

ADULT FISHWAY TEMPERATURES AND FISH PASSAGE DURING 2021

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Walla Walla District, USACE
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US Army Corps
of Engineers®



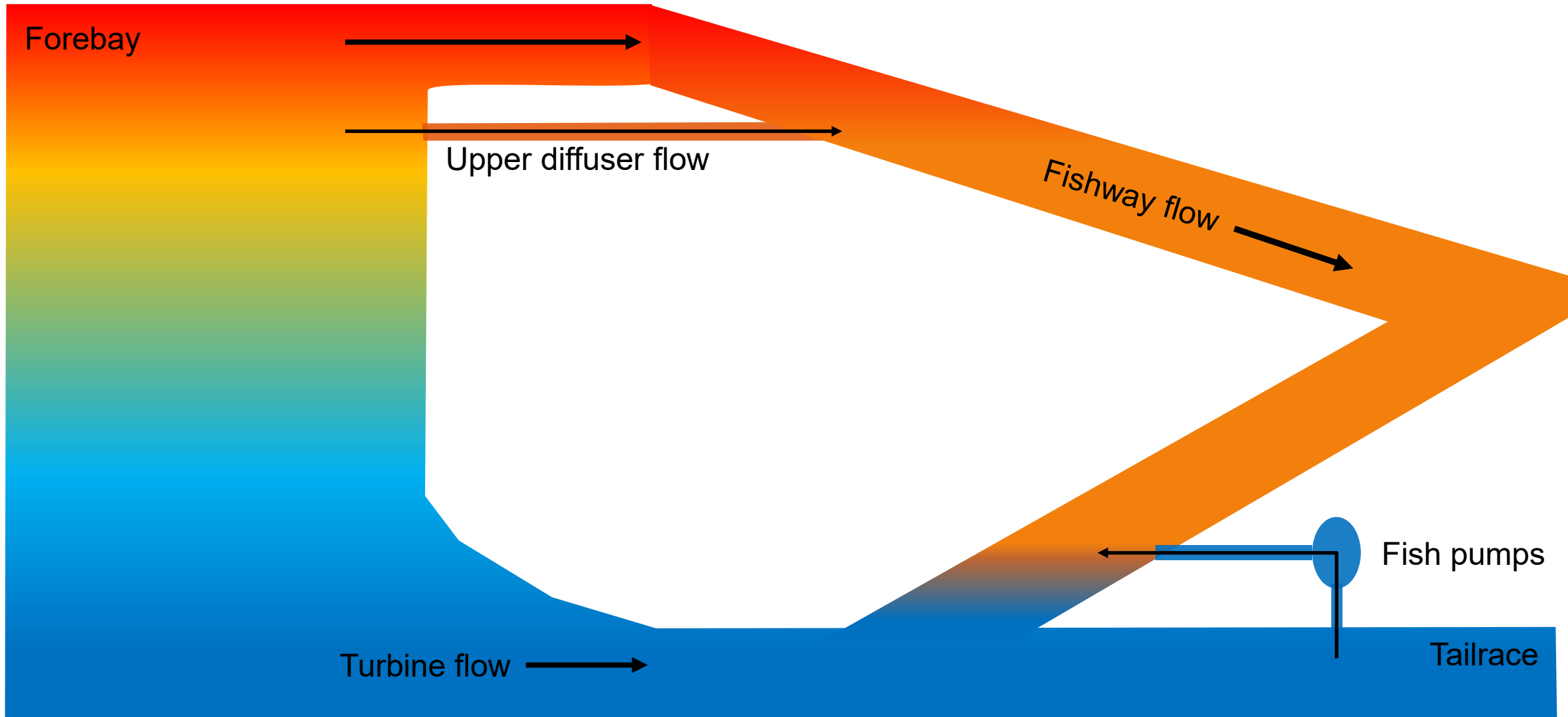
Outline



- Thermal stratification in forebay of dams can cause temperature differentials to develop in fishways.
- Temperature differentials have been associated with slowing adult salmon passage through fishways.
- Forebay pumps and intakes chimneys have been used to reduce fishway temperatures at Lower Granite and Little Goose dams.
- Is there potential to use similar operations at other dams?
- How did warm conditions in 2021 influence fish passage?

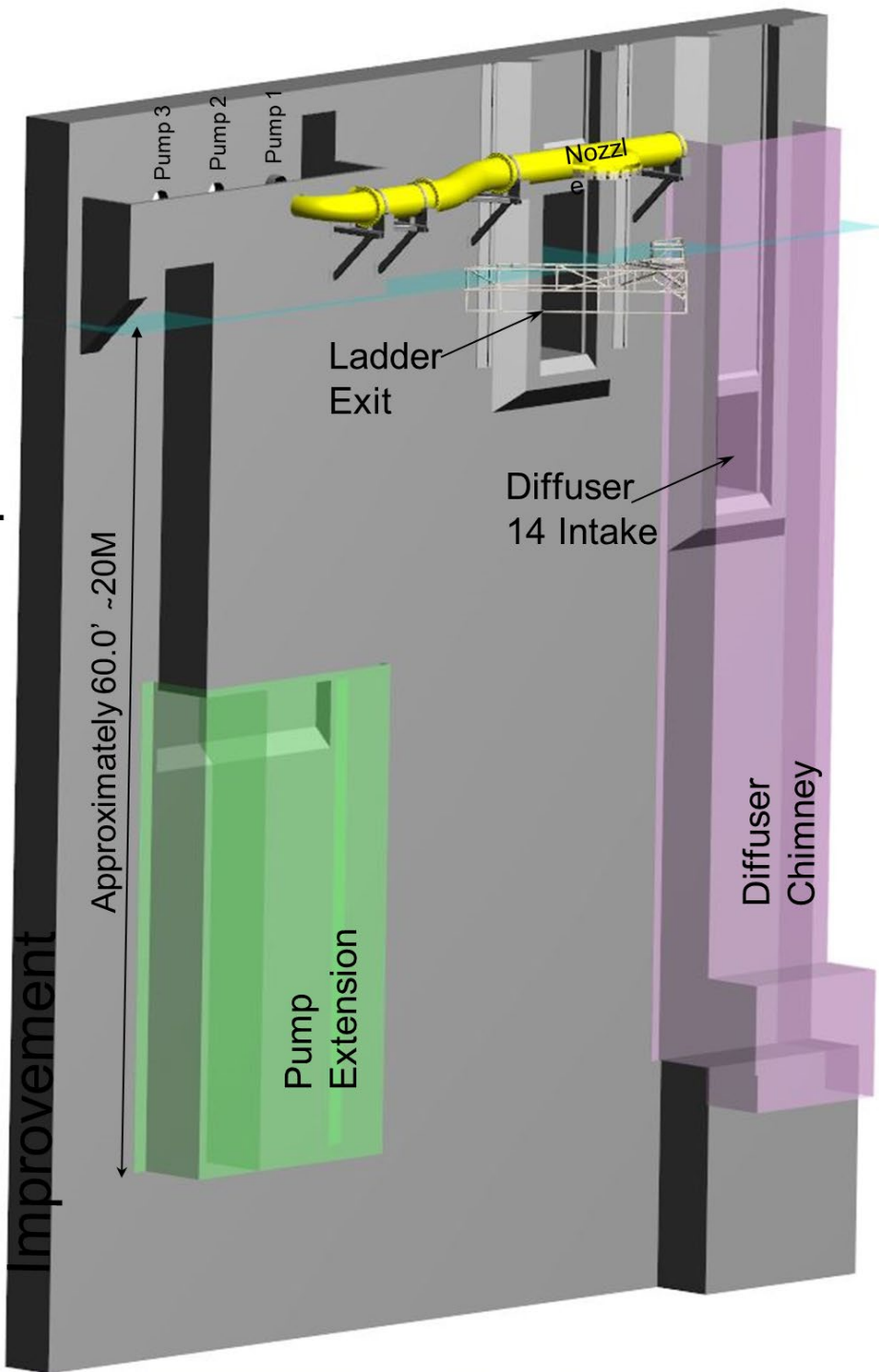


- Thermal stratification in forebay of dams can cause temperature differentials to develop in fishways.
- Temperature differentials have been associated with slowing adult salmon passage through fishways.





Lower Granite Ladder – Temperature



Date	Time	07/29/2021											Battery
		0.5m	1.5m	3m	5m	10m	15m	20m	25m	30m	35m		
07/29/2021	00:00	75.5	74.3	73.5	71.8	70.2	69.0	67.8	65.1	63.4	62.9	12.71	
	01:00	75.5	74.1	73.5	72.1	70.3	69.2	67.9	65.3	63.2	62.8	12.71	
	02:00	75.1	74.5	73.5	72.0	70.3	69.1	67.4	65.1	63.1	62.7	12.71	
	03:00	74.7	74.6	73.7	71.9	70.3	69.3	67.5	65.1	63.1	62.7	12.47	
	04:00	74.4	74.2	73.2	71.9	70.2	69.0	67.9	65.0	63.1	62.8	12.47	
	05:00	74.1	74.1	73.2	71.8	70.4	68.9	67.7	65.2	63.4	62.8	12.47	
	06:00	74.0	74.0	73.6	72.0	70.5	69.0	67.5	65.2	63.4	62.8	12.47	
	07:00	74.0	73.9	73.2	72.1	70.4	69.2	67.6	65.2	63.4	62.8	12.47	
	08:00	74.1	74.0	73.3	72.2	70.3	69.2	67.9	65.6	63.4	62.8	12.71	
	09:00	74.6	74.2	73.4	72.0	70.6	69.1	68.0	65.8	63.1	63.0	12.94	
	10:00	74.9	73.9	73.5	72.1	70.5	69.1	68.1	65.7	63.4	62.9	12.94	
	11:00	75.2	74.2	73.5	72.2	70.4	69.0	67.9	65.9	63.4	62.9	13.17	
	12:00	75.6	74.6	74.0	72.4	70.6	69.2	67.6	65.3	63.6	62.9	13.41	
	13:00	76.2	74.9	74.3	72.4	70.8	69.3	67.7	65.3	63.5	63.0	13.17	
	14:00	76.5	75.1	74.2	72.3	70.6	69.3	67.7	64.8	63.2	63.1	13.17	
	15:00	76.7	75.3	74.2	72.5	70.8	69.0	67.7	65.3	63.4	63.1	13.17	
	16:00	77.4	75.6	74.3	72.8	71.0	68.9	67.8	65.3	63.4	63.1	13.17	
	17:00	79.3	75.6	74.0	72.7	71.2	68.8	67.7	65.2	63.4	63.0	13.17	
	18:00	79.2	75.9	74.0	72.4	70.9	69.0	67.7	65.2	63.4	63.0	13.17	
	19:00	78.9	75.7	74.2	72.5	71.0	69.2	67.7	65.2	63.4	63.0	12.94	
	20:00	78.7	75.6	73.8	72.4	70.9	69.1	67.7	65.5	63.4	63.1	12.71	
	21:00	78.8	75.2	73.8	72.6	70.8	69.0	67.6	65.4	63.5	63.1	12.71	
	22:00	78.1	75.4	74.1	72.6	70.7	69.1	67.7	65.4	63.4	63.2	12.71	
	23:00	77.3	75.5	73.9	72.7	70.9	68.9	67.9	65.6	63.4	63.1	12.71	
Date	Time	0.5m	1.5m	3m	5m	10m	15m	20m	25m	30m	35m	Battery	
07/30/2021	00:00	77.1	75.4	73.7	72.6	70.7	69.2	68.1	65.4	63.3	63.1		12.47
	01:00	76.9	75.4	73.8	72.6	70.6	69.2	68.0	65.4	63.3	63.0		12.47
	02:00	76.7	75.5	73.8	72.5	70.7	69.3	67.8	65.6	63.4	63.0		12.47
	03:00	76.5	75.7	73.6	72.5	70.6	69.1	67.9	65.2	63.4	63.1		12.47
	04:00	76.1	75.0	73.5	72.4	70.6	69.4	68.1	65.2	63.3	63.2		12.47
	05:00	75.9	74.7	73.7	72.5	70.6	69.5	68.1	65.2	63.3	63.2		12.47
	06:00	75.5	75.3	74.0	72.5	70.7	69.4	68.1	65.5	63.3	63.2		12.47
	07:00	75.4	75.3	74.6	72.7	70.8	69.6	68.1	65.2	63.4	63.1		12.47
	08:00	75.1	75.1	74.3	72.8	70.9	69.6	68.1	65.2	63.4	63.2		12.71
	09:00	75.3	75.2	74.8	72.7	70.9	70.1	68.6	65.4	63.4	63.2		12.71
	10:00	75.3	75.2	75.0	72.9	71.1	69.9	68.4	65.6	63.6	63.2		12.94
	11:00	75.6	75.4	75.1	73.3	71.5	70.0	68.7	65.6	63.8	63.2		13.17
	12:00	75.9	75.7	75.2	74.3	71.6	70.0	68.3	66.0	63.5	62.9		13.17
	13:00	76.6	75.7	75.2	74.5	71.7	69.9	68.1	65.4	63.6	62.9		13.17
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	15:00	77.2	76.0	75.6	73.8	71.7	70.2	68.2	65.4	63.7	63.4		13.17
	16:00	77.1	75.7	74.9	74.5	71.6	70.0	68.4	65.7	63.7	63.3		13.17
	17:00	77.7	76.1	75.4	74.5	71.9	70.2	68.5	65.8	63.6	63.4		12.94
	18:00	77.9	75.6	75.5	75.1	72.1	70.0	68.6	65.7	64.0	63.3		12.94
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07/31/2021	00:00	77.3	77.2	76.7	75.7	71.5	69.5	68.4	66.3	64.0	63.1	12.71	
	01:00	77.2	76.9	76.2	75.6	71.3	69.7	68.4	65.8	64.1	63.0	12.47	
	02:00	77.2	76.9	76.1	75.0	71.1	69.6	68.6	66.3	64.2	63.2	12.47	
	03:00	77.0	76.9	76.1	75.3	71.3	69.7	68.5	66.1	64.3	63.3	12.47	



Lower Granite Dam

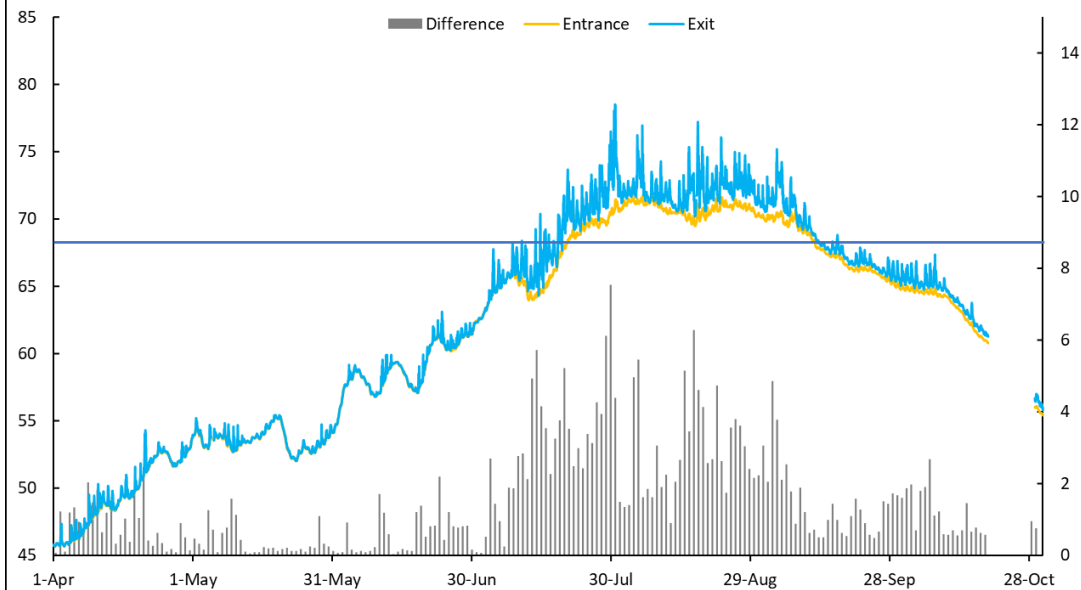


Little Goose Dam

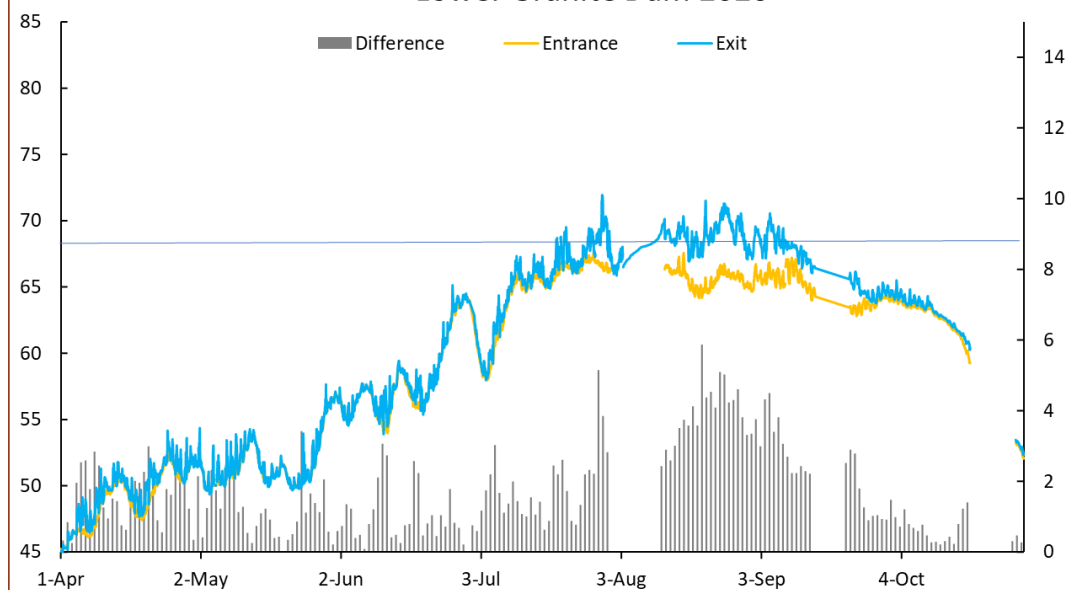




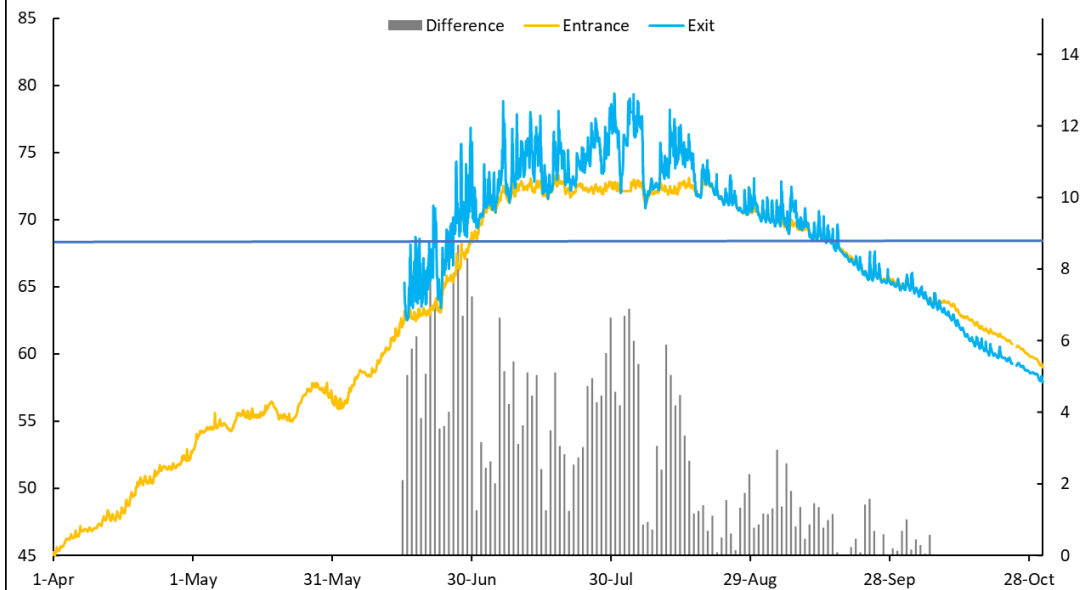
Ice Harbor Dam 2020



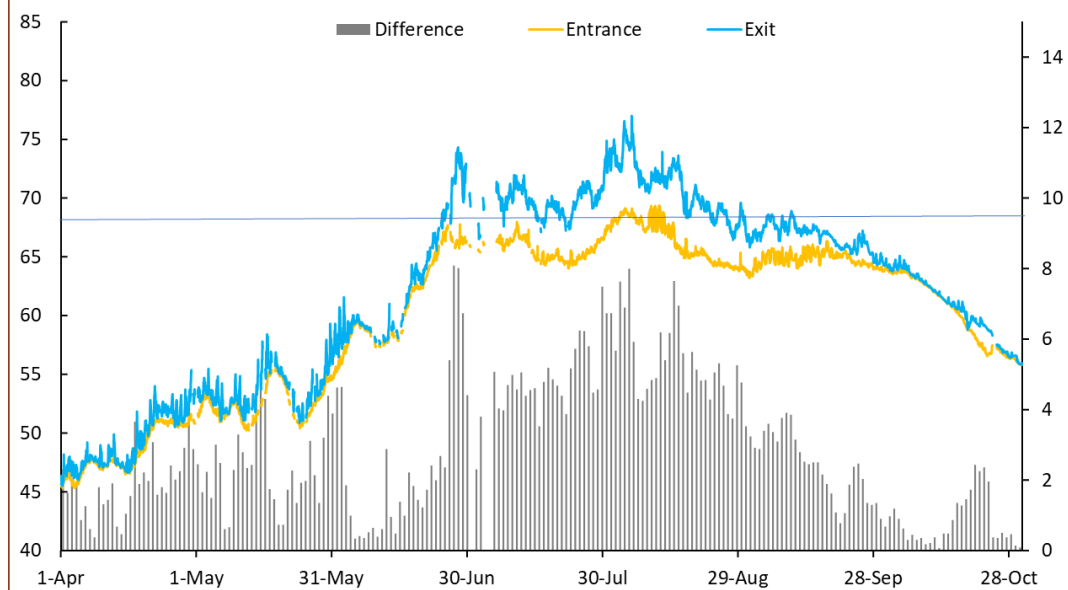
Lower Granite Dam 2020



Ice Harbor Dam 2021



Lower Granite Dam 2021



Exit-Entrance Hourly Differentials $>1^{\circ}\text{C}$ (1.8°F) June 1 to Sept. 30

Ladder	2019 Diffs	Percent of total	2020 Diffs	Percent of total	2021 Diffs	Percent of total
MCN (OR)	719	24.6%	137	4.7%	564	19%
MCN (WA)	207	7.1%	166	5.7%	273	9.5%
IHR (N)	0	0%	3	0.1%	19	0.7%
IHR (S)	174	7.8%	472	16.2%	854	52%
LMN (N)	477	23.4%	446	15.3%	1106	38%
LMN (S)	23	1.2%	404	13.9%	977	36%



2020 95th Percentile Cooling Potential Summary

When the ladder exit is $\geq 70^{\circ}\text{F}$ the tailrace usually ($Y, \Delta y$) degrees cooler and the forebay at depth (15m) is ($Z, \Delta z$) degrees cooler.

Project (Ladder)	Tailrace Temp	Ladder Exit Diff.	Forebay Temp. (15m)	Ladder Exit Diff.
MCN (OR)	69.9	2.8	69.3	3.6
MCN (WA)	69.9	3.2	69.3	4.3
IHR (N)	71.4	1.0	71.2	1.4
IHR (S)	71.4	4.0	71.2	4.6
LMN (N)	70.3	4.8	70.5	5.2
LMN (S)	70.3	5.2	70.5	5.8



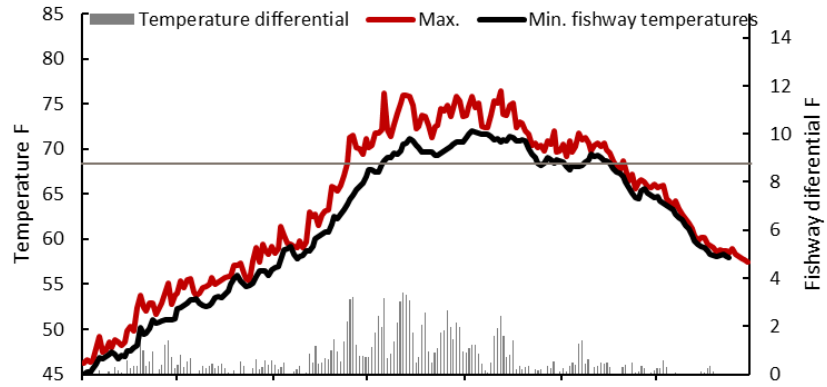
2021 95th Percentile Cooling Potential Summary

When the ladder exit is $\geq 70^{\circ}\text{F}$ the tailrace usually ($Y, \Delta y$) degrees cooler and the forebay at depth (15m) is ($Z, \Delta z$) degrees cooler.

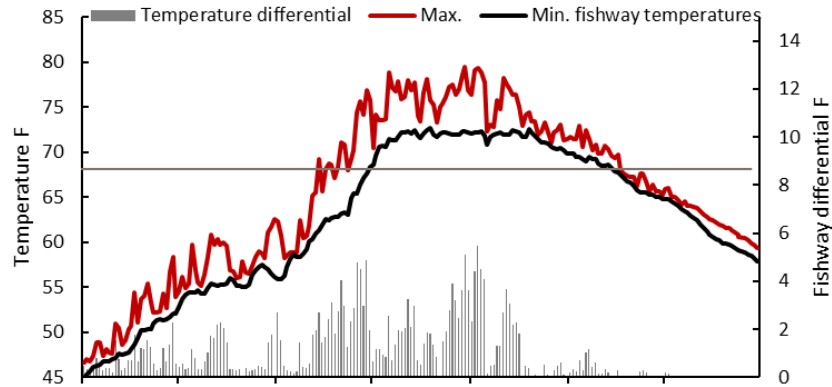
Project (Ladder)	Tailrace Temp	Ladder Exit Diff.	Forebay Temp. (15m)	Ladder Exit Diff.
MCN (OR)	72	4	71.5	5.2
MCN (WA)	72	3	71.5	3.9
IHR (N)	72.8	1.9	72.3	2.6
IHR (S)	72.8	5.4	72.3	6.2
LMN (N)	71.7	5.4	71.7	6
LMN (S)	71.7	5.8	71.7	6.2



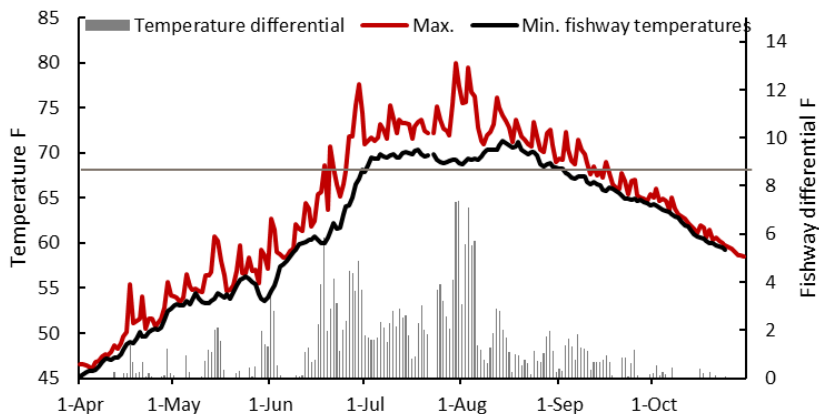
McNary Dam 2021



Ice Harbor Dam 2021

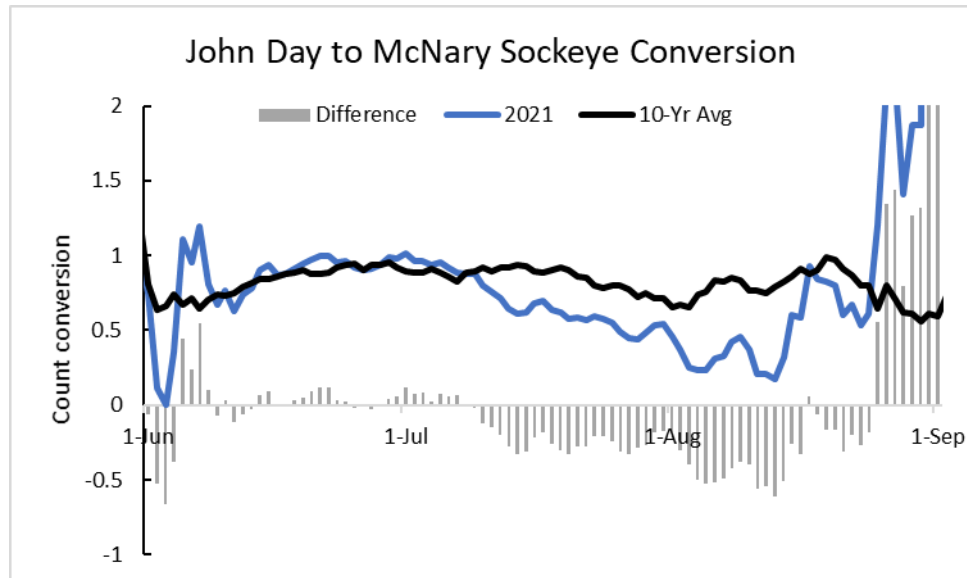
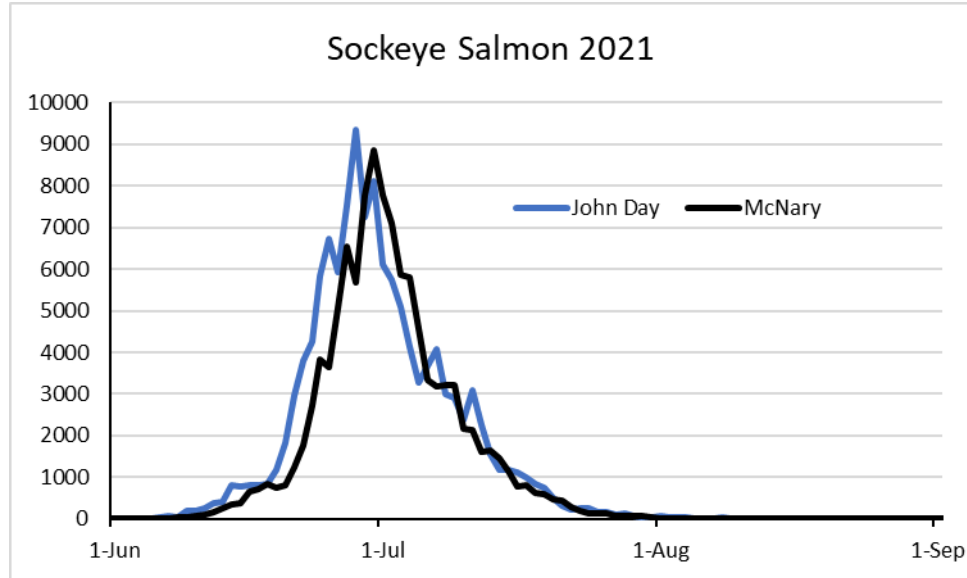


Lower Monumental Dam 2021



Month	Fishway Temperatures			Fishway Differentials		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
McNary Dam South 2021						
April	45.0	55.1	48.9	-0.5	3.4	0.4
May	52.3	59.5	54.8	-0.4	2.1	0.3
June	56.8	71.5	61.9	-0.2	6.2	0.8
July	67.4	76.2	70.9	0.1	6.9	1.8
August	68.2	76.5	71.1	-0.4	5.0	0.7
September	64.5	71.7	67.8	-0.5	3.1	0.3
October	56.2	66.0	60.4	-0.4	1.5	0.0
Overall	45.0	76.5	62.3	-0.5	6.9	0.6
Ice Harbor Dam South 2021						
April	44.9	58.4	49.3	-0.1	5.7	0.7
May	52.8	62.5	56.0	0.0	5.6	0.9
June	55.9	76.9	63.1	-0.2	9.1	2.0
July	68.5	79.4	73.0	-0.1	6.9	2.0
August	69.9	79.4	72.6	-0.4	6.9	1.4
September	64.7	72.9	67.9	-0.4	3.0	0.1
October	57.9	66.1	62.0	-1.7	1.0	-0.9
Overall	44.9	79.4	63.4	-1.7	9.1	0.9
Lower Monumental Dam North 2021						
April	45.2	55.7	48.8	-0.4	6.3	0.1
May	53.0	60.7	54.8	-0.3	6.0	0.5
June	54.7	77.6	62.3	-0.3	9.1	2.0
July	67.9	80.0	71.0	0.2	10.6	2.6
August	68.3	79.5	71.0	-0.2	9.8	1.8
September	64.2	72.3	66.7	-0.2	4.2	0.6
October	57.8	66.1	61.4	-0.3	1.8	0.0
Overall	45.2	80.0	62.3	-0.3	10.6	1.1

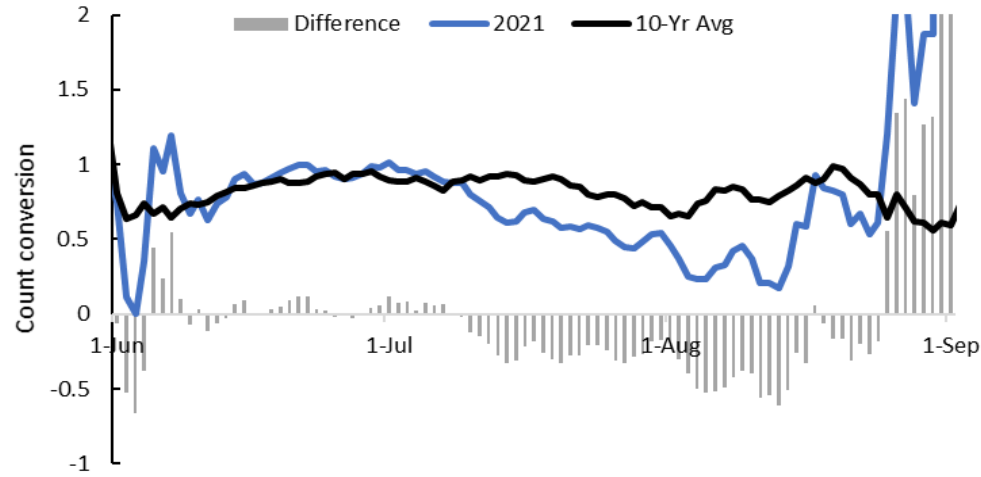
Count Conversions: McNary Sockeye Salmon



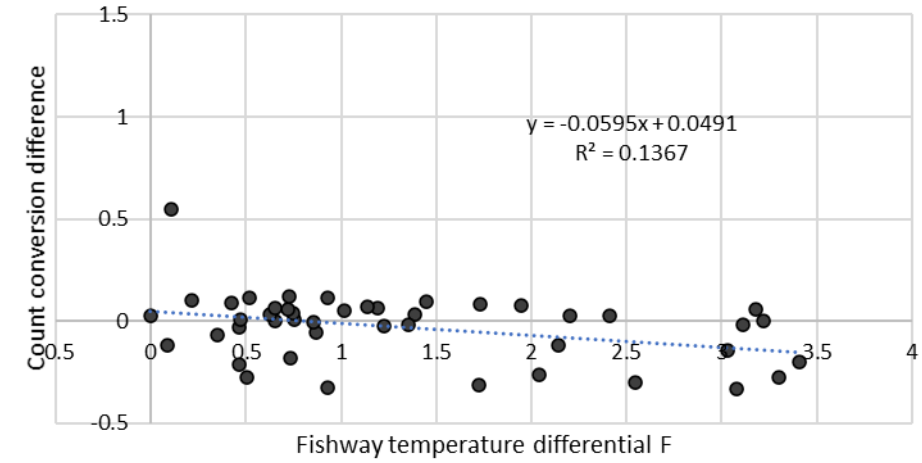
$$\text{Conversion} = \frac{\text{McNary 3-day average count}}{\text{J Day 3-day average count (-2 days)}}$$

McNary Sockeye Salmon Count Conversions vs. Temperatures

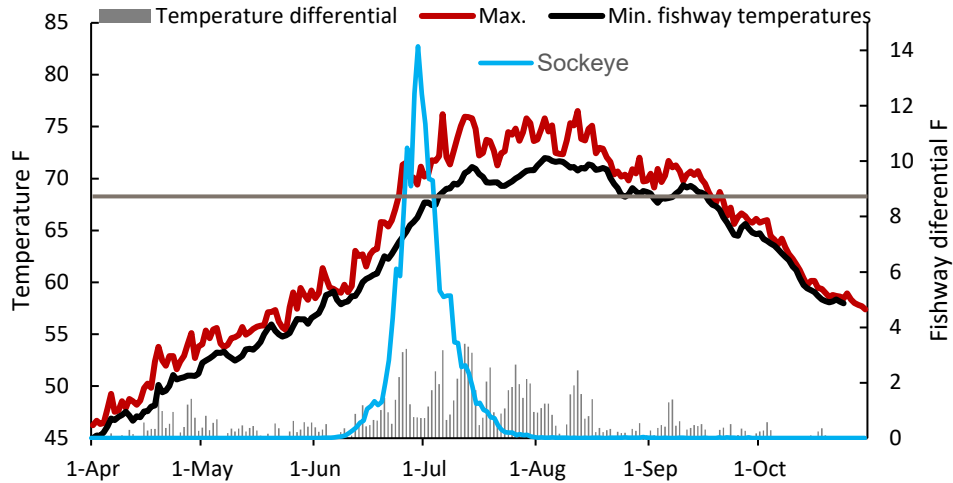
John Day to McNary Sockeye Conversion



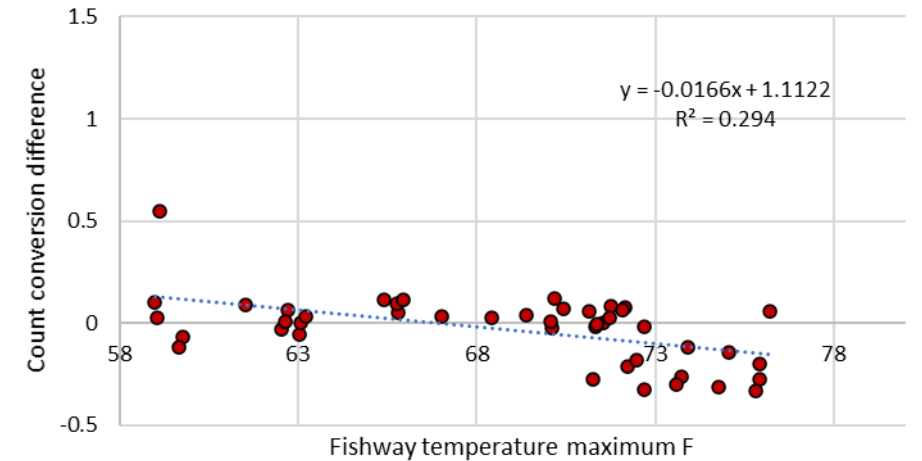
McNary Sockeye Conversion vs. Temp Differential



McNary Dam 2021

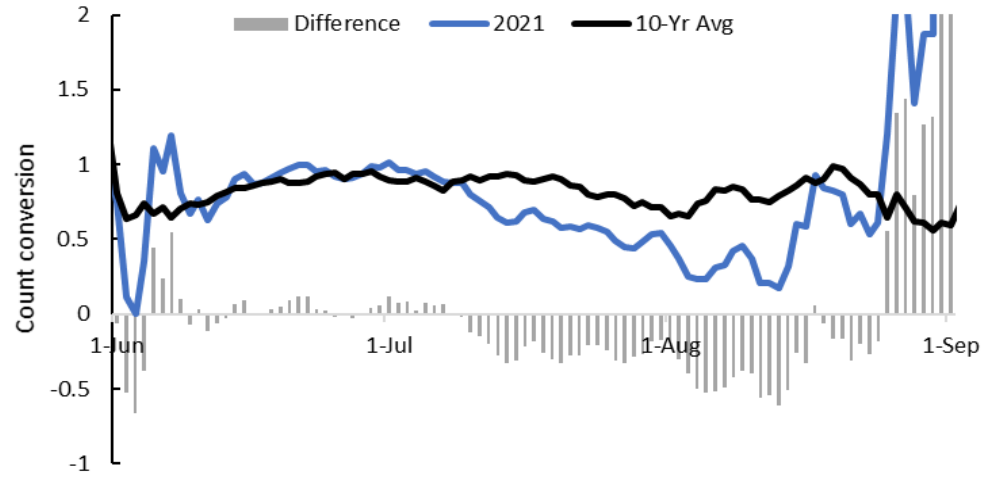


McNary Sockeye Conversion vs . Temp Maximum

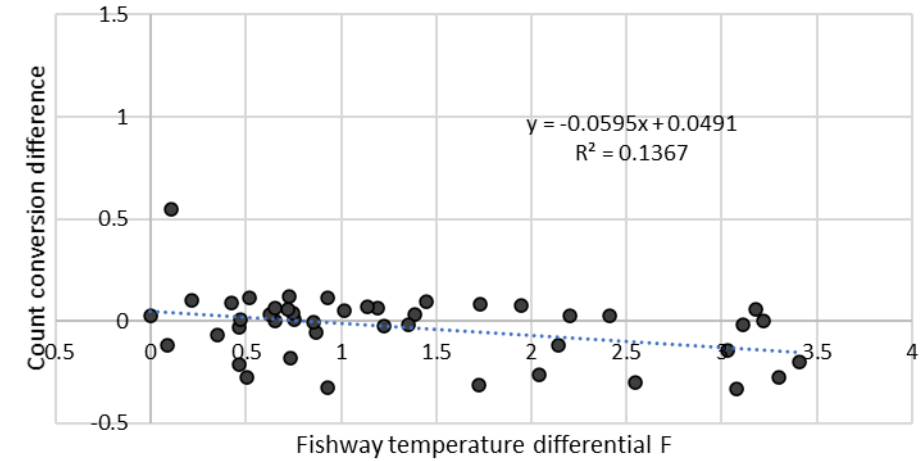


McNary Sockeye Salmon Count Conversions vs. Temperatures

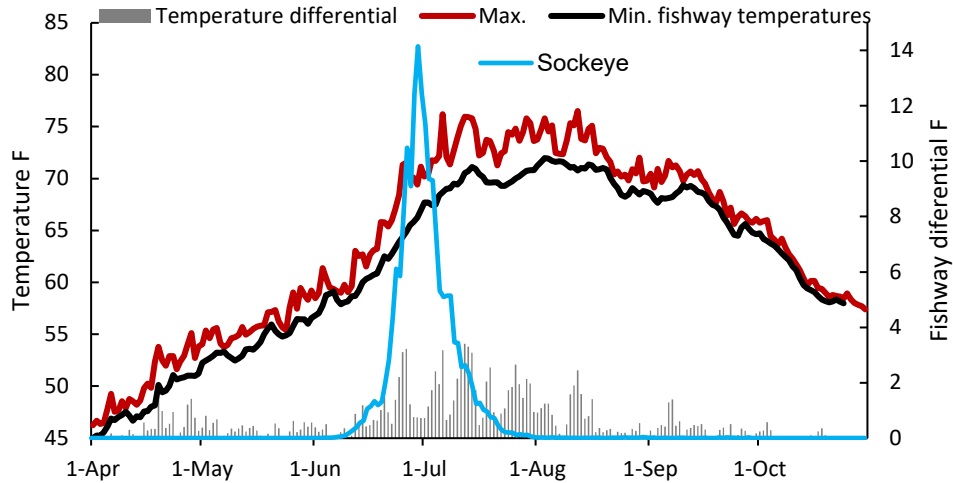
John Day to McNary Sockeye Conversion



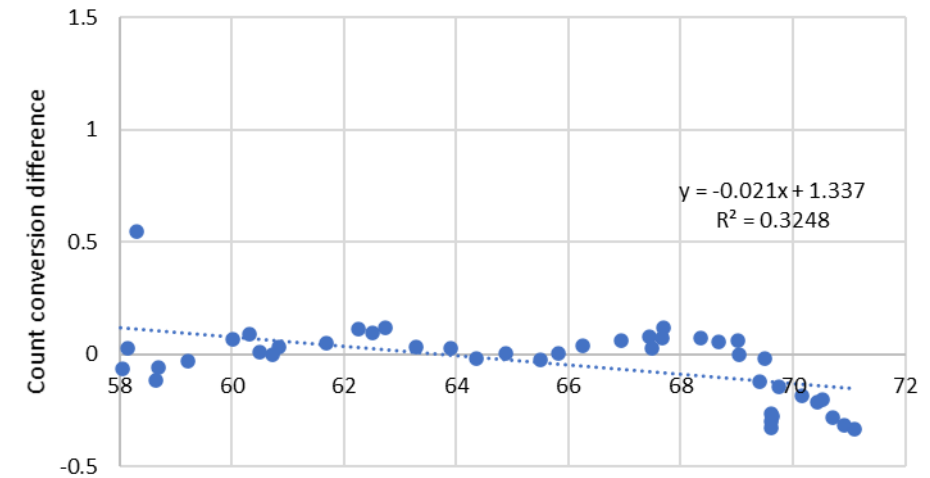
McNary Sockeye Conversion vs. Temp Differential



McNary Dam 2021

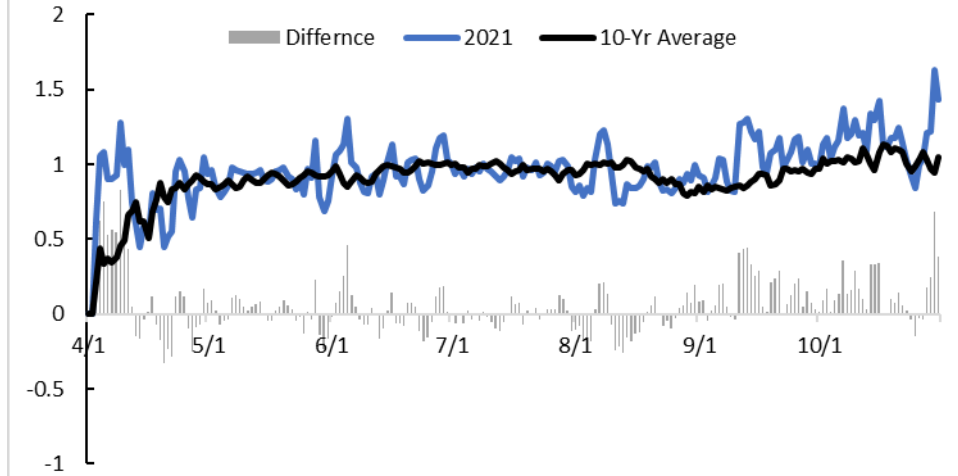


McNary Sockeye Conversion s. Temp Minimum

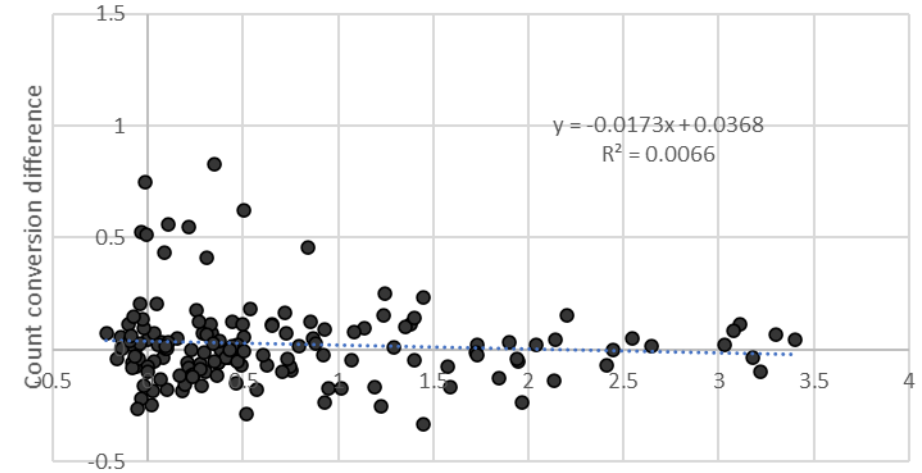


McNary Chinook Salmon Count Conversions vs. Temperatures

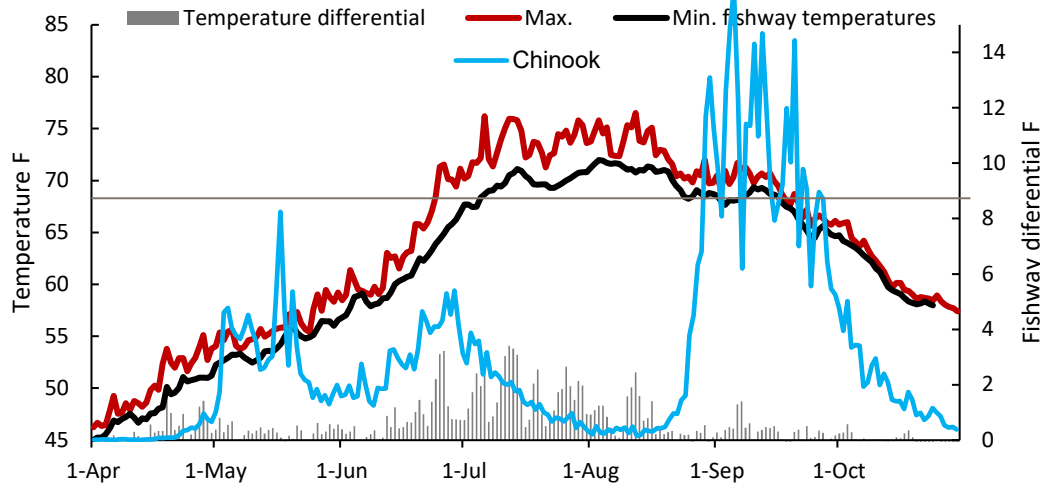
John Day to McNary Chinook Conversion



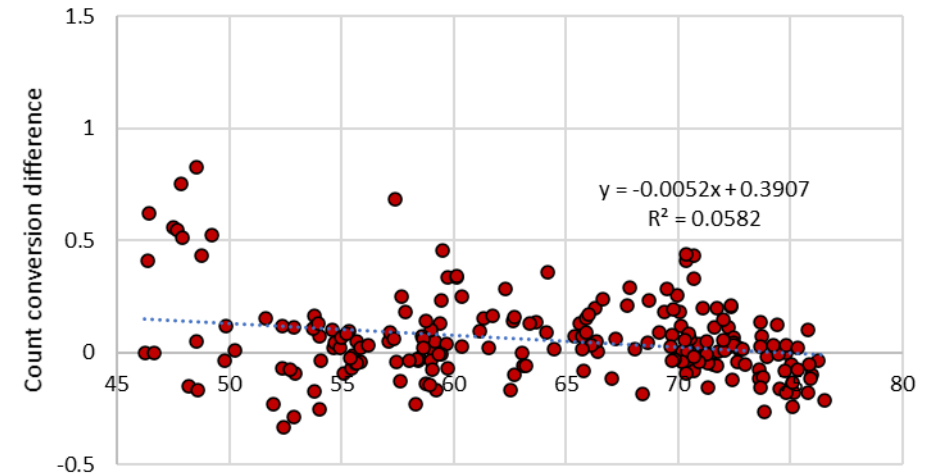
McNary Chinook Conversion vs. Temp Differential



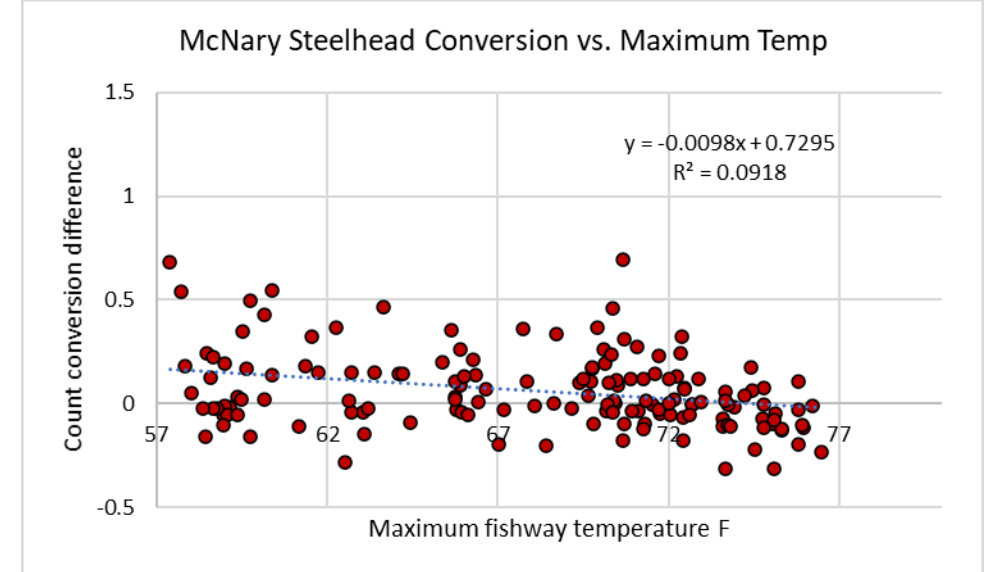
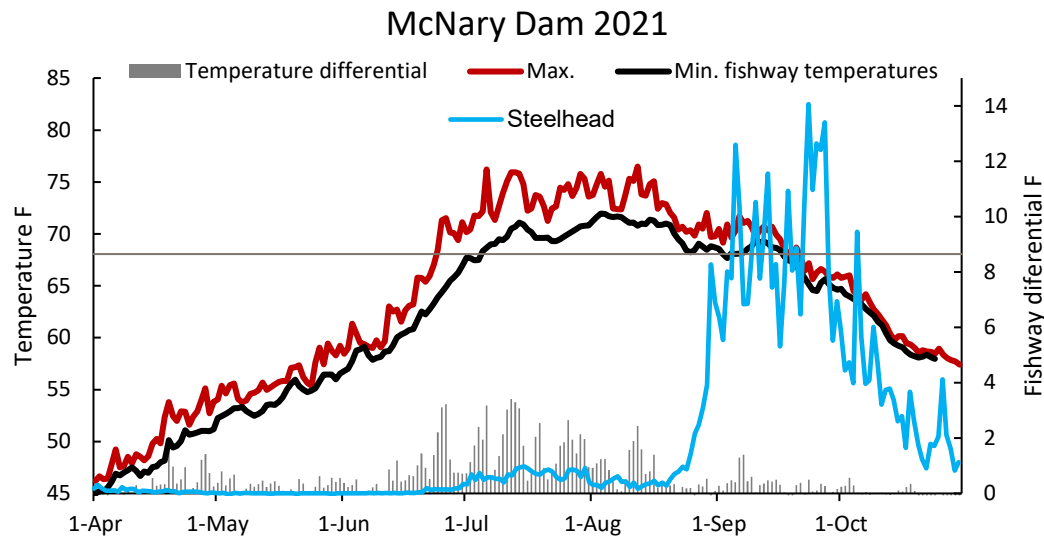
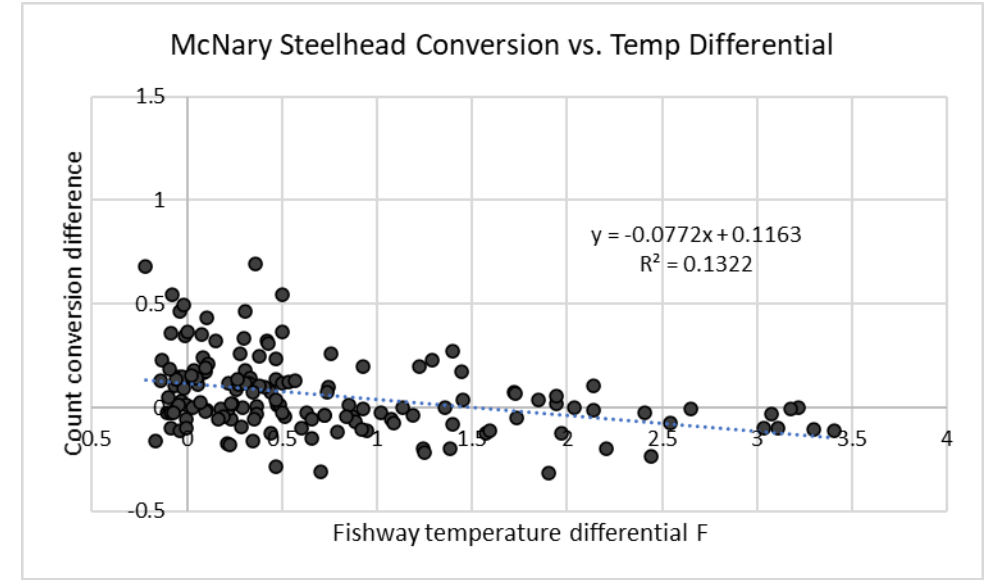
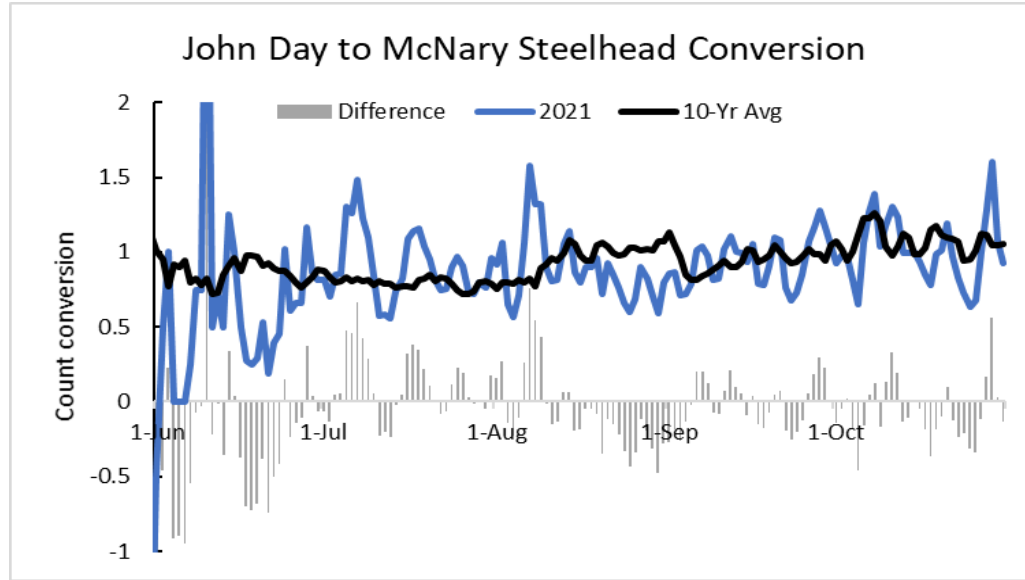
McNary Dam 2021



McNary Chinook Conversion vs. Temp Maximum

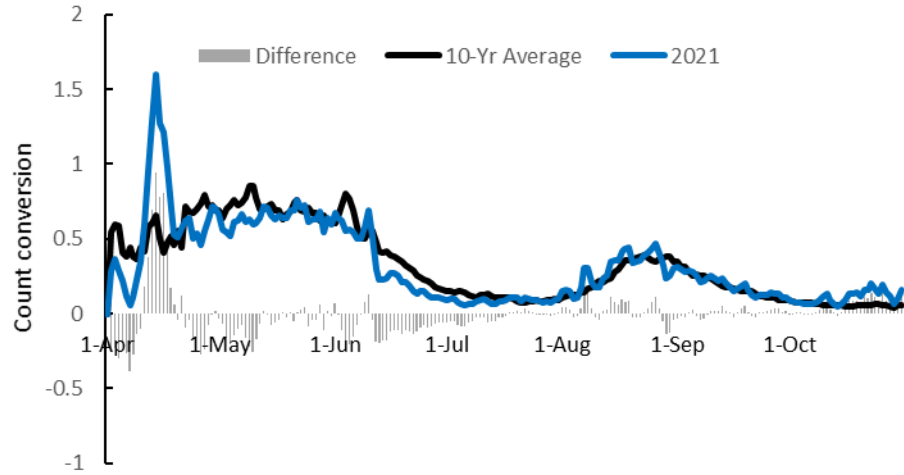


McNary Steelhead Count Conversions vs. Temperatures

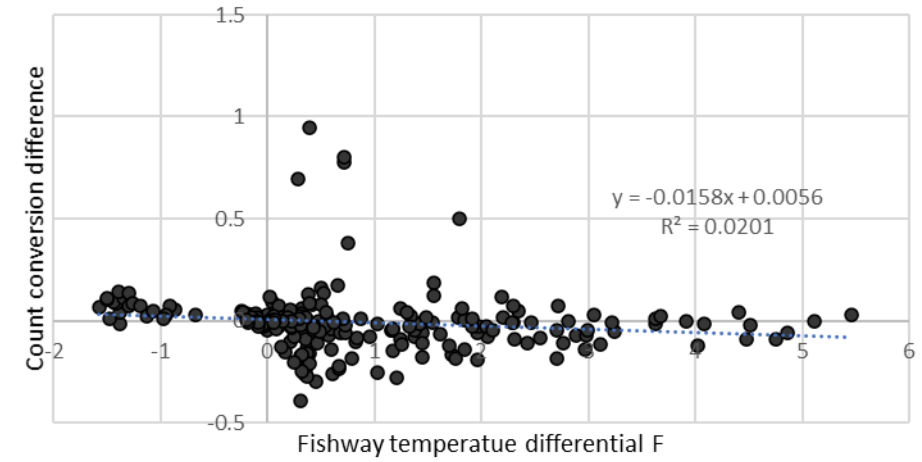


Ice Harbor Chinook Salmon Count Conversions vs. Temperatures

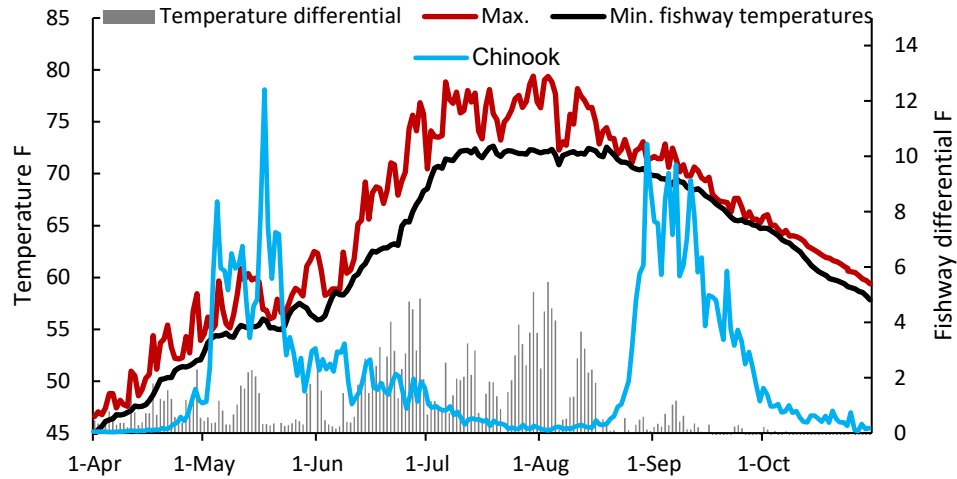
McNary to Ice Harbor Chinook Conversions



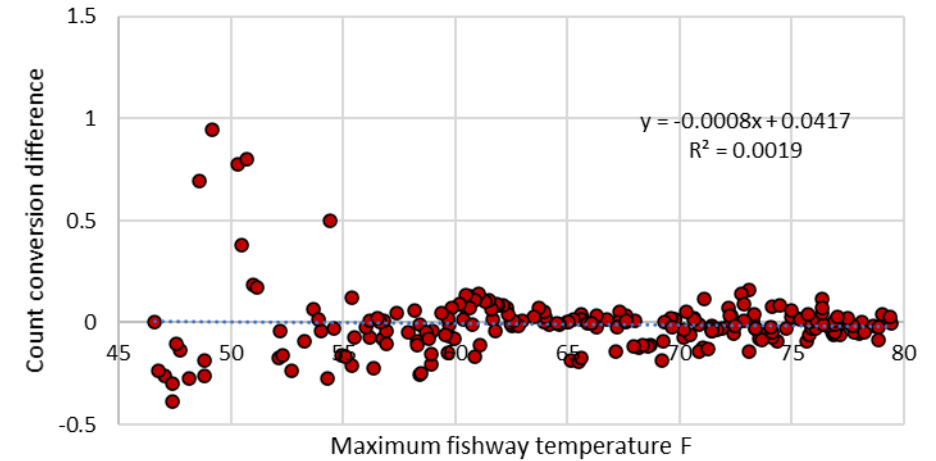
Ice Harbor Chinook vs. Temp Differential



Ice Harbor Dam 2021

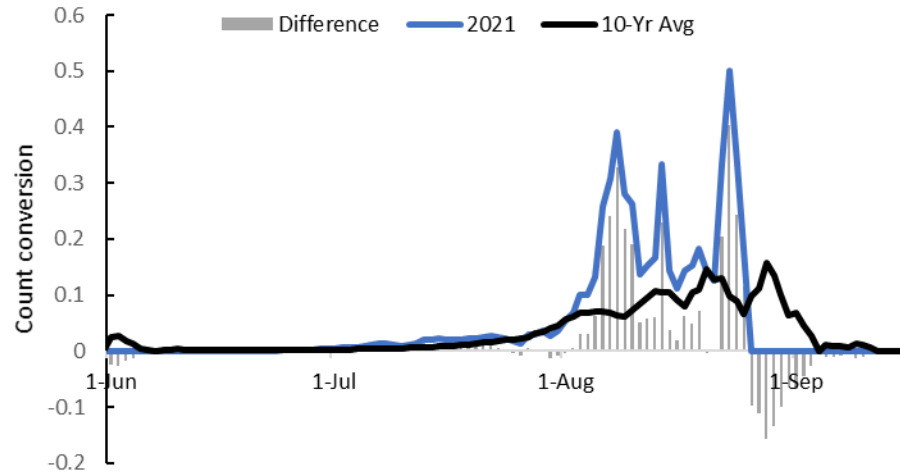


Ice Harbor Chinook vs. Maximum Temp

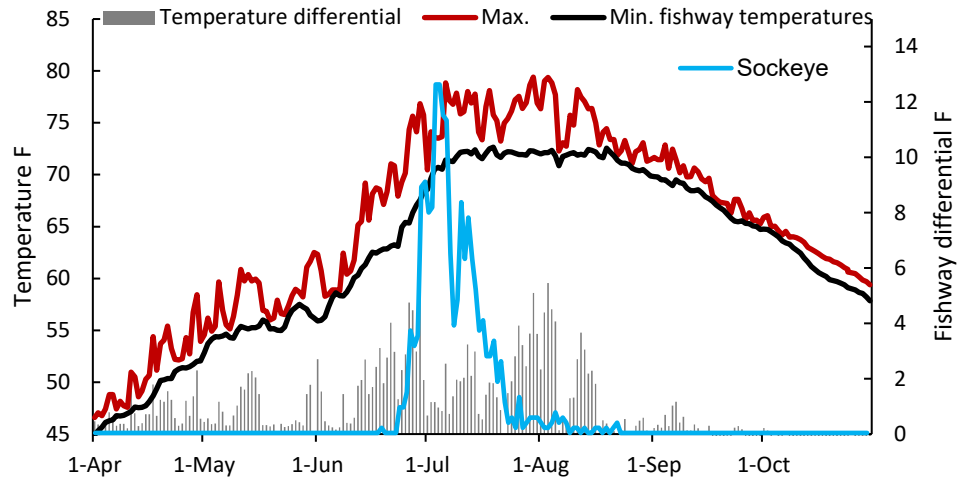


Ice Harbor Sockeye Salmon Count Conversions vs. Temperatures

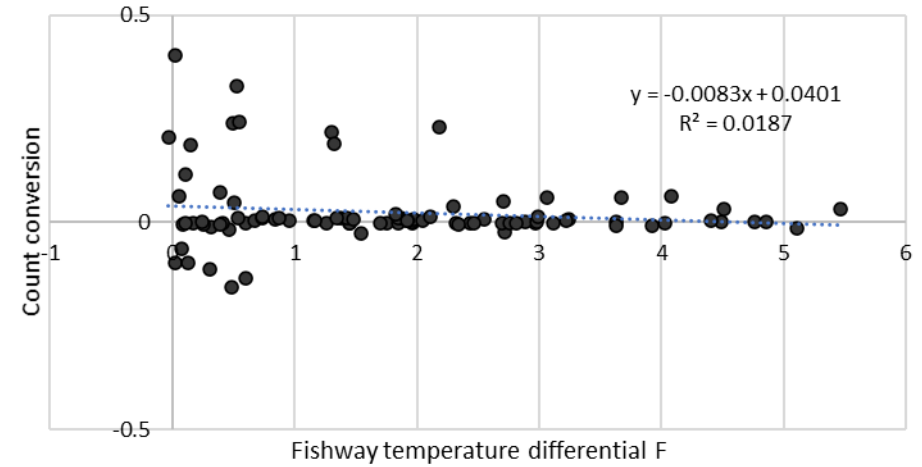
McNary to Ice Harbor Sockeye Conversion



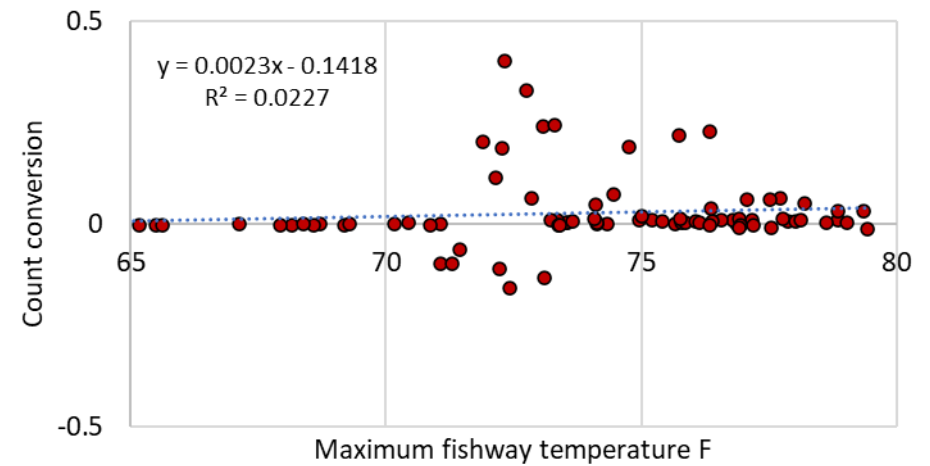
Ice Harbor Dam 2021



Ice Harbor Sockeye Conversion vs. Temp Differential

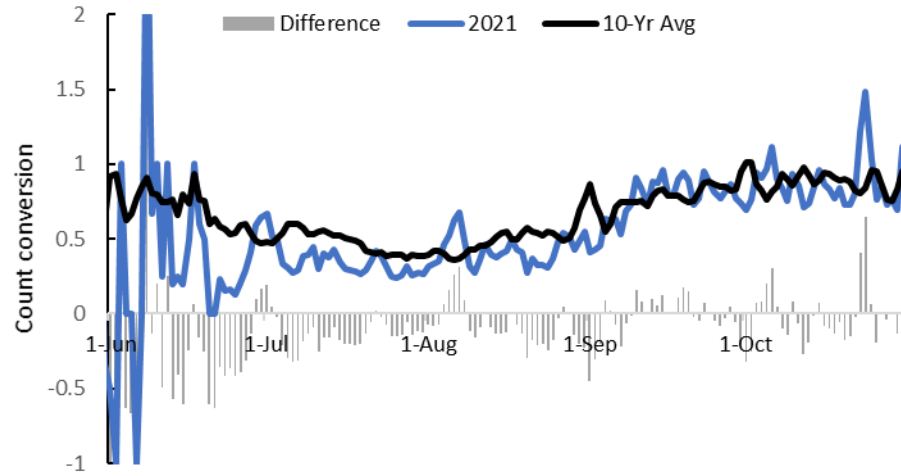


Ice Harbor Sockeye Conversion vs. Maximum Temp

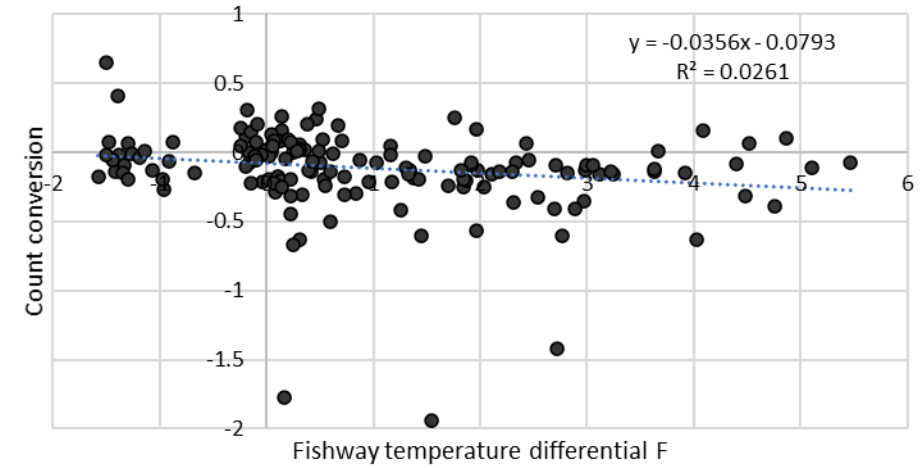


Ice Harbor Steelhead Count Conversions vs. Temperatures

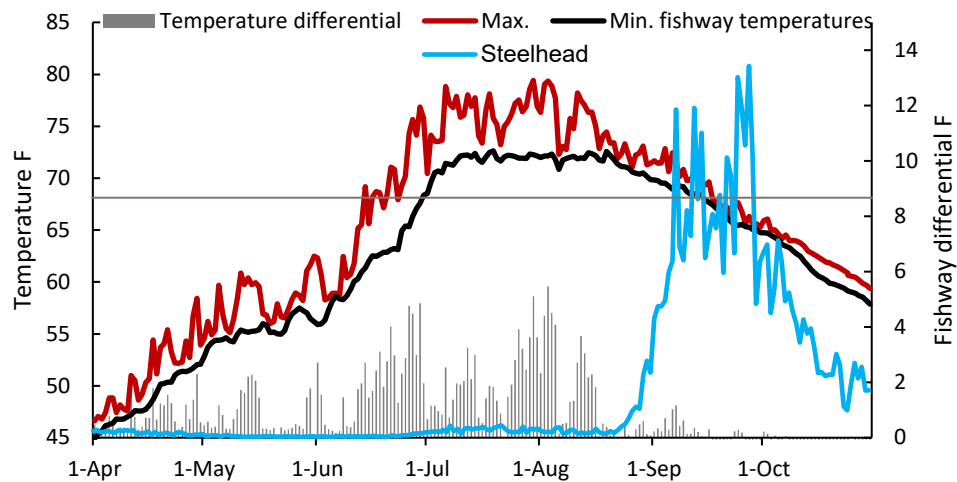
McNary to Ice Harbor Steelhead Conversion



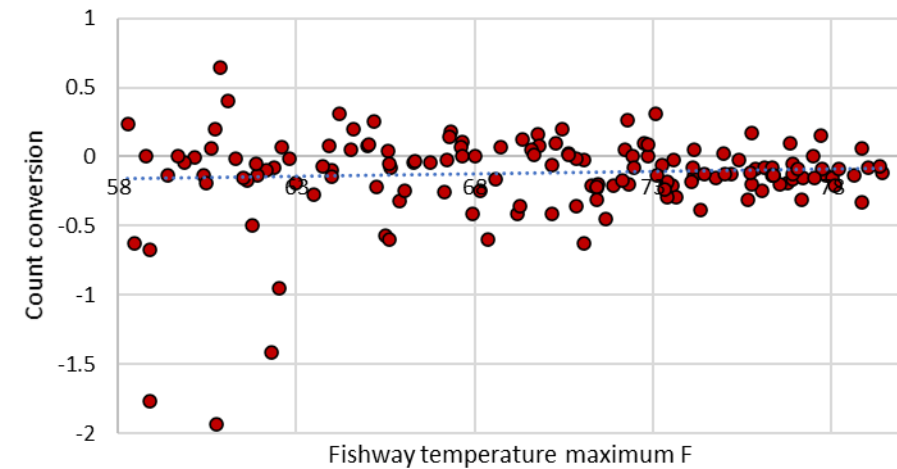
Ice Harbor Steelhead Conversion vs. Temp Differential



Ice Harbor Dam 2021

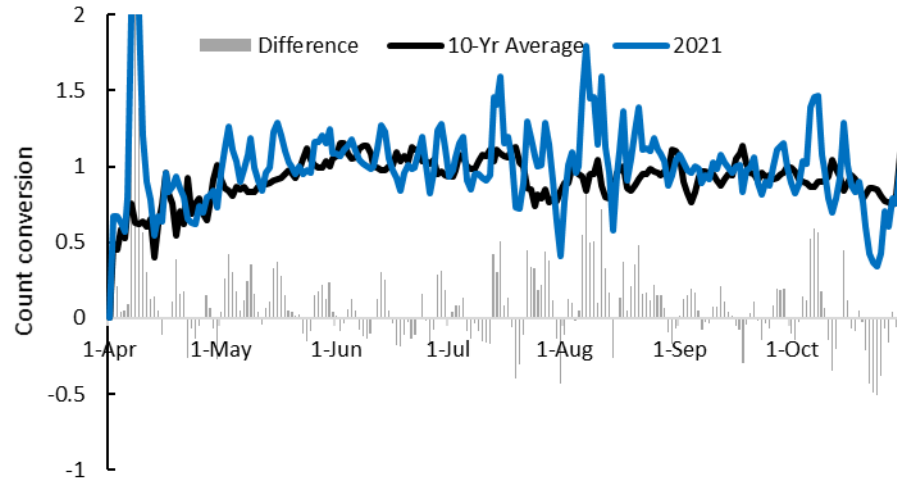


Ice Harbor Steelhead Conversion vs. Maximum Temp

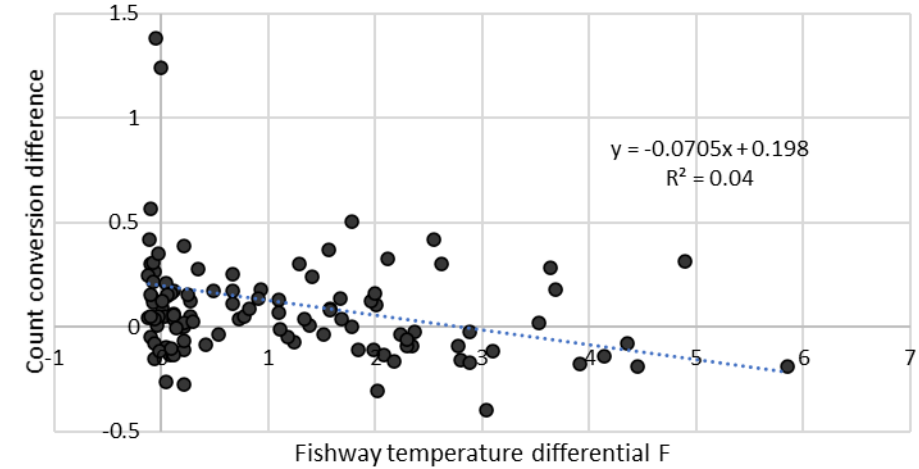


Lower Monumental Chinook Salmon Count Conversions vs. Temperatures

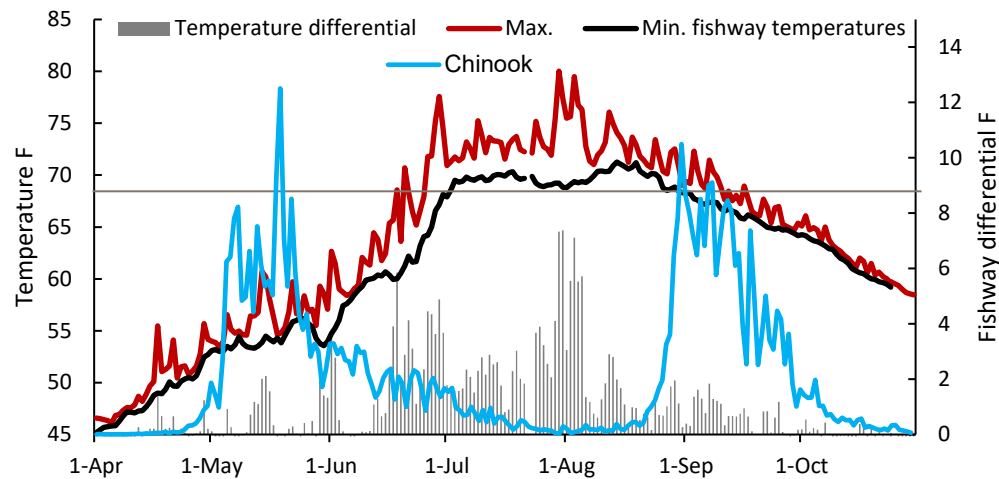
Ice Harbor to L. Monumental Chinook Converstions



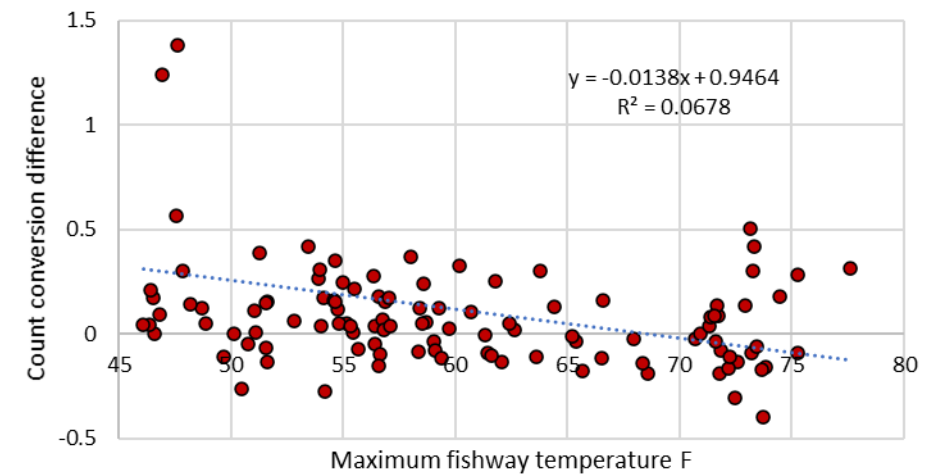
Lower Monumetnal Chinook Conversion vs. Temp Differential



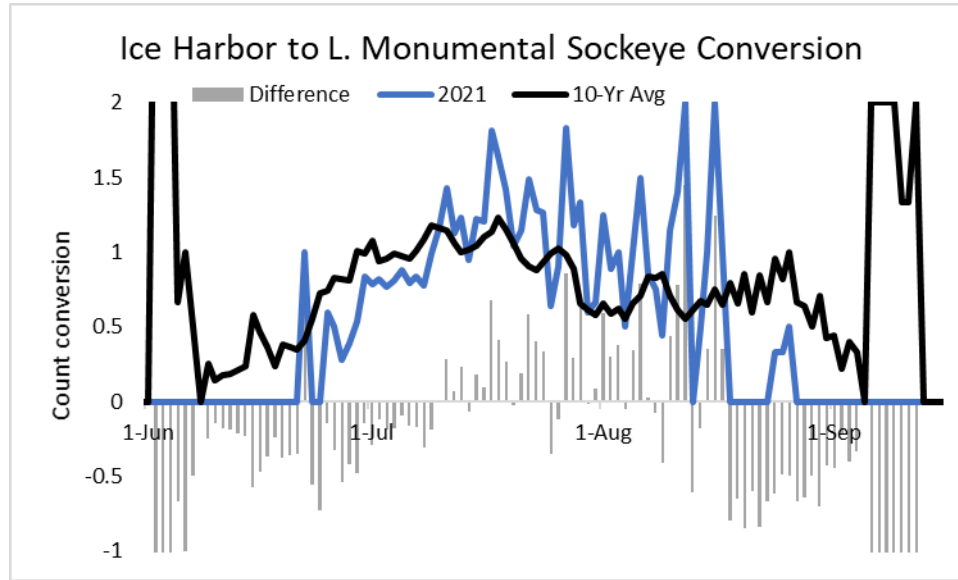
Lower Monumental Dam 2021



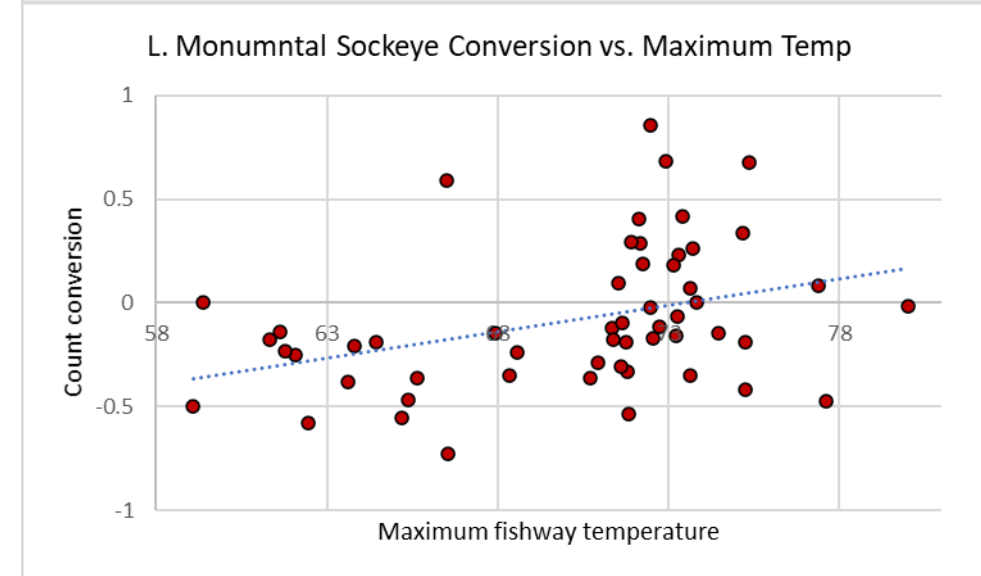
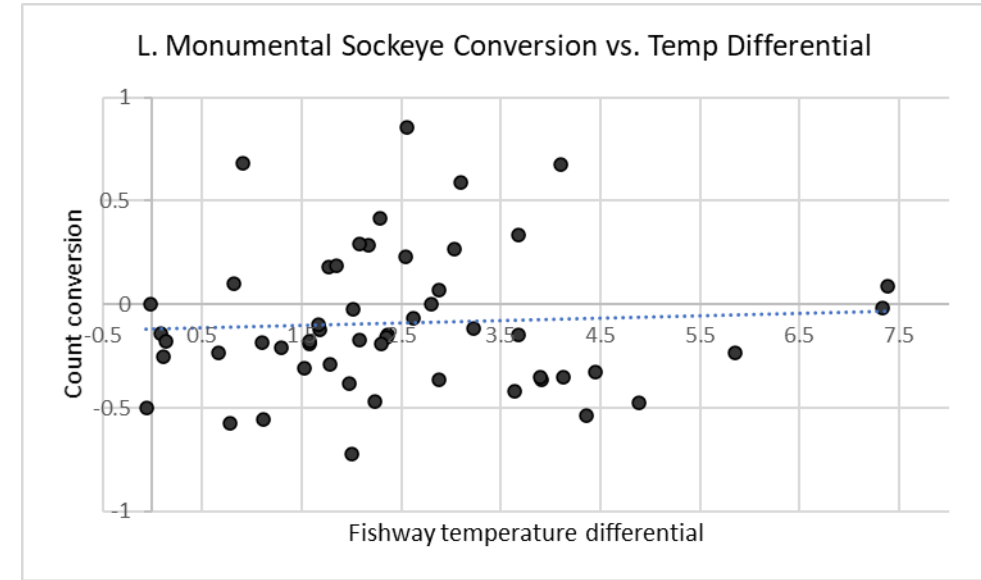
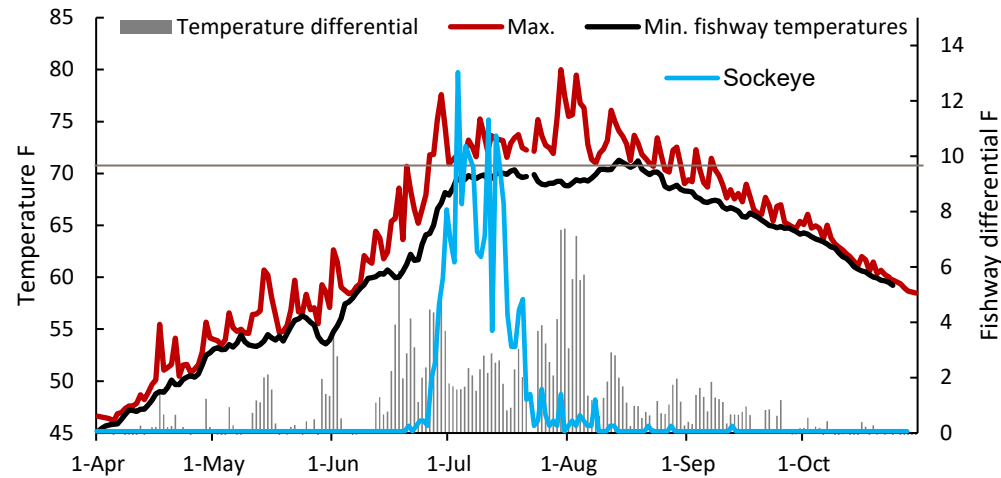
Lower Monumental Chinook Convesion vs. Maximum Temp



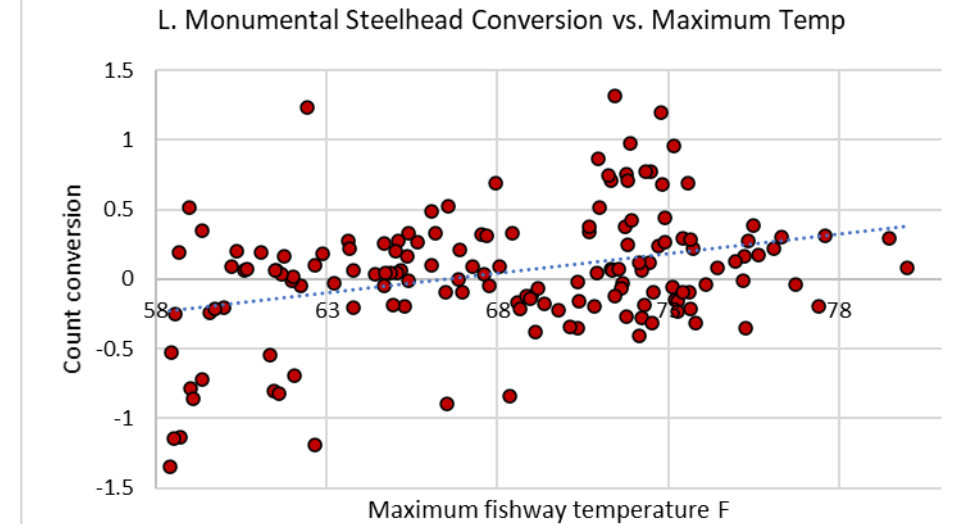
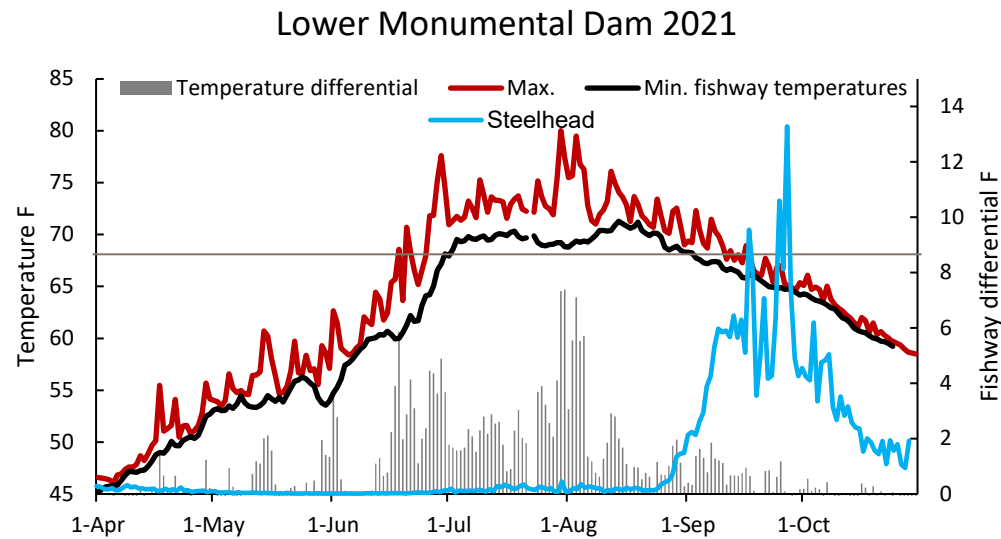
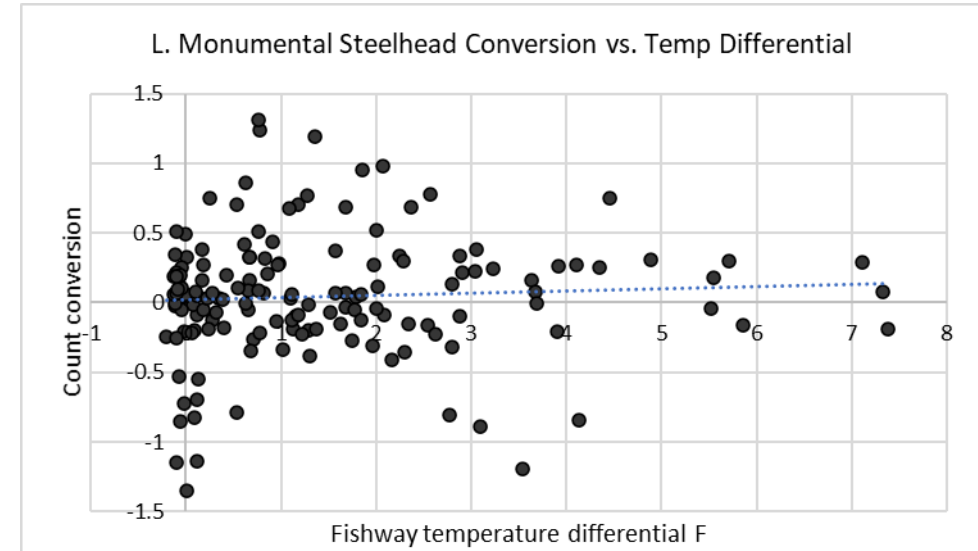
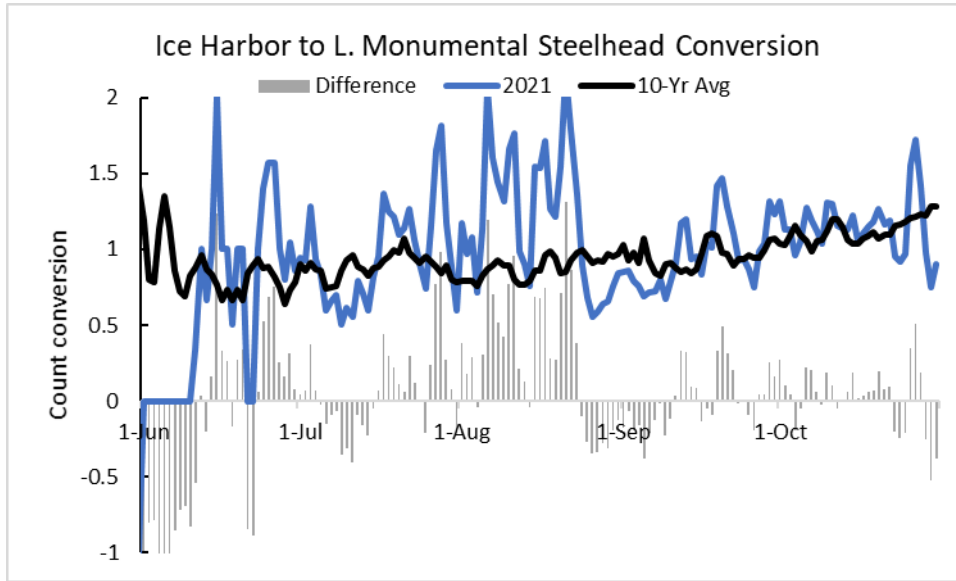
Lower Monumental Sockeye Salmon Count Conversions vs. Temperatures



Lower Monumental Dam 2021



Lower Monumental Steelhead Count Conversions vs. Temperatures





Conclusions

There is potential to cool fishways at McNary, Ice Harbor and Lower Monumental dams.

Lower Monumental $\geq$ Ice Harbor $>$ McNary

More fish pass McNary Dam

Higher priority to fishways with higher passage

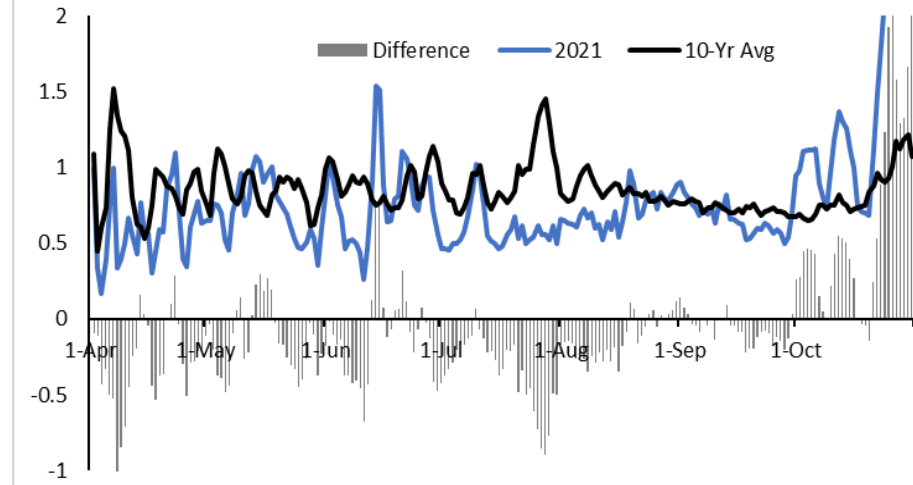
Summaries of count conversions show some relationships with temperature conditions

Maximum temperature more influence than temperature differentials

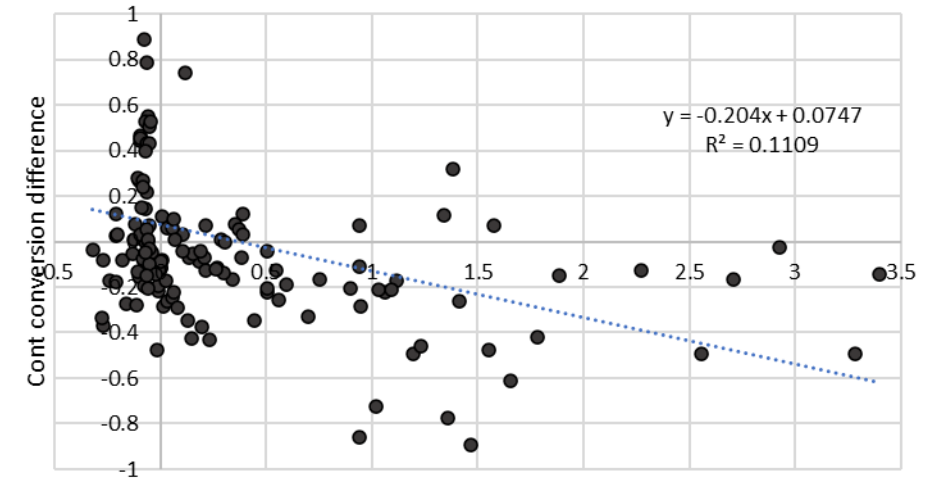
Difficult to separate potential influence of fishway vs. river conditions

Little Goose Chinook Salmon Count Conversions vs. Temperatures

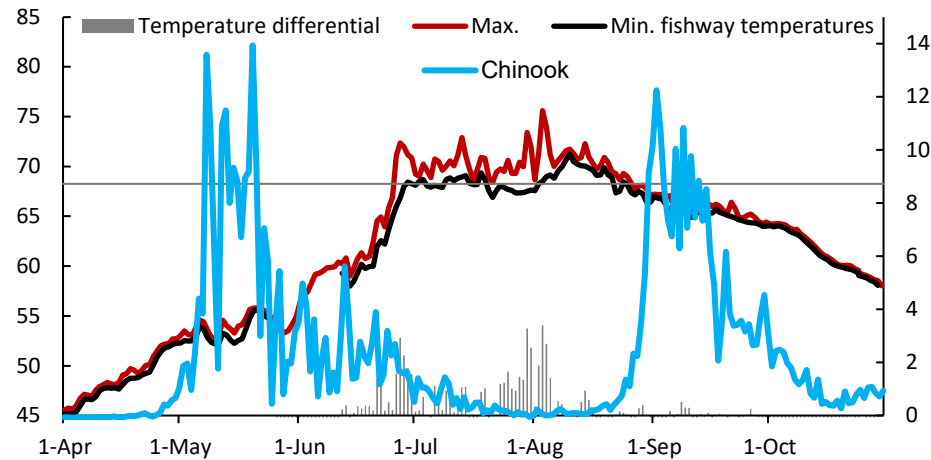
L Monumental to L Goose Chinook Conversion



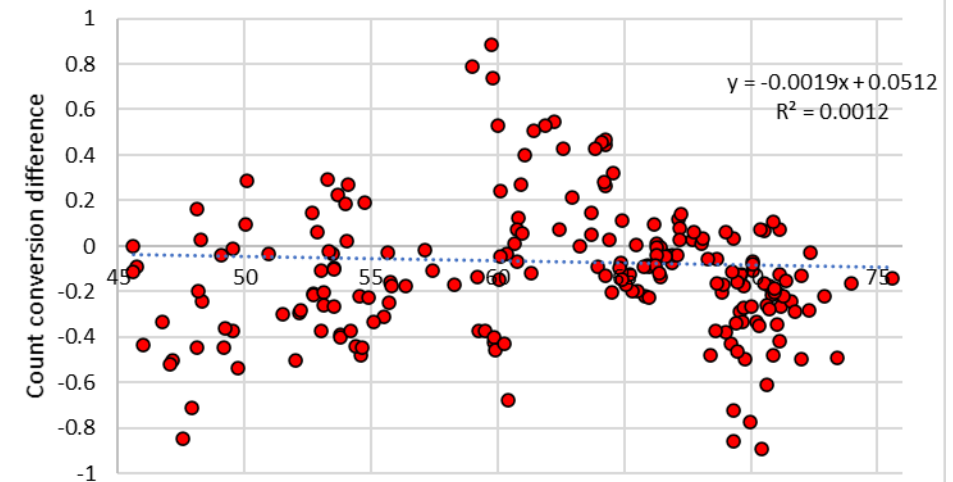
Little Goose Conversion vs. Temp Differential



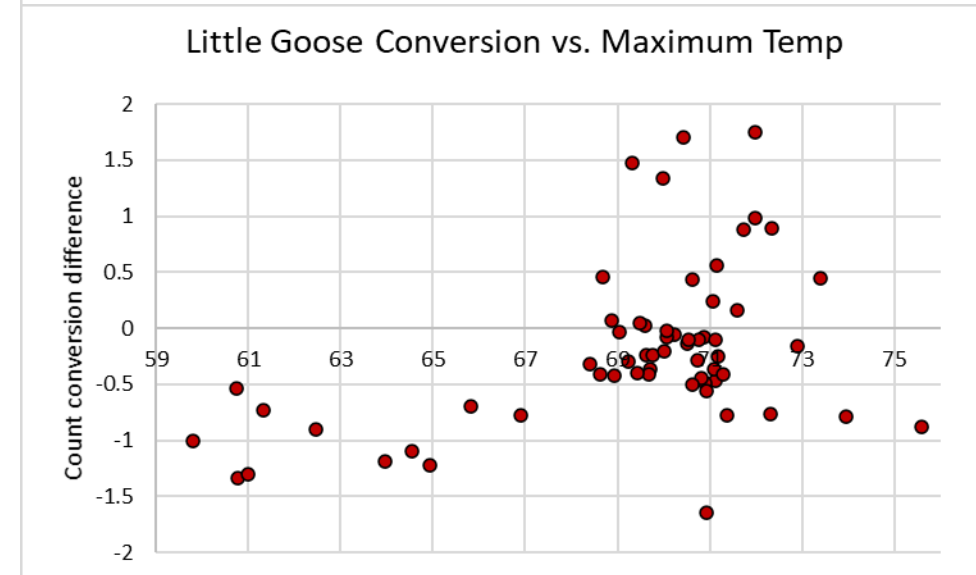
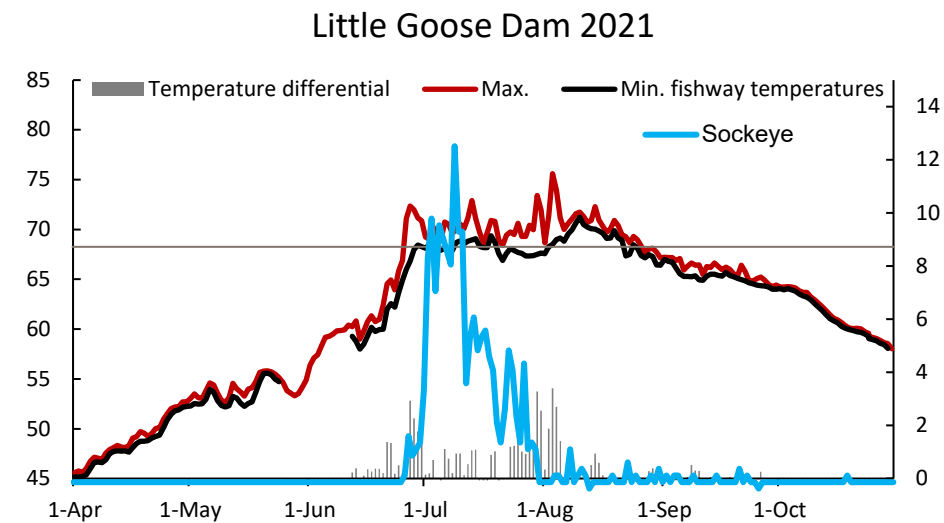
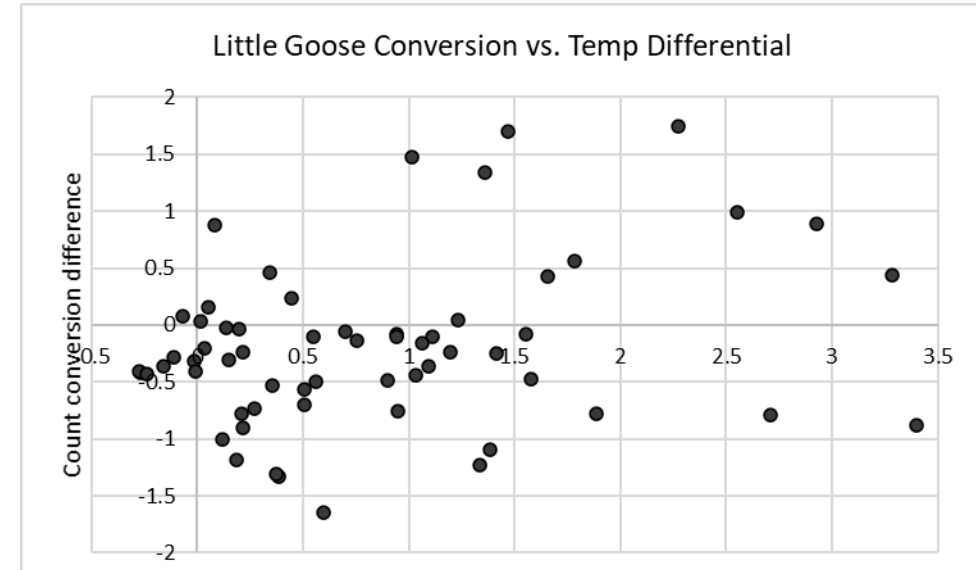
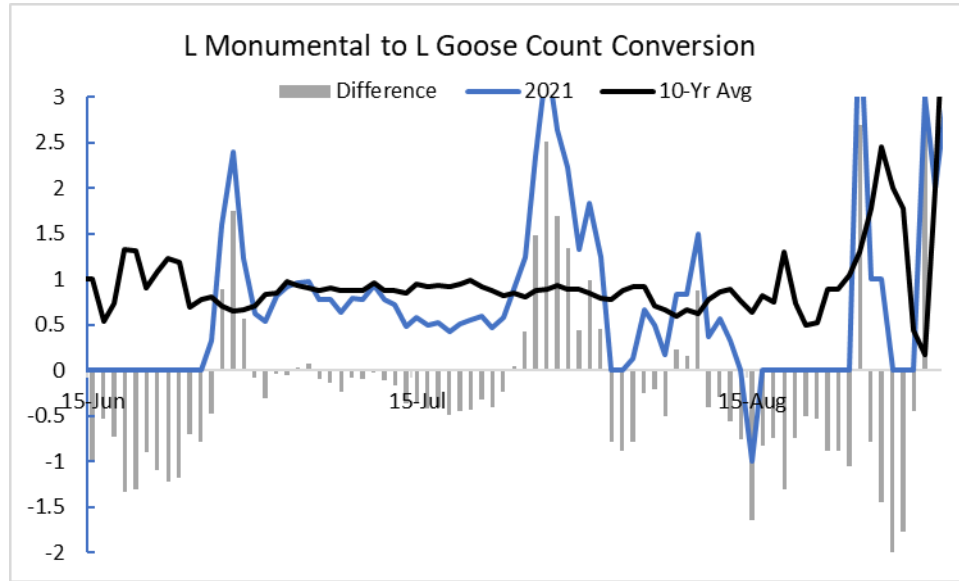
Little Goose Dam 2021



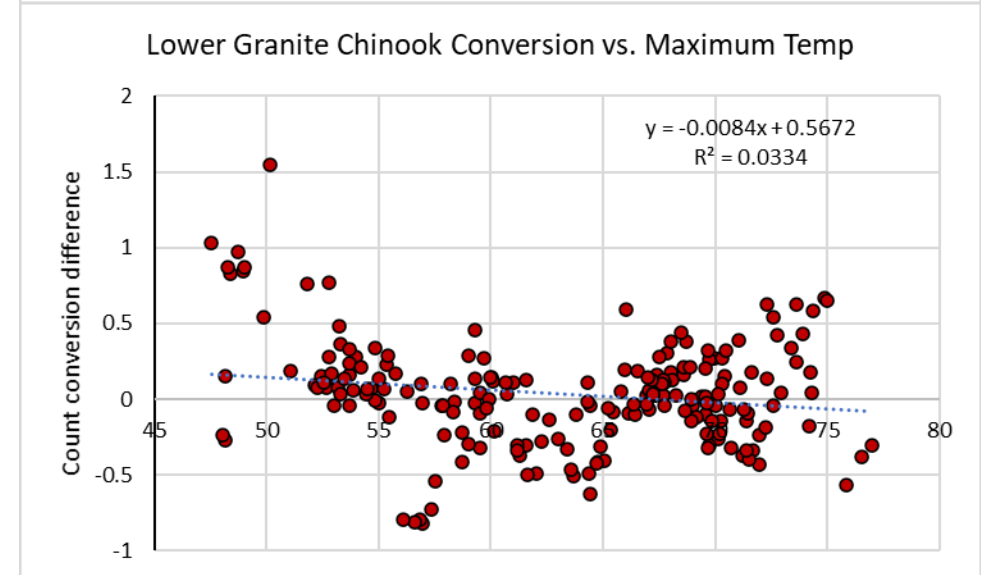
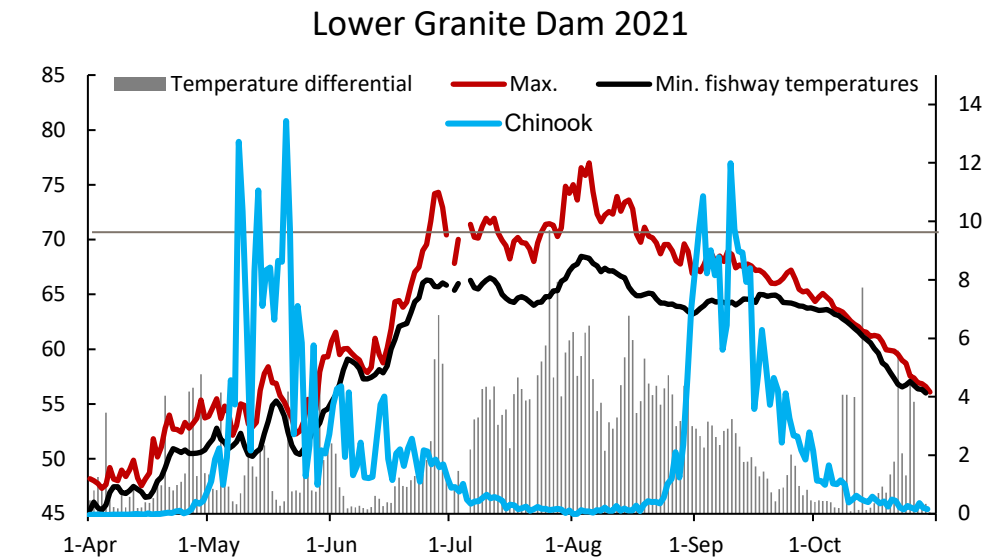
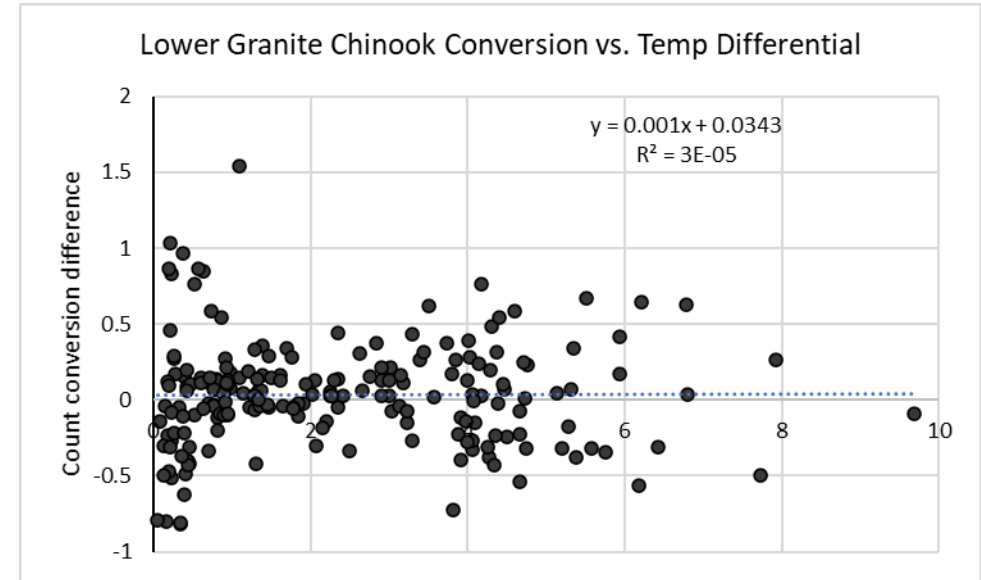
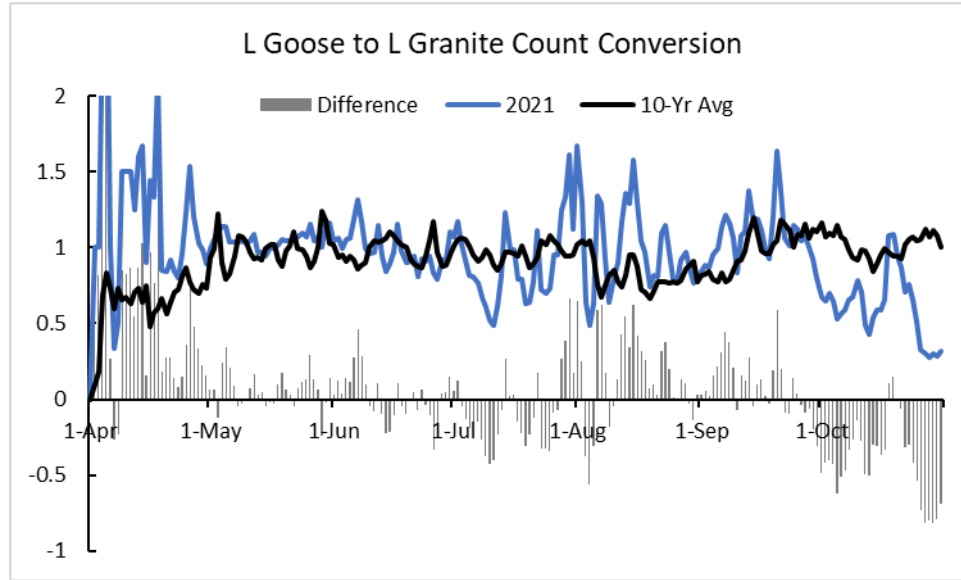
Little Goose Conversions vs. Maximum Temp



Little Goose Sockeye Salmon Count Conversions vs. Temperatures

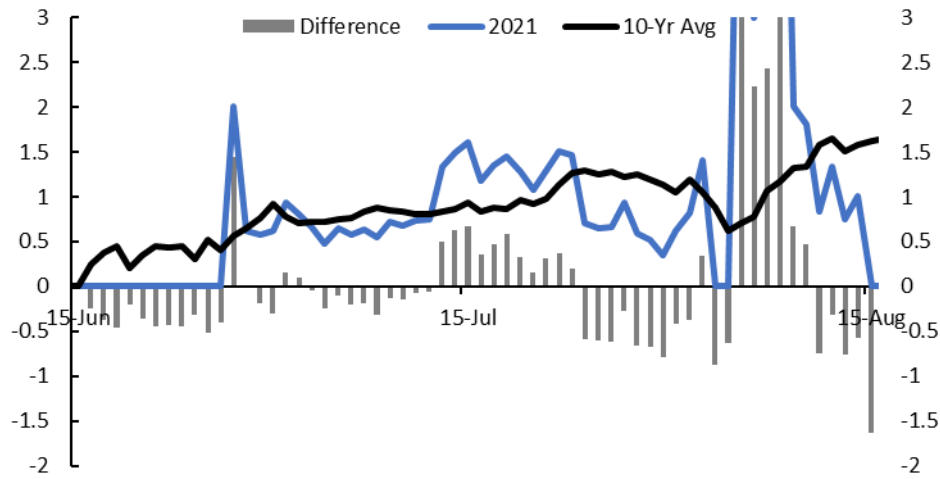


Lower Granite Chinook Salmon Count Conversions vs. Temperatures

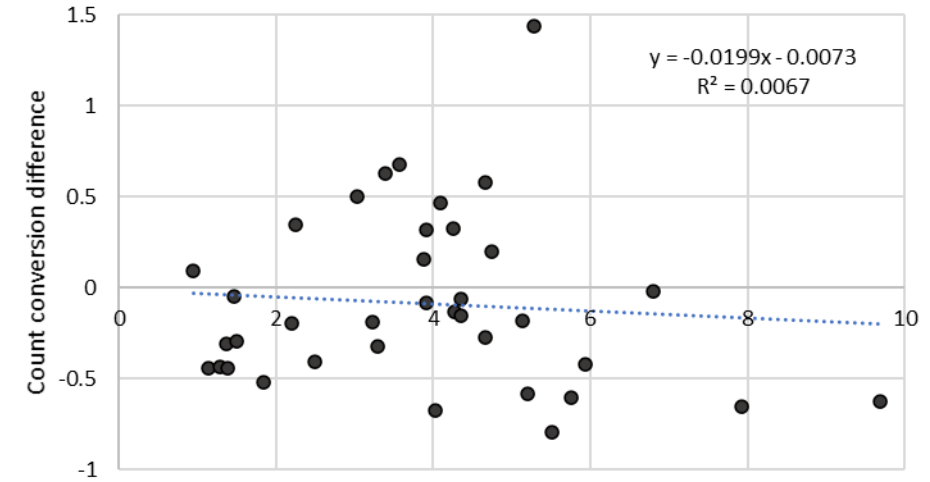


Lower Granite Sockeye Salmon Count Conversions vs. Temperatures

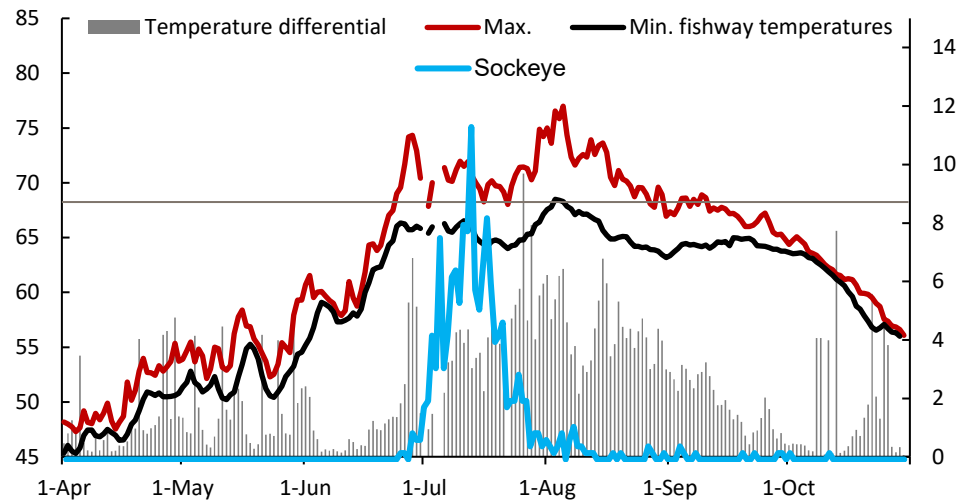
L Goose to L Granite Count Conversion



Lower Granite Sockeye Conversion vs. Temp Differential



Lower Granite Dam 2021



Lower Graite Sockeye Conversion vs. Maximum Temp

