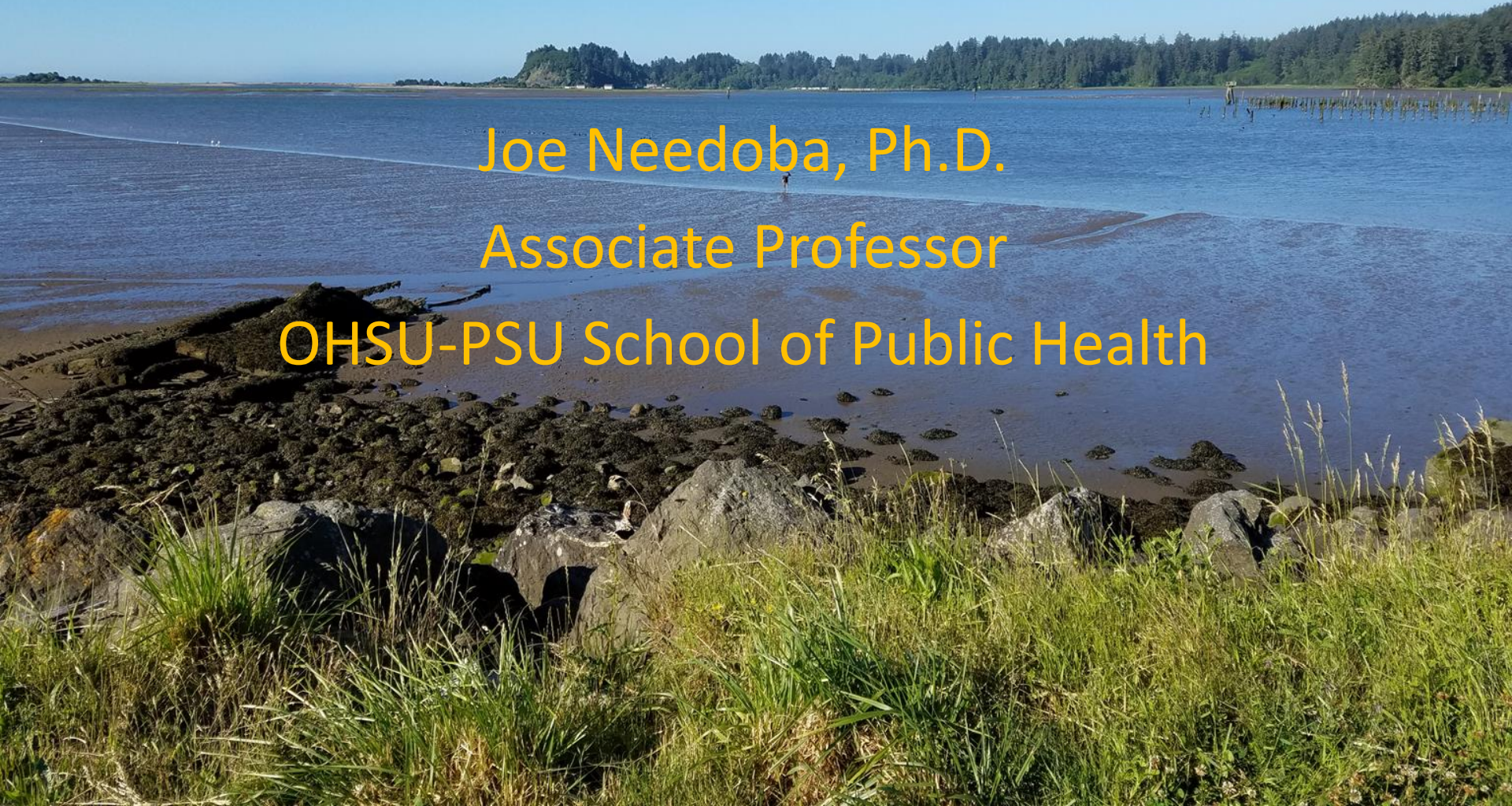


# Potential indicators of habitat and water quality in the lower Columbia River

Joe Needoba, Ph.D.

Associate Professor

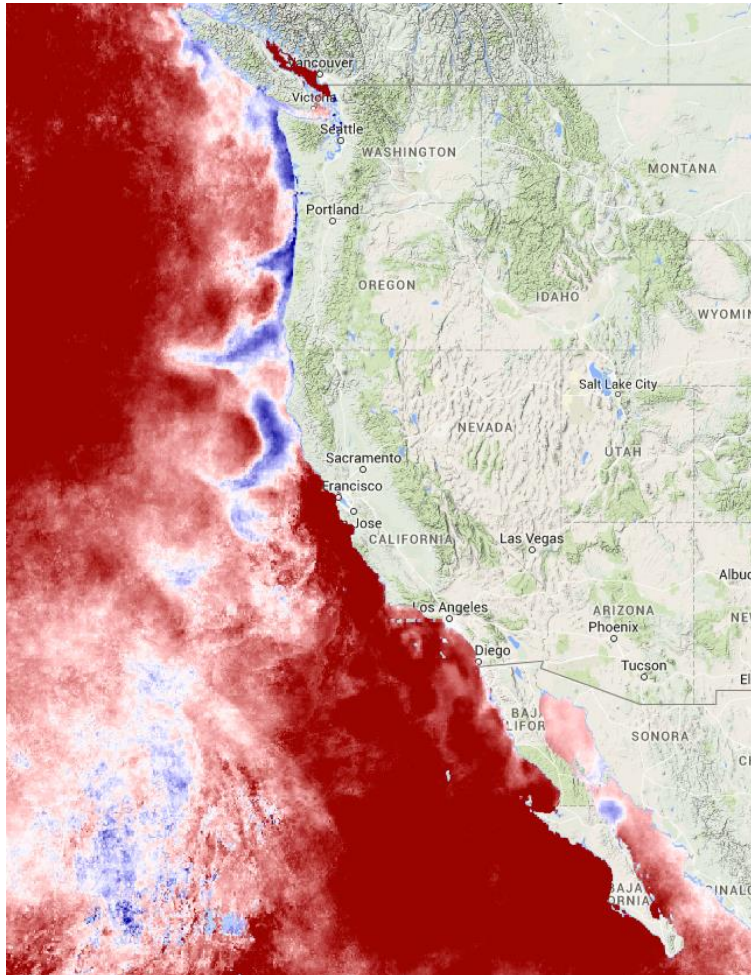
OHSU-PSU School of Public Health



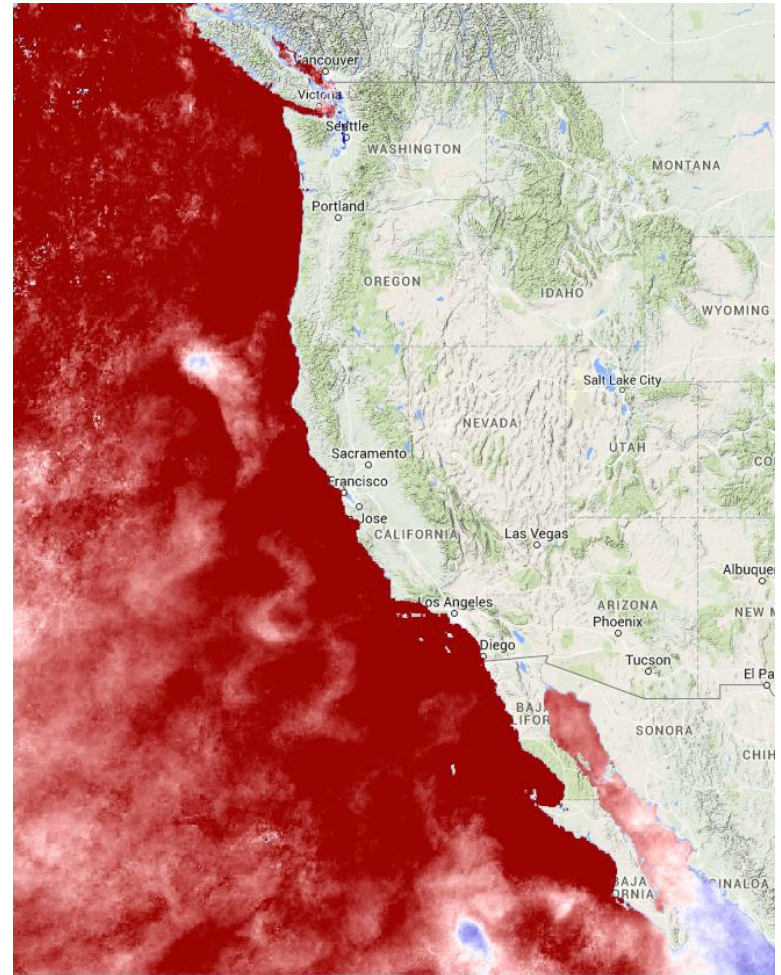


# How did the Blob influence the Columbia River estuary?

August 2014



October 2014

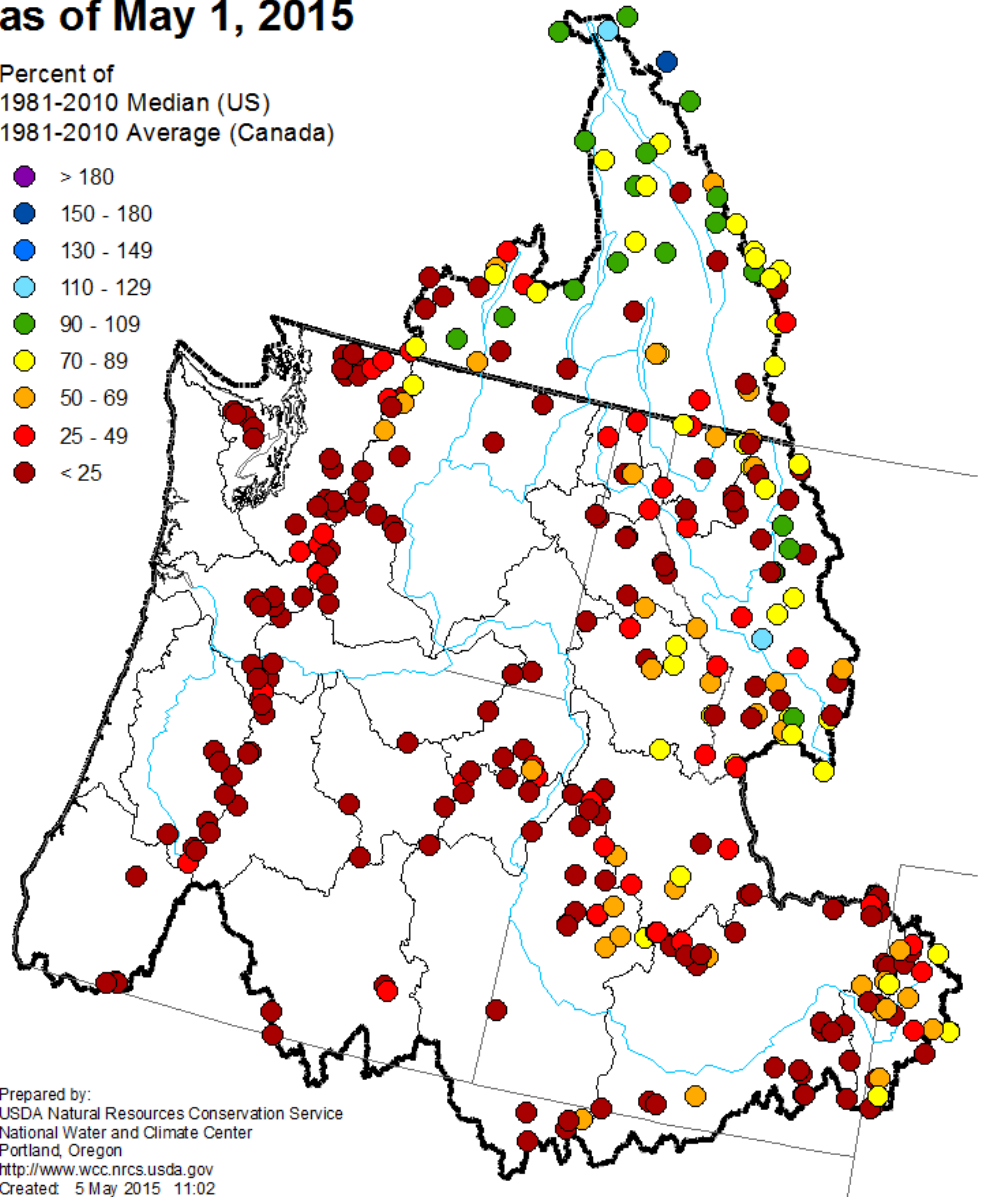


**In 2015 the estuary  
was also influenced  
by warm river  
conditions**

## Columbia River and Pacific Coastal Basins Mountain Snowpack as of May 1, 2015

Percent of  
1981-2010 Median (US)  
1981-2010 Average (Canada)

- > 180
- 150 - 180
- 130 - 149
- 110 - 129
- 90 - 109
- 70 - 89
- 50 - 69
- 25 - 49
- < 25

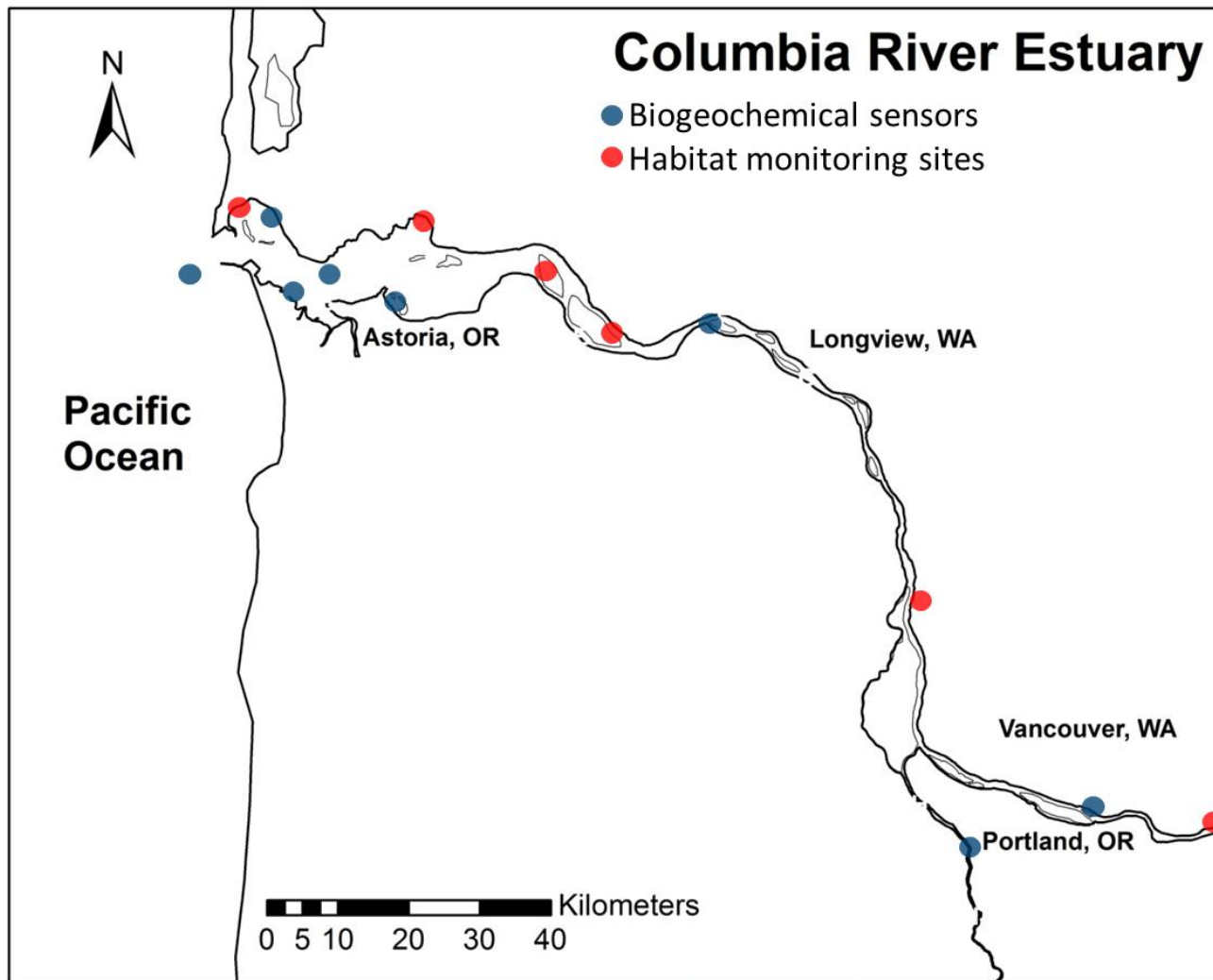


Prepared by:  
USDA Natural Resources Conservation Service  
National Water and Climate Center  
Portland, Oregon  
<http://www.wcc.nrcs.usda.gov>  
Created: 5 May 2015 11:02

For the CRE, how does 2014-2015 compare to previous “anomalous” warm years?

- **1997** Strong El Niño - warm ocean
- **2001** Low snowpack - warm river
- **2005** Delayed upwelling - warm ocean
- **2014-2015** The Blob - **warm ocean and river**

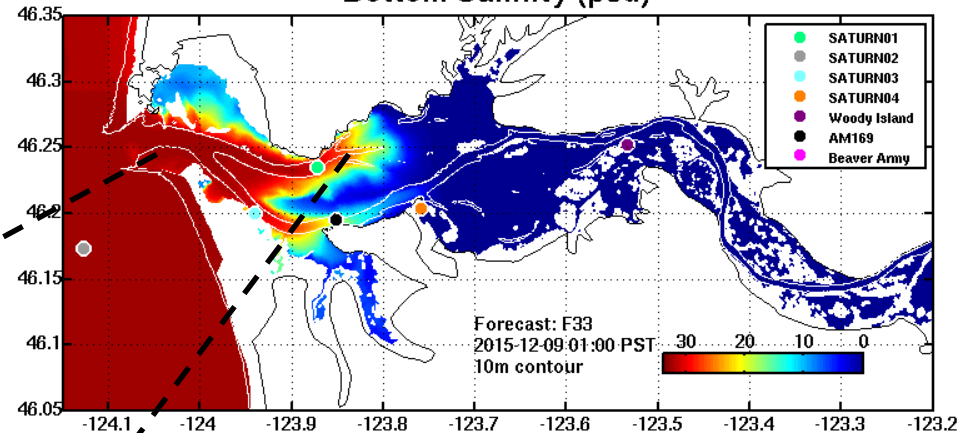
# Sensor Networks in the Columbia River estuary



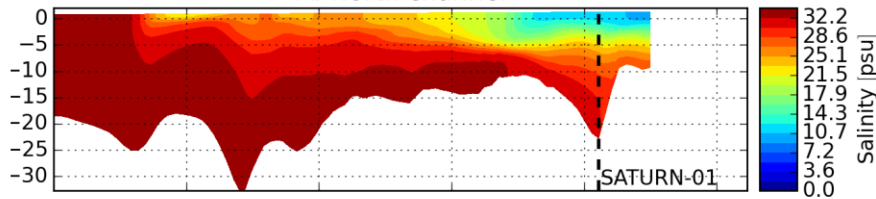
# Measuring ocean water in the estuary



Bottom Salinity (psu)

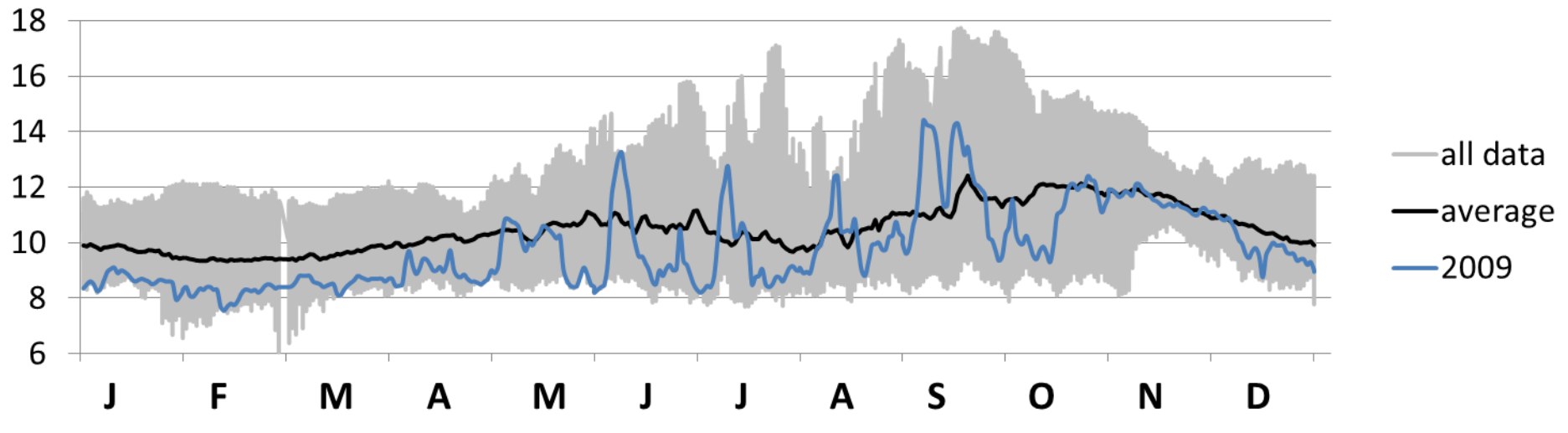


A: North channel



# Measuring ocean water in the estuary

Esturay-Ocean Temp (°C) 2009

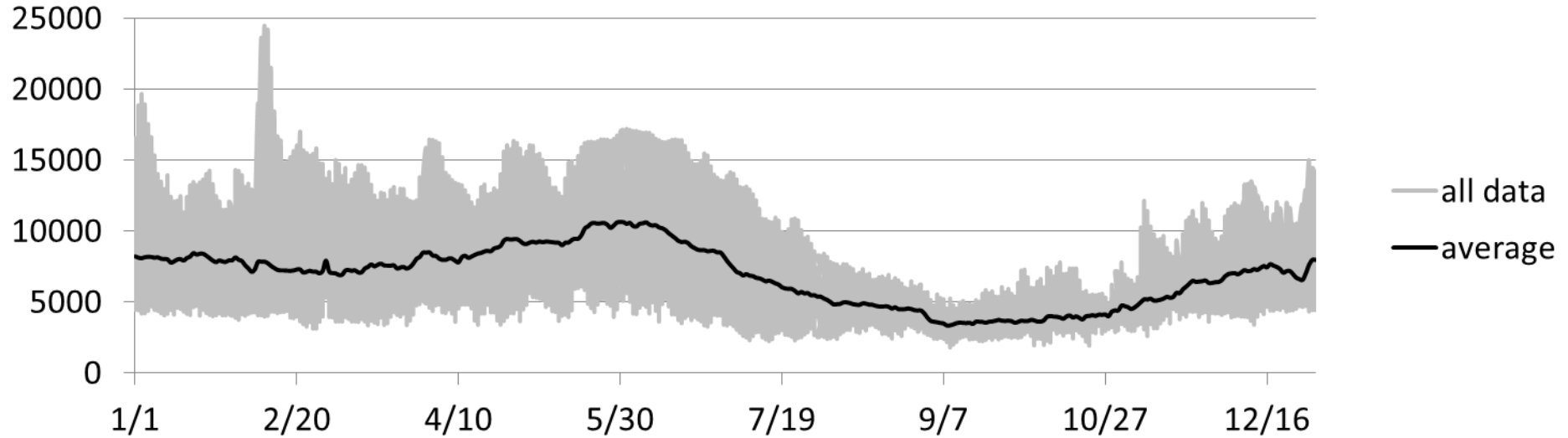


Temperature corresponding to daily highest salinity measurement – 1996-2015

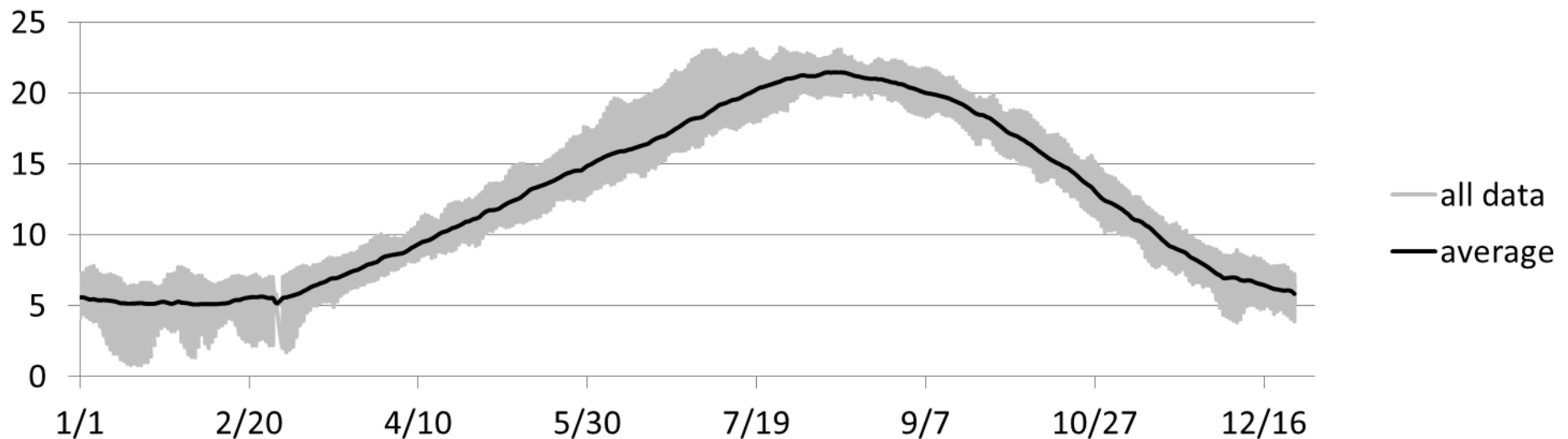


# River Flow and Temperature 1992-2015

## BAT Discharge (m<sup>3</sup>/s)

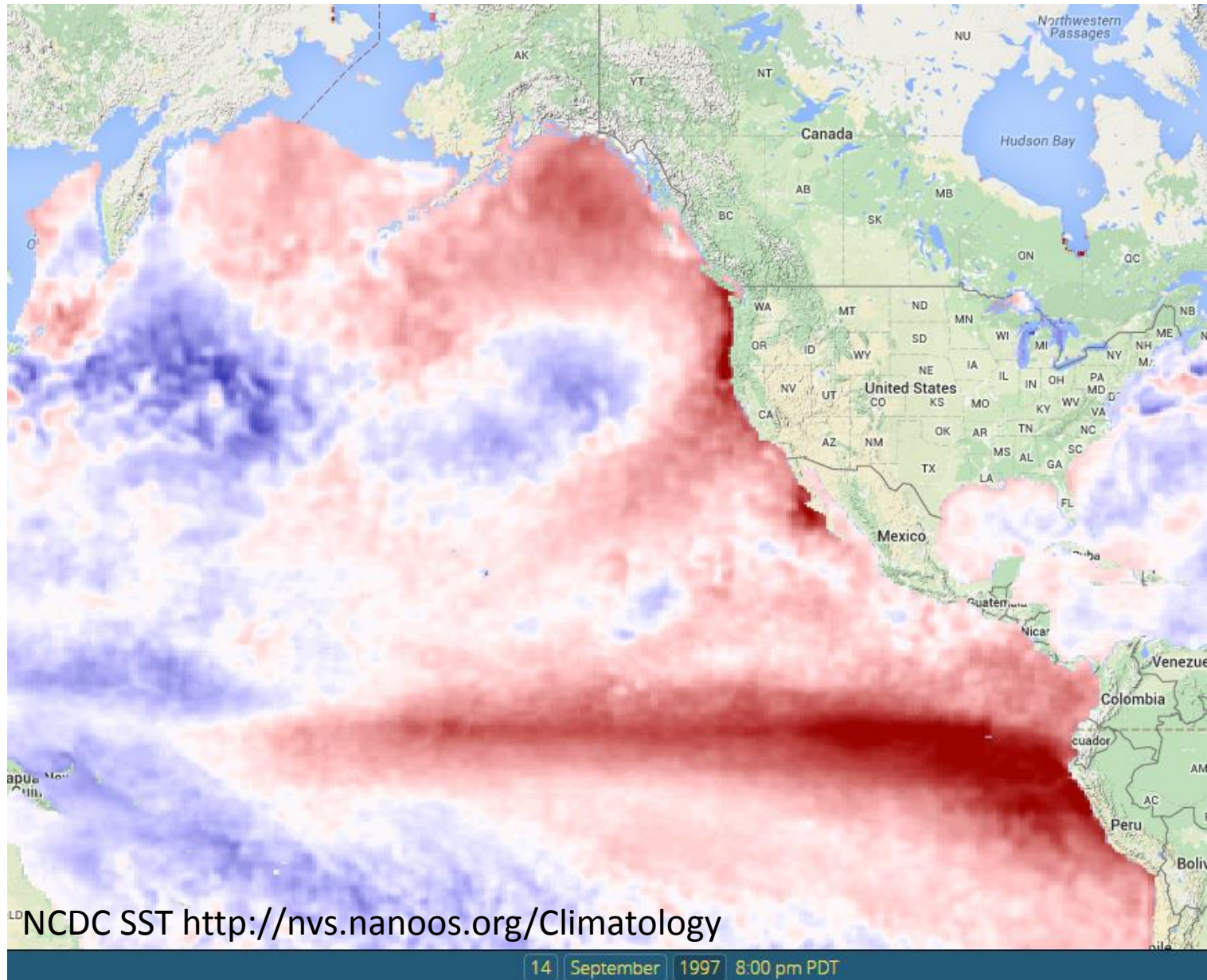


## Mainstem Temp (°C)



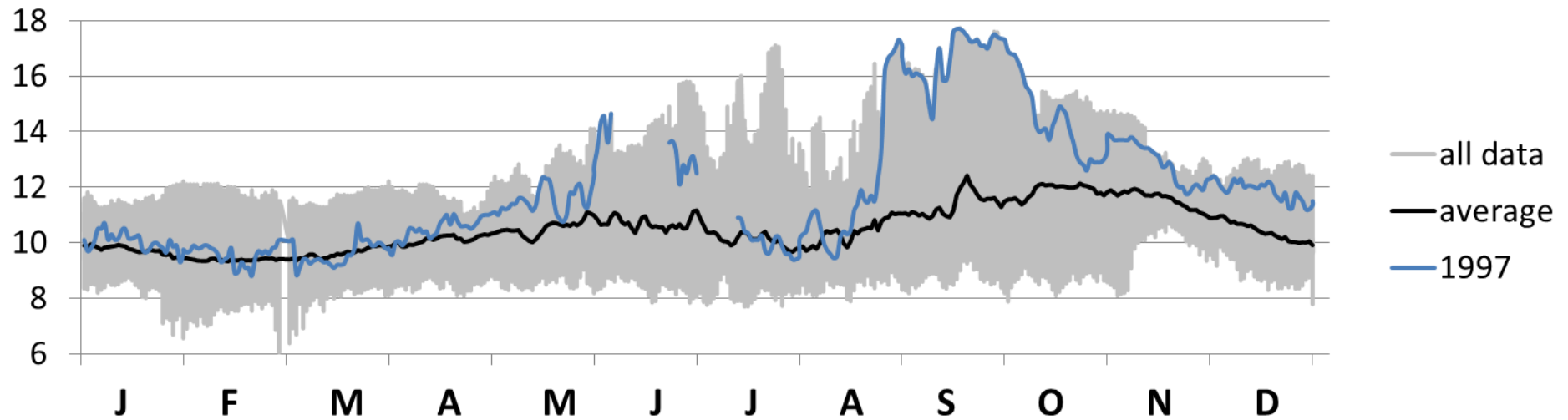


# 1997 Strong El Niño - warm ocean



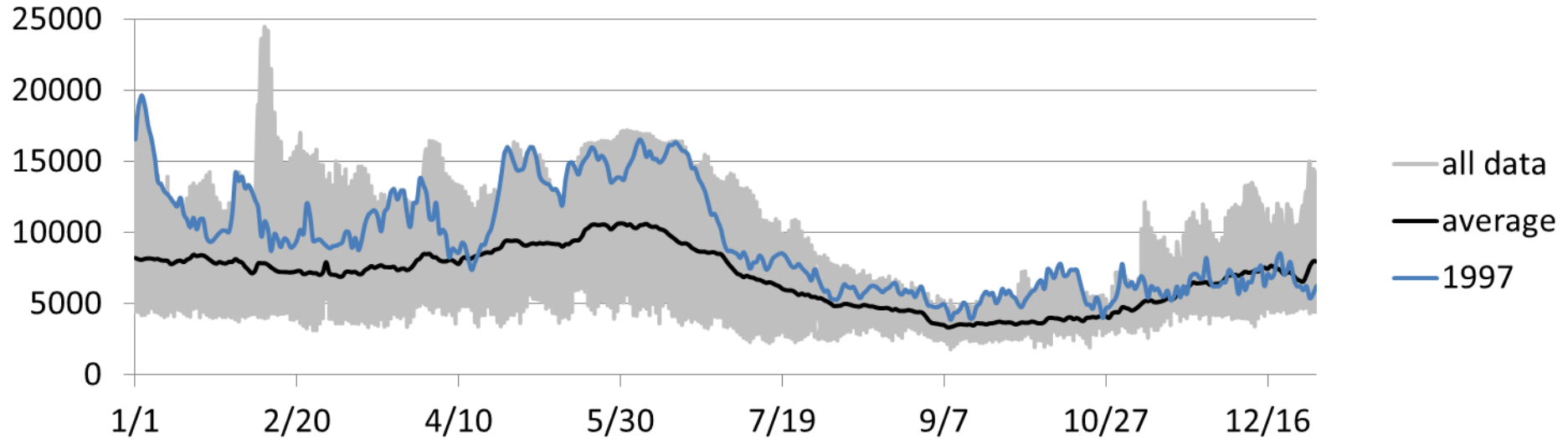
# 1997 Strong El Niño - warm ocean

Estuary-Ocean Temp (°C) 1997

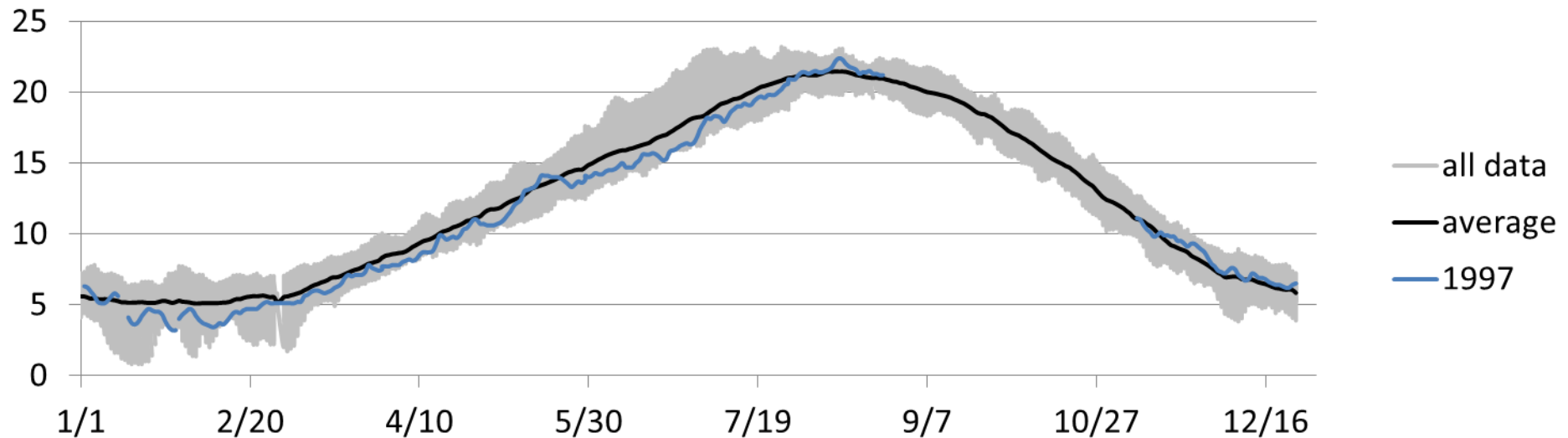


# 1997 Strong El Niño - warm ocean

## BAT Discharge (m<sup>3</sup>/s) - 1997



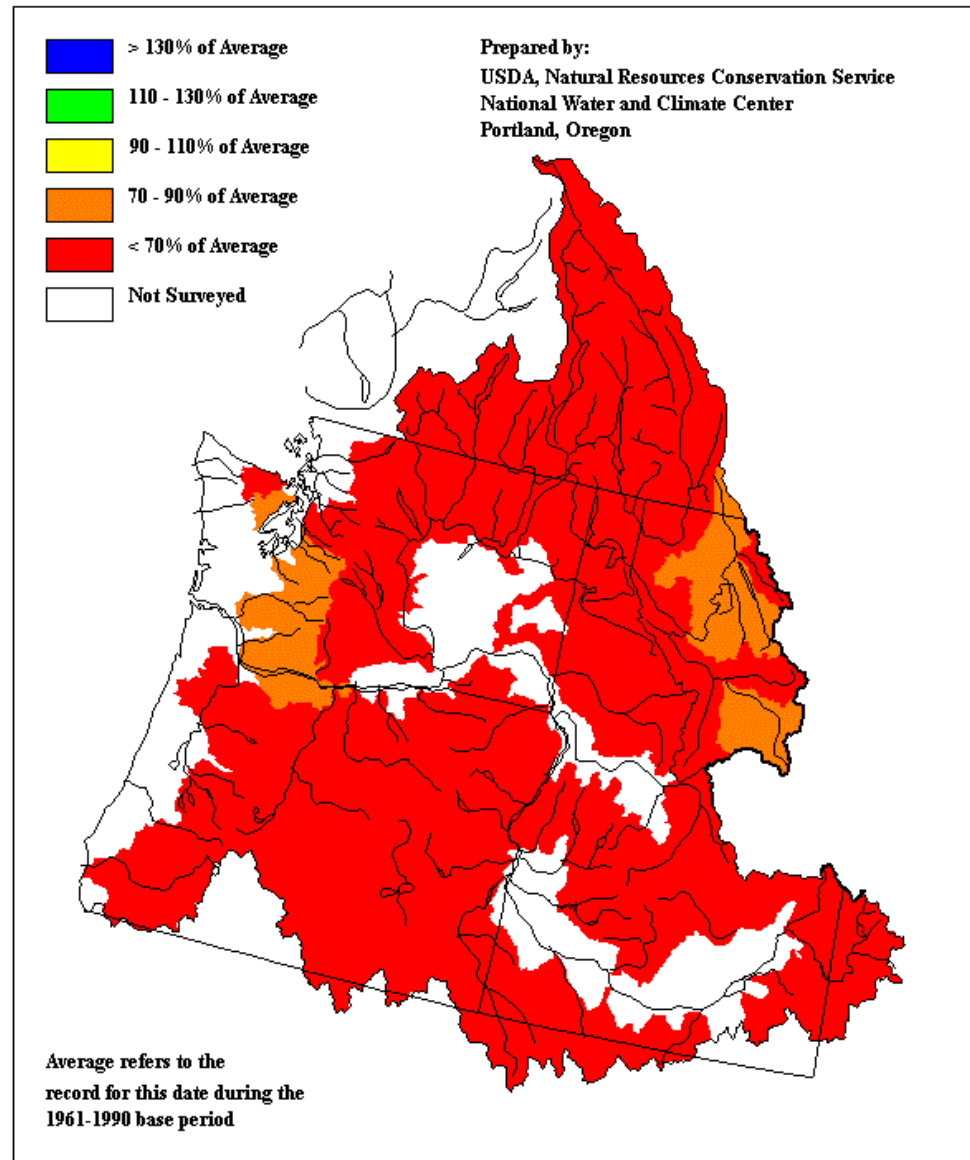
## Mainstem Temp (°C) - 1997



## Mountain Snow Water Equivalent

as of May 1, 2001 (in relation to the average for this date)

**2001 Low snowpack -  
warm river**



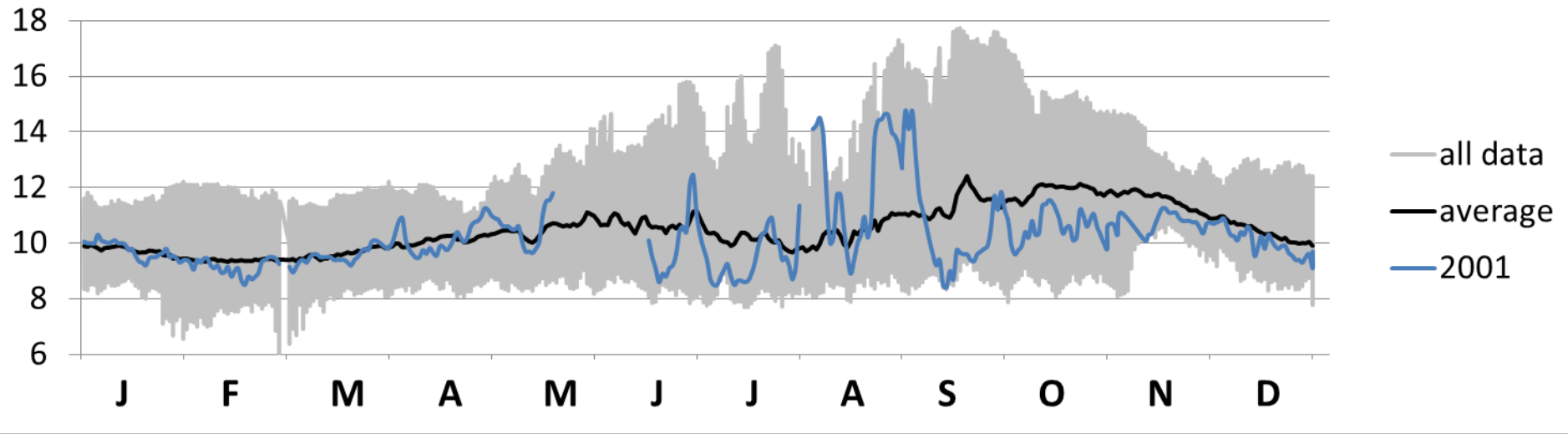
[http://www.wcc.nrcs.usda.gov/ftpref/support/snow/snowpack\\_maps/columbia\\_river/wy2001/cusn0105.gif](http://www.wcc.nrcs.usda.gov/ftpref/support/snow/snowpack_maps/columbia_river/wy2001/cusn0105.gif)

United States Department of Agriculture -- Natural Resources Conservation Service  
in cooperation with  
The Province of British Columbia -- Ministry of the Environment



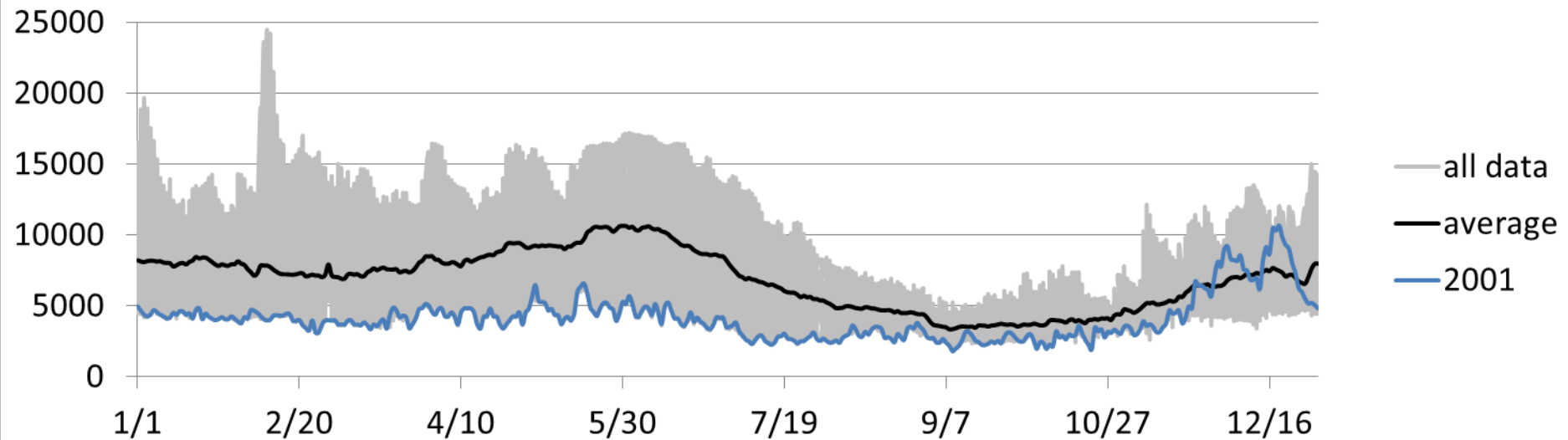
# 2001 Low snowpack - warm river

Estuary-Ocean Temp (°C) 2001

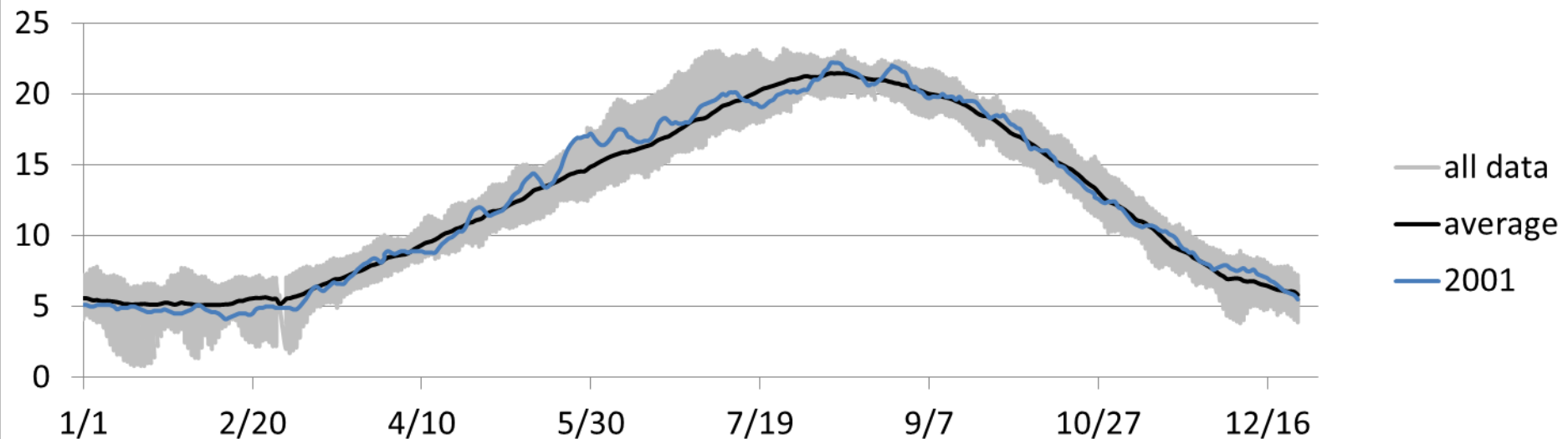


# 2001 Low snowpack - warm river

## BAT Discharge (m<sup>3</sup>/s) - 2001

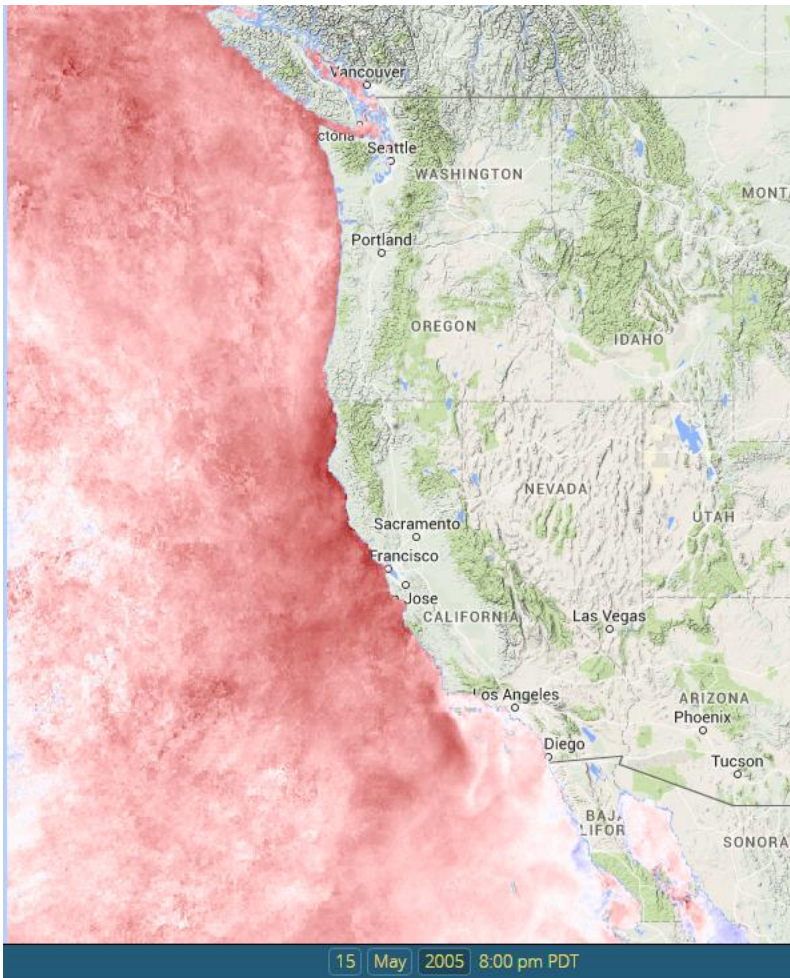


## Mainstem Temp (°C) - 2001

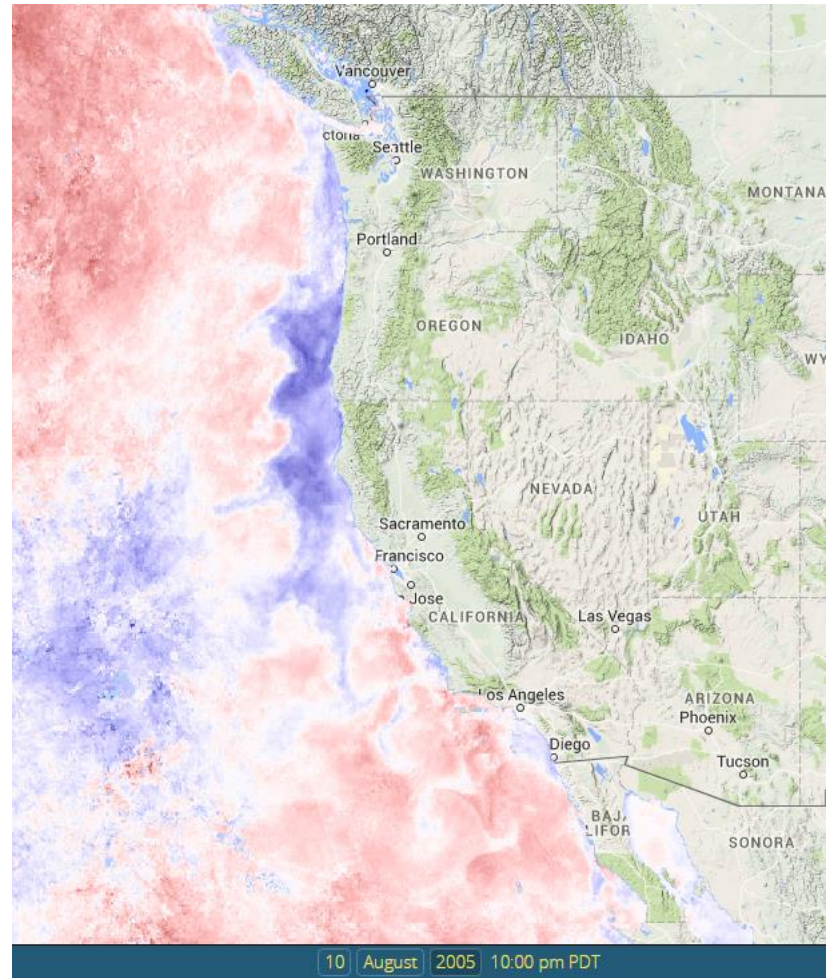


# 2005 Delayed upwelling - warm ocean

May 2005

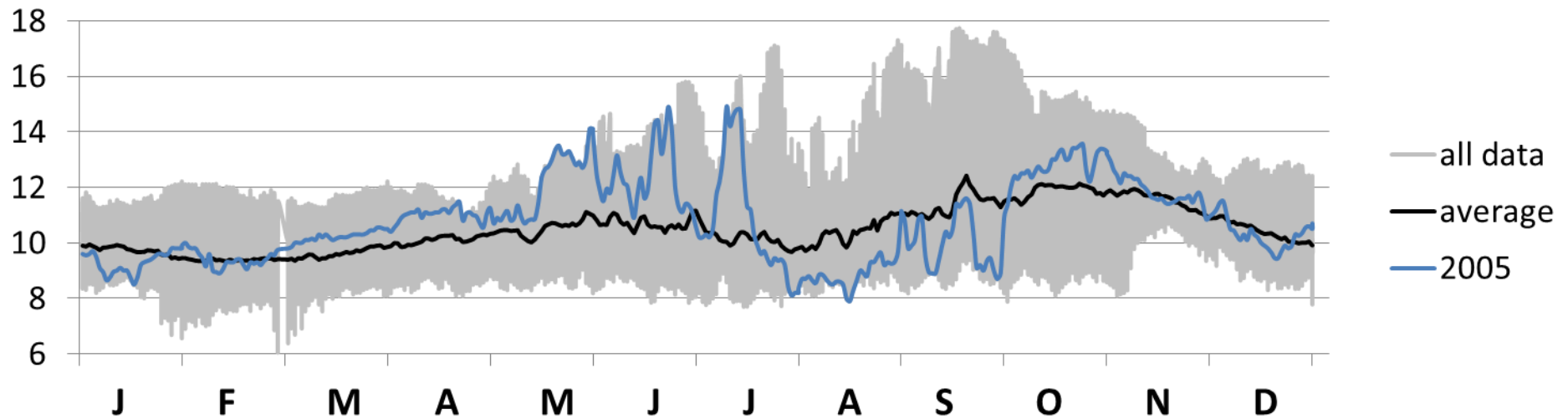


August 2005



# 2005 Delayed upwelling - warm ocean

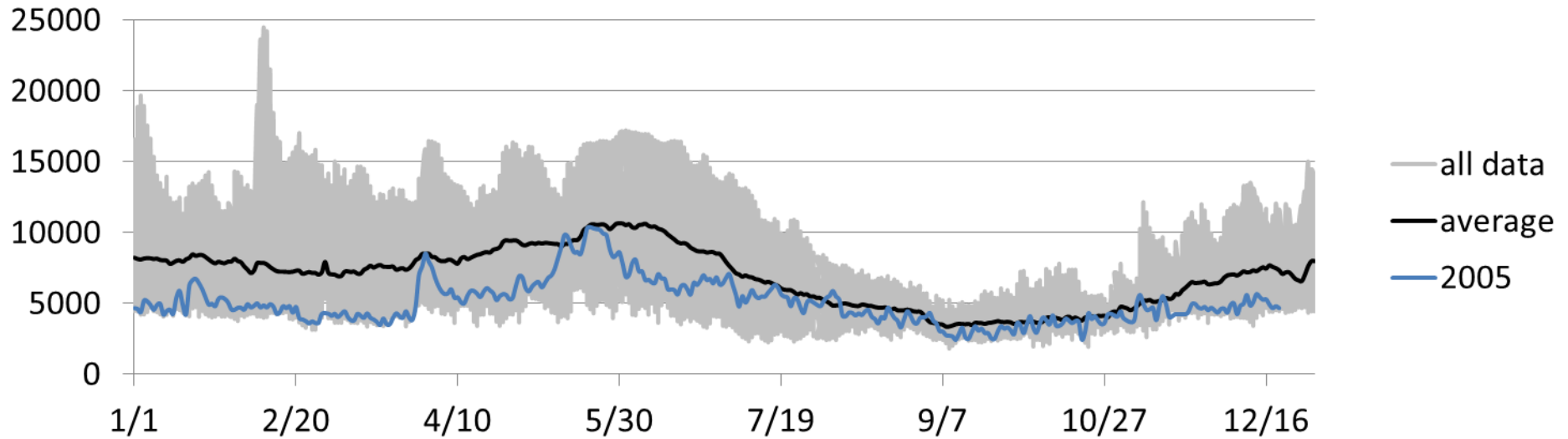
Estuary-Ocean Temp (°C) 2005



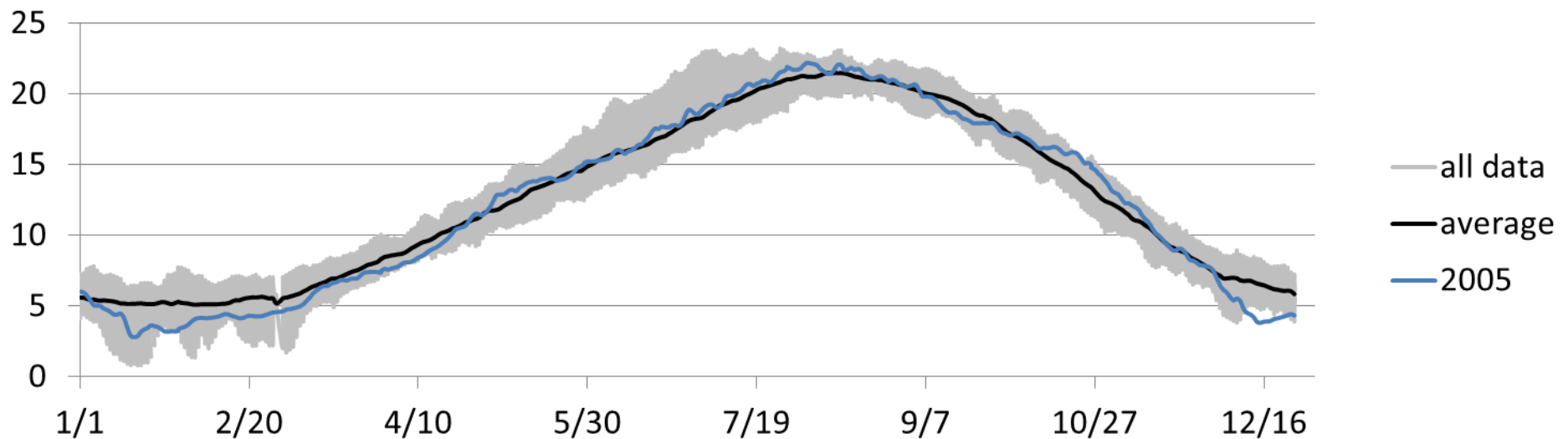


# 2005 Delayed upwelling - warm ocean

## BAT Discharge (m<sup>3</sup>/s) - 2005



## Mainstem Temp (°C) - 2005



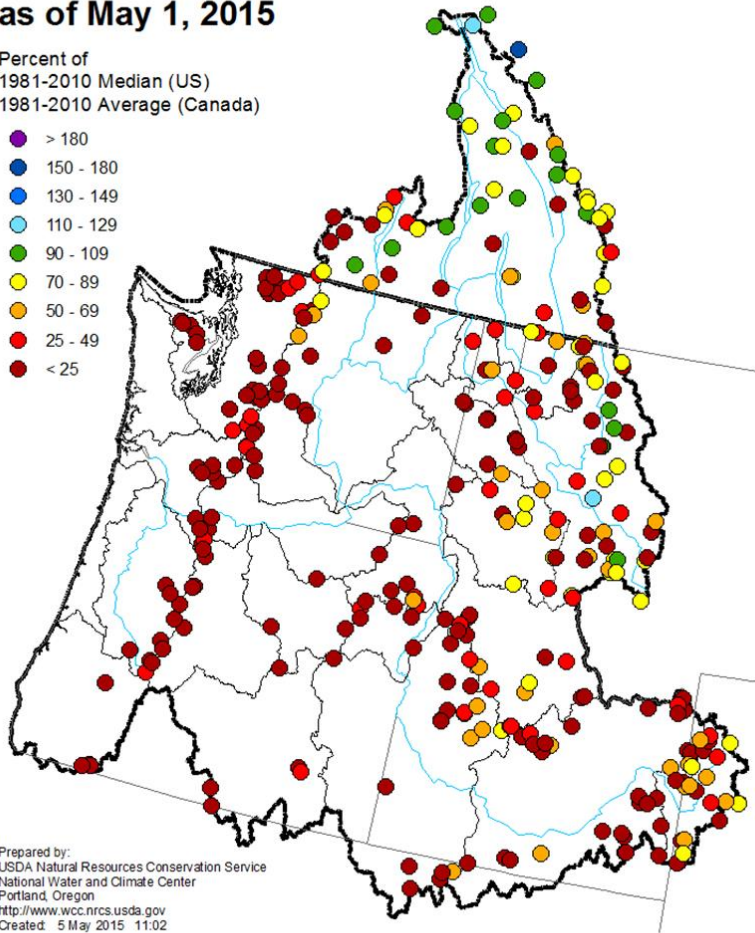
# 2014-2015 The Blob - warm ocean and river

October 2014

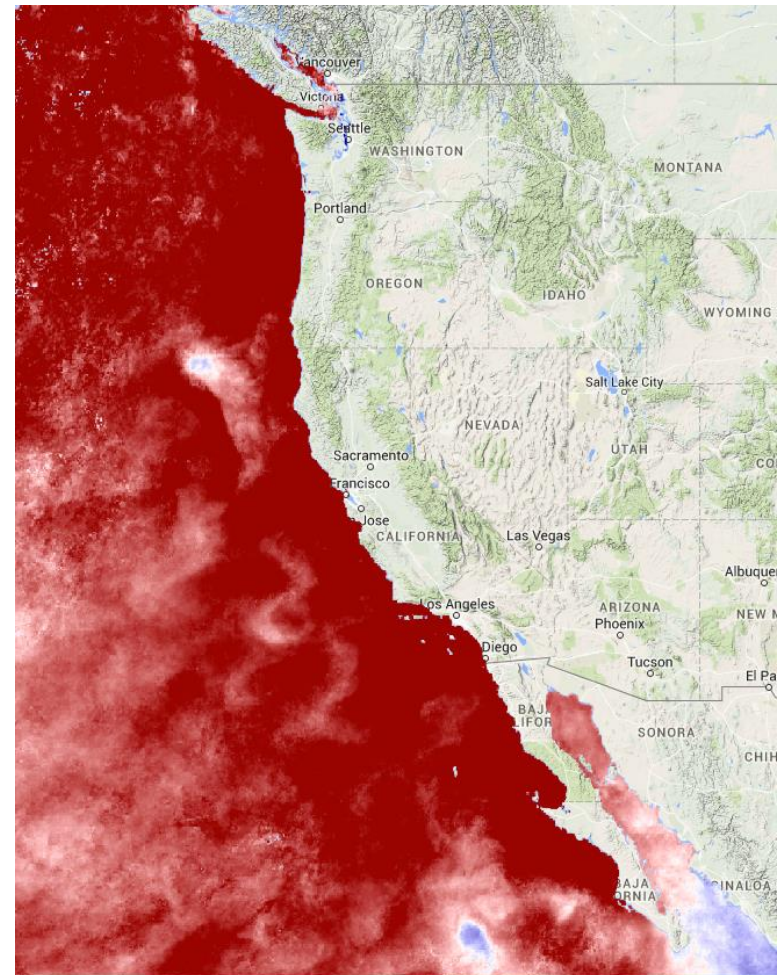
## Columbia River and Pacific Coastal Basins Mountain Snowpack as of May 1, 2015

Percent of  
1981-2010 Median (US)  
1981-2010 Average (Canada)

- > 180
- 150 - 180
- 130 - 149
- 110 - 129
- 90 - 109
- 70 - 89
- 50 - 69
- 25 - 49
- < 25

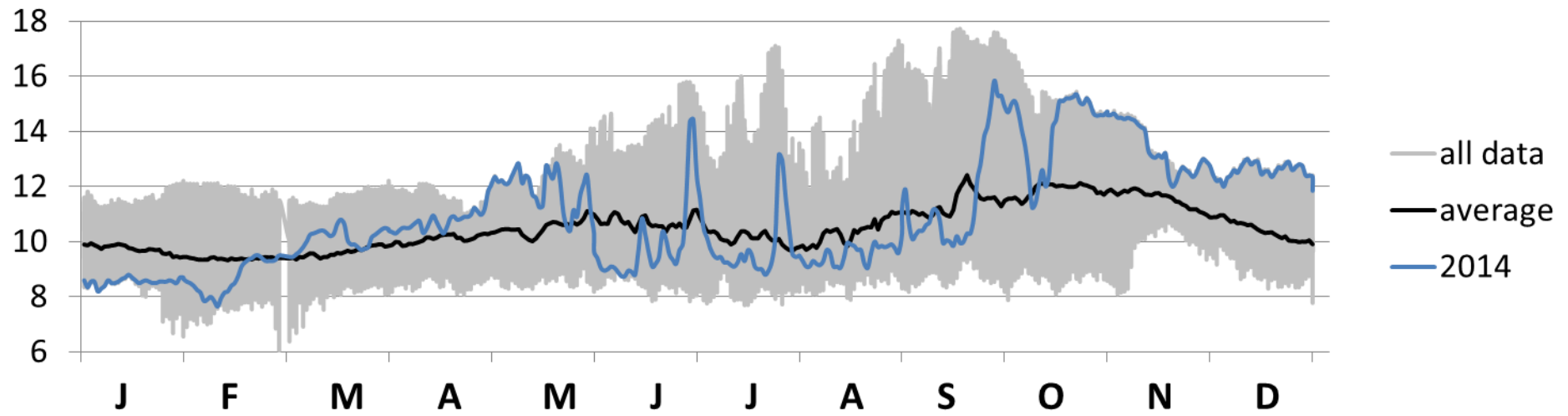


Prepared by:  
USDA Natural Resources Conservation Service  
National Water and Climate Center  
Portland, Oregon  
<http://www.wcc.nrcs.usda.gov>  
Created: 5 May 2015 11:02



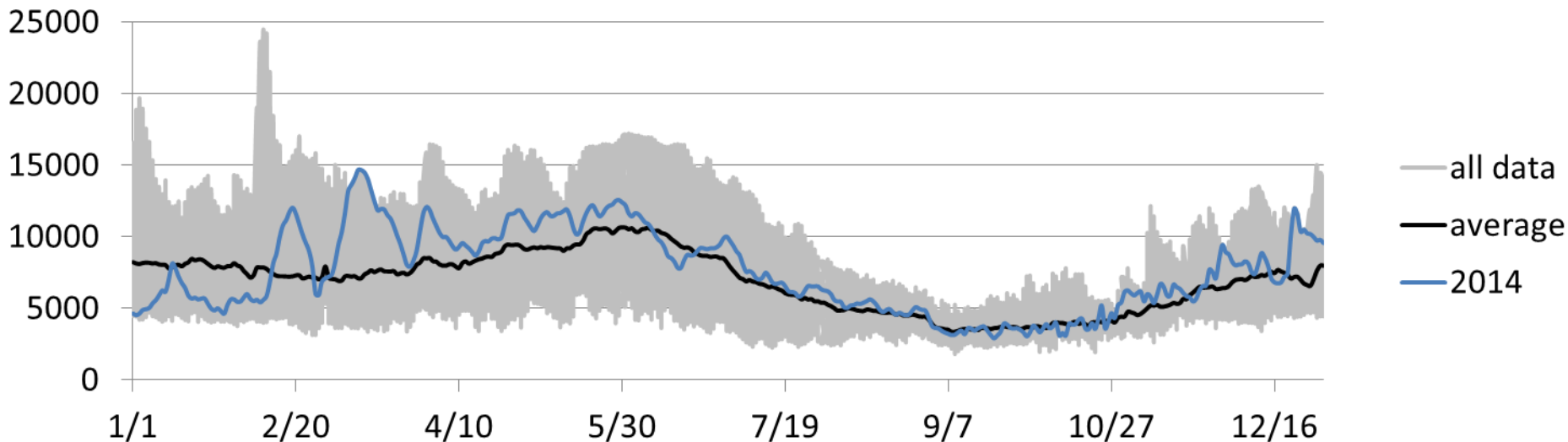
# 2014-2015 The Blob - warm ocean and river

Estuary-Ocean Temp (°C) 2014

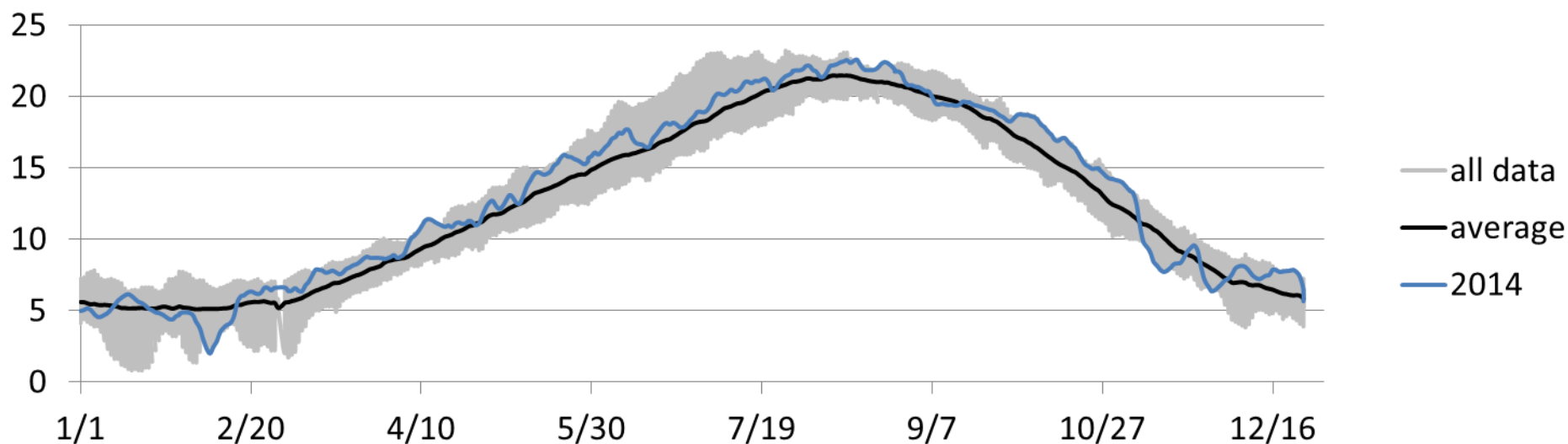


# 2014-2015 The Blob - warm ocean and river

## BAT Discharge (m<sup>3</sup>/s) - 2014



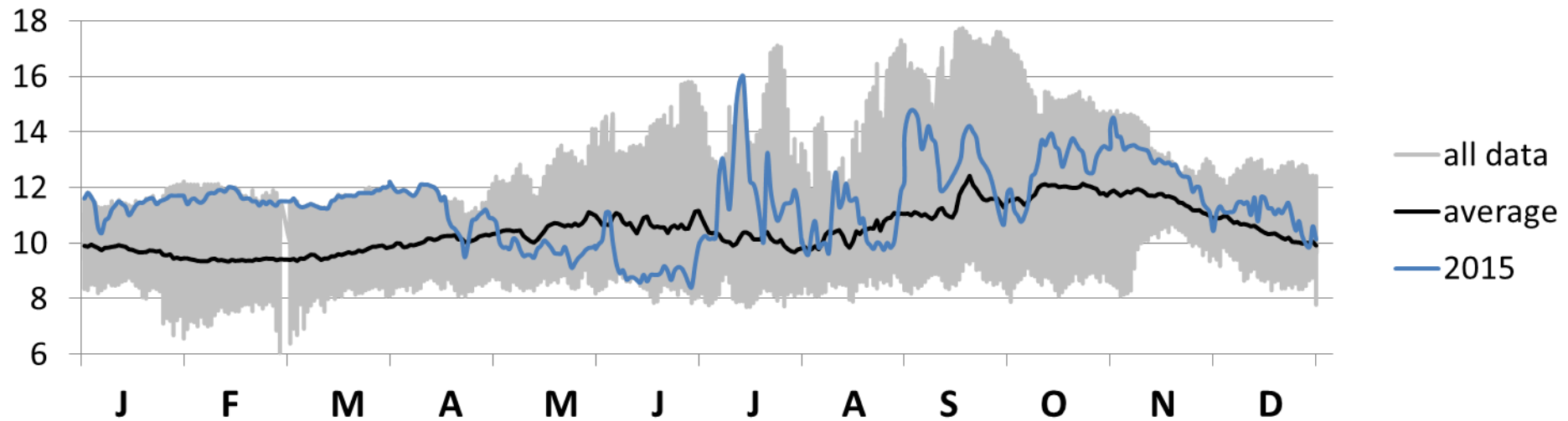
## Mainstem Temp (°C) - 2014





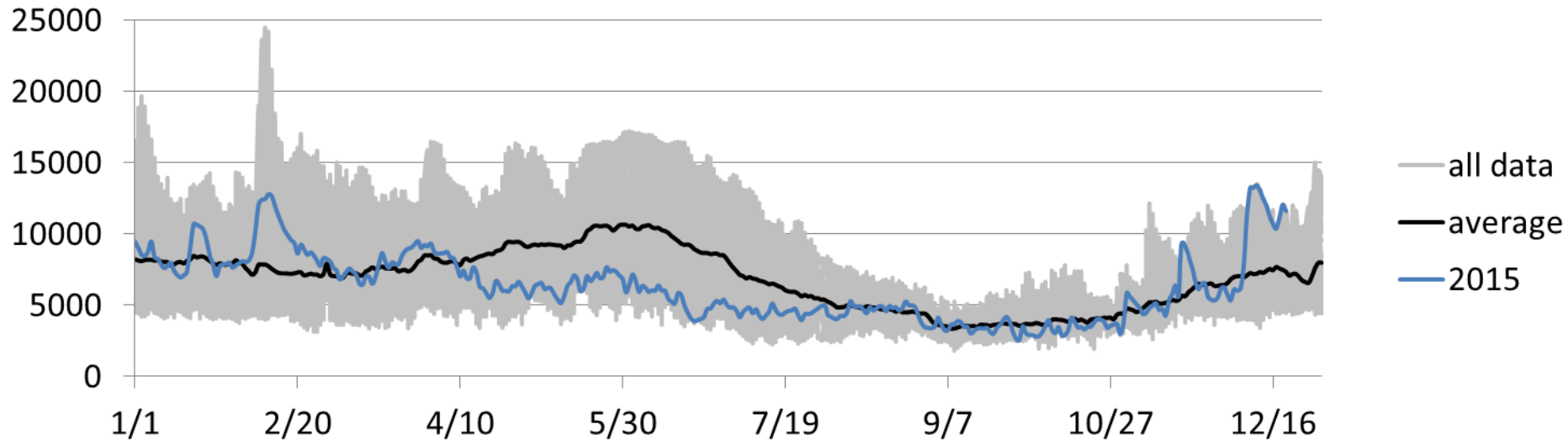
# 2014-2015 The Blob - warm ocean and river

## Estuary-Ocean Temp (°C) 2015

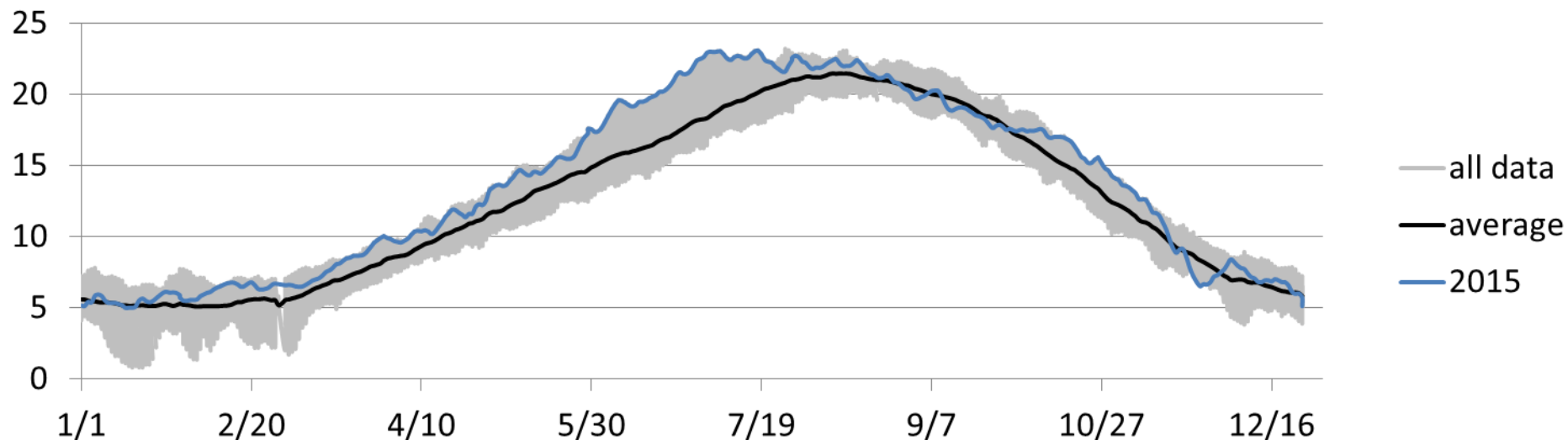


# 2014-2015 The Blob - warm ocean and river

## BAT Discharge (m<sup>3</sup>/s) - 2015



## Mainstem Temp (°C) - 2015



# Summary of Estuary Conditions

Year	Event	Ocean end member	River end member
1997	El Nino	Warm	Cold
2001	Small snowpack	Cold	Average
2005	Delayed upwelling	Warm	Average
2014	Upwelling - blob	Cold - Warm	Average
2015	Blob + small snowpack + unusual warm weather in spring	Warm	Warm

# Water temperature and related variable metrics

**EOT-US:** # days during upwelling season (May-Sept) the estuary-ocean temp was > 1 STD warmer than average for 1997-2015

**EOT-DS:** # days during downwelling season (Oct-Apr) the estuary-ocean temp was > 1 STD warmer than average for 1997-2015

**Upwelling:** a measure of seasonal upwelling inferred from cumulative wind stress on Oregon coast (1985-2015) (Pierce and Barth)

**R-temp:** # days that average river temp was >19 °C between May –Sept (data 1992-2017)

**Freshet:** cumulative river discharge ( $\text{m}^3 \times 10^{10}$ ) for May – Aug (1964-2017) (Bonneville Dam)

**April CRB SWE:** % of median (1981-2010) snow water equivalent across all Columbia River sub-basins (1981-2010) (National water and climate center, USDA)

**April CRB Precip:** % of median (1981-2010) cumulative precipitation across all Columbia River sub-basins (National water and climate center, USDA)

**PDX air:** # of days daily minimum air temperature > 58 °F (1981-2017) ([www.ncdc.noaa.gov](http://www.ncdc.noaa.gov))



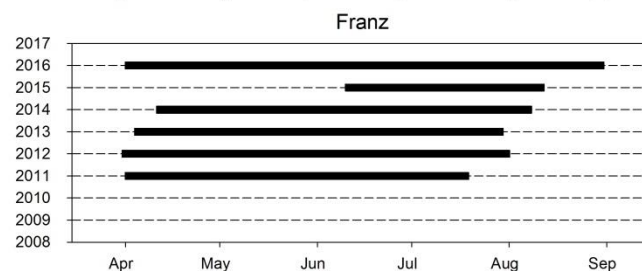
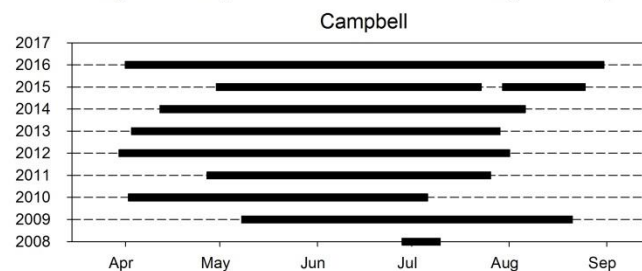
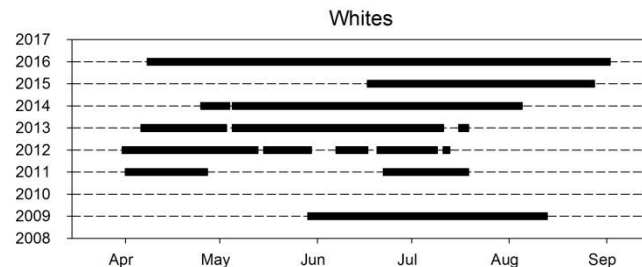
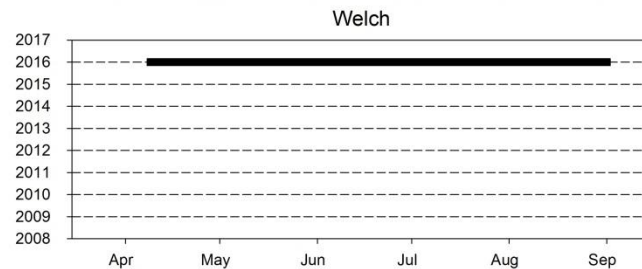
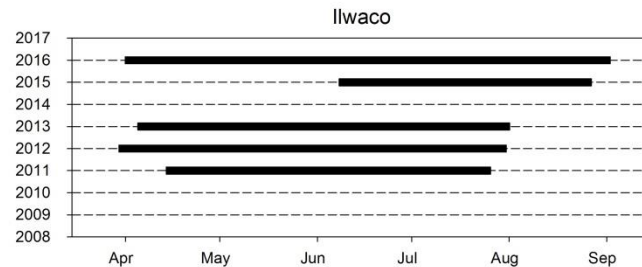
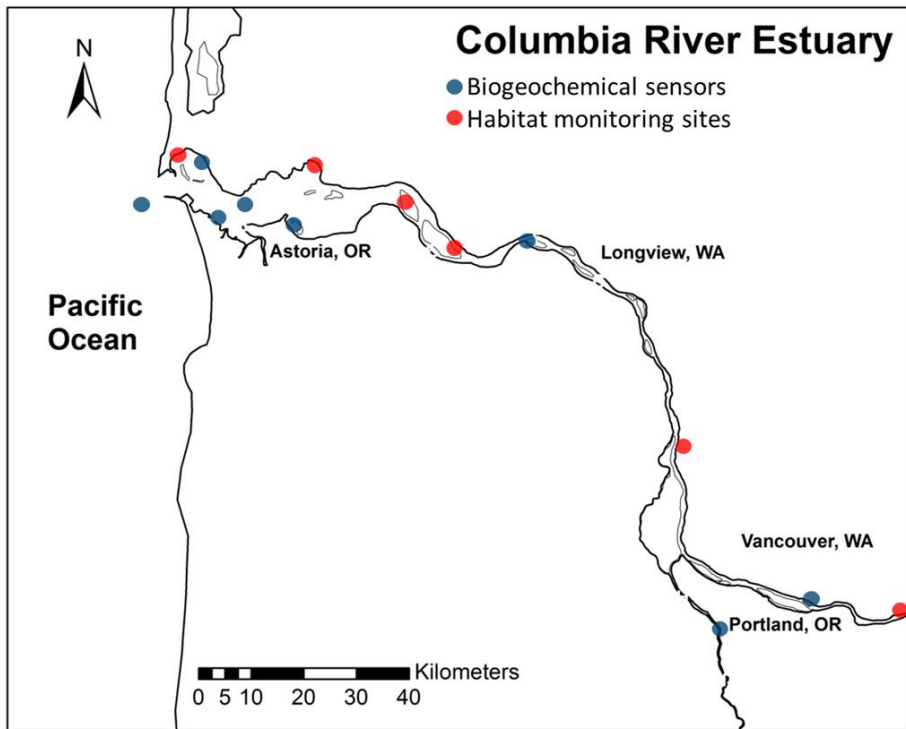
# Variables related to water temperature

Year	EOT-US	EOT-DS	Upwelling	R-Temp	Freshet	CRB SWE	CRB Precip	PDX air temp
<b>Avg</b>	24 ± 13	25 ± 36	-3.0 ± 0.8	76 ± 12	7.0 ± 2.0	105 ± 29	102 ± 19	37 ± 14
<b>1997</b>	54 (2.3)	56 (0.9)	-1.7 (1.5)	69 (-0.5)	10.7 (1.9)	163 (2.0)	147 (2.4)	52 (1.07)
<b>1998</b>	13 (-0.8)	90 (1.8)	-3.0 (-0.0)	85 (0.76)	7.5 (0.3)	99 (-0.1)	94 (-0.3)	48 (0.79)
<b>1999</b>	2 (-1.7)	0 (-0.6)	-2.9 (0.0)	58 (-1.4)	8.3 (0.7)	157 (1.8)	128 (1.4)	34 (-0.2)
<b>2000</b>	28 (0.3)	5 (-0.5)	-2.7 (0.3)	81 (0.44)	6.1 (-0.5)	114 (0.4)	102 (0.1)	31 (-0.4)
<b>2001</b>	22 (-0.1)	0 (-0.6)	-2.7 (0.3)	86 (0.85)	3.6 (-1.8)	60 (-1.4)	60 (-2.0)	24 (-0.9)
<b>2002</b>	9 (-1.1)	0 (-0.6)	-3.8 (-1.0)	73 (-0.2)	7.2 (0.1)	126 (0.8)	108 (0.4)	28 (-0.6)
<b>2003</b>	11 (-1.0)	22 (-0.0)	-3.4 (-0.5)	82 (0.52)	6.3 (-0.4)	88 (-0.5)	92 (-0.4)	44 (0.50)
<b>2004</b>	33 (0.7)	1 (-0.6)	-1.7 (1.5)	81 (0.44)	6.1 (-0.5)	95 (-0.3)	93 (-0.3)	51 (1.00)
<b>2005</b>	42 (1.4)	23 (-0.0)	-3.3 (-0.5)	79 (0.27)	5.6 (-0.7)	59 (-1.5)	72 (-1.4)	38 (0.07)
<b>2006</b>	23 (-0.1)	0 (-0.6)	-5.1 (-2.7)	77 (0.11)	7.4 (0.2)	135 (1.1)	118 (0.9)	33 (-0.2)
<b>2007</b>	35 (0.8)	3 (-0.6)	-3.0 (-0.0)	77 (0.11)	6.1 (-0.5)	83 (-0.7)	103 (0.1)	40 (0.21)
<b>2008</b>	13 (-0.8)	7 (-0.4)	-3.6 (-0.8)	72 (-0.2)	7.7 (0.4)	141 (1.3)	113 (0.6)	36 (-0.0)
<b>2009</b>	20 (-0.3)	0 (-0.6)	-2.8 (0.1)	85 (0.76)	6.3 (-0.3)	112 (0.3)	99 (-0.0)	54 (1.22)
<b>2010</b>	23 (-0.1)	18 (-0.1)	-2.7 (0.3)	47 (-2.3)	6.3 (-0.4)	77 (-0.9)	77 (-1.1)	27 (-0.7)
<b>2011</b>	13 (-0.8)	26 (0.0)	-2.9 (0.1)	59 (-1.3)	10.4 (1.7)	130 (0.9)	121 (1.1)	38 (0.07)
<b>2012</b>	15 (-0.7)	0 (-0.6)	-3.2 (-0.3)	59 (-1.3)	9.2 (1.2)	119 (0.5)	109 (0.5)	38 (0.07)
<b>2013</b>	42 (1.4)	14 (-0.2)	-2.9 (0.1)	84 (0.68)	6.7 (-0.1)	88 (-0.5)	96 (-0.2)	57 (1.43)
<b>2014</b>	31 (0.5)	73 (1.3)	-3.4 (-0.5)	86 (0.85)	7.3 (0.1)	103 (-0.0)	97 (-0.1)	60 (1.65)
<b>2015</b>	33 (0.7)	134 (3.0)	-4.4 (-1.7)	102 (2.15)	4.7 (-1.1)	44 (-2.0)	92 (-0.4)	66 (2.08)
<b>2016</b>	n/a	n/a	-3.6	85 (0.72)	5.5 (-0.7)	105 (0.03)	114 (0.61)	49 (0.86)
<b>2017</b>	n/a	n/a	-3.5	78 (0.15)	8.7 (0.9)	120 (0.55)	138 (1.85)	45 (0.57)

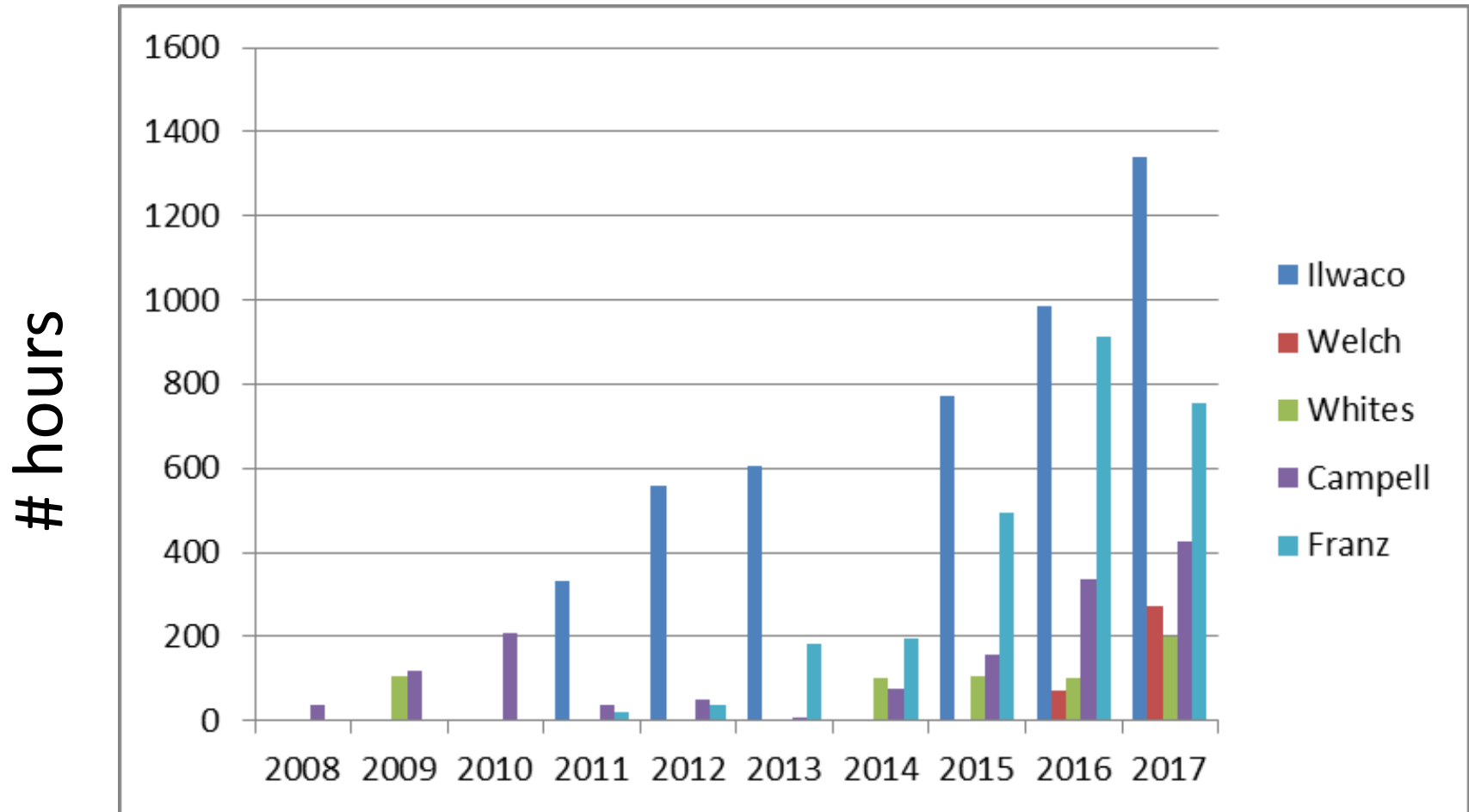
 Record year  
 Runner up

} 2015 ranked high in 5 of 8 categories

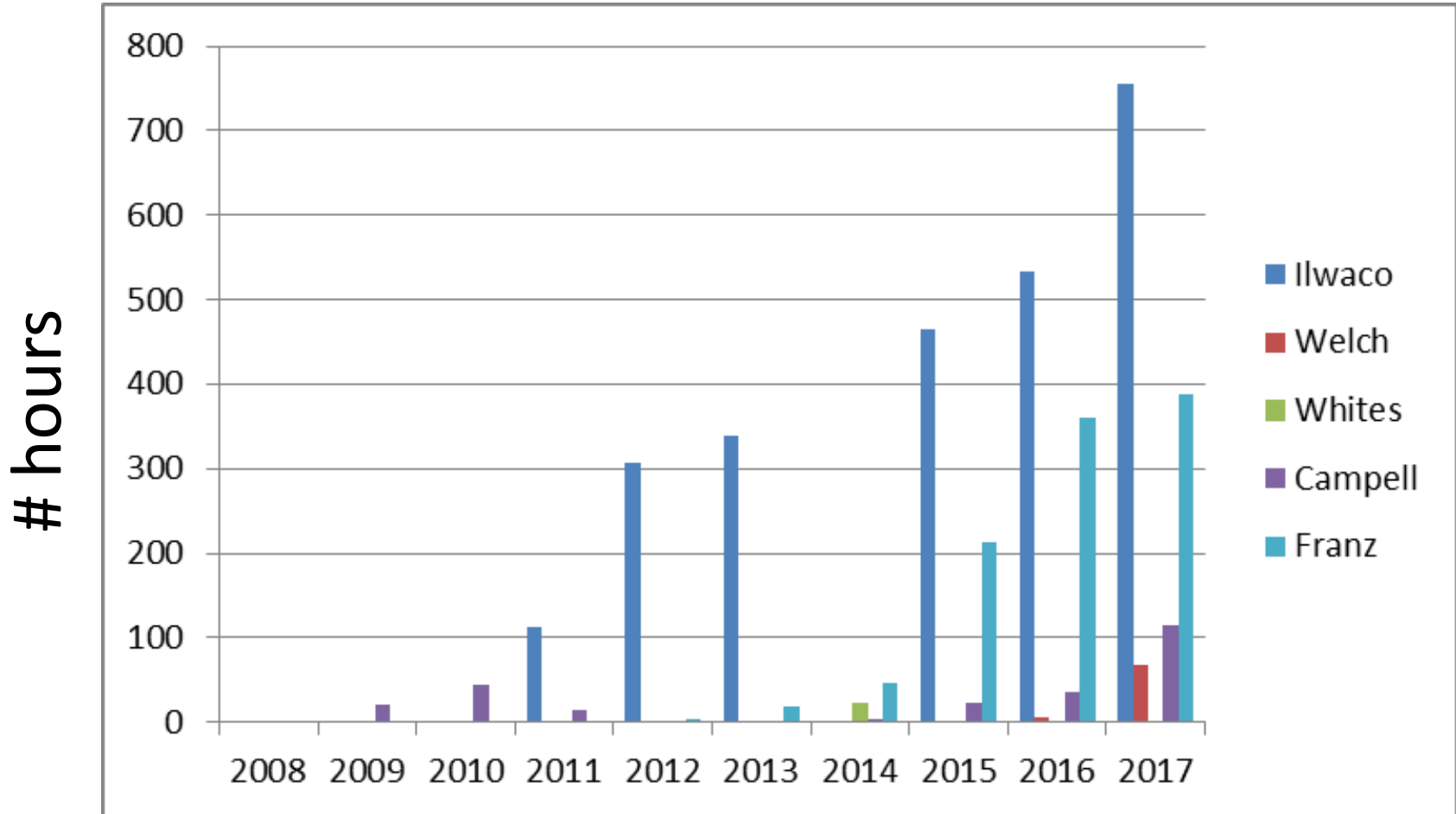
# Water quality time series data from off-channel sites



# Low dissolved oxygen - # hours < 6 mg/L

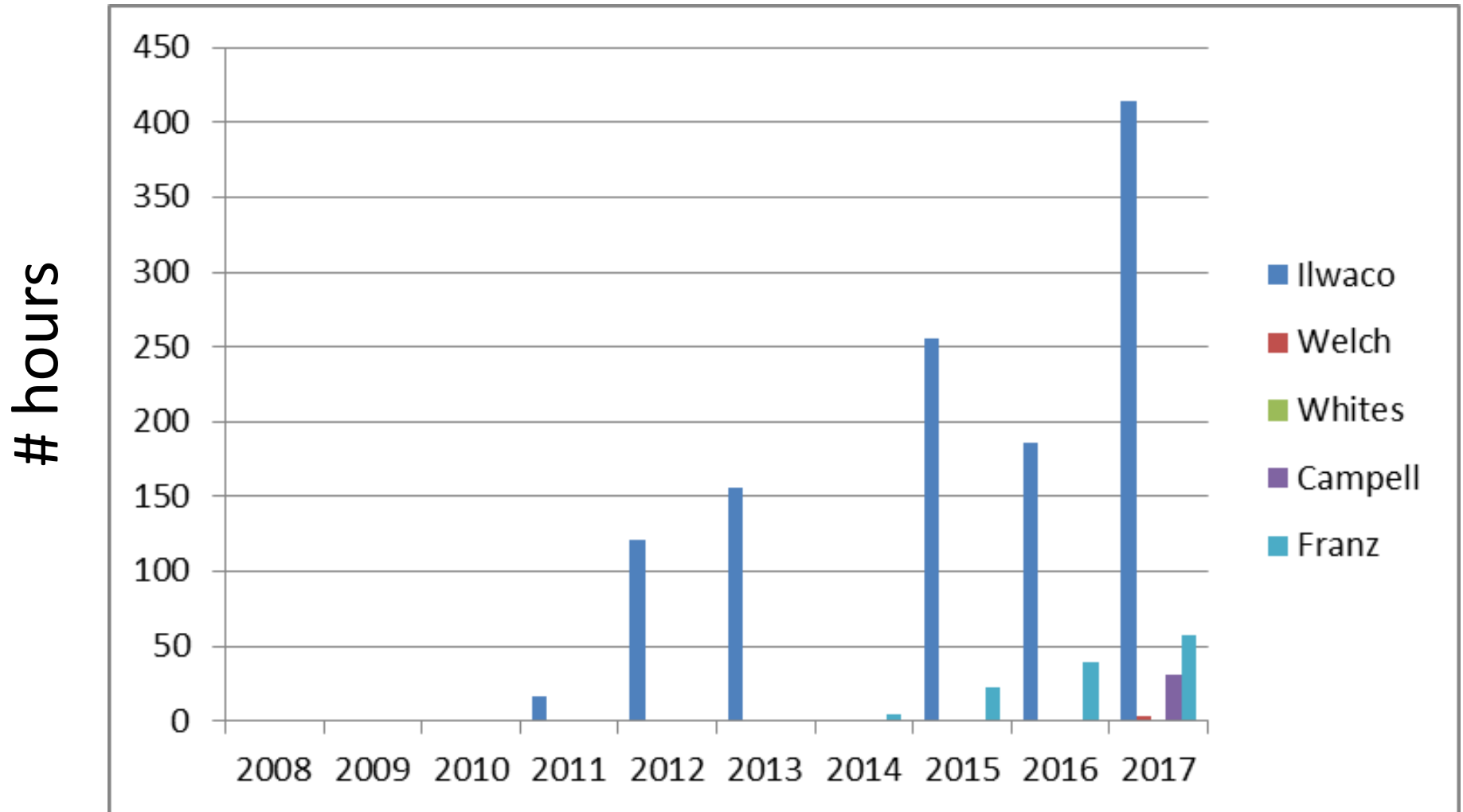


# DO - # hours < 4 mg/L





# DO - # hours < 2 mg/L



# Acknowledgments

Tawnya Peterson, OHSU-PSU School of Public Health  
Catherine Corbett, Lower Columbia Estuary Partnership

Charles Seaton,  
Sarah F. Riseman,  
António M. Baptista



Center for Coastal Margin  
Observation & Prediction,  
OHSU



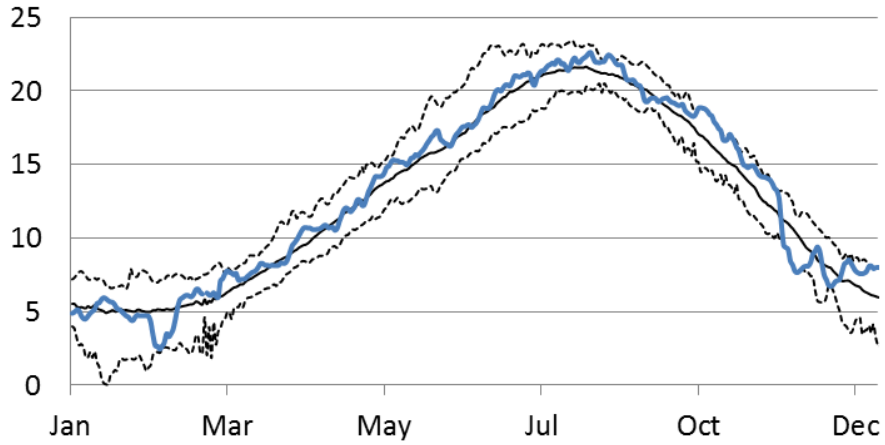
OREGON  
HEALTH & SCIENCE  
UNIVERSITY



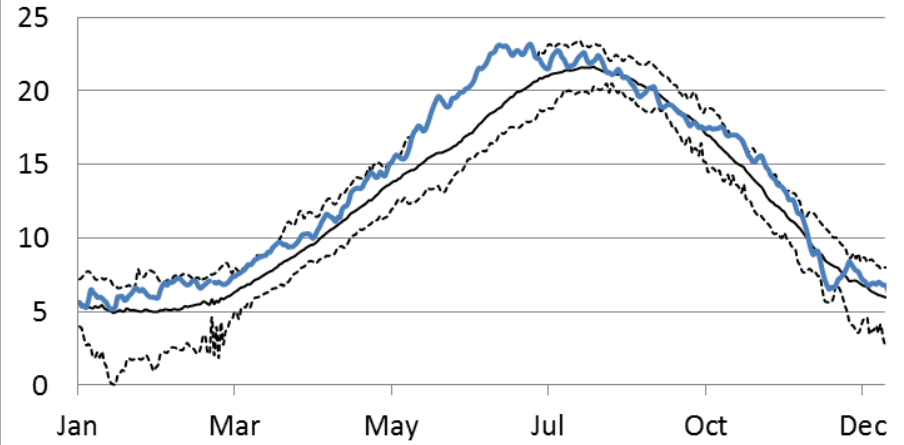
SCHOOL OF  
**PUBLIC HEALTH**

# Mainstem Temperature

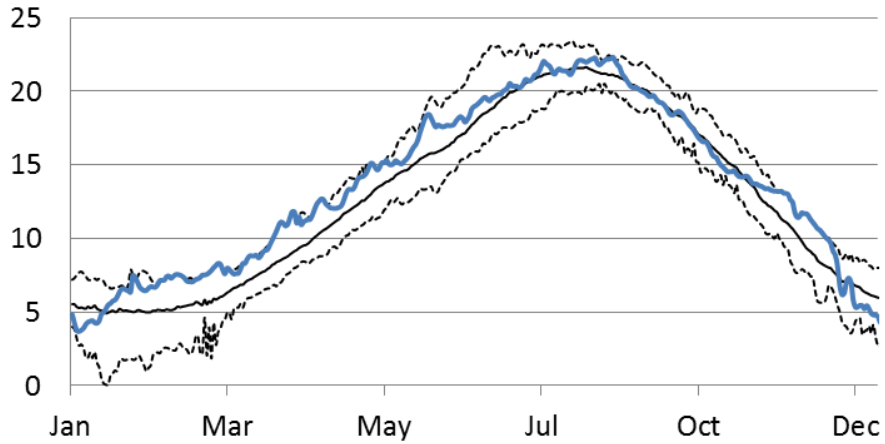
**2014**



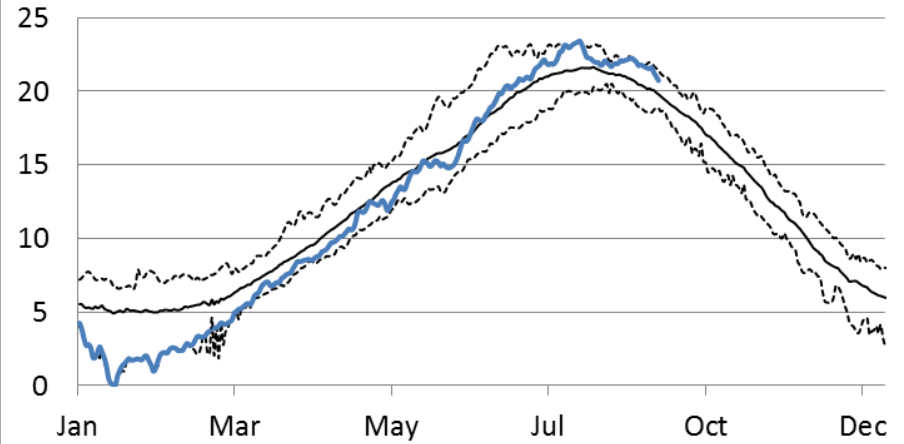
**2015**



**2016**

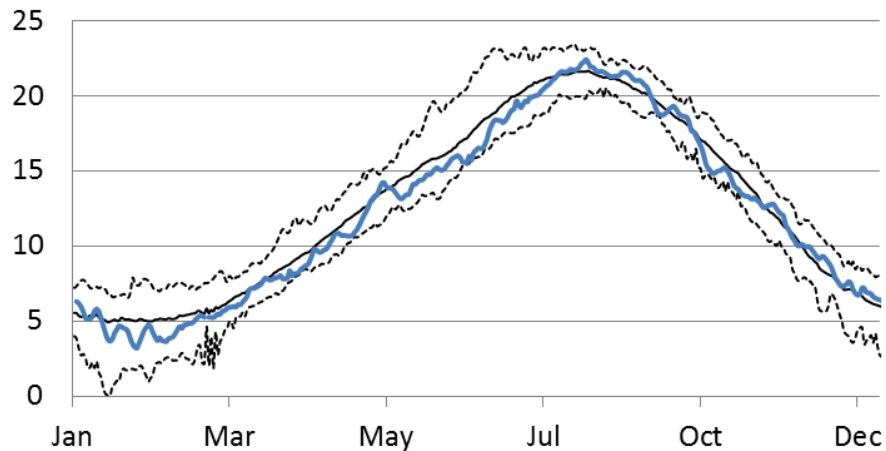


**2017**

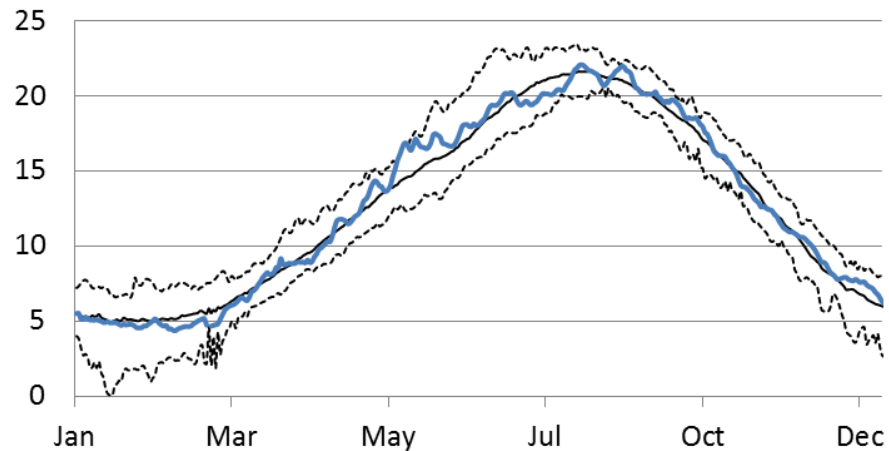


# Mainstem Temperature

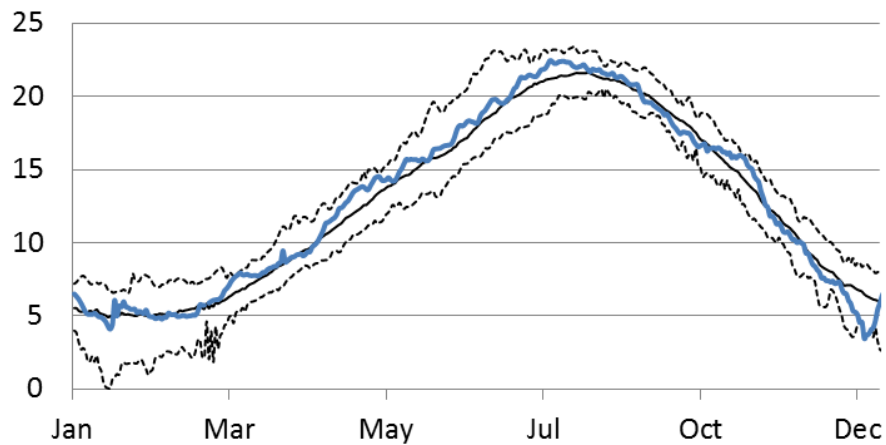
**1997**



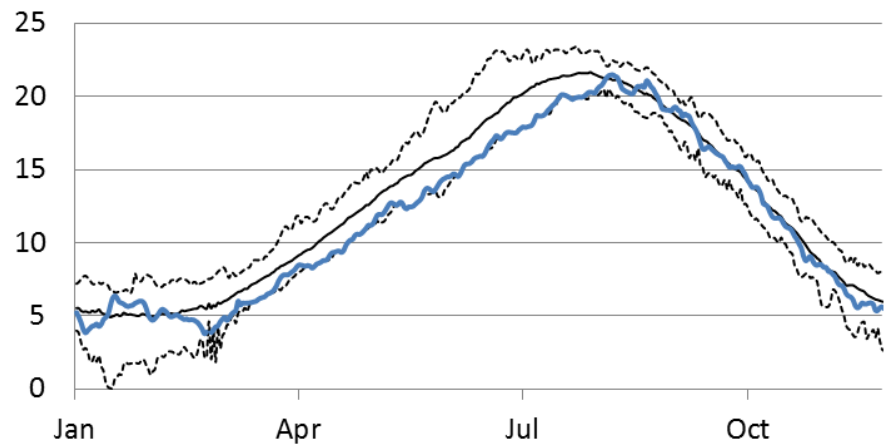
**2001**



**2005**



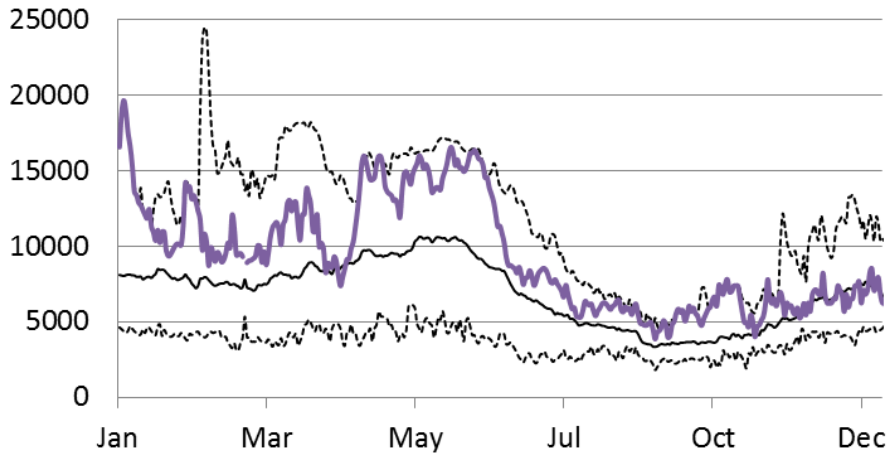
**2011**



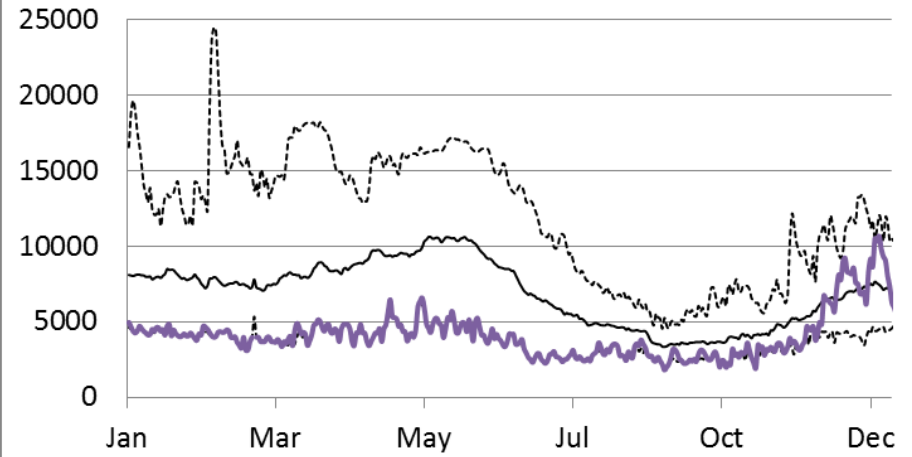


# River Discharge at BAT

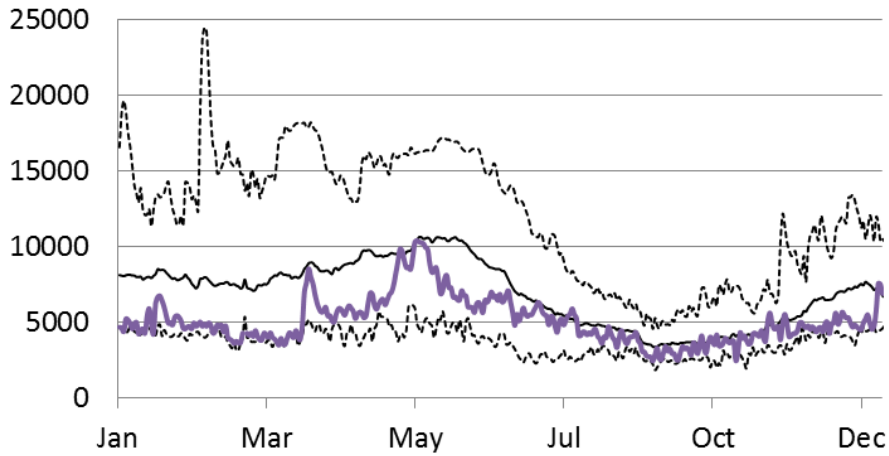
**1997**



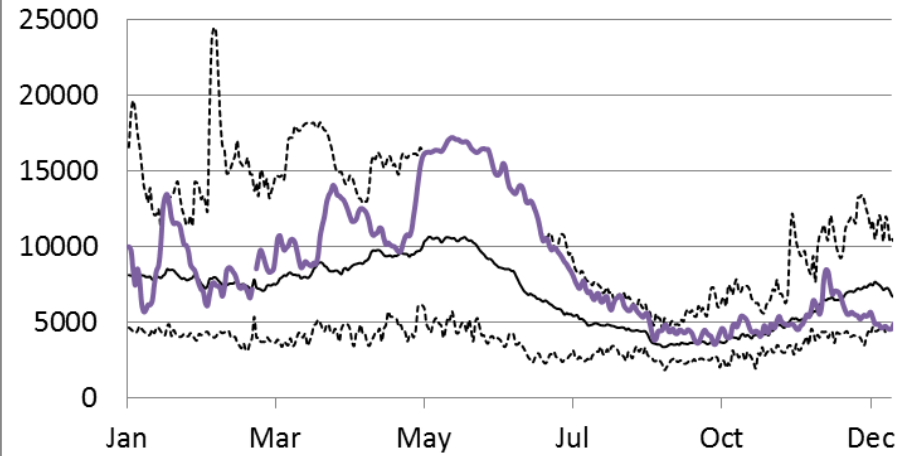
**2001**



**2005**

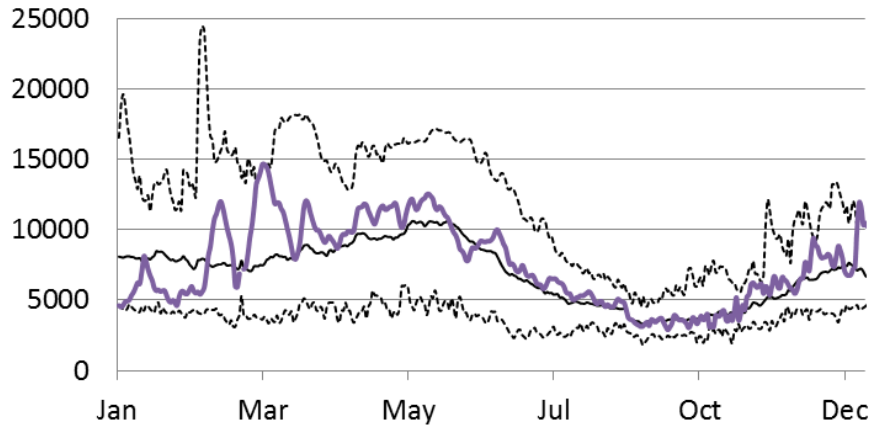


**2011**

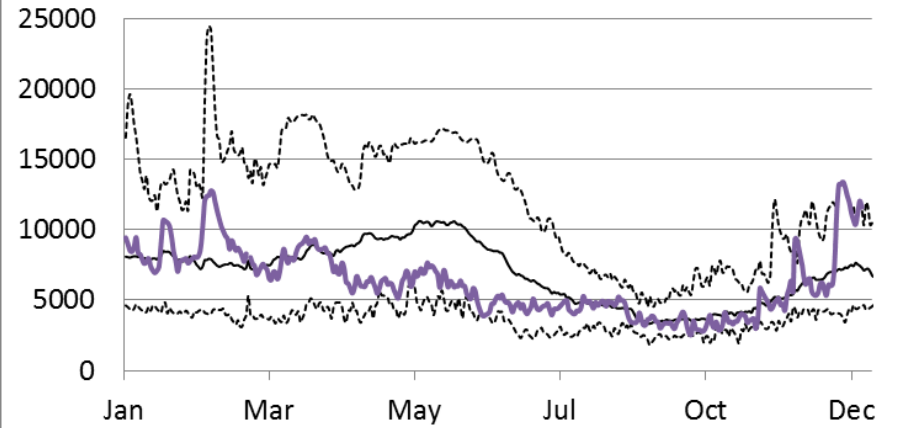


# River Discharge at BAT

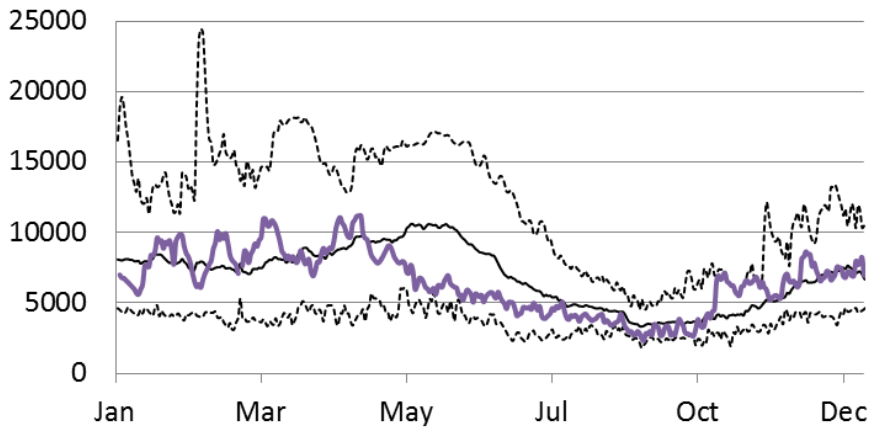
**2014**



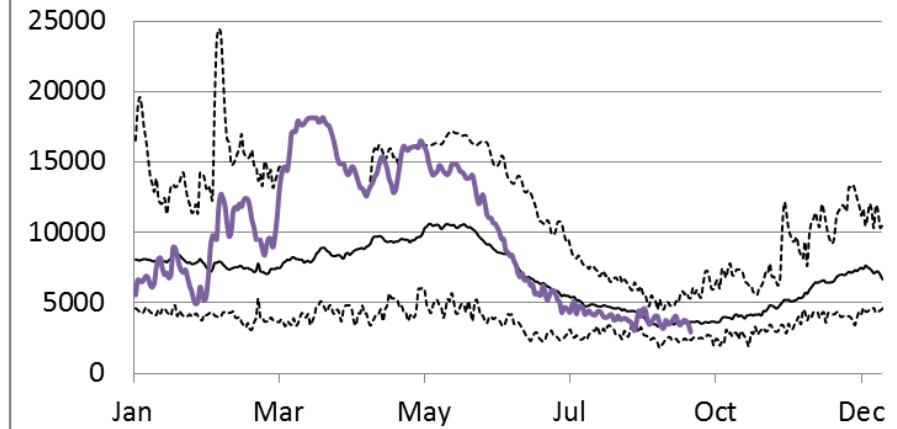
**2015**



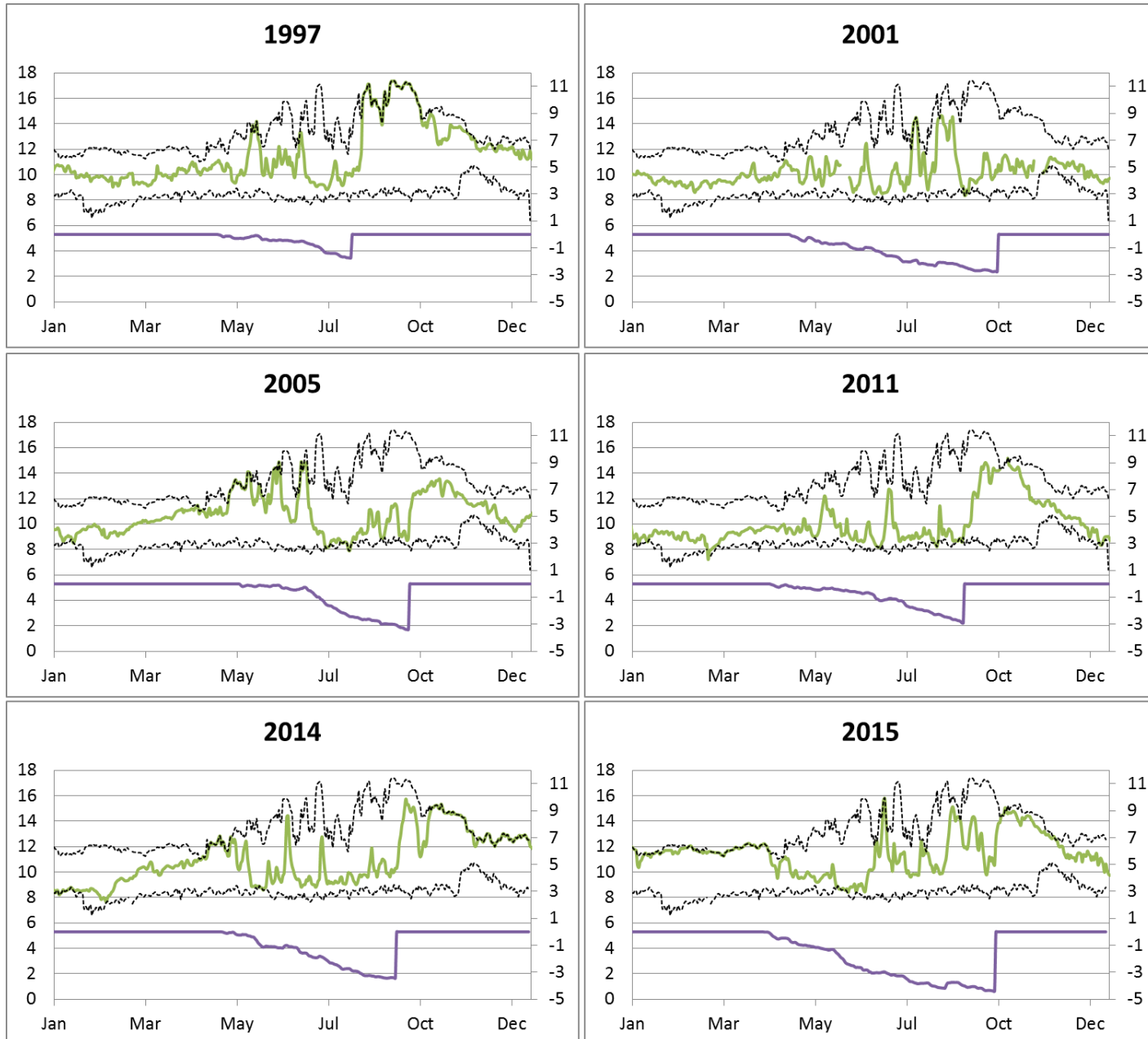
**2016**



**2017**



# Estuary-Ocean Temperature and Cumulative Upwelling



# Off-channel habitats 2015 vs 2017

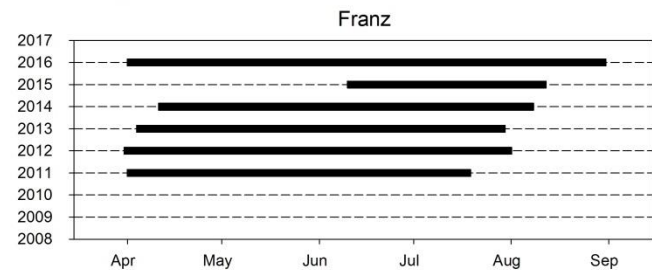
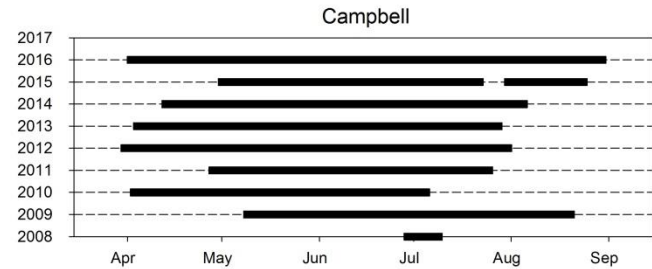
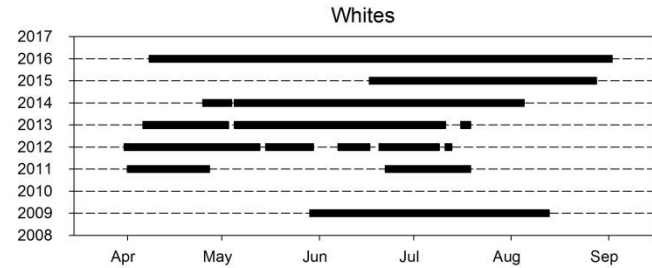
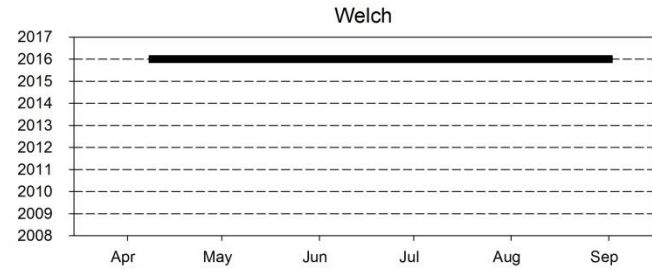
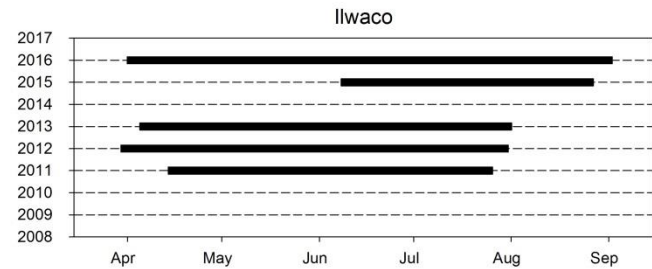
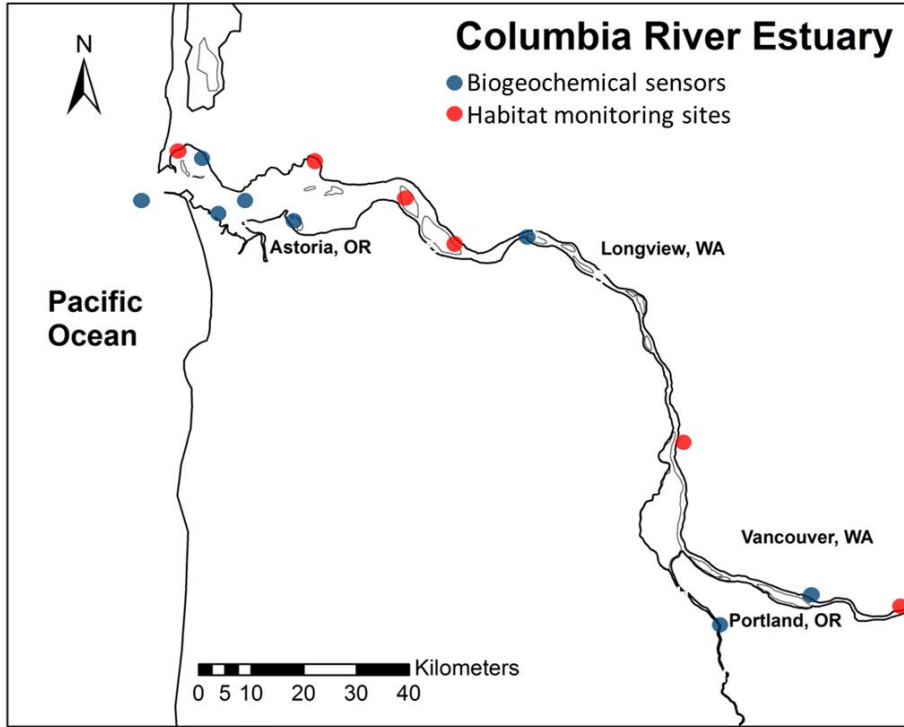




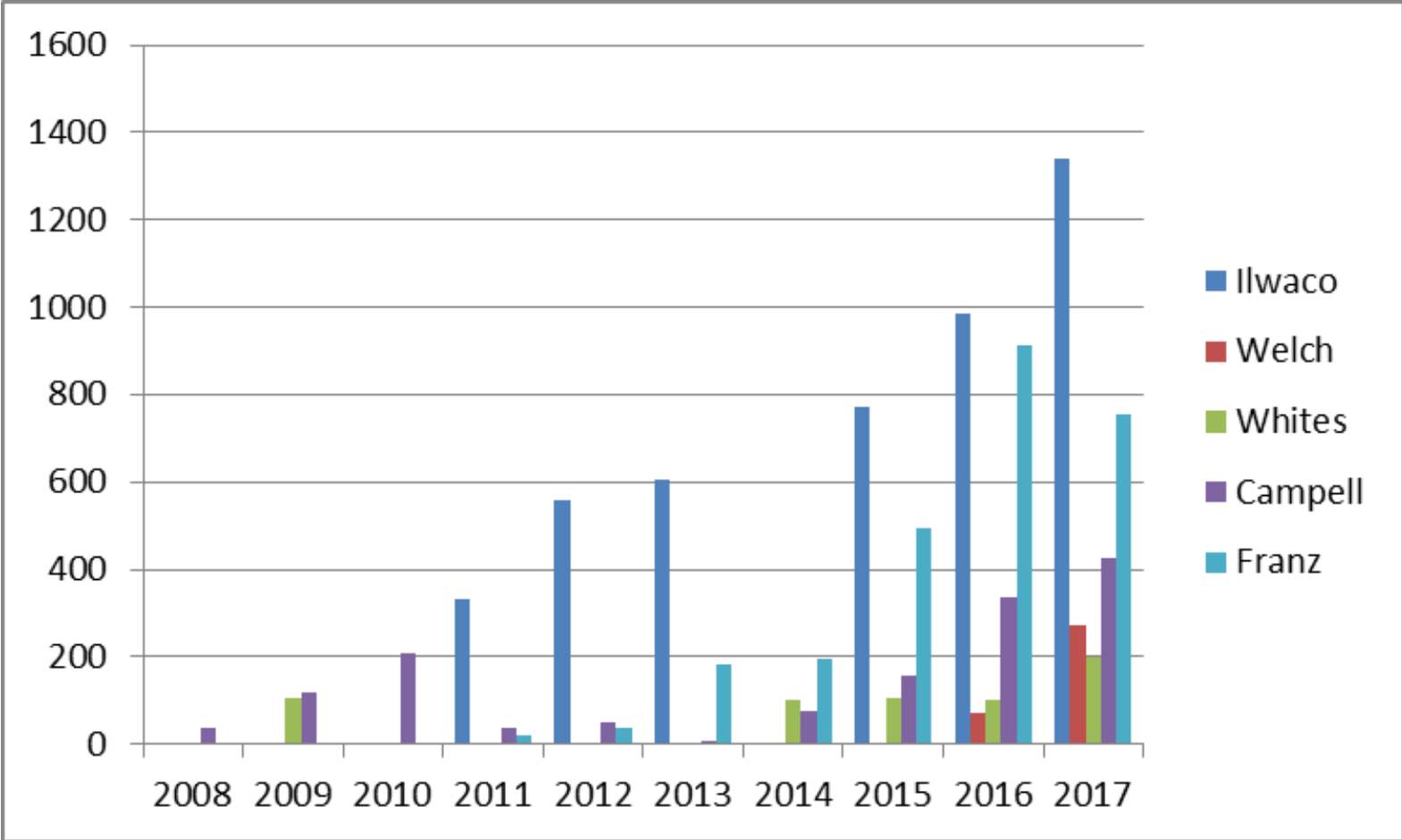
# Off-channel habitats 2015-2017



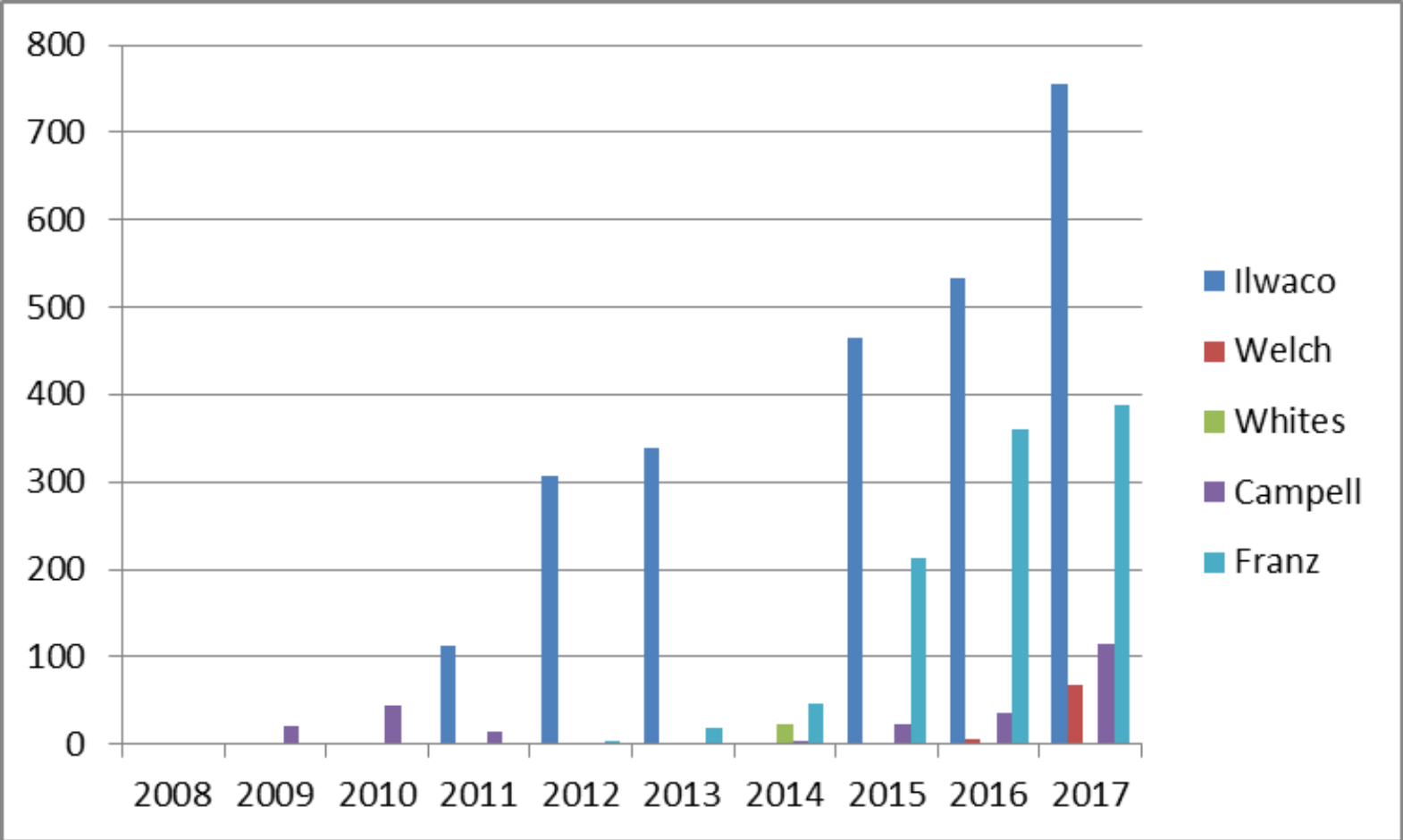
# Water quality time series data from off-channel sites



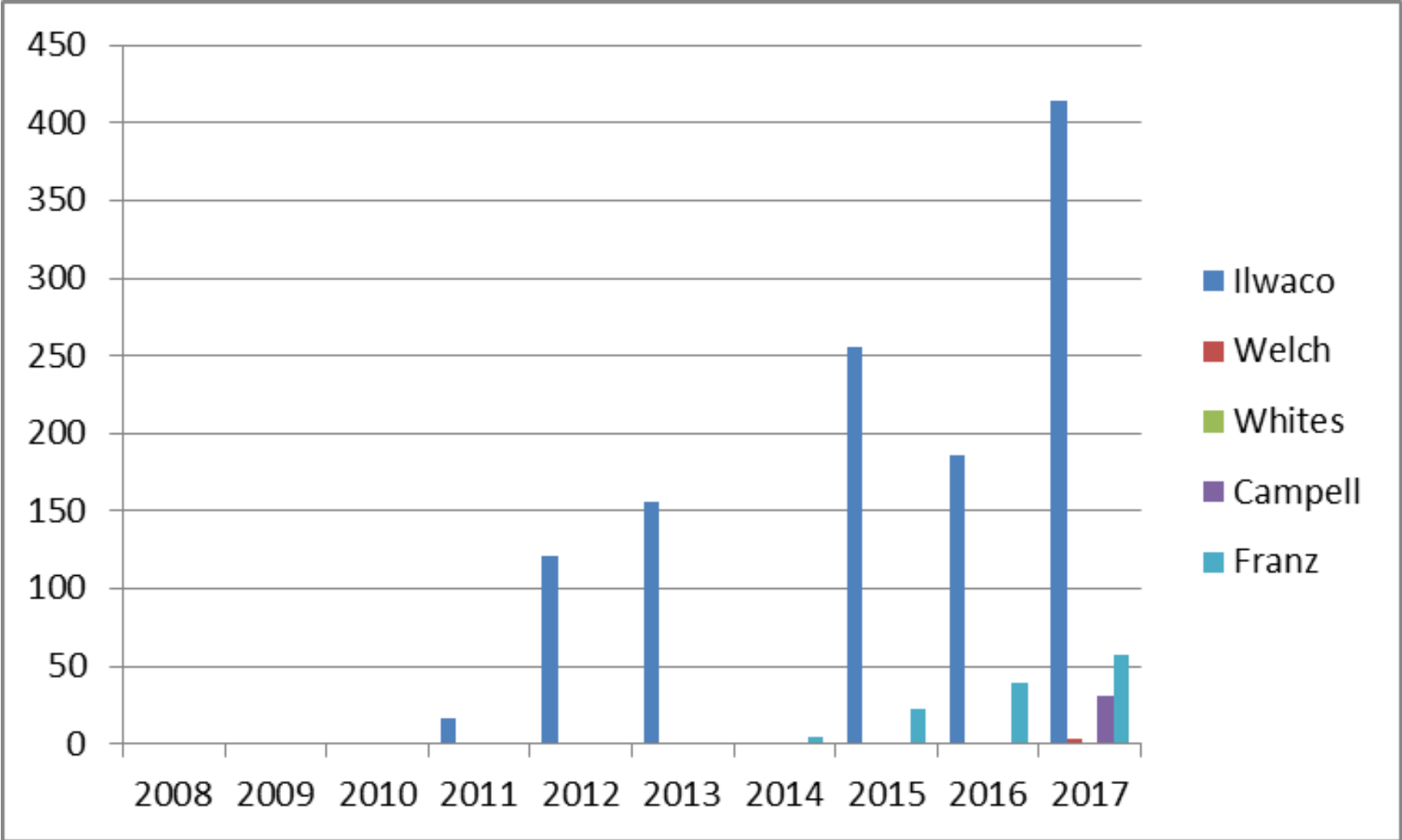
# DO - # hours < 6 mg/L



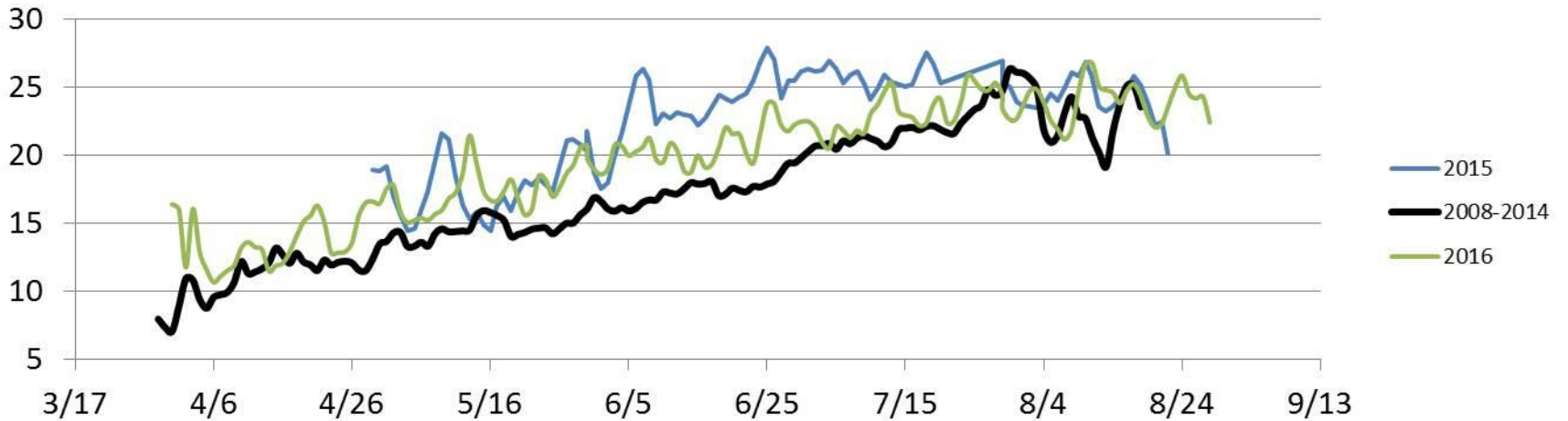
# DO - # hours < 4 mg/L



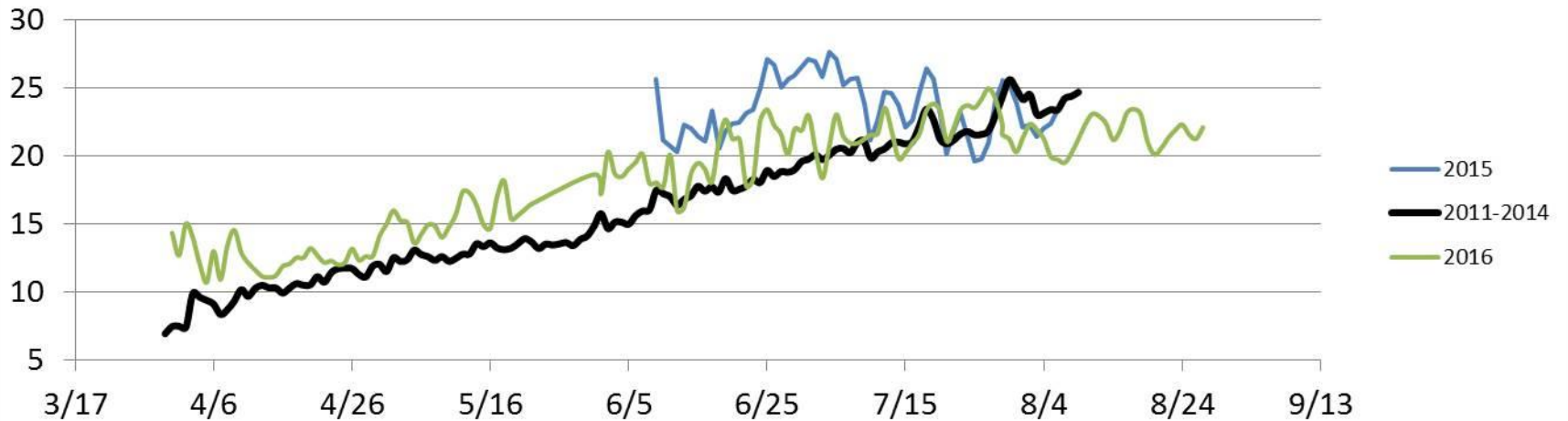
# DO - # hours < 2 mg/L



### Campbell - Daily Avg Temp (°C)

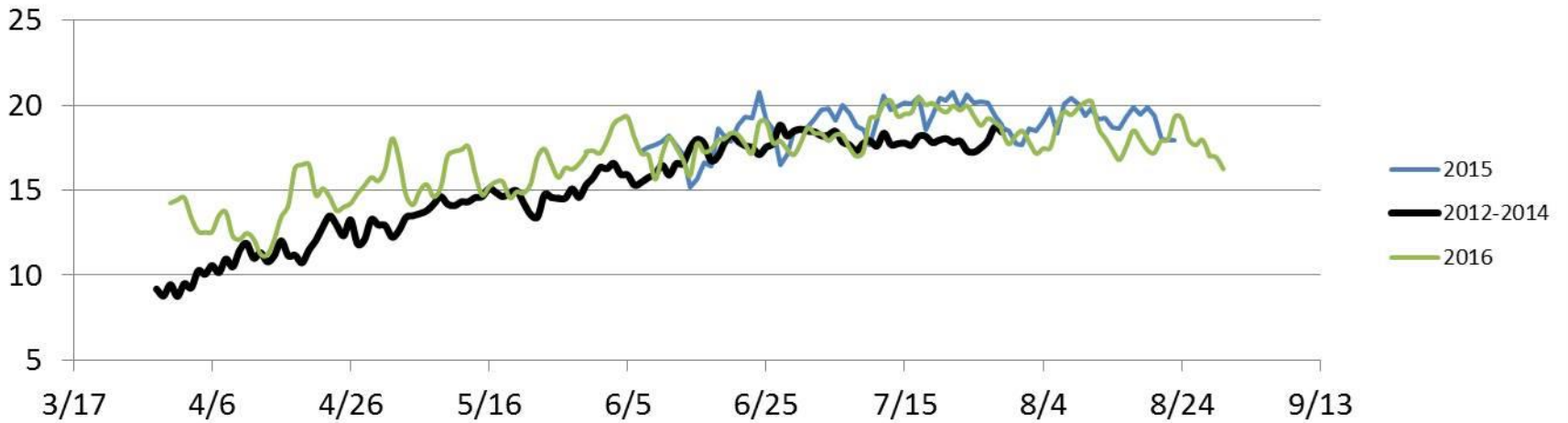


### Franz - Daily Avg Temp (°C)

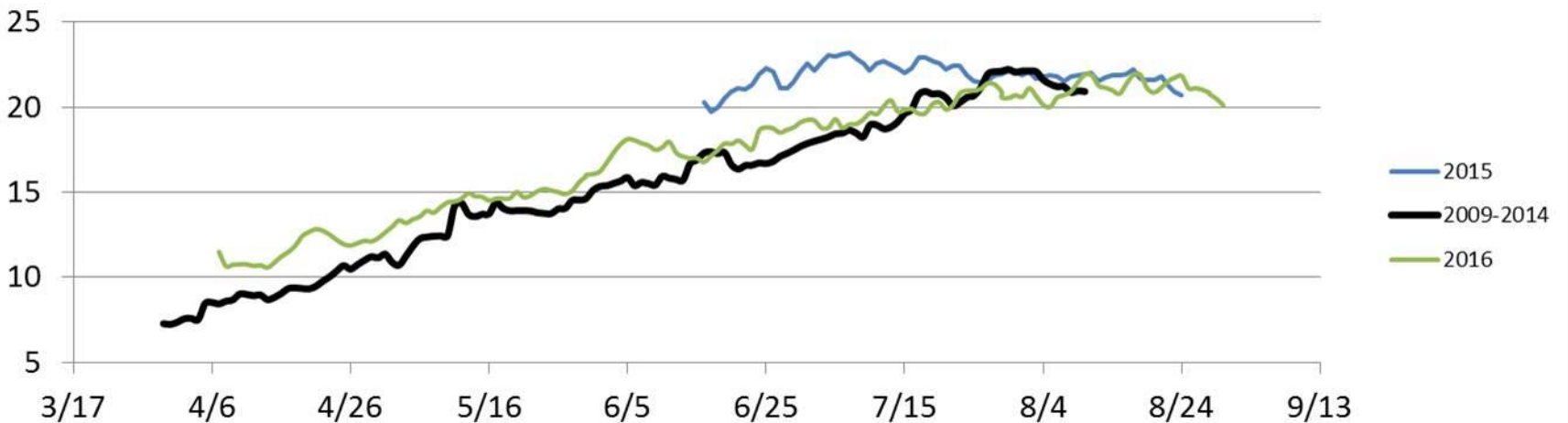




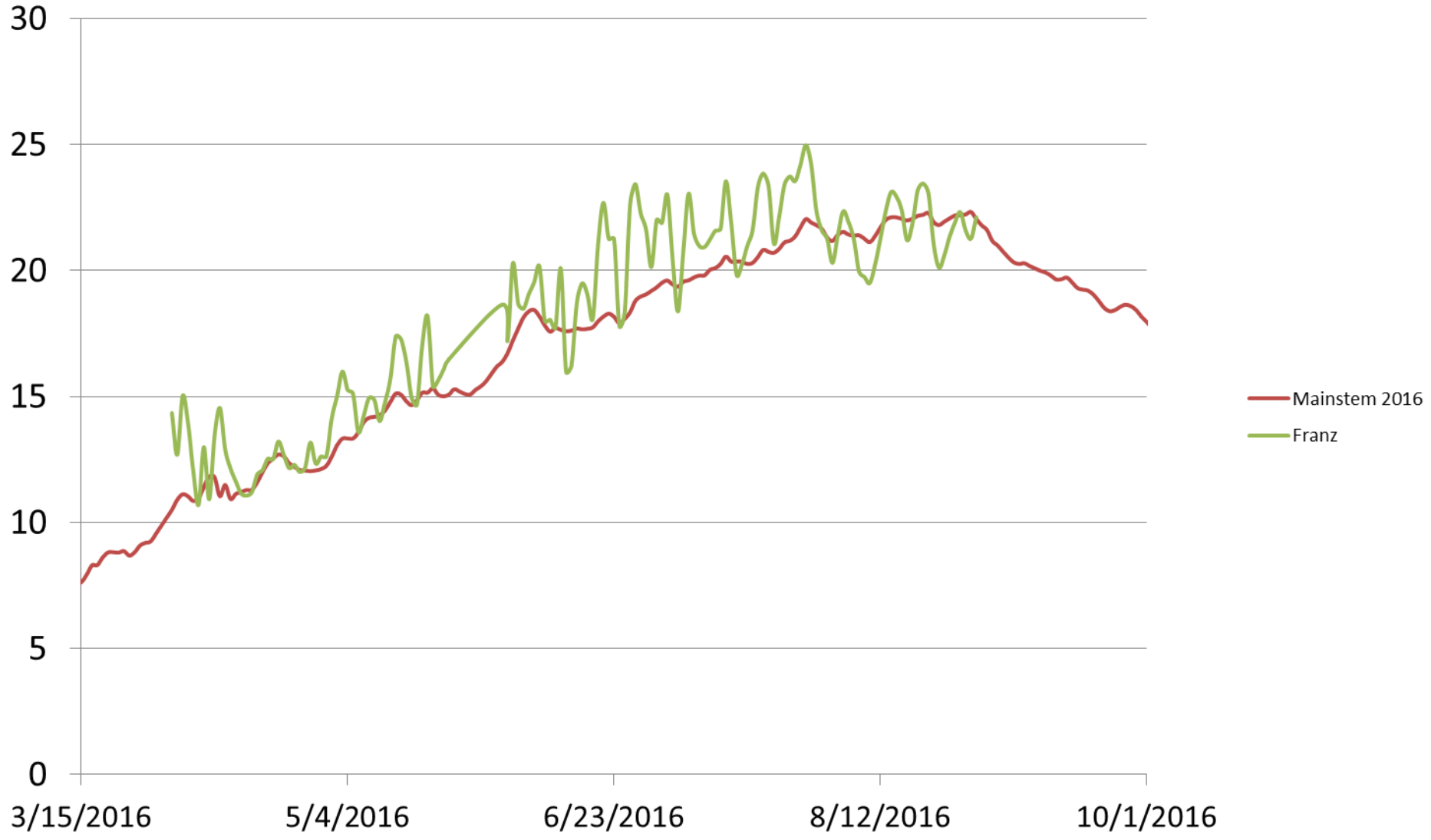
### Ilwaco - Daily Avg Temp (°C)



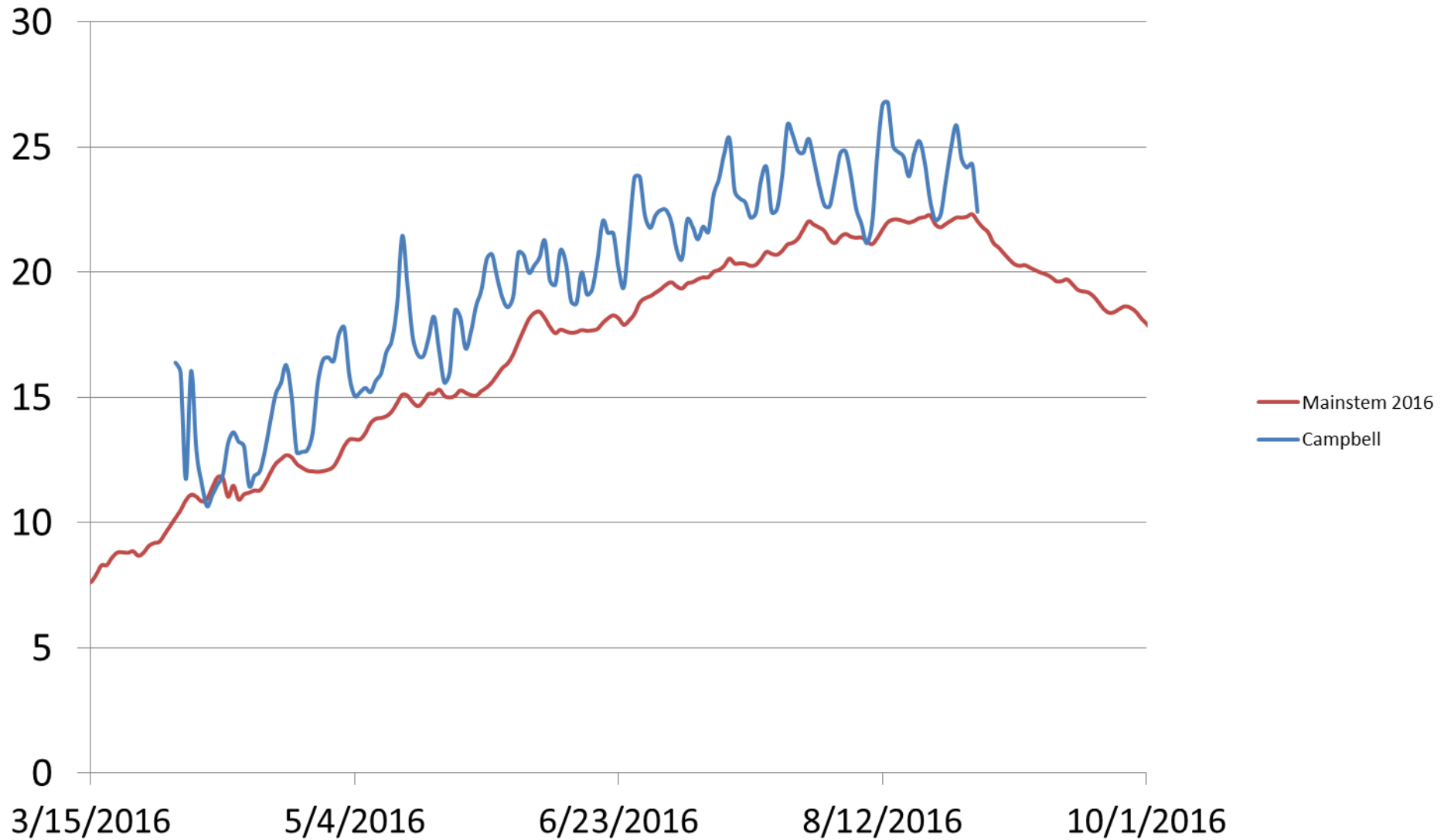
### Whites - Daily Avg Temp (°C)



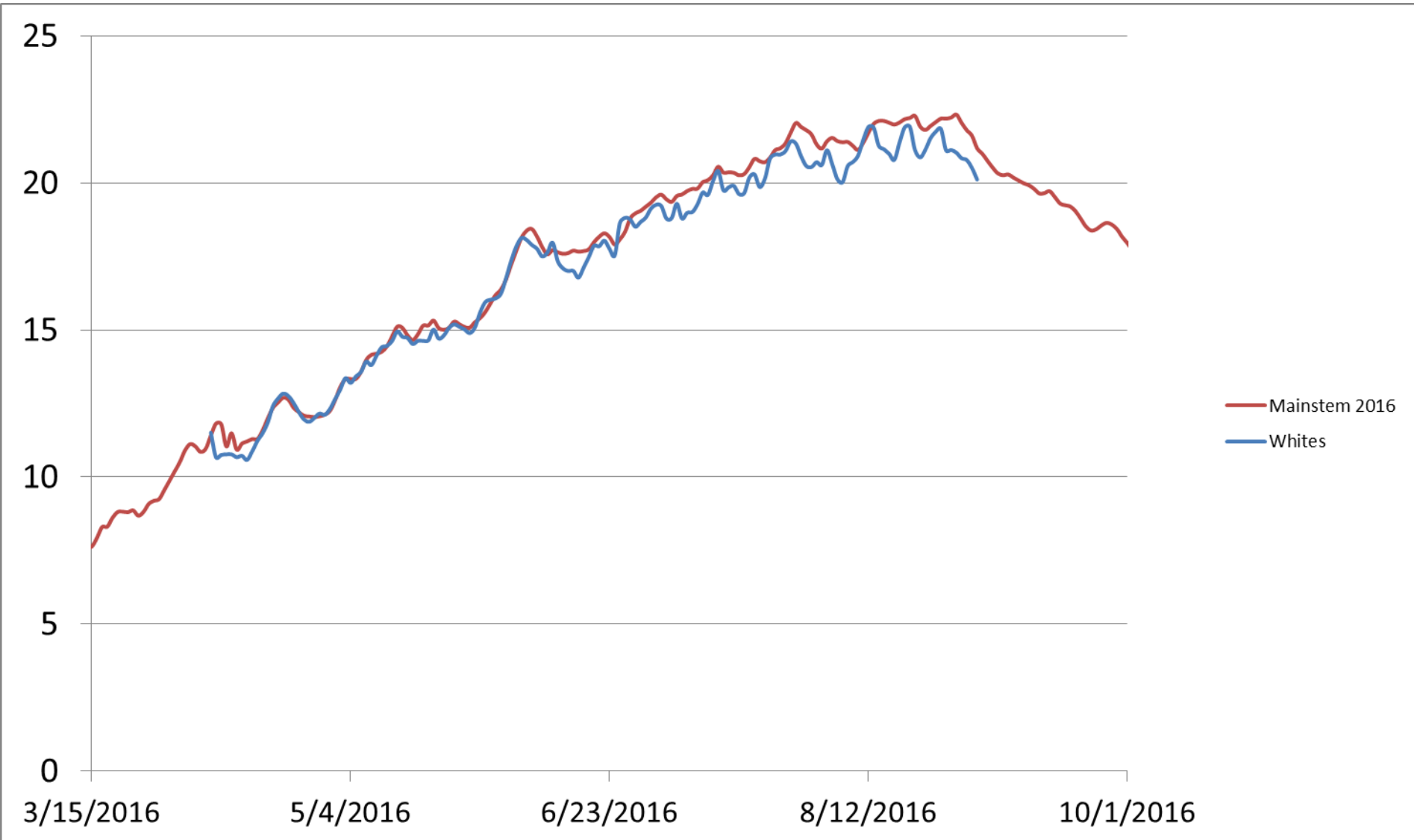
# 2016 Temperature comparison: Franz - Mainstem



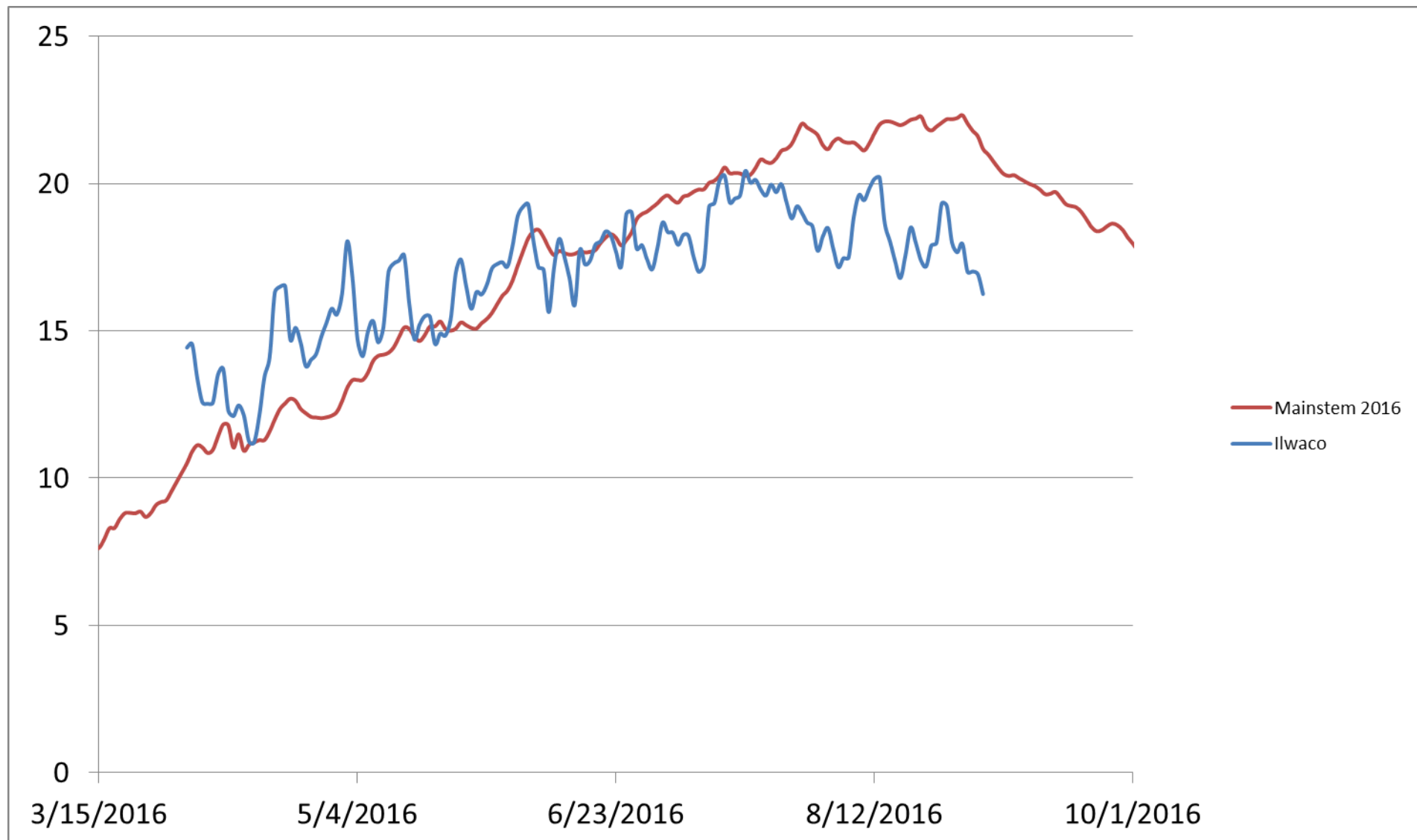
# 2016 Temperature comparison: Campbell - Mainstem



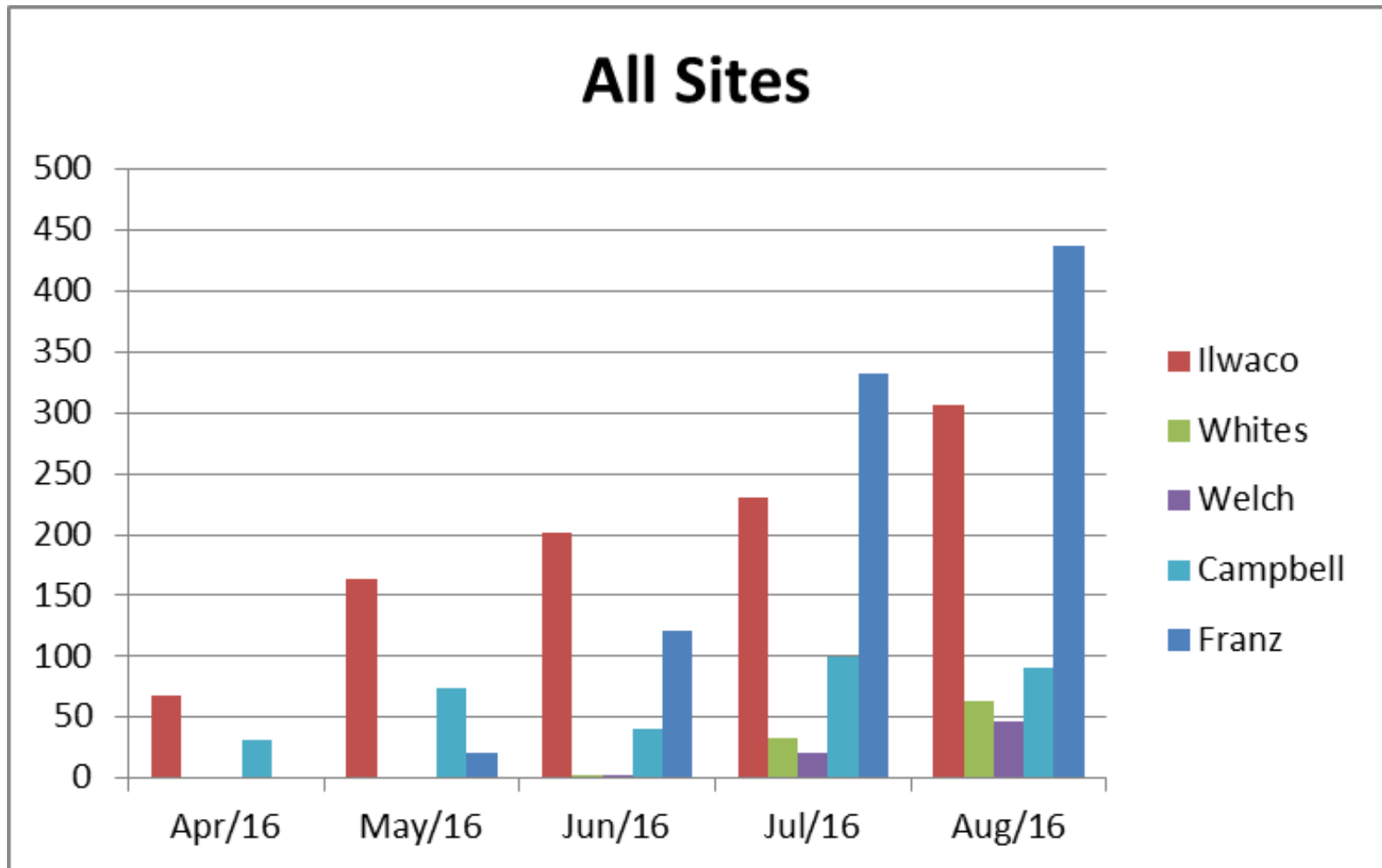
# 2016 Temperature comparison: Whites - Mainstem



# 2016 Temperature comparison: Ilwaco - Mainstem



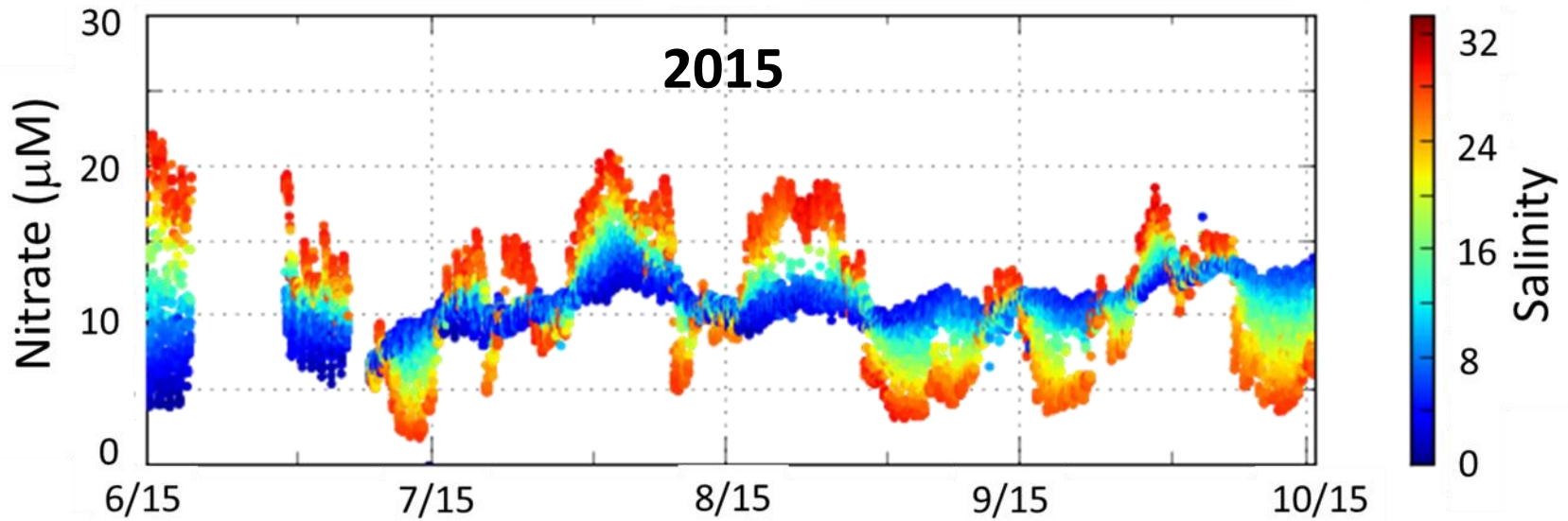
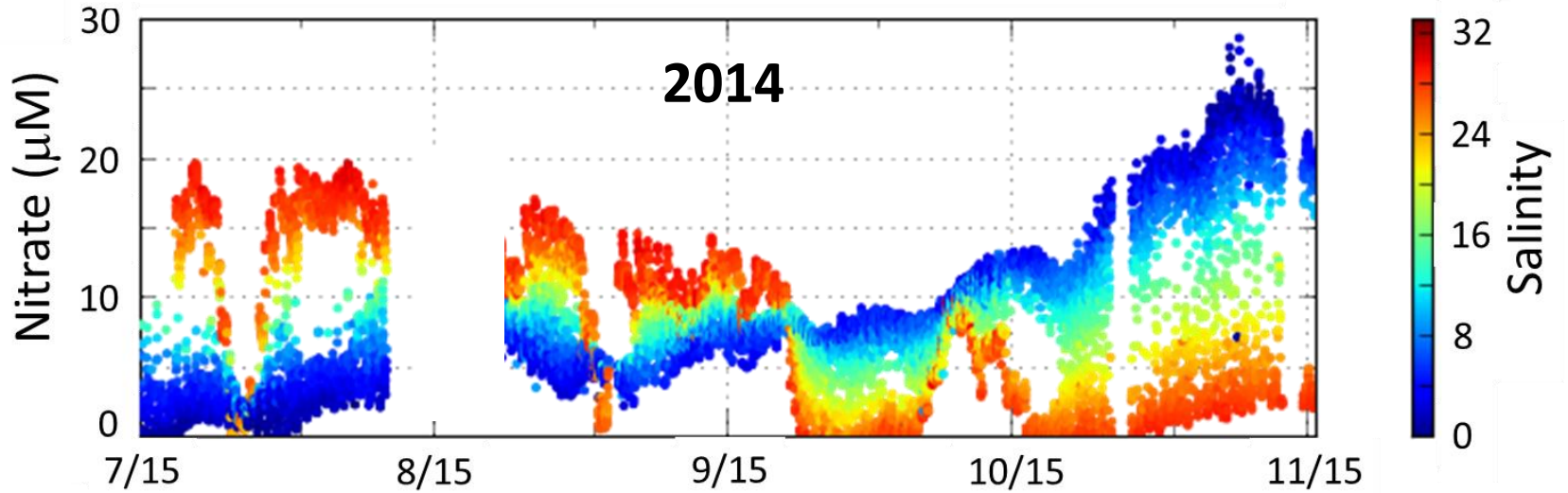
# 2016: # hours per month of dissolved oxygen below threshold of 6 mg/L



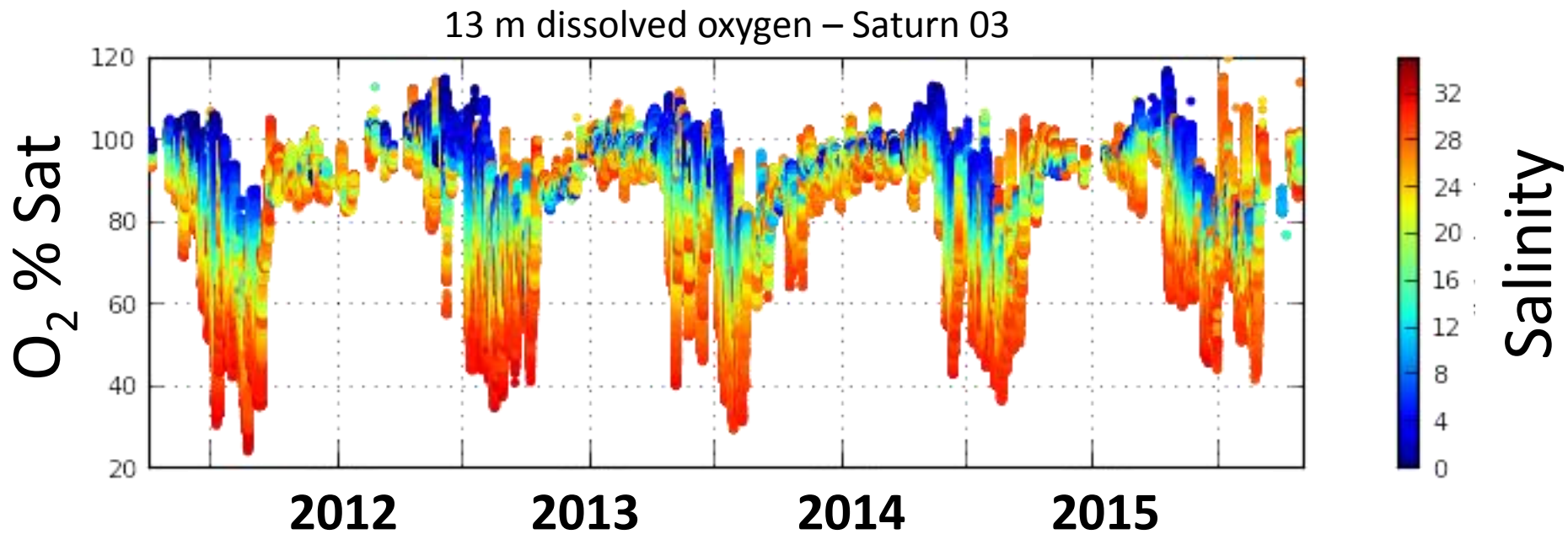




# Nitrate (colored by salinity)



# SATURN-03 Dissolved Oxygen Time Series



No evidence for strong hypoxia formation associated with the blob





















