The Resumption of the Babine Lake Watershed Sockeye Smolt Population Estimation Project

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Table of Contents

Table of Tables

Table of Figures

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. Since 2002 the lack of information on the Babine Lake Watershed sockeye smolt population abundance has been a problem for Skeena sockeye management.

In the spring of 2013, the Lake Babine Nation, in collaboration with the Skeena Fisheries Commission, successfully resumed the Babine Lake Watershed Sockeye Smolt Enumeration Project using the exact same facility, and mark-recapture protocol employed by the Department of Fisheries and Oceans in the past.

The resumption of the Babine Lake Smolt Enumeration Project was a great success, and an example of a fruitful collaboration between two First Nations organizations, LBN and SFC. This project exceeded expectations. Daily out-migrating Babine Lake Watershed sockeye smolt population estimates were calculated for the whole 2013 smolt migration season.

The estimate of the total sockeye smolt population that migrated out of the Babine Lake Watershed in the spring of 2013 was calculated to be 123,358,249 ± 14,554,699.

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 1 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.

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 to what extent 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. The objective of the project being reported on here was to replicate the methodology used by DFO up to 2002 to estimate the daily, and total number of sockeye smolts migrating out of the Babine Lake Watershed in the spring of 2013.

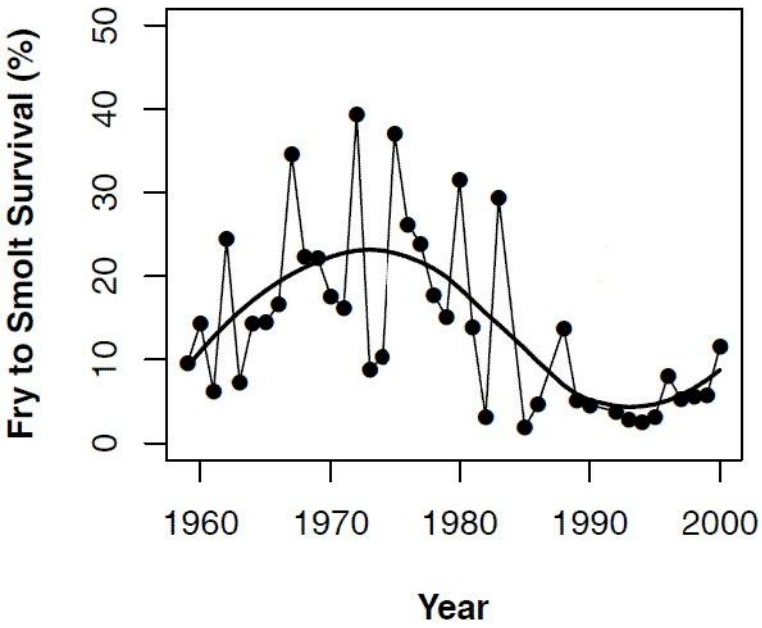


Figure 1. Changes in North Arm of Babine Lake/Nilkitkwa Lake sockeye populations survival during the freshwater component of their life-cycle. Fry numbers were estimated based on spawner counts and smolt numbers were estimated by mark and recapture experiments at the Babine Smolt Fence. The number of 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.

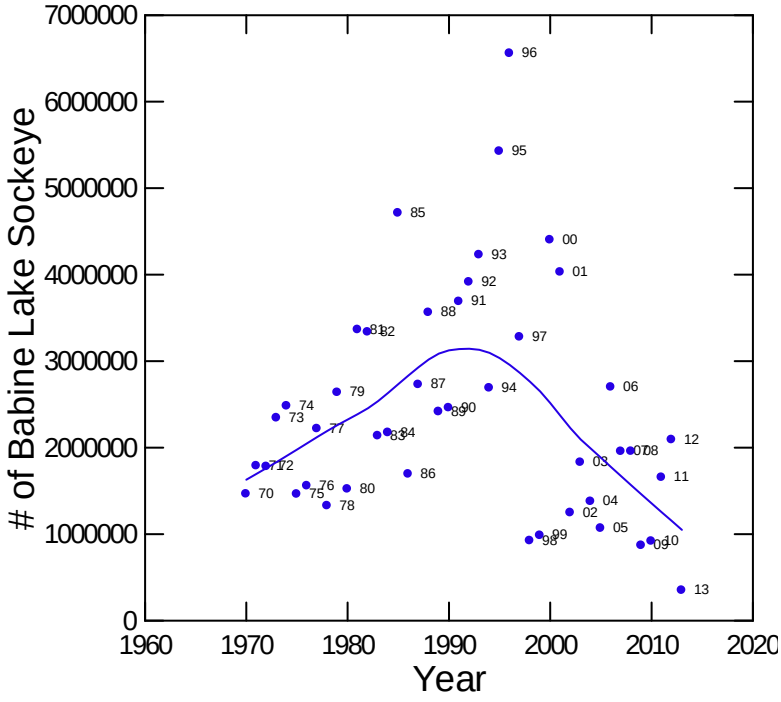


Figure 2. Trends in annual Babine Lake sockeye returns (catch plus escapement), 1970-2010. The trend line is fitted by LOWESS (F=0.5). Updated data from Cox-Rogers and Spilsted 2012. The 2012 and 2013 data points are draft.

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 70km East 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 4and 5), and were used for this project in the spring of 2013, after some repairs.

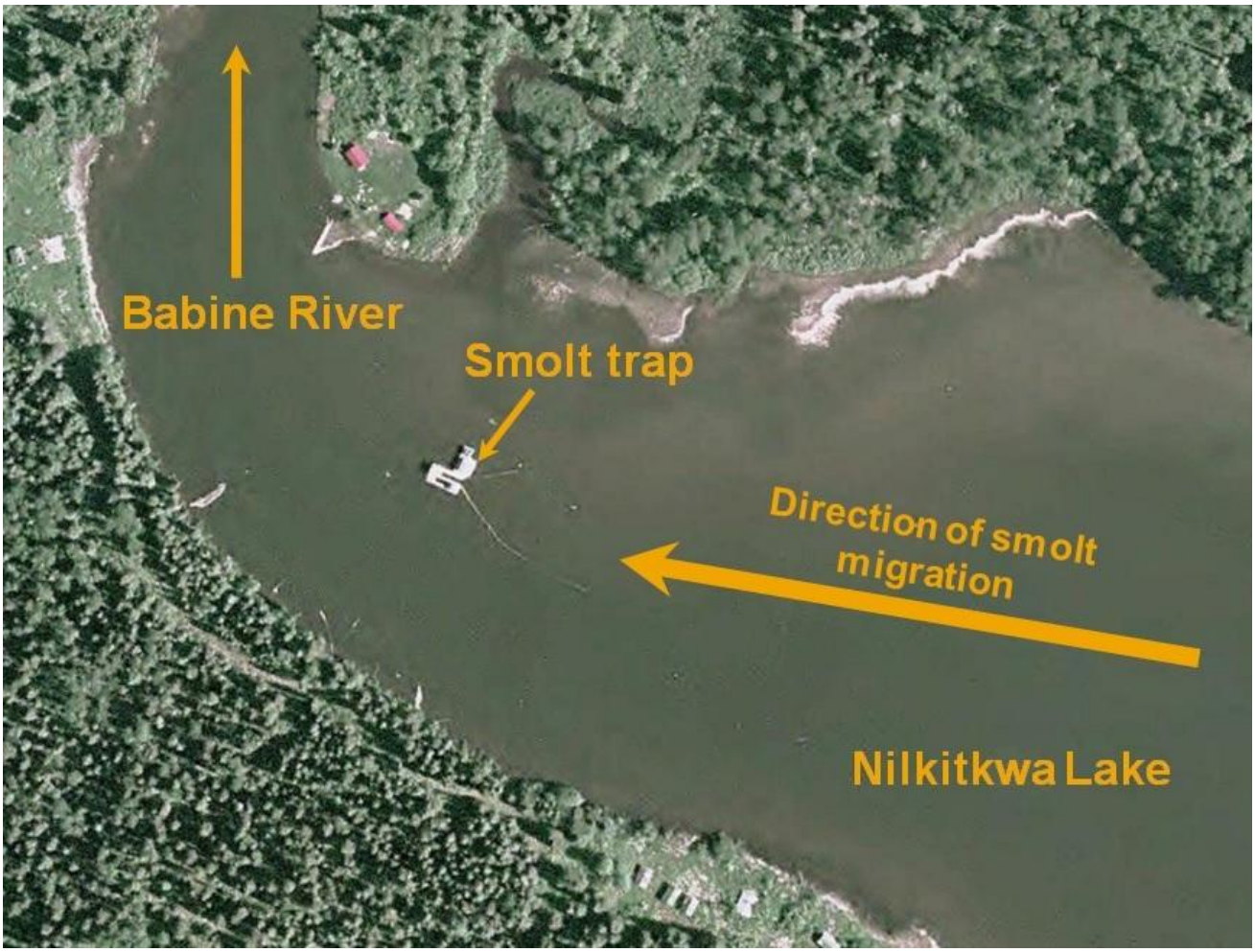


Figure 4. Satellite view of the Babine sockeye smolt enumeration facility, with the associated leads.

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.

Figure 6. A tagged sockeye smolt before release June 4, 2013.

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 4 to June 14 2013, 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, 2,708 of the captured smolts were tagged each day from May 8th to June 4th (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 which day the smolts were tagged. Jordan and Smith (1968) describe the tags, and the process of tagging in more details. The tagged smolts were then 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 7th and June 4th 2013

Date	Number of tagged smolts released	Date	Number of tagged smolts released
May 7	1,003	**May 21**	3,076
May 8	1,523	**May 22**	3,062
May 9	2,049	**May 23**	3,063
May 10	2,536	**May 24**	3,057
May 11	2,531	**May 25**	2,922
May 12	2,520	**May 26**	2,990
May 13	2,967	**May 27**	3,005
May 14	3,081	**May 28**	2,961
May 15	3,057	**May 29**	3,042
May 16	2,037	**May 30**	3,057
May 17	2,988	**May 31**	2,974
May 18	2,871	**June 1**	3,017
May 19	3,006	**June 2**	2,982
May 20	2,428	**June 3**	2,008

Tagged smolt releases were dispersed over a large area extending 6 to 8km from the smolt enumeration facility so that they would randomly mix with the smolt population migrating through Nilkitkwa Lake. This created a flow of marked smolts mixed with the migrating 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 were calculated using the parsimonious model developed by Macdonald and Smith (1980). Daily estimates were summed to give the total estimate for the whole out-migration season.

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 7. View of the inflatable boat used to release tagged sockeye smolts at the south end of Nilkitkwa Lake. The big metal tank was filled with water and held up to 3,000 tagged sockeye smolts for transportation. June 1, 2013.

Figure 8. View of a grid used to help examining sockeye smolts for tags. May 20, 2013.

Results and Discussions

Between May 4th and June 13th, 2013, a total of 1,475,131 sockeye smolts were captured (Table 2). A total of 788 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 4 and June 13, 2013

Date	Tagged smolts	Total smolts	Date	Tagged smolts	Total smolts	Date	Tagged smolts	Total smolts
May 4	0	62	**May 18**	57	182,968	**June 1**	13	25,275
May 5	0	41	**May 19**	84	127,845	**June 2**	16	14,169
May 6	0	67	**May 20**	18	68,049	**June 3**	31	65,725
May 7	0	1,849	**May 21**	59	63,196	**June 4**	6	10,295
May 8	0	3,194	**May 22**	76	149,400	**June 5**	10	6,323
May 9	2	24,372	**May 23**	24	215,477	**June 6**	5	3,860
May 10	8	82,273	**May 24**	9	14,892	**June 7**	1	1,403
May 11	8	43261	**May 25**	51	13,025	**June 8**	1	3,099
May 12	35	31274.6	**May 26**	27	33,398	**June 9**	2	1,292
May 13	23	35227	**May 27**	39	21,359	**June 10**	1	590
May 14	40	32,698	**May 28**	11	9,152	**June 11**	0	1,641
May 15	17	10,885	**May 29**	20	16,803	**June 12**	1	2,432
May 16	9	2,325	**May 30**	22	21,203	**June 13**	0	2,344
May 17	41	116,236	**May 31**	21	18,450	**Total**	788	1,475,131

Figure 9 shows the daily migrating sockeye smolt population estimates between May 9 and June 5, calculated using the parsimonious model. It shows a fairly clear separation on May 17 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 11,055,413 ± 2,805,675 (95%CI), and the "late" migrating smolt run population was estimated at 112,302,836 ± 14,281,718 (95%CI), for a total smolt population of 123,358,249 ± 14,554,699 (95%CI) migrating out of the Babine Lake watershed in the spring of 2013.

"Early" migrating smolts had an average length of 79.6mm, and an average weight of 4.1g (Table 3). "Late" migrating smolts were bigger, with an average length of 81.0mm, and an average weight of 4.4g (Table 3). The parasite *Eubothrium salvelini* affected 13.1% of the "early" migrating smolts, and 10.0% of the "late" migrating smolts (Table 3).

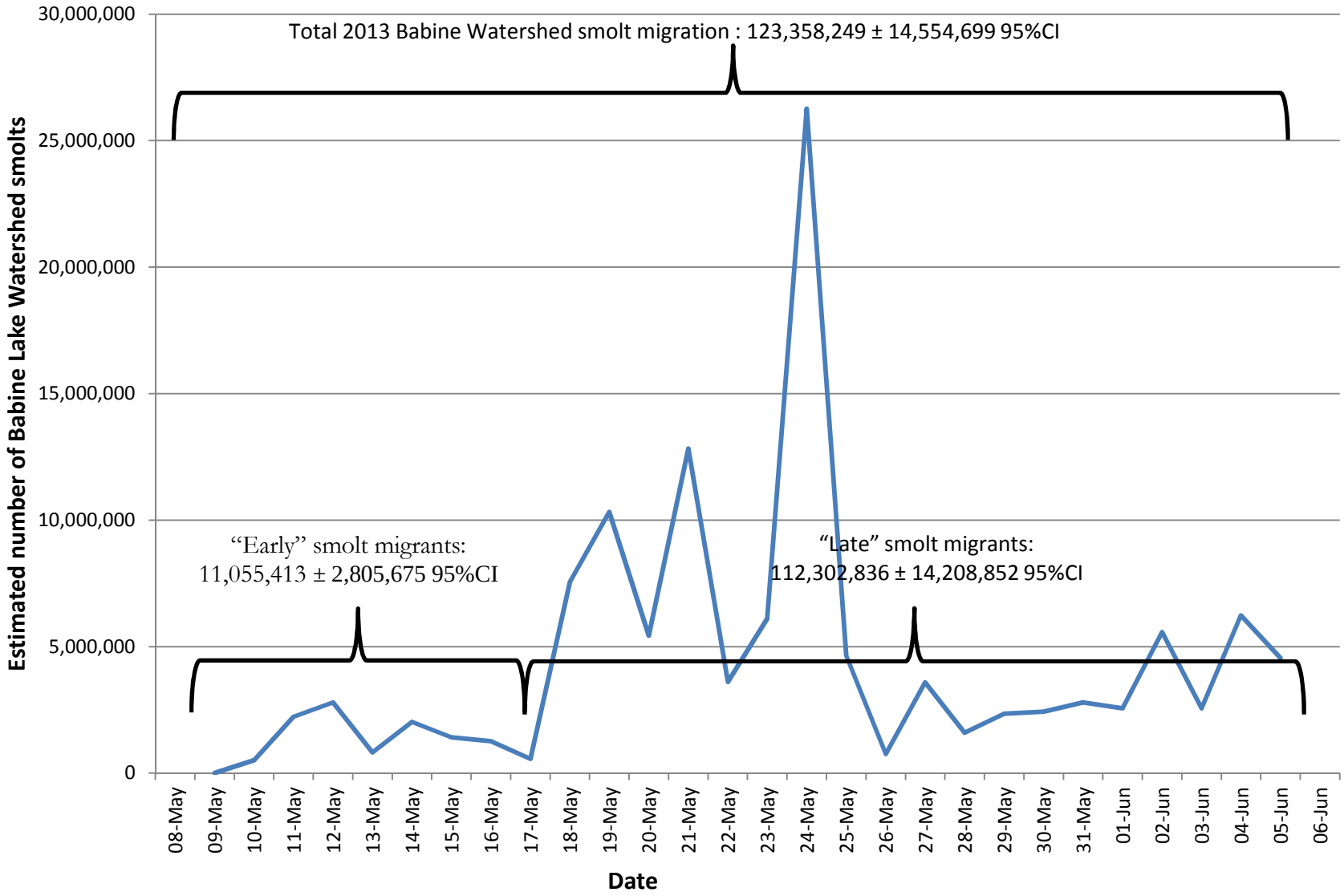


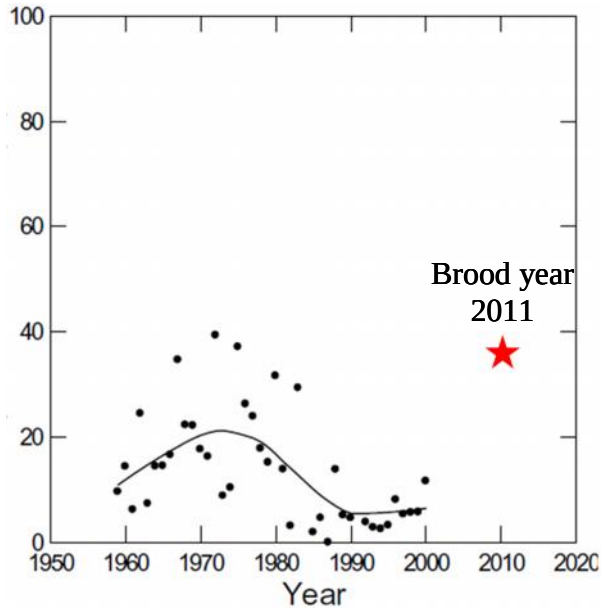
Figure 9. Daily estimated number of smolts migrating out of the Babine Lake Watershed in 2013

Table 3. 2013 Babine smolt enumeration project smolt sample summary

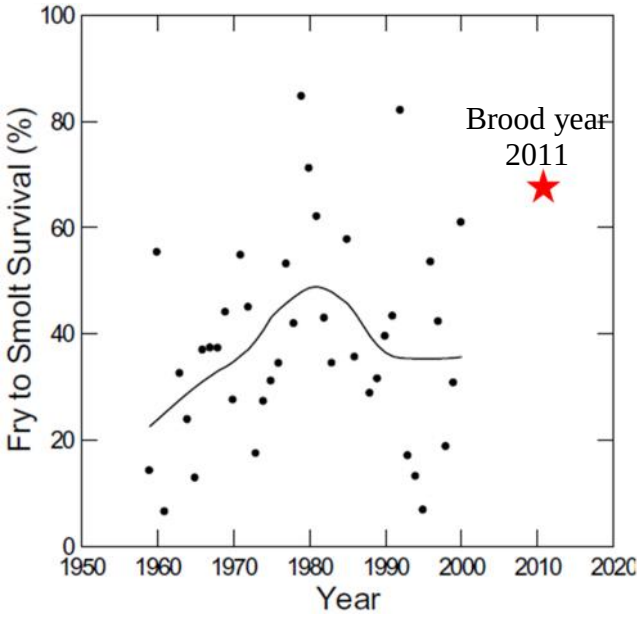
	n	Mean Length (mm)	Std. Dev Length (mm)	Mean Weight (g)	Std. Dev Weight (g)	Presence of *Eubothrium* (%)
"Early" migrants	600	79.6	9.1	4.1	1.5	13.1
"Late" migrants	1348	81.0	6.27	4.4	1.1	10.0

Figures 10 to 12 compare the 2013 Babine sockeye smolt population estimates with historical data. Figure 10 shows the fry to smolt survival trend for brood years 1959 to 2000, and 2011 for the "early" smolt migrants run (Figure 10a), and for the "late" smolt migrants run (Figure 10b). It appears that the fry to smolt survival of the 2011 brood year for both "early" (36%), and "late" (65%) sockeye smolt migrants was relatively high but within the historical range of variation. The same observation can be made about Figure 11. The number of smolts that migrated out of the main basin of Babine Lake is high given the number of fry that entered the main basin compared to historical data, but within the historical range of variation.

Finally, Figure 12 shows the 2011 brood year mean smolt weight to be slightly below the fitted curve of the average relationship between main basin smolt weight and main basin fry 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 migrant. Brood year 1959 to 2000, and 2011. The trend lines are fitted by LOWESS (F=0.5). 1959-2000 data from Cox-Rogers and Spilsted (2012).

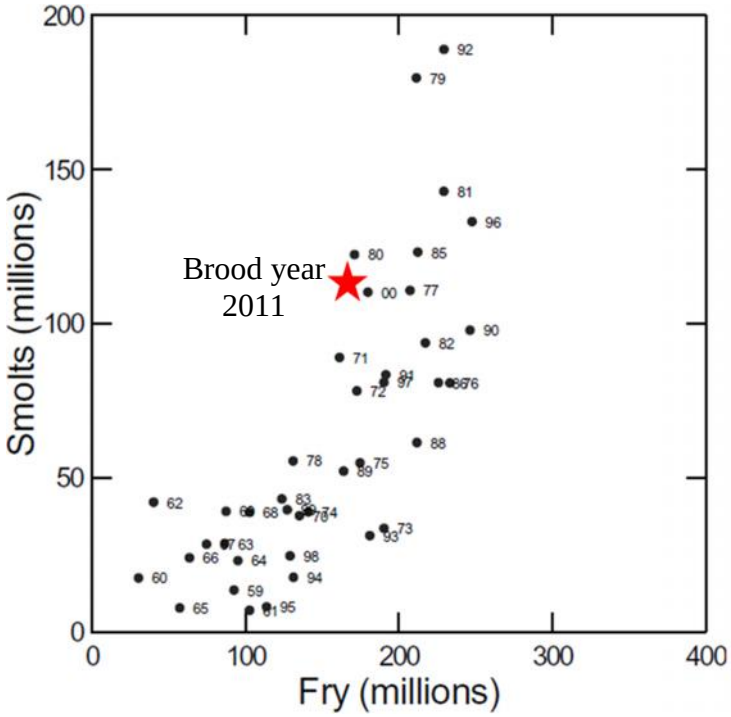


Figure 11. Graph showing the relationship between brood year smolt recruitment and fry number for "late" smolt migrant sockeye rearing in the Main Arm, Morrison Arm, and Hagan Arm of Babine Lake (1959-2000, and 2011). 1959-2000 data from Cox-Rogers and Spilsted (2012).

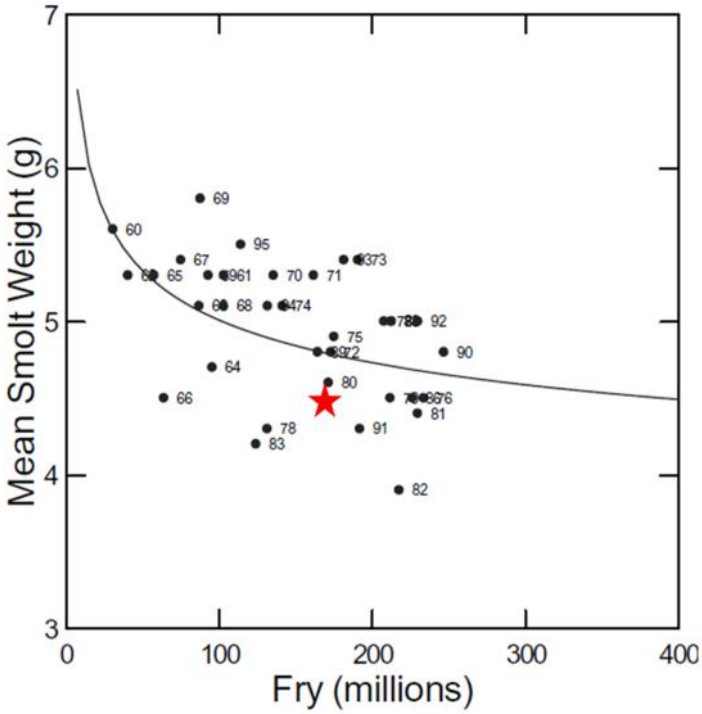


Figure 12. Graph showing the relationship between mean "late" migrant smolts and fry recruitment to the Main Arm of Babine Lake from 1960 to 1995, and 2011. Line fitted as an exponential function. 1960 to 1995 data from Wood *et al.* (1998).

Conclusions

The resumption of the Babine Lake Smolt Enumeration Project was a great success, and an example of a fruitful collaboration between two First Nations organizations: LBN and SFC. This project exceeded expectations. Daily out-migrating Babine Lake Watershed sockeye smolt population estimates were calculated for the whole 2013 smolt migration season.

The estimate of the total sockeye smolt population that migrated out of the Babine Lake Watershed in the spring of 2013 was calculated to be 123,358,249. This number is relatively high in relation to brood year fry abundance, when compared to historical fry to smolt survival data. In general, studies using mark-recapture techniques to estimate populations tend to over-estimate abundance, especially when tag retention rate, tagged fish mortality rate (e.g. from predation), and recovery efficiency of tagged fish during catch inspection are unknown. This is may have been the case for this study. Nonetheless, the study reported here shows that significant numbers of sockeye smolts migrated out of the Babine Lake Watershed in the spring of 2013, and that fry to smolt survival for brood year 2011 was within historical range.

The value of the information provided by the 2013 Babine Lake Smolt Enumeration Project will increase when brood year 2011 adults migrate back to the Babine Lake Watershed in 2014 (three years old jacks), 2015 (four years old adult), and 2016 (five years old adults). It will again be possible to calculate smolt to adult ocean survival, and to evaluate to what extent 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 2014. The same mark-recapture technique will be used again, with some improvement to standardize 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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