Status and Trends from a Decade of Time Series Water Quality Monitoring in Intertidal Wetlands of the Columbia River Estuary

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Lower Columbia Estuary Partnership


https://commons.wikimedia.org/wiki/File:Columbia_River_07788.JPG

Vanport Building
OHSU-PSU School of Public Health

1948 Vanport Flooding

The year 1948 had been a particularly wet year. Large mountain snowpack followed by a warm, rainy May led to a large Columbia River freshet.

By May 25, 1948, both the Columbia and Willamette Rivers reached 23 feet, eight feet above flood stage.

Vanport flooding was one of the policy arguments for establishing Columbia River treaty with Canada

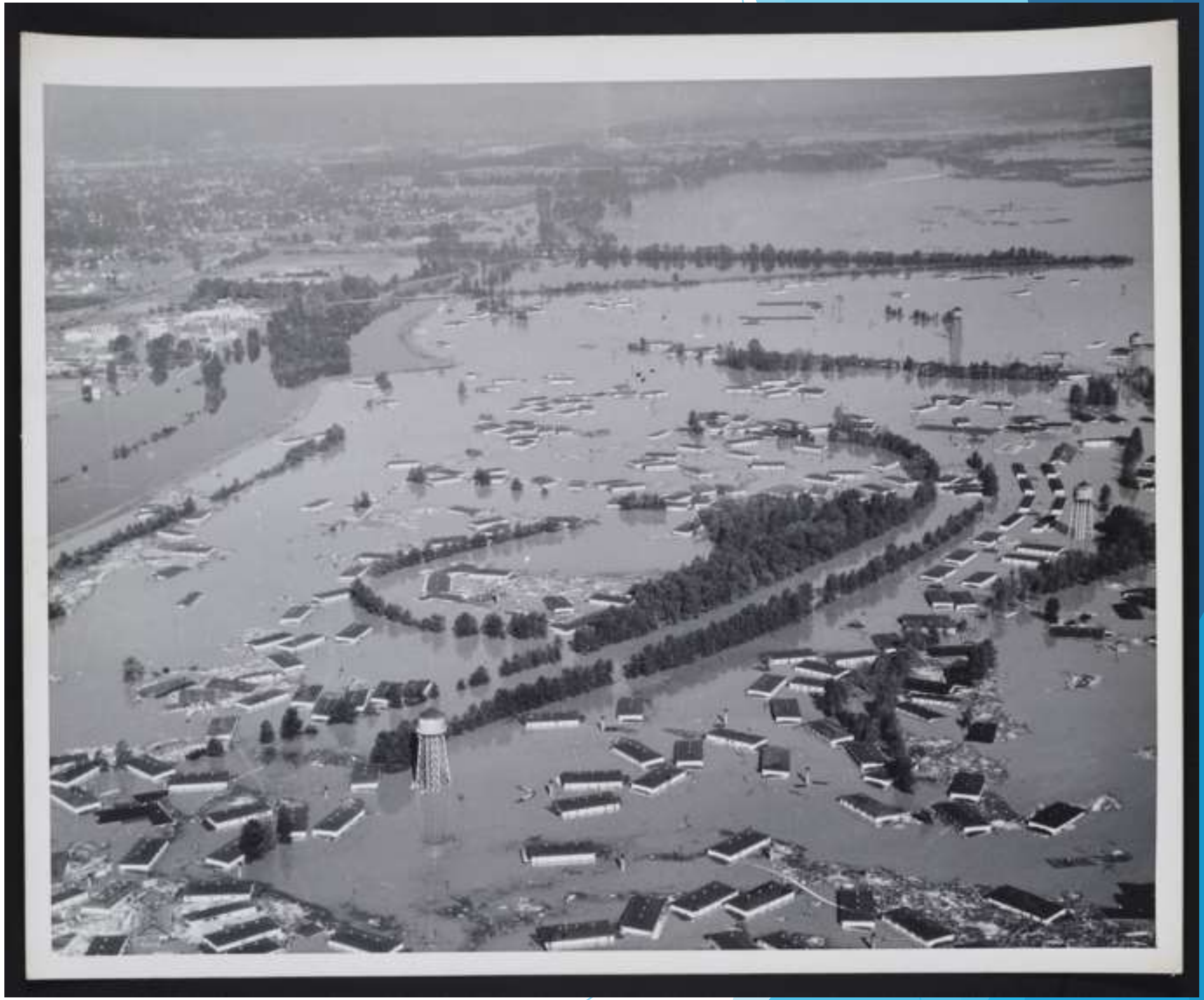


Image provided by the Oregon Historical Society

Modern Day Columbia River

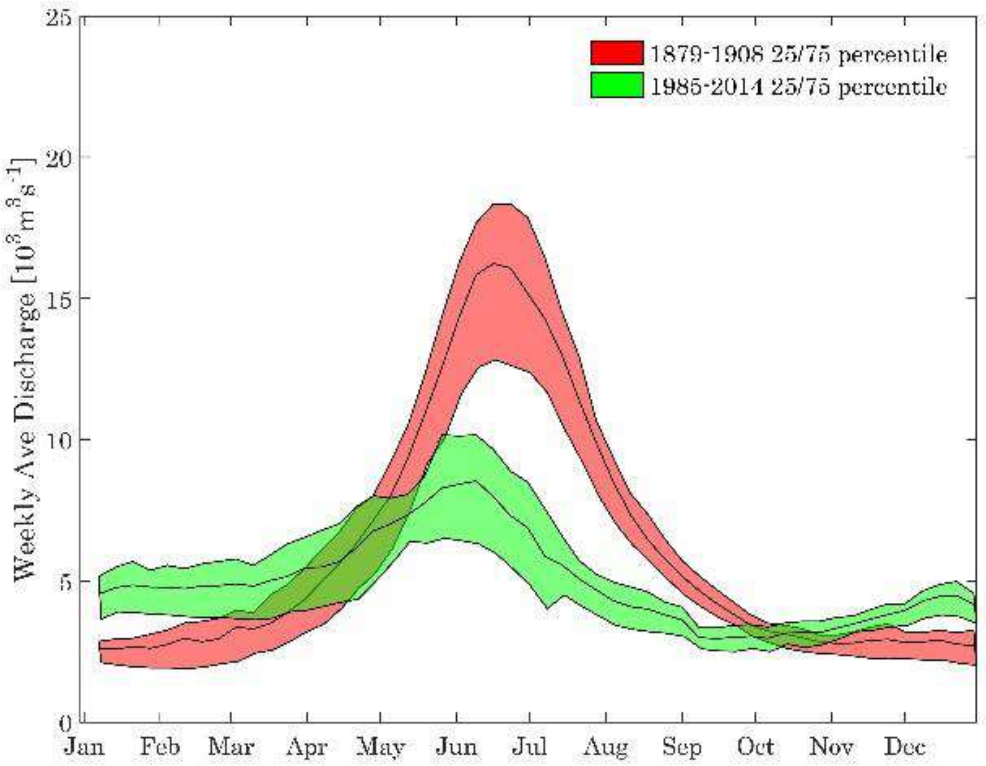
Network of Dams has dramatically changed the hydrology and ecosystems of the Basin

Migratory fish habitat limited in the upper basin

Water use, water quality, habitat availability impacted fish habitat in the lower basin.

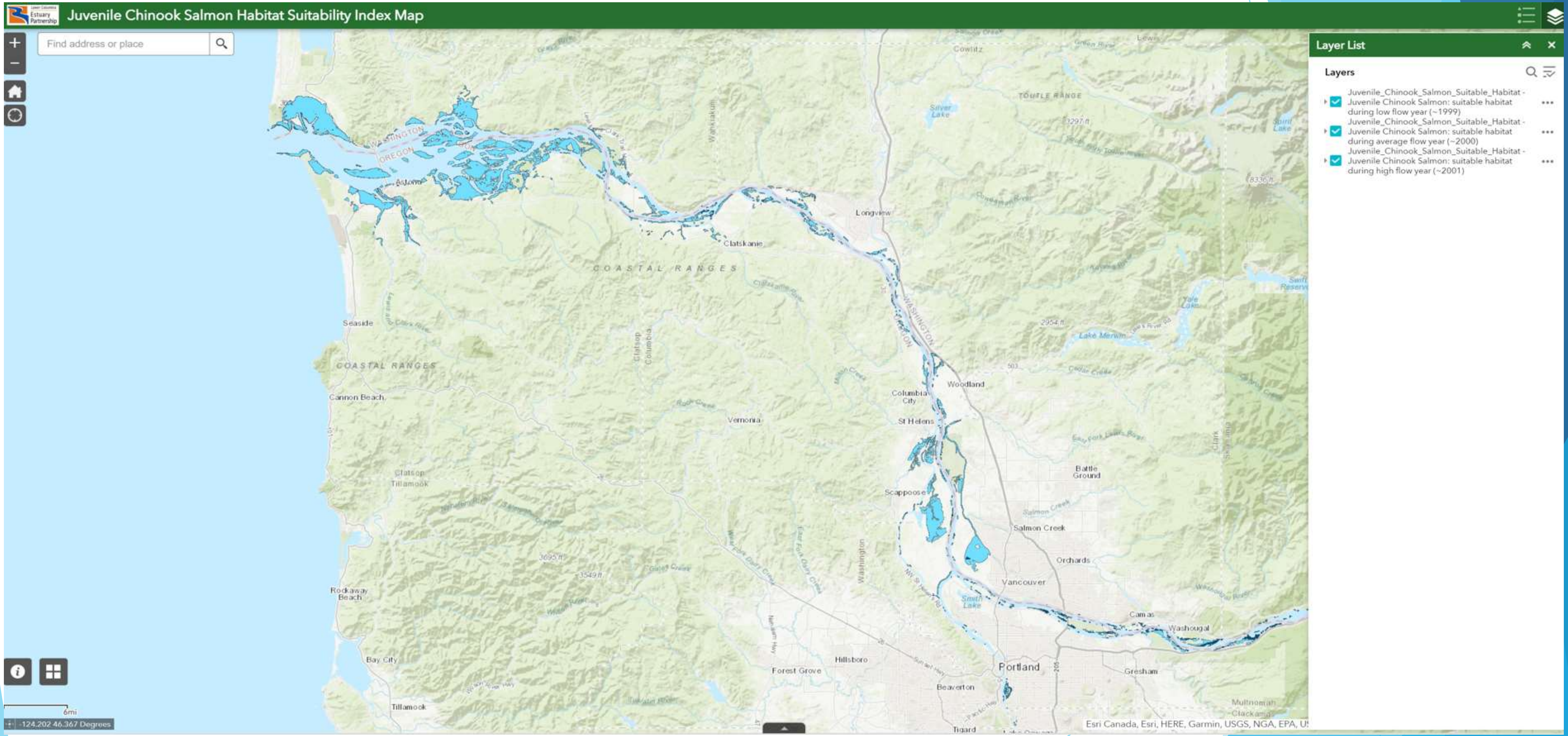
Changes to Columbia River water flow

- Spring freshet has decreased in peak discharge
- Peak discharge has shifted to earlier in the year



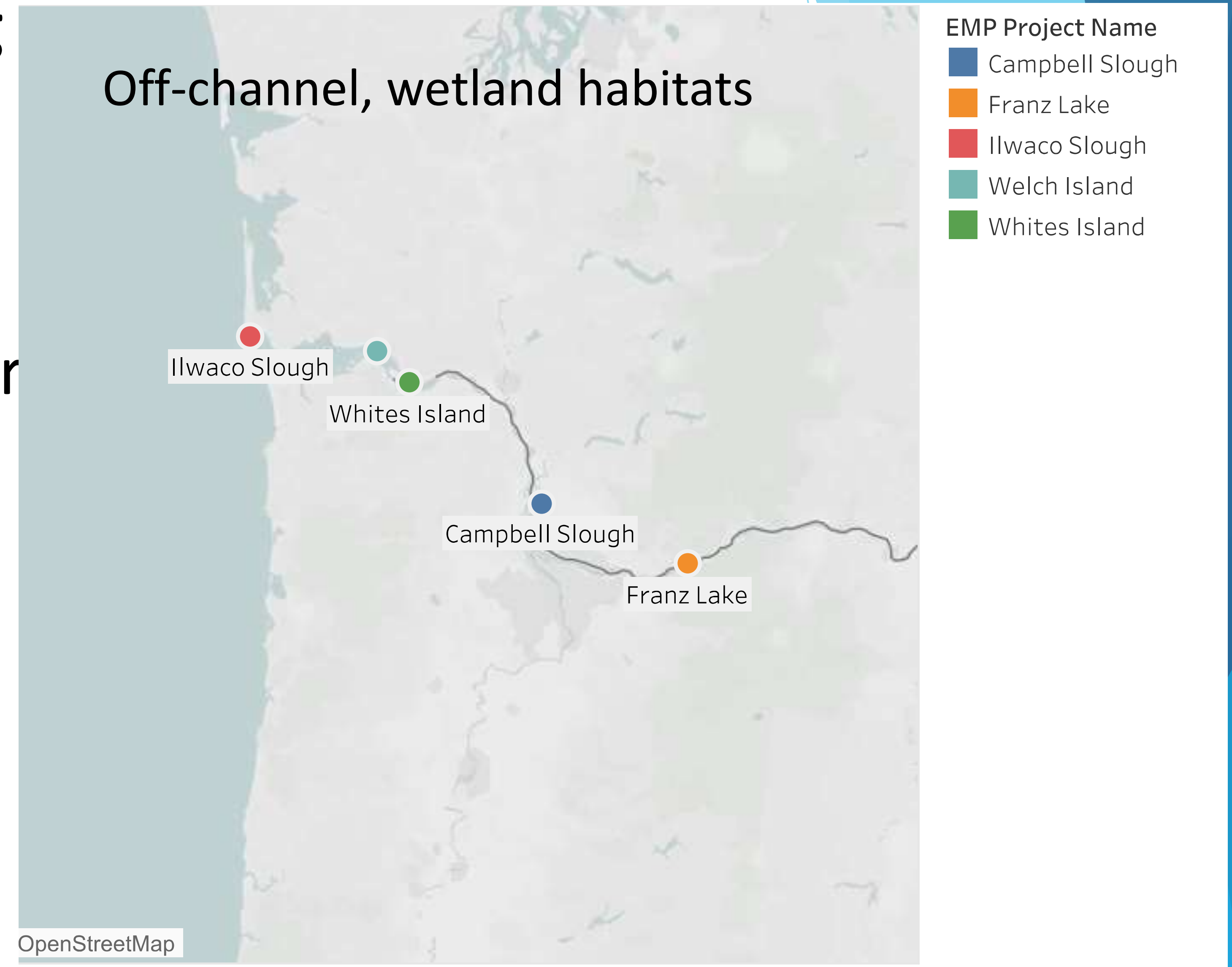
Helaire, Lumas Terence, "Modeling of Historic Columbia River Flood Impacts Based on Delft 3D Simulations" (2016). Dissertations and Theses. Paper 3206.

Juvenile Chinook Salmon Habitat Suitability



https://lcep.maps.arcgis.com/home/index.html

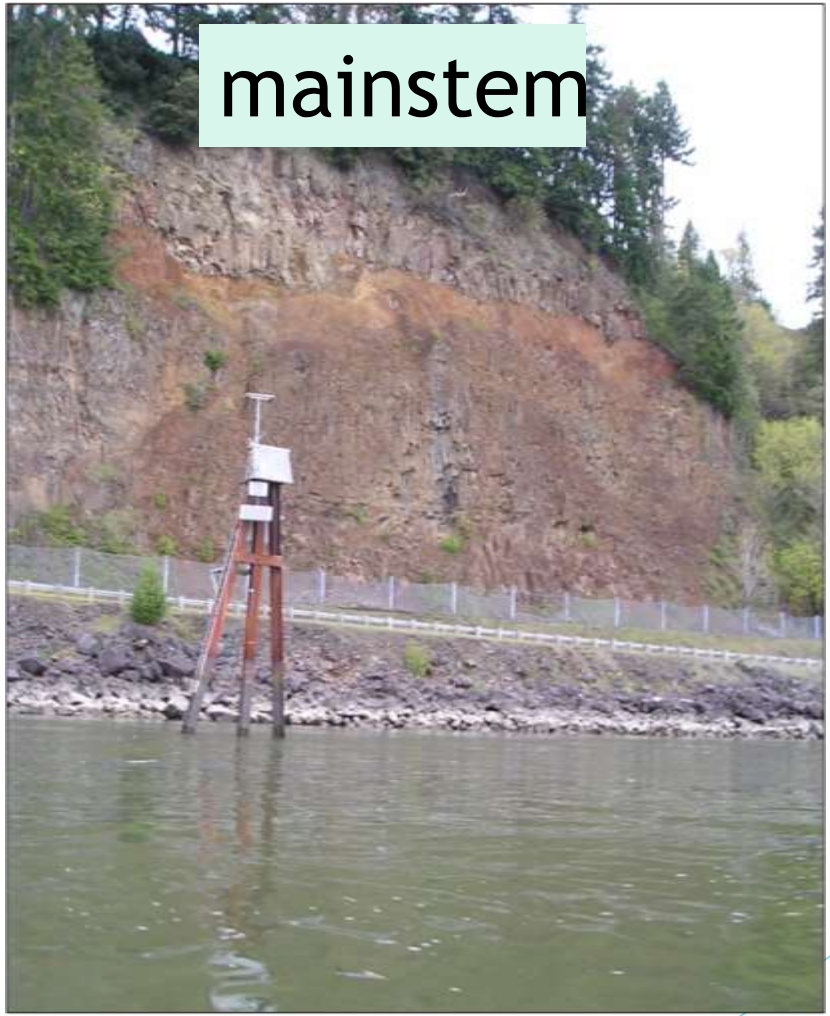
The **Ecosystem Monitoring Program** is providing long-term data about minimally disturbed wetland habitat in the lower Columbia River to develop and inform recovery strategies for salmonids

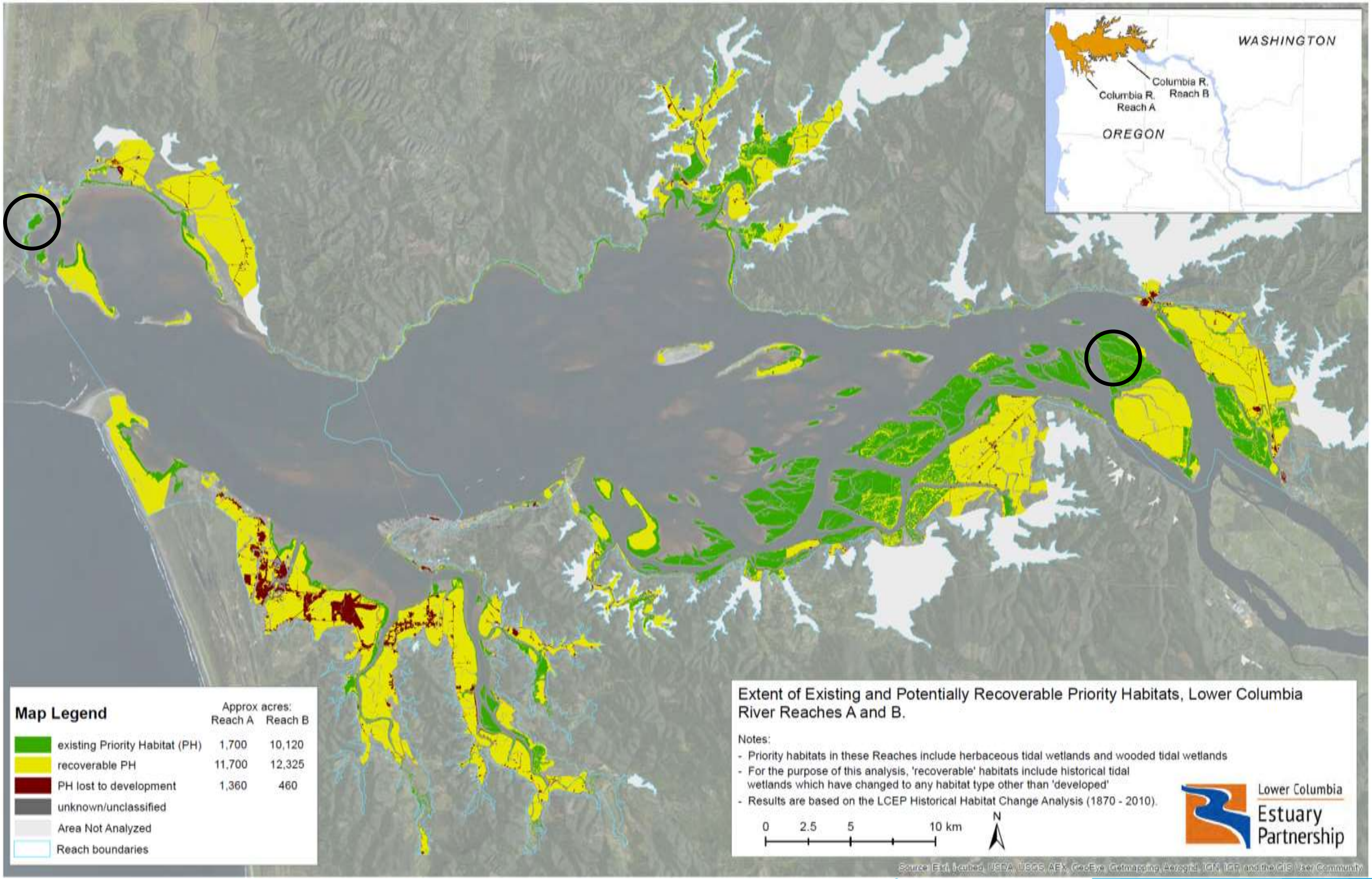


Ecosystem Monitoring Program sites.

EMP includes water quality data from 2008-present: 16 years of data (spring/summer)

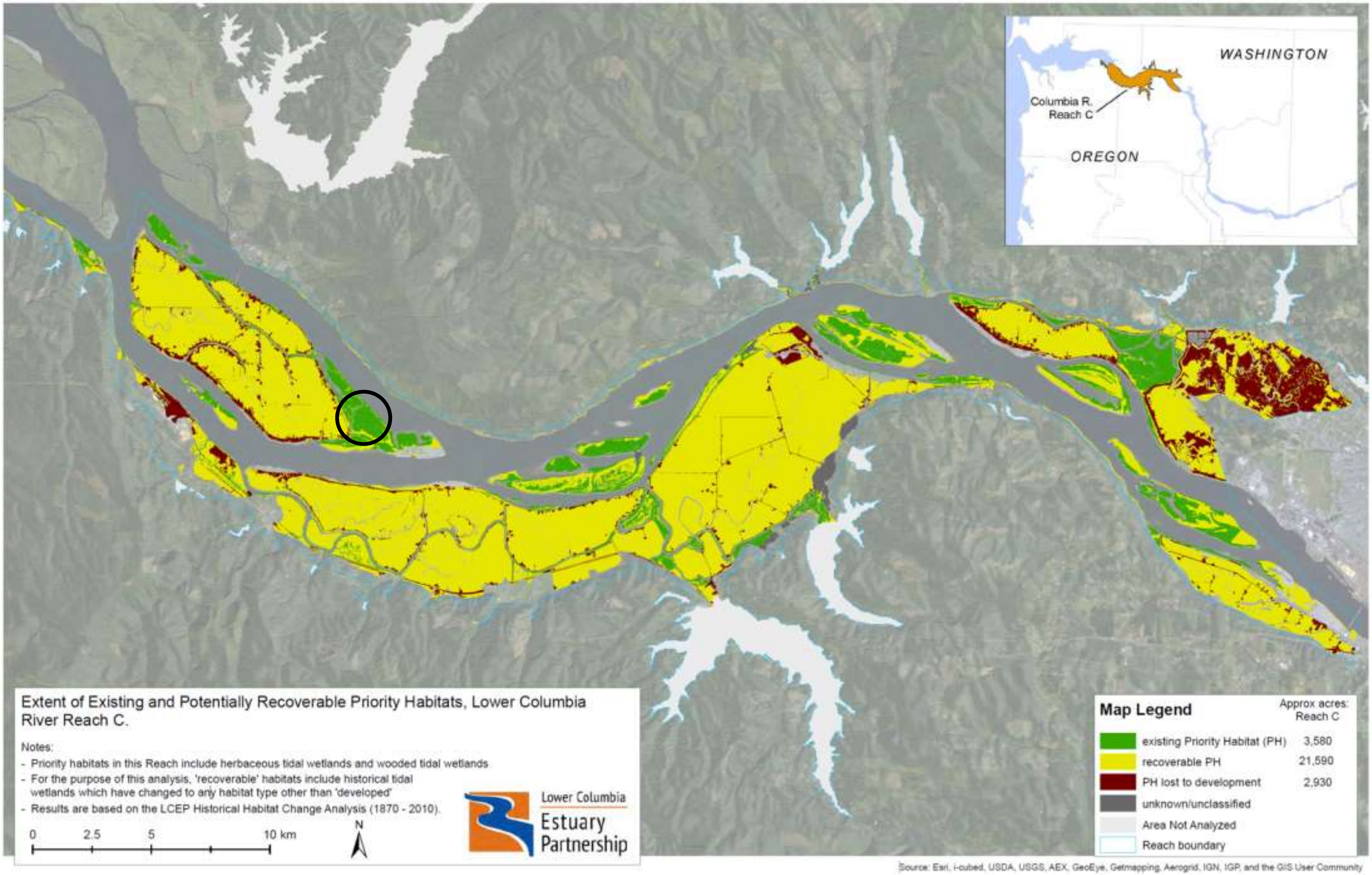
- Temperature
- Conductivity
- Dissolved oxygen
- pH
- Chlorophyll



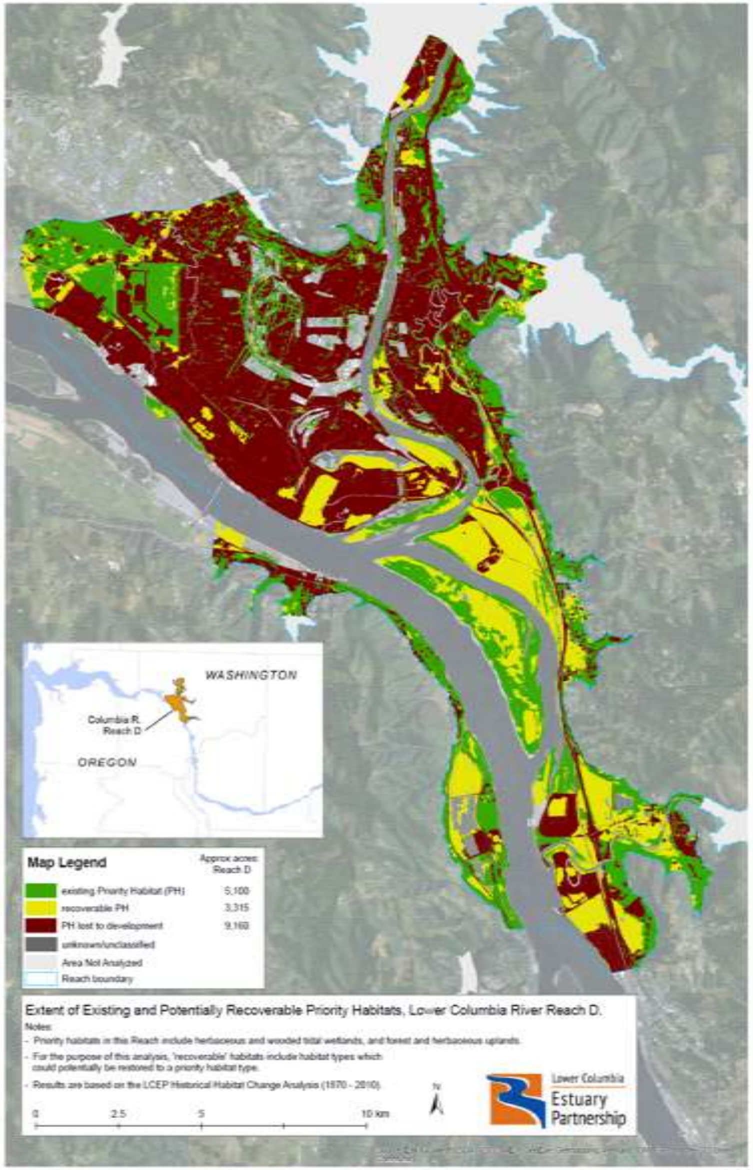

WASHINGTON
OREGON
Columbia R. Reach A
Columbia R. Reach B
Map Legend
Approx acres:
Reach A Reach B
existing Priority Habitat (PH) 1,700 10,120
recoverable PH 11,700 12,325
PH lost to development 1,360 460
unknown/unclassified
Area Not Analyzed
Reach boundaries
Extent of Existing and Potentially Recoverable Priority Habitats, Lower Columbia River Reaches A and B.
Notes:
- Priority habitats in these Reaches include herbaceous tidal wetlands and wooded tidal wetlands
- For the purpose of this analysis, 'recoverable' habitats include historical tidal wetlands which have changed to any habitat type other than 'developed'
- Results are based on the LCEP Historical Habitat Change Analysis (1870 - 2010).
0 2.5 5 10 km
N
Lower Columbia Estuary Partnership
Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

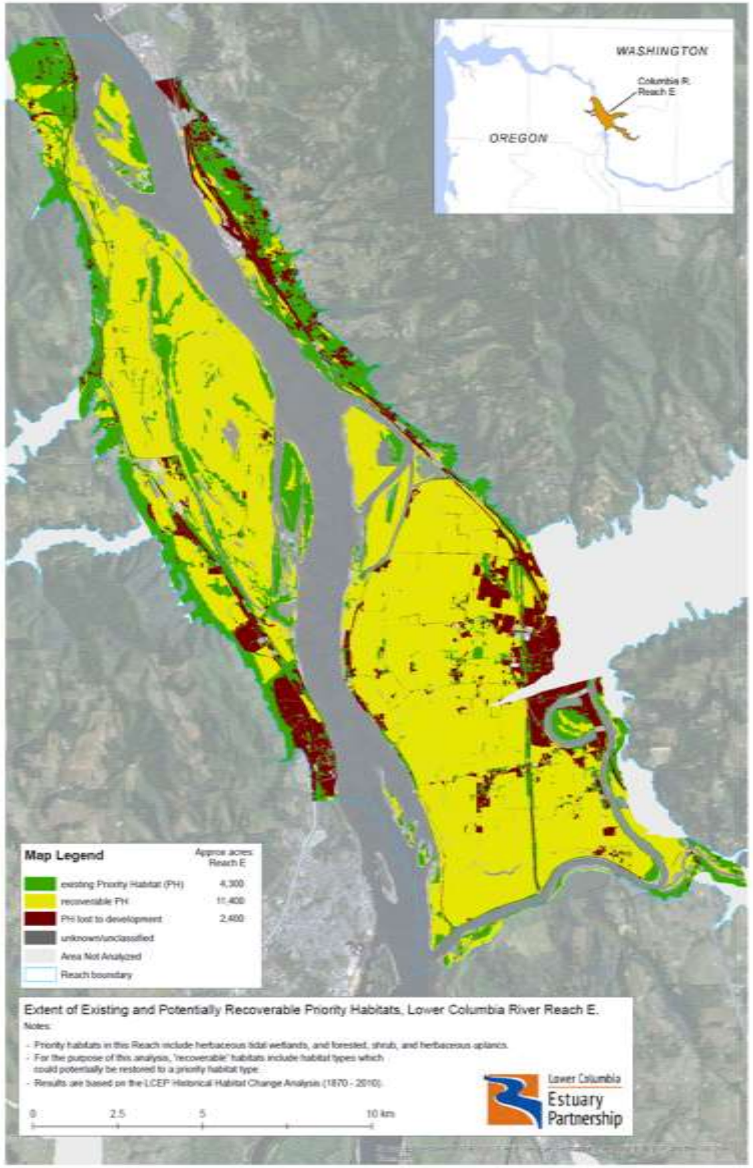
Ilwaco marsh and Welch Island

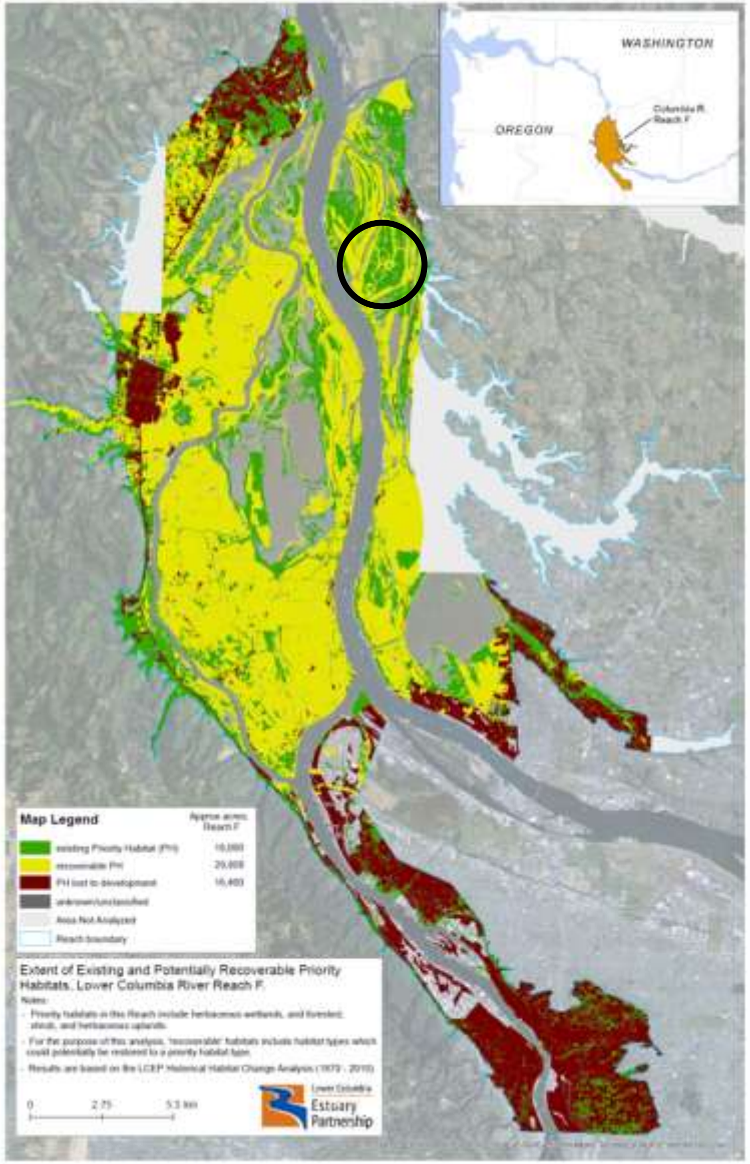



WASHINGTON
Columbia R. Reach C
OREGON
Extent of Existing and Potentially Recoverable Priority Habitats, Lower Columbia River Reach C.
Notes:
- Priority habitats in this Reach include herbaceous tidal wetlands and wooded tidal wetlands
- For the purpose of this analysis, 'recoverable' habitats include historical tidal wetlands which have changed to any habitat type other than 'developed'
- Results are based on the LCEP Historical Habitat Change Analysis (1870 - 2010).
0 2.5 5 10 km
N
Lower Columbia Estuary Partnership
Map Legend
Approx acres: Reach C
existing Priority Habitat (PH) 3,580
recoverable PH 21,590
PH lost to development 2,930
unknown/unclassified
Area Not Analyzed
Reach boundary
Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

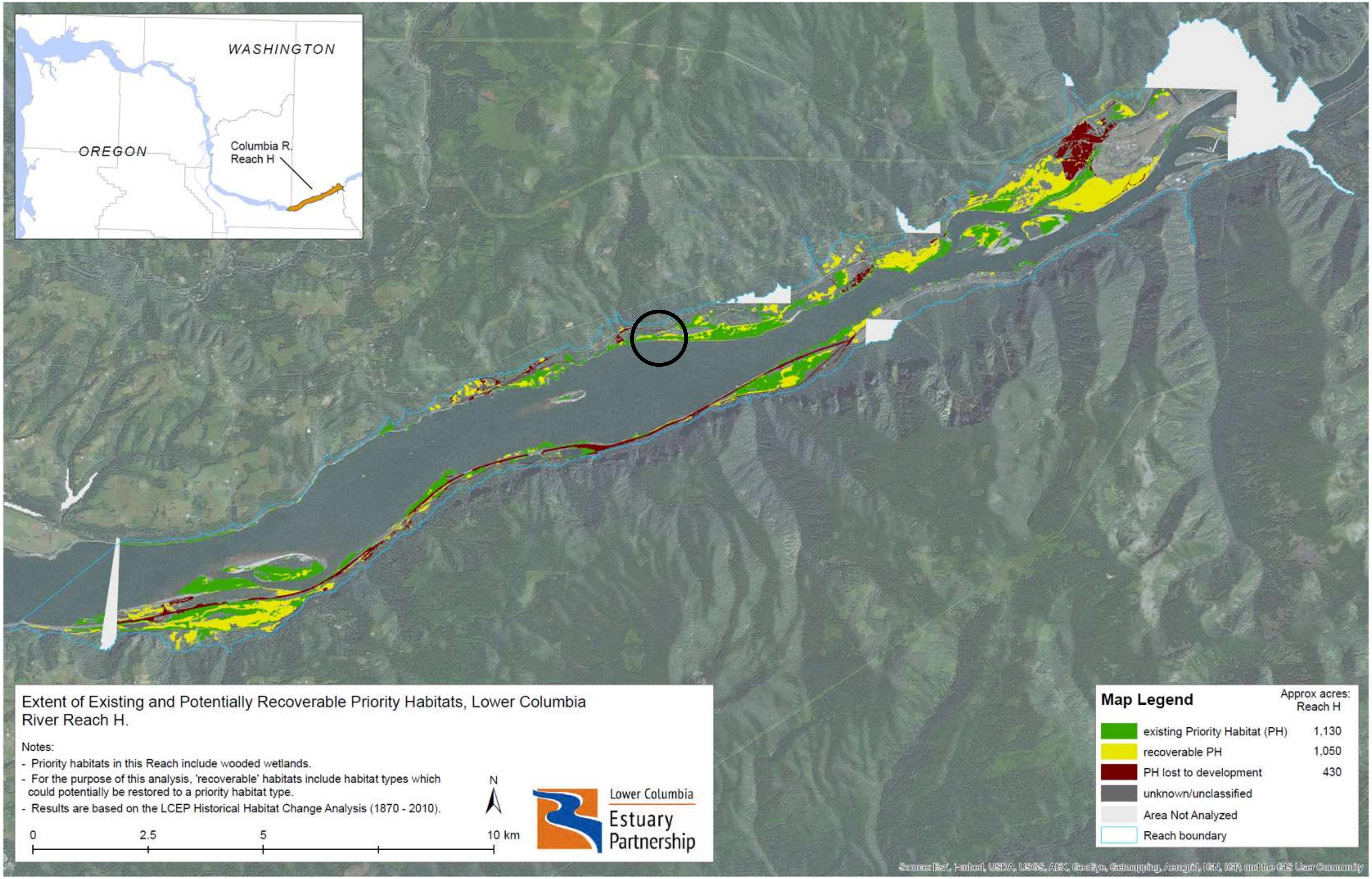
Whites Island


WASHINGTON
Columbia R.
Reach D
OREGON
Map Legend
Approx acres
Reach D
existing Priority Habitat (PH) 5,100
recoverable PH 3,315
PH lost to development 9,160
unknown/unclassified
Area Not Analyzed
Reach boundary
Extent of Existing and Potentially Recoverable Priority Habitats, Lower Columbia River Reach D.
Notes:
- Priority habitats in this Reach include herbaceous and wooded tidal wetlands, and forest and herbaceous uplands.
- For the purpose of this analysis, 'recoverable' habitats include habitat types which could potentially be restored to a priority habitat type.
- Results are based on the LCEP Historical Habitat Change Analysis (1870 - 2010).
0 2.5 5 10 km
N
Lower Columbia
Estuary
Partnership


WASHINGTON
Columbia R.
Reach E
OREGON
Map Legend
Approx acres
Reach E
existing Priority Habitat (PH) 4,300
recoverable PH 11,400
PH lost to development 2,400
unknown/unclassified
Area Not Analyzed
Reach boundary
Extent of Existing and Potentially Recoverable Priority Habitats, Lower Columbia River Reach E.
Notes:
- Priority habitats in this Reach include herbaceous tidal wetlands, and forested, shrub, and herbaceous uplands.
- For the purpose of this analysis, 'recoverable' habitats include habitat types which could potentially be restored to a priority habitat type.
- Results are based on the LCEP Historical Habitat Change Analysis (1870 - 2010).
0 2.5 5 10 km
Lower Columbia
Estuary
Partnership


WASHINGTON
OREGON
Map Legend
Extent of Existing and Potentially Recoverable Priority Habitats, Lower Columbia River Reach F.
0 2.75 5.5 km
Estuary
Partnership

Ridgefield National Wildlife Refuge

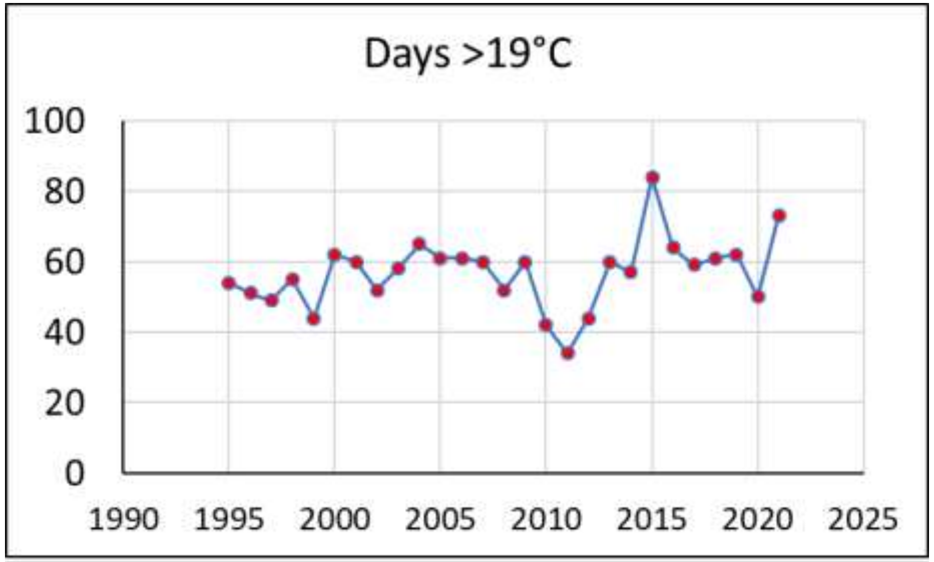

WASHINGTON
OREGON
Columbia R.
Reach H
Extent of Existing and Potentially Recoverable Priority Habitats, Lower Columbia River Reach H.
Notes:
- Priority habitats in this Reach include wooded wetlands.
- For the purpose of this analysis, 'recoverable' habitats include habitat types which could potentially be restored to a priority habitat type.
- Results are based on the LCEP Historical Habitat Change Analysis (1870 - 2010).
N
0
2.5
5
10 km
Lower Columbia Estuary Partnership
Map Legend
Approx acres: Reach H
existing Priority Habitat (PH) 1,130
recoverable PH 1,050
PH lost to development 430
unknown/unclassified
Area Not Analyzed
Reach boundary

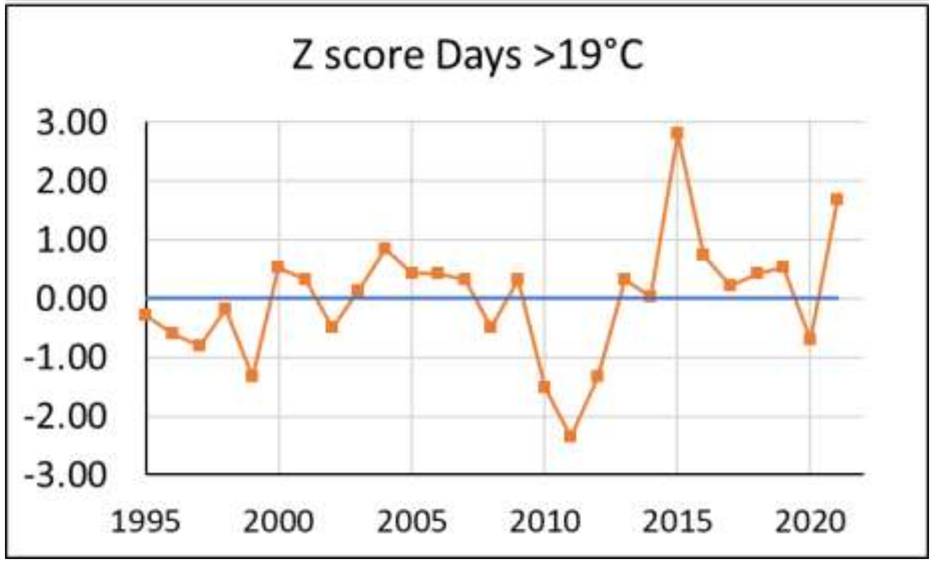
Franz Lake National Wildlife Refuge

Water Quality Monitoring – in situ sensors

Temperature metrics

	Percentage of Days per Month > 19 deg C					Percentage of Days per Month > 22 deg C				
Date	Ilwaco	Welch	Whites	Campbel	Franz	Ilwaco	Welch	Whites	Campbel	Franz
Apr-2015	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
May-2015	#N/A	#N/A	#N/A	32	#N/A	#N/A	#N/A	#N/A	0	#N/A
Jun-2015	17	#N/A	100	90	100	0	#N/A	14	83	67
Jul-2015	74	#N/A	100	100	100	0	#N/A	77	100	77
Aug-2015	56	#N/A	100	100	100	0	#N/A	19	96	91
Sep-2015	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Apr-2016	0	0	0	0	0	0	0	0	0	0
May-2016	0	0	0	19	0	0	0	0	0	0
Jun-2016	10	13	0	87	55	0	0	0	17	14
Jul-2016	55	100	87	100	97	0	0	0	77	48
Aug-2016	23	100	100	100	100	0	13	0	90	33
Sep-2016	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Apr-2017	0	0	0	0	#N/A	0	0	0	0	#N/A
May-2017	0	0	0	0	0	0	0	0	0	0
Jun-2017	7	0	0	33	13	0	0	0	0	0
Jul-2017	42	87	94	100	93	0	0	6	94	93
Aug-2017	29	100	100	100	100	0	13	48	100	81
Sep-2017	0	82	90	100	78	0	0	15	69	28
Apr-2018	0	0	0	0	0	0	0	0	0	0
May-2018	0	0	0	0	0	0	0	0	0	0
Jun-2018	27	17	3	63	30	0	0	0	20	0
Jul-2018	68	97	100	100	100	0	6	10	97	77
Aug-2018	29	100	100	100	90	0	16	52	90	58
Sep-2018	0	46	57	95	42	0	0	0	47	0
Apr-2019	0	0	0	0	0	0	0	0	0	0
May-2019	3	0	0	16	0	0	0	0	0	0
Jun-2019	27	13	7	83	57	0	0	0	33	10
Jul-2019	71	90	97	100	100	3	10	13	97	81
Aug-2019	81	100	100	100	100	0	19	43	100	42
Sep-2019	18	90	#N/A	100	100	0	0	#N/A	77	53
Apr-2020	3	#N/A	0	0	#N/A	0	#N/A	0	0	#N/A
May-2020	6	#N/A	0	0	#N/A	3	#N/A	0	0	#N/A
Jun-2020	23	#N/A	#N/A	33	#N/A	3	#N/A	#N/A	0	#N/A
Jul-2020	#N/A	#N/A	#N/A	87	#N/A	#N/A	#N/A	#N/A	61	#N/A
Aug-2020	61	100	100	100	100	0	15	15	97	93
Sep-2020	0	#N/A	78	76	45	0	#N/A	0	28	25
Apr-2021	0	0	0	23	4	0	0	0	0	0
May-2021	#N/A	0	0	32	3	#N/A	0	0	0	0
Jun-2021	#N/A	37	37	87	63	#N/A	7	3	60	43
Jul-2021	#N/A	100	100	100	100	#N/A	19	26	100	100
Aug-2021	#N/A	97	100	100	94	#N/A	19	100	94	58
Sep-2021	#N/A	52	#N/A	90	70	#N/A	0	#N/A	55	5

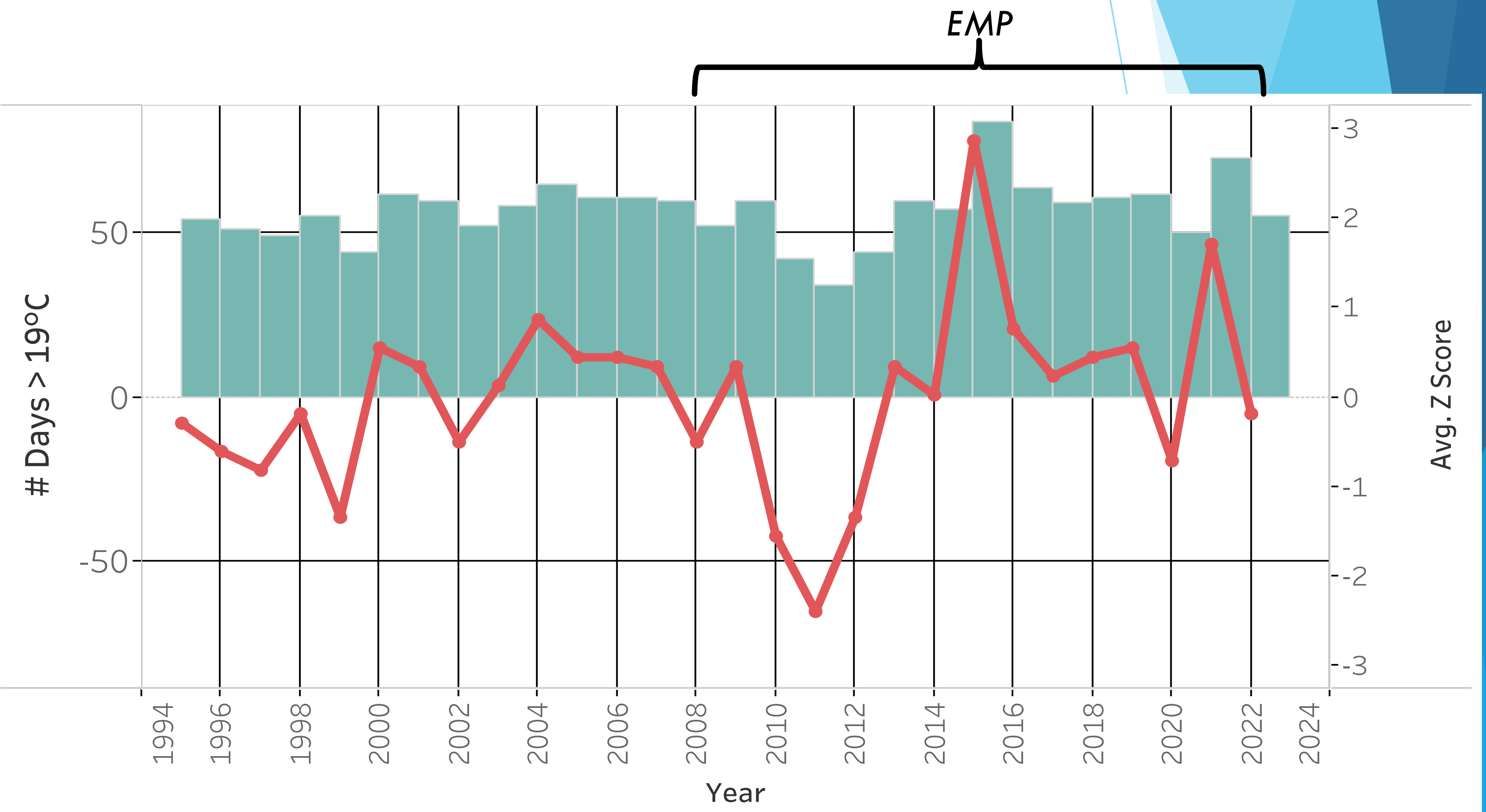




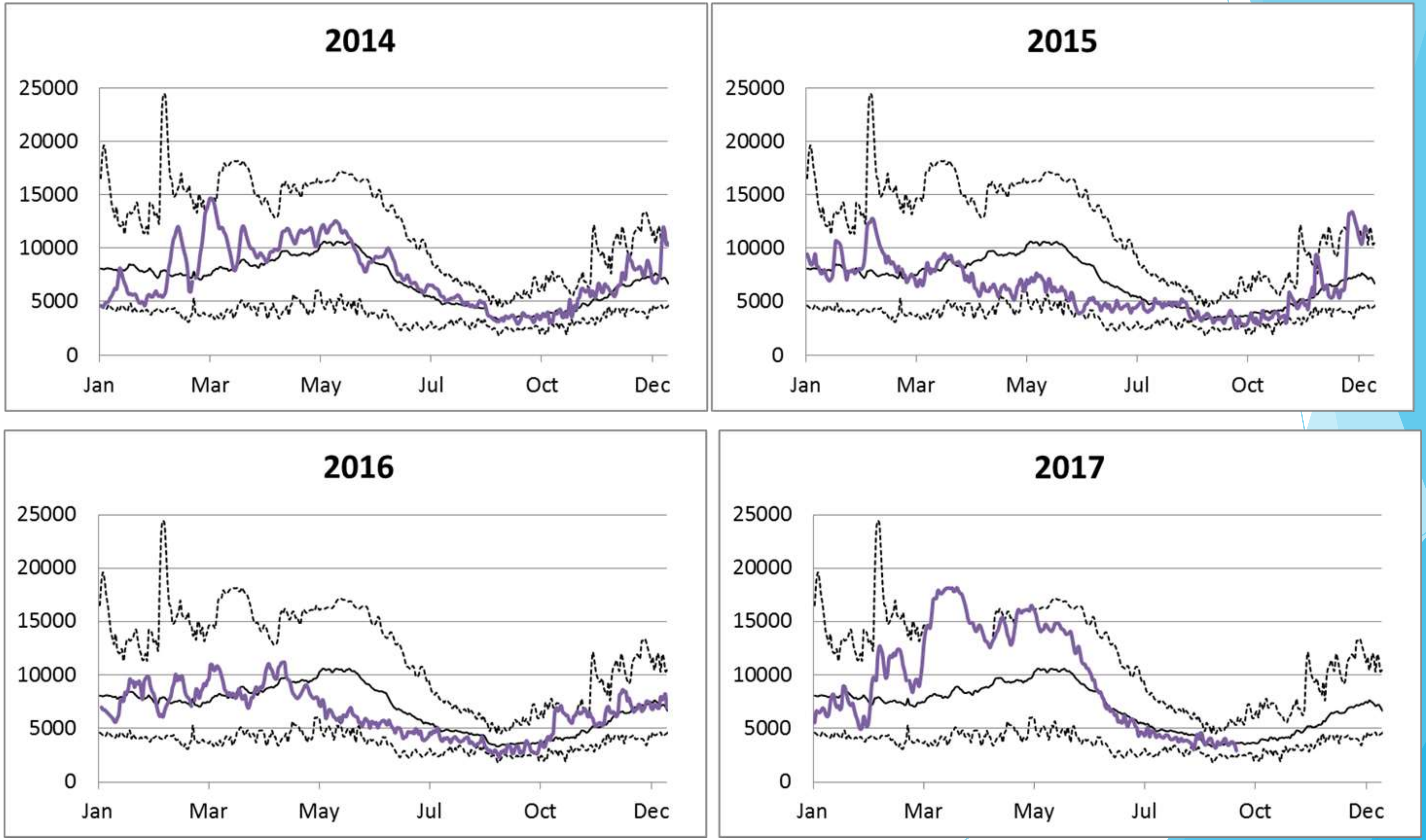
Number of days exceeding 19ºC in the Columbia River mainstem (1994-2022)

We can identify:

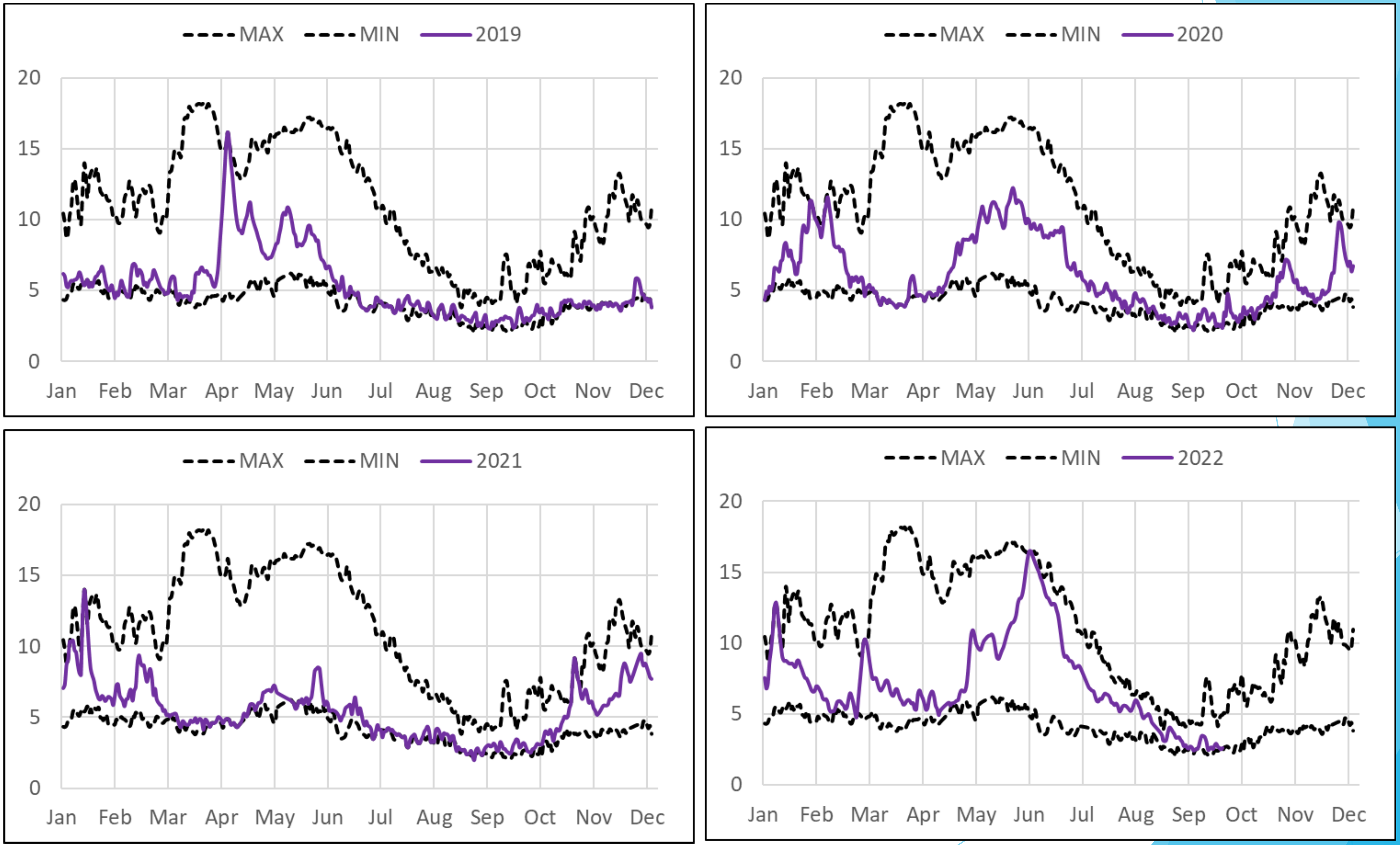
- years that are **cooler** than average (Z-score < 0): **2012, 2020**
- years that are **warmer** than average (Z-score >1, 2): **2015, 2021**



Annual variability in Spring Freshet



Annual variability in Spring Freshet



Among the off-channel sites, Campbell Slough and Franz Lake Slough exceed 19ºC threshold most consistently

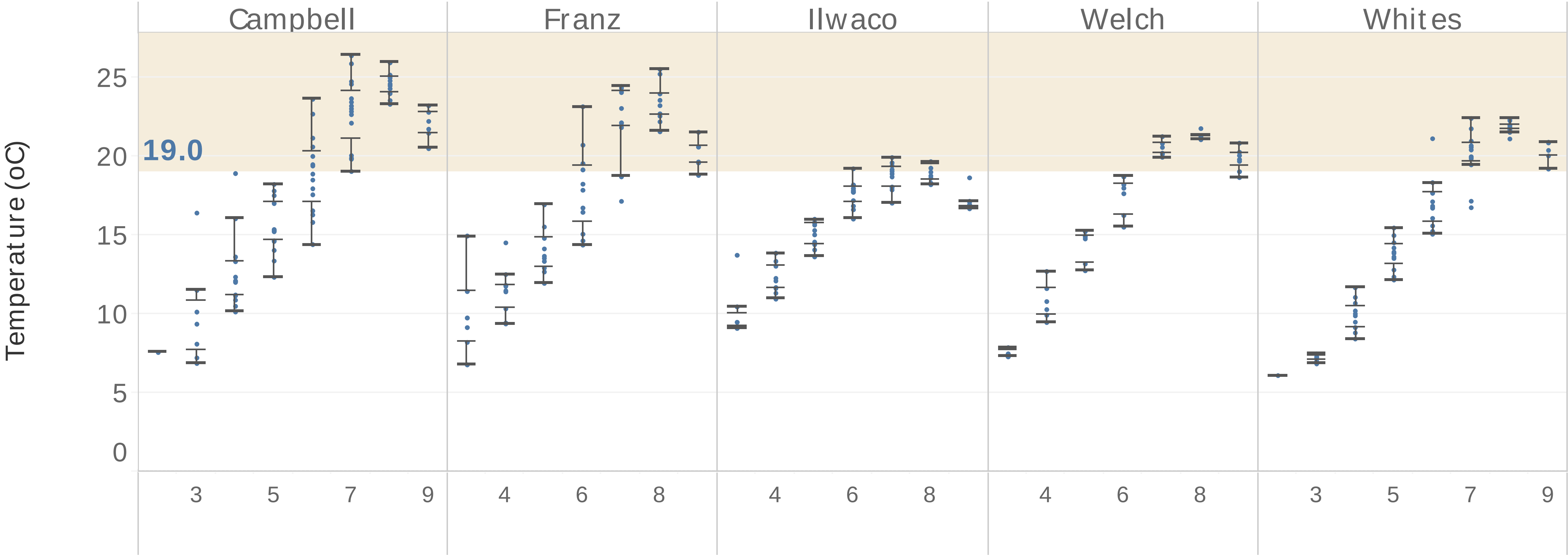
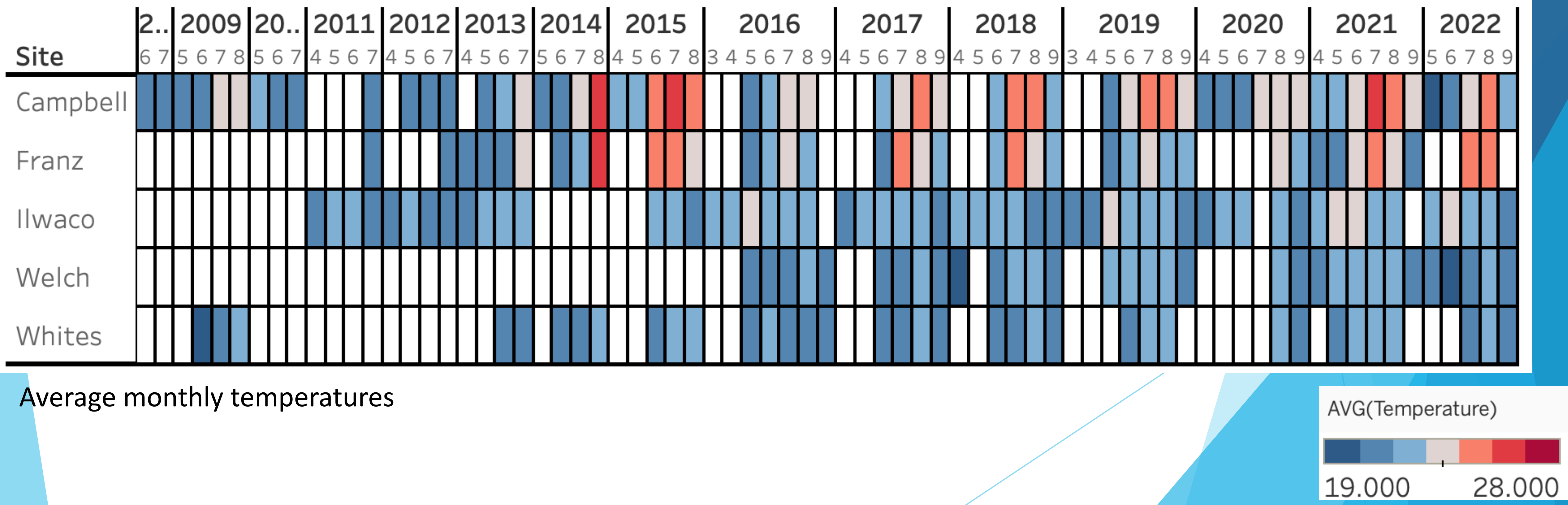


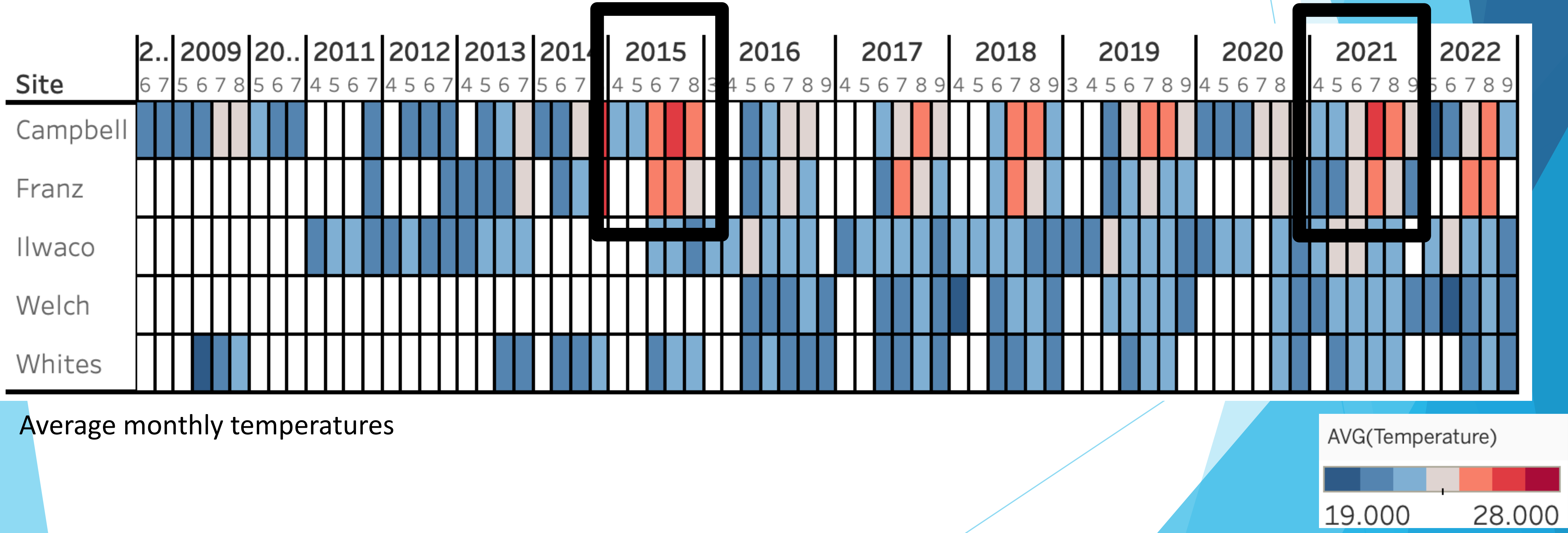
Figure 2.2.3. Box-and-Whisker plots showing variability in temperature by month at the EMP sites over the period of 2008-2022. The shaded area indicates temperatures above a threshold of 19oC. The data show that at Campbell Slough, Franz Lake Slough, Welch Island and Whites Island, the median monthly temperature is above 19oC for the months of July, August, and September.

At Campbell Slough & Franz Lake Slough temps exceeded 19°C in some years more than others



Average monthly temperatures

At Campbell Slough & Franz Lake Slough temps exceeded 19°C in some years more than others

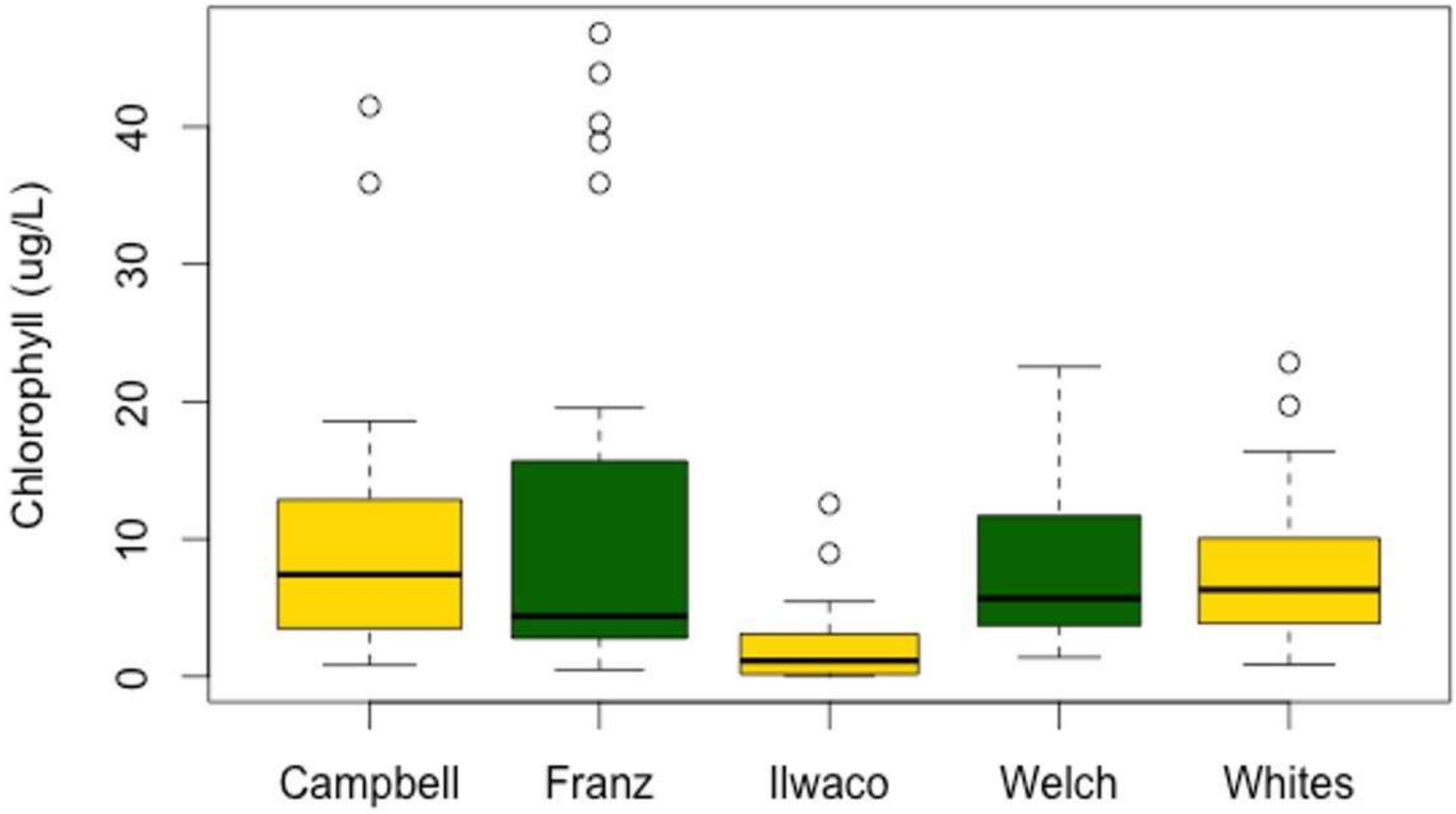


Average monthly temperatures

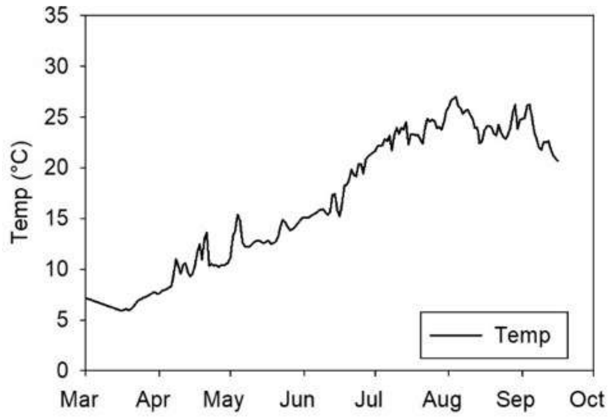
What have we learned?

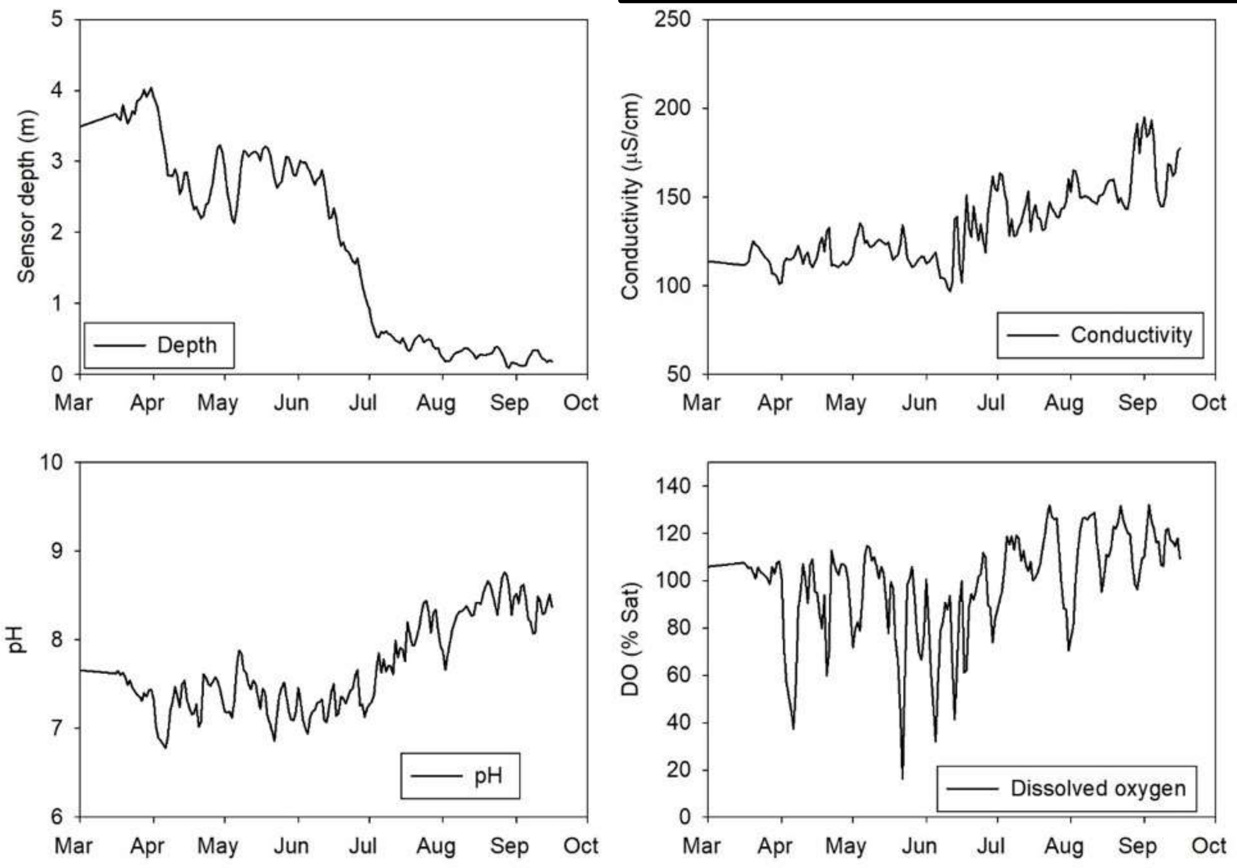
Temperature: while summer temperatures can exceed 19°C at all sites but Ilwaco, the longest periods and hottest temps are seen at Campbell and Franz Lake Sloughs

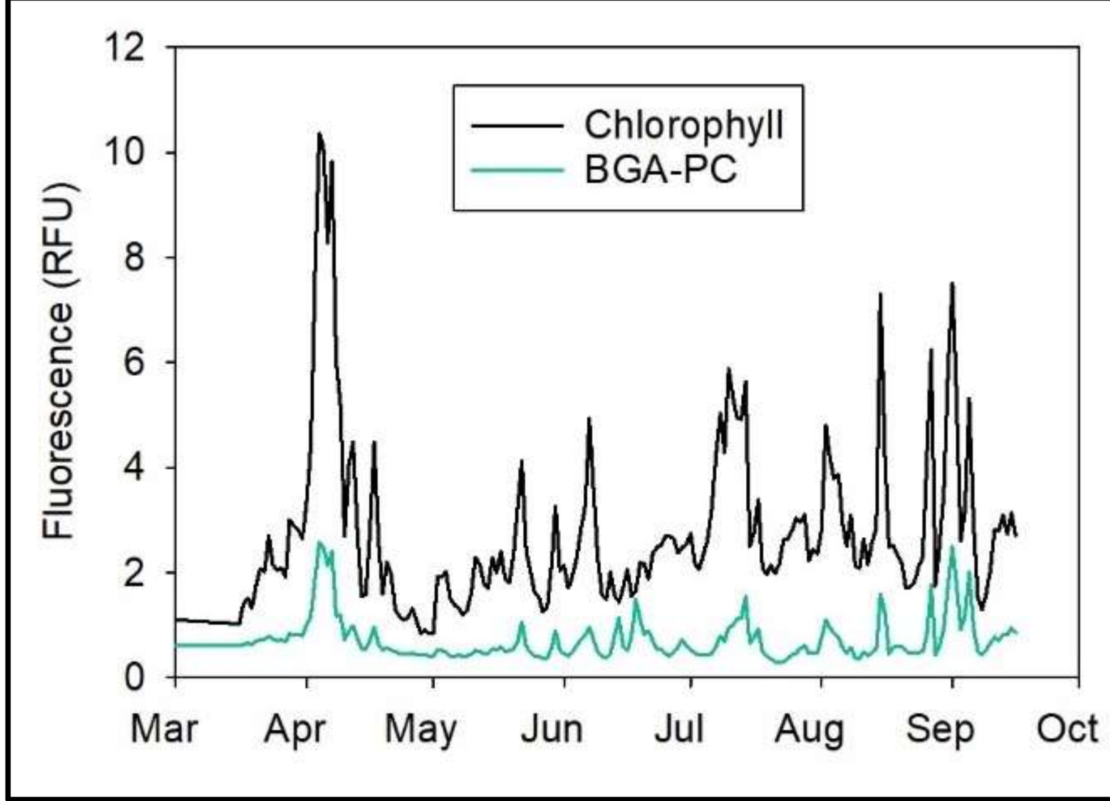
Chlorophyll peaks tend to be observed at sites less well-connected to the mainstem



We can track peak in algal biomass (chlorophyll) and determine when cyanobacteria are present using diagnostic pigment fluorescence (phycocyanin)



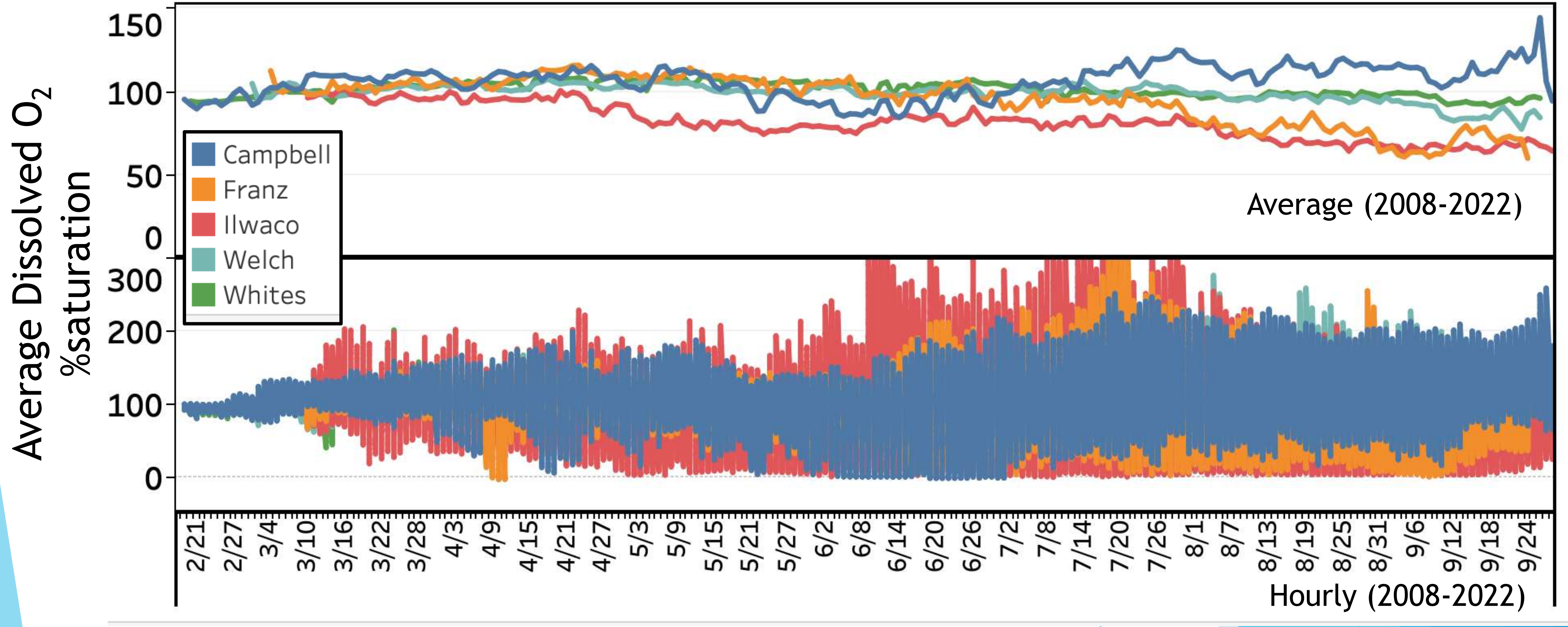


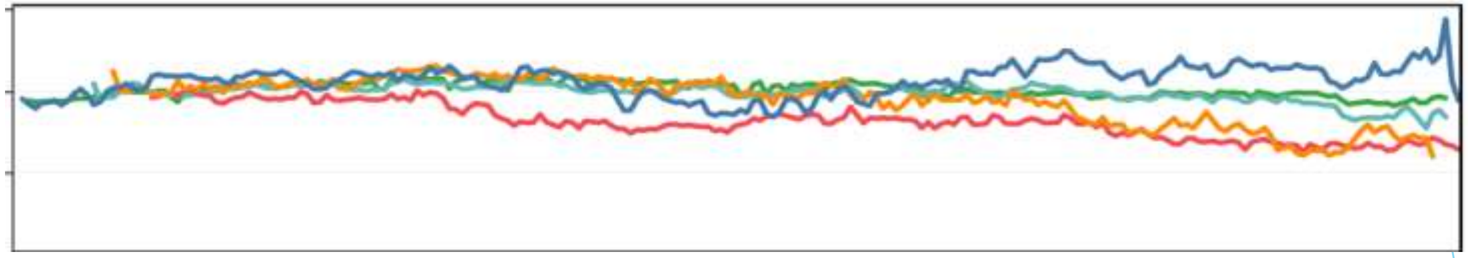


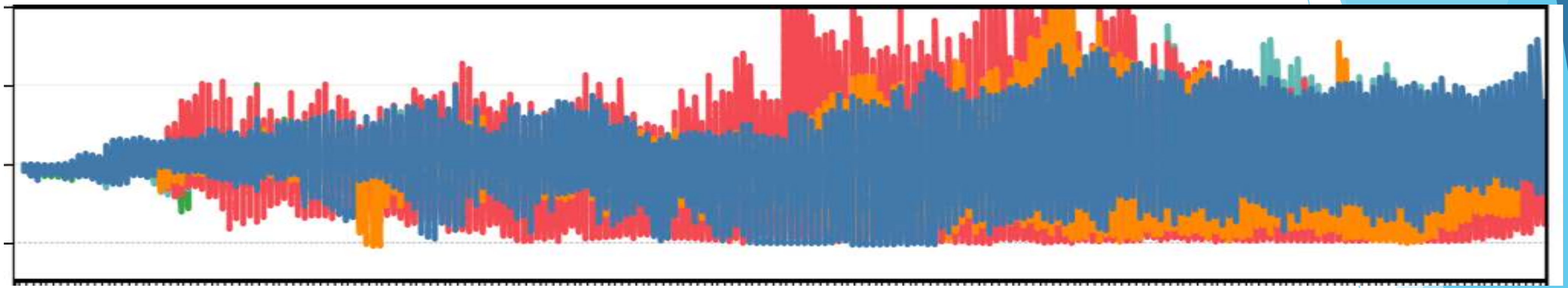
What have we learned?

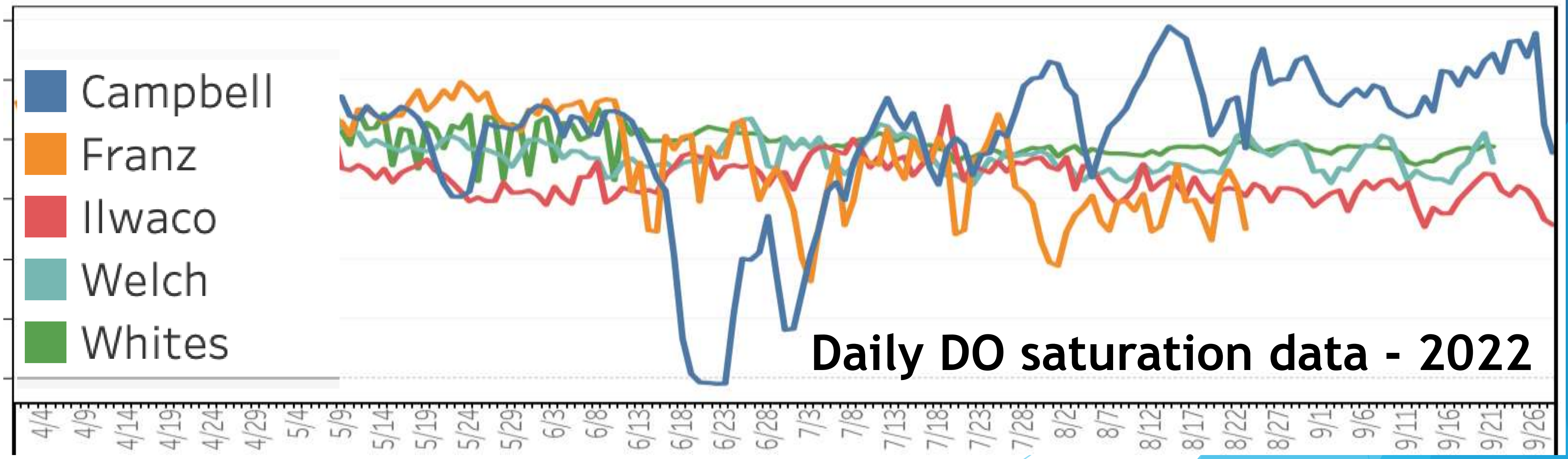
Chlorophyll: River phytoplankton show seasonal changes, with highest densities prior to the freshet. In the summer, noxious cyanobacteria can grow to high densities, which is detected by pigment fluorescence. Phytoplankton densities are highest at sites least connected to the river mainstem.

Dissolved oxygen 2008-2022

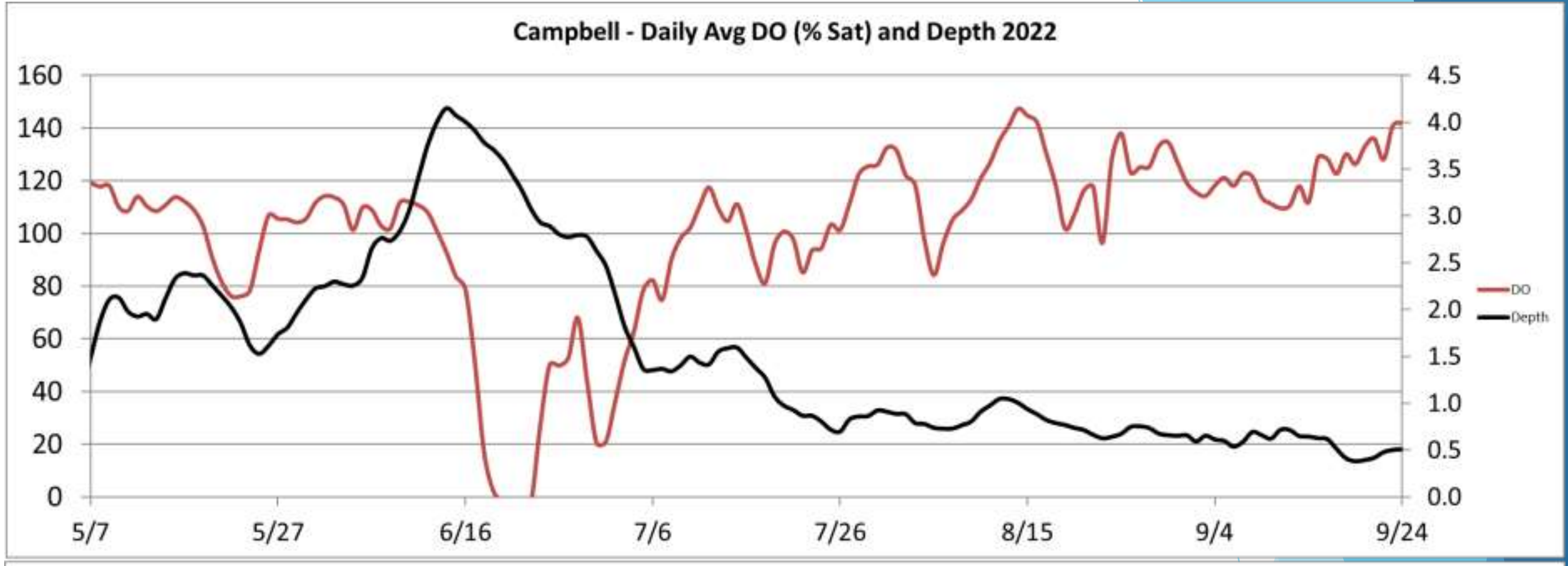


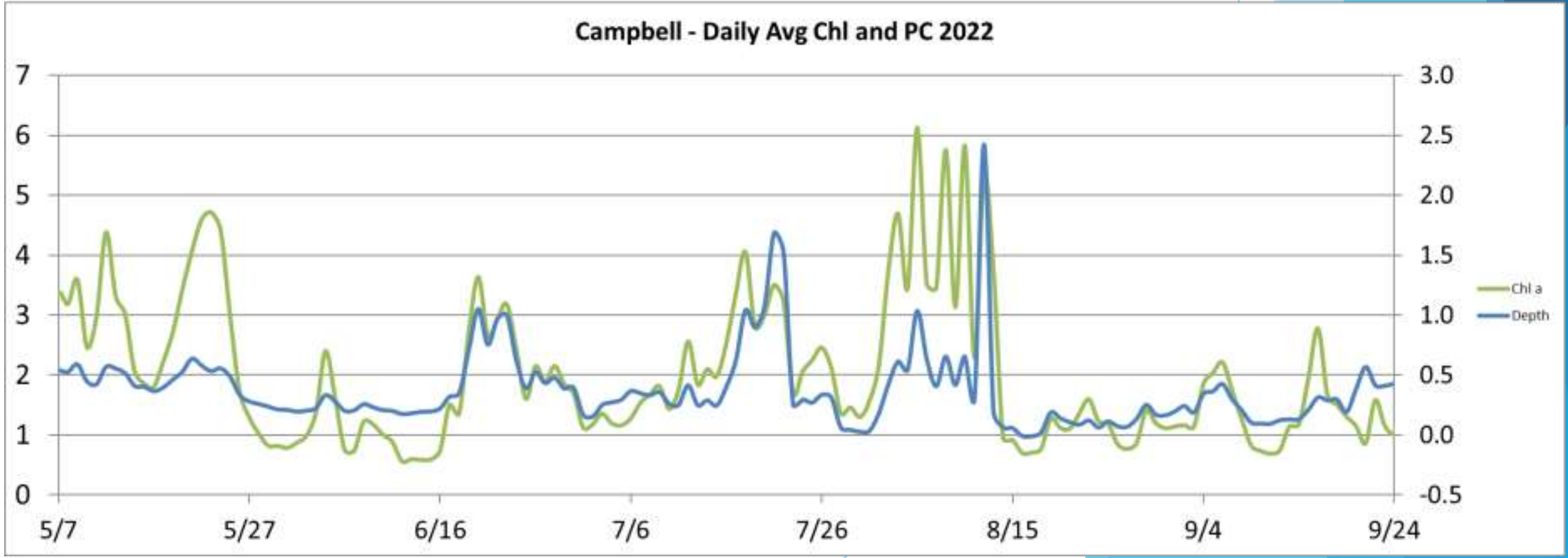





Campbell
Franz
Ilwaco
Welch
Whites
Daily DO saturation data - 2022
4/4 4/9 4/14 4/19 4/24 4/29 5/4 5/9 5/14 5/19 5/24 5/29 6/3 6/8 6/13 6/18 6/23 6/28 7/3 7/8 7/13 7/18 7/23 7/28 8/2 8/7 8/12 8/17 8/22 8/27 9/1 9/6 9/11 9/16 9/21 9/26

Hypoxia resulted from a combination of high water, rapid growth of algae, and limited air-water interaction



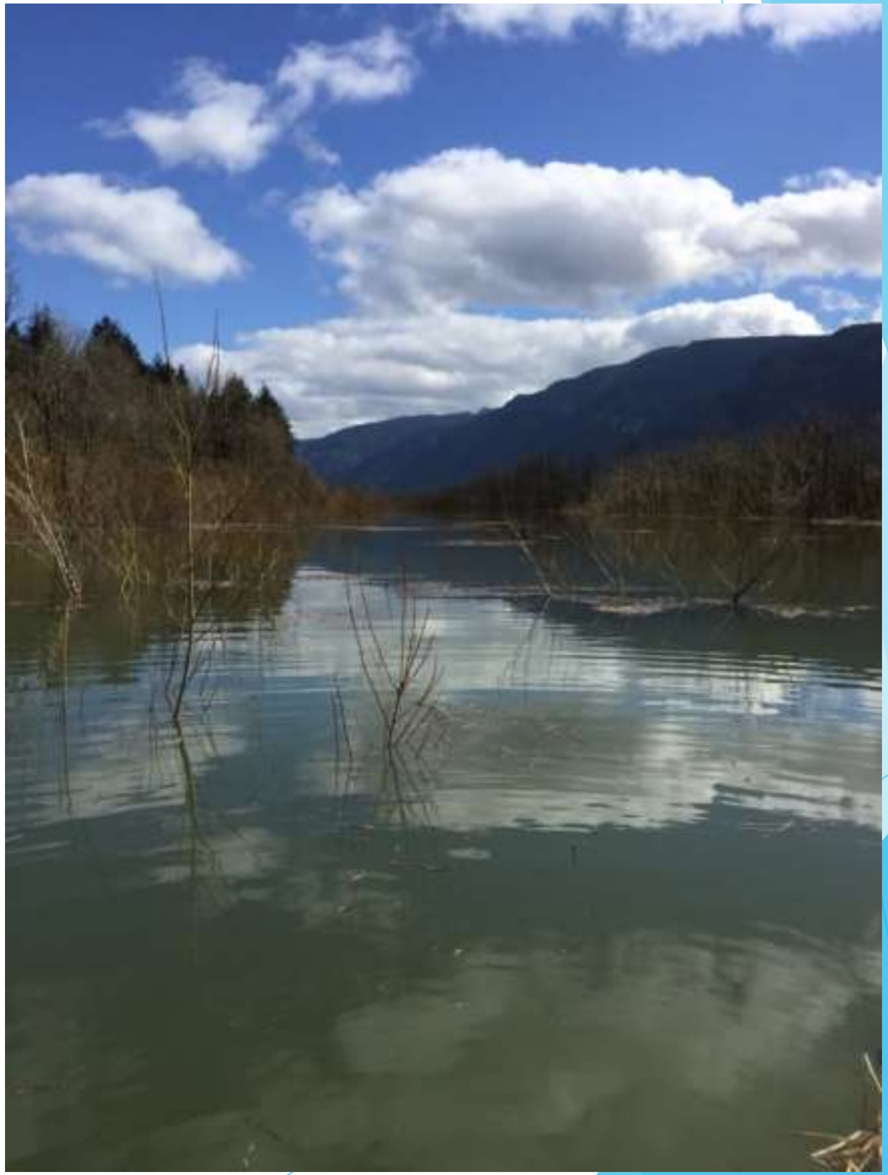


What have we learned?

Dissolved oxygen: DO levels can get low in shallow, wetland habitats but this is modulated by water depth. During peak flows, there is less opportunity for convective exchange and DO saturation can decline, especially at Campbell and Franz where sites are relatively disconnected from mainstem.

Off-channel habitats 2015 vs 2017

Off-channel habitats 2015-2017



Summary

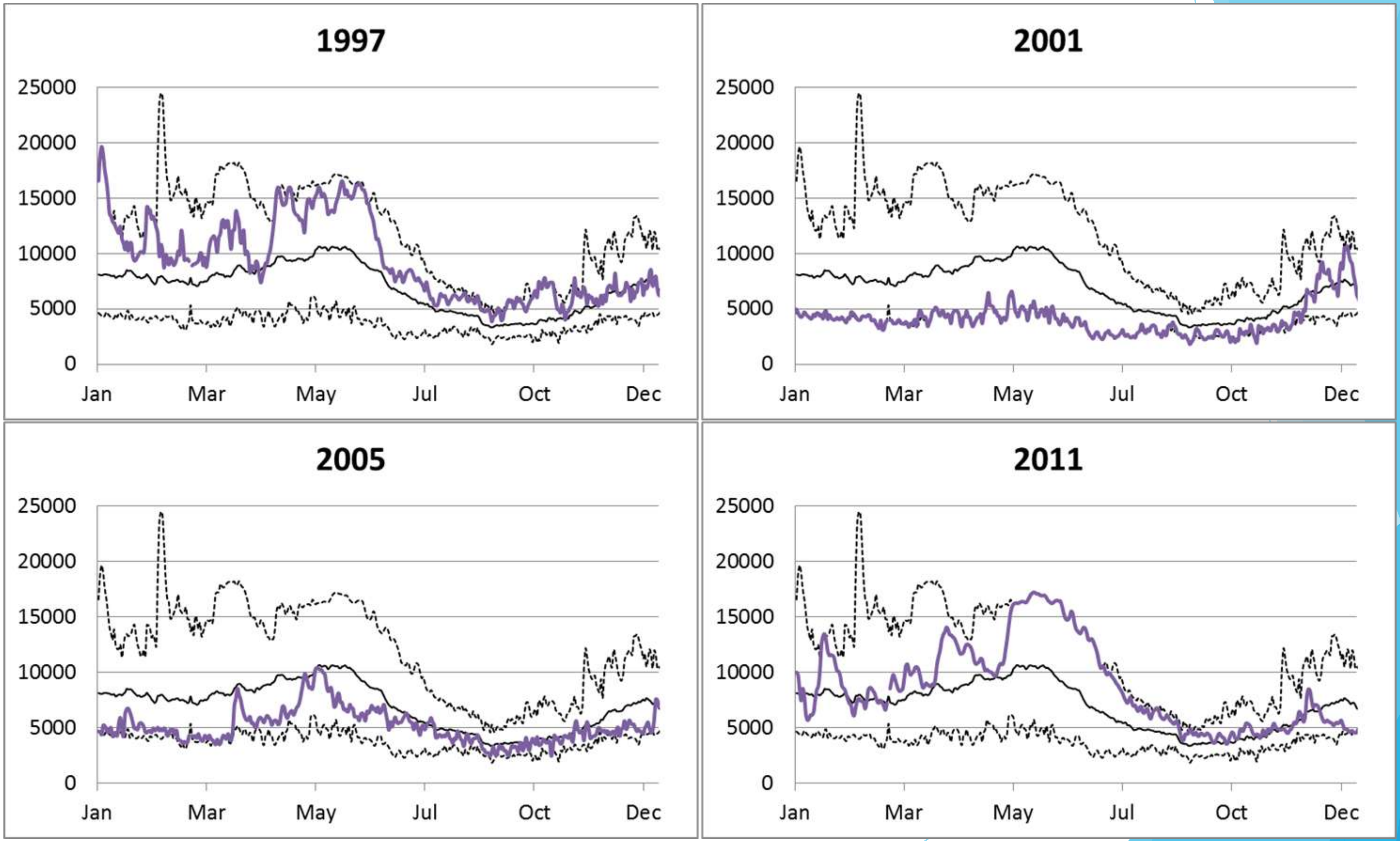
- Off-channel wetland sites reveal periods of good and poor habitat opportunity for juvenile salmonids.

- Warmer water, algae blooms, and hypoxia develop as a result of interrelated effects of size of seasonal freshet, warm vs cool air temperature, and degree of connection with mainstem

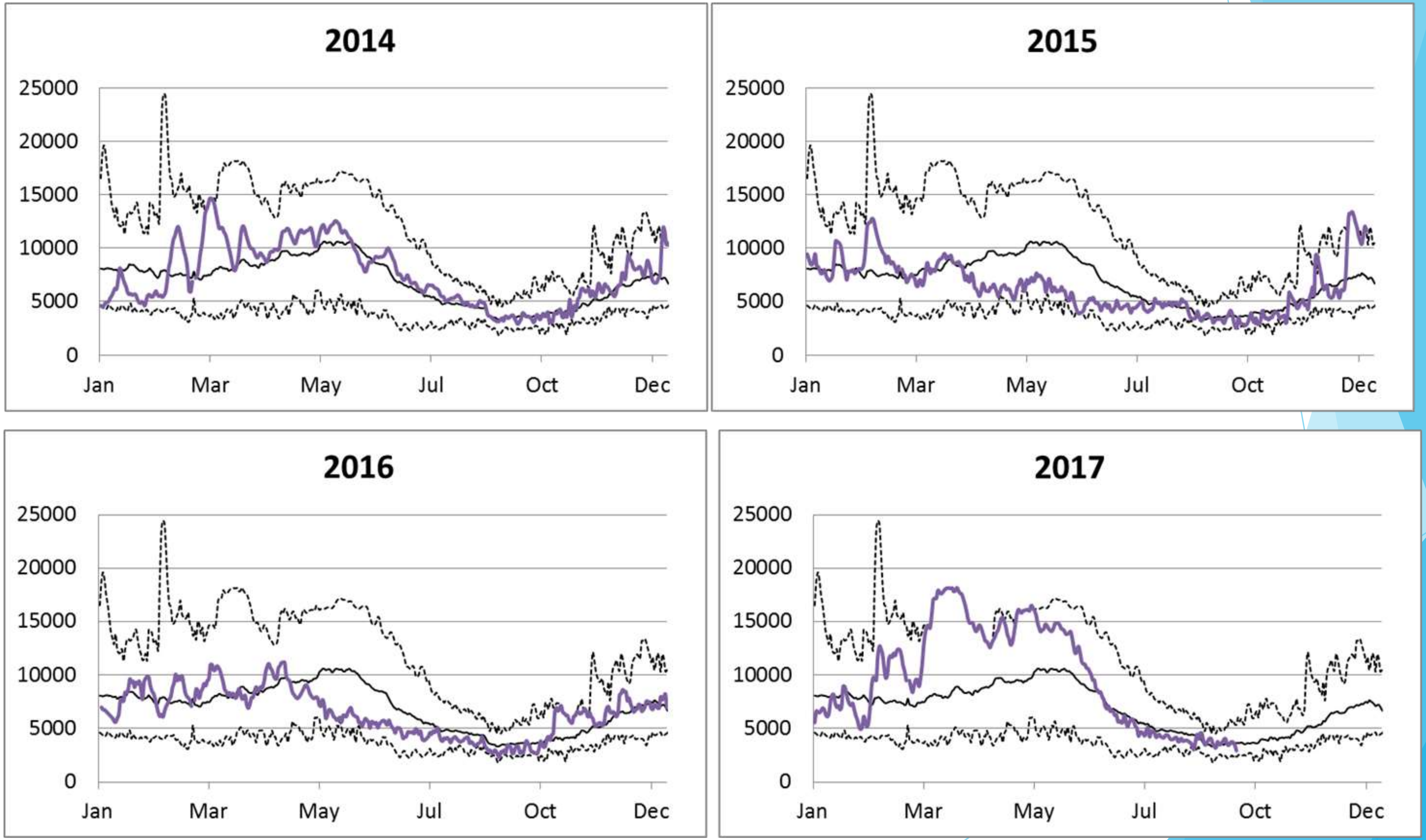
EMP Team

- Joe Needoba (OHSU) –Mainstem and Abiotic Site Conditions
- Sarah Kidd, Sneha Rao, Ian Edgar (EP) (*formerly* Roger Fuller, Katrina Poppe (ETG), Amy Borde (PNNL) –Habitat Structure, Hydrology, Soils, Sediment Accretion, Detritus
- Tawnya Peterson (OHSU) –Food Web, e.g., Planktonic and Macrophyte contributions to Juvenile Salmon Food Web
- Jeff Cordell, Mary Ramirez, Jason Toft, Kerry Accola, (UW) - Fish Prey and Macroinvertebrate Community
- Regan McNatt, Susan Hinton, Curtis Roegner (NOAA) –Fish Community and Occurrence
- Narayan Elasmar, April Silva, (CREST) –Really Awesome!! Field Support!
- Catherine Corbett – Chief Scientist
- Students and Staff of ESHH

Annual variability in Spring Freshet



Annual variability in Spring Freshet



Annual variability in Spring Freshet