Columbia River
Cold Water Refuges Project

June 2018

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EPA Region 10

Background

- NMFS 2015 Jeopardy Biological Opinion on EPA's Approval of Oregon's Temperature Water Quality Standards

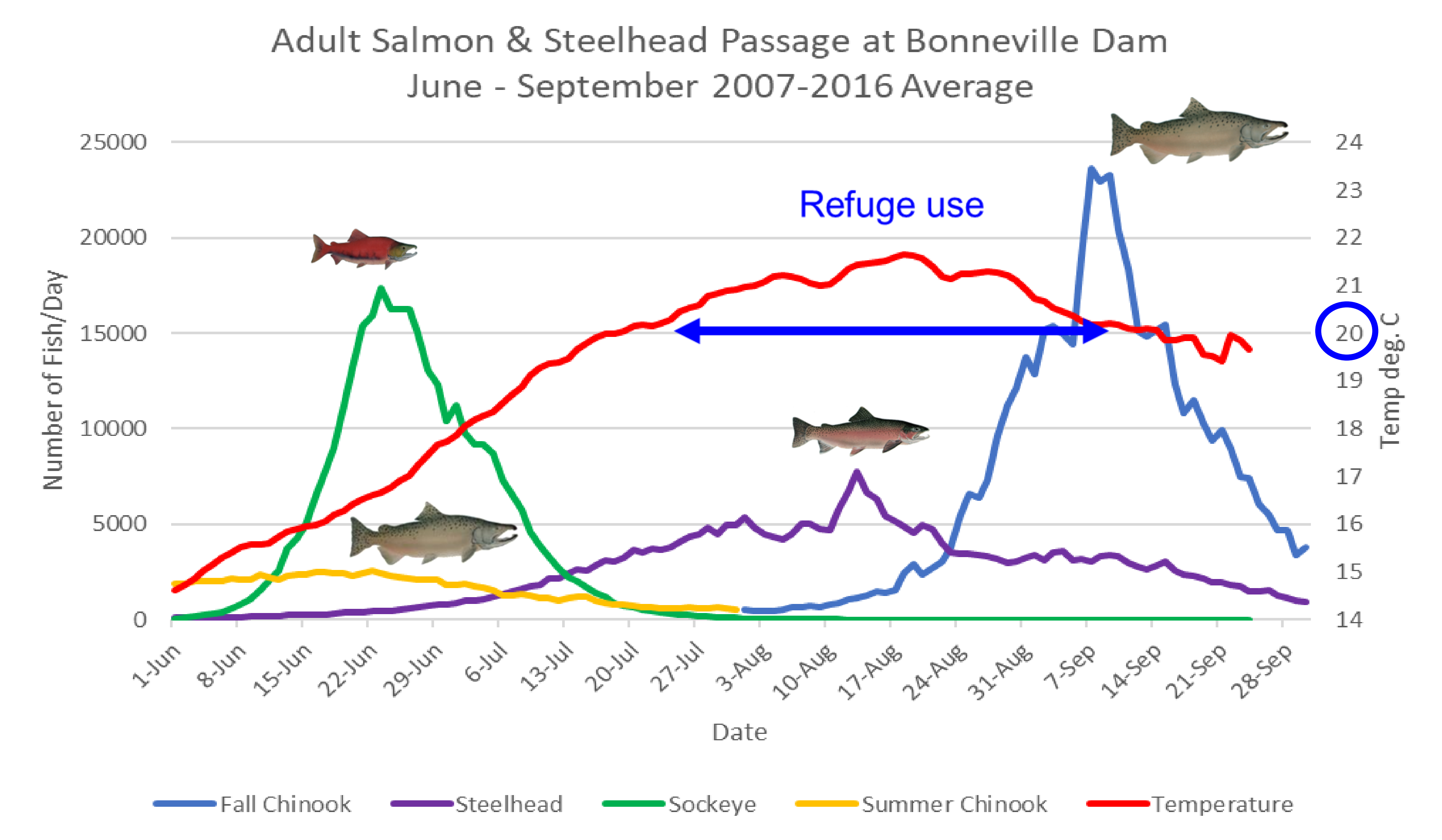
- Oregon Columbia & Lower Willamette River Temperature Criteria
  - 20C numeric criteria, plus
  - Cold Water Refugia (CWR) narrative criteria
    - "must have CWR that's sufficiently distributed so as to allow salmon and steelhead migration without significant adverse effects from higher temperatures elsewhere in the water body"
    - "CWR means those portions of a water body where, or times during the diel cycle when, the water temperature is at least 2C colder than the daily maximum temperature of the adjacent well mixed flow of the water body"

- NMFS concluded CWR narrative criteria is not an effective criteria due to lack of implementation
  - Jeopardy for Steelhead (LCR, UWR, MCR, UCR, SRB); Chinook (LCR, UWR); Sockeye (SR); SR Killer Whales
  - Reasonable and Prudent Alterative (RPA) – EPA develop a Columbia River Cold Water Refuges Plan by November 2018

EPA Columbia River CWR Plan

1. Map and characterize the CWR areas in the Lower Columbia River
2. Characterize the extent to which salmon and steelhead use CWR
3. Assess whether current CWR is sufficient to meet Oregon’s narrative criteria
4. Identify actions to protect, restore, or enhance CWR

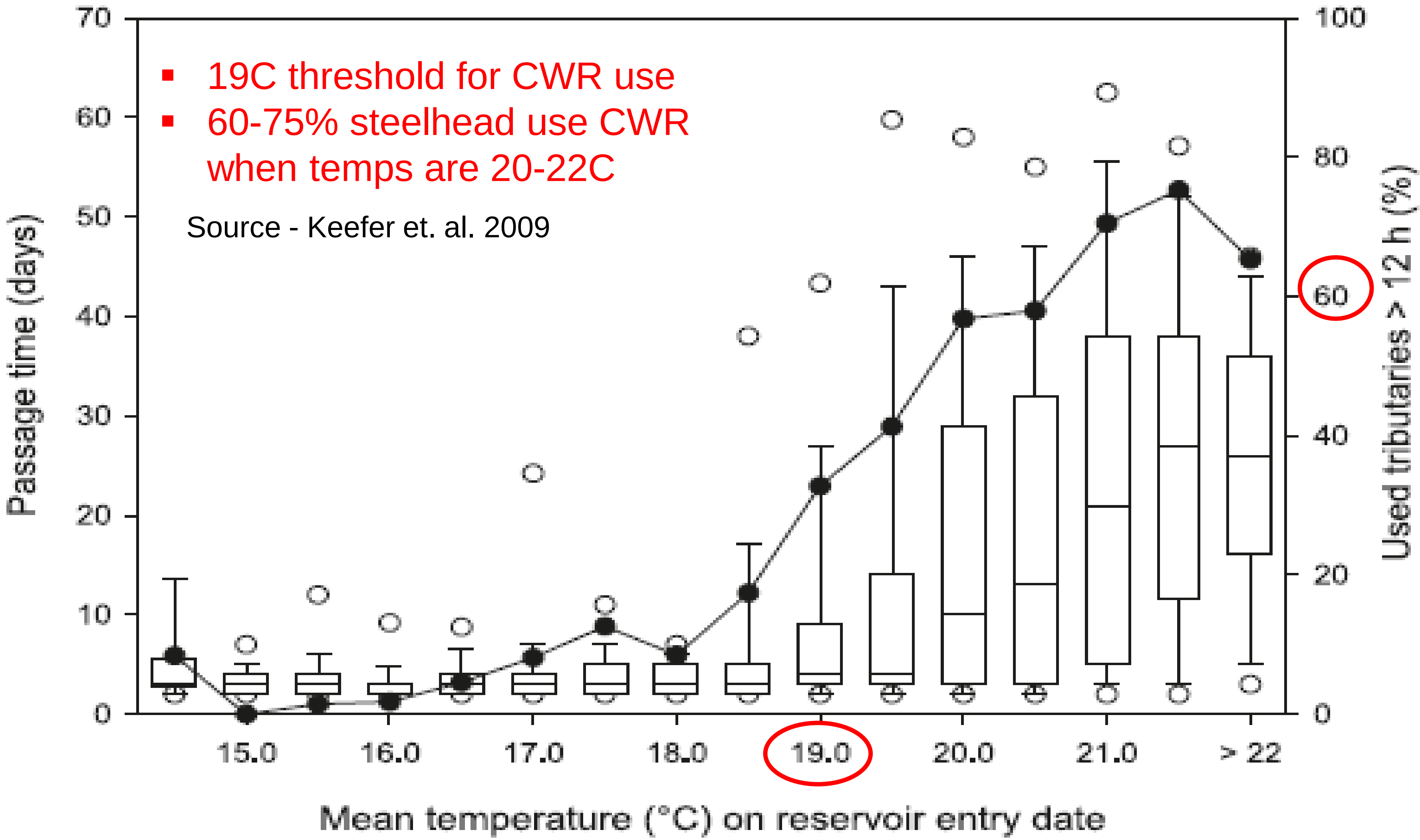
Bonneville Dam Temperatures and Fish Passage



Steelhead use of CWR

- 19C threshold for CWR use
- 60-75% steelhead use CWR when temps are 20-22C

Source - Keefer et. al. 2009



Chinook use of CWR

- 21C threshold for CWR use
- 20-40% use CWR with 21-22C
- Underestimate - plume use not fully counted

Source - Goniea et. al. 2006

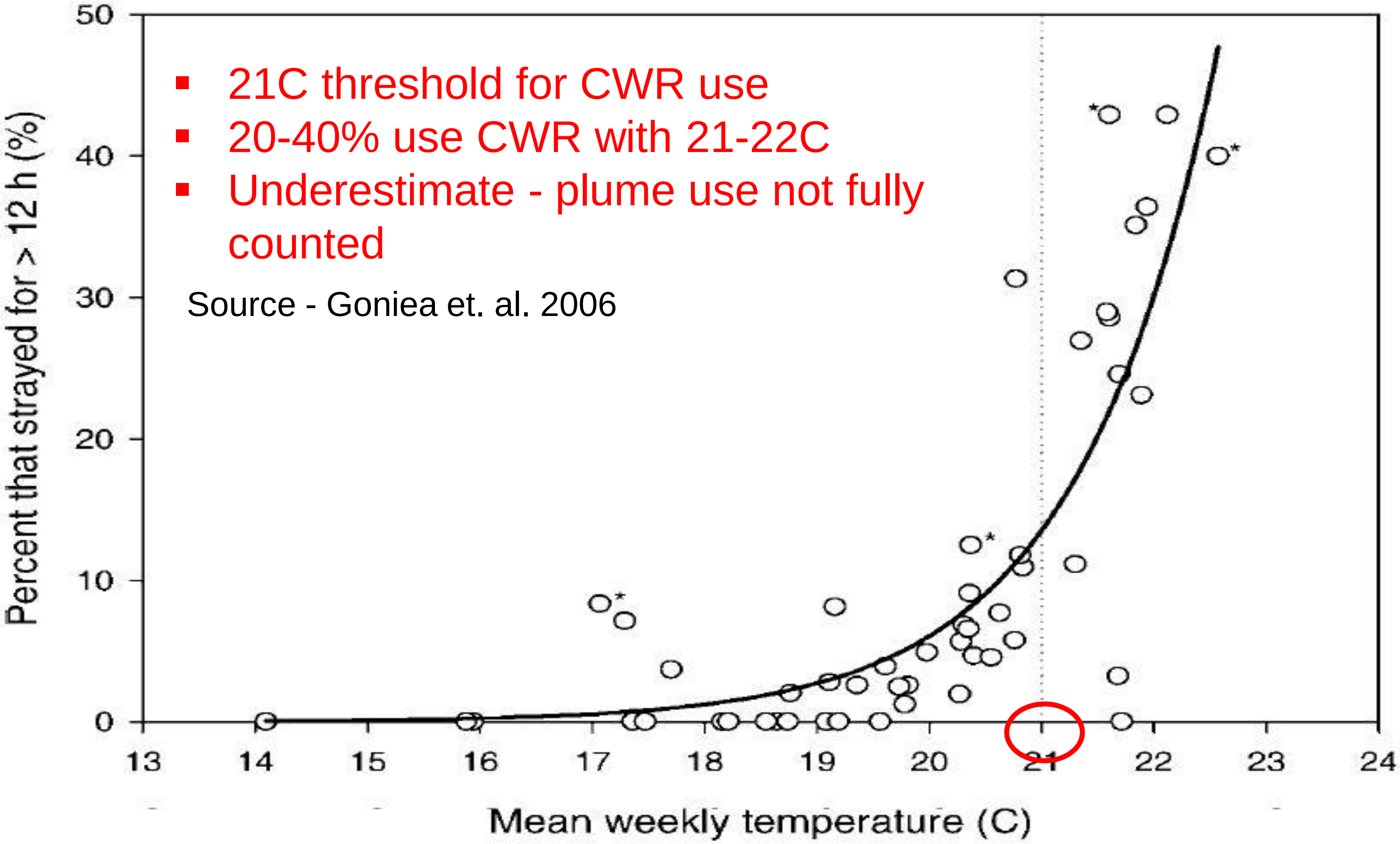
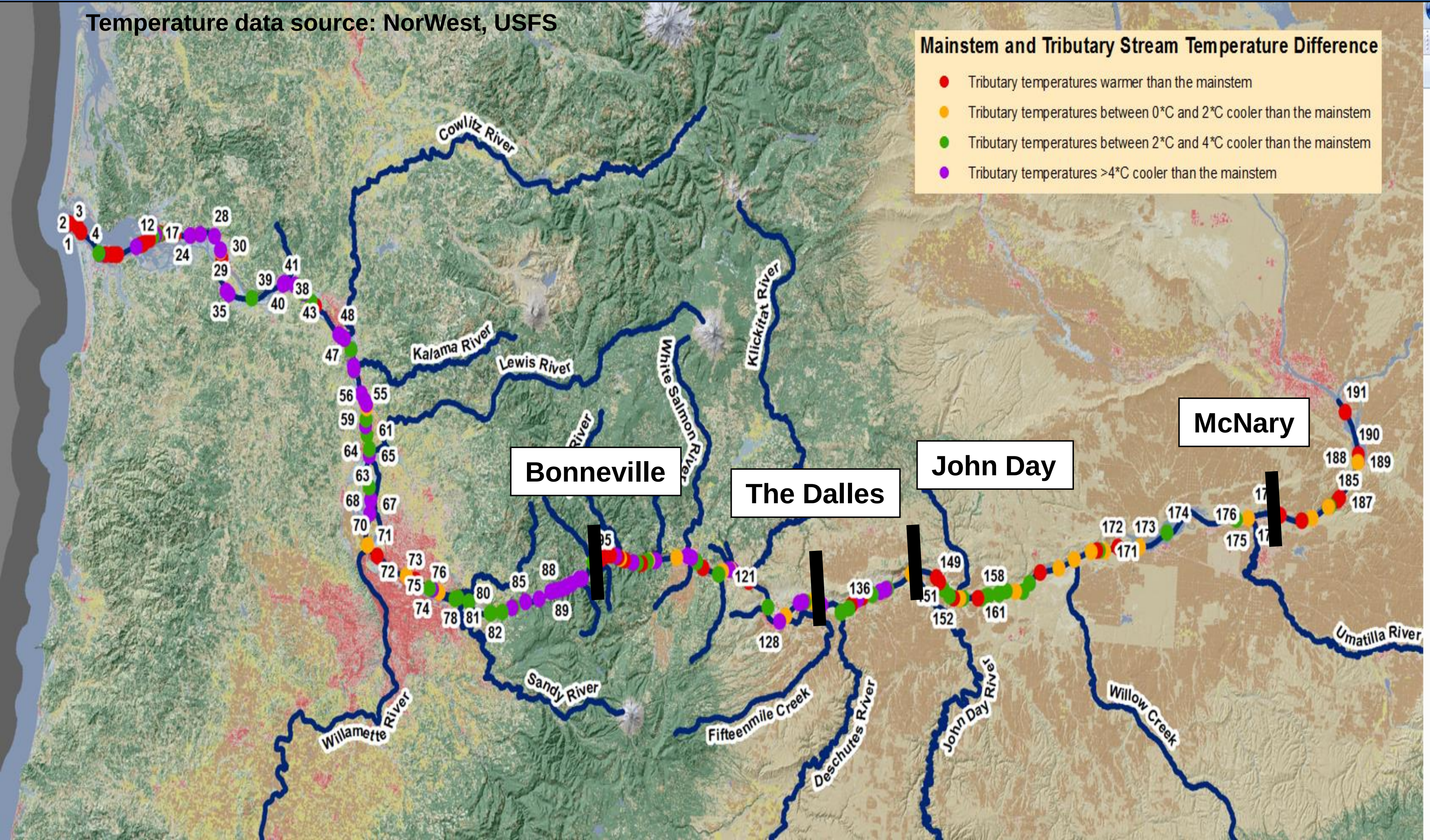
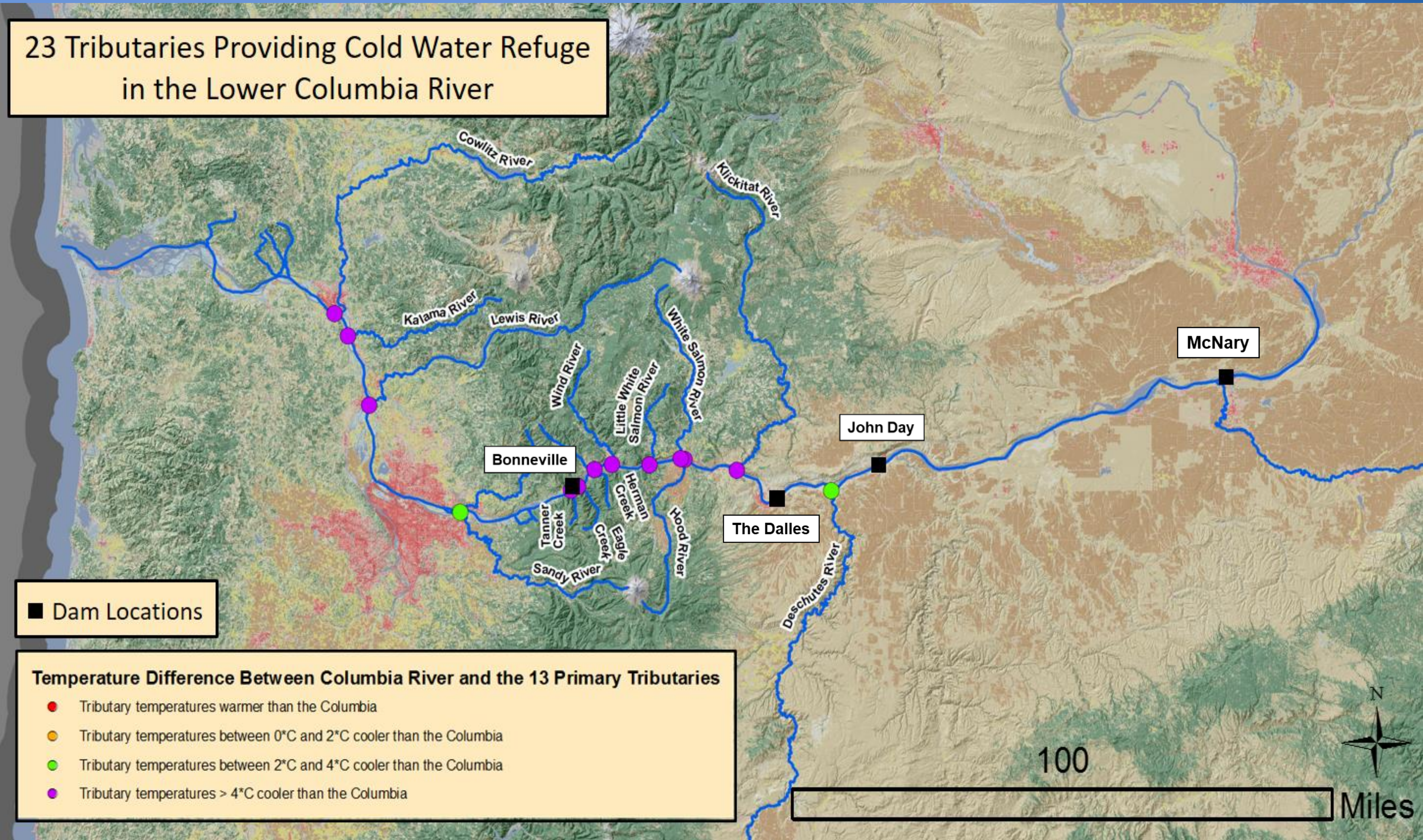


FIGURE 6.—Relationship between the percent of fall Chinook salmon that used (>12 h) coolwater tributaries and mean weekly water temperatures at Bonneville Dam. Circles represent 52 weekly bins (mean = 41 fish/bin; range = 4–122 fish/bin). The curve is the exponential regression line that best fits the data ($r^2 = 0.80$; $P < 0.0001$; percent $= 6.558^{-7} e^{0.802 \times \text{temperature}}$). Asterisks indicate data points with fewer than 10 fish.

191 Columbia River Tributaries below Snake River Confluence



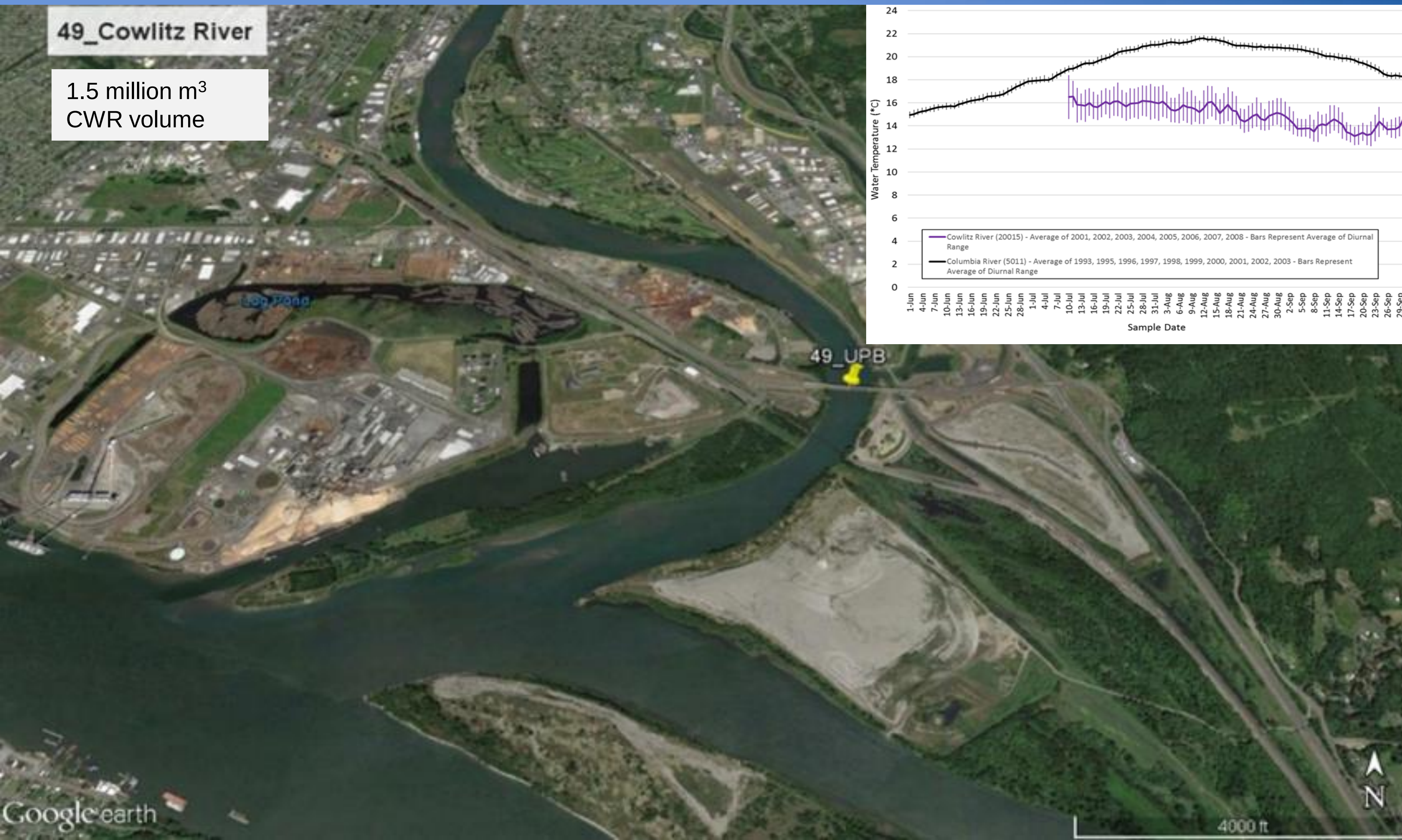
Lower Columbia River CWR



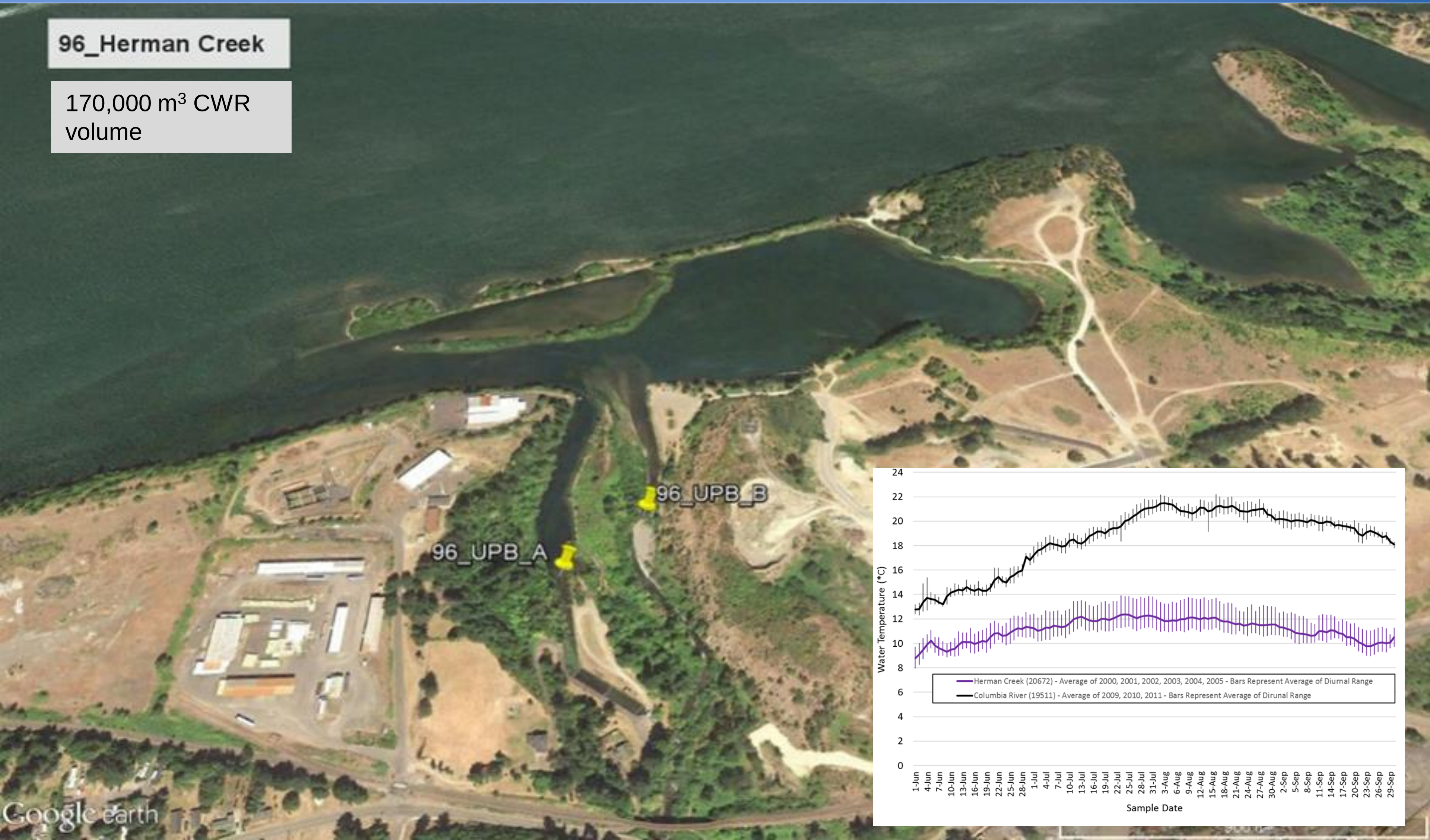
Lower Columbia River CWR
(23 Total/13 Primary)

Tributary Name	River Mile	Mainstem Temp[1]	Tributary Temp[2]	Temp Difference	Tributary Flow[3]	Plume CWR Volume (> 2°C Δ)[4]	Stream CWR Volume (> 2°C Δ)[5]	Total CWR Volume (> 2°C Δ)
		°C	°C	°C	cfs	m3	m3	m3
Skamokawa Creek	30.9	21.3	16.2	-5.1	23	450	1,033	1,483
Mill Creek	51.3	21.3	14.5	-6.8	10	110	446	556
Abernethy Creek	51.7	21.3	15.7	-5.6	10	81	806	887
Germany Creek	53.6	21.3	15.4	-5.9	8	72	446	518
Cowlitz River	65.2	21.3	16.0	-5.4	3634	870,000	684,230	1,554,230
Kalama River	70.5	21.3	16.3	-5.0	314	14,000	57,089	71,089
Lewis River	84.4	21.3	16.6	-4.8	1291	120,000	493,455	613,455
Sandy River	117.1	21.3	18.8	-2.5	469	9,900	129,372	139,272
Washougal River[6]	117.6	21.3	19.2	-2.1	107	740	32,563	33,303
Bridal Veil Creek	128.9	21.3	11.7	-9.6	7	120	0	120
Wahkeena Creek	131.7	21.3	13.6	-7.7	15	220	0	220
Oneonta Creek	134.3	21.3	13.1	-8.2	29	820	54	874
Tanner Creek	140.9	21.3	11.7	-9.6	38	1,300	413	1,713
Bonneville Dam								
Eagle Creek	142.7	21.2	15.1	-6.1	72	2,100	888	2,988
Rock Creek[6]	146.6	21.2	17.4	-3.8	47	530	1,178	1,708
Herman Creek	147.5	21.2	12.0	-9.2	45	168,000	1,698	169,698
Wind River	151.1	21.2	14.5	-6.7	293	60,800	44,420	105,220
Little White Salmon River	158.7	21.2	13.3	-7.9	88	1,097,000	4,126	1,101,126
White Salmon River	164.9	21.2	15.7	-5.5	715	72,000	81,529	153,529
Hood River	165.7	21.4	15.5	-5.9	374	28,000	0	28,000
Klickitat River	176.8	21.4	16.4	-5.0	851	73,000	149,029	222,029
The Dalles Dam								
Deschutes River	200.8	21.4	19.2	-2.2	4772	300,000	580,124	880,124
John Day Dam								
Umatilla River[6]	284.7	20.9	20.8	-0.1	169	0	46,299	46,299

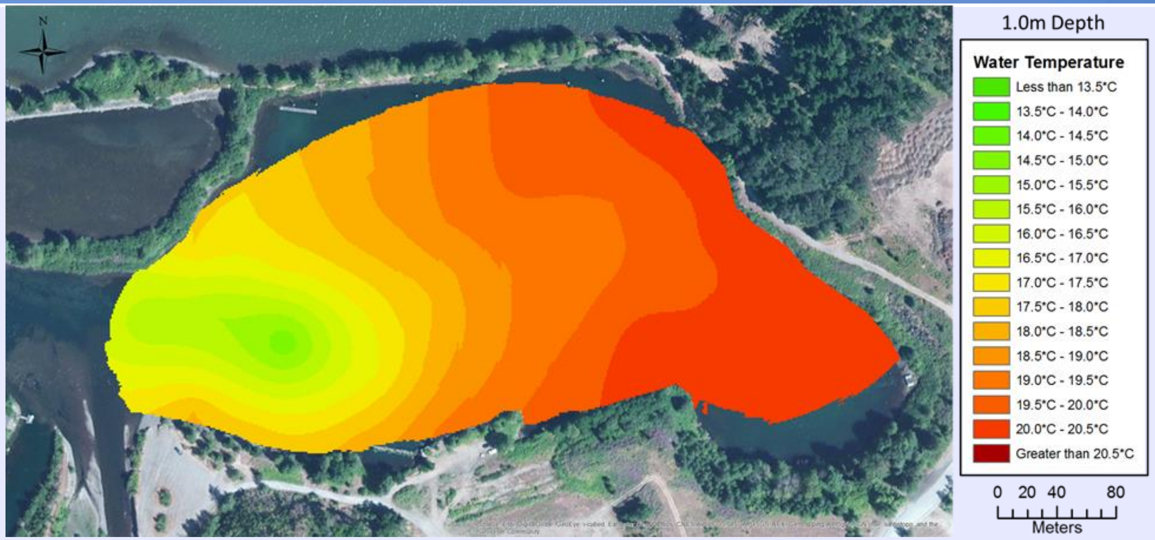
Cowlitz River CWR



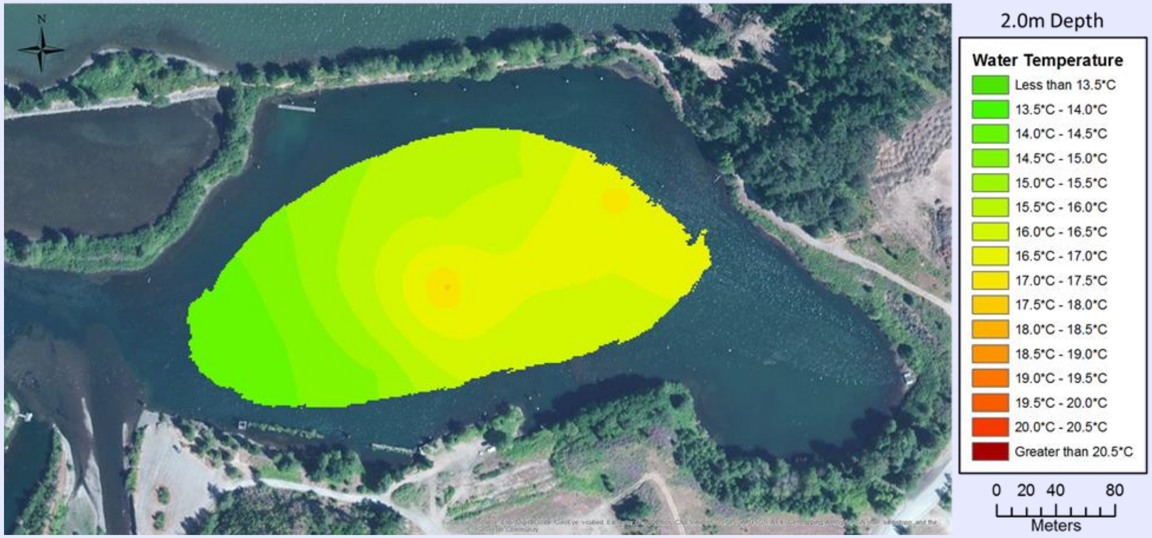
Herman Creek/Cove CWR



Herman Creek/Cove CWR



1 meter depth

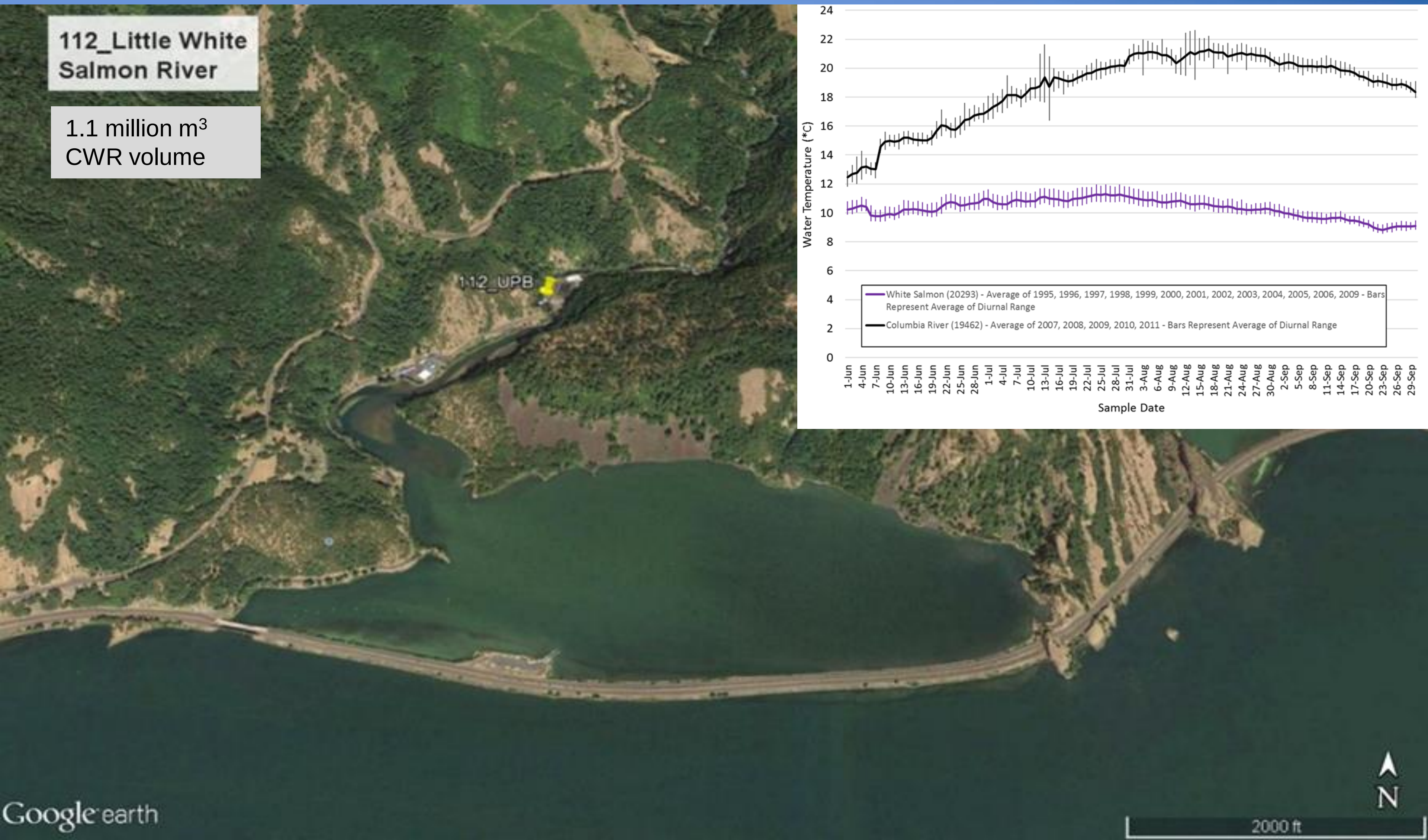


2 meter depth

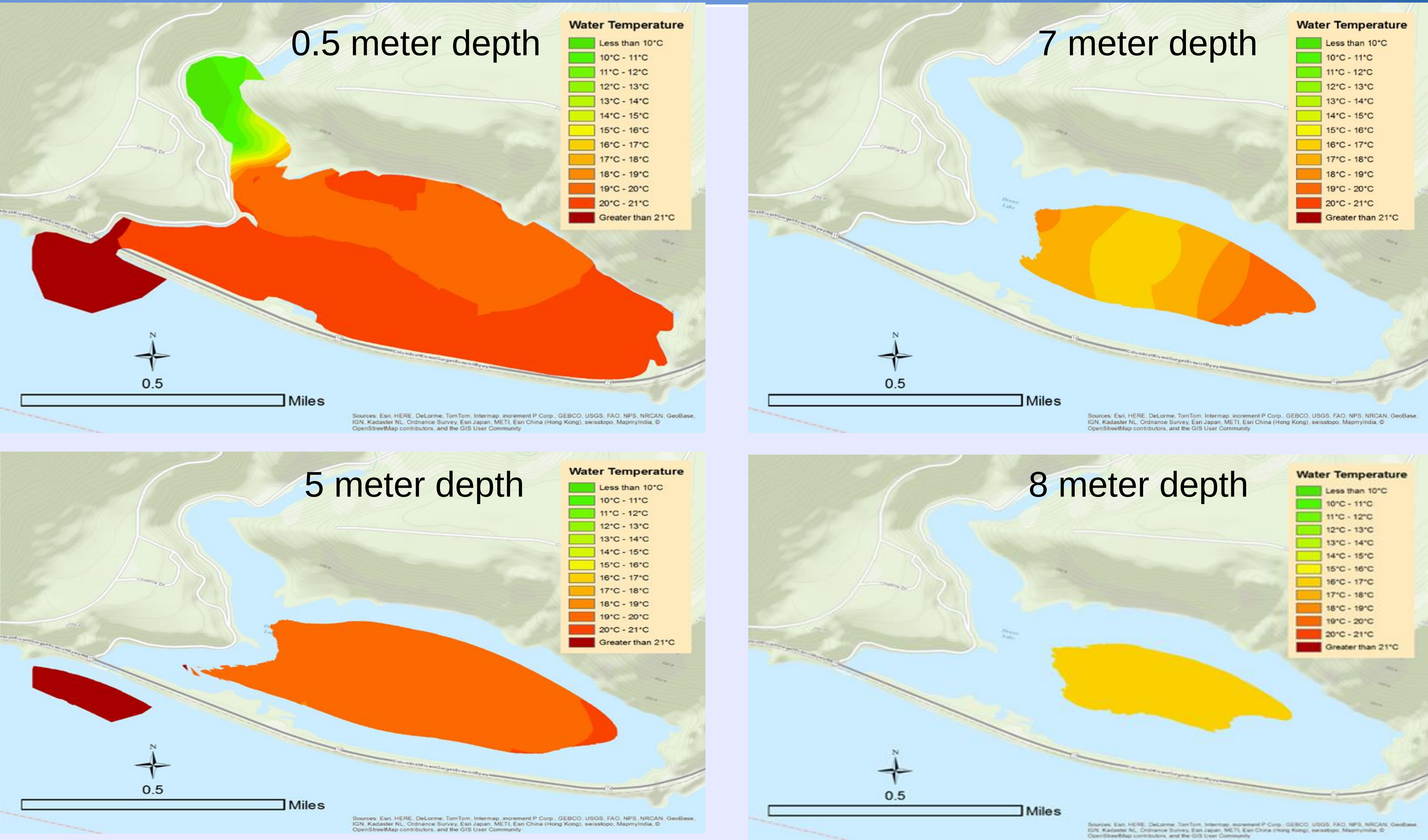
Little White Salmon River/Drano Lake CWR

112_Little White Salmon River

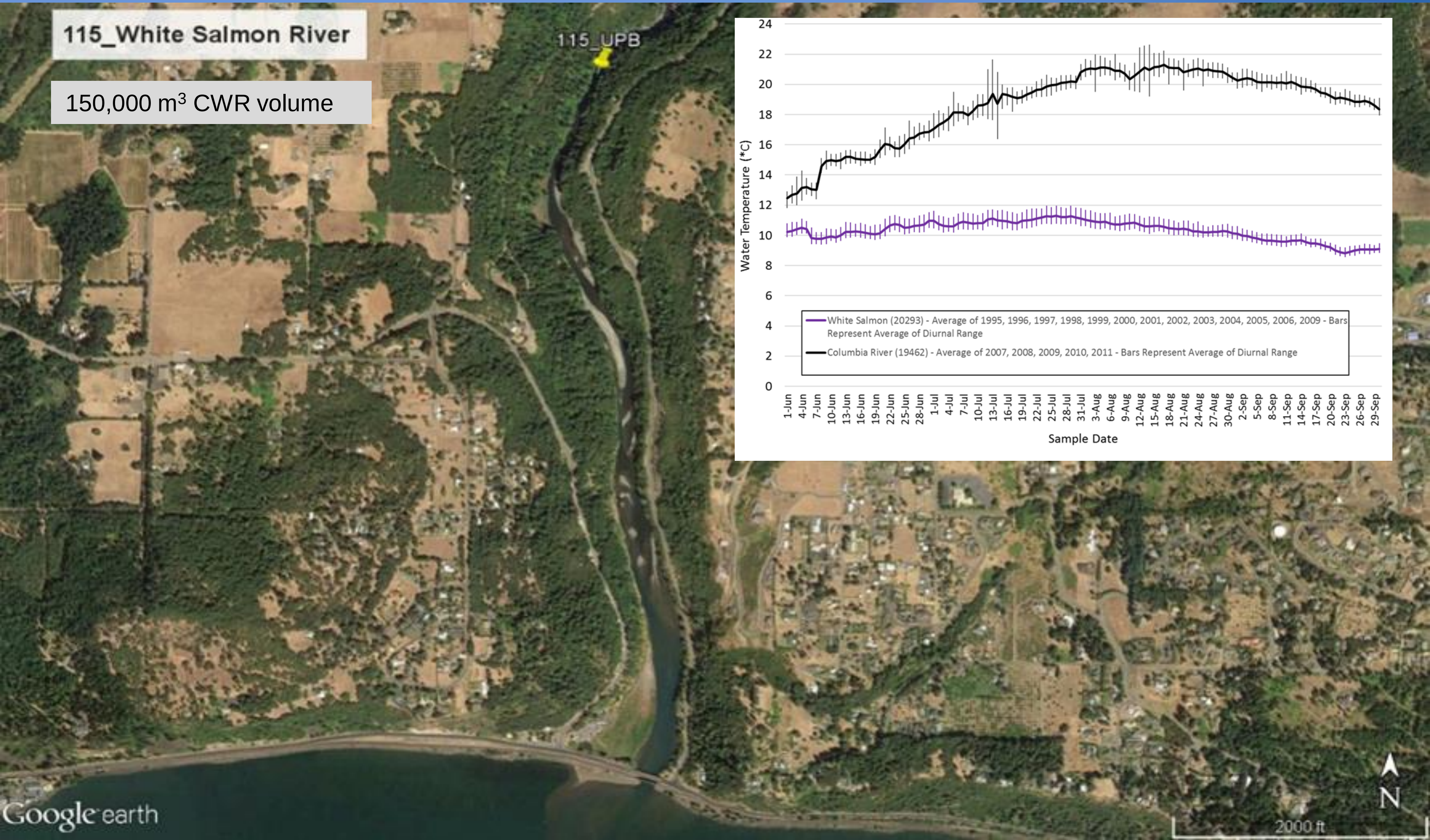
1.1 million m^3 CWR volume



Little White Salmon River/Drano Lake CWR



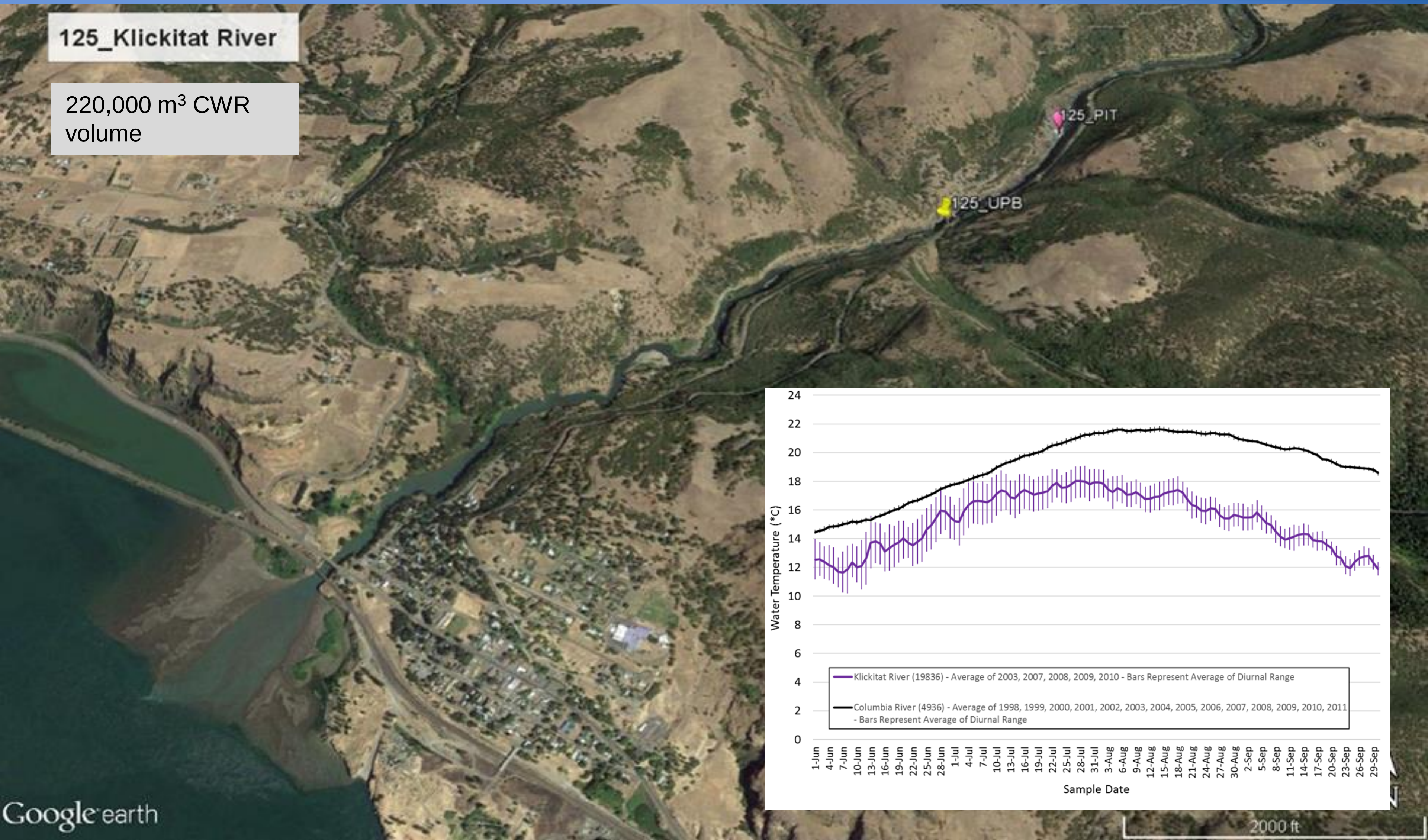
White Salmon River CWR



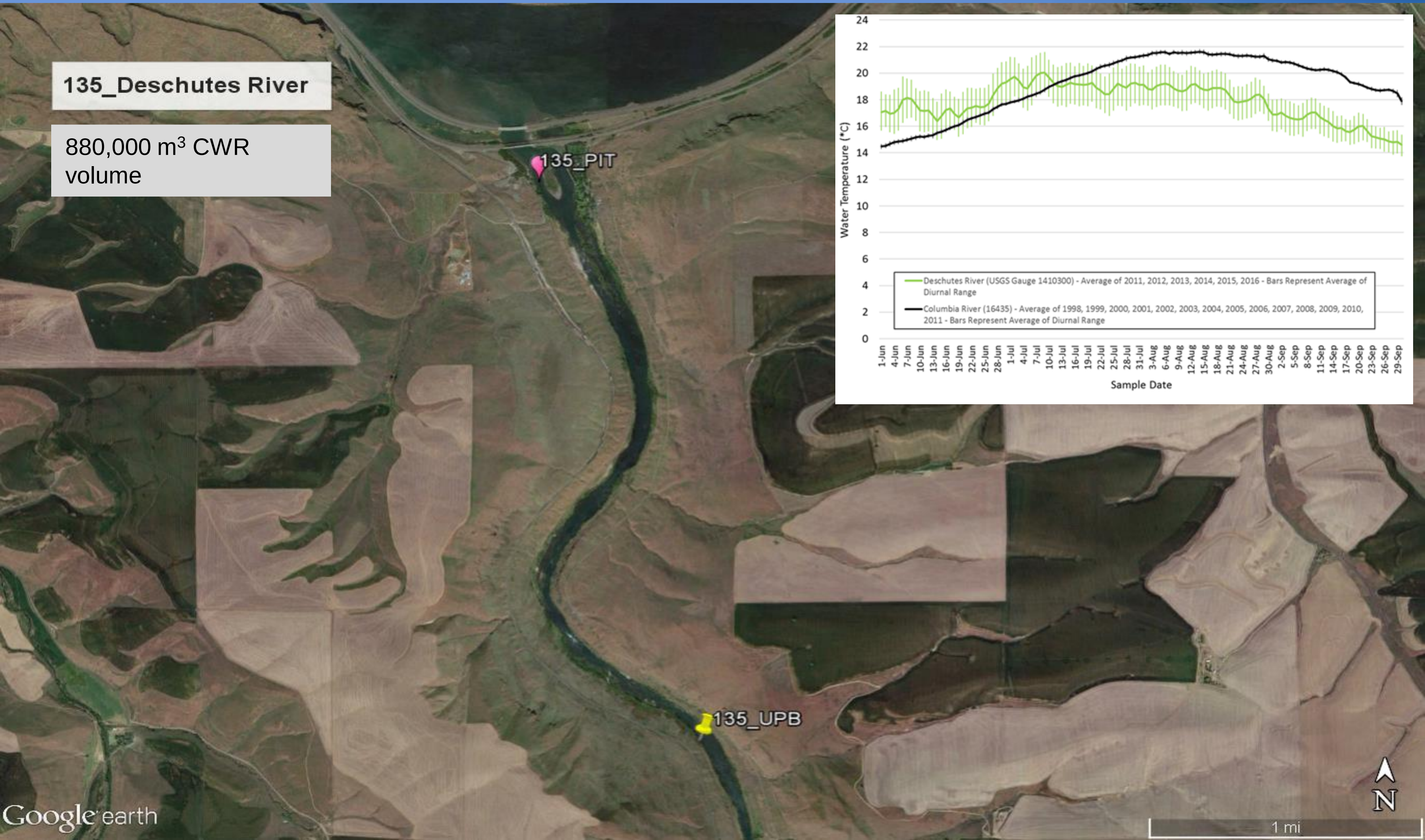
Klickitat River CWR

125_Klickitat River

220,000 m^3 CWR volume

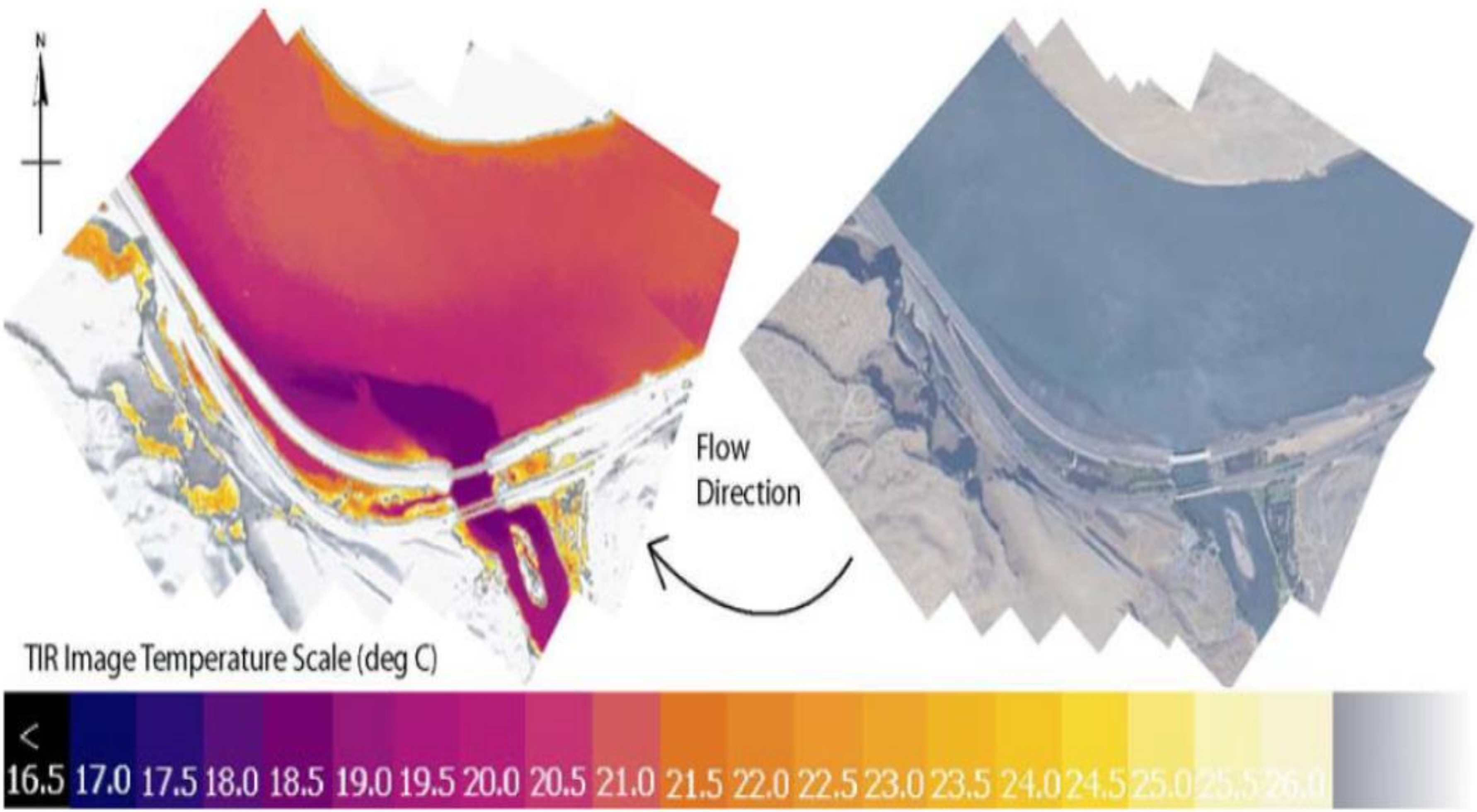


Deschutes River CWR



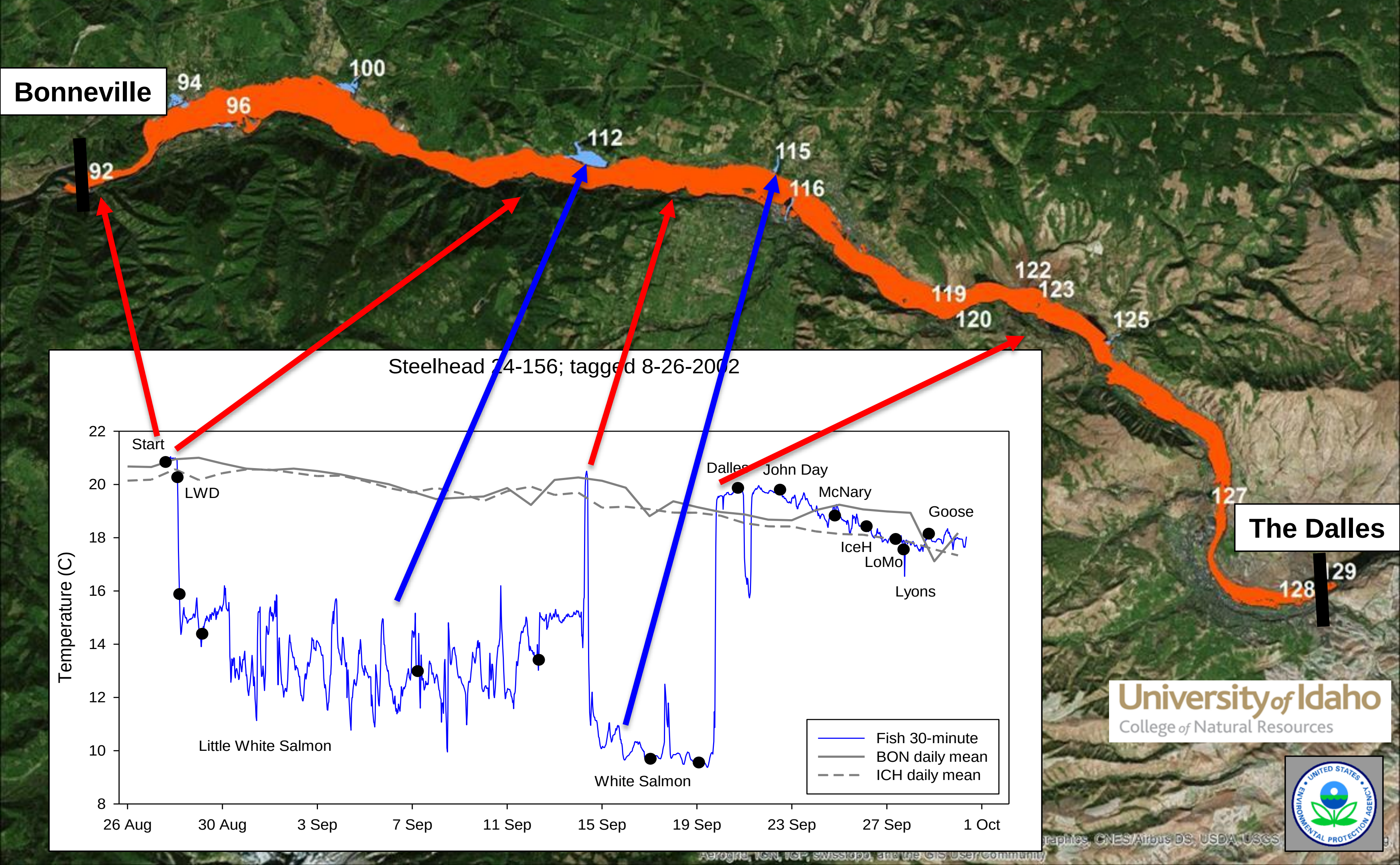
Deschutes River CWR Plume

Source: Watershed Sciences LLC, 2003

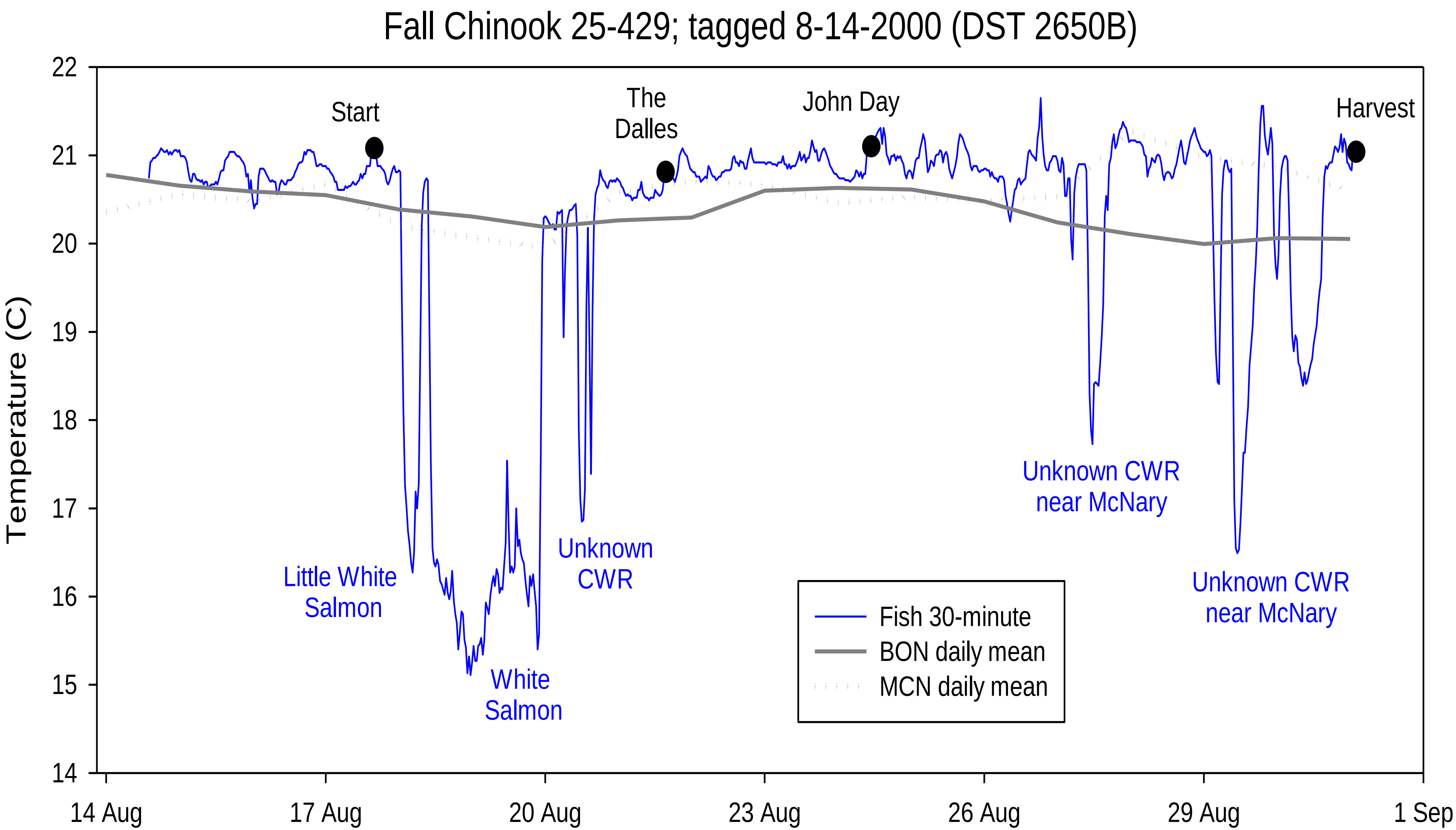


Steelhead use of CWR

Columbia River between Bonneville Dam and The Dalles Dam

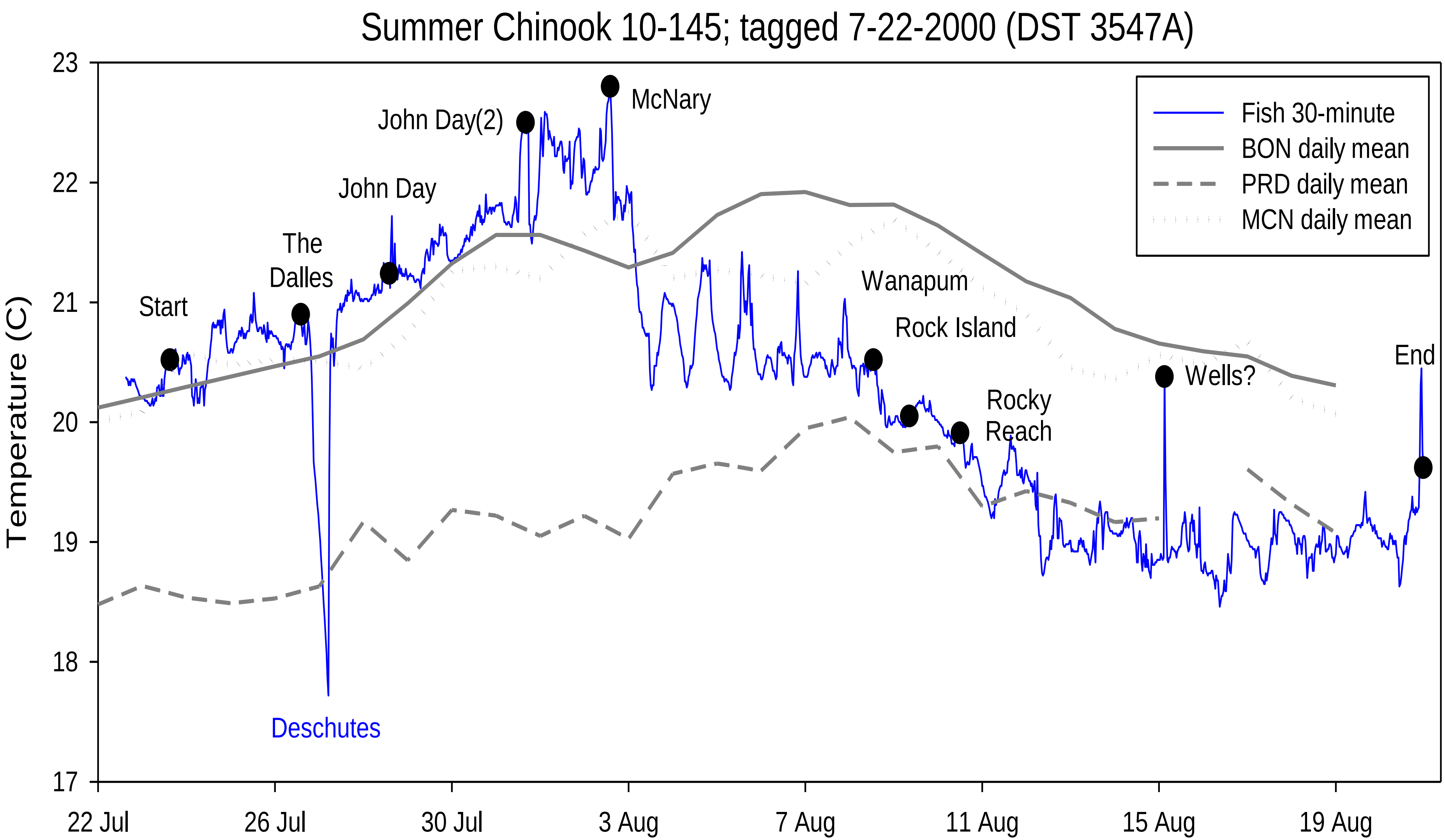


Fall Chinook use of CWR example

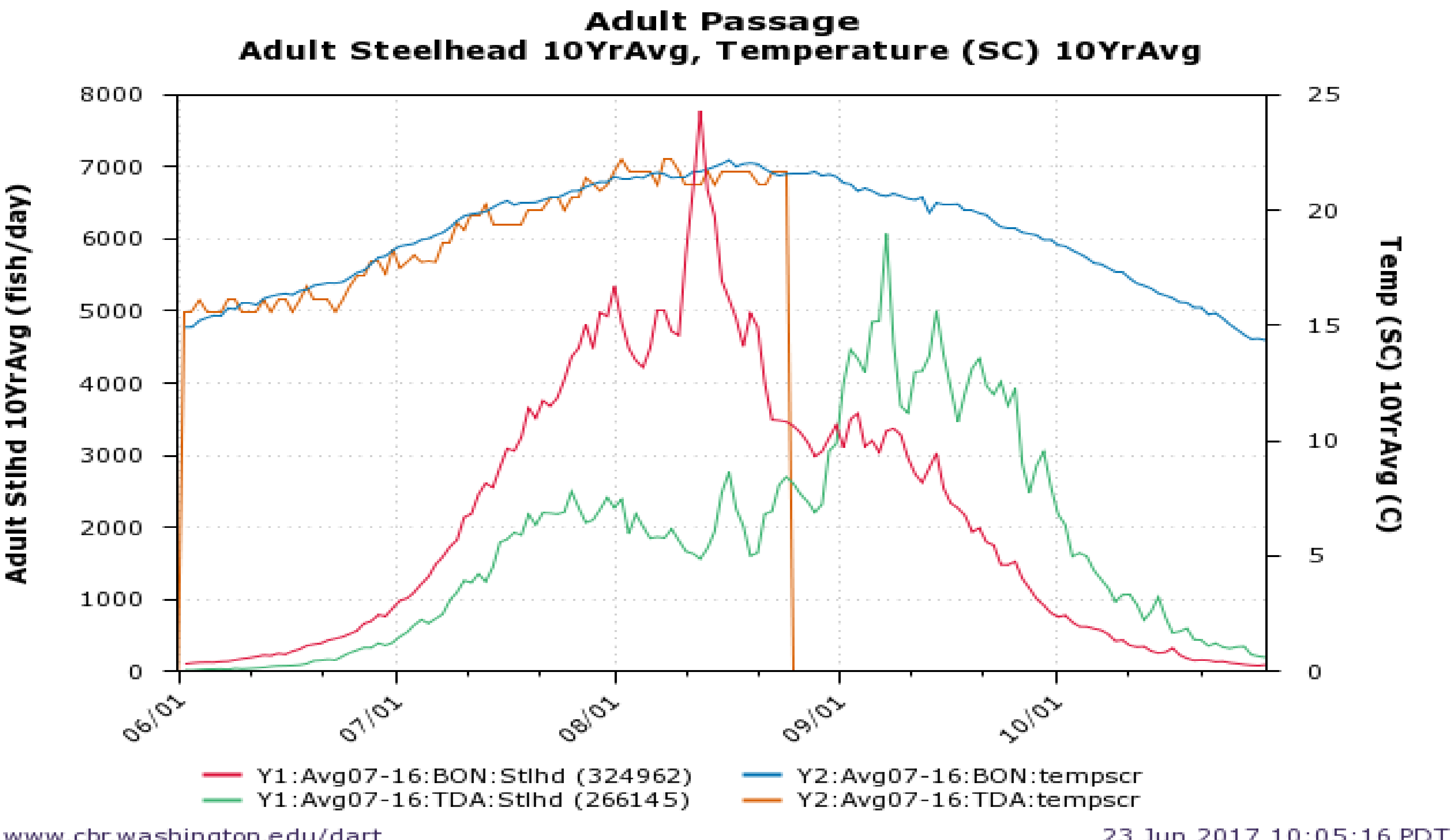


Summer Chinook CWR use example

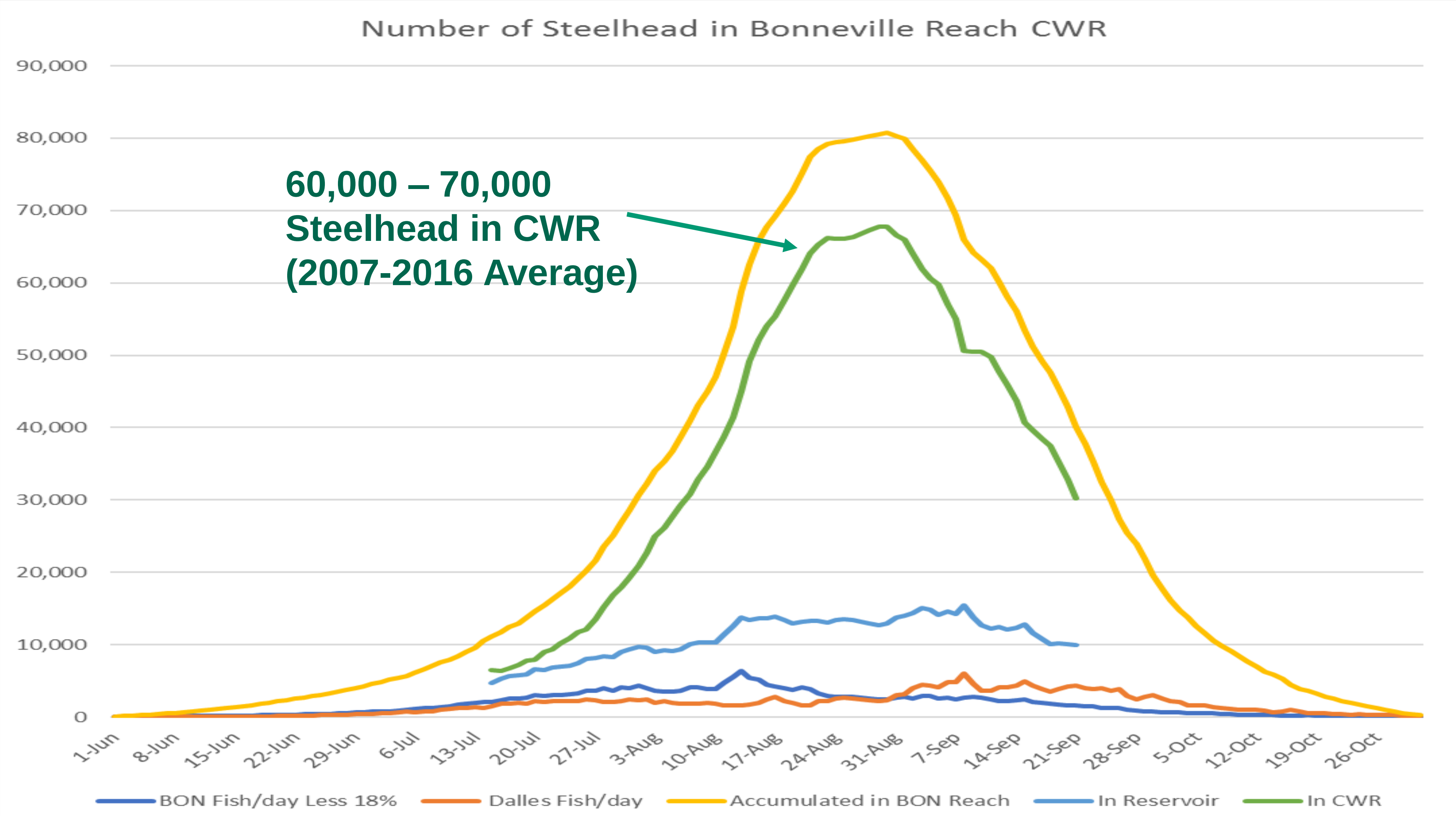
University of Idaho
College of Natural Resources



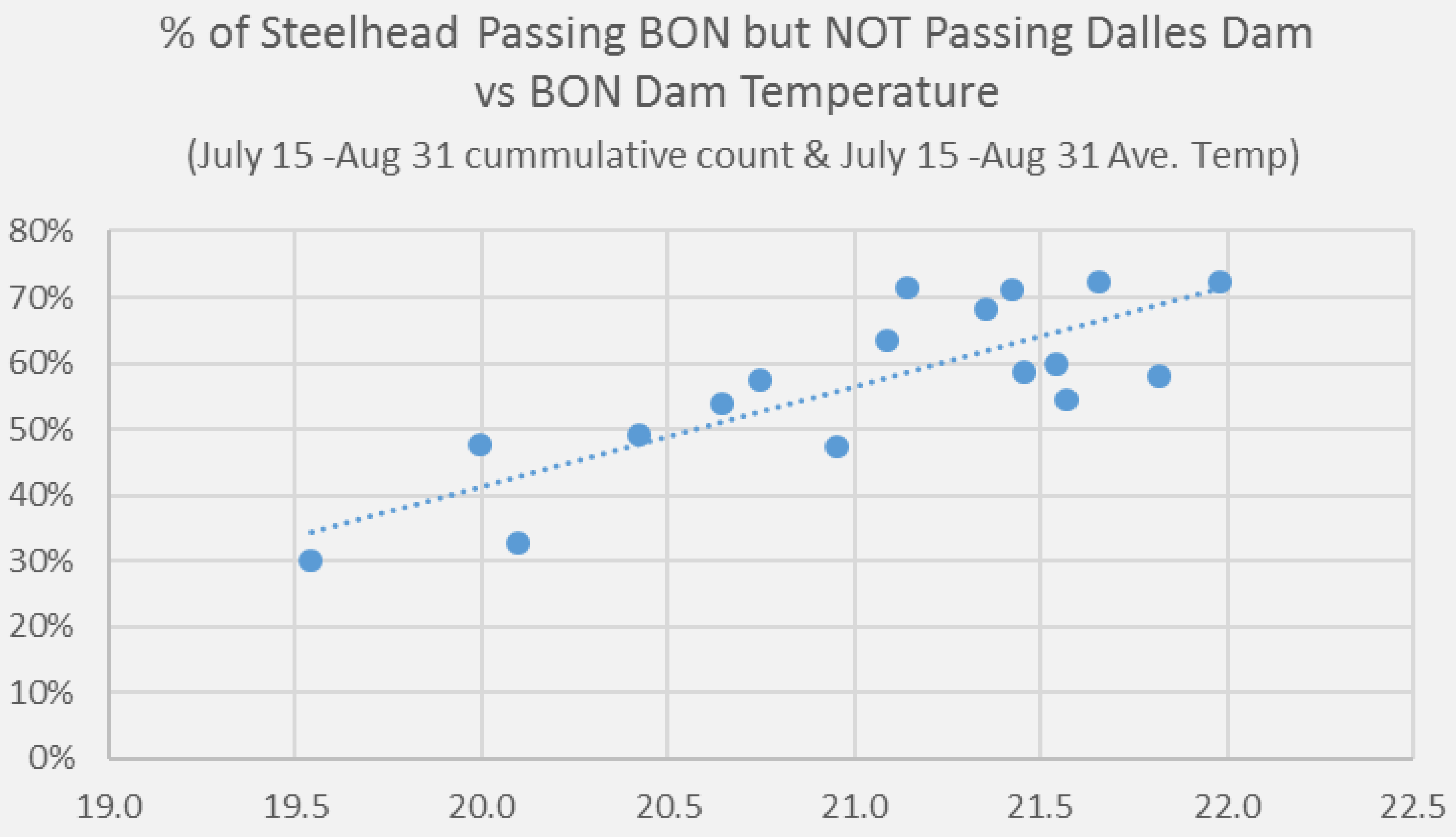
Bonneville Dam vs The Dalles Dam Steelhead Passage



Accumulation of Steelhead in Bonneville Reservoir Reach



Bonneville Reach Steelhead Accumulation vs Temperature



Inter-Annual Variation of the # of Steelhead in Bonneville Reach CWR

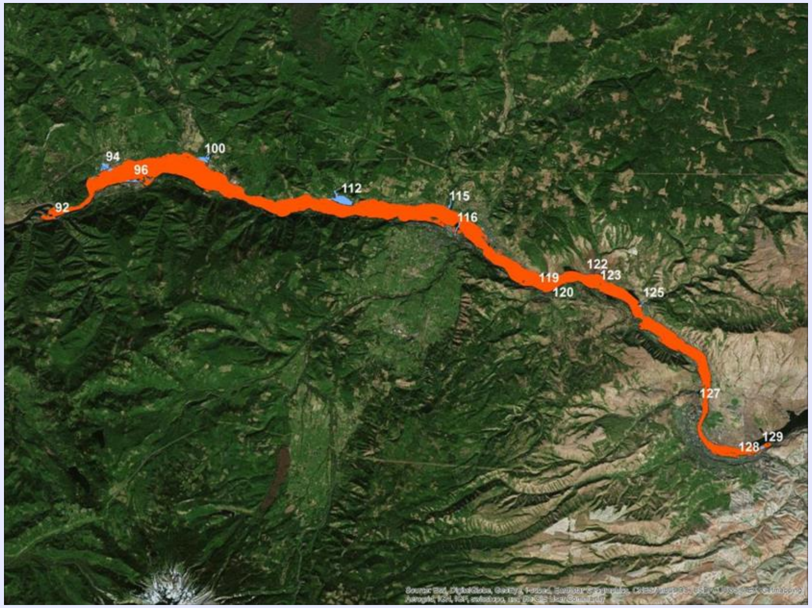
Year	Ave Temp July 15 -Aug 31	Passed BON July 15 -Aug 31	Passed Dalles July 15 -Aug 31	Measured % That Passed Dalles June 1-Oct 31	Expected to Passed Dalles July 15 -Aug 31	In BON Reach Peak	In CWR (85%) Peak
2016	21.4	83,919	24,212	80%	66,868	42,656	36,258
2015	21.8	165,138	69,059	84%	137,893	68,834	58,509
2014	21.5	175,686	70,488	80%	140,923	70,435	59,869
2013	21.5	166,926	68,949	83%	138,059	69,110	58,743
2012	20.1	142,032	95,612	86%	122,797	27,185	23,107
2011	19.5	252,331	176,573	82%	207,452	30,879	26,248
2010	21.0	231,804	121,974	82%	189,445	67,471	57,350
2009	21.6	451,509	205,163	86%	388,094	182,931	155,492
2008	20.0	225,506	117,044	79%	177,048	60,004	51,004
2007	21.1	229,124	83,820	76%	173,420	89,600	76,160
2006	21.1	187,415	53,379	72%	134,561	81,182	69,005
2005	21.4	175,028	55,866	77%	135,090	79,224	67,340
2004	22.0	155,516	42,744	78%	120,905	78,161	66,437
2003	21.7	209,328	58,083	77%	160,904	102,821	87,398
2002	20.4	257,857	131,121	82%	210,238	79,117	67,250
2001	20.7	397,879	169,554	80%	319,544	149,990	127,491
2000	20.6	164,593	75,954	75%	124,114	48,160	40,936
1999	20.0	136,136	76,782	77%	104,458	27,676	23,524
Average	20.9	219,048	98,363		175,585	77,222	65,639

The # of Steelhead in Each Bonneville Reach CWR

Tributary Name	Tributary Temp	Total CWR Volume (> 2°C Δ)	% of CWR in BON Reach	# Steelhead in Each CWR (2007-2016 Ave)	# Steelhead in Each CWR High Year (2009)	# Steelhead in Each CWR Low Year (2012)
	°C	m3				
Eagle Creek	15.1	2,988	0.2%	99	260	39
Rock Creek	17.4	1,708	0.1%	57	149	22
Herman Creek	12.0	169,698	9.5%	5,624	14,788	2,198
Wind River	14.5	105,220	5.9%	3,487	9,169	1,363
Little White Salmon River	13.3	1,101,126	61.7%	36,490	95,957	14,260
White Salmon River	15.7	153,529	8.6%	5,088	13,379	1,988
Hood River	15.5	28,000	1.6%	928	2,440	363
Klickitat River	16.4	222,029	12.4%	7,358	19,349	2,875
Total		1,784,298	100%	59,130	155,492	23,107

Steelhead in Bonneville Reach in Late August – Early Sept

- Bonneville Reservoir – 600,000 acre-feet
- Bonneville Reach CWR – 1,446 acre-feet
- 85% of the steelhead are in 0.2% of the water
- 83 steelhead per Olympic-sized pool (2,500 m3) in an average year
- 400 steelhead per Olympic-sized pool in a high run year in CWR 18°C or less



Yakima Summer Steelhead
(Keefer et. al. 2009)

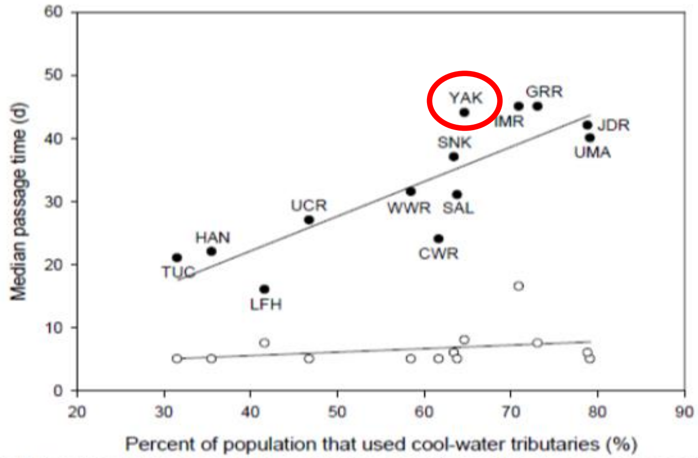


Figure 8. Relationships between median population-specific steelhead passage times from the top of Bonneville Dam to the top of John Day Dam and the percentages of steelhead that were (●) or were not (○) recorded in cool-water tributaries for > 12 h. Labels represent specific upriver populations. From Keefer et al. (2009).

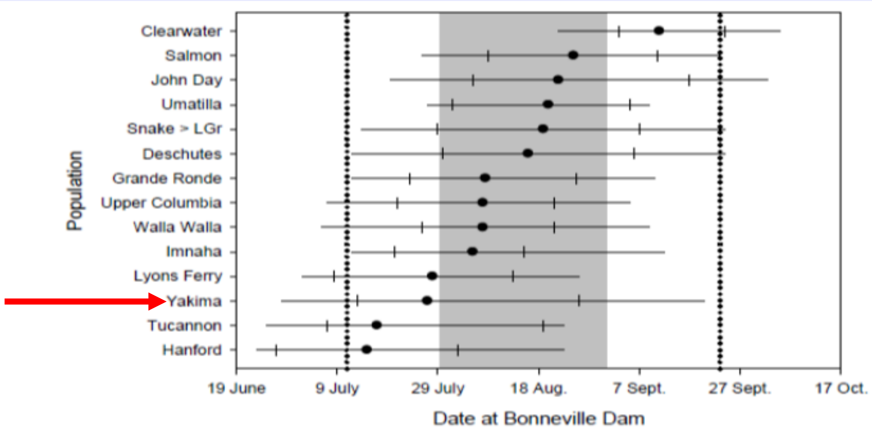
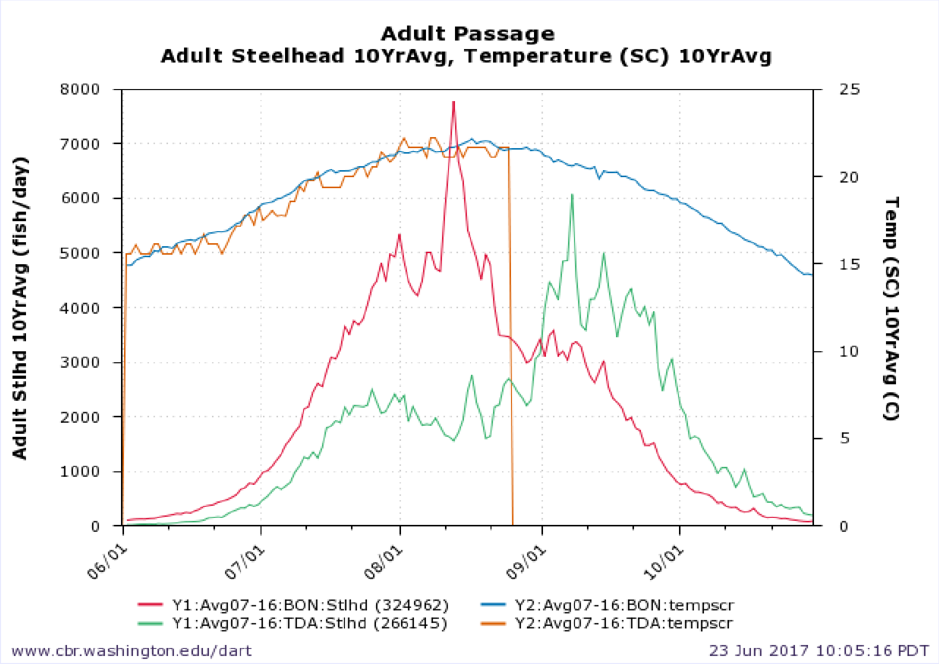


Figure 9. Migration timing distributions (median, quartiles, and 10th and 90th percentiles) at Bonneville Dam for steelhead that successfully returned to tributaries or hatcheries across study years. Vertical dotted lines show mean first and last dates that Columbia River water temperature was 19 °C; the shaded area shows dates with mean temperature ≥21 °C. From Keefer et al. (2009).

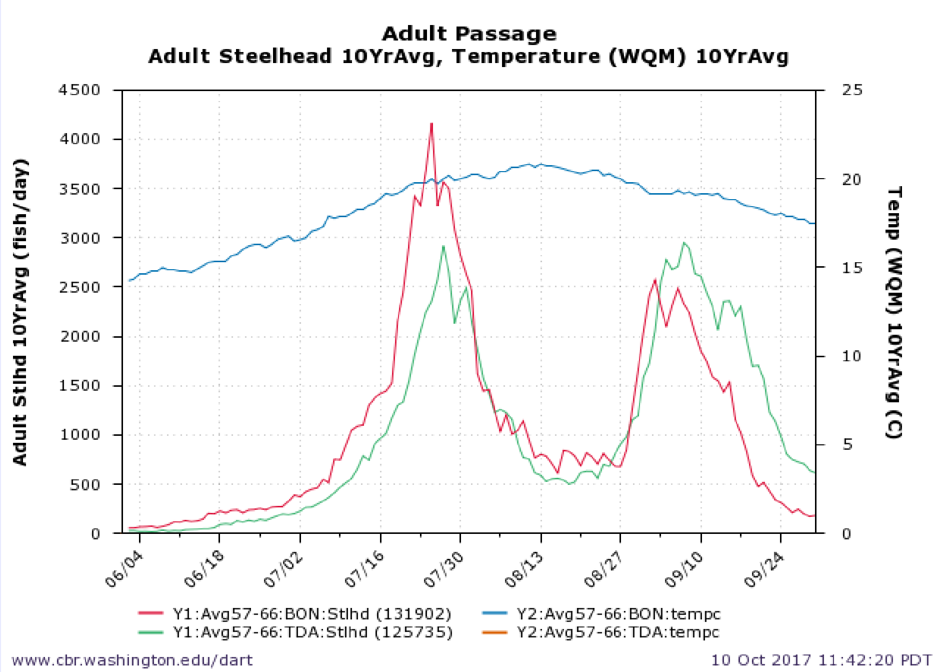
- 65% of population uses CWR between Bonneville Dam and John Day Dam for over a month
- Steelhead that don't use CWR pass thru in late June and early July when temps are cooler

Steelhead Dam Passage – Current vs 1950s/60s

Current 2007- 2016 average

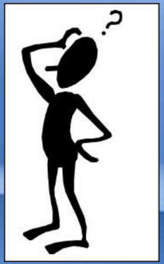


Decade after The Dalles Dam was Built 1957-1966 average



- ***Steelhead CWR use appears to be an adaptation to warmer Columbia River temperatures***
- Current temperatures are 1.8°C warmer in July and 1.5°C increase in August vs 1950s
  - 10 days above 20°C and 0 days above 21°C in an average year (1950s)
  - 57 days above 20°C and 27 days above 21°C in an average year (Current)

Is The Current CWR Sufficient? (preliminary)



Columbia River Temperatures (Aug Mean)

# of Fish	20C (Historic)	21.5C (Current)	22.5C (2040)
Current	Probably	Maybe	Maybe Not
Recovered	Probably	Maybe Not	Probably Not

- Less need for CWR in Lower Columbia River historically
- CWR use important today for Steelhead and Fall Chinook
- CWR likely to be used more in future due to Climate Change
- CWR may not compensate for warmer Columbia River

Priority Action - *Protect and Enhance the 13 Primary CWR*

13 Tributary Assessments

Factors affecting temperature

Water Withdrawals

Climate Change

Riparian Vegetation

Dams and Hydromodifications

Actions to Counteract Climate Change

- CWR tributaries predicted to warm due to climate change
  - 1C increase by 2040 and 2C by 2080 (Aug mean)
  - Deschutes, Klickitat, Wind, Eagle Creek, and Sandy River CWR function at risk
- Actions to protect/restore riparian shade and flow

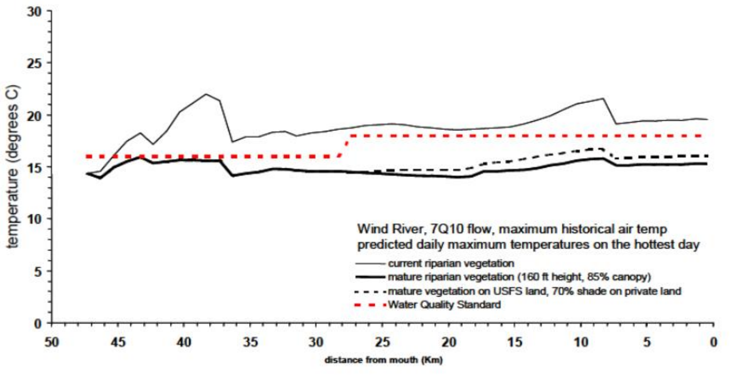


Figure 17. Predicted daily maximum temperature in Wind River under critical conditions for the TMDL.

Wind River Temperature TMDL

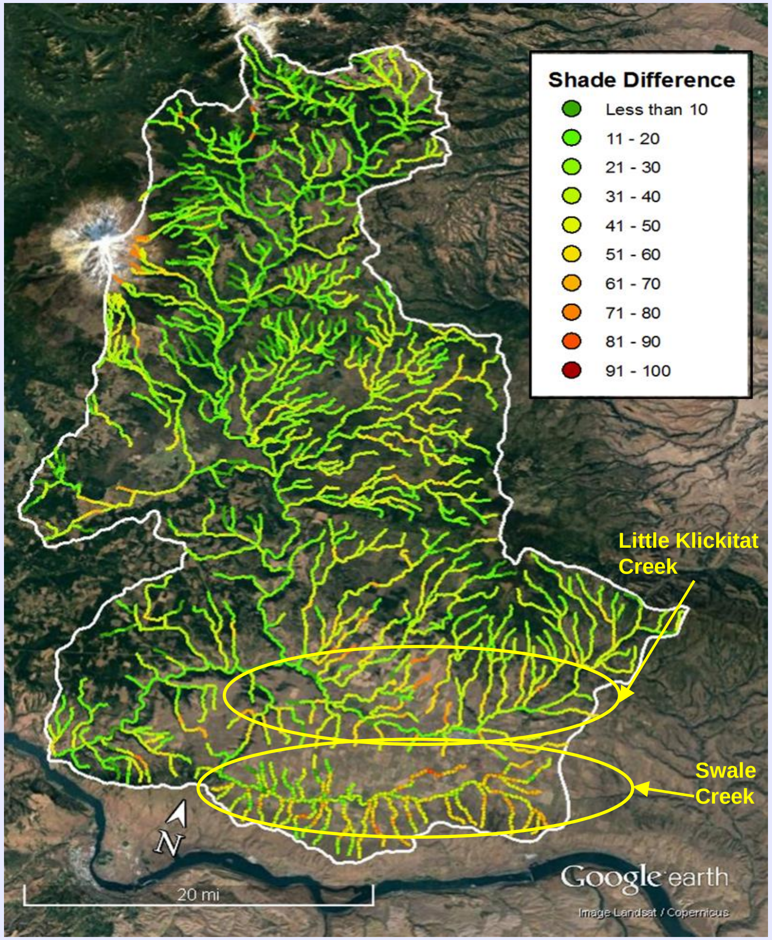


Fig. 5 Klickitat River Shade Difference between System Potential and Current Shade, Peter Leinenbach, 7/14/17

Restore/Enhance Confluence Areas

Herman Creek Cove

Wind River

- White Salmon & Klickitat Rivers Confluence Areas
- LCEP Oneonta Confluence Project