McDonell Lake
Hydroacoustic Survey
2008

Prepared for Gitksan Watershed Authorities by:
Charmaine Carr-Harris

November 2009

Skeena Fisheries Commission
PO Box 166
Hazelton, BC V0J 1Y0

ABSTRACT

Gitksan Watershed Authorities has conducted annual juvenile sockeye hydroacoustic surveys at Mcdonell Lake since 2005. The results of our 2008 survey are contained in this report.

The 2008 McDonell Lake hydroacoustic density estimate ranged from 1,486 to 2,234 “small” class fish/hectare using the integration and tracked target methodologies. These produce McDonell Lake sockeye fry population estimates ranged from 318,614 (Integration) to 478,975 (Tracked target) “small” class fish.

The 2008 *O. nerka* fall fry estimate was the highest observed at McDonell Lake in the four years of surveys beginning in 2004. The high density of juvenile *O. nerka* that was present during our survey was confirmed by an unusually large trawl catch. All of the fish that were sampled in the trawl (n=519) were juvenile *O. nerka*. We collected age date from 146 specimens, of which 145, or 99.3%, were age-0.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Gitksan Watershed Authorities (GWA) conducted a hydroacoustic survey of McDonell Lake in 2008. The main objectives of this survey were to enumerate and sample the juvenile sockeye fry population and to estimate the species composition and relative proportion of competitor limnetic species.

McDonell Lake is located at an elevation of 2712', the lowest of a chain of three lakes at the headwaters of the Zymoetz River (Figure 1). The Zymoetz, also known as the Copper River system is a 6th order tributary of the Skeena River and drains an area of 3,028 km^2 (Hall and Harris 2007). McDonell Lake has a volume of approximately 1.9 x 10^7 m^3 and a surface area of 232 ha. The mean depth is approximately 8.2m and the maximum depth is 15m.

The Gitksan Watershed Authority has conducted annual hydroacoustic surveys of this lake since 2005. Fisheries and Oceans Canada's Cultus Lake Laboratory completed hydroacoustic surveys at McDonell Lake in 2001 and 2002.

METHODS

Hydroacoustic Survey

Our 2008 McDonell Lake hydroacoustic survey was conducted on August 18. The McDonell Lake hydroacoustic survey design (Figure 2) consists of eight transects which were established in 2001 by the Department of Fisheries' Cultus Lake research laboratory (Shortreed et. al. 2002). Wherever possible, surveys are conducted along the same transects as previous surveys to maintain consistency between years. The original McDonell Lake survey design included Transect 1, which was abandoned in 2001 because it was found to be too shallow for effective sampling. We retained the original numbering system, and resurveyed Transects 2 through 9, for our 2008 surveys.

Transects were sampled using a Biosonics DT-X echosounder with a 199 kHz split-beam transducer producing a 6º beam. The downward-pointing transducer was pole-mounted to our inflatable vessel (Bombard Commando C-5). Hydroacoustic data were collected to a threshold of -75 decibels using Biosonics Visual Acquisition software as the vessel proceeded along transects at a constant speed of approximately 1 m/s.

The hydroacoustic system is calibrated prior to each survey by suspending a standard target in the acoustic beam. The observed target strength is compared to the predicted target strength for the standard target, a 36mm tungsten carbide sphere. If a difference between the observed and predicted target strength is observed, it is recorded, and a calibration offset applied to data prior to processing.

Data Analysis

Data analysis was conduced using the same methodology as in previous years (Hall and Carr-Harris 2008, Hall 2007). Post-processing of hydroacoustic data was accomplished using Echoview v. 4.60. Each transect was analyzed separately in 2m depth layers.

Target densities were calculated using three different methods. The Integration method calculates target density as the product of the average acoustic energy divided by the average target strength of each depth layer. The Single Target density is the sampled beam volume divided by the number of only those targets with the specific acoustic characteristics of single fish within the range of target strength corresponding to the desired species and size range. The Tracked Target method groups single targets into individual fish tracks. The sampled wedge volume is divided by the total number of fish tracks to produce the Tracked Target density.

The target 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 are averaged and multiplied by the whole surface area of the lake to produce the total fish estimate for the entire lake or lake section.

Confidence intervals for fish densities and population estimates are determined by using each transect as a separate sample. The variability between transects within a lake or lake basin determines the error estimate around the average density or population estimate.

Population estimates are 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, based on Love’s (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 catch.

Fish Collection

We used different fish capture methods to collect fish samples from near the surface and from deeper layers. We used floating Swedish gillnets to capture fish between 0-2 m depth. These gillnets consisted of 4 variable mesh sizes between ½” and 1”. The gillnets were set at dusk and allowed to soak for the duration of the survey. Fish below 2m depth were sampled using a 2 x 2 m midwater trawl, which was deployed to a maximum depth of 35 m. The net was towed behind the boat at a constant speed of approximately 1 m/s, and retrieved with a winch. The depth of each tow was controlled by the length of the line that was deployed, which was calibrated and marked prior to sampling. Depths were recorded using a Vemco Minilog TDR 8-bit data logger attached to the lower spreader bar of the trawl.

No large fish were captured during the 2008 McDonell Lake survey. Small fish were sorted by species stored in 10% formaldehyde, and weighed and measured after at least 30 days of preservation. Scales were removed from a sample of small fish for age analysis, which was conducted in-house.

Oncorhynchus nerka, including both anadromous (sockeye) and non-anadromous forms (kokanee) will be referred to in this report as "*O. nerka*".

RESULTS

Limnology

Temperature and dissolved oxygen measurements were collected to approximately 13 m depth. The surface temperature was 17.4 degrees Celcius. A weak thermocline was present between 7 and 11 m depth. The hypolimnion temperature was 13 ºC. The water column was well oxygenated with 8.94 mg/L at the surface and 7.89 mg/L at 12.5 m.

Fish Collection

We captured one rainbow trout (*Oncorhynchus mykiss*) fry and one *O. nerka* juvenile in two gillnets with a combined soak time of approximately 12 hours. We captured a large number of juvenile *O. nerka* in one trawl tow over a distance of 600 m. We retained a sample of 519 and released approximately 300 alive. No other species were captured by trawl. The average length of trawl-captured *O. nerka* was 53 mm (Table 1). The average weight of trawl-captured O. nerka was 1.5 g (Table 1). Scale ages data were determined for 146 specimens, of which 145 were age-0, or young of the year, and one was age-1, or one year old. The gillnet-captured *O. nerka* was 92 mm in length, weighed 9.4 grams and was age-1. The gillnet-captured rainbow trout was 130 mm in length, weighed 22.5 grams and was also age-1 (Table 1).

Hydroacoustic Estimate

Our 2008 "small" size class density estimate ranged from 1,436 (Integration method) to 2,251 (Tracked target) fish per hectare (Table 2). The 2008 "small" size population estimate ranged from 316,384 (Integration) to 478,975 (Tracked target) (Table 2) with the assumption that all of the fish captured in our trawl sample were *O. nerka* fry. Based on scale age data, we determined that the relative proportion of age-0 *O. nerka* was 99.3 % of the total "small" size class estimate.

"Large" class fish density estimates ranged from 220 (Single target) to 358 (Tracked target) fish per hectare, resulting in population estimates that ranged from 23,649 (Single target) to 38,329 (Tracked target). We do not know what species they were.

The highest density of fish targets was observed near the bottom of all transects (Figure 5, Figure 7). Fish targets were very densely packed below 10 or 12 meters depth. An example of one of our 2008 echograms is shown in Figure 7.

The highest densities of "small" fish targets were observed in the middle of most transects, and more or less evenly distributed among those transects where the depth was greater than 10 meters (Figure 8, Figure 9, Figure 10). The lowest densities were observed in Transects 6, which is a shallow area between the east and west basins of the lake, and in Transect 9, a relatively shallow nearshore transect (Figure 8).

Relative target strength, which is proportional to fish size, appeared to increase with increasing depth, except at the surface where the average target strength was approximately 50 dB. Average target strength increased steadily from –62 dB at depth to –49 dB at depths greater than 12 m.

DISCUSSION

Annual hydroacoustic surveys at McDonell Lake allow us to monitor changes to the juvenile O. nerka population over time. We added to the McDonell Lake survey series in 2009. Those results will form a regular time series of fall fry estimates since 2005.

The 2008 *O. nerka* fall fry estimate was the highest observed at McDonell Lake in the four years of our surveys. The high density of juvenile *O. nerka* observed during our survey was confirmed by our unusually large trawl catch in 2008.

While our hydroacoustic population number was greater in 2008, the overall biomass of *O. nerka* fry was similar to that of 2005 because the average weight of *O. nerka* juveniles captured in our trawl sample was higher in 2005 than in 2008. The average weight of trawl-captured fry was 2.3 g in 2005 compared to 1.5 g in 2008 (Table 3).

The 2005 survey occurred on September 26, several weeks later in the year than the 2008 survey (Table 4). While some of the difference in population number and average size may be attributable to mortality and growth over time, size distribution is not consistent between years. The average weights of trawl-captured *O. nerka* on August 9, 2006 and September 22, 2007 were 1.2 g and 1.3 g respectively (Table 3).

A photosynthetic rate (PR) capacity model (Shortreed *et al.* 2002) estimates the rearing capacity of a given lake based on its carbon production. The 2007 PR capacity estimate for McDonell Lake (Shortreed *et al.* 2007) provides a benchmark that we can use to measure against hydroacoustic estimates. According to this model, the maximum smolt biomass, or R_{max}, at McDonell Lake is 851 kg (Shortreed *et al.* 2007). Based on our 2008 Integration estimate, the observed *O. nerka* fry biomass was 480 kg, or 56% of R_{max} (Table 3). The total biomass based on the 2005 Integration estimate was 456 kg, or 54% of R_{max} (Table 3). The average weight of trawl-captured fry was 2.3 g in 2005, compared to 1.5 g in 2008 (Table 3).

GWA conducts adult sockeye enumeration in the spawning areas adjacent to McDonell Lake. Adult sockeye enumeration combined with the next year's fall fry hydroacoustic survey allows us to estimate spawner recruitment for a given year.

The 2007 adult sockeye spawner count in the upper Zymoetz was 1,900. This count was lower than in any of the previous 5 years that had counts of 3000 to 4500 returning adults per year (Figure 12). Assuming a 50% male to female spawner ratio, our 2008 population estimate (Integration method) works out to over 300 fry/female for the 2007 brood year (Table 3). This compares to 120 fry/female for the 2004, 40 for the 2005, and 137 for the 2006 brood year (Table 4).

In 2008, only 153 adult sockeye were estimated to be present in the upper Zymoetz system (Figure 12). We expect this poor return will be reflected in the results from the 2009 fall fry hydroacoustic estimate at McDonell Lake.

ACKNOWLEDGEMENTS

Many thanks to Peter Hall, who provided assistance and training during the 2008 hydroacoustic survey at McDonell Lake. Thanks also to Rodney Harris, who worked on the 2008 survey. Steven MacLellan at the Cultus Lake Laboratory provided the transect design and volume calculations for this survey. Allen Gottesfeld assisted with editing this report.

REFERENCES

Carr-Harris, C., 2009. 2006 & 2007 McDonell Lake Hydroacoustic Surveys. Skeena Fisheries Commission. Prepared for Gitksan Watershed Authorities.

Fisheries and Oceans Canada. NUSEDS Escapement Database, 2008.

Hall, P., and Harris, R. 2007. McDonell and Stephens Lakes Hydroacoustic Survey Report 2005. Gitksan Watershed Authorities. Prepared for Fisheries and Oceans Canada.

Hall, P. and Carr-Harris, C. 2008. Skeena and Nass Sockeye Lakes Hydroacoustic Surveys Report 2007. Skeena Fisheries Commission. Prepared for the Pacific Salmon Commission.

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

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

Shortreed, K, Hume, J., and Morton, K. 2002. Trip report and preliminary analysis from limnological and fish surveys of eight North Coast Area lakes in September, 2001. Cultus Lake Laboratory. Fisheries and Oceans Canada, Marine and Environmental Habitat Science Division.

Shortreed, K. and Hume, J. 2004. Report on limnological and limnetic fish surveys of North Coast Area lakes in 2002 and 2003. Cultus Lake Salmon Research Laboratory. Fisheries and Oceans Canada.

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.

Shortreed, K. and Hume, J. 2009. Limnological and limnetic fish surveys of North Coast Area lakes in 2008. Fisheries and Oceans Canada, Cultus Lake Salmon Research Laboratory.

Table 1. 2008 Trawl and gillnet sample data

	***O. nerka* (trawl)**	***O. nerka* (gillnet)**	***O. mykiss* (gillnet)**
n	519	1	1
Mean length (mm)	53	92	130
Max length (mm)	89		
Min. length (mm)	31		
Std. dev. length (mm)	7.0		
Mean weight (g)	1.5	9.4	22.5
Max. weight (g)	11.9		
Min. weight (g)	0.3		
Std. Dev. weight (g)	0.8		

Table 2. 2008 Hydroacoustic estimates

Method	Class	Basin	Density (n/ha)	95% CI	Population	95% CI
Integration	**"Small" fish**	**East**	1,752	985	170,616	95,988
		West	1,265	1,824	147,998	213,412
		Combined	**1,486**	**686**	**318,614**	**147,060**
	Age 0 *O. nerka*	**East**	1,739	979	169,422	95,316
		West	1,256	1,811	146,962	211,918
		Combined	**1,436**	**681**	**316,384**	**146,030**
	Large Fish	**East**	453	547	44,094	53,314
		West	98	230	11,462	26,909
		Combined	**259**	**175**	**55,556**	**37,531**
Single Target	**"Small" fish**	**East**	1,674	850	163,081	82,802
		West	1,374	1,837	160,809	215,036
		Combined	**1,510**	**675**	**323,890**	**144,811**
	Age 0 *O. nerka*	**East**	1,663	844	161,939	82,222
		West	1,364	1,825	159,684	213,531
		Combined	**1,500**	**671**	**321,623**	**143,798**
	Large Fish	**East**	350	235	34,134	22,865
		West	112	255	13,122	29,888
		Combined	**220**	**110**	**47,255**	**23,649**
Tracked Target	**"Small" fish**	**East**	2,541	762	247,462	74,227
		West	1,978	2,695	231,513	315,415
		Combined	**2,234**	**950**	**478,975**	**203,636**
	Age 0 *O. nerka*	**East**	2,523	757	245,730	73,707
		West	1,964	2,676	229,893	313,207
		Combined	**2,218**	**943**	**475,623**	**202,211**
	Large Fish	**East**	594	463	57,824	45,085
		West	162	351	18,935	41,121
		Combined	**358**	**179**	**76,760**	**38,349**

Table 3. % R_{max} observed for all hydroacoustic surveys, 2001-2007

Year	Integration Estimate	Average Weight (g)	Observed biomass (kg)	Rmax	% Rmax observed
2001	7.60E+04[1]	n/a	n/a		n/a
2002	1.30E+05[1]	1.5[1]	195		23%
2005	1.90E+05[2]	2.4[2]	456	851	54%
2006	7.96E+04[3]	1.2[3]	96		11%
2007	2.01E+05[3]	1.3[3]	265		31%
2008	3.16E+05	1.5	480		56%

Table 4. Spawner enumeration and fry recruitment for brood years 2004 – 2007

Brood Year	Stream count	Acoustic survey date	Fall fry estimate (Integration)	Recruits/Female
2004	3,166	22 Sept. 2005	1.90E+05[2]	120
2005	3,444	9 Aug. 2006	7.96E+04[3]	40
2006	3,058	26 Sept. 2007	2.01E+05[3]	137
2007	1,900	18 Aug. 2008	3.16E+05	333

[1] Shortreed & Hume, 2004

[2] Hall and Harris, 2006
[3] Carr-Harris 2008

McDonell Lake / Zymoetz Watershed

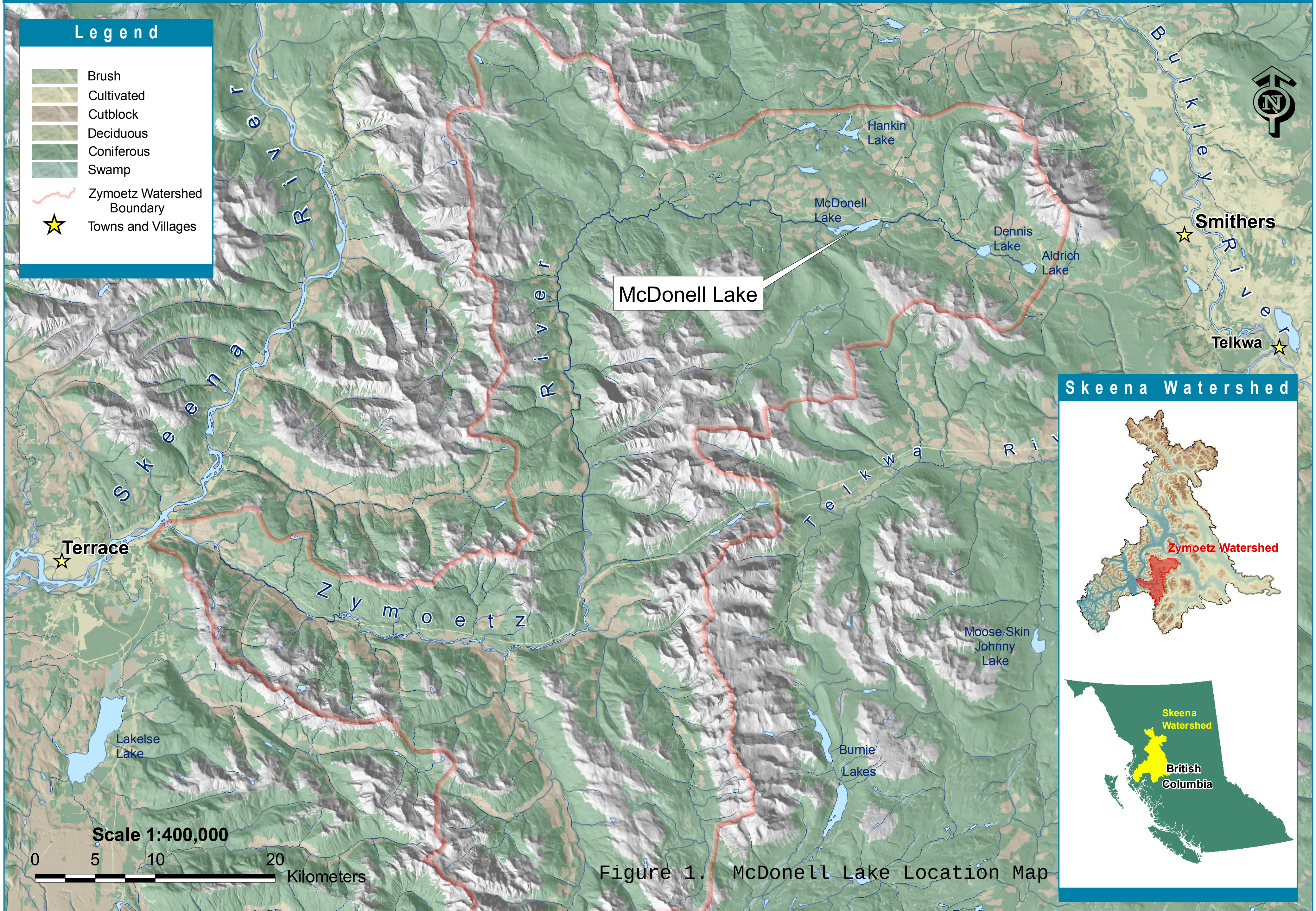

Figure 1. McDonell Lake Location Map

Location Map

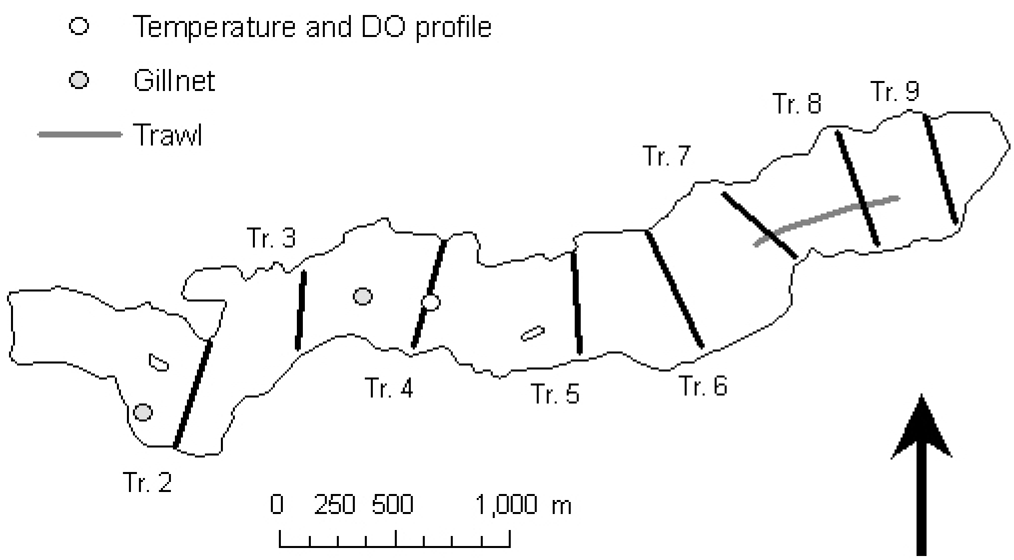

Figure 2. McDonell Lake survey map

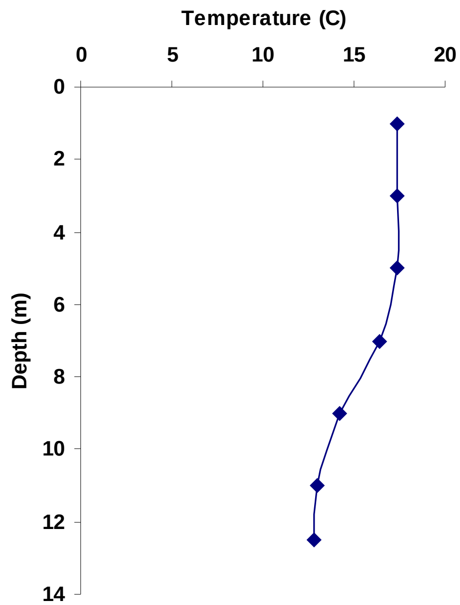

Figure 3. 2008 McDonell Lake temperature profile

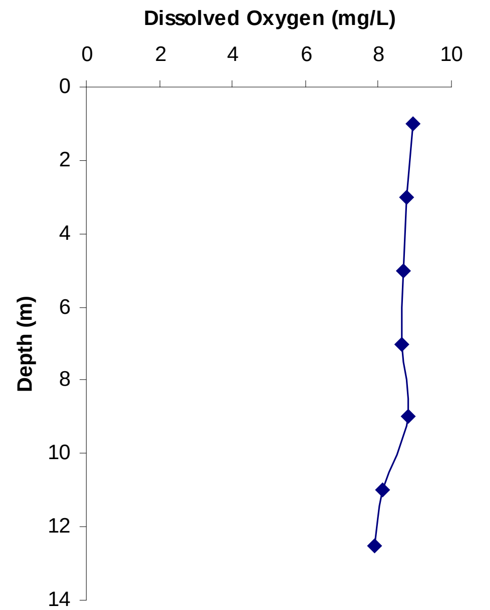

Figure 4. 2008 McDonell Lake dissolved oxygen profile

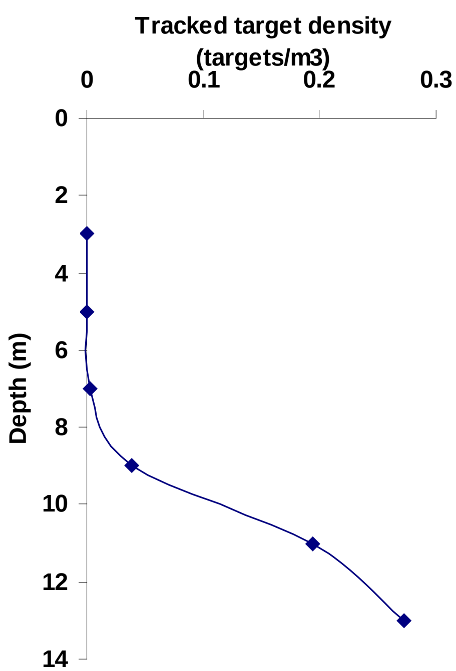

Figure 5. Vertical distribution of target density

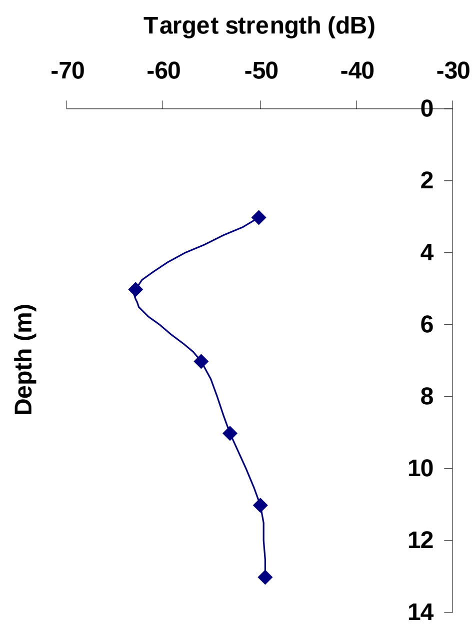

Figure 6. Vertical distribution of target strength

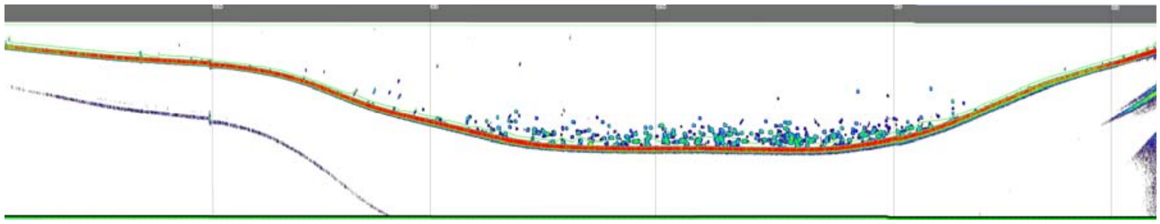

Figure 7. Representative echogram from 2008 Mcdonell Lake hydroacoustic survey, Transect 3.

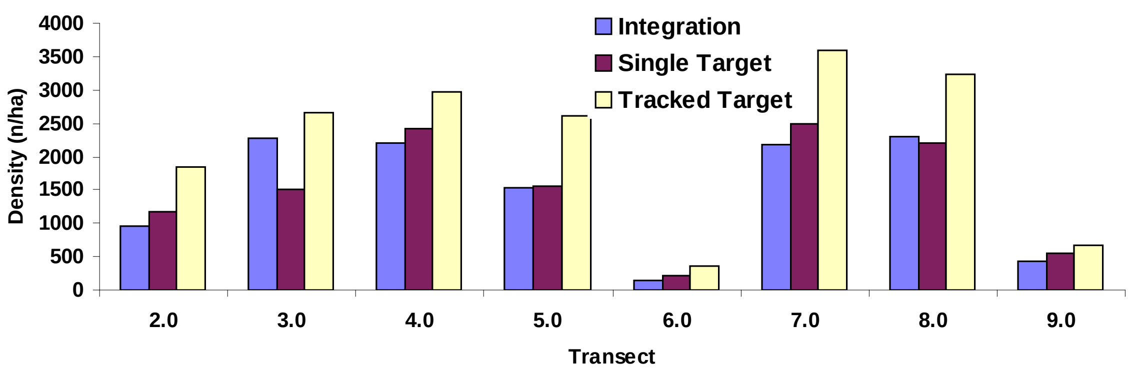

Figure 8. 2008 Age-0 *O. nerka* target densities by transect and analysis method

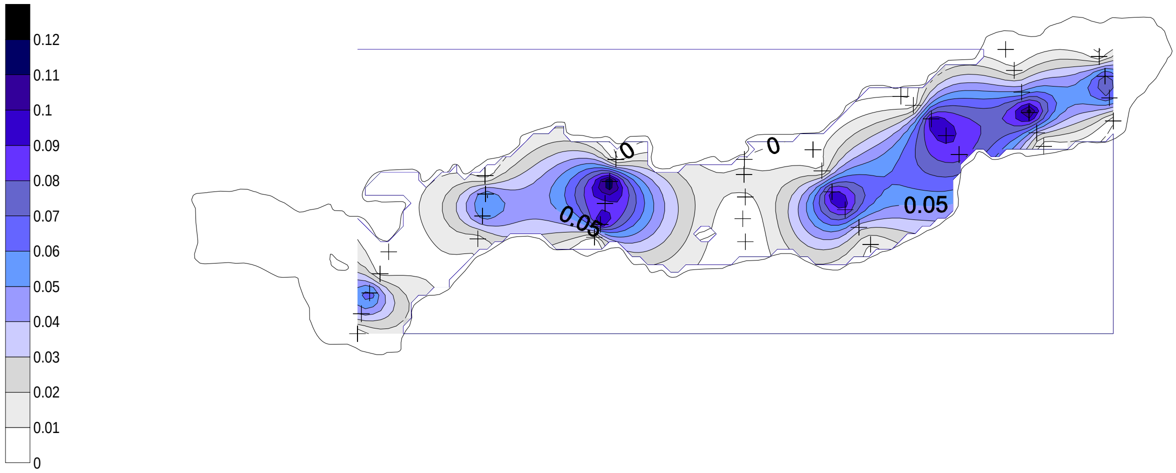

Figure 9. 2-dimensional view of horizontal distribution of "small" size target density (tracked targets/m3). Data points along transect lines are indicated.

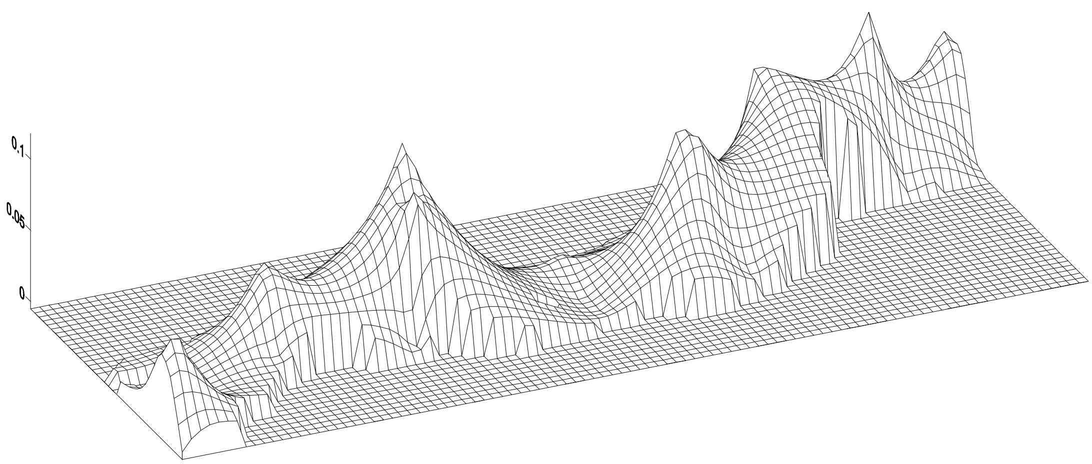

Figure 10. 3-dimensional view of horizontal distribution of "small" size target density

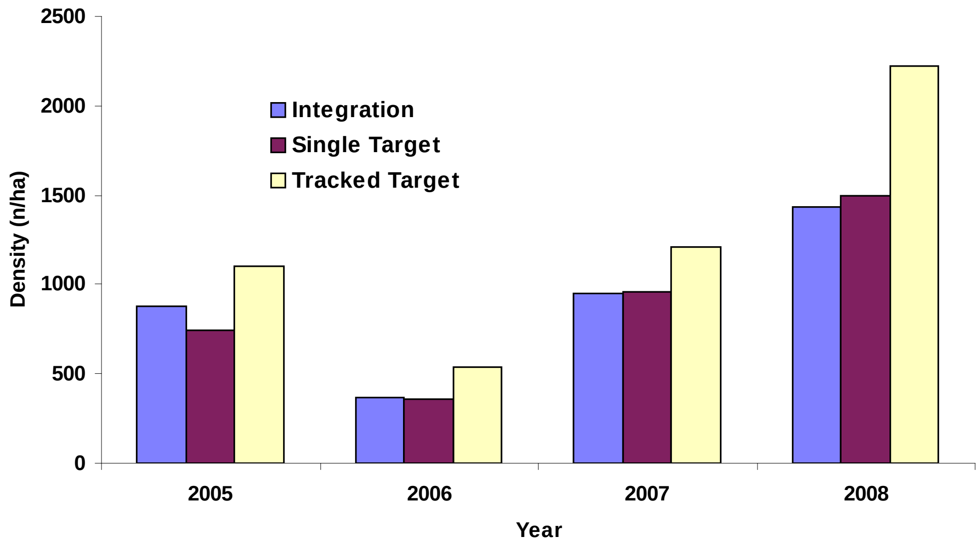

Figure 11. McDonell Lake O. nerka fry population estimates 2005 - 2008

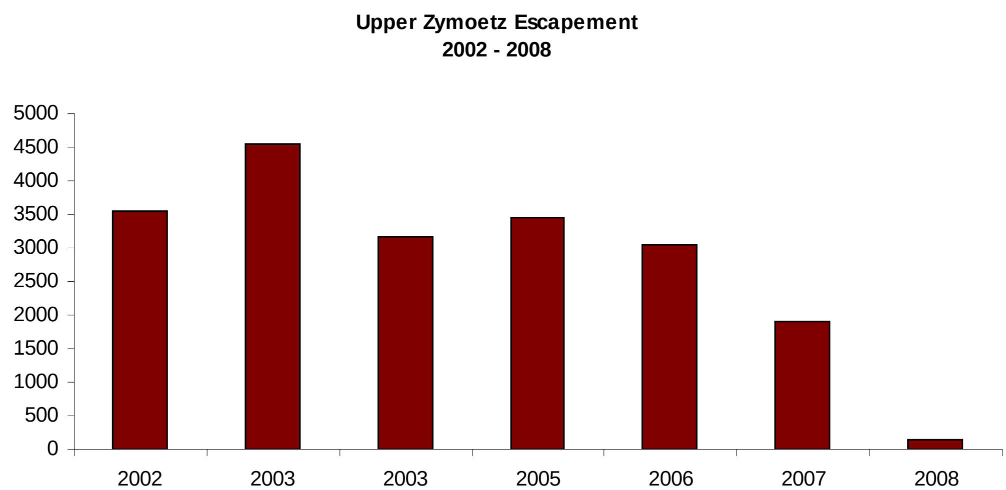

Figure 12. Upper Zymoetz adult sockeye escapement, 2002 – 2008[1]

[1] *NUSEDS* escapement database, Fisheries and Oceans Canada 2008