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# **Skeena & Nass Sockeye Lakes Hydroacoustic Surveys 2008**

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## ABSTRACT

Skeena Fisheries Commission conducted hydroacoustic surveys of 4 juvenile sockeye rearing lakes in the Skeena and Nass Watersheds in 2008. Surveys were completed at Lakelse, Damdochax, Wiiminosik, and Bear Lakes. The results of these surveys 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 mid-water trawl and gillnet gear. The trawl sample was used to determine the species composition of pelagic “small” size fish at each lake.

The overall density of “small” size class fish was highest in Damdochax and lowest in Bear Lake. We captured over 50 juvenile *O. nerka* in Damdochax and Wiiminosik lakes, and over 100 in Lakelse Lake. We were thus able to provide a fall fry population estimate for *O. nerka* in these lakes by apportioning the “small” size hydroacoustic estimates by species according to the trawl catch. The trawl catch at Bear Lake was insufficient to determine the species composition in the lake.

The overall “small” size fish estimates are not proportional to the sizes of each lake. Bear lake was the largest of the lakes surveyed in 2008 with a surface area over 1,900 hectares. Wiiminosik was the smallest lake surveyed with a surface area of only 18 hectares. While Wiiminosik is over 100 times smaller than Bear lake, there are only 10 times more “small” size fish in Bear Lake than Wiiminosik. Damdochax Lake covers roughly one tenth of the surface area of Lakelse, but the overall *O. nerka* population estimates for Damdochax are between 82% and 91% (depending on the method of estimation) of the much larger Lakelse Lake.

## TABLE OF CONTENTS

ABSTRACT.....	2
TABLE OF CONTENTS.....	3
LIST OF TABLES.....	4
LIST OF FIGURES.....	4
INTRODUCTION.....	6
METHODS.....	7
Hydroacoustic Survey.....	7
Fish Collection.....	8
Temperature and Dissolved Oxygen.....	9
RESULTS.....	9
Bathymetry.....	9
Temperature and Oxygen profiles.....	9
Fish Collections.....	10
Lakelse Lake.....	10
Damdochax.....	10
Wiiminosik.....	10
Bear Lake.....	11
Hydroacoustic Estimates.....	11
Lakelse Lake.....	11
Damdochax.....	12
Wiiminosik.....	12
Bear Lake.....	13
DISCUSSION.....	14
PR capacity comparison.....	14
Sockeye Escapement.....	14
Challenges.....	15
ACKNOWLEDGEMENTS.....	16
REFERENCES.....	17

## LIST OF TABLES

Table 1. Trawl location and effort by lake.....	18
Table 2. Trawl catch by lake.....	19
Table 3. Gillnet location and effort by lake .....	20
Table 4. Gillnet catch by lake .....	20
Table 5. Sample (size) data by lake and gear.....	21
Table 6. 2007 and 2008 Lakelse Lake hydroacoustic estimates by method.....	22
Table 7. 2007 and 2008 Damdochax Lake hydroacoustic estimates by method .....	23
Table 7. 2007 and 2008 Damdochax Lake hydroacoustic estimates by method .....	23
Table 8. 2008 Wiiminosik estimate by method .....	24
Table 9. 2007 Wiiminosik estimate by method .....	25
Table 10. 2008 Bear Lake hydroacoustic estimate by method .....	26
Table 11. Small-size class density (n/ha) estimate by transect.....	27
Table 12. PR Capacity comparison chart.....	28

## LIST OF FIGURES

Figure 1. Location of 2008 Lake Surveys.....	29
Figure 2. Lakelse Lake Survey Map .....	30
Figure 3. Damdochax Lake Survey Map .....	31
Figure 4. Wiiminosik Lake Survey Map.....	32
Figure 5. Bear Lake Survey Map .....	33
Figure 6. Bear Lake Bathymetric Map .....	34
Figure 7. Temperature profiles for lakes surveyed in 2008 .....	35
Figure 8. Dissolved oxygen profiles for lakes sampled in 2008.....	36
Figure 9. Average target strength (dB) by depth layer for 2008 lake surveys.....	37
Figure 10. Vertical distribution of target density for 2008 lake surveys .....	38
Figure 11. Surface distribution of fish targets (fish/m <sup>3</sup> ) at Lakelse Lake .....	39
Figure 12. Surface distribution of fish targets (fish/m <sup>3</sup> ) at Damdochax Lake .....	40
Figure 13. Surface distribution of fish targets (fish/m <sup>3</sup> ) at Wiiminosik Lake.....	40
Figure 14. Surface distribution of fish targets (fish/m <sup>3</sup> ) at Bear Lake .....	41
Figure 15. Sockeye rearing lakes in the Skeena Watershed .....	42
Figure 16. Lakelse Lake Transect 0.7 echogram .....	43
Figure 17. Lakelse Lake Transect 1.4 echogram .....	43
Figure 18. Lakelse Lake Transect 2.1 echogram .....	44
Figure 19. Lakelse Lake Transect 2.6 echogram .....	44
Figure 20. Lakelse Lake Transect 3.4 echogram .....	45
Figure 21. Lakelse Lake Transect 4.2 echogram .....	45
Figure 22. Lakelse Lake Transect 4.8 echogram .....	46
Figure 23. Lakelse Lake Transect 7.0 echogram .....	46
Figure 24. Damdochax Lake Transect 1 echogram .....	46
Figure 25. Damdochax Lake Transect 2 echogram .....	47
Figure 26. Damdochax Lake Transect 3 echogram .....	47
Figure 27. Damdochax Lake Transect 4 echogram .....	47



Figure 28. Damdochax Lake Transect 5 echogram .....	48
Figure 29. Damdochax Lake Transect 6 echogram .....	48
Figure 30. Damdochax Lake Transect 7 echogram .....	48
Figure 31. Damdochax Lake Transect 8 echogram .....	49
Figure 32. Wiiminosik Lake Transect 1 echogram.....	49
Figure 33. Wiiminosik Lake Transect 2 echogram.....	49
Figure 34. Wiiminosik Lake Transect 3 echogram.....	50
Figure 35. Wiiminosik Lake Transect 4 echogram.....	50
Figure 36. Wiiminosik Lake Transect 5 echogram.....	50
Figure 37. Wiiminosik Lake Transect 6 echogram.....	50
Figure 38. Wiiminosik Lake Transect 7 echogram.....	50
Figure 39. Bear Lake Transect 1 echogram .....	51
Figure 40. Bear Lake Transect 2 echogram .....	51
Figure 41. Bear Lake Transect 3 echogram .....	51
Figure 42. Bear Lake Transect 4 echogram .....	52
Figure 43. Bear Lake Transect 5 echogram .....	52
Figure 44. Bear Lake Transect 6 echogram .....	52
Figure 45. Bear Lake Transect 7 echogram .....	53
Figure 46. Bear Lake Transect 8 echogram .....	53
Figure 47. Bear Lake Transect 9 echogram .....	53
Figure 48. Bear Lake Transect 10 echogram .....	54
Figure 49. Bear Lake Transect 11 echogram .....	54
Figure 50. Bear Lake Transect 14 echogram .....	55
Figure 51. Bear Lake Transect 15 echogram .....	55

## INTRODUCTION

In 2008, the Skeena Fisheries Commission (SFC) conducted hydroacoustic surveys of four juvenile sockeye rearing lakes in the Skeena and Nass watersheds (Figure 1).

Lakelse Lake is located within the traditional territories of the Tsimshian and Kitselas First Nations. Lakelse Lake is the source of the Lakelse River, a 5th order tributary of the lower Skeena that drains a watershed area of approximately 589 km<sup>2</sup>. The surface area of the lake is approximately 1,360 ha with a volume of  $1.15 \times 10^8$  m<sup>3</sup>. 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 covers 42% of the lake surface (Gottesfeld & Rabnett 2008). Lakelse is the southernmost and warmest of the lakes surveyed in 2008. This is a very productive system, but Lakelse sockeye stocks are an ongoing conservation concern and escapements has been in decline since the 1970s. The SFC has conducted annual hydroacoustic surveys of Lakelse Lake since 2006.

Damdochax Lake is the source of the Damdochax River, a 5th order tributary of the Nass River that drains a watershed area of approximately 116 km<sup>2</sup> (Hall and Carr-Harris 2008). Damdochax Lake is located within the traditional territories of the Gitksan First Nation. Damdochax Lake supports one of the 4 largest non-Meziadin sockeye stocks in the Nass watershed. The surface area of Damdochax Lake is approximately 148 ha with a volume of  $1.42 \times 10^7$  m<sup>3</sup>. The average depth of the lake is 9.6 m and the maximum depth is approximately 21 m. The SFC conducted a hydroacoustic survey of Damdochax Lake in 2007.

Wiiminosik Lake is located approximately 2.4 km upstream of Damdochax Lake. It covers a surface area of 38 ha, with a volume of  $4.1 \times 10^6$  m<sup>3</sup>. The mean depth is approximately 10.7m and the maximum depth is 25m. The SFC conducted the first hydroacoustic survey of Wiiminosik Lake in 2007. Damdochax and Wiiminosik Lakes are located within the traditional territories of the Gitksan First Nation.

Bear Lake drains into the Bear River, a 5<sup>th</sup> order tributary to the Sustut River, in the northeastern Skeena Watershed. The Bear River watershed drains an area of approximately 452 km<sup>2</sup> (Gottesfeld & Rabnett 2008). Bear Lake covers approximately 1961 hectares with a volume of approximately  $2.6 \times 10^8$  m<sup>3</sup>. There are two distinct basins in the north and south ends of with maximum depths of 44 and over 70 m respectively. Tsaytut Bay is a large littoral area that covers 440 ha on the east side of Bear Lake. Stock assessment has never been conducted regularly at Bear Lake, so escapement estimates are not available. The last hydroacoustic survey of Bear Lake was conducted in 2002. Bear Lake is located within the traditional territories of the Gitksan First Nation.

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”.

## **METHODS**

### **Hydroacoustic Survey**

All 2008 surveys were conducted along previously established transects on each lake. The Lakelse Lake transect design (Figure 2) at was revised by the SFC in 2007 (Hall & Carr-Harris 2008). The surveys for Damdochax and Wiiminosik Lakes were designed for our 2007 surveys (Hall & Carr-Harris 2008) (Figures 3 and 4). The Bear Lake survey design (Figure 5) was established by the Department of Fisheries & Oceans Cultus Lake Research Laboratory in 2003 (Hume & Shortreed 2004). The original Bear Lake survey design was 16 transects, of which we completed 13. We did not survey transects 12 and 13 based on advice from previous surveys that they were shallow with few fish. We abandoned Transect 16 in the field because of low water conditions.

Hydroacoustic surveys were conducted using similar technology to that of previous years. (Hall 2006, Hall & Carr-Harris 2008). Transects were sampled using a Biosonics DT-X echosounder with a 199 kHz split-beam transducer producing a 6 degree beam. The downward-pointing transducer was pole-mounted to our inflatable vessel, a Bombard Commando C-4. Hydroacoustic data was collected to a threshold of -75 dB using Biosonics Visual Acquisition software as the vessel proceeded along transects at a constant speed of approximately 1 m/s.

The hydroacoustic system was calibrated prior to each 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.

Acoustic estimates are based on the volumes of each lake. Bathymetric maps were used to calculate volumes for each depth layer and representative transects for Lakelse Lake. Volume calculations for Damdochax and Wiiminosik lakes are based on geo-referenced bathymetry data collected during our 2007 hydroacoustic surveys. We revised the volumes for Lakelse, Damdochax and Wiiminosik Lakes in 2009 based on a change in the method for volume calculation. We adjusted our 2007 estimates for these lakes in accordance with these new volumes. We collected bathymetric data with our DT-X echosounder at Bear Lake in 2008. Bathymetric data was collected from all transects, trawls, and other selected areas of the lake and combined with existing bathymetric data from BC Ministry of Environment maps in ArcInfo to produce a new bathymetric map.

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

Target densities were calculated using three different methods. The integration method divides the average acoustic energy for each depth layer by the average target strength.

The single target method divides the sum of only those targets that have specific acoustic characteristics of single fish by the sampled beam volume. The tracked target estimate is produced by grouping single targets into individual fish tracks, and dividing the total number of fish tracks by the sampled wedge volume.

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.

The fish estimates were divided into “small” fish 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° 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 were 12m long and 1.5 m deep and consisted of 4 variable mesh sizes between ½” and 1”. The gillnets were set at dusk and allowed to soak for approximately 12 hours in Lakelse, Damdochax and Wiiminosik Lakes, and up to 24 hours in Bear Lake. 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 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. Depths were recorded using a Vemco Minilog TDR 8-bit data logger attached to the lower spreader bar of the trawl.

Large fish were counted and released. 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 salmonid fishes.

Trawl-captured fish tend to be smaller on average than those captured by gillnet and it has been suggested that the trawl sample size may be biased against larger fish (McQueen *et al.* 2007, Hall & Carr-Harris 2008). As it is unknown how large the bias is, we have not applied any trawl bias correction factor to the fish sample sizes reported herein.

## **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.

## **RESULTS**

Hydroacoustic surveys were conducted at Lakelse Lake on the nights of August 29<sup>th</sup> and 30<sup>th</sup>, at Damdochax and Wiiminosik Lakes on September 8<sup>th</sup> and 9<sup>th</sup> respectively, and at Bear Lake September 29<sup>th</sup> and 30<sup>th</sup>, 2008. We had scheduled an additional survey on Azuklotz Lake, which is upstream from Bear Lake, but our access was restricted by low water and a large beaver dam between Bear and Azuklotz lakes. The extra time was allocated to additional bathymetric work at Bear Lake.

### **Bathymetry**

Bear Lake is large with complicated bathymetry, and we were not able to collect as much data as would be necessary to construct a bathymetric map for the entire lake. We collected bathymetry data from all sections of the lake, but focused our efforts in the north and center portions of the lake, where we found the most discrepancies between our echosounder data and the Ministry of Environment bathymetric map. We found the area between transects 6 and 8 to be deeper in our survey, but our overall volume and surface area calculations were similar to those determined by Hume and Shortreed prior to their 2003 survey. We combined our DT-X data with existing data from the provincial Ministry of Environment map. The resulting bathymetric map is depicted in Figure 6.

### **Temperature and Oxygen profiles**

Temperature and oxygen data were recorded to the bottom of Lakelse, Damdochax and Wiiminosik Lakes, and to 30 m at Bear Lake. All of the northwest interior BC lakes are dimictic, and summer stratification is typical. Thermal stratification may be poorly developed, particularly in shallow lakes, after windstorms, and as the lakes cool in the fall. The lakes we sampled in 2008 were more or less thermally stratified.

The temperature profile at Lakelse showed a thick epilimnion to 18 m and a thermocline to the bottom of the temperature profile. Damdochax had a 5 m epilimnion over a thermocline to the bottom. Wiiminosik Lake has a thermocline to 14m, and a hypolimnion below. Bear Lake had an epilimnion to 5 m, a thermocline between 5 and 16m and a hypolimnion to the bottom of the temperature data.

The water column at Lakelse and Damdochax lakes were oxygenated to the bottom layers. Bear Lake was oxygenated to the deepest point recorded. Oxygen levels declined to below 1 mg/L at 25 m depth in Wiiminosik Lake (Figure 8).

## Fish Collections

### Lakelse Lake

We completed six tows with a combined distance of 4.2 km with the midwater trawl at Lakelse Lake (Table 1). The trawl catch consisted of 121 *O. nerka* fry, 13 Prickly Sculpin (*Cottus asper*), 12 Threespine Stickleback (*Gasterosteus aculeatus*), and one large Pikeminnow (*Ptychocheilus oregonensis*) (Table 2). Size data for all collections from all lakes are recorded in Table 5. All *O. nerka* were age-0 fry. One *O. nerka* was a hatchery-reared fry that was marked with an adipose fin clip. In addition to finfish, we captured a number of Mysid shrimp (*Neomysis mercedis*) with our trawl gear. We retained several in formaldehyde for identification, but mysids were not counted or measured as part of our survey.

Trawling at Lakelse Lake has been challenging in the past because of gear entanglement with submerged trees, of which there are many in the north section of the lake. In 2008, our trawling effort was limited to a small section of the lake adjacent to Transect 3.4, the only area where there were no trees in the fish layer to snag the trawl net, and sufficient fish density to ensure successful fishing. The sixth trawl was not recorded with our hydroacoustic equipment.

We set 4 gillnets during two nights at Lakelse. The total combined soak time was 24 hours (Table 3). The gillnet sample consisted of four *O. nerka* fry, two Redside Shiners (*Richardsonius balteatus*), 1 large (>20 cm) Chinook (*Oncorhynchus tshawytscha*), and one large Cutthroat Trout (*Oncorhynchus clarki*) (Table 4).

### Damdochax

*O. nerka* were the only species captured by trawl at Damdochax Lake, where we captured 65 *O. nerka* fry during two tows with a total trawl length of 820 m (Tables 1 and 2). We captured four Coho (*Onchorhynchus kisutch*) and one *O. nerka* in two floating gillnets with a combined soak time of 28 hours. One coho was age-1. The remaining Coho and all of the *O. nerka* were young-of-the-year, or age-0.

### Wiiminosik

Seven trawls with a total length of 1936 m were conducted at Wiiminosik Lake (Table 1). The total trawl catch consisted of 46 *O. nerka* fry, 2 Prickly Sculpin, and 38 Pygmy Whitefish (*Prosopium coulterii*) (Table 2). The trawl sample from Wiiminosik Lake was not preserved because of a mix-up of containers. As a result length, weight, and age data is not available for the trawl sample.

We set two floating gillnets in Wiiminosik Lake with a combined soak time of 30 hours (Table 3). The gillnet catch consisted of 9 age-0 *O. nerka*, 3 age-0 and 1 age-1 juvenile Coho, 1 large Bull Trout (*Salvelinus confluentus*) and 2 large Cutthroat Trout (Table 4).

## **Bear Lake**

We conducted 8 tows with a total length of about 3.6 km at Bear Lake (Table 1). The total trawl catch was 14 Pygmy Whitefish and 3 *O. nerka* fry. All of the *O. nerka* were caught in the north section of the lake at approximately 2m depth (Table 2).

The gillnet effort was increased at Bear Lake. A total of eight gillnets were set during our three night survey including one that was checked and re-set at the same location on the following day. The combined soak time for all gillnets was 169 hours (Table 3). The gillnet catch included 36 juvenile *O. nerka*, 1 juvenile Coho, 1 juvenile Chinook, 68 Redside Shiners, 2 large Bull Trout and 2 Pygmy Whitefish. All but one *O. nerka* were age-0, or young of the year fry. The Chinook, Coho and one of the *O. nerka* were age-1 (Table 4).

## **Hydroacoustic Estimates**

The DT-X system was calibrated prior to each survey, and observed target strength of the standard target was similar to the predicted target strengths for the given temperature and depths at all lakes. No calibration offsets were applied to any of our 2008 surveys.

## **Lakelse Lake**

Most of the fish population at Lakelse Lake is contained in the north basin of the lake, where we have focused our survey efforts. The estimates for the north and south basins have not been combined, and the estimate for the south basin, which is based on Transect 7.0, has been excluded from biomass calculations.

The “small” size fish density ranged from 472 to (single target) to 535 (tracked target) fish per hectare in the north basin of the lake, and from 67 to 154 “small” size fish/hectare in the south basin. The “small” size class population estimate for 2008 in the north basin ranged from 297,775 (single target) to 337,817 (tracked target) (Table 6). Our population estimate for “small” size fish in the south basin at Lakelse ranged from 112,354 (Integration) to 49,080 (Tracked target) (Table 6). Based on our trawl catch, we estimate that 91% of the “small” size fish targets are *O. nerka*. If we combine our population estimates with the average fry weight of 3.6g, the observed biomass for sockeye fry in the north basin ranges from 1,071 kg (Single target) to 1,216 kg (Integration).

The integration estimate may be high, especially in transect 7.0, because of the abundance of Mysid shrimp (*Neomysis mercedis*) in Lakelse Lake at the time of our survey. It is likely that high densities of Mysid shrimp exceeded the target strength processing threshold (-65 dB) near the bottom water column layers. Single target and tracked target analysis methods are superior for excluding non-fish targets.

There were too few fish were caught in 2007 to apportion the estimate by limnetic species but the overall (revised) 2007 densities of small and large fish are higher than those of 2008 (Table 6).

The 2008 large fish estimate ranged from 53,447 (Single target) to 59,005 (Tracked target) in the north basin of the lake. We detected no “large” fish in the south basin of the lake (Table 6).

There was no clear pattern of vertical target strength distribution at Lakelse Lake. Fish targets in Lakelse were strongly oriented to the bottom layers of the lake below 22m (Figure 10). The highest surface density of fish targets was in the middle, deepest section of the north basin (Figure 11).

### **Damdochax**

The observed “small” size fish density in Damdochax Lake ranged from 1665 (Integration) to 1858 (Tracked target) fish/hectare. Our population estimate for Damdochax Lake ranged from 246,152 (Integration) to 274,702 (Tracked Target) “small” size class fish (Table 7). No other fish species were captured by trawl at Damdochax, therefore *O. nerka* fry represent 100% of this estimate. If we combine our estimates with an average weight of 2.3 grams per fry, the total observed juvenile *O. nerka* biomass for this survey ranges from 566 kg (Integration) to 631 kg (Tracked target).

The 2008 hydroacoustic estimate is more than twice as high as the hydroacoustic estimate for Damdochax Lake in 2007, which ranged from 96,462 (Integration) to 135,167 (Single Target) “small” size fish targets (Table 7).

Our 2008 estimate for “large” size fish in Damdochax ranged from 32,058 (Single Target) to 38,705 (Tracked Target) (Table 7).

Of all lakes surveyed in 2008, the “Small” size fish density was highest in Damdochax Lake, where the echo integration transect density estimate ranged from 379 fish/ha in Transect 8 to 3,092 fish/ha in Transect 6 (Table 11).

There are no clear patterns of vertical target strength distribution at any lake other than in Damdochax, where the average target strength increases to approximately –47 dB in the region between 9 and 13m depth (Figure 9), which roughly corresponds with the region of highest target density. The highest number of fish targets were detected on the east side of the middle portion of the lake (Figure 12). There is a distinct midwater fish layer between 8-11 m depth demonstrated by the vertical distribution of target density at Damdochax (Figure 10).

### **Wiiminosik**

The estimate for Wiiminosik Lake has been divided into the well-defined east and west basins. In 2008, the fish density was slightly higher in the east basin than the west, but the difference was not as pronounced as in 2007 (Table 8).

Fish density estimates ranged from 865 (Single target) to 972 (Tracked target) “small” fish/hectare in the east basin, and 1,073 (Single target) to 1,194 (Integration) “small”



fish/hectare in the west basin. The combined population hydroacoustic estimate for Wiiminosik Lake ranged from 37,062 (single target) to 45,361 (tracked target) “small” size fish targets (Table 8).

The estimate for *O. nerka* fry in Wiiminosik Lake is smaller in 2008 than in 2007. The revised estimate for 2007 ranges from 44,387 (single target) to 57,145 (tracked target) *O. nerka* fry (Table 9). While the total estimate for “small” size class fish was similar in 2007 and 2008, the estimate for juvenile sockeye was less in 2008 because of the higher proportion of whitefish. *O. nerka* comprised only 55% of the 2008 trawl catch, while the proportion of *O. nerka* captured by trawl in Wiiminosik Lake in 2007 was 90%.

The average weight for trawl-captured *O. nerka* is not available for this survey, and we have applied the mean weight of *O. nerka* from adjacent Damdochax Lake, sampled one night earlier, to our biomass estimate for Wiiminosik. If we combine the average fry weight from Damdochax (2.3 g) with our estimates from Wiiminosik Lake, the observed *O. nerka* biomass ranges from 46 kg (Single target) to 57 kg (Tracked target).

The 2008 “large” fish population estimate for Wiiminosik ranged from 2,487 (Integration) to 3,656 (Tracked target) (Table 8). There is a distinct midwater layer of increased target density between 7 and 11 m depth in Wiiminosik (Figure 10). The highest number of “large” fish targets is in the northwest section of the lake (Figure 15). There is no clear pattern of vertical target strength distribution by depth layer at Wiiminosik, however the curve increases to >40dB at 17 m, suggesting the presence of larger fish deeper in the water column (Figure 9).

### **Bear Lake**

The estimate for Bear Lake was divided into the north basin, south basin, and Tsaytut Bay. “Small” size fish density ranged from 190 to 224 fish/hectare in the north basin, 296 to 366 fish/hectare in the south basin, and 46 to 95 fish/hectare in Tsaytut Bay. The combined Bear Lake population estimate ranged from 379,201 (Single target) to 460,579 (tracked target) “small” class fish (Table 10). Our trawl catch at Bear Lake was not sufficient to apportion the “small” size class estimate by species but it is clear that Pygmy Whitefish comprise a substantial proportion.

The “large” fish estimate varied by basin. “Large” fish density ranged from 37 to 46 fish/hectare in the north basin, and from 78 to 104 fish/hectare in the south basin. No “large” fish were detected in Tsaytut Bay. The combined “large” fish estimate ranged from 79,140 (Single target) to 97,264 (Integration) (Table 10).

The “small” size fish density at Bear Lake was the lowest observed in all of the lakes surveyed in 2008. The echo integration transect density estimates at Bear Lake ranged from 72 fish/ha in Transect 15 to 468 fish/ha in Transect 8 (Table 11). Fish targets in Bear Lake seemed to occupy two distinct layers, at approximately 10-12 m depth and clustered near the bottom below 35m, except where the lake depth exceeded the deepest fish layer at about 60 m (Figure 10). Hydroacoustic target strength (roughly fish size) is relatively constant with depth at Bear Lake (Figure 9). The highest concentrations of fish

targets were found in the north section of the lake, and on the west side of the middle of the lake. The lowest concentrations of fish targets were found in Tsaytut Bay (Figure 16).

The most recent hydroacoustic survey of Bear Lake prior to this one was completed in 2003 by the Cultus Lake Salmon Research Laboratory. Our “small” size fish estimate for Bear Lake, ranging from 379,201 to 467,579 is similar to the sum of the 2003 estimates for *O. nerka* (238,025) and other “small” fish (168,758) (Hume and Shortreed 2004).

Our limited trawl and gillnet sample demonstrated that the limnetic community is complex and not uniformly distributed throughout Bear lake. Hume and Shortreed (2004) suggest that different species may be represented in the two different peak density regions of the water column, but we were not able to confirm this as we caught no fish in the upper region. While we were not able to apportion the hydroacoustic estimate by species in order to estimate the population of *O. nerka* juveniles, the “small” size fish density at Bear Lake was much lower than all other lakes surveyed in 2008.

## **DISCUSSION**

### **PR capacity comparison**

The PR capacity model (Shortreed *et al.* 2007, Shortreed and Hume 2009) provides an estimate of the maximum smolt biomass of a given lake based on its annual carbon production. This estimate provides a benchmark to compare our hydroacoustic estimates. PR capacity predictions for Lakelse and Bear Lakes were revised in Shortreed *et al.* 2007. PR capacity modeling was conducted in 2008 for Damdochax and Wiiminosik Lakes, and those results are reported in Shortreed and Hume 2009.

The PR estimates have been adjusted for the presence of competing limnetic species, but not for other age classes of sockeye, which are not known to inhabit the lakes that we have reported population estimates for *O. nerka* fry. We found no other age classes of *O. nerka* in either our trawl or gillnet samples at Lakelse, Damdochax, and Wiiminosik Lakelse lakes. We found one age-1 *O. nerka* in our gillnet sample at Bear lake, where we did not produce a juvenile sockeye population estimate because of our low trawl catch.

Our observed juvenile sockeye biomass (Integration) for Lakelse Lake was 1,180 kg, which occupies 9% of  $R_{\max}$  (Shortreed *et al.* 2007). The observed biomass at Damdochax Lake was 566 kg, or 48% of  $R_{\max}$ . The observed biomass at Wiiminosik Lake was 61 kg, or 18% of  $R_{\max}$  (Table 12).

### **Sockeye Escapement**

Sockeye spawner enumeration is conducted by regular stream walks at spawning creeks adjacent to Damdochax/Wiiminosik and at Lakelse Lakes.

The average annual returns of sockeye to the Damdochax system has declined steadily from 5,000-10,000 in the 1950s and 1960s to an average of 1,320 fish over the last 10 years. (NuSEDs database). The 2008 Damdochax sockeye escapement was nearly average at 1,944 (Tim Wilson, pers. comm.) The escapement estimates for 2006 and 2007, the brood years for our 2007 and 2008 fall fry population estimates for Damdochax and Wiiminosik together are 1,701 and 2,067 respectively. Our combined sockeye estimates for the two lakes in 2006 and 2007 are 136,544 and 267,915 (Integration) respectively. If we assume a 50 % male to female ratio of spawners, this works out to 160 fry/female for the 2006 brood year, and 259 fry/female for 2007.

The average annual escapement Lakelse system has declined from historic levels of up to 20,000 to about 2,000 sockeye spawners in the last 10 years (NuSEDs database). The low returns have prompted ongoing Lakelse sockeye recovery efforts, which included salmon enhancement in 2006 and 2007. Nearly 300,000 hatchery-reared sockeye fry were released into Williams Creek in the spring of 2008, all of which were marked with an adipose fin clip. Only one of these marked fish were captured in our trawl sample of 121 fish. The estimated return for 2006 and 2007, the brood years for our 2007 and 2008 surveys were 1,450 and 3,010 (NuSEDs database). Our fall fry echo integration estimates were 191,670 "small" fish in 2007 (Hall & Carr-Harris 2008), and 299,149 age-0 nerka in 2008. If we assume a 50% male to female spawner ratio, that hatchery broodstock is included in the spawner count and that all 2007 "small" fish were *O. nerka*, this works out to 199 fry/female for the 2006 brood year, and 264 fry/female for 2007.

There is little available recent sockeye escapement data for Bear Lake, where sockeye enumeration is complicated by the known presence of lakeshore spawners (Gottesfeld & Rabnett, 2008).

## **Challenges**

It is apparent that some lakes are better ideal candidates for our current hydroacoustic methodology than others. A reasonable fish sample is necessary for a quantitative estimate of sockeye fry at any given lake. Our trawling efforts were successful at Damdochax and Wiiminosik because of high fish densities and a relatively simple limnetic community in each lake. Our survey at Bear Lake was challenging because of the small trawl catch that made it impossible to apportion the hydroacoustic estimate of "small" size fish by species. It is evident that while sockeye are present in the water column, the limnetic community is complex, and the species are not uniformly distributed. Only three sockeye were caught by trawl, all of which were captured at 2-4 m depth in the northernmost section of the lake. A much larger trawl sample taken from different locations and depths throughout the lake would be required in order to divide the acoustic estimate for "small" fish by species. While a larger number of sockeye were caught by gillnet at Bear Lake, the gillnet catch represents the top 2m of the water column which is not sampled by our hydroacoustic equipment because of the conical nature of the acoustic beam.

The exclusion of the surface layer from acoustic estimates is problematic because downward-looking mobile hydroacoustic surveys are not suitable for enumerating shallow lakes, or those that are glacially turbid, where juvenile sockeye are thought to occupy the surface layer. While Bear Lake is not shallow or turbid, it is evident that juvenile *O. nerka* are present in the epilimnetic zone. There are 29 known sockeye rearing lakes (Figure 15) in the Skeena watershed, over 30% of which are considered unsuitable for hydroacoustic methodology because of their depth and/or turbidity (Hume and Shortreed 2004). We hope to address this issue in the future by using a horizontally oriented transducer to ensonify the top 2m of the water column (Simmonds and Maclellan 2005).

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**Table 1. Trawl location and effort by lake**

<b>Lake</b>	<b>Trawl</b>	<b>Trawl Length (m)</b>	<b>Start Lat</b>	<b>Start Long</b>	<b>End Lat</b>	<b>End Long</b>	<b>Depth</b>
Damdochax	1	634	56.5053	-128.1021	56.5041	-128.1001	10
Damdochax	2	186	56.5054	-128.0959	56.5094	-128.1027	12
Wiiminosik	1	238	56.4889	-128.0352	56.4898	-128.0388	10
Wiiminosik	2	107	56.4894	-128.0360	56.4897	-128.0374	10
Wiiminosik	3	339	56.4890	-128.0359	56.4885	-128.0358	10
Wiiminosik	4	190	56.4886	-128.0361	56.4900	-128.0381	12
Wiiminosik	5	209	56.4889	-128.0348	56.4900	-128.0373	10
Wiiminosik	6	532	56.4885	-128.0345	56.4904	-128.0373	10
Wiiminosik	7	320	56.4883	-128.0348	56.4899	-128.0372	10
Lakelse	1	709	54.3962	-128.5523	54.3932	-128.5430	26
Lakelse	2	415	54.3944	-128.5455	54.3966	-128.5505	30
Lakelse	3	1078	54.3967	-128.5544	54.3908	-128.5499	26
Lakelse	4	560	54.3953	-128.5470	54.3945	-128.5398	28
Lakelse	5	879	54.3932	-128.5407	54.3979	-128.5512	27
Lakelse	6	~600					27
Bear	1	363	56.0933	-126.8175	56.0959	-126.8206	24
Bear	2	175	56.1244	-126.8306	56.1233	-126.8308	30
Bear	3	428	56.1242	-126.8307	56.1280	-126.8316	12
Bear	4	240	56.1367	-126.8368	56.1387	-126.8381	12
Bear	5	621	56.1450	-126.8391	56.1503	-126.8409	24
Bear	6	650	56.1536	-126.8396	56.1592	-126.8423	26
Bear	7 & 8	1120	56.1904	-126.8739	56.1917	-126.8752	2

**Table 2. Trawl catch by lake**

Lake	Trawl	SK	PS	PWF	WF	3ST	PM
Damdochax	1	21					
Damdochax	2	44					
Wiiminosik	1	5			2		
Wiiminosik	2	8			1		
Wiiminosik	3	2			3		
Wiiminosik	4	11	2				
Wiiminosik	5	6			12		
Wiiminosik	6	7			8		
Wiiminosik	7	7			12		
Lakelse	1	11	2				
Lakelse	2	13	2				
Lakelse	3	12	2			3	
Lakelse	4	36	4			3	
Lakelse	5	20					1
Lakelse	6	29	3			6	
Bear	1						
Bear	2			2			
Bear	3						
Bear	4						
Bear	5			9			
Bear	6			3			
Bear	7 & 8	3		1			

SK: Sockeye; PS: Prickly sculpin; PWF: Pygmy whitefish;  
 WF: Whitefish spp; 3ST: Threespine stickleback; PM: Pikeminnow

**Table 3. Gillnet location and effort by lake**

Lake	Gillnet	UTM			Date	Soak Time (hours)
Lakelse	1	09U	529064	6026833	28-Aug-08	6
Lakelse	2	09U	528961	6027654	28-Aug-08	6
Lakelse	3	09U	530176	6028450	29-Aug-08	6
Lakelse	4	09U	529769	6029302	29-Aug-08	6
Damdochax	1	09V	555822	6262190	8-Sep-08	14
Damdochax	2	09V	555005	6263695	8-Sep-08	14
Wiiminosik	1	09V	558661	6261112	9-Sep-08	15
Wiiminosik	2	09V	559221	6260756	9-Sep-08	15
Bear	1	09V	633784	6224411	30-Sep-08	13
Bear	2	09V	632299	6228095	30-Sep-08	16
Bear	3	09V	632018	6229269	1-Oct-08	2 x 24
Bear	4	09V	637422	6218386	1-Oct-08	24
Bear	5	09V	631803	6229579	1-Oct-08	24
Bear	6	09V	634390	6225063	2-Oct-08	16
Bear	7	09V	632051	6229568	2-Oct-08	14
Bear	8	09V	631896	6229494	2-Oct-08	14

**Table 4. Gillnet catch by lake**

Lake	Gillnet #	SK	CO	CH	RSS	BT	WF	CTT
Bear	1	1			1			
Bear	2				1			
Bear	3	6		1	8			
Bear	4	4			4			
Bear	5	3			34	1		
Bear	6	2			8	1	1	
Bear	7	14	1		6			
Bear	8	7			6			
Lakelse	1	1						
Lakelse	2							1
Lakelse	3	3		1	2			
Lakelse	4	1						
Damdochax	1		2					
Damdochax	2	1	2					
Wiiminosik	1	8						
Wiiminosik	2	1	4			1		2

SK: Sockeye; CO: Coho; CH: Chinook; RSS: Redside Shiner; BT: Bull Trout; WF: Whitefish; CTT: Cutthroat trout



**Table 5. Sample (size) data by lake and gear**

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	Gillnet	Redside shiner	2	92	92	92	0	9.7	10.4	9	1.0
Lakelse	Gillnet	O. nerka	4	74	77	72	3	4.7	5.1	4.3	0.4
Lakelse	Trawl	Prickly sculpin	3	54	57	48	5	1.5	1.8	1.2	0.3
Lakelse	Trawl	Nerka	121	68	89	40	9	3.6	8.4	1	1.3
Lakelse	Trawl	Threespine stickleback	6	45	65	28	13	0.7	1.3	0.3	0.5
Damdochax	Gillnet	Coho	4	89	112	53	7	10.3	17.2	2.2	6.9
Damdochax	Gillnet	O. nerka	1	76	76	76		4.4	4.4	4.4	
Damdochax	Trawl	O. nerka	64	61	77	42	1	2.3	4.5	0.8	0.8
Wiiminosik	Gillnet	Coho	3	95	110	69	23	11.0	14.9	3.3	6.7
Wiiminosik	Gillnet	O. nerka	9	74	85	61	7	4.3	5.6	2.2	1.1
Wiiminosik	Trawl	O. nerka	44	69	83	53	7				
Wiiminosik	Trawl	Pygmy whitefish	3	32	34	30	2	0.1	0.2	0.1	
Wiiminosik	Trawl	Chinook	8	88	110	70		13.6			
Bear	Gillnet	Chinook	1	114	114	114		14.8	14.8	14.8	
Bear	Gillnet	Coho	1	89	89	89		8.0	8	8	
Bear	Gillnet	Redside shiner	68	82	102	62	6	7.2	14.8	4.1	1.8
Bear	Gillnet	O. nerka	37	93	118	70	9	9.8	17.3	3.8	3.0
Bear	Gillnet	Pygmy whitefish	1	110	110	110		13.1	13.1	13.1	
Bear	Trawl	O. nerka	3	62	67	56	6	2.5	2.9	1.8	0.6
Bear	Trawl	Pygmy whitefish	15	68	98	36	23	4.1	9.3	0.4	3.2

**Table 6. 2007 and 2008 Lakelse Lake hydroacoustic estimates by method**

Year	Estimate Method	Basin	Size Class	Density		Population	
				n/ha	95% C.I.	n	95% C.I.
2008	Integration	North	Small	519	235	327,858	148,499
			Large	89	41	56,041	26,016
			Age-0 nerka	474	214	299,149	134,838
		South	Small	154	n/a	112,354	n/a
			Large	0	n/a	0	n/a
	Single Target	North	Small	472	250	297,775	157,628
			Large	85	47	53,447	29,880
			Age-0 nerka	430	227	271,606	143,432
		South	Small	79	n/a	57,711	n/a
			Large	0	n/a	0	n/a
	Tracked Target	North	Small	535	336	337,817	212,398
			Large	93	59	59,005	37,386
			Age-0 nerka	487	306	307,590	193,236
		South	Small	67	n/a	49,080	n/a
			Large	0	n/a	0	n/a
2007	Integration	North	Small	304	175	191,670	110,325
			Large	31	22	19,430	13,624
		South	Small	128	n/a	93,067	n/a
			Large	0	n/a	0	n/a
	Single Target	North	Small	266	161	167,755	101,593
			Large	30	22	19,159	14,202
		South	Small	71	n/a	52,056	n/a
			Large	0	n/a	0	n/a
	Tracked Target	North	Small	335	206	211,262	130,370
			Large	43	30	27,159	19,011
		South	Small	75	n/a	54,344	n/a
			Large	0	n/a	0	n/a

**Table 7. 2007 and 2008 Damdochax Lake hydroacoustic estimates by method**

Year	Estimate Method	Size Class	Density		Population	
			N/ha	95% C.I.	N	95% C.I.
2008	Integration	Small	1,665	820	246,152	121,251
		Large	237	172	35,054	25,411
	Single Target	Small	1,678	754	248,183	111,423
		Large	217	159	32,058	23,461
	Tracked Target	Small	1,858	811	274,702	119,866
		Large	262	184	38,705	27,238
2007	Integration	Small	652	308	96,462	45,566
		Large	126	58	18,569	8,598
	Single Target	Small	723	235	135,167	735
		Large	145	64	21,485	9,492
	Tracked Target	Small	702	231	103,750	34,204
		Large	169	72	25,034	10,616

**Table 8. 2008 Wiiminosik estimate by method**

Estimate Method	Basin	Size Class	Density		Population	
			n/ha	95% C.I.	n	95% C.I.
Integration	West	Small	872	639	16,162	11,851
		Large	117	204	2,173	3,790
		Age-0 nerka	479	352	8,889	6,518
	East	Small	1,194	804	23,408	15,758
		Large	103	143	2,020	2,794
		Age-0 nerka	657	442	12,874	8,667
	Combined	Small	1,037	650	39,570	24,777
		Large	110	204	4,193	2,487
		Age-0 nerka	571	163	21,764	6,233
Single Target	West	Small	865	426	16,037	7,899
		Large	121	262	2,246	4,863
		Age-0 nerka	476	234	8,820	4,344
	East	Small	1,073	1,017	21,025	19,929
		Large	120	171	2,343	3,357
		Age-0 nerka	590	559	11,564	10,961
	Combined	Small	972	342	37,062	13,051
		Large	120	81	4,589	3,092
		Age-0 nerka	534	188	20,384	7,178
Tracked Target	West	Small	1,152	377	21,365	6,991
		Large	163	333	3,029	6,181
		Age-0 nerka	634	207	11,751	3,845
	East	Small	1,224	864	23,995	16,929
		Large	131	184	2,563	3,598
		Age-0 nerka	673	475	13,197	9,311
	Combined	Small	1,189	292	45,361	11,124
		Large	147	96	5,592	3,656
		Age-0 nerka	654	160	24,948	6,118

**Table 9. 2007 Wiiminosik estimate by method**

Estimate Method	Basin	Size Class	Density		Population	
			n/ha	95% C.I.	n	95% C.I.
Integration	West	Small	662	884	12,275	16,397
		Large	103	283	1,908	5,256
	East	Small	1,638	1,375	32,112	26,952
		Large	120	121	2,351	2,368
	Combined	Small	1,164	487	44,387	18,574
		Large	112	75	4,259	2,861
Single Target	West	Small	811	1,114	15,032	20,655
		Large	111	305	2,056	5,648
	East	Small	1,745	1,581	34,197	30,999
		Large	129	140	2,524	2,737
	Combined	Small	1291	569	49229	21718
		Large	120	82	4580	3139
Tracked Target	West	Small	968	1,420	17,950	26,322
		Large	136	358	2,519	6,634
	East	Small	1,999	1,865	39,195	36,566
		Large	140	134	2,740	2,619
	Combined	Small	1498	683	57145	26034
		Large	138	92	5259	3495

**Table 10. 2008 Bear Lake hydroacoustic estimate by method**

Estimate Method	Basin	Size Class	Density		Population	
			n/ha	95% C.I.	n	95% C.I.
Integration	North	Small	190	63	177,079	58,414
		Large	41	37	38,025	34,216
	South	Small	304	152	173,709	86,971
		Large	104	85	59,239	48,351
	Tsaytut Bay	Small	91	67	39,868	29,248
		Large	0	0	0	0
	Combined	Small	201	40	390,656	78,583
		Large	50	23	97,264	43,838
Single Target	North	Small	204	58	190,187	54,240
		Large	37	29	34,845	27,191
	South	Small	296	117	168,923	66,559
		Large	78	45	44,295	25,495
	Tsaytut Bay	Small	46	63	20,091	27,761
		Large	0	0	0	0
	Combined	Small	195	34	379,201	65,162
		Large	41	14	79,140	28,015
Tracked Target	North	Small	224	104	209,461	97,177
		Large	46	37	42,680	34,362
	South	Small	366	175	209,355	99,915
		Large	95	53	54,221	30,010
	Tsaytut Bay	Small	95	155	41,762	67,693
		Large	0	0	0	0
	Combined	Small	237	56	460,579	109,026
		Large	50	18	96,901	34,381

**Table 11. Small-size class density (n/ha) estimate by transect**

<b>Lake</b>	<b>Transect</b>	<b>Integration</b>	<b>Single Target</b>	<b>Tracked Target</b>
<b>Lakelse</b>	0.7	88	68	39
	2.1	635	387	437
	2.6	832	807	1,013
	3.4	789	861	1,115
	4.2	677	502	680
	4.8	372	523	297
	7	209	121	89
<b>Damdochax</b>	1	294	461	488
	2	599	879	844
	3	1,011	1,203	1,548
	4	1,427	1,601	1,983
	5	3,020	2,875	2,845
	6	3,092	2,830	3,207
	7	2,093	2,095	2,394
	8	379	401	470
<b>Wiiminosik</b>	1	891	709	999
	2	1,119	1,048	1,302
	3	605	837	1,156
	4	1,599	706	1,025
	5	1,123	1,175	1,202
	6	1,547	1,927	1,975
	7	507	482	695
<b>Bear</b>	1	265	282	263
	2	201	223	305
	3	221	200	242
	4	200	206	245
	5	161	200	264
	6	90	110	27
	7	400	413	566
	8	468	381	462
	9	223	242	298
	10	242	231	243
	11	188	211	264
	14	110	64	140
	15	72	28	51
<b>Lakelse</b>	0.7	88	68	39
	2.1	635	387	437
	2.6	832	807	1,013
	3.4	789	861	1,115
	4.2	677	502	680
	4.8	372	523	297
	7	209	121	89

**Table 12. 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	12104 <sup>1</sup>	30-Aug-08	Single Target	307,590	3.6	1112	9%
Damdochax	1117 <sup>2</sup>	8-Sep-08	Integration	246,152	2.3	566	51%
Wiiminosik	308 <sup>3</sup>	9-Sep-08	Integration	26,541	2.3	61	20%

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<sup>1</sup> Shortreed, Hume and Malange 2007

<sup>2</sup> Shortreed and Hume 2009

<sup>3</sup> Shortreed and Hume 2009

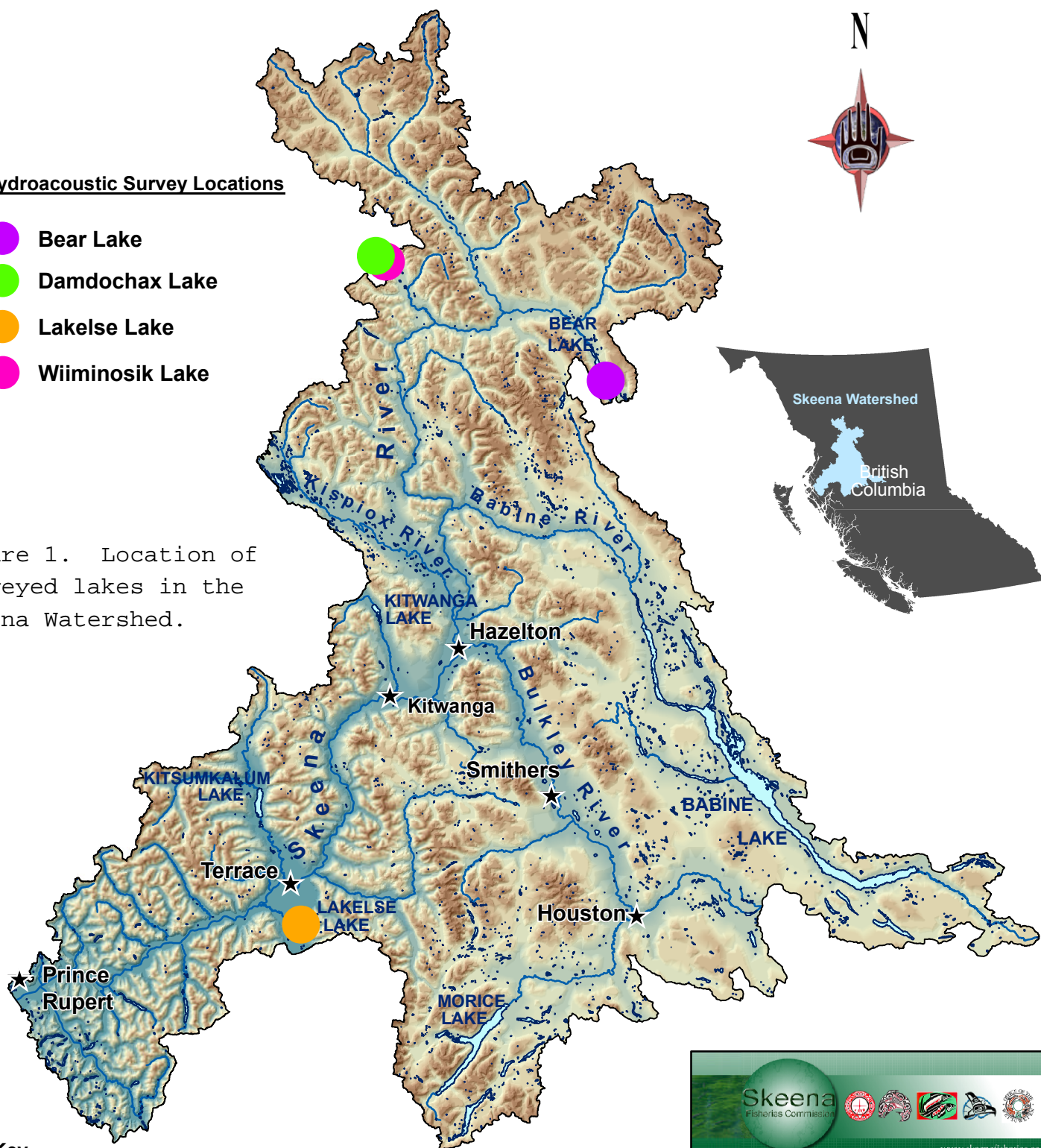


# 2008 Hydroacoustic Surveys

## 2008 Hydroacoustic Survey Locations

-  **Bear Lake**
-  **Damdochax Lake**
-  **Lakelse Lake**
-  **Wiiminosik Lake**

Figure 1. Location of surveyed lakes in the Skeena Watershed.



### Map Key


- ★ Towns and Villages  
 Lakes  
 Rivers


# S k e e n a   W a t e r s h e d

# Lakelse Lake

## Map Legend

- Transect
- ~ Trawl #1
- ~ Trawl #2
- ~ Trawl #3
- ~ Trawl #4
- ~ Trawl #5
- ★ Gillnet Site
- ★ Temperature Station
- North Basin
- South Basin





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Projection: UTM (Universal Transverse Mercator) Datum: NAD83 (North American Datum 1983)	
Map Prepared By: G. Wilson	Date: March 19, 2009
C:\coredata\Projects\Lakelse\apr_mdx\Lakelse.mxd	

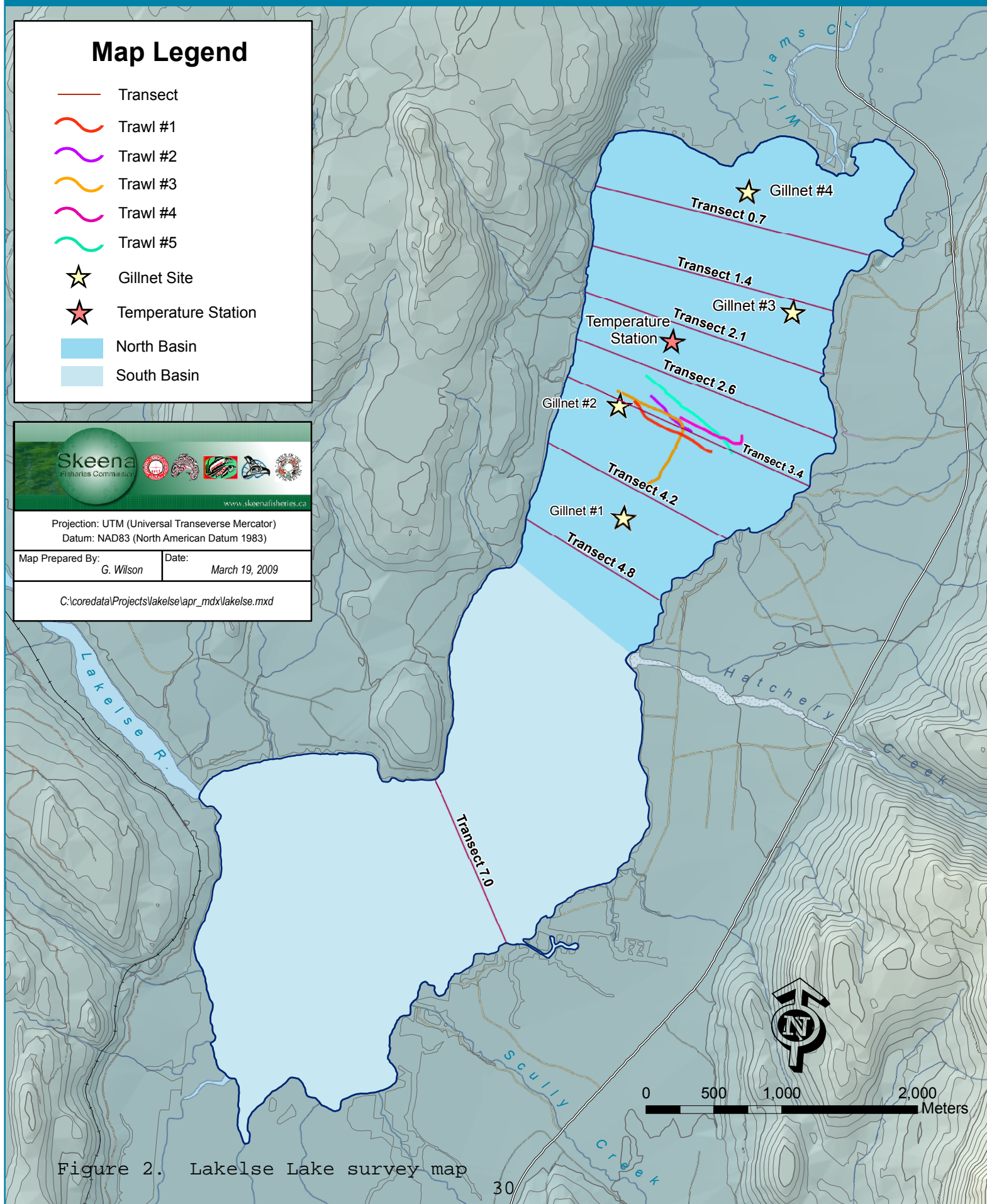
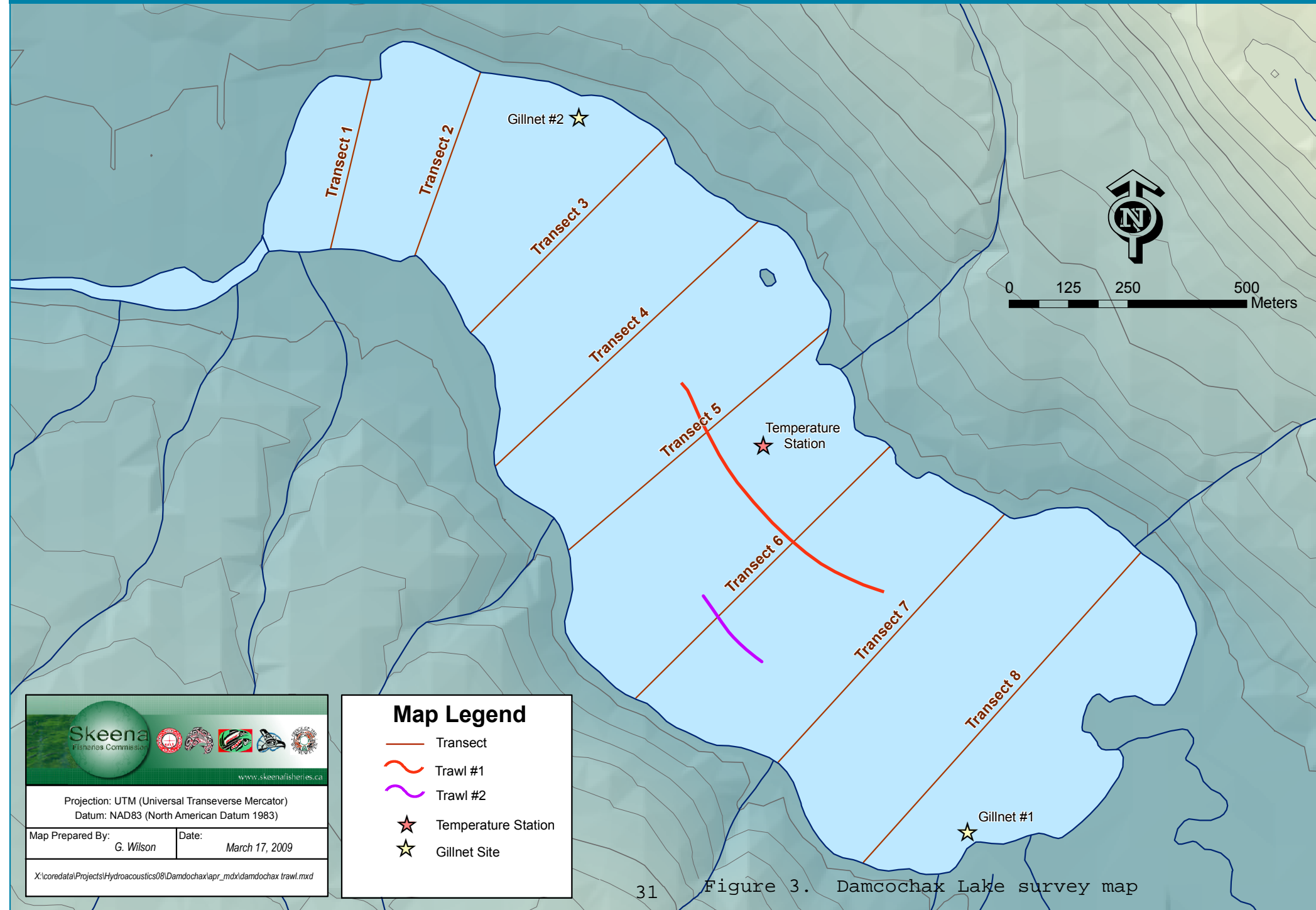


Figure 2. Lakelse Lake survey map



# Damdochax Lake



# W i i m i n o s i k L a k e

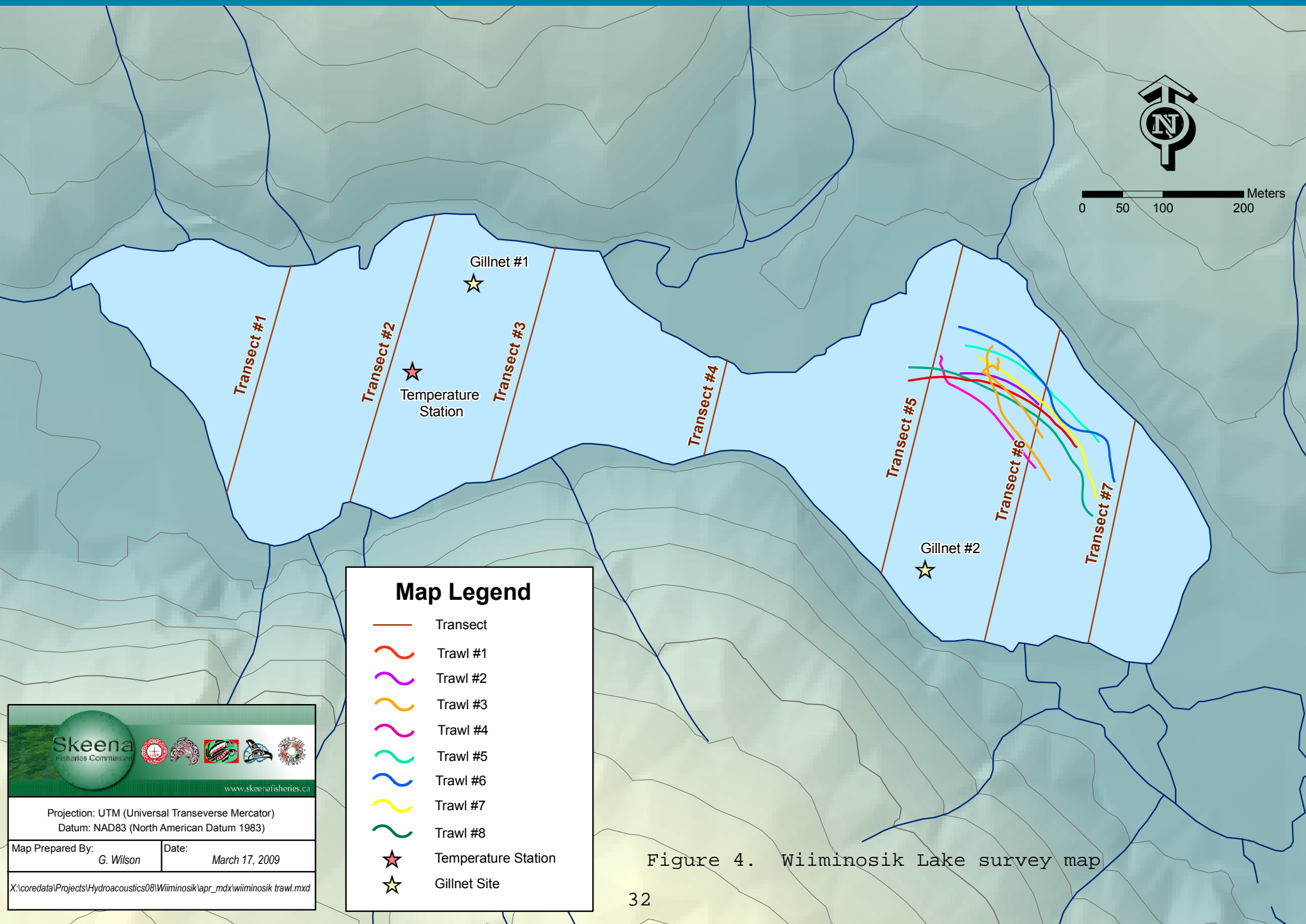


Figure 4. Wiiminosik Lake survey map



# Bear Lake

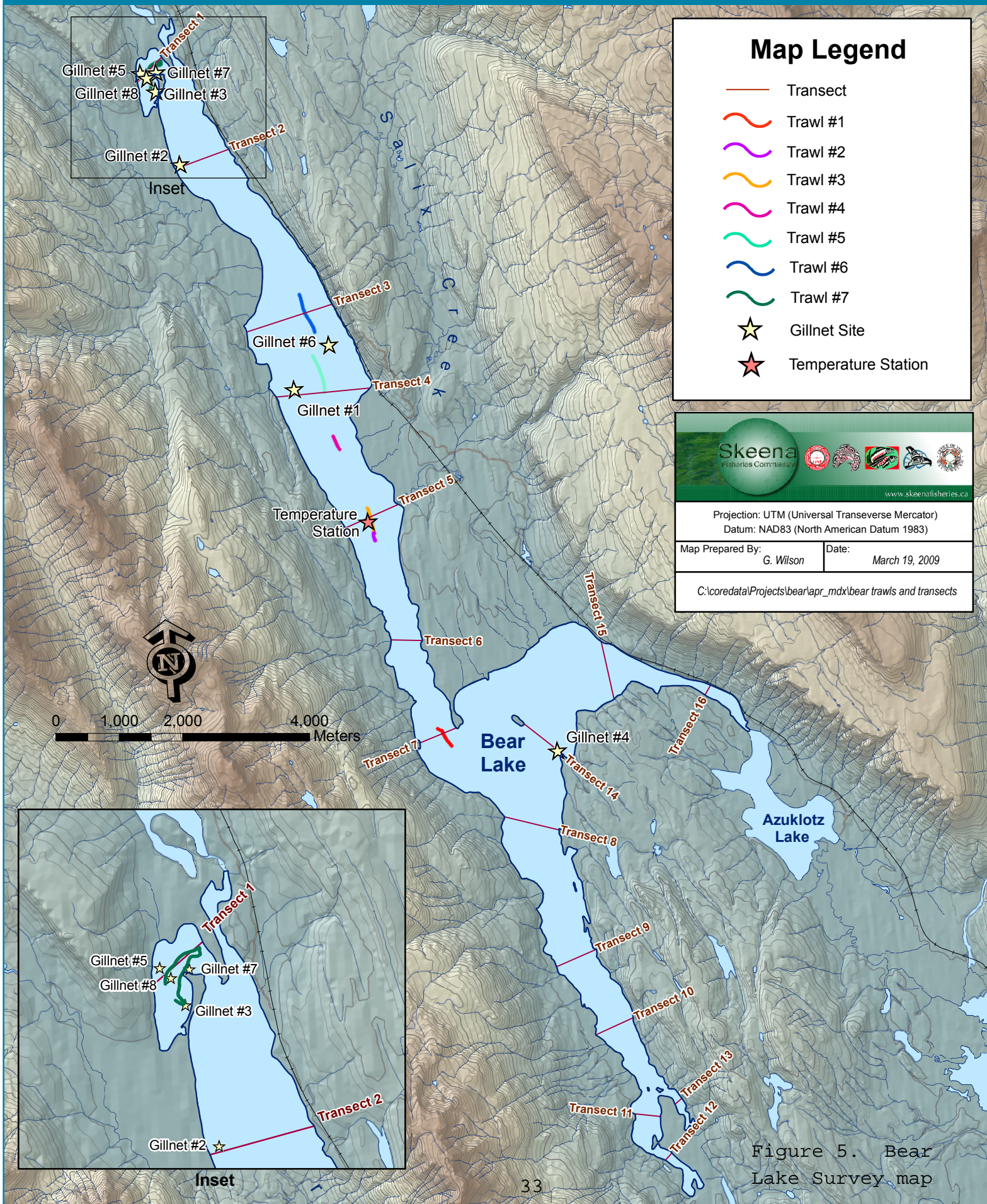
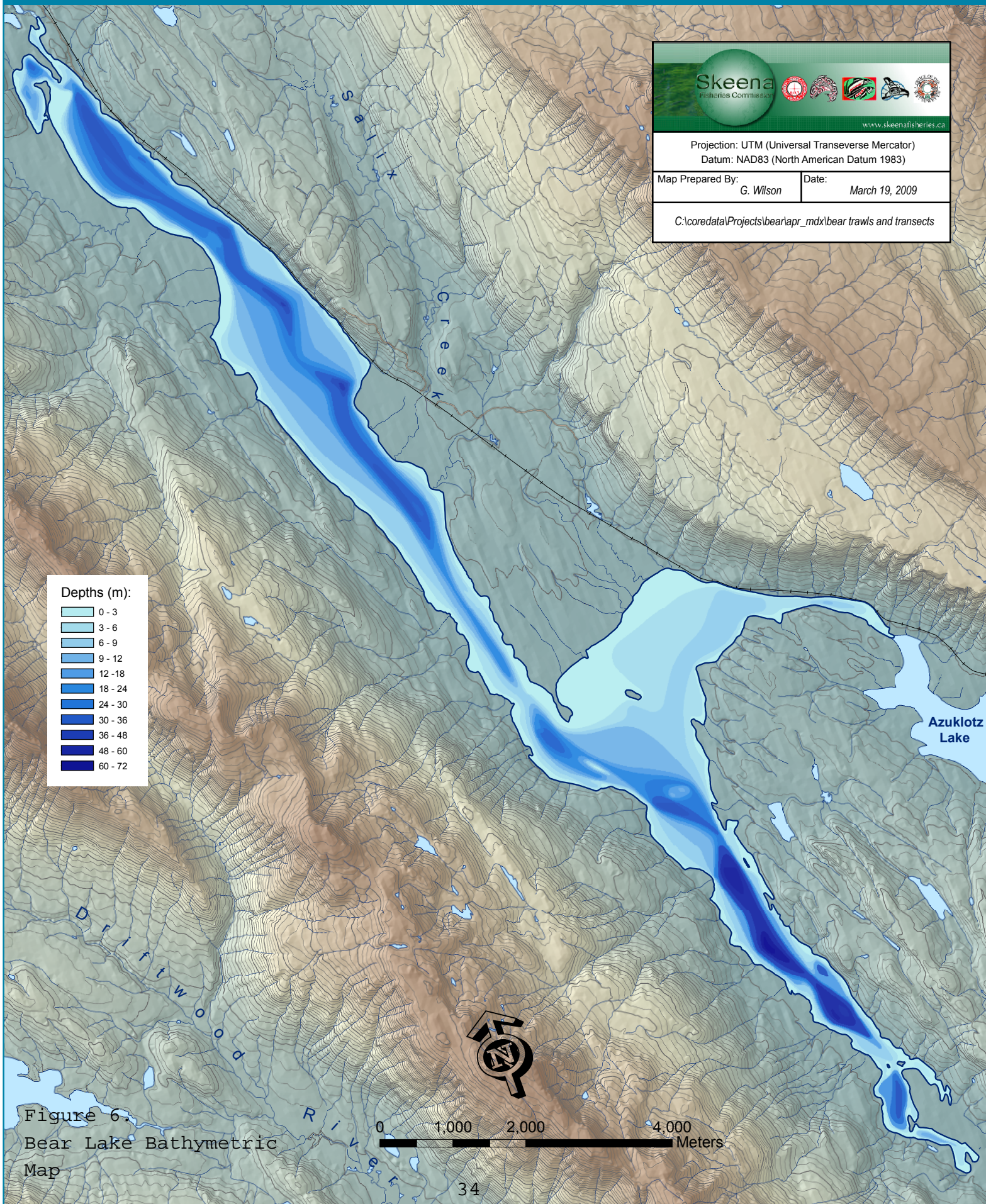


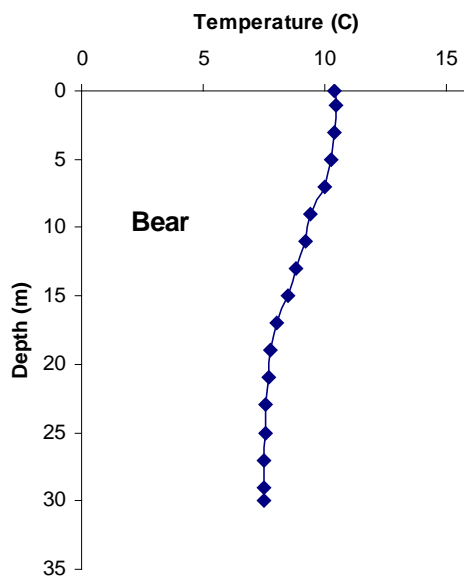
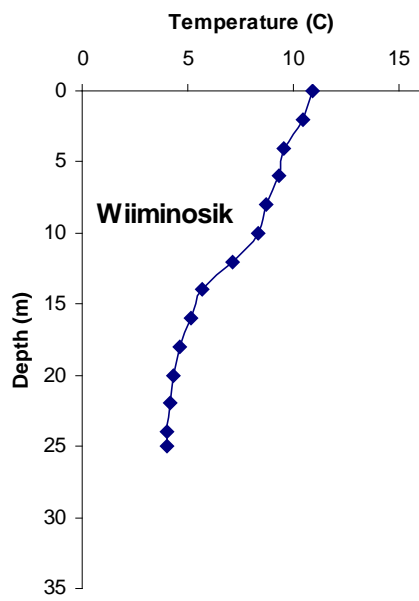
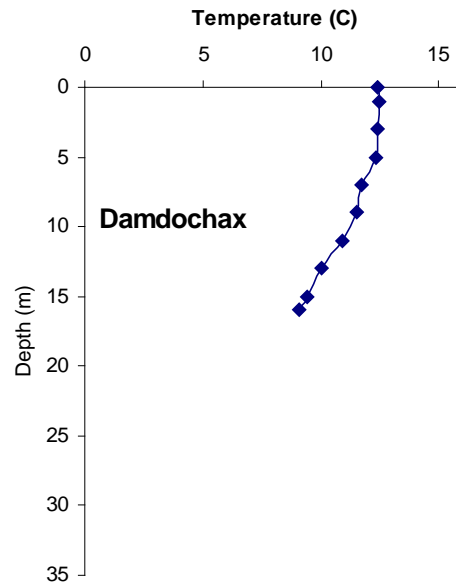
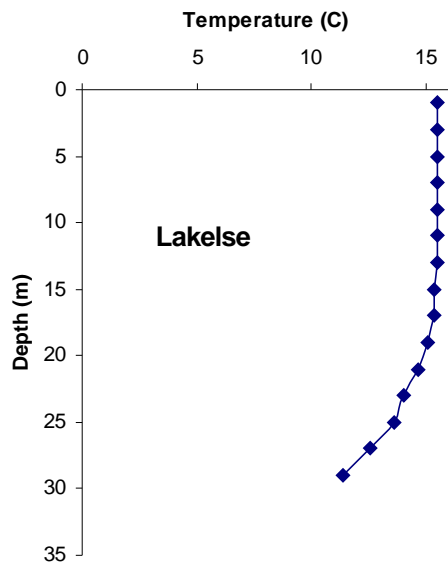
Figure 5. Bear Lake Survey map



# Bear Lake







**Figure 7. Temperature profiles for lakes surveyed in 2008**

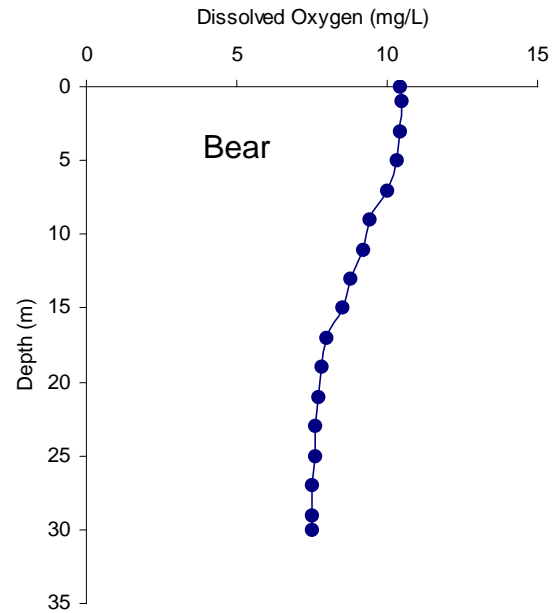
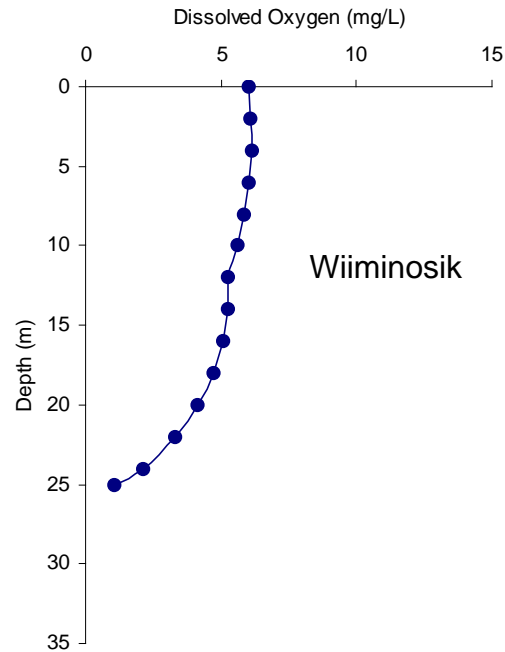
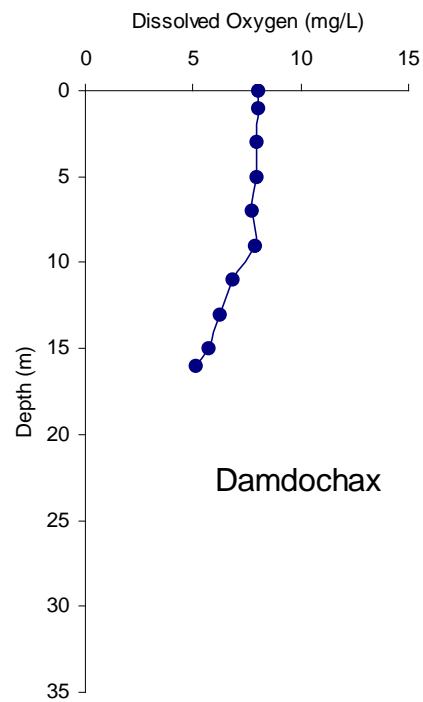
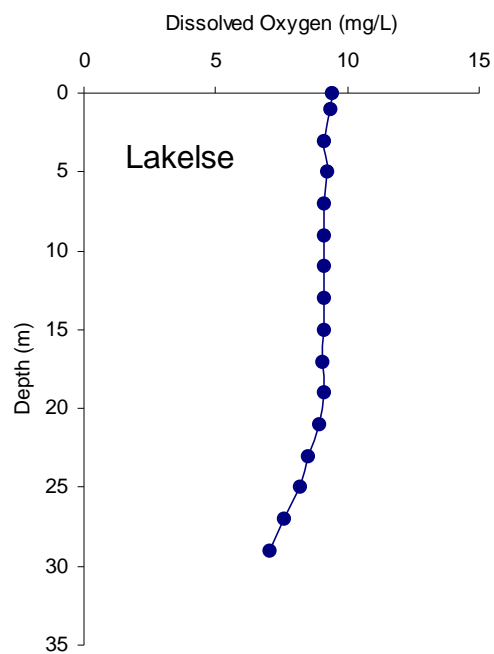


Figure 8. Dissolved oxygen profiles for lakes sampled in 2008



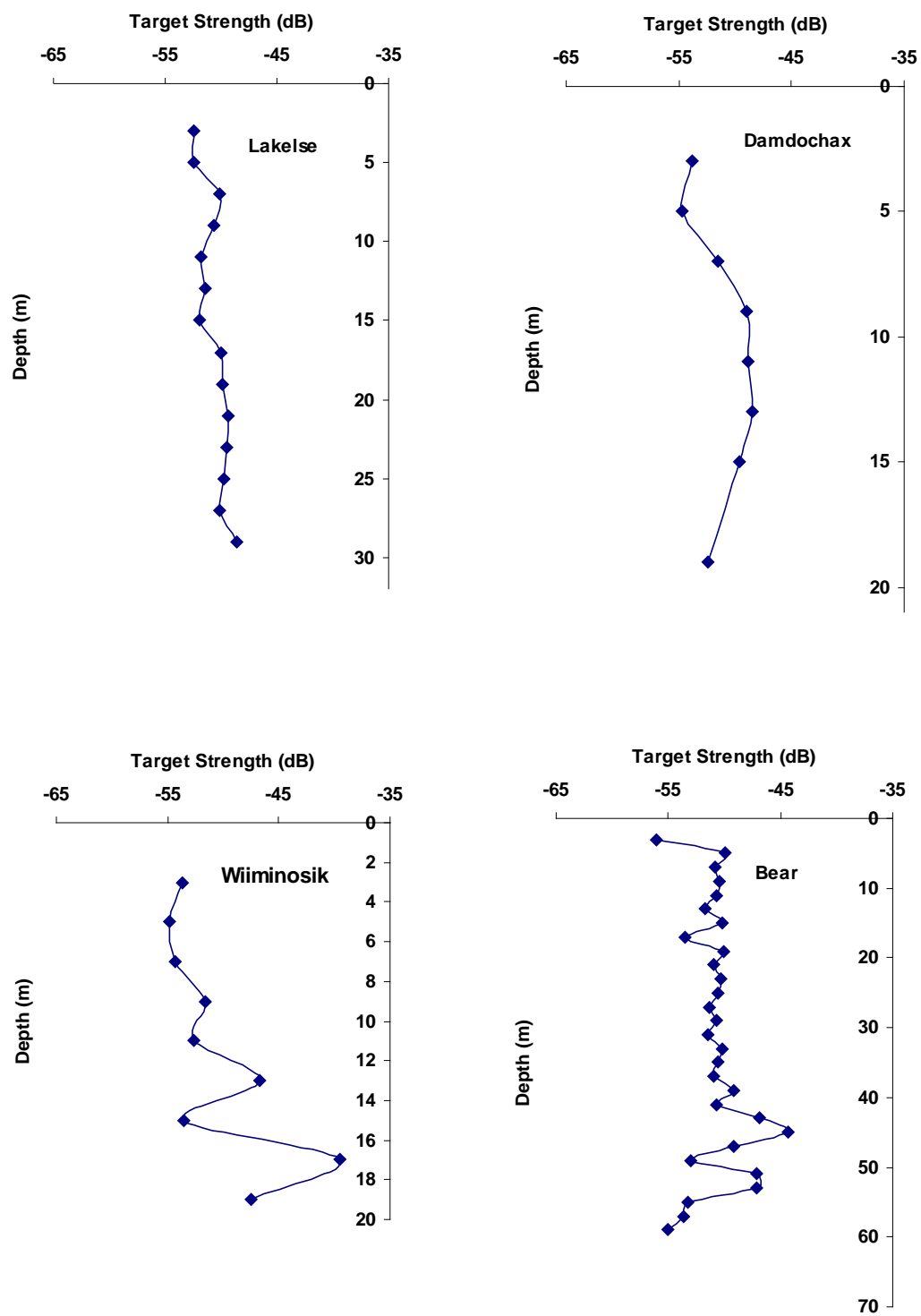


Figure 9. Average target strength (dB) by depth layer for 2008 lake surveys. Note different scales.

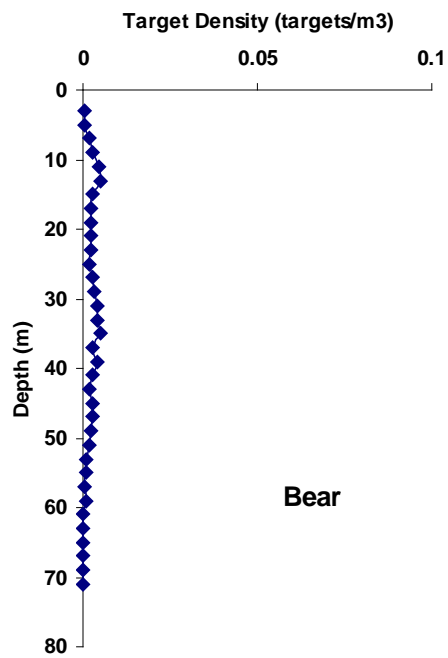
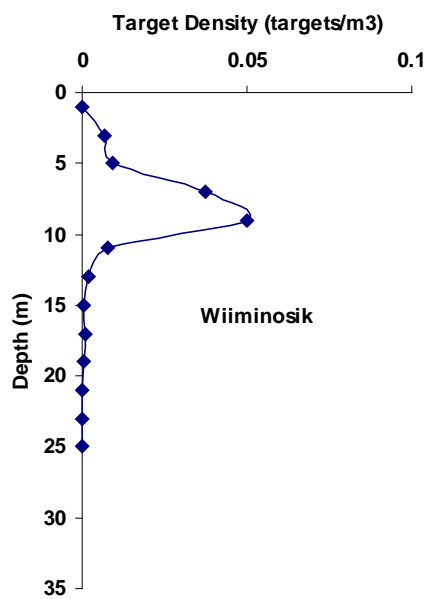
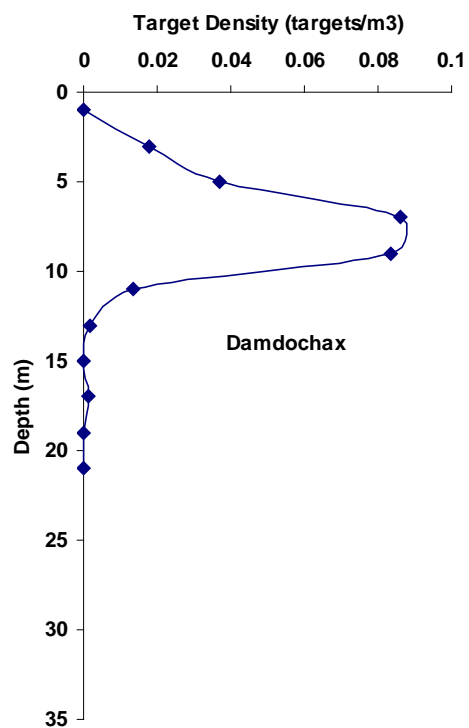
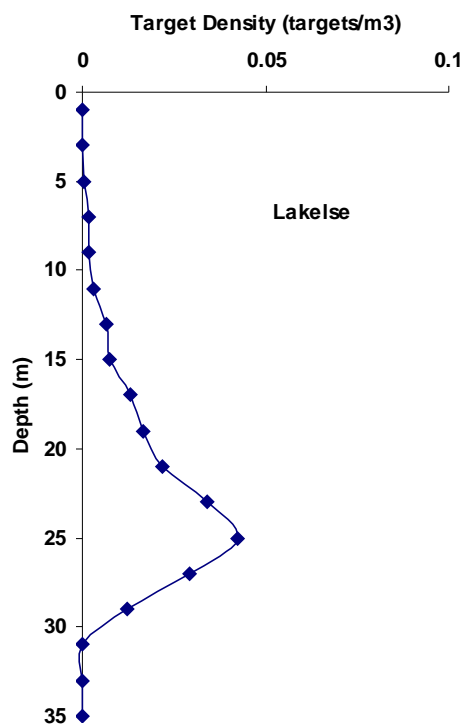


Figure 10. Vertical distribution of target density for 2008 lake surveys. Note different scales

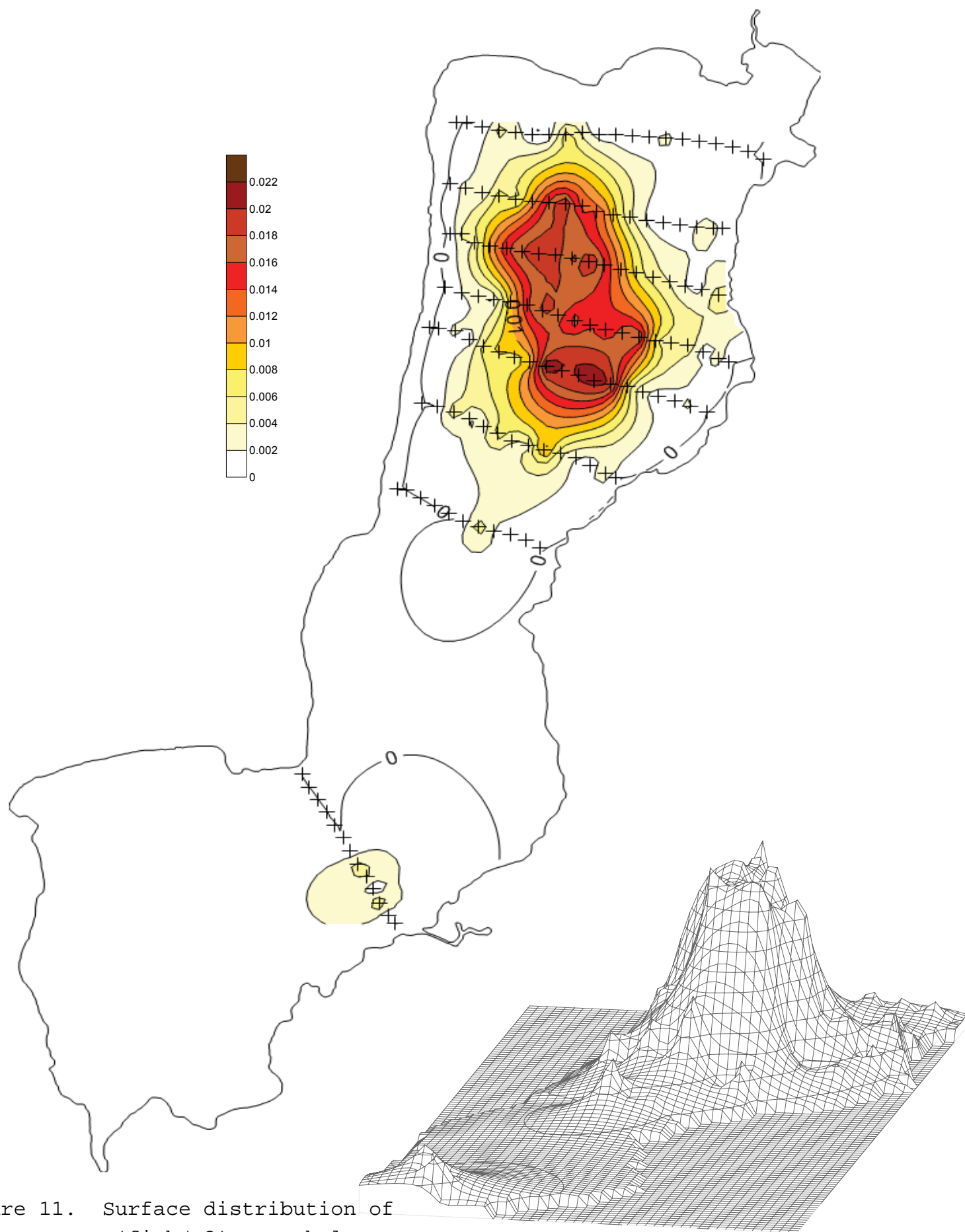


Figure 11. Surface distribution of fish targets (fish/m<sup>3</sup>) at Lakelse Lake, 2008. Data points along transects are indicated by crosses.

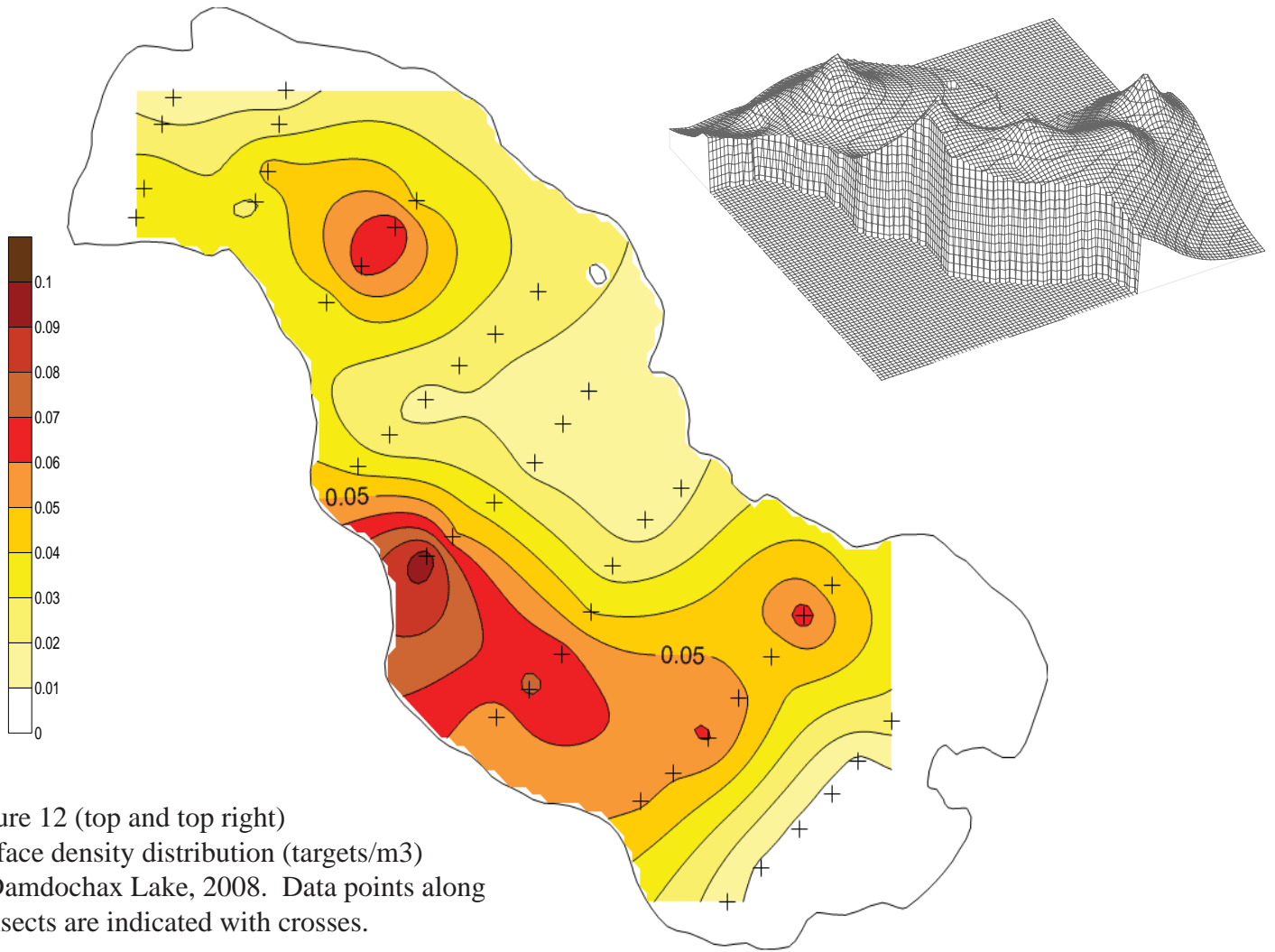


Figure 12 (top and top right)  
Surface density distribution (targets/m<sup>3</sup>)  
at Damdochax Lake, 2008. Data points along  
transects are indicated with crosses.

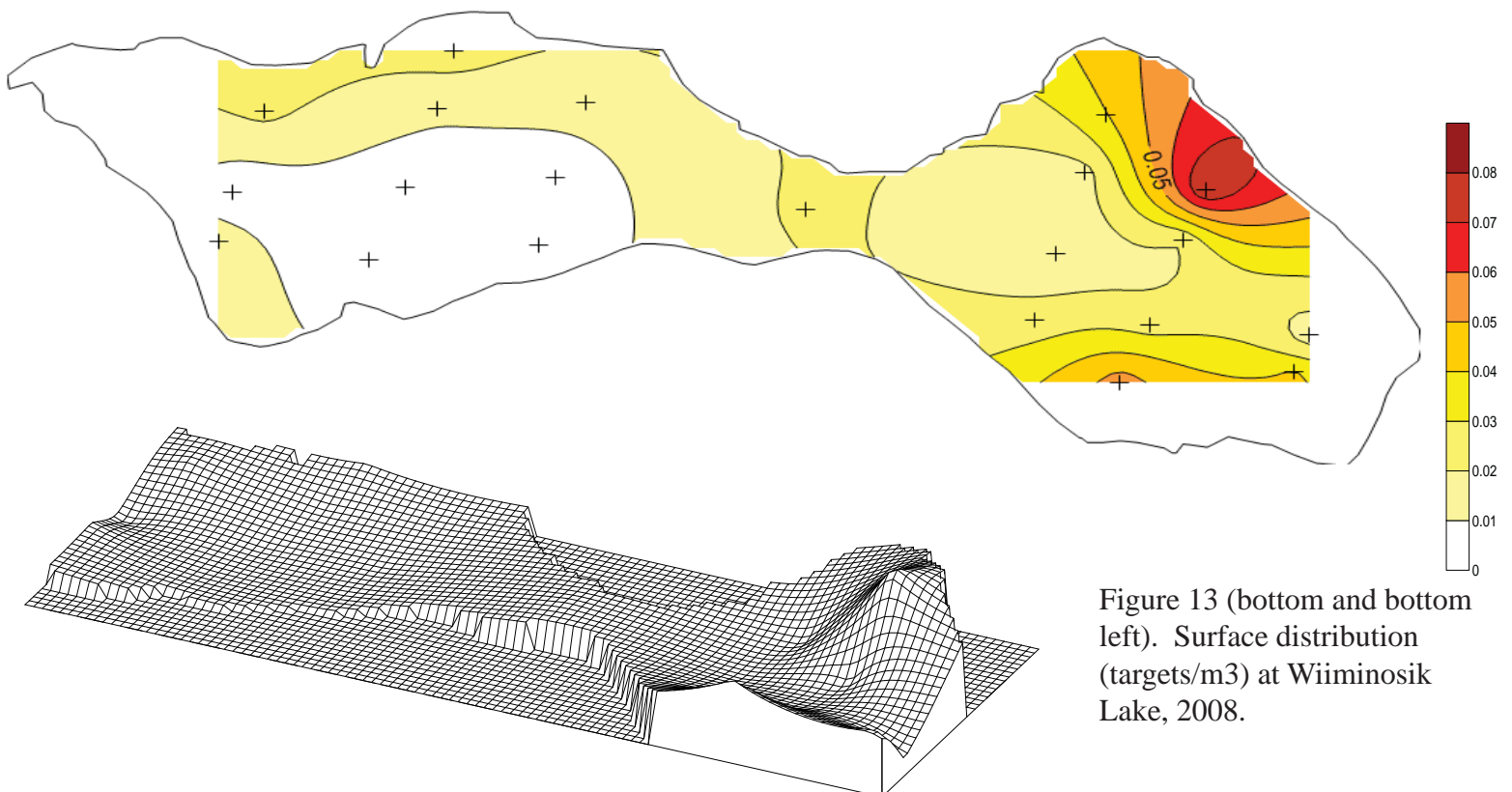


Figure 13 (bottom and bottom  
left). Surface distribution  
(targets/m<sup>3</sup>) at Wiiminosik  
Lake, 2008.

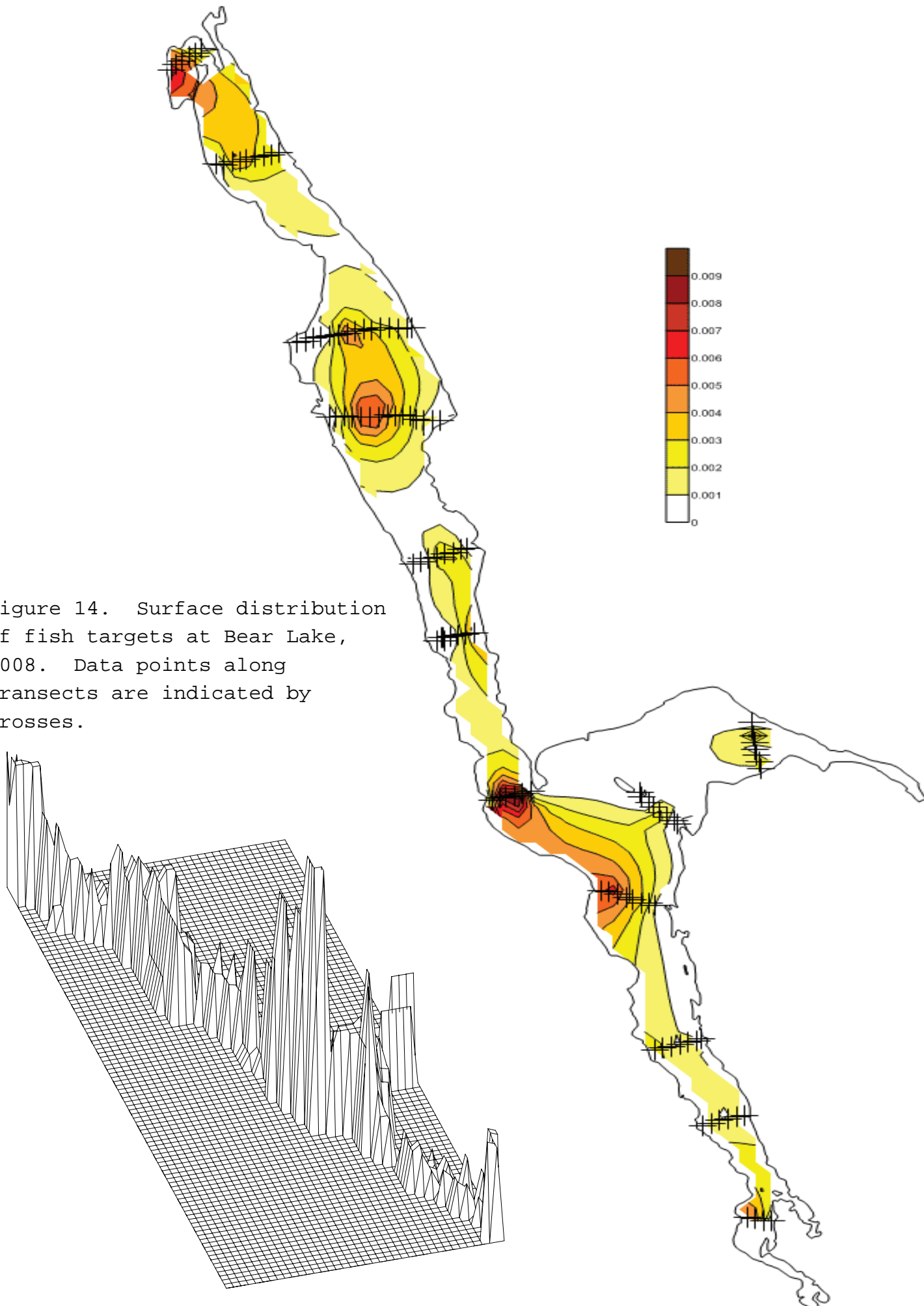
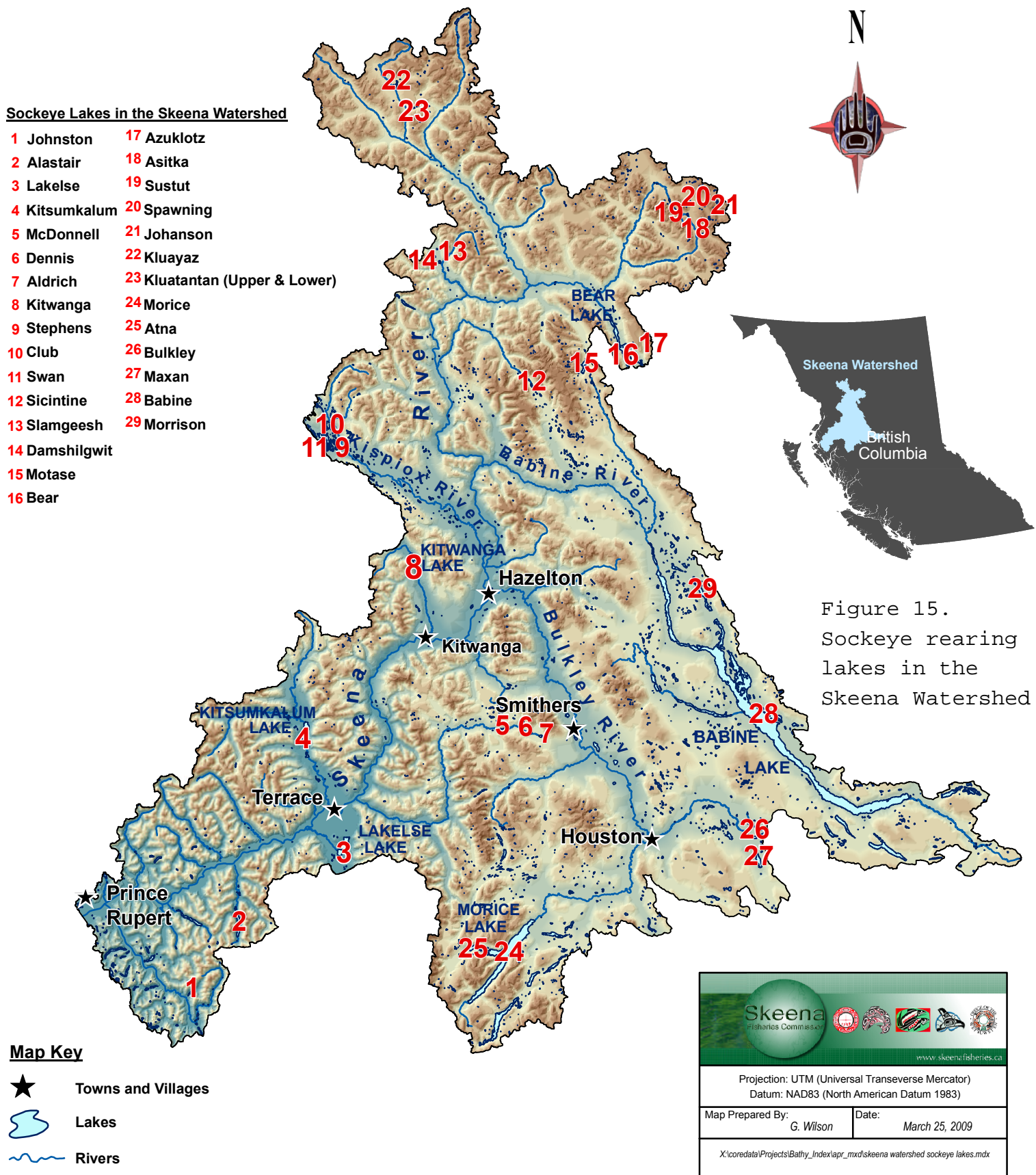


Figure 14. Surface distribution of fish targets at Bear Lake, 2008. Data points along transects are indicated by crosses.



# Sockeye Lakes



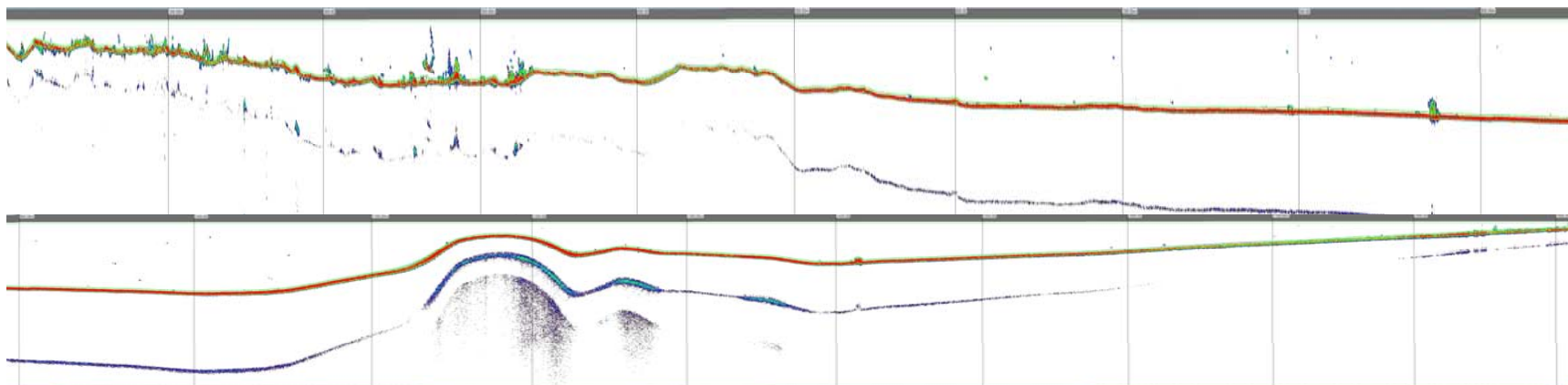


Fig 16. Lakelse Lake 2008 Transect 0.7

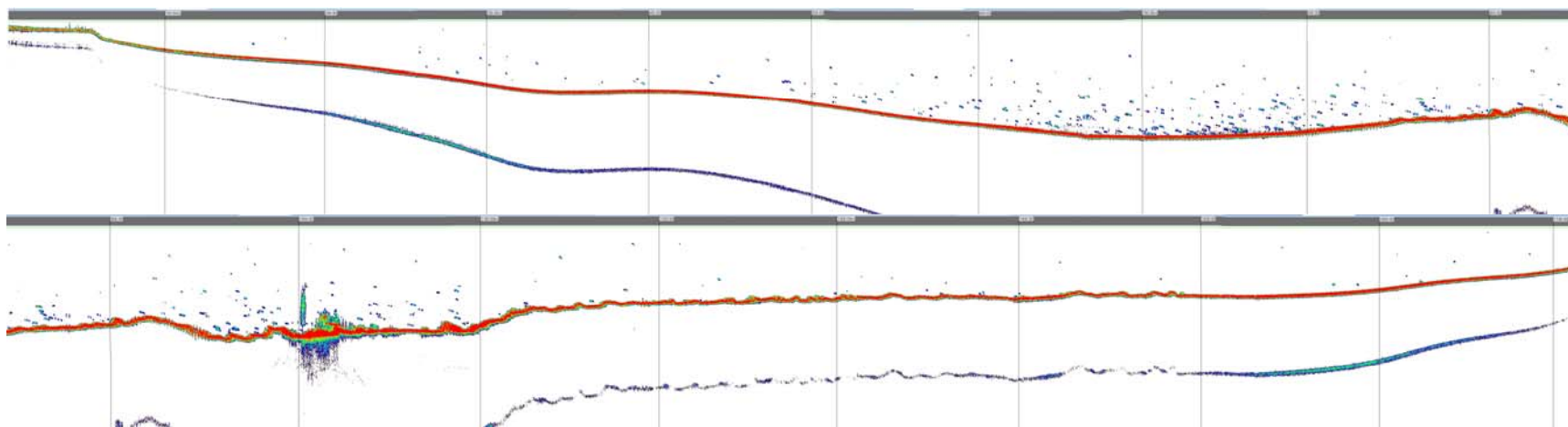


Fig 17. Lakelse Lake 2008 Transect 1.4

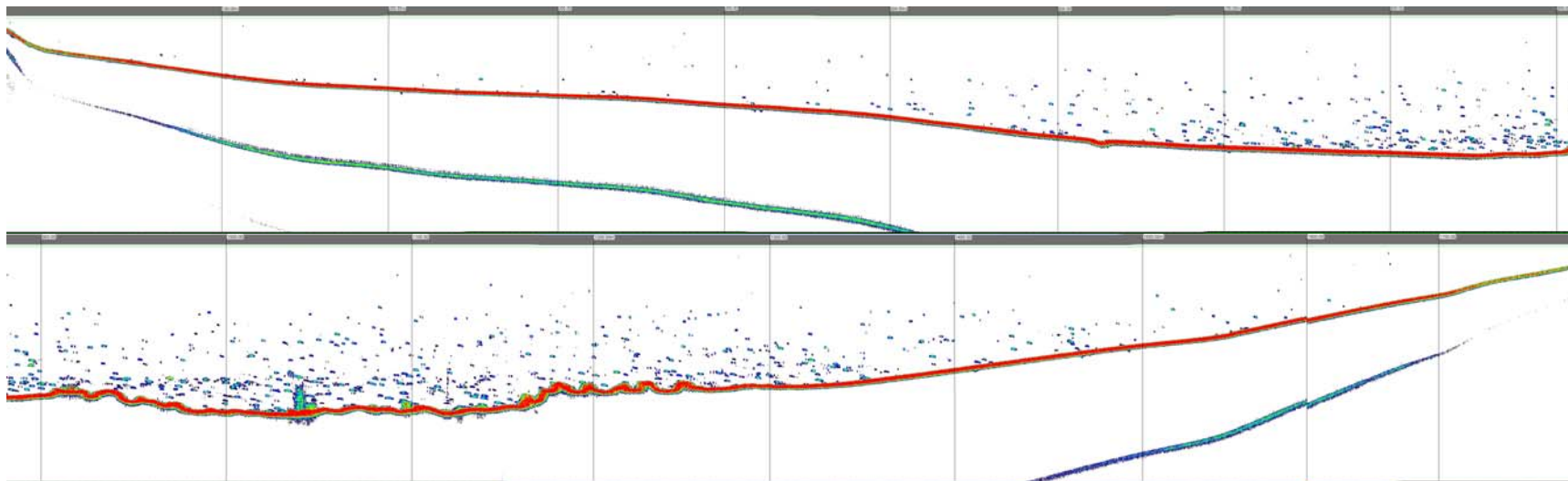


Fig 18. Lakelse Lake 2008 Transect 2.1

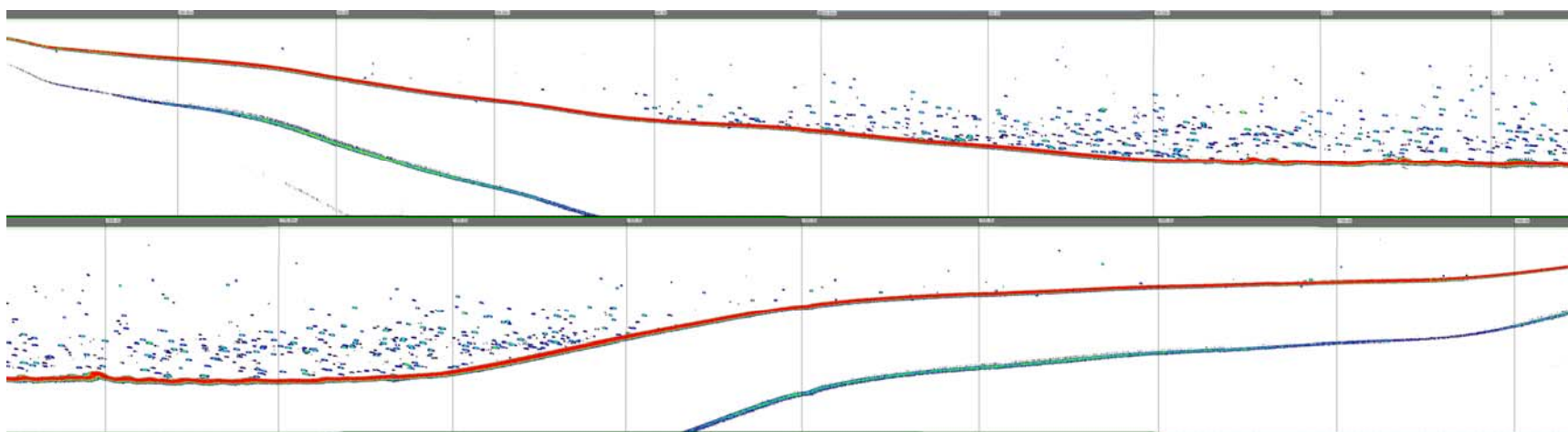


Fig 19. Lakelse Lake 2008 Transect 2.6



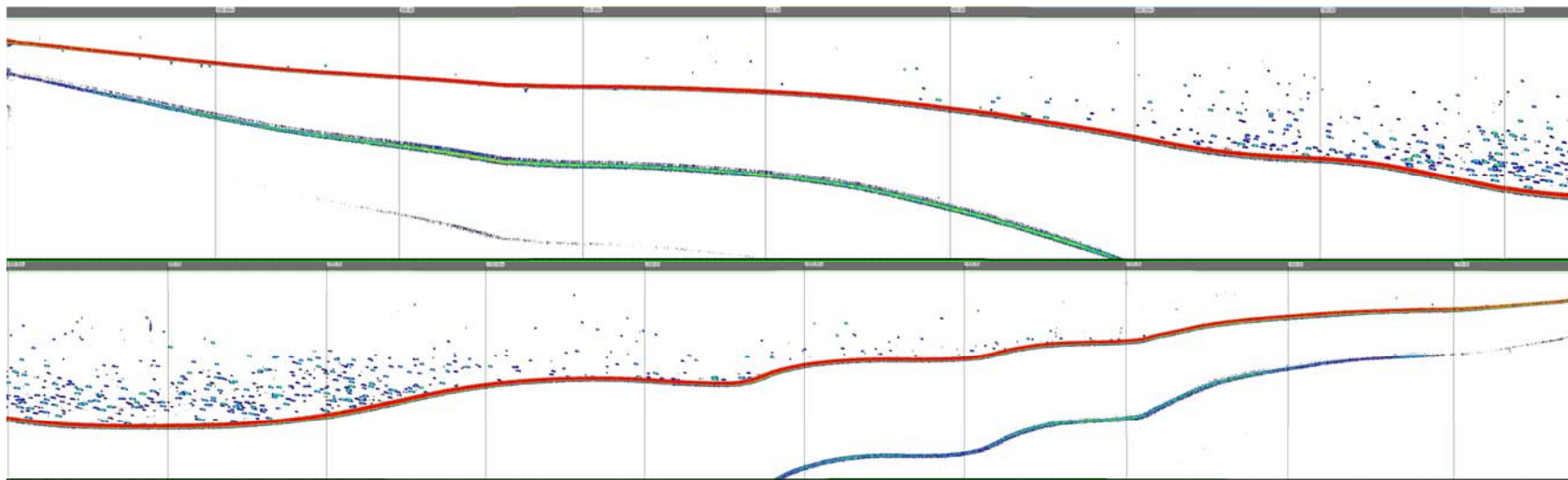


Fig 20. Lakelse Lake 2008 Transect 3.4

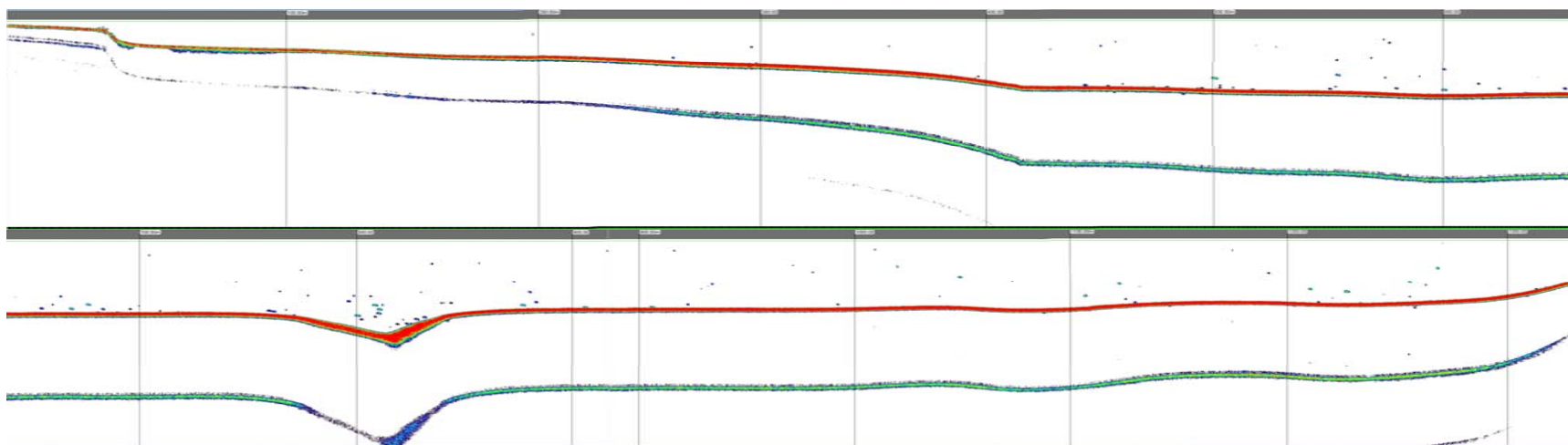


Fig 21. Lakelse Lake 2008 Transect 4.2

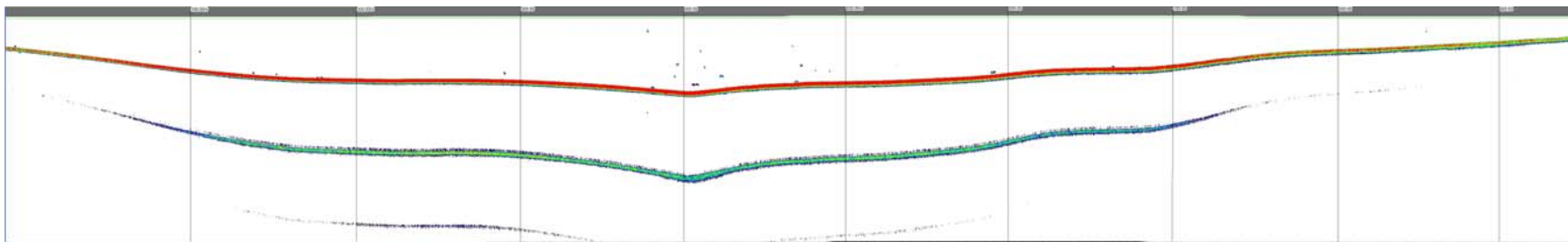


Fig 22. Lakelse Lake 2008 Transect 4.8

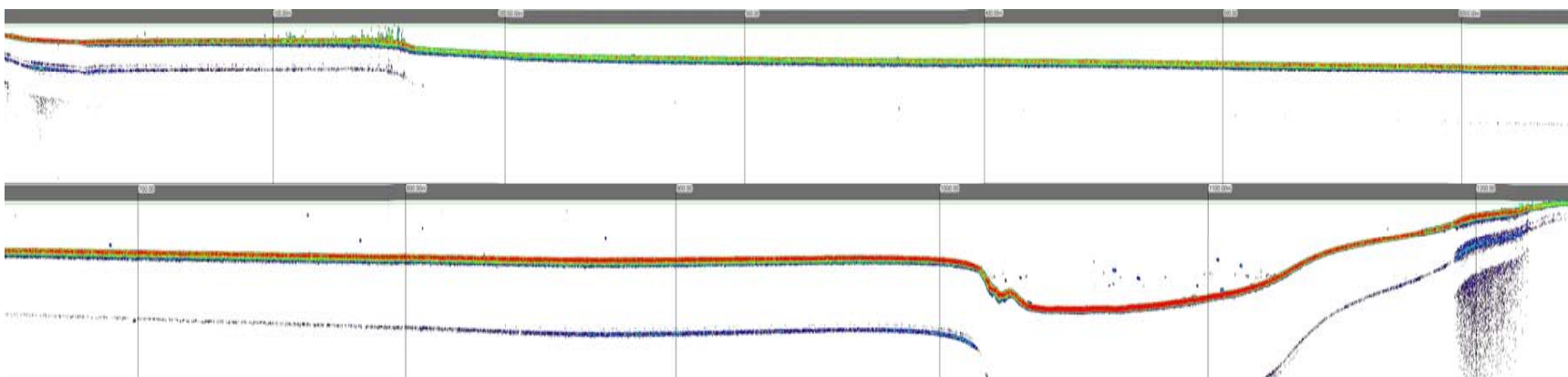


Fig 23. Lakelse Lake 2008 Transect 7.0

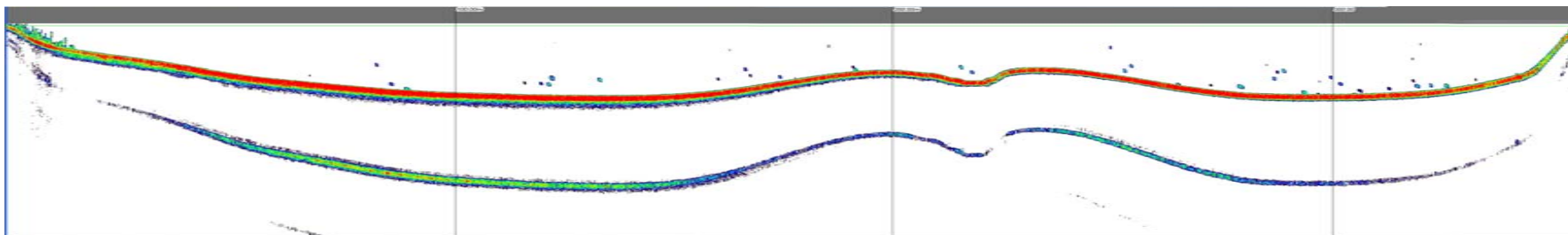


Fig 24. Damdochax Lake 2008 Transect 1

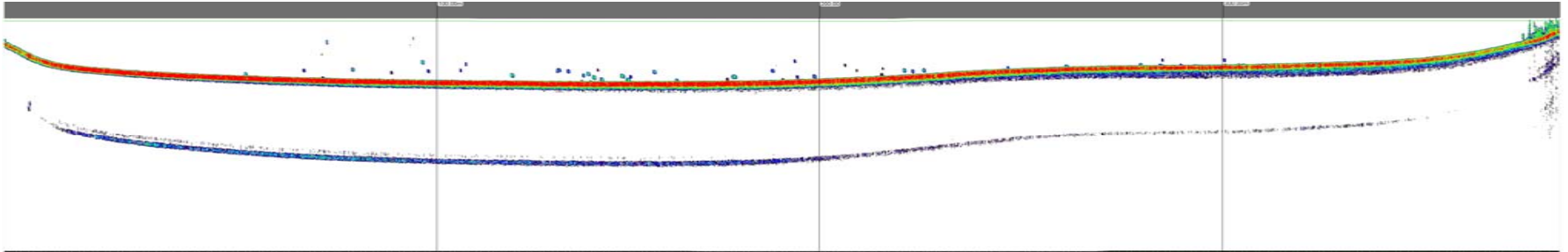


Fig 25. Damdochax Lake 2008 Transect 2

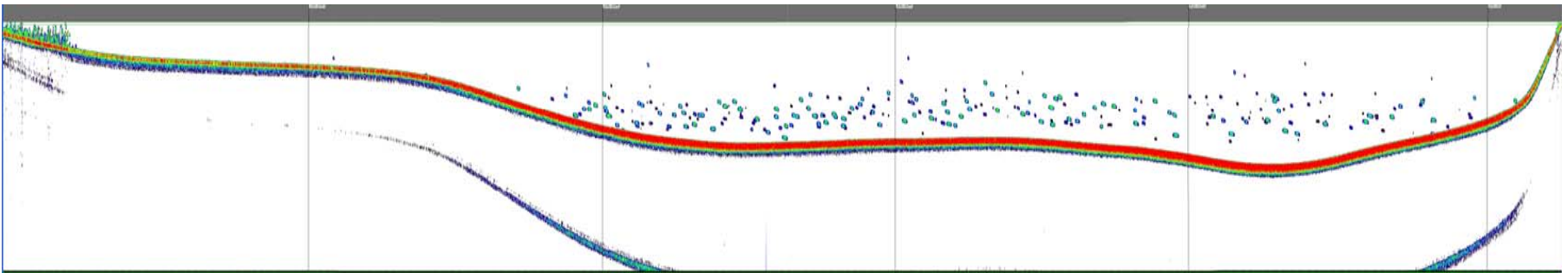


Fig 26. Damdochax Lake 2008 Transect 3

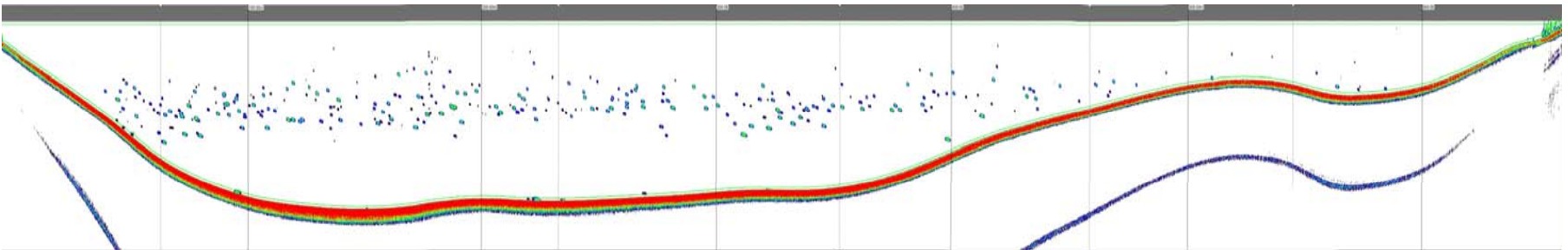


Fig 27. Damdochax Lake 2008 Transect 4

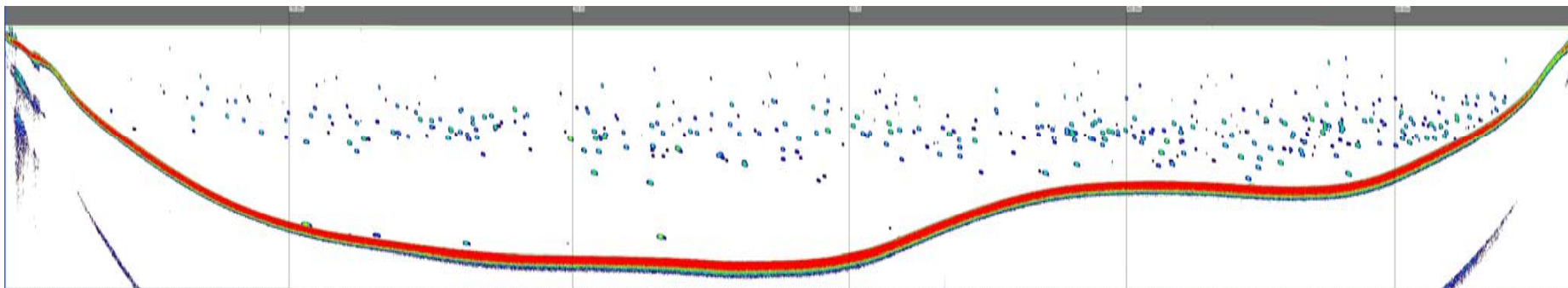


Fig 28. Damdochax Lake 2008 Transect 5

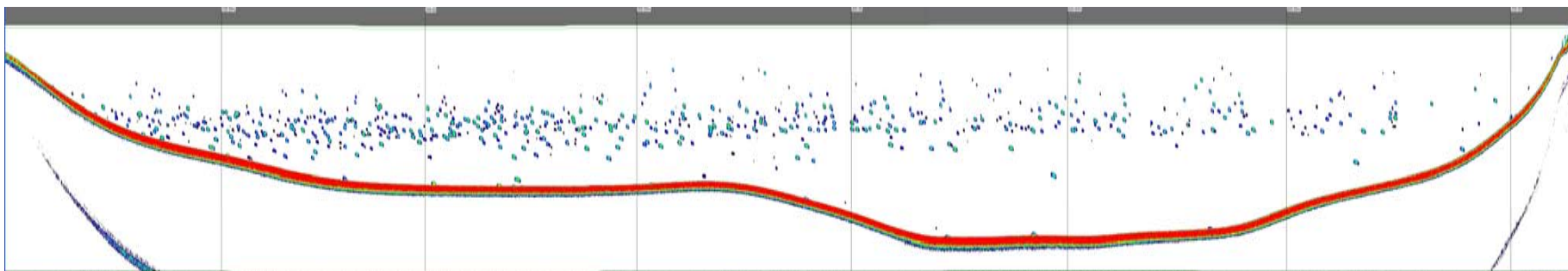


Fig 29. Damdochax Lake 2008 Transect 6

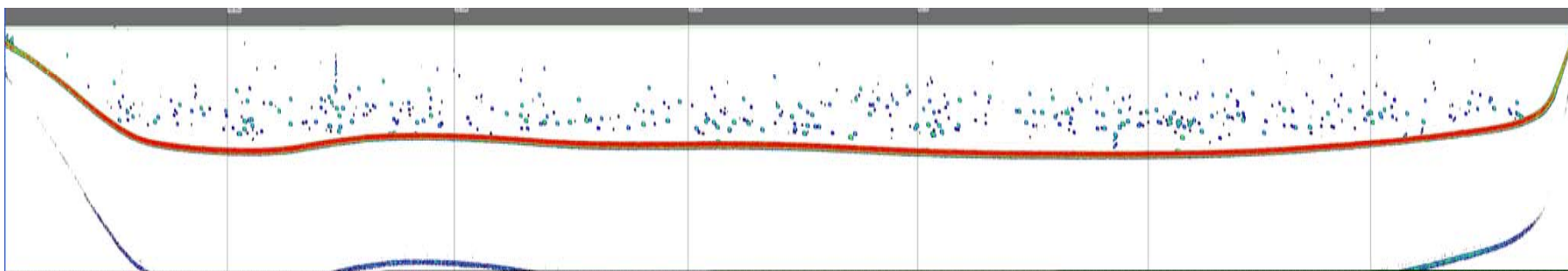


Fig 30. Damdochax Lake 2008 Transect 7

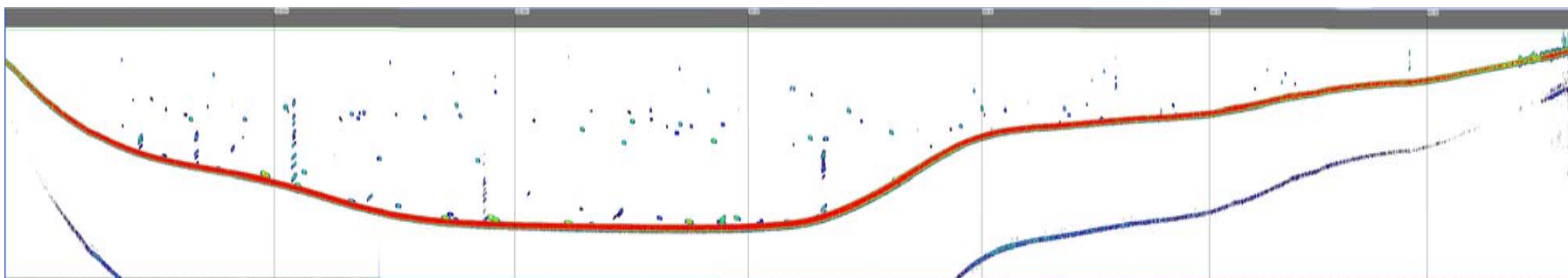


Fig 31. Damdochax Lake 2008 Transect 8

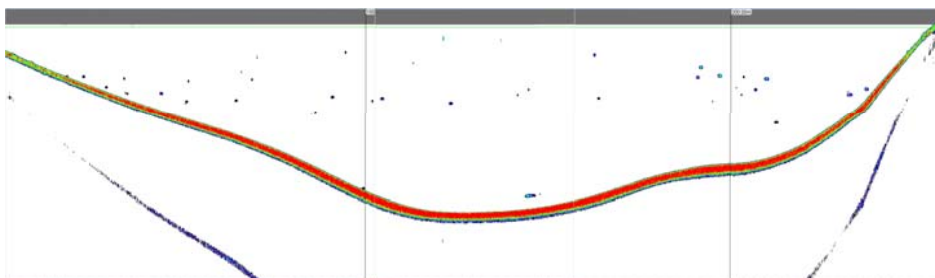


Fig 32. Wiiminosik Lake 2008 Transect 1

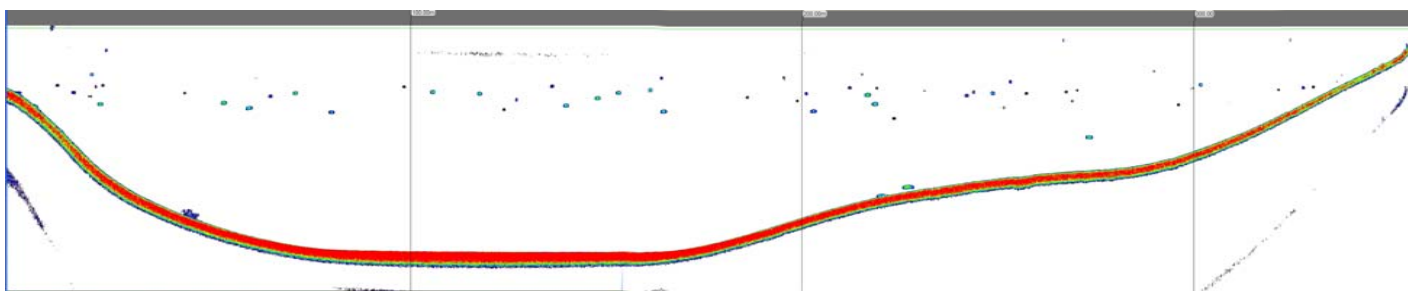


Fig 33. Wiiminosik Lake 2008 Transect 2



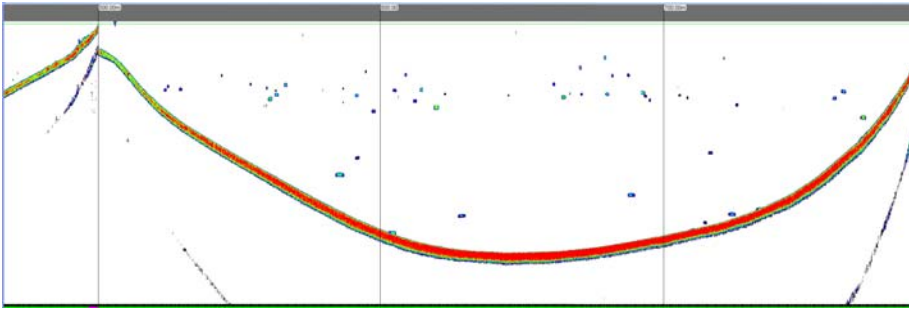


Fig 34. Wiiminosik Lake 2008 Transect 3

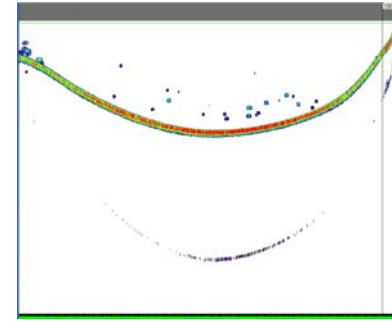


Fig 35. Wiiminosik Lake 2008 Transect 4

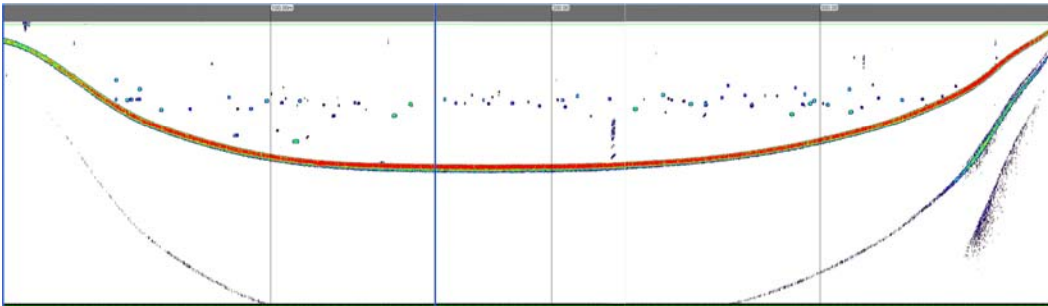


Fig 36. Wiiminosik Lake 2008 Transect 5

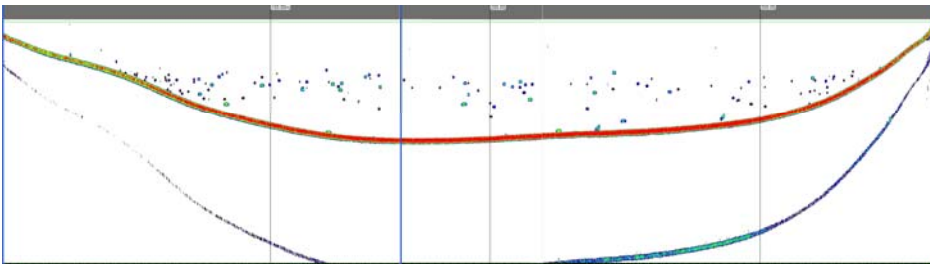


Fig 37. Wiiminosik Lake 2008 Transect 6

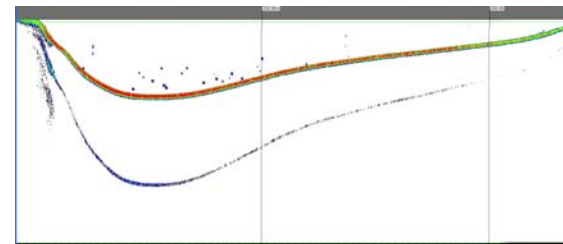


Fig 38. Wiiminosik Lake Transect 7

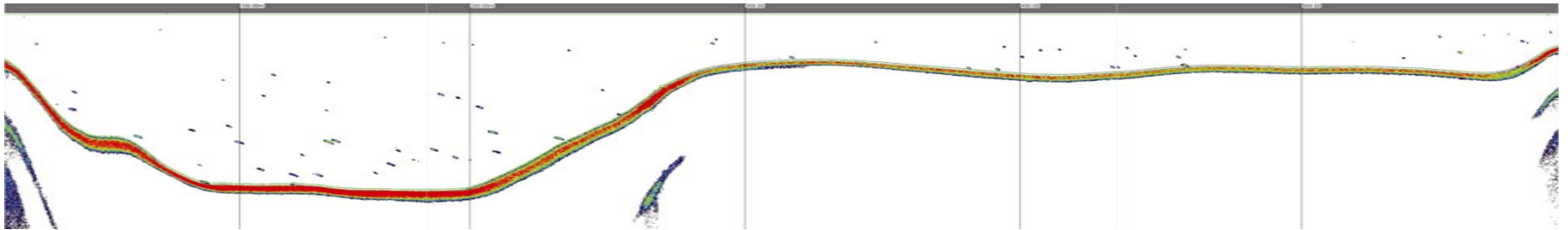


Fig 39. Bear Lake 2008 Transect 1

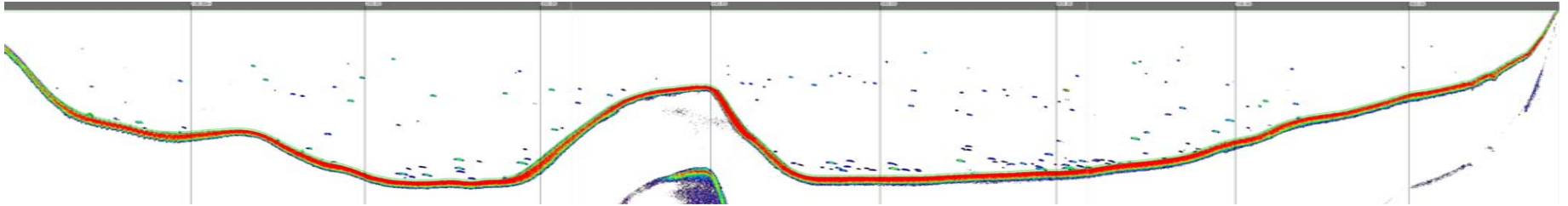


Fig 40. Bear Lake 2008 Transect 2

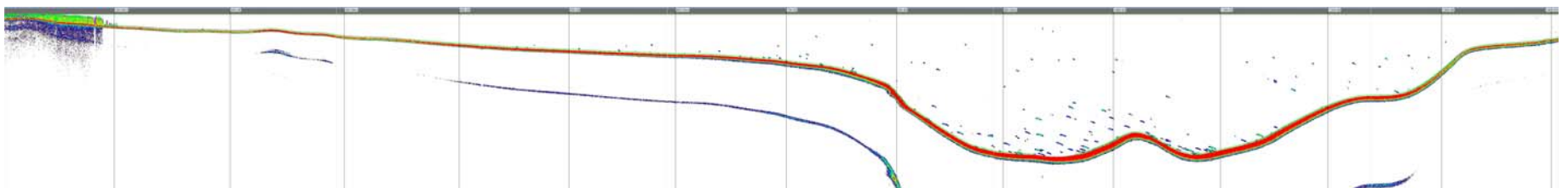


Fig 41. Bear Lake 2008 Transect 3

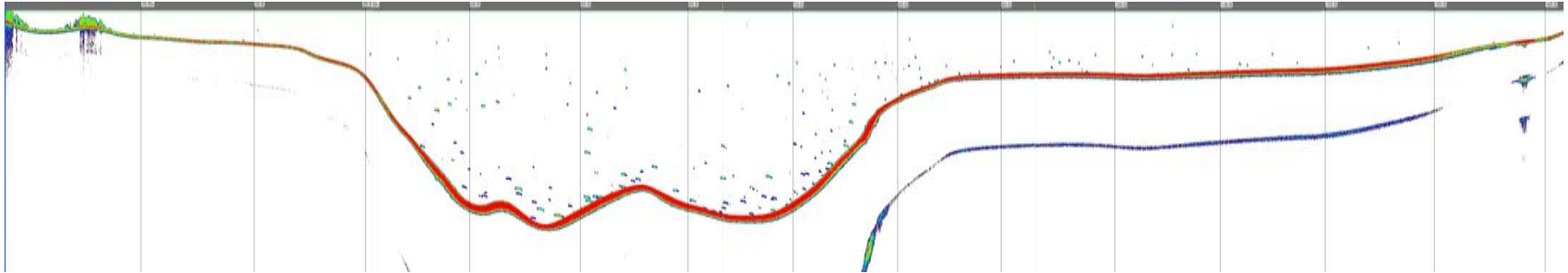


Fig 42. Bear Lake 2008 Transect 4

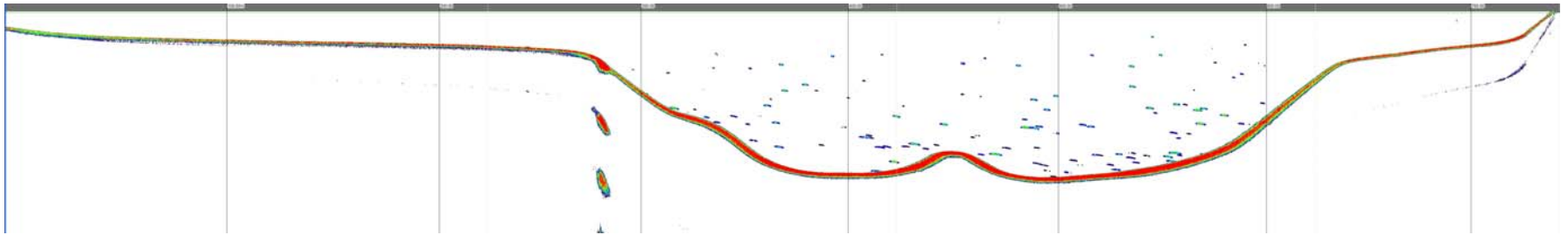


Fig 43. Bear Lake 2008 Transect 5

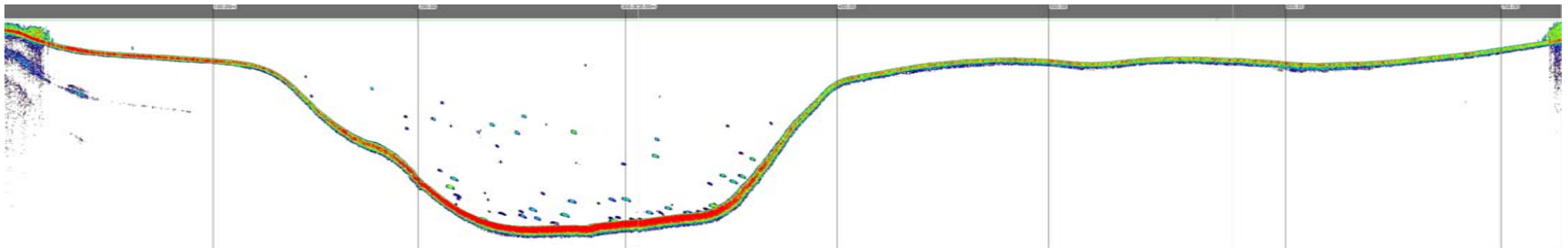


Fig 44. Bear Lake 2008 Transect 6



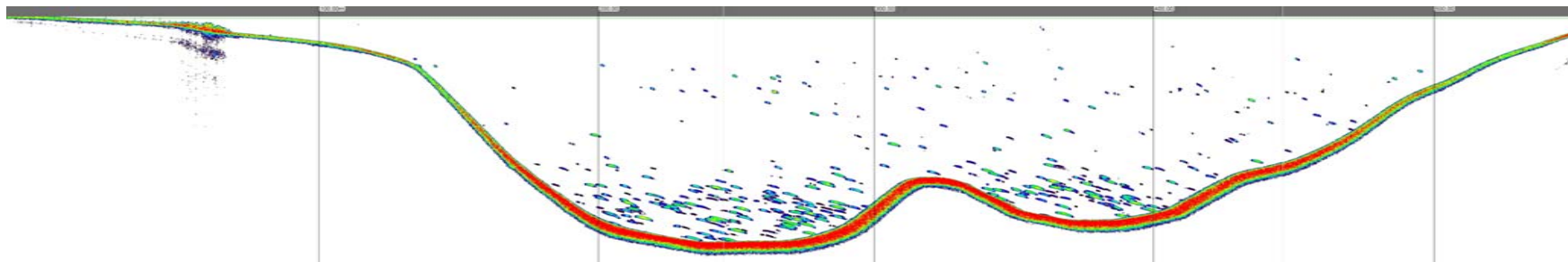


Fig 45. Bear Lake 2008 Transect 7

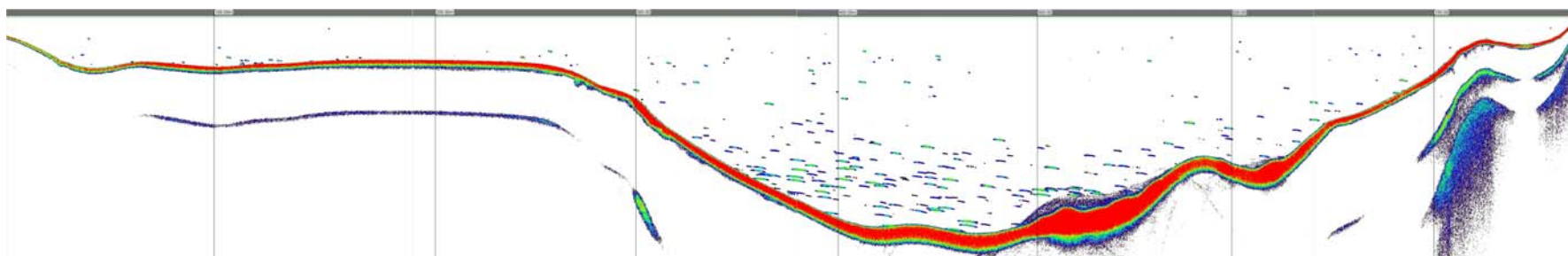


Fig 46. Bear Lake 2008 Transect 8

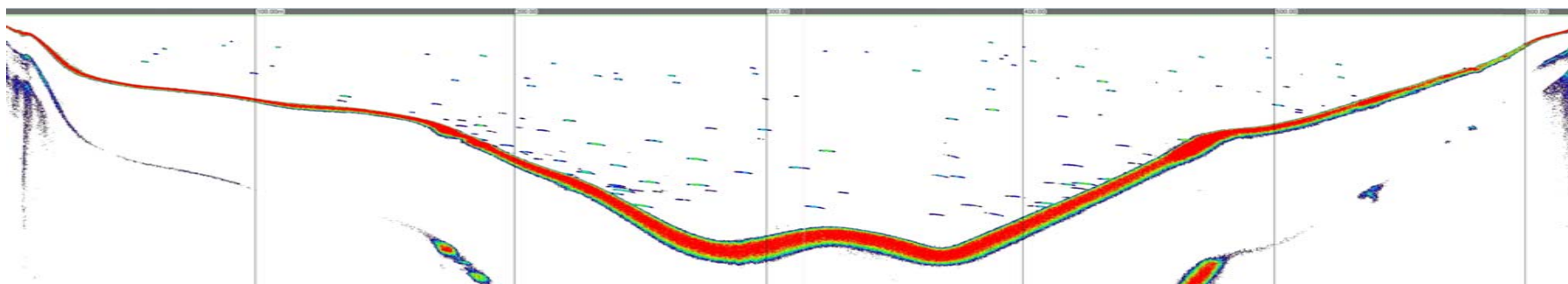


Fig 47. Bear Lake 2008 Transect 9

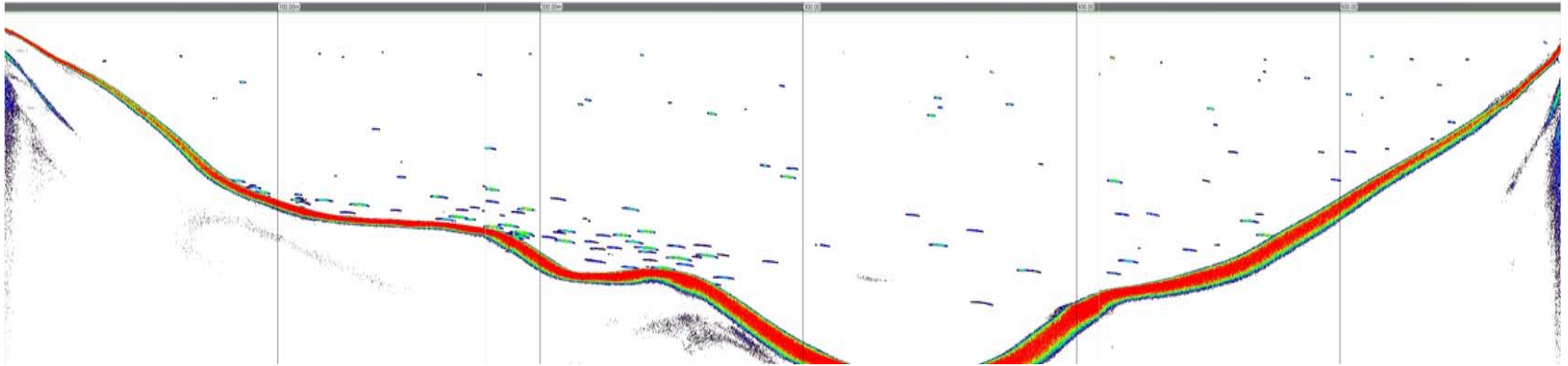


Fig 48. Bear Lake 2008 Transect 10

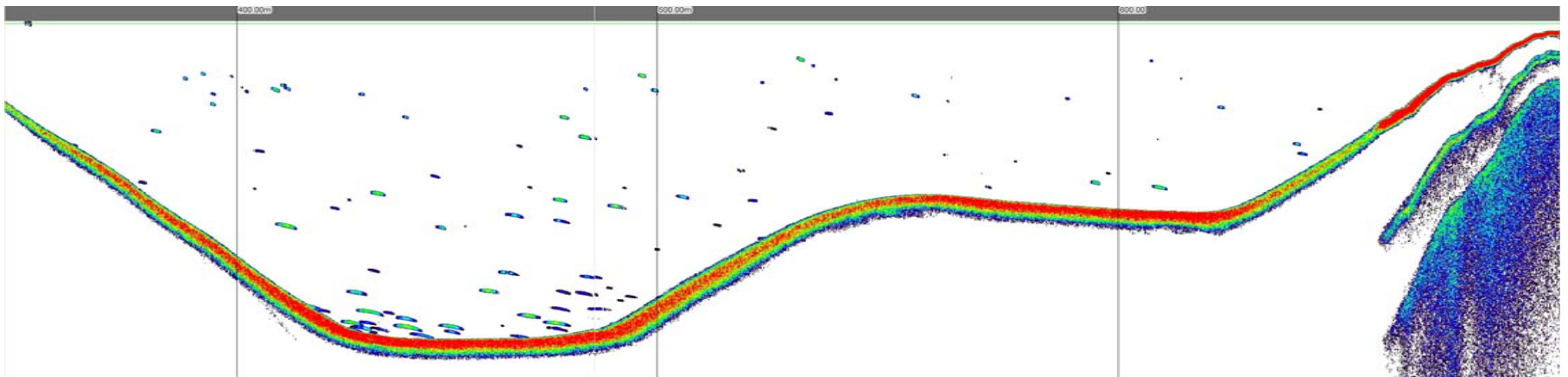


Fig 49. Bear Lake 2008 Transect 11

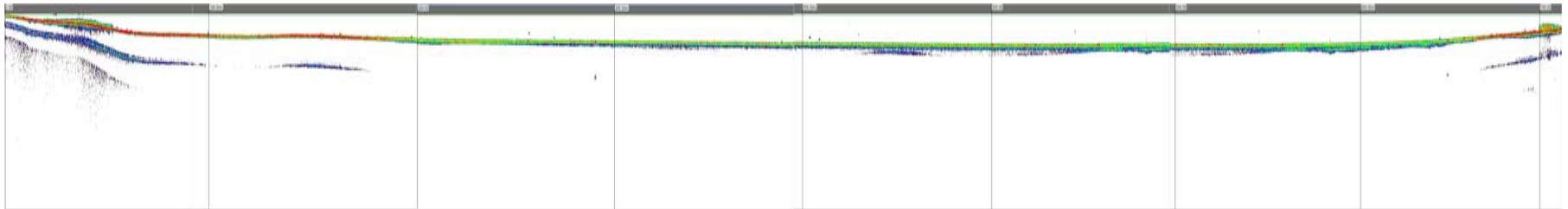


Fig 50. Bear Lake 2008 Transect 14

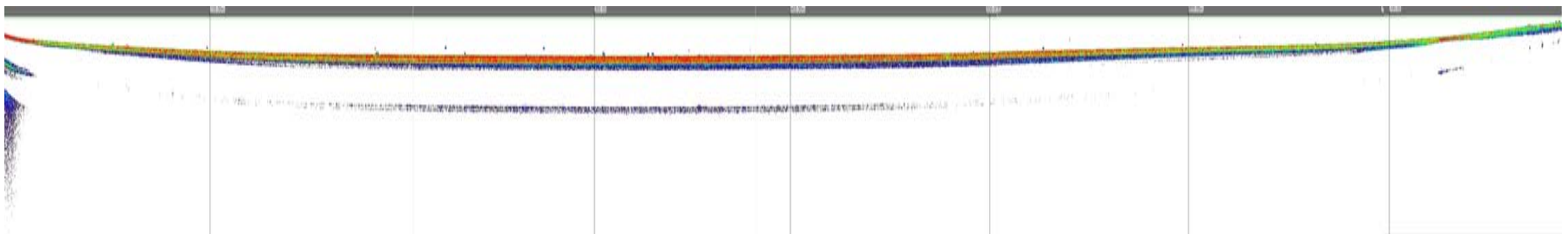


Fig 51. Bear Lake 2008 Transect 15