CHANGES IN FISH BEHAVIOR, LIFE HISTORY, AND SURVIVAL ASSOCIATED WITH TEMPERATURE- WILLAMETTE BASIN, OR

Greg Taylor
Supervisory Fisheries Biologist
Willamette and Rogue Project
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State of the Willamette

US Army Corps of Engineers ®
Portland District

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How does temperature influence fish behavior, life history, and survival?

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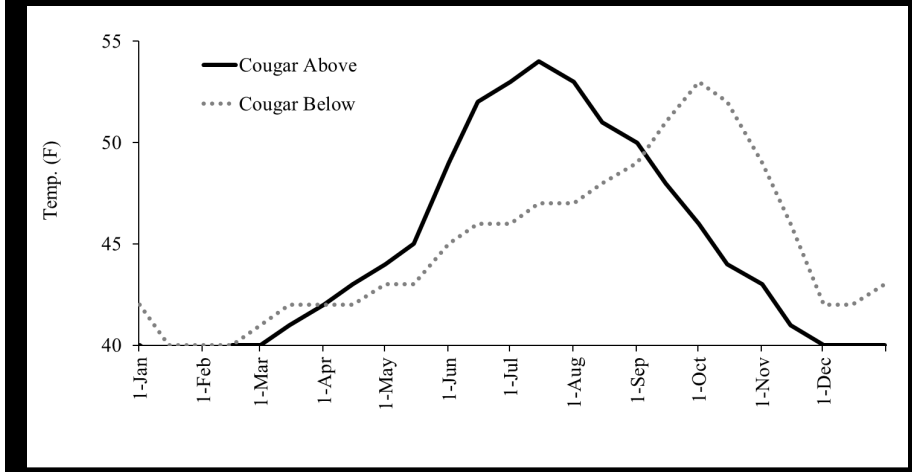
Dams alter downstream temperatures in Willamette Basin

These changes influence fish behavior, life history, and survival



Adult Migration Timing

Cold v Warm Water

High v Low Flow

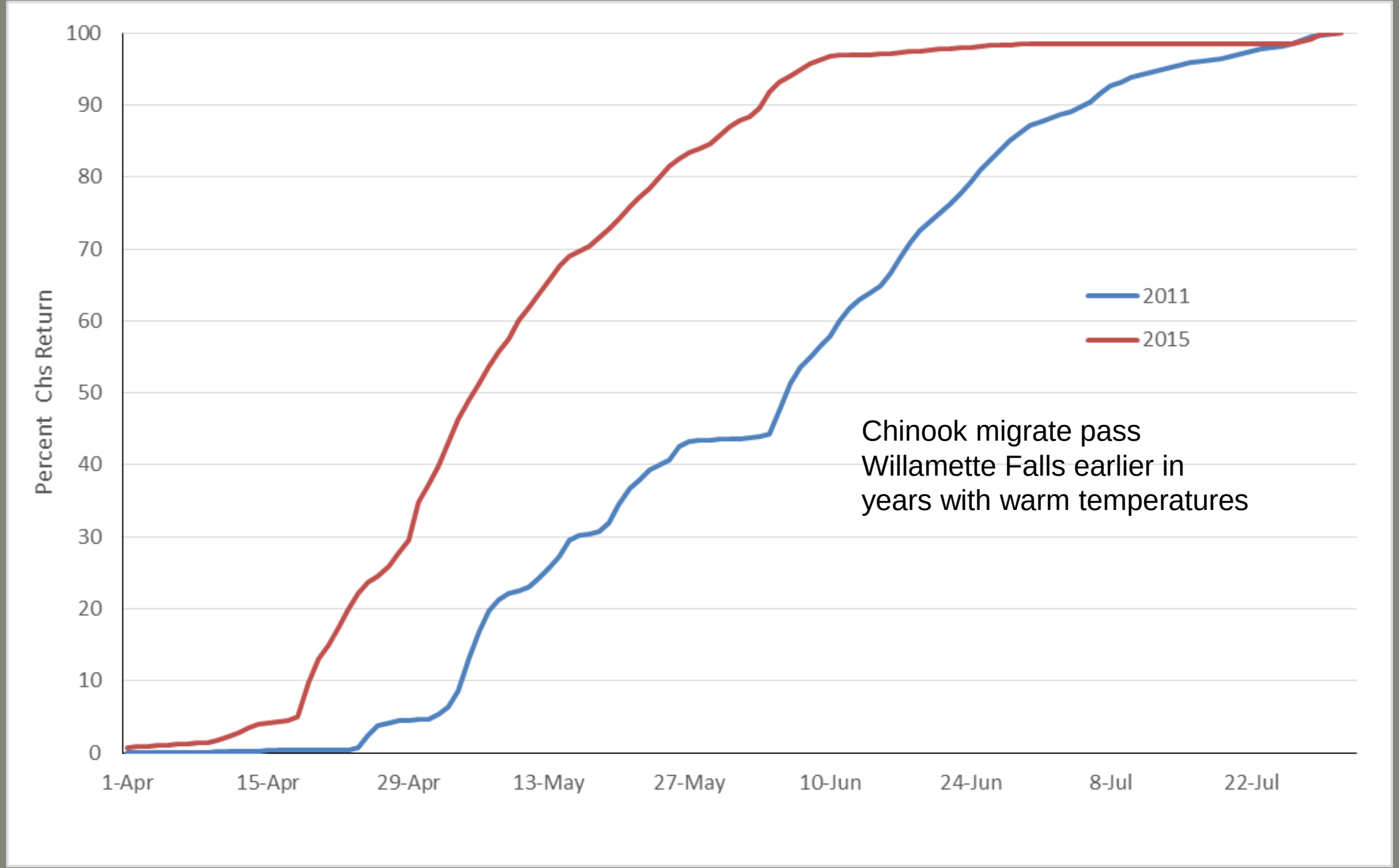
WILLAMETTE FALLS FISHWAY COUNTS

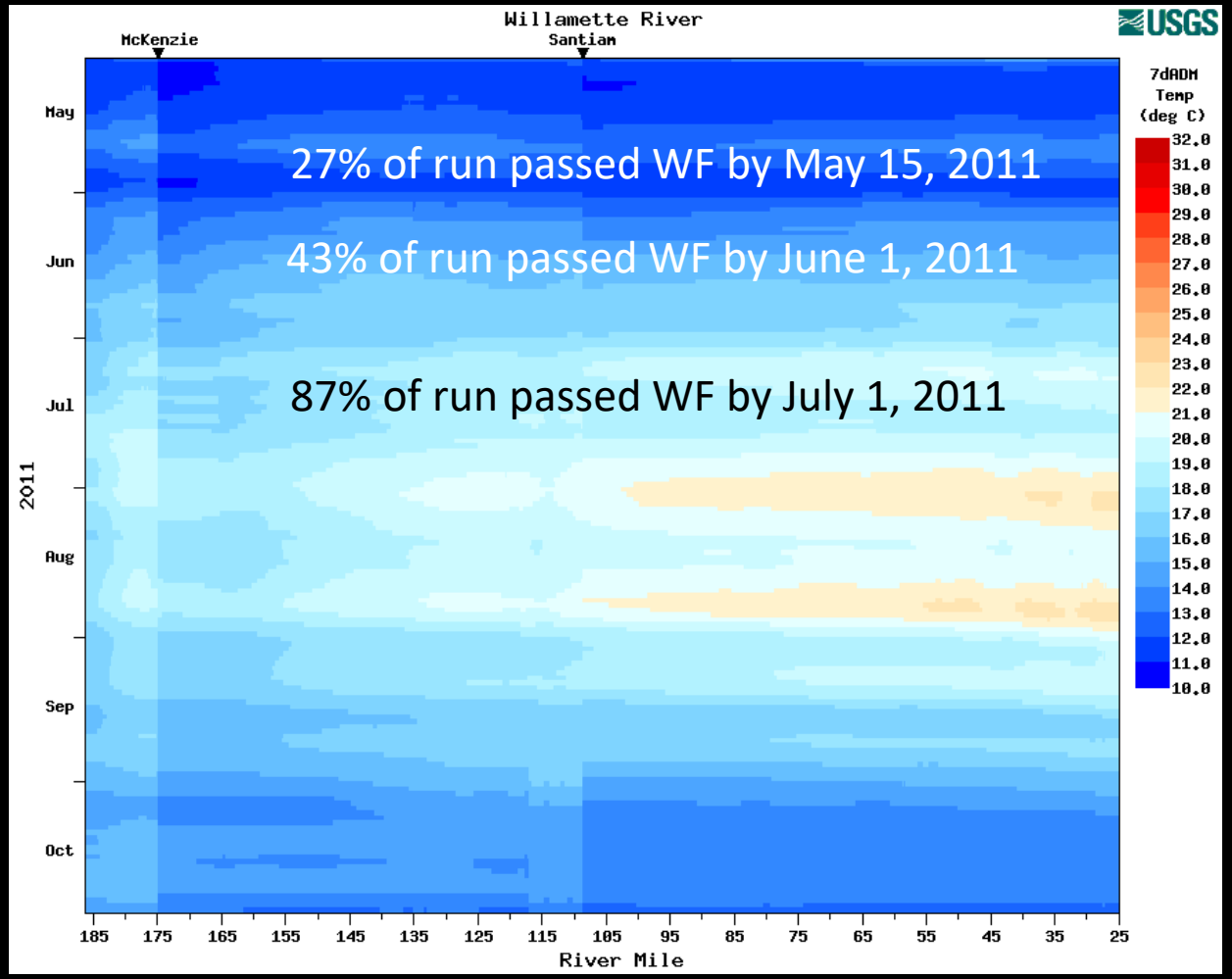
Month June **Year**

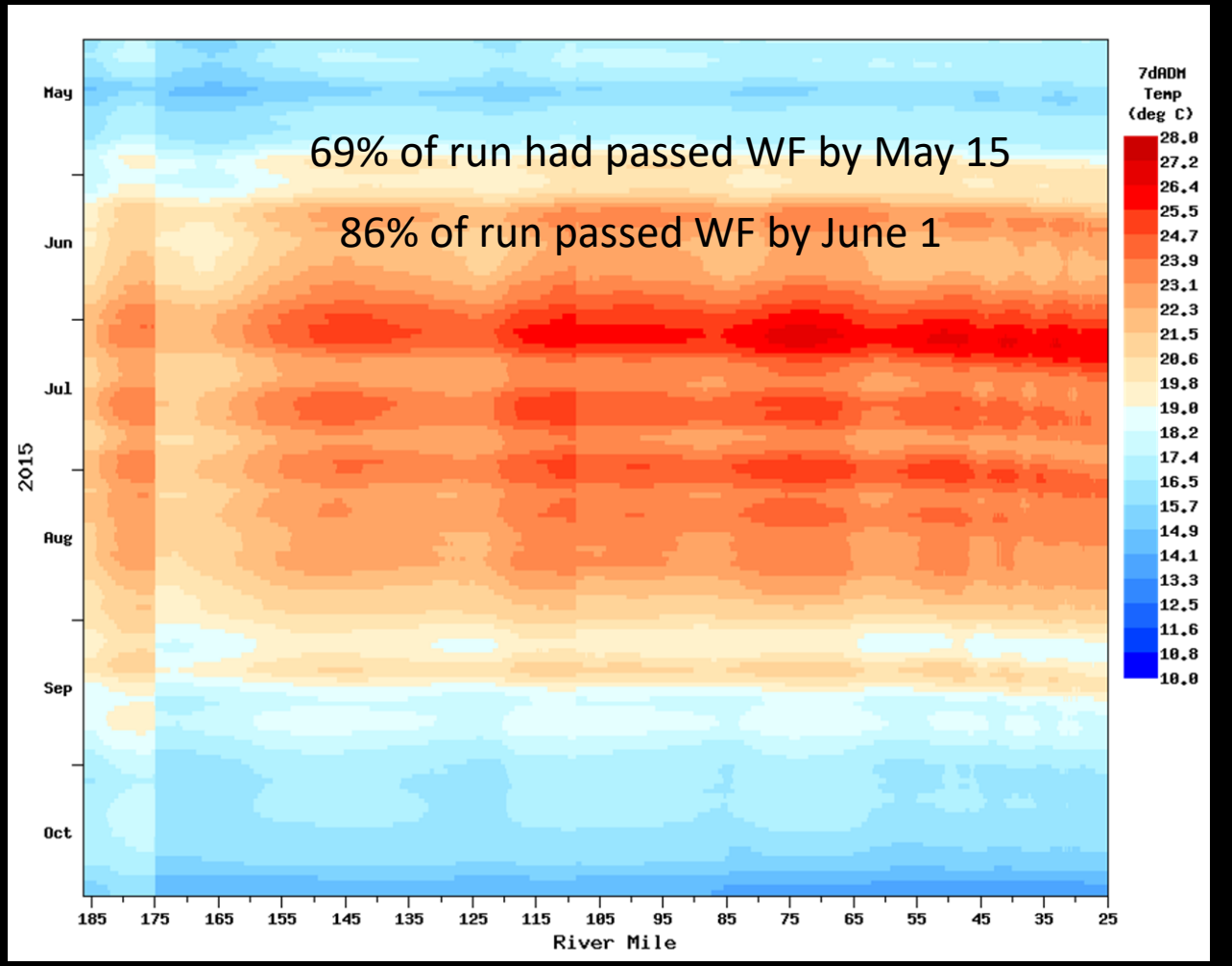
Date	Hydrological Data					Spring Chinook						Adult	
						Adult		Jack		Mini Jack			
	Flow	Tailwtr.	Temp.	Hwtr.	Turbidity	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cu
							18,971		480				
1	35,000	20.6	50	57.0	3.8	41	19,012	5	485				
2	38,000	21.2	52	57.0	3.7	54	19,066	3	488				
3	38,000	21.1	53	57.0	3.5	61	19,127	2	490				
4	35,500					176	19,303	10	500				
5	32,000					1,415	20,718	53	553				
6	30,400	20.1	58	56.8	3.8	1,655	22,373	65	618	5	5		
7	30,000	19.8	58	56.7	4.0	951	23,324	35	653	1	6		
8	28,200	19.5	58	56.5	4.6	585	23,909	19	672	2	8		
9	25,200	19.0	57	56.2	4.8	646	24,555	18	690	3	11		
10	24,000	18.4	57	56.0	4.8	618	25,173	23	713	0	11		
11	23,000					987	26,160	43	756	2	13		

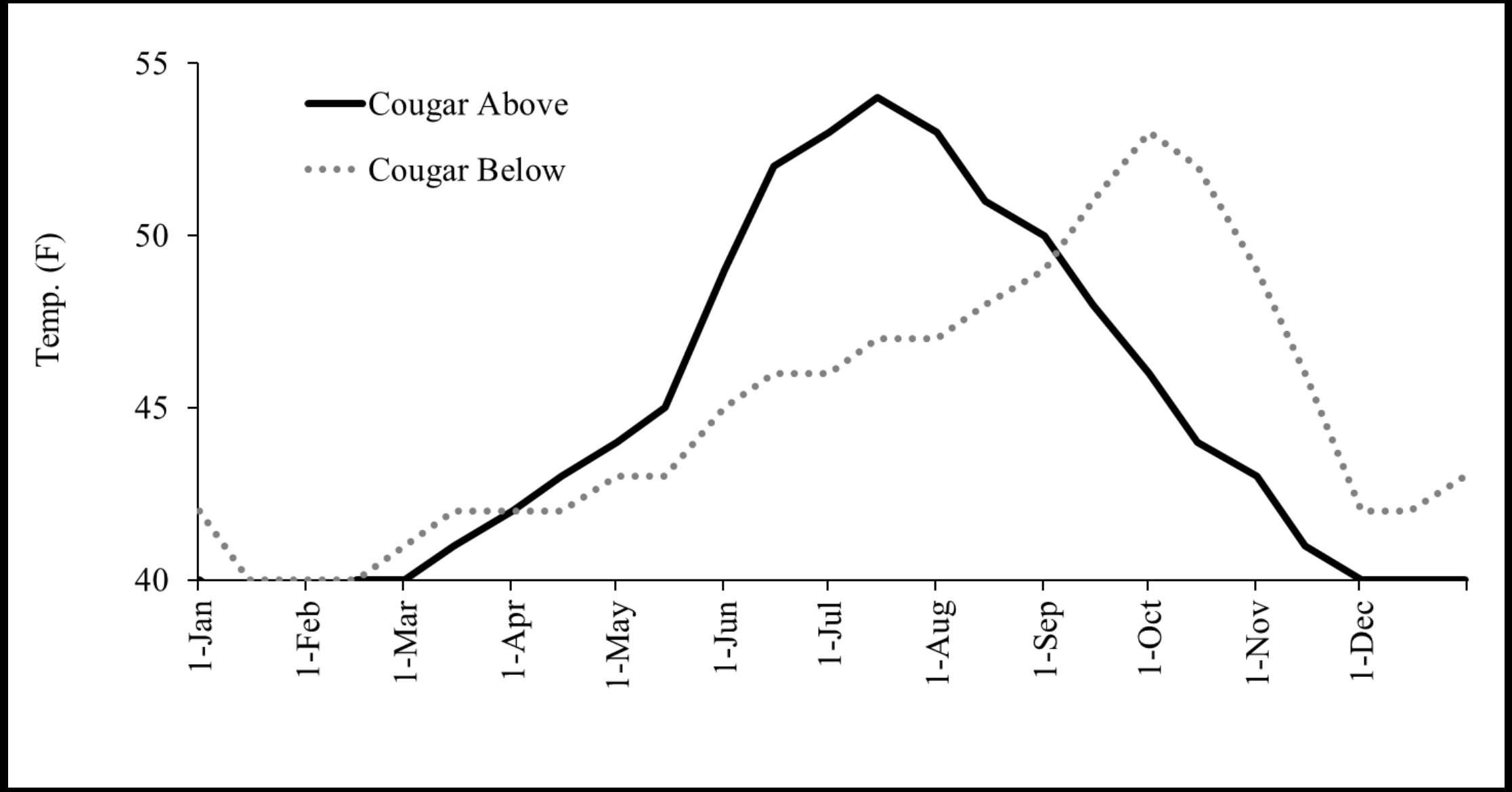
Chinook migration is influenced by temperature thresholds in the low 50's and 70's

Date	Hydrological Data						Spring Chinook									
							Adult				Jack				Mini Jack	
	Flow	HW	TW	Diff	Temp	Vis	Daily			Cum.	Daily			Cum.	Daily	Cum.
							Total	Clipped	Unclip	48	Total	Clipped	Unclip	0		0
1	17,600	59.5	14.7	44.8	52	5.5	17	7	10	65	0	0	0	0	0	0
2	17,700	59.4	14.5	44.9	52	5.5	16	8	8	81	0	0	0	0	0	0
3	22,100	59.9	14.9	45.0	52	5.6	26	9	17	107	0	0	0	0	0	0
4	27,400	60.2	16.7	43.5	52	5.6	12	5	7	119	0	0	0	0	0	0
5	28,800	60.3	17.9	42.4	51	5.8	4	2	2	123	0	0	0	0	0	0
6	37,300						2	0	2	125	0	0	0	0	0	0
7	53,500						1	1	0	126	0	0	0	0	0	0
8	70,900	63.9	25.8	38.1	49	<1.0	0	0	0	126	0	0	0	0	0	0
9	105,000	65.0	30.2	34.8	48		0	0	0	126	0	0	0	0	0	0
10	126,000	65.5	32.6	32.9	48		0	0	0	126	0	0	0	0	0	0
11	138,000	66.0	34.2	31.8	48		0	0	0	126	0	0	0	0	0	0
12	146,000	66.5	36.5	30.0	49		0	0	0	126	0	0	0	0	0	0
13	140,000						0	0	0	126	0	0	0	0	0	0
14	121,000						0	0	0	126	0	0	0	0	0	0
15	108,000	65.2	34.4	30.8	48		1	1	0	127	0	0	0	0	0	0
16	93,300	64.7	32.0	32.7	48		1	1	0	128	0	0	0	0	0	0
17	79,800	63.9	29.5	34.4	48		0	0	0	128	0	0	0	0	0	0
18	67,300	63.1	26.9	36.2	49	1.3	0	0	0	128	0	0	0	0	0	0
19	55,000	62.3	24.4	37.9	51	1.5	1	1	0	129	0	0	0	0	0	0
20	47,900						3	1	2	132	0	0	0	0	0	0
21	42,100						16	8	8	148	1	0	1	1	0	0
22	37,900	61.5	20.0	41.5	53	2.5	43	27	16	191	0	0	0	1	0	0
23	33,900	61.4	19.2	42.2	53	2.5	60	20	40	251	1	1	0	2	0	0
24	29,800	61.3	17.8	43.5	53	2.7	128	70	58	379	2	1	1	4	0	0
25	28,000	61.2	17.2	44.0	54	4.0	178	98	80	557	5	4	1	9	0	0
26	25,800	60.8	17.3	43.5	53	4.0	543	292	251	1,100	9	5	4	18	0	0
27	24,000						603	333	270	1,703	29	17	12	47	0	0
28	23,900						372	190	182	2,075	27	24	3	74	0	0
29	23,000	60.6					452	251	201	2,527	38	28	10	112	0	0
30	21,800	60.5	15.3	45.2	54	4.5	361	232	129	2,888	30	22	8	142	0	0
31																


100
90
80
70
60
50
40
30
20
10
0
Percent Chs Return
1-Apr
15-Apr
29-Apr
13-May
27-May
10-Jun
24-Jun
8-Jul
22-Jul
2011
2015
Chinook migrate pass Willamette Falls earlier in years with warm temperatures

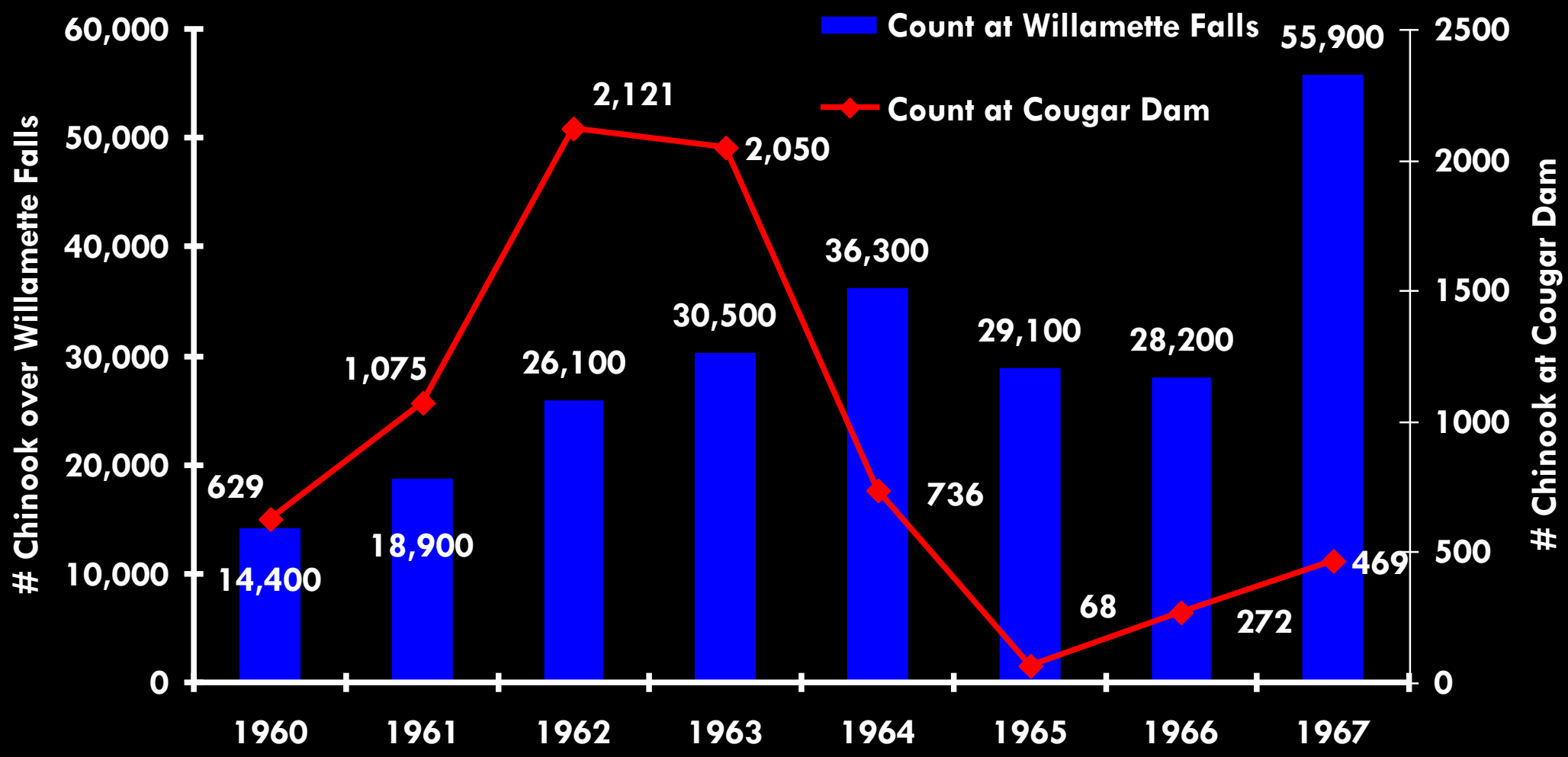

Willamette River
McKenzie
Santiam
USGS
7dADM Temp (deg C)
32.0
31.0
30.0
29.0
28.0
27.0
26.0
25.0
24.0
23.0
22.0
21.0
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
May
Jun
Jul
Aug
Sep
Oct
2011
185 175 165 155 145 135 125 115 105 95 85 75 65 55 45 35 25
River Mile
27% of run passed WF by May 15, 2011
43% of run passed WF by June 1, 2011
87% of run passed WF by July 1, 2011


7dADM Temp (deg C)
28.0
27.2
26.4
25.5
24.7
23.9
23.1
22.3
21.5
20.6
19.8
19.0
18.2
17.4
16.5
15.7
14.9
14.1
13.3
12.5
11.6
10.8
10.0
May
Jun
Jul
Aug
Sep
Oct
2015
185 175 165 155 145 135 125 115 105 95 85 75 65 55 45 35 25
River Mile
69% of run had passed WF by May 15
86% of run passed WF by June 1

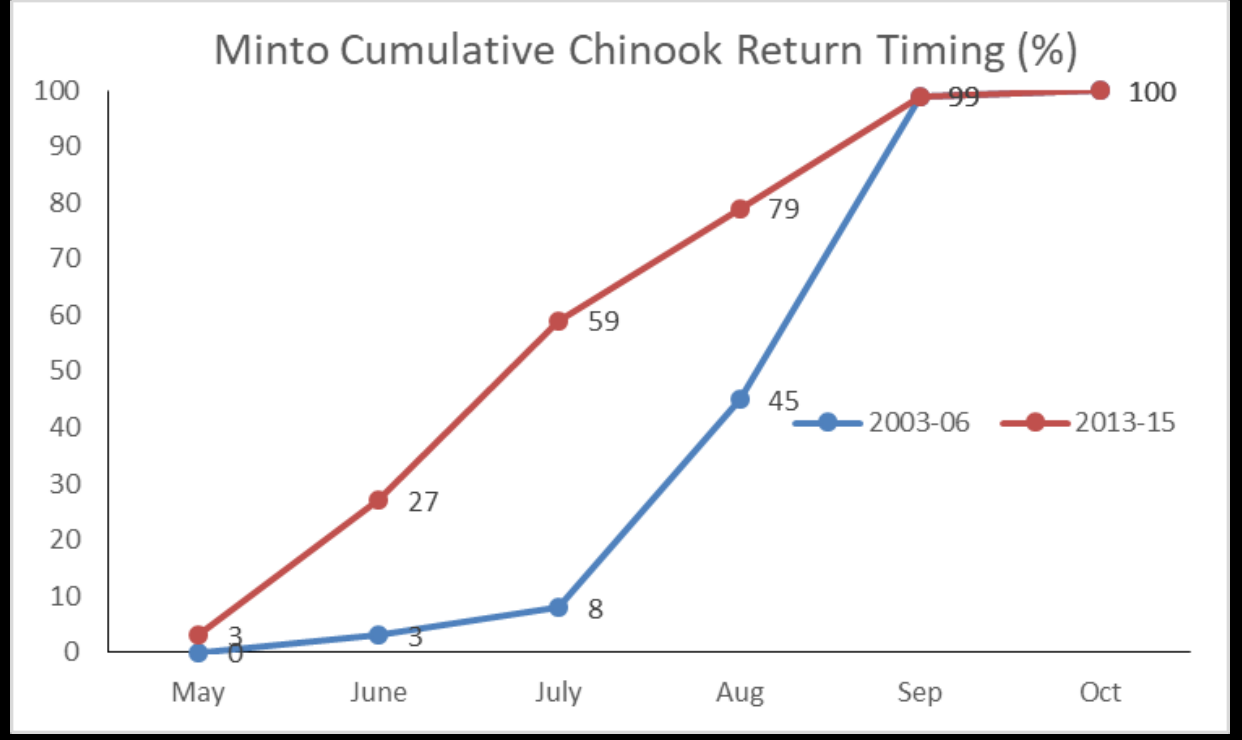


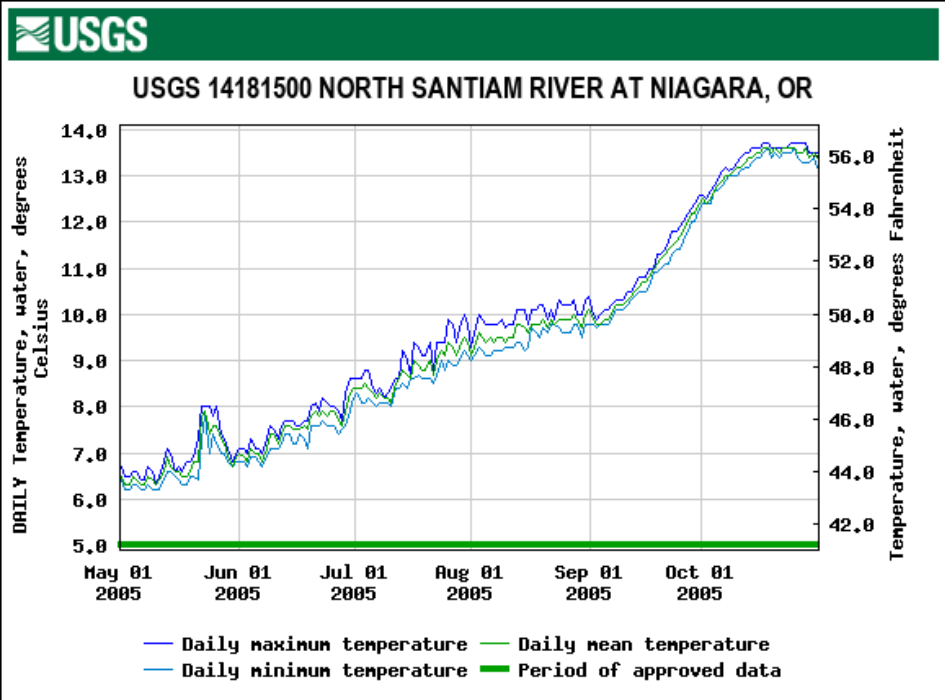
Does the influence of temperature on migration extend into the tributaries?

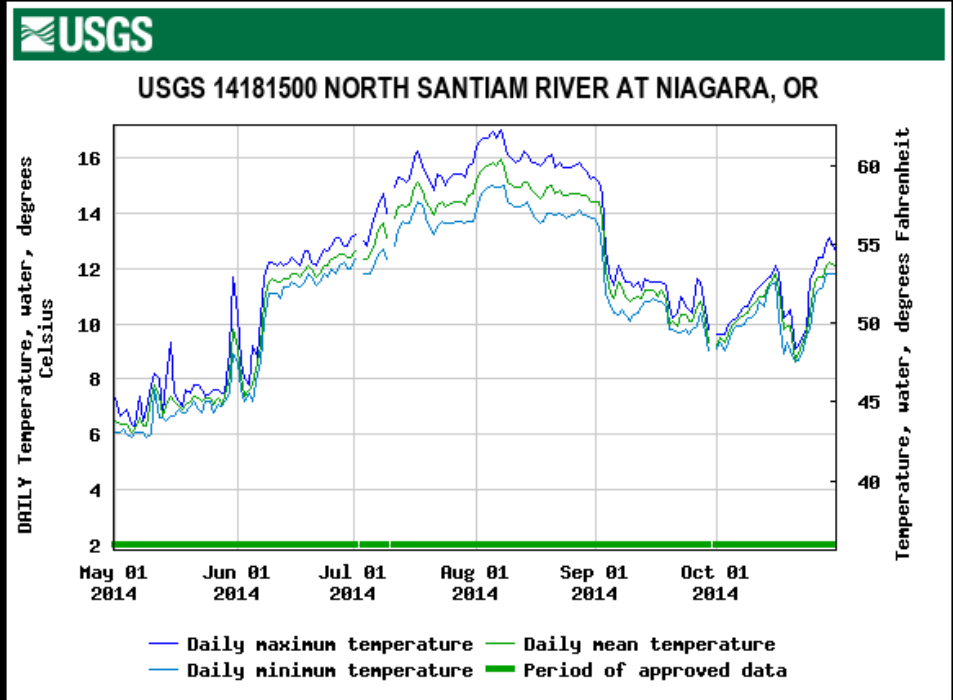
SPRING CHINOOK COUNTS
WILLAMETTE FALLS / COUGAR DAM 1960-67




Do dams still influence migration timing today? How do we fix it?


Minto Cumulative Chinook Return Timing (%)
100
90
80
70
60
50
40
30
20
10
0
May
June
July
Aug
Sep
Oct
3
0
3
27
59
79
99
100
8
45
2003-06
2013-15


USGS
USGS 14181500 NORTH SANTIAM RIVER AT NIAGARA, OR
DAILY Temperature, water, degrees Celsius
Temperature, water, degrees Fahrenheit
May 01 2005
Jun 01 2005
Jul 01 2005
Aug 01 2005
Sep 01 2005
Oct 01 2005
Daily maximum temperature
Daily mean temperature
Daily minimum temperature
Period of approved data


USGS
USGS 14181500 NORTH SANTIAM RIVER AT NIAGARA, OR
DAILY Temperature, water, degrees Celsius
Temperature, water, degrees Fahrenheit
May 01 2014
Jun 01 2014
Jul 01 2014
Aug 01 2014
Sep 01 2014
Oct 01 2014
Daily maximum temperature
Daily mean temperature
Daily minimum temperature
Period of approved data

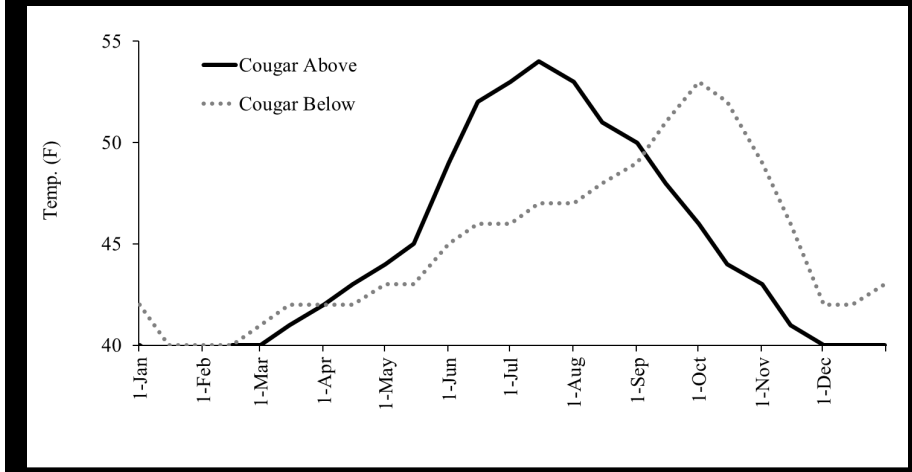
How is spawning success influenced by altered temperatures?

What is emergence?

What factors influence emergence timing and survival? (spawning date, temp, distribution).

Dams alter downstream temperatures in Willamette Basin

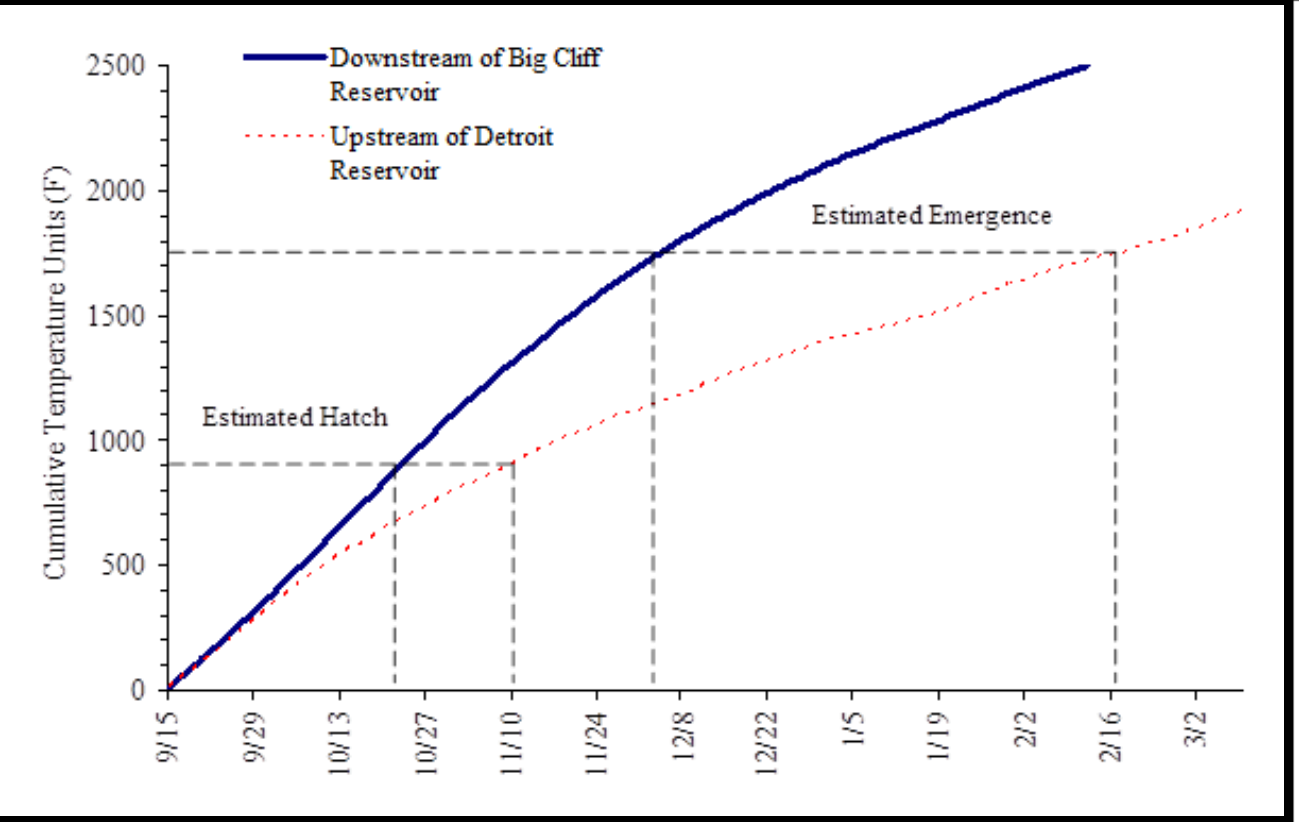
These changes influence fish behavior, life history, and survival

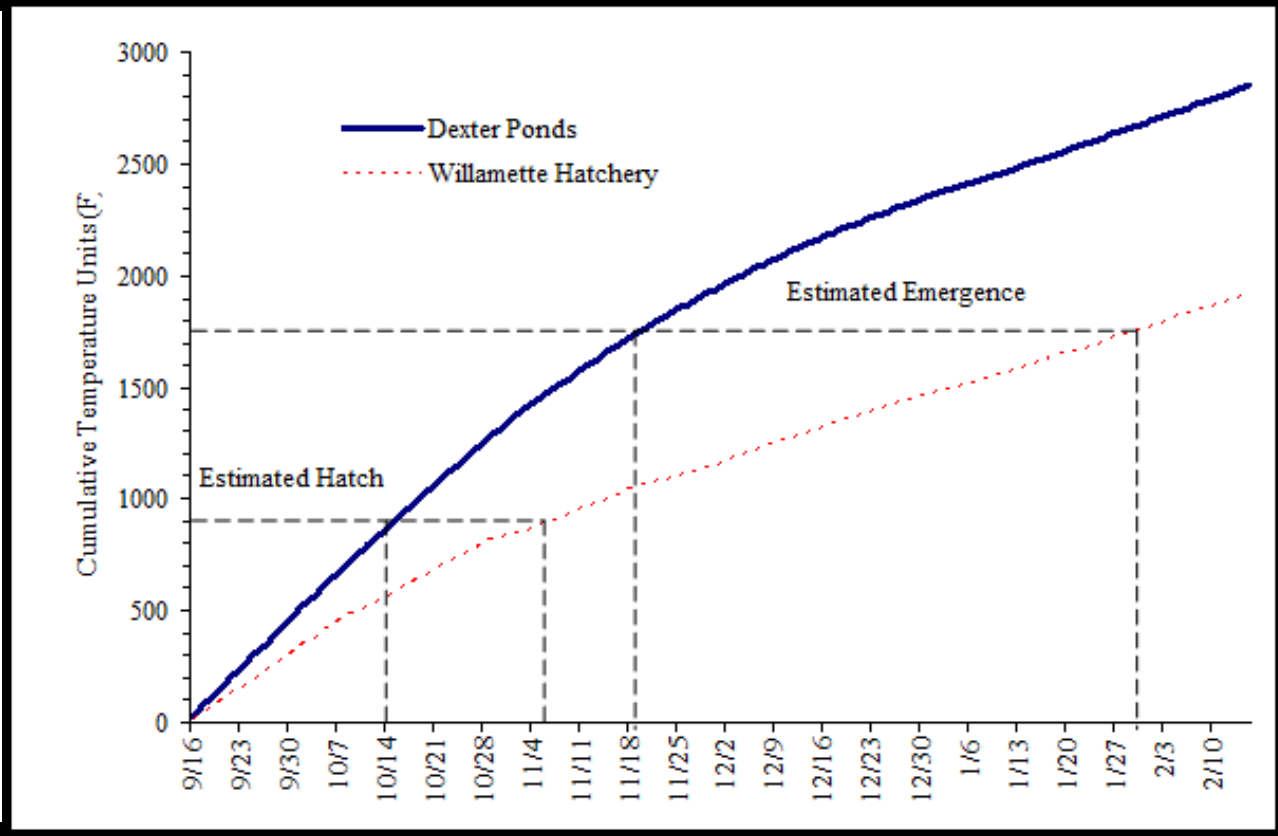


Chinook emerge from the gravel after accumulating 1650-1850 temperature units

Temperatures > 60 F impact egg survival

Subbasin	Location	Number of Eggs	Survival (%)
Middle Fork Willamette	Willamette Hatchery	3,200	81
	Dexter Ponds	3,200	0
South Fork McKenzie	Diversion Tunnel	3,100	68
	South Fork above Cougar	3,100	N/A*
North Santiam	Minto Fish Collection Facility	2,500	89
	Marion Forks Hatchery	2,500	93





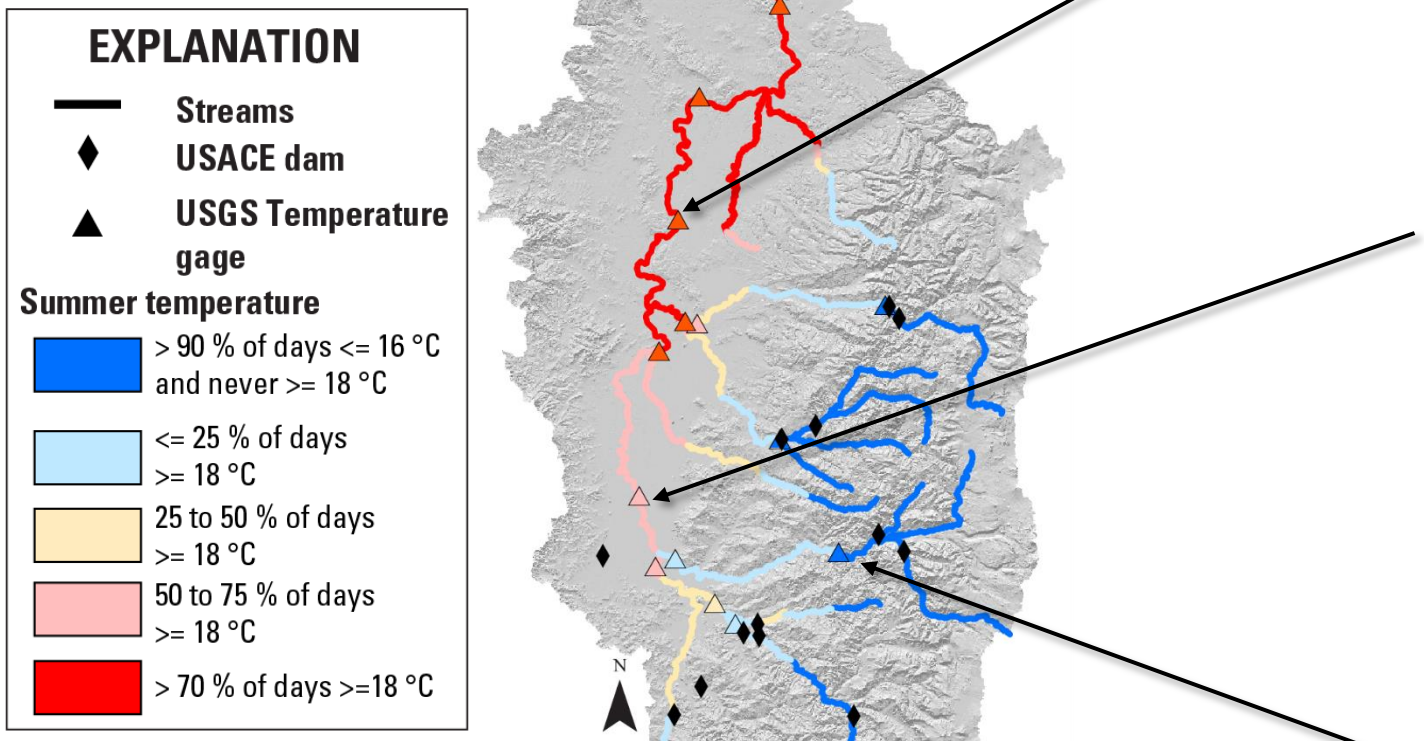
Temperatures influence emergence timing and survival

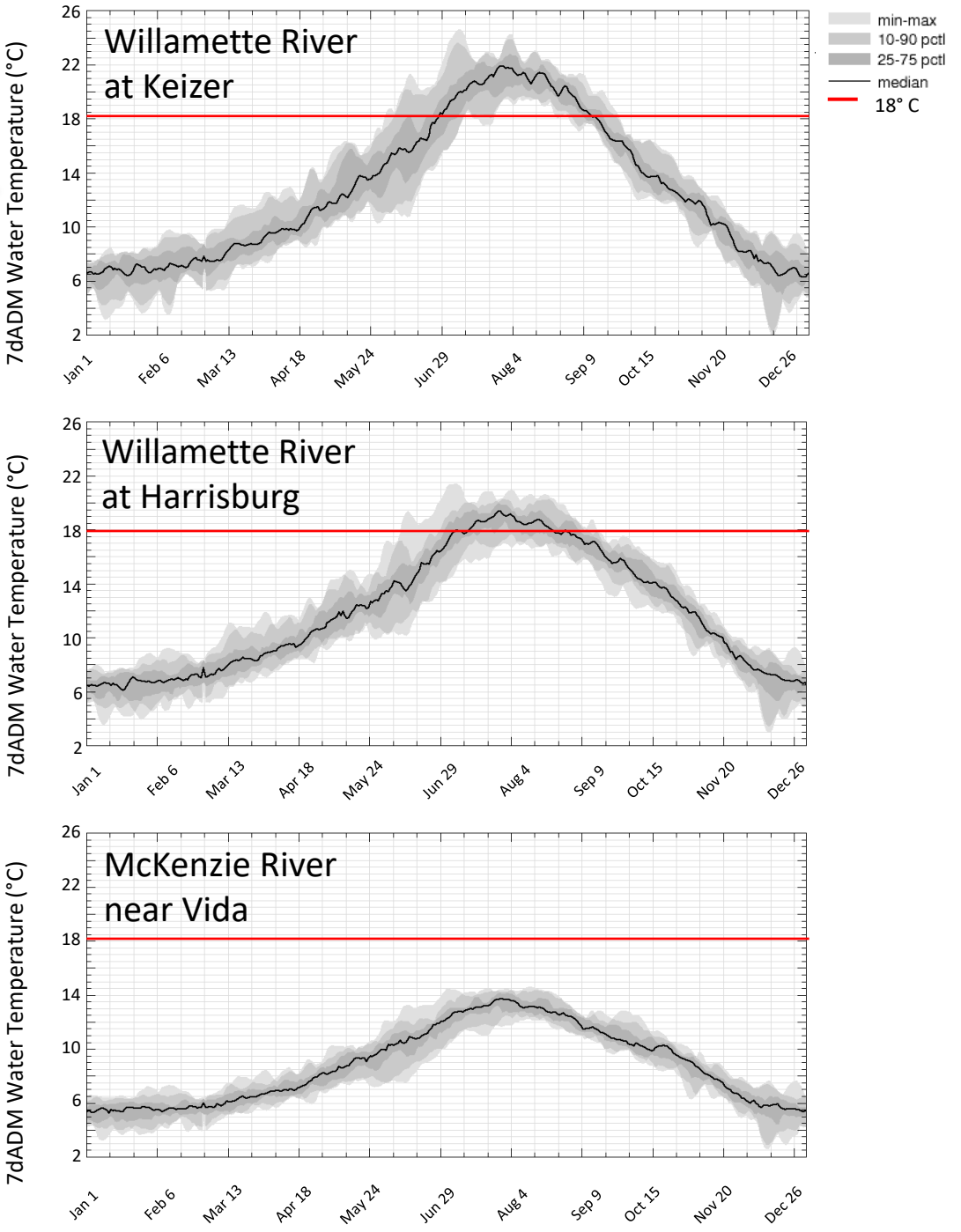
Is the Long Tom chinook rearing habitat?

Temperatures influence distribution of chinook rearing and survival

Appleby 2016

Willamette River Thermal Conditions





USGS science for a changing world

USGS map by Gabe Gordon
Temperature plots from USGS Data Grapher

SUMMARY

Temperature influences fish behavior, life history, and survival of chinook in the Willamette Basin

Adult chinook migration is influenced by temperature thresholds in the low 50's and 70's

- Fish alter their behavior to migrate past Willamette Falls earlier in warm dry years and later in cool wet years.
- Altered temperatures below dams can result in changes in run timing back to fish collection facilities

Survival of incubating chinook eggs is impacted by temperatures > 60 F

Emergence timing of juveniles is based on how quickly they accumulate a range of thermal units

- Altered temperatures below dams can change emergence timing which may impact survival

Temperatures alter the distribution of rearing juvenile chinook seasonally and can influence life history

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