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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**

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

Prepared for:



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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
Colorado State University	CSU
Cook Inlet Beluga Whale	CIBW
Dissolved Oxygen	DO
Department of Defense	DoD
Feet	ft
Height	Ht
Joint Base Elmendorf-Richardson	JBER
Kilometers	km
Length	L
Meters	m
National Marine Fisheries Service	NMFS
National Oceanic & Atmospheric Administration	NOAA
Primary Constituent Element	PCE
United States Army Corps of Engineers	USACE
Width	w

## Table of Contents

<b>Introduction.....</b>	<b>1</b>
<b>Goal and Objectives.....</b>	<b>2</b>
<b>Study Site .....</b>	<b>2</b>
<b>Methods.....</b>	<b>3</b>
<i>Smolt Weir Design and Operation .....</i>	<i>3</i>
<i>Fish Collection.....</i>	<i>4</i>
<i>Adult Weir Design and Operation.....</i>	<i>4</i>
<i>Water Quality Parameters .....</i>	<i>4</i>
<i>Data Analysis .....</i>	<i>4</i>
<b>Results .....</b>	<b>5</b>
<i>Smolt Weir.....</i>	<i>5</i>
<i>Adult Weir .....</i>	<i>7</i>
<i>Water Quality Parameters .....</i>	<i>10</i>
<i>Data Quality Assurance and Quality Control.....</i>	<i>11</i>
<b>Discussion.....</b>	<b>11</b>
<i>Smolt Weir.....</i>	<i>12</i>
<i>Adult Weir .....</i>	<i>17</i>
<b>Acknowledgements .....</b>	<b>23</b>
<b>Recommendations .....</b>	<b>24</b>
<b>Literature Cited .....</b>	<b>25</b>
<b>Appendices.....</b>	<b>27</b>
<i>Appendix 1A. Sockeye smolt daily escapement counts by date, Sixmile Creek drainage, 2003-2018.....</i>	<i>28</i>
<i>Appendix 1B. Coho smolt daily escapement counts by date, Sixmile Creek drainage, 2003-2018.....</i>	<i>30</i>
<i>Appendix 1C. Adult sockeye daily escapement counts by date, Sixmile Creek drainage, 1998-2018.....</i>	<i>32</i>

<i>Appendix 1D. Adult coho daily escapement counts by date, Sixmile Creek drainage, 2003-2018</i> .....	35
<i>Appendix 2: Sixmile Project Inventory &amp; Maintenance Log</i> .....	38
<i>Appendix 3: Sixmile Project Site Dissolved Oxygen Data</i> .....	39

## List of Tables and Figures

<b>Table 1.</b> Average length measurements for coho and sockeye smolt, and coho, sockeye and pink fry, JBER 2018. ....	5
<b>Table 2.</b> Daily and cumulative counts of juvenile sockeye and coho salmon at the Sixmile Creek weir, JBER 2018. ....	6
<b>Table 3.</b> Daily and cumulative counts of adult sockeye and coho salmon at the Sixmile Creek weir, JBER 2018. ....	8
<b>Table 4.</b> Records of annual data collection. ....	12
<b>Figure 1.</b> The Sixmile Creek drainage on JBER, AK (Gumpert 2011).....	3
<b>Figure 2.</b> Water temperature and dissolved oxygen collected by HOBO and temperature collected by handheld thermometer. ....	11
<b>Figure 3.</b> Daily cumulative average comparison of 2018 sockeye smolt out-migration and the daily cumulative average from 2003-2017. Percentages represent amount of smolt that have out-migrated on corresponding date. ....	13
<b>Figure 4.</b> Daily comparison of 2018 sockeye smolt out-migration and the daily average from 2003-2017. ....	14
<b>Figure 5.</b> A comparison of 2018 and 2004-2017 daily average sockeye smolt counts to the water temperature from 2018 and 2004-2017.....	14
<b>Figure 6.</b> Cumulative daily average comparison of 2018 coho out-migration and the cumulative daily average from 2003-2017. Percentages represent amount of smolt that have out-migrated on corresponding date. ....	15
<b>Figure 7.</b> Daily comparison of 2018 coho out-migration and the daily average from 2003-2017.....	16
<b>Figure 8.</b> A comparison of 2018 and daily average 2004-2017 coho out-migration to the water temperature. ....	16
<b>Figure 9.</b> Comparison of the daily cumulative escapement for the 2018 sockeye run and daily cumulative average escapement from 2014-2017. Percentages represent number of adults that have escaped on corresponding date. ....	18
<b>Figure 10.</b> Comparison of the daily cumulative escapement for the 2018 sockeye run and daily cumulative average escapement from 1998-2013. Percentages represent number of adults that have escaped on corresponding date. ....	18
<b>Figure 11.</b> Comparison of daily escapement from the 2018 sockeye run and the daily average escapement from 1998-2017. ....	19

<b>Figure 12.</b> Comparison of the adult sockeye 2018 and daily average 2011-2017 counts to the daily water temperature in 2018 and the daily average water temperature from 2011-2017. ....	19
<b>Figure 13.</b> Comparison of daily cumulative escapement for the 2018 coho run and the average daily cumulative escapement from 2014-2017. Percentages represent number of adults that have escaped on corresponding date. ....	21
<b>Figure 14.</b> Comparison of daily cumulative escapement from the 2018 coho run and the average cumulative escapement from 2003-2013. Percentages represent number of adults that have escaped on corresponding date. ....	21
<b>Figure 15.</b> Comparison of the daily escapement from the 2018 coho run and the average daily escapement from 2003-17. ....	22
<b>Figure 16.</b> Comparison of 2018 and daily average 2011-2017 adult coho counts to the daily average water temperature in 2018 and the daily average water temperature from 2011-2017. ....	22

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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 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 and in accordance with the Magnuson-Stevens Fishery Conservation and Management Act of 1976, as amended through 1996 (MSFCMA) and the Anadromous Fish Act (AS 16.05.871.901).

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 titled “Limnological and Fishery Investigations Concerning Sockeye Salmon Production in Sixmile Lakes, Elmendorf Air Force Base, Alaska” (Gotthardt 2006). This was the first time that 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 has been conducted every year except for 2007, 2008, and 2011.



Since 2012, enumerating the out-migrating smolt has been an annual project conducted by CSU-CEMML through a cooperative agreement with CEIEC.

## **Goal and Objectives**

The primary goal of this project is to continue monitoring the Pacific salmon that utilize the Sixmile lake drainage system, with a focus on coho, sockeye, and chum.

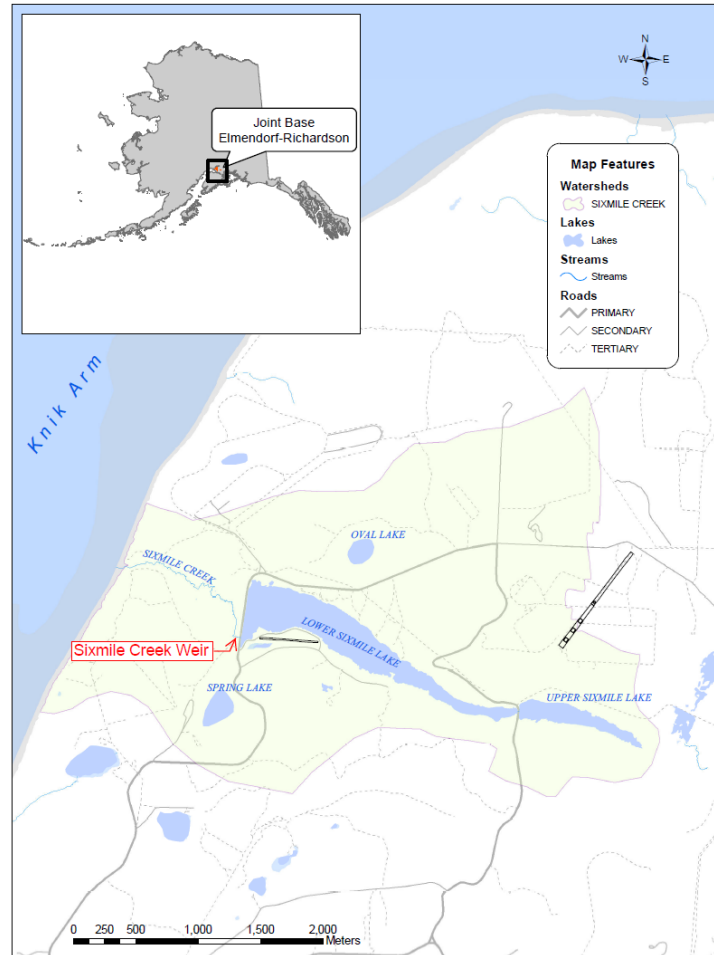
The objectives for the project are as follows:

- Enumeration of out-migrating salmon smolt and returning adult salmon
- Maintain the long-term Sixmile salmon database
- Review and analyze long-term salmon population trends within the Sixmile lake drainage 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 baffler 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 9 May through 6 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.

### *Fish Collection*

The smolt were collected from the live box using small dip nets and placed in acrylic fish viewers filled with lake water to reduce stress on the fish and to aid in identification, measuring (up to 150 millimeters) and photographing. The identification process was done using Pollard et al. (1997) *Field Identification of Costal Juvenile Salmonids* and other available resources. After identification, fish were released. During the 2018 season, smolt and fry were distinguished from one another and counted separately. Sockeye fry were released back into the lake, while the other three species of fry were released just below (downstream) of weir site. During the 2018 season, measurements were taken for the first 12 smolt per species and first 12 fry per species, during each check. Stocked rainbow trout that were found in the trap had their adipose fin clipped (to identify if they were returning to the trap again) and released back into Sixmile Lake.

### *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 daily 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 9 May and removed on 12 October. Water temperature (°C) was recorded twelve times a day, every two 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. Water temperature was also collected during checks using a handheld thermometer.

### *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 2018, for both the smolt and adults, to previous years' cumulative average and daily average

counts was completed. Water temperature for 2018 was graphed alongside the daily smolt and adult counts for 2018, 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

Out-migrating smolt are counted from Lower Sixmile Lake beginning in early May and ending in late June or early July. In previous years, Sixmile smolt out-migration included sockeye and coho salmon. During the 2018 season, pink and chum smolt were identified out-migrating the lake as well. 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.<sup>1</sup>

The Sixmile Creek adult weir was operable by 6 July, with biologists, technicians, and volunteers counting and releasing salmon until 12 October. Sockeye, coho, 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.<sup>2</sup>

### *Smolt Weir*

The smolt weir and trap was installed on 9 May and removed on 6 July for a total of 59 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 7.7°C and 23.2°C, with an average of 16.1° C. A total of 2,092 sockeye and 1,641 coho smolt were counted during the weir operation. The first sockeye smolt and coho smolt were documented on 10 May, and 17 May, respectively. The last documented smolt, both sockeye and coho, were recorded on 4 July. It was also noted and recorded that 364 sockeye fry were identified, counted and released back into Sixmile Lake. For the first time, coho and pink fry were identified leaving Sixmile Lake. There were 17 coho and 9 pinks that were counted and released into Sixmile Creek. For the first time at the project site, 1 chum smolt was recorded on 14 June.

**Table 1.** Average length measurements for coho and sockeye smolt, and coho, sockeye and pink fry, JBER 2018.

	Sockeye Smolt	Coho Smolt	Sockeye Fry	Coho Fry	Pink Fry
<b>Cumulative (N)</b>	2092	1641	364	17	9
<b>Measured (N)</b>	304	293	110	17	6
<b>Average Length (mm)</b>	90	102	52	55	58

<sup>1</sup> Annual counts were from seasons between 2003-2018 timeframe.

<sup>2</sup> Annual counts for Sockeye were from seasons between 1998-2018, and Coho were from seasons between 2003-2018.

**Table 2.** Daily and cumulative counts of juvenile sockeye and coho salmon at the Sixmile Creek weir, JBER 2018.

Date	Temp (°C) HOBO Daily Average	Sockeye			Coho		
		Daily Smolt	Daily Fry	Cumulative	Daily Smolt	Daily Fry	Cumulative
9-May	7.7	0	0	0	0	0	0
10-May	8.4	1	0	1	0	0	0
11-May	9.0	0	0	1	0	0	0
12-May	9.3	1	0	2	0	0	0
13-May	9.7	0	0	2	0	0	0
14-May	10.6	2	0	4	0	0	0
15-May	10.5	0	0	4	0	0	0
16-May	11.0	1	0	5	0	0	0
17-May	11.3	2	0	7	2	0	2
18-May	11.8	0	0	7	2	0	4
19-May	12.4	6	0	13	3	0	7
20-May	12.1	5	0	18	0	0	7
21-May	12.2	6	0	24	0	0	7
22-May	12.7	2	0	26	0	0	7
23-May	13.3	4	0	30	0	0	7
24-May	13.9	8	0	38	0	0	7
25-May	13.7	122	0	160	19	0	26
26-May	13.9	1	0	161	3	0	29
27-May	14.6	1	0	162	1	0	30
28-May	15.2	4	0	166	1	0	31
29-May	15.7	332	0	498	28	0	59
30-May	15.6	15	0	513	7	0	66
31-May	15.9	282	0	795	46	0	112
1-Jun	16.3	574	1	1370	73	0	185
2-Jun	17.2	5	0	1375	6	0	191
3-Jun	17.6	132	1	1508	187	0	378
4-Jun	17.4	69	1	1578	23	0	401
5-Jun	17.4	72	0	1650	33	0	434
6-Jun	17.5	3	0	1653	1	0	435
7-Jun	17.8	78	0	1731	34	0	469
8-Jun	18.1	33	0	1764	39	0	508
9-Jun	18.7	40	9	1813	308	0	816
10-Jun	19.0	129	56	1998	499	0	1315
11-Jun	18.9	70	101	2169	74	6	1395
12-Jun	18.7	42	66	2277	99	4	1498

Date	Temp (°C) HOBO Daily Average	Sockeye			Coho		
		Daily Smolt	Daily Fry	Cumulative	Daily Smolt	Daily Fry	Cumulative
13-Jun	18.9	0	8	2285	13	0	1511
14-Jun	19.4	6	21	2312	39	2	1552
15-Jun	18.8	21	80	2413	71	0	1623
16-Jun	17.9	1	13	2427	5	4	1632
17-Jun	17.7	0	1	2428	0	0	1632
18-Jun	17.6	0	0	2428	0	0	1632
19-Jun	18.0	0	1	2429	0	0	1632
20-Jun	18.8	0	0	2429	0	0	1632
21-Jun	18.7	1	0	2430	2	0	1634
22-Jun	18.3	1	0	2431	0	0	1634
23-Jun	18.4	0	0	2431	0	0	1634
24-Jun	18.2	0	0	2431	0	0	1634
25-Jun	18.3	0	0	2431	0	0	1634
26-Jun	18.7	1	3	2435	0	0	1634
27-Jun	18.9	0	0	2435	0	0	1634
28-Jun	18.9	7	0	2442	16	0	1650
29-Jun	17.8	4	0	2446	3	0	1653
30-Jun	17.6	2	0	2448	1	0	1654
1-Jul	19.6	4	0	2452	2	1	1657
2-Jul	20.3	0	1	2453	0	0	1657
3-Jul	21.3	0	0	2453	0	0	1657
4-Jul	19.5	2	0	2455	1	0	1658
5-Jul	22.5	0	0	2455	0	0	1658
6-Jul	23.2	0	1	2456	0	0	1658
<b>TOTALS</b>	<b>16.1 Season Average</b>	<b>35.5 Daily AVG</b>	<b>6.2 Daily AVG</b>	<b>2456</b>	<b>27.8 Daily AVG</b>	<b>0.3 Daily AVG</b>	<b>1658</b>

### *Adult Weir*

The adult salmon weir was installed on 6 July and removed on 12 October for a total of 99 sampling days. The 2018 season went about 15 days beyond the average removal date to capture the tail end of the run. Water temperature documented during the project ranged between a minimum of 8.9°C and maximum of 23.7°C, with an average of 16.7°C. A total of 1780 sockeye and 279 coho were counted passing through the weir. The first adult sockeye was recorded on 15 July, and the first adult coho was recorded on 8 August. The last documented sockeye and coho to pass through the weir occurred on 11 October and 12 October respectively. Due to an unprecedented high volume of pink and chum schooling

at the weir in 2017, new protocol dictated that both species were to be allowed into the lake. The same protocol was used for 2018 and both species were released into the lake again, totaling 153 pinks and 1 chum.

**Table 3.** Daily and cumulative counts of adult sockeye and coho salmon at the Sixmile Creek weir, JBER 2018.

Date	Temp (°C) Daily Average	Sockeye		Coho	
		Daily	Cumulative	Daily	Cumulative
6-Jul	23.2	0	0	0	0
7-Jul	23.7	0	0	0	0
8-Jul	22.4	0	0	0	0
9-Jul	20.8	0	0	0	0
10-Jul	20.1	0	0	0	0
11-Jul	19.7	0	0	0	0
12-Jul	19.8	0	0	0	0
13-Jul	19.7	0	0	0	0
14-Jul	19.3	0	0	0	0
15-Jul	19.6	0	0	0	0
16-Jul	19.6	0	0	0	0
17-Jul	20.0	0	0	0	0
18-Jul	20.3	6	6	0	0
19-Jul	20.5	23	29	0	0
20-Jul	20.4	2	31	0	0
21-Jul	20.8	0	31	0	0
22-Jul	21.1	0	31	0	0
23-Jul	21.1	0	31	0	0
24-Jul	21.0	0	31	0	0
25-Jul	20.5	0	31	0	0
26-Jul	20.3	0	31	0	0
27-Jul	20.3	0	31	0	0
28-Jul	20.4	0	31	0	0
29-Jul	20.5	1	32	0	0
30-Jul	20.8	0	32	0	0
31-Jul	21.3	0	32	0	0
1-Aug	21.3	2	34	0	0
2-Aug	20.4	41	75	0	0
3-Aug	20.5	8	83	0	0
4-Aug	21.0	164	247	0	0
5-Aug	20.6	99	346	0	0
6-Aug	20.2	159	505	0	0

Date	Temp (°C) Daily Average	Sockeye		Coho	
		Daily	Cumulative	Daily	Cumulative
7-Aug	19.7	78	583	0	0
8-Aug	19.4	89	672	9	9
9-Aug	19.3	86	758	42	51
10-Aug	19.3	34	792	5	56
11-Aug	19.2	130	922	4	60
12-Aug	19.0	49	971	134	194
13-Aug	18.7	31	1002	23	217
14-Aug	17.9	6	1008	8	225
15-Aug	17.5	7	1015	7	232
16-Aug	17.5	17	1032	5	237
17-Aug	17.5	116	1148	0	237
18-Aug	16.8	58	1206	0	237
19-Aug	16.6	73	1279	0	237
20-Aug	16.6	70	1349	0	237
21-Aug	16.4	34	1383	0	237
22-Aug	16.7	55	1438	3	240
23-Aug	16.4	43	1481	0	240
24-Aug	16.3	93	1574	3	243
25-Aug	16.4	41	1615	1	244
26-Aug	16.3	9	1624	0	244
27-Aug	16.1	42	1666	1	245
28-Aug	16.1	21	1687	1	246
29-Aug	16.0	12	1699	0	246
30-Aug	16.0	15	1714	2	248
31-Aug	15.6	6	1720	0	248
1-Sep	15.7	10	1730	0	248
2-Sep	15.6	6	1736	0	248
3-Sep	15.7	2	1738	0	248
4-Sep	15.7	2	1740	0	248
5-Sep	15.6	11	1751	0	248
6-Sep	15.8	4	1755	1	249
7-Sep	15.9	4	1759	0	249
8-Sep	16.0	3	1762	0	249
9-Sep	15.8	0	1762	0	249
10-Sep	15.5	0	1762	0	249
11-Sep	15.2	0	1762	0	249
12-Sep	15.1	1	1763	0	249
13-Sep	15.2	1	1764	0	249
14-Sep	15.3	2	1766	2	251

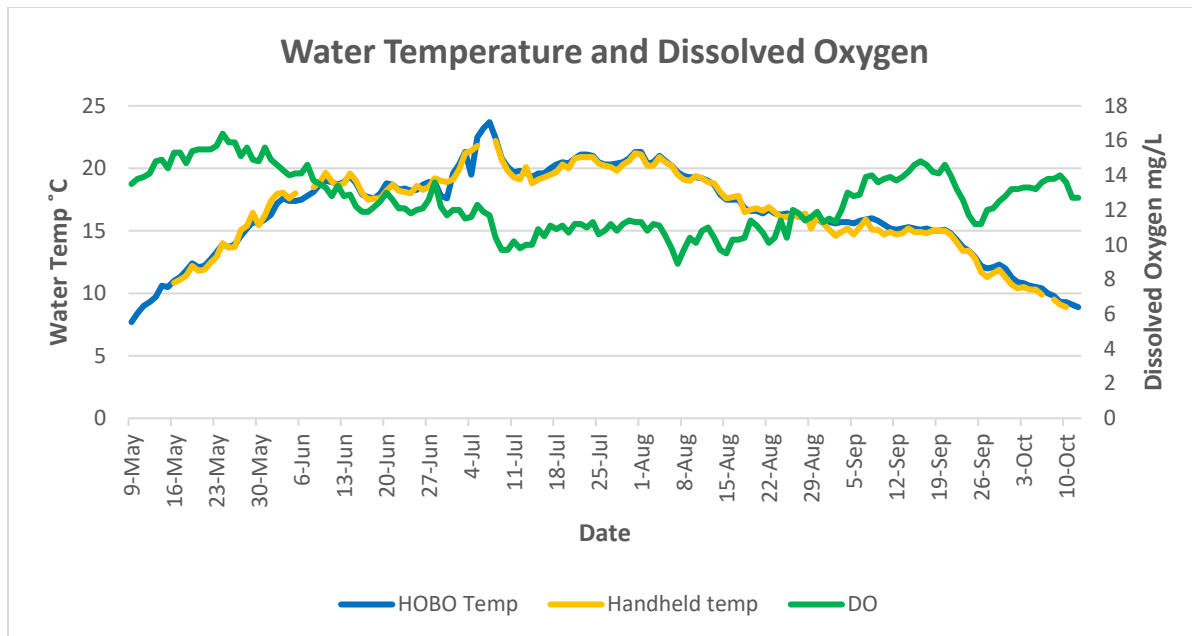


Date	Temp (°C) Daily Average	Sockeye		Coho	
		Daily	Cumulative	Daily	Cumulative
15-Sep	15.2	0	1766	1	252
16-Sep	15.1	0	1766	1	253
17-Sep	15.2	1	1767	0	253
18-Sep	15.0	6	1773	0	253
19-Sep	15.0	0	1773	4	257
20-Sep	15.1	0	1773	4	261
21-Sep	14.8	1	1774	0	261
22-Sep	14.3	1	1775	4	265
23-Sep	13.7	0	1775	0	265
24-Sep	13.4	1	1776	0	265
25-Sep	12.9	0	1776	2	267
26-Sep	12.2	3	1779	3	270
27-Sep	12.0	0	1779	2	272
28-Sep	12.1	0	1779	0	272
29-Sep	12.3	0	1779	0	272
30-Sep	12.0	0	1779	1	273
1-Oct	11.3	0	1779	1	274
2-Oct	10.9	0	1779	0	274
3-Oct	10.8	0	1779	0	274
4-Oct	10.6	0	1779	0	274
5-Oct	10.5	0	1779	0	274
6-Oct	10.4	0	1779	0	274
7-Oct	10.0	0	1779	0	274
8-Oct	9.8	0	1779	0	274
9-Oct	9.3	0	1779	0	274
10-Oct	9.3	0	1779	0	274
11-Oct	9.1	1	1780	3	277
12-Oct	8.9	0	1780	2	279
<b>TOTALS</b>	<b>16.7 Season Average</b>	<b>18 Daily Average</b>	<b>1780</b>	<b>3 Daily Average</b>	<b>279</b>

### *Water Quality Parameters*

Throughout the season, temperature and dissolved oxygen were collected at the site with a HOBO and a separate handheld thermometer used to collect temperature by technicians during daily checks. This data was collected from 9 May until 12 October for a total of 157 days. The average water temperature for

the 2018 season was 16.5°C.<sup>3</sup> The average dissolved oxygen concentration for the season was 12.5 mg/L. The lowest concentration of DO was 8.9 mg/L on 7 August and the highest concentration of DO was 16.4 mg/L on 24 May.<sup>4</sup>



**Figure 2.** Water temperature and dissolved oxygen collected by HOBO and temperature collected by handheld thermometer.

### *Data Quality Assurance and Quality Control*

Data quality assurance and quality control was completed for 2018 and finalized within the electronic database.

## **Discussion**

The primary objective of this project was to enumerate and identify to species the out-migrating smolt salmon and the returning adult salmon for the Sixmile Lake drainage. By using these counts, we identify trends by comparing historical data to the current year's data. We investigated some potential environmental factors, temperature and dissolved oxygen, that might have a negative effect on the salmon stock. As of 2018, JBER has long-term data sets, which include 13 years of data on out-migrating salmon

<sup>3</sup> All temperatures discussed were from the primary temperature collection device-the HOBO.

<sup>4</sup> All DO measurements can be found in the table Appendix 3.

and coho smolt, 21 years of data on returning adult sockeye salmon, and 16 years of data on returning adult coho salmon. The table below is a checklist of the years that data was collected.

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 for temperature, smolt and adult migration are important when evaluating results from the most recent season and comparing to historical averages.

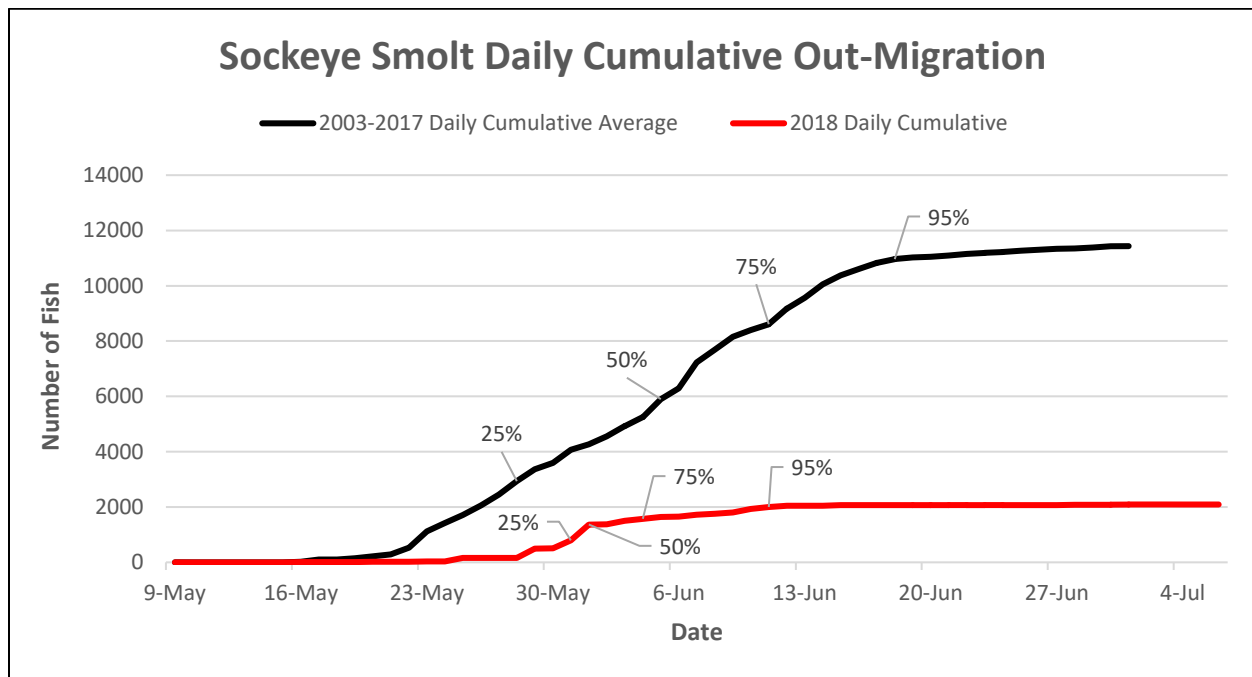
**Table 4.** *Records of annual data collection.*

<b>Year</b>	<b>Sockeye Smolt</b>	<b>Coho Smolt</b>	<b>Temperature for Smolt</b>	<b>Adult Sockeye</b>	<b>Adult Coho</b>	<b>Temperature for Adults</b>
<b>1998</b>	-	-	-	√	-	-
<b>1999</b>	-	-	-	√	-	-
<b>2000</b>	-	-	-	√	-	-
<b>2001</b>	-	-	-	√	-	-
<b>2002</b>	-	-	-	√	-	-
<b>2003</b>	√	√	-	√	√	-
<b>2004</b>	√	√	√	√	√	-
<b>2005</b>	√	√	√	√	√	-
<b>2006</b>	√	√	√	√	√	-
<b>2007</b>	-	-	-	√	√	-
<b>2008</b>	-	-	-	√	√	-
<b>2009</b>	√	√	-	√	√	-
<b>2010</b>	√	√	-	√	√	-
<b>2011</b>	-	-	-	√	√	√
<b>2012</b>	√	√	√	√	√	√
<b>2013</b>	√	√	√	√	√	√
<b>2014</b>	√	√	√	√	√	√
<b>2015</b>	√	√	√	√	√	√
<b>2016</b>	√	√	√	√	√	√
<b>2017</b>	√	√	√	√	√	√
<b>2018</b>	√	√	√	√	√	√

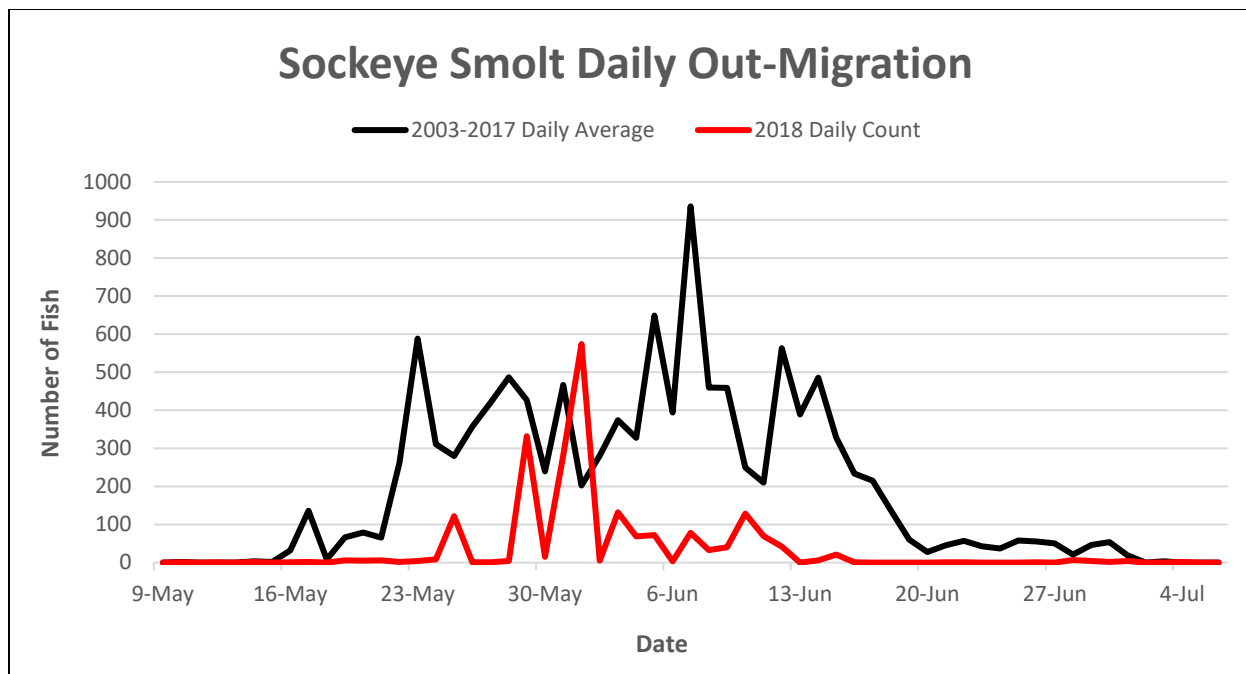
### *Smolt Weir*

The 2018 season sockeye smolt count of 2,092 was the second lowest sockeye smolt count on record (Appendix 1a). The average total sockeye smolt counts for 2003-2018 (10,716) compared to this year's total count (2,092) shows a disparity in smolt numbers. Although, the last couple of year's counts have been low in comparison to other documented years and this year's smolt count remained similar to last year. Overall, there is a general downward trend in the total sockeye smolt counts (Appendix 1a). As seen in Figure 3, only the beginning of the out-migration for sockeye smolt occurred later than the

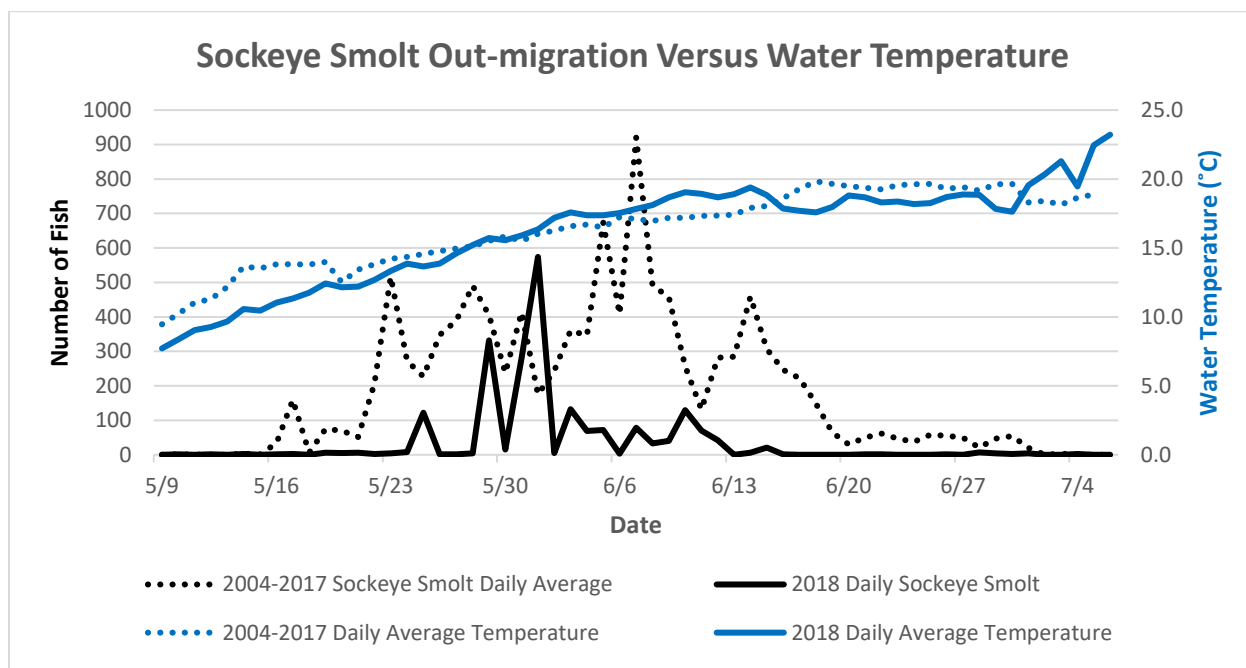
historical average with 25% of the 2018 out-migration occurring 3 days later than previous years. However, 50%, 75%, and 95% of the run occurred four, seven, and seven days earlier, respectively. Between 30 May and 11 June, 71% of the sockeye smolt out-migrated into the creek. The middle of the out-migration was more condensed in 2018 than historical averages with the total count progressing from 513 (24.5%) to 2000 (95.6%) in just 12 days compared to the historical average of 22 days. This later start to the run timing could be due in part to the lower than average temperatures in the early part of summer seen in Figure 5.



**Figure 3.** Daily cumulative average comparison of 2018 sockeye smolt out-migration and the daily cumulative average from 2003-2017. Percentages represent amount of smolt that have out-migrated on corresponding date.

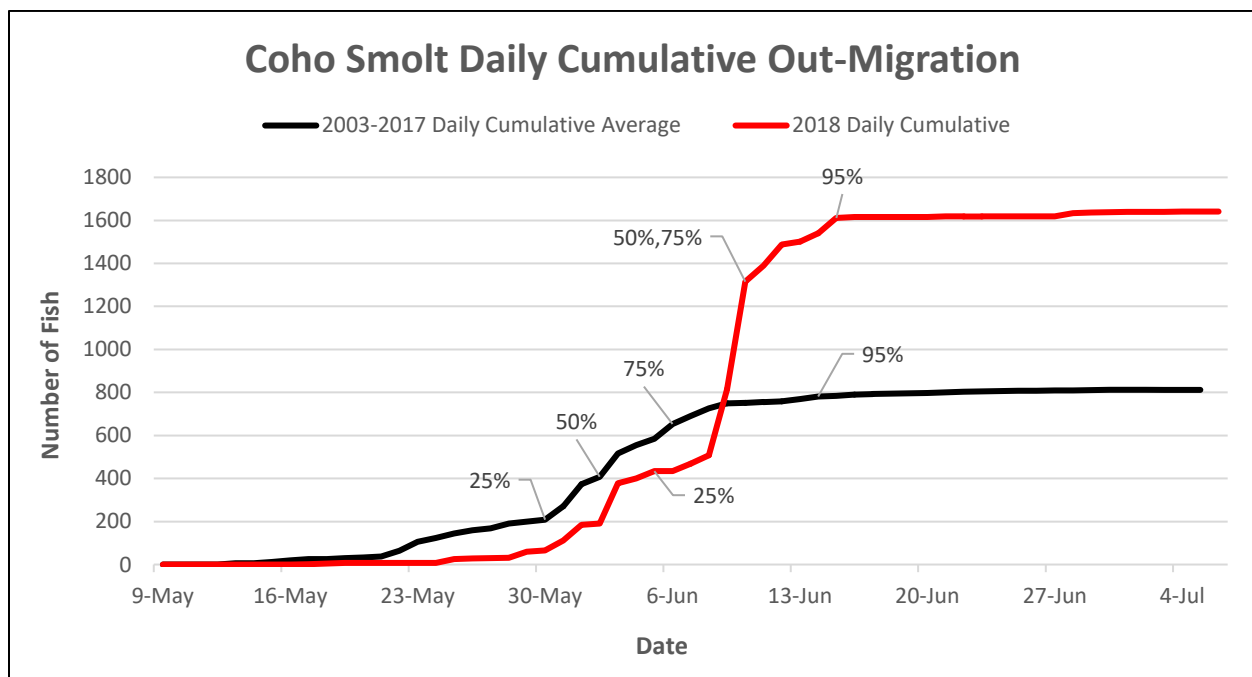


**Figure 4.** Daily comparison of 2018 sockeye smolt out-migration and the daily average from 2003-2017.



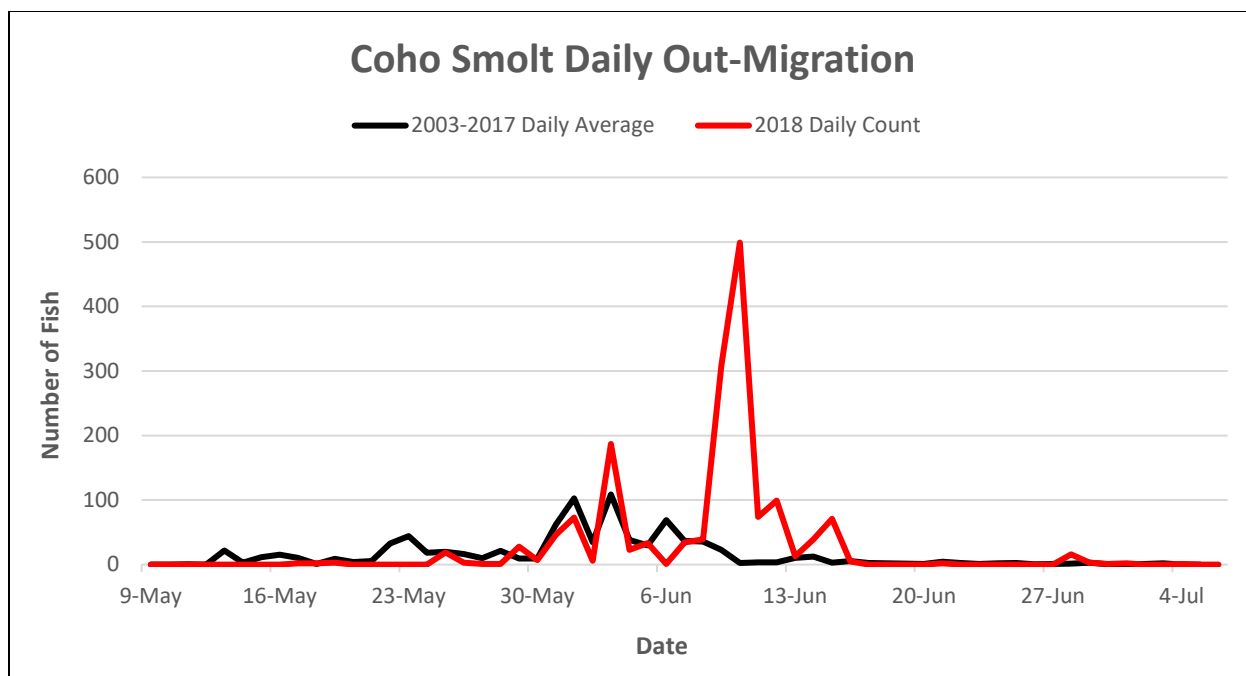
**Figure 5.** A comparison of 2018 and 2004-2017 daily average sockeye smolt counts to the water temperature from 2018 and 2004-2017.

The 2018 coho smolt count of 1,641 was the third highest documented over the course of thirteen sampling years, lower than the highest years in 2014 (3,996) and 2017 (3,227), but notably higher than 2015 (540) and 2016 (862). As seen in Figure 6, due to a large surge of 499 fish (30%) of the out-migration moving out on 10 June, 50% and 75% of the 2018 coho smolt out-migrated in one day. The entire span of coho out-migration reached percentage thresholds later than the historic average, with 25% of the escapement occurring six days later than the historic average, and 50% of the escapement occurred eight days later than the historic average. However, the coho count reached 95% only one day later than the historic average. The data shows that coho smolt percentiles occurred later overall, especially early on, which could suggest colder temperatures slowed the start of their out-migration overall.

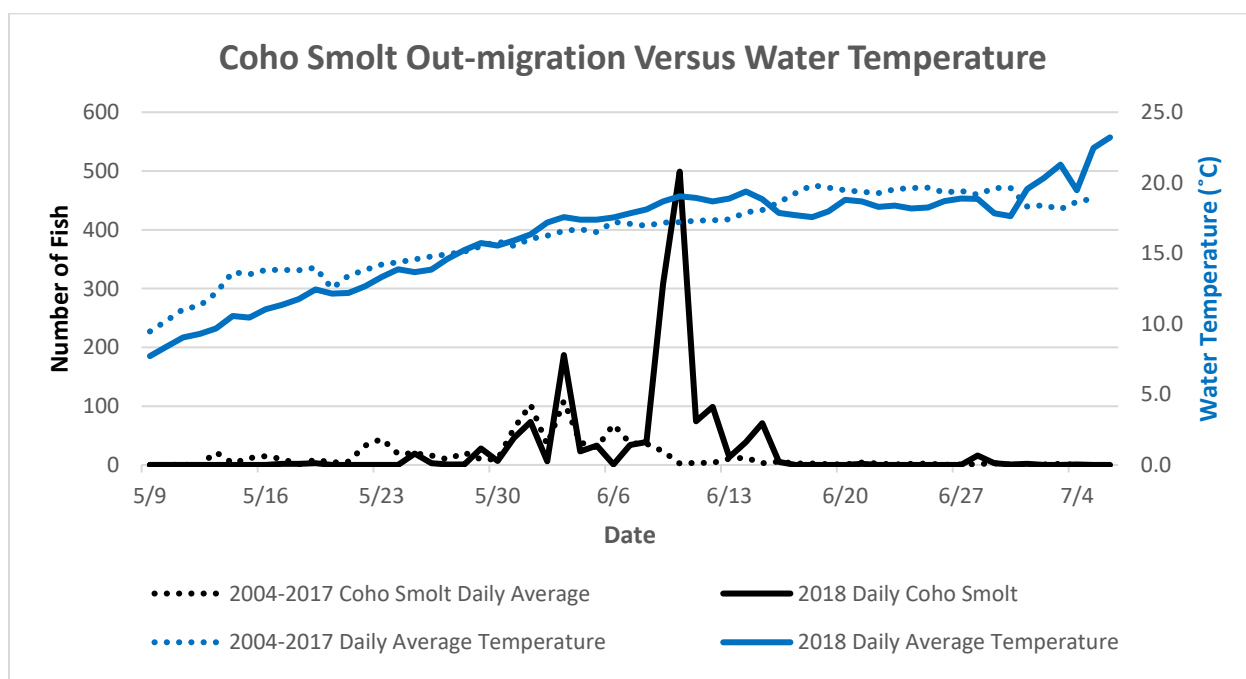


**Figure 6.** Cumulative daily average comparison of 2018 coho out-migration and the cumulative daily average from 2003-2017.<sup>5</sup> Percentages represent amount of smolt that have out-migrated on corresponding date.

<sup>5</sup> Note: Not all years from were sampled for smolt. See Appendix 1A and 1B for years sampled.



**Figure 7.** Daily comparison of 2018 coho out-migration and the daily average from 2003-2017.



**Figure 8.** A comparison of 2018 and daily average 2004-2017 coho out-migration to the water temperature.

The average water temperature for the 2018 smolt enumeration was 16.1°C during the sampling period of 9 May through 6 July. This is lower than the 2004-2017 historical average of 16.4°C. During the 59 days of 2018 sampling for out-migrating smolt, there were 35 non-consecutive days of water

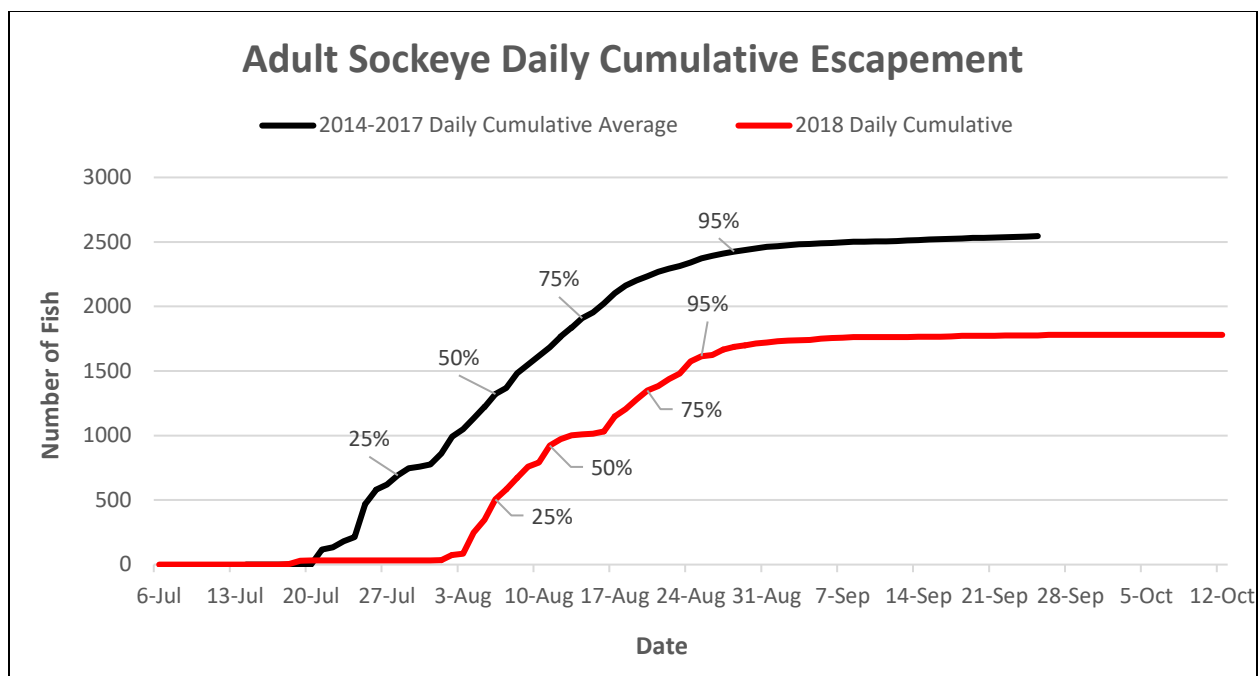
temperature that were colder than the 2004-2017 historical average. The 24 days of higher than average temperature included 28-29 May, 31 May- 15 June, and 1-6 July. During the 2018 season, increase in water temperature did not occur until later in the season (28<sup>th</sup> May), which corresponds with the salmon smolt out-migrating later during the season compared to previous years. Based on visual observation, much 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 coho smolt and only a slight decrease for sockeye smolt. This supports the hypothesis that the lower temperatures in the spring caused a slower out-migration.

### *Adult Weir*

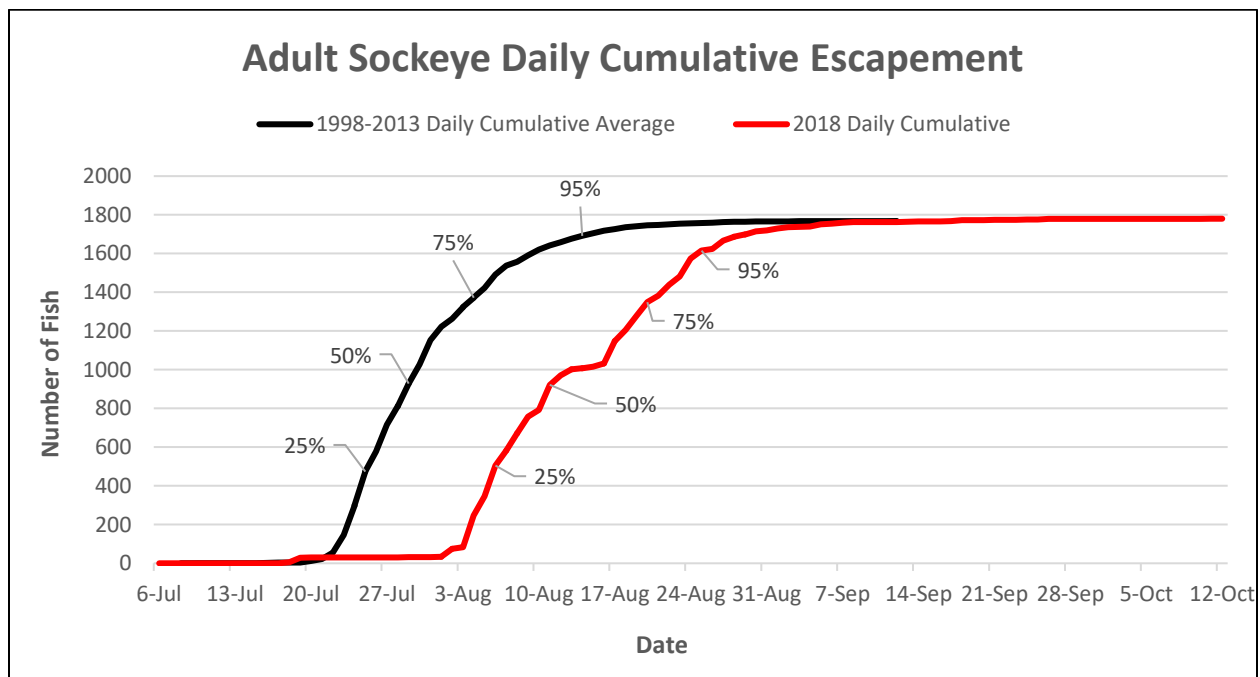
The adult sockeye salmon had a cumulative escapement of 1,780 fish for the 2018 season. This season was lower than the historical average of 2,551 from 2014-2017 (Figure 9) and just above the historical average of 1,768 from 1998-2013 (Figure 10). Figure 9 is slightly skewed due to a higher average of returning adult sockeye from 2014-2017, which included the largest return of sockeye on record in 2015, with 4,768 fish. Figure 9 also shows four 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, 2016, and 2017 cumulative average (extending past September 12). The largest return peak of 2018 occurred on 4 August, with 164 sockeye passing through the weir. During 2018, 25% of the sockeye counted passed through the weir by 6 August, 11 days later than 1998-2013 historic average and nine days later than the 2014-2017 historic average. By 25 August, 95% of the sockeye counted had passed through the weir (Figure 10), 11 days later than the 1998-2013 historic average but three days earlier than the 2014-2017 historic average.

Two different graphs (Figure 9 and Figure 10) illustrate the cumulative daily comparison of adult sockeye. These graphs show that the daily cumulative average of returning sockeye from 1998-2013 was much lower than cumulative average of returning sockeye from 2014, 2015, 2016 and 2017. The graphs also depict that in 2014, 2015, 2016 and 2017 the field seasons end dates were extended so that more of the run was captured.

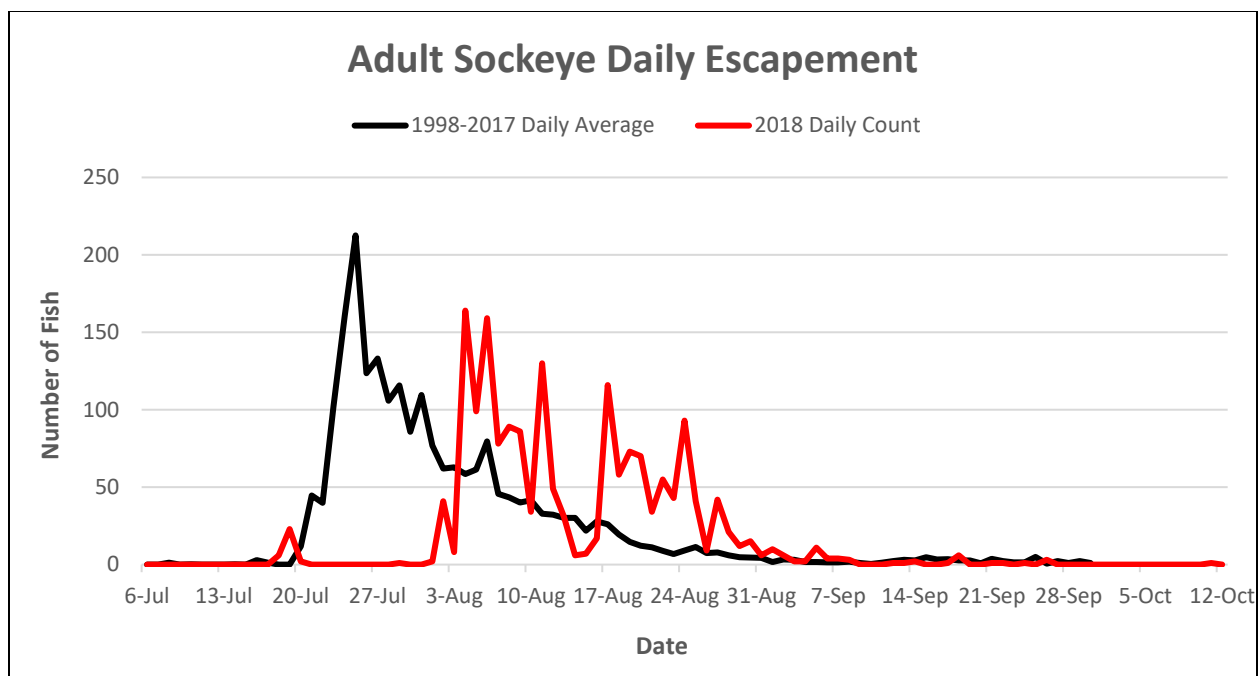




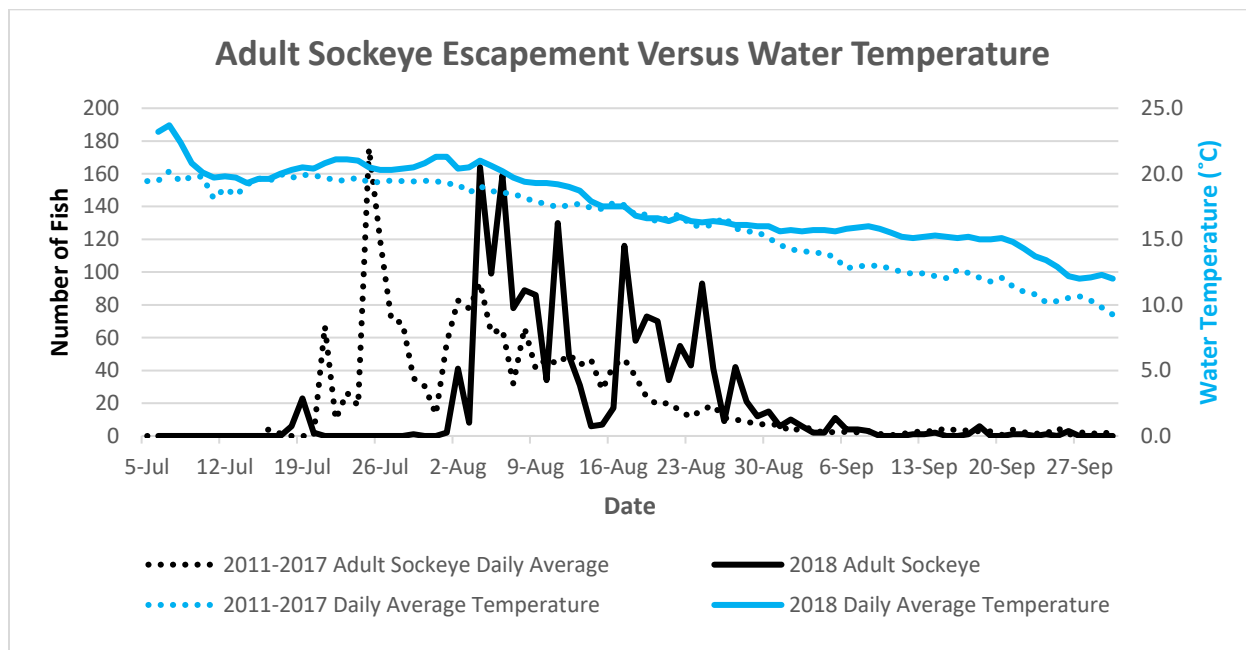
**Figure 9.** Comparison of the daily cumulative escapement for the 2018 sockeye run and daily cumulative average escapement from 2014-2017. Percentages represent number of adults that have escaped on corresponding date.



**Figure 10.** Comparison of the daily cumulative escapement for the 2018 sockeye run and daily cumulative average escapement from 1998-2013. Percentages represent number of adults that have escaped on corresponding date.



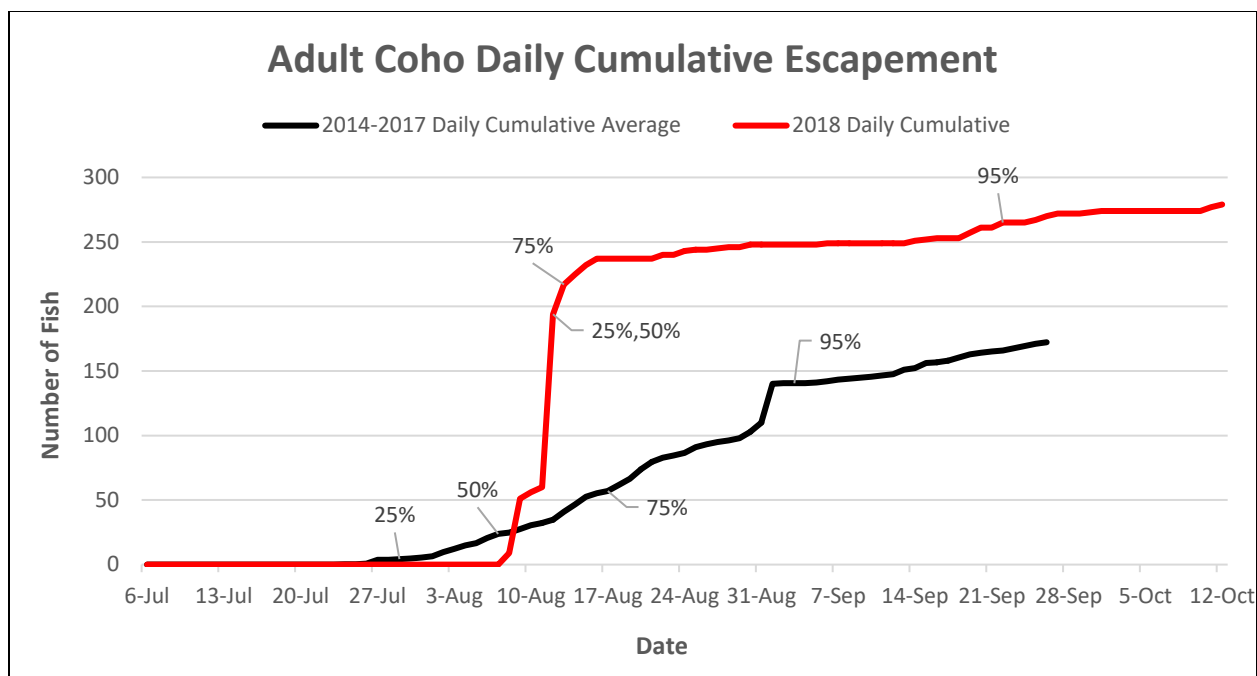
**Figure 11.** Comparison of daily escapement from the 2018 sockeye run and the daily average escapement from 1998-2017.



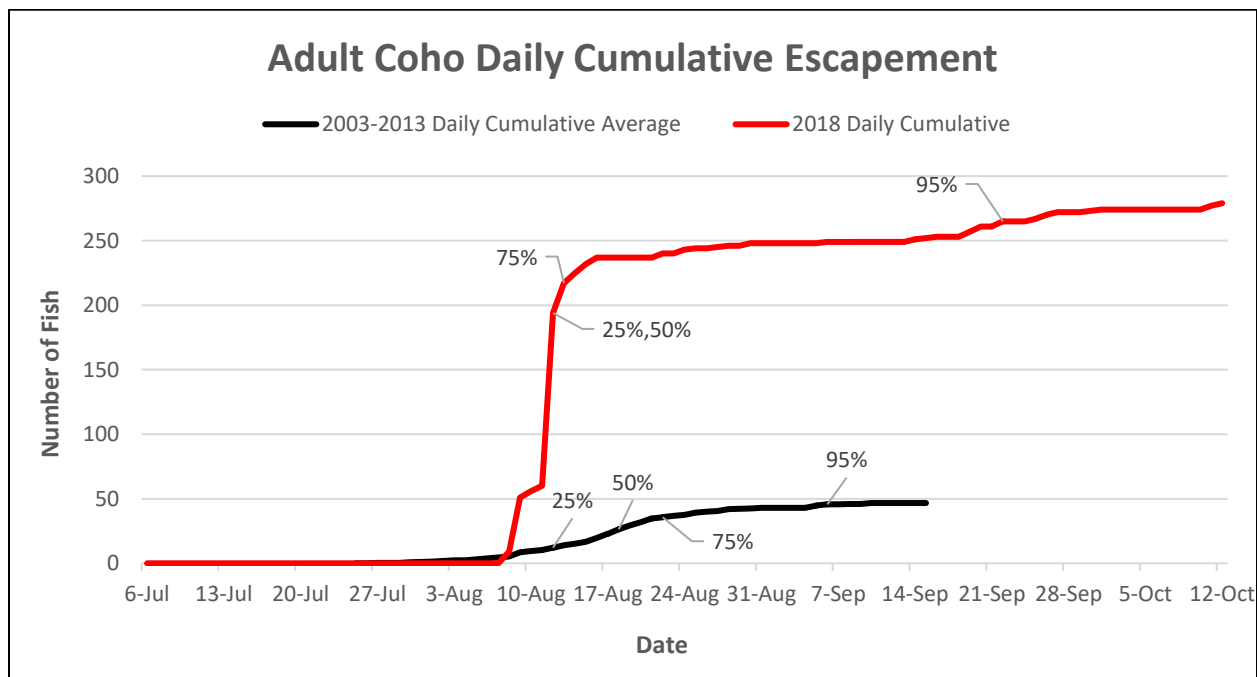
**Figure 12.** Comparison of the adult sockeye 2018 and daily average 2011-2017 counts to the daily water temperature in 2018 and the daily average water temperature from 2011-2017.

The 2018 adult coho cumulative escapement of 279 was higher than the average of all the previous years (78); except for the 2015 season, which had the highest count on record with 527 (Figure 13 and Figure 14). The historical average of 47 from 2003-2013 was surpassed on 9 August and the historical average of 172 from 2014-2017 was surpassed on 12 August. However, it's worth noting that the first coho counted in 2018 occurred nine days later and 13 days later than the 2003-2013 and 2014-2017 averages, respectively. 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 13 and 14. By 13 August, the 2018 coho escapement had 217 fish (78%) pass through the weir, 157 of those fish (56%) were counted on 12 and 13 August. Since the first coho was counted on 8 August, 237 fish (85%) passed through the weir in just nine days by 16 August. After the peak day of 134 fish on 12 August, the run slowed down considerably and did not reach 95% until 22 September, 16 days later than the historical average from 2003-2013 and 19 days later than the historical average from 2014-2017. The coho 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.

Two different graphs (Figure 13 and 14) 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, 2016, and 2017. The graphs also depict that the 2014, 2015, 2016, and 2017 field seasons end dates were extended so that more of the run was captured.

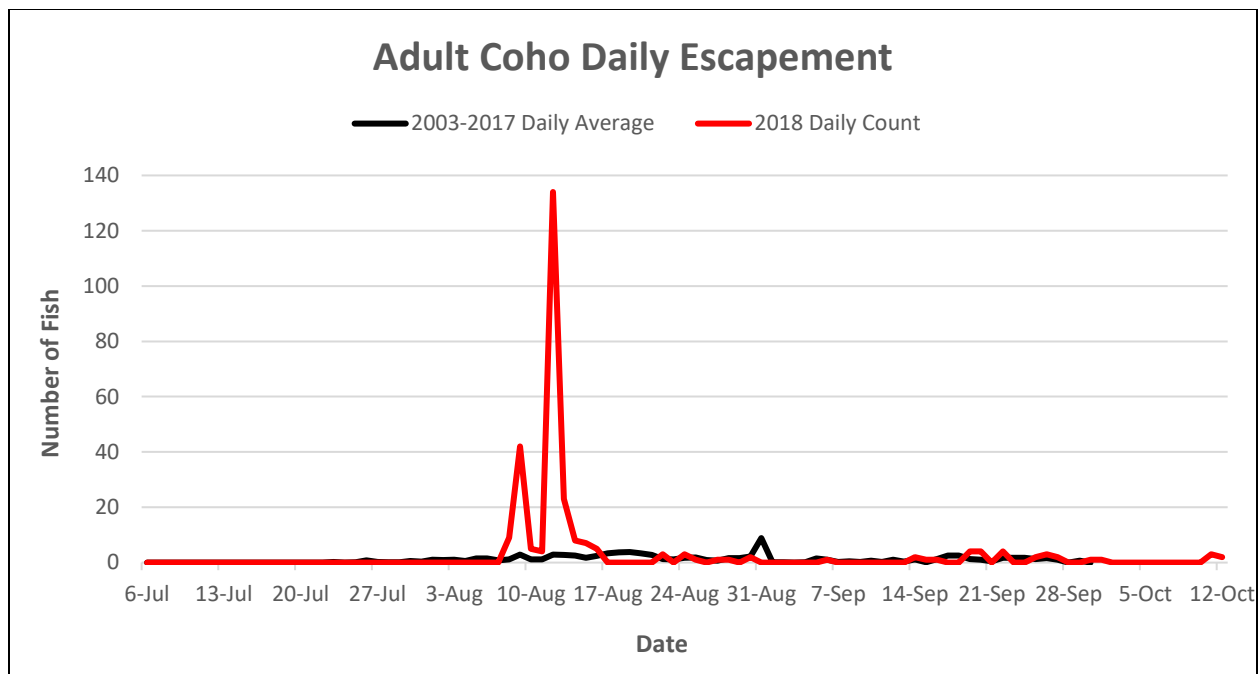


**Figure 13.** Comparison of daily cumulative escapement for the 2018 coho run and the average daily cumulative escapement from 2014-2017. Percentages represent number of adults that have escaped on corresponding date.

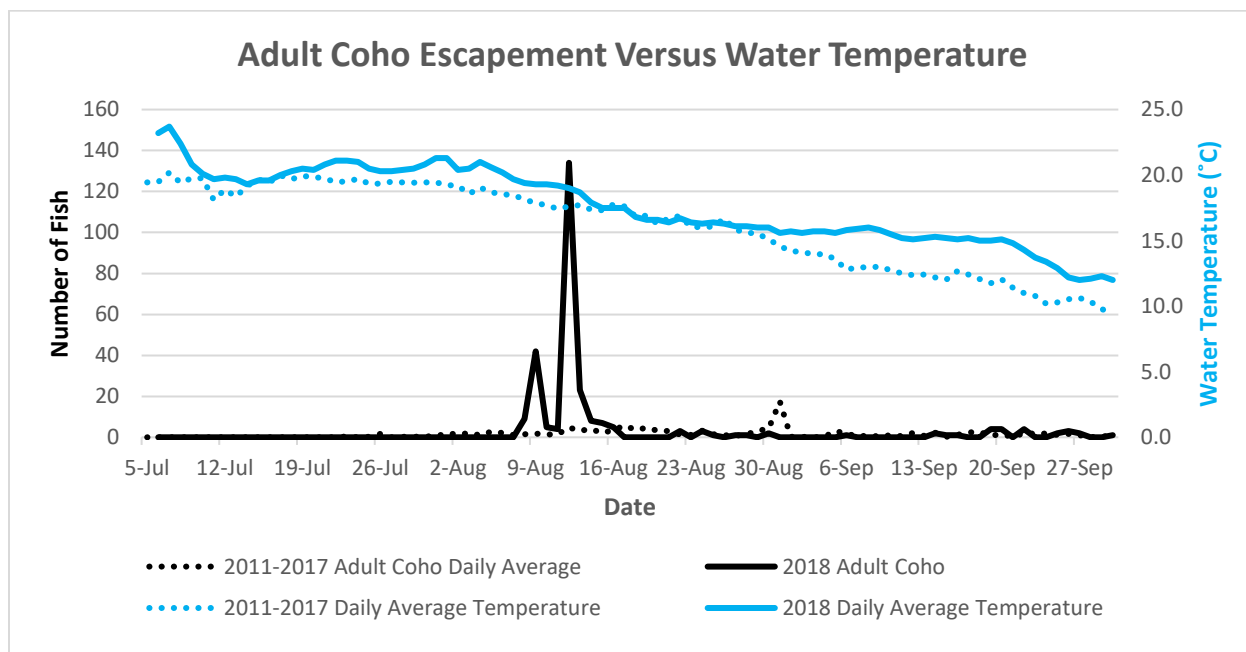


**Figure 14.** Comparison of daily cumulative escapement from the 2018 coho run and the average cumulative escapement from 2003-2013. Percentages represent number of adults that have escaped on corresponding date.<sup>6</sup>

<sup>6</sup> Note that the average cumulative from 2003-2013 ends on 15-Sep because coho were no longer counted after that date.



**Figure 15.** Comparison of the daily escapement from the 2018 coho run and the average daily escapement from 2003-17.



**Figure 16.** Comparison of 2018 and daily average 2011-2017 adult coho counts to the daily average water temperature in 2018 and the daily average water temperature from 2011-2017.

During the 99 days of corresponding sampling time for adult escapement, there were 53 non-consecutive days of water temperature that were warmer than the 2011-2017 historical average. The average water temperature for the 2018 adult enumeration was 16.7°C during the sampling period from 6 July through 12 October, compared to the 2011-2017 historical average of 16.1°C during the sampling period 6 July through 30 September. The 2018 season did not show the same trend of decreased temperature until later in the season, which corresponds with the adult salmon escaping later during the season compared to previous years. In fact, the 2018 average temperatures were warmer than the historic average for 41 days from 5 July-15 August, except for 15 July, which was a tenth of degree colder than the historic average. 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 27 September when it measured as 12°C.

The HOBO device is an ideal tool for environmental impact studies as well as ecological research and provided accurate measurements of DO which are listed in Appendix 3. The device also doubled as a more accurate way to calculate daily average temperature at the study site.<sup>7</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.

## **Acknowledgements**

This study would not have been successful without the efforts of the field technicians: Krystina Bottom, Nolan Schubert, Andrea Gilstad, and Anthony Adams. We would like to thank these technicians for their many hours in the cold water maintaining the equipment, and analyzing and organizing data. We would also like to thank Cassandra Schoofs and Colette Brandt for their guidance and assistance on the project.

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<sup>7</sup> The HOBO records temperature and DO 12 times a day every two hours and therefore can help calculate a more accurate average of daily temperature than an average based on checking a thermometer once-twice a day at varying times each day.

## **Recommendations**

Based on the 2018 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 early 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.
3. Continue to 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. Continue same day removal of the smolt weir and installation 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 is 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 continues to allow for operation of the adult weir into October.
6. Dialogue with ADF&G about the annual stocking of rainbow trout, a juvenile salmon predator, into salmon spawning and rearing areas. Location of stocking is also important, the further from the smolt trap and outlet to the creek, the better. Due to an unprecedented amount of rainbow trout that went into the smolt trap, use the same protocol of clipping adipose fins and release them back at stocking location if possible.
7. Create protocol for allowing adult 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 in 2017 and 2018, that have and could continue to spawn, leading to a more diverse smolt identification than in past years.
8. Create protocol for what to do with all species of fry that are out-migrating from the lake before season starts.

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## **Appendices**

**Appendix 1A.** *Sockeye smolt daily escapement counts by date, Sixmile Creek drainage, 2003-2018.*

Year														Daily Average
Date	2003	2004	2005	2006	2009	2010	2012	2013	2014	2015	2016	2017	2018	2003-2006, 2009-2010,2012-2017
2-May												0		0
3-May												0		0
4-May												0		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	0
10-May										0	0	0	1	1
11-May										1	0	0	0	0
12-May				0				0		0	0	0	1	0
13-May				0						0	0	0	0	0
14-May	0			4						0	9	0	2	3
15-May	0	4		1		0				1	2	0	0	1
16-May	21	2		2		0				177	19	0	1	32
17-May	1	126		1		0				807	18	0	2	136
18-May	21	7		0		0				34	2	0	0	8
19-May	8	402		13	26					25	59	0	6	67
20-May	165	407	92	44	114	0		0		14	31	0	5	79
21-May	220	185	121	118	86	8		-	3	39	3	0	6	65
22-May	815	464	30	181	192			0	1086	91	19	0	2	262
23-May	1,383	146	15	637	402	5		0	3987	479	6	0	4	588
24-May	740	325	155	1,725	87	1	0	0	641	38	21	0	8	311
25-May	864	319	312	986	375	14	70	0	162	182	76	1	122	280
26-May	460	616	309	1,919	83	7	234	0	309	333	14	0	1	357
27-May	731	266	229	1,897	209		69	1	121	1086	12	0	1	420
28-May	445	714	365	229	38	34	2,404	0	196	1335	81	0	4	487
29-May	673	63	125	1,424	28	26	2,134	0	368	243	41	0	332	427
30-May	275	693	20	1,316	23	6	430	40	2	3	71	0	15	240
31-May	1,047	172	595	781	8	5	562	104	2095	74	84	68	282	466
1-Jun	506	74	447	836	64	47	12	320	56	14	37	21	574	203
2-Jun	688	41	961	882	117	117	20	386	49	81	26	0	5	281
3-Jun	521	394	660	418	123	67	23	881	448	924	14	14	132	374
4-Jun	128	92	600	90	238	150	636	615	810	562	10	1	69	328
5-Jun	384	13	608	254	1,071	639	2,049	2,227	155	336	38	15	72	649
6-Jun	243	140	265	350	483	5	891	963	38	1245	17	91	3	394
7-Jun	1,104	37	96	107	963	162	2,677	2,376	2782	596	271	57	78	936
8-Jun	111	25	234	114	1,103	84	1,017	2,255	58	349	117	50	33	460
9-Jun	478	47	274	65	636	616	1,029	1,349	358	567	76	11	40	459
10-Jun	173	22	129	174	357	427	813	779	0	80	27	12	129	249
11-Jun	1,076	0	143	29	44	277	195	352	10	364	7	27	70	210
12-Jun	3,660	58	144	62	123	281	505	1,757	1	146	9	9	42	563

Year														Daily Average
Date	2003	2004	2005	2006	2009	2010	2012	2013	2014	2015	2016	2017	2018	2003-2006, 2009-2010,2012-2017
13-Jun	1,536	7	134	148	488	176	1,129	771	0	0	16	261	0	389
14-Jun	779	26	132	223	303	30	2,603	1,395	1	43	8	289	6	486
15-Jun	573	18	344	230	237	23	1,075	1,049	0	0	0	398	21	329
16-Jun	96	11	190	113	10	181	799	1,256	0	0	0	152	1	234
17-Jun	134	2	161	596	42	80	612	737	0	0	0	218	0	215
18-Jun	20	12	118	188	318	220	546	159	1	3	4	55	0	137
19-Jun	14	17	366	30	47	28	146	50	0	1	0	28	0	61
20-Jun	6	16	88	72	38	20	34	49	0	4	0	5	0	28
21-Jun	3	5	122	53	35	26	97	14	0	1	0	190	1	46
22-Jun	9	1	213	14		26	60	291	0	0	0	10	1	57
23-Jun	2	35	62	12	29	61	101	93	6	4	0	112	0	43
24-Jun			27	73	12	99	15	44	5	1		59	0	37
25-Jun			308	16	0	51	51	45	0	0		54	0	58
26-Jun			218	188	18	9	41	18	2	0		3	1	55
27-Jun			88	80		2	203	7	0	0		20	0	50
28-Jun			20	129	3	3	23	1	1	1		8	7	21
29-Jun			27	297	1	16	60	12	5	0		0	4	46
30-Jun			28	100		8	279	11	4	0		1	2	54
1-Jul					40	0		56	0			2	4	20
2-Jul									0			0	0	0
3-Jul												3	0	3
4-Jul												0	2	0
5-Jul												0	0	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	2,092	10,716

The total in the average column (10,716) is the average from all the yearly totals (2003-2018).

Appendix 1B. Coho smolt daily escapement counts by date, Sixmile Creek drainage, 2003-2018.

Year														Daily Average
Date	2003	2004	2005	2006	2009	2010	2012	2013	2014	2015	2016	2017	2018	2003-2006, 2009-2010,2012-2017
2-May												0		0
3-May												0		0
4-May												0		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	0
10-May										4	0	0	0	0
11-May										0	1	0	0	0
12-May										0	0	0	0	0
13-May										64	1	0	0	16
14-May	1									6	4	0	0	2
15-May	2	0				0				66	1	0	0	10
16-May	2	0				0				53	36	0	0	13
17-May	0	0				0				52	8	1	2	9
18-May	0	0			0	0				3	3	0	2	1
19-May	0	0			0					8	44	0	3	8
20-May	0	0	1		0	0		0		4	30	0	0	4
21-May	24	0	3	1	0	0		0	19	9	4	0	0	5
22-May	13	4	5	9	7			0	263	12	12	2	0	30
23-May	0	0	0	24	3	0		0	447	9	2	1	0	41
24-May	0	0	47	24	1	0	25	0	103	5	17	0	0	17
25-May	0	0	39	19	11	2	0	0	88	26	52	2	19	20
26-May	0	0	16	48	3	4	0	0	73	36	14	0	3	15
27-May	0	0	7	19	1		15	0	28	25	12	0	1	9
28-May	0	0	5	7	0	2	20	0	82	25	111	1	1	20
29-May	0	1	0	9	0	0	10	0	51	4	38	0	28	11
30-May	1	14	7	9	1	2	2	0	41	2	32	0	7	9
31-May	0	1	17	3	0	0	1	15	153	2	7	546	46	61
1-Jun	0	0	51	1	2	1	0	12	230	0	26	910	73	100
2-Jun	0	0	59	3	0	1	1	9	145	0	19	180	6	33
3-Jun	0	0	1	1	0	1	0	54	1004	9	8	226	187	115
4-Jun	0	0	16	0	0	0	0	13	363	11	6	50	23	37
5-Jun	1	0	7	2	4	0	9	17	202	2	55	56	33	30
6-Jun	3	0	15	2	0	0	1	16	390	13	19	368	1	64
7-Jun	0	0	6	1	1	4	1	26	123	1	127	153	34	37
8-Jun	0	0	4	0	3	1	4	17	53	64	44	241	39	36
9-Jun	0	1	5	0	2	1	1	21	76	15	79	73	308	45
10-Jun	0	0	4	0	0	3	0	11	1	2	2	6	499	41
11-Jun	0	0	8	1	0	6	0	2	12	3	7	3	74	9

Year														Daily Average
Date	2003	2004	2005	2006	2009	2010	2012	2013	2014	2015	2016	2017	2018	2003-2006, 2009-2010,2012-2017
12-Jun	0	0	3	5	0	1	2	12	4	8	5	1	99	11
13-Jun	0	1	2	0	0	5	0	5	0	0	32	81	13	11
14-Jun	0	0	5	1	3	1	3	3	0	0	3	128	39	14
15-Jun	0	0	4	0	0	0	0	7	0	0	0	25	71	8
16-Jun	0	0	28	1	0	2	4	4	1	0	0	28	5	6
17-Jun	0	0	3	13	0	0	2	3	0	1	0	7	0	2
18-Jun	0	0	6	1	4	4	0	1	0	0	1	9	0	2
19-Jun	2	0	8	0	1	0	2	0	0	0	0	5	0	1
20-Jun	0	0	2	0	2	0	0	0	1	0	0	5	0	1
21-Jun	0	1	4	0	0	0	1	0	1	0	0	44	2	4
22-Jun	0	0	1	0		0	1	1	18	0	0	7	0	2
23-Jun	0	0	0	0	0	0	0	0	0	0	0	12	0	1
24-Jun			1	0	0	1	0	0	0	0		18	0	2
25-Jun			1	0	1	0	0	0	2	0		18	0	2
26-Jun			1	0	0	0	0	0	0	0		2	0	0
27-Jun			1	0		0	2	1	0	0		2	0	1
28-Jun			0	0		0	0	0	0	0		10	16	3
29-Jun			0	0		0	0	0	19	0		3	3	3
30-Jun			0	0		0	0	0	3	0		0	1	0
1-Jul								0				0	2	1
2-Jul												1	0	1
3-Jul												2	0	1
4-Jul												0	1	1
5- Jul												0	0	0
Totals	49	23	393	204	50	42	107	250	3,996	540	862	3,227		876

The total in the average column (876) is the average from all of the yearly totals (2003-2018).

Appendix 1C. Adult sockeye daily escapement counts by date, Sixmile Creek drainage, 1998-2018.

Year																						Daily Average																	
Date	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	1998-2017																	
1-Jul	0										0										0																		
2-Jul											0								0			0																	
3-Jul	0										0										0																		
4-Jul																			0			0																	
5-Jul											0										0																		
6-Jul																			0	0	0	0																	
7-Jul											0										0	0	0																
8-Jul				4							1								0	0	0	1																	
9-Jul	0										0										0	0	0	0															
10-Jul				1							0								0	0	0	0																	
11-Jul	0										0										0	0	0	0															
12-Jul											0			0					0	0	0	0																	
13-Jul	0										0										0	0	0	0															
14-Jul							1				0	0	0	0			0	0	0	0	0	0																	
15-Jul	0										0	0	0	0	0										0	0	0	0											
16-Jul	2										0	0	0	2	0	27	0	0	0	0	0	3																	
17-Jul	3	0										0	0	0	0	0	10	0	0	0	0	0	0	1															
18-Jul	1				0						0	0	0	0	0	0	0	0	0	0	6	1																	
19-Jul	0										1	0	0	0	0	0	0	0	0	39	0	23	2																
20-Jul	3			149	0						0	0	0	0	0	0	0	0	2	0	2	11																	
21-Jul	17	133										0	5	1										0	0	469	0	52	0	0	42								
22-Jul	17			285	0		107			1	0	0	119	0	0	1	69	0	11	0	0	37																	
23-Jul	43	518										300	0	100										1	0	0	487	0	0	0	142	4	1	0	0	96			
24-Jul	487			178	1,188	0		18			1	8	358	200	0	0	0	122	5	0	0	151																	
25-Jul	184	78										405	328	158	0	276										4	516	582	67	198	1	3	111	862	0	1	0	201	
26-Jul	56			21	26	173	251	2	124			344	268	0	241	4	152	48	337	0	42	0	117																
27-Jul	48	3										130	476	364	2	22										219	100	537	0	18	1	309	30	61	0	75	0	126	
28-Jul	4			286	300	394	13	2		14	32	264	7	0	4	197	61	144	0	77	0	100																	
29-Jul	154	200										297	363	279	24	2										1	9	260	247	2	1	27	27	11	29	149	1	110	
30-Jul	20			180	91	162	132	321	31	205	3	67	86	119	1	141	14	51	1	3	1	0	81																
31-Jul	20	133										305	59	176	301	160	359	80	112	181	103	0	22	0	49	8	13	0	0	104									
1-Aug	21			44	151	91	95	43	92	50	171	46	70	187	0	57	3	16	28	1	294	2	73																
2-Aug	0	38										59	40	44	26	72										2	34	31	100	151	2	28	27	9	288	2	223	41	61
3-Aug	138			24	45	86	88	41	40	3	13	17	12	140	115	10	196	10	101	40	73	8	60																
4-Aug	48	5										70	76	86	59	35	3	7										21	14	34	57	0	255	15	182	13	132	164	64
5-Aug	0			33	26	65	128	30	50	154	36	20	44	141	5	0	83	38	234	2	77	99	63																
6-Aug	115	386	11										49	70	9	21	84	125	2	76	107	0	10	45	25	313	1	62	159	84									

Year																						Daily Average
Date	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	1998-2017
7-Aug	56	206	48	16	67	83	17	51	39	37	9	21	40	0	5	29	26	146	3	15	78	47
8-Aug	0	1	17			34	62	14	41	1	14	37	98	0	0	13	66	266	6	112	89	46
9-Aug	56	7	3	13	62	58	39	28	18	5	15	74	135	0	0	19	54	180	1	34	86	42
10-Aug	40		30		28	18	147	37	12	9	5	32	61	0	8	46	27	215	1	33	34	41
11-Aug	29			9	30	11	38	14	33	22	22	64	11	2	0	39	17	177	8	64	130	38
12-Aug	25	4	4	2		82	22	16	15	48	9	31	4	0	3	17	20	132	113	64	49	33
13-Aug	24	14	3		42	22	31	16	70	6	21	13	9	0	0	27	33	83	111	50	31	30
14-Aug	17	3	1			40	12	65	7	10	18	13		0	3	32	11	65	68	147	6	29
15-Aug	13	3			36	41	21	18	5	11	3	37	9	5	2	12	9	75	40	55	7	21
16-Aug	9	3		23		44	9	18	16	5	3	61	10	0	4	20	17	66	67	127	17	27
17-Aug	12		3			32	14	7	8	4	0	17	17	0	10	3	9	130	73	104	116	31
18-Aug	0	3	5	4	11	15	6	41	11	10	9	16	4	0	1	8	11	94	44	95	58	21
19-Aug	0			5		9	1	17	16		2	14	6	3	0	7	10	44	56	44	73	18
20-Aug	0				19	3	7	9	9	4	1	15	5	1	0	4	12	62	19	37	70	15
21-Aug	0	1					7	7	6	2	1	8	3	0	0	5	7	60	33	37	34	12
22-Aug	0	2	1		15	2	0	9	10	8	2	9	2	0	0	0	6	32	27	42	55	11
23-Aug	0	4	1				1	12	3	8	0	4	2	0	0	2	1	34	8	35	43	9
24-Aug				1			7	3	1	1	0	5	5	2	0	1	3	41	32	34	93	14
25-Aug						10	0	10	3		0	5	0	0	0	3	0	62	23	43	41	13
26-Aug		7					13	6	1		0	1	0	0	0	0	2	32	20	23	9	8
27-Aug		2				9	28	5	1		1	1	0	0	0	0	0	39	22	10	42	10
28-Aug		6			1		15	0	4	2	0	0		0	0	0	1	25	19	16	21	7
29-Aug							3	4	0		0	4	0	1	0	0	0	15	15	20	12	5
30-Aug							4	2	3		0	0	0	0	0	0	1	12	17	19	15	5
31-Aug							0	5	0		0	0	2	0	0	3	0	24	10	11	6	4
1-Sep							1		0		0		0	0	0	0	0	5	3	11	10	2
2-Sep							0		0		0		0	2	1	3	0	9	5	16	6	4
3-Sep		3					3		0		0		0	0	0	3	0	9	10	9	2	3
4-Sep		7					1		0		0		0	0	0	1	0	5	1	4	2	2
5-Sep							0		0		0		0	0	0	0	0	9	4	6	11	3
6-Sep		1					0		0		0		0	0	0	2	0	2	9	4	4	2
7-Sep							0		0		0		0	0	0	0	1	2	10	3	4	2
8-Sep							0		0		0		0	0	1	1	1	6	7	4	3	2
9-Sep													0	0	0	2	0	3	4	0	0	1
10-Sep													1	0	0	0	1	0	0	2	0	0
11-Sep														0	0	0	0	0	5	2	0	1
12-Sep														0	0	1	0	2	7	3	1	2
13-Sep														0			0	1	10	1	1	3



Year																						Daily Average
Date	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	1998-2017
14-Sep														0			0	2	4	5	2	3
15-Sep	0													0	4	12	3	0	4			
16-Sep																	0	3	10	0	0	3
17-Sep	0																	4	10	0	1	3
18-Sep																	0	1	6	4	6	3
19-Sep	0																	3	8	0	0	2
20-Sep																	0	2	1	0	0	1
21-Sep	0																	4	10	1	1	3
22-Sep																	0	0	9	0	1	2
23-Sep	0																	0	5	1	0	1
24-Sep																	0	0	6	0	1	1
25-Sep	0																	2	10	8	0	4
26-Sep																	0		1	1	3	1
27-Sep	0																		6	1	0	2
28-Sep																	0		3	0	0	1
29-Sep	0																		5	2	0	2
30-Sep																	0		2		0	1
1-Oct	0																			0	0	
2-Oct																					0	0
3-Oct	0																					0
4-Oct																					0	0
5-Oct	0																					0
6-Oct																					0	0
7-Oct	0																					0
8-Oct																					0	0
9-Oct	0																					0
10-Oct																					0	0
11-Oct	1																					1
12-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	1,780	1,975

The total in the average column (1,975) is the average from all of the yearly totals (1998-2018).

**Appendix 1D.***Adult coho daily escapement counts by date, Sixmile Creek drainage, 2003-2018.*

Year																	Daily Average
Date	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2003-2018
5-Jul														0	0	0	0
6-Jul														0	0	0	0
7-Jul														0	0	0	0
8-Jul														0	0	0	0
9-Jul														0	0	0	0
10-Jul														0	0	0	0
11-Jul														0	0	0	0
12-Jul														0	0	0	0
13-Jul														0	0	0	0
14-Jul	0												0	0	0	0	0
15-Jul	0												0	0	0	0	0
16-Jul	0												0	0	0	0	0
17-Jul	0												0	0	0	0	0
18-Jul	0												0	0	0	0	0
19-Jul	0												0	0	0	0	0
20-Jul	0												0	0	0	0	0
21-Jul	0												0	0	0	0	0
22-Jul	0												0	0	0	0	0
23-Jul	0												0	1	0	0	0
24-Jul	0												0	0	0	0	0
25-Jul	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
26-Jul	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	1
27-Jul	0	0	1	0	0	0	3	0	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	0
29-Jul	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
30-Jul	0	0	5	0	0	0	0	0	0	0	0	0	3	0	0	0	1
31-Jul	0	0	0	1	0	1	0	0	0	0	0	0	4	0	0	0	0
1-Aug	0	0	0	0	0	3	0	0	0	0	0	0	13	0	0	0	1
2-Aug	0	0	0	0	0	0	4	0	0	0	0	1	8	0	0	0	1
3-Aug	0	0	0	0	0	2	0	0	0	4	0	0	10	0	0	0	1
4-Aug	2	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	1
5-Aug	0	0	0	1	0	1	1	0	0	3	0	0	16	0	0	0	1
6-Aug	0	0	4	0	0	0	1	2	0	2	0	0	12	1	0	0	1
7-Aug	1	0	0	0	1	0	2	0	0	4	0	0	4	0	0	9	1
8-Aug	0	0	0	0	0	0	6	0	0	0	0	0	9	2	0	42	2
9-Aug	0	0	1	0	1	5	21	3	0	1	0	2	10	0	1	5	5
10-Aug	0	0	0	1	0	1	5	2	0	2	0	0	7	0	0	4	1
11-Aug	1	0	0	2	0	0	6	1	0	6	3	1	9	0	0	134	1
12-Aug	0	0	0	11	2	0	3	2	0	0	1	0	24	0	0	23	11
13-Aug	0	0	0	7	1	0	0		0	3	1	1	22	0	0	8	4

14-Aug	1	0	0	0	2	5	2	1	0	3	1	0	22	0	0	7	3
15-Aug	0	0	0	4	0	4	3	1	0	15	3	2	11	0	0	5	2
16-Aug	0	0	0	2	2	0	7	0	0	17	4	1	5	0	1	0	3
17-Aug	0	0	0	4	4	1	20	0	0	6	1	1	17	1	1	0	3
18-Aug	0	0	0	3	0	2	21	0	3	0	0	0	18	0	1	0	3
19-Aug	1	0	0	5	0	0	20	1	0	0	0	1	27	2	0	0	4
20-Aug	0	0	0	1	0	1	18	0	1	7	0	0	8	14	0	0	3
21-Aug	0	0	0	3	2	0	4	0		0	1	1	4	8	2	3	3
22-Aug	0	0	0	6	1	0	3	0	0	0	0	1	5	0	0	0	1
23-Aug	0	0	1	0	0	0	2	0	2	0	3	1	6	0	0	3	1
24-Aug	1	0	2	4	0	0	11	0	0	0	1	0	17	0	0	1	2
25-Aug	0	0	1	6	0	0	0	0	0	0	0	0	9	0	0	0	2
26-Aug	1	0	0	4	0	1	0	0	0	0	0	1	3	2	1	1	1
27-Aug		0	0	4	1	0	5	0	0	4	0	2	4	0	0	1	1
28-Aug		0	0	0	0	0	2		1	0	0	3	5	0	0	0	2
29-Aug		1	0	0	0	0	0	0	0	1	1	0	14	3	0	2	2
30-Aug		0	1	0	0	0	1	0	0	1	1	0	27	1	0	0	2
31-Aug		0	0	0	0	0	0	0	0	0	0	2	118	1	1	0	8
1-Sep		0	0	0	0	0	0	0	1	0	1	0	0	0	4	0	0
2-Sep		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
3-Sep		0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
4-Sep		0	0	0	0	0	0	0	0	0	17	1	2	0	3	0	0
5-Sep		0	0	0	0	0	0	1	0	0	8	0	2	0	1	1	1
6-Sep		0	0	0	0	0	0	0	0	0	0	1	1	0	2	0	1
7-Sep		0	0	0	0	0	0	0	0	0	3	0	1	0	3	0	0
8-Sep		0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
9-Sep		0	0	0	0	0	0	0	0	0	0	1	1	0	6	0	0
10-Sep		0	0	0	0	0	0	0	0	0	1	4	3	0	0	0	1
11-Sep		0	0	0	0	0	0	0	0	0	0	2	1	0	1	0	0
12-Sep		0	0	0	0	0	0	0	0	0	0	6	1	6	1	0	1
13-Sep		0	0	0	0	0	0	0	0	0	0	0	0	2	4	2	0
14-Sep												0	2	2	1	1	1
15-Sep												3	2	0	2	1	0
16-Sep												1	4	0	2	0	1
17-Sep												0	2	4	3	0	2
18-Sep												0	3	2	4	4	2
19-Sep												0	4	0	2	4	2
20-Sep												1	0	2	4	0	2
21-Sep												0	0	0	2	4	0
22-Sep												1	2	1	1	0	2
23-Sep												0	0	3	0	0	1
24-Sep												0	2	2	2	2	1
25-Sep												0	0	1	0	3	1
26-Sep												0		3	0	2	2

27-Sep												0		2	0	0	1
28-Sep												0		0	0	0	0
29-Sep												0		0	0	1	1
30-Sep												0				1	0
1-Oct												0				0	1
2-Oct																0	0
3-Oct																0	0
4-Oct																0	0
5-Oct																0	0
6-Oct																0	0
7-Oct																0	0
8-Oct																0	0
9-Oct																0	0
10-Oct																3	0
11-Oct																2	3
12-Oct																0	2
Totals	8	1	16	69	17	27	178	18	8	79	54	44	527	67	61	279	91

The total in the average column (91) is the average from all of the yearly totals (2003-2018).

*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	0	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*

<b>Date</b>	<b>DO Daily Average</b>
9-May	13.5
10-May	13.8
11-May	13.9
12-May	14.1
13-May	14.8
14-May	14.9
15-May	14.4
16-May	15.3
17-May	15.3
18-May	14.7
19-May	15.4
20-May	15.5
21-May	15.5
22-May	15.5
23-May	15.7
24-May	16.4
25-May	15.9
26-May	15.9
27-May	15.1
28-May	15.6
29-May	14.9
30-May	14.8
31-May	15.6
1-Jun	14.9
2-Jun	14.6
3-Jun	14.3
4-Jun	14.0
5-Jun	14.1
6-Jun	14.1
7-Jun	14.6
8-Jun	13.7
9-Jun	13.5
10-Jun	13.3
11-Jun	12.8
12-Jun	13.4
13-Jun	12.8
14-Jun	12.9
15-Jun	12.2
16-Jun	11.9
17-Jun	11.9
18-Jun	12.2
19-Jun	12.5
20-Jun	13.0
21-Jun	12.6

22-Jun	12.1
23-Jun	12.1
24-Jun	11.8
25-Jun	12.0
26-Jun	12.1
27-Jun	12.6
28-Jun	13.6
29-Jun	12.2
30-Jun	11.7
1-Jul	12.0
2-Jul	12.0
3-Jul	11.5
4-Jul	11.6
5-Jul	12.3
6-Jul	11.9
7-Jul	11.7
8-Jul	10.4
9-Jul	9.7
10-Jul	9.7
11-Jul	10.2
12-Jul	9.8
13-Jul	10.0
14-Jul	10.0
15-Jul	10.9
16-Jul	10.5
17-Jul	11.1
18-Jul	10.9
19-Jul	11.1
20-Jul	10.7
21-Jul	11.2
22-Jul	11.2
23-Jul	11.0
24-Jul	11.3
25-Jul	10.6
26-Jul	10.8
27-Jul	11.2
28-Jul	10.8
29-Jul	11.2
30-Jul	11.4
31-Jul	11.3
1-Aug	11.3
2-Aug	10.8
3-Aug	11.2
4-Aug	11.1
5-Aug	10.5

6-Aug	9.8
7-Aug	8.9
8-Aug	9.7
9-Aug	10.4
10-Aug	10.1
11-Aug	10.8
12-Aug	11.0
13-Aug	10.4
14-Aug	9.7
15-Aug	9.5
16-Aug	10.3
17-Aug	10.3
18-Aug	10.4
19-Aug	11.4
20-Aug	11.1
21-Aug	10.7
22-Aug	10.1
23-Aug	10.4
24-Aug	11.4
25-Aug	10.4
26-Aug	12.0
27-Aug	11.8
28-Aug	11.4
29-Aug	11.6
30-Aug	11.9
31-Aug	11.3
1-Sep	11.5
2-Sep	11.3
3-Sep	12.0
4-Sep	13.0
5-Sep	12.8
6-Sep	12.9
7-Sep	13.9
8-Sep	14

9-Sep	13.6
10-Sep	13.8
11-Sep	13.9
12-Sep	13.7
13-Sep	13.9
14-Sep	14.2
15-Sep	14.6
16-Sep	14.8
17-Sep	14.6
18-Sep	14.2
19-Sep	14.1
20-Sep	14.6
21-Sep	14.0
22-Sep	13.2
23-Sep	12.6
24-Sep	11.7
25-Sep	11.2
26-Sep	11.2
27-Sep	12.0
28-Sep	12.1
29-Sep	12.5
30-Sep	12.8
1-Oct	13.2
2-Oct	13.2
3-Oct	13.3
4-Oct	13.3
5-Oct	13.2
6-Oct	13.6
7-Oct	13.8
8-Oct	13.8
9-Oct	14.0
10-Oct	13.6
11-Oct	12.7
12-Oct	12.7