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**UNITED STATES AIR FORCE  
JOINT BASE ELMENDORF-RICHARDSON  
ALASKA**

***ENVIRONMENTAL CONSERVATION PROGRAM***

**ABUNDANCE AND RUN TIMING OF SMOLT AND  
ADULT SALMON IN SIXMILE LAKE, JOINT BASE  
ELMENDORF-RICHARDSON, ALASKA**

**Final**

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# **ABUNDANCE AND RUN TIMING OF SMOLT AND ADULT SALMON IN SIXMILE LAKE, JOINT BASE ELMENDORF- RICHARDSON, ALASKA**

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## Symbols and Abbreviations

Alaska Department of Fish and Game	ADF&G
Air Force Base	AFB
Celsius	°C
Center for Environmental Management of Military Lands	CEMML
Civil Engineers Installation Environmental Conservation	CEIEC
Cook Inlet Beluga Whale	CIBW
Dissolved Oxygen	DO
Department of Defense	DoD
Feet	‘ or ft
Height	H
Joint Base Elmendorf-Richardson	JBER
Kilometers	km
Length	L
Meters	m
National Marine Fisheries Service	NMFS
National Oceanic & Atmospheric Administration	NOAA
Primary Constituent Elements	PCE
United States Army Corps of Engineers	USACE
Width	w

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## Introduction

In 2008, the National Marine Fisheries Service (NMFS) listed the Cook Inlet beluga whale (*Delphinapterus leucas*) as endangered (NMFS 2008). Beluga whales are predatory in nature and follow eulachon (*Thaleichthys pacificus*) into the Upper Cook Inlet during the spring, then switch to consuming salmon (*Oncorhynchus* spp.) as the eulachon numbers decline (NMFS 2009). In 2011, critical habitat was established within Cook Inlet, including Knik Arm in front of the mouth of Sixmile Creek (76 FR 20180, April 11, 2011). Included in the designation was a list of factors that the NMFS deemed essential to the survival and recovery of the Cook Inlet beluga. These factors, or Primary Constituent Elements (PCEs), include four (4) of the Pacific salmon species, excluding pink salmon (*O. gorbuscha*). The Sixmile Creek drainage, located on Joint Base Elmendorf-Richardson (JBER), supports sockeye (*O. nerka*), coho (*O. kisutch*), chum (*O. keta*), and pink salmon. Belugas are commonly observed milling at the mouth of Sixmile creek during the fall, and it is assumed that they are foraging for salmon returning to the creek. Monitoring this population is important in terms of the beluga (i.e., PCE), as well as for management of the small sport fishery at the mouth.

The Sixmile drainage (Figure 1) consists of Upper and Lower Sixmile lakes and Sixmile Creek on JBER. In 1951, Sixmile Creek was dammed to create lakes to support a floatplane base (Abbott and Allgair n.d.). The first records of sockeye salmon in the Sixmile Creek drainage occurred in 1975 (Rothe et al. 1983). These sockeye have been genetically linked to stocks in Big Lake and Fish Creek (Habicht et al. 2007).

In 1988, the Conservation and Planning Element of the Environmental Flight, 3<sup>rd</sup> Civil Engineering Squadron began monitoring the returning adult salmon using a weir and continued to monitor through 2008. In 2003, Tracey Gotthardt, with the Alaska Natural Heritage Program, conducted a field study, “Limnological and Fishery Investigations Concerning Sockeye Salmon Production in Sixmile Lakes, Elmendorf Air Force Base, Alaska” (Gotthardt 2006). This was the first time that the out-migrating smolt were enumerated from the Sixmile lakes. In 2009 and 2010, the Alaska Department of Fish and Game (ADF&G) was contracted to conduct data collection and daily operations of the weir. In 2011, JBER’s Civil Engineers Installation Environmental Conservation Section (CEIEC) in partnership with Colorado State University – Center for Environmental Management of Military Lands (CSU-CEMML) once again operated the weir and collected salmon escapement data. From 2003 to 2010, enumeration of the out-migrating smolt was sporadic. Since 2012, enumerating the out-migrating smolt has been an annual project conducted by CSU-CEMML through a cooperative agreement with CEIEC.

Out-migrating smolt are counted from Lower Sixmile Lake beginning in early May and ending in late June or early July. Sixmile smolt out-migration includes sockeye and coho salmon. Sockeye salmon

smolt are the most abundant species, with annual counts ranging from 1,245 to 23,644, while counts of coho salmon smolt range from 23 to 3,996 fish.

The Sixmile Creek adult weir is operable by early-July, with biologists, technicians, and volunteers counting and releasing salmon until the end of September. Sockeye, coho, and a small fraction of the pink and chum salmon are enumerated at the weir. Adult sockeye salmon are the most abundant species, with annual counts ranging between 317 and 4,768, while counts of adult coho salmon range between 1 and 527 fish.

## **Goal and Objectives**

The primary goal of this project is to continue monitoring the Pacific salmon that utilize the Sixmile lake system, with a focus on coho, a CIBW prey item.

The objectives for the project are as follows:

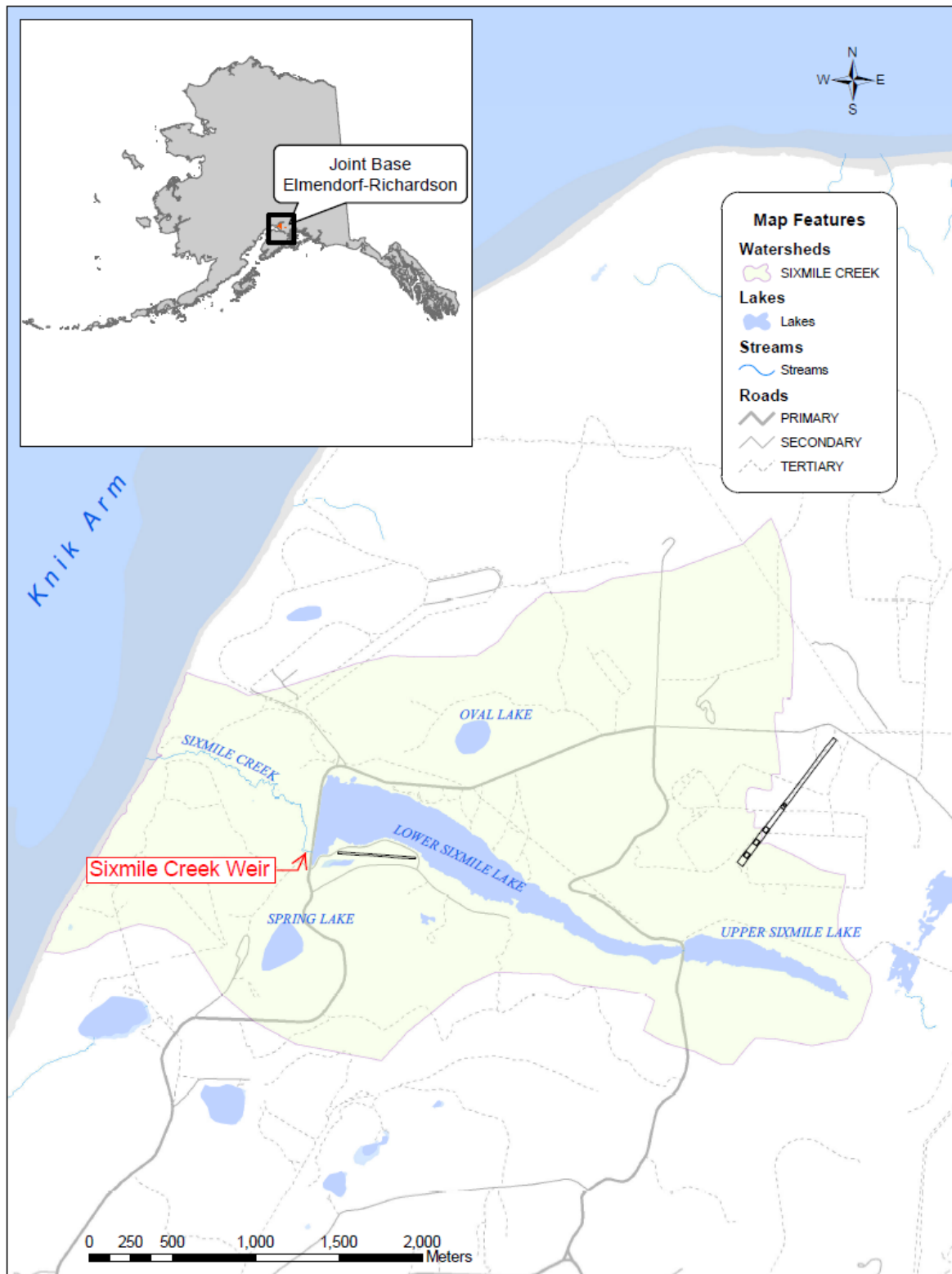
- Enumeration of out-migrating salmon smolt and spawning adult salmon
- Maintain the long-term Sixmile salmon database
- Review and analyze long-term salmon population trends within the Sixmile lake system

## **Study Site**

The Sixmile Creek drainage encompasses approximately 2,033 acres on JBER (Figure 1). The drainage includes Sixmile Creek, Lower Sixmile Lake, and Upper Sixmile Lake. The lakes and creek occupy a valley created by an old channel of Eagle River (U.S. Department of Defense 2012). The system is recharged primarily by groundwater entering the south side of Upper Sixmile Lake. The lakes have a combined surface area of approximately 155 acres (62.7 ha). Sixmile Creek flows approximately 1.5 km from Lower Sixmile Lake draining into the Knik Arm of Cook Inlet.

Sockeye salmon were first recorded in Sixmile Creek drainage in 1975, when a fish ladder was installed at the outflow of Lower Sixmile Lake (Gotthardt 2006). During the summer of 1996, a new fish friendly culvert with splash pool was placed between Upper and Lower Sixmile lakes. The culvert was revamped in 2004 to add a beaver baffle to prevent beavers from clogging the culvert and preventing fish passage. From 1988 until 1997, the adult weir was located in a meadow halfway between Lower Sixmile Lake and Cook Inlet (61.29209 -149.82277). In 1998, the adult weir was relocated at the outflow of Lower Sixmile Lake under the Fairchild Avenue Bridge. The adult and smolt weirs are currently located at this site.





**Figure 1.** The Sixmile Creek drainage on JBER, AK (Gumpert 2011).

## Methods

### *Smolt Weir Design and Operation*

Sockeye and coho salmon smolt out-migrating from the Sixmile lakes were enumerated from 2 May through 5 July. To obtain a more accurate count of smolt out-migration, the counts were started earlier and ended later than previous years. Smolt were captured using a weir and live box, which was checked at least twice daily. The weir consisted of four 1.22 m x 2.44 m panels that spanned from the bridge abutment; this ensured that the entire stream width was effectively fished. The panels are aluminum frames covered in poly vinyl mesh netting. The panels narrow to a cylindrical entrance into a rectangular aluminum box (1.0 m x 0.85 m x 0.80 m (L x W x H)). The panels were inspected daily for gaps that could allow smolt to pass through undetected. The smolt were collected from the live box using small dip nets and identified using Pollard et al. (1997) *Field Identification of Coastal Juvenile Salmonids* and other available resources. After identification, fish were released.

### *Adult Weir Design and Operation*

Adult salmon sockeye, coho, pink and chum were counted from 6 July through 29 September using a custom mobile picket weir with a gate that can be lifted to allow controlled fish passage into Lower Sixmile Lake. The weir was visually inspected twice on a daily basis to ensure that there were no gaps that would allow salmon to pass through undetected and was cleaned of debris. Before the gate was opened to allow fish passage, the exit of the fish ladder was blocked so that fish were unable to escape downstream. A beach seine net was used to corral the fish through the open gate where they were identified using ADF&G's identification pdf and released into the lake.

### *Water Quality Parameters*

Two water quality parameters, temperature and dissolved oxygen, were collected over the course of the entire project using a HOBO Dissolved Oxygen Logger (Onset, Bourne MA) with an integrated temperature sensor. It was deployed at the study site directly under the bridge on April 29 and removed on November 26. Water temperature (°C) was recorded four times a day, every six hours, using the HOBO DO Logger (Onset, Bourne MA) to generate a daily average temperature, as well as, high and low temperature at the project site.

### *Data Analysis*

CEIEC maintains two long-term databases, one for the number and timing of the out-migrating smolt and the other for the number and timing of returning adults. The total number of smolt and adult sockeye and coho were each added to their representative database. Comparison of cumulative and daily counts for 2017, for both the smolt and adults, to previous years' cumulative average and daily average counts was completed. Water temperature for 2017 was graphed alongside the daily smolt and adult

counts for 2017, and average water temperature for previous years was graphed alongside the daily average smolt and adult counts for previous years. Analysis of water temperature and smolt and adult daily counts was completed to identify if there is any correlation to run timing and water temperature.

## Results

### *Smolt Weir*

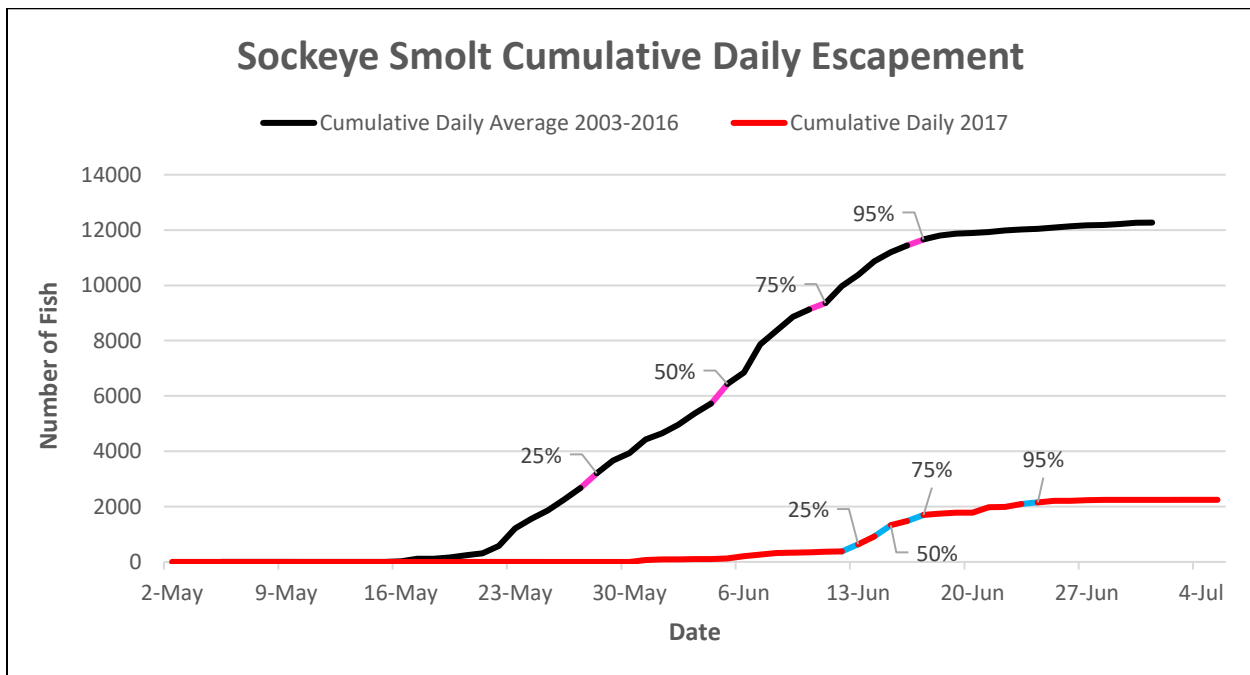
The smolt weir was installed on May 2, 2017 and removed on July 5, 2017, for a total of 65 sampling days. The weir remained in place a week longer than previous years due to cold temperatures in the spring, which curtailed early escapement of smolt. During the smolt weir operation, water temperature measured between 6.77°C and 18.94°C, with an average of 14.57° C. A total of 3,227 coho and 2,245 sockeye were counted during the weir operation. The first coho smolt and sockeye smolt were documented on May 17, 2017, and May 25, 2017, respectively. The last documented smolt, both coho and sockeye, were recorded on July 3, 2017. It was also noted and recorded that 254 sockeye fry were identified, counted and released into Sixmile Creek.

**Table 1.** Smolt daily and cumulative counts of sockeye and coho salmon at the Sixmile Creek weir, JBER 2017.

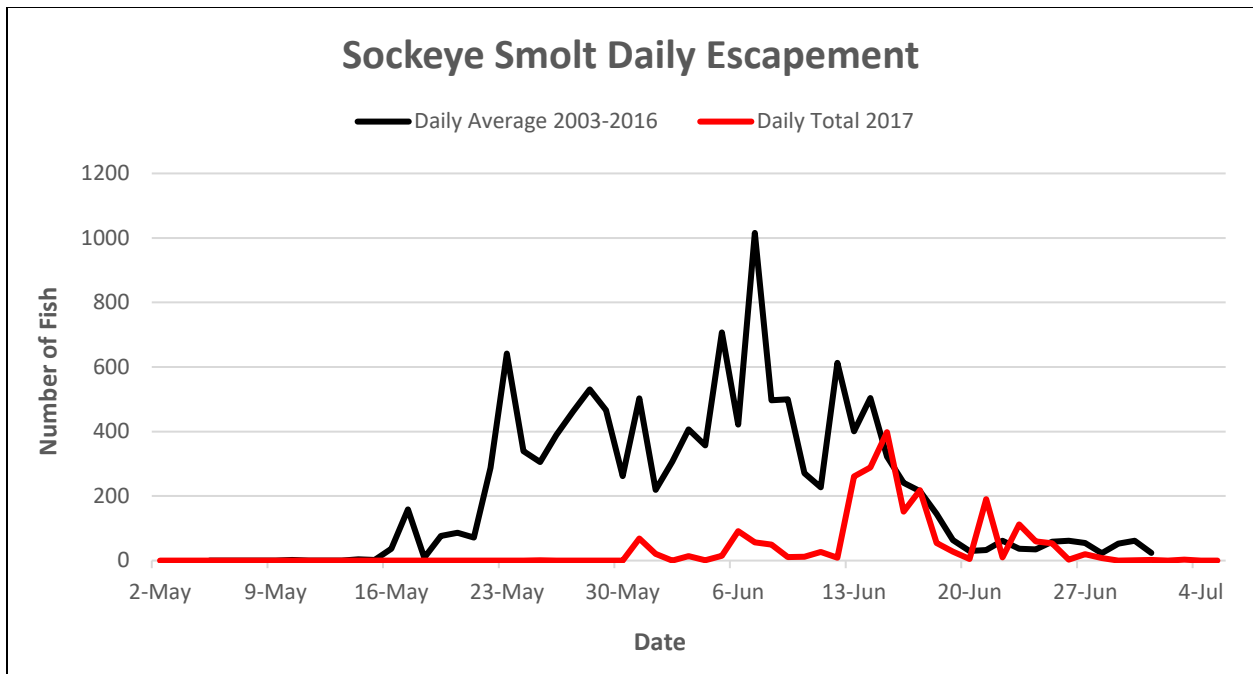
Date	Temp (°C) Daily Average	Sockeye		Coho	
		Daily	Cumulative	Daily	Cumulative
2-May	6.80	0	0	0	0
3-May	6.77	0	0	0	0
4-May	7.41	0	0	0	0
5-May	7.48	0	0	0	0
6-May	6.59	0	0	0	0
7-May	6.75	0	0	0	0
8-May	6.96	0	0	0	0
9-May	7.38	0	0	0	0
10-May	7.90	0	0	0	0
11-May	9.08	0	0	0	0
12-May	9.78	0	0	0	0
13-May	10.73	0	0	0	0
14-May	11.13	0	0	0	0
15-May	12.07	0	0	0	0
16-May	12.90	0	0	0	0
17-May	13.15	0	0	1	1
18-May	13.27	0	0	0	1
19-May	13.20	0	0	0	1
20-May	13.38	0	0	0	1

Date	Temp (°C) Daily Average	Sockeye		Coho	
		Daily	Cumulative	Daily	Cumulative
21-May	13.22	0	0	0	1
22-May	13.33	0	0	2	3
23-May	13.41	0	0	1	4
24-May	13.24	0	0	0	4
25-May	12.62	1	1	2	6
26-May	12.40	0	1	0	6
27-May	11.91	0	1	0	6
28-May	11.88	0	1	1	7
29-May	11.93	0	1	0	7
30-May	12.79	0	1	0	7
31-May	14.06	68	69	546	553
1-Jun	14.93	21	90	910	1463
2-Jun	16.08	0	90	180	1643
3-Jun	16.92	14	104	226	1869
4-Jun	17.36	1	105	50	1919
5-Jun	17.20	15	120	56	1975
6-Jun	16.98	91	211	368	2343
7-Jun	17.05	57	268	153	2496
8-Jun	17.49	50	318	241	2737
9-Jun	17.91	11	329	73	2810
10-Jun	17.48	12	341	6	2816
11-Jun	17.16	27	368	3	2819
12-Jun	16.84	9	377	1	2820
13-Jun	16.97	261	638	81	2901
14-Jun	17.09	289	927	128	3029
15-Jun	17.49	398	1325	25	3054
16-Jun	18.13	152	1477	28	3082
17-Jun	18.71	218	1695	7	3089
18-Jun	18.94	55	1750	9	3098
19-Jun	18.57	28	1778	5	3103
20-Jun	18.29	5	1783	5	3108
21-Jun	18.22	190	1973	44	3152
22-Jun	18.08	10	1983	7	3159
23-Jun	17.83	112	2095	12	3171
24-Jun	18.17	59	2154	18	3189
25-Jun	18.52	54	2208	18	3207
26-Jun	18.90	3	2211	2	3209
27-Jun	18.41	20	2231	2	3211

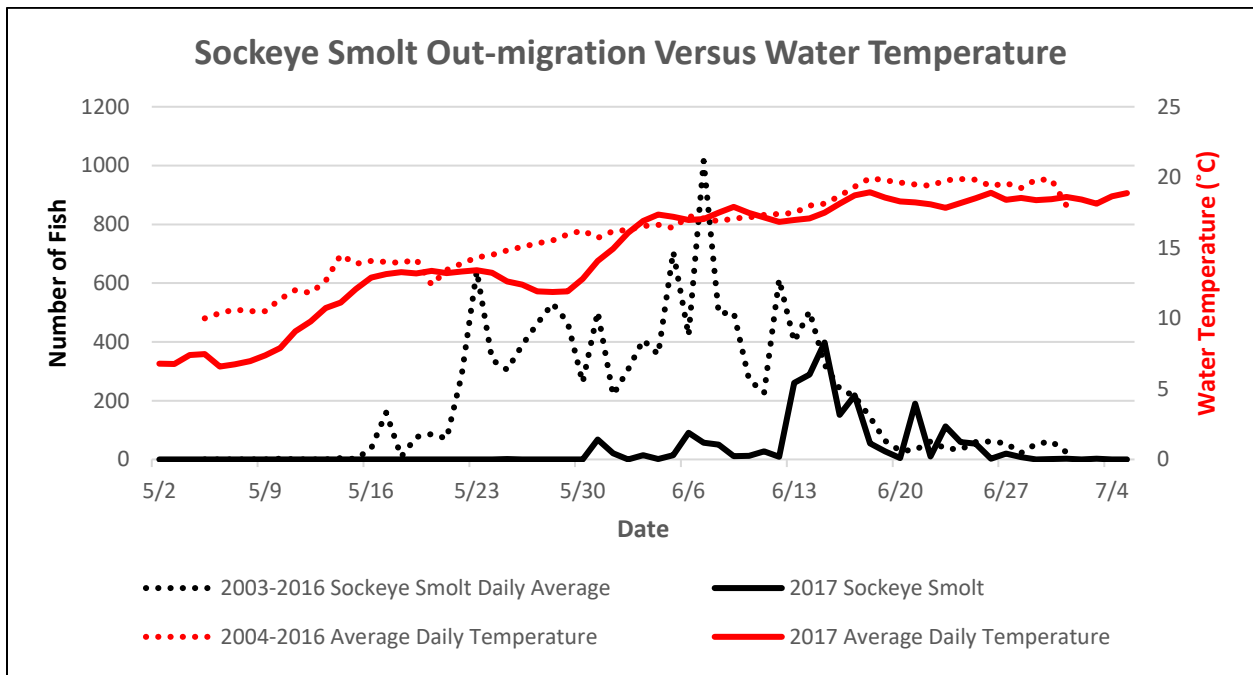
Date	Temp (°C) Daily Average	Sockeye		Coho	
		Daily	Cumulative	Daily	Cumulative
28-Jun	18.54	8	2239	10	3221
29-Jun	18.38	0	2239	3	3224
30-Jun	18.45	1	2240	0	3224
1-Jul	18.61	2	2242	0	3224
2-Jul	18.42	0	2242	1	3225
3-Jul	18.14	3	2245	2	3227
4-Jul	18.65	0	2245	0	3227
5-Jul	18.89	0	2245	0	3227
<b>TOTALS</b>	<b>14.57</b> Season Average	<b>34.54</b> Daily Average	<b>2245</b>	<b>49.65</b> Daily Average	<b>3227</b>



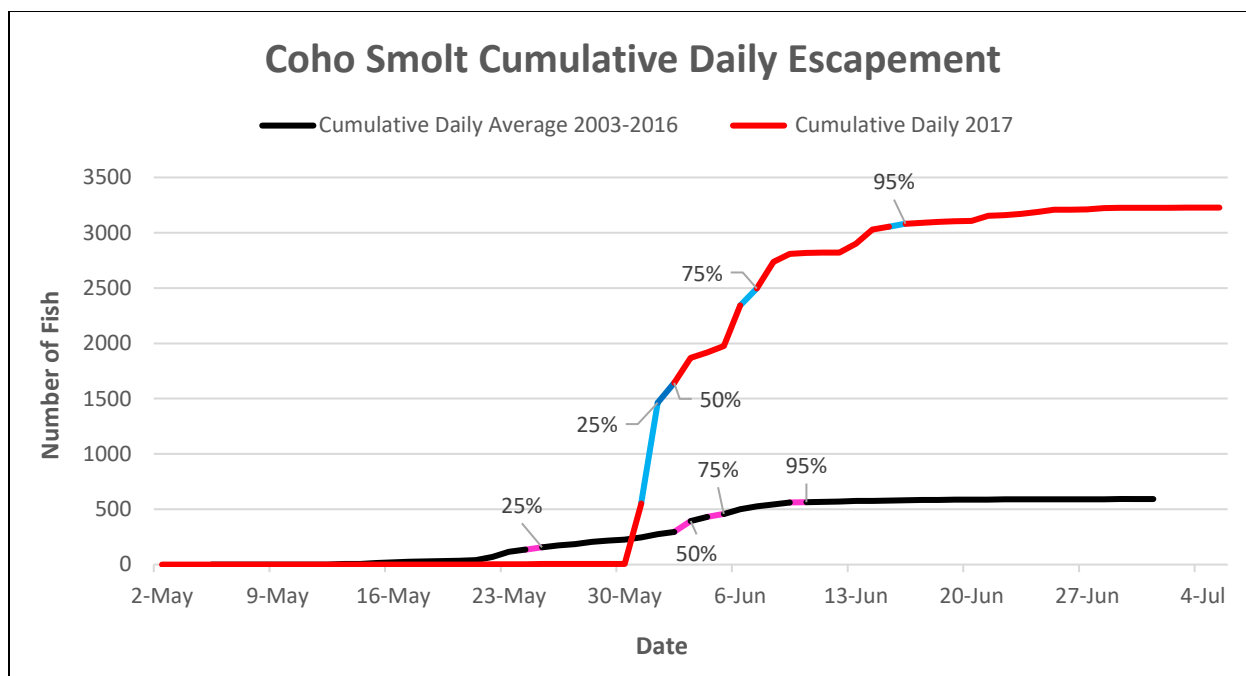
**Figure 2.** Cumulative daily average comparison of 2017 sockeye out-migration and the cumulative daily average from 2003-2016. Percentages represent amount of smolt that have out-migrated on corresponding date and change in color.



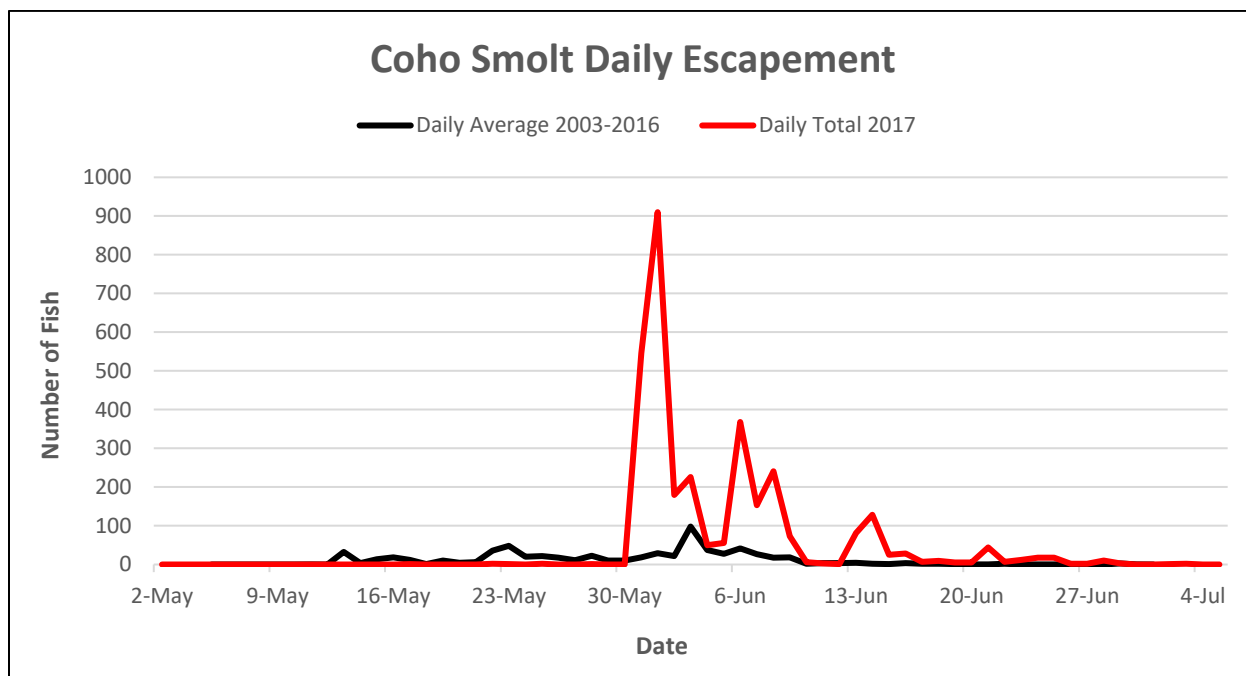
**Figure 3.** Daily comparison of 2017 sockeye out-migration and the daily average from 2003-2016.



**Figure 4.** A comparison of 2017 and daily average 2003-2016 sockeye smolt counts to the water temperature from 2017 and 2004-2016.



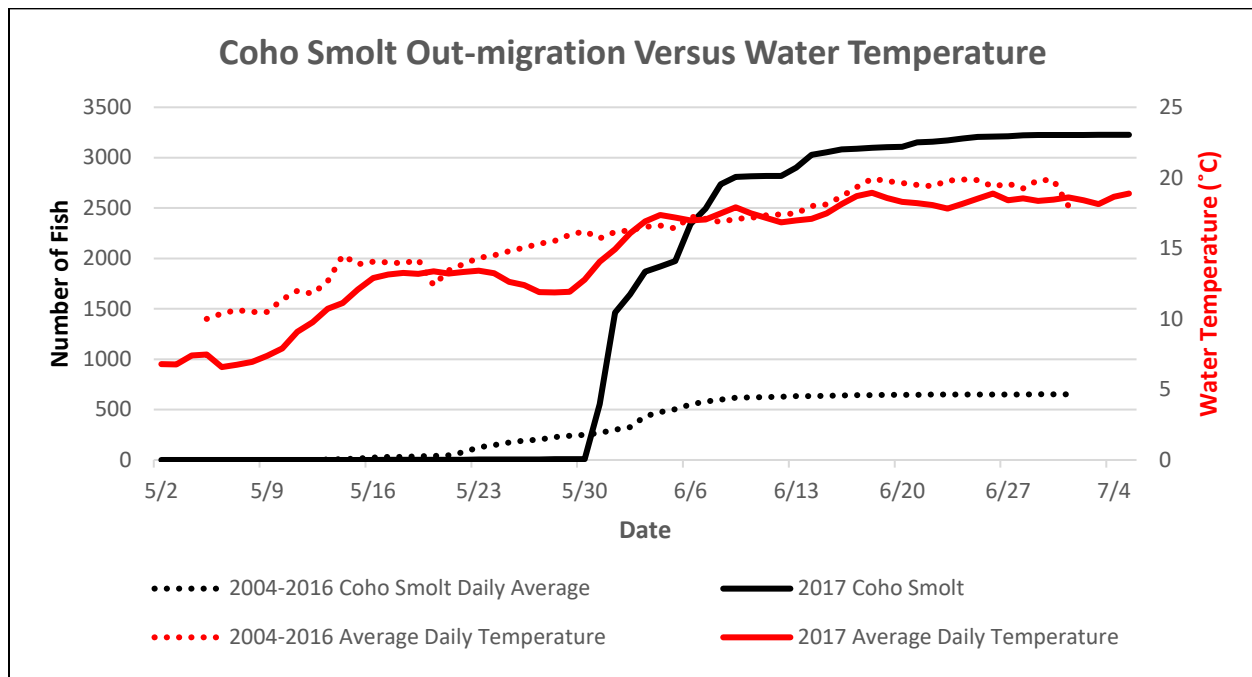
**Figure 5.** Cumulative daily average comparison of 2017 coho out-migration and the cumulative daily average from 2003-2016.<sup>1,2</sup> Percentages represent amount of smolt that have out-migrated on corresponding date and change in color.



**Figure 6.** Daily comparison of 2017 coho out-migration and the daily average from 2003-2016.

<sup>1</sup> Note: Not all years from 2003-2014 were sampled for smolt. See Appendix 1A and 1B for years sampled.

<sup>2</sup> Note: Coho salmon have not always been counted and recorded.



**Figure 7.** A comparison of 2017 and daily average 2003-2016 coho smolt counts to the water temperature.

### *Adult Weir*

The adult salmon weir was installed on July 6, 2017 and removed on September 29, 2017 for a total of 86 sampling days. No major issues or problems occurred during the weir operation. Water temperature documented during the project ranged between a minimum of 11.20°C and maximum of 21.30°C, with an average of 17.01°C. A total of 2568 sockeye and 61 coho were counted passing through the weir. The first adult sockeye was recorded on July 25, and the first adult coho was recorded on August 2. The last documented sockeye and coho to pass through the weir occurred on September 29. Due to an unprecedented high volume of pink and chum schooling at the weir, both species were released into the lake, totaling 605 pinks and 32 chum.

**Table 2.** Adult daily and cumulative counts of sockeye and coho salmon at the Sixmile Creek weir, JBER 2017.

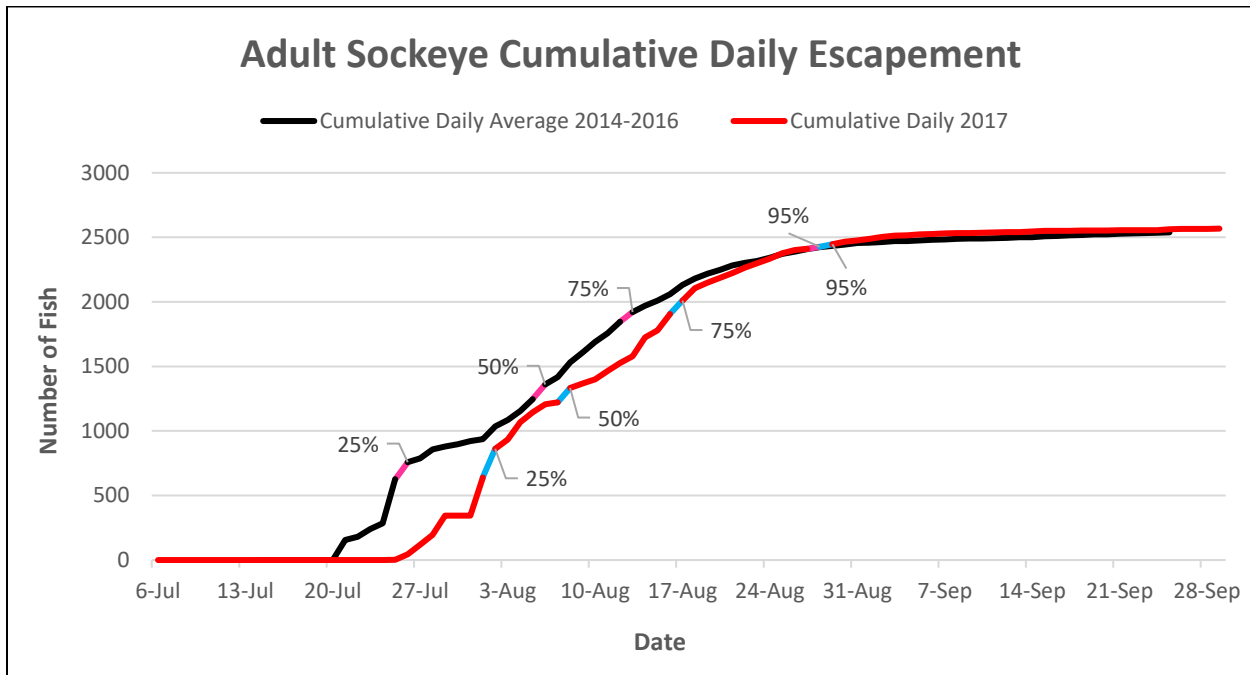
Date	Temp (°C) Daily Average	Sockeye		Coho	
		Daily	Cumulative	Daily	Cumulative
6-Jul	19.42	0	0	0	0
7-Jul	20.38	0	0	0	0
8-Jul	19.82	0	0	0	0
9-Jul	19.54	0	0	0	0
10-Jul	19.54	0	0	0	0



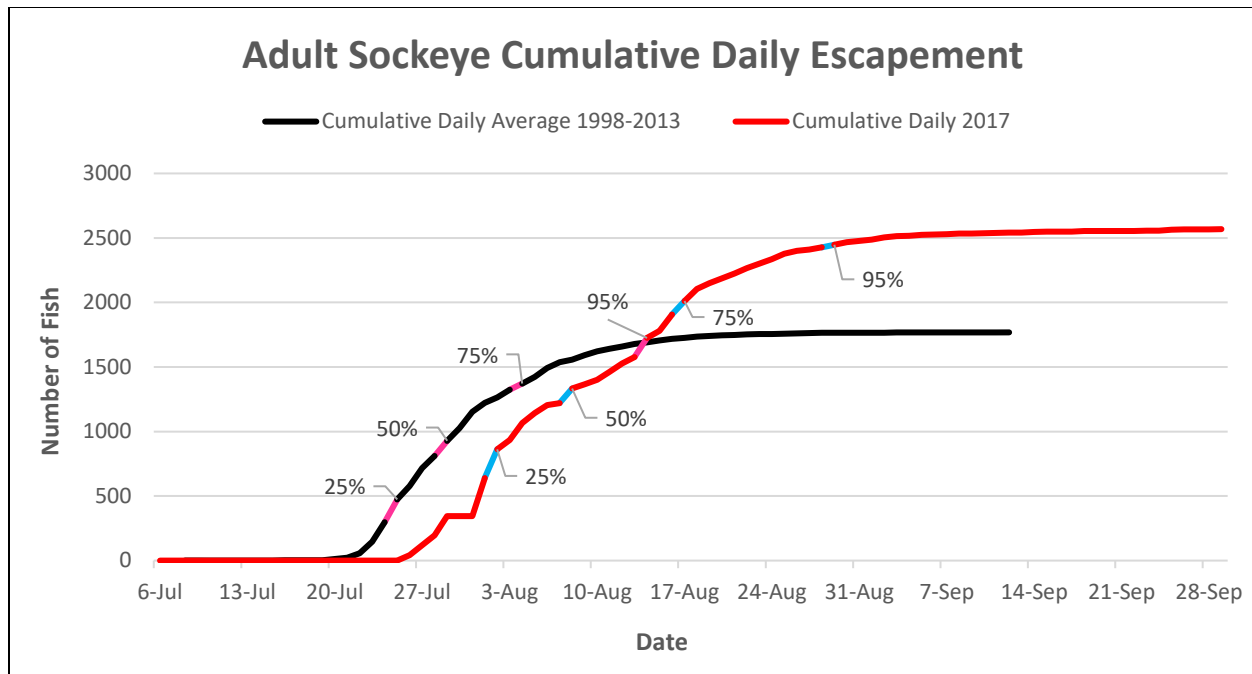
Date	Temp (°C) Daily Average	Sockeye		Coho	
		Daily	Cumulative	Daily	Cumulative
11-Jul	19.82	0	0	0	0
12-Jul	19.95	0	0	0	0
13-Jul	20.53	0	0	0	0
14-Jul	21.25	0	0	0	0
15-Jul	21.21	0	0	0	0
16-Jul	21.23	0	0	0	0
17-Jul	20.86	0	0	0	0
18-Jul	20.36	0	0	0	0
19-Jul	19.58	0	0	0	0
20-Jul	19.70	0	0	0	0
21-Jul	20.11	0	0	0	0
22-Jul	20.55	0	0	0	0
23-Jul	21.07	0	0	0	0
24-Jul	21.30	0	0	0	0
25-Jul	20.56	1	1	0	0
26-Jul	20.15	42	43	0	0
27-Jul	20.43	75	118	0	0
28-Jul	19.91	77	195	0	0
29-Jul	19.99	149	344	0	0
30-Jul	20.18	1	345	0	0
31-Jul	20.50	0	345	0	0
1-Aug	20.02	294	639	0	0
2-Aug	19.61	223	862	1	1
3-Aug	19.34	73	935	0	1
4-Aug	20.14	132	1067	0	1
5-Aug	20.27	77	1144	0	1
6-Aug	20.37	62	1206	0	1
7-Aug	20.53	15	1221	0	1
8-Aug	20.89	112	1333	0	1
9-Aug	20.46	34	1367	0	1
10-Aug	20.22	33	1400	0	1
11-Aug	19.57	64	1464	0	1
12-Aug	19.26	64	1528	0	1
13-Aug	18.93	50	1578	0	1
14-Aug	18.92	147	1725	1	2
15-Aug	18.96	55	1780	0	2
16-Aug	18.12	127	1907	0	2
17-Aug	17.69	104	2011	0	2
18-Aug	17.30	95	2106	0	2
19-Aug	17.20	44	2150	0	2

Date	Temp (°C) Daily Average	Sockeye		Coho	
		Daily	Cumulative	Daily	Cumulative
20-Aug	16.87	37	2187	0	2
21-Aug	16.17	37	2224	1	3
22-Aug	16.86	42	2266	1	4
23-Aug	16.34	35	2301	1	5
24-Aug	16.36	34	2335	0	5
25-Aug	16.23	43	2378	0	5
26-Aug	16.48	23	2401	2	7
27-Aug	16.43	10	2411	0	7
28-Aug	16.67	16	2427	0	7
29-Aug	16.09	20	2447	0	7
30-Aug	16.28	19	2466	0	7
31-Aug	15.66	11	2477	1	8
1-Sep	15.45	11	2488	0	8
2-Sep	15.12	16	2504	0	8
3-Sep	14.45	9	2513	0	8
4-Sep	14.51	4	2517	0	8
5-Sep	13.81	6	2523	1	9
6-Sep	13.30	4	2527	4	13
7-Sep	13.11	3	2530	1	14
8-Sep	13.42	4	2534	2	16
9-Sep	13.65	0	2534	3	19
10-Sep	13.60	2	2536	1	20
11-Sep	13.64	2	2538	2	22
12-Sep	13.25	3	2541	3	25
13-Sep	13.34	1	2542	1	26
14-Sep	13.17	5	2547	6	32
15-Sep	13.18	3	2550	0	32
16-Sep	13.06	0	2550	1	33
17-Sep	12.95	0	2550	1	34
18-Sep	12.79	4	2554	4	38
19-Sep	12.82	0	2554	1	39
20-Sep	12.24	0	2554	2	41
21-Sep	11.90	1	2555	2	43
22-Sep	11.70	0	2555	3	46
23-Sep	11.66	1	2556	4	50
24-Sep	11.55	0	2556	2	52
25-Sep	11.66	8	2564	4	56
26-Sep	11.45	1	2565	2	58
27-Sep	11.43	1	2566	1	59
28-Sep	11.37	0	2566	0	59

Date	Temp (°C) Daily Average	Sockeye		Coho	
		Daily	Cumulative	Daily	Cumulative
29-Sep	11.50	2	2568	2	61
<b>TOTALS</b>	<b>17.01 Season Average</b>	<b>29.86 Daily Average</b>	<b>2568</b>	<b>0.71 Daily Average</b>	<b>61</b>

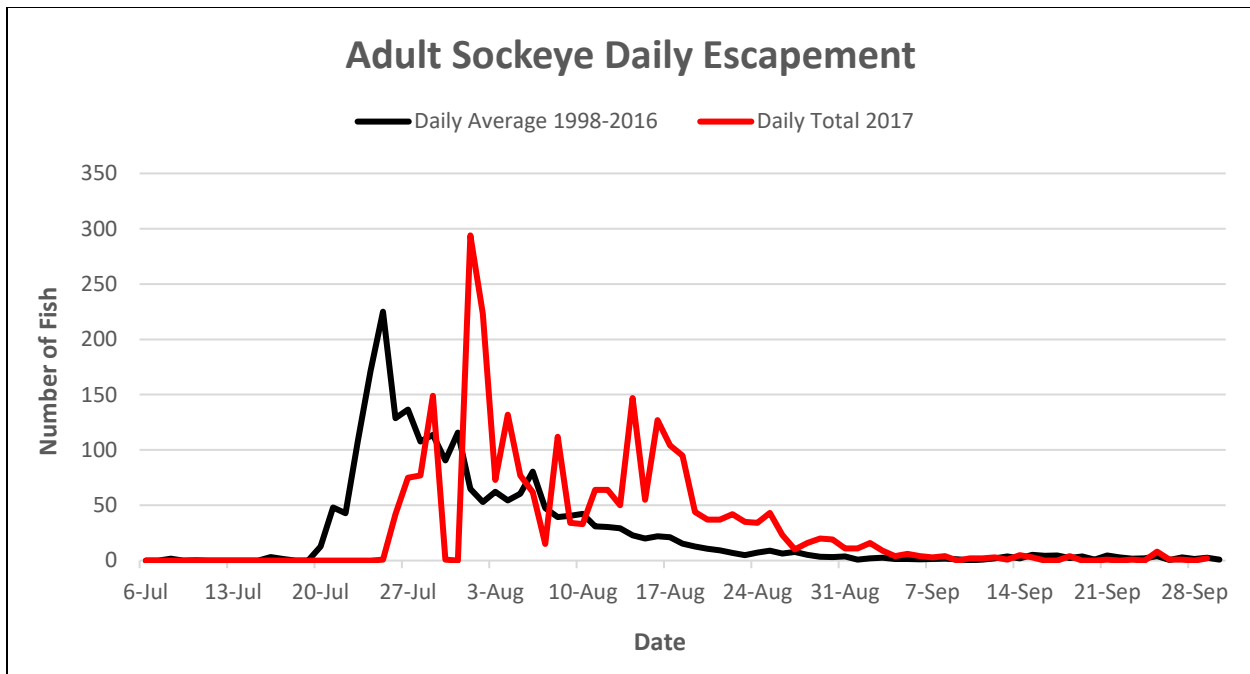


**Figure 8.** Comparison of the daily cumulative escapement for the 2017 sockeye run and average cumulative escapement from 2014-2016. Percentages represent amount of adults that have out-migrated on corresponding date and change in color.

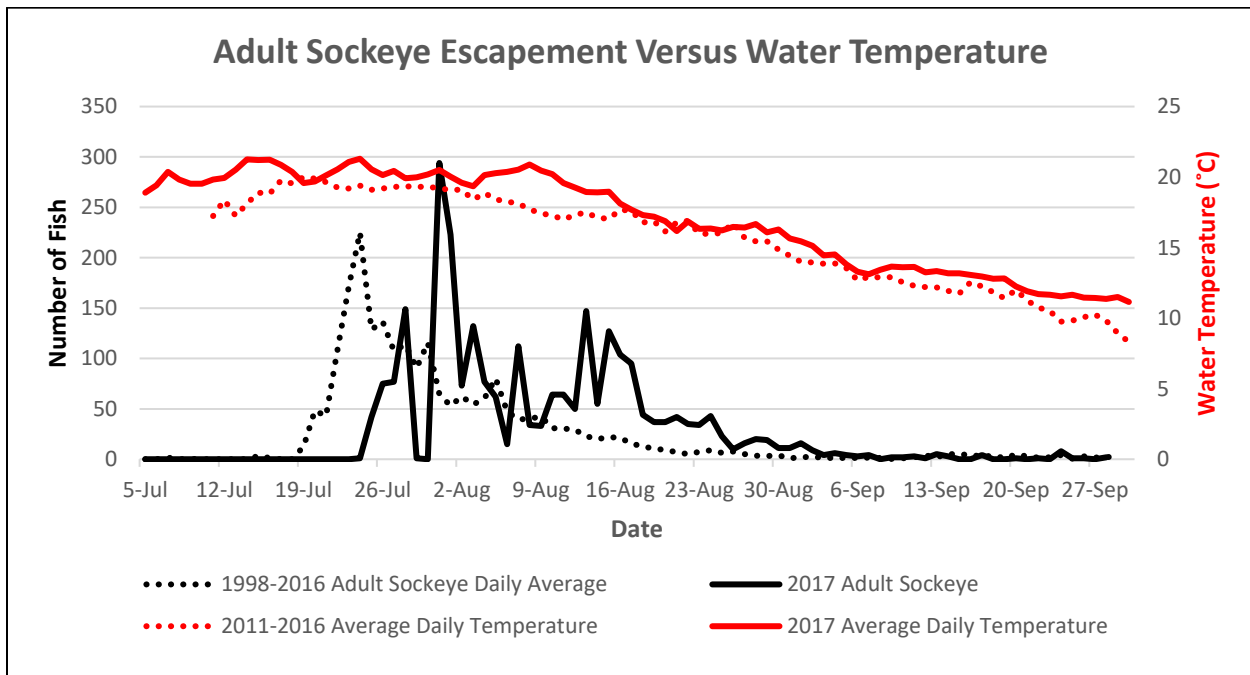


**Figure 9.** Comparison of the daily cumulative escapement for the 2017 sockeye run and average cumulative escapement from 1998-2013. Percentages represent amount of adults that have out-migrated on corresponding date and change in color.

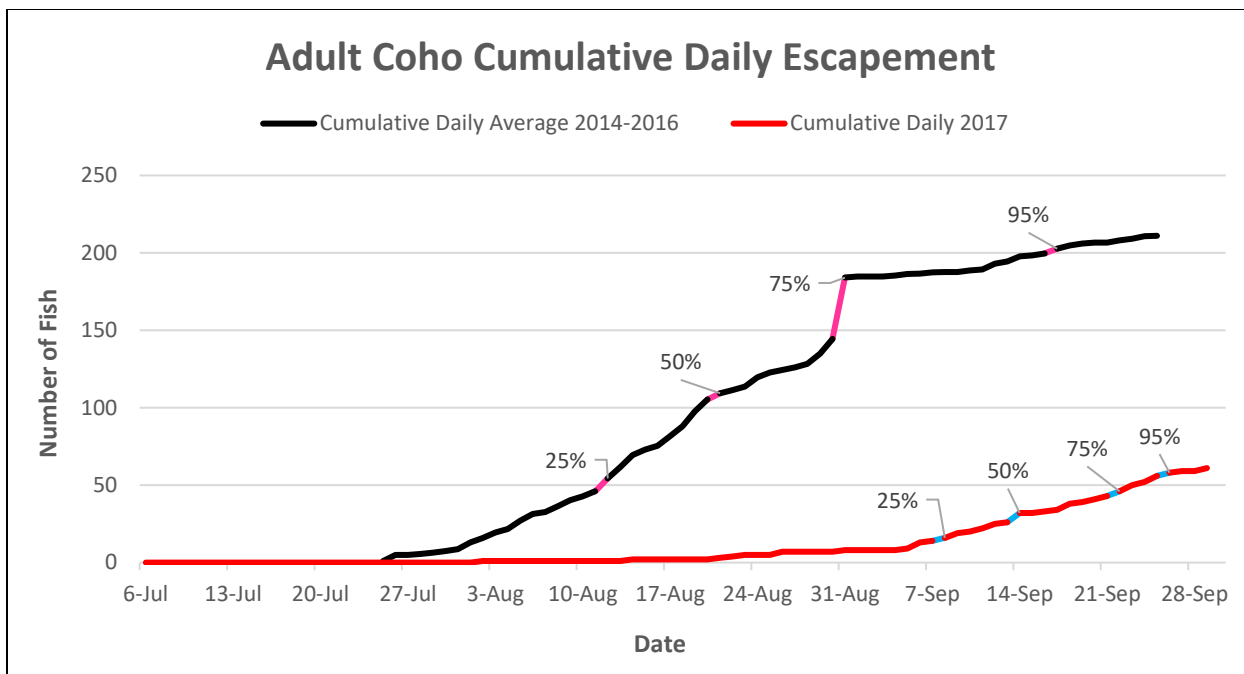
Two different graphs (Figure 8 and 9) illustrate the cumulative daily comparison of adult sockeye. These graphs show that the cumulative average of returning sockeye from 1998-2013 was much lower than cumulative average of returning sockeye from 2014, 2015 and 2016. The graphs also depict that in 2014, 2015 and 2016 the field seasons end dates were extended so that more of the run was captured.



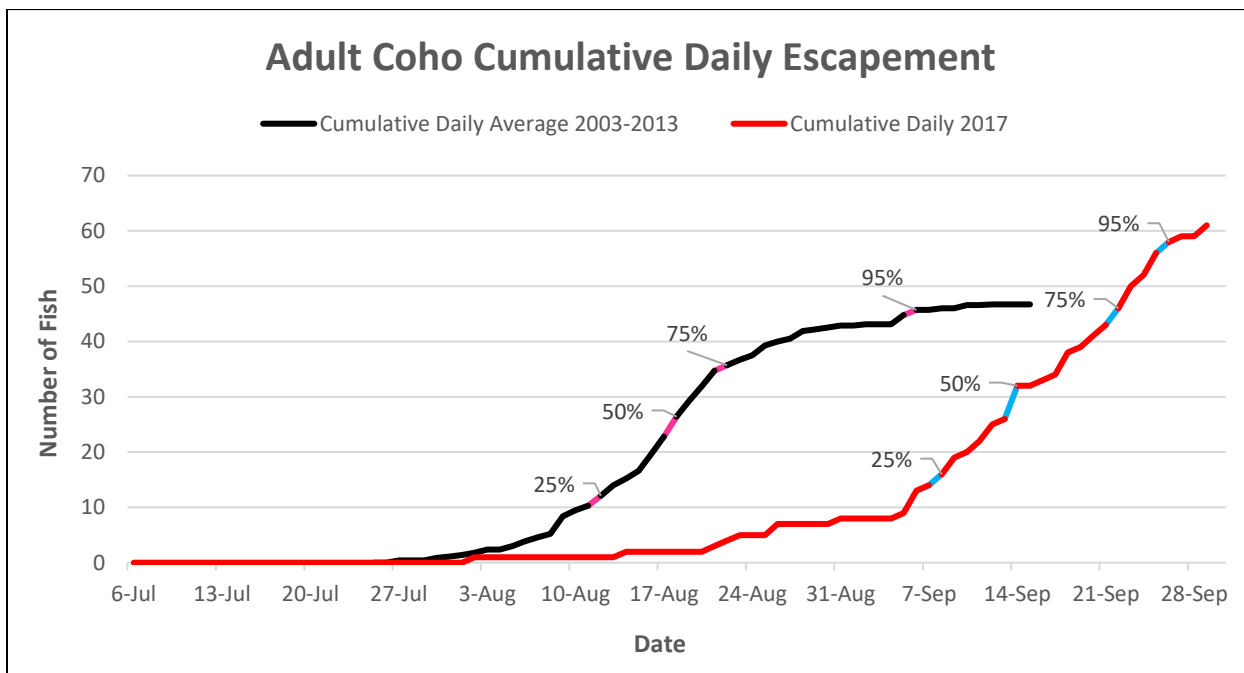
**Figure 10.** Comparison of daily escapement from the 2017 sockeye run and the average daily escapement from 1998-2016.



**Figure 11.** Comparison of the 2017 and daily average 2003-2016 adult sockeye counts to the daily water temperature in 2017 and the average daily water temperature from 2011-2016.

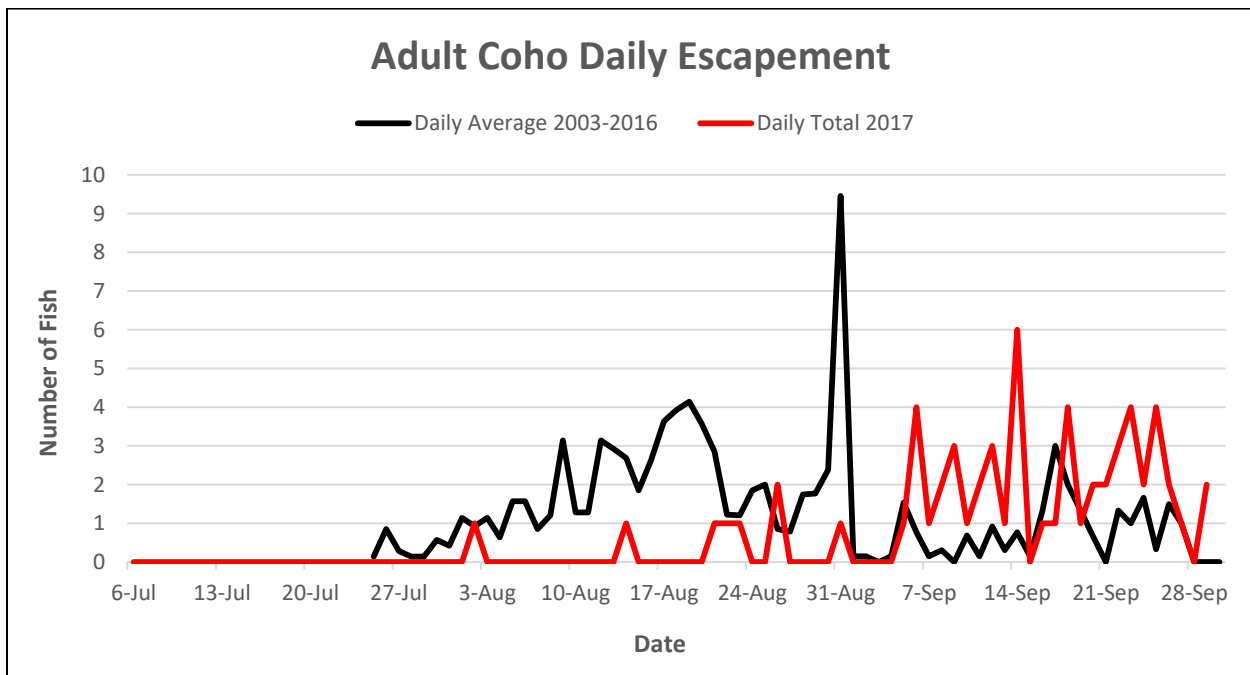


**Figure 12.** Comparison of daily cumulative escapement for the 2017 coho run and the average daily cumulative escapement from 2014-2016. Percentages represent amount of adults that have out-migrated on corresponding date and change in color.

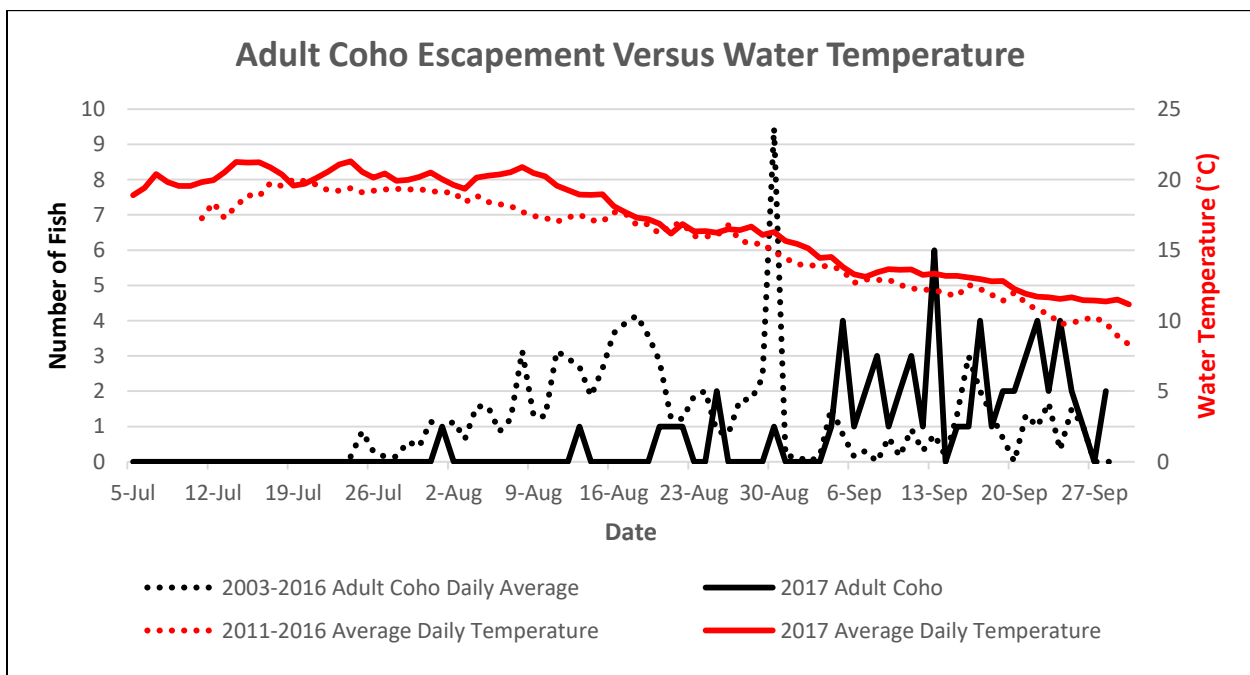


**Figure 13.** Comparison of daily cumulative escapement from the 2017 coho run and the average cumulative escapement from 2003-2013. Note that the average cumulative from 2003-2013 ends on 15-Sep because coho were no longer counted after that date. Percentages represent amount of adults that have out-migrated on corresponding date and change in color.

Two different graphs (Figure 12 and 13) illustrate the cumulative daily comparison of adult coho. These graphs show that the cumulative average of returning coho from 2003-2013 was much lower than cumulative average of returning coho from 2014, 2015 and 2016. The graphs also depict that the 2014, 2015, and 2016 field seasons end dates were extended so that more of the run was captured.



**Figure 14.** Comparison of the daily escapement from the 2017 coho run and the average daily escapement from 2003-16.



**Figure 15.** Comparison of 2017 and daily average 2003-2016 adult coho counts to the daily water temperature in 2017 and the average daily water temperature from 2011-2016.

## Discussion

The primary objective of this project was to identify and count the out-migration of smolt salmon and the returning adult salmon for the Sixmile Lake drainage. By using these counts, we expect to identify trends by comparing historical data to the current year's data. We investigated some potential environmental factors that might cause a negative effect on the salmon stock, which included temperature and dissolved oxygen. As of 2017, JBER has long-term data sets, which includes 12 years of data on out-migrating salmon smolt, 19 years of data on the returning adult sockeye salmon, and 15 years for returning adult coho salmon.

### *Smolt Weir*

The 2017 season sockeye smolt count of 2,245 was the second lowest sockeye smolt count on record (Appendix 1a). The average total sockeye smolt counts for 2003-2016 (12,269) compared to this year's total count (2,245) shows a disparity in smolt numbers. Although the last couple of year's counts have been low in comparison to other documented years, the smolt count increased compared to last year. However, there is a general downward trend in the total sockeye smolt counts (Appendix 1a).

As depicted in Figures 3 and 4, the beginning, main period, and end of the out-migration for sockeye smolt occurred later than the documented averages. 25% of the 2017 sockeye smolt run occurred 16 days later than the historical average, and two days later than the 75% of the historical average (Figure 2). The main period of the run lasted twelve days (between 13 and 24 June), with the total count progressing from 377 (16.8%) to 2154 (95%). This later run timing could be due in part to the lower than average temperatures in the early part of summer seen in Figure 4.

The 2017 coho smolt count of 3,227 was the second highest documented over the course of ten sampling years, slightly lower than the highest year in 2014 (3,996) and remarkably higher than 2015 (540) and 2016 (862). Due to a large surge of fish moving out within two consecutive days, 25% and 50% of the 2017 coho smolt out-migrated on June 1 and June 2, respectively. 25% of the escapement occurred eight days later than the historic average of May 25 and 50% of the escapement occurred one day earlier than the historic average of June 3 (Figure 5). The coho escapement reached 95% on 16 June, six days later than the historic average (Figure 5). The data shows that coho smolt percentiles occurred later overall. The out-migration occurred later in the season but tallied higher totals.

The average water temperature for the 2017 smolt enumeration was 14.57°C during the sampling period of 2 May through 5 July. This is lower than the 2004-2016 historical average of 16.02°C during the sampling period of 5 May through 1 July. During the 58 days of 2017 sampling for out-migrating



smolt, there were 50 non-consecutive days of water temperature that were colder than the 2004-2016 historical average. The eight days of higher than average temperature included 20 May, 3-5 June, 8-10 June, and 1 July. During the 2017 season, increase in water temperature did not occur until later in the season (20<sup>th</sup> May), which corresponds with the salmon smolt out-migrating later during the season compared to previous years. Based on visual observation, the majority of the lake still had ice cover into the beginning of the season in early May. Although this season was colder on average than previous seasons, there was, as previously mentioned, an increase in out-migration counts for both sockeye and coho smolt. This supports the hypothesis that the lower temperatures in the spring caused a slower out-migration.

### *Adult Weir*

The adult sockeye salmon had a cumulative escapement of 2,568 fish for the 2017 season. This season was consistent with the historical average of 2,539 from 2014-2016 (Figure 8) and above the historical average of 1,768 from 1998-2013 (Figure 9). Figure 8 is skewed due to a higher average of returning adult sockeye from 2014-2016, which included the largest return of sockeye in 2015, with 4,768 fish. Figure 8 also shows three of the only seasons that recorded data beyond 12 September. As a result, the data was split into two figures to display the cumulative average of 2017 against the historical average for 1998-2013 (ending on September 12), and against the 2014, 2015, and 2016 cumulative average (extending past September 12). The largest and main return peak of 2017 occurred on 1 August, with 294 sockeye passing through the weir. During 2017, 25% of the sockeye counted passed through the weir by 2 August, eight days later than 1998-2013 historic average and seven days later than the 2014-2016 historic average. By 29 August, 95% of the sockeye counted had passed through the weir (Figure 9), 15 days later than the 1998-2013 historic average but only one day later than the 2014-2016 historic average.

The 2017 adult coho cumulative escapement of 61 was similar to the average of all of the previous years (80); with the exception of the 2015 season, which had the highest count on record with 527 (Figure 12 and Figure 13). The historical average from 2003-2013 was surpassed on 23 September 2017. Like the adult sockeye records, the end date of counting adult coho salmon was extended until the end of September in 2014. This allowed for a more complete documentation of the final coho run at Sixmile but created a skewed representation of averages, especially due to the exceptionally high count in 2015 in both Figures 12 and 13. By 15 September, the 2017 coho escapement had only reached 50% and the historical average from 2014-2016 had reached 93%. In 2017, 87% of coho passed through the weir after 3 September when the temperature dropped below 15 degrees Celsius. During 2017, 25% of the coho were counted by 8 September, 26 days later than the historical average from 2003-2013 and 27 days later than the historical average from 2014-2016. By 26 September, 95% of the coho had passed through the weir, 21 days later than the historical average from 2003-2013 and nine days later than the historical

average from 2014-2016. The run started and ended substantially later than both sets of historical data, which again alludes to the run timing correlation between water temperature changes occurring later in the season. Therefore, it is prudent to continue collecting future water temperatures to evaluate any possible correlations between fish run timing and water temperature based on long-term statistics.

During the 82 days of corresponding sampling time for adult escapement, there were 77 days of water temperature that were warmer than the 2011-2016 historical average. The average water temperature for the 2017 adult enumeration was 17.01°C during the sampling period from 6 July through 30 September, compared to the 2011-2016 historical average of 15.60°C during the sampling period 11-July through 30 September. The 2017 season did not show the same trend in decreased temperature until later in the season, which corresponds with the adult salmon escaping later during the season compared to previous years. Water temperature can be a factor in whether the salmon choose to migrate up-river to spawn or not. Ideal migration temperatures for adult salmon range from 6.0 °C to 12.0°C (Wilson and Kelly 1984). The average water temperature was above this range until 21 September when it measured as 11.90°C. The HOBO device is an ideal tool for environmental impact studies as well as ecological research and provided accurate measurements of DO. The device also doubled as a more accurate way to calculate average daily temperature at the study site.<sup>3</sup>

This detailed evaluation of each species helped increase the accuracy in identification and in final adult salmon counts. The use of the custom picket weir also allowed for a more organized release and thus improved identification of fish species. The only element hindering identification under the bridge site is the amount of light, making it more difficult to see certain identification characteristics such as spots, eyes, and fins.

#### *Data Quality Assurance and Quality Control*

Temperature at the bridge site was recorded for the smolt out-migration season from 2004 through 2016 and recorded for the adult season from 2011 through 2016. Sockeye and coho smolt out-migration was documented at the bridge site from 2003 until 2017, excluding 2007, 2008, and 2011. Adult sockeye escapement was documented from 1998 through 2017. Between 1998 through 2007, the start dates for adult sockeye were sporadic, and from 1998 through 2010, the end dates are irregular. Adult coho escapement was documented from 2003 until 2017, with late start dates from 2003 until 2014 and early end dates from 2004 until 2013.

The historical databases cause skewed results when comparing current data to historical data. When the databases are incomplete and inconsistent they do not allow for accurate and comprehensive long-term analysis when comparing results from historical trends. It is important to note that these dates

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<sup>3</sup> The HOBO records temperature four times a day every six hours and therefore can help calculate a more accurate average of daily temperature than an average based on checking a thermometer twice a day at varying times each day.

for temperature, smolt and adult migration are important when evaluating results from the most recent season and comparing to historical averages. Data quality assurance and quality control was completed for 2017 and finalized within the electronic database.

## Recommendations

Based on the 2017 field season, the following recommendations are for consideration of future sampling:

1. Continue water temperature monitoring to support the determination of when smolt and adults may be migrating. The HOBO DO and temperature logger was remarkably better at ascertaining DO and temperature averages at the study site than a thermometer and manual DO calculations. It only requires one day for deployment, and one day for removal. Advise continued use of the device. Suggest deploying the HOBO DO and temperature logger even earlier in the spring to capture the temperature for a longer sampling period.
2. Continue to install the smolt trap and weir at an earlier date in case of early warming temperatures and ice melt. This will ensure the capture of any fish that may be out-migrating at an earlier date. Also keep the smolt trap and weir in until a later date to make sure to record the entire run in case of later ice melt and colder temperatures.
3. Keep the smolt trap deployed until there has been a week of zero smolt out-migrating and use the same logic with the adult trap. The deployment and removal of both the smolt trap and weir and adult weir should be based on present year's data and environmental factors, and not the historical average.
4. Do not allow for a gap in between removing the smolt weir and installing the adult weir. Even if there is no record of fish passage between those gaps in dates, the only way to know for sure is to have a weir in at all times. Data of zeros is better than no data.
5. Due to adult coho numbers increasing toward the end of September, it may be wise to continue counting fish at the Sixmile weir later into the season in order to better assess the coho run. Recommend that the permit allow for operation of the adult weir until the end of October.
6. At the very least, try to sample the same dates as the previous year for consistent analysis of data. If possible, start earlier and end later to create a better table for comparing and contrasting data.
7. There is now 19 complete years of adult sockeye salmon monitoring. Suggest looking into population trends.
8. Dialogue with ADF&G about the annual stocking of rainbow trout, a predator, into salmon spawning and rearing areas.
9. Create protocol for allowing pink and chum salmon into the lake before the season starts. Be aware that a large number of pink and small number of chum have been released into the lake and could potentially spawn, leading to a more diverse smolt identification than in past years.
10. In the future, it could be helpful to create a report based on data only collected by CSU, and not data collected by volunteers, other organizations etc that we cannot verify. A long-term database can be stored but it seems to be inconsistent when comparing current project statistics and previous years.

## Literature Cited

- Alaska Department of Fish and Game – Division of Sport Fish. 2016. Pacific Salmon Identification – 2016 Southcentral Alaska Sport Fish Regulations Summary [Internet]. Available from: [http://www.adfg.alaska.gov/index.cfm?adfg=fishregulations.sc\\_sportfish](http://www.adfg.alaska.gov/index.cfm?adfg=fishregulations.sc_sportfish)
- Abbott, Maj G. A. and Lt Col J. A. Allgair. n.d. "Float Plane Base: Assigned Project No. 21-50A." Elmendorf Air Force Base, Alaska. Copy available in the 673<sup>rd</sup> Air Base Wing History Office, Joint Base Elmendorf-Richardson.
- 673<sup>rd</sup> Civil Engineer Squadron, Civil Engineer Installation Management, Environmental, Conservation section. 2014. "Abundance and Run Timing of Smolt and Adult Salmon in the Sixmile Creek Drainage on Joint Base Elmendorf-Richardson, Alaska, 2013.
- Espmark, A.M., K. Hjelde, G. Baeverfjord. 2010. Development of gas bubble disease in juvenile Atlantic salmon exposed to water supersaturated with oxygen. *Aquaculture*. 306: 198-204.
- Federal Register 76:69. 2011. "Endangered and Threatened Species: Designation of Critical Habitat for Cook Inlet Beluga Whale: National Oceanic and Atmospheric Administration (Final Rule)". p. 20180. Available from: National Marine Fisheries Service Alaska Regional Office. <<http://alaskafisheries.noaa.gov/protectedresources/whales/beluga/management.htm>>. Accessed 1/07/2014.
- Gotthardt, T. 2003. Inventory and Mapping of Sixmile Lakes sockeye spawning habitat on Elmendorf Air Force Base, Alaska. Alaska Natural Heritage Program, Environment and Natural Resources Institute. Univ. Alaska, Anchorage.
- Gotthardt, T. 2006. Limnological and fishery investigations concerning sockeye salmon production in Sixmile Lakes, Elmendorf Air Force Base, Alaska. Alaska Natural Heritage Program, Environment and Natural Resources Institute. Univ. Alaska, Anchorage.
- Groot, C., and L. Margolis 1991. *Pacific Salmon Life Histories*. UBC Press, Vancouver, British Columbia.
- Gumpert, J. 2011. Sixmile Creek Watershed. JBER 673 Civil Engineer Group, JBER, Alaska.
- Habicht, C., W. D. Templin, T. M. Willett, L. F. Fair, S. W. Raborn, L. W. Seeb. 2007. Post-season stock composition analysis of Upper Cook Inlet sockeye salmon harvest, 2005-2007. Alaska Department of Fish and Game, Fishery Manuscript No. 07-07, Anchorage.
- National Marine Fisheries Service. 2008. Conservation Plan for the Cook Inlet beluga whale (*Delphinapterus leucas*). National Marine Fisheries Service, Juneau, Alaska.
- National Marine Fisheries Service, Alaska Regional Office. Cook Inlet Beluga Whales. 2009. Web. 14 Mar. 2012. <<http://www.fakr.noaa.gov/protectedresources/whales/beluga/cibrochure09.pdf>>.
- National Weather Service, Anchorage Forecast Office. 2016. 2016 Anchorage Annual Temperatures. Accessed 21 Nov. 2016. < <http://www.weather.gov/afc/localClimate> >

- Pollard, W.R., G.F. Hartman, C. Groot, P. Edgell. 1997. Field Identification of Coastal Juvenile Salmonids. Madeira Park, BC Canada: Harbour Publishing.
- Rothe, T. C., S. H. Lanigan, P. A. Martin, G. F. Tande. 1983. Natural Resource Inventory of Elmendorf Air Force Base, Alaska, Part I. U.S. Fish and Wildlife Service, Special Studies.
- Ruggerone, G.T. 1999. Differential survival of juvenile sockeye and coho salmon exposed to low dissolved oxygen during winter. *Journal of Fish Biology*. 56: 1013-1016.
- U.S. Department of Defense. 2012. Joint Base Elmendorf-Richardson Integrated Natural Resource Management Plan 2012-2016. 673d Civil Engineer Squadron Asset Management Flight Natural Resources Element. Available at: <[www.jber.af.mil/shared/media/document/AFD-130314-044.pdf](http://www.jber.af.mil/shared/media/document/AFD-130314-044.pdf)>. Accessed: 1/08/2014.
- Wilson, W. J. and M. D. Kelly. "Instream Temperature Modeling and Fishery Impact Assessment for the Proposed Susitna Hydroelectric Project". Arctic Environmental Information and Data Center, University of Alaska, 1984. Web. 4 Apr. 2012.  
<<http://www.arlis.org/docs/vol2/hydropower/SUS418.pdf>>

## **Appendices**

Appendix 1A. Sockeye smolt daily escapement counts by date, Sixmile drainage, 2003-2017.

Year													Daily Average
Date	2003	2004	2005	2006	2009	2010	2012	2013	2014	2015	2016	2017	2003-2006, 2009-2010,2012-2016
2-May												0	
3-May												0	
4-May												0	
5-May										0	0	0	0
6-May										0	0	0	0
7-May										0	0	0	0
8-May										0	0	0	0
9-May										0	0	0	0
10-May										0	0	0	2
11-May										1	0	0	0
12-May				0				0		0	0	0	0
13-May				0						0	0	0	0
14-May	0			4						0	9	0	4
15-May	0	4		1		0				1	2	0	2
16-May	21	2		2		0				177	19	0	37
17-May	1	126		1		0				807	18	0	159
18-May	21	7		0		0				34	2	0	9
19-May	8	402		13	26					25	59	0	76
20-May	165	407	92	44	114	0		0		14	31	0	87
21-May	220	185	121	118	86	8		-	3	39	3	0	71
22-May	815	464	30	181	192			0	1086	91	19	0	288
23-May	1,383	146	15	637	402	5		0	3987	479	6	0	642
24-May	740	325	155	1,725	87	1	0	0	641	38	21	0	339
25-May	864	319	312	986	375	14	70	0	162	182	76	1	305
26-May	460	616	309	1,919	83	7	234	0	309	333	14	0	389
27-May	731	266	229	1,897	209		69	1	121	1086	12	0	462
28-May	445	714	365	229	38	34	2,404	0	196	1335	81	0	531
29-May	673	63	125	1,424	28	26	2,134	0	368	243	41	0	466
30-May	275	693	20	1,316	23	6	430	40	2	3	71	0	262
31-May	1,047	172	595	781	8	5	562	104	2095	74	84	68	502
1-Jun	506	74	447	836	64	47	12	320	56	14	37	21	219
2-Jun	688	41	961	882	117	117	20	386	49	81	26	0	306
3-Jun	521	394	660	418	123	67	23	881	448	924	14	14	407
4-Jun	128	92	600	90	238	150	636	615	810	562	10	1	357
5-Jun	384	13	608	254	1,071	639	2,049	2,227	155	336	38	15	707
6-Jun	243	140	265	350	483	5	891	963	38	1245	17	91	422
7-Jun	1,104	37	96	107	963	162	2,677	2,376	2782	596	271	57	1016
8-Jun	111	25	234	114	1,103	84	1,017	2,255	58	349	117	50	497
9-Jun	478	47	274	65	636	616	1,029	1,349	358	567	76	11	500
10-Jun	173	22	129	174	357	427	813	779	0	80	27	12	271
11-Jun	1,076	0	143	29	44	277	195	352	10	364	7	27	227
12-Jun	3,660	58	144	62	123	281	505	1,757	1	146	9	9	613
13-Jun	1,536	7	134	148	488	176	1,129	771	0	0	16	261	400
14-Jun	779	26	132	223	303	30	2,603	1,395	1	43	8	289	504
15-Jun	573	18	344	230	237	23	1,075	1,049	0	0	0	398	323



Year													Daily Average
Date	2003	2004	2005	2006	2009	2010	2012	2013	2014	2015	2016	2017	2003-2006, 2009-2010,2012-2016
16-Jun	96	11	190	113	10	181	799	1,256	0	0	0	152	241
17-Jun	134	2	161	596	42	80	612	737	0	0	0	218	215
18-Jun	20	12	118	188	318	220	546	159	1	3	4	55	144
19-Jun	14	17	366	30	47	28	146	50	0	1	0	28	64
20-Jun	6	16	88	72	38	20	34	49	0	4	0	5	30
21-Jun	3	5	122	53	35	26	97	14	0	1	0	190	32
22-Jun	9	1	213	14		26	60	291	0	0	0	10	61
23-Jun	2	35	62	12	29	61	101	93	6	4	0	112	37
24-Jun			27	73	12	99	15	44	5	1		59	35
25-Jun			308	16	0	51	51	45	0	0		54	59
26-Jun			218	188	18	9	41	18	2	0		3	62
27-Jun			88	80		2	203	7	0	0		20	54
28-Jun			20	129	3	3	23	1	1	1		8	23
29-Jun			27	297	1	16	60	12	5	0		0	52
30-Jun			28	100		8	279	11	4	0		1	61
1-Jul					40	0		56	0			2	24
2-Jul									0			0	0
3-Jul												3	
4-Jul												0	
5-Jul												0	
Totals	20,113	6,004	9,575	17,221	8,614	4,037	23,644	20,463	13,760	10,280	1,245	2,245	11,704
Totals	20,113	6,004	9,575	17,221	8,614	4,037	23,644	20,463	13,760	10,280	1,245	2,245	11,434

The first total in the average column (11,704) is the sum of those daily averages (2003-2017). The second total in the average column (11,434) is the average from all of the yearly totals (2003-2017).

Appendix 1B. Coho smolt daily escapement counts by date, Sixmile drainage, 2003-2017.

	Year												Daily Average
Date	2003	2004	2005	2006	2009	2010	2012	2013	2014	2015	2016	2017	2003-2006, 2009-2010,2012-2016
2-May												0	
3-May												0	
4-May												0	
5-May										0	0	0	0
6-May										0	0	0	0
7-May										0	0	0	0
8-May										0	0	0	0
9-May										0	0	0	0
10-May										4	0	0	0
11-May										0	1	0	1
12-May										0	0	0	0
13-May										64	1	0	33
14-May	1									6	4	0	4
15-May	2	0				0				66	1	0	14
16-May	2	0				0				53	36	0	18
17-May	0	0				0				52	8	1	12
18-May	0	0			0	0				3	3	0	1
19-May	0	0			0					8	44	0	10
20-May	0	0	1		0	0		0		4	30	0	4
21-May	24	0	3	1	0	0		0	19	9	4	0	6
22-May	13	4	5	9	7			0	263	12	12	2	36
23-May	0	0	0	24	3	0		0	447	9	2	1	49
24-May	0	0	47	24	1	0	25	0	103	5	17	0	20
25-May	0	0	39	19	11	2	0	0	88	26	52	2	22
26-May	0	0	16	48	3	4	0	0	73	36	14	0	18
27-May	0	0	7	19	1		15	0	28	25	12	0	11
28-May	0	0	5	7	0	2	20	0	82	25	111	1	23
29-May	0	1	0	9	0	0	10	0	51	4	38	0	10
30-May	1	14	7	9	1	2	2	0	41	2	32	0	10
31-May	0	1	17	3	0	0	1	15	153	2	7	546	18
1-Jun	0	0	51	1	2	1	0	12	230	0	26	910	29
2-Jun	0	0	59	3	0	1	1	9	145	0	19	180	22
3-Jun	0	0	1	1	0	1	0	54	1004	9	8	226	98
4-Jun	0	0	16	0	0	0	0	13	363	11	6	50	37
5-Jun	1	0	7	2	4	0	9	17	202	2	55	56	27
6-Jun	3	0	15	2	0	0	1	16	390	13	19	368	42
7-Jun	0	0	6	1	1	4	1	26	123	1	127	153	26
8-Jun	0	0	4	0	3	1	4	17	53	64	44	241	17
9-Jun	0	1	5	0	2	1	1	21	76	15	79	73	18
10-Jun	0	0	4	0	0	3	0	11	1	2	2	6	2
11-Jun	0	0	8	1	0	6	0	2	12	3	7	3	4
12-Jun	0	0	3	5	0	1	2	12	4	8	5	1	4
13-Jun	0	1	2	0	0	5	0	5	0	0	32	81	4
14-Jun	0	0	5	1	3	1	3	3	0	0	3	128	2

	Year												Daily Average
Date	2003	2004	2005	2006	2009	2010	2012	2013	2014	2015	2016	2017	2003-2006, 2009-2010,2012-2016
15-Jun	0	0	4	0	0	0	0	7	0	0	0	25	1
16-Jun	0	0	28	1	0	2	4	4	1	0	0	28	4
17-Jun	0	0	3	13	0	0	2	3	0	1	0	7	2
18-Jun	0	0	6	1	4	4	0	1	0	0	1	9	2
19-Jun	2	0	8	0	1	0	2	0	0	0	0	5	1
20-Jun	0	0	2	0	2	0	0	0	1	0	0	5	0
21-Jun	0	1	4	0	0	0	1	0	1	0	0	44	1
22-Jun	0	0	1	0		0	1	1	18	0	0	7	2
23-Jun	0	0	0	0	0	0	0	0	0	0	0	12	0
24-Jun			1	0	0	1	0	0	0	0		18	0
25-Jun			1	0	1	0	0	0	2	0		18	1
26-Jun			1	0	0	0	0	0	0	0		2	0
27-Jun			1	0		0	2	1	0	0		2	1
28-Jun			0	0		0	0	0	0	0		10	0
29-Jun			0	0		0	0	0	19	0		3	3
30-Jun			0	0		0	0	0	3	0		0	0
1-Jul								0				0	0
2-Jul												1	
3-Jul												2	
4-Jul												0	
5- Jul												0	
Totals	49	23	393	204	50	42	107	250	3,996	540	862	3,227	674
Totals	49	23	393	204	50	42	107	250	3,996	540	862	3,227	812

The first total in the average column (867) is the sum of those daily averages (2003-2017). The second total in the average column (812) is the average from all of the yearly totals (2003-2017).

Appendix 1C. Adult sockeye daily escapement counts by date, Sixmile Creek drainage, 1998-2017.

	Year																				Daily Average
Date	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	1998-2017
1-Jul											0								0		
2-Jul											0								0		
3-Jul											0								0		
4-Jul																			0		
5-Jul																			0	0	
6-Jul																			0	0	
7-Jul																			0	0	
8-Jul				4							1								0	0	
9-Jul											0								0	0	
10-Jul				1							0								0	0	
11-Jul											0			0					0	0	
12-Jul											0			0					0	0	
13-Jul											0		0	0					0	0	
14-Jul							1				0	0	0	0			0	0	0	0	
15-Jul											0	0	0	0			0	0	0	0	
16-Jul	2										0	0	0	2	0	27	0	0	0	0	
17-Jul	3										0	0	0	0	0	10	0	0	0	0	
18-Jul	1				0						0	0	0	0	0	0	0	0	0	0	
19-Jul					0						1	0	0	0	0	0	0	0	39	0	
20-Jul	3			149	0						0	0	0	0	0	0	0	0	2	0	
21-Jul	17			133	0		5				1	0	0	1	0	0	469	0	52	0	
22-Jul	17			285	0		107			1	0	0	119	0	0	1	69	0	11	0	
23-Jul	43		518	300	0		100			1	0	0	487	0	0	0	142	4	1	0	
24-Jul	487		178	1,188	0		18			1	8	358	200	0	0	0	122	5	0	0	
25-Jul	184		78	405	328	158	0	276		4	516	582	67	198	1	3	111	862	0	1	
26-Jul	56		21	26	173	251	2	124			344	268	0	241	4	152	48	337	0	42	
27-Jul	48		3	130	476	364	2	22		219	100	537	0	18	1	309	30	61	0	75	
28-Jul	4			286	300	394	13	2		14	32	264	7	0	4	197	61	144	0	77	
29-Jul	154		200	297	363	279	24	2		1	9	260	247	2	1	27	27	11	29	149	
30-Jul	20		180	91	162	132	321	31	205	3	67	86	119	1	141	14	51	1	3	1	
31-Jul	20		133	305	59	176	301	160	359	80	112	181	103	0	22	0	49	8	13	0	
1-Aug	21		44	151	91	95	43	92	50	171	46	70	187	0	57	3	16	28	1	294	
2-Aug	0		38	59	40	44	26	72	2	34	31	100	151	2	28	27	9	288	2	223	
3-Aug	138		24	45	86	88	41	40	3	13	17	12	140	115	10	196	10	101	40	73	
4-Aug	48		5	70	76	86	59	35	3	7	21	14	34	57	0	255	15	182	13	132	
5-Aug	0		33	26	65	128	30	50	154	36	20	44	141	5	0	83	38	234	2	77	
6-Aug	115	386		11	49	70	9	21	84	125	2	76	107	0	10	45	25	313	1	62	
7-Aug	56	206	48	16	67	83	17	51	39	37	9	21	40	0	5	29	26	146	3	15	
8-Aug	0	1	17			34	62	14	41	1	14	37	98	0	0	13	66	266	6	112	

	Year																				Daily Average
Date	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	1998-2017
9-Aug	56	7	3	13	62	58	39	28	18	5	15	74	135	0	0	19	54	180	1	34	40
10-Aug	40		30		28	18	147	37	12	9	5	32	61	0	8	46	27	215	1	33	42
11-Aug	29			9	30	11	38	14	33	22	22	64	11	2	0	39	17	177	8	64	31
12-Aug	25	4	4	2		82	22	16	15	48	9	31	4	0	3	17	20	132	113	64	30
13-Aug	24	14	3		42	22	31	16	70	6	21	13	9	0	0	27	33	83	111	50	29
14-Aug	17	3	1			40	12	65	7	10	18	13		0	3	32	11	65	68	147	23
15-Aug	13	3			36	41	21	18	5	11	3	37	9	5	2	12	9	75	40	55	20
16-Aug	9	3		23		44	9	18	16	5	3	61	10	0	4	20	17	66	67	127	22
17-Aug	12		3			32	14	7	8	4	0	17	17	0	10	3	9	130	73	104	21
18-Aug	0	3	5	4	11	15	6	41	11	10	9	16	4	0	1	8	11	94	44	95	15
19-Aug	0			5		9	1	17	16		2	14	6	3	0	7	10	44	56	44	13
20-Aug	0				19	3	7	9	9	4	1	15	5	1	0	4	12	62	19	37	11
21-Aug	0	1					7	7	6	2	1	8	3	0	0	5	7	60	33	37	9
22-Aug	0	2	1		15	2	0	9	10	8	2	9	2	0	0	0	6	32	27	42	7
23-Aug	0	4	1				1	12	3	8	0	4	2	0	0	2	1	34	8	35	5
24-Aug					1		7	3	1	1	0	5	5	2	0	1	3	41	32	34	7
25-Aug						10	0	10	3		0	5	0	0	0	3	0	62	23	43	9
26-Aug		7					13	6	1		0	1	0	0	0	0	2	32	20	23	6
27-Aug		2				9	28	5	1		1	1	0	0	0	0	0	39	22	10	8
28-Aug		6			1		15	0	4	2	0	0		0	0	0	1	25	19	16	5
29-Aug							3	4	0		0	4	0	1	0	0	0	15	15	20	4
30-Aug							4	2	3		0	0	0	0	0	0	1	12	17	19	3
31-Aug							0	5	0		0	0	2	0	0	3	0	24	10	11	4
1-Sep							1		0		0		0	0	0	0	0	5	3	11	1
2-Sep							0		0		0		0	2	1	3	0	9	5	16	2
3-Sep		3					3		0		0		0	0	0	3	0	9	10	9	3
4-Sep		7					1		0		0		0	0	0	1	0	5	1	4	1
5-Sep							0		0		0		0	0	0	0	0	9	4	6	1
6-Sep		1					0		0		0		0	0	0	2	0	2	9	4	1
7-Sep							0		0		0		0	0	0	0	1	2	10	3	1
8-Sep							0		0		0		0	0	1	1	1	6	7	4	2
9-Sep													0	0	0	2	0	3	4	0	1
10-Sep													1	0	0	0	1	0	0	2	0
11-Sep														0	0	0	0	0	5	2	1
12-Sep														0	0	1	0	2	7	3	2
13-Sep														0			0	1	10	1	4
14-Sep														0			0	2	4	5	2
15-Sep														0			0	4	12	3	5
16-Sep																	0	3	10	0	4
17-Sep																	0	4	10	0	5
18-Sep																	0	1	6	4	2

	Year																				Daily Average
Date	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	1998-2017
19-Sep																	0	3	8	0	4
20-Sep																	0	2	1	0	1
21-Sep																	0	4	10	1	5
22-Sep																	0	0	9	0	3
23-Sep																	0	0	5	1	2
24-Sep																	0	0	6	0	2
25-Sep																	0	2	10	8	4
26-Sep																	0		1	1	1
27-Sep																	0		6	1	3
28-Sep																	0		3	0	2
29-Sep																	0		5	2	3
30-Sep																	0		2		1
1-Oct																	0				0
Totals	1,662	663	1,571	4,034	2,580	2,778	1,611	1,341	1,192	903	1,463	3,334	2,533	658	317	1,652	1,638	4,768	1,245	2,568	2,217
Totals	1,662	663	1,571	4,034	2,580	2,778	1,611	1,341	1,192	903	1,463	3,334	2,533	658	317	1,652	1,638	4,768	1,245	2,568	1,924

The first total in the average column (2,217) is the sum of those daily averages (1998-2017). The second total in the average column (1,924) is the average from all of the yearly totals (1998-2017).

Appendix 1D. Adult coho daily escapement counts by date, Sixmile Creek drainage, 2003-2017.

	Year																Daily Average
Date	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2003-2017	
5-Jul														0	0	0	
6-Jul														0	0	0	
7-Jul														0	0	0	
8-Jul														0	0	0	
9-Jul														0	0	0	
10-Jul														0	0	0	
11-Jul														0	0	0	
12-Jul														0	0	0	
13-Jul														0	0	0	
14-Jul	0												0	0	0	0	
15-Jul	0												0	0	0	0	
16-Jul	0												0	0	0	0	
17-Jul	0												0	0	0	0	
18-Jul	0												0	0	0	0	
19-Jul	0												0	0	0	0	
20-Jul	0												0	0	0	0	
21-Jul	0												0	0	0	0	
22-Jul	0												0	0	0	0	
23-Jul	0												0	1	0	0	
24-Jul	0												0	0	0	0	
25-Jul	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	
26-Jul	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	1	
27-Jul	0	0	1	0	0	0	3	0	0	0	0	0	0	0	0	0	
28-Jul	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	
29-Jul	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	
30-Jul	0	0	5	0	0	0	0	0	0	0	0	0	3	0	0	1	
31-Jul	0	0	0	1	0	1	0	0	0	0	0	0	4	0	0	0	
1-Aug	0	0	0	0	0	3	0	0	0	0	0	0	13	0	0	1	
2-Aug	0	0	0	0	0	0	4	0	0	0	0	1	8	0	0	1	
3-Aug	0	0	0	0	0	2	0	0	0	4	0	0	10	0	0	1	
4-Aug	2	0	0	0	0	0	0	0	0	0	0	0	7	0	0	1	
5-Aug	0	0	0	1	0	1	1	0	0	3	0	0	16	0	0	2	
6-Aug	0	0	4	0	0	0	1	2	0	2	0	0	12	1	0	2	
7-Aug	1	0	0	0	1	0	2	0	0	4	0	0	4	0	0	1	
8-Aug	0	0	0	0	0	0	6	0	0	0	0	0	9	2	0	1	
9-Aug	0	0	1	0	1	5	21	3	0	1	0	2	10	0	1	3	
10-Aug	0	0	0	1	0	1	5	2	0	2	0	0	7	0	0	1	
11-Aug	1	0	0	2	0	0	6	1	0	6	3	1	9	0	0	1	
12-Aug	0	0	0	11	2	0	3	2	0	0	1	0	24	0	0	3	
13-Aug	0	0	0	7	1	0	0		0	3	1	1	22	0	0	3	
14-Aug	1	0	0	0	2	5	2	1	0	3	1	0	22	0	0	3	
15-Aug	0	0	0	4	0	4	3	1	0	15	3	2	11	0	0	2	
16-Aug	0	0	0	2	2	0	7	0	0	17	4	1	5	0	1	3	
17-Aug	0	0	0	4	4	1	20	0	0	6	1	1	17	1	1	4	
18-Aug	0	0	0	3	0	2	21	0	3	0	0	0	18	0	1	4	

19-Aug	1	0	0	5	0	0	20	1	0	0	0	1	27	2	0	4
20-Aug	0	0	0	1	0	1	18	0	1	7	0	0	8	14	0	4
21-Aug	0	0	0	3	2	0	4	0		0	1	1	4	8	2	3
22-Aug	0	0	0	6	1	0	3	0	0	0	0	1	5	0	0	1
23-Aug	0	0	1	0	0	0	2	0	2	0	3	1	6	0	0	1
24-Aug	1	0	2	4	0	0	11	0	0	0	1	0	17	0	0	2
25-Aug	0	0	1	6	0	0	0	0	0	0	0	0	9	0	0	2
26-Aug	1	0	0	4	0	1	0	0	0	0	0	1	3	2	1	1
27-Aug		0	0	4	1	0	5	0	0	4	0	2	4	0	0	1
28-Aug		0	0	0	0	0	2		1	0	0	3	5	0	0	2
29-Aug		1	0	0	0	0	0	0	0	1	1	0	14	3	0	2
30-Aug		0	1	0	0	0	1	0	0	1	1	0	27	1	0	2
31-Aug		0	0	0	0	0	0	0	0	0	0	2	118	1	1	9
1-Sep		0	0	0	0	0	0	0	1	0	1	0	0	0	4	0
2-Sep		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
3-Sep		0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
4-Sep		0	0	0	0	0	0	0	0	0	17	1	2	0	3	0
5-Sep		0	0	0	0	0	0	1	0	0	8	0	2	0	1	2
6-Sep		0	0	0	0	0	0	0	0	0	0	1	1	0	2	1
7-Sep		0	0	0	0	0	0	0	0	0	3	0	1	0	3	0
8-Sep		0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
9-Sep		0	0	0	0	0	0	0	0	0	0	1	1	0	6	0
10-Sep		0	0	0	0	0	0	0	0	0	1	4	3	0	0	1
11-Sep		0	0	0	0	0	0	0	0	0	0	2	1	0	1	0
12-Sep		0	0	0	0	0	0	0	0	0	0	6	1	6	1	1
13-Sep		0	0	0	0	0	0	0	0	0	0	0	0	2	4	0
14-Sep												0	2	2	1	1
15-Sep												3	2	0	2	0
16-Sep												1	4	0	2	1
17-Sep												0	2	4	3	3
18-Sep												0	3	2	4	2
19-Sep												0	4	0	2	1
20-Sep												1	0	2	4	1
21-Sep												0	0	0	2	0
22-Sep												1	2	1	1	1
23-Sep												0	0	3	0	1
24-Sep												0	2	2	2	2
25-Sep												0	0	1	0	0
26-Sep												0		3	0	2
27-Sep												0		2	0	1
28-Sep												0		0	0	0
29-Sep												0		0	0	0
30-Sep												0				0
1-Oct												0				0
Totals	8	1	16	69	17	27	178	18	8	79	54	44	527	67	61	94
Totals	8	1	16	69	17	27	178	18	8	79	54	44	527	67	61	78

The first total in the average column (94) is the sum of those averages (2003-2017). The second total in the average column (78) is the average from all of the yearly totals (2003-2017).



## Appendix 2: Sixmile Project Inventory & Maintenance Log

Sixmile Project Inventory & Maintenance Log				
Smolt Salmon Project				
Item	Quantity	Maintenance	Replacement Frequency	Year of Last Replacement
Small Dipnets	2	Annually	As needed	2017
8ft x 3ft Weir Panels	4	Annually	As needed	2017
Smolt Trap Box	1	Annually	As needed	Unknown
Smolt Trap Funnel	1	Annually	3-4 years	Unknown
Zip Ties	1 bag	--	Annually	2017
Brush (Long Handle)	2	--	As needed	2017
Brush (short handle)	2	--	As needed	2017
Rubber Gloves	2 pair	--	Annually	2017
Thermometer	1	--	Annually	2014
HOBO	1	Annually	As needed	2017
Adult Salmon Project				
Item	Quantity	Maintenance	Replacement Frequency	Year of Last Replacement
Beach Seine Net	1	Annually	4-5 years	2017
Picket Weir w/Gate	1 (4 pieces)	Annually	As needed	2015
Dipnet	2	Annually	As needed	2016
Fish Counter (multi)	1	--	As needed	2011
Thermometer	1	--	Annually	2014
HOBO	1	Annually	As needed	2017

### Appendix 3: Sixmile Project Site Dissolved Oxygen Data

Date	DO Daily Average
2-May	15.96
3-May	14.91
4-May	15.97
5-May	17.07
6-May	17.52
7-May	17.10
8-May	16.21
9-May	12.56
10-May	13.18
11-May	13.72
12-May	13.95
13-May	13.84
14-May	13.37
15-May	14.22
16-May	13.58
17-May	13.53
18-May	13.82
19-May	14.31
20-May	14.76
21-May	14.01
22-May	13.46
23-May	13.56
24-May	13.32
25-May	12.73
26-May	13.02
27-May	13.28
28-May	14.07
29-May	14.27
30-May	13.82
31-May	14.60
1-Jun	14.58
2-Jun	14.64
3-Jun	14.45
4-Jun	14.06
5-Jun	13.50
6-Jun	14.36
7-Jun	14.70
8-Jun	14.34
9-Jun	14.43
10-Jun	13.39
11-Jun	13.58
12-Jun	13.19
13-Jun	13.29
14-Jun	13.19
15-Jun	13.08
16-Jun	13.38
17-Jun	13.56

18-Jun	13.14
19-Jun	13.05
20-Jun	13.40
21-Jun	13.11
22-Jun	13.13
23-Jun	12.12
24-Jun	12.45
25-Jun	13.17
26-Jun	13.07
27-Jun	12.60
28-Jun	13.09
29-Jun	12.34
30-Jun	12.21
1-Jul	12.63
2-Jul	11.86
3-Jul	12.04
4-Jul	12.08
5-Jul	12.77
6-Jul	12.79
7-Jul	12.95
8-Jul	12.19
9-Jul	11.43
10-Jul	11.77
11-Jul	12.56
12-Jul	12.28
13-Jul	11.62
14-Jul	12.80
15-Jul	12.31
16-Jul	11.70
17-Jul	11.02
18-Jul	11.36
19-Jul	10.88
20-Jul	10.74
21-Jul	11.16
22-Jul	10.90
23-Jul	11.41
24-Jul	11.38
25-Jul	10.60
26-Jul	10.66
27-Jul	11.09
28-Jul	9.80
29-Jul	10.83
30-Jul	10.89
31-Jul	10.80
1-Aug	10.47
2-Aug	10.98
3-Aug	10.45
4-Aug	10.97
5-Aug	11.37

6-Aug	11.10
7-Aug	11.01
8-Aug	11.23
9-Aug	10.90
10-Aug	11.05
11-Aug	10.42
12-Aug	10.85
13-Aug	10.61
14-Aug	11.00
15-Aug	10.93
16-Aug	9.50
17-Aug	10.10
18-Aug	10.23
19-Aug	10.40
20-Aug	10.50
21-Aug	9.90
22-Aug	10.84
23-Aug	10.24
24-Aug	11.70
25-Aug	11.03
26-Aug	11.14
27-Aug	10.91
28-Aug	11.97
29-Aug	11.66
30-Aug	11.94
31-Aug	10.89
1-Sep	10.53
2-Sep	10.61

3-Sep	10.82
4-Sep	10.81
5-Sep	10.78
6-Sep	10.15
7-Sep	10.50
8-Sep	10.82
9-Sep	11.61
10-Sep	11.66
11-Sep	11.95
12-Sep	11.67
13-Sep	12.33
14-Sep	12.53
15-Sep	12.36
16-Sep	12.58
17-Sep	12.55
18-Sep	12.26
19-Sep	12.10
20-Sep	11.92
21-Sep	12.70
22-Sep	11.92
23-Sep	12.24
24-Sep	12.23
25-Sep	12.78
26-Sep	13.03
27-Sep	13.70
28-Sep	13.44
29-Sep	13.46