2014 Babine Lake Sockeye Smolt Enumeration - Hydroacoustic Feasibility

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ABSTRACT

Skeena Fisheries Commission (SFC) conducted a study to investigate the feasibility of using hydroacoustic methodology to enumerate outmigrating sockeye smolts at the outlet of Nilkitkwa Lake in the spring of 2014. Hydroacoustic techniques have the potential to produce accurate data and be less invasive and labour intensive, and more cost effective than the mark-recapture currently method used to estimate the abundance of sockeye smolts during the annual seasonal migration from the Babine Lake Watershed. The specific goals of the 2014 feasibility project were (1) to identify a suitable location near the outlet of Nilkitkwa Lake with an appropriate depth cross-section so that one or two side-looking 6 degree-beam acoustic transducers could ensonify most of the cross-section of the channel; (2) to acoustically sample migrating smolt; and (3) to analyze acoustic data collected to calculate a smolt population estimate for the period sampled. Here we report the results from the 2014 project.

We identified a suitable location with a deep U-shaped channel suitable for hydroacoustic sampling at the outlet of Nilkitkwa Lake in 2014. . However, tests conducted with side-looking hydroacoustic gear at this location demonstrated that two 6 degree beam transducers positioned on either side of the Babine River would sample less than 2/3 of the river's cross-section, and would not sample the middle of the channel, rendering a robust statistical estimation of the total migrating smolt population impossible. Furthermore the acoustic data collected in 2014 contained a significant amount of acoustic noise, mainly from the water surface, that could not be edited to allow for accurate data analysis. Thus, side-looking hydroacoustic methodology is not appropriate for accurately estimating the migrating sockeye smolt populations at the outlet of Nilkitkwa Lake.

While the 2014 results of our investigation into the feasibility of using side-looking hydroacoustic methodology to enumerate sockeye smolts at Babine Lake are disappointing, we are still confident that a hydroacoustic method can be used to accurately estimate the sockeye smolt population out-migrating from the Babine Lake Watershed at the outlet of Nilkitkwa Lake, and are preparing to apply the experience gained during the 2014 feasibility study to test an upwards-oriented hydroacoustic technique at the outlet of Nilkitkwa Lake in May 2015.

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INTRODUCTION

The Babine Lake Watershed is the principal sockeye salmon (*Oncorhyncus nerka*) rearing area for Skeena sockeye, producing up to 90% of the sockeye returns to the Skeena River. The Skeena watershed supports an average yearly harvest of 1.5 million sockeye in commercial (Canada and United States), recreational, and First Nations fisheries and an average spawning escapement of 1 million sockeye.

Sockeye salmon returns to Babine Lake have declined significantly during the past two decades (Figure 1). The outmigrating sockeye smolt population from the Babine Lake Watershed was not estimated between 2002 (brood year 2000), and 2013 (brood year 2011) it is not known to what extent the decreasing returns are due to freshwater versus ocean limitations. In the spring of 2013, the Skeena Fisheries Commission (SFC) in collaboration with the Lake Babine Nations (LBN) successfully resumed the sockeye smolt mark-recapture population estimation program (Doire and Macintyre, 2014) previously carried out by the Department of Fisheries and Oceans from 1959 to 2002. The reactivation of the mark-recapture sockeye smolt program for the Babine Watershed is particularly valuable because of the long history of accurate adult counts through a weir, an accurate reconstruction process to estimate the catch component of the stock, fry counts from the enhancement facilities, and detailed past lake productivity studies. However, mark-recapture methods generally tend to over-estimate populations size, especially when tag retention, and tagged fish mortality (e.g. from predation) rates are unknown.

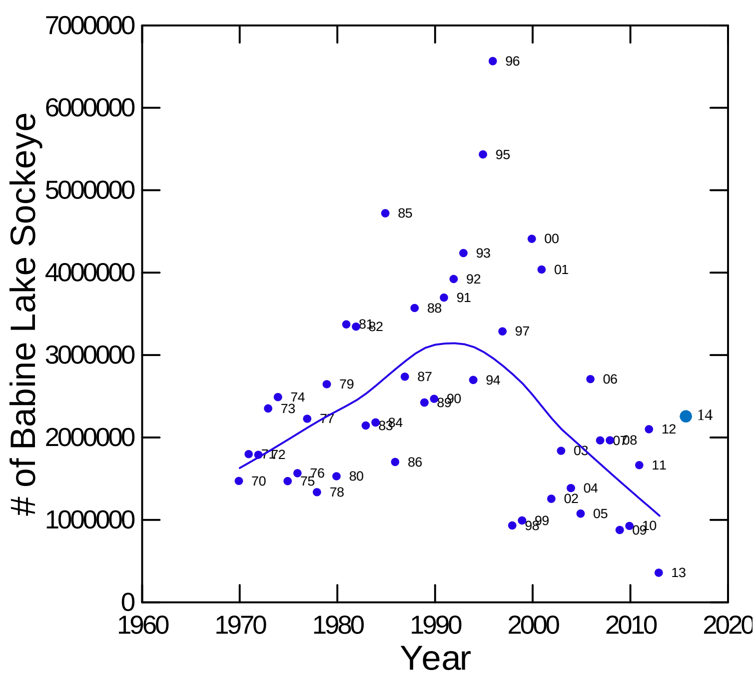

Figure 1. Trends in annual Babine Lake sockeye returns (catch plus escapement), 1970-2010.

Note: 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.

Hydroacoustic methods are commonly used in fisheries science, notably to estimate fish populations, and fish biomass (Simmonds and MacLennan, 2005). The main advantages to hydroacoustic methods over other fish sampling methods include the ability to sample large volume of water efficiently, and to remotely sample fish, without handling, or other disruption. The Skeena Fisheries Commission (SFC) has gained significant expertise using hydroacoustic technology to estimate juvenile sockeye populations in small lakes and has conducted nearly 50 successful mobile hydroacoustic surveys on small sockeye lakes in the Skeena and Nass Watersheds since 2005. During mobile lake surveys, the acoustic equipment samples the water column vertically from a boat following pre-determined transects. It is also possible to use the same acoustic equipment in a side-looking, stationary position to horizontally sample the cross-section of a body of water. Studies on the Kvichak River in Alaska have tested the use of acoustic equipment in such a configuration to estimate out-migrating sockeye smolts, and concluded that the stationary, side-looking hydroacoustic method was feasible, but that site-specific environmental variables greatly affected its effectiveness (Mueller *et al.* 2006 and Maxwell *et al.* 2009).

The SFC began testing the feasibility of using a stationary side-looking hydroacoustic technique to estimate the sockeye smolt population migrating out of the Babine Watershed in the spring of 2014. Our objectives for this first year of testing were modest. In 2014, the main objective was to identify a suitable location near the outlet of Nilkitkwa Lake (where the Babine Lake Watershed drains into the lower Babine River – see Figure 2) with an appropriate depth cross-section so that one or two side-looking transducers could ensonify most of the channel width, and water column. If a suitable location was found, out-migrating smolt would be sampled acoustically in tandem with the mark-recapture program for at least a full day (24 hours). Finally, the acoustic data would be analyzed to calculate a daily smolt population estimate, which could then be compared to the daily estimate from the mark-recapture program.

If feasible, this side-looking hydroacoustic technique has the potential to improve the accuracy of the Babine sockeye smolt estimate because it is not dependent on a number of variables related to mark-recapture method (tag retention, mortality, predation rates, etc.) and has the potential of sampling a greater portion of the sockeye smolt population. The trap currently used for the mark-recapture program samples only approximately 1% of the out-migrating sockeye smolt population, and the mark-recapture estimate is derived from this small sample. Furthermore, if found feasible and effective, this hydroacoustic technique may not only be a more accurate option to the standard mark-recapture, but will also be less labour intensive, more cost effective, and will require no handling of the smolts. As a result, the hydroacoustic method may be a more efficient, effective, and viable method to enumerate Babine Watershed out-migrating sockeye smolts over the long term.

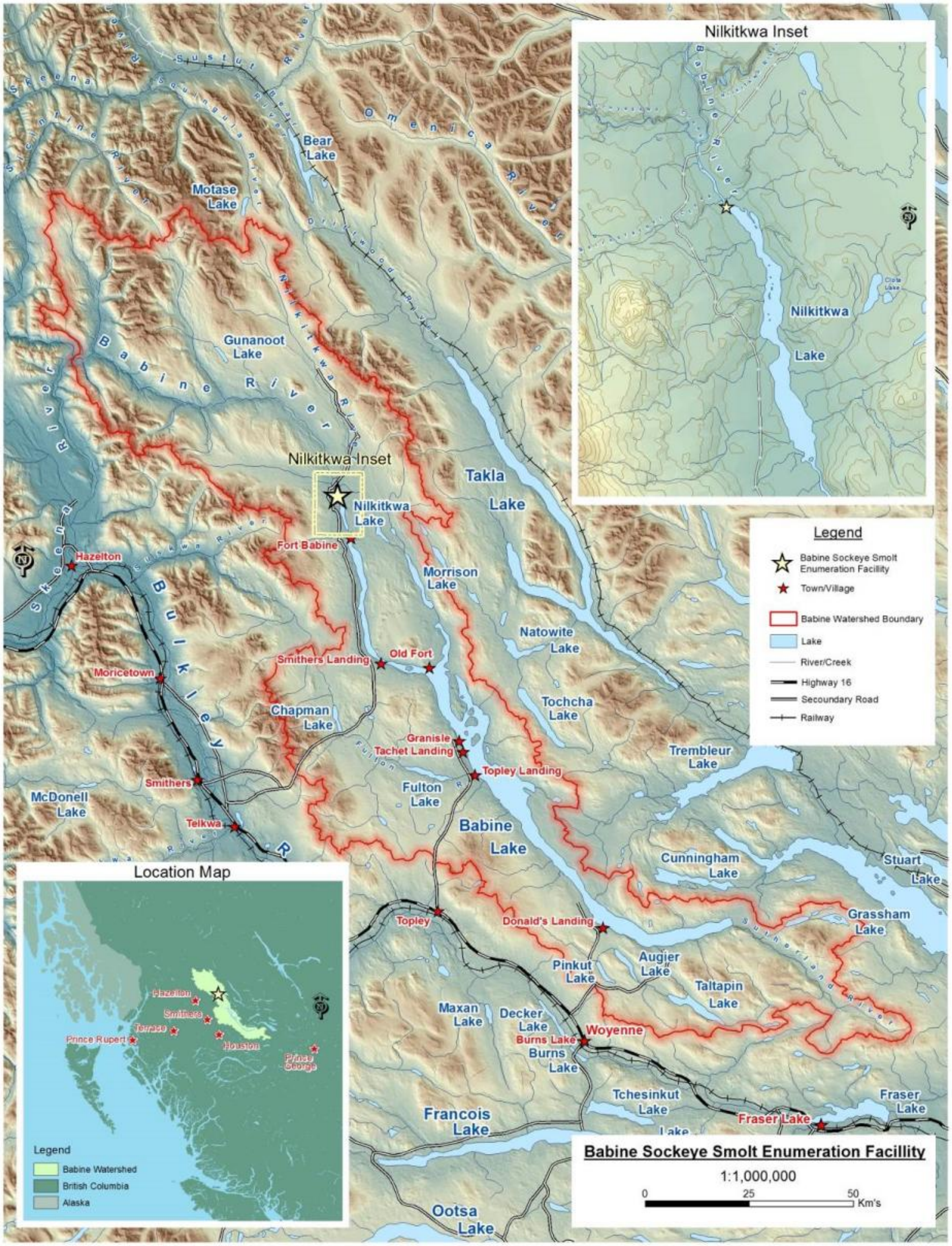

Figure 2. Map showing the Babine Lake Watershed, and the location of the Babine Sockeye Smolt Enumeration Facility. Map by Gordon Wilson - Gitksan Watershed Authorities.

METHODS

Study Area

The Babine Lake Watershed is located in the eastern part of the Skeena River Watershed, approximately 70km northeast of Smithers, British Columbia (Figure 2). All of the juvenile sockeye rearing within the Babine Lake Watershed travel through the outlet of Nilkitkwa Lake before entering the Babine River during their seaward migration. The Department of Fisheries and Oceans (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 from 1959 until 2002. We used this facility in the spring of 2014 to conduct the Babine Lake Watershed Sockeye Smolt Mark-Recapture project.

The section of the Babine River immediately downstream of the smolt enumeration facility was chosen for the site of the 2014 hydroacoustic feasibility study because it has appropriate characteristics, such as a narrow, deep, and steep channel cross-section configuration (Figure 3). The site is easily accessible from the smolt fence infrastructure, with sufficient level terrain on both banks to accommodate the hydroacoustic installation.

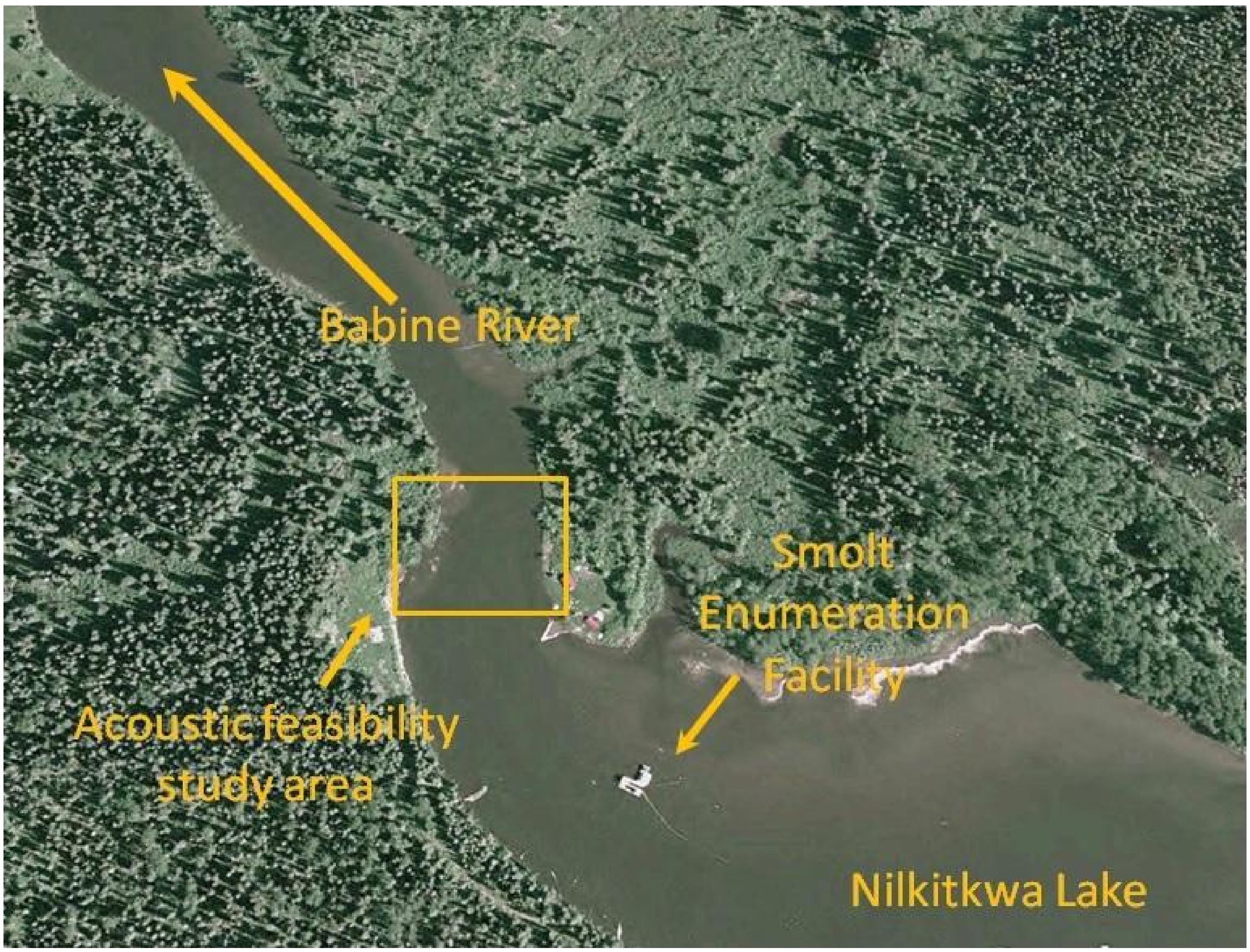

Figure 3. Satellite view of the acoustic feasibility study area.

Acoustic Equipment and data collection

The acoustic equipment tested in the field during this feasibility project consisted of a Biosonics DTX echosounder coupled with a 200 kHz split-beam transducer producing a 6 degree beam. The transducer was mounted to a steel structure specially fabricated for this project (Figure 4). The design of the steel structure allowed for the transducer to be positioned horizontally, and for the height, and pitch angle of the transducer to be quickly adjusted.

Hydroacoustic data collection tests were conducted with a single transducer installed at two stations, positioned on either sides of the river to measure the proportion of the river cross-section that could be ensonified using two transducers deployed on each of the river's banks simultaneously. The two data collection test stations were chosen so they would be off-set from each other rather than facing each other directly, in order to prevent cross signalling between the two transducers in the event that both be used simultaneously.

Figure 4. Photo of the steel structure designed and fabricated to mount the acoustic transducer horizontally.

Figure 5. Photo of the hydroacoustic system collecting side-looking acoustic data from the river's left shore. May 25, 2014.

Figure 6. Photo of the hydroacoustic system collecting side-looking acoustic data from the river's right shore. June 6, 2014.

Researchers at Kvichak River, Alaska observed that most of the sockeye smolt migrating out of Lake Iliamna travelled in close proximity to the surface (Mueller *et al.* 2006, Maxwell *et al.* 2009, and Wade *et al.* 2010a). During the 2013 smolt mark-recapture enumeration project, we also observed that sockeye smolt migrating out of the Babine Lake Watershed through the Babine River remained close to the water surface when travelling down the river (Doire, 2013). Because of this skewed smolt distribution in the water column, and to replicate the sampling protocol used by Mueller *et al.* (2006), Maxwell *et al.* (2009), the transducer was positioned just below the surface, at an angle that allowed the upper edge of the acoustic beam to parallel the surface only a few centimeters below (Figures 5 and 6).

Data collected was stored on a laptop computer to a threshold of -80dB, using Biosonics Visual Acquisition software. The acoustic system and the laptop computer were powered using two 12V batteries in rotation. One battery powered the system for approximately 12 hours, while the other battery was being re-charged using the camp's diesel generator.

Channel cross-section depth profile measurements

We measured the channel cross-section depth profile was measured from a boat, using a graduated staff gauge. The boat was moved across the channel along a measuring tape that spanned the channel. Depth was measured to the closest centimeter every 2 meters as measured on the measuring tape.

Ensonification zone measurements

A standard tungsten carbide hydroacoustic calibration sphere with a diameter of 36mm was drifted from a boat in front of the transducer at different depths, and distances to determine the zone that was being effectively ensonified by one transducer, from both sides of the river.

Hydroacoustic data post-processing

Hydroacoustic data was imported into the Echoview software (v. 6.0.94) for editing, and analysis. Acoustic targets below -65 decibels were eliminated from analysis using the Parker-Stetter (2009) method of linking the Sv threshold to a TS threshold of -71 decibels, in order to include off-axis sub-threshold targets that would exceed the -65 threshold once compensation for their position is applied by the ST, or single target detection algorithm. Data analysis was to be conducted using the same integration methodology described by Mueller *et al.* (2006), and Maxwell *et al.* (2009). The integration method integrates the average acoustic energy for each range strata by the average target strength volumetric fish density for the stratum (n/m^3).

RESULTS AND DISCUSSION

Channel cross-section depth profile and ensonification zone

Figure 7 illustrates the cross-section depth profile as measured from the river's right and left transducer stations. At both transducer stations, and on both sides of the river, the depth increases quickly to a maximum depth of approximately 250 to 300 cm, giving the river channel an obvious deep U-shape. These are the channel characteristics that were looked for when choosing a site where to install the transducer to start testing the side-looking hydroacoustic technique. No other site at the outlet of Nilkitkwa Lake provided more appropriate channel characteristics for this feasibility project.

Figure 7 also shows the results from the effective ensonification test conducted for both the river's right and left transducer stations. The ensonified zone from both transducer stations was parallel to and approximately 5 cm below the surface, and extended to a range of approximately 17m. As expected the effective range of ensonification was limited by the depth of the channel. The maximum effective ensonification range is the range from the transducer face at which the bottom edge of the acoustic beam meets the bottom of the river. Beyond that range, the acoustic signal from the river bottom is too strong overwhelming all other acoustic signals. Therefore, that the two transducers installed on both side of the Babine River at the outlet of Nilkitkwa Lake would ensonify 34m of the 54m river cross-section where migrating smolt travel. This means that approximately 20m in the middle of the river's cross-section would not be sampled by two transducers installed on either sides of the river.

Hydroacoustic data collection and post processing

Approximately 60 hours of hydroacoustic data was collected from both transducer stations on May 22 to 28, and June 4 to 6. An example of the data collected is shown in Figure 8. This echogram shows two sockeye smolt schools (large bright yellow/red masses), and other individual fish (small yellow dots) passing through the ensonified zone. The recorded data contained substantial acoustic noise (blue and black colors), and much time was spent editing the data in Echoview in order to eliminate or reduce the acoustic noise from the data without affecting the acoustic data from migrating fish. The side-looking hydroacoustic technique tested here to estimate migrating smolt is known to be extremely sensitive to noise from the water surface because the transducer has to be positioned so the upper edge of the acoustic beam parallels the surface, just below it (Wade *et al.* 2010a, and Maxwell *et al.* 2009). Any small disturbance of the water surface (wind, rain, etc.), or even an acoustic side-lobe has potential to introduce noise in the acoustic data. Ultimately, the data from the side-looking transducers that were collected in 2014 were too noisy to allow us to produce an accurate estimate of the number of sockeye smolts that had passed through the ensonified zone over any period of time.

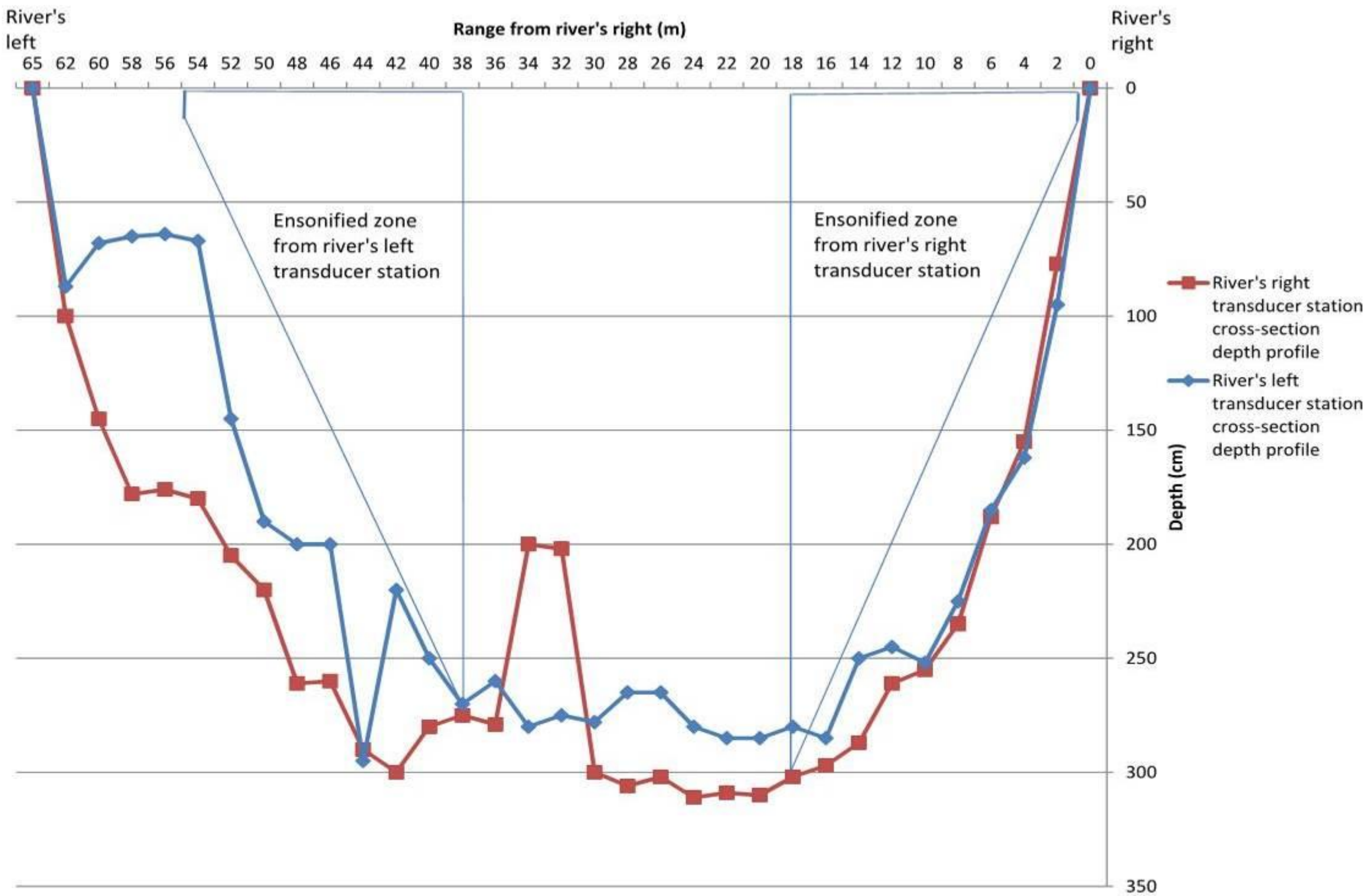

Figure 7. Graph showing the Babine River channel cross-sections depth profiles at the two transducer stations located at the Nilkitkwa Lake outlet, and the approximate ensonified zones.

Note different scales for x and y axes.

Researchers in Alaska have developed a technique to sample sockeye smolts using upward-facing, rather than side-looking hydroacoustic gear to estimate the abundance of sockeye salmon smolts migrating through the Kvichak, Egegik, and Ugashik Rivers (Wade *et al.* 2010a, Wade *et al.* 2010b, Wade *et al.* 2012a, Wade *et al.* 2012b, Wade *et al.* 2013, and Nemeth *et al.* 2014). The U-shaped channel of the location identified during our 2014 feasibility study may be appropriate for estimating the sockeye smolt population migrating from Babine Lake (Don Degan, pers. comm).

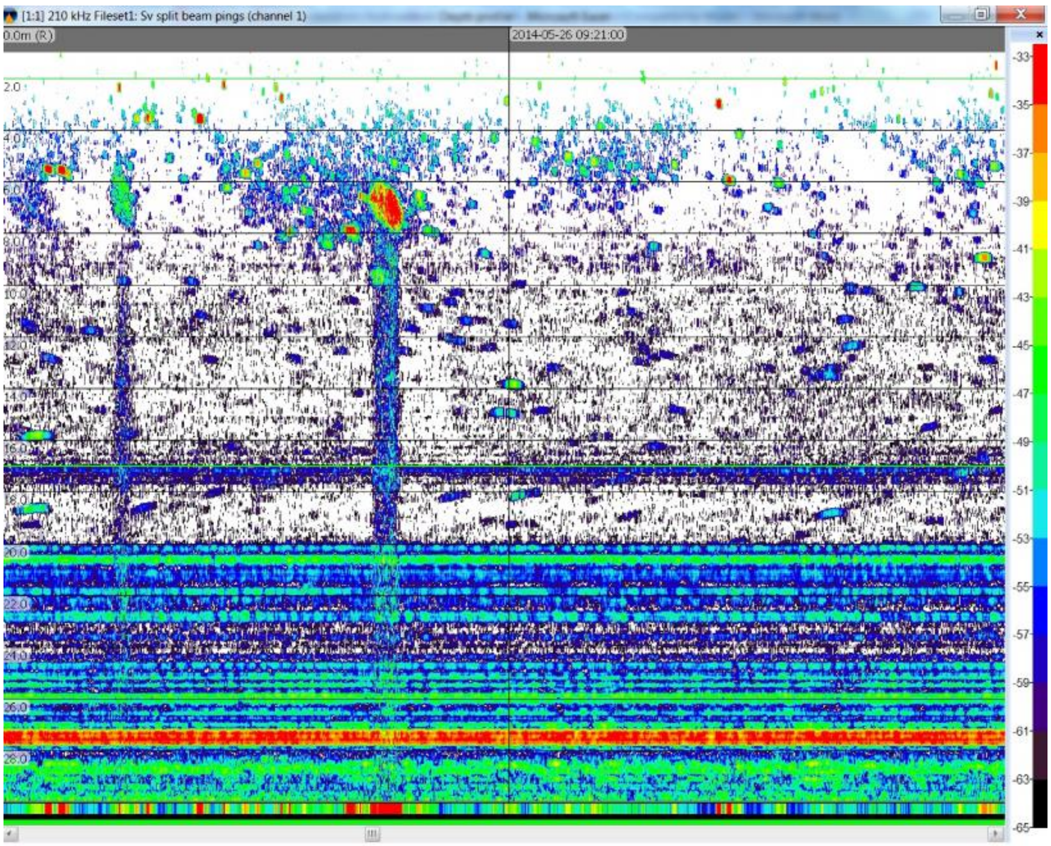

Figure 8. Echogram showing almost two minutes of hydroacoustic data collected on May 26, 2014.

Note: The two red and yellow masses to the left of the echogram represent two sockeye smolt schools migrating down the Babine River. The smaller yellow dots are individual smolt. The thick horizontal lines are rocks on the bottom. The first thick horizontal line in the middle of the echogram represents the maximum useful range of the data. The blue and black colors above the first thick horizontal line is noise. The y axis is the range from the transducer's face with 0 m at the top, and the x axis is time.

CONCLUSION

The specific goals of the feasibility project were to identify a suitable location near the outlet of Nilkitkwa Lake with an appropriate depth cross-section so that one or two side-looking 6 degree-beam acoustic transducers could ensonify most of the channel cross-section; to sample acoustically migrating smolt; and to analyze the acoustic data collected to calculate a sockeye smolt population estimate for the period sampled.

While we successfully identified a location with a deep U-shape channel, suitable for hydroacoustic sampling at the outlet of Nilkitkwa Lake, the side-looking hydroacoustic test conducted at this location demonstrated that two 6 degree beam transducers positioned on either side of the Babine River would sample less than 2/3 of the river's cross-section, and would not sample the middle of the channel, making it impossible to produce a robust statistical estimate of the migrating smolt population. Furthermore the acoustic data collected in 2014 contained a significant amount of noise that could not be edited to allow for accurate data analysis. The side-looking hydroacoustic technique is too sensitive to acoustic noise from the water surface, and is not appropriate to estimate migrating sockeye smolt at the outlet of Nilkitkwa Lake.

Despite the results from this project, we are still confident that a hydroacoustic method can be used to accurately estimate the sockeye smolt population out-migrating from the Babine Lake Watershed at the outlet of Nilkitkwa Lake. An upward-looking hydroacoustic method has successfully been used to estimate the smolt population migrating out of Iliamna Lake, through the Kvichak River since 2008, and the deep U-shaped channel identified at the outlet of Nilkitkwa Lake is likely to be suitable for the up-looking hydroacoustic method. We therefore plan to test the upward-looking hydroacoustic technique at the outlet of Nilkitkwa Lake in the spring of 2015.

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REFERENCES

Cox-Rogers, S., and B. Spilsted. 2012. Updated assessment of sockeye salmon production from Babine Lake, British Columbia. *Can. Tech. Rep. Fish. Aquat. Sci.*2956, viii + 65p.

MacDonald, P.D.M., and Smith, H.D. 1980. Mark-recapture estimation of salmon smolt runs. Biometrics. **36,** 401-417.

Maxwell, S., A. Mueller, D. Degan, D. Crawford, L. McKinley, and N. Hughes. 2009. An evaluation of the Bendix smolt counter used to estimate outmigrating sockeye salmon smolt in the Kvichak River, Alaska, and the development of a replacement sonar, 2000-2001. Alaska Department of Fish and Game, Fishery Manuscript No. 09-02, Anchorage

Mueller. A., D. Degan , R. Kieser, and T. Mulligan. 2006. Estimating Sockeye Salmon Smolt Flux and Abundance with Side-Looking Sonar, North American Journal of Fisheries Management, 26:3, 523-534

Simmonds, J. and MacLennan, J. Fisheries Acoustics: Theory and Practices. 2005. Blackwell Publishing.

Wade, G. D., D. J. Degan, M. R. Link, and S. W. Raborn. 2010a. Evaluation of an up-looking sonar system designed to enumerate sockeye salmon smolts on the Kvichak River, 2008. Report prepared by LGL Alaska Research Associates, Inc., Anchorage, AK, and Aquacoustics, Inc. Sterling, AK, for the Bristol Bay Science and Research Institute, Dillingham, AK, 45 p + Appendix.

Wade, G. D., D. J. Degan, M. R. Link, and S. W. Raborn. 2010b. Estimates of hourly, daily, and seasonal sockeye salmon smolt abundance on the Kvichak River in 2009. Report prepared by LGL Alaska Research Associates, Inc., Anchorage, AK, and Aquacoustics, Inc. Sterling, AK, for the Bristol Bay Science and Research Institute, Dillingham, AK, 44 p + Appendix.

Wade, G.D., D.J. Degan, M.R. Link, and S.W. Raborn. 2012a. Estimates of hourly, daily, and seasonal sockeye salmon smolt abundance on the Kvichak and Ugashik Rivers in 2010. Report prepared by LGL Alaska Research Associates, Inc., Anchorage, AK, and Aquacoustics, Inc. Sterling, AK, for the Bristol Bay Science and Research Institute, Dillingham, AK, 61 p + Appendix A.

Wade, G.D., D.J. Degan, M.R. Link, and M.J. Nemeth. 2012b. Monitoring of sockeye salmon smolt abundance and inriver distribution using sonar on the Kvichak, Egegik, and Ugashik rivers in 2011. Report prepared by LGL Alaska Research Associates, Inc., Anchorage, AK, and Aquacoustics, Inc. Sterling, AK, for the Bristol Bay Science and Research Institute, Dillingham, AK, 64 p.

Wade, G.D., D.J. Degan, M.R. Link, and M.J. Nemeth. 2013. Monitoring sockeye salmon smolt abundance and inriver distribution using sonar on the Kvichak and Ugashik rivers in 2012. Report prepared by LGL Alaska Research Associates, Inc., Anchorage, AK, and Aquacoustics, Inc. Sterling, AK, for the Bristol Bay Science and Research Institute, Dillingham, AK, 65 p.