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ABUNDANCE AND RUN TIMING OF SMOLT AND ADULT SALMON IN THE SIXMILE CREEK DRAINAGE ON JOINT BASE ELMENDORF-RICHARDSON, ALASKA, 2014

FINAL

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Abundance and Run Timing of Smolt and Adult Salmon in the Sixmile Creek Drainage on Joint Base Elmendorf-Richardson, Alaska, 2014

Prepared for:

673rd Civil Engineer Squadron, Civil Engineer Installation Management,

Environmental, Conservation Section

Prepared by:

Jessica Johnson
Research Associate II: Fisheries Biologist

Krystina Bottom
Fisheries Technician

Colorado State University
Center for Environmental Management of Military Lands

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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
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
United States Army Corp of Engineers	USACE
Width	w

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Abstract

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 (*Thaleichtys 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). The Sixmile drainage, located on Joint Base Elmendorf-Richardson (JBER), produces sockeye (*O. nerka*), coho (*O. kisutch*), chum (*O. keta*) and pink (*O. gorbuscha*) salmon. These salmon are likely food sources for the beluga whales and are part of a small sport fishery. Thus, monitoring these populations is a necessity for JBER.

A fyke weir was used to enumerate smolt, and a weir was used to enumerate adult salmon at the outlet of Lower Sixmile Lake using the same methodology that was used in 2013 (CEIEC 2013). Two stream surveys were also conducted below the weir location to get an index of the pink salmon and any other salmonids that might be spawning in the creek.

The estimated smolt out-migration for 2014 for sockeye was 13,760, and for coho it was 3,996. The 95th percentile of sockeye smolt in the previous years' cumulative average was reached on 24 June, while this year's 95th percentile of cumulative sockeye smolt was reached on 7 June. The 95th percentile of coho was reached on 7 June, which is 10 days earlier than the cumulative previous years' average.

1,638 adult sockeye and 44 adult coho were enumerated using the weir in 2014. For adult sockeye, this is lower than the previous 15-year cumulative average of 1,768 salmon. The 2014 adult coho cumulative escapement was slightly lower compared to the average for the last nine years.

Current management recommendations for this system are: (1) continue to monitor the out-migrating smolt salmon and the returning adult salmon, (2) extend the adult salmon sampling period to ensure a more representative count of cohos occurs, (3) continue monitoring the water temperature, and (4) replace the current fish ladder.

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 (*Thaleichtys 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 all of the Pacific salmon species with the exception of pink salmon (*O. grobuscha*). The Sixmile drainage, located on Joint Base Elmendorf-Richardson (JBER), produces sockeye (*O. nerka*), coho (*O. kisutch*), chum (*O. keta*) and pink salmon. Belugas are commonly seen milling at the mouth of Sixmile during the fall, and it is assumed that they are foraging for salmon returning to the creek. Monitoring productivity of this population is important in terms of the beluga (i.e., PCE productivity) as well as for management of the small sport fishery at the mouth.

The Sixmile Creek drainage (Figure 1), located in south-central Alaska, consists of Upper and Lower Sixmile lakes and Sixmile Creek on JBER. The lakes were created in 1951 when Sixmile Creek was dammed in two locations (Abbott and Allgair n.d.) to create a floatplane base. The first records of sockeye salmon (*Oncorhynchus nerka*) in 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 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 had been enumerated from the Sixmile lakes. Since 2003, enumeration of the out-migrating smolt has been sporadic.

Historically, smolts have been counted out-migrating from Lower Sixmile Lake from mid-May through June. Sixmile smolt out-migration includes sockeye and coho salmon, while pink salmon spawn below the lake, and chum salmon occasionally spawn in the creek[1]. Sockeye salmon smolts are the most abundant species with annual counts ranging from 4,037 – 23,644, while counts of coho salmon smolt have ranged from 23 – 3,996 fish.

In 1988, the Conservation and Planning Element of the Environmental Flight, 3rd Civil Engineering Squadron began monitoring the returning adult salmon using a weir and continued to monitor them through 2008. 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,

[1] Thus, the vast majority of juvenile pink and chum would not pass through the fyke weir to allow enumeration.

JBER Environmental Conservation Section (CEIEC) once again operated the weir and collected salmon escapement data.

The Sixmile Creek adult weir is operable by mid-July, with biologists, technicians, and volunteers counting and releasing salmon until mid-September. Four out of the five North American Pacific salmon species can be found spawning in the Sixmile Creek drainage. Sockeye, coho, and a small fraction of the pink salmon can be enumerated at the weir. Chum salmon and pink salmon spawn primarily in the creek; thus, a stream walk is necessary to enumerate their spawning numbers. Sockeye salmon are the most abundant species with annual counts ranging from 317 – 4,034, while counts of coho salmon have ranged from 1 – 178 fish.

Objective

The primary objective of this project was to enumerate the out-migrating sockeye smolt and the adult sockeye salmon returning to the Sixmile Creek drainage to spawn. The secondary objective was to maintain the historical database and evaluate long-term salmon population trends.

Study Site

The Sixmile Creek drainage covers 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 charged primarily by groundwater entering the south side of Upper Sixmile Lake. The lakes are approximately 3.4 kilometers (km) in length. Sixmile Creek flows approximately 1.5 km from Lower Sixmile Lake into the Knik Arm of the Cook Inlet.

During 1975, when sockeye were first recorded in Sixmile Creek drainage, 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 then revamped in 2004 to add a beaver baffler to prevent beaver 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). Since 1998, the adult weir has been located at the outflow of Lower Sixmile Lake under the Fairchild Avenue Bridge. This site is where both the adult weir and smolt weir are located.

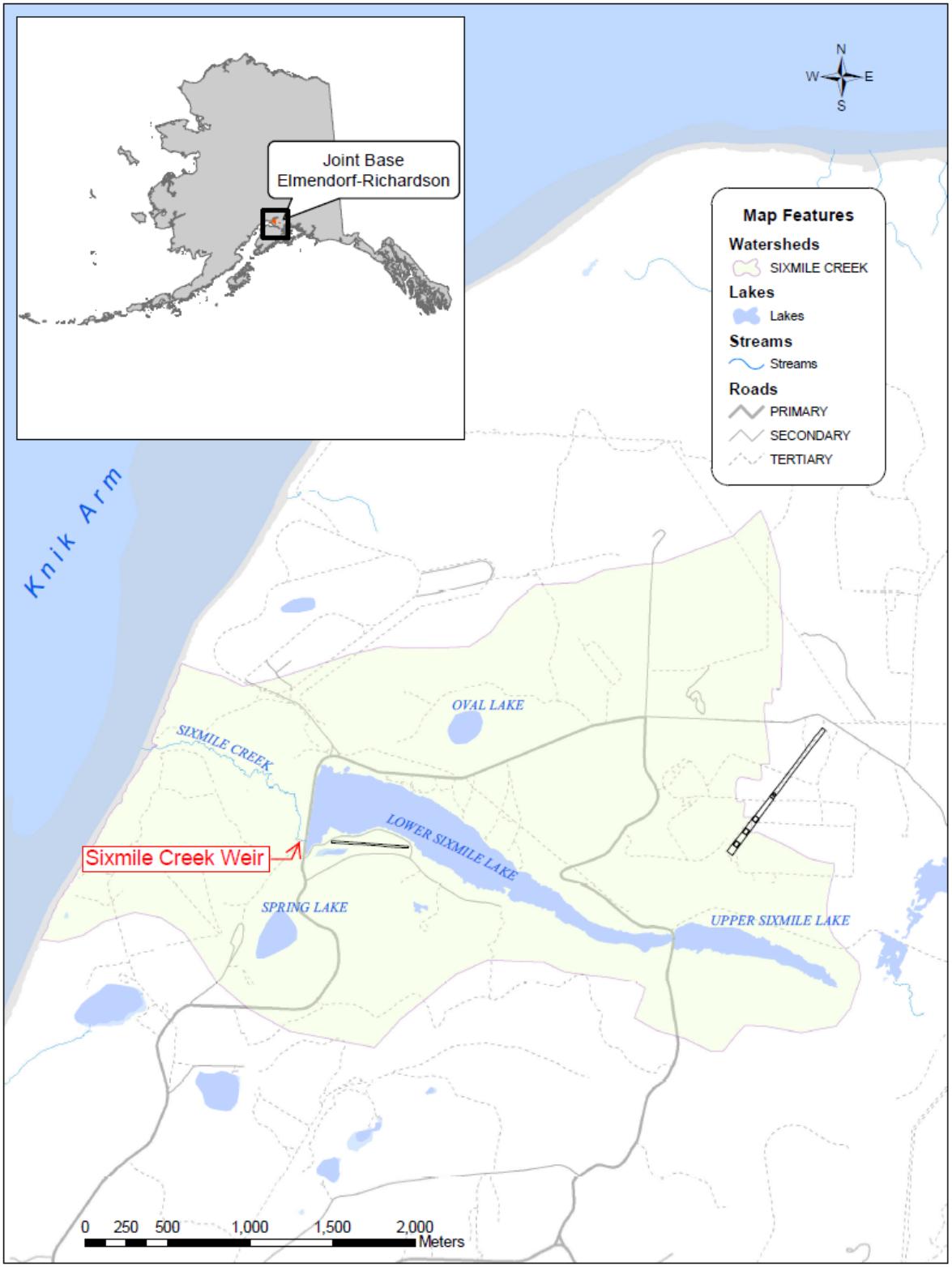

Figure 1. The Sixmile Creek drainage on JBER, AK (Gumpert 2011).

Methods

Smolt Weir Design and Operation

Sockeye and coho salmon smolt out-migrating from the Sixmile lakes are typically counted from mid-May through the end of June. In 2014, the smolts were enumerated from 20 May through 30 June.

The smolts were captured by use of a weir with a live box, which was checked at least twice daily. The weir consisted of four 4’ x 8’ panels that spanned from the bridge abutment; this ensured that the entire stream width was effectively fished. These panels were made out of aluminum frame covered in poly vinyl mesh netting. The panels narrowed to a cylindrical entrance into a rectangular aluminum box with 1.0 m x 0.85 m x 0.80 m (L x W x H) dimensions. The panels were inspected daily by the sampling crew for gaps that could allow smolt to pass through undetected. Water temperature, in Celsius (°C), was collected on a daily basis.

Adult Weir Design and Operation

Adult sockeye, coho, and a few pink salmon were counted and released in to Lower Sixmile Lake. The adult salmon counts typically occur between mid-July and mid-September. In 2014, adults were counted from 14 July until 1 October. A custom mobile picket weir with a gate that can be lifted to allow controlled fish passage was used for the first time this year. The weir was visually inspected daily to ensure that there were no gaps that would allow salmon to pass through undetected and also cleaned of debris. For the majority of the season, 14 July through 4 September, the weir was checked twice a day. Later in the season, there were less fish so the weir was only checked once a day. Before the gate was opened to pass fish, the exit of the fish ladder was blocked so that fish were unable to escape downstream. A beach seine net was used to school the fish through the open gate where they were identified and counted. Water temperature, in °C, was collected at the site on a daily basis.

Genetics Collection

As part of the ADF&G Fish Resource Permit, genetic samples were collected from adult coho before being counted and released into the lake. Using dog nail clippers, the axillary process was clipped and placed into a labeled bottle of ethanol for preservation. A count for the amount of fin clips collected was recorded. The preserved fin clips were given to ADF&G for analysis.

Stream Surveys

Two stream surveys for adult salmon, both alive and dead, were conducted on foot. These surveys started at the mouth of Sixmile Creek, from Knik Arm tide line up to the weir at the outfall of Lower Sixmile Lake (approximately 1.5 km). The first quarter of the creek walk, the crew was forced to walk in the creek due to the steep banks and thick vegetation. The second quarter of the walk required the crew to walk along the bank on either side of the creek. The third quarter of the walk took the crew through a meadow where the stream was too deep to walk in, therefore, the crew walked along the bank. It should be noted that, in the meadow, it is difficult to see the salmon because of bank overhangs and tall grasses along the bank. During the final quarter of the walk, the crew was able to walk along the bank in most of the areas, but there were a few areas where it was necessary for the crew to walk in the creek. The crew consisted of a minimum of three people. One person wearing polarized sunglasses continually counted fish in the creek and the carcasses along the creek. The other two personnel were surveying the area for bears. Personnel looking for bears occasionally helped spot and count fish. The first survey is usually conducted in mid-August, at the peak of the pink salmon return, and the second is usually completed in the end of September. The second survey is done on the last day of the weir operation for the season.

Data Analysis

CEIEC maintains two historical databases, one for the enumeration of the out-migrating smolt and the other for the enumeration of the returning adults. The total number of smolt and adult sockeye and coho were added to their representative database. Graphs depicting cumulative and daily counts for 2014, for both the smolt and adults, were compared to previous years' average counts. Water temperature was graphed alongside the daily smolt counts for 2014 and the daily average smolt counts for previous years, in order to illustrate whether a correlation existed.

Results

Smolt Weir

The weir was fully operational at 1400 hours on 20 May 2014, with no fish counted. The first smolt counted for the season was one sockeye smolt on 21 May. Sockeye smolt were still being counted on 30 June, the last day of the operation. The first coho smolt was counted on 21 May, while the last one was counted on 30 June (Table 1). A total of 13,760 sockeye and 3,996 coho were counted for the year. The weir was checked at least twice daily, if not three times a

day, depending on the number of smolt out-migrating. The average water temperature during the smolt out-migration was 16.0 °C. Anchorage experienced an earlier than average spring in 2014 which attributed to a higher observed early summer ambient temperature and therefore a higher observed water temperature. To maintain consistency with the historical data, the weir was removed on 30 June 2014 at 1045 hours.

Table 1. Smolt daily and cumulative counts of sockeye and coho salmon at the Sixmile Creek weir, JBER 2014.

		Sockeye		**Coho**	
Date	*Temp (°C)*	*Daily*	*Cumulative*	*Daily*	*Cumulative*
21-May	15	3	3	19	19
22-May	15.5	1086	1089	263	282
23-May	15.5	3987	5076	447	729
24-May	15.5	641	5717	103	832
25-May	16	162	5879	88	920
26-May	14.5	309	6188	73	993
27-May	15.5	121	6309	28	1021
28-May	15.5	196	6505	82	1103
29-May	15.5	368	6873	51	1154
30-May	15	2	6875	41	1195
31-May	14	2095	8970	153	1348
1-Jun	13	56	9026	230	1578
2-Jun	13.5	49	9075	145	1723
3-Jun	13.5	448	9523	1004	2727
4-Jun	15	810	10333	363	3090
5-Jun	16	155	10488	202	3292
6-Jun	17	38	10526	390	3682
7-Jun	17	2782	13308	123	3805
8-Jun	16	58	13366	54	3859
9-Jun	17	358	13724	76	3935
10-Jun	17	0	13724	0	3935
11-Jun	16.5	10	13734	12	3947
12-Jun	17	1	13735	4	3951
13-Jun	16	0	13735	0	3951
14-Jun	15	1	13736	0	3951
15-Jun	15.5	0	13736	0	3951
16-Jun	16	0	13736	1	3952
17-Jun	16	0	13736	0	3952
18-Jun	16	1	13737	0	3952

		Sockeye		Coho	
Date	*Temp (°C)*	*Daily*	*Cumulative*	*Date*	*Temp (°C)*
19-Jun	17	0	13737	0	3952
20-Jun	17	0	13737	1	3953
21-Jun	17	0	13737	1	3954
22-Jun	16	0	13737	18	3972
23-Jun	17.5	6	13743	0	3972
24-Jun	18.5	5	13748	0	3972
25-Jun	18	0	13748	2	3974
26-Jun	17.5	2	13750	0	3974
27-Jun	17	0	13750	0	3974
28-Jun	17	1	13751	0	3974
29-Jun	19.5	5	13756	19	3993
30-Jun	18.5	4	13760	3	3996
TOTALS	**16.1 Average**		**13,760**		**3,996**

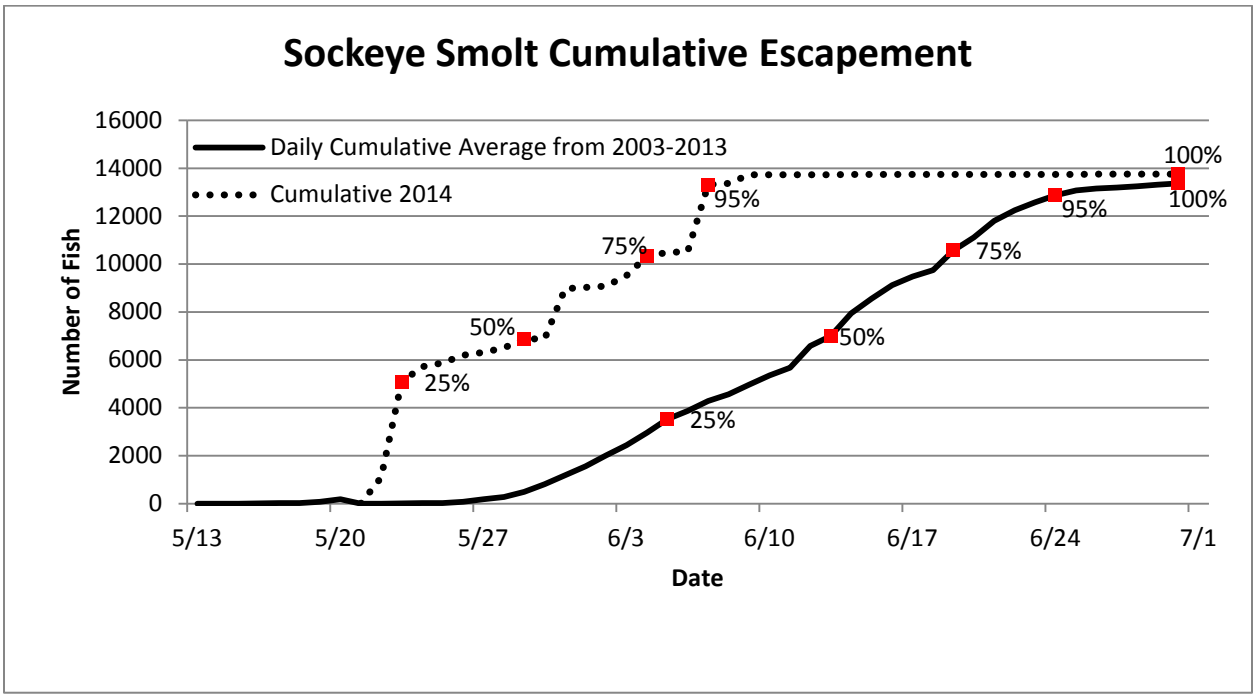

Figure 2. Daily cumulative comparison of 2014 sockeye out-migration and the average from 2003-2013.

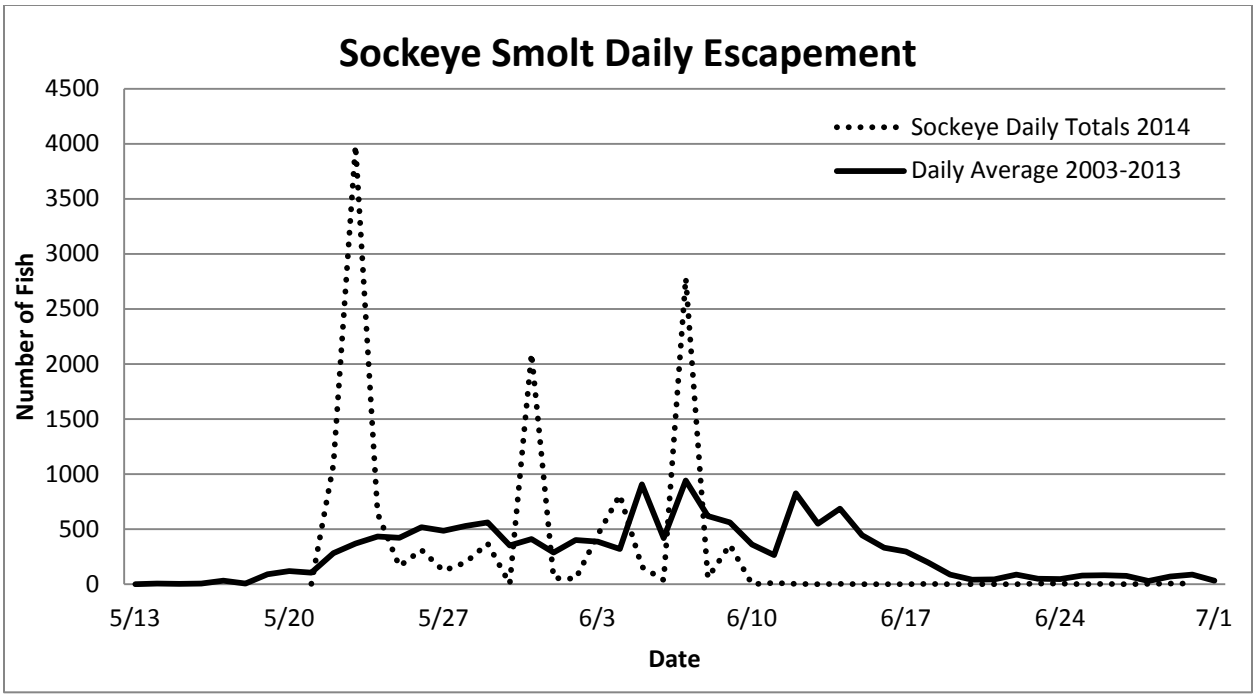

Figure 3. Daily comparison of 2014 sockeye out-migration and the average from 2003-2013.

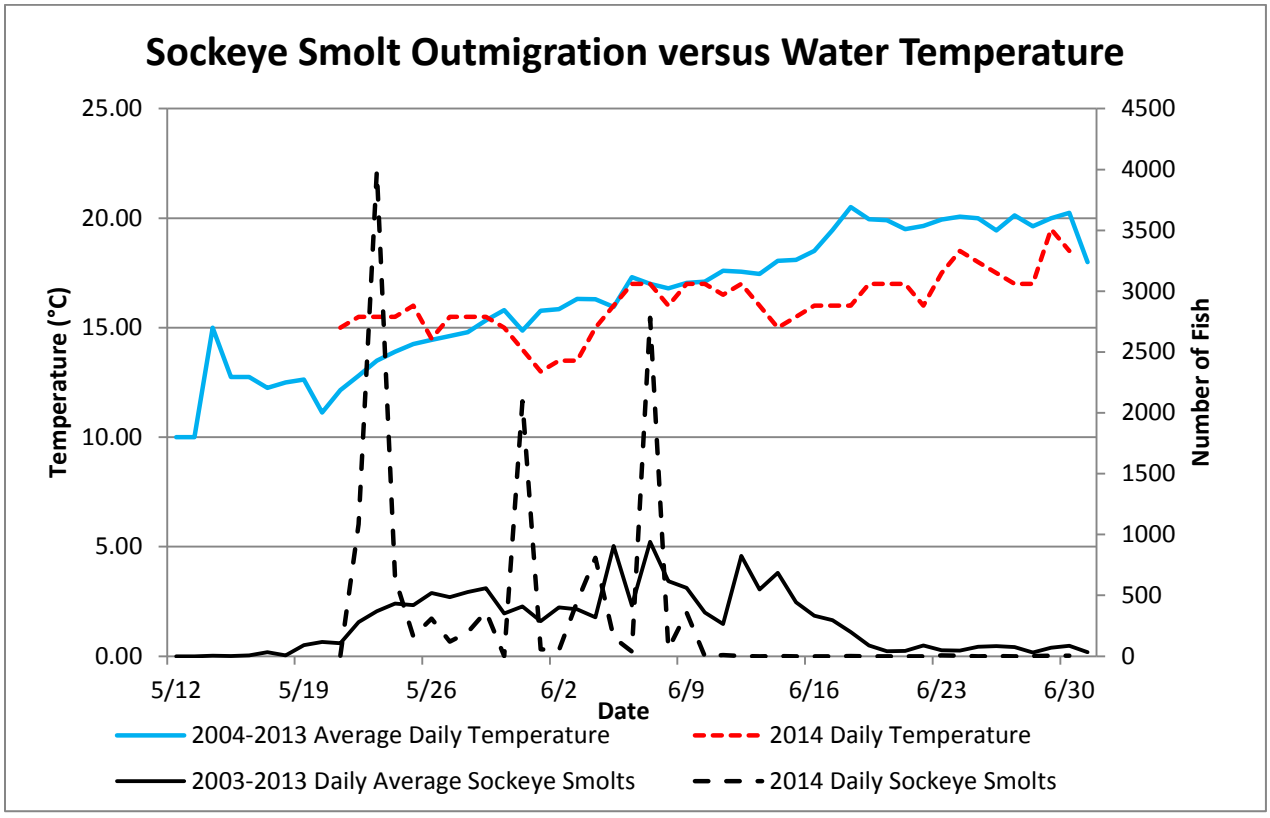

Figure 4. A comparison of 2014 and daily average 2003-2013 sockeye smolt counts to the water temperature for each relative timeframe.

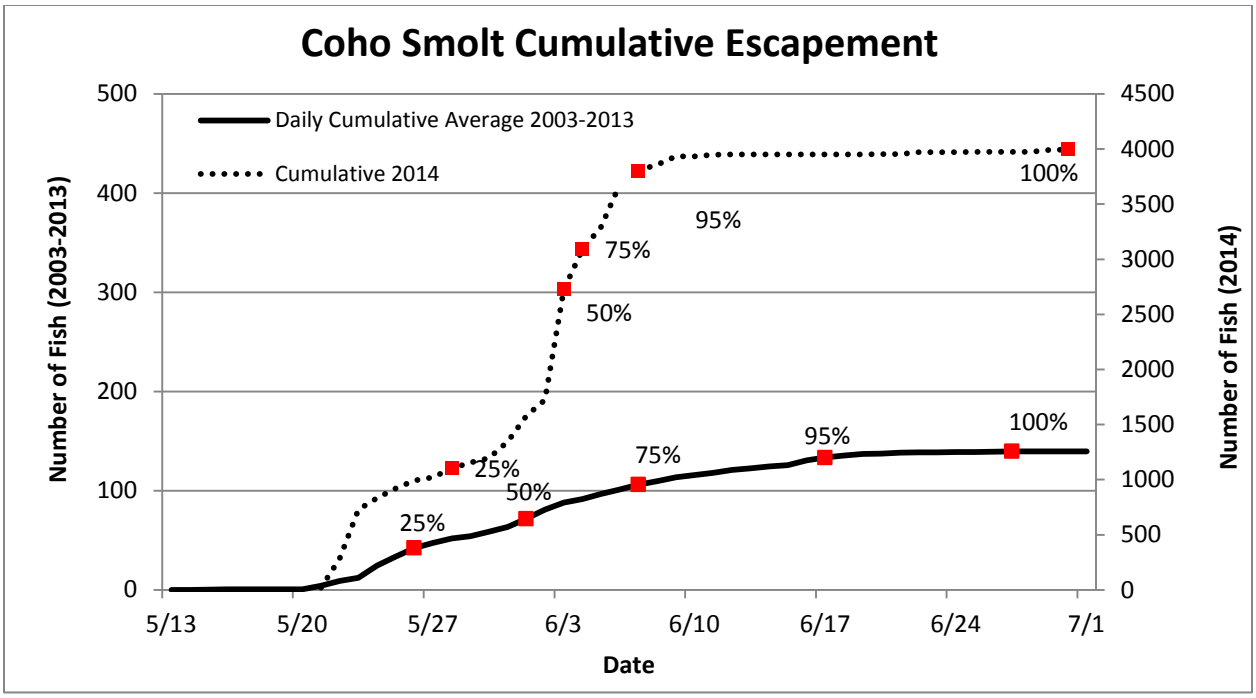

Figure 5. Daily cumulative comparison of 2014 coho out-migration and the average from 2003-2013.[2,3] *Coho smolt numbers in 2014 had a 2,853% increase from previous year averages and required its own axis in order to show comparative differences.

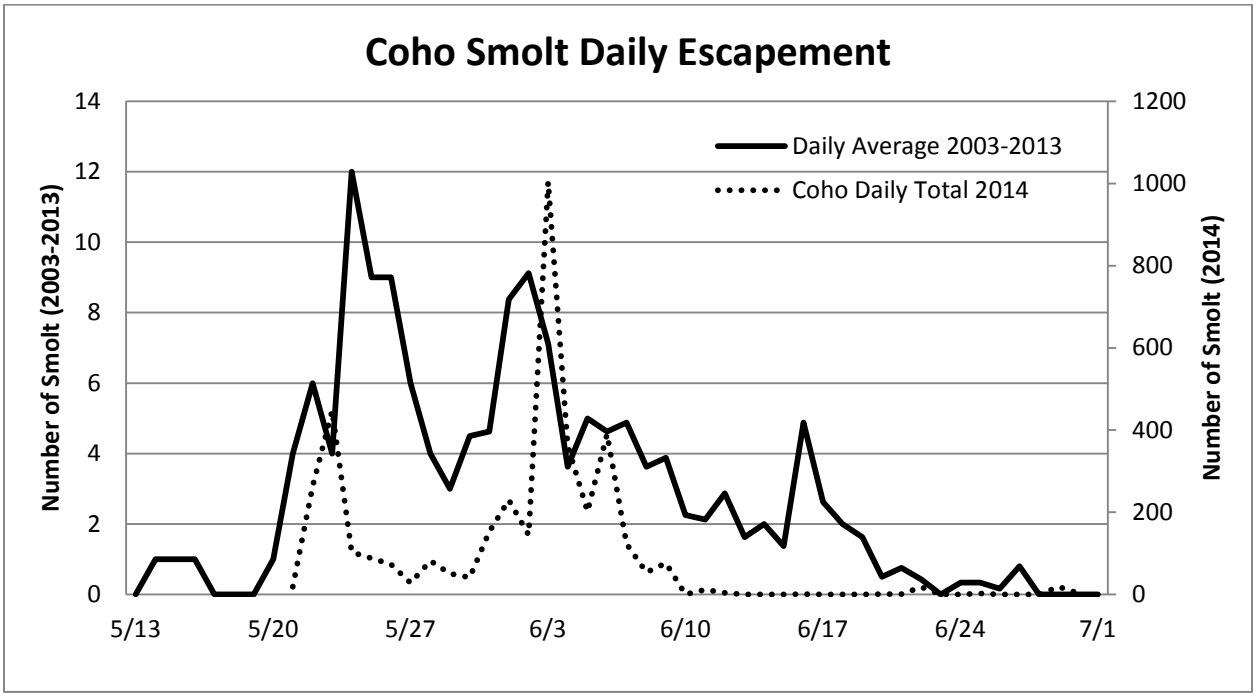

Figure 6. Daily comparison of 2014 coho out-migration and the average from 2003-2013.

[2] Note that not all years from 2003-2013 were sampled for smolt. See Appendix 1 for years sampled.
[3] Note coho salmon have not always been counted and recorded.

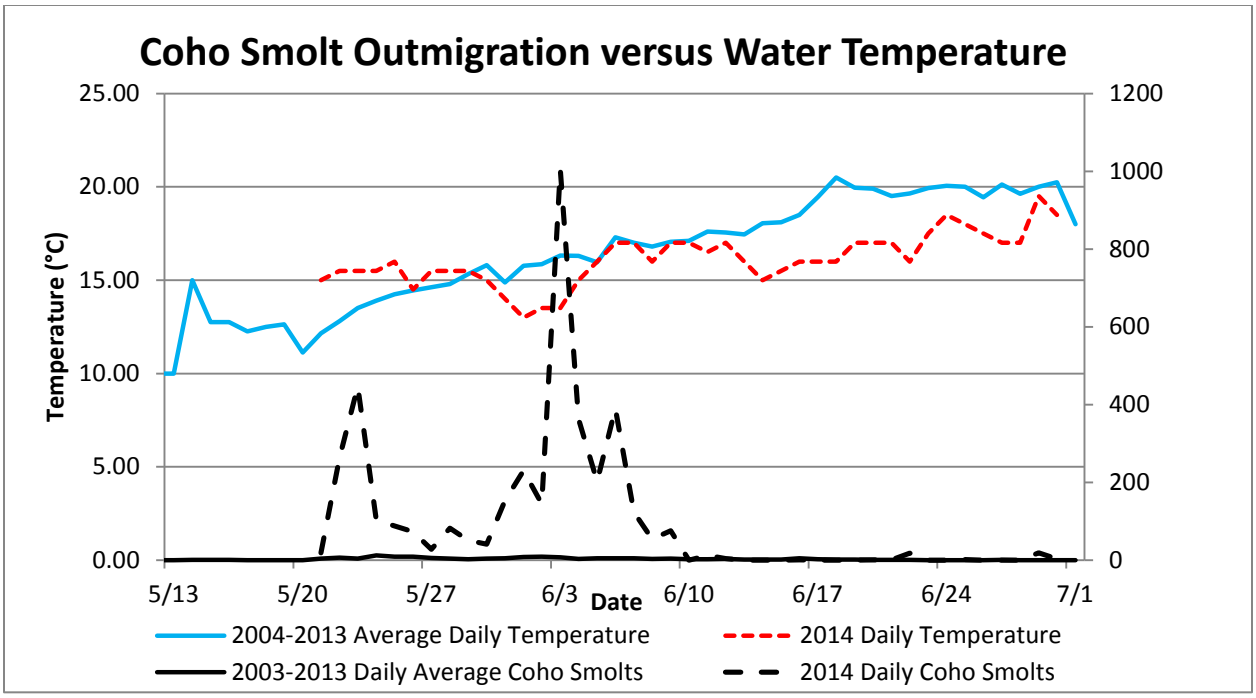

Figure 7. A comparison of 2014 and Daily average 2003-2013 coho smolt counts to the water temperature for each relative timeframe.

Adult Stream Surveys

The first survey was conducted on 21 August, from 0945-1142, with foggy skies. The second survey was conducted on 1 October, from 0950-1100, with clear skies. During both surveys, living and dead salmon were counted. A total of 57 sockeye, 3,733 pink, 24 coho, and 188 unknown salmon were counted during both of these surveys (Table 2). These numbers likely under-represent the true number of salmon that actually spawned below the weir due to the potential for missing salmon during the surveys (e.g., fish positioned behind logs or under banks, and carcasses pulled into the brush) and missing salmon between the surveys due to predators or the salmon had already spawned and left the system. The first survey was conducted during what is thought to be the peak of the pink salmon run, while the second survey was conducted during what is thought to be the end of the pink salmon run.

Table 2. Results of the 2014 adult stream surveys.

Date	Sockeye		Pink		Coho		Unknown	
	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead
21-Aug	40	4	3,624	104	6	0	0	69
1-Oct	9	4	0	5	13	5	0	119
Total	**49**	**8**	**3,624**	**109**	**19**	**5**	**0**	**188**

Adult Weir Data

The weir was fully operational at 1215 hours on 14 July 2014. This was the first year that there was an emphasis on counting adult coho salmon, therefore; the weir was operated until 1 October 2014. Adult salmon were counted at the weir from 14 July until 1 October, with a total of 1,638 sockeye, 44 coho, 29 pink, and zero chum passing through the weir. The first sockeye passed the weir on 21 July, and the last sockeye passed the weir on 10 September (Table 3). The first coho passed through the weir on 25 July and the last coho passed the weir on 24 September (Table 3). After operation had stopped for the season, coho salmon could still be observed in the creek, below the ladder into early November. No major problems occurred during the time that the weir was in use. The weir was removed at 1419 hours on 1 October, immediately following the second adult stream survey.

The average water temperature for the 2014 adult enumeration was 17.3 °C. This year showed a higher than average ambient temperature early in the season (April-May), causing the temperature to increase only gradually throughout the summer (National Weather Service 2014). 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).

Table 3. Adult daily and cumulative counts of sockeye and coho salmon at the Sixmile Creek weir, JBER 2014.

		Sockeye		**Coho**	
Date	*Temp (°C)*	*Daily*	*Cumulative*	*Daily*	*Cumulative*
14-Jul	-	0	0	0	0
15-Jul	-	0	0	0	0
16-Jul	-	0	0	0	0
17-Jul	20	0	0	0	0
18-Jul	20.5	0	0	0	0
19-Jul	21	0	0	0	0
20-Jul	21	0	0	0	0
21-Jul	20	469	469	0	0
22-Jul	20	69	538	0	0
23-Jul	20	142	680	0	0
24-Jul	20.5	122	802	0	0
25-Jul	19	111	913	1	1
26-Jul	20	48	961	0	1
27-Jul	20.5	30	991	0	1
28-Jul	20	61	1052	0	1

		Sockeye		Coho	
Date	*Temp (°C)*	*Daily*	*Cumulative*	*Daily*	*Cumulative*
29-Jul	19.5	27	1079	0	1
30-Jul	19.5	51	1130	0	1
31-Jul	20	49	1179	0	1
1-Aug	20.25	16	1195	0	1
2-Aug	20.5	9	1204	1	2
3-Aug	20.5	10	1214	0	2
4-Aug	21	15	1229	0	2
5-Aug	20.5	35	1267	0	2
6-Aug	20	25	1292	0	2
7-Aug	20	26	1318	0	2
8-Aug	19	66	1384	0	2
9-Aug	18.5	54	1438	2	4
10-Aug	19.5	27	1465	0	4
11-Aug	19	17	1482	1	5
12-Aug	19	20	1502	1	6
13-Aug	19.5	33	1535	0	6
14-Aug	17.5	11	1546	1	7
15-Aug	17.25	9	1555	0	7
16-Aug	17.5	17	1572	2	9
17-Aug	17	9	1581	1	10
18-Aug	16.75	11	1592	1	11
19-Aug	17.5	10	1602	0	11
20-Aug	17.5	12	1614	1	12
21-Aug	18.75	7	1621	0	12
22-Aug	18	6	1627	1	13
23-Aug	18.25	1	1628	1	14
24-Aug	17.75	3	1631	1	15
25-Aug	17	0	1631	0	15
26-Aug	16.75	2	1633	0	15
27-Aug	16.75	0	1633	1	16
28-Aug	16.5	1	1634	2	18
29-Aug	16.5	0	1634	3	21
30-Aug	15.75	1	1635	0	21
31-Aug	15.5	0	1635	0	21
1-Sep	15	0	1635	2	23
2-Sep	14.5	0	1635	0	23
3-Sep	15	0	1635	0	23
4-Sep	14.25	0	1635	0	23
5-Sep	14	0	1635	1	24
6-Sep	13.5	0	1635	0	24

		Sockeye		Coho	
Date	*Temp (°C)*	*Daily*	*Cumulative*	*Daily*	*Cumulative*
7-Sep	13	1	1636	1	25
8-Sep	13.5	1	1637	0	25
9-Sep	14	0	1637	0	25
10-Sep	14	1	1638	0	25
11-Sep	13	0	1638	1	26
12-Sep	13.5	0	1638	4	30
13-Sep	13.5	0	1638	2	32
14-Sep	13.5	0	1638	6	38
15-Sep	13	0	1638	0	38
16-Sep	13	0	1638	0	38
17-Sep	13	0	1638	3	41
18-Sep	13	0	1638	1	42
19-Sep	12	0	1638	0	42
20-Sep	13	0	1638	0	42
21-Sep	12	0	1638	0	42
22-Sep	12	0	1638	1	43
23-Sep	12	0	1638	0	43
24-Sep	10.5	0	1638	1	44
25-Sep	10.5	0	1638	0	44
26-Sep	10	0	1638	0	44
27-Sep	10	0	1638	0	44
28-Sep	10	0	1638	0	44
29-Sep	8.5	0	1638	0	44
30-Sep	7.5	0	1638	0	44
1-Oct	-	0	1638	0	44
TOTALS	**17.3 Average**		**1638**		**44**

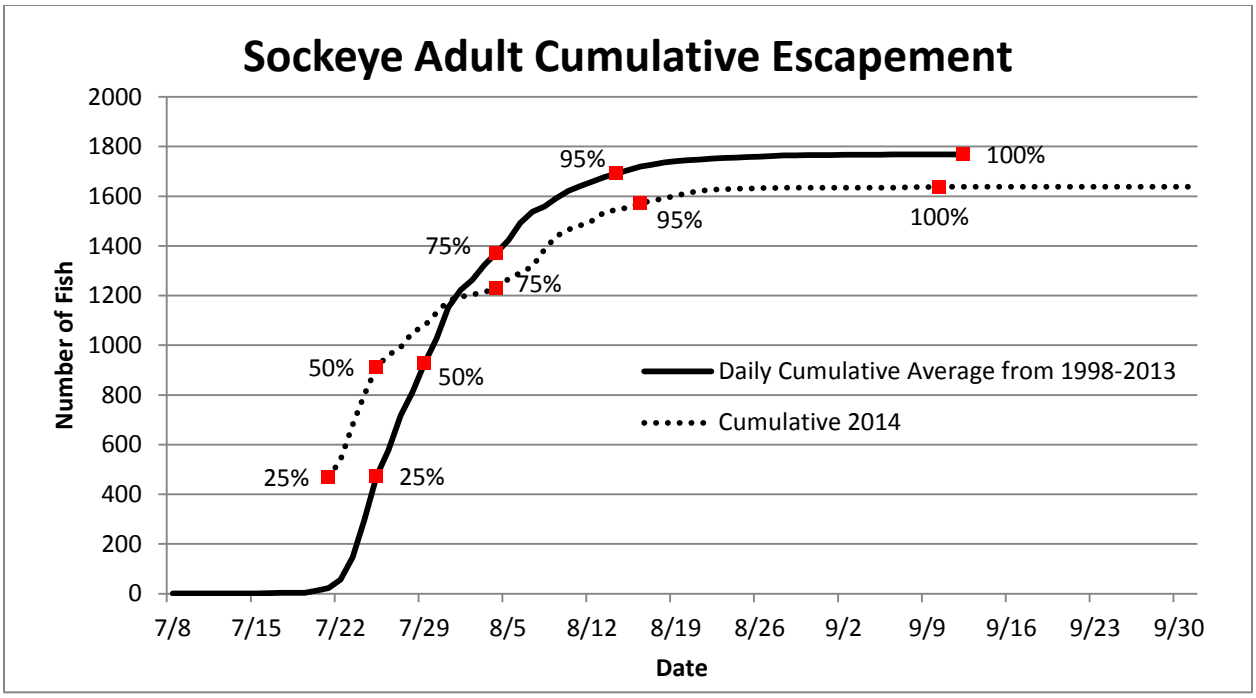

Figure 8. Comparison of cumulative for the 2014 sockeye run and the average cumulative from 1998-2013.

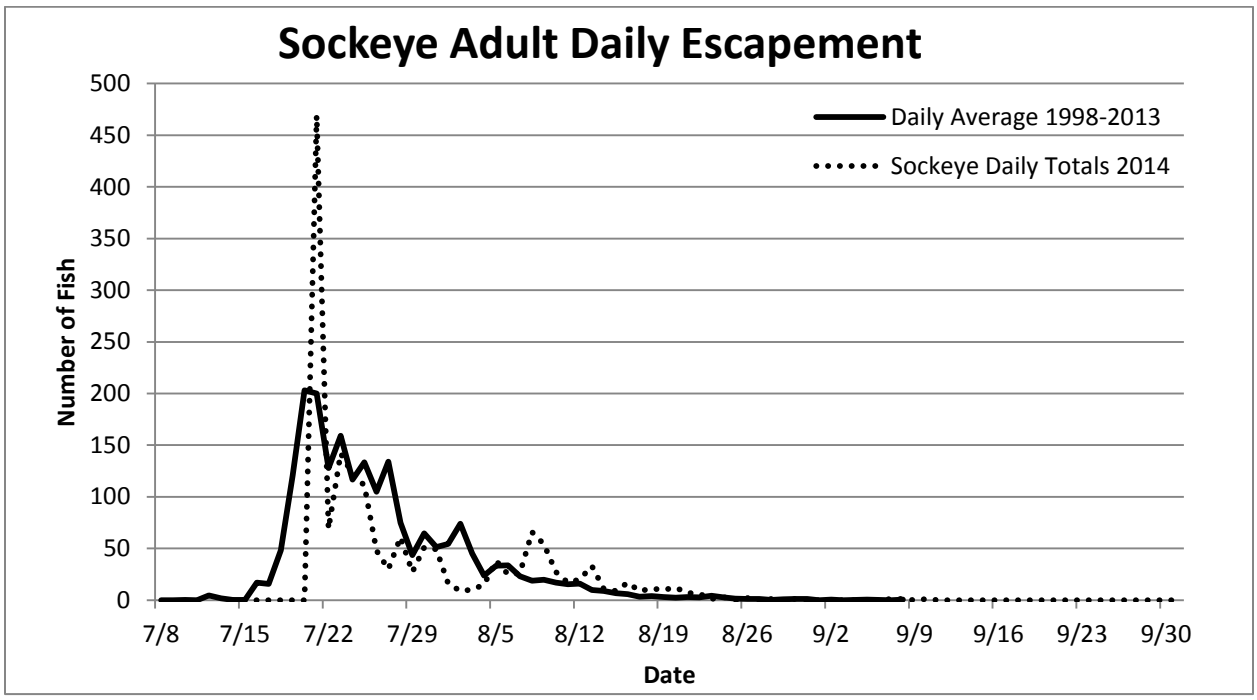

Figure 9. Comparison of daily totals from the 2014 sockeye run and the average from 1998-2013.

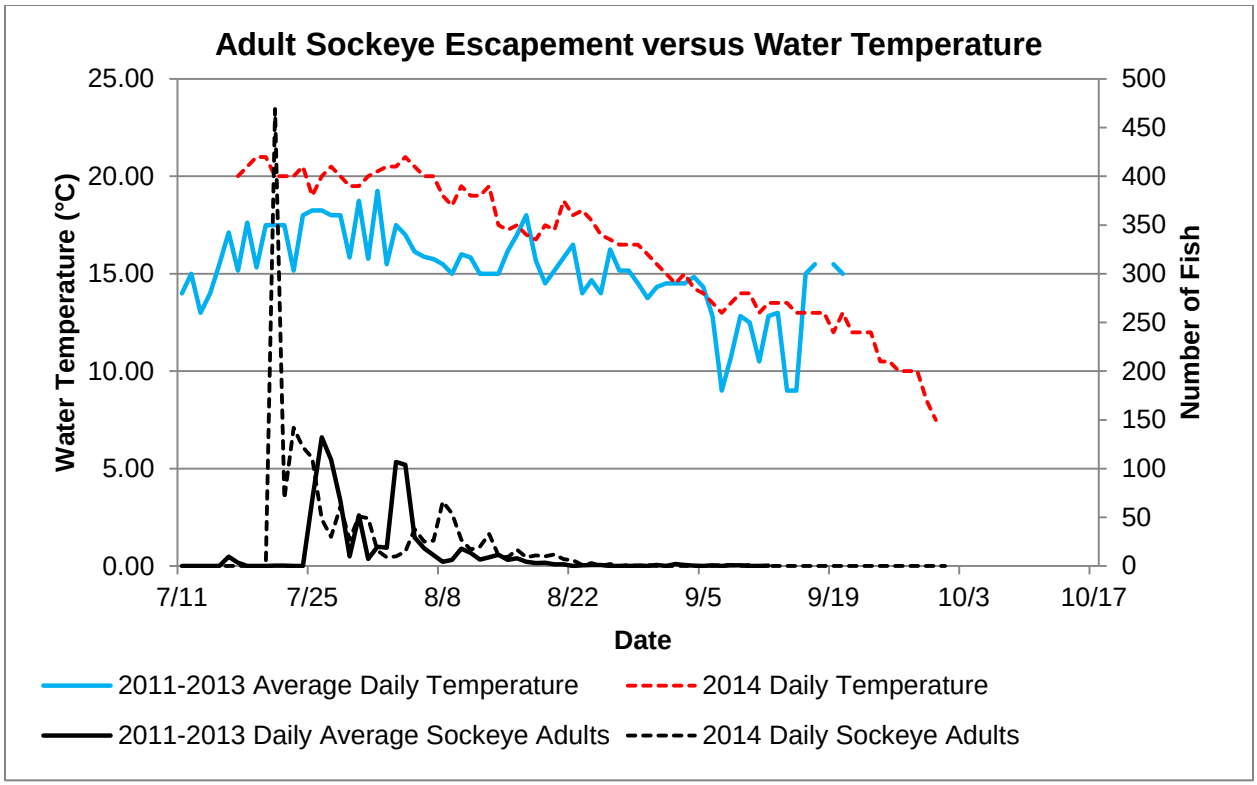

Figure 10. A comparison of 2014 and daily average 2003-2013 sockeye adult counts to the water temperature for each relative timeframe.

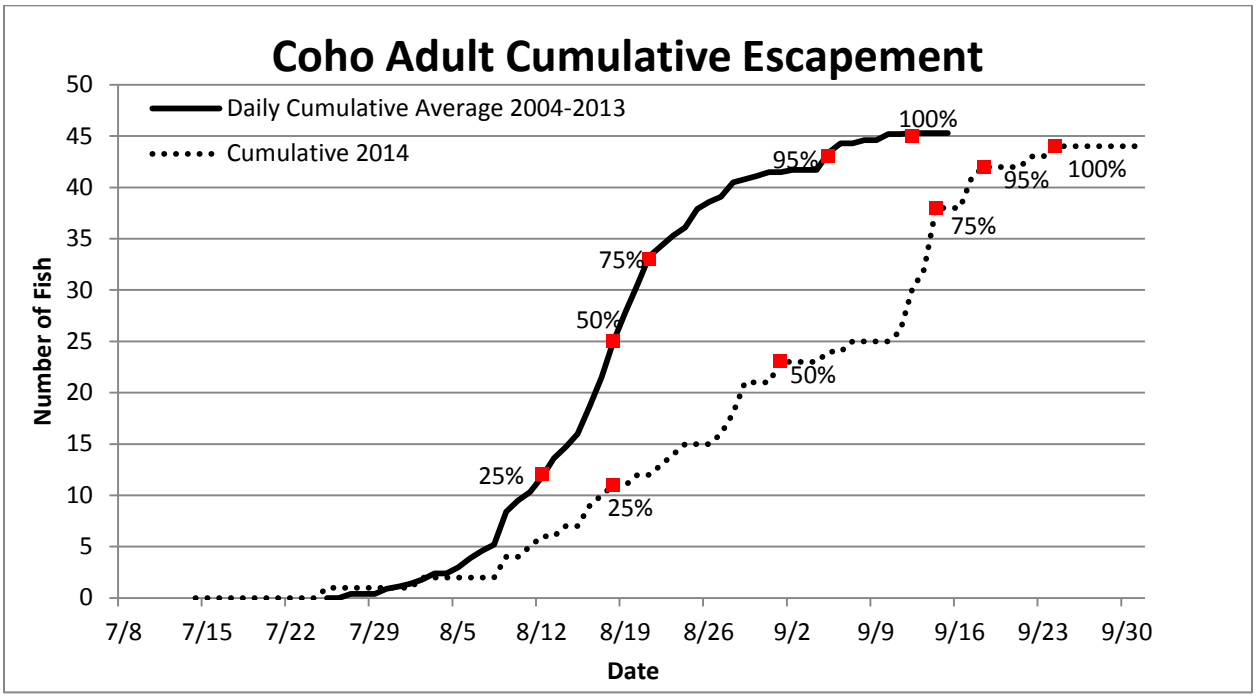

Figure 11. Comparison of cumulative for the 2014 coho run and the average cumulative from 2004-2013[4].

[4] This was the first year that a comprehensive adult coho survey was conducted.

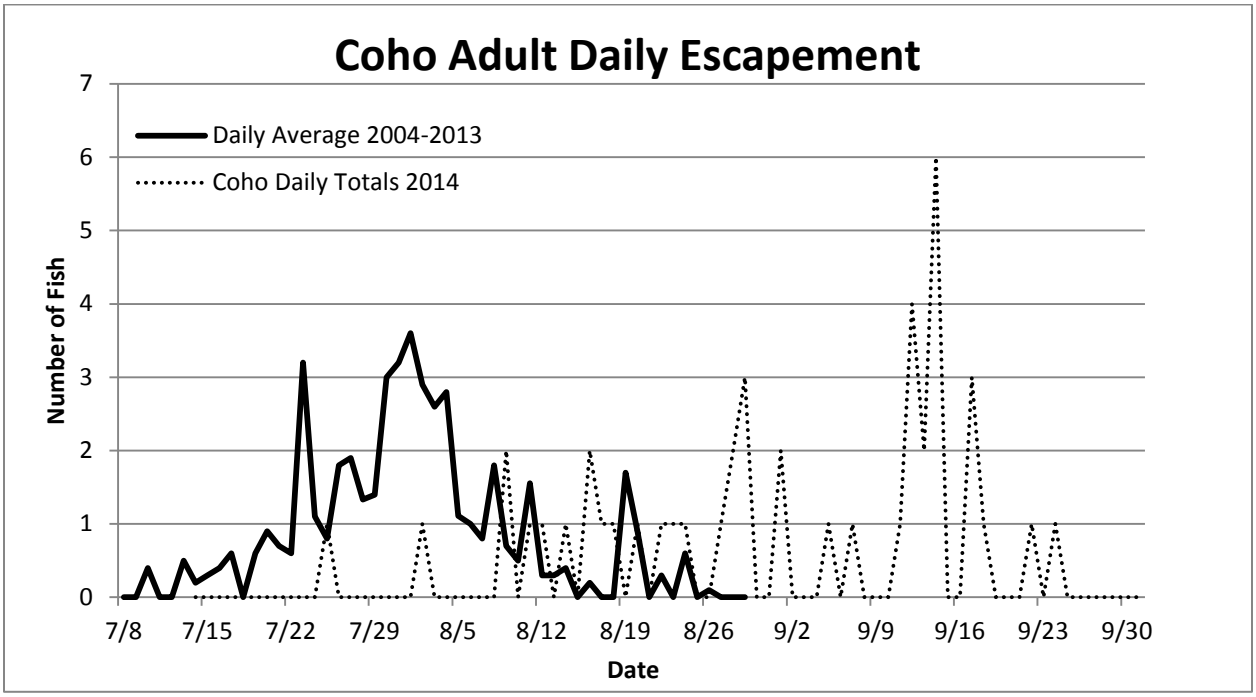

Figure 12. Comparison of daily totals from the 2014 coho run and the average from 2004-2013.

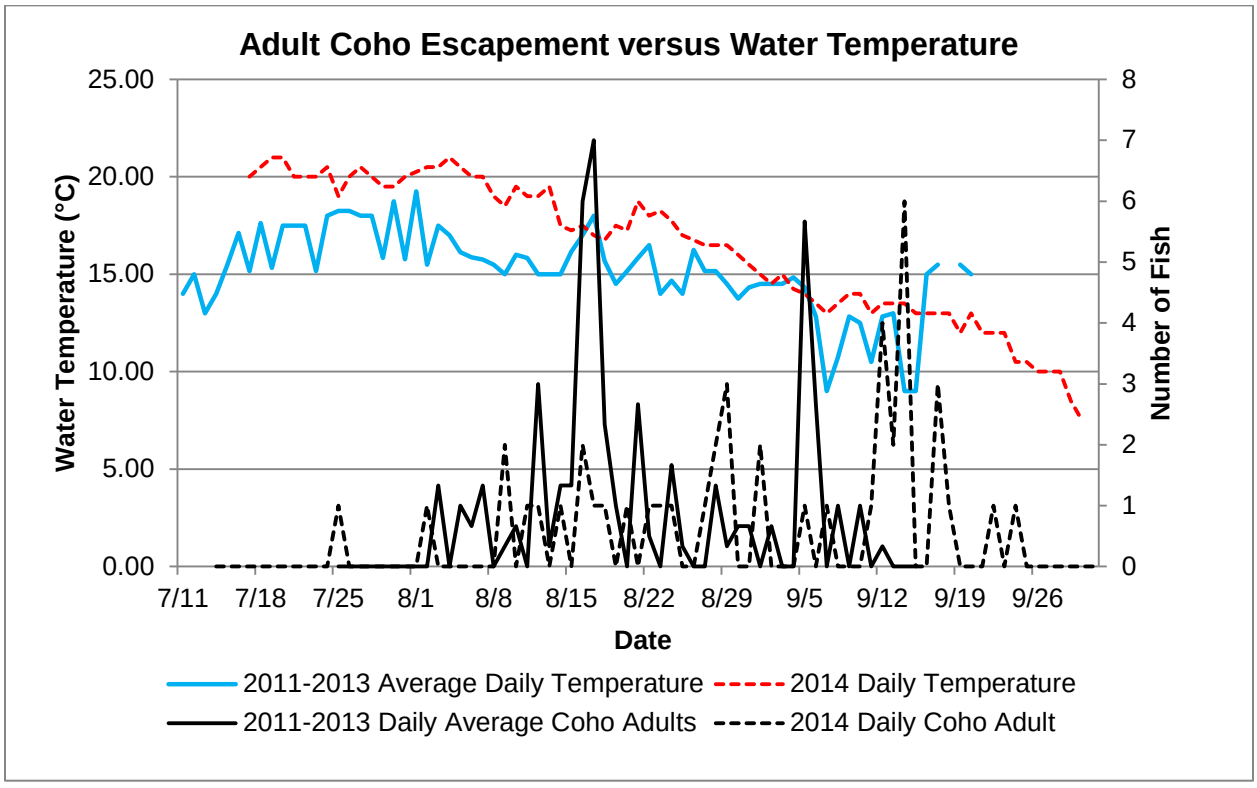

Figure 13. A comparison of 2014 and daily average 2003-2013 coho adult counts to the water temperature for each relative timeframe.

Discussion and Conclusion

The objective of this project was to identify and count the out-migration of smolt salmon and the returning adult salmon for the Sixmile Creek drainage. By using these counts, we expect to identify inter annual trends by comparing historical data to the current year's data. We were also trying to identify any environmental factors that may have caused negative effects on the salmon stock. As of 2014, there are nine years of data on out-migrating salmon smolt, and 17 years of data on the returning adult salmon at the bridge location.

During the 2014 season, Sixmile Creek reached the fifth highest recorded annual count of out-migrating sockeye smolt (Appendix 1). The 2003-2013 average was compared to this year's count of 13,760 fish. For 2014, the major push of out-migrating sockeye smolt occurred earlier than in 2013 and earlier than the historical average (Figures 2 and 4). The cumulative historical 95th percentile for out-migrating sockeye smolt has typically been reached on 24 June. The 2014 field season reached the cumulative 95th percentile of out-migrating sockeye smolt on 7 June (Figure 2). This difference could be explained by environmental factors. In May of 2014, there were about 20 days that were warmer than average (National Weather Service 2014). These warmer days caused the ice on Lower and Upper Sixmile lakes to melt at a faster rate. With the ice cover melting earlier, the water temperature increased earlier than previous years (Figure 4). This could have led to the earlier start of the 2014 sockeye out-migration (Groot and Margolis 1991).

The 2014 coho smolt count was the highest recorded in nine sampling years. The total counted was 3,996, as seen in Table 1. This season's total smolt count accounts for 78% of the total coho smolt (5,114) ever recorded at Sixmile Creek and shows a 2,853% increase as compared to the 2003-2013 cumulative average of 568 out-migrating smolt (Figure 5). The first 50% of the 2014 coho smolt out-migrated about 2 days later on the 3rd of June, than the previous years' average of the 1st of June (Figure 5). However, the 95th percentile of coho was reached on 7th of June, 10 days earlier than the cumulative historic average (Figure 5). Compared to the 2003-2013 average daily out-migration peak of the 24th of May, the 2014 daily out-migration peak was about 10 days later occurring on the 3rd of June (Figure 6). Interestingly, coho out-migration peaked at a water temperature of 13.5° C, with a decline in out-migration numbers at water temperatures about 17° C (Figure 7). This apparent correlation between out-migration timing and water temperatures in this system should be investigated further.

The adult sockeye salmon had a total return of 1,638 fish for 2014. This is lower than the 16 year historic cumulative average of 1,768 fish (Figure 8). However, there were two days when the daily peaks for 2014 were higher than the 16 year average (Figure 9). On 21 July, 469

sockeye were counted, and on 8 August, 66 sockeye were counted (Table 3). For 2014, 95% of the sockeye had passed through the weir by 16 August (Figure 8), just two days later than the 1998-2013 average. When the peak of the sockeye run for all years sampled is examined, the week of 20 July to 27 July has the highest average returning sockeye counts (Figure 9 and Appendix 3).

The 2014 adult coho cumulative escapement of 44 was slightly lower when compared to the average for the last nine years (Figure 11). Daily escapements were about the same as the nine year average until 14 September when 6 coho passed the weir (Table 3 and Figure 12). The average peak of the coho run for previous years was observed to be 1 August, however; the 2014 year observed the peak of the coho run on 14 September. Figure 12, also shows that there seems to be more coho migrating to the lakes later in the year than in years past. This could be due to the expansion of the sampling time to 1 October, allowing for sampling of the end of the coho run. Fourteen percent of the adult coho counted were observed during this expanded sampling period. No correlation could be determined after the examination of coho escapement and water temperature (Figure 13). It would be beneficial to continue collecting water temperature so that the database containing water temperatures can be enlarged to more than just 4 years of data. After the weir was removed and into the early weeks of November, a couple of coho could still be observed spawning in the creek just below the fish ladder.

The collection of genetics required a thorough and careful identification process of adult spawning salmon. Each salmon was vigilantly identified before clipping genetics or releasing into the lake. This detailed evaluation of each species created a confidence in identification and in final adult salmon counts. The use of the new and custom picket weir also allowed for a more organized release and thus improved identification of fish species.

The expansion of the project into 1 October allowed for more enhanced run timing for adult coho. It may be prudent to continue this expanded sampling period into future years in order to have a better understanding of the later coho run.

Recommendations

1. Adult sockeye escapement in Sixmile drainage has been monitored for 26 years. This should be continued and expanded to include the adult coho salmon return. There is little information about the return time and run strength of the adult coho in Sixmile drainage. Also, monitoring the out-migrating smolts needs to be continued for both for sockeye and coho salmon species.

2. Water temperature monitoring should be continued because it is a key factor for determining when smolts and adults migrate. During the 2013 and 2014 field seasons, it was noticed that water temperature played a key role when smolt started to out-migrate.
3. The current fish ladder needs to be replaced because it is acting as a velocity barrier for juvenile salmonids returning to the lake. Also, the ladder is perched, which can act like a height barrier for juvenile salmonids and adult salmon to some degree.

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Appendices

Appendix 1. Smolt sockeye escapement counts by date, Sixmile Creek drainage, 2003-2014.

	Year									Average
Date	2003	2004	2005	2006	2009	2010	2012	2013	2014	2003-2006, 2009-2010,2012-2013
12-May				0				0		0
13-May				0						0
14-May	0			4						4
15-May	0	4		1		0				2
16-May	21	2		2		0				6
17-May	1	126		1		0				32
18-May	21	7		0		0				6
19-May	8	402		13	26					90
20-May	165	407	92	44	114	0		0		117
21-May	220	185	121	118	86	8		-	3	105
22-May	815	464	30	181	192			0	1086	280
23-May	1,383	146	15	637	402	5		0	3987	370
24-May	740	325	155	1,725	87	1	0	0	641	433
25-May	864	319	312	986	375	14	70	0	162	420
26-May	460	616	309	1,919	83	7	234	0	309	518
27-May	731	266	229	1,897	209		69	1	121	486
28-May	445	714	365	229	38	34	2,404	0	196	529
29-May	673	63	125	1,424	28	26	2,134	0	368	559
30-May	275	693	20	1,316	23	6	430	40	2	350
31-May	1,047	172	595	781	8	5	562	104	2095	409
1-Jun	506	74	447	836	64	47	12	320	56	288
2-Jun	688	41	961	882	117	117	20	386	49	402
3-Jun	521	394	660	418	123	67	23	881	448	386
4-Jun	128	92	600	90	238	150	636	615	810	319
5-Jun	384	13	608	254	1,071	639	2,049	2,227	155	906
6-Jun	243	140	265	350	483	5	891	963	38	418
7-Jun	1,104	37	96	107	963	162	2,677	2,376	2782	940
8-Jun	111	25	234	114	1,103	84	1,017	2,255	58	618
9-Jun	478	47	274	65	636	616	1,029	1,349	358	562

	Year									Average
Date	2003	2004	2005	2006	2009	2010	2012	2013	2014	2003-2006, 2009-2010,2012-2013
10-Jun	173	22	129	174	357	427	813	779	0	359
11-Jun	1,076	0	143	29	44	277	195	352	10	265
12-Jun	3,660	58	144	62	123	281	505	1,757	1	824
13-Jun	1,536	7	134	148	488	176	1,129	771	0	549
14-Jun	779	26	132	223	303	30	2,603	1,395	1	686
15-Jun	573	18	344	230	237	23	1,075	1,049	0	444
16-Jun	96	11	190	113	10	181	799	1,256	0	332
17-Jun	134	2	161	596	42	80	612	737	0	296
18-Jun	20	12	118	188	318	220	546	159	1	198
19-Jun	14	17	366	30	47	28	146	50	0	87
20-Jun	6	16	88	72	38	20	34	49	0	40
21-Jun	3	5	122	53	35	26	97	14	0	44
22-Jun	9	1	213	14		26	60	291	0	88
23-Jun	2	35	62	12	29	61	101	93	6	49
24-Jun			27	73	12	99	15	44	5	45
25-Jun			308	16	0	51	51	45	0	79
26-Jun			218	188	18	9	41	18	2	82
27-Jun			88	80		2	203	7	0	76
28-Jun			20	129	3	3	23	1	1	30
29-Jun			27	297	1	16	60	12	5	69
30-Jun			28	100		8	279	11	4	85
1-Jul					40	0		56	0	32
2-Jul									0	0
Totals	20,113	6,004	9,575	17,221	8,614	4,037	23,644	20,463	13,760	14,180
Totals	20,113	6,004	9,575	17,221	8,614	4,037	23,644	20,463	13,760	13,715

The first total in the average column (14,180) is the sum of those averages. The second total in the average column (13,715) is the average from all of the yearly totals.

Appendix 2. Smolt coho escapement counts by date, Sixmile Creek drainage, 2003-2014.

	Year									Average
Date	2003	2004	2005	2006	2009	2010	2012	2013	2014	2003-2006, 2009-2010,2012-2013
12-May										0
13-May										0
14-May	1									1
15-May	2	0				0				1
16-May	2	0				0				1
17-May	0	0				0				0
18-May	0	0			0	0				0
19-May	0	0			0					0
20-May	0	0	1		0	0		0		0
21-May	24	0	3	1	0	0		**0**	19	4
22-May	13	4	5	9	7			0	263	6
23-May	0	0	0	24	3	0		0	447	4
24-May	0	0	47	24	1	0	25	0	103	12
25-May	0	0	39	19	11	2	0	0	88	9
26-May	0	0	16	48	3	4	0	0	73	9
27-May	0	0	7	19	1		15	0	28	6
28-May	0	0	5	7	0	2	20	0	82	4
29-May	0	1	0	9	0	0	10	0	51	3
30-May	1	14	7	9	1	2	2	0	41	5
31-May	0	1	17	3	0	0	1	15	153	5
1-Jun	0	0	51	1	2	1	0	12	230	8
2-Jun	0	0	59	3	0	1	1	9	145	9
3-Jun	0	0	1	1	0	1	0	54	1004	7
4-Jun	0	0	16	0	0	0	0	13	363	4
5-Jun	1	0	7	2	4	0	9	17	202	5
6-Jun	3	0	15	2	0	0	1	16	390	5
7-Jun	0	0	6	1	1	4	1	26	123	5
8-Jun	0	0	4	0	3	1	4	17	53	4
9-Jun	0	1	5	0	2	1	1	21	76	4

	Year									Average
Date	2003	2004	2005	2006	2009	2010	2012	2013	2014	2003-2006, 2009-2010,2012-2013
10-Jun	0	0	4	0	0	3	0	11	1	2
11-Jun	0	0	8	1	0	6	0	2	12	2
12-Jun	0	0	3	5	0	1	2	12	4	3
13-Jun	0	1	2	0	0	5	0	5	0	2
14-Jun	0	0	5	1	3	1	3	3	0	2
15-Jun	0	0	4	0	0	0	0	7	0	1
16-Jun	0	0	28	1	0	2	4	4	1	5
17-Jun	0	0	3	13	0	0	2	3	0	3
18-Jun	0	0	6	1	4	4	0	1	0	2
19-Jun	2	0	8	0	1	0	2	0	0	2
20-Jun	0	0	2	0	2	0	0	0	1	1
21-Jun	0	1	4	0	0	0	1	0	1	1
22-Jun	0	0	1	0		0	1	1	18	0
23-Jun	0	0	0	0	0	0	0	0	0	0
24-Jun			1	0	0	1	0	0	0	0
25-Jun			1	0	1	0	0	0	2	0
26-Jun			1	0	0	0	0	0	0	0
27-Jun			1	0		0	2	1	0	1
28-Jun			0	0		0	0	0	0	0
29-Jun			0	0		0	0	0	19	0
30-Jun			0	0		0	0	0	3	0
1-Jul								0		0
2-Jul										0
Totals	49	23	393	204	50	42	107	250	3,996	148
Totals	49	23	393	204	50	42	107	250	3,996	568

The first total in the average column (148) is the sum of those averages. The second total in the average column (568) is the average from all of the yearly totals.

Appendix 3. Adult sockeye escapement counts by date, Sixmile Creek drainage, 1998-2014.

	Year																	Average
Date	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	1998-2013
1-Jul											0							0
2-Jul											0							0
3-Jul											0							0
4-Jul																		0
5-Jul																		0
6-Jul																		0
7-Jul																		0
8-Jul				4							1							3
9-Jul											0							0
10-Jul				1							0							1
11-Jul											0			0				0
12-Jul											0			0				0
13-Jul											0		0	0				0
14-Jul							1				0	0	0	0			0	0
15-Jul											0	0	0	0			0	0
16-Jul	2										0	0	0	2	0	27	0	4
17-Jul	3										0	0	0	0	0	10	0	2
18-Jul	1				0						0	0	0	0	0	0	0	0
19-Jul					0						1	0	0	0	0	0	0	0
20-Jul	3			149	0						0	0	0	0	0	0	0	17
21-Jul	17			133	0		5				1	0	0	1	0	0	469	16
22-Jul	17			285	0		107			1	0	0	119	0	0	1	69	48
23-Jul	43		518	300	0		100			1	0	0	487	0	0	0	142	121
24-Jul	487		178	1,188	0		18			1	8	358	200	0	0	0	122	203
25-Jul	184		78	405	328	158	0	276		4	516	582	67	198	1	3	111	200
26-Jul	56		21	26	173	251	2	124			344	268	0	241	4	152	48	128
27-Jul	48		3	130	476	364	2	22		219	100	537	0	18	1	309	30	159
28-Jul	4			286	300	394	13	2		14	32	264	7	0	4	197	61	117

	Year																	Average
Date	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	1998-2013
29-Jul	154		200	297	363	279	24	2		1	9	260	247	2	1	27	27	133
30-Jul	20		180	91	162	132	321	31	205	3	67	86	119	1	141	14	51	105
31-Jul	20		133	305	59	176	301	160	359	80	112	181	103	0	22	0	49	134
1-Aug	21		44	151	91	95	43	92	50	171	46	70	187	0	57	3	16	75
2-Aug	0		38	59	40	44	26	72	2	34	31	100	151	2	28	27	9	44
3-Aug	138		24	45	86	88	41	40	3	13	17	12	140	115	10	196	10	65
4-Aug	48		5	70	76	86	59	35	3	7	21	14	34	57	0	255	15	51
5-Aug	0		33	26	65	128	30	50	154	36	20	44	141	5	0	83	38	54
6-Aug	115	386		11	49	70	9	21	84	125	2	76	107	0	10	45	25	74
7-Aug	56	206	48	16	67	83	17	51	39	37	9	21	40	0	5	29	26	45
8-Aug	0	1	17			34	62	14	41	1	14	37	98	0	0	13	66	24
9-Aug	56	7	3	13	62	58	39	28	18	5	15	74	135	0	0	19	54	33
10-Aug	40		30		28	18	147	37	12	9	5	32	61	0	8	46	27	34
11-Aug	29			9	30	11	38	14	33	22	22	64	11	2	0	39	17	23
12-Aug	25	4	4	2		82	22	16	15	48	9	31	4	0	3	17	20	19
13-Aug	24	14	3		42	22	31	16	70	6	21	13	9	0	0	27	33	20
14-Aug	17	3	1			40	12	65	7	10	18	13		0	3	32	11	17
15-Aug	13	3			36	41	21	18	5	11	3	37	9	5	2	12	9	15
16-Aug	9	3		23		44	9	18	16	5	3	61	10	0	4	20	17	16
17-Aug	12		3			32	14	7	8	4	0	17	17	0	10	3	9	10
18-Aug	0	3	5	4	11	15	6	41	11	10	9	16	4	0	1	8	11	9
19-Aug	0			5		9	1	17	16		2	14	6	3	0	7	10	7
20-Aug	0				19	3	7	9	9	4	1	15	5	1	0	4	12	6
21-Aug	0	1					7	7	6	2	1	8	3	0	0	5	7	3
22-Aug	0	2	1		15	2	0	9	10	8	2	9	2	0	0	0	6	4
23-Aug	0	4	1				1	12	3	8	0	4	2	0	0	2	1	3
24-Aug					1		7	3	1	1	0	5	5	2	0	1	3	2
25-Aug						10	0	10	3		0	5	0	0	0	3	0	3
26-Aug		7					13	6	1		0	1	0	0	0	0	2	3
27-Aug		2				9	28	5	1		1	1	0	0	0	0	0	4

	Year																Average	
Date	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	1998-2013
28-Aug		6			1		15	0	4	2	0	0		0	0	0	1	3
29-Aug							3	4	0		0	4	0	1	0	0	0	1
30-Aug							4	2	3		0	0	0	0	0	0	1	1
31-Aug							0	5	0		0	0	2	0	0	3	0	1
1-Sep							1		0		0		0	0	0	0	0	0
2-Sep							0		0		0		0	2	1	3	0	1
3-Sep		3					3		0		0		0	0	0	3	0	1
4-Sep		7					1		0		0		0	0	0	1	0	1
5-Sep							0		0		0		0	0	0	0	0	0
6-Sep		1					0		0		0		0	0	0	2	0	0
7-Sep							0		0		0		0	0	0	0	1	0
8-Sep							0		0		0		0	0	1	1	1	0
9-Sep													0	0	0	2	0	1
10-Sep													1	0	0	0	1	0
11-Sep														0	0	0	0	0
12-Sep														0	0	1	0	0
13-Sep														0			0	0
14-Sep														0			0	0
15-Sep														0			0	0
16-Sep																	0	0
17-Sep																	0	0
18-Sep																	0	0
19-Sep																	0	0
20-Sep																	0	0
21-Sep																	0	0
22-Sep																	0	0
23-Sep																	0	0
24-Sep																	0	0
25-Sep																	0	0

	Year																	Average
Date	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	1998-2013
26-Sep																	0	0
27-Sep																	0	0
28-Sep																	0	0
29-Sep																	0	0
30-Sep																	0	0
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	2,064
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	1,761

The first total in the average column (2,064) is the sum of those averages. The second total in the average column (1,761) is the average from all of the yearly totals.

Appendix 4. Adult coho escapement counts by date, Sixmile Creek drainage, 2004-2014.

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

	Year											Average
Date	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	1998-2012
22-Aug	0	0	3	2	0	4	0		0	1	1	1
23-Aug	0	0	6	1	0	3	0	0	0	0	1	1
24-Aug	0	1	0	0	0	2	0	2	0	3	1	1
25-Aug	0	2	4	0	0	11	0	0	0	1	0	2
26-Aug	0	1	6	0	0	0	0	0	0	0	0	1
27-Aug	0	0	4	0	1	0	0	0	0	0	1	1
28-Aug	0	0	4	1	0	5	0	0	4	0	2	2
29-Aug	0	0	0	0	0	2		1	0	0	3	0
30-Aug	1	0	0	0	0	0	0	0	1	1	0	0
31-Aug	0	1	0	0	0	1	0	0	1	1	0	0
1-Sep	0	0	0	0	0	0	0	0	0	0	2	0
2-Sep	0	0	0	0	0	0	0	1	0	1	0	0
3-Sep	0	0	0	0	0	0	0	0	0	0	0	0
4-Sep	0	0	0	0	0	0	0	0	0	0	0	0
5-Sep	0	0	0	0	0	0	0	0	0	17	1	2
6-Sep	0	0	0	0	0	0	1	0	0	8	0	1
7-Sep	0	0	0	0	0	0	0	0	0	0	1	0
8-Sep	0	0	0	0	0	0	0	0	0	3	0	0
9-Sep	0	0	0	0	0	0	0	0	0	0	0	0
10-Sep	0	0	0	0	0	0	3	0	0	3	0	1
11-Sep	0	0	0	0	0	0	0	0	0	0	1	0
12-Sep	0	0	0	0	0	0	0	0	0	1	4	0
13-Sep	0	0	0	0	0	0	0	0	0	0	2	0
14-Sep	0	0	0	0	0	0	0	0	0	0	6	0
15-Sep	0	0	0	0	0	0	0	0	0	0	0	0
16-Sep											0	
17-Sep											3	
18-Sep											1	
19-Sep											0	

	Year											Average
Date	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2004-2013
20-Sep											0	
21-Sep											0	
22-Sep											1	
23-Sep											0	
24-Sep											1	
25-Sep											0	
26-Sep											0	
27-Sep											0	
28-Sep											0	
29-Sep											0	
30-Sep											0	
1-Oct											0	
Totals	1	16	69	17	27	178	18	8	79	54	44	49
Totals	1	16	69	17	27	178	18	8	79	54	44	46

The first total in the average column (49) is the sum of those averages. The second total in the average column (46) is the average from all of the yearly totals.