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Kokanee Out-Migration

Implementation Year 5

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LGL Limited

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Evaluation of the Migration Success of *O. nerka* (Kokanee / Sockeye) from the Alouette Reservoir, 2012

Prepared for:

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Water License Requirements
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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 (< 100 mm FL) from the reservoir. This was the eighth 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 2007–2011, estimates of *O. nerka* smolt migrations from the reservoir ranged from 4,287 (95% CL: 3,833–4,741) in 2009 to 62,923 (95 CL: 48,436–77,410) in 2007.

The Mud Creek RST was operated from 13 April to 1 June 2012, which covered the duration of the *O. nerka* smolt migration from the Alouette Reservoir. Of the 83 *O. nerka* smolts captured, 80 fish were fin-clipped and released below the Alouette Dam, 89 fish were inspected for fin clips, and nine clipped fish were recaptured. Using a pooled Petersen estimator, an estimated 728 *O. nerka* smolts (95% CL: 348–1,108) migrated from the Alouette Reservoir between 17 April and 1 June. This was the lowest estimate in seven years of studies. In 2012, average daily flows from the spillway gate to the South Alouette River prior to 1 June were maintained at similar levels to past years and ranged from 3.16–4.66 m^3/s. In contrast, from 15 April to 1 June, average daily flows via the adit gate at the northeast end of the Alouette Reservoir in 2012 (25.8m^3/s) were higher than in the previous seven years (range: 0.0–21.7 m^3/s). Unlike the previous three years, there was no post-surface release flush at the end of the typical *O. nerka* migration timing in 2012.

A subsample of *O. nerka* smolts, captured at the Mud Creek RST were sampled for length, weight, age (scales), and genetics (fin tissue). Randomly chosen *O. nerka* smolts (< 100 mm FL) averaged 80 mm FL (range: 70–99 mm FL; n = 40) and 4.3 g (range: 2.9–8.6 g; n = 40). All other species were counted and released, including 424 steelhead smolts (> 90 mm FL).

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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 Alouette Reservoir or through the diversion to Stave Lake at the north end of 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 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, 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 RST, located 1.5 km downstream of the Alouette Dam (Figure 2). An estimated 62,923 (95% CL: 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 Water Use Plan, 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; and this included a mark-recapture estimate of 7,712 fish (95% CL: 6,682–8,742) passing Mud Creek from 21 April to 8 May and 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% CL: 3,833–4,741) for the period of 21 April to 28 May 2009 (Mathews and Bocking 2010).

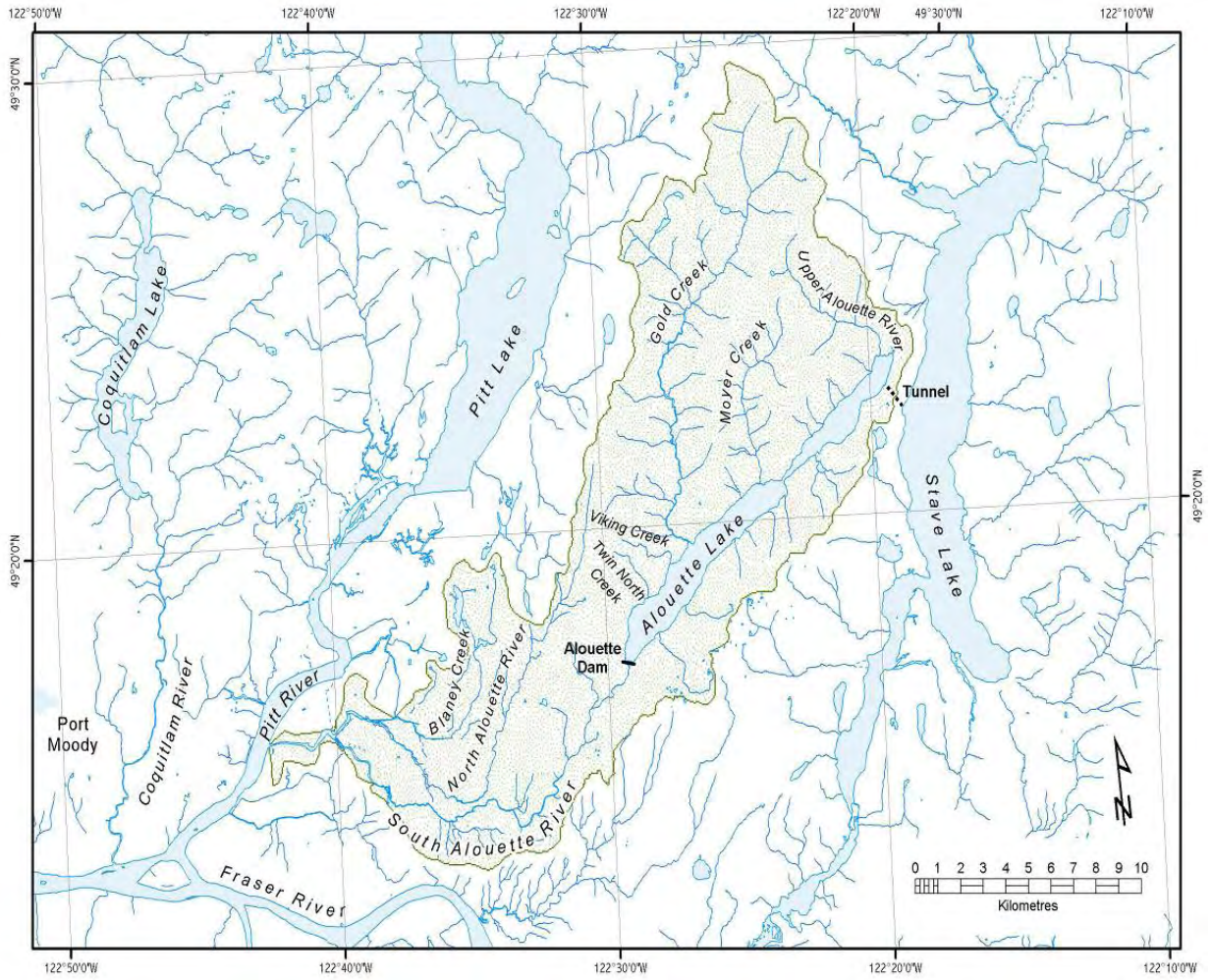

Figure 1. Map of the Alouette Watershed showing local communities and features.

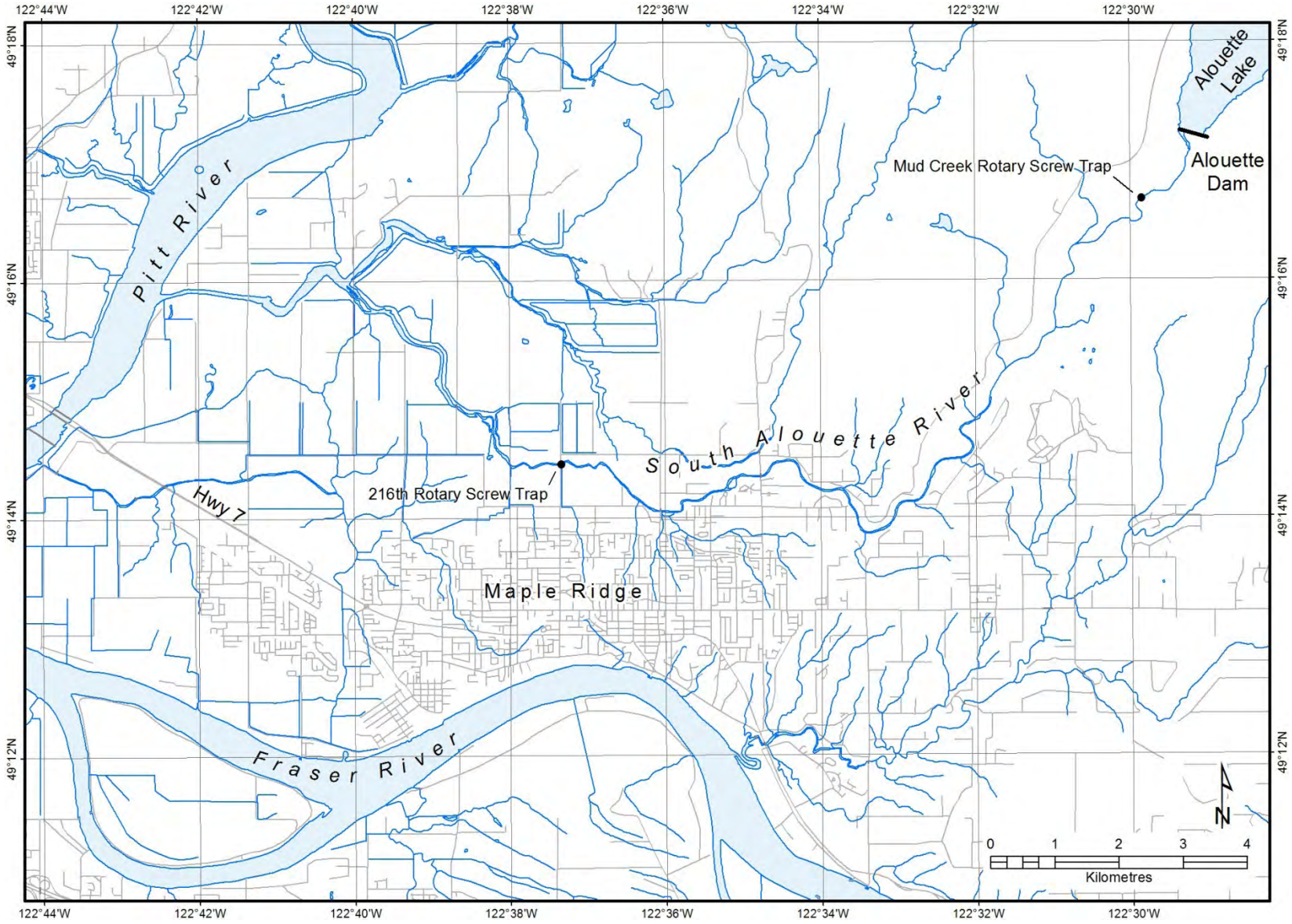

Figure 2. Map of the South Alouette River and locations of the rotary screw traps operational in 2012.

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% CL: 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 was generated (Mathews et al. 2012).

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). The 2010 Alouette adult sockeye salmon returns proved to be the largest run thus far as 113 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 4 were tagged (E. Plate, LGL Limited, pers. comm.). These five 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 the surface release and associated *O. nerka* out-migration enumeration through 2014. Due to run timing uncertainty, it has been proposed that the surface release be done for a period of eight weeks and annual monitoring of the migration should continue to identify the typical start, duration and peak in hopes of shortening the duration of the release and reducing the corresponding flood risks. Although the migration timing has remained relatively consistent during the three 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. Subsequent years of monitoring are, therefore, beneficial to help to improve the 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, the results of the downstream movement pattern assessment and the smolt out-migration data of other coastal systems. This result will then form the basis for an alternative surface release regime to be considered at the next WUP review in 2014.

Project Objectives

Specific objectives for the 2012 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 an 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 (differing fin clips to distinguish pre-flush and flush migrants) 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 2012 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. A post-surface release flush of 6.0–9.0 m^3/s lasting seven days following the tail end of the migration period was also planned for 2012. However, due to the small *O. nerka* migration and the fact that catches at the Mud Creek RST diminished in late May, no post-surface release flush occurred in 2012.

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 collected until this goal was reached (up to a maximum of 10 fish per day). All target fish received 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. Rotary screw trap at the Mud Creek site on the South Alouette River, 23 May 2012.

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:

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

$$\text{Standard error} = \sqrt{VarianceofN} \quad (3)$$

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

Fish Lengths and Weights

Lengths of randomly chosen *O. nerka* smolts (< 100 mm FL) were compared by year of monitoring using ANOVA. Length-at-age data from 2005 to 2010 indicated that all one-year old fish measured less than 100 mm FL (Mathews and Bocking 2011). Tukey's HSD post-hoc multiple comparison was used to indicate any significant differences among years. Also, a non-parametric Wilcoxon/Kruskal-Wallis test on rank sums was also used to confirm the results of the ANOVA. A two-sample t-test assuming unequal variances was used to compare the weights of all 2011 and 2012 *O. nerka* sampled.

216th Street Rotary Screw Trap

As part of a separate study conducted by Westslope Fisheries Ltd., a second RST was operated on the South Alouette River approximately 16 km downstream of the Alouette Dam near 216th Street (Figure 2; Cope 2013). The main objective of this study was to obtain abundance estimates of emigrant fry and smolts (by species) using mark-recapture techniques. Crews at the 216th 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 open from 16 April (0956 hours) to 14 June (1400 hours) in 2012. The maximum daily spillway gate position over this period ranged from 134–200 mm (Appendix A). During the *O. nerka* smolt migration period from 17 April to 25 May, average daily releases from the spillway gate ranged from 3.16–4.66 m^3/s (Figure 3; Appendix A). The low level outlet gate was closed from 16 April (1018 hours) to 14 June (1401 hours). The spillway release and low level closure were consistent throughout the duration of the trapping operations. Apart from 23–28 May, the majority of flow from the Alouette Reservoir during the *O. nerka* smolt migration period was diverted to the Stave Reservoir via the adit gate (Appendix A). From 15 April to 1 June, daily flows from the adit gate averaged 25.8 m^3/s. Over the period from 30 April to 8 May, flows via the adit gate ranged from 50–51 m^3/s.

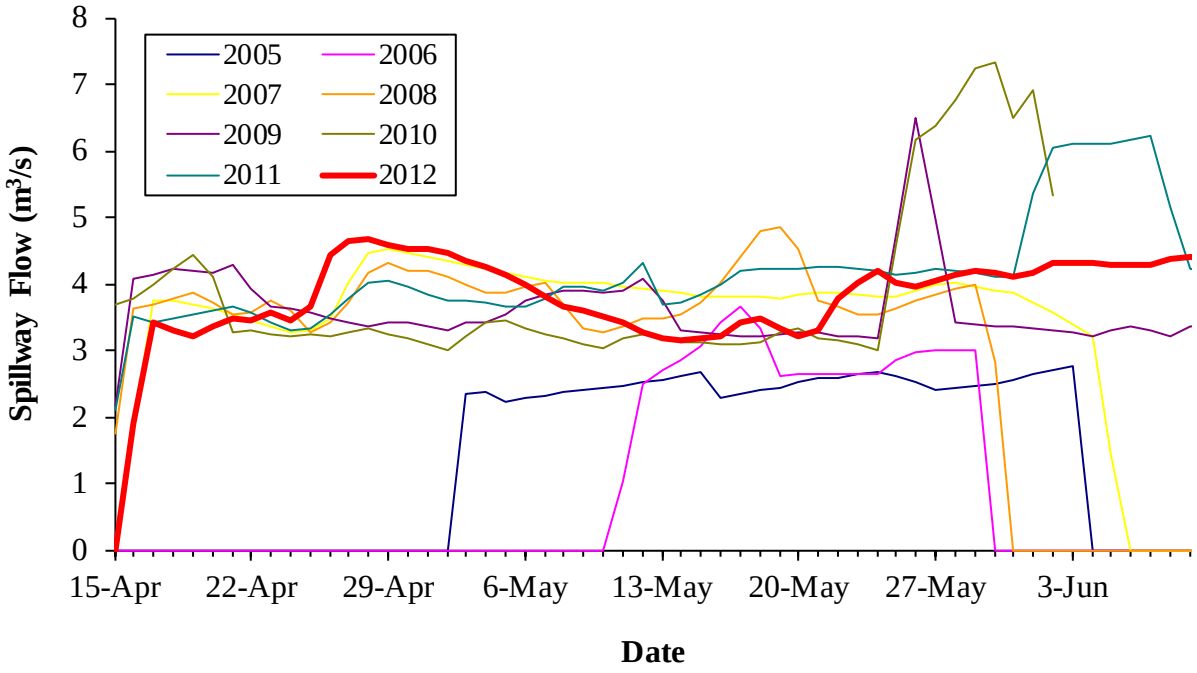

Figure 3. Comparison of flows at the Alouette Dam spillway gate during the *O. nerka* migration period, 2005–2012.

Fishing Effort and Physical Conditions

The Mud Creek RST was operated almost continuously from 13 April (1150 hours) to 1 June (1000 hours). The RST was stopped for 40 minutes (0950–1030 hours) on 27 April when water levels and the amount of debris increased due to BC Hydro adjusting the spillway gate position. Although spillway flows continued as planned until 14 June, monitoring ceased on 1 June once daily catches diminished and the migration had presumably ended.

Water temperature, water depth, RST rotational speed, and general weather conditions were recorded daily each morning from 13 April to 1 June 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 2.6–11.8 m^3/s (mean = 4.7 m^3/s) between 13 April and 1 June (Figure 4). The second spike in South Alouette River discharge at the end of April was not associated with large increase in spillway flows at the Alouette Dam (Figure 4; Appendix A).

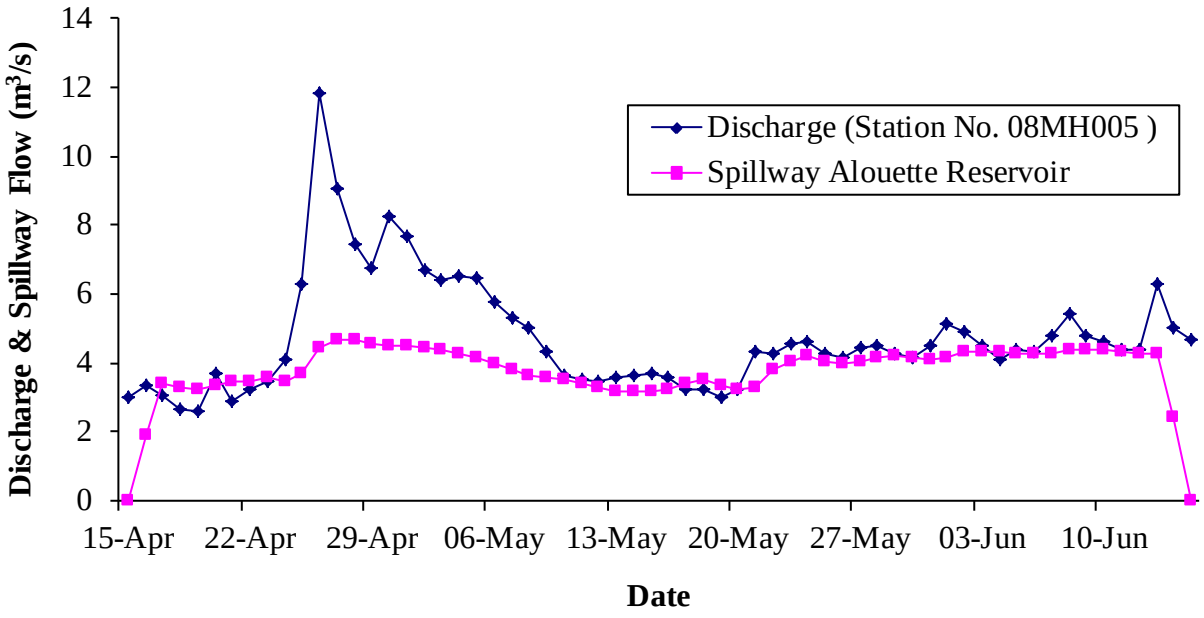

Figure 4. Daily discharge (m^3/s) at Water Survey of Canada Station No. 08MH005 and spillway flows from the Alouette Reservoir. The WSC station is located on the mainstem South Alouette River at the 232nd Street bridge (discharge data from Water Survey of Canada website: http://www.ec.gc.ca/rhc-wsc/).

Fish Capture and Sampling

O. nerka

From 13 April to 1 June 2012, 83 unmarked *O. nerka* were captured in the Mud Creek RST (Table 1; Figure 5). The first *O. nerka* was captured on 17 April, and the last one was captured on 25 May, which was a migration duration of 39 days. Daily catches peaked at 10 fish on 14 May.

Table 1. Daily catch of *O. nerka* in the Mud Creek and 216th Street rotary screw traps, 2012.

	Mud Creek		216th Street	
Date	Unmarked	Clip Recaptures	Unmarked[a]	Clip Recaptures[b]
13-Apr	0	0		
14-Apr	0	0		
15-Apr	0	0	0	
16-Apr	0	0	0	
17-Apr	1	0	0	
18-Apr	2	0	0	
19-Apr	1	0	0	
20-Apr	1	0	0	
21-Apr	1	0	0	
22-Apr	0	0	0	
23-Apr	1	0	0	
24-Apr	2	0	1	
25-Apr	1	0	0	
26-Apr	2	0	1	
27-Apr	2	2	1	
28-Apr	4	0	2	
29-Apr	0	0	1	
30-Apr	3	0	1	
01-May	0	0	2	
02-May	1	2	0	
03-May	2	1	0	
04-May	1	1	1	
05-May	2	0	0	
06-May	5	0	1	
07-May	1	0	1	1
08-May	1	0	1	
09-May	2	1	1	
10-May	1	0	1	
11-May	1	0	0	
12-May	3	0	1	
13-May	1	0	0	1
14-May	10	1	1	
15-May	1	0	0	1
16-May	8	0	1	
17-May	9	0	0	
18-May	4	0	1	

Table 1. Continued.

	Mud Creek		216th Street	
Date	Unmarked	Clip Recaptures	Unmarked[a]	Clip Recaptures[b]
19-May	6	0	1	
20-May	1	1	1	
21-May	0	0	0	
22-May	1	0	1	
23-May	0	0	0	
24-May	0	0	0	1
25-May	1	0	0	
26-May	0	0	1	
27-May	0	0	1	
28-May	0	0	1	
29-May	0	0	0	
30-May	0	0	0	
31-May	0	0	0	
1-Jun	0	0	0	
2-Jun			0	
3-Jun			0	
4-Jun			0	
5-Jun			0	
6-Jun			0	
7-Jun			0	
8-Jun			1	
9-Jun			0	
10-Jun			0	
11-Jun			0	
12-Jun			0	
13-Jun			0	
14-Jun			0	
Total	**83**	**9**	**26**	**4**

[a] Daily unmarked total on 26 and 27 April was estimated based on avg. of adjacent days.

[b] Recaptures on 7 & 15 May were marked at 216 St; recaptures on 13 & 24 May at Mud Creek.

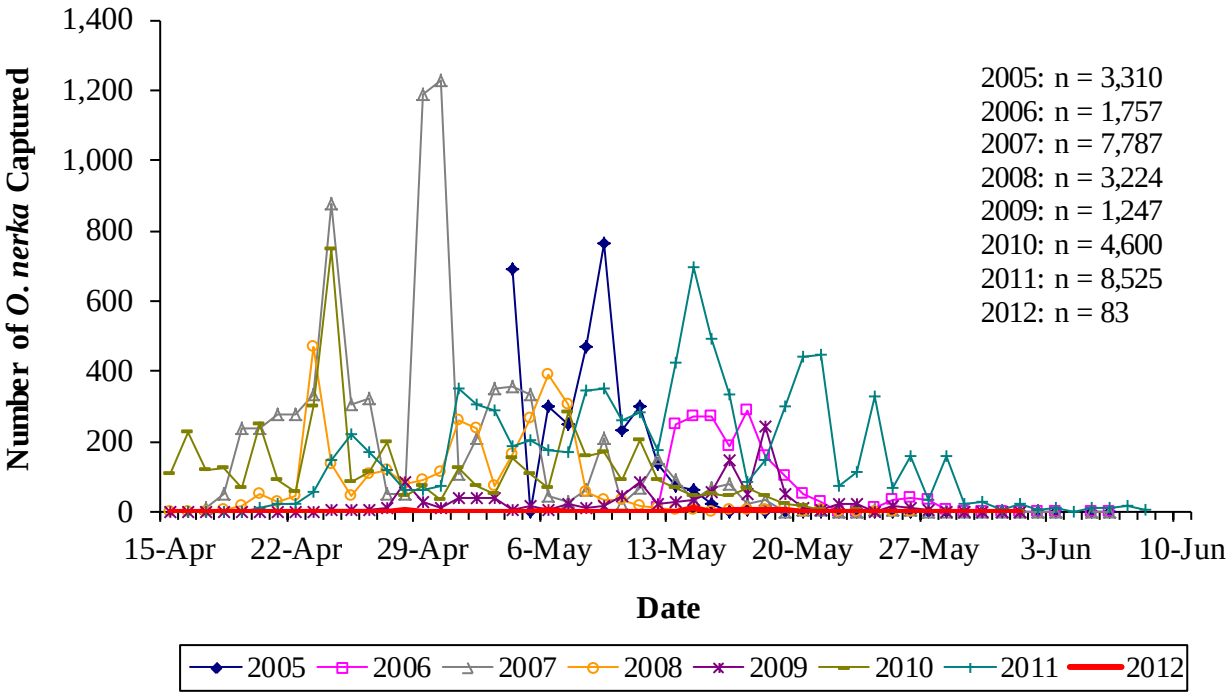

Figure 5. Daily catch of *O. nerka* at the Mud Creek rotary screw trap in 2012 in comparison to the previous seven years (spillway opened 3 May, 11 May, 16 April, 15 April, 15 April, 14 April and 15 April, and 16 April for 2005–2012, respectively).

From 17 April to 25 May 2012, 80 *O. nerka* were marked and released below the dam (Table 2). This excluded one fish that was marked on 17 May but died prior to release. Of the 89 *O. nerka* inspected for marks at the Mud Creek RST that were considered available for recapture as part of the mark-recapture experiment, nine (10.1%) were fin-clipped. Three *O. nerka* captured from 17–18 April were censored from the second-event sample because it was assumed fish required two days to travel from the plunge pool to the RST site (i.e., it was highly unlikely that these three fish were already marked). The capture efficiency of the Mud Creek RST was estimated to be 11.3% (9 recaptures out of 80 marked fish released). Using a pooled Petersen estimator, an estimated 728 (95% CL: 348–1,108) smolts migrated from the Alouette Reservoir from 13 April to 1 June (Table 2).

All but one of the unmarked *O. nerka* captured were biosampled at the Mud Creek RST in 2012. The lengths of *O. nerka* sampled ranged from 70–184 mm FL (mean = 111 mm FL; n = 81; Figure 6; Appendix C). The largest number of *O. nerka* were in the 71-75 mm (n = 13) and 76-80 mm (n = 13) size classes . The weights of *O. nerka* sampled ranged from 2.9–58.6 g and averaged 15.7 g (n = 81). A length-weight relationship was established for *O. nerka* (Figure 7). Of the 81 scale samples collected in 2012, 20 were age-1 (70–82 mm FL), 48 were age-2 (80–184 mm FL), and 13 could not be read (Figure 6). Eighty-two fin clips (genetic stock identification) were collected; however, these samples had not been analyzed by the time this report was completed.

Table 2. Total estimated *O. nerka* migration from the Alouette Reservoir, 2012.

No. *O. nerka* Clipped and Released Below Dam ('M')	80
No. *O. nerka* Examined for Clips ('C')	89
No. *O. nerka* Recaptures ('R')	9
Estimated *O. nerka* Passage (17 April - 1 June 2012)	**728**
95% Confidence Limits	(348 - 1,108)
Trap Efficiency	11.3%

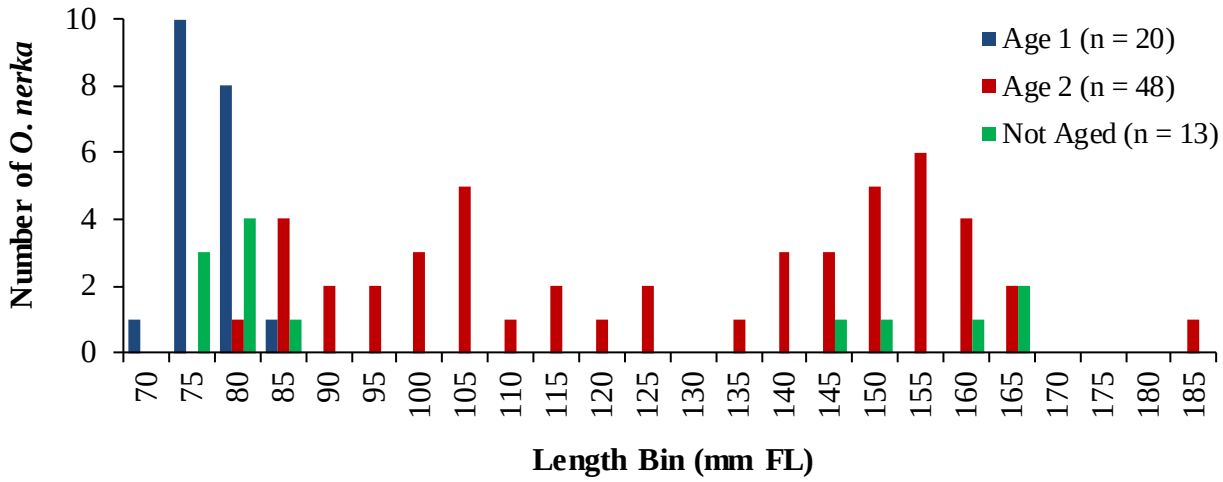

Figure 6. Length frequency distribution of *O. nerka*, by age class, captured in the Mud Creek rotary screw trap operated in the South Alouette River, 2012.

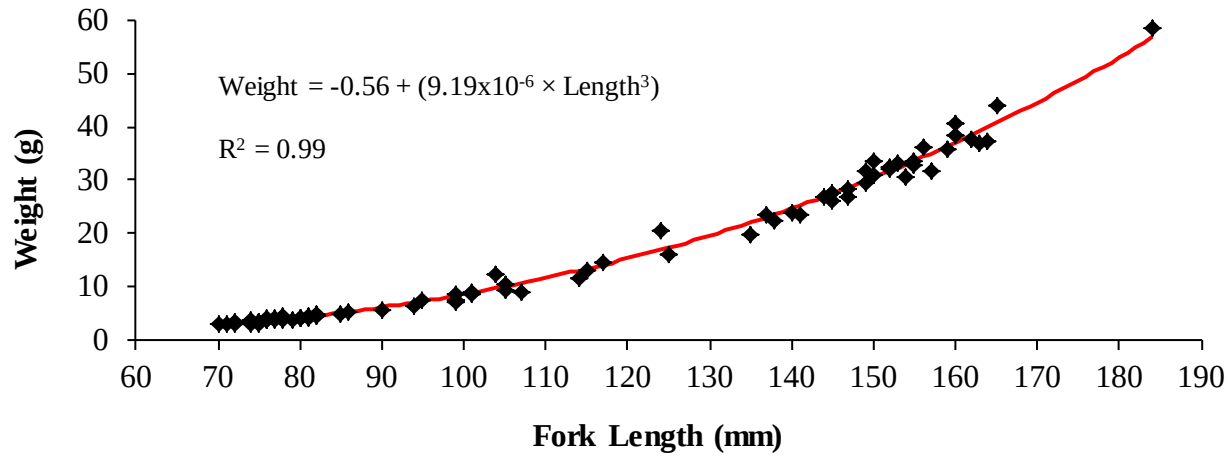

Figure 7. Length-weight relationship of *O. nerka* smolts migrating from the South Alouette Reservoir, 2012.

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 ($F_{7, 3822}$ = 376.7, $P < 0.0001$; 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 length from all other year combinations differed from one another. Although model residuals were non-normal ($P = 0.01$) and had unequal variance across groups ($P < 0.0001$), a common problem in large datasets, visual inspection of the data showed an approximately normal distribution and reasonably similar variances. Nevertheless, we conducted a non-parametric Wilcoxon/Kruskal-Wallis test on rank sums to confirm results of our parametric ANOVA, and indeed there was a significant year effect on fork lengths (χ^2=1565.5, df = 7, $P < 0.0001$).

Based on a comparison of the predicted length-weight relationships, there did not appear to be substantial variation in fish condition across years (Figure 8). 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.

The average weight of *O. nerka* in 2012 (15.7 g) was significantly different than the 2011 mean of 4.5 g (t_{85} = 7.2, $P < 0.0001$). Note that the sample size in 2012 (n = 81) was considerably smaller than in 2011 (n = 1,667).

Table 3. Mean length of *O. nerka* less than 100 mm FL (random samples only), 2005–2012.

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

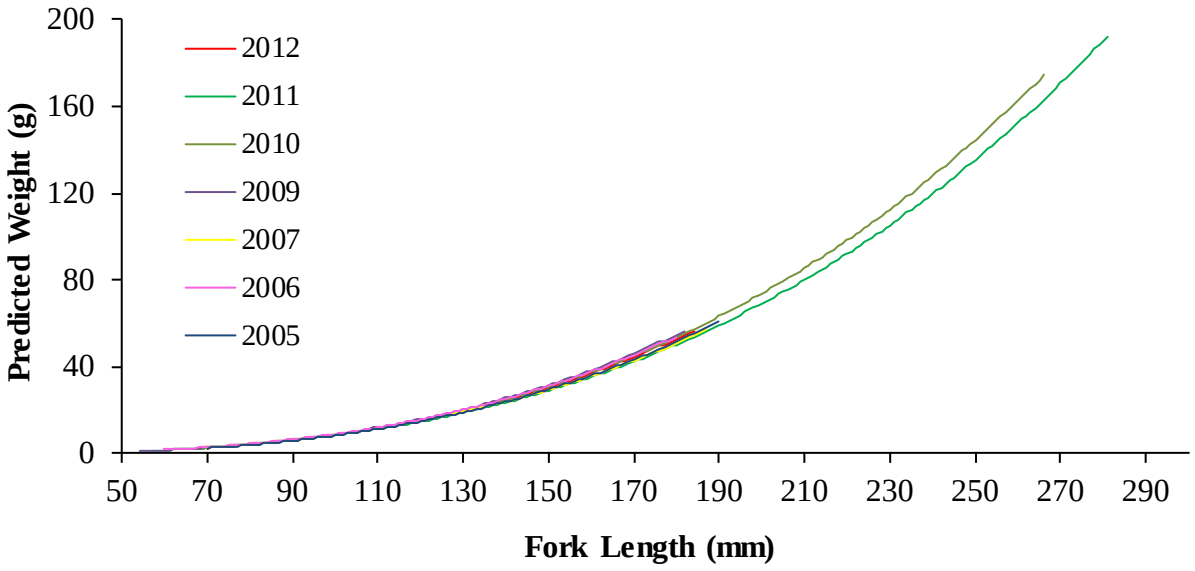

Figure 8. Comparison of the predicted length-weight relationships for *O. nerka* that migrated from the South Alouette Reservoir from 2005–2007 and 2009–2012.

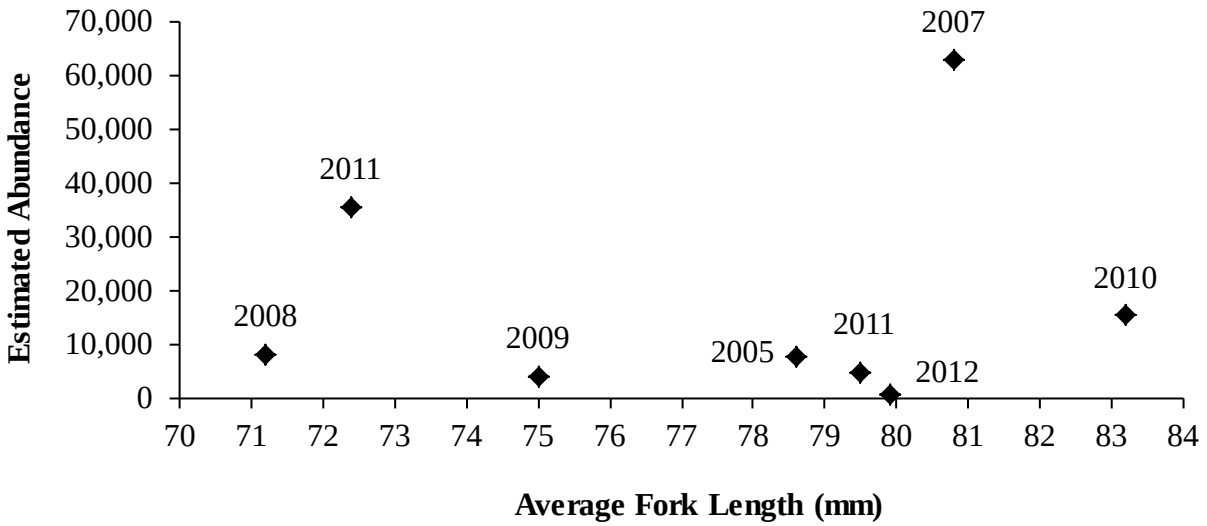

Figure 9. Comparison of the average length of *O. nerka* smolts measuring less than 100 mm FL and the estimated abundance of *O. nerka* that migrated from the South Alouette Reservoir, 2005–2012. Labels above the data points indicate the study year.

Steelhead Smolts

A total of 424 wild steelhead smolts (> 90 mm FL) were captured in the Mud Creek RST in 2012. The first one was captured on 14 April and the last one was captured on 31 May. Peak catches occurred on 26 April (n = 36; Figure 10). No adipose-clipped steelhead were captured.

Other Species

Many other non-target species were captured in the Mud Creek RST in 2012, including over 47,645 salmonid fry (Appendix D). The vast majority of fry were chum salmon (*O. keta*), while the remainder consisted of Chinook (*O. tshawytscha*), coho, and pink (*O. gorbuscha*) salmon fry. A total of 1,258 coho salmon parr/smolts (> 70 mm FL), 94 Chinook salmon parr/smolts (> 70 mm FL), and 13 steelhead (< 90 mm FL) were counted and released. In addition to these fish, dace (*Rhinichthys* sp.), sculpin, stickleback, lamprey (*Lampetra* sp.), cutthroat trout, northern pikeminnow, pumpkinseed (*Lepomis gibbosus*), and redside shiner were captured. Two beavers (*Castor Canadensis*) were also found in the RST.

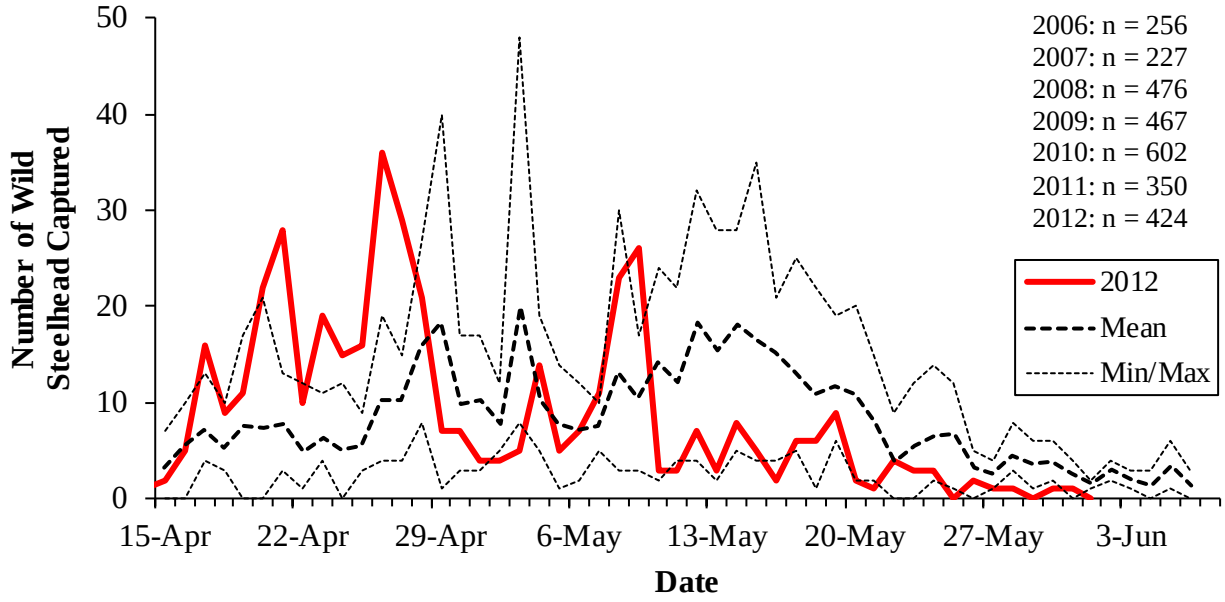

Figure 10. Daily catch of wild steelhead smolts (> 90 mm FL) at the Mud Creek rotary screw trap, 2012. Minimum, maximum, and mean daily catches from 2006–2011 were plotted for reference.

216th Street Rotary Screw Trap

The 216th Street RST operated consistently from 15 April to 14 June 2012, with the exception of two days (26-27 April). Catches included 26 unmarked *O. nerka*, two fin-clipped fish that were marked at the 216th Street RST and two fin-clipped fish that were marked at the Mud Creek RST (Table 1). The estimated catch efficiency of the 216th Street RST was 16.7% (two recaptures out of 12 marked fish released).

DISCUSSION

BC Hydro Operations

In 2012, average daily flows from the spillway gate to the South Alouette River prior to 1 June were maintained at similar levels to past years and ranged from 3.16–4.66 m^3/s (Figure 3). In contrast, from 15 April to 1 June, flows via the adit gate at the northeast end of the Alouette Reservoir were higher on average in 2012 (25.8 m^3/s) than in the previous seven years (range: 0.0–21.7 m^3/s). Unlike the previous three years, there was no post-surface release flush in 2012 because *O. nerka* catches at the Mud Creek RST diminished in late May (only 3 fish were caught after 19 May).

Fishing Effort

For the third 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 little down time.

Abundance Estimate

The 2012 estimate of *O. nerka* migrating from the Alouette Reservoir into the South Alouette River from 17 April to 1 June (N = 728) was the lowest estimate in seven years (Table 4). The 2012 estimate was six times smaller than the next lowest estimate (4,287 fish in 2009) and more than 86 times smaller than the highest estimate (62,923 fish in 2007). The total catch of *O. nerka* (83 fish) and capture efficiency (11.3%) of the Mud Creek RST in 2012 were also the lowest observed since the project's inception in 2005 (Table 4; Figure 5). The low capture efficiency in 2012 did not appear to be the result of any operational issues at the RST site. This was supported by the fact that a large number of non-target species were captured at the Mud Creek RST and by the extremely low catches of *O. nerka* at the 216th Street RST in 2012. Relative to previous years, there was no significant variation in the location of the RST, cross-sectional position of the RST in the channel (i.e., relative to the thalweg), or channel morphology in 2012. Interestingly, the capture efficiency was also low (12%) in 2007, the year of the highest abundance estimate.

Several hypotheses have been proposed to explain the poor migration of *O. nerka* from the Alouette Reservoir in 2012. First, poor environmental conditions in the Spring of 2011 may have contributed to low zooplankton biomass in the Alouette Reservoir; and limited food availability may have then contributed to poor survival of *O. nerka* fry (and subsequently to low numbers of smolts in 2012; Shannon Harris, Ministry of Environment, pers. comm.). Second, the loss of nutrients, zooplankton biomass, *O. nerka* fry, or some combination of these, may increase with discharge levels from the Alouette Reservoir. Zooplankton biomass would decrease if the rate of flushing exceeded the rate of population growth. If this were the case, the relatively high discharges to the Stave Reservoir via the adit gate in 2011 may have contributed to low numbers of *O. nerka* fry (and subsequently to low numbers of smolts in 2012; James Bruce, BC Hydro, pers. comm.). And lastly, it was also possible that a portion of *O. nerka* smolts in 2012 passed into the Stave Reservoir via the relatively high discharges at the adit gate

instead of passing via the spillway gate at the Alouette Dam (Geoff Clayton, Alouette River Management Society, pers. comm.).

Table 4. Total catch at the Mud Creek rotary screw trap and the corresponding population estimate of *O. nerka* migrating from the Alouette Reservoir, 2005–2012.

Year	Total Catch	Abundance Estimate (N)	Lower 95% C.I.	Upper 95% C.I.	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

[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% C.L. 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% C.L. 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)*.

Run Timing

The duration of the 2012 *O. nerka* migration (17 April to 25 May; 39 days) was shorter than those observed from 2007 to 2011 (range: 40–51 days; Figure 5). The start and peak dates for the 2005 and 2006 migrations were not comparable to those from 2007 to 2012 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.

The start date of the 2012 migration on 17 April was similar to the start dates observed from 2007 to 2011 (15–19 April). However, given the initial high catches of *O. nerka* upon immediately opening the spillway in 2010, and to a lesser extent in 2007, it was possible that the migrations in these years could have begun earlier if the spillway had been opened earlier. No

O. nerka were captured in the first four days of RST operation in 2012 (13–16 April) which indicated the spillway opening was timed well with the onset of the migration.

O. nerka catches peaked on 14 May in 2012, which was similar to the peak dates in 2009 and 2011 (14–18 May), but considerably later than those in 2007, 2008, and 2010 (23–30 April). Similar to the 2008 to 2011 study years, the date of peak catches in 2012 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 2012 migration on 25 May was similar to those observed in 2005 and 2008 (24–25 May); 3–7 days earlier than those observed in 2006, 2007, 2009, and 2010; and two weeks earlier than the end date in 2011 (8 June). Due to the variation in start dates, peak timing, and end dates observed since 2005, additional years of monitoring are required to better understand the run timing of *O. nerka* from of the Alouette Reservoir. However, based on the available data, 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 average length of *O. nerka* (<100 mm FL) sampled in 2012 (79.9 mm FL; n = 40) was within the range of average lengths observed annually since 2005 (71.2–83.2 mm FL; Table 3). On average, fish sampled in 2012 were most similar in fork length to those sampled from 2005 to 2007. These years, together with 2010 could be considered the 'large fish years' (mean > 78 mm FL), and contrast notably with three years in which fish lengths were smaller (2008, 2009, and 2011). In 2012, the largest number of fish were in the 71–75 and 76–80 mm FL size classes (Figure 6). Size classes comprising the largest number of *O. nerka* has varied over the years: 66–70 (2008), 71–75 (2009, 2011), 76–80 (2005, 2006), and 81–85 mm FL (2007, 2010). Unlike the previous two years when *O. nerka* captured at the Mud Creek RST reached 266 (2010) and 284 mm FL (2011), no fish sampled in 2012 measured greater than 184 mm FL.

Analysis of scales collected from 2005 to 2010 indicated that the majority of *O. nerka* were one-year old fish (68–96%), while the remainder were two- (3–32%) and three-year olds (1–12%; Mathews and Bocking 2011). In 2011, 351 scale samples were analyzed, of which 299 were successfully aged. Of these, 96.0% were age-1 (57–168 mm FL), 2.0% were age-2 (105–191 mm FL), and 2% were age-3 (180–251 mm FL) fish.

As mentioned earlier, genetic samples from the 2012 study year had not been analyzed by the time this report was completed. Of the 100 fin clips collected in 2010 for stock identification, genetic analysis revealed that all 100 fish were from the Alouette Reservoir (Mathews and Bocking 2011). Genetic results from 2011 and 2012 will be documented in a separate publication (Lyse Godbout, DFO, pers. comm.).

Steelhead Smolts (> 90 mm FL)

The number of wild steelhead smolts captured in 2012 (424 fish) was greater than the previous six-year average (396 fish; Figure 10). Catches in 2012 were also greater than those observed in 2011 (350 fish), which had been the lowest number since 2007. The date of peak catch in 2012 (26 April) was similar to 2008 (29 April) and 2011 (28 April), 7 days earlier than 2010, and 13–18 days earlier than 2006, 2007, and 2009 (9–14 May).

RECOMMENDATIONS

The following recommendations are proposed for the monitoring of *O. nerka* migration from the Alouette Reservoir in 2013:

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.

ACKNOWLEDGMENTS

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APPENDICES

Appendix A. BC Hydro operations at the Alouette Reservoir during the 2012 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 (m)	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	122.359	0	0.000	open	2.662	25.440
15-Apr	122.303	0	0.000	open	2.656	25.406
16-Apr	122.246	50 @ 9:56; 200 @ 17:01	1.912	closed (10:18)	1.121	25.371
17-Apr	122.207	200	3.415	closed	0.000	25.347
18-Apr	122.166	200	3.317	closed	0.000	25.322
19-Apr	122.129	200	3.225	closed	0.000	25.299
20-Apr	122.190	200	3.366	closed	0.000	25.335
21-Apr	122.237	200	3.475	closed	0.000	25.365
22-Apr	122.228	200	3.457	closed	0.000	25.359
23-Apr	122.292	200	3.580	closed	0.000	25.397
24-Apr	122.419	180 @ 12:43; 159 @ 13:13	3.461	closed	0.000	25.473
25-Apr	122.854	159	3.675	closed	0.000	25.733
26-Apr	123.543	159	4.452	closed	0.000	12.136
27-Apr	123.971	150 @ 9:28	4.653	closed	0.000	0.000
28-Apr	124.121	150	4.663	closed	0.000	24.298
29-Apr	124.008	150	4.580	closed	0.000	50.722
30-Apr	123.923	150	4.514	closed	0.000	50.614
1-May	123.922	150	4.515	closed	0.000	50.615
2-May	123.851	150	4.462	closed	0.000	50.528
3-May	123.711	150	4.358	closed	0.000	50.356
4-May	123.574	150	4.250	closed	0.000	50.186
5-May	123.455	150	4.139	closed	0.000	50.038

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 (m)	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	123.296	150	3.991	closed	0.000	49.842
7-May	123.120	150	3.811	closed	0.000	49.623
8-May	122.978	150	3.650	closed	0.000	37.919
9-May	122.928	150	3.593	closed	0.000	27.091
10-May	122.868	150	3.526	closed	0.000	27.053
11-May	122.784	150	3.424	closed	0.000	26.999
12-May	122.691	150	3.287	closed	0.000	26.939
13-May	122.621	150	3.181	closed	0.000	26.894
14-May	122.607	150	3.158	closed	0.000	26.884
15-May	122.630	150	3.192	closed	0.000	26.899
16-May	122.647	150	3.219	closed	0.000	26.910
17-May	122.616	170 @ 10:30	3.416	closed	0.000	26.891
18-May	122.549	170	3.495	closed	0.000	26.849
19-May	122.462	170	3.347	closed	0.000	26.793
20-May	122.378	170	3.203	closed	0.000	26.739
21-May	122.447	170	3.309	closed	0.000	26.779
22-May	122.729	170	3.791	closed	0.000	12.342
23-May	122.890	170	4.031	closed	0.000	0.000
24-May	123.015	170	4.191	closed	0.000	0.000
25-May	123.116	151 @ 9:06	4.020	closed	0.000	0.000
26-May	123.221	151	3.953	closed	0.000	0.000
27-May	123.332	151	4.059	closed	0.000	0.000

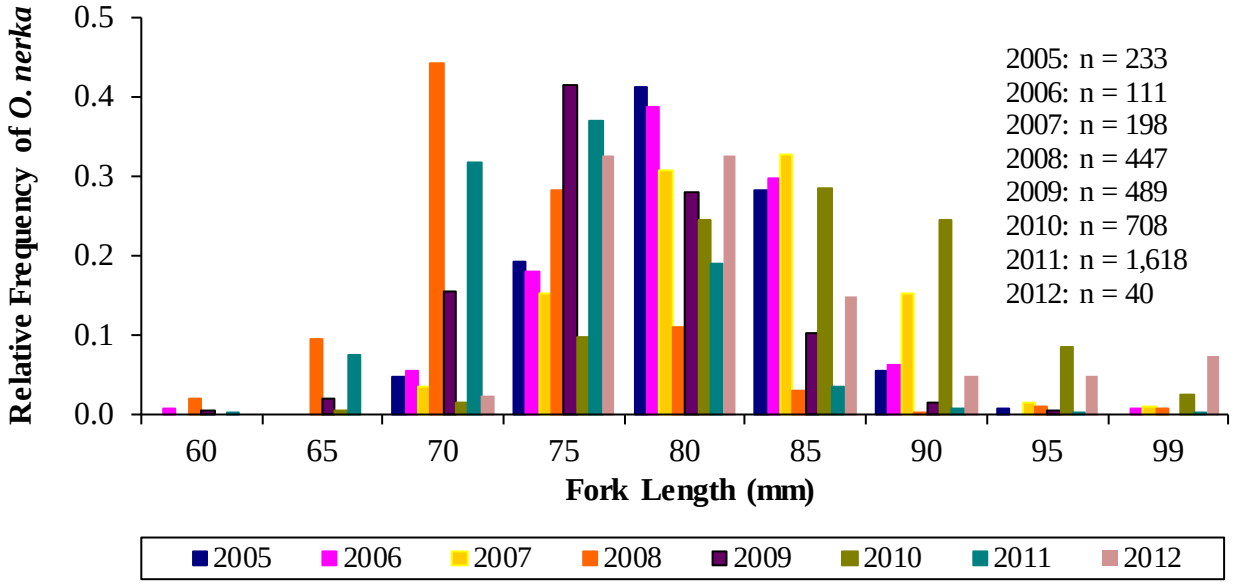
Appendix A. Continued.

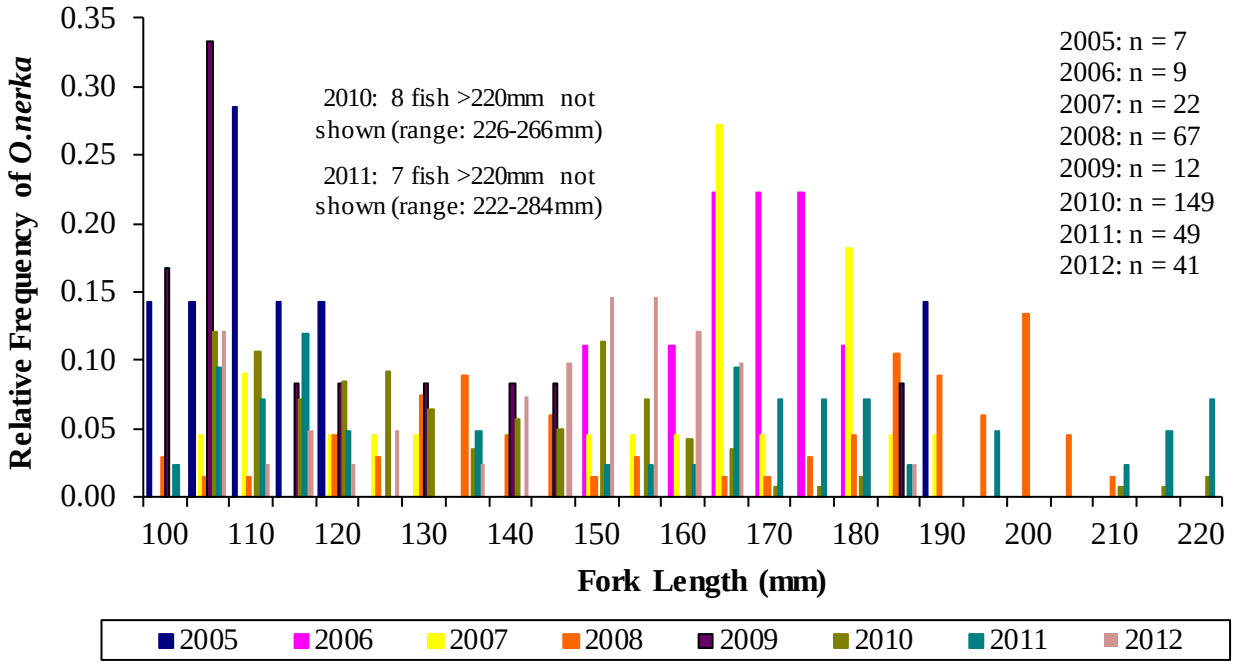
Date	Daily Average Alouette Reservoir Elevation (m)	Alouette Spillway Gate Position (mm)	Daily Average Alouette Reservoir Spill to Alouette River (cms)	Alouette Low Level Outlet Gate Position (m)	Daily Average Alouette Reservoir Spill to Alouette River Via Low Level Outlet (cms)	Daily Average Alouette Reservoir Spill to Stave Reservoir Via Adit Gate (cms)
28-May	123.423	151	4.147	closed	0.000	0.000
29-May	123.483	151	4.205	closed	0.000	12.141
30-May	123.431	151	4.157	closed	0.000	22.796
31-May	123.384	151	4.111	closed	0.000	22.771
1-Jun	123.447	151	4.167	closed	0.000	22.802
2-Jun	123.595	151	4.308	closed	0.000	22.883
3-Jun	123.614	151	4.326	closed	0.000	22.894
4-Jun	123.590	151	4.306	closed	0.000	22.881
5-Jun	123.565	151	4.282	closed	0.000	22.867
6-Jun	123.571	151	4.287	closed	0.000	22.870
7-Jun	123.574	151	4.289	closed	0.000	22.871
8-Jun	123.685	151	4.378	closed	0.000	22.931
9-Jun	123.706	151	4.395	closed	0.000	22.943
10-Jun	123.672	151	4.370	closed	0.000	22.925
11-Jun	123.617	151	4.328	closed	0.000	22.896
12-Jun	123.571	151	4.288	closed	0.000	22.871
13-Jun	123.579	151	4.294	closed	0.000	22.874
14-Jun	123.605	134 @ 12:15; 0 @ 14:00	2.431	open (14:01)	1.178	22.889
15-Jun	123.577	0	0.000	open	2.786	22.874

Appendix B. Physical data collected at the Mud Creek rotary screw trap site, 2012.

Date	Water Temp (ºC)	Weather Conditions	RST Speed (RPM)	Water Depth (cm)
13-Apr	5	cloudy	9	31
14-Apr	6	overcast	9	30
15-Apr	6	overcast	10	30
16-Apr	8	rainy	9	31
17-Apr	7	overcast	9	32
18-Apr	6	rainy	9	30
19-Apr	7	sunny	9	30
20-Apr	7	sunny	9	29
21-Apr	8	sunny	9	29
22-Apr	8.5	overcast	9	29
23-Apr	10	sunny	9	29
24-Apr	7	rainy	9	30
25-Apr	8	rainy	9	32
26-Apr	7	rainy	12	39
27-Apr	7	overcast	9	38
28-Apr	8	overcast	10	37
29-Apr	9	overcast	9	37
30-Apr	7	rainy	12	38
01-May	6	rainy	12	38
02-May	6	cloudy	11	37
03-May	7	overcast	11	36
04-May	7	rainy	11	36
05-May	7	overcast	11	36
06-May	8	sunny	11	36
07-May	9	sunny	11	33
08-May	11	sunny	11	32
09-May	11	sunny	11	32
10-May	5	sunny	10	31
11-May	7	sunny	10	30
12-May	9	sunny	10	30
13-May	9	sunny	10	30
14-May	10	sunny	10	30
15-May	10	sunny	10	30
16-May	8	sunny	10	30
17-May	8	sunny	10	30
18-May	9	cloudy	10	30
19-May	9	sunny	10	30
20-May	10	overcast	10	29
21-May	9	rainy	10	31
22-May	10	cloudy	10	31
23-May	11	rainy	10	33
24-May	11	overcast	10	33
25-May	11	sunny	10	33
26-May	13	sunny	10	33
27-May	11	sunny	11	33
28-May	10	rainy	11	34
29-May	10	sunny	11	34
30-May	11	rainy	11	34
31-May	12	rainy	11	34
01-Jun	13	overcast	11	34

Appendix C. 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), 2005–2012.





Appendix D. Catch of non-target species at the Mud Creek rotary screw trap, 2012.

	Species Composition (%)[a]		Total Catch (# fish)												
Date	Chum Fry	Chinook/ Coho Fry (<70mm)	Salmon Fry (est.)	Chinook Parr/Smolt (>70mm)	Coho Parr/Smolt (>70mm)	Steel-head (<90mm)	Dace Spp.	Sculpin Spp.	Northern Pike-minnow	Stickle-back	Cut-throat	Lamprey	Crayfish	Other[b]
14-Apr	100	0	500	0	5	1	4	3	0	0	0	0		
15-Apr	99	1	2,000	0	3	1	6	7	0	0	1	0		
16-Apr	100	0	2,000	0	2	3	33	5	0	0	0	0	1	
17-Apr	99	1	5,000	1	4	4	29	7	0	0	0	1	1	
18-Apr	98	2	3,000	0	3	1	7	11	0	0	0	1		
19-Apr	99	1	4,000	0	2	1	8	9	1	0	0	0		
20-Apr	98	2	4,500	5	2	0	6	5	0	0	1	2		
21-Apr	98	2	2,000	4	8	0	3	6	2	1	0	2	1	
22-Apr	99	1	2,000	0	5	0	23	8	1	0	0	0		
23-Apr	99	1	2,000	0	1	1	26	4	1	0	0	0		
24-Apr	97	3	2,000	1	3	0	1	9	1	0	0	1		
25-Apr	96	4	4,000	1	13	0	5	13	1	0	0	1		
26-Apr	95	5	4,000	19	34	0	2	6	0	0	0	5		
27-Apr	96	4	2,000	18	20	0	4	8	0	0	0	0		
28-Apr	98	2	1,000	16	10	0	0	4	3	0	0	4		
29-Apr	90	10	2,000	1	8	0	10	4	0	0	0	1		
30-Apr	90	10	1,000	0	8	0	6	5	0	1	0	1		
01-May	90	10	500	0	19	0	1	4	0	0	0	0		
02-May	70	30	400	1	16	0	0	6	0	0	0	0		
03-May	90	10	300	0	10	0	2	3	1	1	0	1		
04-May	95	5	1,000	0	20	0	0	2	0	1	0	3	1	
05-May	95	5	200	0	25	0	0	10	0	0	0	0	1	
06-May	98	2	200	0	30	0	1	2	0	0	0	0		
07-May	98	2	100	0	22	0	6	4	0	1	0	0		
08-May	99	1	<100	2	49	0	7	8	6	1	0	0	3	
09-May	80	20	100	0	106	0	2	8	2	2	1	1		
10-May	80	20	<100	0	60	0	0	1	0	0	0	6	1	
11-May	80	20	25	1	29	0	0	3	0	1	0	0		

Appendix D. Continued.

	Species Composition (%)[a]		Total Catch (# fish)												
Date	Chum Fry	Chinook/ Coho Fry (<70mm)	Salmon Fry (est.)	Chinook Parr/Smolt (>70mm)	Coho Parr/Smolt (>70mm)	Steel-head (<90mm)	Dace Spp.	Sculpin Spp.	Northern Pike-minnow	Stickle-back	Cut-throat	Lamprey	Crayfish	Other[b]
12-May	98	2	100	0	27	0	0	7	0	1	0	1		
13-May	99	1	150	1	27	0	0	1	0	1	1	0		1
14-May	80	20	400	6	36	0	4	7	0	2	0	0	3	
15-May	50	50	400	0	40	0	0	3	0	0	0	1		1
16-May	80	20	100	1	73	0	0	4	0	0	0	0	1	
17-May	50	50	<100	1	78	0	0	0	0	0	0	0	0	
18-May	50	50	<100	0	58	0	0	2	0	0	0	0		
19-May	50	50	<50	5	54	0	1	3	0	2	0	0		
20-May	50	50	<50	1	40	0	1	0	0	0	0	0		
21-May	50	49	400	2	35	1	0	2	0	0	0	0		1
22-May	20	80	100	4	74	0	1	8	1	0	0	0		
23-May	95	5	<50	0	54	0	6	10	1	0	0	1	1	
24-May	50	50	50	1	41	0	3	4	0	1	0	1	2	
25-May	50	50	100	0	23	0	11	6	0	3	0	1		
26-May	50	50	<50	0	12	0	12	7	4	1	0	0		
27-May	50	50	<50	0	12	0	4	1	0	2	0	0		
28-May	50	50	<10	0	18	0	8	5	0	1	1	0	1	
29-May	40	60	<20	0	9	0	3	6	5	2	0	1		
30-May	50	50	<20	0	7	0	10	3	0	1	0	0	1	
31-May	50	50	20	0	3	0	8	5	2	0	0	0		
01-Jun	50	50	<20	2	20	0	18	3	3	1	0	1		
Totals	--	--	>47,645	94	1,258	13	282	252	35	27	5	37	18	3

[a] An estimated 1% of salmonid fry captured on 21 May were pink salmon.

[b] Other fish species included: 1 stickleback (13 May), 1 pumpkinseed (21 May), and 1 redside shiner (15 May).