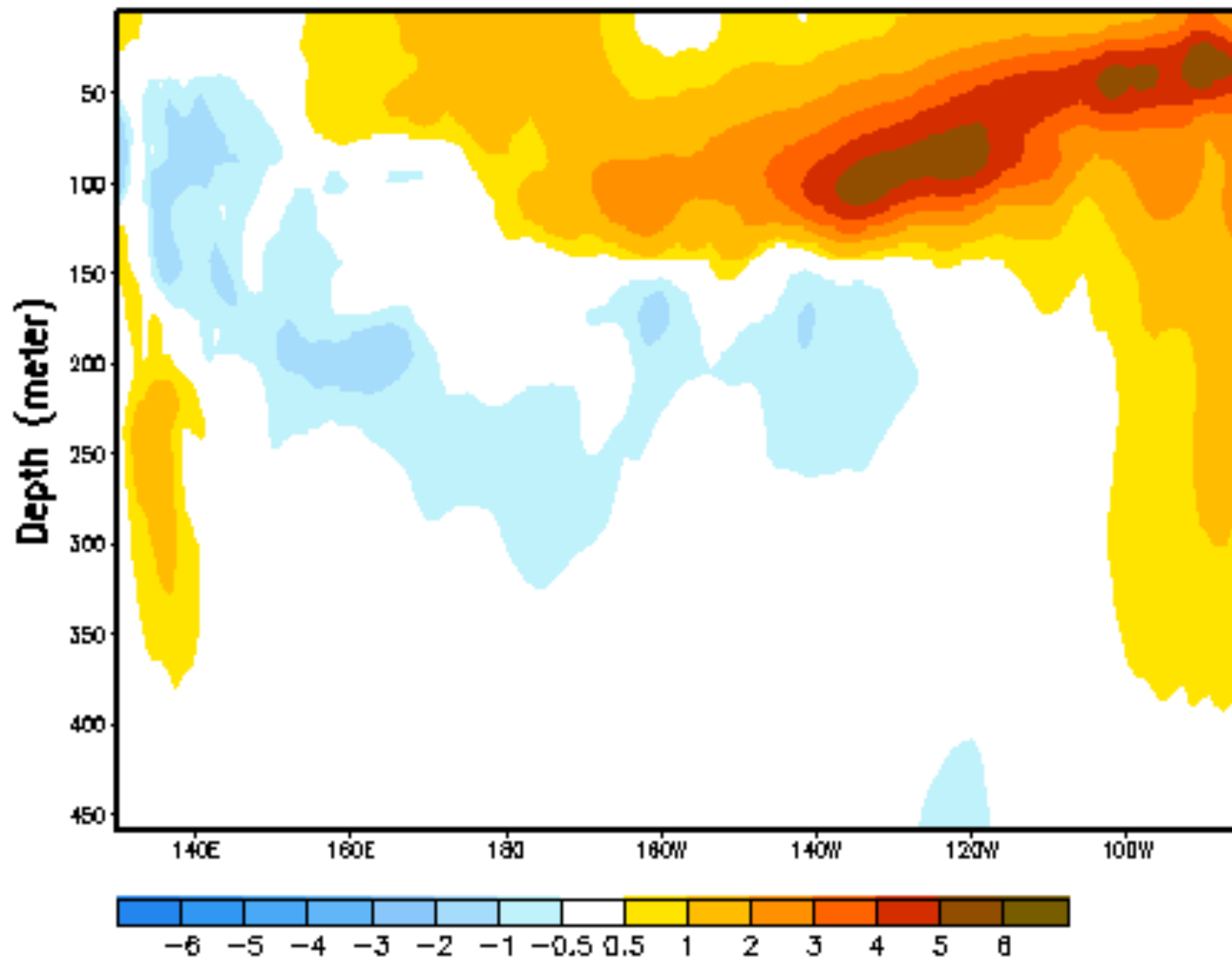


Current Sea Surface Temperatures

SST Anomalies - Tropical Pacific

Equatorial Temperature Anomaly (°C)

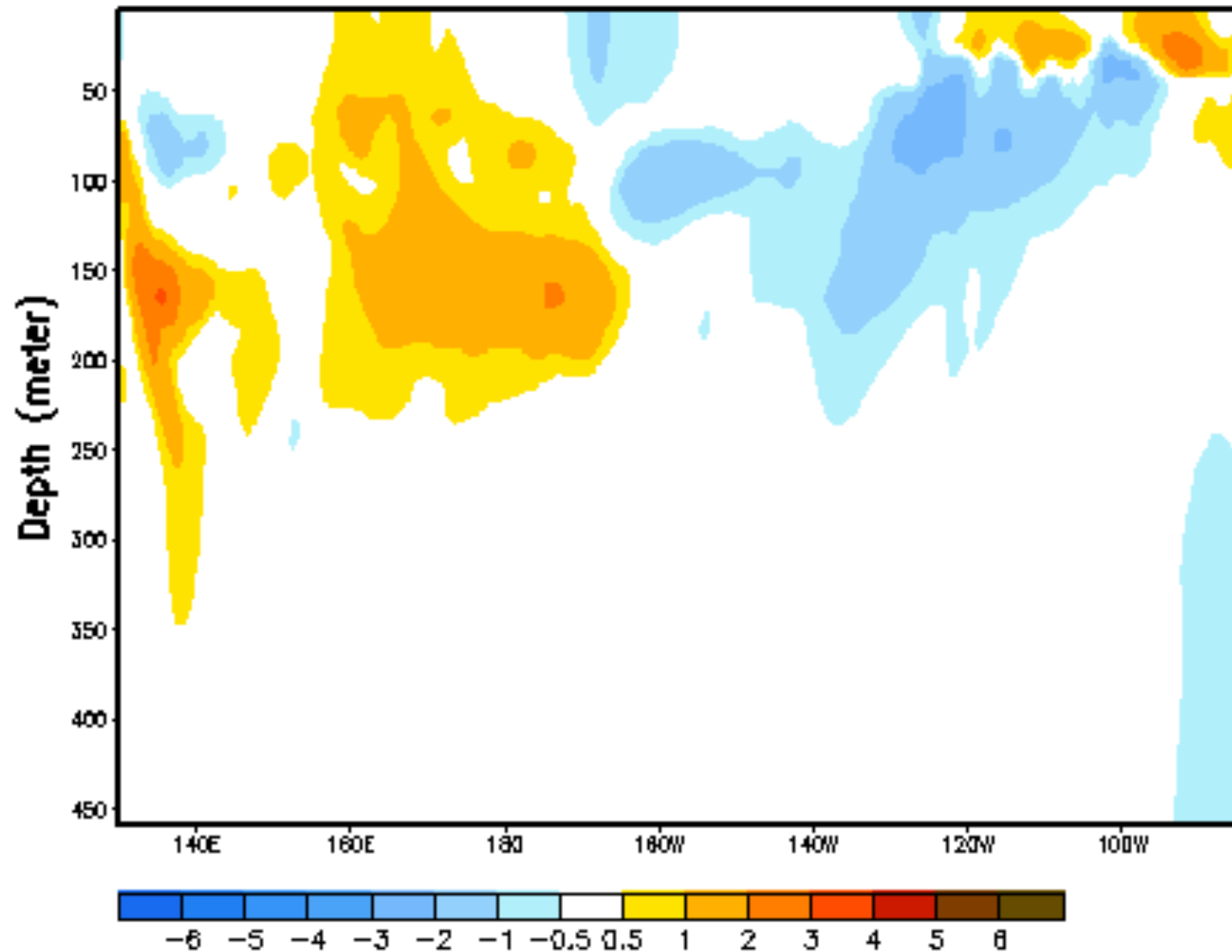
Pentad centered on 28 MAY 2014



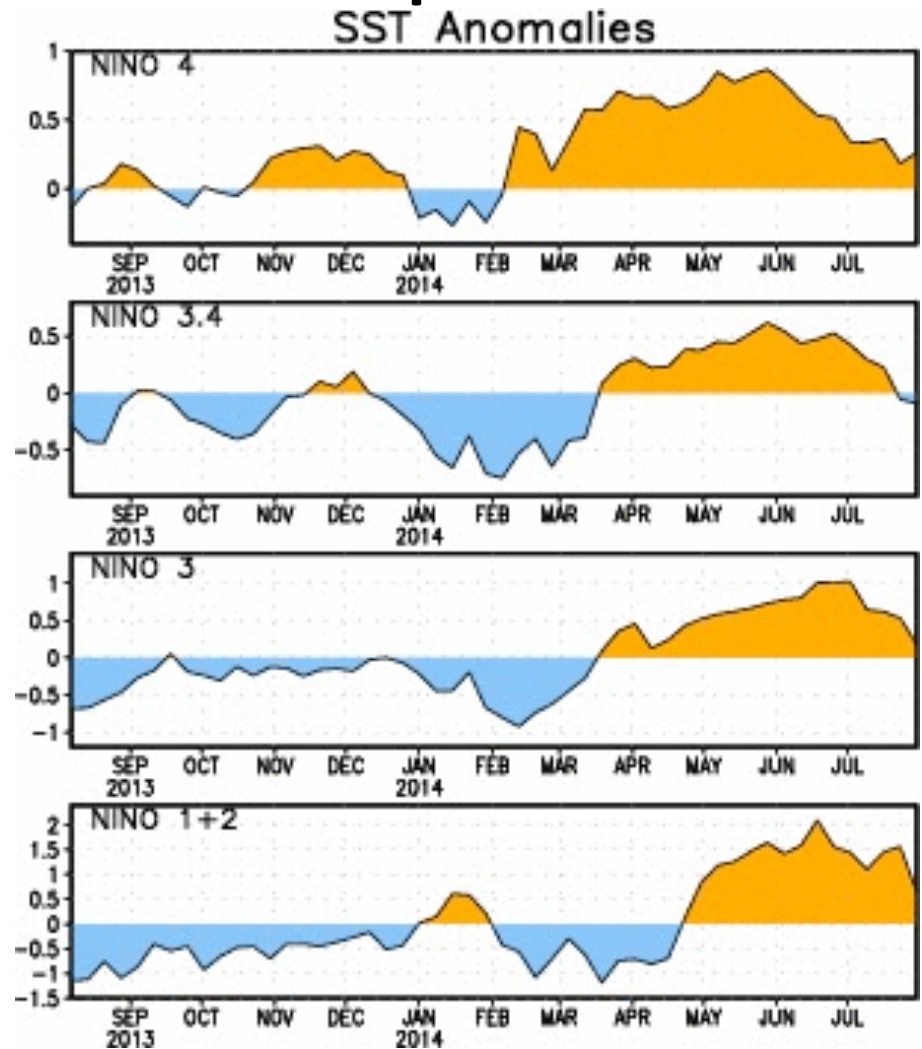
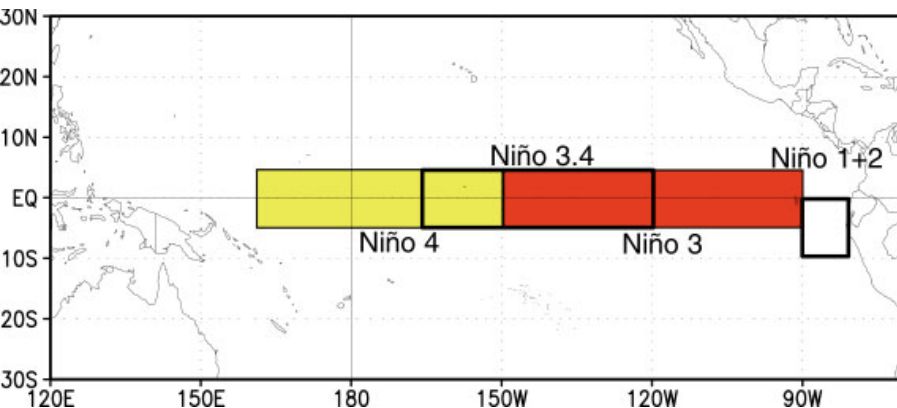
<http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/enso.shtml>

Equatorial Temperature Anomaly ($^{\circ}\text{C}$)

Pentad centered on 27 JUL 2014

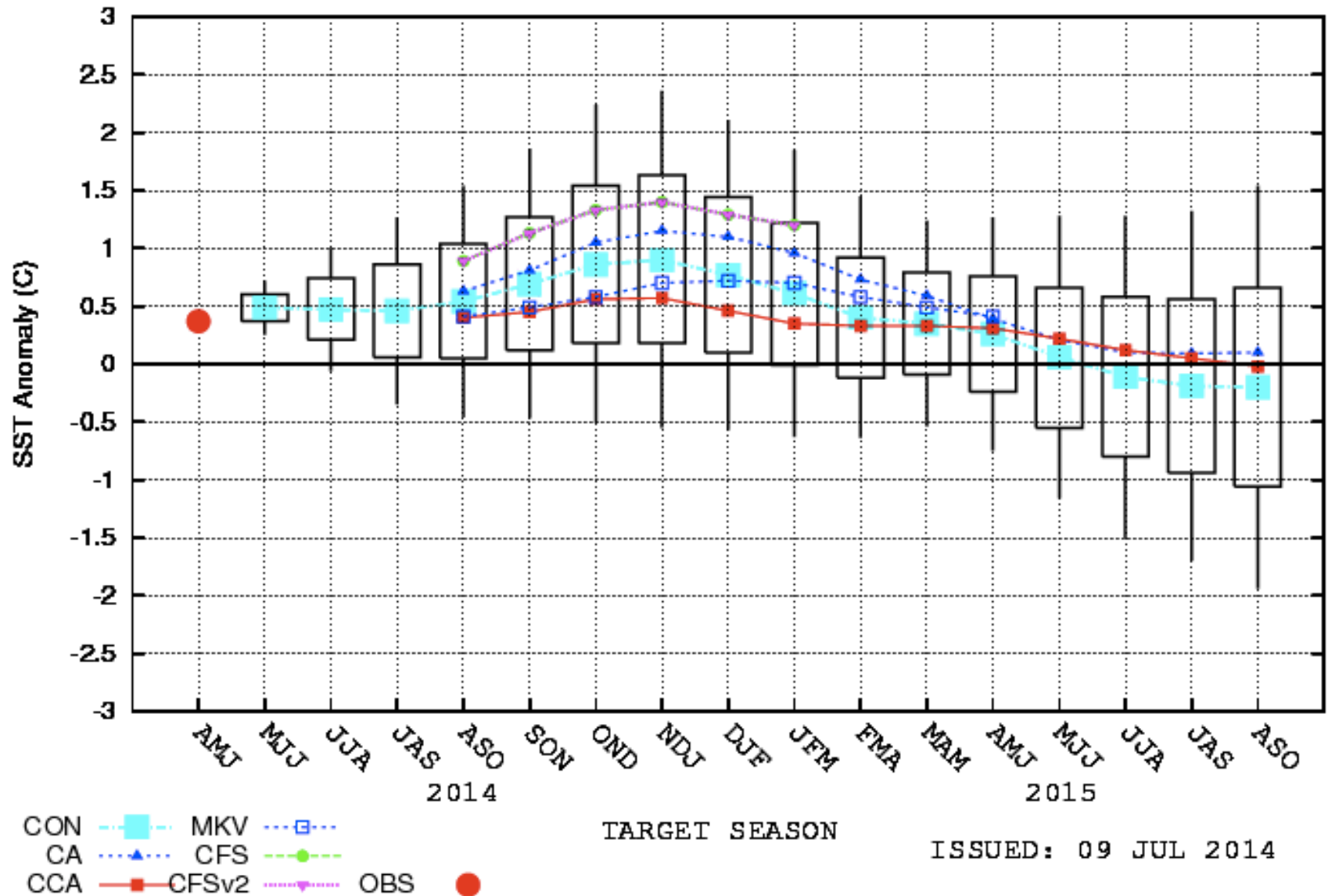


Current Sea Surface Temperatures



Forecast SSTs

SST CONSOLIDATION NINO 3.4



ISSUED: 09 JUL 2014

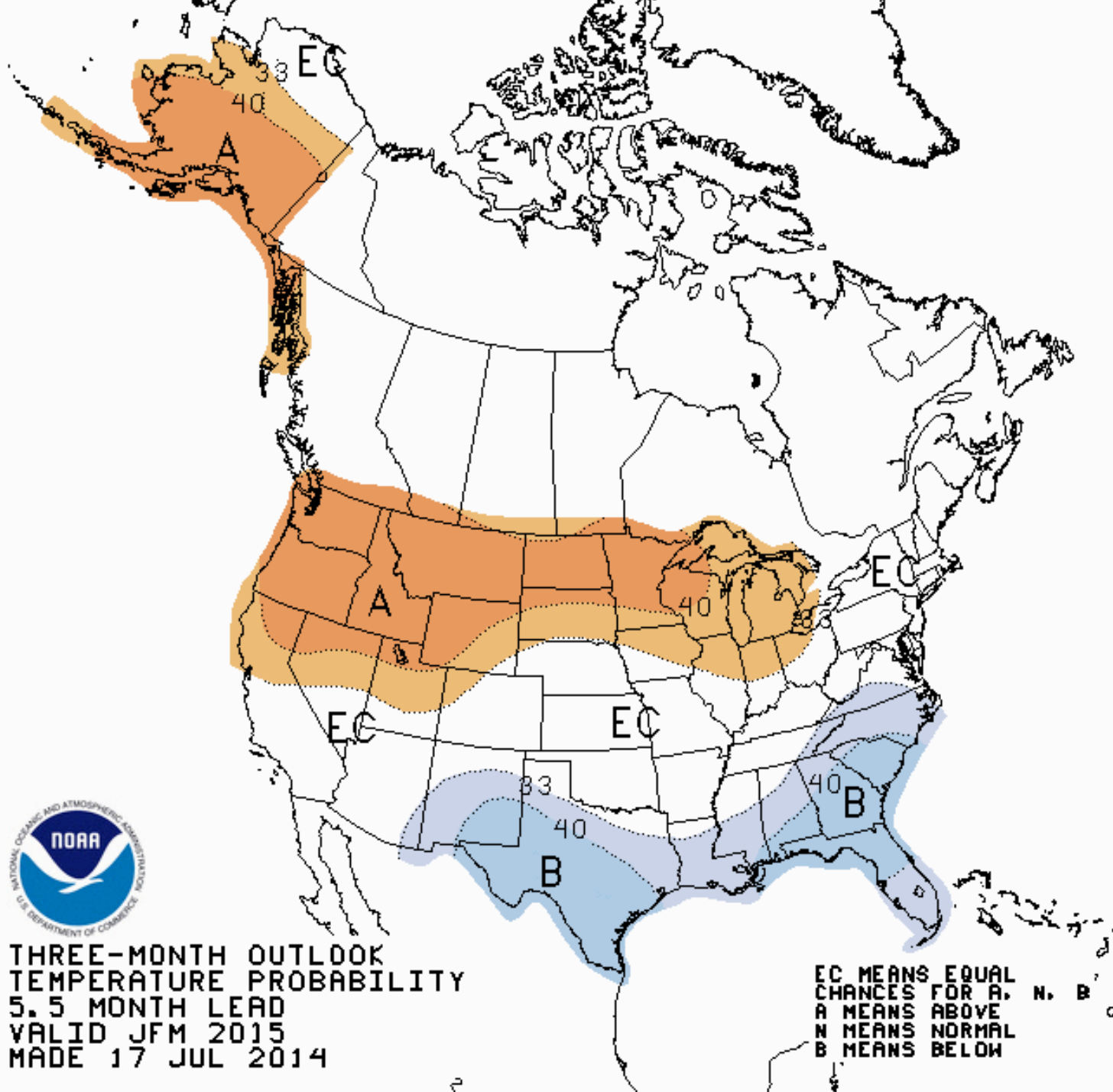
Source: NOAA/CPC

EL NIÑO/SOUTHERN OSCILLATION (ENSO) DIAGNOSTIC DISCUSSION

issued by
CLIMATE PREDICTION CENTER/NCEP/NWS
and the International Research Institute for Climate and Society
10 July 2014

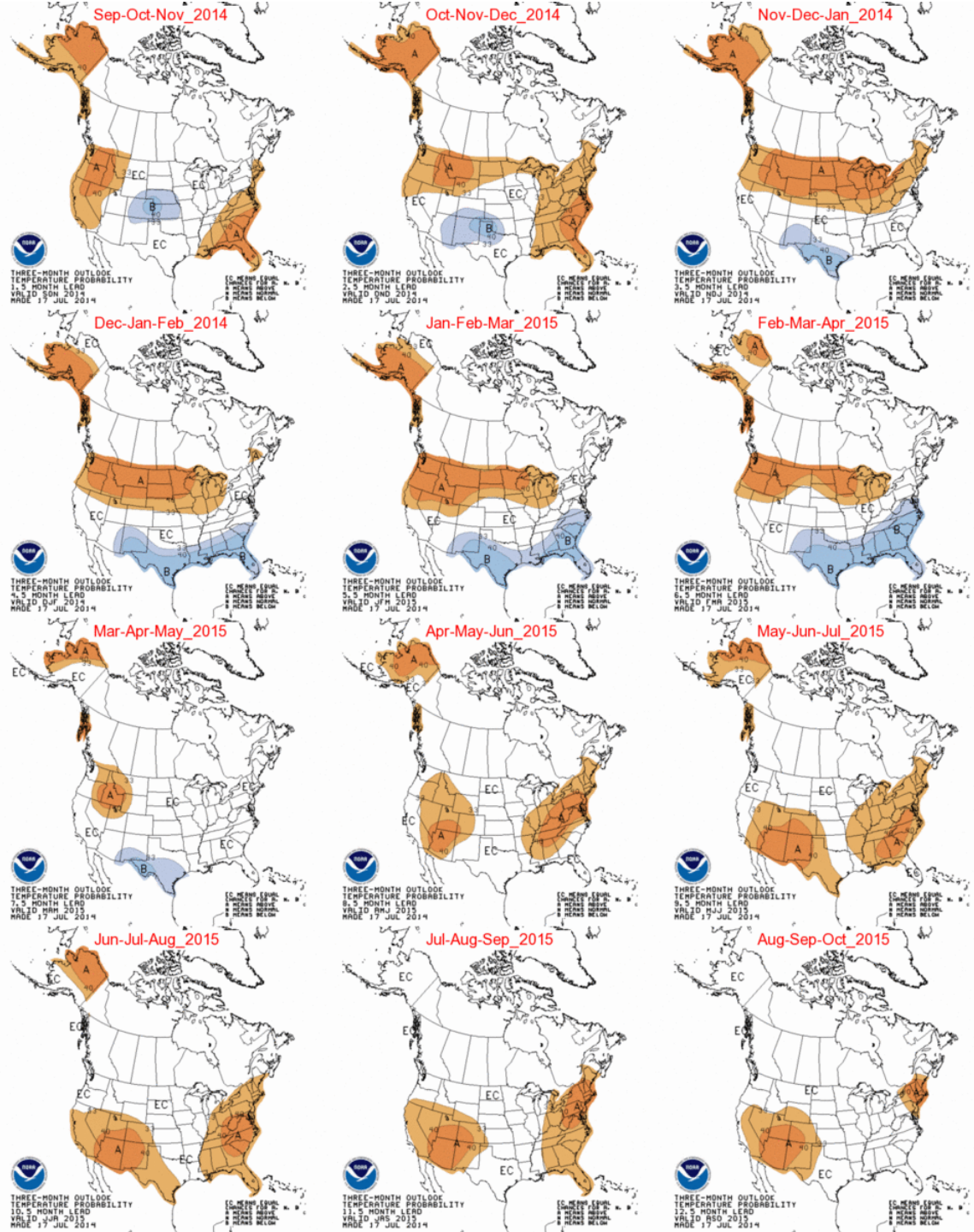
ENSO Alert System Status: [El Niño Watch](#)

Synopsis: **The chance of El Niño is about 70% during the Northern Hemisphere summer and is close to 80% during the fall and early winter.**



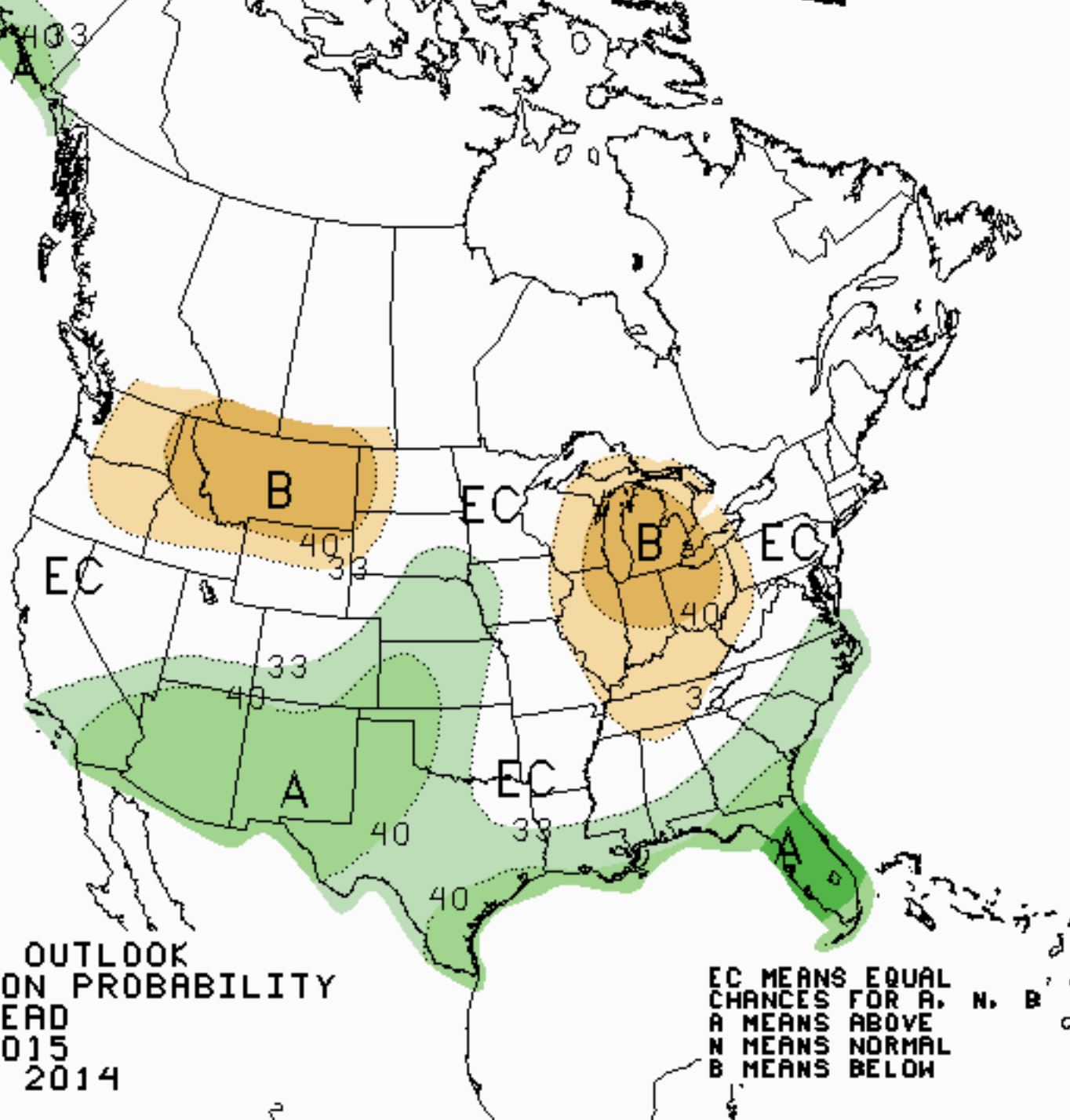
THREE-MONTH OUTLOOK
TEMPERATURE PROBABILITY
5.5 MONTH LEAD
VALID JFM 2015
MADE 17 JUL 2014

US Forecasts



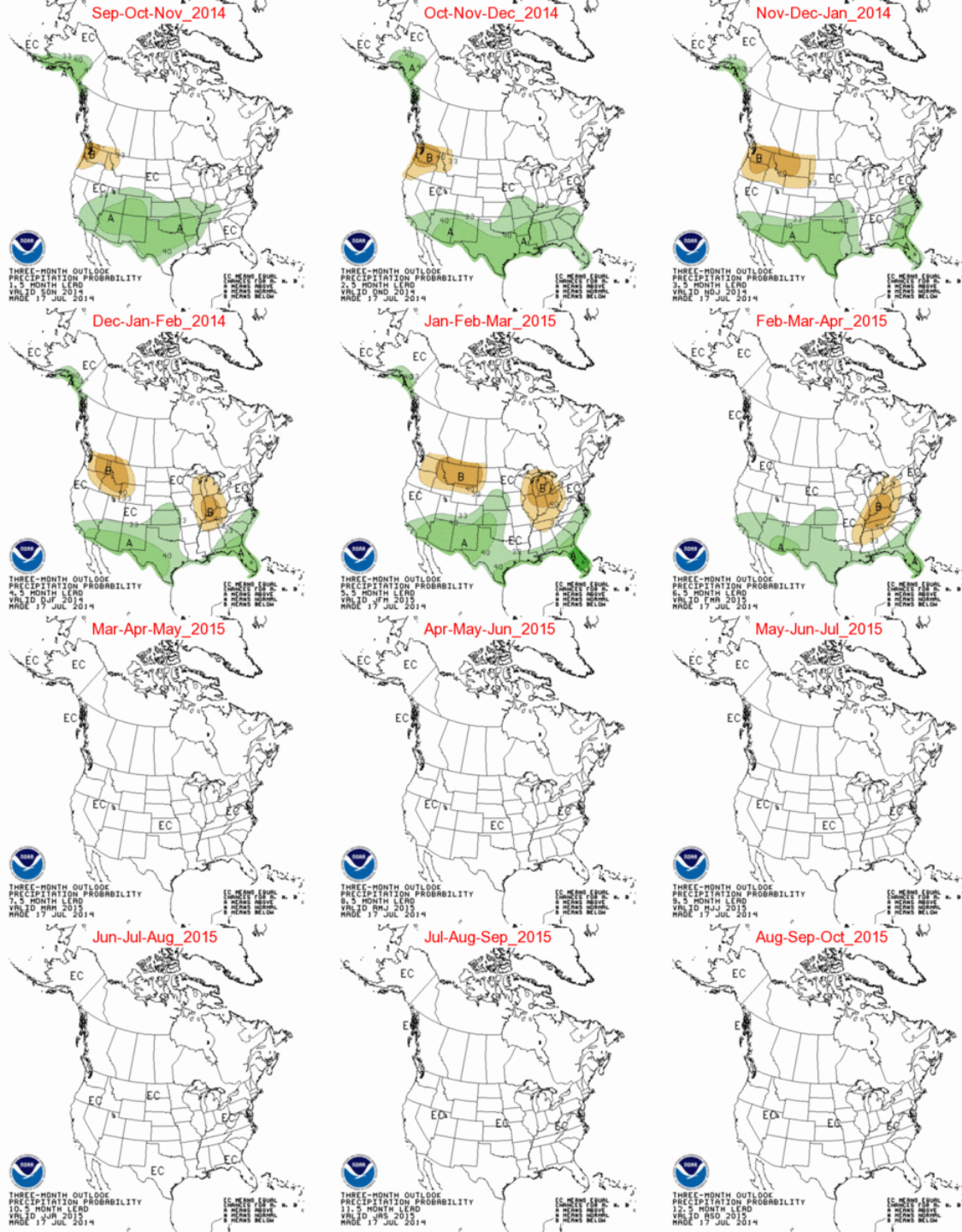


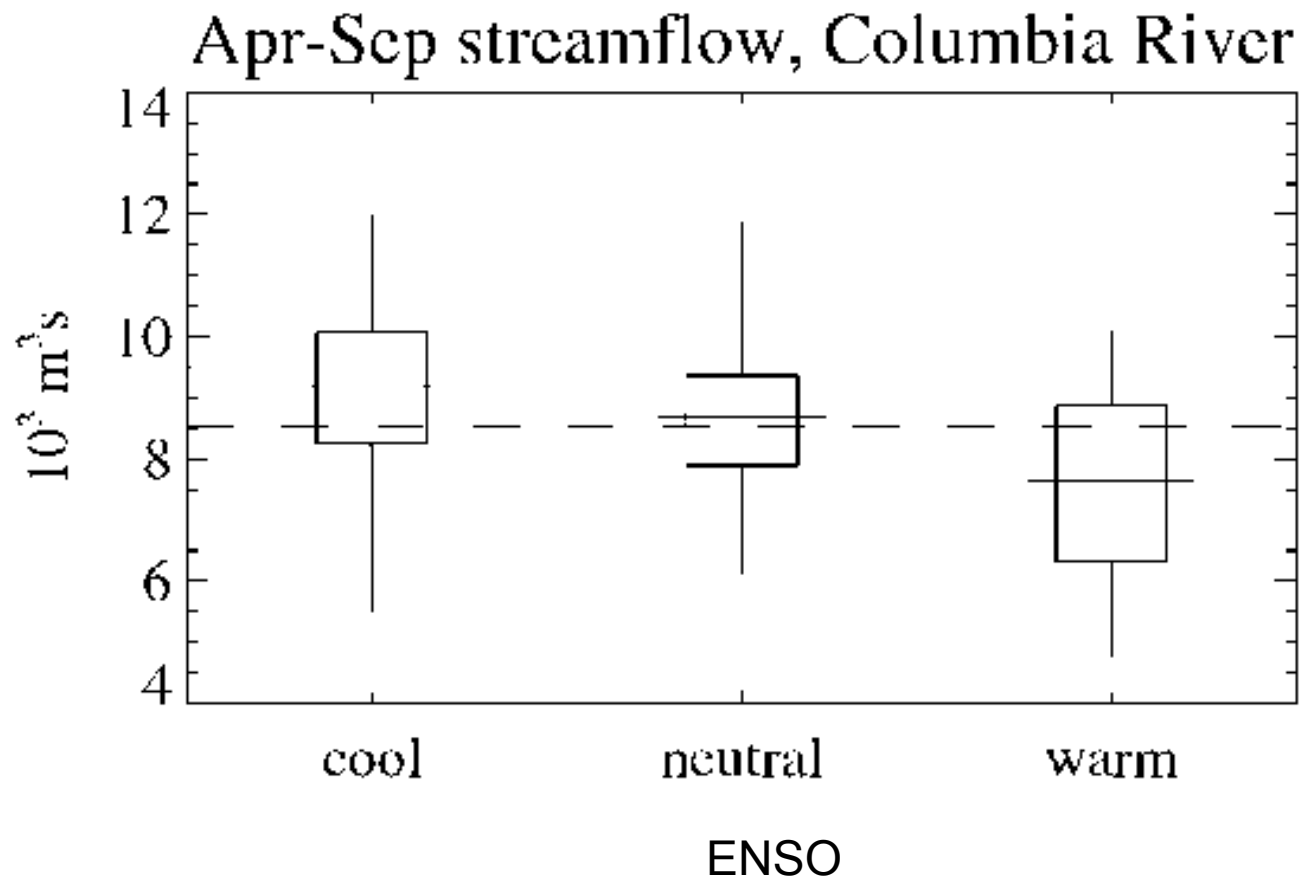
THREE-MONTH OUTLOOK
PRECIPITATION PROBABILITY
5.5 MONTH LEAD
VALID JFM 2015
MADE 17 JUL 2014



EC MEANS EQUAL
CHANCES FOR A, N, B
A MEANS ABOVE
N MEANS NORMAL
B MEANS BELOW

IIS Forecasts



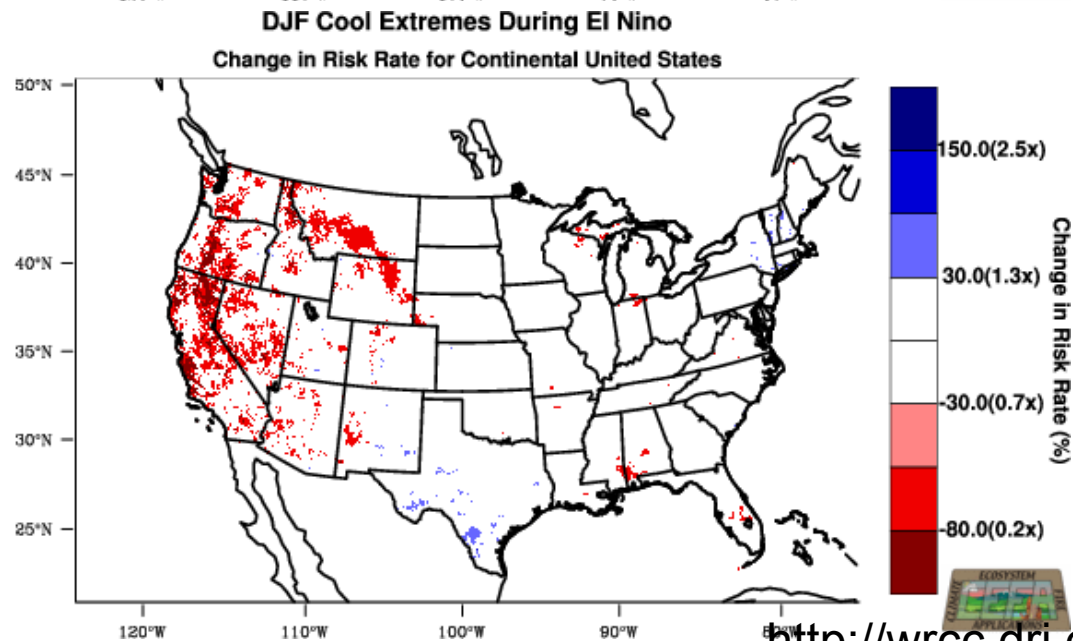
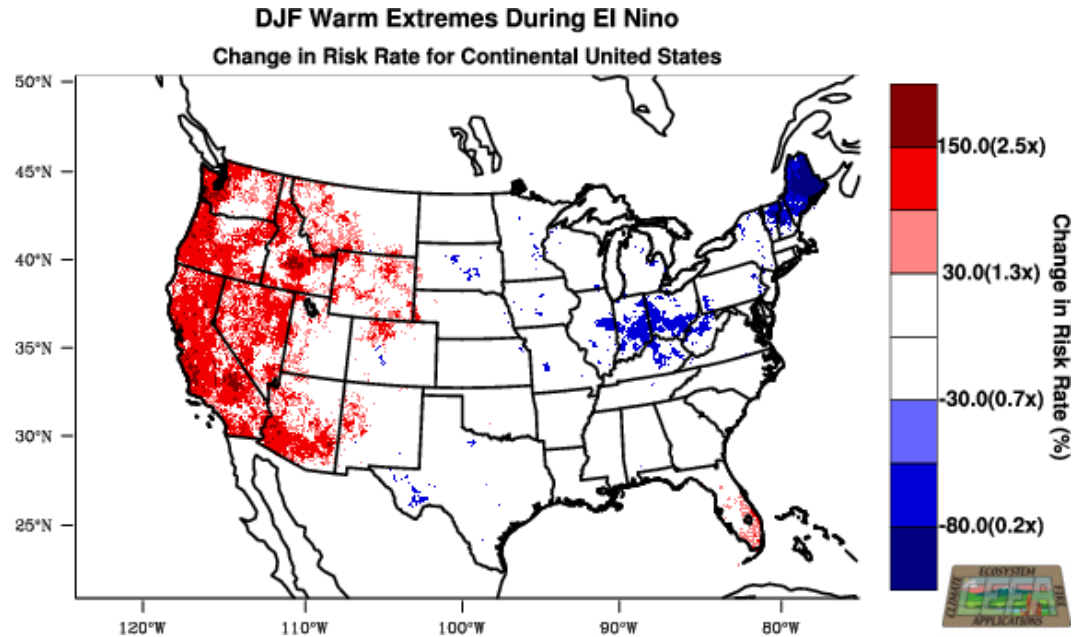


Mote et al. 2003

Summary

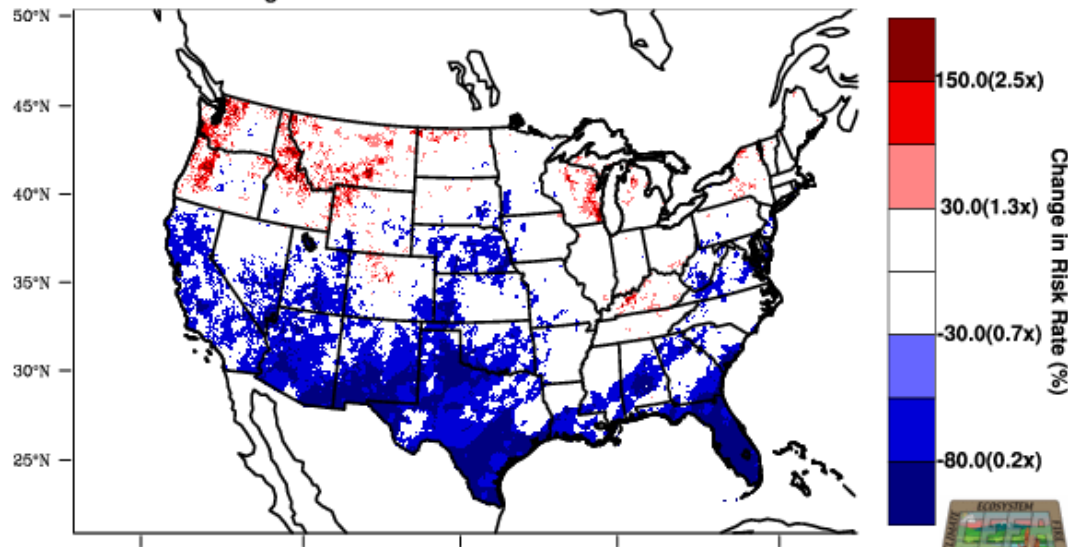
- NOAA forecasts a 70% chance of a (weak) El Niño next fall/winter
- Increases the odds for a warm/dry winter, lower spring snowpack and summer streamflow
- There's some chance of 'nothing'

ENSO Risk of seasonal extremes



ENSO Risk

DJF Dry Extremes During El Nino
Change in Risk Rate for Continental United States



DJF Wet Extremes During El Nino
Change in Risk Rate for Continental United States

