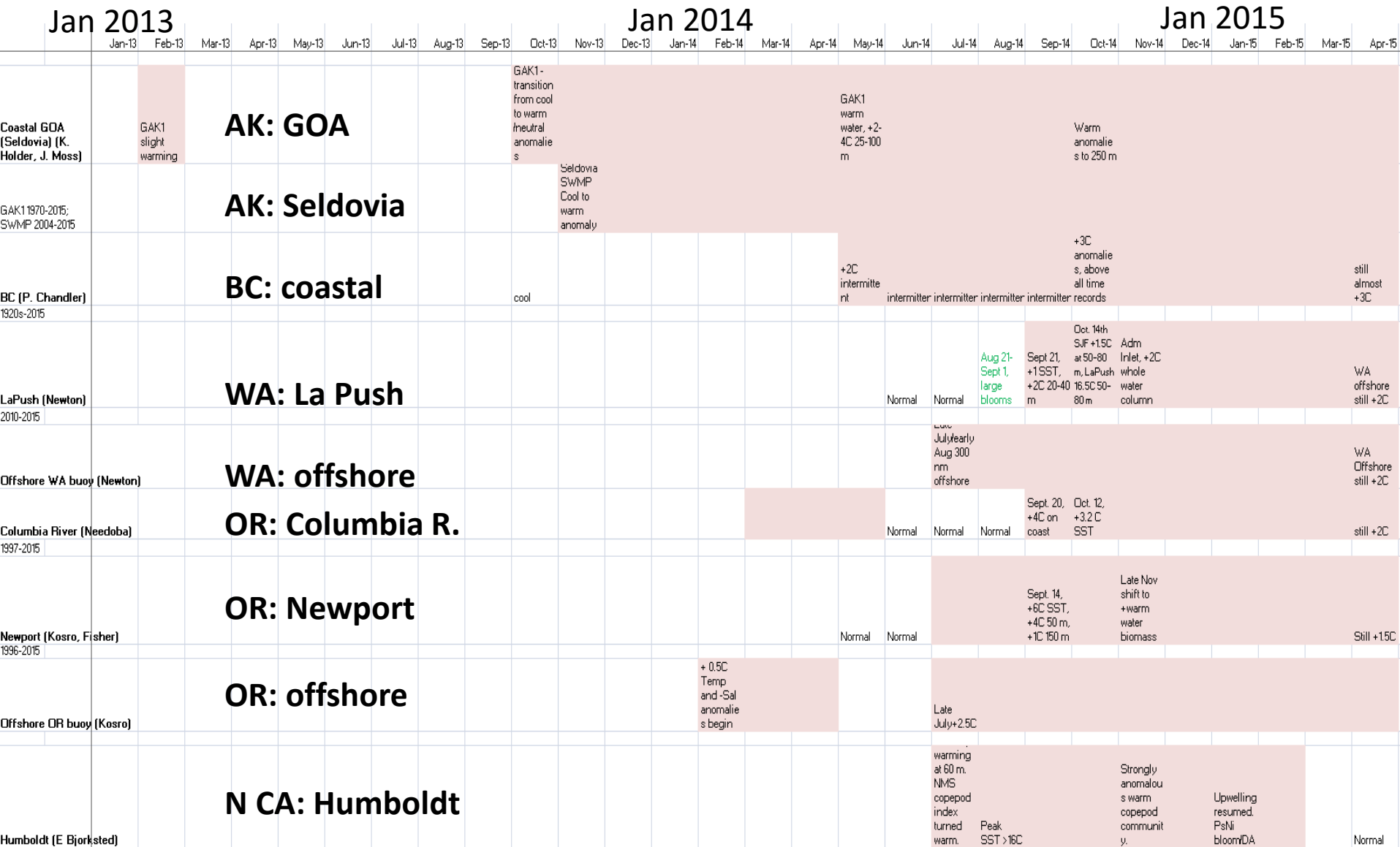
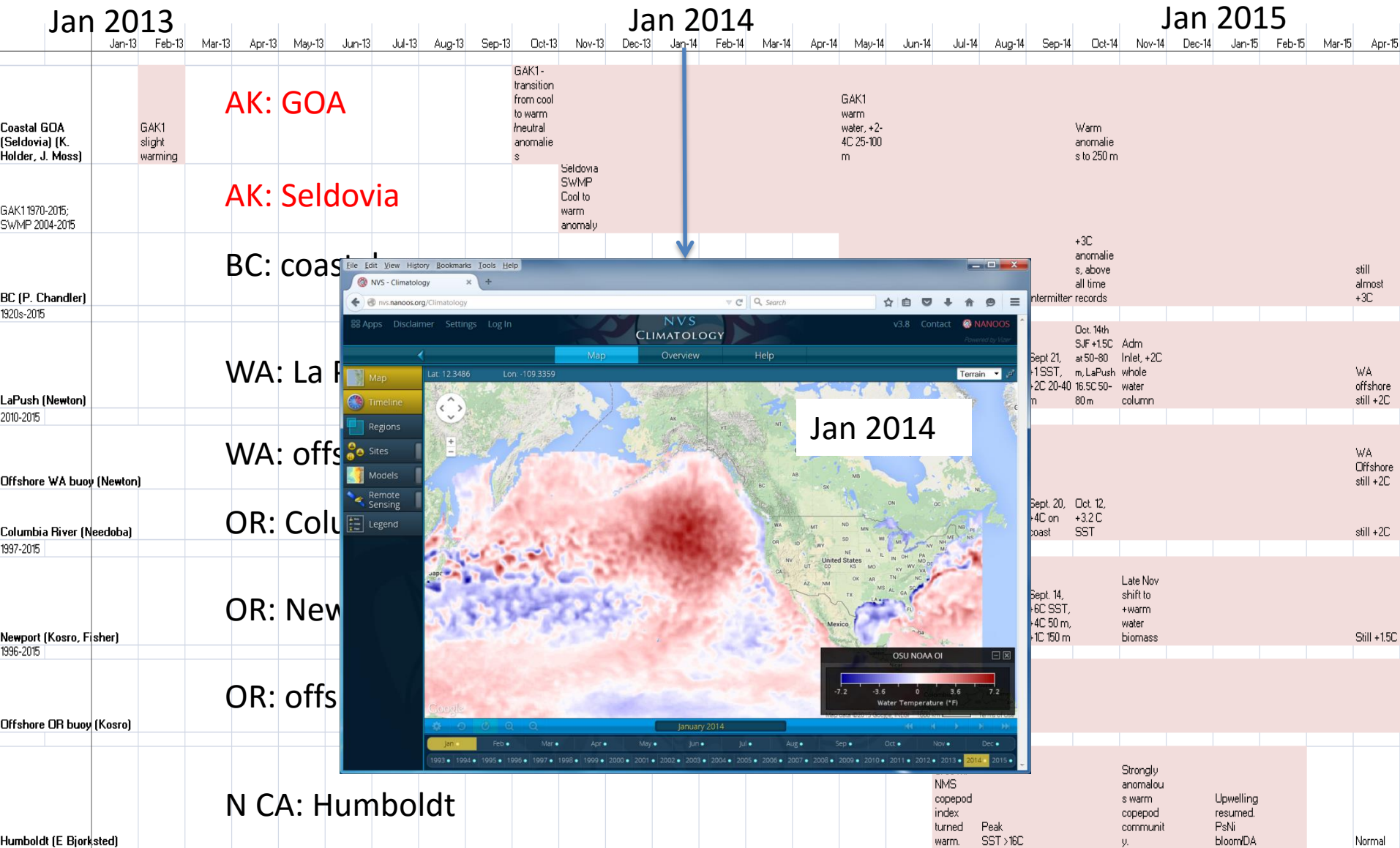


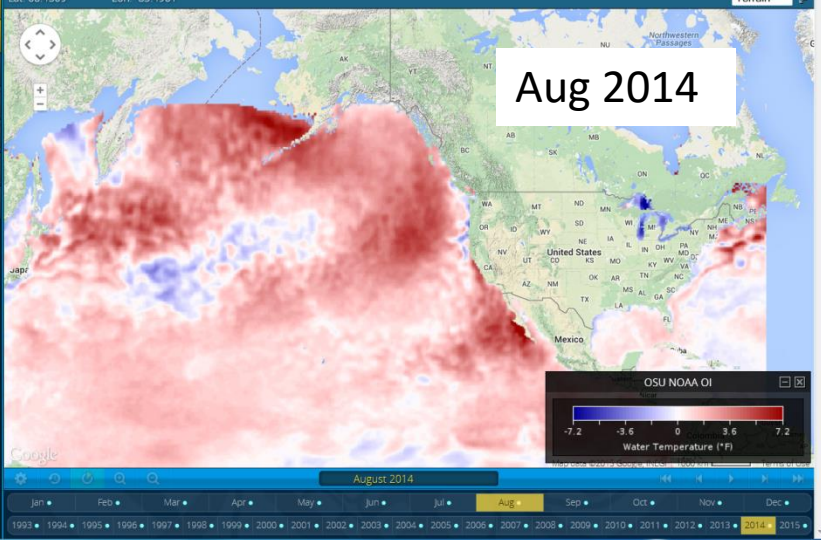
# Pacific Northwest

# PAW1: NE Pacific timeline



# Warm Temps: In GOA first, Fall 2013





# Then arrive PNW offshore during summer '14

Jan 2014

Jan 2015

Dec-13 Jan-14 Feb-14 Mar-14 Apr-14 May-14 Jun-14 Jul-14 Aug-14 Sep-14 Oct-14 Nov-14 Dec-14 Jan-15 Feb-15 Mar-15 Apr-15

Location	Dec-13	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	
<b>BC: coastal</b> BC (P. Chandler) 1920s-2015									cool									
<b>WA: La Push</b> LaPush (Newton) 2010-2015																		
<b>WA: offshore</b> Offshore WA buoy (Newton)																		
<b>OR: Columbia R.</b> Columbia River (Needoba) 1997-2015																		
<b>OR: Newport</b> Newport (Kosro, Fisher) 1996-2015																		
<b>OR: offshore</b> Offshore OR buoy (Kosro)																		
<b>N CA: Humboldt</b> Humboldt (E Bjorksted)																		

GAK1 warm water, +2-4C 25-100 m

Warm anomalies to 250 m

+2C intermittent

+3C anomalies, above all time records

still almost +3C

Normal

Normal

Late July/early Aug 300 nm offshore

Oct. 14th SJF +1.5C at 50-80 m, LaPush 16.5C 50-80 m

Adm Inlet, +2C whole water column

WA offshore still +2C

Normal

Normal

Normal

Sept. 20, +4C on coast

Oct. 12, +3.2 C SST

still +2C

Normal

Normal

Sept. 14, +6C SST, +4C 50 m, +1C 150 m

Late Nov shift to +warm water biomass

Still +1.5C

+0.5C Temp and -Sal anomalies begin

Late July +2.5C

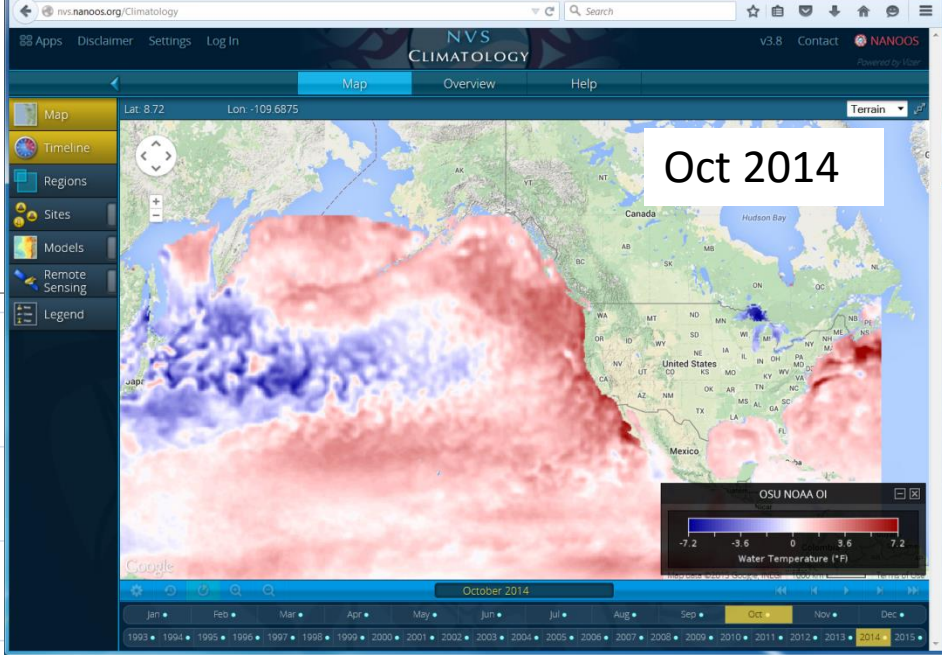
warming at 60 m. NIMS copepod index turned warm.

Peak SST >16C

Strongly anomalous warm copepod community.

Upwelling resumed. PsNi bloom/DA

Normal



# Then come inshore fall '14

Jan 2013  
Jan-13 Feb-13

Coastal GOA (Seldovia) (K. Holder, J. Moss)  
GAK1 slight warming

GAK1 1970-2015; SWMP 2004-2015

BC (P. Chandler) 1920s-2015

WA: La Push

LaPush (Newton) 2010-2015

WA: offshore

Offshore WA buoy (Newton)

OR: Columbia R.

Columbia River (Needoba) 1997-2015

OR: Newport

Newport (Kosro, Fisher) 1996-2015

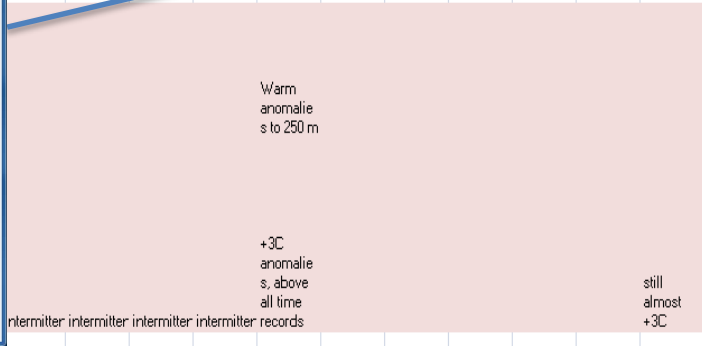
OR: offshore

Offshore OR buoy (Kosro)

N CA: Humboldt

Humboldt (E Bjorksted)

Jun-14 Jul-14 Aug-14 Sep-14 Oct-14 Nov-14 Dec-14 Jan-15 Feb-15 Mar-15 Apr-15



Normal Normal  
 Aug 21- Sept 1, large blooms  
 Sept 21, +2C 20-40 m  
 Oct 14th SJJ +1.5C 50-80 m, LaPush whole water column  
 Adm Inlet, +2C  
 WA offshore still +2C

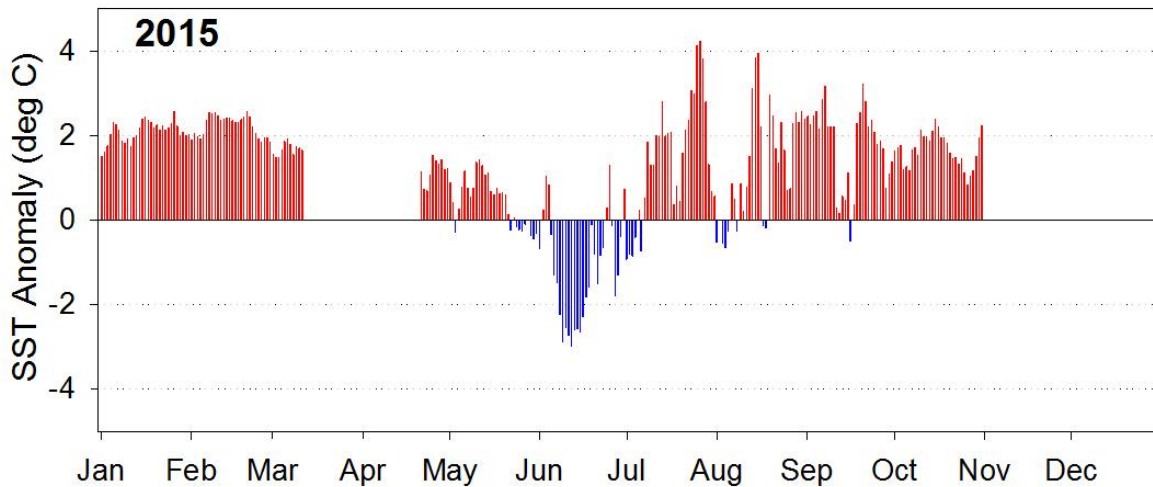
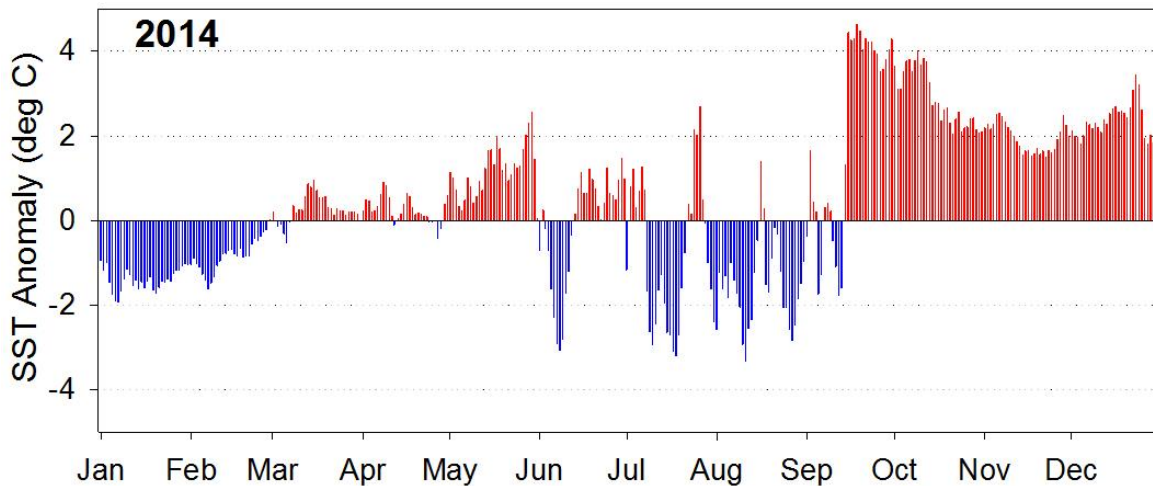
Low July/yearly Aug 300 nm offshore  
 Sept 20, +4C on coast  
 Oct 12, +3.2 C SST  
 WA Offshore still +2C

Normal Normal  
 Sept 14, +6C SST, +4C 50m, +1C 150 m  
 Late Nov shift to +warm water biomass  
 Still +1.5C

+ 0.5C Temp and -Sal anomalies begin  
 Late July +2.5C

warming at 60 m. NIMS copepod index turned warm. Peak SST >16C  
 Strongly anomalous warm copepod community.  
 Upwelling resumed. PsNi bloom/DA  
 Normal

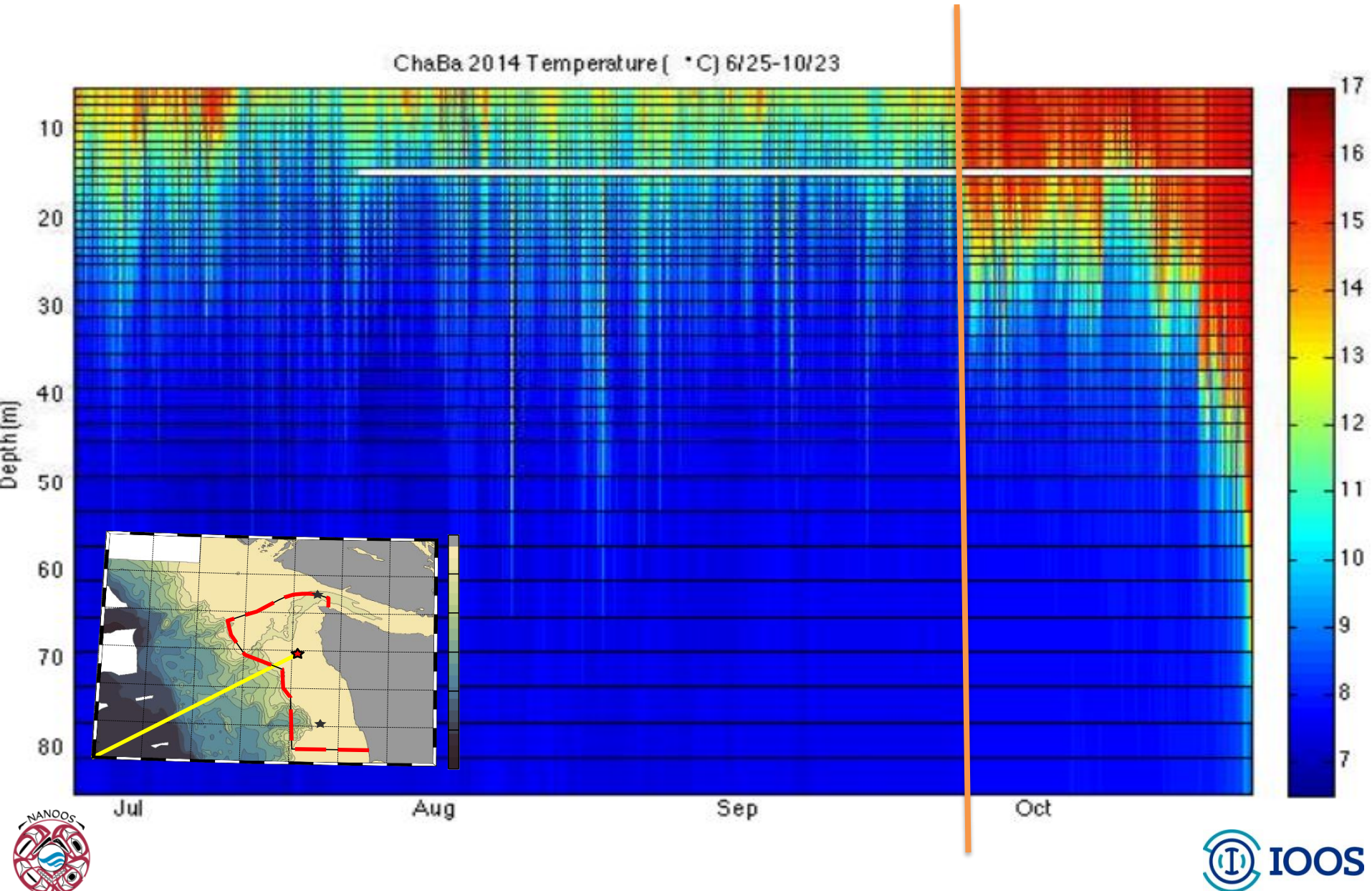
# SST at NOAA Buoy 46050 Stonewall Bank off Newport

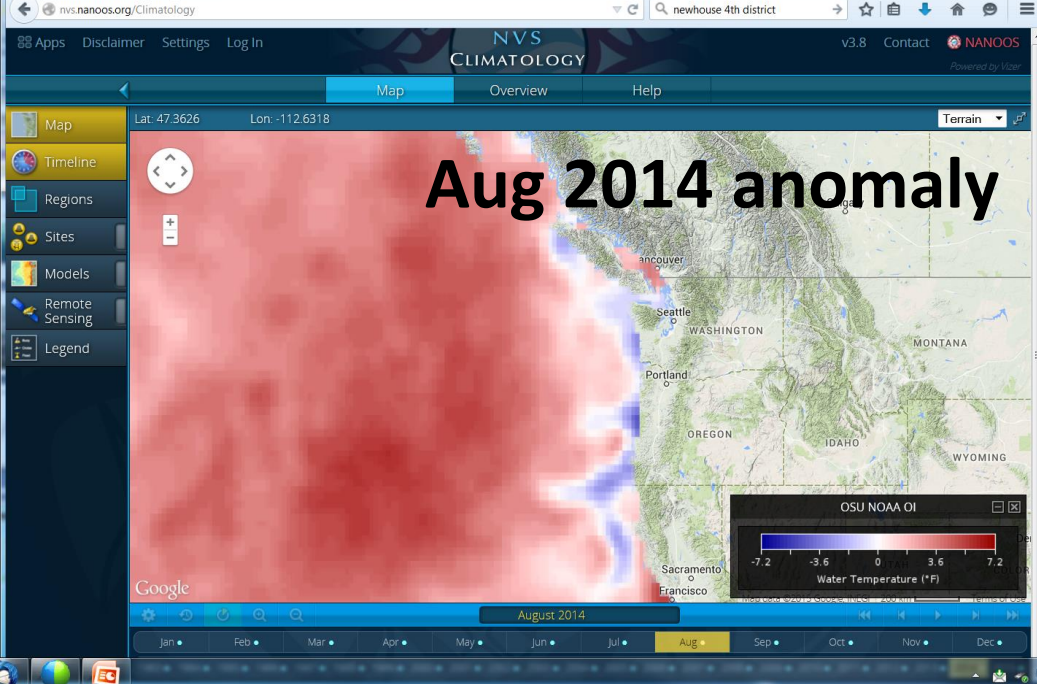


- 'The Blob' came onshore **14 Sep 2014 at 10 pm**
- The temperature increased  $6^{\circ}\text{C}$  in a few hours
- Peak temperature reached  $19.4^{\circ}\text{C}$

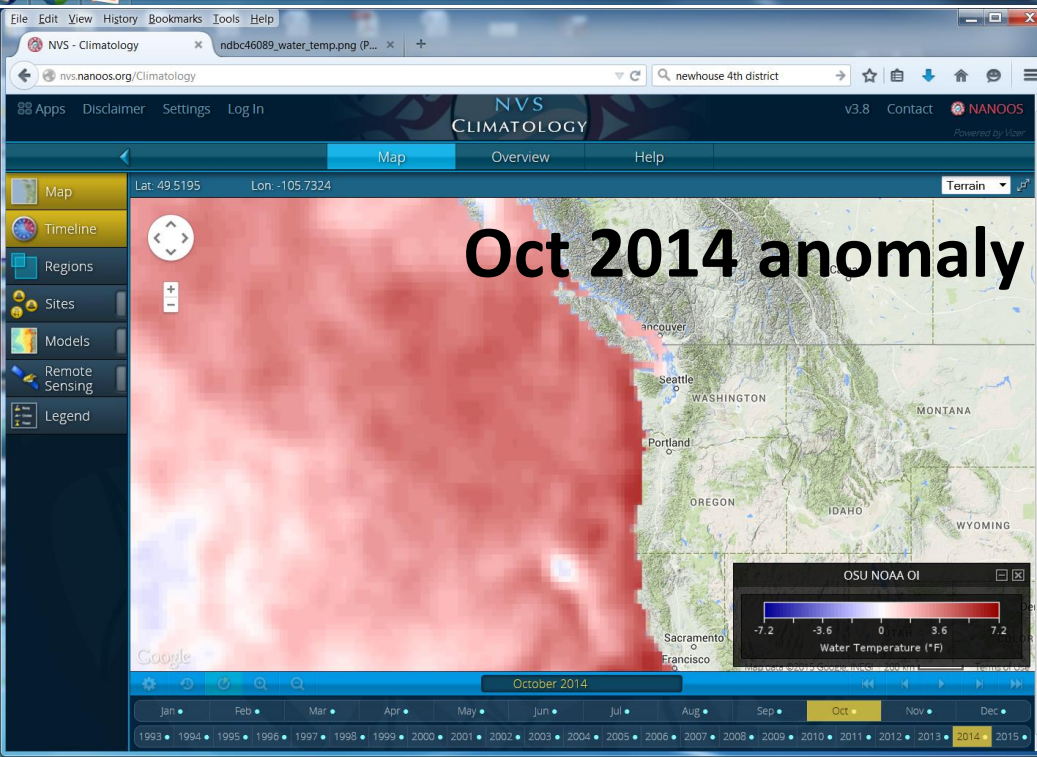


# 2014 SHIFT TO DOWNWELLING SUDDEN (ON SEPT. 25) EVIDENT AT CHA'BA OFF LA PUSH, WA



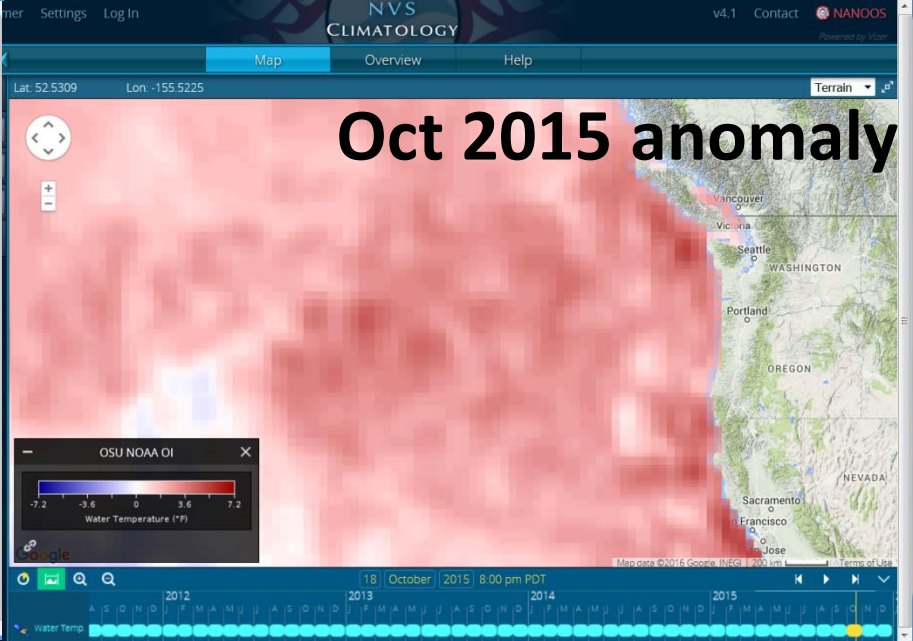
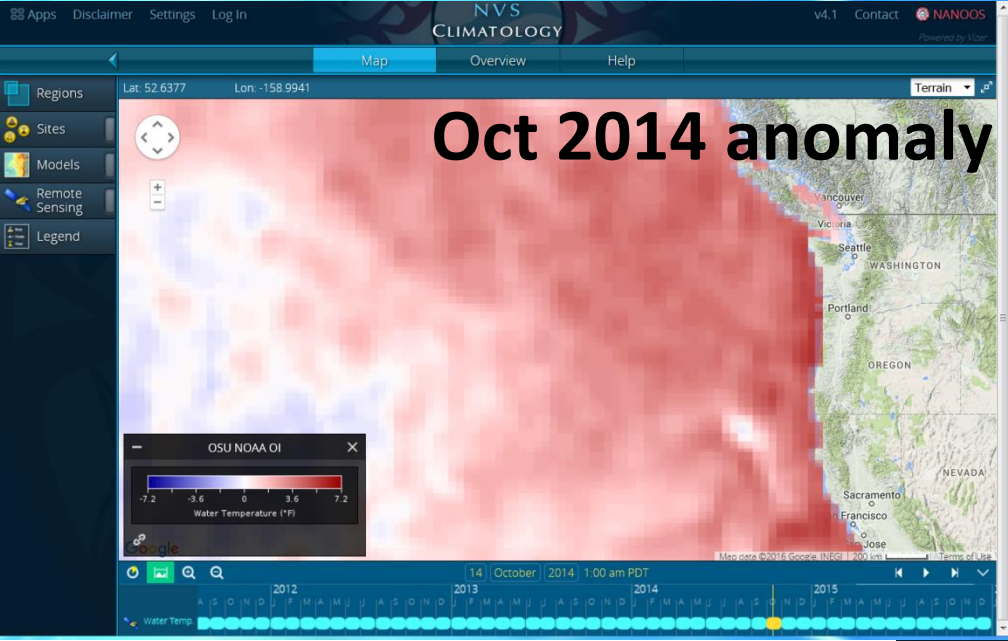
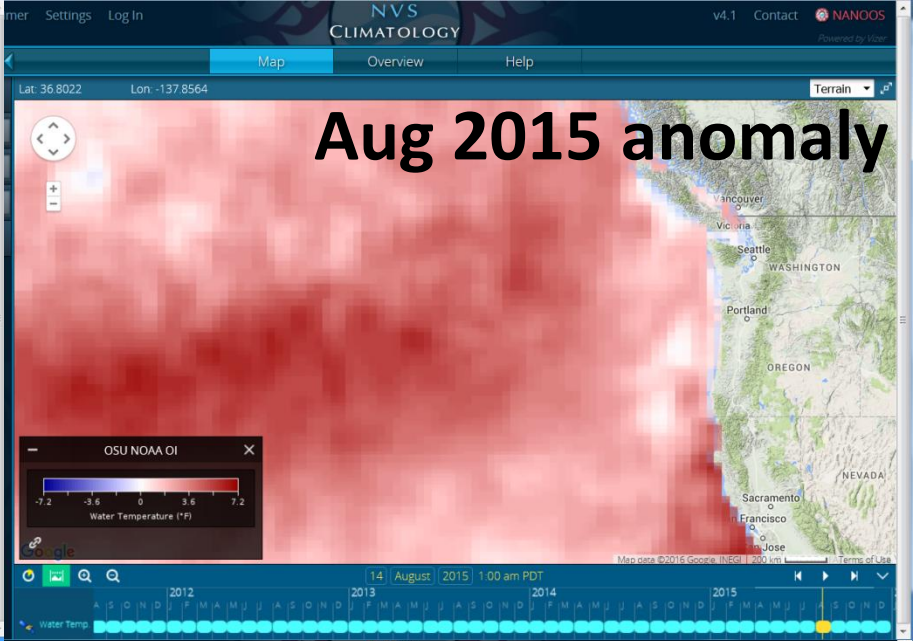
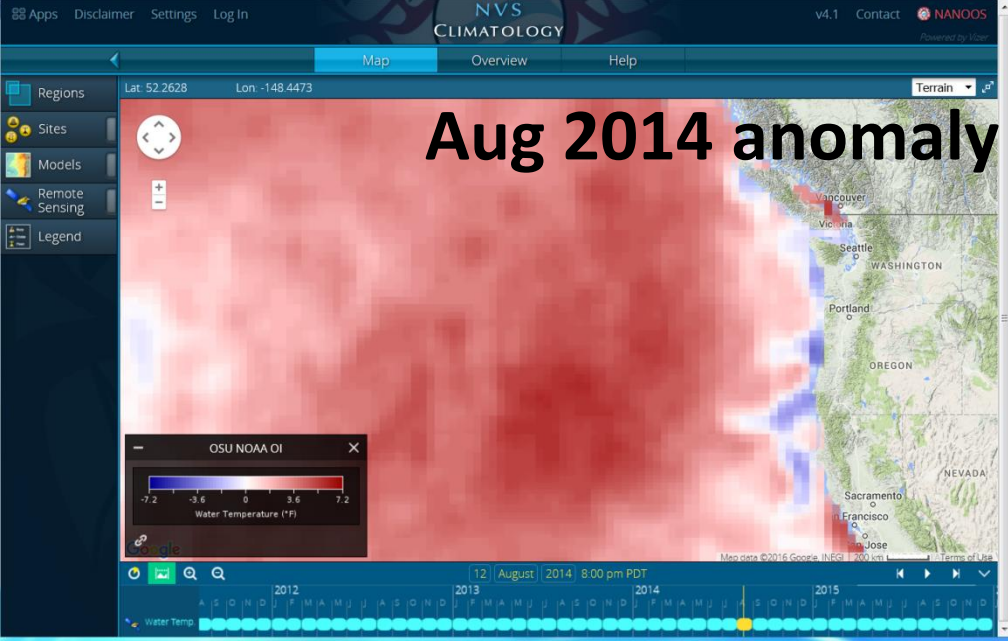


**A major story for 2014 is that despite strong offshore positive T anomalies, the near coastal waters were normal to cooler than average until the Sept 2014 fall transition**



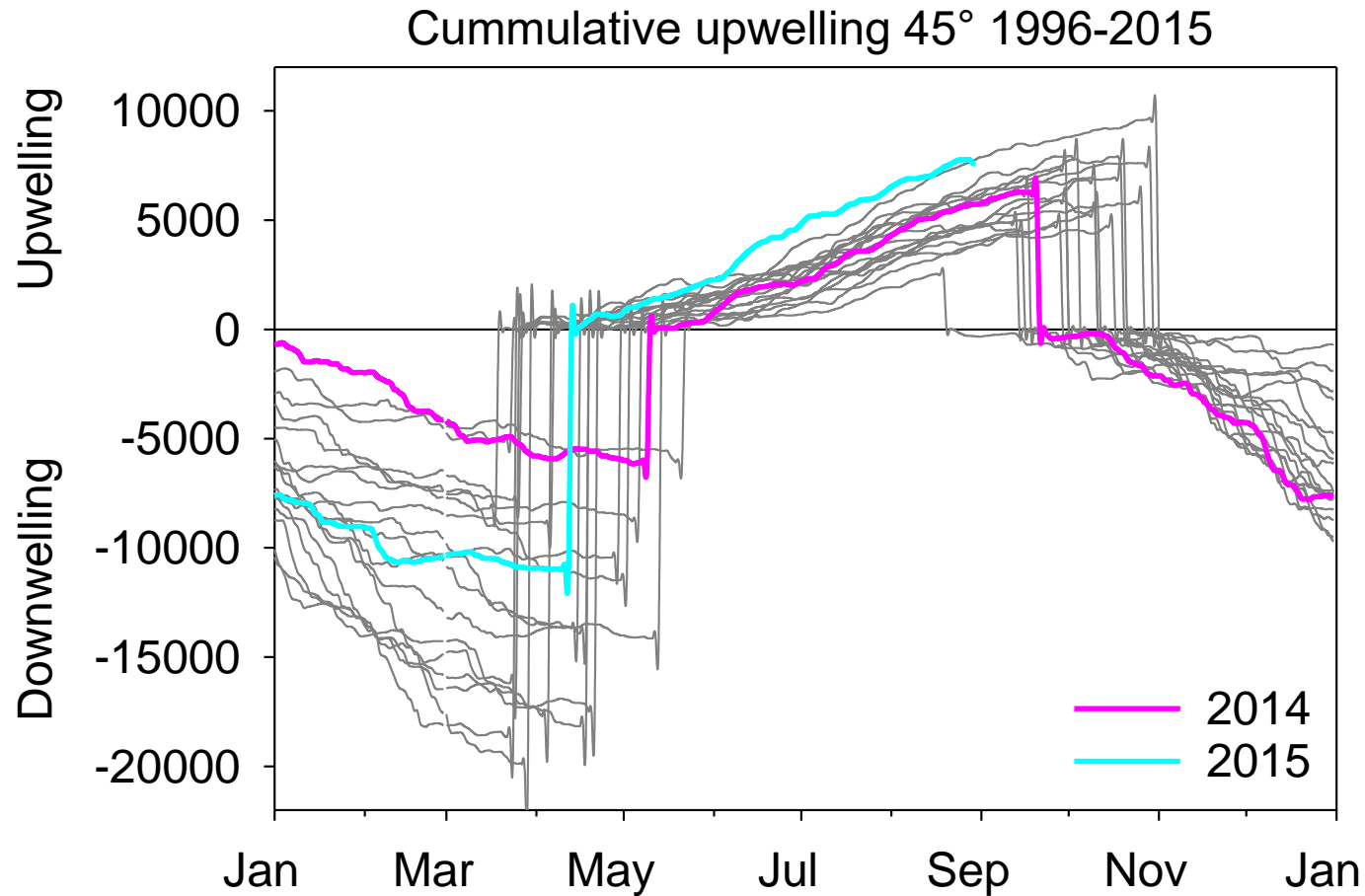
**How does this compare for 2015?**





**Aug 2015 had already warmer than avg waters at coast**

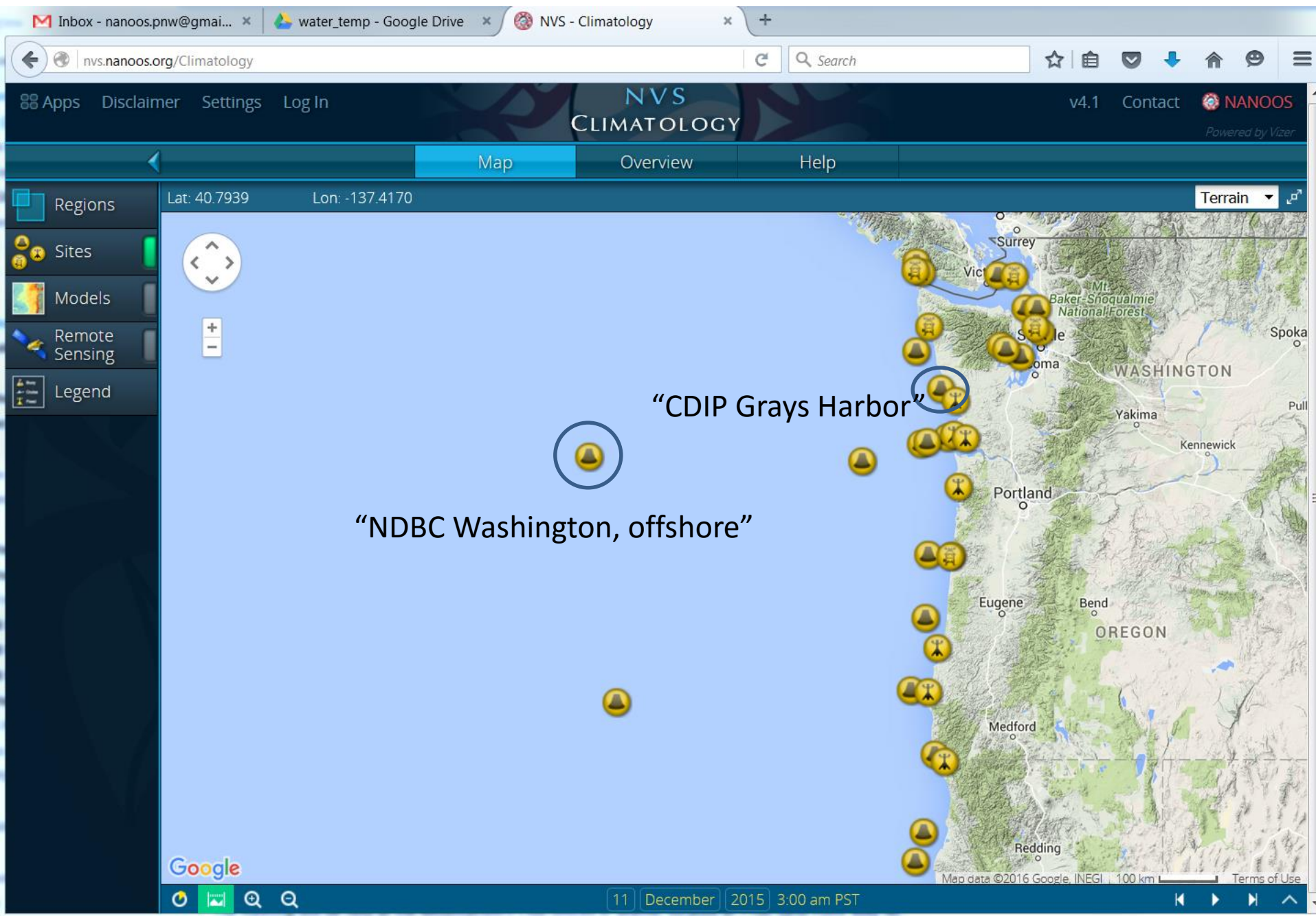
# Upwelling 45°N 1996 - 2015



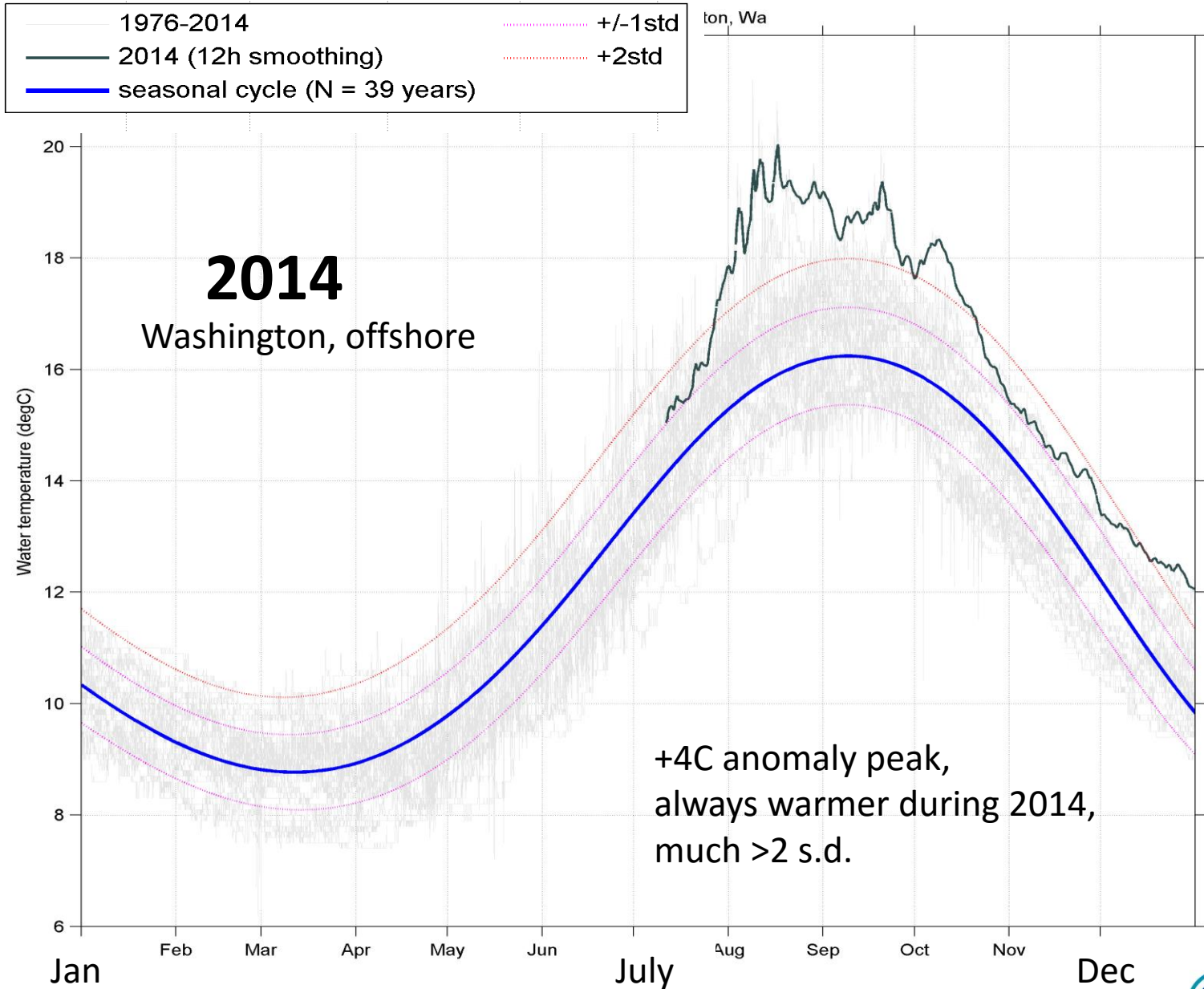
- 2014- upwelling delayed until late June (nearly matched 2005) then was average
- 2015- upwelling began on time and has been the strongest in the past 20 years



# Offshore-onshore gradients

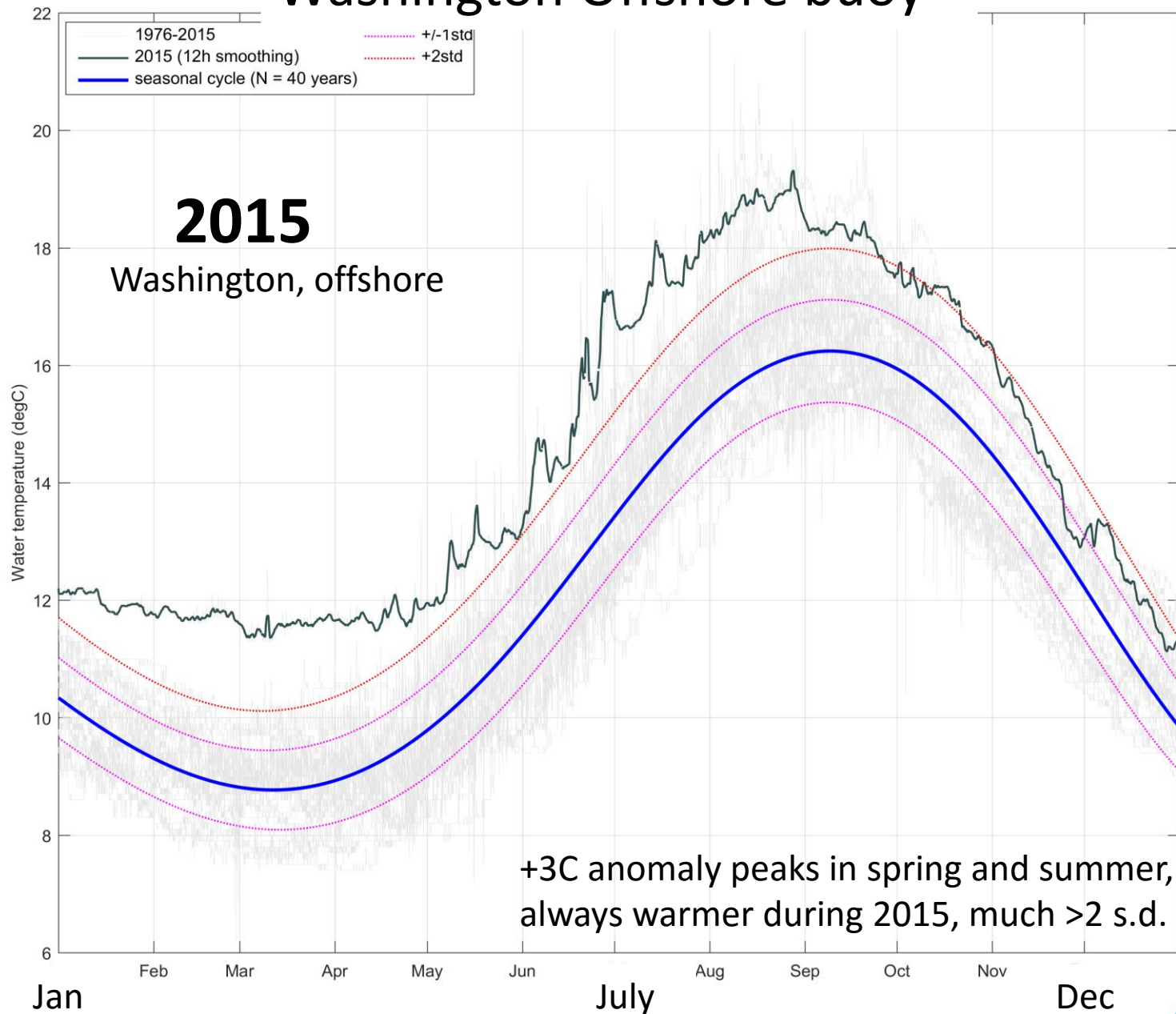


# Washington Offshore buoy

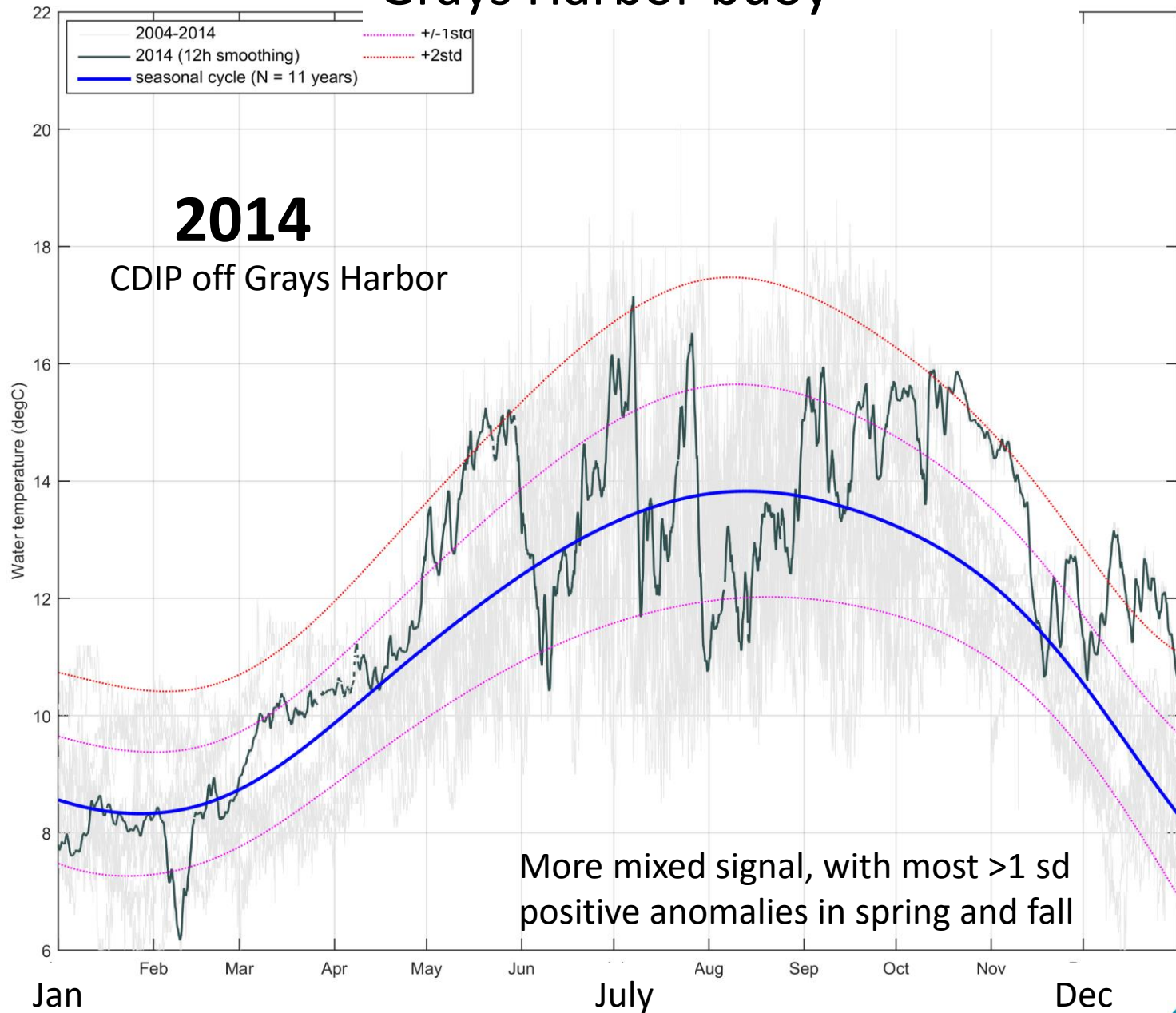




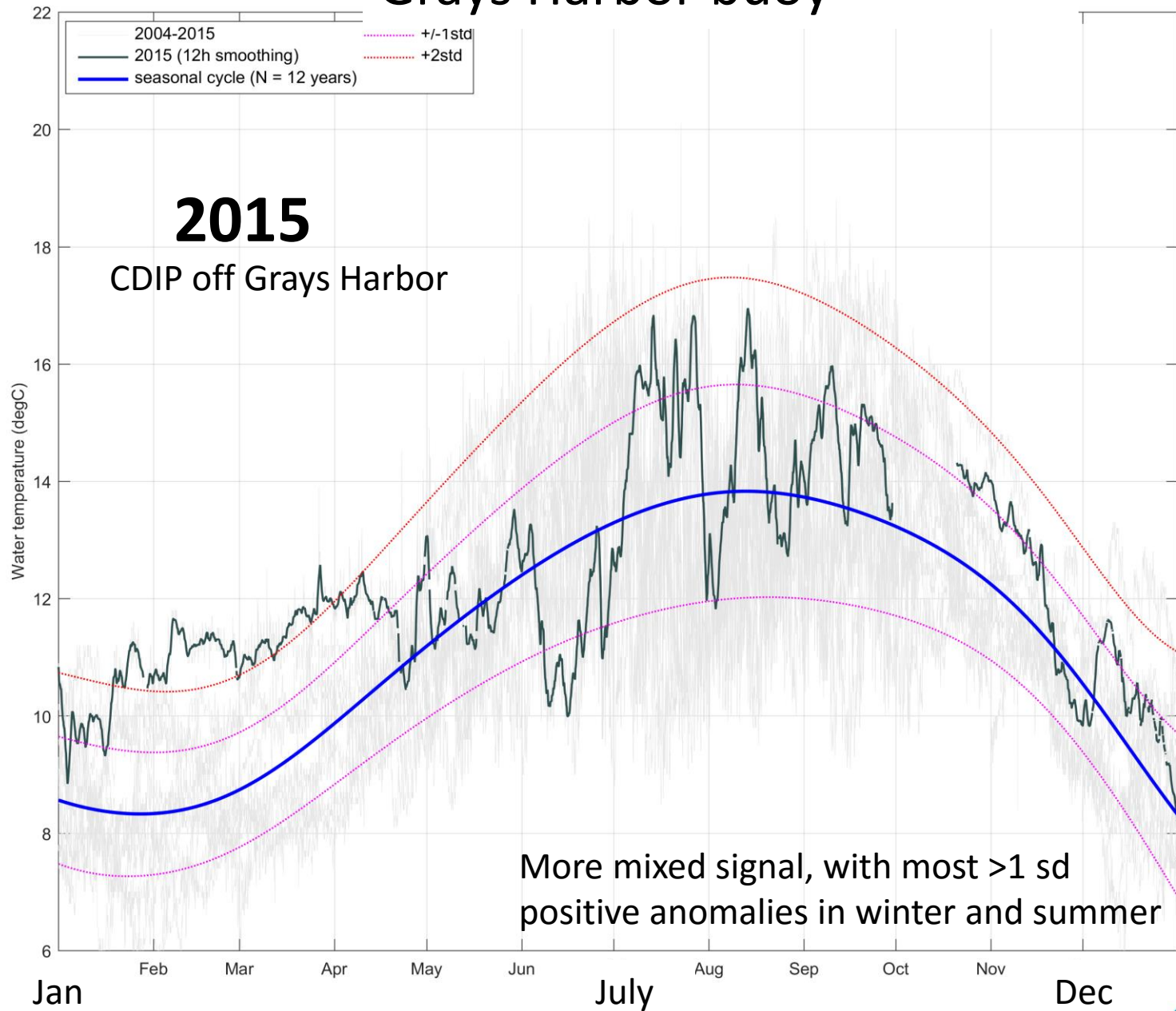
# Washington Offshore buoy



# Grays Harbor buoy



# Grays Harbor buoy

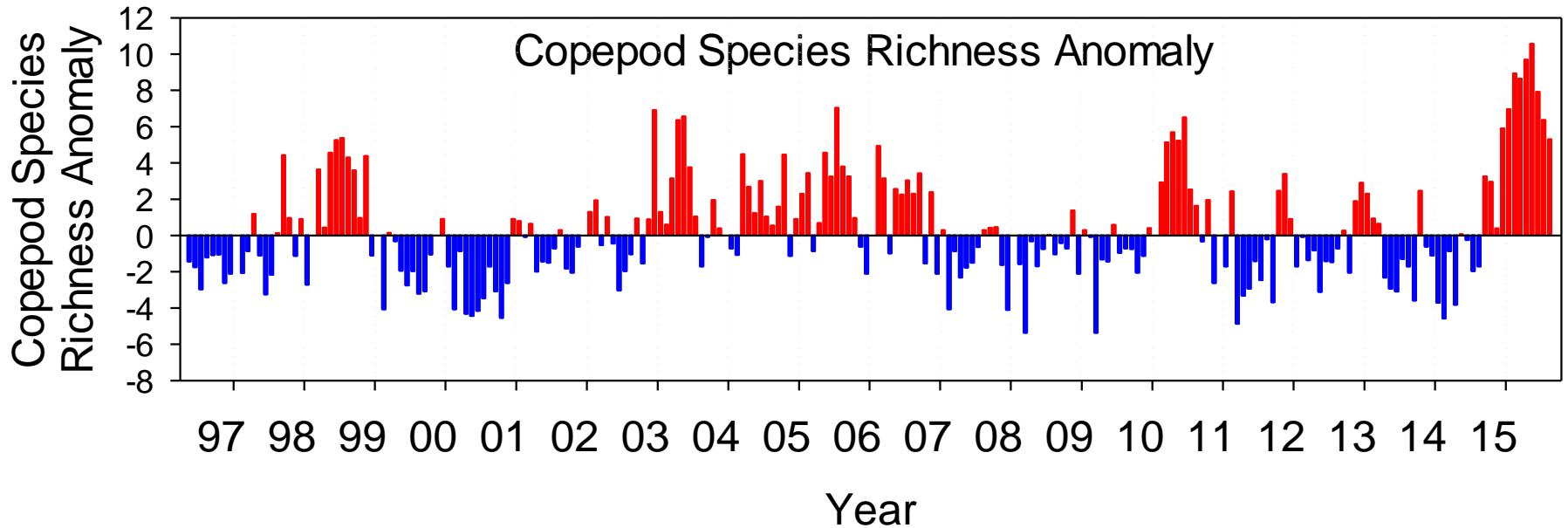


# In general

- Most extreme positive T anomalies ( $>2$  s.d.) were offshore whereas near coastal waters were mostly only  $>1$  s.d.
- For near coastal waters, highest T anomalies: spring and fall 2014, winter and summer 2015
- Coastal upwelling: cooler than normal T during 2014 but warmer than normal T in July & August 2015

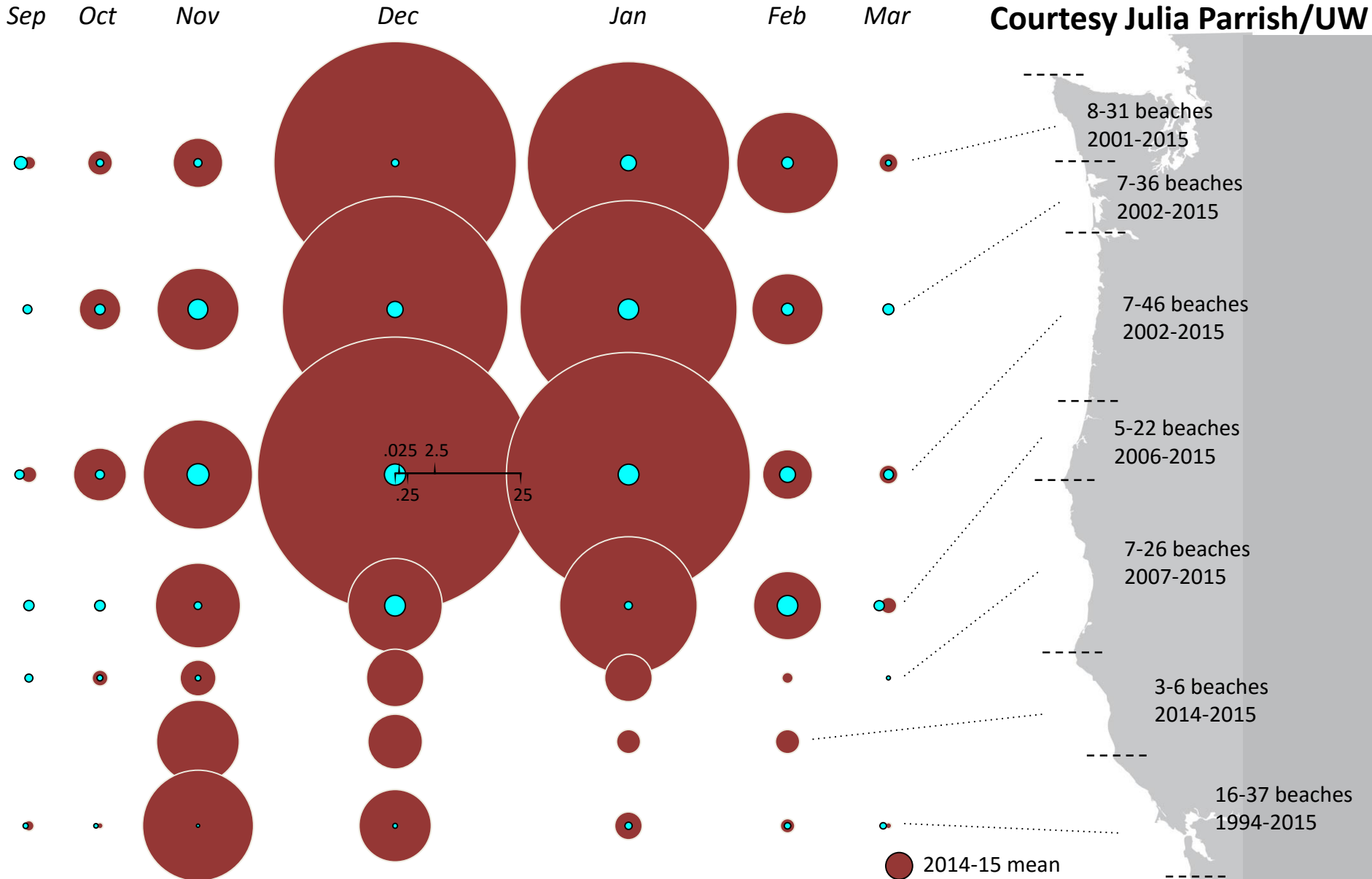


# NH-5 Copepod Species Richness



17 new copepod species observed in 2014-2015,  
many are Transition Zone/North Pacific Current species  
as opposed to coastal southern species

# Unprecedented Mass Mortality Event (~100,000 dead Cassin's Auklets)

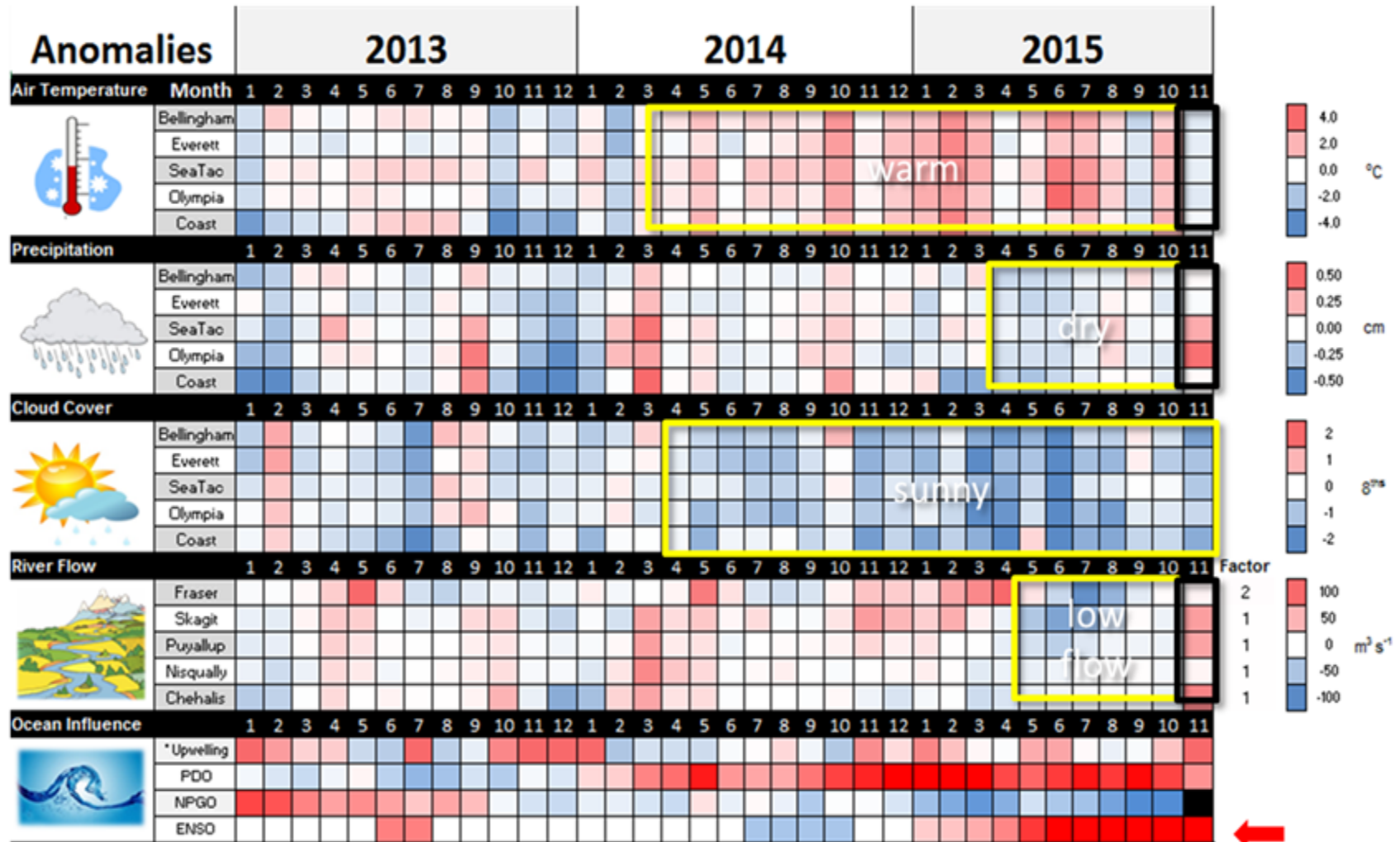


COASST: Neah Bay WA to Mendocino, BeachWatch: Mendocino to San Francisco Bay.  
 Data are Cassin's Auklets carcasses/km, new finds only. Sample size is number of beach sites over the listed year range.

Courtesy Julia Parrish/UW

# Puget Sound conditions

Eyes Over Puget Sound, condition report, [http://www.ecy.wa.gov/programs/eap/mar\\_wat/surface.html](http://www.ecy.wa.gov/programs/eap/mar_wat/surface.html)



\*Upwelling Anomalies (PFEL)

higher expected lower

No data

Christopher Krembs

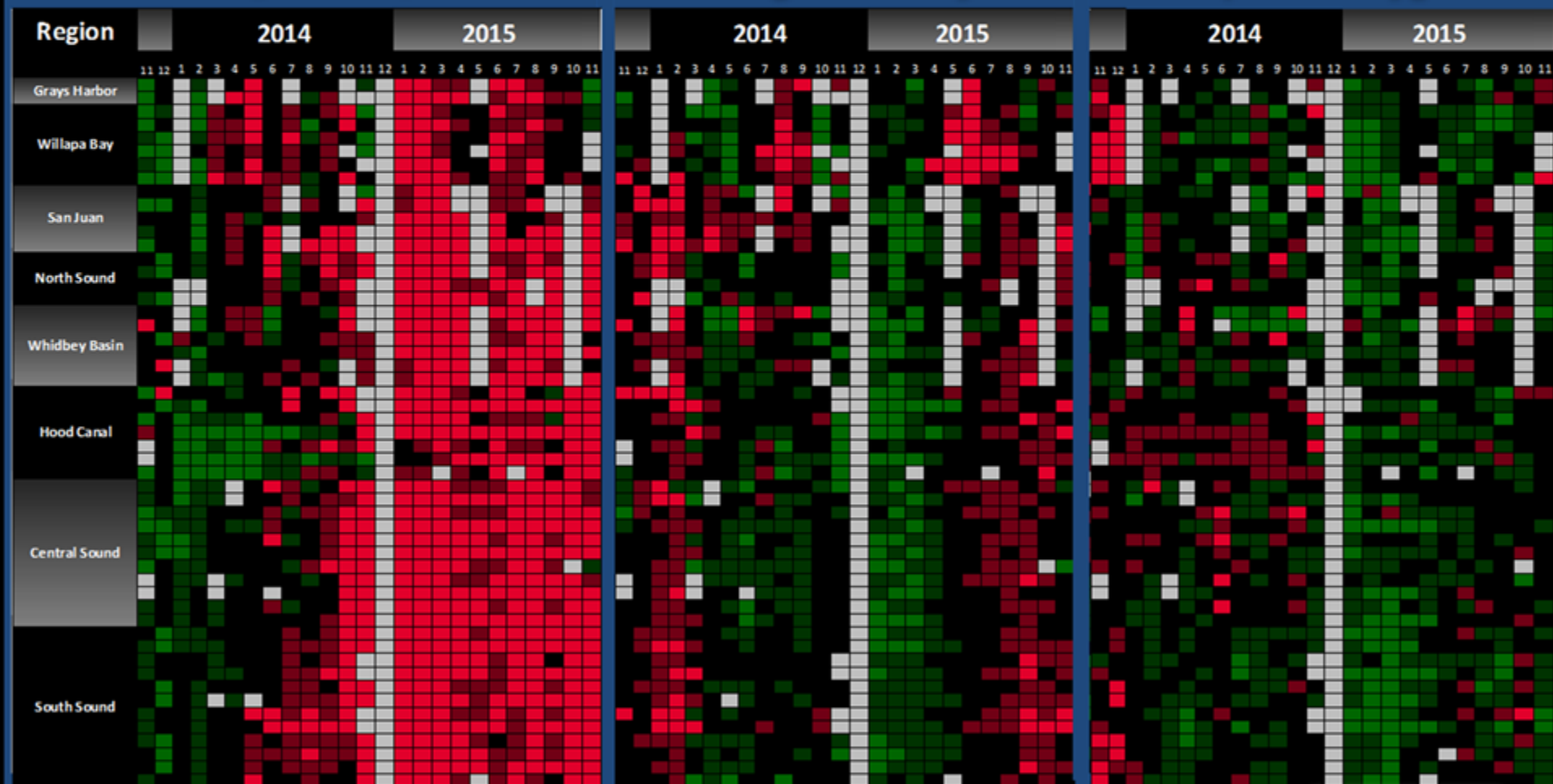
# Anomalies relative to 1999-2014 conditions for Coast Bays and Puget Sound

Eyes Over Puget Sound, condition report, [http://www.ecy.wa.gov/programs/eap/mar\\_wat/surface.html](http://www.ecy.wa.gov/programs/eap/mar_wat/surface.html)

## Higher Temperature!

## Higher Salinity

## Expected Oxygen



■ = higher than expected (>IQR, n=13)    
 ■ = expected (=IQR, n=13)    
 ■ = lower than expected (<IQR, n=13)  
■ = higher than previous measurements    
 ■ = no data    
■ = lower than previous measurements



Eyes Over Puget Sound, condition report, [http://www.ecy.wa.gov/programs/eap/mar\\_wat/surface.html](http://www.ecy.wa.gov/programs/eap/mar_wat/surface.html)

A.



*Extensive smacks of moon jellies both in size and density with pinkish tint.*

Location: A. On the water, B. From air showing location on the water, Budd Inlet (South Sound), 3:50 PM.

# Aerial photography 8-4-2015

Eyes Over Puget Sound, condition report, [http://www.ecy.wa.gov/programs/eap/mar\\_wat/surface.html](http://www.ecy.wa.gov/programs/eap/mar_wat/surface.html)



*Numerous large patches of jellyfish in water containing red-brown algal bloom.*

Location: Budd Inlet (South Sound), 3:12 PM.

- Slides and data provided by:
  - Jan Newton
  - Bill Peterson
  - Julia Parrish
  - Christopher Krembs