



Skeena & Nass Sockeye Lakes Hydroacoustic Surveys Report 2007

Prepared for the Pacific Salmon Commission by:
Peter Hall, B.Sc., R.P. Bio. and Charmaine Carr-Harris, B.A.

April 2008

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

EXECUTIVE SUMMARY

The Skeena Fisheries Commission 2007 sockeye (*Oncorhynchus nerka*) fry hydroacoustic survey program consisted of a survey of Damdochax, Wiiminosik, Lakelse, Kitsumkalum and Kitwanga lakes. Hydroacoustic data was collected using a Biosonics DT-X split beam echo sounder with a 200 kHz transducer. The Kitsumkalum and Kitwanga lake surveys replicated previous DFO surveys while the other lakes' survey designs were modified or developed for the first time in 2007.

Limnetic fish were sampled using two different methodologies. The primary catch method was with a 2 x 2 m mid-water trawl. The second method was with two 12 m floating Swedish gillnets which had variable mesh size panels. Temperature and dissolved oxygen measurements were taken using a YSI meter. Bathymetric maps of Damdochax and Wiiminosik lakes were produced from GPS geo-referenced depth data collected from the Biosonics DT-X echo sounder.

Wiiminosik Lake was the only lake where no bathymetric map was available prior to the survey. The maximum depth (25 m) of the lake was surprising since it was deeper than the much larger Damdochax Lake. The Damdochax Lake bathymetry agreed closely with the results from a previous survey.

Trawl catches in Damdochax, Wiiminosik, and Kitsumkalum lakes exceeded 45 young-of-the-year *O. nerka* in each lake. The “small” size class hydroacoustic estimates were apportioned 100%, 90% and 98% to young-of-the-year *O. nerka* for each of the former lakes. Trawl catches were poor in Lakelse and Kitwanga lakes, which make it impossible to apportion the “small” size class hydroacoustic estimates with any degree of certainty.

Of all the 8 lakes/lake basins, the highest “small” size class densities were found in the east basin of Wiiminosik Lake followed by the west basin. Damdochax Lake had the next highest density estimates followed by the Kitwanga Lake south basin. The Lakelse Lake north basin and Kitsumkalum Lake had similar, but lower, densities. When the “small” size class densities were expanded for the size of the lake to get population estimates, the trend reverses with the lakes with the highest densities having the smallest population estimates. Despite having low densities, the large size of Kitsumkalum and Lakelse lakes result in higher population estimates than Damdochax and Wiiminosik lakes.

TABLE OF CONTENTS

| | |
|---|-----|
| EXECUTIVE SUMMARY | ii |
| TABLE OF CONTENTS | iii |
| LIST OF TABLES | iv |
| LIST OF FIGURES | v |
| INTRODUCTION | 1 |
| METHODS | 2 |
| RESULTS | 4 |
| Lake Bathymetry | 4 |
| Temperature and Oxygen Profiles | 4 |
| Fish Catch | 4 |
| Hydroacoustic Fish Estimates | 6 |
| Damdochax Lake | 6 |
| Wiiminosik Lake | 6 |
| Lakelse Lake | 7 |
| Kitsumkalum Lake | 7 |
| Kitwanga Lake | 8 |
| All Lakes | 8 |
| DISCUSSION | 9 |
| Damdochax Lake | 9 |
| Wiiminosik Lake | 9 |
| Lakelse Lake | 10 |
| Kitsumkalum Lake | 11 |
| Kitwanga Lake | 11 |
| REFERENCES | 12 |
| ACKNOWLEDGEMENTS | 14 |
| APPENDIX 1: Damdochax Lake Transect Echograms | 44 |
| APPENDIX 2: Wiiminosik Lake Transect Echograms | 47 |
| APPENDIX 3: Lakelse Lake Transect Echograms | 49 |
| APPENDIX 4: Kitsumkalum Lake Transect Echograms | 53 |
| APPENDIX 5: Kitwanga Lake Transect Echograms | 55 |
| APPENDIX 6: Damdochax Lake Fish Catch | 58 |
| APPENDIX 7: Wiiminosik Lake Fish Catch | 60 |
| APPENDIX 8: Lakelse Lake Fish Catch | 62 |
| APPENDIX 9: Kitsumkalum Lake Fish Catch | 63 |
| APPENDIX 10: Kitwanga Lake Fish Catch | 65 |
| APPENDIX 11: Hydroacoustic Data By Transect | 66 |

LIST OF TABLES

| | | |
|-----------|---|----|
| Table 1. | Damdochax Lake trawl catch summary..... | 15 |
| Table 2. | Fish capture data by gear and lake..... | 16 |
| Table 3. | Gillnet location and effort by lake..... | 17 |
| Table 4. | Wiiminosik Lake trawl catch summary..... | 17 |
| Table 5. | Lakelse Lake trawl catch summary..... | 17 |
| Table 6. | Kitsumkalum Lake trawl catch summary..... | 17 |
| Table 7. | Kitwanga Lake trawl catch summary..... | 18 |
| Table 8. | Damdochax Lake hydroacoustic fish population estimates..... | 18 |
| Table 9. | Wiiminosik Lake hydroacoustic fish population estimates by basin..... | 18 |
| Table 10. | Lakelse Lake hydroacoustic fish population estimates by basin..... | 19 |
| Table 11. | Kitsumkalum Lake hydroacoustic fish population estimates..... | 19 |
| Table 12. | Kitwanga Lake hydroacoustic fish population estimates by basin..... | 19 |
| Table 13. | Damdochax Lake integration estimates and biomass by survey year..... | 20 |
| Table 14. | Lakelse Lake integration estimates and biomass by survey year..... | 20 |
| Table 15. | Lakelse Lake PR model smolt estimates vs. observed fall fry..... | 20 |
| Table 16. | Kitsumkalum Lake integration estimates and biomass by survey year..... | 21 |
| Table 17. | Kitsumkalum Lake PR model smolt estimates vs. observed fall fry..... | 21 |
| Table 18. | Damdochax Lake small size class fish estimates by transect and analysis method..... | 66 |
| Table 19. | Damdochax Lake large size class fish estimates by transect and analysis method..... | 66 |
| Table 20. | Wiiminosik Lake small size class fish estimates by transect and analysis method..... | 66 |
| Table 21. | Wiiminosik Lake large size class fish estimates by transect and analysis method..... | 67 |
| Table 22. | Lakelse Lake small size class fish estimates by transect and analysis method..... | 67 |
| Table 23. | Lakelse Lake large size class fish estimates by transect and analysis method..... | 67 |
| Table 24. | Kitsumkalum Lake small size class fish estimates by transect and analysis method..... | 68 |
| Table 25. | Kitsumkalum Lake large size class fish estimates by transect and analysis method..... | 68 |
| Table 26. | Kitwanga Lake small size class fish estimates by transect and analysis method..... | 68 |
| Table 27. | Kitwanga Lake large size class fish estimates by transect and analysis method..... | 69 |

LIST OF FIGURES

| | | |
|------------|---|----|
| Figure 1. | Location of surveyed lakes in the Skeena watershed | 22 |
| Figure 2. | Damdochax Lake aerial photograph (T. Wilson) | 23 |
| Figure 3. | Wiiminosik Lake east basin aerial photograph (T. Wilson) | 24 |
| Figure 4. | Lakelse Lake aerial photograph (D. Gordon) | 25 |
| Figure 5. | Kitsumkalum Lake photograph (www.ourbc.com) | 26 |
| Figure 6. | Kitwanga Lake aerial photograph (M. Cleveland) | 27 |
| Figure 7. | Damdochax Lake survey map | 28 |
| Figure 8. | Wiiminosik Lake survey map..... | 29 |
| Figure 9. | Lakelse Lake survey map..... | 30 |
| Figure 10. | Kitsumkalum Lake survey map..... | 31 |
| Figure 11. | Kitwanga Lake survey map..... | 32 |
| Figure 12. | Damdochax Lake bathymetric map | 33 |
| Figure 13. | Wiiminosik Lake bathymetric map | 34 |
| Figure 14. | Temperature & oxygen profiles for Damdochax Lake..... | 35 |
| Figure 15. | Temperature profile for Wiiminosik Lake (west basin)..... | 35 |
| Figure 16. | Temperature profile for Lakelse Lake..... | 36 |
| Figure 17. | Temperature & oxygen profiles for Kitsumkalum Lake | 36 |
| Figure 18. | Temperature & oxygen profiles for Kitwanga Lake (south basin) | 37 |
| Figure 19. | Damdochax Lake small size class target densities by transect and analysis method..... | 37 |
| Figure 20. | Average TS and target densities by depth layer for Damdochax Lake | 38 |
| Figure 21. | Wiiminosik Lake small size class target densities by transect and analysis method | 38 |
| Figure 22. | Average TS and target densities by depth layer for Wiiminosik Lake..... | 39 |
| Figure 23. | Lakelse Lake small size class target densities by transect and analysis method | 39 |
| Figure 24. | Average TS and target densities by depth layer for Lakelse Lake..... | 40 |
| Figure 25. | Kitsumkalum Lake small size class target densities by transect and analysis method..... | 40 |
| Figure 26. | Average TS and target densities by depth layer for Kitsumkalum Lake | 41 |
| Figure 27. | Kitwanga Lake small size class target densities by transect and analysis method..... | 41 |
| Figure 28. | Average TS and target densities by depth layer for Kitwanga Lake | 42 |
| Figure 29. | Small size class density estimates by analysis method and lake basin..... | 42 |
| Figure 30. | Small size class population estimates by analysis method and lake basin | 43 |
| Figure 31. | Damdochax Lake transect 1 echogram..... | 44 |
| Figure 32. | Damdochax Lake transect 2 echogram..... | 44 |
| Figure 33. | Damdochax Lake transect 3 echogram..... | 44 |
| Figure 34. | Damdochax Lake transect 4 echogram..... | 45 |
| Figure 35. | Damdochax Lake transect 5 echogram..... | 45 |
| Figure 36. | Damdochax Lake transect 6 echogram..... | 45 |
| Figure 37. | Damdochax Lake transect 6 daylight echogram..... | 45 |
| Figure 38. | Damdochax Lake transect 7 echogram..... | 46 |
| Figure 39. | Damdochax Lake transect 8 echogram..... | 46 |
| Figure 40. | Wiiminosik Lake transect 1 echogram | 47 |
| Figure 41. | Wiiminosik Lake transect 2 echogram | 47 |
| Figure 42. | Wiiminosik Lake transect 3 echogram | 47 |
| Figure 43. | Wiiminosik Lake transect 4 echogram | 47 |
| Figure 44. | Wiiminosik Lake transect 5 echogram | 48 |

| | | |
|------------|--|----|
| Figure 45. | Wiiminosik Lake transect 6 echogram | 48 |
| Figure 46. | Wiiminosik Lake transect 6 daylight echogram | 48 |
| Figure 47. | Wiiminosik Lake transect 7 echogram | 48 |
| Figure 48. | Lakelse Lake transect 0.7 echogram | 49 |
| Figure 49. | Lakelse Lake transect 1.4 echogram | 49 |
| Figure 50. | Lakelse Lake transect 2.1 echogram | 50 |
| Figure 51. | Lakelse Lake transect 2.6 echogram | 50 |
| Figure 52. | Lakelse Lake transect 3.4 echogram | 51 |
| Figure 53. | Lakelse Lake transect 4.2 echogram | 51 |
| Figure 54. | Lakelse Lake transect 4.8 echogram | 52 |
| Figure 55. | Lakelse Lake transect 7.0 echogram | 52 |
| Figure 56. | Kitsumkalum Lake transect 1 echogram | 53 |
| Figure 57. | Kitsumkalum Lake transect 2 echogram | 53 |
| Figure 58. | Kitsumkalum Lake transect 3 echogram | 53 |
| Figure 59. | Kitsumkalum Lake transect 4 echogram | 53 |
| Figure 60. | Kitsumkalum Lake transect 5 echogram | 54 |
| Figure 61. | Kitsumkalum Lake transect 6 echogram | 54 |
| Figure 62. | Kitsumkalum Lake transect 7 echogram | 54 |
| Figure 63. | Kitwanga Lake transect 1 echogram | 55 |
| Figure 64. | Kitwanga Lake transect 2 echogram | 56 |
| Figure 65. | Kitwanga Lake transect 3 echogram | 56 |
| Figure 66. | Kitwanga Lake transect 4 echogram | 56 |
| Figure 67. | Kitwanga Lake transect 5 echogram | 56 |
| Figure 68. | Kitwanga Lake transect 6 echogram | 57 |

INTRODUCTION

The Skeena Fisheries Commission (SFC) 2007 sockeye (*Oncorhynchus nerka*) fry hydroacoustic survey program consisted of a survey of Damdochax, Wiiminosik, Lakelse, Kitsumkalum and Kitwanga lakes (Fig. 1).

Damdochax Lake (Fig. 2) is located in the headwaters of the Damdochax River which is a 5th order tributary of the Nass River that drains a watershed area of approximately 116 km². Damdochax Lake is located within the traditional territories of the Gitx̓san First Nation. The 6th cabin on the Yukon Telegraph Line is located on the north shore of Damdochax Lake. Damdochax Lake supports one of the 4 largest non-Meziadin Lake sockeye stocks in the Nass watershed. Recent escapements of 505 in 2005 and 1,701 in 2006 are well below the 1990s average escapement of 3,470 (DFO SEDS Database). The surface area of Damdochax Lake is approximately 148 ha with a volume of 1.56×10^7 m³. The average depth of the lake is 10.6 m and the maximum depth is approximately 21 m.

Wiiminosik Lake (Fig. 3) is located approximately 2.4 km upstream of Damdochax Lake. Relatively little was known about this lake prior to the 2007 hydroacoustic survey.

Lakelse Lake (Fig. 4) is the source of the Lakelse River, which is a 5th order tributary of the lower Skeena that drains a watershed area of approximately 589 km². Lakelse Lake is located within the traditional territories of the Tsimshian and Kitselas First Nations. The sockeye stock from Lakelse Lake is one of the top eight producers in the Skeena although escapements to the system have been depressed since the 1990s (Gottesfeld *et al.* 2002). The surface area of the lake is approximately 1,360 ha with a volume of 1.25×10^8 m³. The average depth of the lake is 8.5 m and the maximum depth is approximately 32 m.

Kitsumkalum Lake (Fig. 5) is located in the middle reaches of the Kitsumkalum River which is a 5th order tributary of the lower Skeena that drains a watershed area of 2,255 km². Kitsumkalum Lake (a.k.a. Kalum Lake) is a part of the Kitsumkalum First Nation's traditional territory. Sockeye escapements to Kitsumkalum Lake reached an average decadal low of 1,430 in the 1980s but increased to an average of 4,791 in the period from 2000 to 2006 (DFO SEDS Database). This increase in escapement may be partially attributed to the establishment of a spawning channel at the northeast end of the lake in 1984, which was upgraded in the late 1990s (Gottesfeld *et al.* 2002). Kitsumkalum Lake is a large, deep lake with surface area of 1,850 ha. The average depth of the lake is 75 m and the maximum depth is approximately 140 m.

Kitwanga Lake (Fig. 6) is located in the headwaters of the Kitwanga River which is a 5th order tributary of the middle Skeena that drains a watershed area of approximately 833 km². Kitwanga Lake (also known as Kitwancool or Gitanyow Lake) is located within the traditional territories of the Gitanyow First Nation. Sockeye returning to Kitwanga Lake were once an important source of food for the Gitanyow and Gitx̓san but declining escapements since the 1960s led them to forgo catching these fish since the 1970s for conservation purposes (Gottesfeld *et al.* 2002). The surface area of Kitwanga Lake is approximately 779 ha with a volume of 5.47×10^7 m³. The average depth of the lake is 6.9 m and the maximum depth is approximately 15 m.

METHODS

Hydroacoustic data was collected using a Biosonics DT-X split beam echo sounder with a 200 kHz transducer producing a 6° beam. Survey designs and transect waypoints for Lakelse, Kitsumkalum and Kitwanga lakes (Fig. 9 - 11) were provided by Steven MacLellan (DFO Cultus Lake Laboratory). The Kitsumkalum and Kitwanga Lake surveys replicated previous DFO surveys. The Lakelse Lake survey design was redesigned in 2007 based on results from several previous surveys. The Damdochax Lake survey design (Fig. 7) was based on a previous hydroacoustic survey of the lake (Murdoch *et al.* 1993). The 2007 survey design included 3 more transects to improve the precision of the estimate. There were no previous surveys of Wiiminosik Lake therefore the survey design (Fig. 8) was based on the surrounding topography of the lake. All hydroacoustic data were collected at night. Damdochax Lake was surveyed on the night of September 17/18, Wiiminosik Lake on September 19/20, Lakelse Lake on September 26/27, Kitsumkalum Lake on October 18/19 and Kitwanga Lake on October 24/25, 2007.

Each transect was analyzed in separate 2 m depth layers except for Kitwanga Lake which was analyzed in 1 m depth layers. Average target densities were calculated for each layer by three separate methods. Briefly, the Integration calculation method takes the average sound energy return from each layer and divides it by the average target strength to get target densities for each layer. The Single Target calculation method looks at the wave form of the sound energy that returns (the echo), and selects only those echoes that have specific wave form characteristics that are typical of echoes reflected from single fish, classifying these echoes as single targets. The total number of single targets in a layer is then divided by the sum of the volumes sampled by all pings, within the layer, to determine a layer density. The Tracked Target calculation method groups single targets together into individual target (fish) tracks which are divided by a smaller sampled wedge volume, roughly the cross sectional dimensions of the sound beam times the length of the transect, to generate a density for each layer.

Once the densities are determined for each layer they are multiplied by the layer volume of the lake area represented by that transect to produce a transect layer population estimate. Layer population estimates are then summed to produce transect 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 derived by taking 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 from -64 to -46 dB. For salmoniform fish, this target strength is approximately equivalent to fish <135 mm, based on Love’s (1977) 45° aspect formula. Small fish were then apportioned into “*O. nerka*” and “other small fish” based on the relative proportion of species in the trawl catch.

Limnetic fish were sampled using two different methodologies. The primary catch method was with a 2 x 2 m mid-water trawl. The trawl can be deployed to approximately 35 m depth. Maximum depths (± 1.0 m) were recorded with a Vemco Minilog TDR 8-bit data logger attached to the lower aluminum spreader bar of the trawl. Depths were calibrated against the amount of line deployed and the RPM of the motor prior to the survey so that these variables could be used to set the trawl depth during the

survey. The second method was with two 12 m floating Swedish gillnets which had variable mesh size panels of 1/2", 5/7", 3/4" and 1" stretched mesh.

All fish were preserved in 10% formalin to obtain size and age information and no measurements were taken until the samples had been preserved for at least 30 days to ensure length and weight stabilization. The 2 x 2 m trawl has been reported to be increasingly biased larger fry, especially those >100 mm in length (McQueen *et al.* 2007). Mean trawl caught *O. nerka* lengths were corrected for this bias using the equation developed for Woss and Vernon lakes: corrected mean length = 0.629 x (mean length in trawl)^{1.125} (McQueen *et al.* 2007). Mean corrected weights were derived from lake specific length to weight relationships. In the size range of *O. nerka* collected, the corrections are small, less than 5%.

Temperature and dissolved oxygen measurements were taken in Damdochax, Wiiminosik and Lakelse lakes using an OxyGuard Handy Beta meter from a location near the deepest part of the lake. Dissolved oxygen readings took an atypically long time to stabilize so those measurements were abandoned for Wiiminosik and Lakelse lakes. Temperature and dissolved oxygen measurements for Kitsumkalum and Kitwanga lakes were taken using a YSI meter (model 85). The YSI meter was calibrated for elevation to the nearest 100 ft and allowed to stabilize for approximately 15 minutes before values were recorded.

Bathymetric maps were used to calculate volumes for each depth layer and representative transect area. BC Ministry of Environment bathymetric maps were available for Lakelse, Kitsumkalum and Kitwanga lakes. Bathymetric maps of Damdochax and Wiiminosik lakes were produced from GPS geo-referenced depth data collected from the Biosonics DT-X echo sounder. Depth data were collected from each transects and each trawl. Additional depth data were also collected to a lesser degree in poorly sampled areas of the lake specifically for developing the bathymetric maps. Depth data were combined in Arc/Info with the perimeter of the lake which was taken from 1:50,000 topographic maps to produce the bathymetric maps.

In the lakes sampled, *Oncorhynchus nerka* probably includes both anadromous (sockeye) and non-anadromous forms (kokanee). In this report they will be referred to as "*O. nerka*". Anadromous *O. nerka* will be referred to as "sockeye" and non-anadromous *O. nerka* will be referred to as "kokanee". Ages of all the Pacific salmon (*Oncorhynchus spp.*) collected in these surveys have been confirmed by the inspection of scales.

RESULTS

Lake Bathymetry

Damdochax Lake is a relatively small lake with a surface area of 148 ha (Fig. 12). The volume of the lake is $1.56 \times 10^7 \text{ m}^3$ which results in a mean depth of 10.6 m. The maximum depth of the lake is 20.7 m and is located in the middle of the lake. The southwest shoreline of Damdochax Lake is relatively steep with very little littoral area compared with the shallower northwest and northeast areas of the lake which have well developed aquatic plant communities.

Wiiminosik Lake is a very small lake with a surface area of only 38 ha, however the lake is surprisingly deep with a mean depth of 12.4 m and a volume of $4.72 \times 10^6 \text{ m}^3$ (Fig. 13). There are two distinct basins of the lake with the west basin nearly 25 m deep and the east basin 16 m deep.

Temperature and Oxygen Profiles

Damdochax Lake showed a thermocline between 7 m and 11 m depth with a decline in temperature of nearly 3°C over those 4 m (Fig. 14). Dissolved oxygen concentrations declined abruptly from 15 m to 17 m depth to values of $<2 \text{ mg/l}$ which was well below the thermocline. Although it was sampled only one day later, water temperatures in Wiiminosik Lake were 3 degrees Celsius colder than in Damdochax (Fig. 15). The thermocline in Wiiminosik Lake was also more gradual with a decline of nearly 3°C over 8 m compared to 4 m in Damdochax Lake.

By September 26th Lakelse Lake was isothermal at just less than 13°C (Fig. 16). Kitsumkalum Lake was also isothermal on October 18th at least for the maximum measured depth (30 m) but much colder than Lakelse at just over 7°C (Fig. 17). Kitwanga Lake was isothermal at 8°C until the bottom where it was one degree colder. Most of the water column was well oxygenated but it was nearly anoxic on the bottom (Fig. 18).

Fish Catch

In Damdochax Lake, the trawl caught 48 young-of-the-year (age-0) *O. nerka* and 2 sculpin (*Cottus sp.*) in 5 tows for a combined linear distance of 4.8 km sampled (Table 1). Three *O. nerka* and one large bull trout (*Salvelinus confluentus*) (Table 2) were caught in the 2 floating gillnets set overnight in the lake (Table 3). The mean size of the *O. nerka* caught in the gillnets was larger than the mean size of the *O. nerka* caught in the trawl (Table 2). The 2 sculpin were very small with a mean weight of less than one tenth of a gram and since they lack an air bladder, it is unlikely sculpin of that size exceeded the minimum threshold for inclusion in the hydroacoustic analysis. The “small” size hydroacoustic fish estimates are therefore apportioned 100% to age-0 *O. nerka* for Damdochax Lake.

In Wiiminosik Lake, two tows of the trawl covered a total distance of 852 m and caught 63 age-0 *O. nerka*, 7 mountain whitefish (*Prosopium williamsoni*) and one sculpin (Table 4). The tow in the east basin of the lake caught 93% of the total trawl catch. The mean size of the whitefish was slightly larger than the *O. nerka* but well within the “small” size category. One age-1 *O. nerka*, 2 coho (*Oncorhynchus kisutch*), 1 Chinook (*Oncorhynchus tshawytscha*) and 1 “large” bull trout were caught (Table 2) in the two gillnets set in Wiiminosik Lake (Table 3). The one age-1 *O. nerka* caught in the gillnet was larger than

any of the age-0 *O. nerka* caught in the trawl (Table 2). The sculpin was larger than the ones caught in Damdochax but still very small at less than 1 g. Ten percent of the trawl catch was whitefish (not including the one sculpin) so the “small” size hydroacoustic estimate for Wiiminosik Lake was therefore apportioned 90% to age-0 *O. nerka*. The “small” size age-1 *O. nerka*, coho and Chinook caught in the gillnets suggests that a small fraction of the “small” size hydroacoustic estimate might be from those two species and an older age class of *O. nerka* but it is impossible to quantify the amount using the gillnet catch.

Four tows of the trawl covering 2.0 km in Lakelse Lake resulted in the catch of 8 age-0 *O. nerka* and 2 sculpin (Table 5). Six age-0 *O. nerka* (Table 2) were caught in the floating gillnets set in Lakelse Lake (Table 3). The mean size of the age-0 *O. nerka* caught in the gillnets was larger than the mean size of the age-0 caught in the trawl. The mean size of the sculpin was less than 1 g. The low sample size of fish caught in the trawl make it unreasonable to apportion the “small” size hydroacoustic estimate into different fish species.

In Kitsumkalum Lake the trawl caught 46 age-0 *O. nerka* and 1 coho in 3 tows covering 2.8 km (Table 6). Nine coho, 2 “large” cutthroat (*Oncorhynchus clarki*), 1 “large” bull trout and 1 “large” rainbow trout (*Oncorhynchus mykiss*) were caught (Table 2) in the two floating gillnets set in Kitsumkalum Lake (Table 3). The anchor ropes for the gillnets were only 100’ long consequently they had to be set relatively close to shore due to the steep shores of Kitsumkalum Lake. The gillnet catch is more representative of the littoral fish species assemblage, however the catch of a coho in the trawl confirms a small fraction of the limnetic fish were coho. Two percent of the trawl catch were coho therefore 98% of the “small” size hydroacoustic estimate was apportioned to age-0 *O. nerka*.

Only one age-0 *O. nerka* and 1 redbside shiner (*Richardsonius balteatus*) were caught in 6 tows covering over 5.3 km in Kitwanga Lake (Table 7). Two age-0 *O. nerka*, 1 coho, 1 “large” cutthroat trout and 1 “large” peamouth (*Mylocheilus caurinus*) were caught (Table 2) in the two gillnets set overnight in Kitwanga Lake (Table 3). The low sample size of fish caught in the trawl make it unreasonable to apportion the “small” size hydroacoustic estimate into different fish species.

Although fish sampling occurred in 5 different lakes over a 5 week period, the mean trawl caught age-0 *O. nerka* size was very consistent between lakes. Kitwanga Lake, sampled on October 25th, had the smallest mean length (55.0 mm) and Lakelse Lake, sampled on September 27th, had the largest mean length (59.0 mm) for a difference of only 4 mm. Damdochax and Wiiminosik lakes were surveyed only one day apart and the trawl caught age-0 *O. nerka* had exactly the same mean length (57.7 mm) in both lakes.

Hydroacoustic Fish Estimates

Damdochax Lake

Fish densities in Damdochax Lake computed by the three calculation techniques, Integration, Single Target, and Tracked Target are shown in Figure 19. The highest densities were observed in transect 7. Transects 1 and 2 had the lowest densities. Fish densities were strongly vertically compressed (Fig. 20) with the highest densities located at or near the thermocline (Fig. 14). Target strengths were relatively consistent throughout the water column except for the bottom layer which was somewhat higher (Fig. 20).

“Small” size class fish densities ranged from 561 (± 290) fish/ha using the Single Target analysis method to 694 (± 329) fish/ha using the Tracked Target method (Table 8). These densities result in population estimates of 82,976 ($\pm 42,859$) to 102,684 ($\pm 48,664$). “Large” size class fish estimates were roughly 18% to 20% of the total fish population of the lake. The trawl catch suggests that 100% of these fish are age-0 *O. nerka*. Using the trawl bias corrected mean weight of age-0 *O. nerka* caught in the trawl (2.4 g), the total age-0 *O. nerka* biomass in Damdochax Lake ranges from 199 to 246 kg.

Wiiminosik Lake

“Small” size class fish densities for Wiiminosik Lake computed by three techniques are shown in Figure 21. The lowest densities were located over the deepest part of the west basin of the lake (Fig. 8 & 13). The highest densities of the lake were observed in transects 4-6 of the east basin of the lake. Fish densities were vertically compressed in a manner similar to Damdochax Lake but peak fish densities were slightly higher in the water column and just above the thermocline in Wiiminosik Lake (Fig. 22). Average target strengths show a slight decline with depth (Fig. 22).

Hydroacoustic estimates of Wiiminosik Lake were divided into the west and east basins which is justified based on the bathymetry and the observed fish densities. West basin “small” size class fish densities ranged from 703 (± 992) fish/ha using the Integration analysis method to 1,031 ($\pm 1,603$) fish/ha using the Tracked Target method (Table 9). Confidence intervals on these estimates were large because of the small number of transects (3) and the large variability between them. East basin “small” size class fish densities were much higher and ranged from 1,879 ($\pm 1,198$) fish/ha using the Integration analysis method to 2,307 ($\pm 1,568$) fish/ha using the Tracked Target method (Table 9). “Large” size class fish estimates were roughly 12% of the total fish population of the west basin and 7% in the east basin.

The trawl catch suggests that 90% of the “small” size fish targets are age-0 *O. nerka* with the other 10% being whitefish. Gillnet catches show that coho and Chinook are also present in small proportions. Using the trawl bias corrected mean weight of age-0 *O. nerka* caught in the trawl (2.4 g), the total estimated age-0 *O. nerka* biomass in the combined east and west basins ranges from 108 kg to 139 kg.

Lakelse Lake

“Small” size class fish densities for Lakelse Lake are shown in Fig. 23. The highest transect densities of “small” size class targets were found in transects 2.1 and 2.6 while the lowest were found in transects 0.7 and 7.0 which were the shallowest areas surveyed. Average target strengths were fairly consistent throughout the water column except for slightly lower target strengths in the top two depth layers and a slight increase in the bottom depth layer (Fig. 24). Target densities were very low for the first 15 m then increased substantially with depth so that the deepest layer was the densest (Fig. 24).

Hydroacoustic estimates of Lakelse Lake were divided into the north and south basins. This is justified based on the bathymetry and the observed fish densities. Previous surveys have also shown very low densities in the south basin (Steven MacLellan pers. com.). The survey design was changed in 2007 to increase the sampling rate in the north basin and to decrease the sampling of the south basin to just one transect. “Small” size class density estimates for the north basin ranged from 282 fish/ha (± 197) using the Single Target analysis method to 356 (± 260) fish/ha using the Tracked Target method (Table 10). “Large” size class fish estimates were roughly 10% of the total fish population of the north basin of the lake. No “large” size fish targets were observed in the south basin of the lake.

Only 2 sculpin were caught in trawl other than age-0 *O. nerka* but the sample size (10) is too small to apportion the “small” size class targets to different fish species. The uncorrected average trawl caught age-0 *O. nerka* weight of 2.4 g was used to develop a biomass estimate which resulted in a biomass ranging from 427 kg to 540 kg.

Kitsumkalum Lake

There was more than twice the “small” size class density in transect 1 than in any other transect in Kitsumkalum Lake (Fig. 25). Average fish densities declined abruptly below 25 m to nearly zero by 40 m depth (Fig. 26). Hydroacoustic data were not collected below 80 m depth although the lake is 140 m deep in places; however, the extremely low densities below 40 m justifies this data collection cut-off depth. Target strengths gradually declined with depth and increased variability (Fig. 26).

“Small” size class fish density estimates ranged from 222 (± 155) fish/ha using the Integration analysis method to 324 (± 237) fish/ha using the Tracked Target method (Table 11). “Large” size class fish estimates were roughly 6% of the total fish population of the lake. The trawl catch suggests that 98% of the “small” size fish targets are age-0 *O. nerka* with the other 2% being coho. Gillnet catches confirm the small proportion of coho. Using the trawl bias corrected mean weight of age-0 *O. nerka* caught in the trawl (2.2 g), the total estimated age-0 *O. nerka* biomass in Kitsumkalum Lake ranges from 885 kg to 1,291 kg.

Kitwanga Lake

Kitwanga Lake was divided into north and south basins based on bathymetry. Two of the four transects in the north basin showed no “small” size targets (Fig. 27). Target strengths were highly variable but generally increased with depth (Fig. 28). Target densities also increased with depth until 10.5 m then abruptly decreased (Fig. 28) which was likely due to the anoxic conditions measured at the bottom of the lake (Fig. 18).

Previous surveys of Kitwanga Lake have found very high densities of phantom midge (*Chaoborus sp.*) that can confound the estimates of “small” size class fish (Shortreed & Hume 2004, Hall 2007). Because of the *Chaoborus* densities, the only appropriate method to generate a small size class fish estimate was using the Tracked Target method. Collecting the hydroacoustic data at a high ping rate, combined with the Tracked Target analysis method which uses target tracking algorithms (parameters developed by DFO Cultus Lake Laboratory) to reject *Chaoborus* targets allows for a reasonable small size class fish population estimate.

The “small” size class fish density estimate for the north basin was 171 fish/ha and 553 fish/ha for the south basin (Table 12). The “large” size class fish density estimate for the south basin was extremely high relative to the “small” size class estimate (37%) compared to only 2% in the north basin. Only two fish were caught in trawl which is far too small to apportion the “small” size class targets to different fish species.

All Lakes

Of all the 8 lakes/lake basins, the highest “small” size class densities were found in the east basin of Wiiminosik Lake followed by the west basin (Fig. 29). Damdochax Lake had the next highest density estimates followed by the Kitwanga Lake south basin. The Lakelse Lake north basin and Kitsumkalum Lake had similar but low densities. When the “small” size class densities were expanded for the size of the lake to get population estimates, the trend reverses with the lakes with the highest densities having the smallest population estimates (Fig. 30). Despite having low densities, the large size of Kitsumkalum and Lakelse lakes result in higher population estimates than Damdochax and Wiiminosik lakes.

DISCUSSION

Damdochax Lake

The Damdochax Lake bathymetric data developed for this report was very similar to those reported by Murdoch *et al.* (1993). Seven transects were used by Murdoch *et al.* (1993) to develop the bathymetric map of Damdochax Lake. We used 8 transects, acoustic soundings during 5 trawls and 2 extra shoreline transects to increase the precision of the bathymetric map. The two sets of data were similar including surface area (148 vs. 146 ha) volume (1.56×10^7 vs. 1.49×10^7 m³) mean depth (10.6 vs. 10 m) and maximum depth (20.7 vs. 22 m).

Damdochax Lake was an ideal lake for the hydroacoustic survey methodology. The lake was deep enough to trawl effectively and the fish were distributed in relatively high densities at a mid-water depth layer. This allows both the echo sounder and the trawl to effectively capture the fish, whereas accurate population estimates are difficult to make when fish are distributed too near the bottom or the surface. The trawl caught only *O. nerka* except for one very small sculpin. This was consistent with trawl catches from surveys completed in 1991 and 1993 (Johannes *et al.* 1995), however trawl catches in 1992 included whitefish, sculpin and suckers (*Catostomus sp.*). Whitefish were caught by the trawl in Wiiminosik Lake in 2007, so it is reasonable to assume that they are present as some low proportion of the “small” size class hydroacoustic estimate for Damdochax Lake.

Previous hydroacoustic surveys of Damdochax Lake (Johannes *et al.* 1995) found first year *O. nerka* densities as high as 2,314 fish/ha in 1991 and as low as 608 fish/ha in 1992 (Table 13). The 2007 density estimate (624 fish/ha) was just slightly higher than the lowest previous estimate of 608 fish/ha in 1992. Biomass estimates ranged from 299 kg in 1992 to 654 kg in 1993. The 2007 biomass estimate (221 kg) was less than any previous survey due to the small mean weight of the age-0 *O. nerka* caught in the trawl. Mean fall fry weight varied from 2.0 g in 1991 to 4.3 g in 1993. The year with lowest mean weight (1991) corresponds with the highest density, which suggests that intraspecific competition for food resources was limiting growth. This relationship is contradicted in 1993, where the second highest density estimate corresponds with the largest mean weight (Table 13). The highest two mean weights were also the latest survey dates but by only about 2 weeks. No photosynthetic rate (PR) model carrying capacity has been developed for this lake.

Wiiminosik Lake

Little was known about Wiiminosik Lake prior to the survey in 2007. The lake bathymetry was surprising in that the lake was deeper than the much larger Damdochax Lake located only 2.4 km downstream. The distribution of the age-0 *O. nerka* was also surprising with the highest densities located in the smaller and shallower east basin of the lake. Vertically the fish were distributed similarly to Damdochax Lake with a well defined mid-water fish layer. This made Wiiminosik Lake a good lake for the hydroacoustic survey methodology despite the relatively small size. Fishing the trawl in the east basin was challenging to reach the desired depth with the length of line (~30 m) deployed and the small surface area of the basin to maneuver in; however, the high densities located in the east basin resulted in the largest catch of fish for any tow in the 2007 field season despite the shortest distance covered.

Depending on the analysis method, Wiiminosik Lake “small” size fish population estimates ranged from 35% to 40% of the combined Damdochax and Wiiminosik Lake population estimate. Wiiminosik Lake is therefore a significant contributor of *O. nerka* lake rearing capacity in the Damdochax watershed and must be considered when developing escapement targets for the system. The relatively large number of *O. nerka* in Wiiminosik Lake is not only surprising because of the smaller lake surface area but also because the main spawning grounds are located downstream in the section of stream between the two lakes. GWA crews surveying that section have seen several pairs of spawners located upstream of Wiiminosik Lake when flying overhead, but far less than the numbers of sockeye spawners observed on foot in the section between the two lakes. This implies that either sockeye fry move both upstream and downstream from the spawning grounds upon emergence, that the sockeye escapement upstream of Wiiminosik Lake is significantly underestimated, or that Wiiminosik Lake hosts lake spawners.

Lakelse Lake

Lakelse Lake has proven to be a difficult lake to survey with the hydroacoustic methodology. The primary difficulty has been with obtaining an adequate sample of the limnetic fish community using the mid-water trawl. There are several reasons for this difficulty. The first is that submerged trees from a landslide that occurred in 1962 are located in areas where the highest densities of fish are observed, and the trawl can not be fished at those locations. The second reason for the low catches is that the highest densities are near the bottom at the deepest point of the lake which is nearing the maximum depth fishable using the trawl. The third reason is that fish densities higher in the water column or not near submerged trees are low which drastically reduces the catch.

An inadequate sample size in the trawl catch makes it impossible to apportion the “small” size class fish population estimates into different species. Previous surveys (Shortreed *et al.* 1998, Shortreed & Hume 2004, Shortreed & Hume 2005, Hume & Shortreed 2006) have apportioned from 0% to 22% of the “small” size class fish estimates to species such as stickleback (*Gasterosteus aculeatus*), lamprey (*Lampetra ayresi*), sculpin, and reidside shiner (Table 14). An adequate sample size of age-0 *O. nerka* is also needed to generate a robust mean weight estimate that is used to calculate biomass. The mean weight of the age-0 *O. nerka* caught in the trawl in 2007 was 1 g less than observed in any other fall survey of Lakelse Lake (Table 14) and the mean weight of the *O. nerka* caught in the gillnets was more than double (Table 1).

If we assume that the “small” size class fish estimates were all age-0 *O. nerka* and the mean weight of the age-0 *O. nerka* caught in the trawl is representative then the biomass of age-0 *O. nerka* in Lakelse Lake is low at only 17% of the adjusted maximum carrying capacity (Cox-Rogers *et al.* 2004) of the lake (Table 15). The estimated mean weight of the age-0 *O. nerka* population is, however relatively unreliable and population estimates show that similar numbers of age-0 *O. nerka* were estimated in 2003 and 2004 (Table 14). Some unknown proportion of the “small” size class population estimate is probably kokanee and other species which reduces the age-0 sockeye population estimate. Despite the uncertainties around the age-0 *O. nerka* population and biomass estimates, the very low estimates in recent years agree with the low escapements observed (DFO SEDS Database) and confirm that the Lakelse Lake sockeye population is depressed.

Kitsumkalum Lake

The relatively high “small” size class fish densities observed on transect 1 was also observed in 2005 (Steven MacLellan pers. com.) which suggests that it is a persistent phenomenon in Kitsumkalum Lake. Densities throughout the rest of the lake were very low, which would have required significantly higher mid-water trawling effort to catch a reasonable sample of the limnetic fish community. No trawling occurred in sections of the lake other than near transect 1, so the trawl catch may not be representative of the whole lake.

The 2007 hydroacoustic estimates of age-0 *O. nerka* was somewhat less than the estimate from 2005 but higher than the estimate from 1994 (Table 16). The mean size of the age-0 *O. nerka* caught in the trawl was relatively similar between survey years. The estimated biomass of age-0 *O. nerka* in Kitsumkalum Lake was 885 kg in 2007 which was 40% of the predicted carrying capacity of the lake based on the PR model (Cox-Rogers *et al.* 2004). Biomasses in previous years were from 43% to 17% of the carrying capacity (Table 17).

Kitwanga Lake

Previous surveys of Kitwanga Lake have yielded similar poor trawl catches with only 21 age-0 *O. nerka* caught in over 4 separate surveys (Shortreed *et al.* 1998, Shortreed & Hume 2004, 2005, and Hall 2007). Despite these poor results, Kitwanga Lake was surveyed in 2007 because we expected to find high densities of fry due to the 2006 sockeye escapement of 5,139 which was the largest recorded escapement since 1940 (DFO SEDS Database).

Trawl catch results suggest very low densities and two of the four surveyed transects in the north basin did not identify any targets. Higher densities were observed in transect 5, where a large portion of the trawling effort was expended, but post-survey analysis showed that 65% of the targets observed were in the “large” size class and not vulnerable to the trawl. Transect 5 is located near known sockeye lakeshore spawning areas (Mark Cleveland pers. com.) and the timing of the survey suggest that a component of the “large” size class estimate for transect 5 were adult sockeye.

Continued failure to catch adequate numbers of age-0 *O. nerka* in the mid-water trawl despite expected high densities suggest that juvenile sockeye do not occupy the limited pelagic region of this lake and are rearing elsewhere, possibly in near shore habitats. In any case, hydroacoustic surveys are not an appropriate stock assessment tool for this lake. A smolt fence would be a more appropriate technique for assessing freshwater survival of Kitwanga sockeye but more research and other methods are necessary in order to evaluate their rearing habitat.

REFERENCES

- Cleveland, M. 2007. Senior Biologist. Gitanyow Fisheries Authority. Gitanyow, BC.
- Cox-Rogers, S., J. Hume and K. Shortreed. 2004. Stock status and lake based production relationships for wild Skeena River sockeye salmon. Fisheries and Oceans Canada. Canadian Science Advisory Secretariat. Research Document 2004/010.
- Gottesfeld, A., K. Rabnett, and P. Hall. 2002. Conserving Skeena fish populations and their habitat. Skeena Stage 1 watershed-based sustainability plan. Skeena Fisheries Commission. Hazelton, BC.
- Hall, P. 2007. Skeena sockeye lakes hydroacoustic surveys report 2006. Skeena Fisheries Commission. Hazelton, BC. Report to the Pacific Salmon Commission.
- Hume, J. and K. Shortreed. 2006. Limnological and limnetic fish surveys of North Coast Area lakes in 2005. Fisheries and Oceans Canada. Marine and Environmental Habitat Science Division. Cultus Lake Laboratory. Unpublished report.
- Johannes, M.R.S., K.D. Hyatt, D.P. Rankin, and D.K. McCreight. 1995. Hydroacoustic/trawl survey estimates of limnetic fish population abundance in salmonid nursery lakes of the Nass River system. Salmon Index Methods and Data Systems Section. Stock Assessment Division. Department of Fisheries & Oceans, Pacific Biological Station. Nanaimo, BC.
- Love, R. H. 1977. Target strength of an individual fish at any aspect. *Journal of the Acoustical Society of America* 62:1397-1403.
- MacLellan, Steven. 2007. Research Technician, Freshwater Ecosystems Section, Cultus Lake Salmon Research Laboratory. Fisheries & Oceans Canada.
- McCreight D.K., M.R.S. Johannes, S.P. Murdoch and K.D. Hyatt. 1993. Fish catch statistics in salmonid nursery lakes of the Nass River System under study by the Interim Measures Fisheries Program. *Canadian Data Report of Fisheries and Aquatic Science* 904: 55p.
- McQueen, D.J., K.D. Hyatt, D.P. Rankin, and C.J. Ramcharan. 2007. Changes in algal species composition affect juvenile sockeye salmon production at Woss Lake, British Columbia: A lake fertilization and food web analysis. *North American Journal of Fisheries Management*. 27: 369-386.
- Murdoch, S.P., M.R.S. Johannes, D.K. McCreight, K.D. Hyatt and D.P. Rankin. 1993. Physical parameters of Nass River salmonid nursery lakes under study by the Interim Measures Fisheries Program. Salmon-Recruitment Assessment Program. Department of Fisheries & Oceans. Nanaimo, BC.
- Shortreed, Ken. 2007. Research Biologist, Freshwater Ecosystems Section, Cultus Lake Salmon Research Laboratory. Fisheries and Oceans Canada.

- Shortreed, K., J. Hume K. Morton and S. MacLellan. 1998. Trophic status and rearing capacity of smaller sockeye lakes in the Skeena River system. Canadian Technical Report of Fisheries and Aquatic Science. 2240.
- Shortreed, K., J. Hume and K. Morton. 2002. Trip report and preliminary analysis from limnological and fish surveys of eight North Coast Area lakes in September, 2001. Fisheries and Oceans Canada. Marine and Environmental Habitat Science Division. Cultus Lake Laboratory. Unpublished report.
- Shortreed, K., and J. Hume. 2004. Report on limnological and limnetic fish surveys of North Coast Area lakes in 2002 and 2003. Fisheries and Oceans Canada. Marine and Environmental Habitat Science Division. Cultus Lake Laboratory. Unpublished report.
- Shortreed, K., and J. Hume. 2005. Report on limnological and limnetic fish surveys of North Coast Area lakes in 2004. Fisheries and Oceans Canada. Marine and Environmental Habitat Science Division. Cultus Lake Laboratory. Unpublished report.
- Shortreed, K., and J. Hume. 2007. Limnological and limnetic fish surveys of North Coast Area lakes in 2006. Fisheries and Oceans Canada. Marine and Environmental Habitat Science Division. Cultus Lake Laboratory. Unpublished report.

ACKNOWLEDGEMENTS

Rodney Harris (Gitksan Watershed Authorities) assisted with the Lakelse, Kitsumkalum and Kitwanga Lakes surveys. Tim Wilson (GWA) assisted with the Damdochax and Wiiminosik Lakes surveys. Alicia Hooper (GWA) provided all the fish measurements. Gordon Wilson (Skeena Fisheries Commission) developed all the maps presented in this report. Allen Gottesfeld (SFC) provided editorial comments for the report.

Thanks are due to Jeremy Hume and Ken Shortreed (DFO Cultus Lake Laboratory) for supporting the Skeena Fisheries Commission's hydroacoustic program and providing assistance with the writing of this report. Special thanks are required for Steven MacLellan (DFO Cultus Lake Laboratory) who endured innumerable phone calls for technical advice on hydroacoustic analysis methodologies and many other issues.

Table 1. Damdochax Lake trawl catch summary

| Lake | Tow | Location (Transect) | Length (m) | Average Depth (m) | SK | CAS |
|------------------|----------|------------------------|---------------|----------------------|-----------|----------|
| Damdochax | 1 | 6-3 | 910 | 11 | 25 | 0 |
| | 2 | 3-6 | 1,031 | 11 | 10 | 0 |
| | 3 | 6-3 | 766 | 8 | 4 | 0 |
| | 4 | 4-7 | 1,001 | 10 | 5 | 0 |
| | 5 | 7-4 | 1,083 | 8 | 4 | 2 |
| Total | 5 | n/a | 4,791 | n/a | 48 | 2 |

SK= sockeye, CAS = prickly sculpin

Table 2. Fish capture data by gear and lake

| Lake | Gear | Species | Length (mm) | | | | Weight (g) | | 2x2 Trawl Bias correction | |
|------------|---------|---------|-------------|-------|-------|----|------------|------|---------------------------|------------|
| | | | N | Mean | SD | N | Mean | SD | Length (mm) | Weight (g) |
| Damdochax | Trawl | SK | 48 | 57.7 | 11.4 | 48 | 2.4 | 1.4 | 60.2 | 2.4 |
| | | CAS | 2 | 16.0 | 2.8 | 2 | 0.03 | 0.03 | | |
| | Gillnet | SK | 3 | 75.7 | 6.7 | 3 | 5.2 | 1.5 | | |
| | | BT | 1 | 400 | n/a | | | | | |
| Wiiminosik | Trawl | SK | 63 | 57.7 | 7.2 | 63 | 2.2 | 0.8 | 60.3 | 2.4 |
| | | MW | 7 | 66.6 | 17.6 | 7 | 2.4 | 1.7 | | |
| | | CAS | 1 | 24.0 | n/a | 1 | 0.8 | n/a | | |
| | Gillnet | SK | 1 | 100.0 | n/a | 1 | 10.4 | n/a | | |
| | | CO | 2 | 98.0 | 8.5 | 2 | 10.9 | 2.8 | | |
| | | CH | 1 | 49.0 | n/a | 1 | 5.7 | n/a | | |
| | | BT | 1 | >300 | n/a | | | | | |
| Lakelse | Trawl | SK | 8 | 59.0 | 11.46 | 8 | 2.4 | 1.5 | n/a | n/a |
| | | CAS | 2 | 40.0 | 14.1 | 2 | 0.8 | 0.8 | | |
| | Gillnet | SK | 5 | 75.2 | 4.4 | 5 | 5.2 | 1.0 | | |
| Kalum | Trawl | SK | 46 | 56.7 | 7.2 | 46 | 2.1 | 0.7 | 59.1 | 2.2 |
| | | CO | 1 | 73.0 | n/a | 0 | n/a | n/a | | |
| | Gillnet | CO | 9 | 85.7 | 12.3 | 9 | 8.4 | 3.3 | | |
| | | RB | 1 | 175 | n/a | | | | | |
| | | CT | 2 | 315 | 0.0 | | | | | |
| | | BT | 1 | 535 | n/a | | | | | |
| Kitwanga | Trawl | SK | 1 | 55.0 | n/a | 1 | 1.88 | n/a | n/a | n/a |
| | | RSC | 1 | 88.0 | n/a | 1 | 8.66 | n/a | | |
| | Gillnet | SK | 2 | 81.5 | 12.0 | 2 | 4.8 | 1.7 | | |
| | | CO | 1 | 108 | n/a | 1 | 12.1 | n/a | | |
| | | CT | 1 | 265 | n/a | | | | | |
| | | PCC | 1 | 245 | n/a | | | | | |

MW = mountain whitefish, BT= bull trout, CO = coho, CH=Chinook, RB= rainbow trout, CT= cutthroat trout, RSC = reidside shiner, PCC = peamouth, SK= sockeye, CAS = prickly sculpin

Table 3. Gillnet location and effort by lake

| Lake | Gillnet | UTM | Soak Time (Hours) |
|------------|---------|---------------------|-------------------|
| Damdochax | 1 | 09 V 555771 6262400 | 18 |
| | 2 | 09 V 554830 6263675 | 18 |
| Wiiminosik | 1 | 09 V 558486 6261077 | 13 |
| | 2 | 09 V 559251 6260813 | 13 |
| Lakelse | 1 | 09 U 530119 6028908 | 12 |
| | 2 | 09 U 528968 6026895 | 11 |
| Kalum | 1 | 09 U 513159 6072350 | 15 |
| | 2 | 09 U 513977 6073267 | 14 |
| Kitwanga | 1 | 09 U 556344 6136686 | 12 |
| | 2 | 09 U 556717 6134188 | 12 |

Table 4. Wiiminosik Lake trawl catch summary

| Lake | Tow | Location (Basin) | Length (m) | Average Depth (m) | SK | MW | CAS |
|--------------|----------|------------------|------------|-------------------|-----------|----------|----------|
| Wiiminosik | 1 | West | 460 | 7 | 5 | 0 | 0 |
| | 2 | East | 392 | 8 | 58 | 7 | 1 |
| Total | 2 | n/a | 852 | n/a | 63 | 7 | 1 |

Table 5. Lakelse Lake trawl catch summary

| Lake | Tow | Location (Transect) | Length (m) | Average Depth (m) | SK | CAS |
|--------------|----------|---------------------|--------------|-------------------|----------|----------|
| Lakelse | 1 | 2.6 | 604 | * | 0 | 0 |
| | 2 | 2.6 | 435 | * | 0 | 0 |
| | 3 | 2.6 | 439 | * | 4 | 1 |
| | 4 | 3.4-2.6 | 489 | * | 4 | 1 |
| Total | 4 | n/a | 1,967 | n/a | 8 | 2 |

*Data logger lost

Table 6. Kitsumkalum Lake trawl catch summary

| Lake | Tow | Location (Transect) | Length (m) | Average Depth (m) | SK | CO |
|--------------|----------|---------------------|--------------|-------------------|-----------|----------|
| Kalum | 1 | 1 | 1,136 | 24 | 20 | 0 |
| | 2 | 1 | 777 | 25 | 19 | 1 |
| | 3 | 1 | 903 | 24 | 7 | 0 |
| Total | 3 | n/a | 2,816 | n/a | 46 | 1 |

Table 7. Kitwanga Lake trawl catch summary

| Lake | Tow | Location (Basin) | Length (m) | Average Depth (m) | SK | RSC |
|--------------|-----|------------------|------------|-------------------|----|-----|
| Kitwanga | 1 | South | 950 | 8 | 0 | 1 |
| | 2 | South | 878 | 11 | 1 | 0 |
| | 3 | South | 575 | 11 | 0 | 0 |
| | 4 | South | 396 | 12 | 0 | 0 |
| | 5 | North | 1,271 | 5 | 0 | 0 |
| | 6 | North | 1,298 | 4 | 0 | 0 |
| Total | 6 | n/a | 5,368 | n/a | 1 | 1 |

Table 8. Damdochax Lake hydroacoustic fish population estimates

| Estimate Method | Size Class | Density | | Population | |
|-----------------|------------|---------|----------|------------|----------|
| | | N/ha | 95% C.I. | N | 95% C.I. |
| Integration | Small | 624 | 412 | 92,262 | 60,931 |
| | Large | 135 | 46 | 19,979 | 6,850 |
| Single Target | Small | 561 | 290 | 82,976 | 42,859 |
| | Large | 141 | 87 | 20,777 | 12,838 |
| Tracked Target | Small | 694 | 329 | 102,684 | 48,664 |
| | Large | 173 | 88 | 25,530 | 13,051 |

Table 9. Wiiminosik Lake hydroacoustic fish population estimates by basin

| Estimate Method | Basin | Size Class | Density | | Population | |
|-----------------|----------|------------|---------|----------|------------|----------|
| | | | N/ha | 95% C.I. | N | 95% C.I. |
| Integration | West | Small | 703 | 992 | 13,028 | 18,396 |
| | | Large | 108 | 293 | 1,999 | 5,435 |
| | East | Small | 1,879 | 1,198 | 36,826 | 23,483 |
| | | Large | 148 | 92 | 2,896 | 1,801 |
| | Combined | Small | 1,307 | 447 | 49,853 | 17,056 |
| | | Large | 128 | 73 | 4,896 | 2,768 |
| Single Target | West | Small | 859 | 1,246 | 15,925 | 23,102 |
| | | Large | 116 | 315 | 2,156 | 5,839 |
| | East | Small | 1,974 | 1,427 | 38,693 | 27,976 |
| | | Large | 157 | 107 | 3,082 | 2,107 |
| | Combined | Small | 1,432 | 540 | 54,617 | 20,601 |
| | | Large | 137 | 79 | 5,238 | 3,020 |
| Tracked Target | West | Small | 1,031 | 1,603 | 19,118 | 29,729 |
| | | Large | 143 | 370 | 2,647 | 6,856 |
| | East | Small | 2,307 | 1,568 | 45,223 | 30,739 |
| | | Large | 177 | 75 | 3,476 | 1,470 |
| | Combined | Small | 1,687 | 623 | 64,341 | 23,752 |
| | | Large | 161 | 87 | 6,123 | 3,318 |

Table 10. Lakelse Lake hydroacoustic fish population estimates by basin

| Estimate Method | Basin | Size Class | Density | | Population | |
|-----------------|-------|------------|---------|----------|------------|----------|
| | | | N/ha | 95% C.I. | N | 95% C.I. |
| Integration | North | Small | 321 | 218 | 202,474 | 137,410 |
| | | Large | 33 | 26 | 20,637 | 16,299 |
| | South | Small | 41 | n/a | 30,153 | n/a |
| | | Large | 0 | n/a | 0 | n/a |
| Single Target | North | Small | 282 | 197 | 178,037 | 124,386 |
| | | Large | 32 | 27 | 20,368 | 16,830 |
| | South | Small | 30 | n/a | 21,856 | n/a |
| | | Large | 0 | n/a | 0 | n/a |
| Tracked Target | North | Small | 356 | 260 | 224,843 | 164,001 |
| | | Large | 46 | 36 | 28,975 | 22,435 |
| | South | Small | 34 | n/a | 24,802 | n/a |
| | | Large | 0 | n/a | 0 | n/a |

Table 11. Kitsumkalum Lake hydroacoustic fish population estimates

| Estimate Method | Size Class | Density | | Population | |
|-----------------|------------|---------|----------|------------|----------|
| | | N/ha | 95% C.I. | N | 95% C.I. |
| Integration | Small | 222 | 155 | 410,907 | 286,137 |
| | Large | 15 | 9 | 27,269 | 16,603 |
| Single Target | Small | 238 | 177 | 439,977 | 326,534 |
| | Large | 16 | 9 | 30,258 | 17,313 |
| Tracked Target | Small | 324 | 237 | 599,631 | 438,001 |
| | Large | 21 | 11 | 38,786 | 20,939 |

Table 12. Kitwanga Lake hydroacoustic fish population estimates by basin

| Estimate Method | Basin | Size Class | Density | | Population | |
|-----------------|----------|------------|---------|----------|------------|----------|
| | | | N/ha | 95% C.I. | N | 95% C.I. |
| Tracked Target | North | Small | 171 | 380 | 110,202 | 244,853 |
| | | Large | 4 | 10 | 2,396 | 6,339 |
| | South | Small | 553 | 2,108 | 75,123 | 286,155 |
| | | Large | 319 | 621 | 43,307 | 84,313 |
| | Combined | Small | 238 | 206 | 185,325 | 160,334 |
| | | Large | 59 | 18 | 45,702 | 13,856 |

Table 13. Damdochax Lake integration estimates and biomass by survey year

| Survey | | Trawl Caught Age-0 <i>O. nerka</i> | | Integration Estimate | | |
|--------|----------|---------------------------------------|--------------------|-----------------------|---------------------------------------|---|
| Year | Date | N | Mean Weight (g) | Age-0 <i>O. nerka</i> | Age-0 <i>O. nerka</i> Biomass (kg) | Age-0 <i>O. nerka</i> Density (#/ha) |
| 1991 | Sept. 6 | 100 | 2.0 ^a | 265,696 ^b | 531 | 2,314 ^b |
| 1992 | Sept. 23 | 83 | 3.9 ^a | 76,576 ^b | 299 | 608 ^b |
| 1993 | Sept. 25 | 215 | 4.3 ^b | 152,116 ^b | 654 | 1,222 ^b |
| 2007 | Sept. 5 | 48 | 2.4 | 92,262 | 221 | 624 |

a. McCreight *et al.* 1993. b. Johannes *et al.* 1995.

Table 14. Lakelse Lake integration estimates and biomass by survey year

| Survey | | Trawl Caught Age-0 <i>O. nerka</i> | | Integration Estimate | | Age-0 <i>O. nerka</i> Biomass (kg) |
|-------------------|----------|---------------------------------------|-----------------|-----------------------|------------------|--|
| Year | Date | N | Mean Weight (g) | Age-0 <i>O. nerka</i> | Other | |
| 1994 ^a | Oct. 9 | 82 | 6.1 | 420,227 | 22% TSB | 2,563 |
| 2003 ^b | July 14 | 11 | 2.0 | 195,875 | 16% RL, CAS, RSC | 392 ^f |
| 2004 ^c | Sept. 25 | 67 | 3.4 | 215,365 | 15% TSB,CAS | 732 ^g |
| 2005 ^d | Sept. 5 | 153 | 4.0 | 391,401 | | 1,566 ^h |
| 2006 ^e | Oct. 11 | 1 | 6.1 | 103,928 | 15% unknown | 634 ⁱ |
| 2007 | Sept. 26 | 8 | 2.4 | 202,474 | | 486 |

a. Shortreed *et al.* 1998. b. Shortreed and Hume 2004. c. Shortreed and Hume 2005. d. Hume and Shortreed 2006. e. Hall 2007. f. Summer biomass. g. Reported as 734 kg due to rounding differences. h. Reported as 194 kg due to typographical error. i. Reported as 620 kg due to rounding differences. TSB = threespine stickleback, RL = river lamprey

Table 15. Lakelse Lake PR model smolt estimates vs. observed fall fry

| Year | PR Model ^a | | | | Observed | | |
|-------------------|-----------------------|---------------------|--------------------------|---------------------------------|------------------------|---------------------|------------------------|
| | Rmax (kg) | RmaxN (# smolts) | Adjusted Rmax (kg) | Adjusted RmaxN (# smolts) | Fry Biomass (kg) | Fry Pop. (# fry) | % Adj. Rmax (kg) |
| 1994 ^b | 6,390 | 1,420,000 | 2,880 | 640,000 | 2,563 | 420,227 | 89% |
| 2004 ^c | | | | | 734 | 215,365 | 25% |
| 2005 ^d | | | | | 1,720 ^f | 391,401 | 60% |
| 2006 ^e | | | | | 620 | 103,928 | 22% |
| 2007 | | | | | 486 | 202,474 | 17% |

a. Cox-Rogers *et al.* 2004. b. Shortreed *et al.* 1998. c. Shortreed and Hume 2005. d. Hume and Shortreed 2006. e. Hall 2007. f. Ken Shortreed pers. com.

Table 16. Kitsumkalum Lake integration estimates and biomass by survey year

| Survey | | Trawl Caught Age-0 <i>O. nerka</i> | | Integration Estimate | | Age-0 <i>O. nerka</i> Biomass (kg) |
|-------------------|---------|---------------------------------------|------------------|-----------------------|--------------|--|
| Year | Date | N | Mean Weight (g) | Age-0 <i>O. nerka</i> | Other | |
| 1994 ^a | Oct. 8 | 114 | 1.6 ^c | 230,569 | 2.5% lamprey | 371 |
| 2005 ^b | Sep. 4 | 42 | 2.0 | 470,322 | | 941 ^d |
| 2007 | Oct. 19 | 46 | 2.2 | 402,278 | 2.1% coho | 885 |

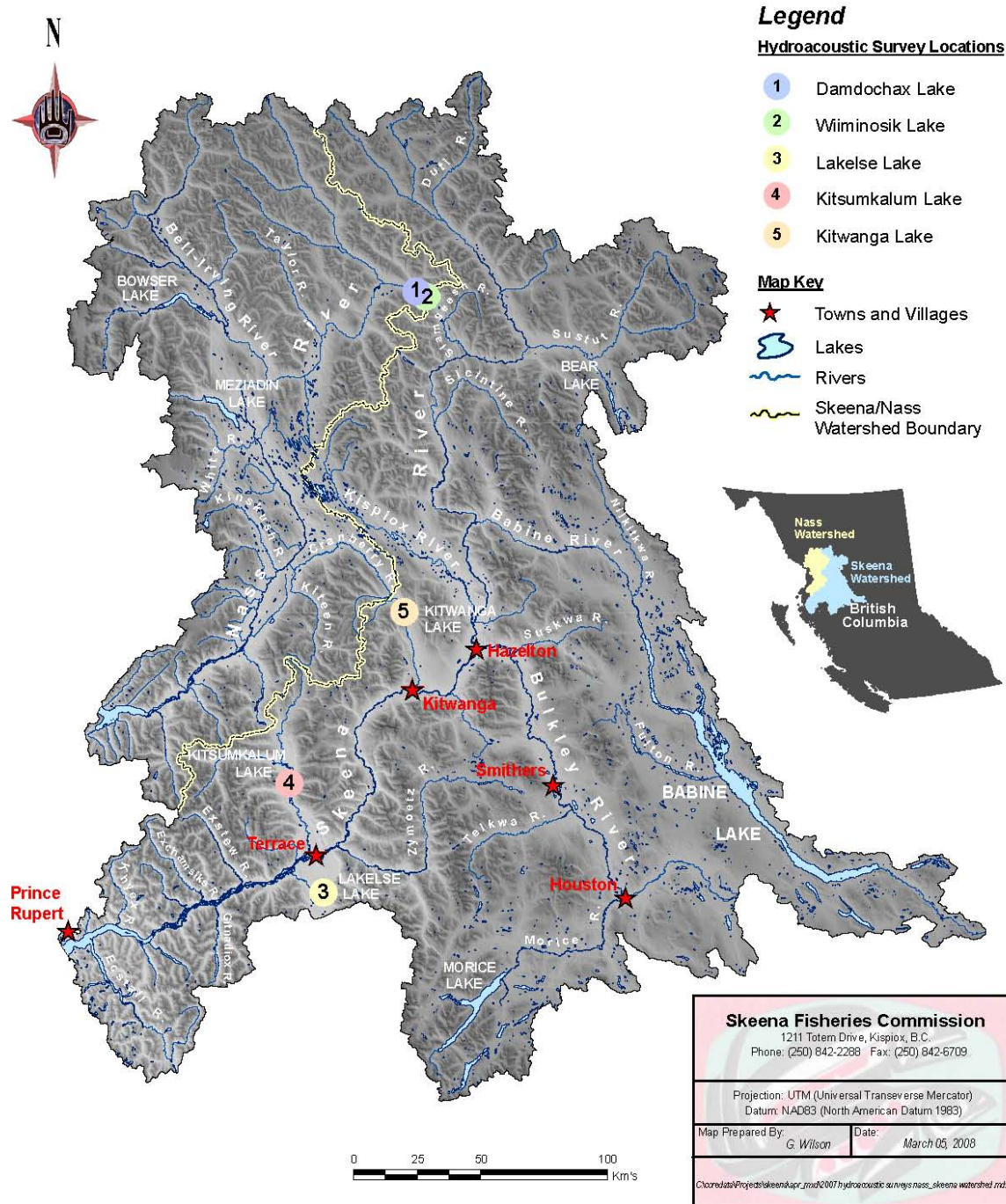
a. Shortreed *et al.* 1998. b. Hume and Shortreed 2006. c. Uncorrected for trawl bias. d. Reported as 955 kg due to rounding differences.

Table 17. Kitsumkalum Lake PR model smolt estimates vs. observed fall fry

| Year | PR Model ^a | | | | Observed | | |
|-------------------|-----------------------|---------------------|--------------------------|---------------------------------|------------------------|---------------------|------------------------|
| | Rmax (kg) | RmaxN (# smolts) | Adjusted Rmax (kg) | Adjusted RmaxN (# smolts) | Fry Biomass (kg) | Fry Pop. (# fry) | % Adj. Rmax (kg) |
| 1994 ^b | 5,000 | 1,111,110 | 2,200 | 488,889 | 371 | 230,569 | 17% |
| 2005 ^c | | | | | 955 | 470,322 | 43% |
| 2007 | | | | | 885 | 402,278 | 40% |

a. Cox-Rogers *et al.* 2004. b. Shortreed *et al.* 1998. c. Hume and Shortreed 2006.

2007 Hydroacoustic Surveys



Nass and Skeena Watersheds

Figure 1. Location of surveyed lakes in the Skeena watershed



Figure 2. Damdochax Lake aerial photograph (T. Wilson)



Figure 3. Wiiminosik Lake east basin aerial photograph (T. Wilson)



Figure 4. Lakelse Lake aerial photograph (D. Gordon)



Figure 5. Kitsumkalum Lake photograph (www.ourbc.com)



Figure 6. Kitwanga Lake aerial photograph (M. Cleveland)

Damdochax Lake

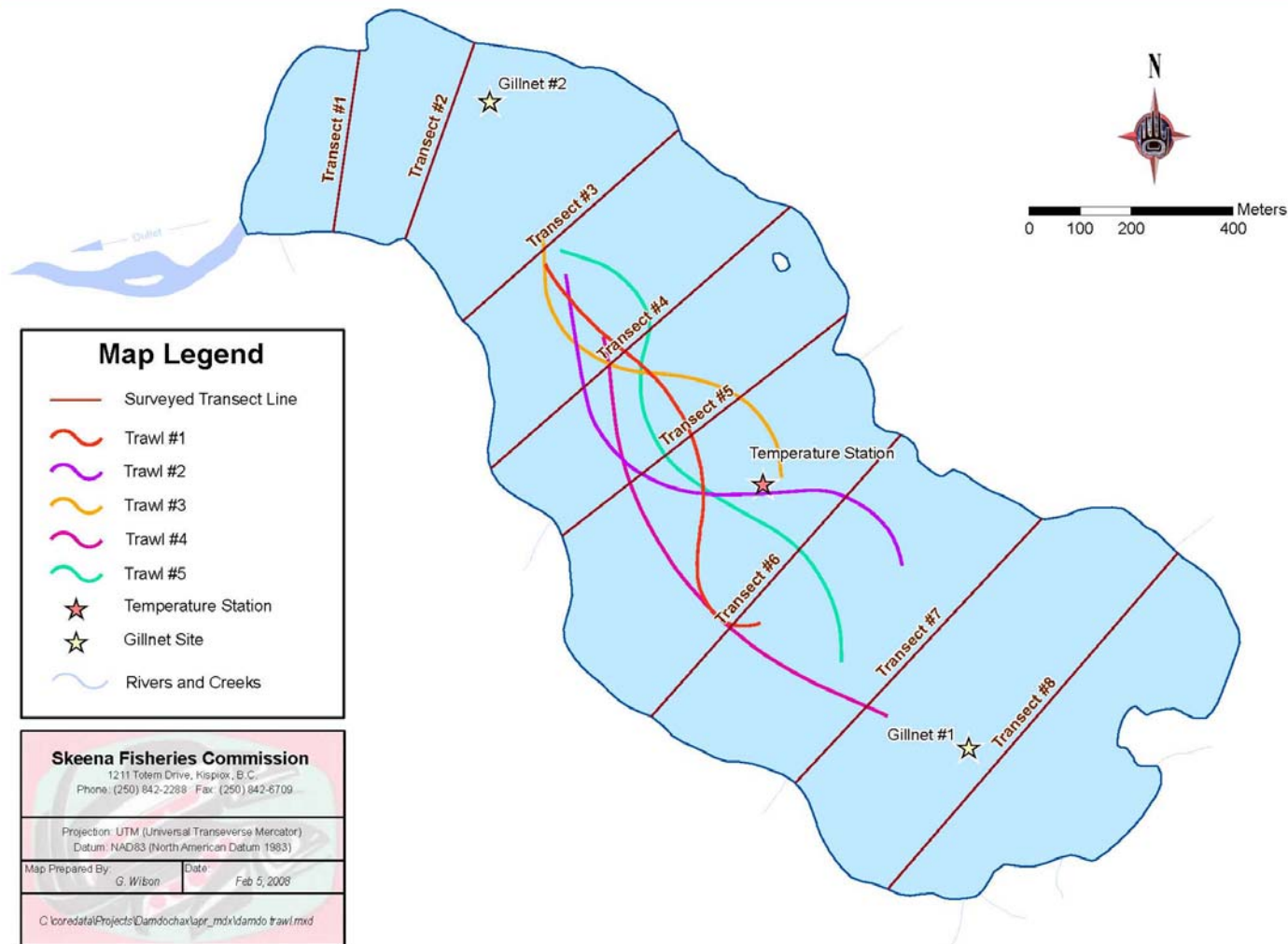


Figure 7. Damdochax Lake survey map

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

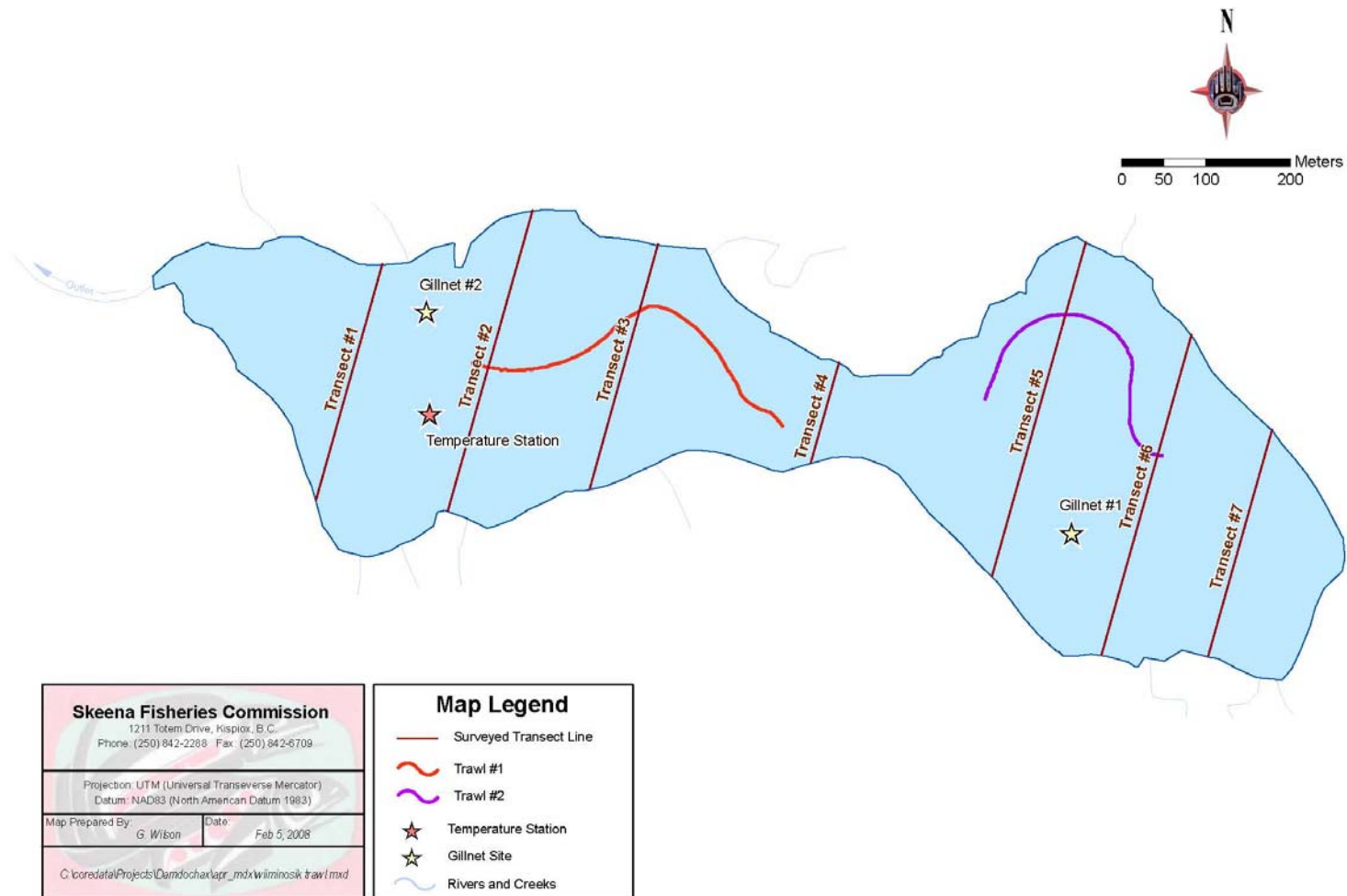


Figure 8. Wiiminosik Lake survey map

Lakelse Lake

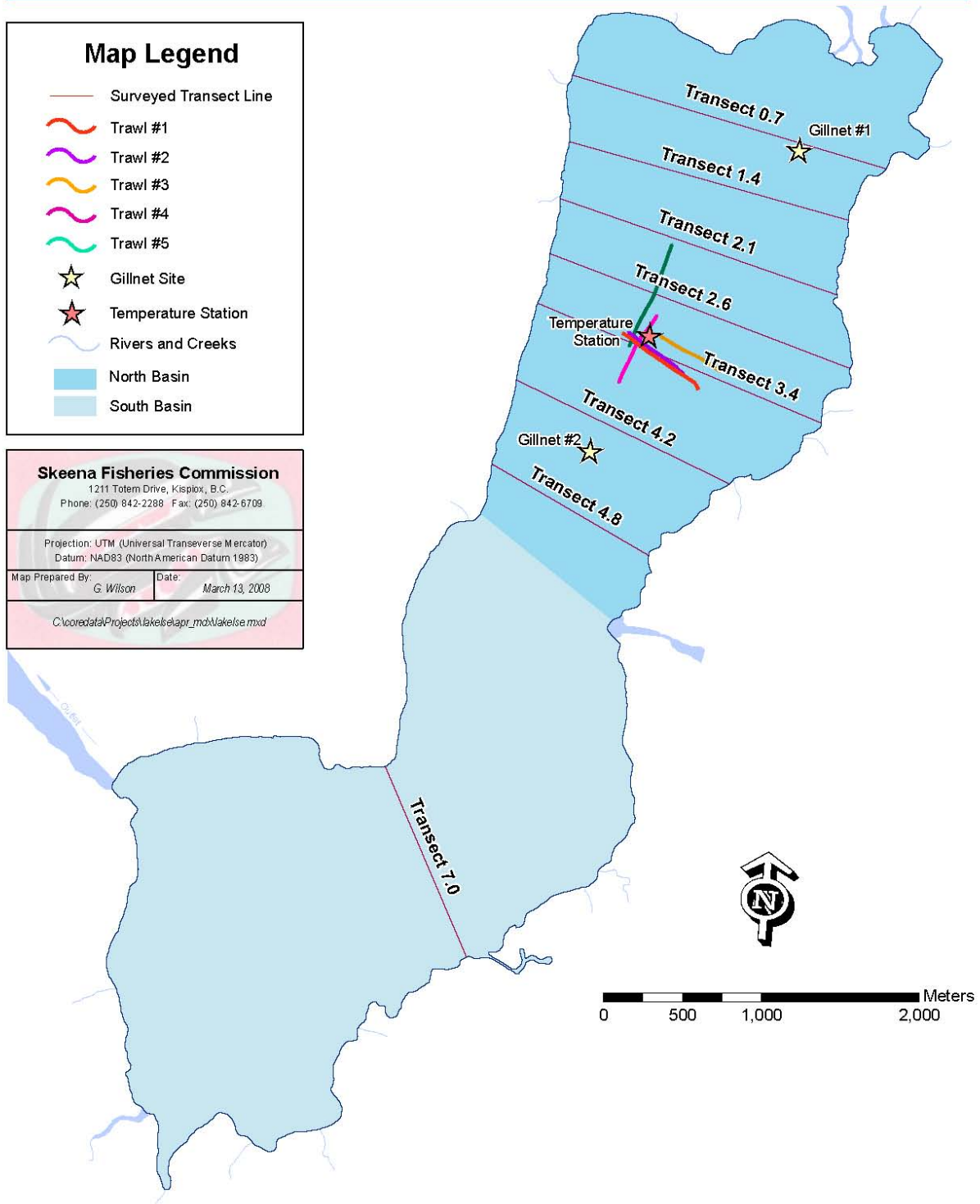


Figure 9. Lakelse Lake survey map

Kitsumkalum Lake

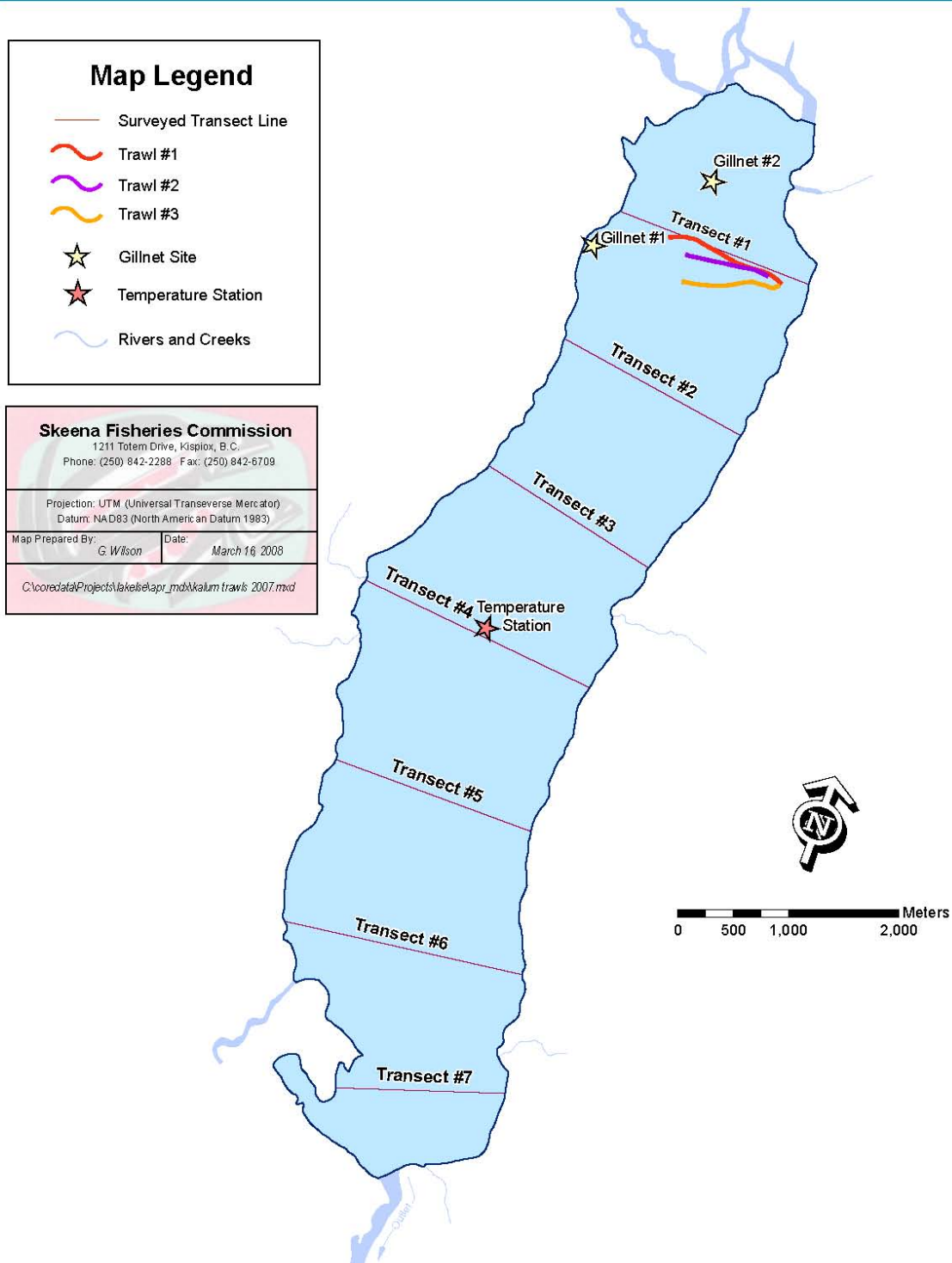


Figure 10. Kitsumkalum Lake survey map

Kitwanga Lake

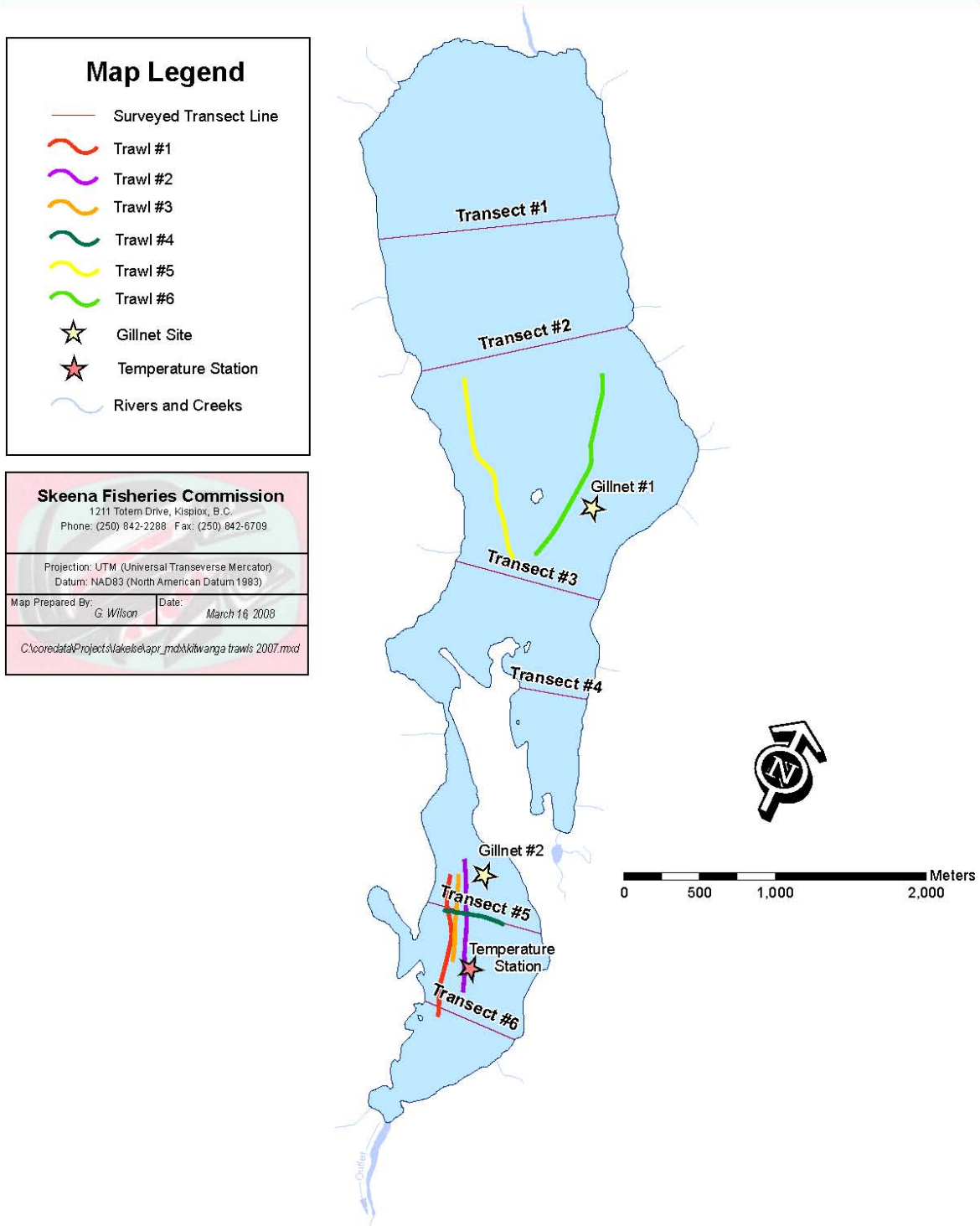


Figure 11. Kitwanga Lake survey map

Damdochax Lake

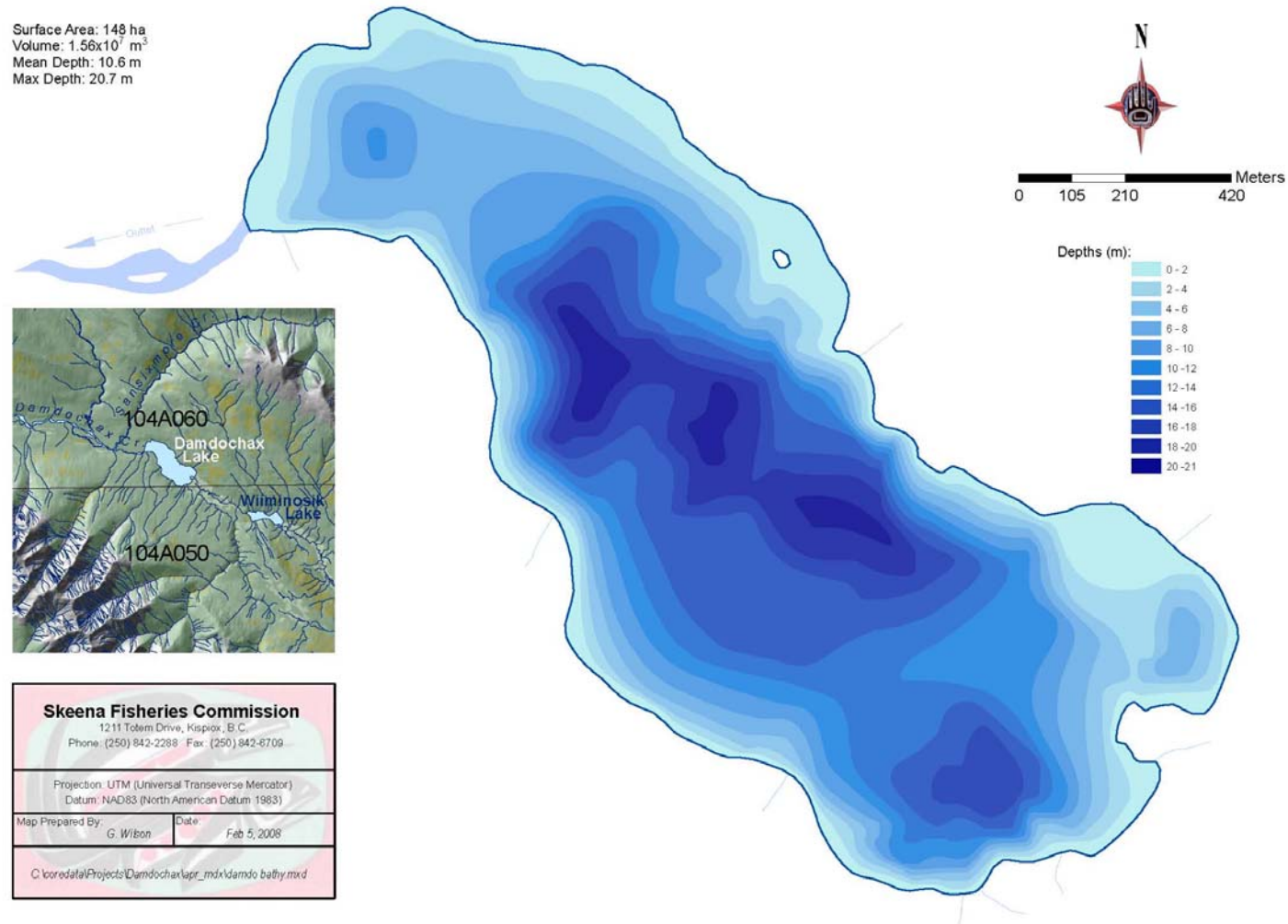


Figure 12. Damdochax Lake bathymetric map

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

Surface Area: 38.1 ha
Volume: $4.72 \times 10^5 \text{ m}^3$
Mean Depth: 12.4 m
Max Depth: 24.7 m

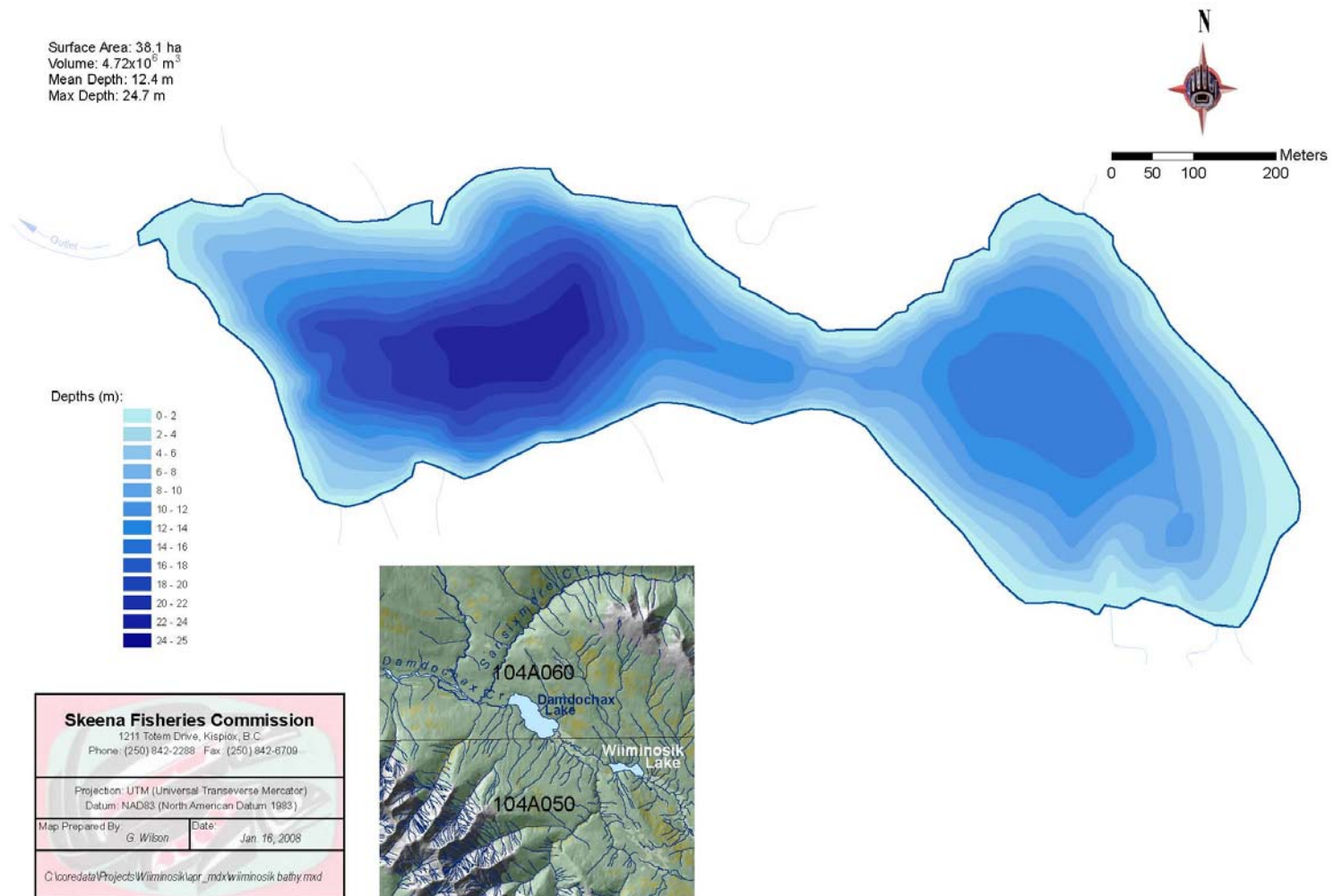


Figure 13. Wiiminosik Lake bathymetric map

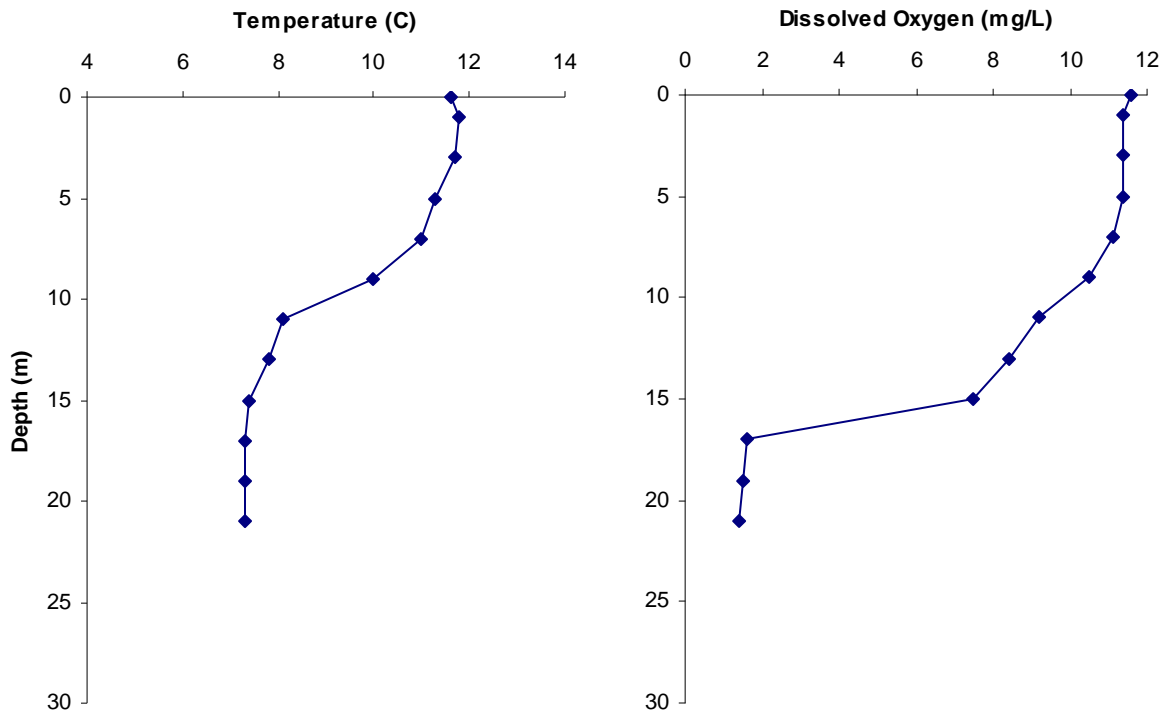


Figure 14. Temperature & oxygen profiles for Damdochax Lake

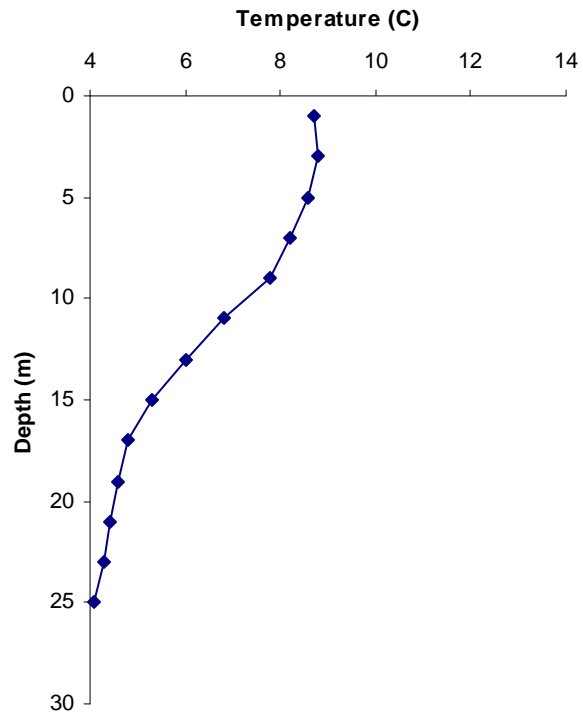


Figure 15. Temperature profile for Wiiminosik Lake (west basin)

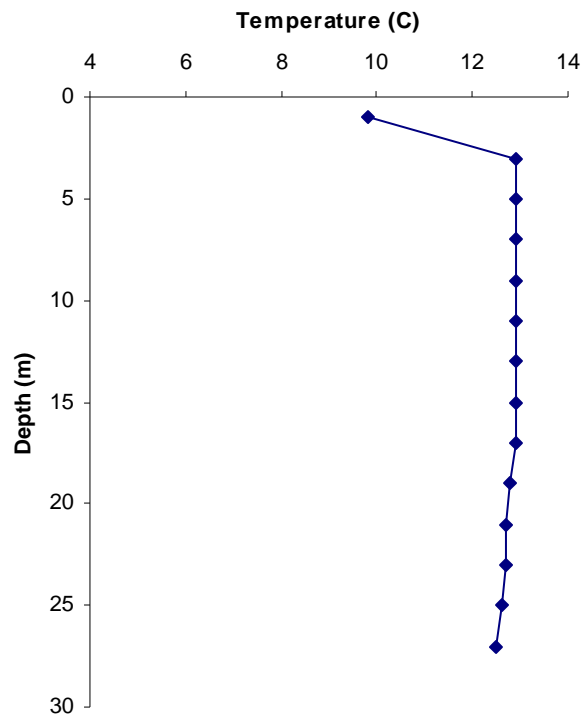


Figure 16. Temperature profile for Lakelse Lake

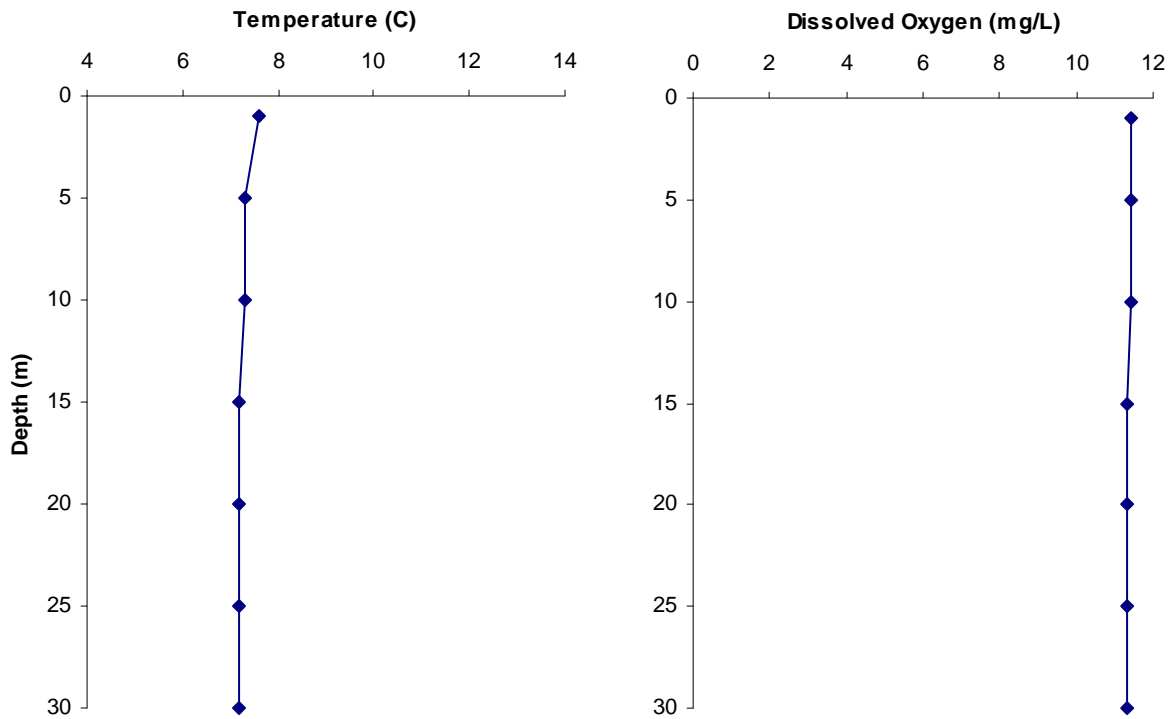


Figure 17. Temperature & oxygen profiles for Kitsumkalum Lake

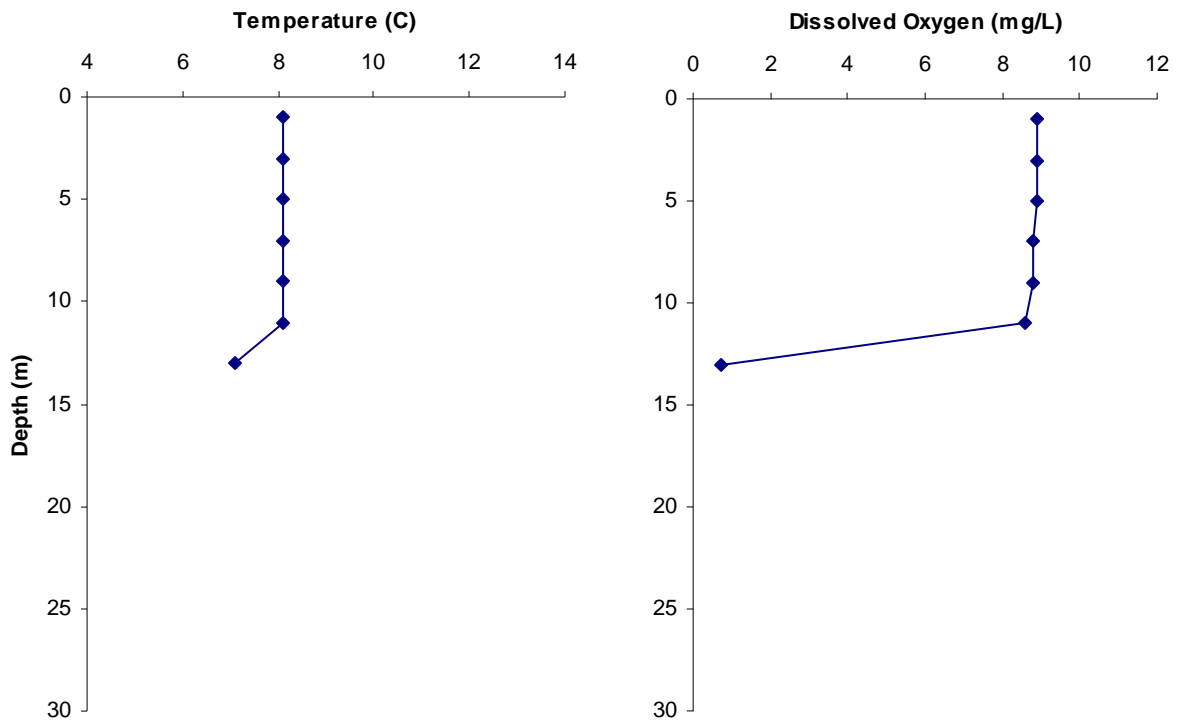


Figure 18. Temperature & oxygen profiles for Kitwanga Lake (south basin)

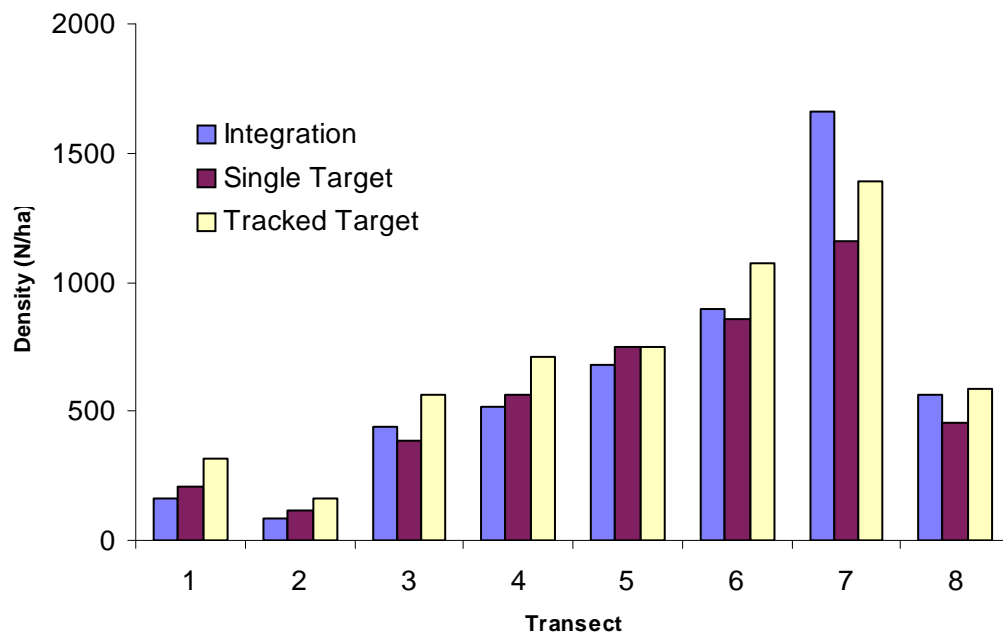


Figure 19. Damdochax Lake small size class target densities by transect and analysis method

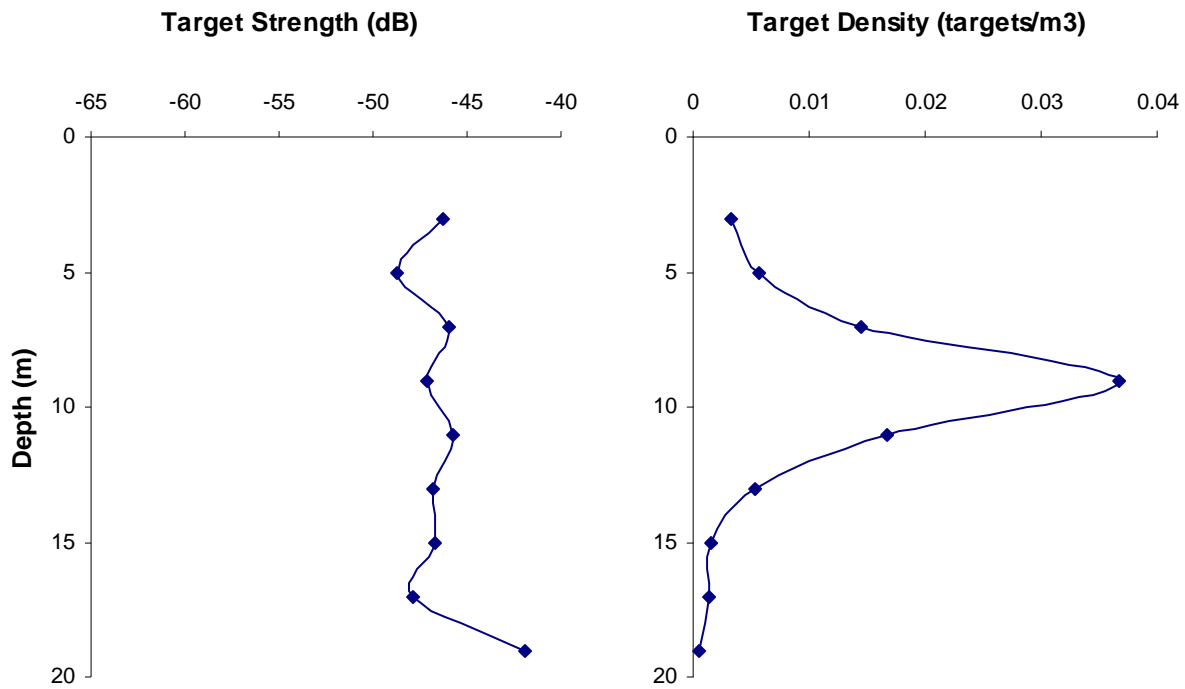


Figure 20. Average TS and target densities by depth layer for Damdochax Lake

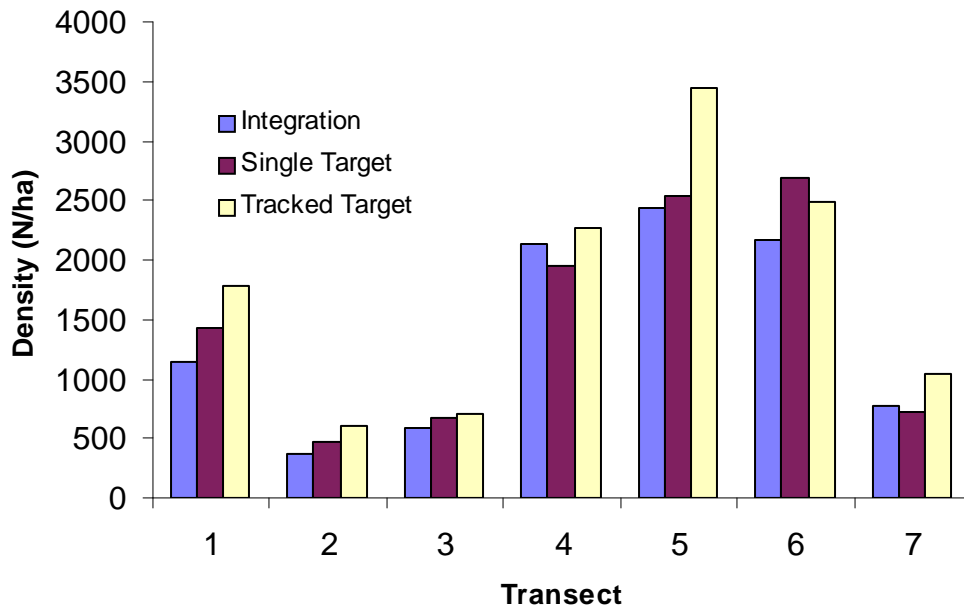


Figure 21. Wiiminosik Lake small size class target densities by transect and analysis method

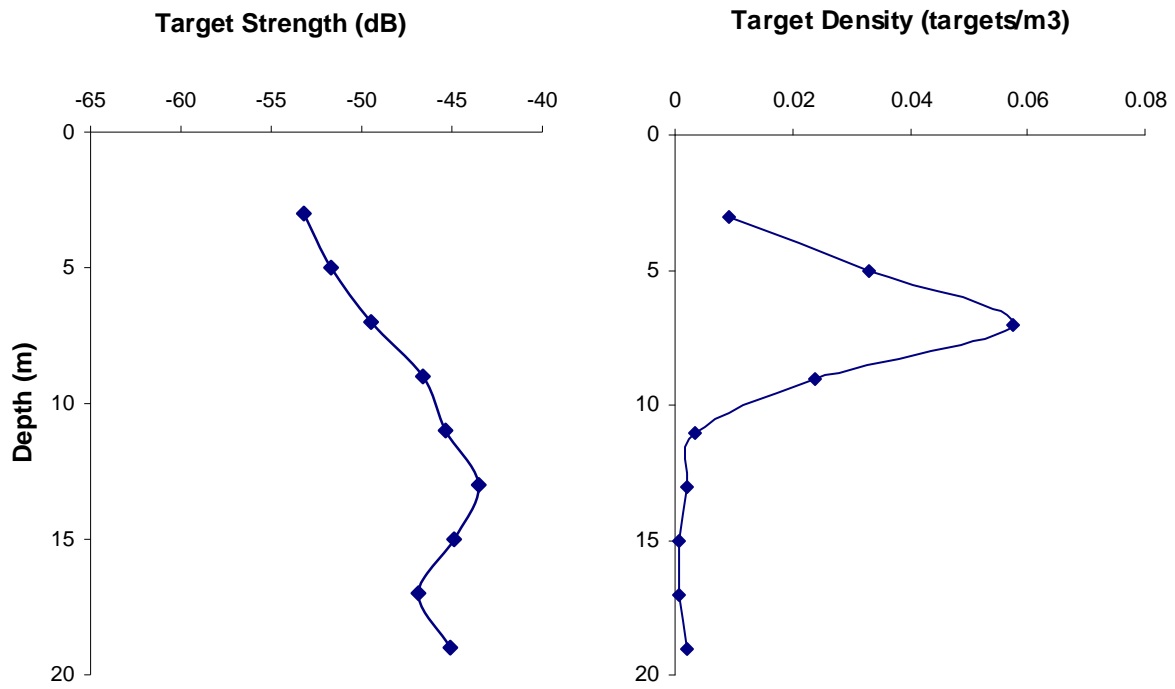


Figure 22. Average TS and target densities by depth layer for Wiiminosik Lake

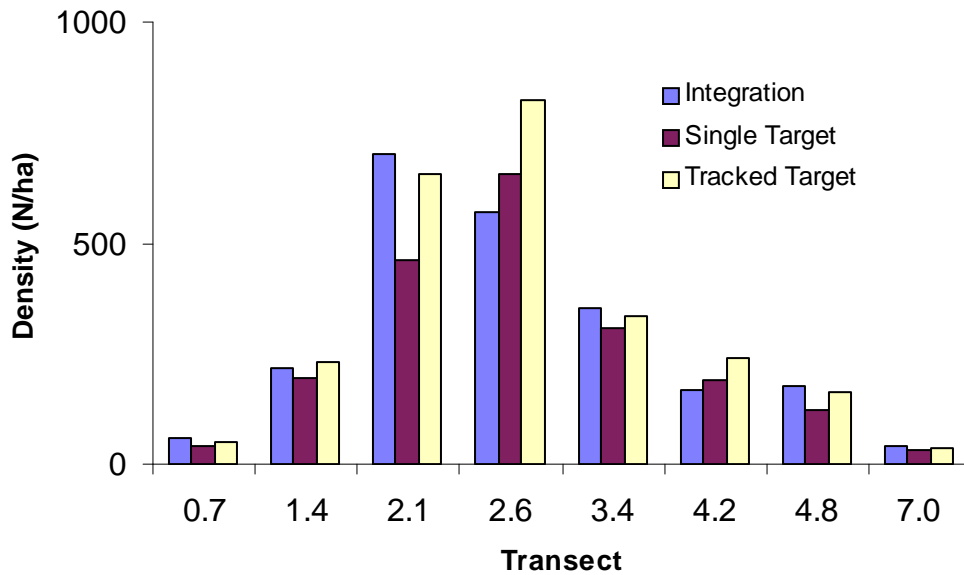


Figure 23. Lakelse Lake small size class target densities by transect and analysis method

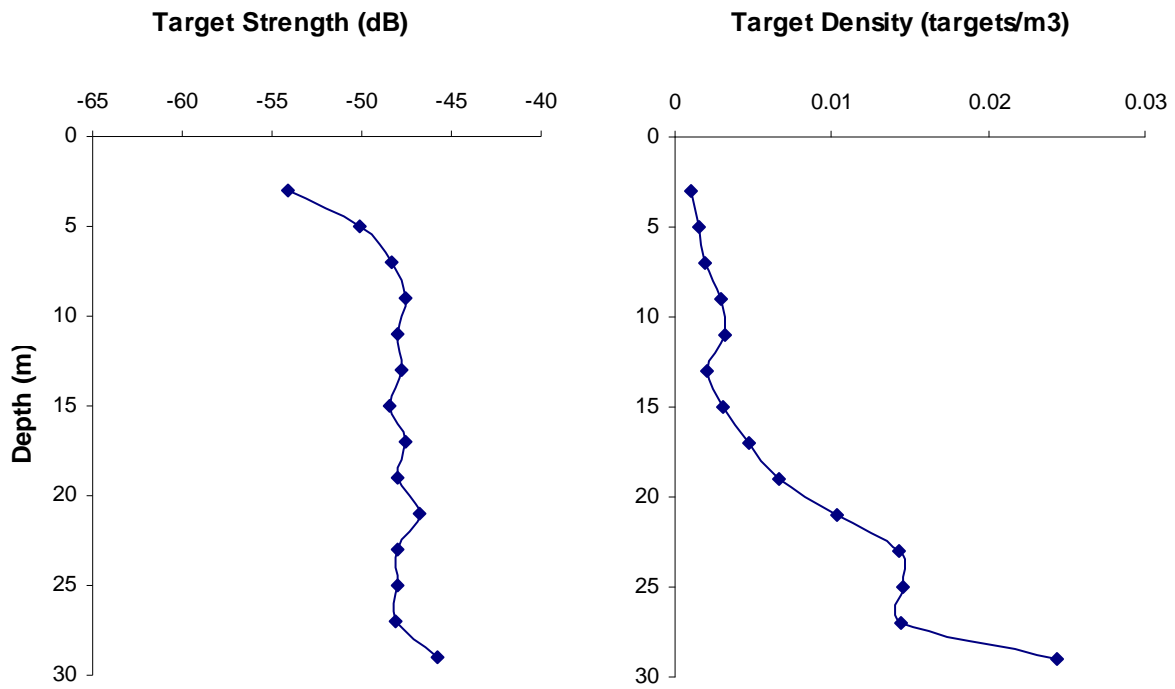


Figure 24. Average TS and target densities by depth layer (excluding transect 7.0) for Lakelse Lake

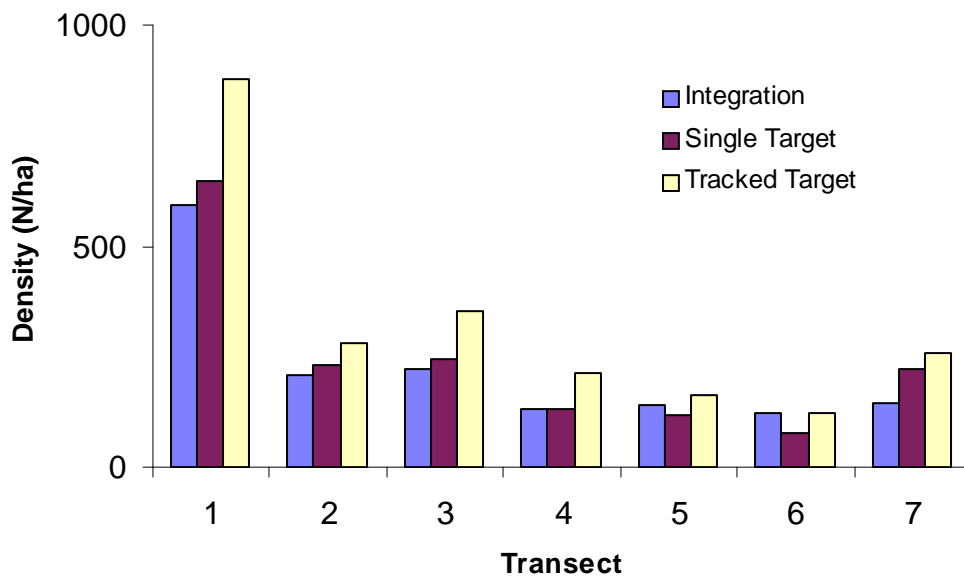


Figure 25. Kitsumkalum Lake small size class target densities by transect and analysis method

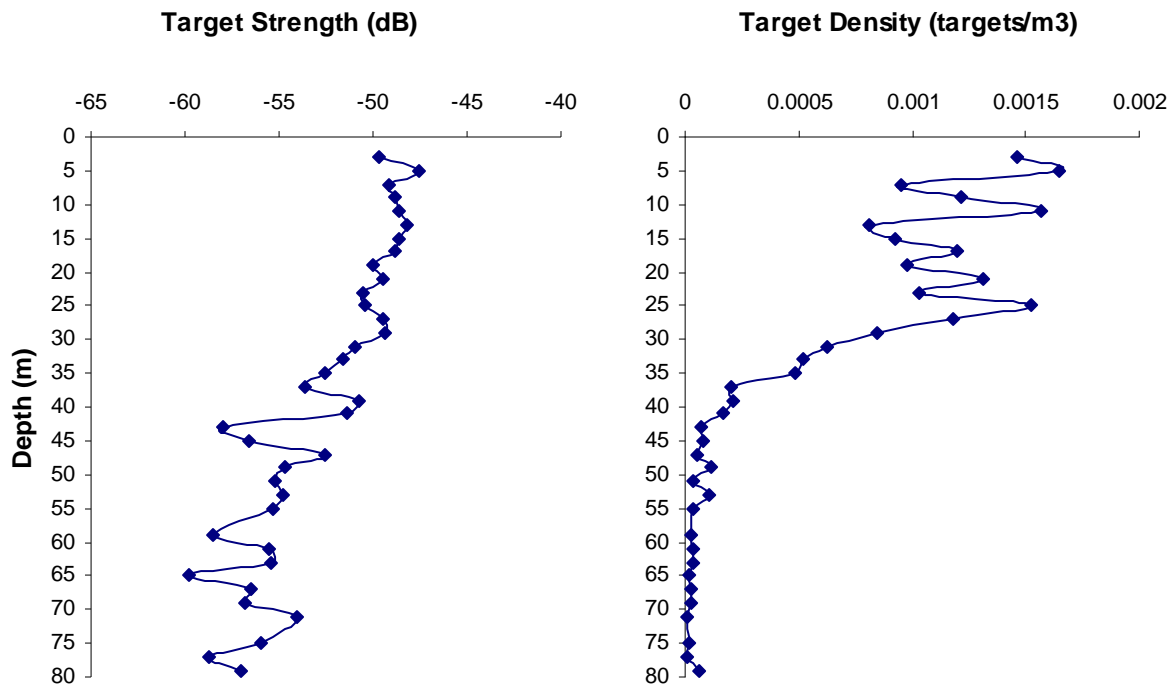


Figure 26. Average TS and target densities by depth layer for Kitsumkalum Lake

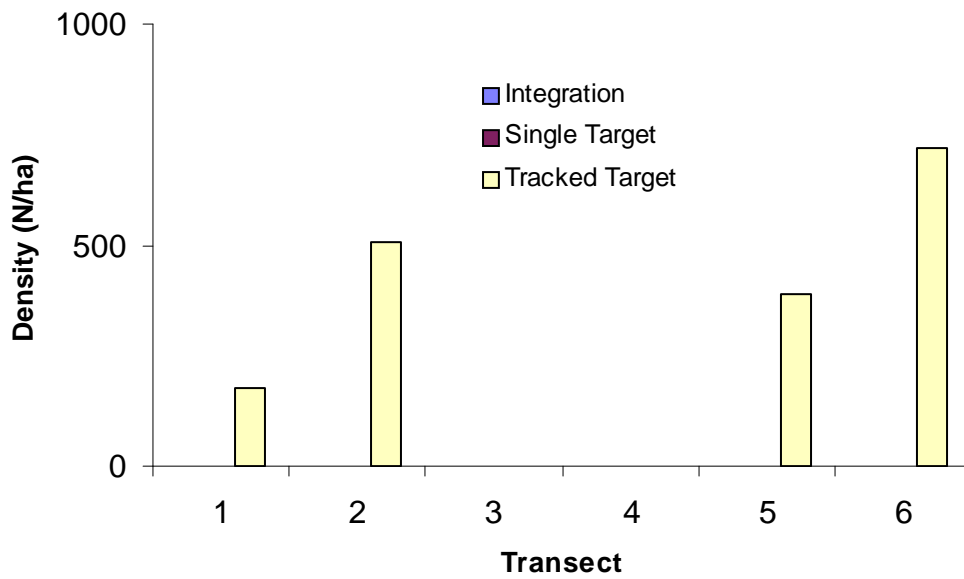


Figure 27. Kitwanga Lake small size class target densities by transect and analysis method

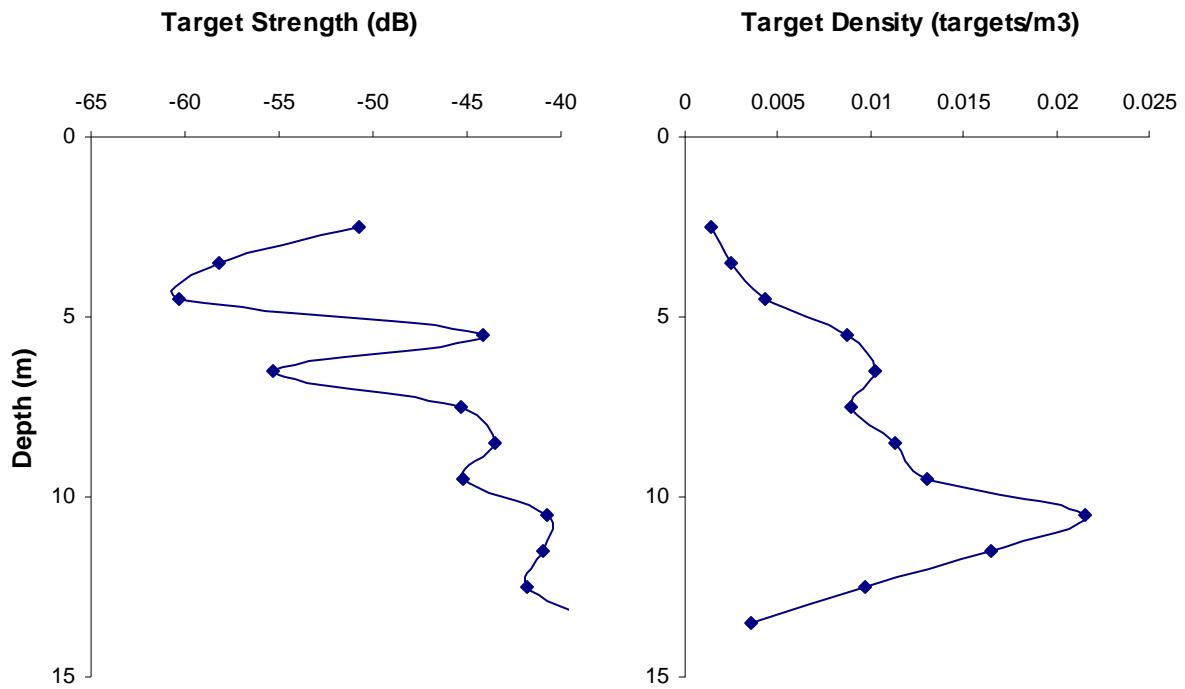


Figure 28. Average TS and target densities by depth layer for Kitwanga Lake

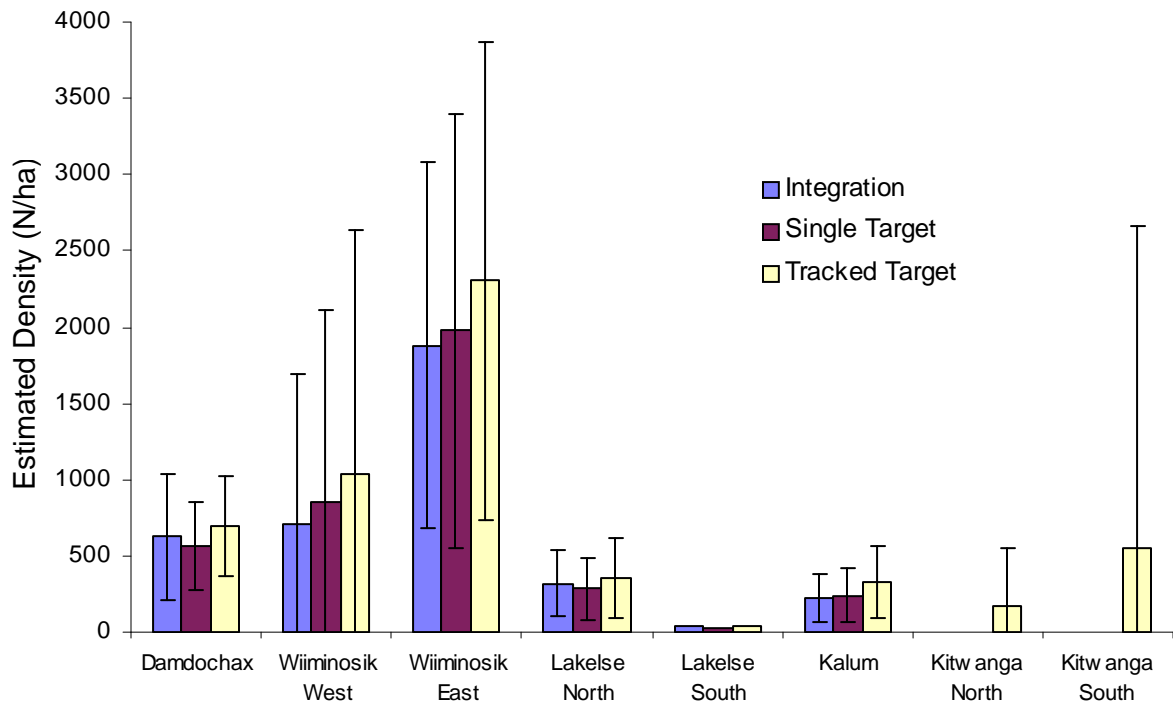


Figure 29. Small size class density estimates by analysis method and lake basin

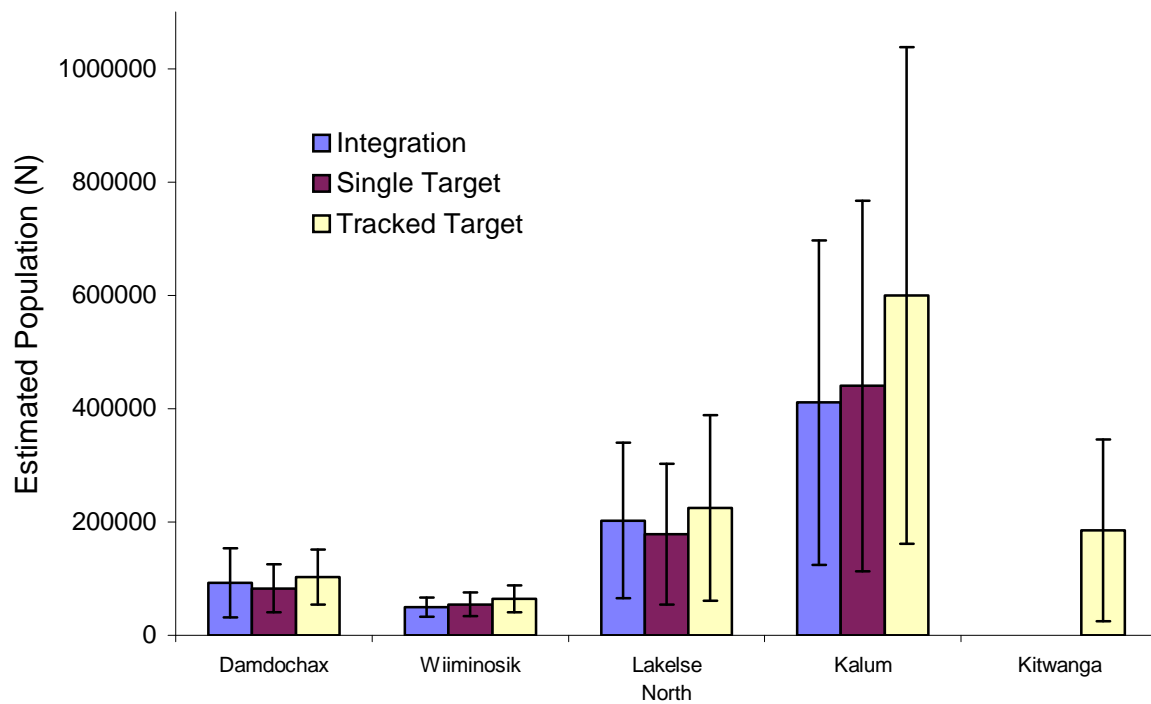


Figure 30. Small size class population estimates by analysis method and lake basin

APPENDIX 1: Damdochax Lake Transect Echograms

Note: All echograms are vertically exaggerated by varying amounts based on transect length.

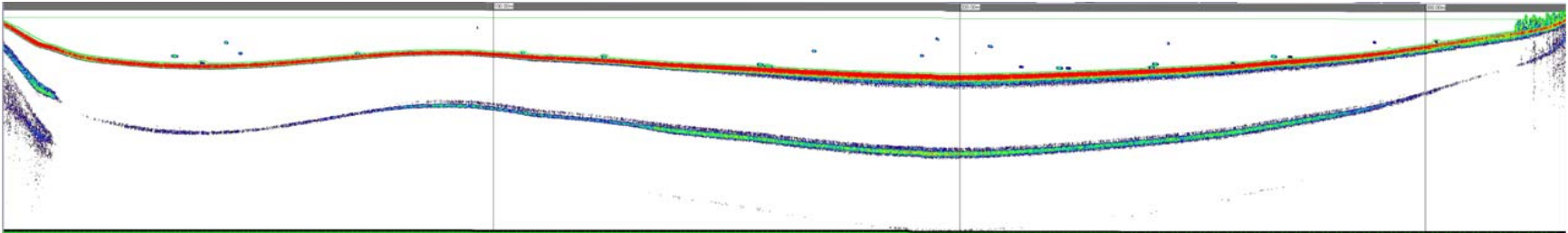


Figure 31. Damdochax Lake transect 1 echogram

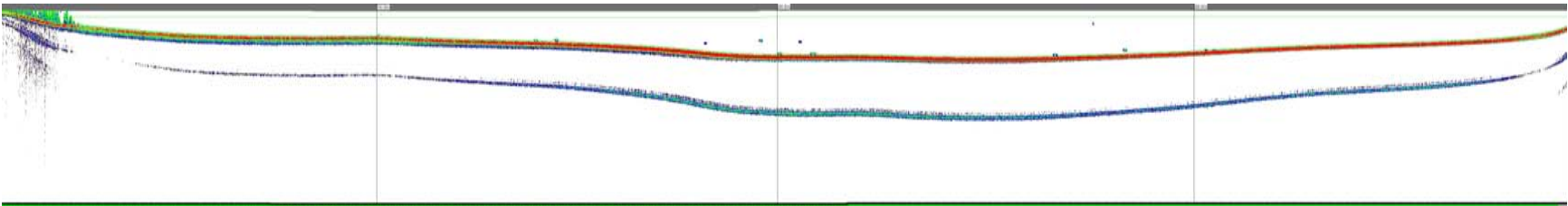


Figure 32. Damdochax Lake transect 2 echogram

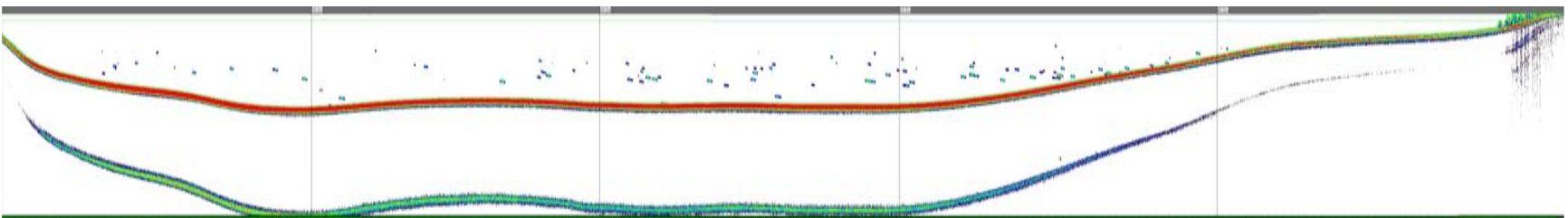


Figure 33. Damdochax Lake transect 3 echogram

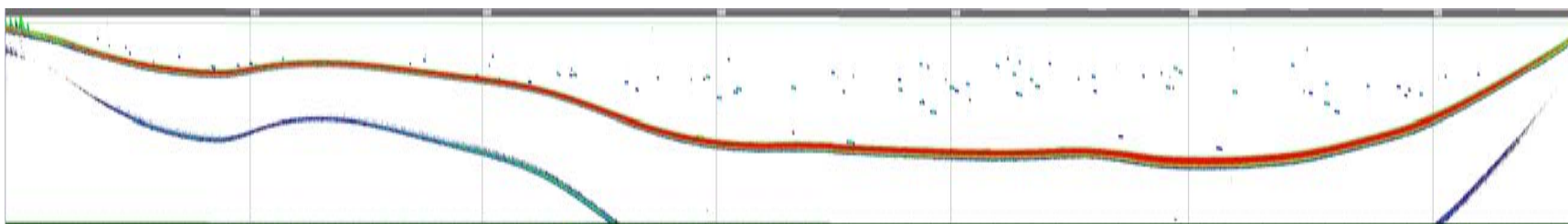


Figure 34. Damdochax Lake transect 4 echogram

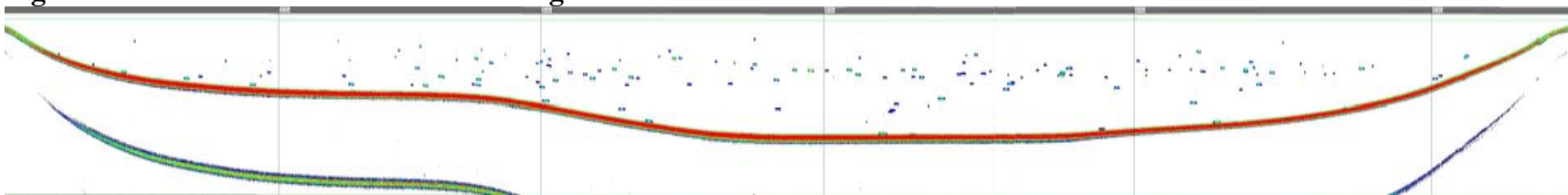


Figure 35. Damdochax Lake transect 5 echogram

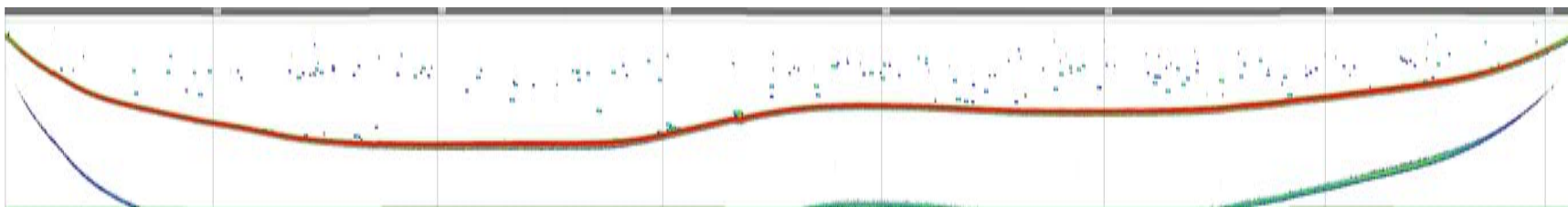


Figure 36. Damdochax Lake transect 6 echogram

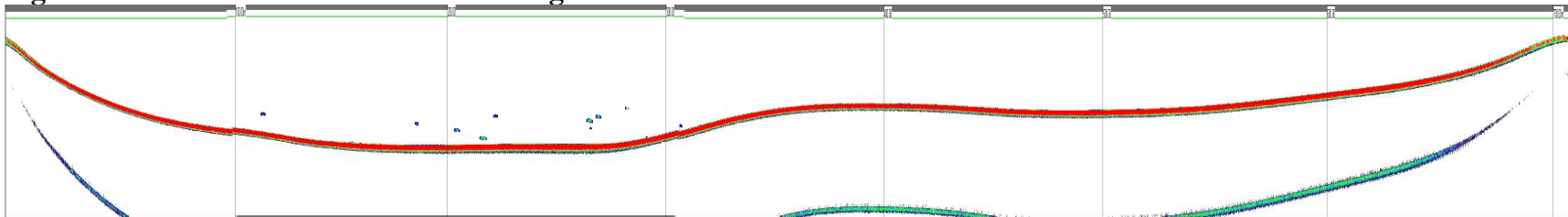


Figure 37. Damdochax Lake transect 6 daylight echogram

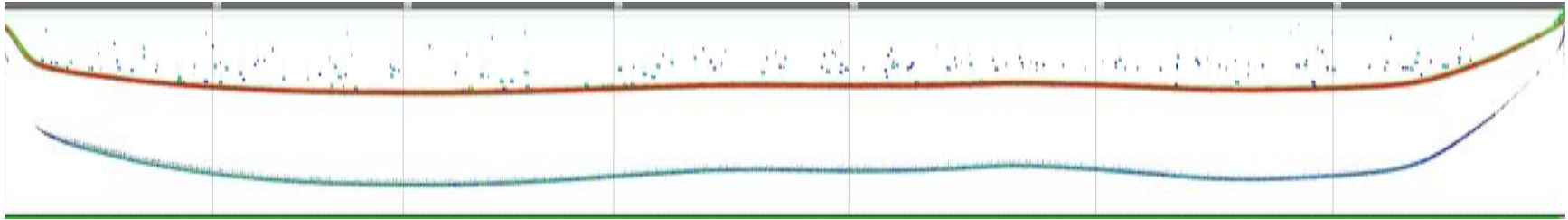


Figure 38. Damdochax Lake transect 7 echogram

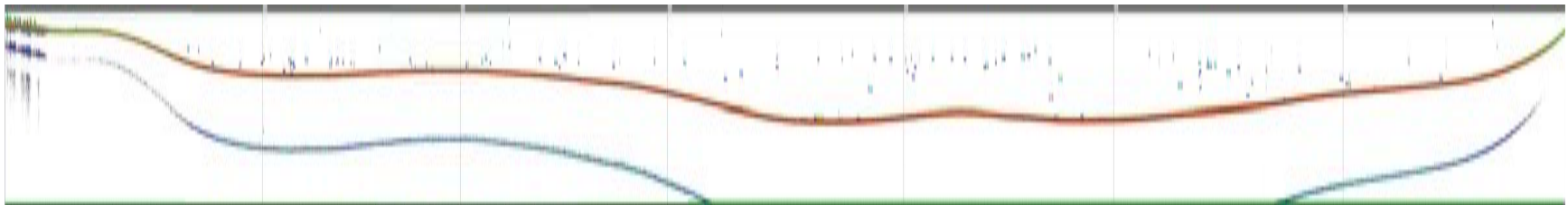


Figure 39. Damdochax Lake transect 8 echogram

APPENDIX 2: Wiiminosik Lake Transect Echograms

Note: All echograms are vertically exaggerated by varying amounts based on transect length.

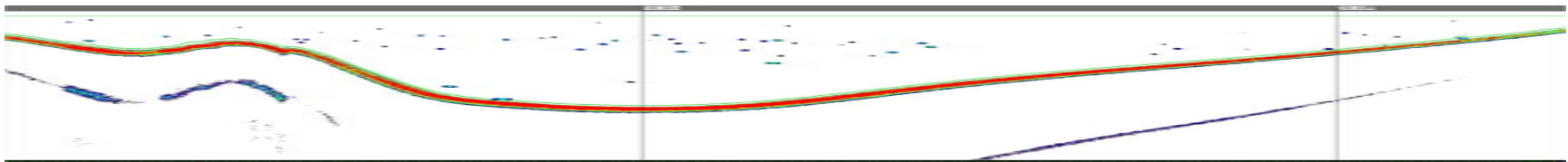


Figure 40. Wiiminosik Lake transect 1 echogram

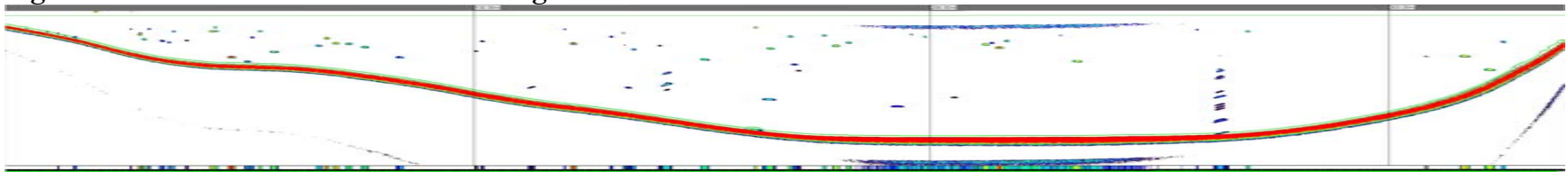


Figure 41. Wiiminosik Lake transect 2 echogram

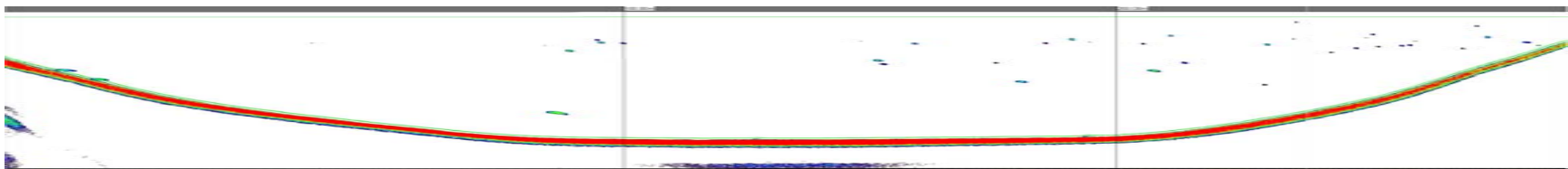


Figure 42. Wiiminosik Lake transect 3 echogram

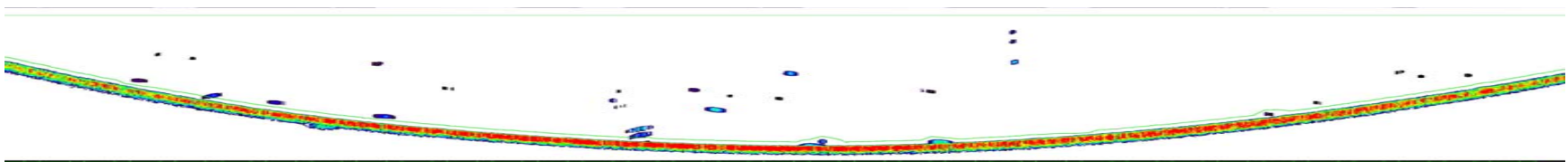


Figure 43. Wiiminosik Lake transect 4 echogram

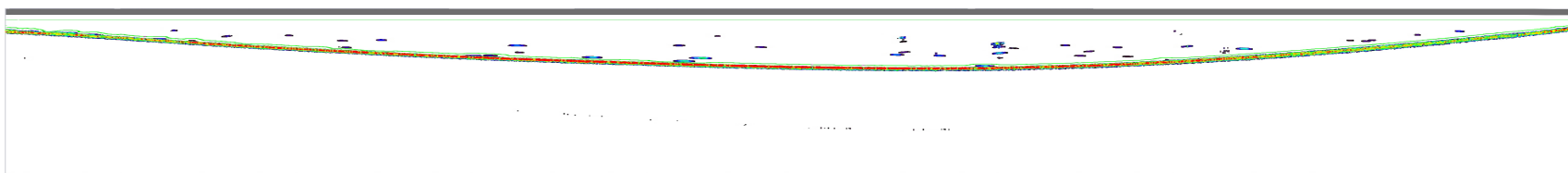


Figure 44. Wiiminosik Lake transect 5 echogram



Figure 45. Wiiminosik Lake transect 6 echogram

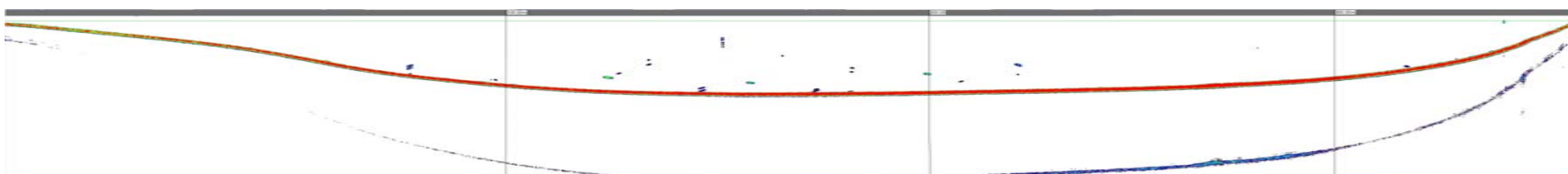


Figure 46. Wiiminosik Lake transect 6 daylight echogram

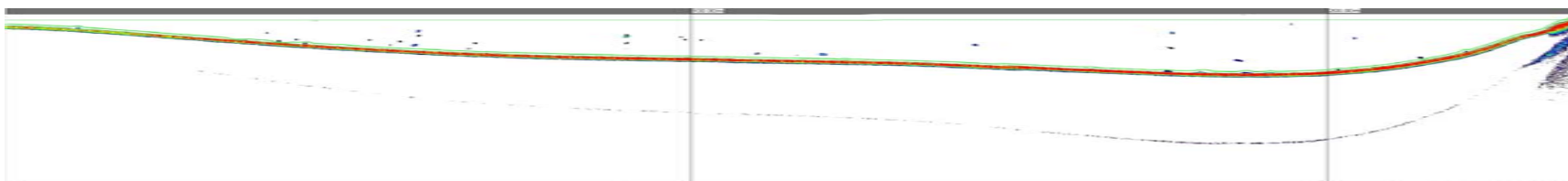


Figure 47. Wiiminosik Lake transect 7 echogram

APPENDIX 3: Lakelse Lake Transect Echograms

Note: All echograms are vertically exaggerated by varying amounts based on transect length.

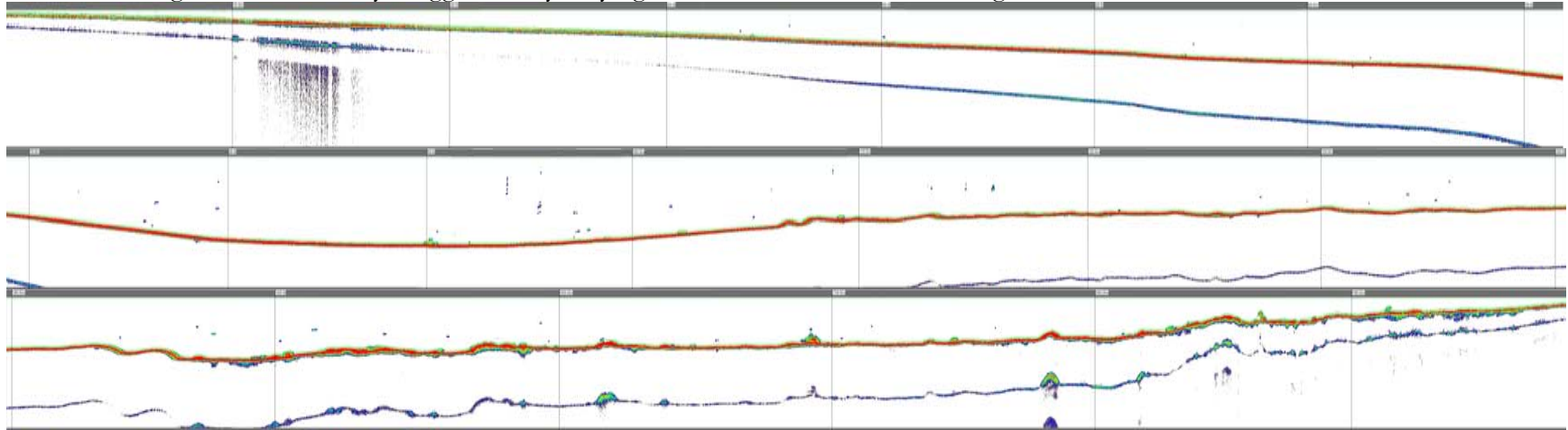


Figure 48. Lakelse Lake transect 0.7 echogram

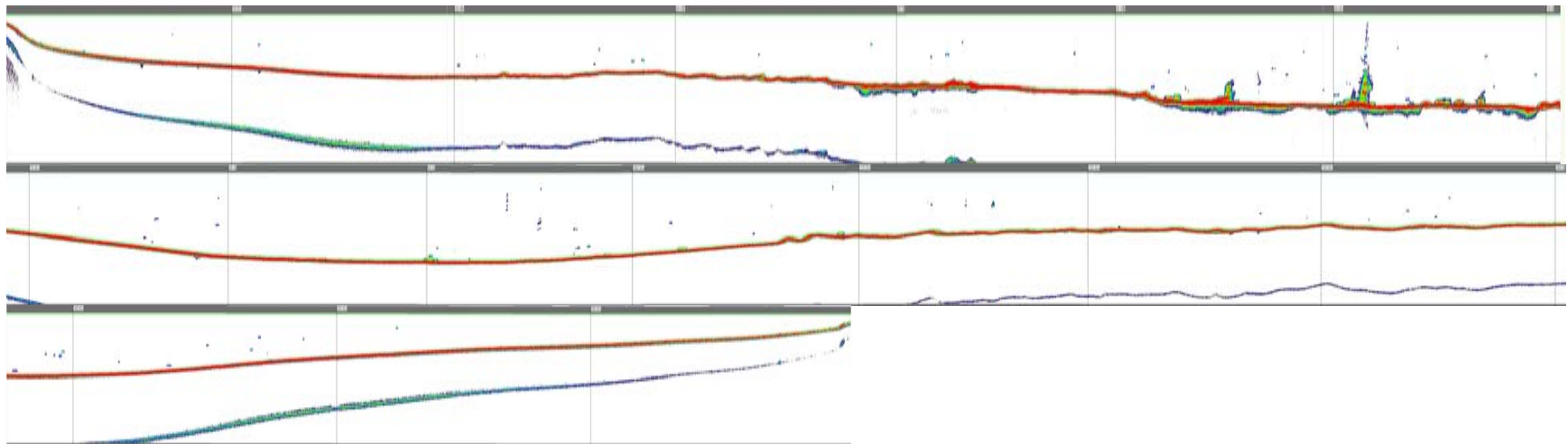


Figure 49. Lakelse Lake transect 1.4 echogram

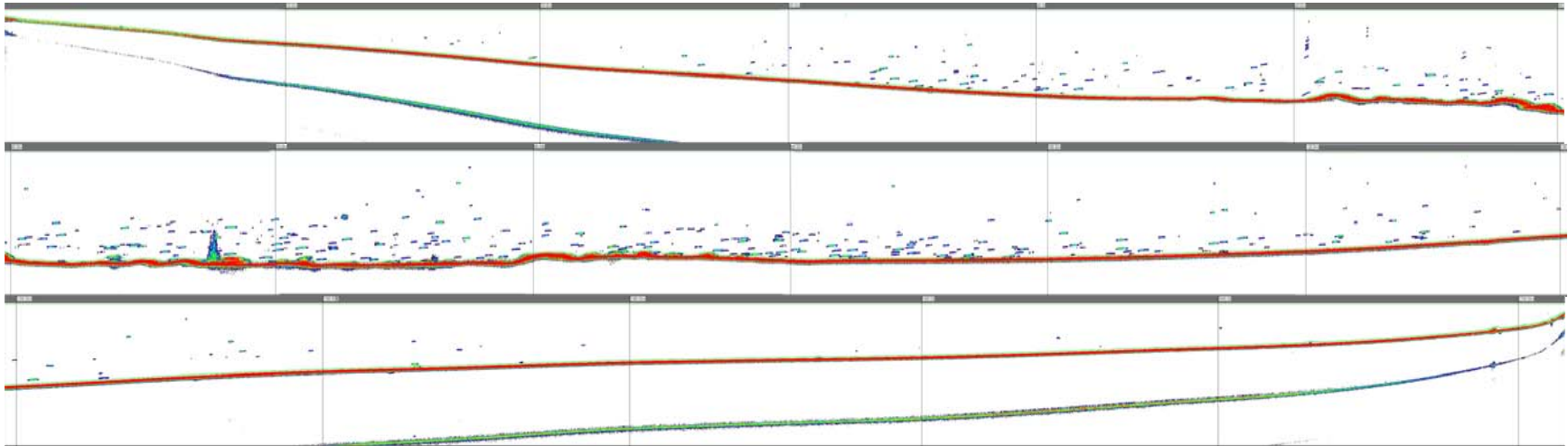


Figure 50. Lakelse Lake transect 2.1 echogram

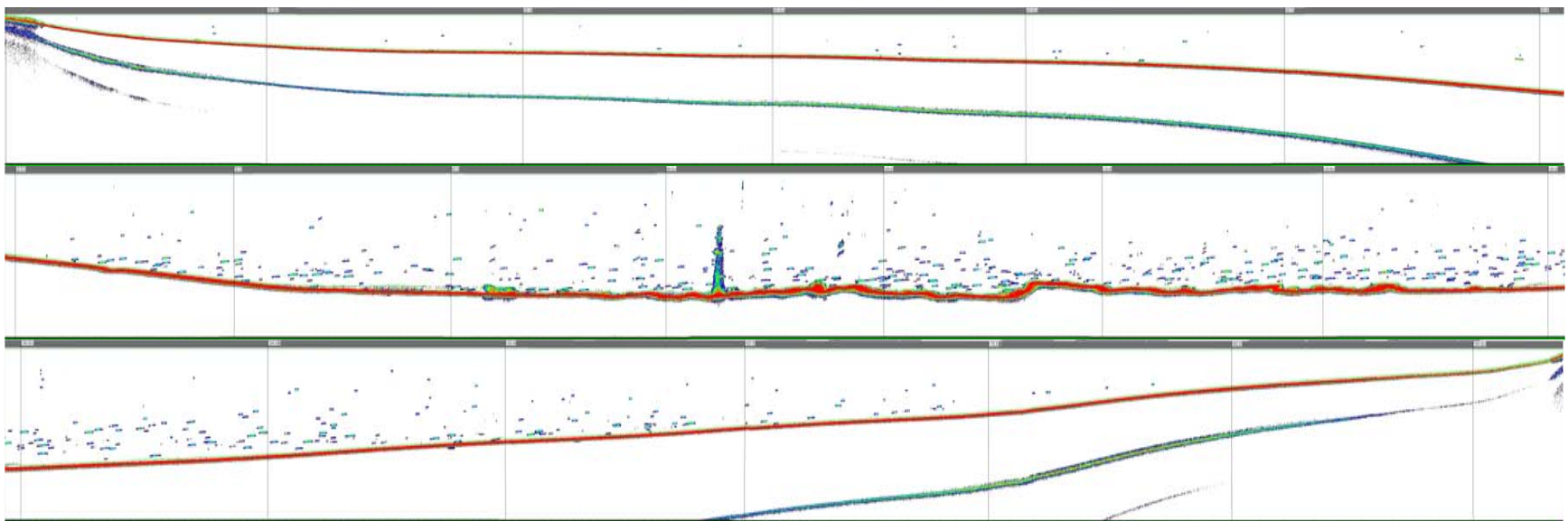


Figure 51. Lakelse Lake transect 2.6 echogram

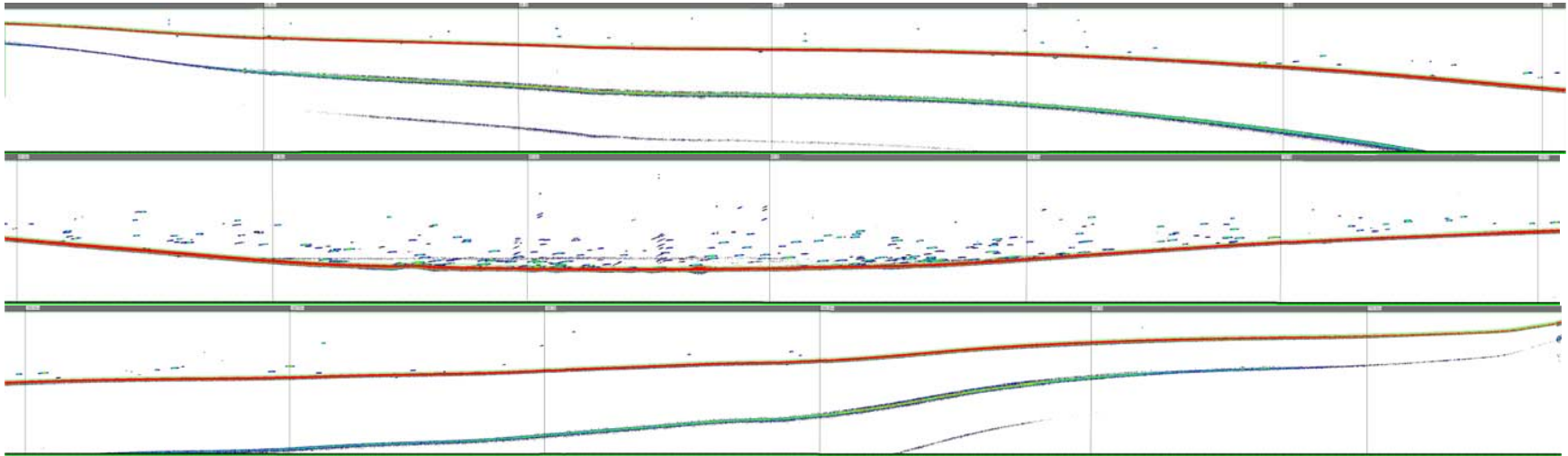


Figure 52. Lakelse Lake transect 3.4 echogram

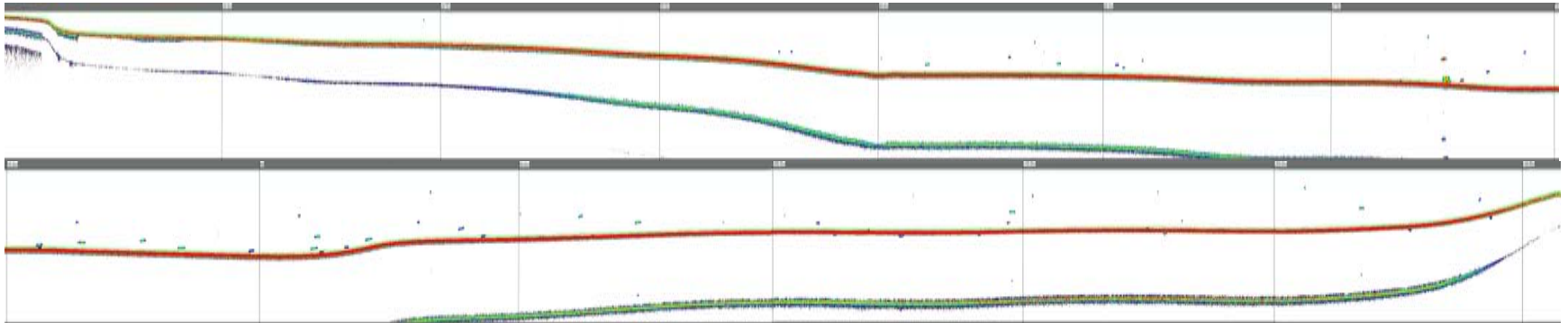


Figure 53. Lakelse Lake transect 4.2 echogram

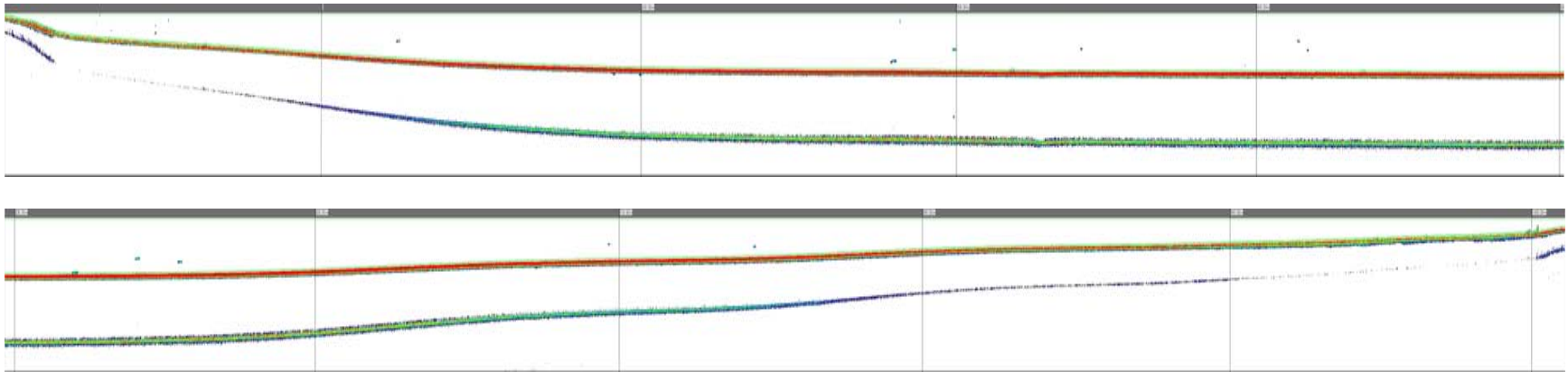


Figure 54. Lakelse Lake transect 4.8 echogram

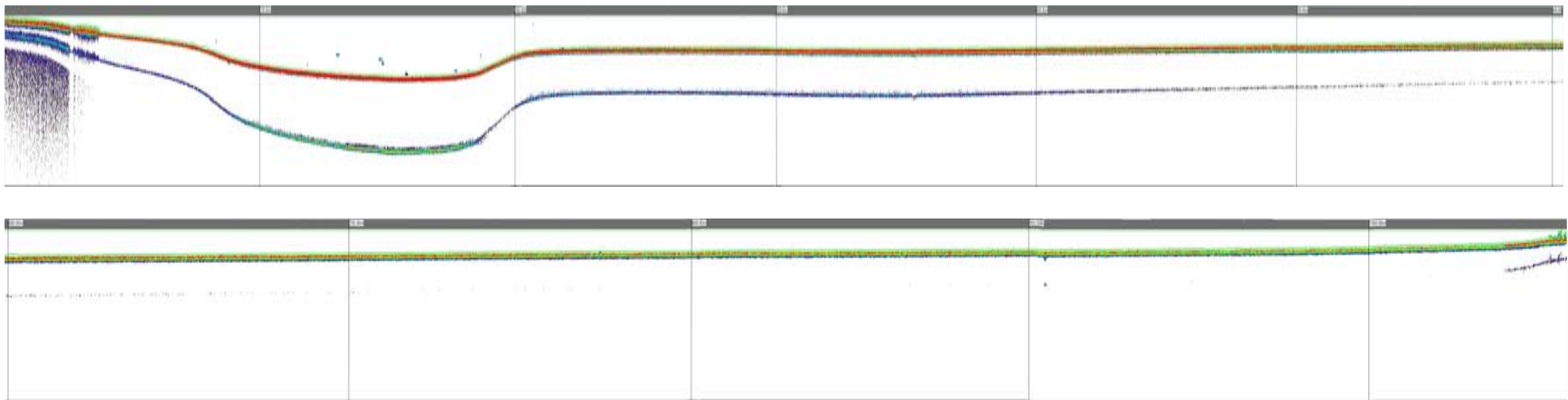


Figure 55. Lakelse Lake transect 7.0 echogram

APPENDIX 4: Kitsumkalum Lake Transect Echograms

Note: All echograms are vertically exaggerated by varying amounts based on transect length.

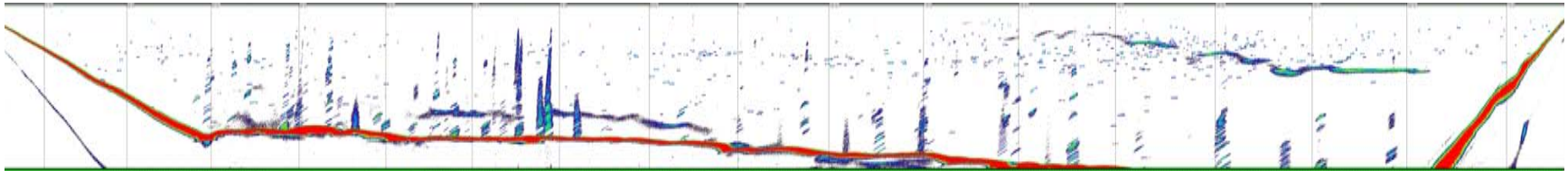


Figure 56. Kitsumkalum Lake transect 1 echogram

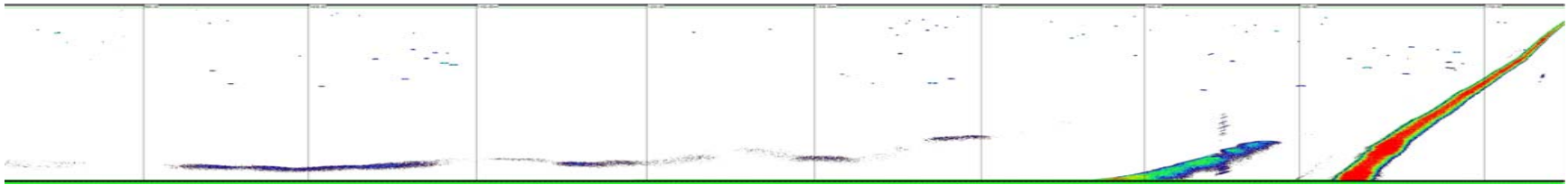


Figure 57. Kitsumkalum Lake transect 2 echogram



Figure 58. Kitsumkalum Lake transect 3 echogram



Figure 59. Kitsumkalum Lake transect 4 echogram



Figure 60. Kitsumkalum Lake transect 5 echogram

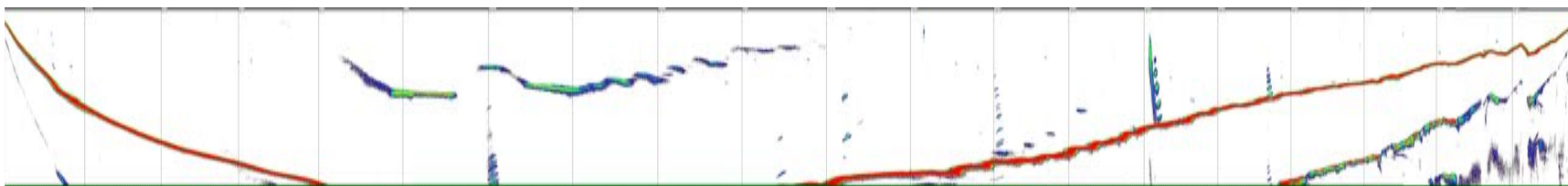


Figure 61. Kitsumkalum Lake transect 6 echogram

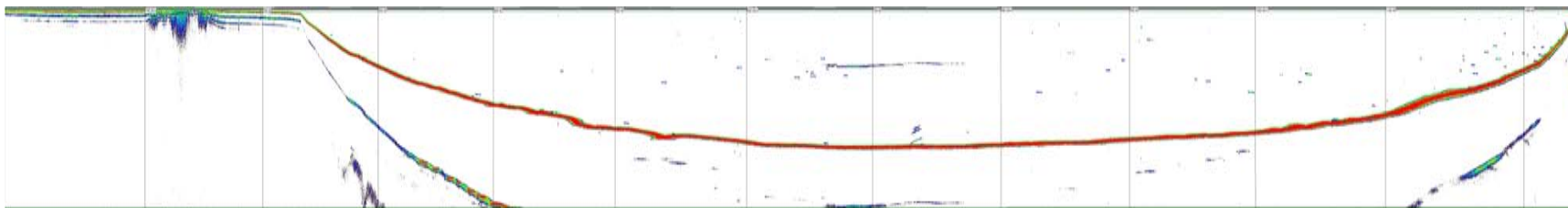


Figure 62. Kitsumkalum Lake transect 7 echogram

APPENDIX 5: Kitwanga Lake Transect Echograms

Note: All echograms are vertically exaggerated by varying amounts based on transect length.

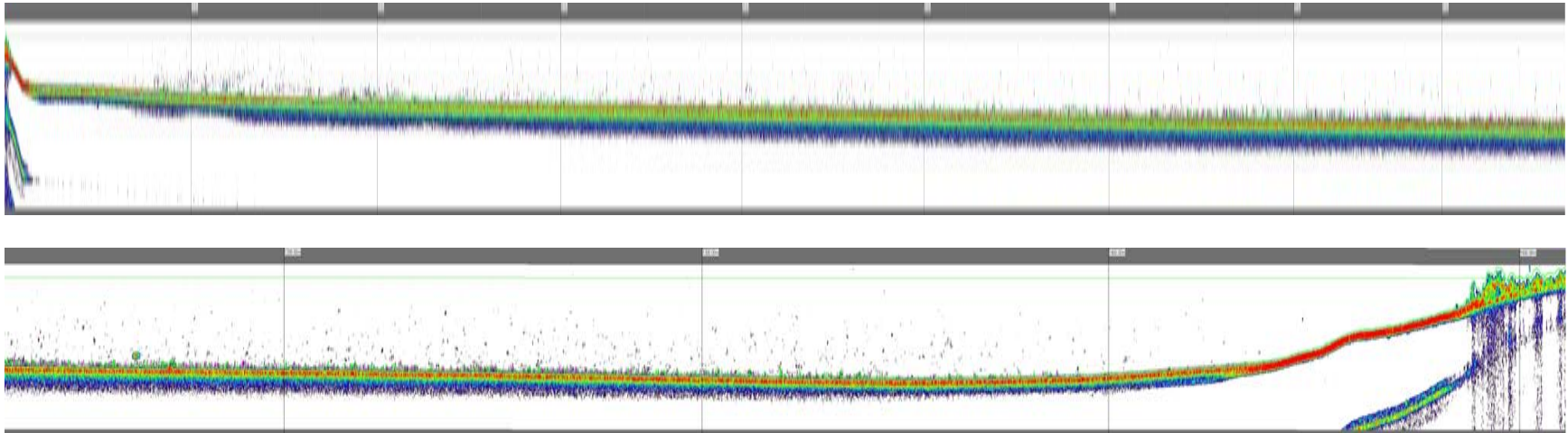


Figure 63. Kitwanga Lake transect 1 echogram

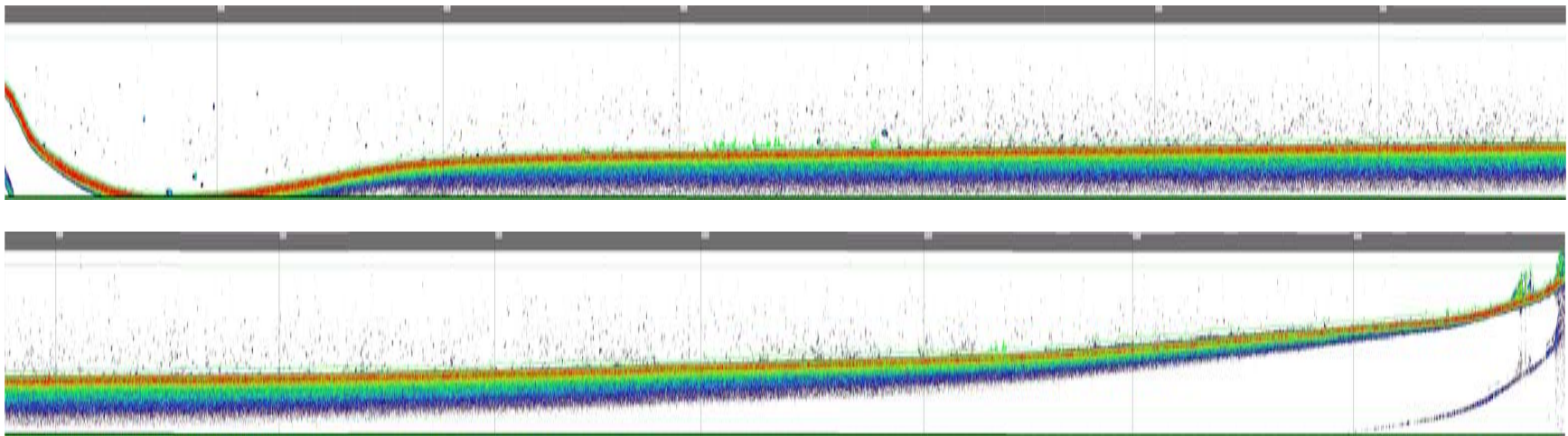


Figure 64. Kitwanga Lake transect 2 echogram

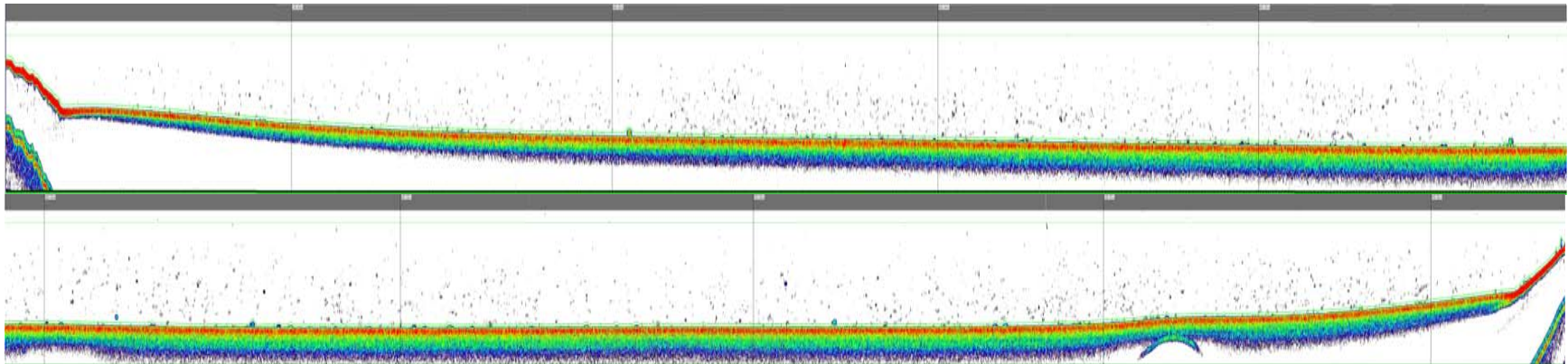


Figure 65. Kitwanga Lake transect 3 echogram

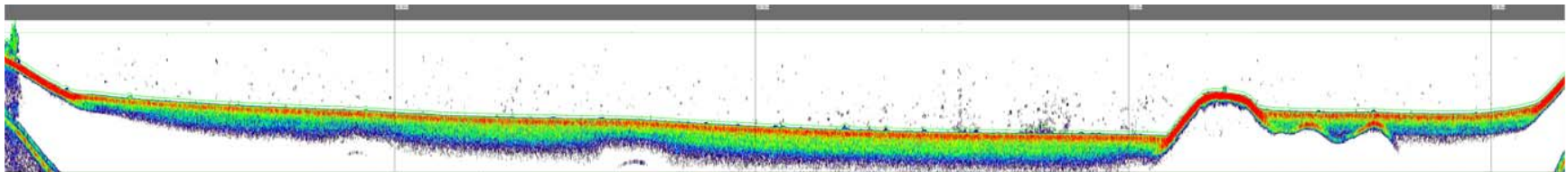


Figure 66. Kitwanga Lake transect 4 echogram

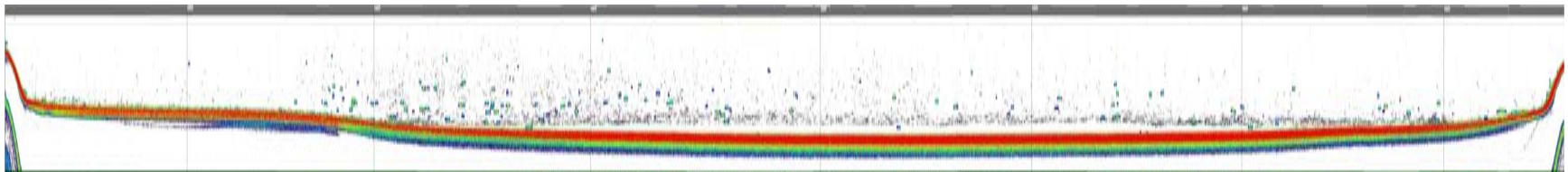


Figure 67. Kitwanga Lake transect 5 echogram

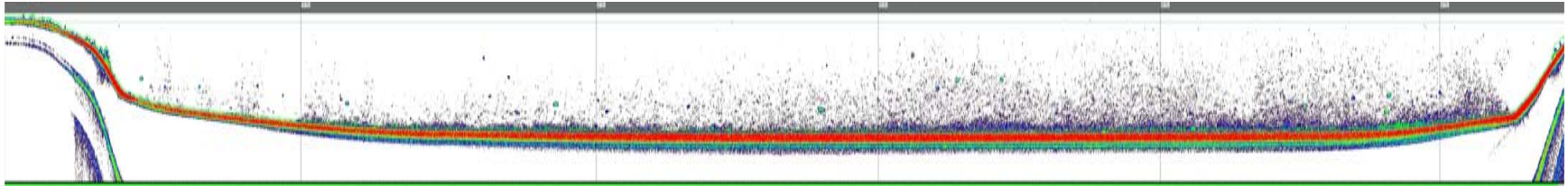


Figure 68. Kitwanga Lake transect 6 echogram

APPENDIX 6: Damdochax Lake Fish Catch

| Method | Species | Length (mm) | Weight (g) | Comment |
|--------|-----------------|-------------|------------|-------------------------------|
| Trawl | sockeye | 26 | 0.97 | |
| Trawl | sockeye | 71 | 4.80 | |
| Trawl | sockeye | 65 | 2.71 | |
| Trawl | sockeye | 58 | 2.37 | |
| Trawl | sockeye | 62 | 2.69 | |
| Trawl | sockeye | 68 | 3.73 | |
| Trawl | sockeye | 69 | 4.16 | |
| Trawl | sockeye | 43 | 0.77 | |
| Trawl | sockeye | 58 | 2.15 | |
| Trawl | sockeye | 62 | 3.09 | |
| Trawl | sockeye | 44 | 0.81 | scales scraped off |
| Trawl | sockeye | 66 | 3.65 | |
| Trawl | sockeye | 65 | 1.95 | |
| Trawl | sockeye | 63 | 2.84 | |
| Trawl | sockeye | 56 | 2.33 | |
| Trawl | sockeye | 51 | 1.22 | |
| Trawl | sockeye | 54 | 1.28 | |
| Trawl | sockeye | 59 | 1.86 | |
| Trawl | sockeye | 57 | 2.10 | |
| Trawl | sockeye | 60 | 2.43 | |
| Trawl | sockeye | 40 | 0.70 | |
| Trawl | sockeye | 44 | 0.95 | |
| Trawl | sockeye | 38 | 0.55 | bad sample - scales too small |
| Trawl | prickly sculpin | 14 | 0.01 | |
| Trawl | prickly sculpin | 18 | 0.05 | |
| Trawl | sockeye | 53 | 1.70 | |
| Trawl | sockeye | 83 | 6.34 | |
| Trawl | sockeye | 75 | 5.11 | |
| Trawl | sockeye | 71 | 4.09 | |
| Trawl | sockeye | 74 | 5.10 | |
| Trawl | sockeye | 73 | 4.47 | |
| Trawl | sockeye | 54 | 1.68 | |
| Trawl | sockeye | 58 | 1.98 | |
| Trawl | sockeye | 55 | 1.90 | |
| Trawl | sockeye | 50 | 1.54 | few scales |
| Trawl | sockeye | 68 | 2.71 | |
| Trawl | sockeye | 62 | 2.73 | |
| Trawl | sockeye | 45 | 1.32 | |
| Trawl | sockeye | 67 | 3.50 | |
| Trawl | sockeye | 59 | 2.21 | |
| Trawl | sockeye | 65 | 3.34 | |
| Trawl | sockeye | 67 | 3.12 | |

| | | | | |
|---------|------------|------|------|----------|
| Trawl | sockeye | 65 | 3.35 | |
| Trawl | sockeye | 62 | 2.56 | |
| Trawl | sockeye | 52 | 1.43 | |
| Trawl | sockeye | 49 | 1.10 | |
| Trawl | sockeye | 46 | 1.05 | |
| Trawl | sockeye | 53 | 1.63 | |
| Trawl | sockeye | 43 | 0.82 | |
| Trawl | sockeye | 41 | 0.68 | |
| Gillnet | sockeye | 83 | 6.97 | |
| Gillnet | sockeye | 74 | 4.77 | |
| Gillnet | sockeye | 70 | 4.00 | |
| Gillnet | bull trout | 400+ | - | released |

APPENDIX 7: Wiiminosik Lake Fish Catch

| Method | Species | Length (mm) | Weight (g) | Comment |
|---------|---------|-------------|------------|--|
| Trawl | sockeye | 57 | 2.21 | |
| Trawl | sockeye | 54 | 1.85 | |
| Trawl | sockeye | 60 | 2.60 | |
| Trawl | sockeye | 53 | 1.86 | |
| Trawl | sockeye | 63 | 2.93 | |
| Trawl | sockeye | 61 | 2.67 | |
| Trawl | sockeye | 56 | 2.20 | |
| Trawl | sockeye | 65 | 3.10 | |
| Trawl | sockeye | 60 | 2.22 | |
| Trawl | sockeye | 59 | 1.52 | |
| Trawl | sockeye | 68 | 3.33 | |
| Trawl | sockeye | 55 | 1.83 | |
| Trawl | sockeye | 64 | 3.05 | |
| Trawl | sockeye | 65 | 3.03 | |
| Trawl | sockeye | 70 | 4.14 | |
| Trawl | sockeye | 59 | 2.14 | |
| Trawl | sockeye | 64 | 2.65 | |
| Trawl | sockeye | 65 | 3.03 | |
| Trawl | sockeye | 64 | 2.99 | |
| Trawl | sockeye | 64 | 2.80 | |
| Trawl | sockeye | 63 | 2.63 | |
| Trawl | sockeye | 59 | 2.46 | |
| Trawl | sockeye | 45 | 1.06 | |
| Trawl | sockeye | 43 | 0.77 | |
| Trawl | sockeye | 73 | 3.89 | |
| Trawl | sockeye | 63 | 2.75 | |
| Trawl | sockeye | 55 | 1.68 | |
| Trawl | sockeye | 62 | 2.52 | |
| Trawl | sockeye | 59 | 2.28 | |
| Trawl | sockeye | 65 | 3.45 | |
| Trawl | sockeye | 54 | 1.47 | |
| Trawl | sockeye | 64 | 3.08 | |
| Trawl | sockeye | 58 | 2.22 | |
| Trawl | sockeye | 36 | 0.40 | |
| Trawl | sockeye | 53 | 1.57 | |
| Gillnet | sockeye | 100 | 10.43 | long gill rakers |
| Gillnet | chinook | 49 | 5.72 | 120 pyloric caeca, 16 branchiolstegals |
| Gillnet | coho | 92 | 8.92 | 13 branchiolstegals |
| Gillnet | coho | 104 | 12.86 | 13 branchiolstegals |
| Trawl | sockeye | 65 | 2.93 | |
| Trawl | sockeye | 60 | 2.41 | |
| Trawl | sockeye | 61 | 2.34 | |
| Trawl | sockeye | 66 | 3.61 | |

| | | | | |
|---------|--------------------|------|------|--|
| Trawl | sockeye | 66 | 3.00 | |
| Trawl | sockeye | 64 | 2.93 | |
| Trawl | sockeye | 65 | 2.97 | |
| Trawl | sockeye | 56 | 1.99 | |
| Trawl | sockeye | 49 | 1.31 | |
| Trawl | sockeye | 47 | 1.07 | |
| Trawl | sockeye | 47 | 1.11 | |
| Trawl | sockeye | 62 | 2.53 | |
| Trawl | sockeye | 54 | 1.58 | |
| Trawl | sockeye | 51 | 1.48 | |
| Trawl | sockeye | 64 | 2.65 | |
| Trawl | sockeye | 54 | 1.51 | |
| Trawl | sockeye | 59 | 2.26 | |
| Trawl | sockeye | 50 | 1.43 | |
| Trawl | sockeye | 56 | 1.74 | |
| Trawl | sockeye | 54 | 1.18 | in separate bottle for future verification |
| Trawl | prickly sculpin | 24 | 0.80 | |
| Trawl | sockeye | 50 | 1.22 | |
| Trawl | sockeye | 51 | 1.50 | |
| Trawl | sockeye | 58 | 1.99 | |
| Trawl | sockeye | 50 | 1.43 | |
| Trawl | sockeye | 50 | 1.30 | |
| Trawl | sockeye | 48 | 1.24 | |
| Trawl | sockeye | 53 | 1.72 | |
| Trawl | sockeye | 49 | 1.36 | |
| Trawl | mountain whitefish | 50 | 1.08 | |
| Trawl | mountain whitefish | 66 | 2.69 | |
| Trawl | mountain whitefish | 45 | 1.04 | |
| Trawl | mountain whitefish | 83 | 5.75 | |
| Trawl | mountain whitefish | 95 | 1.16 | |
| Trawl | mountain whitefish | 67 | 2.99 | |
| Trawl | mountain whitefish | 60 | 2.34 | |
| Gillnet | bull trout | 400+ | - | released |

APPENDIX 8: Lakelse Lake Fish Catch

| Method | Species | Length (mm) | Weight (g) | Comment |
|---------|-----------------|-------------|------------|------------------------------------|
| Gillnet | sockeye | 72 | 4.57 | |
| Gillnet | sockeye | - | - | missing head- approx. length 85 mm |
| Gillnet | sockeye | 80 | 6.00 | |
| Gillnet | sockeye | 72 | 4.50 | |
| Gillnet | sockeye | 72 | 4.31 | |
| Gillnet | sockeye | 80 | 6.48 | |
| Trawl | sockeye | 75 | 4.99 | |
| Trawl | sockeye | 68 | 3.15 | |
| Trawl | sockeye | 54 | 1.60 | |
| Trawl | sockeye | 74 | 4.33 | parasite |
| Trawl | sockeye | 54 | 1.54 | |
| Trawl | sockeye | 51 | 1.49 | |
| Trawl | sockeye | 47 | 1.04 | |
| Trawl | sockeye | 49 | 1.23 | |
| Trawl | prickly sculpin | 50 | 1.37 | |
| Trawl | prickly sculpin | 30 | 0.23 | |

APPENDIX 9: Kitsumkalum Lake Fish Catch

| Method | Species | Length (mm) | Weight (g) | Comment |
|--------|---------|----------------|---------------|---------|
| Trawl | sockeye | 53 | 1.82 | |
| Trawl | sockeye | 58 | 2.35 | |
| Trawl | sockeye | 58 | 2.17 | |
| Trawl | sockeye | 60 | 2.35 | |
| Trawl | sockeye | 62 | 2.33 | |
| Trawl | sockeye | 59 | 2.16 | |
| Trawl | sockeye | 57 | 1.91 | |
| Trawl | sockeye | 68 | 2.55 | |
| Trawl | sockeye | 59 | 1.98 | |
| Trawl | sockeye | 61 | 2.84 | |
| Trawl | sockeye | 47 | 1.14 | |
| Trawl | sockeye | 49 | 1.98 | |
| Trawl | sockeye | 51 | 1.21 | |
| Trawl | sockeye | 58 | 1.98 | |
| Trawl | sockeye | 65 | 2.97 | |
| Trawl | sockeye | 67 | 2.91 | |
| Trawl | sockeye | 61 | 2.65 | |
| Trawl | sockeye | 50 | 1.28 | |
| Trawl | sockeye | 53 | 1.72 | |
| Trawl | sockeye | 50 | 1.32 | |
| Trawl | coho | 73 | | |
| Trawl | sockeye | 62 | 2.43 | |
| Trawl | sockeye | 59 | 2.25 | |
| Trawl | sockeye | 60 | 2.36 | |
| Trawl | sockeye | 63 | 2.73 | |
| Trawl | sockeye | 52 | 1.52 | |
| Trawl | sockeye | 62 | 2.78 | |
| Trawl | sockeye | 53 | 1.53 | |
| Trawl | sockeye | 75 | 4.87 | |
| Trawl | sockeye | 59 | 2.24 | |
| Trawl | sockeye | 53 | 1.46 | |
| Trawl | sockeye | 60 | 2.17 | |
| Trawl | sockeye | 64 | 2.97 | |
| Trawl | sockeye | 61 | 2.32 | |
| Trawl | sockeye | 42 | 1.43 | |
| Trawl | sockeye | 58 | 2.15 | |
| Trawl | sockeye | 55 | 1.83 | |
| Trawl | sockeye | 56 | 1.69 | |
| Trawl | sockeye | 49 | 1.16 | |
| Trawl | sockeye | 38 | 0.56 | |
| Trawl | sockeye | 65 | 2.91 | |
| Trawl | sockeye | 48 | 1.18 | |
| Trawl | sockeye | 58 | 1.89 | |
| Trawl | sockeye | 61 | 2.49 | |
| Trawl | sockeye | 56 | 1.97 | |
| Trawl | sockeye | 54 | 1.63 | |

| | | | | |
|---------|------------|-----|-------|----------|
| Trawl | sockeye | 41 | 0.79 | |
| Gillnet | coho | 84 | 7.80 | |
| Gillnet | coho | 82 | 6.98 | |
| Gillnet | coho | 91 | 10.29 | |
| Gillnet | coho | 90 | 8.13 | |
| Gillnet | coho | 79 | 7.30 | |
| Gillnet | coho | 87 | 8.10 | |
| Gillnet | coho | 63 | 3.39 | |
| Gillnet | coho | 85 | 7.68 | |
| Gillnet | coho | 110 | 15.92 | |
| Gillnet | cutthroat | 315 | - | released |
| Gillnet | cutthroat | 315 | - | released |
| Gillnet | bull trout | 535 | - | released |
| Gillnet | rainbow | 175 | - | released |

APPENDIX 10: Kitwanga Lake Fish Catch

| Method | Species | Length (mm) | Weight (g) | Comment |
|---------|----------------|-------------|------------|-------------------------|
| Trawl | sockeye | 55 | 1.88 | |
| Trawl | redside shiner | 88 | 8.66 | |
| Gillnet | coho | 108 | 12.07 | |
| Gillnet | sockeye | 90 | 6.05 | silver, not many scales |
| Gillnet | sockeye | 73 | 3.63 | |
| Gillnet | peamouth | 245 | - | released |
| Gillnet | cutthroat | 265 | - | released |

APPENDIX 11: Hydroacoustic Data By Transect

Table 18. Damdochax Lake small size class fish estimates by transect and analysis method

| Transect | Surface Area (ha) | Population (N) | | | Density (N/ha) | | |
|----------|-------------------|-----------------------|-----------------------|-----------------------|----------------|-------|-------|
| | | NTG | ST | TT | NTG | ST | TT |
| 1 | 9.0 | 1.44 x10 ³ | 1.88 x10 ³ | 2.87 x10 ³ | 160 | 208 | 318 |
| 2 | 11.0 | 8.94 x10 ² | 1.25 x10 ³ | 1.79 x10 ³ | 82 | 114 | 164 |
| 3 | 15.4 | 6.73 x10 ³ | 5.98 x10 ³ | 8.63 x10 ³ | 438 | 388 | 561 |
| 4 | 18.9 | 9.82 x10 ³ | 1.06 x10 ⁴ | 1.33 x10 ⁴ | 521 | 563 | 708 |
| 5 | 20.4 | 1.39 x10 ⁴ | 1.53 x10 ⁴ | 1.53 x10 ⁴ | 683 | 752 | 750 |
| 6 | 20.6 | 1.84 x10 ⁴ | 1.76 x10 ⁴ | 2.21 x10 ⁴ | 892 | 856 | 1,070 |
| 7 | 24.1 | 4.00 x10 ⁴ | 2.79 x10 ⁴ | 3.36 x10 ⁴ | 1,656 | 1,155 | 1,393 |
| 8 | 28.5 | 1.60 x10 ⁴ | 1.29 x10 ⁴ | 1.68 x10 ⁴ | 560 | 452 | 591 |

NTG = Integration ST = Single Target TT = Tracked Target

Table 19. Damdochax Lake large size class fish estimates by transect and analysis method

| Transect | Surface Area (ha) | Population (N) | | | Density (N/ha) | | |
|----------|-------------------|-----------------------|-----------------------|-----------------------|----------------|-----|-----|
| | | NTG | ST | TT | NTG | ST | TT |
| 1 | 9.0 | 6.58 x10 ² | 6.91 x10 ² | 1.18 x10 ³ | 73 | 77 | 131 |
| 2 | 11.0 | 1.42 x10 ² | 1.42 x10 ² | 2.75 x10 ² | 13 | 13 | 25 |
| 3 | 15.4 | 2.18 x10 ³ | 2.03 x10 ³ | 2.96 x10 ³ | 142 | 132 | 193 |
| 4 | 18.9 | 1.18 x10 ³ | 1.27 x10 ³ | 2.15 x10 ³ | 62 | 68 | 114 |
| 5 | 20.4 | 4.60 x10 ³ | 5.46 x10 ³ | 5.06 x10 ³ | 226 | 268 | 248 |
| 6 | 20.6 | 5.77 x10 ³ | 5.87 x10 ³ | 7.11 x10 ³ | 280 | 285 | 345 |
| 7 | 24.1 | 3.71 x10 ³ | 5.35 x10 ³ | 6.04 x10 ³ | 154 | 222 | 250 |
| 8 | 28.5 | 1.73 x10 ³ | 1.75 x10 ³ | 2.15 x10 ³ | 61 | 61 | 76 |

NTG = Integration ST = Single Target TT = Tracked Target

Table 20. Wiiminosik Lake small size class fish estimates by transect and analysis method

| Transect | Surface Area (ha) | Population (N) | | | Density (N/ha) | | |
|----------|-------------------|-----------------------|-----------------------|-----------------------|----------------|-------|-------|
| | | NTG | ST | TT | NTG | ST | TT |
| 1 | 5.8 | 6.61 x10 ³ | 8.22 x10 ³ | 1.02 x10 ⁴ | 1,147 | 1,427 | 1,774 |
| 2 | 6.6 | 2.48 x10 ³ | 3.17 x10 ³ | 4.05 x10 ³ | 375 | 479 | 612 |
| 3 | 6.2 | 3.61 x10 ³ | 4.14 x10 ³ | 4.36 x10 ³ | 585 | 670 | 706 |
| 4 | 2.5 | 5.31 x10 ³ | 4.84 x10 ³ | 5.62 x10 ³ | 2,141 | 1,951 | 2,262 |
| 5 | 7.1 | 1.74 x10 ⁴ | 1.80 x10 ⁴ | 2.45 x10 ⁴ | 2,441 | 2,531 | 3,441 |
| 6 | 5.7 | 1.23 x10 ⁴ | 1.53 x10 ⁴ | 1.40 x10 ⁴ | 2,165 | 2,696 | 2,481 |
| 7 | 4.3 | 3.34 x10 ³ | 3.12 x10 ³ | 4.54 x10 ³ | 768 | 717 | 1,044 |

NTG = Integration ST = Single Target TT = Tracked Target

Table 21. Wiiminosik Lake large size class fish estimates by transect and analysis method

| Transect | Surface Area (ha) | Population (N) | | | Density (N/ha) | | |
|----------|-------------------|--------------------|--------------------|--------------------|----------------|-----|-----|
| | | NTG | ST | TT | NTG | ST | TT |
| 1 | 5.8 | 3.73×10^2 | 5.25×10^2 | 7.04×10^2 | 65 | 91 | 122 |
| 2 | 6.6 | 1.82×10^3 | 1.96×10^3 | 2.33×10^3 | 275 | 297 | 352 |
| 3 | 6.2 | 5.64×10^2 | 4.76×10^2 | 6.01×10^2 | 91 | 77 | 97 |
| 4 | 2.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 7.1 | 1.07×10^3 | 1.09×10^3 | 1.40×10^3 | 151 | 154 | 198 |
| 6 | 5.7 | 1.15×10^3 | 1.28×10^3 | 1.19×10^3 | 204 | 226 | 211 |
| 7 | 4.3 | 3.85×10^2 | 3.98×10^2 | 5.37×10^2 | 89 | 91 | 123 |

NTG = Integration

ST = Single Target

TT = Tracked Target

Table 22. Lakelse Lake small size class fish estimates by transect and analysis method

| Transect | Surface Area (ha) | Population (N) | | | Density (N/ha) | | |
|----------|-------------------|--------------------|--------------------|--------------------|----------------|-----|-----|
| | | NTG | ST | TT | NTG | ST | TT |
| 0.7 | 121 | 7.32×10^3 | 5.14×10^3 | 5.89×10^3 | 61 | 43 | 49 |
| 1.4 | 91 | 1.96×10^4 | 1.75×10^4 | 2.08×10^4 | 217 | 193 | 229 |
| 2.1 | 81 | 5.66×10^4 | 3.71×10^4 | 5.30×10^4 | 701 | 460 | 657 |
| 2.6 | 92 | 5.28×10^4 | 6.07×10^4 | 7.62×10^4 | 571 | 657 | 825 |
| 3.4 | 93 | 3.30×10^4 | 2.89×10^4 | 3.11×10^4 | 353 | 309 | 333 |
| 4.2 | 82 | 1.37×10^4 | 1.57×10^4 | 1.96×10^4 | 166 | 191 | 238 |
| 4.8 | 71 | 1.25×10^4 | 8.66×10^3 | 1.15×10^4 | 175 | 121 | 161 |
| 7.0 | 728 | 3.02×10^4 | 2.19×10^4 | 2.48×10^4 | 41 | 30 | 34 |

NTG = Integration

ST = Single Target

TT = Tracked Target

Table 23. Lakelse Lake large size class fish estimates by transect and analysis method

| Transect | Surface Area (ha) | Population (N) | | | Density (N/ha) | | |
|----------|-------------------|--------------------|--------------------|--------------------|----------------|----|-----|
| | | NTG | ST | TT | NTG | ST | TT |
| 0.7 | 121 | 4.83×10^0 | 7.23×10^0 | 1.06×10^1 | 0 | 0 | 0 |
| 1.4 | 91 | 1.11×10^3 | 1.12×10^3 | 1.40×10^3 | 12 | 12 | 15 |
| 2.1 | 81 | 5.48×10^3 | 4.32×10^3 | 6.71×10^3 | 68 | 54 | 83 |
| 2.6 | 92 | 6.78×10^3 | 7.97×10^3 | 1.02×10^4 | 73 | 86 | 110 |
| 3.4 | 93 | 1.86×10^3 | 2.23×10^3 | 2.77×10^3 | 20 | 24 | 30 |
| 4.2 | 82 | 1.73×10^3 | 2.02×10^3 | 3.27×10^3 | 21 | 25 | 40 |
| 4.8 | 71 | 2.45×10^3 | 1.79×10^3 | 3.08×10^3 | 34 | 25 | 43 |
| 7.0 | 728 | 0 | 0 | 0 | 0 | 0 | 0 |

NTG = Integration

ST = Single Target

TT = Tracked Target

Table 24. Kitsumkalum Lake small size class fish estimates by transect and analysis method

| Transect | Surface Area (ha) | Population (N) | | | Density (N/ha) | | |
|----------|-------------------|-----------------------|-----------------------|-----------------------|----------------|-----|-----|
| | | NTG | ST | TT | NTG | ST | TT |
| 1 | 253 | 1.50 x10 ⁵ | 1.63 x10 ⁵ | 2.22 x10 ⁵ | 591 | 645 | 878 |
| 2 | 271 | 5.59 x10 ⁴ | 6.23 x10 ⁴ | 7.63 x10 ⁴ | 207 | 230 | 282 |
| 3 | 254 | 5.60 x10 ⁴ | 6.22 x10 ⁴ | 8.95 x10 ⁴ | 220 | 245 | 352 |
| 4 | 314 | 4.13 x10 ⁴ | 4.06 x10 ⁴ | 6.68 x10 ⁴ | 132 | 129 | 213 |
| 5 | 282 | 3.99 x10 ⁴ | 3.37 x10 ⁴ | 4.64 x10 ⁴ | 142 | 120 | 165 |
| 6 | 291 | 3.51 x10 ⁴ | 2.20 x10 ⁴ | 3.52 x10 ⁴ | 121 | 76 | 121 |
| 7 | 186 | 2.65 x10 ⁴ | 4.07 x10 ⁴ | 4.78 x10 ⁴ | 143 | 220 | 258 |

NTG = Integration

ST = Single Target

TT = Tracked Target

Table 25. Kitsumkalum Lake large size class fish estimates by transect and analysis method

| Transect | Surface Area (ha) | Population (N) | | | Density (N/ha) | | |
|----------|-------------------|-----------------------|-----------------------|-----------------------|----------------|----|----|
| | | NTG | ST | TT | NTG | ST | TT |
| 1 | 253 | 4.84 x10 ³ | 4.16 x10 ³ | 5.62 x10 ³ | 19 | 16 | 22 |
| 2 | 271 | 4.68 x10 ³ | 5.05 x10 ³ | 6.39 x10 ³ | 17 | 19 | 24 |
| 3 | 254 | 7.98 x10 ³ | 7.49 x10 ³ | 1.02 x10 ⁴ | 31 | 29 | 40 |
| 4 | 314 | 3.08 x10 ³ | 3.87 x10 ³ | 5.71 x10 ³ | 10 | 12 | 18 |
| 5 | 282 | 1.92 x10 ³ | 2.20 x10 ³ | 2.96 x10 ³ | 7 | 8 | 11 |
| 6 | 291 | 4.87 x10 ³ | 5.22 x10 ² | 7.98 x10 ² | 2 | 2 | 3 |
| 7 | 186 | 3.18 x10 ³ | 5.20 x10 ³ | 5.43 x10 ³ | 17 | 28 | 29 |

NTG = Integration

ST = Single Target

TT = Tracked Target

Table 26. Kitwanga Lake small size class fish estimates by transect and analysis method

| Transect | Surface Area (ha) | Population (N) | | | Density (N/ha) | | |
|----------|-------------------|----------------|-----|-----------------------|----------------|-----|-----|
| | | NTG | ST | TT | NTG | ST | TT |
| 1 | 252 | n/a | n/a | 4.48 x10 ⁴ | n/a | n/a | 178 |
| 2 | 209 | n/a | n/a | 1.06 x10 ⁵ | n/a | n/a | 507 |
| 3 | 137 | n/a | n/a | 0 | n/a | n/a | 0 |
| 4 | 45 | n/a | n/a | 0 | n/a | n/a | 0 |
| 5 | 76 | n/a | n/a | 2.94 x10 ⁴ | n/a | n/a | 387 |
| 6 | 60 | n/a | n/a | 4.31 x10 ⁴ | n/a | n/a | 719 |

NTG = Integration

ST = Single Target

TT = Tracked Target

Table 27. Kitwanga Lake large size class fish estimates by transect and analysis method

| Transect | Surface Area (ha) | Population (N) | | | Density (N/ha) | | |
|----------|-------------------|----------------|-----|--------------------|----------------|-----|-----|
| | | NTG | ST | TT | NTG | ST | TT |
| 1 | 253 | n/a | n/a | 5.01×10^2 | n/a | n/a | 2 |
| 2 | 271 | n/a | n/a | 2.70×10^3 | n/a | n/a | 13 |
| 3 | 254 | n/a | n/a | 0 | n/a | n/a | 0 |
| 4 | 314 | n/a | n/a | 0 | n/a | n/a | 0 |
| 5 | 282 | n/a | n/a | 2.79×10^4 | n/a | n/a | 368 |
| 6 | 291 | n/a | n/a | 1.62×10^4 | n/a | n/a | 270 |

NTG = Integration

ST = Single Target

TT = Tracked Target