Lakelse Lake
Hydroacoustic Survey
2012

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ABSTRACT

Skeena Fisheries Commission (SFC) conducted a hydroacoustic survey of Lakelse Lake in August 2012. The main objective of the survey was to enumerate and sample the sockeye fry population in Lakelse Lake. The results of the survey are contained in this report.

Hydroacoustic sampling was conducted using a DT-X echosounder with a downward-pointing split-beam 199 kHz transducer. Fish samples were captured with a mid-water trawl. The trawl sample was used to determine the species composition of the pelagic "small" size fish.

The 2012 hydroacoustic estimate of the juvenile sockeye population at Lakelse Lake appears to be significantly higher than hydroacoustic estimates generated in previous surveys of the same lake. The increase in the juvenile sockeye population at Lakelse Lake is most likely the result of strong sockeye returns to Lakelse Lake in 2011. Even though the juvenile sockeye population appears to have increased at Lakelse Lake, it is still below the lake's rearing capacity.

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INTRODUCTION

Skeena Fisheries Commission (SFC) has conducted mobile hydroacoustic surveys in small lakes throughout the Skeena Watershed since 2005. Data of fall fry abundance obtained by hydroacoustic techniques for sockeye in their critical rearing habitat can be directly compared to lake productivity potential (Cox-Rogers et. al 2004) to provide an unbiased estimate of the status of the sampled conservation unit.

During mid-August of 2012, the Skeena Fisheries Commission (SFC) conducted a hydroacoustic survey of Lakelse Lake (Figure 1). The main objectives of this survey were to estimate the sockeye population size and the relative proportions of juvenile sockeye and competitor limnetic species of Lakelse Lake.

Lakelse Lake is the source of the Lakelse River, a fifth order tributary of the lower Skeena River that drains a watershed area of approximately 589 km^2. The surface area of the lake is approximately 1,360 ha with a volume of 1.15x108 m^3 (Table 1). The average depth of the lake is 8.5 m and the maximum depth is approximately 32 m. The southwest basin of the lake is an extensive littoral area that contains 42% (571 ha) of the lake surface (Gottesfeld & Rabnett 2008). SFC has conducted annual hydroacoustic surveys of Lakelse Lake since 2006. Lakelse is the warmest lake in the Skeena Watershed and is considered to be a very productive system. Sockeye escapement to Lakelse tributaries has been depressed since the 1990s, but appears to have improved somewhat in the past two years. The estimated sockeye escapement to Lakelse tributaries in 2011 was over 16,000 spawners (Fisheries and Oceans Canada, 2012), which is higher than the previous decadal average of 2,265 (Fisheries and Oceans Canada 2012).

The species "*Oncorhynchus nerka*" may include both anadromous (sockeye) and nonanadromous forms (kokanee) in all lakes surveyed. Separation of the two forms was not conducted as part of this study. In this report they will be referred to as "*O. nerka*".

Table 1. Physical characteristics of Lakelse Lake

Lake	Watershed	Elevation (m)	Average Depth (m)	Maximum Depth (m)	Surface Area (ha)	Clarity
Lakelse	Lakelse	77	9	32	1360	Clear

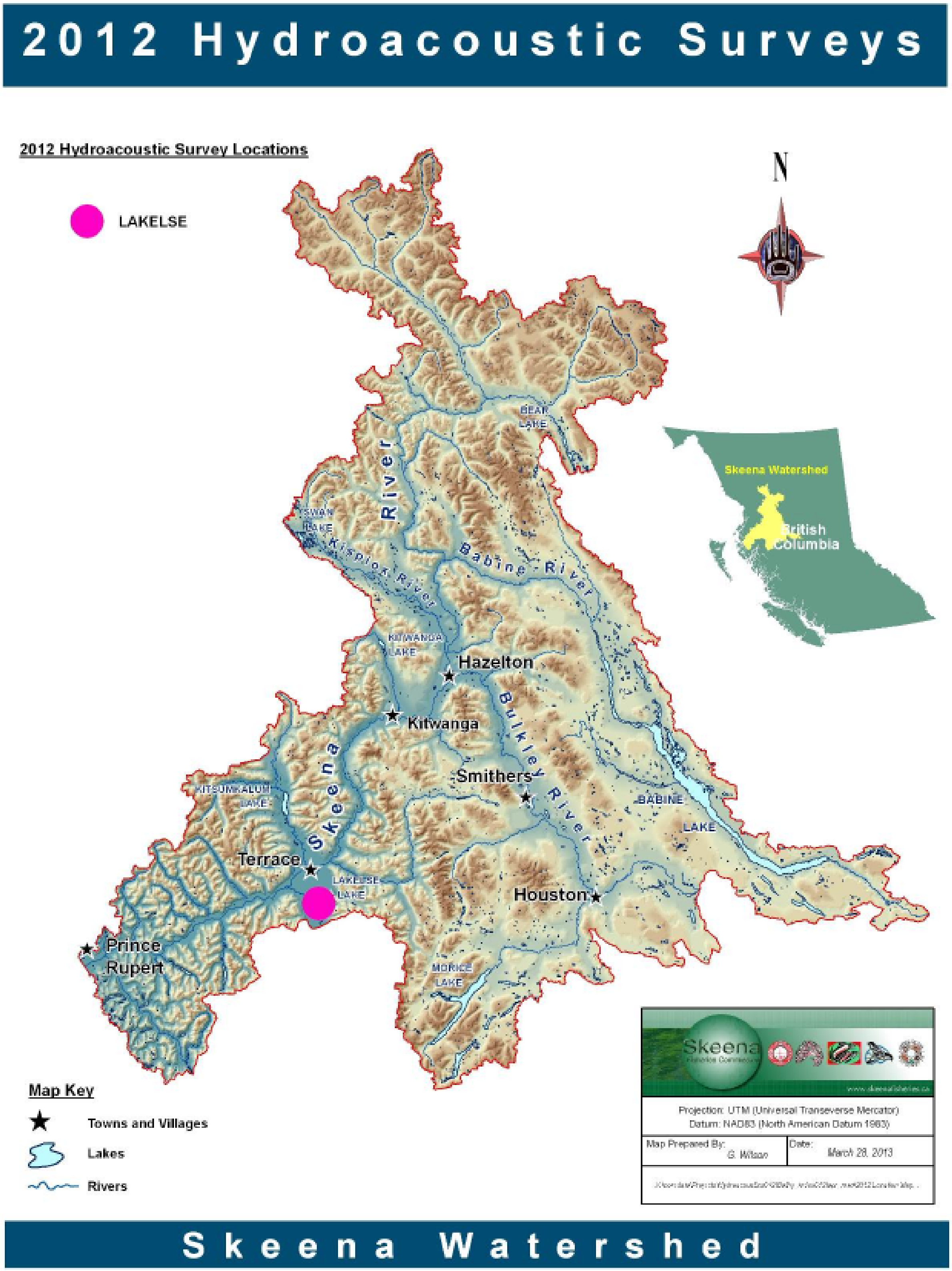

Figure 1. Location of Lakelse Lake in the Skeena watershed

METHODS

Hydroacoustic Survey

The Lakelse Lake hydroacoustic survey was conducted using similar methods and technology as in previous hydroacoustic surveys (Hall 2007, Hall and Carr-Harris 2008, MacLellan and Hume 2010 and Parker-Stetter *et. al.* 2009). Transects were sampled using a Biosonics DT-X echosounder with a 200 kHz split-beam transducer producing a 6 degree beam. The single downward-pointing transducer was pole-mounted to our inflatable vessel, a Bombard Commando C-5 (Figure 2). Hydroacoustic data were collected to an acoustic threshold of -100 dB using Biosonics Visual Acquisition software as the vessel proceeded along transects at a constant speed of 0.7 m/sec.

Figure 2. Photo of the inflatable vessel with the hydroacoustic gear.

The hydroacoustic survey at Lakelse Lake was conducted along transects that had been established by the Cultus Lake Laboratory of Fisheries and Oceans Canada (Figure 3). These include seven transects in the north basin, and one transect in the south basin of the lake, however the data from the south basin transect was not analyzed as Hume and MacLellan (2008) showed *O.nerka* did not use the southern basin. Previous studies by Hall (2007), Hall and Carr-Harris (2008), and Carr-Harris (2009, 2011, and 2012) also assume that *O.nerka* did not occupy the shallow southern basin of Lakelse Lake. Hydroacoustic estimates for the north basin of Lakelse Lake are based on depth layer volumes that were calculated using bathymetric maps provided by the BC Ministry of Environment (MOE)

The hydroacoustic system was calibrated prior to the survey by suspending a standard tungsten carbide sphere (36 mm diameter) in the acoustic beam. The observed target strength was compared to the predicted target strength at that temperature for the standard target. The difference between the observed and predicted target strength produced a calibration offset, which would be applied prior to post-processing of the data.

Hydroacoustic data analysis

Post-processing of hydroacoustic data was performed using Echoview software (v. 5.30). Data analysis was conducted using the same methodology as in previous years (Hall & Carr-Harris 2008, Hall 2007). 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.

Fish densities were calculated using the integration estimation method for down-looking acoustic data only. The integration method integrates the average acoustic energy from the Sv output for each depth layer by the average target strength volumetric fish density for the stratum (n/m^3). The high fish density and the windy conditions during sampling prevented data analysis using the single target (ST) and tracked target (TT) methods.

Primary analysis outputs from Echoview were processed in Excel to calculate estimates of total age-0 *O.nerka* for each lake. Population estimation procedures were consistent with a stratified systematic transects sampling technique described and used by MacLennan and Hume (2010). The north basin of Lakelse Lake was separated into two distinct sections: one shallow section represented by transects 0.7, 4.2, and 4.8, and one deep section represented by transects 1.4, 2.1, 2.6, and 3.4.

Data from each transects were analyzed in 2m depth layers. The volumetric densities calculated for each transect layer are multiplied by the layer volume of the lake area represented by that transect to produce a transect layer population estimate. Transect estimates are produced from the sum of layer population estimates. Transect densities in a lake section were averaged to provide an estimate of density relative to surface area (n/ha) for the section. The mean density was then multiplied by the surface area of the section to provide a population estimate for the section. The section population estimates were summed to provide a total population estimate for the whole lake. Mean lake density was calculated by dividing the lake population estimate by the total surface area.

The fish estimates were divided into "small" and "large" fish based on the distribution of target strengths from each transect and each layer. "Small" fish were classified as fish with target strengths between –64 and –46 dB. This target strength is approximately equivalent to salmoniform fish <135 mm in length, based on Love (1977) 45^{o} aspect formula. Small fish were apportioned into "O. nerka" and "other small fish" based on the relative proportion of species in the trawl and gillnet catch.

Variances for fish densities and population estimates for both sections were calculated independently by using each transects within both sections as a separate sample. The variances for both sections were then weighted by the square of the section area. The sum of the weighted variances was divided by the square of the lake area to provide a variance for the lake population estimate.

The variance calculated using the stratified systematic transects technique reflects the statistical confidence in the precision of the population estimate and is largely driven by the horizontal fish distribution throughout the lake. During data analysis, we observed that most of the fish targets, likely age-0 *O.nerka*, were constrained within specific depth layers, close to the thermocline. The age-0 *O. nerka* density varied greatly from depth layer to depth layer, which contributed to an increase in the variance calculated using the stratified systematic transects technique. In order to reduce the overall variance, we tested an alternative stratified random population estimation procedure that exploited this vertical distribution characteristic of age-0 *O. nerka*. The area surveyed was stratified by depth layers instead of transect, and each transect provided one replicate for each depth stratum. The mean volumetric fish density was calculated for each depth stratum, and multiplied by the total layer volume to obtain an estimate of abundance for each depth stratum. All the abundance estimates were then summed to a total population for the lake. Variance was calculated for each depth stratum then summed, and the 95% confidence interval was calculated for the whole lake.

Fish Sampling

Pelagic fish were sampled using a 2 x 2 m midwater trawl, which was deployed to a maximum depth of 21 m. The net was towed behind the boat at a constant speed of approximately 1m/s, and retrieved with a portable winch. The depth of each tow varied according to the length of the line that was deployed, which was calibrated and marked prior to sampling. Small fish were sorted by species and stored in 10% formaldehyde, and weighed and measured after at least 30 days of preservation. Scales were removed and inspected under a compound microscope to determine the age of salmonids.

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen data were collected at all lakes using a hand held YSI meter (model 85) with a maximum cable length of 30 m. The YSI meter was calibrated to the nearest 100' elevation and allowed to stabilize for at least 15 minutes before data were recorded.

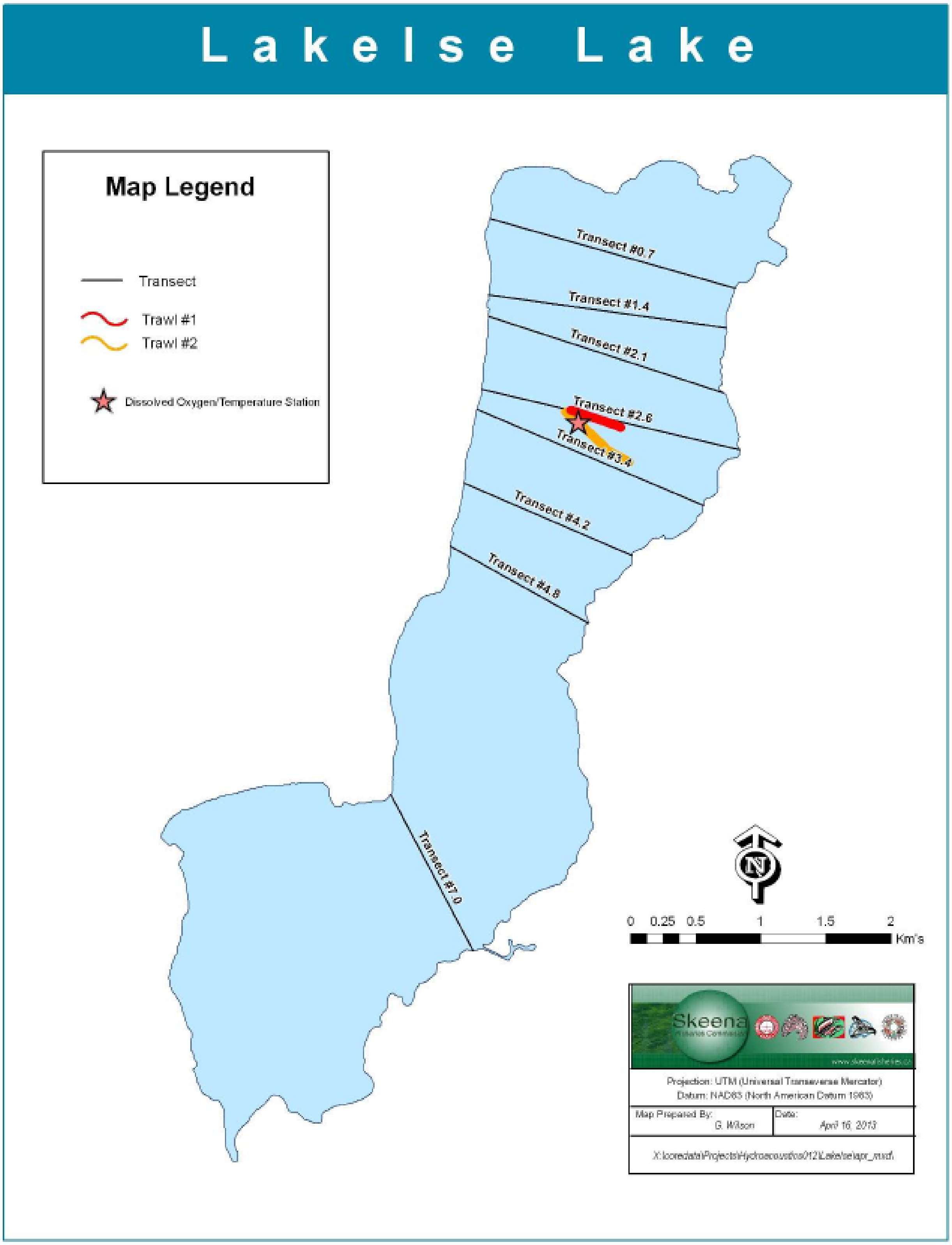

Figure 3. Lakelse Lake survey map

RESULTS AND DISCUSSION

Age-0 *O.nerka* population abundance estimates for Lakelse Lake calculated using the systematic stratification by transect and the random stratification by depth layer population estimation procedures are compared in Figure 4. The results of the two methods are nearly identical, with a total population estimate of approximately 1,030,000 age-0 *O.nerka*. The stratification by depth layer method resulted in confidence intervals more than three times smaller than stratification by transect. Thus, the population estimate calculated using the stratification by depth layer is more precise than the population estimate produced using stratification by transect, which demonstrates that the vertical distribution of *O. nerka* in Lakelse Lake varied more than the horizontal distribution at the time of this survey.

Previous hydroacoustic reports by SFC and the Cultus Lake Salmon Research Laboratory have always presented age-0 *O.nerka* population estimates using the stratification by transect procedure. While the current report contains results obtained using both estimation methods, we have selected estimates calculated using the stratification by transect method in order to maintain consistency with and compare to past estimates.

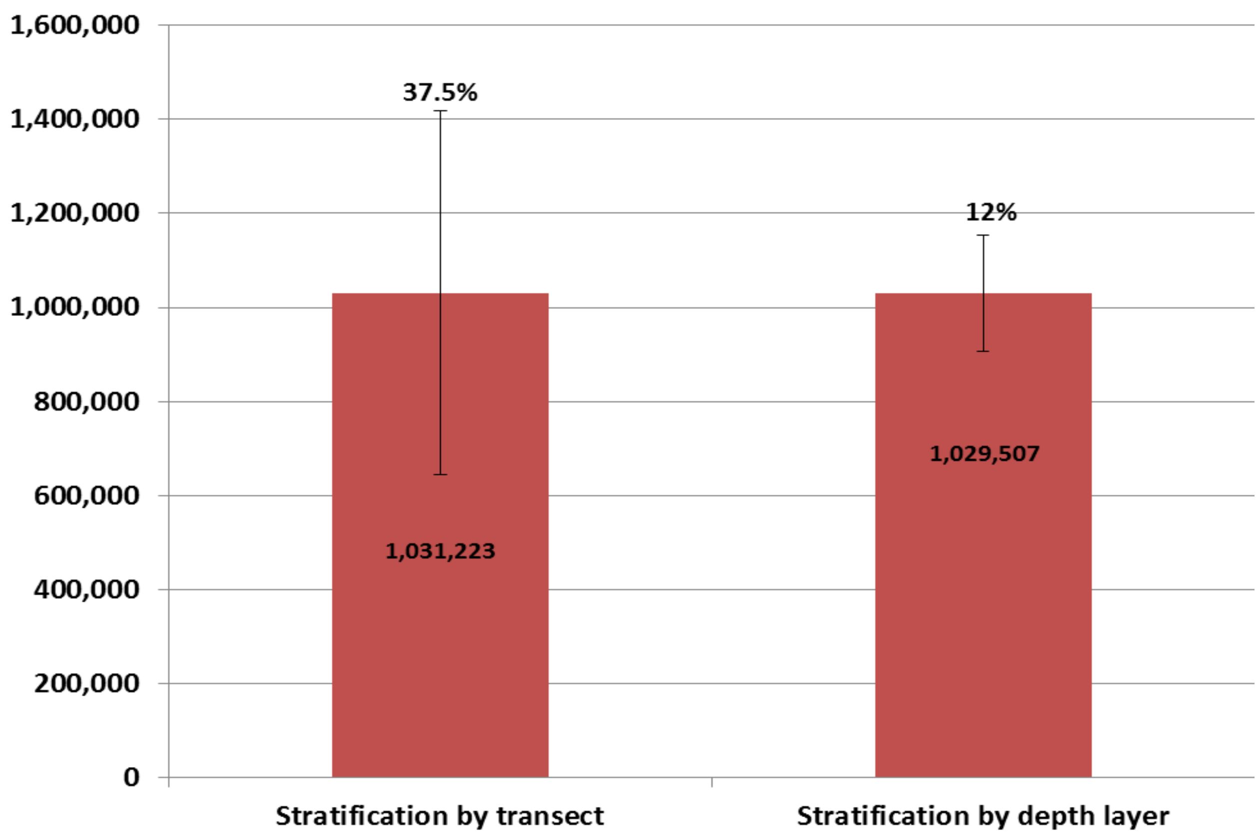

Figure 4. Graph showing age-0 *O.nerka* population abundance estimates for Lakelse Lake, using the stratification by transects and the stratification by depth layers population estimation procedures. The error bars show the 95% confidence intervals.

Lakelse Lake was surveyed on the nights of August 21 and 22, 2012. The surface temperature was 18.0ºC degrees, with a gradual decline to 17.4 ºC at 8 m, and a thermocline between 8 and 16 m with another gradual decline to a hypolimnion of 10.5 ºC below 20 m (Figure 6).

We captured 65 age-0 O. nerka during two trawl tows with a combined length of about 1.0 km (Figures 3, 5 and Table 2). The average length of O. nerka fry captured by trawl was 63.1 mm, with an average weight of 2.5 grams (Table 3). All of the O. nerka fry were age-0, or young of the year fry, and were all of wild origin (adipose fin present).

Most fish targets were found below 14 m depth in the water column, with peak densities occurring at 18-19m depth (Figures 7 and 9). The highest densities of fish targets were found in the deepest section of the lake, along Transects 3.4, 2.6, and 2.1(Figure 8). The hydroacoustic population estimate for age-0 *O.nerka* in Lakelse Lake ranged from 1,029,507 or 1,632/ha ± 12% (stratification by layer) to 1,031,223 or 1,633/ha ± 37.5% (stratification by transect) (Figure 4 and Table 4). The total age-0 *O.nerka* biomass ranged from 2,574 kg (stratification by layer) to 2,578 kg (stratification by transect) (Table 5).

Figure 5. Photo of juvenile sockeye caught by trawl at Lakelse Lake. August 22, 2012.

The PR capacity model (Cox-Rogers et. al 2004) provides a benchmark that can be used to compare an observed sockeye fry biomass with the rearing capacity of a given lake. According to the PR capacity model, the biomass of O. nerka fry observed during the 2012 hydroacoustic survey represents 21% (using both stratification by transect and stratification by layer methods) of the rearing capacity, or R_{max}, at Lakelse Lake (Table 5).

The 2012 Lakelse Lake sockeye fry population estimate is significantly higher than the estimates from hydroacoustic surveys undertaken since 2003 (Table 6). This significant increase in the abundance of age-0 *O. nerka* in 2012 is most likely the result of strong sockeye returns to Lakelse Lake in 2011

CONCLUSION

Hydroacoustic surveys allow us to gauge trends in juvenile sockeye populations in lakes that represent ongoing or potential conservation concerns. Regular hydroacoustic surveys provide a baseline that we can use to compare estimates across years. Where escapement is known, hydroacoustic data provides an indicator of freshwater survival.

The 2012 juvenile sockeye population estimates at Lakelse Lake appear to be significantly higher than hydroacoustic estimates generated in previous surveys of the same lake (Table 6). The increases observed are likely the result of the strong sockeye returns observed in 2011. Even though the juvenile sockeye population appears to have increased at Lakelse Lake, it is still well below the rearing capacity. The portion of the rearing capacity used in 2012 for Lakelse Lake was 21%.

ACKNOWLEDGEMENTS

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REFERENCES

Carr-Harris 2009. Skeena and Nass Sockeye Lakes Hydroacoustic Surveys 2008. Skeena Fisheries Commission, prepared for the Pacific Salmon Commission.

Carr-Harris 2011. Skeena Sockeye Lakes Hydroacoustic Surveys 2010. Skeena Fisheries Commission, prepared for the Pacific Salmon Commission.

Carr-Harris 2012. 2011 Skeena and Nass Sockeye Lakes Hydroacoustic Surveys. Skeena Fisheries Commission, prepared for the Pacific Salmon Commission.

Cox-Rogers, S., Hume, J.M.B, and Shortreed, K.S. 2004. Stock Status and Lake-Based Production Relationships for Wild Skeena River Sockeye Salmon. Canadian Science Advisory Secretariat Research Document 2004/010.

Fisheries and Oceans Canada 2012. NuSEDs database.

Gottesfeld, A. and Rabnett, K. 2008. Skeena River Fish and Their Habitat. Skeena Fisheries Commission. Hazelton, B.C.

Hall, P. and Carr-Harris C. 2008. Skeena & Nass Sockeye Lakes Hydroacoustic Surveys Report 2007. Skeena Fisheries Commission. Hazelton, B.C. Report to the Pacific Salmon Commission.

Hall, 2007. Skeena Sockeye Lakes Hydroacoustic Surveys Report 2006. Skeena Fisheries Commission. Prepared for Pacific Salmon Commission.

Hume, J. and MacLellan, S. 2008. Pelagic Fish Surveys of 23 Sockeye Rearing Lakes in the Skeena River System and in Northern British Columbia Coastal Watersheds from 1997 to 2005. Fisheries and Oceans Canada. Salmon and Freshwater Ecosystems Division, Science Branch. Cultus Lake Salmon Research Laboratory. Canadian Technical Report of Fisheries and Aquatic Sciences 2812.

Love 1977. Target strength of an individual fish at any aspect. J. Acoust. Soc. Am. 62:6.

MacLellan, S.G. and Hume, J.M.B. 2010. An evaluation of methods used by the freshwater ecosystems section for pelagic fish surveys of sockeye rearing lakes in British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 2886: v + 67 p.

Parker-Stetter, S.L., Rudstam, L.G., Sullivan, P.J. and Warner, D.M. 2009. Standard operating procedures for fishery acoustics in the Great Lakes. Great Lakes Fisheries Commission Special Publication 09-01. 180 pp. Available at: http://www.glfc.org/pubs/SpecialPubs/Sp09_1.pdf. Accessed April 22, 2009.

Shortreed, K., Hume, J., and Malange, K. 2007. Preliminary Categorization of the Productivity of 37 Coastal and Skeena River System Lakes in British Columbia. Canadian Technical Report of Fisheries and Aquatic Sciences 2718. Fisheries and Oceans Canada. Science Branch, Pacific Region, Cultus Lake Salmon Research Laboratory.

Table 2. 2012 Lakelse Lake hydroacoustic survey trawl summary

Lake	Date	Trawl #	Time Start	Time End	Easting Start	Northing Start	Easting End	Northing End	Depth (m)	ON
Lakelse	22-Aug-12	1	2219	2226	529277	6027797	529666	6027662	21	19
Lakelse	22-Aug-12	2	2248	2300	529237	6027797	529731	6027397	21	46

ON: *O. nerka*

Table 3. 2012 Fish sample summary

Lake	Gear	Species	n	Mean Length (mm)	Max. Length (mm)	Min. Length (mm)	Std. Dev Length (mm)	Mean Weight (g)	Max. Weight (g)	Min. Weight (g)	Std. Dev Weight (g)
Lakelse	Trawl	*O. nerka*	65	63.1	78	36	7.5	2.5	4.9	0.3	0.9

Table 4. 2012 Lakelse Lake hydroacoustic estimates by method

Lake	Estimate Method	Size Class	Density		Population	
			n/ha	95% C.I.	n	95% C.I.
Lakelse	Integration (Stratification by transect)	Age-0 *O. nerka*	1,633	37.5%	1,031,223	37.5%
		Other Small	n/a	n/a	n/a	n/a
		Large	62	63.7%	38,877	63.7%
	Integration (Stratification by layer)	Age- *O. nerka*	1,632	12%	1,029,507	12%
		Other Small	n/a	n/a	n/a	n/a
		Large	12	61.2%	34,517	61.2%

Table 5. PR Capacity comparison chart

Lake	Adjusted Rmax	Acoustic survey date	Estimation Method	Observed O. nerka fall fry	Avg. Weight	Observed biomass (kg)	% Rmax (adjusted)
Lakelse	12,156*	21-22-Aug-12	Integration	1,031,223	2.5	2,578	21%

* - From Shortreed *et al.* 2007

Table 6. Past hydroacoustic estimates for lakes surveyed in 2012

Lake	Year	Date	Age-0 sockeye		Method	Source
			n/ha	n		
Lakelse (North basin only)	2003	13-Jul	469	295,846	Tracked Targets	Hume and MacLellan 2008
	2003	30-Sept	195	123,036	Tracked Targets	Hume and MacLellan 2008
	2004	25-Sept	378	238,429	Tracked Targets	Hume and MacLellan 2008
	2005	05-Sept	620	391,401	Integration	Hume and MacLellan 2008
	2006	10-Oct	113	71,086*	Tracked Targets	Hall 2007
	2007	26-Sept	321	202,474*	Integration	Hall and Carr-Harris 2008
	2008	29-Aug	474	299,149	Integration	Carr-Harris 2009
	2009	25-Aug	719	453,798	Integration	Unpublished data
	2010	30 Sept	385	242,900*	Integration	Car-Harris 2011
	2011	03-Sept	433	273,145	Integration	Carr-Harris 2012
	2012	21-22-Aug	1,633	1,031,223	Integration	This report

*- Total small fish population. Not apportioned for age-0 *O.nerka*

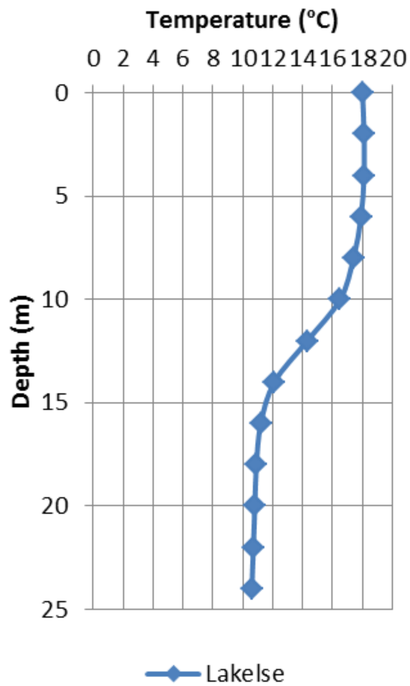

Figure 6. Temperature profiles for Lakelse Lake in mid-August 2012.

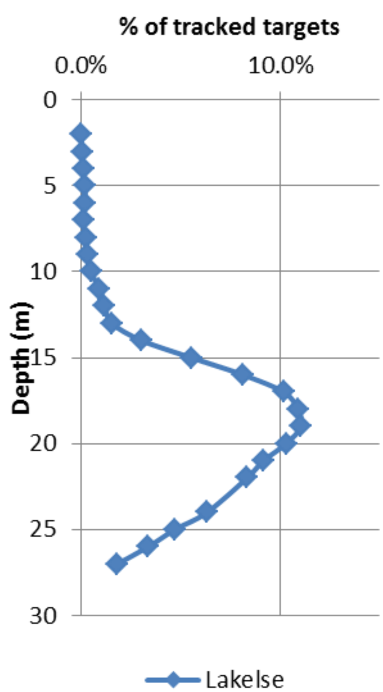

Figure 7. Vertical distribution of target density for Lakelse Lake in mid-August 2012.

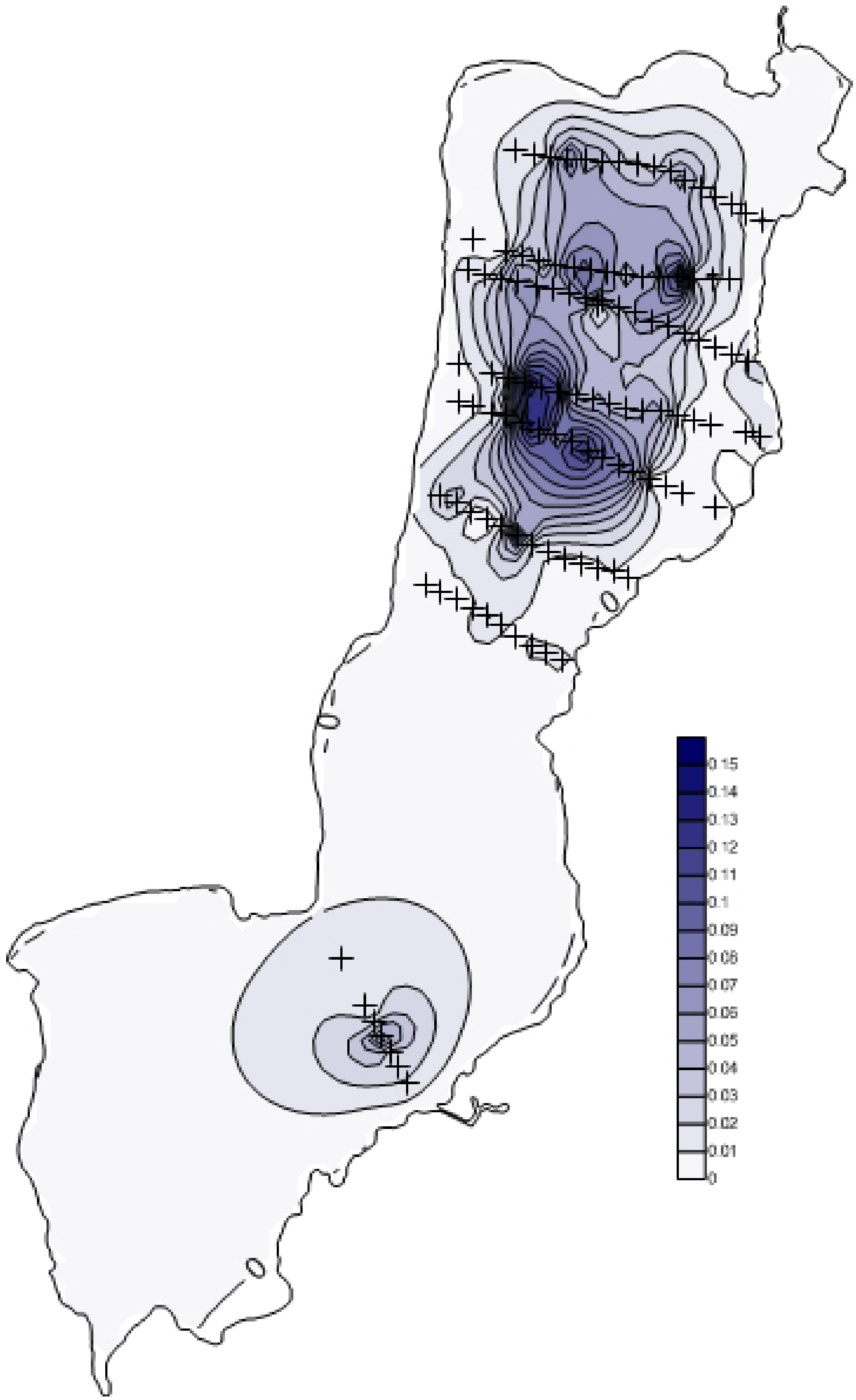

Figure 8. Surface distribution of fish targets (fish/m3) at Lakelse Lake.

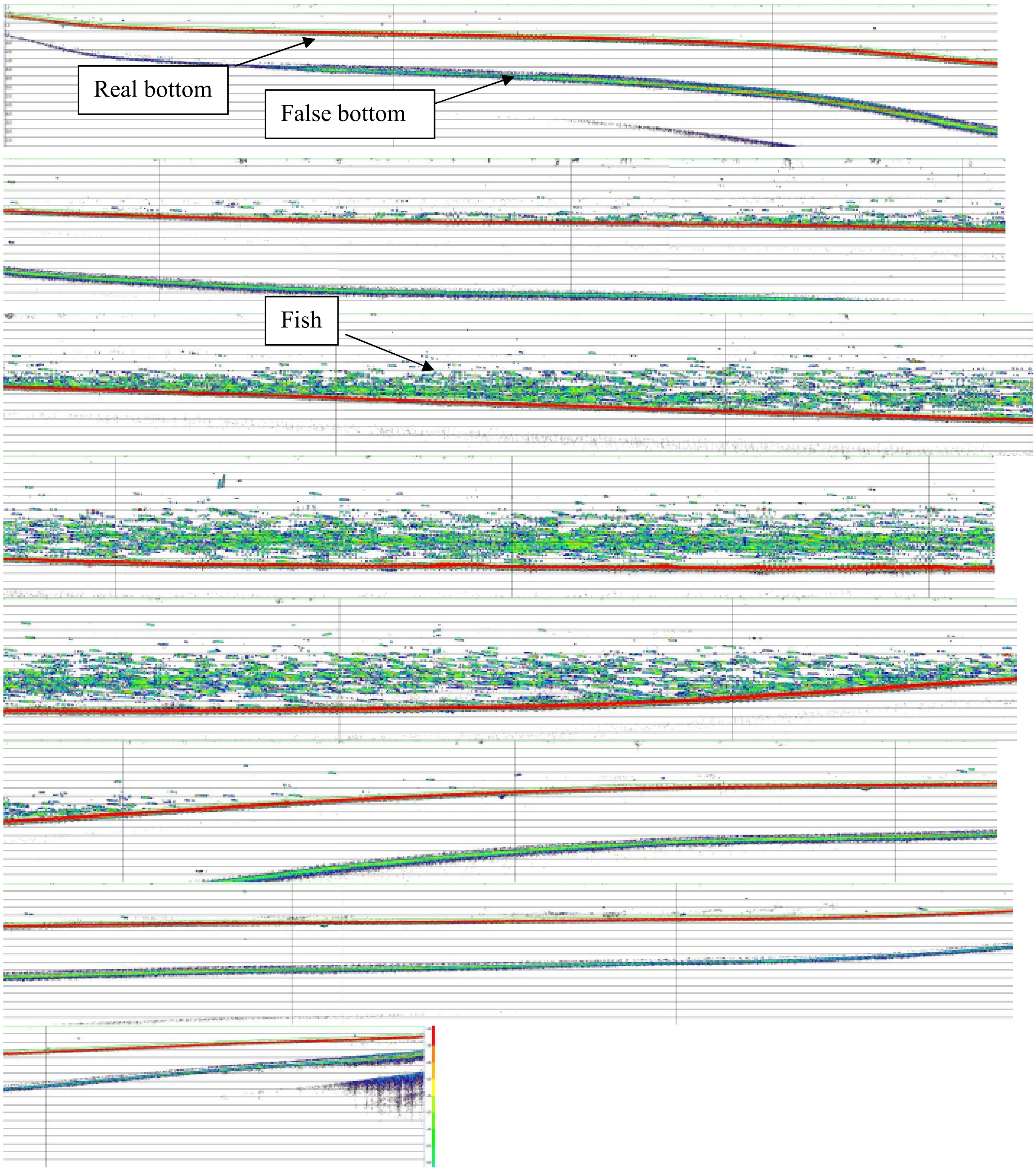

Figure 9. Lakelse Lake transect 2.6 echogram