2014 Babine Lake Watershed Sockeye Smolt Population Estimation Project – Mark-Recapture

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Abstract

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The Babine Lake Watershed is the principal sockeye salmon (*Oncorhyncus nerka*) rearing area for Skeena River sockeye salmon, producing up to 90% of the sockeye returns to the Skeena River over the last few decades. The Department of Fisheries and Oceans has estimated the number of out-migrating Babine Lake Watershed sockeye smolts between 1959 and 2002 at a trap located at the outlet of Nilkitkwa Lake. Following the cessation of the project in 2002, the lack of information on the abundance of sockeye salmon smolts in the Babine Lake Watershed has hampered Skeena sockeye management.

In the spring of 2013, the Lake Babine Nation (LBN), in collaboration with the Skeena Fisheries Commission (SFC), successfully resumed the Babine Lake Watershed Sockeye Smolt Enumeration Project, and continued it again in 2014. In 2014, the exact same facility, and mark-recapture protocol employed by the Department of Fisheries and Oceans in the past were used. In 2014, the marked smolt recovery efficiency during catch examinations was improved with the use of a coded-wire tag detector.

The 2014 Babine Lake Smolt Enumeration Project was once again a great success, and an example of a fruitful collaboration between two First Nations organizations, LBN and SFC. Daily out-migrating Babine Lake Watershed sockeye smolt population estimates were calculated for the whole 2014 smolt migration season.

The estimate of the total sockeye smolt population that migrated out of the Babine Lake Watershed in the spring of 2014 was calculated to be 94,707,541 ± 16,292,293.

Introduction

Babine Lake is the largest natural lake in British Columbia, and the Babine Lake Watershed is the principal sockeye salmon (*Oncorhyncus nerka*) rearing area for Skeena River sockeye salmon, producing up to 90% of the sockeye returns to the Skeena River over the last few decades (Wood *et al.* 1998, McKinnell and Rutherford 1994). This important watershed supports an average yearly harvest of 1.5 million sockeye in the commercial (Canada and United States), recreational, and First Nations fisheries and an average escapement to spawning of one million.

There is a long history of intensive science and careful monitoring of salmon populations in the Babine Lake Watershed. The Department of Fisheries and Oceans (DFO) has counted adult sockeye returning to the Babine Lake Watershed at the Babine adult counting fence since 1946, and estimated the number of out-migrating sockeye smolts between 1959 and 2002 at a trap located at the outlet of Nilkitkwa Lake (part of the Babine Lake Watershed, just north of Babine Lake itself). The data from both the adult and smolt counting fences, and from the spawning channel (Fulton and Pinkut) fry counts, have historically allowed fisheries managers to estimate sockeye recruitment, and fry to smolt survival in the Babine Lake Watershed. The Babine sockeye smolt enumeration facility was closed in 2002 due to government budget constraints. Available pre-2002 data shows a significant decline in some of the Babine sockeye population fry to smolt survival starting in the mid-1980s (Figure 1). Patterns of freshwater survival (fry to smolt survival) and marine survival (smolt to returning adult) of the Babine sockeye stocks have been unknown since 2002 due to the discontinuation of the program.

Babine sockeye returns have also declined significantly in numbers in the past two decades (Figure 2). As the Babine Lake Watershed sockeye smolt productions of the past ten years are unknown, it is impossible to determine the extent to which the decreasing returns are due to freshwater versus ocean limitations.

Reliable estimates of the sockeye smolt populations leaving the Babine Lake Watershed are required for sound management of the stock. For that reason the Lake Babine Nation (LBN), in collaboration with the Skeena Fisheries Commission (SFC), with funding from the Pacific Salmon Commission (PSC), resumed the Babine Lake Watershed sockeye smolt population estimation project in the spring of 2013 (Doire and Macintyre, 2014), and continued the effort in 2014. The objective of the project was to estimate the daily and total number of sockeye smolts migrating out of the Babine Lake Watershed in the spring of 2014 while maintaining consistency with the methodology used by DFO from 1959 to 2002 to permit historical comparisons.

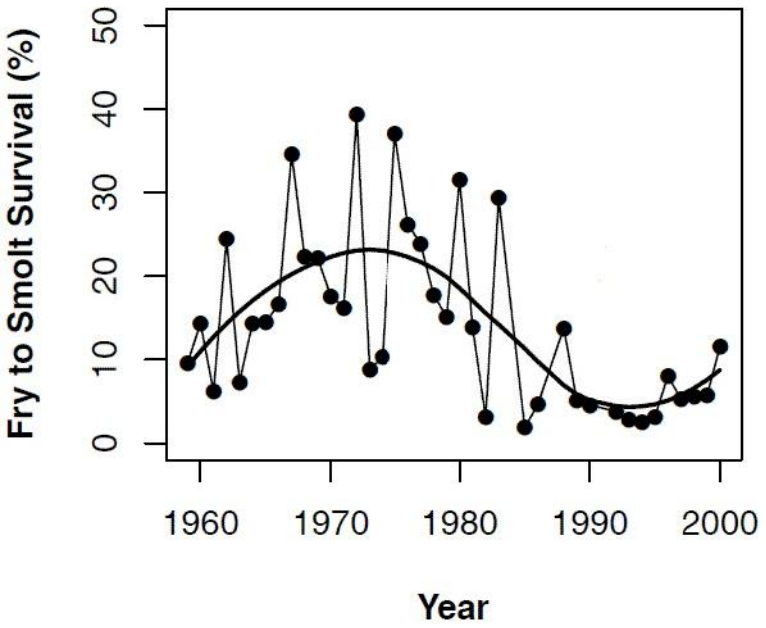


Figure 1. Changes in North Arm of Babine Lake/Nilkitkwa Lake sockeye populations survival during the freshwater component of their life-cycle. Fry numbers were estimated based on spawner counts and smolt numbers were estimated by mark and recapture experiments at the Babine Smolt Fence. The number of eggs per female and the egg to fry survival are based on experience at the Babine spawning channels. Data from Cox-Rogers and Spilsted 2012. Data after the 2000 brood year is not available due to the discontinuation of the program.

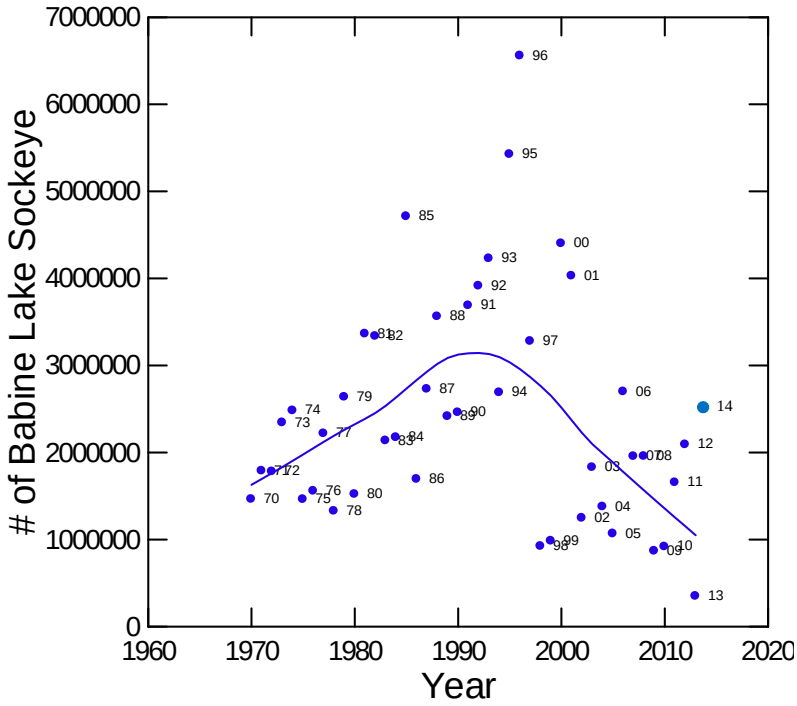


Figure 2. Trends in annual Babine Lake sockeye returns (catch plus escapement), 1970-2010. The trend line is fitted by LOWESS (F=0.5). Updated data from Cox-Rogers and Spilsted 2012. The 2012, 2013, and 2014 data points are interim values.

Figure 3. Map showing the Babine Lake Watershed, and the location of the Babine Sockeye Smolt Enumeration Facility. Map by Gordon Wilson - Gitksan Watershed Authorities.

Methods

2.1 Study Area

The Babine Lake Watershed is located in the Eastern part of the Skeena River Watershed, approximately 70 km Northeast of Smithers, BC (Figure 3). During their migration to the ocean, all of the juvenile sockeye rearing within the Babine Lake Watershed travel through the outlet of Nilkitkwa Lake before entering the Babine River. From 1959 to 2002, the DFO operated a smolt enumeration facility (including a trap, and associated leads, a working platform, and sheltered working sheds) at the outlet of Nilkitkwa Lake. The main components of the smolt enumeration facility are still in place (Figures 4 and 5), and were used for the 2014 study, after some basic maintenance work.

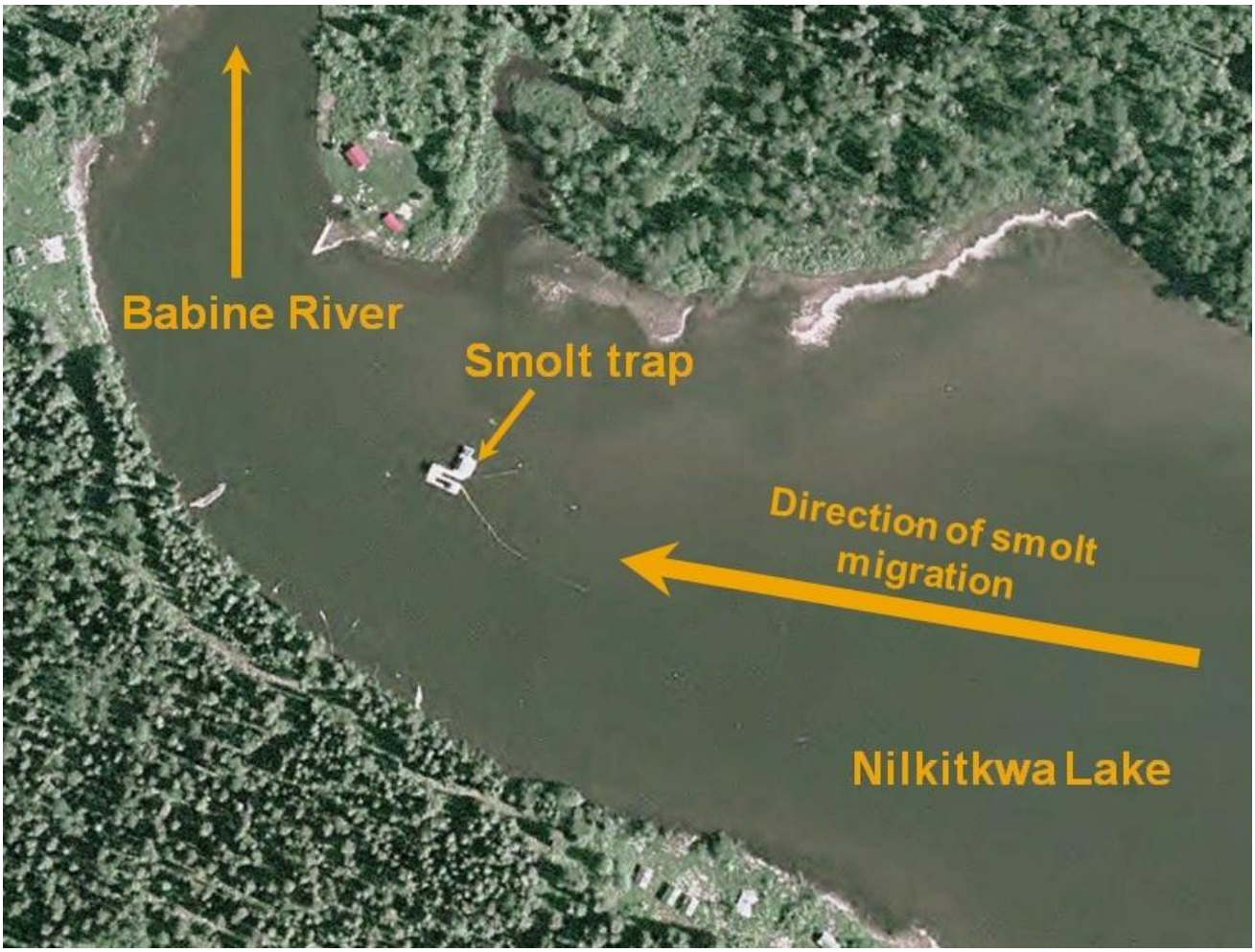


Figure 4. Satellite view of the Babine sockeye smolt enumeration facility, with the associated leads.

Figure 5. Front view of the Babine smolt enumeration facility, with the wire mesh leads, and the entrance to the smolt trap in the middle of the two leads.

2.2 Study Protocol

The mark-recapture sampling techniques and protocol used during this project were those that were extensively developed, documented, and standardized by the DFO and others (Jordan and Smith, 1968, MacDonald and Smith, 1980, and MacDonald et al. 1987).

From May 2nd to June 12th 2014, a portion of the daily sockeye smolt run was captured in the fish trap, part of the Babine smolt enumeration facility, located at the North end of Nilkitkwa Lake. On average, 3,001 of the captured smolts were tagged each day from May 5th to June 2nd (Table 1). The tags used to mark the smolts were color-coded bent staples secured to the back of the smolts, immediately in front of the dorsal fin (Figure 6). Ten different color codes painted on the bent staples identified the day on which the smolts were tagged. Jordan and Smith (1968) describe the tags, and the process of tagging in more detail. The tagged smolts were transferred into a big tank filled with approximately 500 liters of aerated lake water, installed on an inflatable boat (Figure 7), and transported to the southern part of Nilkitkwa Lake to be released. Daily numbers of tagged smolts released are presented in Table 1.

Table 1. Daily number of sockeye smolts tagged and released between May 5th and June 2nd 2014.

Date	Number of tagged smolts released	Date	Number of tagged smolts released
May 5	2,004	**May 20**	3,079
May 6	2,548	**May 21**	3,091
May 7	2,531	**May 22**	3,086
May 8	3,108	**May 23**	3,086
May 9	3,095	**May 24**	3,088
May 10	3,099	**May 25**	3,074
May 11	3,083	**May 26**	3,053
May 12	3,095	**May 27**	3,078
May 13	3,108	**May 28**	3,042
May 14	3,101	**May 29**	3,017
May 15	3,101	**May 30**	3,039
May 16	3,098	**May 31**	3,050
May 17	3,080	**June 1**	3,015
May 18	3,080	**June 2**	3,011
May 19	3,079		

Tagged smolt releases were dispersed over a large area extending 6 to 8 km from the smolt enumeration facility so that they randomly mix with the smolt population migrating through Nilkitkwa Lake. This created a flow of marked smolts mixed with the unmarked smolts migrating through the outlet of Nilkitkwa Lake. Daily count and examination of the smolts captured at the enumeration facility (Figure 8) provided tagged/untagged smolt ratios from which daily run estimates and related standard errors were calculated using the parsimonious model developed by Macdonald and Smith (1980). Daily estimates and standard errors were summed to provide the total estimate for the whole out-migration season, and the related standard error was multiplied by 1.96 to provide the 95% confidence interval.

In 2014, a coded-wire tag detector was used as a metal detector to help detect tagged smolt (Figure 8), and minimise human error during smolt examination. There were concerns that an unknown number of tagged smolts may have been missed during the smolt examinations in 2013, which would have led to an over-estimation of the migrating smolt population estimate. The use of the coded-wire tag detector is believed to have eliminated the chance of missing tagged smolts during smolt examinations.

Finally, 50 smolts were sampled daily for length and weight measurements, and to record the prevalence of *Eubothrium salvelini*, a parasite affecting the digestive tract of sockeye smolts in the Babine Lake Watershed.

Figure 6. A tagged sockeye smolt before release.

Figure 7. View of the inflatable boat used to release tagged sockeye smolts at the south end of Nilkitkwa Lake. The metal tank was filled with water and held over 3,000 tagged sockeye smolts for transportation.

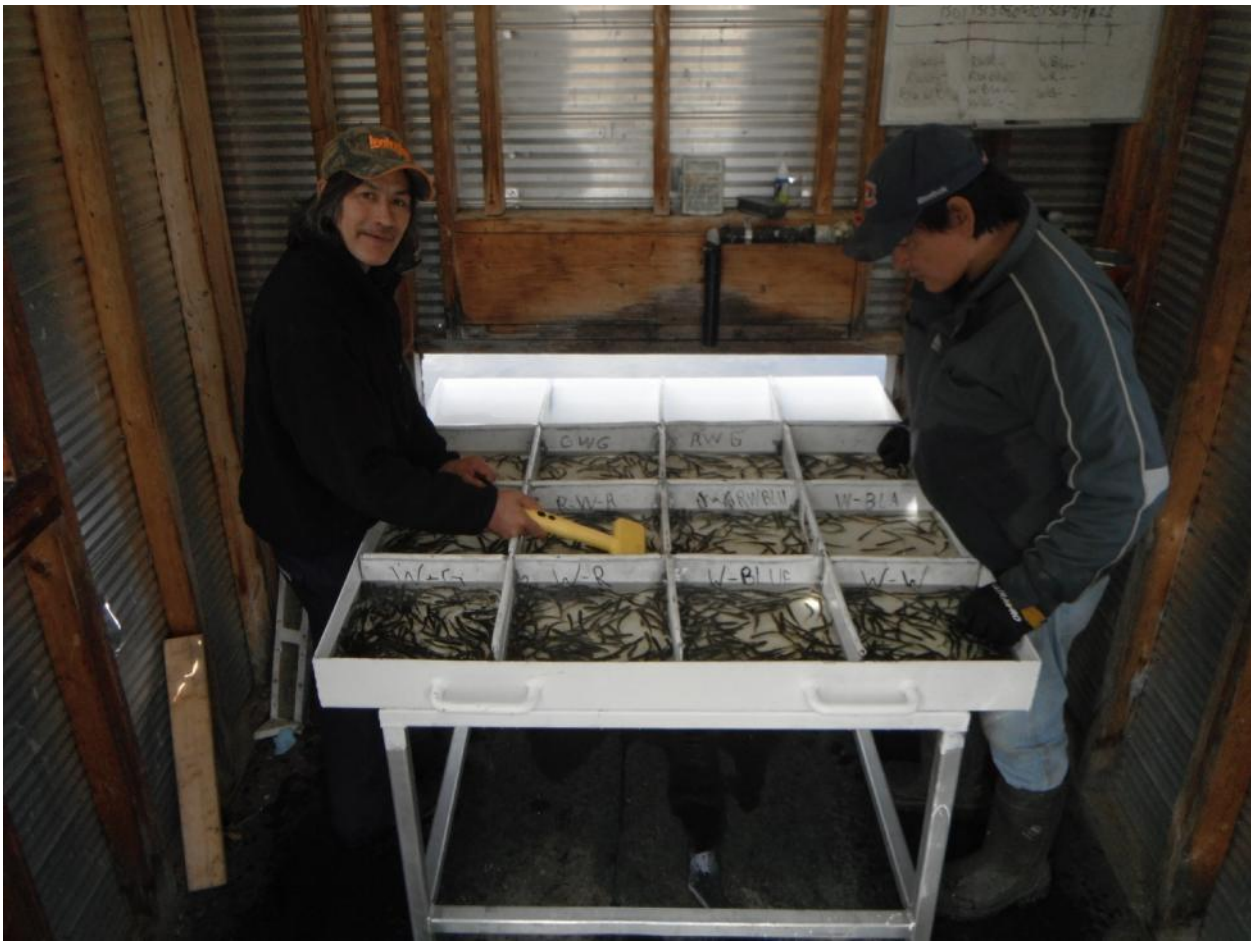


Figure 8. View of two technicians examining sockeye smolt for tags using a coded-wire tag detector as a metal detector. May 17, 2014.

Results and Discussions

Between May 2nd and June 12th, 2014, a total of 1,327,842 sockeye smolts were captured (Table 2). A total of 4,339 of these were recaptured tagged smolts (Table 2).

Table 2. Daily number of tagged sockeye smolts, and total sockeye smolts captured at the Babine smolt enumeration facility between May 2 and June 12, 2014

Date	Tagged smolts	Total smolts	Date	Tagged smolts	Total smolts	Date	Tagged smolts	Total smolts
May 2	0	5	**May 16**	491	27,669	**May 30**	61	54,646
May 3	0	8	**May 17**	136	8,076	**May 31**	27	15,603
May 4	0	2,565	**May 18**	308	14,446	**June 1**	51	65,293
May 5	0	8,802	**May 19**	354	38,550	**June 2**	62	41,166
May 6	1	12,530	**May 20**	214	51,184	**June 3**	30	21,115
May 7	32	19,120	**May 21**	132	55,470	**June 4**	30	7,173
May 8	79	21,721	**May 22**	70	113,897	**June 5**	17	16,789
May 9	165	33,904	**May 23**	33	96,664	**June 6**	14	13,496
May 10	60	9,557	**May 24**	32	31,816	**June 7**	2	19,397
May 11	250	17,809	**May 25**	49	114,327	**June 8**	9	8,742
May 12	246	16,296	**May 26**	42	102,596	**June 9**	2	5,148
May 13	323	24,047	**May 27**	36	73,367	**June 10**	2	4,490
May 14	435	31,337	**May 28**	8	61,326	**June 11**	0	2,182
May 15	514	32,759	**May 29**	23	32,767	**Total**	4,339	1,327,842

Figure 9 shows the daily migrating sockeye smolt population estimates between May 6 and June 11 2014, calculated using the parsimonious model. It shows a fairly clear separation on May 19 between the "early" migrating smolt run, from the North Arm of Babine Lake and Nilkitkwa Lake, and the "late" migrating smolt run, from the main basin of Babine Lake, Hagan Arm, Morrison Arm, and Morrison Lake. The "early" migrating smolt run population was estimated at 4,259,598 ± 1,885,129 (95%CI), and the "late" migrating smolt run population was estimated at 90,447,943 ± 16,182,862 (95%CI), for a total smolt population of 94,707,541 ± 16,292,293 (95%CI) migrating out of the Babine Lake watershed in the spring of 2014.

"Early" migrating smolts had an average length of 79.8mm, and an average weight of 4.5g (Table 3). "Late" migrating smolts were bigger, with an average length of 83.8mm, and an average weight of 5.0g (Table 3). The parasite *Eubothrium salvelini* affected 29.7% of the "early" migrating smolts, and 23.1% of the "late" migrating smolts (Table 3).

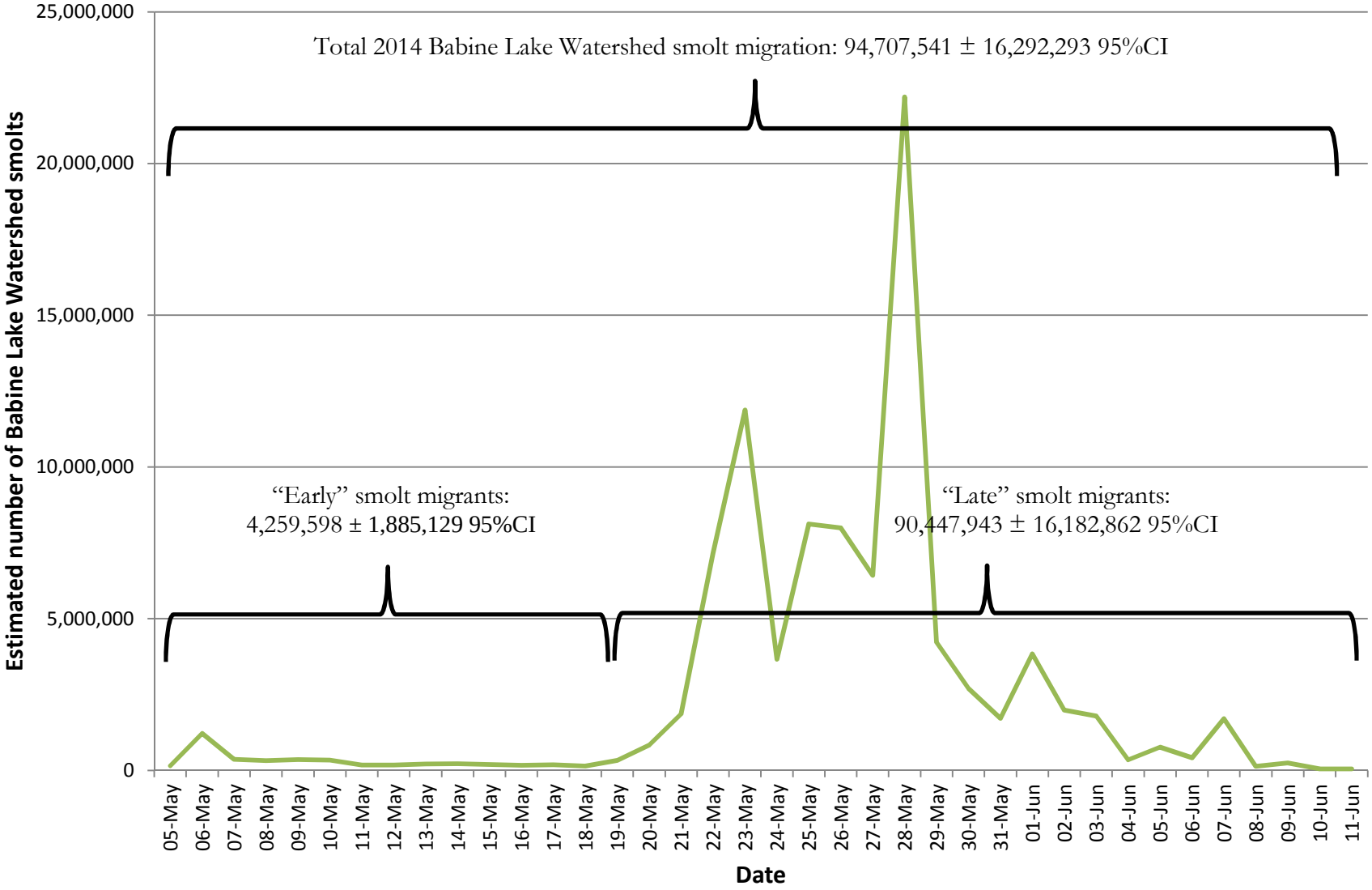


Figure 9. Daily estimated number of smolts migrating out of the Babine Lake Watershed in 2014.

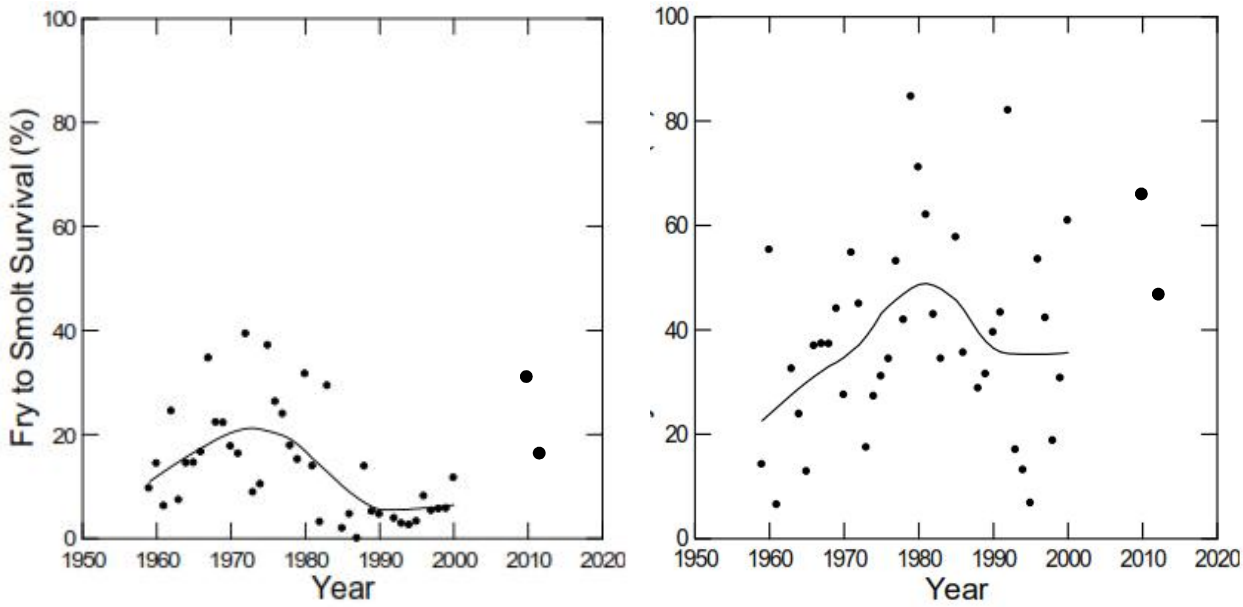
Table 3. 2014 Babine smolt enumeration project smolt sample summary

	n	Mean Length (mm)	Std. Dev Length (mm)	Mean Weight (g)	Std. Dev Weight (g)	Presence of *Eubothrium* (%)
"Early" migrants	763	79.8	8.5	4.5	1.4	29.7
"Late" migrants	1200	83.8	6.5	5.0	9.2	23.1

Figures 10 and 11 compare data from the 2014 Babine sockeye smolt project with historical data. Figure 10 shows the fry to smolt survival trend for brood years 1959 to 2000, 2011, and 2012 for the "early" smolt migrants run (Figure 10-a), and for the "late" smolt migrants run (Figure 10-b). It appears that the fry to smolt survival of the 2012 brood year for both "early" (16%), and "late" (47%) sockeye smolt migrants was within the historical range of variation, and well above the very low fry to smolt survival observed in the 1990's.

In general, the freshwater fry to smolt survival observed for brood year 2012 appears to be lower than the survival observed for brood year 2011 (Figure 10); however this difference may be due to the potential over-estimation of the migrating smolt population suspected to have occurred in 2013 due to difficulties observing re-captured marked smolts mixed with unmarked smolts (Doire and Macintyre, 2014). The use of the coded-wire-tag detector minimised the potential for missed re-captured marked smolts during catch examination in 2014, increasing the accuracy of brood year 2012 migrating smolt population estimation. Even though the 2013 smolt estimate may have been over-estimated, the true freshwater survival rates of brood years 2011 and 2012 in the Babine watershed were still certainly above the low freshwater survival observed in the 1990's, and within the range of the historical variation.

Finally, Figure 11 shows the 2012 brood year mean smolt weight to be slightly above the fitted curve of the average relationship between main basin smolt weight and main basin fry recruitment numbers, but again well within the observed range of variability of past data.



a – "Early" migrant smolts from the North arm of Babine Lake and Nilkitkwa Lake

b – "Late" migrant smolts from the Main Arm, Morrison Arm, and Hagan Arm of Babine Lake

Figure 10. Trends in fry to smolt survival rate for "early" and "late" smolt migrants. Brood years 1959 to 2000, 2011, and 2012. The trend lines are fitted by LOWESS (F=0.5). 1959-2000 data from Cox-Rogers and Spilsted (2012).

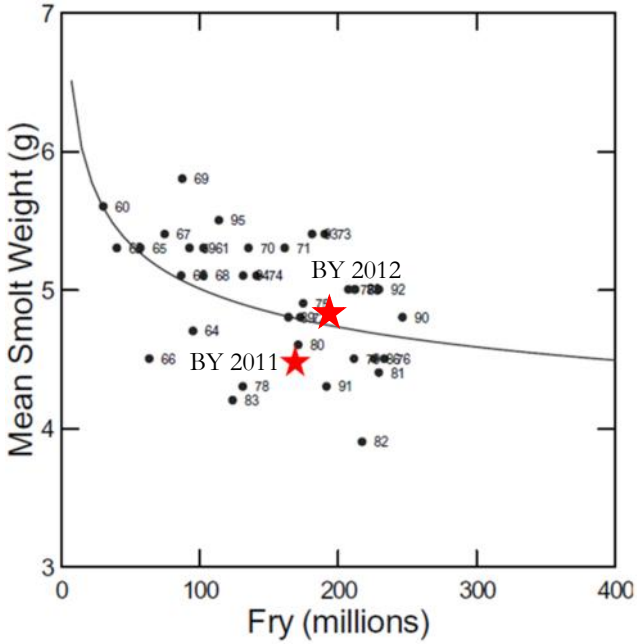


Figure 11. Graph showing the relationship between mean "late" migrant smolt weight and fry recruitment to the Main Arm of Babine Lake from 1960 to 1995, 2011, and 2012. Line fitted as an exponential function. 1960 to 1995 data from Wood *et al.* (1998).

Conclusions

The Babine Lake Smolt Enumeration Project was again a great success in 2014, and an example of a fruitful collaboration between two First Nations organizations: LBN and SFC. Daily out-migrating Babine Lake Watershed sockeye smolt population estimates were successfully calculated for the entirety of the 2014 smolt migration season.

The estimate of the total sockeye smolt population that migrated out of the Babine Lake Watershed in the spring of 2014 was calculated to be 94,707,541. When compared to brood year 2012 fry recruitment to the Babine Watershed to provide an idea of freshwater survival for brood year 2012, this number is within the historical range of variation, and well above the very low fry to smolt survival observed in the 1990's.

The value of the information provided by the 2014 Babine Lake Smolt Enumeration Project will increase when brood year 2012 adults migrate back to the Babine Lake Watershed in 2015 (three years old jacks), 2016 (four years old adult), and 2017 (five years old adults). It will again be possible to calculate smolt to adult ocean survival, and to evaluate the extent to which the decreasing Babine Lake Watershed sockeye returns are due to freshwater versus ocean limitations.

Finally, the Babine Lake Watershed Sockeye Smolt Enumeration Project will continue in the spring of 2015. The same mark-recapture technique will be used again, including the use of the coded-wire tag detector which greatly improved the recovery efficiency of tagged fish during catch inspection. In addition, a hydroacoustic technique will be developed and tested in parallel to the standard mark-recapture method as a new technique to estimate sockeye smolt population migrating out of the Babine Lake Watershed.

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