Alouette Project Water Use Plan

Alouette Sockeye Adult Enumeration

Implementation Year 7

Reference: ALUMON-4

Alouette Adult Sockeye Enumeration – 2014

Study Period: 2014

Alouette River Management Society

July 2015

Alouette Adult Sockeye
2008 – 2014

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Executive Summary

Through BC Hydro's Water Use Plan for the Alouette Watershed, a spring surface release from the Alouette Dam has allowed for Kokanee/Sockeye smolts to migrate to the ocean for the last ten years. The first spring surface release occurred in 2005, and in 2007 the first adult Sockeye returned to the Alouette Watershed.

A total of 308 adult Sockeye returned to the Alouette Watershed from 2007–2014 during typical 'summer run' timing (with a few late fall exceptions), 262 of which were released alive back into the reservoir. Adult returns to the fish fence ranged from a high of 115 fish in 2010 to zero fish in 2014 (two adult Sockeye were observed downstream of the fence during the summer of 2014). Although the number of total Sockeye return is low, the return of adults show that re-anadromization of Kokanee/Sockeye to the Alouette watershed is possible.

The purpose of the ALUMON #4 study is to determine if the Alouette Lake Kokanee smolts have successfully adapted to an anadromous existence by returning successfully as adults from the ocean back to their native Alouette Reservoir to spawn; to determine the run timing of the adult Sockeye; to determine if the adult Sockeye are the returning smolt from the Alouette Reservoir or if they are strays from another watershed; and to determine if the ocean survival rates of the returning re-anadromized Kokanee are similar to elsewhere in BC.

The latter three management questions have been answered throughout the monitoring study. The run timing has consistently been 'summer run' as the returns arrive at the reservoir during the summer months; a few fish were captured during the fall months, however, all of those late returns that were genetically sampled proved to be strays from a nearby system. Genetic testing has been done on the vast majority of returns (exception of 2009) and concluded all 'summer run' returns tested have been Alouette stock; only six October returns in 2010 were confirmed as strays from Weaver Creek. Comparisons of ocean survival rates found current marine survival rates of Alouette River Sockeye are lower but remain in the same range as other Fraser River and nearby Sockeye systems with data available (CSAS 2010; Plate et al. 2014; Rensel et al. 2010).

The initial question of whether Alouette Kokanee smolts have adapted to anadromy and successfully spawned in Alouette Lake upon their adult return has not been definitively answered at the completion of this monitoring program. Telemetry tracking studies have identified possible spawning locations within Alouette Reservoir (Plate and Bocking 2010, 2011, 2013). Genetic studies have concluded returning adult Sockeye are indeed Alouette stock, and that both the migrating Kokanee smolts and returning adults are progeny of Alouette Reservoir Kokanee (Candy 2009; Godbout et al. 2011). However studies based on all genetic analysis to date have concluded it is unlikely that many, if any, of the returning Sockeye are successfully spawning together as pairs. A hatchery-based experiment has been proposed to better answer this management question (Godbout et al. 2013, 2014).

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Introduction

During the 2006 review of the Alouette Water Use Plan (WUP), the consultative Alouette Monitoring Committee identified the restoration of an anadromous Sockeye salmon run as a key issue in the Alouette River system. Construction of the dam in the 1920s impounded the reservoir and extirpated the Sockeye run soon after. As a means of re-establishing the stock, a spring surface release from the dam was integrated into the WUP. The release of $3m^3s^{-1}$ from April to June has indeed facilitated Kokanee/Sockeye out-migration from the reservoir. Since 2005, smolts have successfully migrated through the spillway gate during the spring release and to the ocean via the Alouette River (Table 1; Mathews et al. 2015).

Table 1 Estimated number of smolts leaving the Alouette Reservoir during the spring surface release, 2005–2014.

Year of Smolt Migration	Estimated Number of Smolts
2005	**7,900**
2006	**5,064**
2007	**62,923** *(95% CI: 48,436–77,410)*
2008	**8,257**
2009	**4,287** *(95% CI: 3,833–4,741)*
2010	**15,434**
2011	**35,542** *(95% CI: 34,034–37,051)*
2012	**728** *(95% CI: 348–1,108)*
2013	**6,179** *(95% CI: 5,350–7,008)*
2014	**13,413** *(95% CI: 12,423–14,403)*

The viability and authenticity of Kokanee smolt "re-anadromization" is dependent on the stocks ability to adapt to salt water conditions, to adopt behavioural strategies to compete and avoid predation in an ocean environment, and to recognize and return to their native lake/stream system to spawn. Through the Alouette Adult Sockeye Enumeration monitoring program, Sockeye returning to the Alouette River are collected, counted, aged, genetically tested, and released into Alouette Lake. The first run of adult Alouette Sockeye salmon since extirpation were trapped in 2007 and genetically proven to be Alouette stock (Godbout et al. 2011).

Objectives

The main purpose of the seven year Alouette Adult Sockeye Enumeration monitoring program is to establish whether out-migrating Alouette Lake Kokanee/Sockeye smolts are capable of adapting to an anadromous existence. Adaptation is considered successful when Sockeye return from the ocean environment to spawn in Alouette Lake. Additionally, the monitoring program seeks to establish the timing and genetic structure of the returning Sockeye run and to assess whether ocean survival rates of returning re-anadromized Kokanee are comparable to that of

Sockeye stocks found elsewhere. During the first three years of the program (2008–2010), the Allco Hatchery fish fence was operated from April to December to determine the timing and volume of the run. Based on the results of these efforts, the following four years (2011−2014) involved a shorter fence operation period, commencing mid-June through to the fall. Tissue samples were also collected to confirm that returning adults were Alouette stock and not strays from other nearby coastal systems.

The following Management Questions were taken directly from the Terms of Reference (BC Hydro 2009):

1) Are the Alouette Lake Kokanee smolts successfully adapting to an anadromous existence by returning from the ocean environment to spawn in Alouette Lake?

This question cannot be answered without first addressing the following three critical data gaps:

2) What is the run timing of the adult Sockeye return so that an appropriate enumeration study can be carried out?
3) Are the adult Sockeye caught during the monitor members of the Alouette stock or are they strays from other nearby coastal systems?
4) Are the ocean survival rates of returning re-anadromized Kokanee comparable to that of Sockeye stocks found elsewhere?

Study Area

The South Alouette Watershed (144 km^2), comprised of the South Alouette River and Alouette Reservoir, is located within the communities of Maple Ridge and Pitt Meadows (Figure 1). The site of the Alouette Adult Sockeye Enumeration program is approximately 8 km downstream from the Alouette Reservoir at the Allco Fish Hatchery operated by BC Corrections Fraser Regional Correctional Centre. The hatchery is well positioned to intercept all migrating adult Sockeye on their way back to the reservoir.

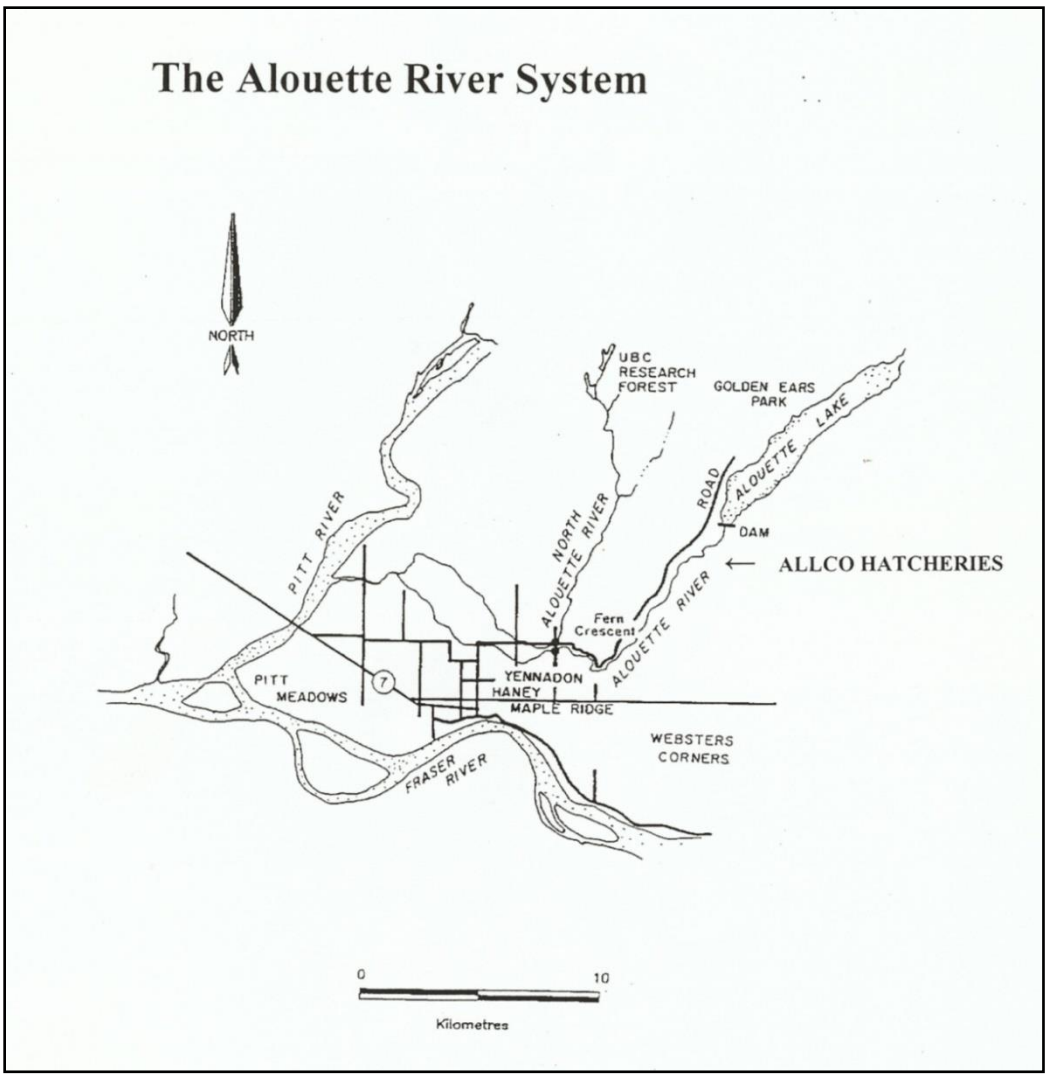

Figure 1 Map of the Alouette Watershed

Methods

From the first year of monitoring in 2008, the adult Sockeye run appeared to be a summer run, arriving in the Alouette Watershed in July and August (Balcke 2009a). Taking this into consideration, as well as the maintenance requirements, and downstream steelhead kelt passage, the Alouette Monitoring Committee decided that the fence would operate between April and December in 2009 and 2010, rather than year round (Cruickshank 2010). In 2011, the fence operation was shortened and the operations began on 15 June 2011.

Figure 2 Allco Fish Hatchery fence and trap, May 2014

Figure 3 Allco Fish Hatchery fence and bladder, May 2014

The fish fence was designed to direct Sockeye and other salmon into the trap, which was monitored daily by BC Corrections staff and crew (Figure 2 and Figure 3). In case of a breach at the Allco fish fence, BC Hydro installed a trap at the low level outlet of the Alouette Dam to catch returning Sockeye that may have escaped capture at the Allco fish fence. Once trapped, the Sockeye were biosampled for fork length, scale sampled for age, and tissue sampled for genetics prior to transportation via truck by BC Corrections to Alouette Lake where they were released. The Sockeye were transported to the reservoir in specifically designed tanks fitted for both the Allco Hatchery truck and Sockeye transport trailer (Figure 4). At the lake, a slide was connected to the tanks and the Sockeye were released (Figure 5). As no adult Sockeye were captured in 2014, no biosampling or transporting of fish occurred in 2014.

Figure 4 Sockeye transport tanks, May 2014

Figure 5 Sockeye transport tank with release slide connected, January 2010

In 2011 and 2012, returning Sockeye were also tagged by LGL Limited with motion sensitive MAP tags, which were used to track the Sockeye migration in the Alouette Reservoir (Figure 6−8). The Allco Hatchery fish trap, the transport trailer and tanks (Balcke 2009b), and the LGL Limited tagging projects (Plate and Bocking 2013) were funded by Coastal Fish and Wildlife Compensation Program (formerly Bridge Coastal Restoration Program), which is not part of the Alouette Water Use Plan monitoring programs.

Figure 6 Placing radio tag

Figure 7 Radio tag placement

Figure 8 Radio tag in dead Sockeye

Results and Discussion

Adult Sockeye Returns

A total of 308 adult Sockeye returned to the Alouette Allco fish fence during the 2007–2014 runs, of which 262 were successfully released back into the Alouette Reservoir (Table 2). Although the number of total Sockeye returns is low, the data shows that re-anadromization of Kokanee/Sockeye to the Alouette watershed is possible.

Table 2 Number of returning adult Alouette Sockeye enumerated 2007–2014

Year of Adult Return	Number of Adults Which Returned to Allco Fish Fence	Number of Adults Released Alive into Alouette Reservoir
2007	28	5
2008	54	53
2009	45	43
2010	115	103
2011	11	8
2012	45	43
2013	10	7
2014[1]	0	0
Total	**308**	**262**

[1]Two adult Sockeye were observed in the Alouette River downstream of the fence.

The Alouette Sockeye run demonstrates timing comparable to a Fraser River summer run Sockeye population, arriving at the Allco Fish Hatchery trapping location in July and August (Figure 9). The peak of the Alouette Sockeye run throughout 2008–2014 typically occurred from the last week of July to the second week of August.

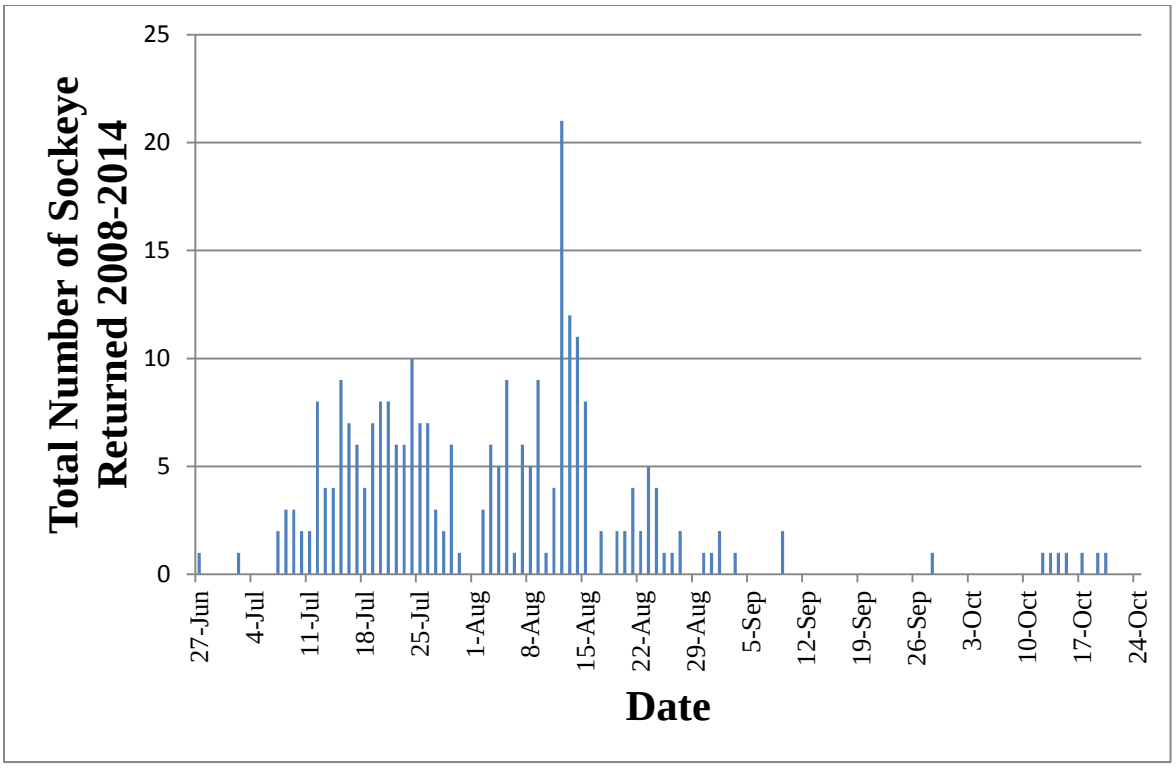

Figure 9 Total number of adult Sockeye which returned to the Alouette fish fence from 2008–2014 by date (note: zero fish returned in 2014)

Smolt to Spawner Survival

From 2005 to 2012, smolt to spawner survival has ranged from a low of 0.084% to a high of 1.344% (Table 3). Smolt-to-spawner survival was calculated from age specific estimates of the number of smolts migrating from the Alouette Reservoir and the number of adults which returned to above the Allco fish fence (Bob Bocking, pers. comm.). The 2015 adult return data has not yet informed the 2012 smolt:TRS (total return to spawn) ratio, but it is expected to be close to zero given the low number of smolts in 2012 (728) and the expected low proportion of 3 year ocean stay adults that would return in 2015 as part of that cohort.

Table 3 Alouette Sockeye brood survivals, 2005–2012 (Bob Bocking, pers. comm.)

Year of Smolt Migration	Survival (smolt:TRS)
2005	0.532%
2006	0.750%
2007	0.084%
2008	1.344%
2009	0.171%
2010	0.282%
2011[1]	0.028%
2012[1]	0%

[1] Survival estimate for 2011 and 2012 is preliminary based on unreported data for age classes that have yet to return.

Fork Length

The number of returning adult Sockeye measured each year ranged from zero in 2014 (as no fish were captured) to 115 fish in 2010; mean fork length ranged from 46.6 cm in 2013 to 60.4 cm in 2011 (Table 4; Figure 10).

Table 4 Average Sockeye fork length, 2008–2013

Year of Adult Return	Number of Adults Measured	Mean Fork Length (cm)
2008	54	59.3
2009	15	59.1
2010	115	58.1
2011	10	60.4
2012	42	57.8
2013	8	46.6
2014	N/A	N/A

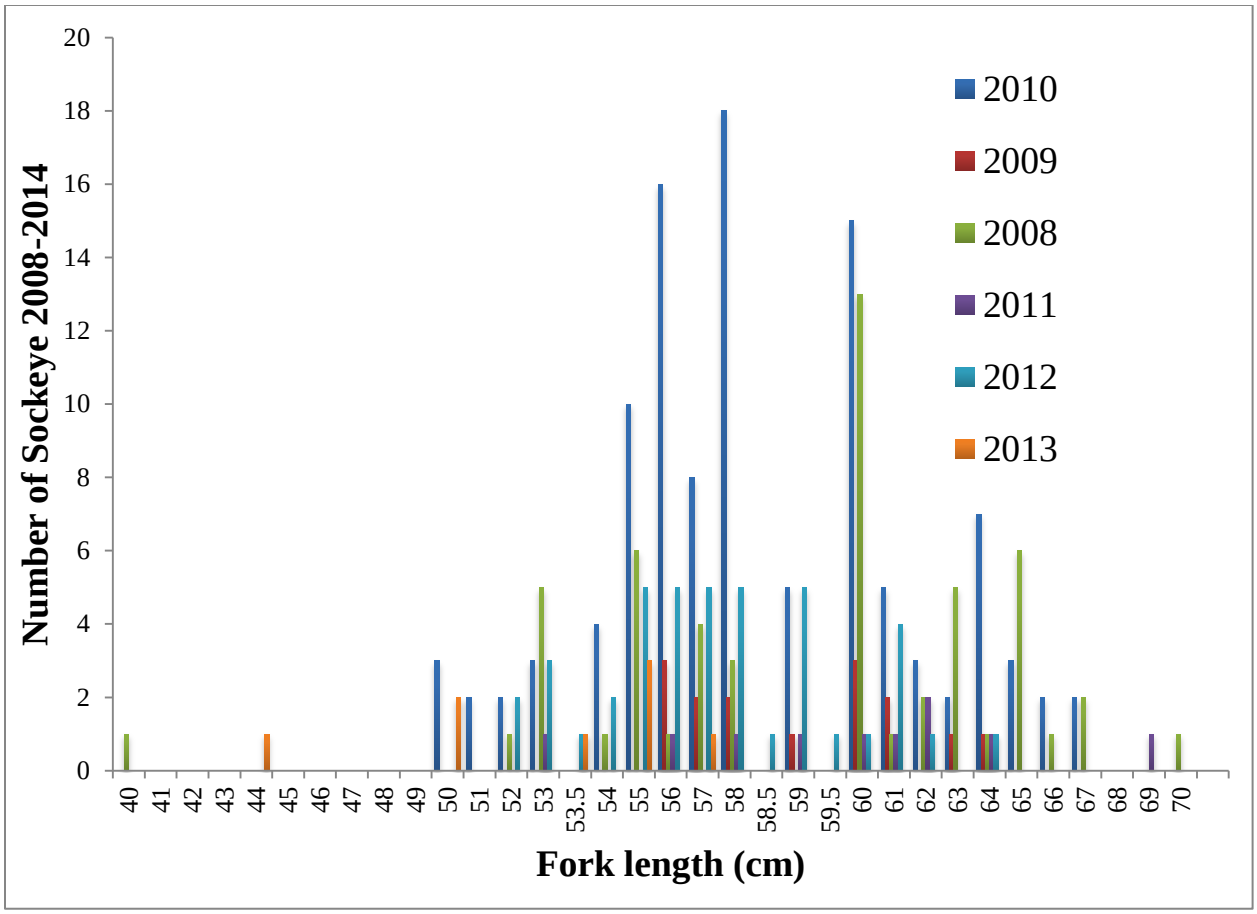

Figure 10 Fork length of returning Alouette Sockeye, 2008–2014 (note: zero fish were captured in 2014)

Age Structure

In earlier years, the age class analysis completed by the Pacific Salmon Commission (e.g., in 2008 and 2009) showed that the returning Sockeye salmon were fairly evenly distributed between 4.2 and 5.3 age classes. The 2010 returning Sockeye also showed this distribution which may be typical for Alouette Sockeye, with 53% and 19%, respectively. The 2011 returning Sockeye had fish in the 6.3 age class, which had not been seen in other study years (Table 5; Latham, unpublished data, 2011). In 2007, there was a large smolt outmigration, which corresponded to the 2009 4.2 and 2010 5.3 age classes. In 2011, the age class structure was spread from 4.2 to 6.3 age classes. The low returns for 2011 left considerable uncertainty in the age results (Table 5; Bocking, unpublished data, 2012). The age structure for 2012 showed a distribution from 4.2 to 6.4 age classes. There were three aged 4.2 scale samples which were determined to be resorbed. This may indicate that the age of these three Sockeye is actually 5.2 due to the unreliability of the samples. The age class analysis completed for the 2013 season showed that the returning adult Alouette Sockeye were represented by two fish in age class 4.2 (Table 5; Sellars, unpublished data, 2014). Due to errors in the two other samples, an age class

could not be determined (Reichardt, pers. comm., 2014). Given that no fish were captured in 2014, no age analysis was done.

The overall number of returning Alouette Sockeye sampled for age from 2008 to 2014 was 171. The majority (77.3%) of these returning spawners were age 4.2 years and 5.3 years fish (i.e., 51% were 2 years old and 26.3% were 3 years old when they left the Alouette Reservoir and then spent 2 years in the marine environment). Five other age classes have been identified for the Alouette Sockeye, representing 21.4% of the fish sampled (Table 5).

Table 5 Alouette adult Sockeye age structure analysis, 2008–2014 (Latham, Bocking, Sellars, pers. comm[s].)

Year (total fish sampled)	Age Class (Gilbert Rich Scale) (% sampled)						
	4.2	**4.3**	**5.2**	**5.3**	**5.4**	**6.3**	**6.4**
2008 (53)	19 (36%)	1 (2%)	14 (26%)	19 (36%)			
2009 (11)	7 (63%)			4 (36%)			
2010 (68)	36 (53%)		3 (4%)	13 (19%)	1 (1%)		15 (22%)
2011 (6)	3 (50%)			1 (17%)		2 (33%)	
2012 (29)	20 (69%)			8 (28%)			1 (3%)
2013 (4)	2 (50%)						
2014 (0)							
Total (171)	**87 (50.8%)**	**1 (0.6%)**	**17 (9.9%)**	**45 (26.3%)**	**1 (0.6%)**	**2 (1.2%)**	**16 (9.4%)**

Genetic Analysis

The genetic sampling from 2008 found that there was a significant variation between Alouette Sockeye adults and Sockeye from neighbouring systems, such as Coquitlam, Cultus, Harrison, and Weaver. The 2008 Sockeye run did not include any stray Sockeye from other systems; however the same cannot be definitively stated for the 2009 run as only 15 adult Sockeye were sampled (Candy 2009, as quoted in Balcke 2009a; Candy 2010; Mathews and Bocking 2009). The 2010 run included six strays from Weaver stock. These six strays were the last six Sockeye to arrive at the Allco Fish Hatchery in mid-to-late October and are presumed to be a part of the fall-run Sockeye from Weaver. The rest of the 106 Sockeye sampled in 2010 were Alouette stock (Godbout, unpublished data, 2011). The 10 Sockeye sampled in 2011 were determined to be Alouette stock (Godbout, unpublished data, 2012). All adult Sockeye sampled in 2012 were determined to be of Alouette stock (Godbout, unpublished data, 2013). As an interesting side note, it was found that based on microsatellite DNA, two out of the three “Sockeye” that returned to Coquitlam in 2012 were actually Alouette sea-run Kokanee both being female (Godbout, unpublished data 2013). All adult Sockeye sampled in 2013 were determined to be of Alouette stock (Godbout, unpublished data, 2014).

Conclusions and Recommendations

Management Questions

The 2014 adult Sockeye enumeration study was the final year of the project (ALUMON#4) funded through the Alouette WUP Monitoring Program. The monitoring program attempted to address the four management questions originally proposed in the terms of reference (see the Methods section; BC Hydro 2009).

The initial question of whether the Alouette Lake Kokanee smolts have successfully adapted to an anadromous existence by returning from the ocean environment to successfully spawn in Alouette Lake has not been definitively answered at this point. Genetic testing has determined that no genetic difference exists between the migrating smolts from Alouette Reservoir and the returning adult Sockeye, and the returning adults appear to be the progeny of emigrating Alouette Kokanee smolts (Candy 2009). Godbout et al. (2011) later determined *O. nerka* smolts which migrated from the reservoir in 2005 and 2006, and the returning adult Sockeye in 2007 and 2008, were the progeny of Alouette Reservoir Kokanee, concluding that if given an opportunity for both downstream and upstream migration, at least a portion of the Alouette Kokanee population appears to be successfully capable of reverting to an anadromous form.

Plate and Bocking (2010, 2011, 2013) used radio and acoustic telemetry to help determine spawning locations and timing of Alouette Sockeye in the reservoir; possible spawning locations for Sockeye were suggested in their earliest results. Final telemetry tracking identified probable spawning locations, depths, substrates and groundwater inflow into spawning beds for Alouette Kokanee and the authors concluded likely for Alouette Sockeye as well.

However, when genetic testing examined the brood years of 2008 to 2010 in an attempt to determine whether the returning adult Sockeye are successfully spawning once transferred to the reservoir, Godbout et al. (2013) concluded it is unlikely that many, if any, of the returning Sockeye are successfully spawning together as pairs. Possible explanations for the failure may be the inability of the returning adults to find each other, or to find suitable spawning conditions, but the study concludes that further investigation of possible reasons for this failure are warranted.

Godbout et al. (2014) then re-examined the question of successful spawning for brood years 2008 to 2012 and concluded again that it continues to seem unlikely that the returning adult Sockeye are successfully spawning together as pairs, adding pre-spawning mortality to the list of possible reasons for spawning failure. Further efforts are warranted to determine the causes of the suspected failure to spawn. This should include a hatchery-based experiment designed to aid the restoration of an anadromous Sockeye run by increasing the total of migrating smolts while simultaneously further investigating the suspected poor spawning success of the returning adults that are transferred back into Alouette Reservoir.

The second question of run timing of the adult Sockeye returns has been answered as the adult Alouette population has consistently demonstrated timing comparable to a summer run, arriving below the reservoir during the summer months (July to August). A few fish were captured during September and October of 2009 and 2010; however, all 2010 fall returns were genetically analyzed and determined to be strays from a nearby stock and not Alouette fish. Unfortunately the two late returns of 2009 were not sampled for genetics and hence their stream origin cannot be confirmed. The third management question inquires if the returning adult Sockeye are Alouette stock or strays from nearby coastal systems. With the exception of 2009, in which only one third of the returns were genetically sampled (15 of 45), the vast majority of returning adults have been sampled every year.

Lastly the fourth management question asks for comparisons of ocean survival rates of the returning re-anadromized adults with other Sockeye stocks. Plate et al. (2014) examined this question and found current marine survival rates for Alouette River Sockeye from smolt to adult (Table 3) are lower but remain in the same range as Chilko Lake Sockeye which has seen marine survivals less than 3.5% since the 2007 return year and as low as 0.3% for the 2009 adult return year (2007 smolt year), respectively (Rensel et al. 2010). Plate et al. (2014) were unable to obtain survival rates from Fisheries and Oceans for other Fraser River Sockeye stocks, in particular the Pitt River and Early Summer run stock grouping. Cultus Lake Sockeye, which has undergone a re-building effort, has also had poor survival rates in recent years (CSAS 2010).

Recommendations

- Continue monitoring Alouette Sockeye adult returns to determine total returns to the reservoir.
- To ensure the beginning of the Sockeye run is captured, begin operation of the Allco fish fence from the middle of June and operate until late October.
- Continue the practice of releasing captured Sockeye to the reservoir on the same day and handle as little as possible.
- Ensure future scale samples are obtained from the correct location above the lateral line on the fish body, correctly placed in the sample vials, and not taken near scars.
- Continue with the biosampling protocol of fork length, scale, and tissue samples taken for all returning Sockeye.
- Ensure the Allco hatchery trap remains otter-proofed to decrease losses due to predation in the trap itself.
- Due to some predator loss, an assessment of returning Sockeye downstream of the Allco fish fence should be implemented.
- Conduct the recommended hatchery-based experiment discussed above (see the Management Questions section) to help to answer the outstanding management question of whether Alouette Lake Kokanee smolts have successfully adapted to an anadromous existence by returning from the ocean environment to successfully spawn in Alouette Lake.

Acknowledgements

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