Alouette Project Water Use Plan

Kokanee Out-Migration

Implementation Year 6

Reference: ALUMON-2

Evaluation of the Migration Success of O. nerka (Kokanee/Sockeye) from the Alouette Reservoir, - 2013

Study Period: 2013

LGL Limited

June 2014

EA 3071

Evaluation of the Migration Success of *O. nerka* (Kokanee / Sockeye) from the Alouette Reservoir, 2013

Prepared for:

BC Hydro
Water License Requirements
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EVALUATION OF THE MIGRATION SUCCESS OF *O. NERKA* (KOKANEE / SOCKEYE) FROM THE ALOUETTE RESERVOIR, 2013

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EXECUTIVE SUMMARY

In order to assess the feasibility of anadromous sockeye salmon (*Oncorhynchus nerka*) re-introduction into the Alouette Reservoir, studies are being conducted to determine the migration success of *O. nerka* smolts from the reservoir; 2013 was the ninth year of study of juvenile salmon migration from the Alouette Reservoir. In 2005, spillway releases at the Alouette Dam occurred from 3 May to 3 June to evaluate the migration success of marked coho salmon (*O. kisutch*) smolts as they were captured in the Mud Creek rotary screw trap (RST), located 1.5 km downstream of the Alouette Dam. In 2006, spillway releases at the Alouette Dam again occurred from 11–31 May to evaluate the migration success of marked steelhead trout (*O. mykiss*) from the Alouette Reservoir. In both years, coincidental *O. nerka* migrations were monitored and an estimated 7,900 and 5,064 smolts migrated from the reservoir, respectively. From 2007 to 2012, the spillway was opened from mid-April until mid-June (closed approximately two weeks earlier in 2007, 2008, and 2010 once the migration had ceased) and estimates of *O. nerka* smolt migrations from the reservoir ranged from 728 (95% CI: 348–1,108) in 2012 to 62,923 (95% CI: 48,436–77,410) in 2007.

The Mud Creek RST was operated during the complete duration of the *O. nerka* smolt migration from the Alouette Reservoir in 2013, from 13 April to 31 May. In total 1,032 *O. nerka* smolts were captured, 794 of which were lower caudal clipped and released below the Alouette Dam, 1,165 fish were inspected for clips, and 149 clipped fish were recaptured. Using a pooled Petersen estimator, an estimated 6,179 *O. nerka* smolts (95% CI: 5,350–7,008) migrated from the Alouette Reservoir between 16 April and 31 May. This was the sixth highest estimate in nine years of studies. Average daily spillway flows to the South Alouette River during the *O. nerka* migration were maintained at similar levels to past years and ranged from 3.27–4.29 m^3/s; no post-surface release flush occurred in 2013.

A subsample of *O. nerka* smolts captured at the Mud Creek RST in 2013 were sampled for length, weight, age (scales), and genetics (fin tissue). Randomly chosen *O. nerka* smolts (< 100 mm FL) averaged 86 mm FL (range: 61–99 mm FL; n = 464) and 5.5 g (range: 2.0–9.6 g; n = 464).

All other species captured were counted and released, including 254 steelhead smolts (> 90 mm FL), 555 coho parr /smolts (> 70 mm FL) and more than 371,415 salmonid fry, most of which were chum salmon (*O. keta*).

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INTRODUCTION

Numerous interested parties in the Alouette Watershed, including government agencies, the Katzie First Nation, stewardship groups, environmental Non-Government Organizations (NGOs), and concerned citizens have a vision of restoring historic salmon (*Oncorhynchus* spp.) runs above the Alouette Dam at the outlet of the Alouette Reservoir (Figure 1). Among other things, salmon re-introduction to the Alouette Reservoir hinges on determining whether or not sufficient numbers of juvenile salmonids (smolts) will exit over the dam at the south end of the Alouette Reservoir or through the diversion to Stave Lake at the north end of the Alouette Reservoir. A previous feasibility assessment on fish passage by Bengeyfield et al. (2001) suggested that the majority of out-migrating smolts would orient to the much higher diversion flows in watersheds with inter-basin water transfers (Alouette, Coquitlam, and Carpenter). As a consequence, Bengeyfield et al. (2001) believed there was a reduced likelihood of successful re-introduction of anadromous salmonids above dams in these watersheds.

In 2002, LGL Limited (Sidney, B.C.) developed a framework for evaluating fish passage issues in the Bridge-Coastal hydro operating area (Bocking and Gaboury 2002). Following this, the Bridge Coastal Restoration Program (BCRP) sponsored an evaluation of the feasibility of restoring anadromous fish passage into the Alouette Reservoir (Gaboury and Bocking 2004). Numerous recommendations were made for future studies to address the fish-passage question at the Alouette Reservoir. To address the issue of whether smolts would exit over the dam or the diversion to Stave Lake, the BCRP sponsored a study in 2005 that monitored the migration of coho salmon (*O. kisutch*) smolts out of the Alouette Reservoir and down the South Alouette River using unique colours of visible implant elastomer (VIE) tags during a test surface release of ~3 m^3/s from the Alouette Dam (Baxter and Bocking 2006). Estimated migration success rates of coho salmon smolts to the lower Alouette River ranged from 79% for fish released at the spillway to 31–38% for fish released in the reservoir. The 2005 study also monitored the migration of sockeye salmon (*O. nerka*; raised to a suitable size) that were tagged with acoustic transmitters for subsequent detection in listening arrays in the lower Fraser River, Juan de Fuca Strait, and Strait of Georgia. From the release location, the estimated migration success was 26% to the lower Fraser River detection array and 5.3% to the Juan de Fuca detection array. In 2005, an estimated 7,900 *O. nerka* also emigrated from the reservoir. This unexpected result prompted the Water Use Plan Consultative Committee (WUP CC) to recommend that the surface release occur annually.

In 2006, a study was conducted to monitor steelhead (*O. mykiss*) smolt migration success out of the Alouette Reservoir and down the South Alouette River using both VIE tags and adipose fin clips (Humble et al. 2006). The estimated migration success rate to the lower Alouette River was only 5.8% for steelhead smolts released in the reservoir. This low success rate was believed to be, at least in part, related to the delayed opening of the spillway gate due to low water levels in the reservoir. The 2006 project also provided a second year of *O. nerka* passage with an estimated 5,064 fish migrating from the reservoir during the surface release flow of ~3 m^3/s.

The 2005 and 2006 study results indicated that *O. nerka* smolts were successfully migrating from the Alouette Reservoir and there was the potential for adult sockeye salmon to return as early as 2007. In order to assess the feasibility of sockeye salmon re-introduction into the Alouette Reservoir, the 2007 smolt study was conducted to determine the volitional migration success of

O. nerka from the reservoir during the surface release flow of ~3 m^3/s. In 2007, a total of 7,787 *O. nerka* were captured in the Mud Creek rotary screw trap (RST), located 1.5 km downstream of the Alouette Dam (Figure 2). An estimated 62,923 (95% confidence interval [CI]: 48,436−77,410) *O. nerka* emigrated from the Alouette Reservoir that year (Mathews and Bocking 2007). Supported by the previous three years of results, and as part of the Alouette Project Water Use Plan (BC Hydro 2009), surface release flows were scheduled to continue annually with the expectation of re-establishing a sockeye salmon run. In 2008, 3,224 *O. nerka* were captured at Mud Creek from 15 April to 26 May. The total 2008 migration was estimated to be 8,257 fish; this included a mark-recapture estimate of 7,712 fish (95% CI: 6,682–8,742) passing Mud Creek from 21 April to 8 May, plus an additional 545 fish (estimate based on trap efficiency) that passed outside of the marking period (Mathews and Bocking 2009). Monitoring continued at Mud Creek throughout the 2009 migration. In total, 1,247 *O. nerka* were captured in the RST, yielding a total estimate of 4,287 (95% CI: 3,833–4,741) for the period of 21 April to 28 May 2009 (Mathews and Bocking 2010).

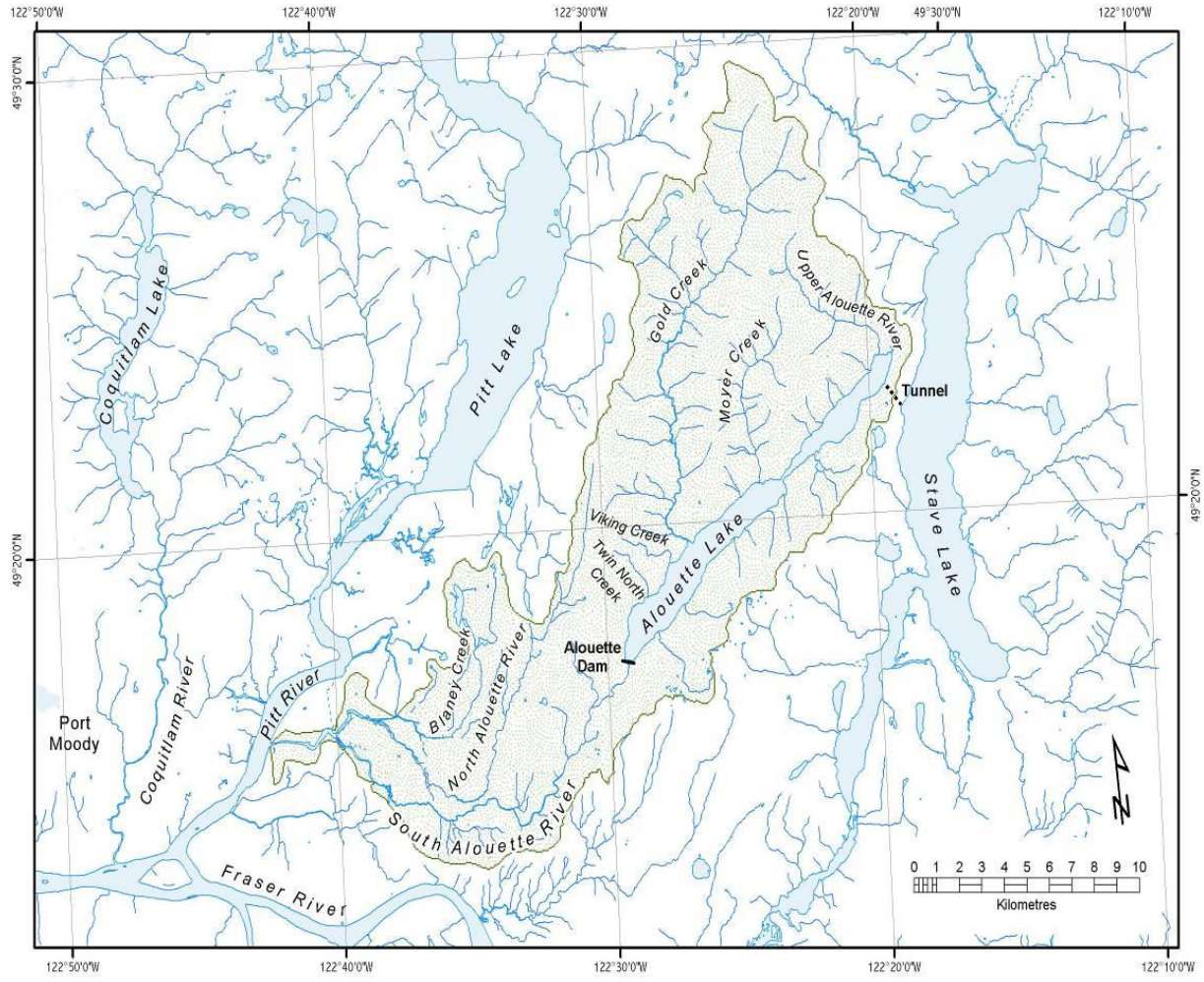

Figure 1. Map of the Alouette Watershed showing local communities and features.

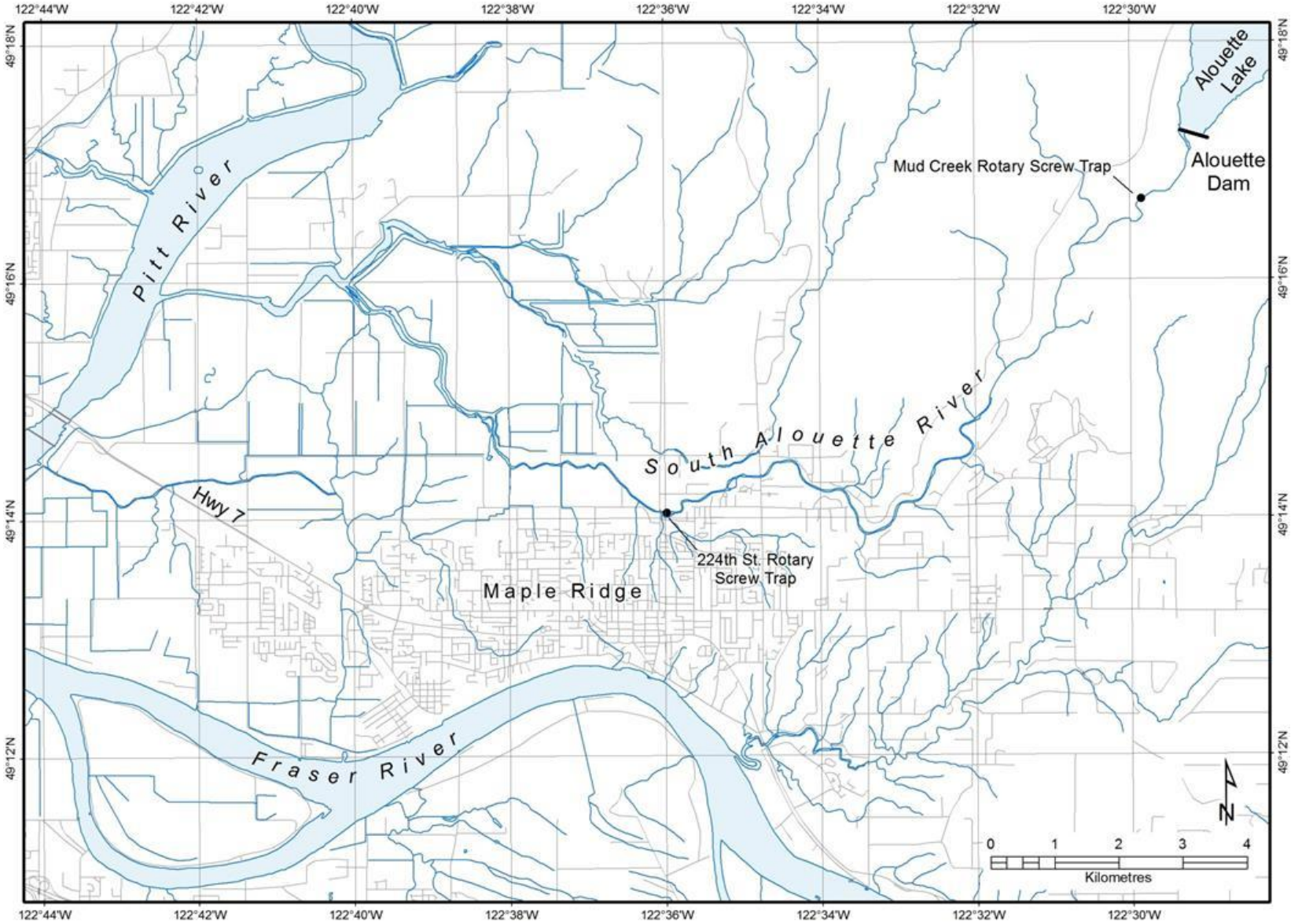

Figure 2. Map of the South Alouette River and locations of the rotary screw traps operational in 2013.

In 2010, two sites were to be used for the mark-recapture study. The Mud Creek RST was initially intended to operate as the recapture site. Two inclined plane traps (IPTs) located approximately 500 m upstream from the RST were intended to operate as the marking site. The IPTs were also to be used as a safe and effective trapping method during the flush. However, despite numerous modifications to the IPTs and the trapping site, they were not successful at capturing *O. nerka* smolts and were removed in early May. Fortunately, the RST operated as both the mark and recapture sites (as in previous years), and was used effectively during the 2010 flush period. In total, 4,600 *O. nerka* were captured at the RST, yielding a total estimate of 14,201 fish (95% CI: 13,624–14,778) from 18 April to 24 May. An additional 1,233 migrants were estimated based on trap efficiency (37.2%) outside of the marking period, resulting in a total estimate of 15,434 *O. nerka* (Mathews and Bocking 2011). In 2011, 9,841 *O. nerka* were captured at the Mud Creek RST and a mark-recapture estimate of 35,542 fish (95% CI: 34,034−37,051) was generated (Mathews et al. 2012). The 2012 study recorded the lowest catches (83 *O. nerka*) since trapping began at the Mud Creek site; resulting in a mark-recapture estimate of 728 fish (95% CI: 348-1,108; Mathews et al. 2013).

In the summer of 2007, 28 adult sockeye salmon returned to the South Alouette River. Genetic and scale-sample analyses indicated that these fish were from the 2005 *O. nerka* smolt migration from the reservoir (Godbout et al. 2011). During the summer of 2008, 54 adult sockeye salmon returned to the South Alouette River and genetic analysis indicated no discernible difference between these returning adults and the *O. nerka* smolt migrants (Mathews and Bocking 2009). Adult returns continued in 2009 as 45 sockeye salmon returned to the outlet of the Alouette Reservoir; 15 of these fish were tagged and tracked with radio telemetry to help determine the spawning location and timing of returns (Plate and Bocking 2010). Returns of adult sockeye salmon to the Alouette River in 2010 were the largest thus far as 115 migrants returned to the outlet of the reservoir. Radio telemetry was again used to help determine spawning locations and timing; 20 sockeye salmon were tagged and tracked (Plate and Bocking 2011). In 2011, 10 adult sockeye salmon returned, of which four were tagged (E. Plate, LGL Limited, pers. comm.). Adult returns then increased again in 2012 as 45 sockeye salmon returned to the South Alouette River (Borick-Cunningham 2012). Of these fish, 21 were tagged and tracked which improved our understanding of spawning timing and locations within the reservoir (Plate and Bocking 2013). These six years of returns, along with the continued smolt migration, lend support to the expectation that a South Alouette River sockeye salmon run, extirpated since the mid-1920s following the impoundment of the reservoir, could be re-established.

The revised Alouette Water License issued in April 2009 confirmed that the surface release and associated *O. nerka* out-migration enumeration would be conducted through 2014. Due to run-timing uncertainty, it was proposed that the surface release be done for a period of eight weeks each year. Annual monitoring would continue in order to identify the typical start, duration, and peak of the outmigration in hopes of shortening the duration of the surface release and reducing the corresponding flood risks. Although the migration timing has remained relatively consistent during the six years of full-season monitoring, there have been differences in peak timing and duration. The 2011 migration continued through the first week of June, which was approximately a week later than the 2007 and 2009 migrations, and two weeks later than in 2008 and 2010. The peak of the 2009 migration occurred in the latter half of May, while the peaks in 2007, 2008, and 2010 occurred late April. The 2010 migration also began with high

catches immediately once the spillway was opened in mid-April. Peak catches in 2012 occurred on the same date as 2011 (14 May); however, daily catches were extremely low and hence not readily comparable to previous years. Subsequent years of monitoring are, therefore, beneficial to help to improve our understanding of the timing of the run.

To address the uncertainty of whether the current magnitude of release is sufficient to promote migration among all seaward smolts, an experimental post-surface release flush was proposed for every second year of monitoring to determine if a doubling of flows for seven days could induce additional migrants to move out of the reservoir. The first year of flush was attempted in 2009 and was scheduled for seven days at the tail end of the migration. However, once flows reached a maximum of 6.5 m^3/s, the integrity of the RST and safety of the crew and fish captured became a concern, so the flush was terminated after only three days. As a result, it was proposed that a flush occur again in 2010 with an alternative gear type (IPTs) that could be operated safely during high flows. However, as discussed earlier, the IPTs were not effective at capturing *O. nerka* smolts, so operational modifications were made to the RST so that it could operate safely and effectively during the seven day flush period. No increases in *O. nerka* catches were observed at the Mud Creek RST during the 2010 and 2011 post-surface release flush periods.

Management Questions

Three management questions will be addressed throughout the subsequent years of monitoring:

1) Is the surface release of at least 3 m^3/s from the Alouette Dam (obtained through the spillway gate) adequate to promote the downstream migration of *O. nerka* smolts out of the Alouette Reservoir?

To address Question 1, the following hypothesis will be tested:

> H_O1: The seaward movement of kokanee/sockeye smolts, as identified from RST data collected at the confluence of Mud Creek, has a start, peak, and end that are characteristic of kokanee/sockeye smolts found in other systems (e.g., Cultus Lake sockeye salmon).

2) Does a post-surface release flush of 6-9 m^3/s, lasting seven days following the tail end of the out-migration period encourage more smolts to leave the system?

To address Question 2, the following hypothesis will be tested:

> H_O2: The seaward movement of kokanee/sockeye smolts, as identified from RST data collected at the confluence of Mud Creek, has a start, peak, and end (i.e., a bimodal out-migration pattern) during those years when a post-surface release flush of 6-9 m^3/s is implemented (the post surface release flush will be implemented on average every two years).

3) How long should the surface release last to ensure out-migration of all smolts prepared to leave the system?

Question 3 will be addressed through consideration of the results of the two hypotheses identified above, the start, peak and end dates of the migration period, the duration of the surface release, an assessment of downstream movement patterns, and smolt out-migration data from other coastal systems. These findings will then form the basis for an alternative surface release regime to be considered at the next WUP review in 2014/2015.

Project Objectives

Specific objectives for the 2013 study year were to:

1) Operate the Alouette Dam spillway to allow ~3.0–4.5 m^3/s of flow from 15 April to 14 June; flows through the low level outlet will be held near 0.0 m^3/s for the study period;
2) Install and operate a RST at the Mud Creek site, located 1.5 km downstream of the Alouette Dam, from 15 April to 14 June (or earlier if the migration ceases) to monitor the migration of *O. nerka* from the reservoir;
3) Capture *O. nerka* from the Alouette Reservoir in the Mud Creek RST;
4) Mark all *O. nerka* captured (up to a maximum of 150 fish + 10 target samples / day) throughout the entire migration and re-capture these same marked *O. nerka* in the Mud Creek RST to estimate total migration;
5) Determine the abundance, timing and biological characteristics of *O. nerka* migrating from the Alouette Reservoir;
6) Collect genetic tissue from 100 individuals of *O. nerka* to determine stock identification; and
7) Record incidental catches of all other species.

METHODS

Study Area

The Alouette Reservoir is located in east Maple Ridge in southwest British Columbia (Figure 1). The Alouette River watershed is a relatively small system (144 km^2) that arises in the Coastal Mountains of Golden Ears Provincial Park, approximately 50 km northeast of Vancouver, B.C. The upper watershed flows into an impounded reservoir known as Alouette Lake. At the reservoir's river outlet, the South Alouette River flows for 21 km before entering Pitt River near Pitt Meadows and the Pitt River, in turn, flows south into the Fraser River at Douglas Island.

Present fish resources within the Alouette Reservoir include kokanee (*O. nerka*), rainbow trout (*O. mykiss*), bull trout (*Salvelinus confluentus*), cutthroat trout (*O. clarki clarki*), lake trout (*Salvelinus namaycush*), stickleback (*Gasterosteus sp.*), sculpin (*Cottus* sp.), northern pikeminnow (*Ptycheilus oregonensis*), peamouth chub (*Mylocheilus caurinus*), bridgelip sucker (*Catostomus columbianus*), largescale sucker (*Catostomus macrocheilus*), and redside shiner (*Richardsonius balteatus*; Wilson et al. 2003).

BC Hydro Operations

To facilitate the 2013 study, BC Hydro agreed to release water over the spillway at the Alouette Dam, while closing the low level outlet, for the period of 15 April to 14 June. The spillway

release and low level outlet closure were consistent throughout the duration of the RST operation.

Fish Capture and Sampling

All fish for this study were captured at the Mud Creek RST, located on the South Alouette River approximately 1.5 km downstream of the Alouette Dam (Figure 2; Photo 1). The Mud Creek RST was checked twice daily. Each morning, crews enumerated all species of fish in the holding box. Unmarked non-target fish were enumerated to species and released downstream of the trap. All steelhead were examined for adipose fin clips (applied in 2006); and if clipped, were also examined for the presence of a fluorescent VIE tag prior to release. Each evening, crews checked the RST for debris and ensured that all fish in the holding box were healthy. All fish captured after the morning check were processed the following morning.

Up to a daily maximum of 150 randomly chosen *O. nerka* were marked with a lower caudal fin clip. If the random sample did not produce ten large fish (≥ 100 mm FL), then additional target samples were to be collected until this goal was reached (up to a maximum of 10 fish per day). All target fish were to receive an adipose fin clip instead of a lower caudal fin clip. All marked fish were released into the plunge pool below the dam during the evening on the day they were marked which allowed adequate time for recovery.

The first 40 randomly chosen *O. nerka* each day, as well as any target samples of large fish, were measured for fork length (to the nearest millimetre) and weighed (to the nearest tenth of a gram). Fish scales were collected from the first 10 randomly chosen *O. nerka* each day, and from all target samples. Scales were sent to the Pacific Salmon Commission (Vancouver, B.C.) for ageing. Genetic samples (fin tissue) were collected from the first 40 randomly chosen *O. nerka* each day, from all target samples, and from any mortalities. Genetic samples were sent to the Pacific Biological Station (Nanaimo, B.C.) to process for stock identification.

Photo 1. Mud Creek rotary screw trap.

Statistical Analyses

Abundance Estimate

A pooled Petersen estimator with Chapman modification was used to estimate the number of *O. nerka* migrating from the reservoir:

$$N = \frac{(M+1)(C+1)}{R+1} - 1, \text{ where} \quad (1)$$

C = total number of fish caught in second sample (including recaptures),
M = number of fish caught, marked, and released in first sample,
N = population estimate, and
R = number of recaptures in the second sample (i.e., fish that were marked and released in the first sample).

The variance, standard error, and approximate 95% confidence interval for the abundance estimate (N) were calculated as follows:

$$\text{Variance of } N = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)^2(R+2)} \quad (2)$$

$$\text{Standard error} = \sqrt{Variance of N} \quad (3)$$

$$N \pm 1.96 * \text{Standard Error} \quad (4)$$

Fish Lengths, Weights and Condition Factor

The lengths, weights, and condition factors of randomly chosen one-year-old *O. nerka* smolts (i.e., fish considered to have over-wintered for one year in the Alouette Reservoir) were compared by year of monitoring using ANOVA. Length-at-age data from 2005 to 2010 (Mathews and Bocking 2011) indicated that one-year-old fish were 100 mm FL or less, thus bigger fish were excluded from the length and weight analyses. When ANOVA results were statistically significant, Tukey's HSD post-hoc multiple comparison was used to assess pairwise differences.

224th Street Rotary Screw Trap

Westslope Fisheries Ltd. has been conducting a separate smolt migration enumeration study on the South Alouette River since 1998. This monitoring project has been a requirement of the Alouette DAM WUP (ALUMON-1) since 2008. The current trapping site is located approximately 14 km downstream of the Alouette Reservoir near 224th Street (Figure 2; Cope 2014). The main objective of this annual study was to obtain abundance estimates of emigrant fry and smolts (by species) using mark-recapture techniques. Crews at the 224th Street RST inspected all *O. nerka* for fin clips that were applied at the Mud Creek RST.

RESULTS

BC Hydro Operations

The Alouette Dam spillway gate was opened on 15 April 2013 at 1101 hours and remained open until 14 June at 1326 hours. During the *O. nerka* smolt migration period from 16 April to 23 May, average daily releases from the spillway gate ranged from 3.27–4.29 m^3/s (Figure 3; Appendix A). The low level outlet gate was closed from 15 April (1115 hours) to 14 June (1310 hours). The spillway release and low level closure were consistent throughout the duration of the trapping operations. Spillway flows were very similar to those maintained during the full monitoring years (2007 and later); however, no flushing flows occurred at the tail end of the 2013 migration. Also, as has been the case in past years, the majority of Alouette flows in 2013 were diverted to the Stave Reservoir via the adit gate (ranged from 27.55 to 28.28 m^3/s during the migration).

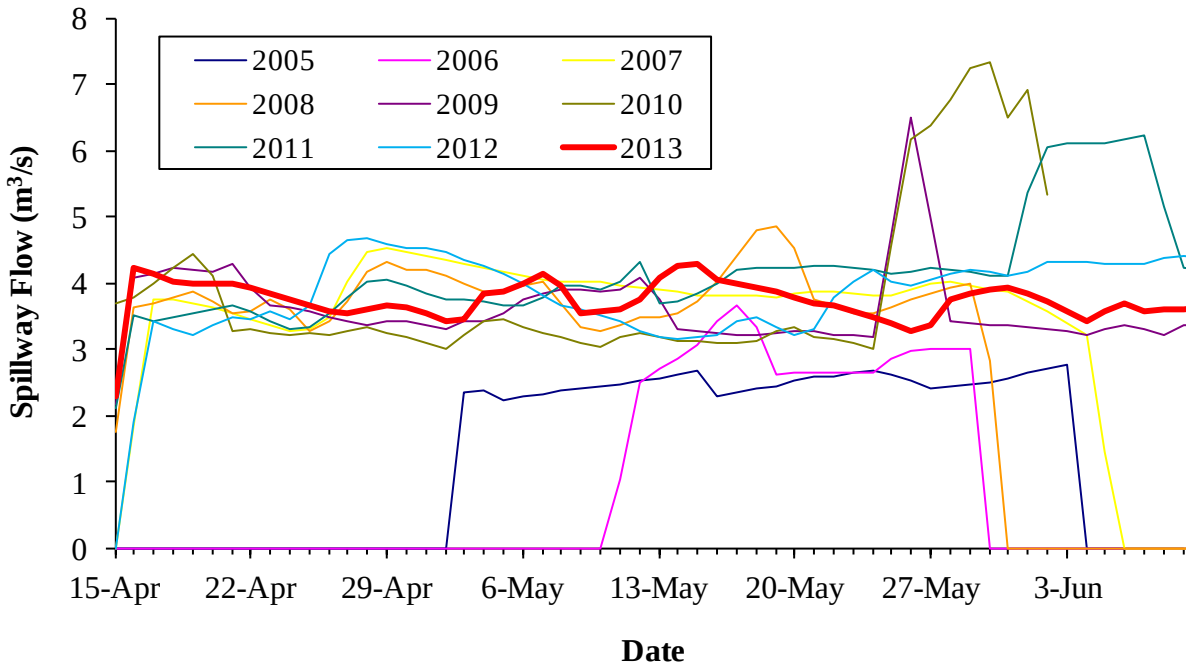

Figure 3. Comparison of flows at the Alouette Dam spillway gate during the *O. nerka* migration period, 2005–2013.

Fishing Effort and Physical Conditions

The Mud Creek RST was operated almost continuously from 13 April (1200 hours) to 31 May (1000 hours). The RST was stopped for 5 minutes (0940–0945 hours) on 7 May to remove debris from the drum. Although spillway flows continued as planned until 14 June, monitoring ceased on 31 May because no *O. nerka* had been captured since 23 May, and the migration had presumably ended.

Water temperature, water depth, RST rotational speed, and general weather conditions were recorded daily each morning from 15 April to 30 May at the Mud Creek site (Appendix B). Water temperature was measured using a hand-held thermometer. Daily discharge of the South Alouette River was recorded at the Water Survey of Canada Station No. 08MH005 (~10 km downstream of the Mud Creek RST site), and ranged from 3.14–9.37 m^3/s (mean = 4.76 m^3/s) between 13 April and 31 May (Figure 4). Three spikes in Alouette River discharge occurred during the smolt migration; however, none of these were associated with large increases in spillway flows at the Alouette Dam (discharge increases were likely due to increases in tributary inputs; Figure 4; Appendix A).

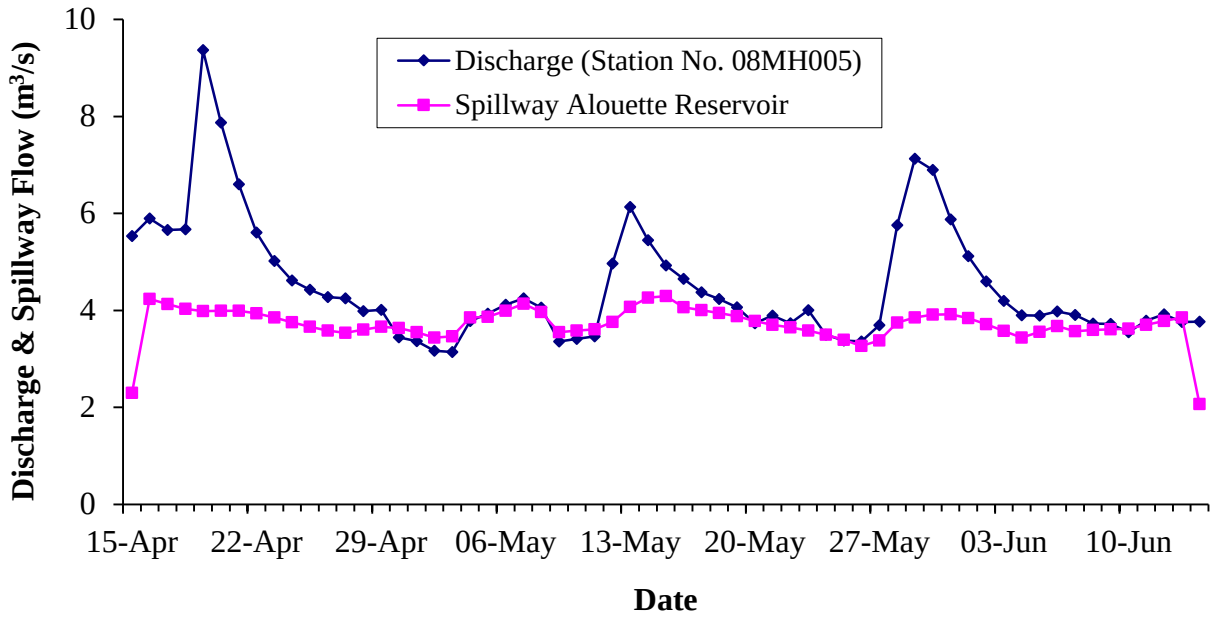

Figure 4. Daily discharge (m^3/s) at Water Survey of Canada Station No. 08MH005 and spillway flows from the Alouette Reservoir (15 April–15 June 2013). The WSC station is located on the mainstem South Alouette River at the 232nd Street bridge (discharge data from Water Survey of Canada website: http://www.ec.gc.ca/rhc-wsc/).

Fish Capture and Sampling

O. nerka

In 2013, 1,032 unmarked *O. nerka* were captured in the Mud Creek RST from 13 April to 31 May (Table 1; Figure 5). The peak catch of 388 smolts occurred on 5 May. The first *O. nerka* was captured on 16 April, and the last *O. nerka* was captured on 23 May, a migration duration of 38 days.

A total of 794 *O. nerka* ('M') were marked (lower caudal clipped) and released below the dam from 16 April to 23 May 2013 (Table 2). In total 1,165 smolts ('C') captured at the Mud Creek RST were examined for marks and considered available for recapture, 149 ('R'; 12.8%) of those examined were lower caudal clipped recaptures. Sixteen *O. nerka* captured from 16–17 April were censored from the second-event sample due to the assumption of a two day travel time from the plunge pool release site to the RST capture site (i.e., it was highly unlikely that these 16 fish were already marked and hence had the potential of being recaptures). Capture efficiency at the Mud Creek RST was estimated to be 18.8% (149 recaptures out of 794 marked fish released). Using a pooled Petersen estimator, an estimated 6,179 ('N'; 95% CI: 5,350–7,008) smolts migrated from the Alouette Reservoir from 16 April to 31 May (Table 2). No target fish were sampled in 2013 hence no *O. nerka* were adipose clipped.

Table 1. Daily catch of *O. nerka* in the Mud Creek and 224th Street rotary screw traps, 2013.

	Mud Creek		224th Street	
Date	Unmarked	Clip Recaptures	Unmarked	Clip Recaptures[a]
13-Apr	0			
14-Apr	0	0		
15-Apr	0	0		
16-Apr	5	0		
17-Apr	11	0	1	
18-Apr	4	0	1	
19-Apr	5	2		
20-Apr	0	1		
21-Apr	4	0		
22-Apr	6	0		
23-Apr	9	0		
24-Apr	18	1		
25-Apr	27	0		
26-Apr	35	0		
27-Apr	20	6	1	
28-Apr	11	10	3	
29-Apr	4	8	1	
30-Apr	23	2	1	
1-May	17	1	3	
2-May	26	3	2	1
3-May	32	4	3	
4-May	132	9	7	1
5-May	388	16	73	1
6-May	84	30	35	1
7-May	36	24	28	1
8-May	30	10	15	3
9-May	37	5	5	2
10-May	28	8	7	
11-May	16	4		1
12-May	4	3	1	1
13-May	3	0	1	1
14-May	11	1	1	
15-May	2	0	1	
16-May	1	0		
17-May	1	1	1	
18-May	0	0		

Table 1. Continued.

	Mud Creek		224th Street	
Date	Unmarked	Clip Recaptures	Unmarked	Clip Recaptures[a]
19-May	0	0		
20-May	0	0	1	
21-May	0	0		
22-May	1	0		
23-May	1	0		
24-May	0	0		
25-May	0	0		
26-May	0	0		
27-May	0	0		
28-May	0	0		
29-May	0	0		
30-May	0	0		
31-May	0	0		
1-Jun				
2-Jun				
3-Jun				
4-Jun				
5-Jun				
6-Jun				
7-Jun				
8-Jun				
9-Jun				
10-Jun				
11-Jun				
12-Jun				
13-Jun				
14-Jun				
Total	**1,032**	**149**	**192**	**13**

[a] Clip recaptures from Mud Creek RST; an additional 8 fish (not displayed) were recaptures from 224th Street location.

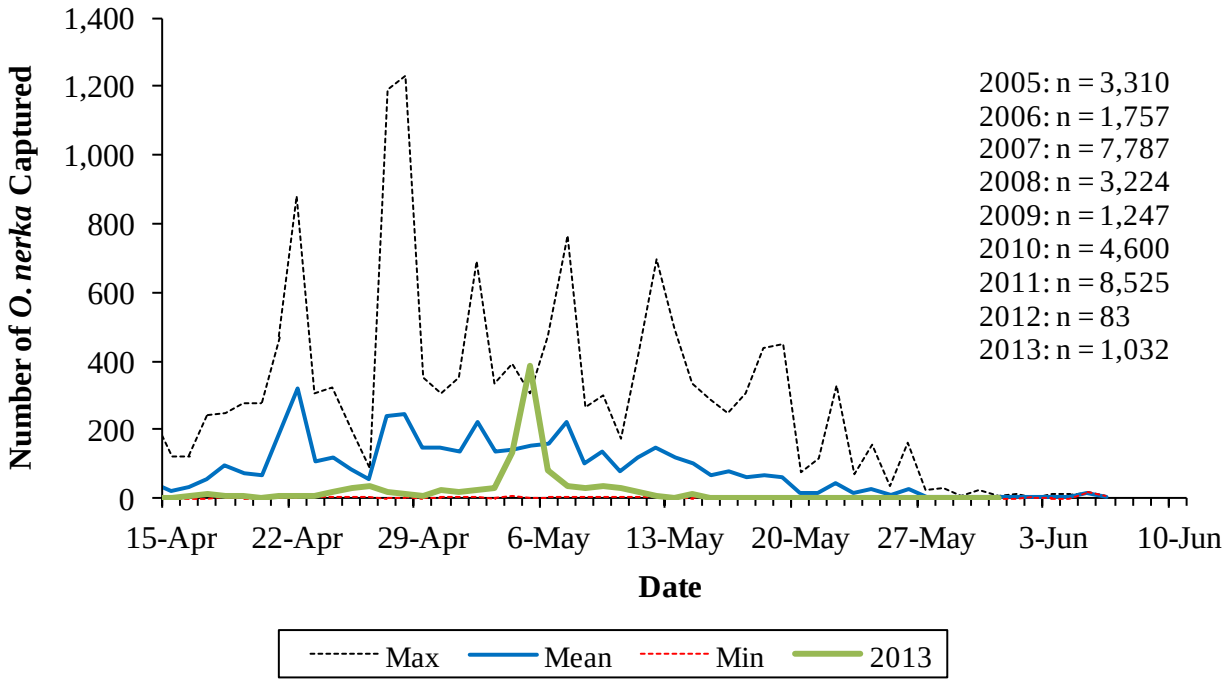

Figure 5. Daily catch of *O. nerka* at the Mud Creek rotary screw trap in 2013 in comparison to the maximum, mean and minimum catches of the previous eight years (spillway opened 3 May, 11 May, 16 April, 15 April, 15 April, 14 April, 15 April, 16 April, and 15 April for 2005–2013, respectively).

Table 2. Total estimated *O. nerka* migration from the Alouette Reservoir, 2013.

No. *O. nerka* Clipped and Released Below Dam ('M')	794
No. *O. nerka* Examined for Clips ('C')	1,165
No. *O. nerka* Recaptures ('R')	149
Estimated *O. nerka* Passage (16 April–31 May 2013) ('N')	**6,179**
95% Confidence Intervals	(5,350–7,008)
Trap Efficiency	18.8%

Of the 1,032 *O. nerka* captured at Mud Creek in 2013, 552 were biosampled for fork length and weight (one fish was later excluded from size analysis due to erroneous measurements), and their corresponding fin clips were collected for genetic stock identification. Of those biosampled, 246 smolts were also scale-sampled for age analysis. Scale and genetic samples collected from *O. nerka* in 2013 had not been analyzed at the time this report was prepared.

The lengths of *O. nerka* sampled ranged from 61–218 mm FL (mean = 94 mm FL; n = 551; Figure 6). The largest number of *O. nerka* were in the 81-85 mm (n = 170) size class, followed closely by the 86-90 mm (n = 168) size class. The weights of *O. nerka* sampled ranged from 2.0–106.0 g and averaged 9.1 g (n = 551). Figure 7 displays a length-weight relationship established for the 2013 *O. nerka* smolts migrating from the Alouette Reservoir.

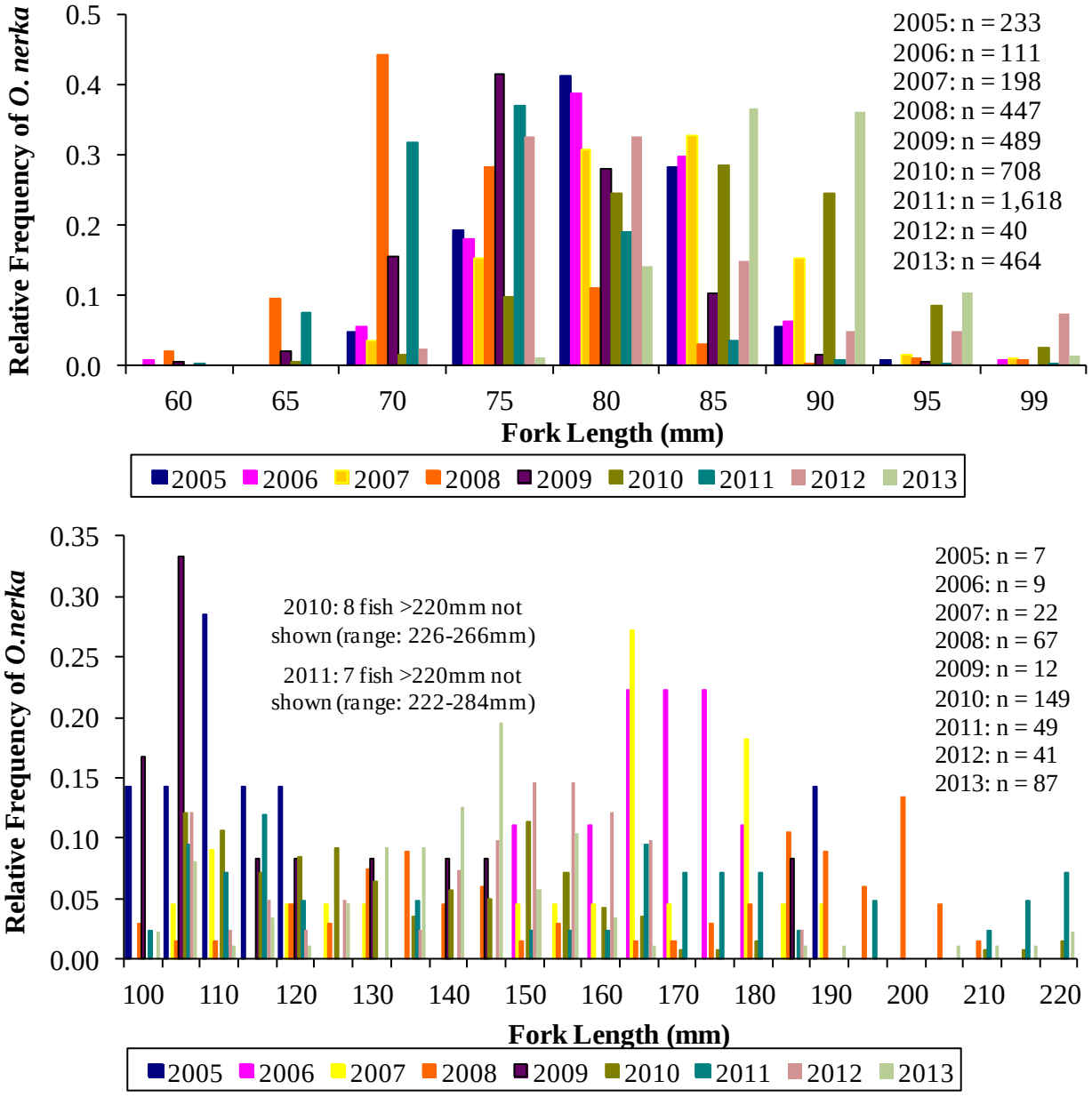

Figure 6. Length frequency distribution of *O. nerka* measuring less than 100 mm FL (top panel), and 100 mm FL or greater (bottom panel), captured in the Mud Creek rotary screw trap operated in the South Alouette River (random and target samples), 2005−2013.

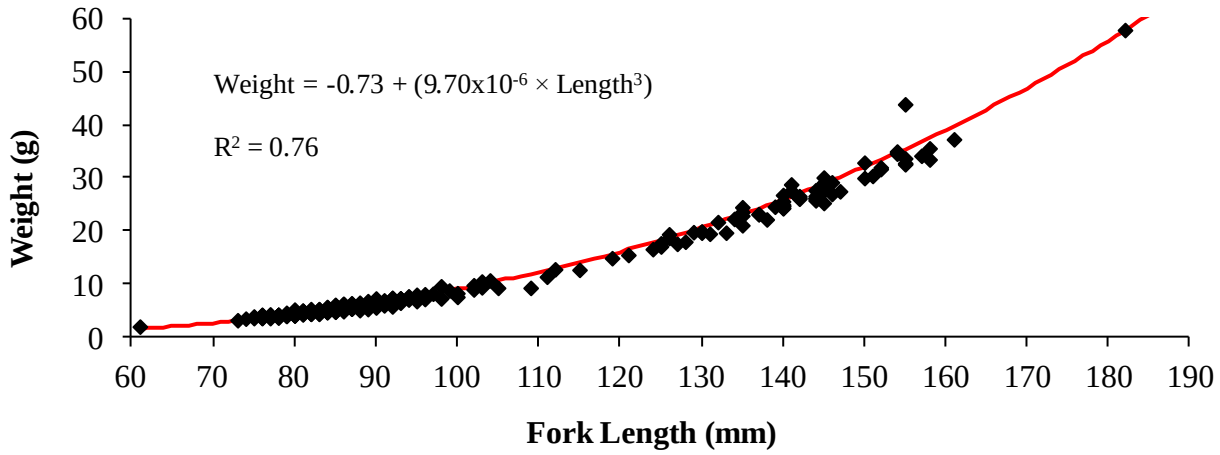

Figure 7. Length-weight relationship of *O. nerka* smolts migrating from the South Alouette Reservoir, 2013.

Of those *O. nerka* measuring less than 100 mm FL (i.e., fish considered to have over-wintered for one year in the Alouette Reservoir), mean lengths varied significantly among years ($F_{8, 4285}$ = 519.6, $P < 0.0001$; Table 3). Post-hoc pairwise comparisons between years indicated the 2005, 2006, and 2012 mean fork lengths (78.6, 79.5, and 79.9 mm, respectively) were not significantly different, and neither were the 2006, 2007, and 2012 mean fork lengths (79.5, 80.8, and 79.9 mm FL, respectively). However, the mean fork lengths from all other year combinations differed from one another. The mean fork length of fish measured in 2013 (85.6 mm) was the highest observed in the nine years of study.

Table 3. Mean length of *O. nerka* less than 100 mm FL (random samples only), 2005−2013.

Year	Mean FL (mm)	SE	n
2005	78.6	0.31	233
2006	79.5	0.54	97
2007	80.8	0.38	198
2008	71.2	0.28	447
2009	75.0	0.23	489
2010	83.2	0.23	708
2011	72.4	0.12	1,618
2012	79.9	1.24	40
2013	85.6	0.22	464

No weight data was collected in 2008, and the weight data collected in 2005 was excluded due to sampling biases. The average weight of one-year-old *O. nerka* varied significantly among the remaining study years ($F_{6, 3583}$ = 678.2, $P < 0.0001$; Table 4). Post-hoc pairwise comparisons

between years indicated that the mean weights in 2006, 2007, and 2012 (4.6, 4.8, and 4.3 g, respectively) were not significantly different, but that all other pairs of years differed significantly. The mean weight of fish measured in 2013 (5.5 g) was the highest observed in the seven years of study.

Table 4. Mean weights of *O. nerka* less than 100 mm FL (random samples only), 2006−2007 and 2009–2013.

Year	Mean Wt (g)	SE	n
2006	4.6	0.08	97
2007	4.8	0.08	198
2009	3.7	0.04	489
2010	5.0	0.05	684
2011	3.1	0.02	1,618
2012	4.3	0.22	40
2013	5.5	0.04	464

No condition factors were calculated from data collected in 2005 or 2008. The average condition factor varied significantly among the remaining study years ($F_{6, 3583} = 151.7$, $P < 0.0001$). Results of the post-hoc pairwise comparisons between years are shown in Figure 8, where years that are not connected by the same letter are significantly different (2013 was not different from 2009; 2012 was not different from 2010 or 2011, etc.).

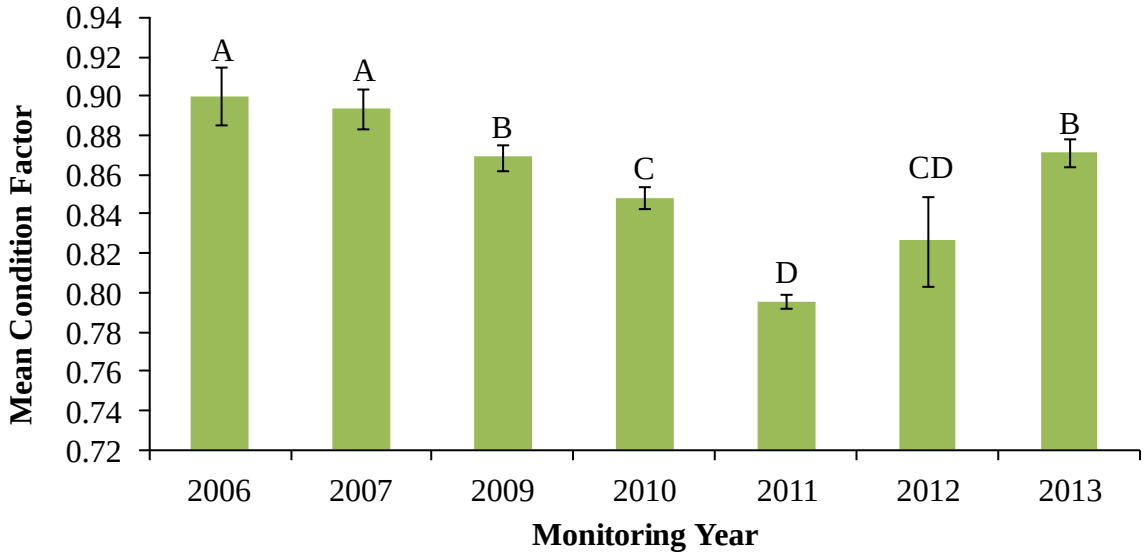

Figure 8. Comparison of mean condition factors from sampling years 2006–2007 and 2009−2013. Letters indicate results of the post-hoc pairwise comparisons between years, where years that are not connected by the same letter are significantly different.

Additionally, we compared the average length of *O. nerka* smolts measuring less than 100 mm FL and the estimated abundance of *O. nerka* (all sizes) that migrated from the South Alouette Reservoir (Figure 9). There was no apparent relationship between smolt size and abundance.

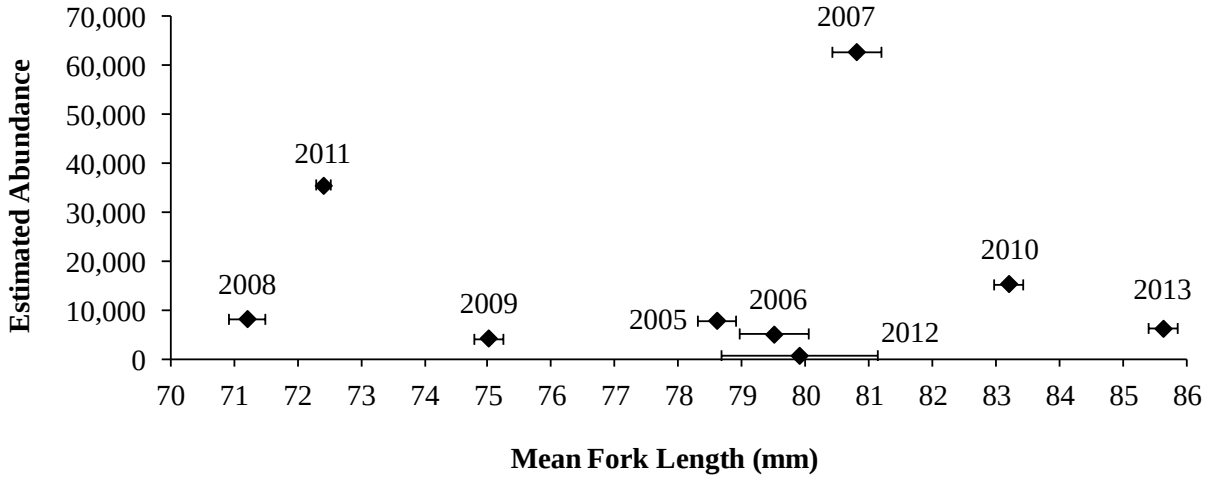

Figure 9. Comparison of the average length of *O. nerka* smolts measuring less than 100 mm FL and the estimated abundance of *O. nerka* (all sizes) that migrated from the South Alouette Reservoir, 2005–2013. Labels above the data points indicate the study year.

Steelhead Smolts

In 2013, a total of 254 wild steelhead smolts (> 90 mm FL) were captured in the Mud Creek RST. Steelhead were caught consistently from 15 April to 29 May, and the peak catch occurred on 6 May (n = 35; Figure 10). As has been the case consistently since 2010, no adipose-clipped steelhead were captured in 2013.

Other Species

Consistent with past sampling years, many other non-target species were captured in the Mud Creek RST in 2013. Greater than 371,415 salmonid fry were estimated from daily catches, the vast majority were chum salmon (*O. keta*), and the remainder consisted of Chinook (*O. tshawytscha)*, and coho salmon fry (Appendix C). Other salmonid catches included a total of 555 coho salmon parr/smolts (> 70 mm FL), 55 Chinook salmon parr/smolts (> 70 mm FL), 22 steelhead (< 90 mm FL), 25 rainbow trout, and 1 cutthroat trout. In addition to these salmonids, dace (*Rhinichthys* spp.), sculpin, northern pikeminnow, stickleback, peamouth chub and lamprey (*Lampetra* sp.) were also counted and released.

224th Street Rotary Screw Trap

The 224th Street RST operated from 1 March to 14 June 2013. In total, 192 unmarked *O. nerka* were captured from 17 April to 20 May and 13 lower caudal clipped *O. nerka* (from Mud Creek)

were captured (Table 1). In addition to the Mud Creek marking site recaptures, 8 upper caudal clipped fish were recaptured after having been previously caught and marked at the 224th Street site. The estimated *O. nerka* catch efficiency of the 224th Street RST was 4.2% (eight recaptures out of 189 marked fish released) and the corresponding population estimate of *O. nerka* at the 224th Street site was 4,349 (95% CI: 2,597–11,818).

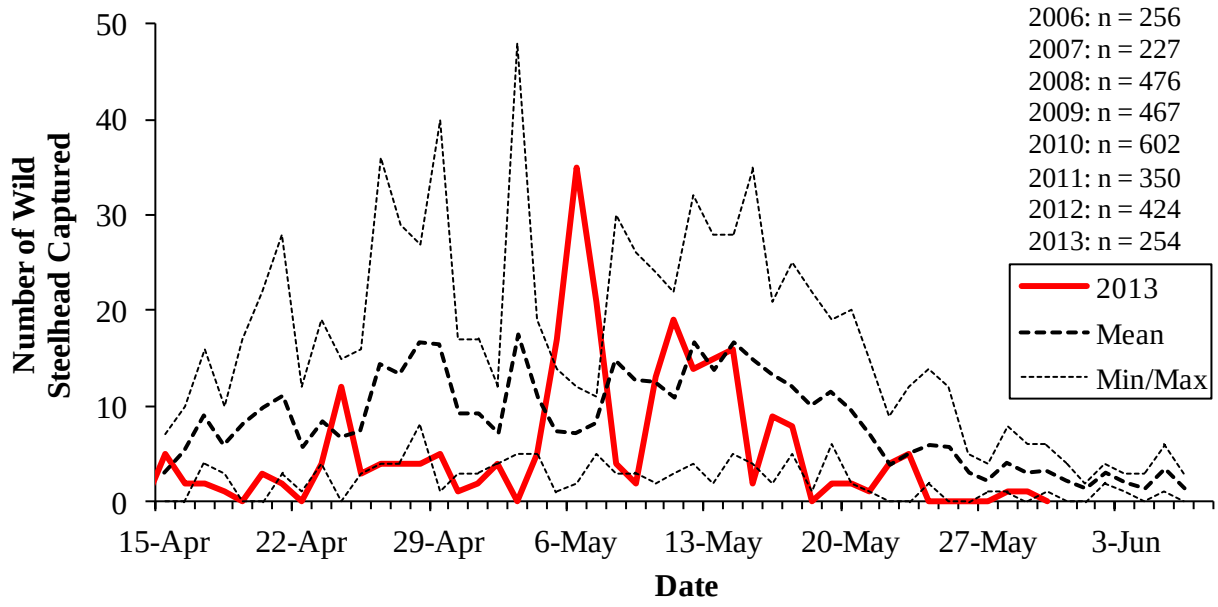

Figure 10. Daily catch of wild steelhead smolts (> 90 mm FL) at the Mud Creek rotary screw trap, 2013. Minimum, maximum, and mean daily catches from 2006−2012 were plotted for reference.

DISCUSSION

BC Hydro Operations

Average daily spillway gate flows to the South Alouette River during the smolt migration were maintained at a similar range as past full monitoring years (2007 onward); 2013 flows ranged from 3.27–4.29 m^3/s (Figure 3). As was the case in 2012, no post-surface release flush occurred in 2013 as catches ceased by 23 May. A post-surface release flush is scheduled for the 2014 migration period to allow one more flush-period analysis prior to the next WUP review process.

Flows to the Stave Reservoir via the adit gate in 2013 (27.55 to 28.28 m^3/s) were similar to previous years with the exception of 2012 (2012 adit gate flows were approximately double those of other years).

Fishing Effort

For the fourth consecutive year, the Mud Creek RST was operated consistently throughout the *O. nerka* migration period. Crews were able to effectively and safely operate the RST over a

range of water conditions with very minimal down time. Substantial peaks in spillway flow did not occur when large increases in Alouette River discharge were noted.

Abundance Estimate

At Mud Creek, the South Alouette River *O. nerka* smolt migration was estimated to be 6,179 (CI: 5,350–7,008) fish for the period of 16 April to 31 May 2013. This was the sixth highest estimate in the nine years of study, almost 80% of the median estimate (N = 7,900 in 2005), and approximately eight times larger than the lowest estimate (N = 728 in 2012; Table 5).

Although the 2013 abundance estimate ranked sixth highest (or fourth lowest) of the nine years of study, the total catch of 1,032 *O. nerka* ranked second lowest, following the extreme low in 2012 of only 83 smolts. The Mud Creek RST capture efficiency in 2013 of 18.8% was also lower than the range of 28–42% observed in earlier years of study (2005–2011, excluding 2007; Table 5; Figure 5). As was the case in 2012 (capture efficiency of 11.3%), the low capture efficiency did not appear to be the result of any operational issues at the RST site. This was again supported by the fact that a large number of non-target species were captured at the Mud Creek RST. Also, the total catch of 192 *O. nerka* at the 224th Street RST was proportional to 19% of the Mud Creek RST catch (Table 1), which is within the range of 9–31% observed since the current WUP monitoring period began in 2008. Again, relative to previous years, there was no significant variation in the location or cross-sectional position of the RST in the channel (i.e., relative to the thalweg). A few weeks prior to the study period, significant rainfall did cause erosion problems at the culvert confluence of Mud Creek; however, this did not appear to alter the channel morphology of the RST site.

Table 5. Total catch at the Mud Creek rotary screw trap and the corresponding population estimate of *O. nerka* migrating from the Alouette Reservoir, 2005−2013.

Year	Total Catch	Abundance Estimate (N)	Lower 95% CI	Upper 95% CI	Trap Efficiency (%)
2005[a]	3,310	7,900	-	-	42
2006[b]	1,757	5,064	-	-	35
2007[c]	7,787	62,923	48,436	77,410	12
2008[d]	3,224	8,257	-	-	40
2009[e]	1,247	4,287	3,833	4,741	34
2010[f]	4,600	15,434	-	-	37
2011[g]	8,525	35,542	34,034	37,051	28
2012[h]	83	728	348	1,108	11
2013[i]	1,032	6,179	5,350	7,008	19

[a] Based on coho salmon trap efficiency *(Baxter and Bocking 2006)*.

[b] Based on *O. nerka* trap efficiency *(Humble et al. 2006)*.

[c] Pooled Petersen estimate (19 April to 1 June) *(Mathews and Bocking 2007)* .

[d] Trap efficiency estimate of 545 (15 April to 20 April & 9 May to 26 May) + Pooled Petersen estimate of 7,712 (95% CI 6,682 to 8,742; 21 April to 8 May) (*Mathews and Bocking 2009)*.

[e] Pooled Petersen estimate (21 April to 1 June) *(Mathews and Bocking 2010)*.

[f] Trap efficiency estimate of 1,232 (15 to 17 April) + Pooled Petersen estimate of 14,201 (95% CI 13,624 to 14,778; 18 April to 24 May) + Total catch of 1 (25 May to 1 June) *(Mathews and Bocking 2011)*.

[g] Pooled Petersen estimate (15 April to 8 June) *(Mathews et al. 2012)*.

[h] Pooled Petersen estimate (17 April to 1 June) *(Mathews et al. 2013)*.

[i] Pooled Petersen estimate (16 April to 31 May) *(Mathews et al. 2014 In Press)*.

Run Timing

The 38-day duration of the 2013 Alouette Reservoir *O. nerka* migration (16 April to 23 May) was the shortest of all full seasons monitored (2007–2012, range: 39–51 days; Figure 5). The start and peak dates for the 2005 and 2006 migrations were not comparable to those from 2007 to 2013 because the spillway was opened much later in those years (3 May 2005 and 11 May 2006), and presumably after the onset of the *O. nerka* migrations.

In 2013, the first *O. nerka* were captured on 16 April, which was one day after the spillway was opened. This timing was similar to the start dates observed from 2007 to 2012 during full season monitoring (15–19 April). For the third consecutive year, catches during the first week of migration were consistently low, indicating the spillway opening was timed well with the onset of the migration. This was not always the case in past years. High catches of *O. nerka* upon

immediate opening of the spillway in 2010, and to a lesser extent in 2007, indicated it was possible that the migrations in these years may have begun earlier if the spillway had been opened earlier.

Peak catches of *O. nerka* at both the Mud Creek and 224th Street RSTs occurred on 5 May in 2013. This was the only year that peak catches have occurred on the same day for both traps. Since full-season monitoring began, peak catches have been staggered by one day during two of the study years (2009 and 2010), and by several days during the other years. The occurrence of peak catches on the same day at both traps is unexpected given the 224th Street RST is located approximately 12.5 km downstream from the Mud Creek RST. The timing of peak catch in 2013 was in the range of past study years, ranging from 5–12 days later than 2007, 2008, and 2010 (23−30 April), and 4–13 days earlier than 2005, 2006, 2009, 2011, and 2012 (9–18 May). Similar to the 2008 to 2012 study years, the date of peak catch in 2013 did not correspond to the date of peak spillway flows. In contrast, peak catches in 2007 did occur during the period of highest spillway flows.

End dates of the *O. nerka* migrations have varied considerably since 2005. The end date of the 2013 migration on 23 May was very similar to those observed in 2005, 2008, and 2012 (24−25 May); approximately one week earlier than those observed in 2006, 2007, 2009, and 2010 (28 May–1 June); and approximately two weeks earlier than the end date in 2011 (8 June). Due to the continued variation in start dates, peak timing, and end dates observed since 2005, additional years of monitoring are still required to better understand the run timing of *O. nerka* from of the Alouette Reservoir. However, the target spill period from mid-April to mid-June (as effected from 2007 to 2012) appears to cover the bulk of the smolt migration window in most years monitored to-date.

Biosamples

The mean fork length of *O. nerka* (< 100 mm FL) sampled in 2013 (85.6 mm FL; n = 464) was significantly larger than the mean fork lengths observed in previous study years (Table 3). On average, the other 'large fish years' (mean > 78 mm FL), occurred in 2005 to 2007, 2012, and 2010, of which the latter year produced the second greatest mean of all study years (83.2 mm FL; n = 708). The mean fork lengths in these years contrast notably with those in 2008, 2009, and 2011, in which mean lengths were smaller (range: 71.2–75.0 mm FL). In 2013, the largest number of fish were in the 81–85 mm FL size class, followed closely by the 86–90 mm size class (Figure 6). Size classes comprising the largest number of *O. nerka* have varied over the years: 66–70 (2008), 71–75 (2009, 2011, 2012), 76–80 (2005, 2006, 2012; equal numbers of fish measured in 2012 were in both the latter two size classes), and 81–85 mm FL (2007, 2010). The smallest *O. nerka* sampled in 2013 measured 61 mm FL, while the largest fish measured 218 mm FL. As was the case with fork length, *O. nerka* sampled (< 100 mm FL) in 2013 had the heaviest mean weight (5.5 g; n = 464); and it was significantly different from all other years with measured weight data (Table 4).

Condition factor was compared across all years with length and weight data (2005 and 2008 excluded). The mean condition factor of the 2013 *O. nerka* smolts was 0.87 (n = 464), which

was within the mean range of 0.80–0.90 from previous study years, and statistically significant from all other years except 2009 (mean condition factor = 0.87; n = 489; Figure 8).

As mentioned earlier, age and genetic samples from the 2013 study year had not been analyzed by the time this report was completed. Results of genetic analysis of the Alouette Reservoir sockeye salmon population, including *O. nerka* smolt samples collected at Mud Creek during past study years, are found in Godbout et al. (2011) and Godbout et al. (2013).

Steelhead Smolts (> 90 mm FL)

The total catch of wild steelhead smolts (> 90 mm FL) at the Mud Creek RST in 2013 (254 fish) was the second lowest of the past eight years of monitoring (Figure 10). This was just 27 more fish than the lowest catch year (227 fish in 2007), only 2 fish less than the 2006 catch of 256 smolts, and almost 100 fish less than the next highest catch year of 350 fish in 2011. The date of peak catch in 2013 (6 May) was similar to 2010 (3 May) and 2007 (9 May), 8–11 days later than 2008, 2011, and 2012, and 7 and 9 days earlier than 2006 and 2009, respectively.

RECOMMENDATIONS

The following recommendations are proposed for the monitoring of *O. nerka* migration from the Alouette Reservoir in 2014:

1) Maintain similar flows from the Alouette Dam spillway gate (3.0–4.5 m^3/s), including a post-surface release flush of 6.0–9.0 m^3/s, lasting seven days following the tail end of the out-migration period;
2) Conduct daily marking of *O. nerka* at the RST across the entire migration period to ensure an accurate abundance estimate can be generated;
3) Collect genetic tissue from at least 100 *O. nerka* for stock identification;
4) Collect scale samples from *O. nerka* for ageing; and
5) Continue to enumerate all non-target fish species, including steelhead.

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APPENDICES

Appendix A. BC Hydro operations at the Alouette Reservoir during the 2013 study period.

Date	Daily Average Alouette Reservoir Elevation (m)	Alouette Spillway Gate Position (mm)	Daily Average Alouette Reservoir Spill to Alouette River (cms)	Alouette Low Level Outlet Gate Position (open/closed)	Daily Average Alouette Reservoir Spill to Alouette River Via Low Level Outlet (cms)	Daily Average Alouette Reservoir Spill to Stave Reservoir Via Adit Gate (cms)
14-Apr	123.742	0	0.000	open	2.803	28.276
15-Apr	123.657	30 @ 11:01; 150 @ 11:16	2.300	closed (11:15)	1.305	28.221
16-Apr	123.555	150	4.235	closed	0.000	28.154
17-Apr	123.443	150	4.130	closed	0.000	28.081
18-Apr	123.334	150	4.028	closed	0.000	28.009
19-Apr	123.293	150	3.987	closed	0.000	27.981
20-Apr	123.298	150	3.992	closed	0.000	27.984
21-Apr	123.293	150	3.988	closed	0.000	27.982
22-Apr	123.240	150	3.940	closed	0.000	27.948
23-Apr	123.158	150	3.855	closed	0.000	27.894
24-Apr	123.067	150	3.752	closed	0.000	27.834
25-Apr	122.983	150	3.658	closed	0.000	27.779
26-Apr	122.916	150	3.582	closed	0.000	27.735
27-Apr	122.878	150	3.537	closed	0.000	27.709
28-Apr	122.937	150	3.603	closed	0.000	27.747
29-Apr	122.987	150	3.661	closed	0.000	27.781
30-Apr	122.964	150	3.637	closed	0.000	27.767
1-May	122.886	150	3.550	closed	0.000	27.716
2-May	122.789	150	3.435	closed	0.000	27.653
3-May	122.694	180 @ 17:48	3.462	closed	0.000	27.590
4-May	122.640	180	3.854	closed	0.000	27.554
5-May	122.648	180	3.865	closed	0.000	27.558

Appendix A. Continued.

Date	Daily Average Alouette Reservoir Elevation (m)	Alouette Spillway Gate Position (mm)	Daily Average Alouette Reservoir Spill to Alouette River (cms)	Alouette Low Level Outlet Gate Position (open/closed)	Daily Average Alouette Reservoir Spill to Alouette River Via Low Level Outlet (cms)	Daily Average Alouette Reservoir Spill to Stave Reservoir Via Adit Gate (cms)
6-May	122.719	180	3.992	closed	0.000	27.604
7-May	122.799	180	4.134	closed	0.000	27.657
8-May	122.854	170 @ 15:14; 150 @ 15:44	3.962	closed	0.000	27.693
9-May	122.887	150	3.547	closed	0.000	27.715
10-May	122.916	150	3.580	closed	0.000	27.734
11-May	122.943	150	3.610	closed	0.000	27.751
12-May	123.083	150	3.762	closed	0.000	27.840
13-May	123.383	150	4.067	closed	0.000	28.037
14-May	123.585	150	4.258	closed	0.000	28.171
15-May	123.624	150	4.294	closed	0.000	28.198
16-May	123.374	150	4.064	closed	0.000	28.035
17-May	123.309	150	4.003	closed	0.000	27.992
18-May	123.245	150	3.944	closed	0.000	27.951
19-May	123.177	150	3.876	closed	0.000	27.906
20-May	123.093	150	3.782	closed	0.000	27.851
21-May	123.025	150	3.704	closed	0.000	27.806
22-May	122.975	150	3.649	closed	0.000	27.774
23-May	122.916	150	3.582	closed	0.000	27.735
24-May	122.839	150	3.496	closed	0.000	27.685
25-May	122.759	150	3.391	closed	0.000	27.632
26-May	122.677	150	3.268	closed	0.000	27.578
27-May	122.604	180 @ 15:35	3.378	closed	0.000	27.531

Appendix A. Continued.

Date	Daily Average Alouette Reservoir Elevation (m)	Alouette Spillway Gate Position (mm)	Daily Average Alouette Reservoir Spill to Alouette River (cms)	Alouette Low Level Outlet Gate Position (open/closed)	Daily Average Alouette Reservoir Spill to Alouette River Via Low Level Outlet (cms)	Daily Average Alouette Reservoir Spill to Stave Reservoir Via Adit Gate (cms)
28-May	122.581	180	3.746	closed	0.000	27.515
29-May	122.640	180	3.851	closed	0.000	27.553
30-May	122.675	180	3.914	closed	0.000	27.576
31-May	122.675	180	3.916	closed	0.000	27.577
1-Jun	122.631	180	3.839	closed	0.000	27.549
2-Jun	122.561	180	3.713	closed	0.000	27.503
3-Jun	122.484	180	3.575	closed	0.000	27.453
4-Jun	122.406	180	3.435	closed	0.000	27.401
5-Jun	122.336	210 @ 12:16	3.558	closed	0.000	27.355
6-Jun	122.267	210	3.677	closed	0.000	27.310
7-Jun	122.217	210	3.567	closed	0.000	17.135
8-Jun	122.230	210	3.595	closed	0.000	7.650
9-Jun	122.237	210	3.609	closed	0.000	7.651
10-Jun	122.243	210	3.622	closed	0.000	4.554
11-Jun	122.281	210	3.702	closed	0.000	0.000
12-Jun	122.318	210	3.782	closed	0.000	0.000
13-Jun	122.351	210	3.854	closed	0.000	0.000
14-Jun	122.386	190 @ 10:06; 0 @ 13:26	2.068	opened (13:10)	1.189	0.000
15-Jun	122.423	0	0.000	open	2.670	0.000

Appendix B. Physical data collected at the Mud Creek rotary screw trap site, 2013.

Date	Water Temp (ºC)	Weather Conditions	RST Speed (RPM)	Water Depth (cm)	Date	Water Temp (ºC)	Weather Conditions	RST Speed (RPM)	Water Depth (cm)
15-Apr	8	sunny	8	26	8-May	8	sunny	8	28
16-Apr	6	sunny	8	30	9-May	9	sunny	8	26
17-Apr	6	sunny	8	30	10-May	8	sunny	8	26
18-Apr	6	rainy	8	29	11-May	11	overcast	8	26
19-Apr	6	rainy	8	31	12-May	11	rain	8	27
20-Apr	6	overcast	8	30	13-May	10	rain	8	29
21-Apr	5	rainy	8	30	14-May	9	overcast	8	30
22-Apr	5	sunny	8	29	15-May	12	overcast	8	30
23-Apr	6	sunny	8	28	16-May	12	overcast	8	31
24-Apr	6	sunny	8	28	17-May	10	overcast	8	30
25-Apr	6	sunny	8	27	18-May	11	overcast	8	30
26-Apr	7	sunny	8	27	19-May	11	overcast	8	29
27-Apr	8	rainy	8	26	20-May	11	overcast	8	29
28-Apr	7	overcast	8	27	21-May	10	rain	8	28
29-Apr	5	sunny	8	27	22-May	10	sunny	8	28
30-Apr	5	sunny	8	27	23-May	10	sunny	8	28
1-May	6	sunny	8	27	24-May	11	sunny	8	27
2-May	8	sunny	8	27	25-May	10	overcast	8	27
3-May	7	sunny	8	27	26-May	12	rainy	8	27
4-May	8	sunny	8	27	27-May	12	overcast	8	26
5-May	10	sunny	8	27	28-May	13	overcast	8	29
6-May	11	sunny	8	27	29-May	12	rainy	8	30
7-May	10	sunny	8	28	30-May	10	overcast	8	30

Appendix C. Catch of non-target species at the Mud Creek rotary screw trap, 2013.

	Species Composition (%)		Total Catch (# fish)													
Date	Chum Fry	Chinook/ Coho Fry	Salmon Fry (est.)	Chinook Parr/Smolt (>70mm)	Coho Parr/Smolt (>70mm)	Steelhead (<90mm)	Steelhead (>90mm)	Rainbow no Clip	Cutthroat	Dace Spp.	Sculpin Spp.	Northern Pike-minnow	Stickle-back	Peamouth Chub	Red Side Shiner	Lamprey
14-Apr	100	0	10,000	0	0	0	0	0	0	0	0	0	0	0	0	0
15-Apr	100	0	33,000	0	0	0	5	1	0	0	1	0	1	0	0	0
16-Apr	100	0	32,000	0	3	2	2	0	0	5	4	0	0	0	0	1
17-Apr	100	0	28,000	0	4	1	2	0	0	6	0	0	1	0	0	1
18-Apr	100	0	32,000	0	3	1	1	0	0	6	0	0	0	0	0	0
19-Apr	99	1	50,000	0	5	3	0	0	0	3	1	0	0	0	0	1
20-Apr	99	1	39,000	0	14	2	3	0	0	5	2	0	0	0	0	0
21-Apr	99	1	13,000	1	6	1	2	0	0	2	5	0	0	0	0	0
22-Apr	100	0	21,000	0	5	0	0	0	0	2	3	0	0	0	0	0
23-Apr	100	0	18,000	0	5	1	4	1	0	3	2	0	0	0	0	0
24-Apr	100	0	19,000	0	14	1	12	0	0	10	1	0	1	0	0	0
25-Apr	100	0	10,000	1	3	0	3	0	0	1	1	0	0	0	0	1
26-Apr	100	0	12,000	0	12	0	4	0	0	13	1	0	0	0	0	0
27-Apr	100	0	20,000	0	5	0	4	0	1	15	1	0	0	0	0	1
28-Apr	99	1	12,000	0	5	1	4	0	0	26	6	0	0	0	0	0
29-Apr	99	1	6,000	0	10	0	5	1	0	1	10	0	1	0	0	1
30-Apr	100	0	1,000	0	15	1	1	1	0	0	2	0	0	0	0	0
1-May	100	0	3,000	0	18	1	2	0	0	2	0	0	0	0	0	0
2-May	100	0	3,000	0	15	1	4	0	0	25	8	0	0	0	0	0
3-May	100	0	2,000	0	15	1	0	0	0	2	1	0	0	0	0	2
4-May	100	0	1,500	14	7	0	5	0	0	8	6	0	0	0	0	0
5-May	100	0	2,000	11	6	0	17	2	0	51	11	1	1	0	0	0
6-May	100	0	1,000	6	9	0	35	5	0	22	18	1	3	0	0	2
7-May	100	0	1,000	9	41	0	21	4	0	12	13	0	0	0	0	0
8-May	100	0	500	0	48	0	4	0	0	4	9	1	1	0	0	1
9-May	99	1	500	8	35	1	2	1	0	3	2	0	0	0	0	1
10-May	100	0	500	0	25	1	13	1	0	4	3	0	0	0	0	0
11-May	60	40	200	2	19	0	19	1	0	7	1	1	0	0	0	1
12-May	100	0	<100	0	26	1	14	1	0	6	5	0	0	0	0	1
13-May	100	0	100	0	55	2	15	2	0	1	4	0	0	1	0	1
14-May	100	0	<100	1	34	0	16	0	0	6	2	0	1	0	0	0
15-May	50	50	25	0	12	0	2	0	0	1	4	1	1	0	0	0

Appendix C. Continued.

	Species Composition (%)		Total Catch (# fish)													
Date	Chum Fry	Chinook/ Coho Fry	Salmon Fry (est.)	Chinook Parr/Smolt (>70mm)	Coho Parr/Smolt (>70mm)	Steelhead (<90mm)	Steelhead (>90mm)	Rainbow no Clip	Cutthroat	Dace Spp.	Sculpin Spp.	Northern Pike-minnow	Stickle-back	Peamouth Chub	Red Side Shiner	Lamprey
16-May	100	0	<25	0	5	0	9	0	0	5	5	2	1	0	0	0
17-May	50	50	<50	0	10	0	8	0	0	1	2	2	1	0	0	1
18-May	50	50	20	0	8	0	0	1	0	0	0	0	0	0	0	0
19-May	40	60	50	0	2	0	2	0	0	0	2	3	0	0	0	0
20-May	50	50	<50	1	12	0	2	1	0	1	5	0	0	0	0	0
21-May	50	50	<20	0	1	0	1	1	0	2	5	3	1	0	0	0
22-May	40	60	<20	1	9	0	4	0	0	2	2	0	0	0	0	0
23-May	60	40	<20	0	2	0	5	0	0	0	4	0	1	0	0	0
24-May	50	50	<10	0	6	0	0	0	0	0	0	1	0	0	0	0
25-May	50	50	<20	0	4	0	0	0	0	0	4	0	2	0	0	0
26-May	40	60	<20	0	7	0	0	0	0	2	3	0	0	1	0	0
27-May	30	70	20	0	3	0	0	0	0	2	0	0	0	0	0	1
28-May	50	50	<20	0	4	0	1	0	0	1	6	0	0	0	0	0
29-May	40	60	<20	0	7	0	1	0	0	2	3	1	0	0	0	0
30-May	30	70	<20	0	1	0	0	1	0	2	3	0	1	0	0	0
31-May	--	--	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	--	--	> 371,415	55	555	22	254	25	1	272	171	17	18	2	0	17