Skeena Sockeye Lakes Hydroacoustic Surveys Report 2006

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EXECUTIVE SUMMARY

The Skeena Fisheries Commission 2006 sockeye (*Oncorhynchus nerka*) fry hydroacoustic survey program consisted of a survey of Kitwanga, Lower Kluatantan, Upper Kluatantan and Lakelse Lakes. Hydroacoustic data was collected using a Biosonics DT-X split beam echosounder with a 200 kHz transducer. The Kitwanga and Lakelse lake surveys replicated previous DFO surveys but the Kluatantan lakes survey designs were developed for the first time in 2006.

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 the Kluatantan lakes were produced from GPS geo-referenced depth data collected from the Biosonics DT-X echosounder.

The bathymetry data showed that Lower Kluatantan Lake is a relatively small, shallow lake with an average depth of only 2.8 m, a maximum depth of 6.7 m, a surface area of 26.0 ha and a volume of 7.32×10^5 m^3. Upper Kluatantan Lake is relatively small, deep lake with an average depth of 7.6 m, a maximum depth of 27.9 m, a surface area of 29.0 ha and a volume of 2.19×10^6.

No fish from Kitwanga Lake were caught in the mid-water trawl so no species can be attributed to the fish targets collected in the hydroacoustic data. High densities of *Chaoborus sp.* were observed in the spring hydroacoustic survey so the Tracked Target analysis method was the only appropriate method to use for generating a hydroacoustic fish estimate. Kitwanga Lake small size class Tracked Target hydroacoustic estimates were 165 fish/ha (±149 fish/ha) in the north basin and 320 fish/ha (±1 fish/ha) in the south basin. Large size class estimates were much lower than the small size class estimates for both basins but followed the same trend with the highest densities observed in the south basin.

No fish from Lower Kluatantan Lake were caught in the mid-water trawl so no species can be attributed to the fish targets collected in the hydroacoustic data. The hydroacoustic fish estimate was divided into the two basins of the lake and since no fish targets were observed in the west basin the hydroacoustic fish estimate is zero for that basin. Only small size fish targets were observed in the east basin. Lower Kluatantan Lake east basin small size class fish density estimates ranged from 27 fish/ha (±77 fish/ha) using the Single Target analysis method to 34 fish/ha (±93 fish/ha) using the Tracked Target analysis method.

No fish targets were recorded in any of the transects surveyed in Upper Kluatantan Lake so the hydroacoustic fish estimate for the lake is zero.

Lakelse Lake north section small size class fish density estimates ranged from 89 fish/ha (±94 fish/ha) using the Single Target analysis method to 220 fish/ha (±261 fish/ha) using the Integration analysis method (Table 9). Large size class fish density estimates were half or less of the small size class density estimates. Using 6.0 g for the average age-0 *nerka* weight and 15% non-sockeye in the small size class Integration population estimate, the biomass of age-0 *nerka* in Lakelse Lake is estimated at 620 kg. This biomass is approximately 22% of the PR Model Adjusted Rmax for the lake and is lower than the biomass estimated from previous surveys in 2005, 2004 and 2003.

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INTRODUCTION

The Skeena Fisheries Commission (SFC) 2006 sockeye (*Oncorhynchus nerka*) fry hydroacoustic survey program consisted of a survey of Kitwanga, Lower Kluatantan, Upper Kluatantan and Lakelse Lakes (Fig. 1). Kitwanga Lake (Fig. 2) 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 km^2. Kitwanga Lake (a.k.a. Kitwancool and 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 Gitxsan but declining escapements since the 1960's led them to forgo catching these fish since the 1970's for conservation purposes (Gottesfeld *et al.* 2002). The surface area of Kitwanga Lake is approximately 779 ha with a volume of 5.47x10^7 m^3. The average depth of the lake is 6.9 m and the maximum depth is approximately 15 m.

The Upper and Lower Kluatantan lakes (Fig. 3 & 4) flow into the Kluatantan River which is a 5th order tributary of the upper Skeena that drains a watershed area of approximately 610 km^2. These lakes are located within the Gitxsan First Nations' traditional territory and a historic fishing site was located at the mouth of Kluatantan River (Gottesfeld & Rabnett 2007). Relatively little was known about these lakes prior to the hydroacoustic surveys reported here. Since 1950 there has been only one estimate of sockeye escapement recorded in the Department of Fisheries and Oceans' (DFO) Salmon Escapement Database (SED) which was 50 in 1970. No sockeye were observed in 1997 and an unknown number were observed in 2003.

Lakelse Lake (Fig. 5) 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 km^2. 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 1990's (Gottesfeld *et al.* 2002). The surface area of the lake is approximately 1360 ha with a volume of 1.16x10^8 m^3. The average depth of the lake is 8.5 m and the maximum depth is approximately 32 m.

METHODS

Hydroacoustic data was collected using a Biosonics DT-X split beam echosounder with a 200 kHz transducer producing a 6^{o} beam. Survey designs and transect waypoints for all lakes (Fig. 6 - 9) were provided by Steven MacLellan (DFO Cultus Lake Laboratory). The Kitwanga and Lakelse lake surveys replicated previous DFO surveys but the Kluatantan lakes survey designs were developed for the first time in 2006 based on topographic maps (no bathymetric data available). All hydroacoustic data were collected at night. Kitwanga Lake was surveyed on the night of April 28/29, Lower Kluatantan Lake on August 26/27, Upper Kluatantan Lake on August 27/28 and Lakelse Lake on October 10/11, 2006.

Hydroacoustic surveys for sockeye fry are typically done in the fall in northern BC in order to maximize the size of the fry at the time of the survey but before the lakes freeze over for the winter. Kitwanga Lake was surveyed in the spring in order to test the hypothesis that densities of the larval form of the phantom midge (*Chaoborus*) might be lower than observed in previous fall surveys. High densities of *Chaoborus* in previous surveys prevented the ability to estimate sockeye fry populations by two of the three analysis methods (Shortreed & Hume 2004, 2005).

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 Echo 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 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. Volumes for each depth layer and representative transect area in Kitwanga and Lakelse lakes were provided by the DFO Cultus Lake Laboratory. Volumes for the Kluatantan lakes were calculated from the bathymetric map produced in Arc/Info. Layer population estimates are then summed to produce transect estimates which are in turn summed 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^{o} aspect formula. Small fish were then apportioned into "*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 ($\pm$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 ½”, 5/7”, ¾” 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.

Temperature and dissolved oxygen measurements were taken using a YSI meter (model 85) from a location near the deepest part of the lake. The YSI meter was calibrated for elevation to the nearest 100 ft and allowed approximately 15 minutes in order to stabilize before readings were recorded.

Bathymetric maps of the Kluatantan lakes were produced from GPS geo-referenced depth data collected from the Biosonics DT-X echosounder. Depth data were collected from each transects and each trawl. To a lesser degree, additional depth data were also collected in poorly sampled areas of the lake specifically for developing the bathymetric maps.

Sockeye salmon, including both anadromous and non-anadromous forms (kokanee) will be referred to in this report as “*nerka*”. Anadromous sockeye will be referred to as “sockeye” and non-anadromous sockeye will be referred to as “kokanee”.

RESULTS

Lake Bathymetry

Lower Kluatantan Lake is a relatively small, shallow lake with an average depth of only 2.8 m, a maximum depth of 6.7 m, a surface area of 26.0 ha and a volume of 7.32×10^5 m^3 (Fig. 10). The lake is divided into two distinct basins (west and east) separated by a shallow narrow section. Each basin reaches the approximate maximum depth of the lake but the east basin has a much larger area.

Upper Kluatantan Lake is relatively small, deep lake with an average depth of 7.6 m, a maximum depth of 27.9 m, a surface area of 29.0 ha and a volume of 2.19×10^6 (Fig. 11). Most of the southwest end of the lake is less than 4 m deep but the east end of the lake has a large deep section. Even though the surface area of Upper Kluatantan Lake is only 12% greater than Lower Kluatantan Lake, the volume is roughly 200% greater due to the greater depth.

Trawl Catch

No fish were caught in the mid-water trawl in Kitwanga or Upper and Lower Kluatantan Lakes (Tables 1-3). Kitwanga Lake fishing effort with the trawl net exceeded 2 km over two separate tows with one tow for each basin (Fig. 6). Sunrise occurred at 04:58 and the second tow commenced at 05:28; however, hydroacoustic data recorded during the second tow showed fish targets available for capture at the depth of the trawl. Trawling on both Kluatantan Lakes were all virtually surface tows and none exceeded 400 m in length due to the small surface area and shallow average depth of the lakes (Tables 2 & 3).

One *nerka* and 39 sculpin (*Cottus sp.*) were caught in 5 tows covering over 4 km in Lakelse Lake (Table 4). The tachometer malfunctioned on this survey so the depth of each tow of the trawl was not known till after the survey was completed. The first two tows collected a large amount of fine sediment which indicated that it had been dragging on the bottom for some distance. The one *nerka* caught in the trawl had a fork length of 80 mm and a weight of 6.1 g. The average sculpin size was 60 mm total length with a minimum length of 39 mm and a maximum length of 130 mm.

Gillnet Catch

Two floating gillnets were set overnight in all of the surveyed lakes for a varying amount of total soak time (Table 5 and Fig. 6-9). Four sockeye smolts were caught in Kitwanga Lake from the gillnet located closest to the outlet of the lake (Table 6). They had an average fork length of 108 mm and an average weight of 14.1 g.

Five coho (*Oncorhynchus kisutch*), two mountain whitefish (*Prosopium williamsoni*) and three longnose suckers (*Catostomus catostomus*) were caught in the two gillnets from Lower Kluatantan Lake. All but one coho (137 mm) were less than the small size class threshold of 135 mm. The average length and weight for coho were: 115 mm and 21.6 g, for suckers were 85 mm and 8.3 g, and for whitefish were 95 mm and 9.5 g.

Thirteen coho, two mountain whitefish and three longnose suckers were caught in the two gillnets from Upper Kluatantan Lake. One whitefish (210 mm) and one sucker (escaped from net) were larger than the small size class threshold of 135 mm. The average length and weight for coho were: 108 mm and 18.5 g, for suckers were 87 mm and 9.3 g (excluding the sucker that escaped the net), and for whitefish was 112 mm and 16.6 g (excluding the 210 mm fish).

Nine redside shiners (*Richardsonius balteatus*), five cutthroat trout (*Oncorhynchus clarki*), one rainbow trout (*Oncorhynchus mykiss*), one northern pikeminnow (*Ptychocheilus oregonensis*) and one peamouth chub (*Mylocheilus caurinus*) were caught in the two gillnets from Lakelse Lake. The peamouth chub (140 mm) and the northern pikeminnow (136) were marginally larger than the small size class threshold of 135 mm. The average length and weight for the redside shiners were 92 mm and 9.4 g.

<u>Temperature and Oxygen Profiles</u>

Kitwanga Lake was surveyed only days after it was ice-free and during the day of the survey there were high winds and whitecaps on the lake. The temperature and oxygen profiles show a well mixed lake with virtually no change in temperature (decline of 0.7°C) or oxygen (decline of 2.1 mg/L) with depth except for the oxygen reading (5.6 mg/L) closest to the bottom (Fig. 12). In addition to the absence of a thermocline, Kitwanga Lake was relatively cold (<6°C) which is also due to the timing of the survey.

The temperature and oxygen profiles of both the west and east basins of Lower Kluatantan Lake show a well oxygenated water column with temperature declining almost uniformly from 14°C to 12°C with depth (Fig. 13 & 14). Upper Kluatantan Lake's temperature and oxygen profile was radically different with an extremely sharp thermocline (10°C difference) from 2 m to 5 m in depth (Fig. 15). The oxygen profile showed nearly the same rapid decline as temperature with oxygen levels below 5 mg/L at depths greater than 5 m.

The late season survey of Lakelse Lake (Oct. 10) resulted in nearly uniform temperature and oxygen throughout the water column (Fig. 16).

<u>Hydroacoustic Fish Estimates</u>

Kitwanga Lake

No fish from Kitwanga Lake were caught in the mid-water trawl so no species can be attributed to the fish targets collected in the hydroacoustic data. High densities of the phantom midge *Chaoborus sp.* were observed in the spring hydroacoustic survey similar to densities observed in past fall surveys by DFO (Shortreed & Hume 2004, 2005). *Chaoborus* have acoustical target strengths that can overlap other small mid-water fish species like juvenile *nerka*. The Tracked Target analysis method is the only method which allows for the use of tracking algorithms to reject acoustic returns from *Chaoborus* (Shortreed & Hume 2006). The parameters used for the Tracked Target estimate were the same that were used by the DFO for other lakes surveyed with high densities of *Chaoborus* (MacLellan S. personal communication).

Kitwanga Lake small size class Tracked Target hydroacoustic estimates were 165 fish/ha (±149 fish/ha) in the north basin and 320 fish/ha (±1 fish/ha) in the south basin (Table 7). Large size class estimates were much lower than the small size class estimates for both basins but followed the same trend with the highest densities observed in the south basin. The confidence intervals for the south basin were much smaller due to the high similarity in fish densities observed between the two transects in that basin (Fig. 17). Average target strength (TS) over all transects showed no trend with depth but target density showed a weak (linear regression $R^2 = 0.29$) increase with depth (Fig. 18).

Lower Kluatantan Lake

No fish from Lower Kluatantan Lake were caught in the mid-water trawl so no species can be attributed to the fish targets collected in the hydroacoustic data. Transect 8 had to be abandoned since it was too shallow where it cut near to the shore. Transect 7 was the only transect where fish targets were observed (Fig. 19) and the fish densities for each 2 m depth layer were applied to the lake volumes represented by transect 7 and transect 8.

The hydroacoustic fish estimate was divided into the two basins of the lake and since no fish targets were observed in the west basin the hydroacoustic fish estimate is zero for that basin. Only small size fish targets were observed in the east basin despite the fact that one coho caught in the gillnets was nominally larger than the small size class by 2 mm.

Lower Kluatantan Lake east basin small size class fish density estimates ranged from 27 fish/ha ($\pm$77 fish/ha) using the Single Target analysis method to 34 fish/ha ($\pm$93 fish/ha) using the Tracked Target analysis method (Table 8). Confidence intervals are quite wide on all of these estimates since all transects had zero fish targets except for transect 7.

Upper Kluatantan Lake

The south half of transect 2 had to be abandoned since it was too shallow for the survey equipment. No fish targets were recorded in any of the transects surveyed in Upper Kluatantan Lake so the hydroacoustic fish estimate for the lake is zero.

Lakelse Lake

Transects 1 to 4 surveyed the north section of the lake and transects 5 to 7 surveyed the south section of the lake. Only transect 5 from the shallow south section of Lakelse Lake was surveyed in order to confirm the low fish densities observed in this section of the lake from previous DFO surveys (Shortreed & Hume 2006, 2005, 2004). Hydroacoustic fish estimates were therefore developed solely for the north section of the lake which is the only section where age-0 *nerka* were attributed to hydroacoustic fish targets in recent previous surveys (Shortreed & Hume 2006, 2005, 2004).

Lakelse Lake north section small size class fish density estimates ranged from 89 fish/ha ($\pm$94 fish/ha) using the Single Target analysis method to 220 fish/ha ($\pm$261 fish/ha) using the Integration analysis method (Table 9). Large size class fish density estimates were half or less of the small size class density estimates. Confidence intervals are quite wide on all of these estimates since there was a fair degree of variability between the transects (Fig. 20). Transect 3 produced the highest small size class target densities for the integration analysis method while transect 2 produced the highest densities for the Single Target and Tracked Target analysis methods.

Averaged over all transects surveyed, TS showed no trend with respect to depth other than its variability decreased with depth (Fig. 21). Average target densities, however, increased significantly with depth (linear regression $R^2 = 0.83$).

Two pieces of information, that were not successfully collected during the survey, are needed in order to estimate the biomass of the age-0 *nerka* biomass in Lakelse Lake: the proportion of the small size class fish estimate that represents age-0 *nerka* and the average weight of age-0 *nerka* at the time of the survey. All but one of the sculpin were caught in trawl tows 1 and 2 which also contained substantial amounts of fine sediment. It was clear that the trawl was sampling the bottom of the lake on these tows. Because of the benthic nature of sculpin and their lack of an airbladder, it is unlikely that they contributed significantly to the fish targets collected in the hydroacoustic data. Therefore it would not be appropriate to use the trawl catch to apportion the small size class fish estimates by species.

Previous surveys have attributed 10% (Shortreed & Hume 2006), 15% (Shortreed & Hume 2005) and 52% (Shortreed & Hume 2004) of the small size class targets to species other than *nerka* including Pacific lamprey (*Lampetra tridentate*), river lamprey (*Lampetra ayresi*) and three-spine stickleback (*Gasterosteus aculeatus*). For the purpose of this report, the middle of the 3 values (15%) will be arbitrarily used as the proportion of the small size class targets that were not age-0 *nerka*.

The same previous hydroacoustic surveys of Lakelse Lake found the average weight of the age-0 *nerka* caught in the trawl was 4.0 g (n=153, Sept. 5) in 2005 (Shortreed & Hume 2006) and 3.4 g (n=67, Sept. 25) in 2004 (Shortreed & Hume 2005). No age-0 *nerka* were caught in 2003 and Shortreed and Hume (2004) used 6 g as their average weight based on a survey from 1994 which caught 82 age-0 *nerka* in the trawl on October 9th 1994 (Shortreed *et al.* 1998). The survey of Lakelse Lake reported here was performed later in the season (Oct. 10/11) than any of the other recent surveys so there would be more time for *nerka* fry to grow. In the absence of any other contradictory data, 6.0 g will be used for the average weight of age-0 *nerka* from Lakelse Lake on October 10th.

Using 6.0 g for the average age-0 *nerka* weight and 15% non-sockeye in the small size class Integration population estimate, the biomass of age-0 *nerka* in Lakelse Lake is estimated at 620 kg (Table 10). This biomass is approximately 22% of the PR Model Adjusted Rmax for the lake (Cox-Rogers *et al.* 2004) and is lower than the biomass estimated from previous surveys in 2005, 2004 and 2003.

All Lakes

Of all 4 lake basins where hydroacoustic fish estimates were made, the Tracked Target estimate for the south basin of Kitwanga Lake showed the highest densities of small size class fish targets (Fig. 22). The east basin of Lower Kluatantan Lake showed the lowest densities for all analysis methods. Since the south basin of Kitwanga Lake is relatively small, the small size class population estimate for that basin was smaller than all basins except the east basin of Lower Kluatantan Lake which is both small and had low densities (Fig. 23).

DISCUSSION

Kitwanga Lake

The purpose of surveying Kitwanga Lake in the spring was to test the hypothesis that *Chaoborus* densities would be lower than previously observed in the late summer and fall surveys. *Chaoborus* densities in the spring appeared to be lower than in the fall of 2004 but similar to the fall survey of 2003 (MacLellan S. personal communication) so there was no advantage with the spring survey compared to the fall survey. 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.

There were four problems with surveying Kitwanga Lake in the spring: short survey timing window, short night-time work window, large average size sockeye smolts, and potential smolt schooling behavior. Firstly, sockeye smolts tend to migrate out of the lake shortly after the ice melts from Kitwanga Lake (Kingston D. personal communication) which results in a very short survey timing window from after the lake melts and before the smolts migrate out. We encountered ice in the narrows between the lake basins during the survey in 2006 and yet much later would have been too late since 90% of the smolt migration had occurred by May 15th and the peak migration occurred May 4th which was only 5 days after the survey (Kingston 2007).

Another difficulty with the spring survey is the short amount of nighttime (9 hours between sunset and sunrise or 7.5 hours from end to start of civil twilight) to complete the survey. Our last tow of the trawl net started after sunrise. We could have trawled the following night but since smolts were migrating out of the lake so quickly it would have taken only a few days of separation before the trawl data wouldn't be representative of the hydroacoustic survey data.

A third difficulty with the spring survey of Kitwanga Lake is the large size of the sockeye smolts since the 2x2 m trawl is increasingly biased against fish >40 mm (McQueen *et al*. 2007). The average size of the sockeye smolts sampled in 2006 by the Gitanyow Fisheries Authority was 115 mm (n=750) which compares favorably with the average caught in our gillnets 108 mm (n=4) set near the outlet of the lake (Kingston 2007). These average smolt sizes are considerably larger than 40 mm and may be a large part of the reason no fish were caught in the trawl in 2006.

Age data from scale pattern analysis of Kitwanga sockeye smolts by the DFO Scale Laboratory in Nanaimo showed a significant proportion of age-2 smolts (Kingston D. personal communication). This created the expectation that there would be age-1 sockeye fry available to capture in Kitwanga Lake in the spring. Recent reinterpretation of the scale pattern data shows that nearly all of the smolts from Kitwanga Lake are age-1 and since age-0 fry have been observed emerging from the gravel in June (Kingston D. personal communication), the only sockeye available for capture in Kitwanga Lake at the time of the survey were large age-1 smolts.

The fourth difficulty with a spring hydroacoustic survey of Kitwanga Lake is that there was the potential of smolt schooling behavior. If this schooling behavior, which is well documented in other lakes (Burgner 1991), occurred during the survey then it would violate the assumption of random distribution of the fish that is used to extrapolate the data collected from the transects to the entire lake. The high densities of both small and large size fish targets observed in the south basin of the lake would agree with the hypothesis that smolts were staging in there in preparation for migrating out of the lake and predators were also taking advantage of these higher prey densities. Alternatively, the south basin may always have high densities because of better habitat conditions.

No population estimate of age-0 *nerka* can be produced for Kitwanga Lake because there were no fish caught in the trawl to apportion the catch to the various potential mid-water species in Kitwanga Lake. The difficulty catching age-0 *nerka* in Kitwanga Lake is not limited to the spring survey. Past surveys have yielded only 4 age-0 *nerka* fry in 1995 (Shortreed *et al.* 1998), 15 in 2003 (Shortreed & Hume 2004) and 2 in 2004 (Shortreed & Hume 2005). Low densities and a relatively shallow lake probably are mostly to blame for the poor trawl catches in Kitwanga Lake. Unless densities increase substantially and result in more successful trawl catches, Kitwanga Lake may be a poor candidate for the methodologies employed by hydroacoustic surveys. The spring smolt capture program which has been operating for several years by the Gitanyow Fisheries Authority is likely to be a more appropriate technique for evaluating freshwater survival, growth and population size.

<u>Lower Kluatantan Lake</u>

The survey design for the Kluatantan Lakes was developed from topographic maps without any bathymetric data since none existed prior to the surveys completed in 2006. The top depth layer (2 m) is typically excluded from the hydroacoustic analysis since the sample volume is very small due to the beam width of the transducer and surface noise from small waves and propeller wash is often detected in the top layer. Transect 3 was less than 2 m deep throughout and therefore could not be analyzed.

Transect 7 had the only fish targets surveyed in the entire lake. Fish densities observed in transect 7 ranged from 133 targets/ha to 168 targets/ha depending on analysis method, which is relatively high; however, no targets were observed in the adjacent transect 6 that sampled the same basin with approximately the same depth range. No targets were also observed in transect 1 which sampled the deepest part of the west basin of the lake.

Using the mid-water trawl was extremely difficult in this lake due to the small area that was deep enough to be fishable. In addition to only being able to set the trawl very close to the surface, it could not be set very far back from the boat so the trawl fished water that had recently been passed through by the boat and propeller resulting in the potential for boat avoidance behavior. These reasons made it unsurprising that the trawl failed to catch any fish. Two small floating gillnets are inadequate to definitively determined the presence or absence of *nerka*; however, the gillnets did manage to capture coho, whitefish and suckers which suggests if *nerka* were present they were not present in high densities.

It is clear from the bathymetry that Lower Kluatantan Lake provides very little limnetic rearing habitat for sockeye fry. With a Secchi disk reading of 5.3 m, a mean depth of 2.8 m and a maximum depth of 6.7 m, the lake is virtually all littoral habitat. It is also clear from the hydroacoustic data that, on average, there were low densities of targets even in the deeper areas of the lake. If there was a significant population of sockeye fry rearing in the lake they must either be extensively utilizing the shallow areas of the lake or extremely surface oriented.

Upper Kluatantan Lake

The bathymetric map for Upper Kluatantan Lake shows an extremely deep lake given its surface area and surrounding topography. Despite having a much larger limnetic zone compared with Lower Kluatantan Lake, the lake showed no fish targets on any of the transects surveyed. Upper Kluatantan showed a very strong thermocline and anoxic conditions below 5 m depth which made the majority of the limnetic zone inhospitable for fish. The relatively great depth and small surface area makes wind driven circulation difficult. The anoxic conditions may be caused by the resulting stable thermocline that in turn prevents oxygenated water from reaching the lower depths. Similar to Lower Kluatantan Lake, Upper Kluatantan Lake provides very little limnetic rearing habitat for sockeye fry but for very different reasons.

The absence of any conclusive results from the hydroacoustic surveys of both Kluatantan Lakes, combined with the paucity of escapement data for adult sockeye, makes this sockeye stock a high priority for further work to evaluate stock status. Hydroacoustic surveys are likely not the best method for evaluating this stock.

Lakelse Lake

There are several difficulties in developing an age-0 *nerka* fry estimate for Lakelse Lake. The failure of the tachometer during the survey made it difficult to fish with the trawl effectively. This resulted in only one *nerka* being caught using the trawl. Although 39 fish were also caught in the trawl they were all sculpins (2 species) and all but one of them were caught with large amounts of fine sediment. The presence of the fine sediment demonstrates that the trawl was sampling the bottom of the lake and it is likely that most, if not all, of the sculpins were captured on the bottom of the lake. It is unlikely that sculpins (with no air bladder) located on the bottom of the lake are detectable by the hydroacoustic equipment. Therefore the trawl catch cannot be used to apportion the small size class hydroacoustic estimate by species. The small sample size of age-0 *nerka* also prevents the accurate estimation of the population biomass using the average weight of the *nerka* caught in the trawl. To generate a population estimate and biomass for age-0 *nerka* a proportion value (15%) and mean weight (6 g) from previous surveys of Lakelse Lake was used.

The biomass estimate is also based on the estimate generated using the Integration analysis method. Integration estimates have been used to estimate biomass in other survey reports (Shortreed & Hume 2004, 2005, 2006); however the Integration analysis method may not be appropriate for this survey because the Integration method produced density estimates for transects 3 to 5 that were more than double the estimates from the other analysis methods. Typically, the Integration estimate from Lakelse Lake is very similar to the Single Target estimate (within 5%) while the Tracked Target estimate is up to 50% higher (Shortreed *et al.* 2007). Careful scrutiny of the hydroacoustic data from the anomalous transects failed to locate the source of this deviancy.

Even using the high Integration estimate, the 2006 biomass and population estimate is the lowest recorded in the past 4 years and is only 22% of the Adjusted Rmax estimated for the lake (Table 10). This result is a cause for concern about the status of Lakelse Lake sockeye since all of the assumptions used to generate the biomass estimate are biased towards a high estimate: the average weight used for the biomass estimate is the largest weight for fall fry recorded in any survey of Lakelse Lake, the population estimate is based on the Integration analysis method which appears to be anomalously high compared with the two other analysis methods, and value used for the proportion of *nerka* in the small size class may be high given the low densities observed in 2006.

In addition, there is a kokanee population documented in Lakelse Lake and previous surveys have estimated the kokanee proportion of the age-0 *nerka* population from 38% to 59% based on length frequency analysis (Shortreed *et al.* 2007). If the high Integration estimate is used and is reduced arbitrarily by 50% to account for a kokanee population in the lake, the estimated anadromous age-0 sockeye fry population is just over 50,000.

The survey of Lakelse Lake in 2006, although not conclusive due to difficulties sampling for mid-water fish species, strongly suggests that population of age-0 sockeye is quite low relative to lake capacity and absolute numbers. The brood year escapement (2005) for the age-0 sockeye surveyed in 2006 was 2,865 (DFO SEDS) from the 3 most important tributary creeks in the Lakelse system. Using the small size class Integration estimate, reduced for other species, and further reduced for kokanee, the escapement from 2005 produced approximately 18 fry per spawner.

REFERENCES

Burgner, R.L. 1991. Life history of sockeye salmon (*Oncorhynchus nerka*). *In* Pacific Salmon Life Histories. *Ed.* C. Groot and L. Margolis. UBC Press.

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.

Gottesfeld, A. and K. Rabnett. 2007. Skeena fish populations and their habitat. Skeena Fisheries Commission. Hazelton, BC.

Kingston Derek. 2007. Biologist, Gitanyow Fisheries Authority.

Kingston, D. 2007. The 2006 Kitwanga River sockeye smolt assessment. Gitanyow Fisheries Authority. Report to Fisheries and Oceans Canada.

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 and Oceans Canada.

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.

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. 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.

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.

Shortreed, K., J. Hume and K. Malange. 2007. Preliminary categorization of the productivity of 37 coastal and Skeena River system lakes in British Columbia. Canadian Technical Report of Fisheries and Aquatic Science. *In press.*

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Brock Stables (Shuksan Fisheries Consulting) and Rodney Harris (Gitksan Watershed Authorities) performed the Kluatantan Lakes surveys. Mark Cleveland (Gitanyow Fisheries Authority) assisted with the Kitwanga Lake survey and Rodney Harris assisted with the Lakelse Lake survey. Tim Wilson (Gitksan Watershed Authorities) provided all the fish measurements. Gordon Wilson (Skeena Fisheries Commission) developed all the maps presented in this report. Allen Gottesfeld 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. Kitwanga Lake trawl catch summary

Lake	Tow	Location (Basin)	Length (m)	Average Depth (m)	Sockeye	Sculpin
Kitwanga	1	North	1,240	6.5	0	0
	2	South	810	7	0	0
Total	**2**	**n/a**	**2,050**	**n/a**	**0**	**0**

Table 2. Lower Kluatantan Lake trawl catch summary

Lake	Tow	Location (Transect)	Length (m)	Average Depth (m)	Sockeye	Sculpin
Lower Kluatantan	1	6 - 7	150	3	0	0
	2	6 - 8	210	2.5	0	0
	3	5 - 7	370	2	0	0
Total	**3**	**n/a**	**730**	**n/a**	**0**	**0**

Table 3. Upper Kluatantan Lake trawl catch summary

Lake	Tow	Location (Transect)	Length (m)	Average Depth (m)	Sockeye	Sculpin
Upper Kluatantan	1	2 - 5	250	*	0	0
	2	3 - 6	290	*	0	0
	3	2 - 5	310	*	0	0
Total	**3**	**n/a**	**850**	**n/a**	**0**	**0**

*Depths not recorded

Table 4. Lakelse Lake trawl catch summary

Lake	Tow	Location (Transect)	Length (m)	Average Depth (m)	Sockeye	Sculpin
Lakelse	1	2 - 4	1,050	21	1	22
	2	3 - 4	380	17	0	16
	3	2 - 4	1,310	16	0	0
	4	2 - 3	1,030	20	0	0
	5	3 - 4	530	21	0	1
Total	**5**	**n/a**	**4,300**	**n/a**	**1**	**39**

Table 5. Gillnet location and effort by lake

Lake	Gillnet	UTM	Soak Time (Hours)
Kitwanga	1	09 U 555910 6136467	9
	2	09 U 556887 6133052	8
Lower Kluatantan	1	09 U 555535 6311218	11
	2	09 U 555926 6311391	9
Upper Kluatantan	1	09 U 557485 6312212	13.5
	2	09 U 557568 6312091	13
Lakelse	1	09 U 530689 6029461	16
	2	09 U 528285 6026234	16

Table 6. Gillnet catch summary

Lake	Gill-net	SK	CT	MW	RB	NSC	CO	LSU	PCC	RSC
Kitwanga	1	0	0	0	0	0	0	0	0	0
	2	4	0	0	0	0	0	0	0	0
Lower Kluatantan	1	0	0	2	0	0	4	2	0	0
	2	0	0	0	0	0	1	1	0	0
Upper Kluatantan	1	0	0	0	0	0	4	0	0	0
	2	0	0	2	0	0	9	3	0	0
Lakelse	1	0	4	0	1	0	0	0	1	3
	2	0	1	0	0	1	0	0	0	6

SK=sockeye, CT=cutthroat trout, MW=mountain whitefish, RB=rainbow trout, NSC=northern pikeminnow, CO=coho, LSU=longnose sucker, PCC= peamouth chum, RSC=redside shiner

Table 7. Kitwanga Lake hydroacoustic fish population estimates

Estimate Method	Basin	Size Class	Density		Population	
			N/ha	95% C.I.	N	95% C.I.
Tracked Targets	North	Small	165	149	106,175	95,863
		Large	39	26	25,125	16,547
	South	Small	320	1	43,418	137
		Large	128	26	17,364	3,584
	Combined	Small	192	77	149,593	60,245
		Large	55	13	42,489	10,414

Table 8. Lower Kluatantan Lake east basin hydroacoustic fish population estimates

Estimate Method	Size Class	Density N/ha	Density 95% C.I.	Population N	Population 95% C.I.
Integration	Small	28	77	539	1,496
Single Target	Small	27	74	519	1,442
Tracked Targets	Small	34	93	656	1,821

Table 9. Lakelse Lake north basin hydroacoustic fish population estimates

Estimate Method	Size Class	Density N/ha	Density 95% C.I.	Population N	Population 95% C.I.
Integration	Small	220	261	122,268	144,625
	Large	110	217	60,856	120,149
Single Target	Small	89	94	49,268	51,960
	Large	27	27	14,945	14,836
Tracked Targets	Small	128	148	71,086	82,040
	Large	41	47	22,995	25,968

Table 10. 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)
2003[b]	6,390	1,420,000	2,880	640,000	660[e]	108,837	23%
2004[c]					730	215,365	25%
2005[d]					1,720	391,401	60%
2006					620[e]	103,928	22%

a. Cox-Rogers et al. 2004. b. Shortreed and Hume 2004. c. Shortreed and Hume 2005. d. Ken Shortreed personal communication. e. Based on 6.0g fry average fry weight.

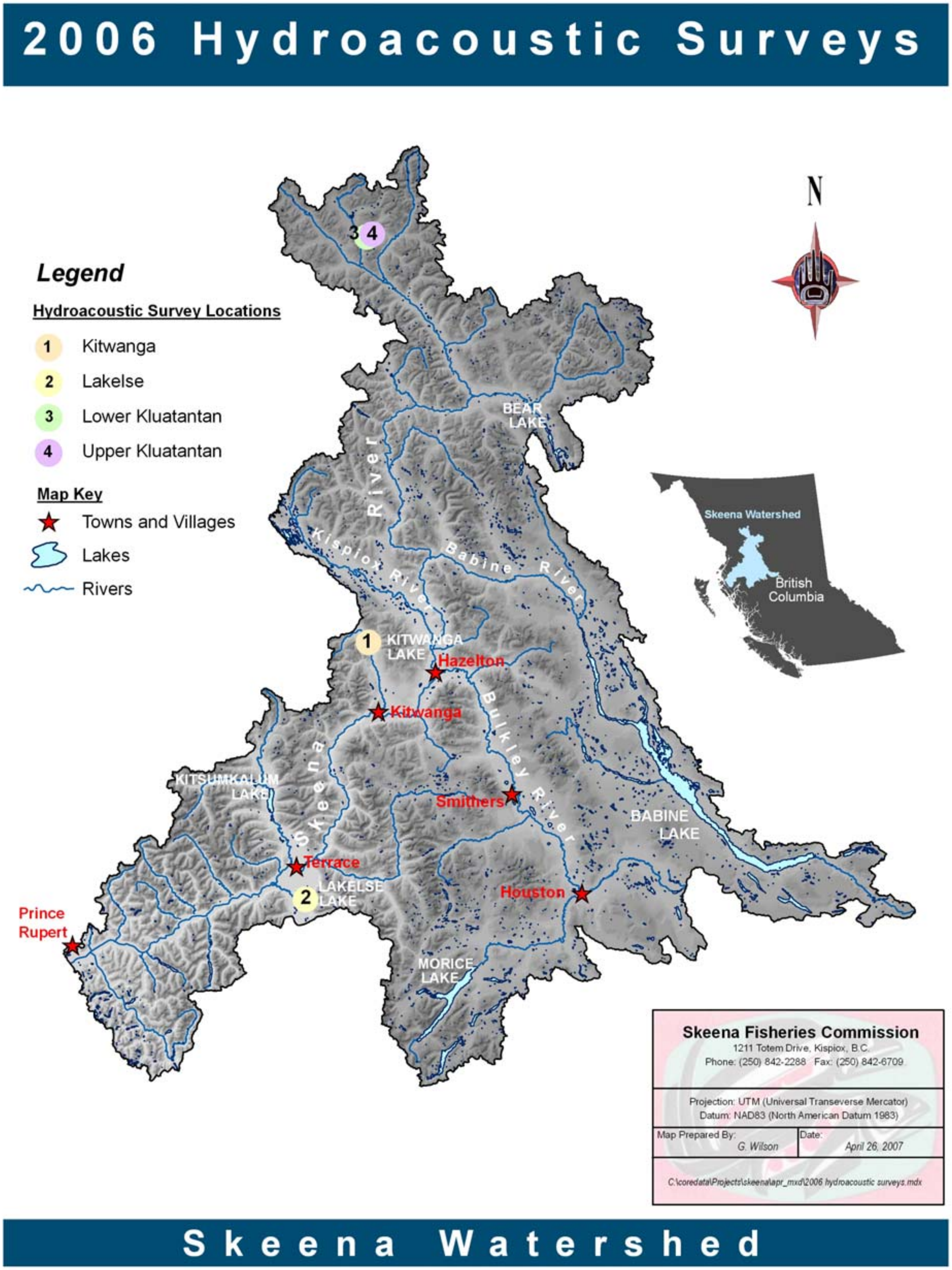

Figure 1. **Location of surveyed lakes in the Skeena watershed**

Figure 2. Kitwanga Lake aerial photograph (M. Cleveland)

Figure 3. Lower Kluatantan Lake east basin aerial photograph (A. Gottesfeld)

Figure 4. Upper Kluatantan Lake aerial photograph (A. Gottesfeld)

Figure 5. Lakelse Lake aerial photograph (D. Gordon)

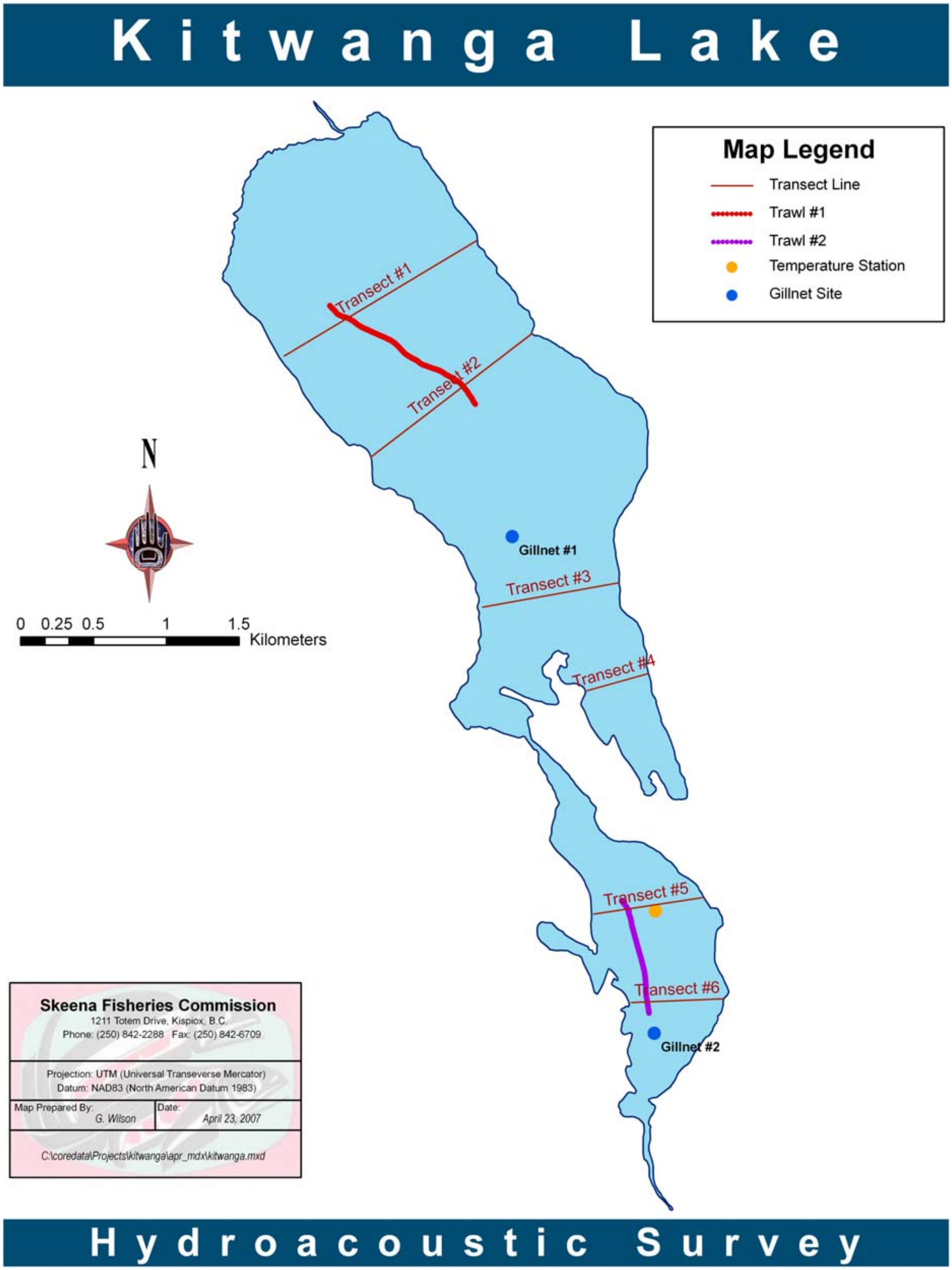

Figure 6. **Kitwanga Lake survey map**

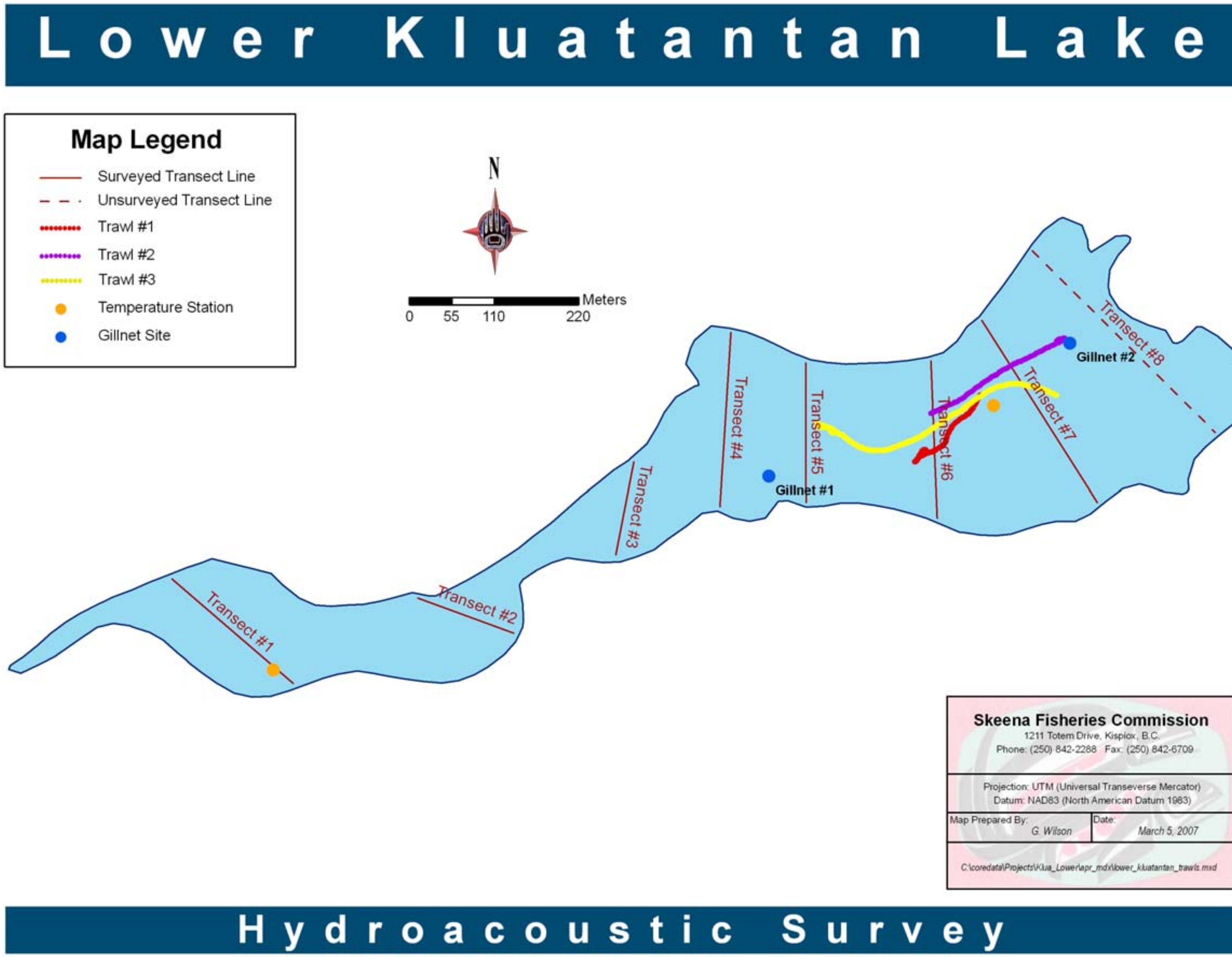

Figure 7. **Lower Kluatantan Lake survey map**

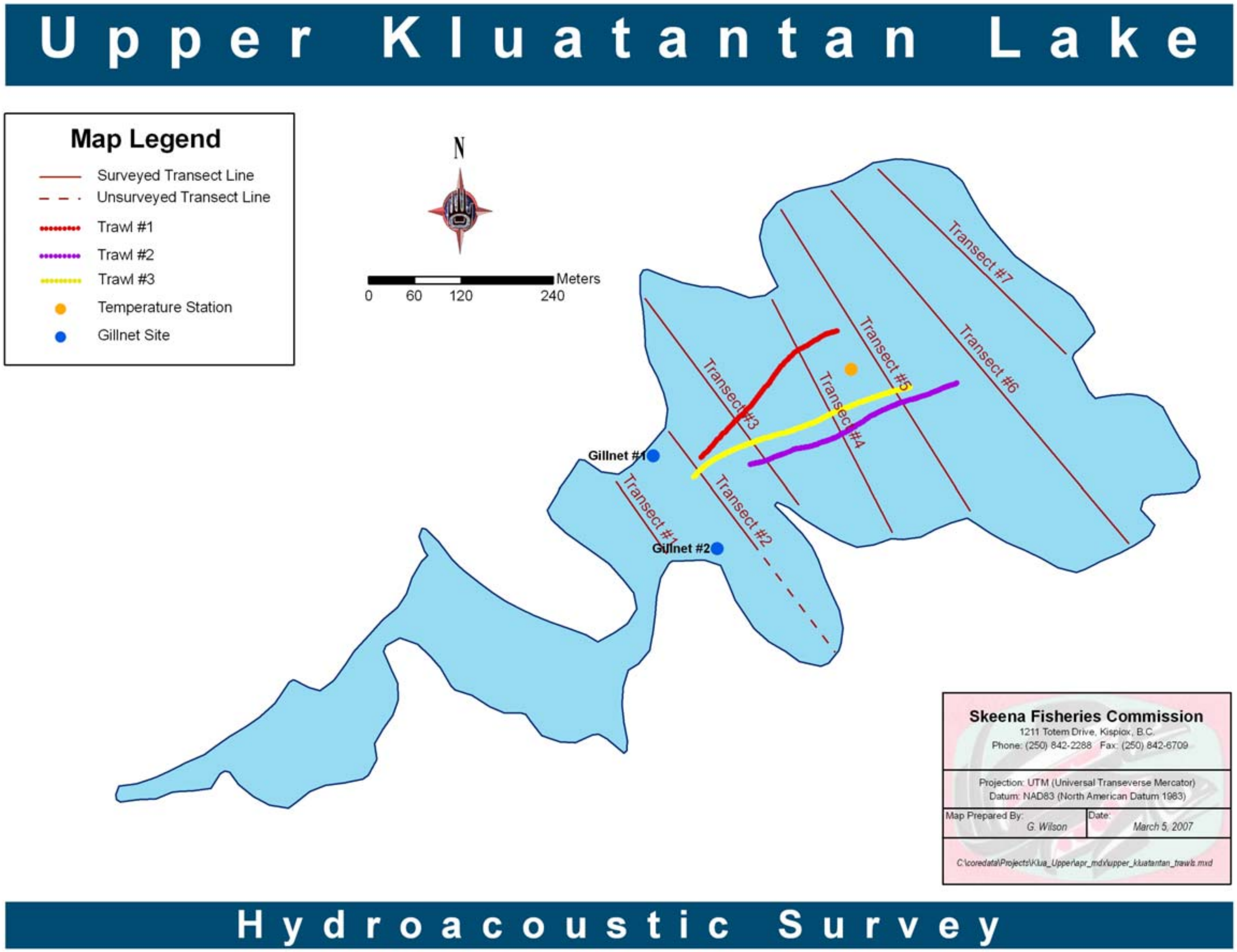

Figure 8. **Upper Kluatantan Lake survey map**

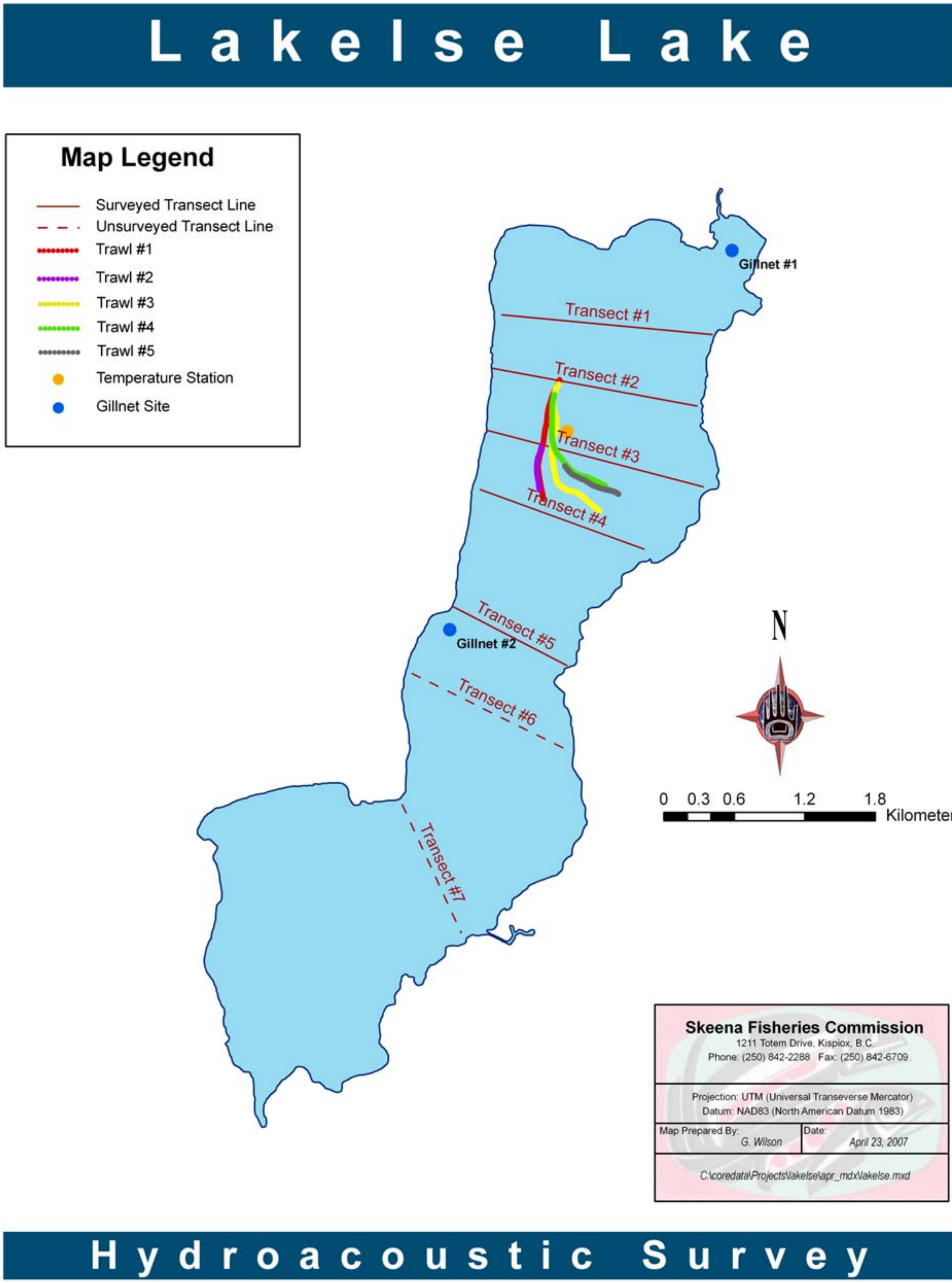

Figure 9. Lakelse Lake survey map

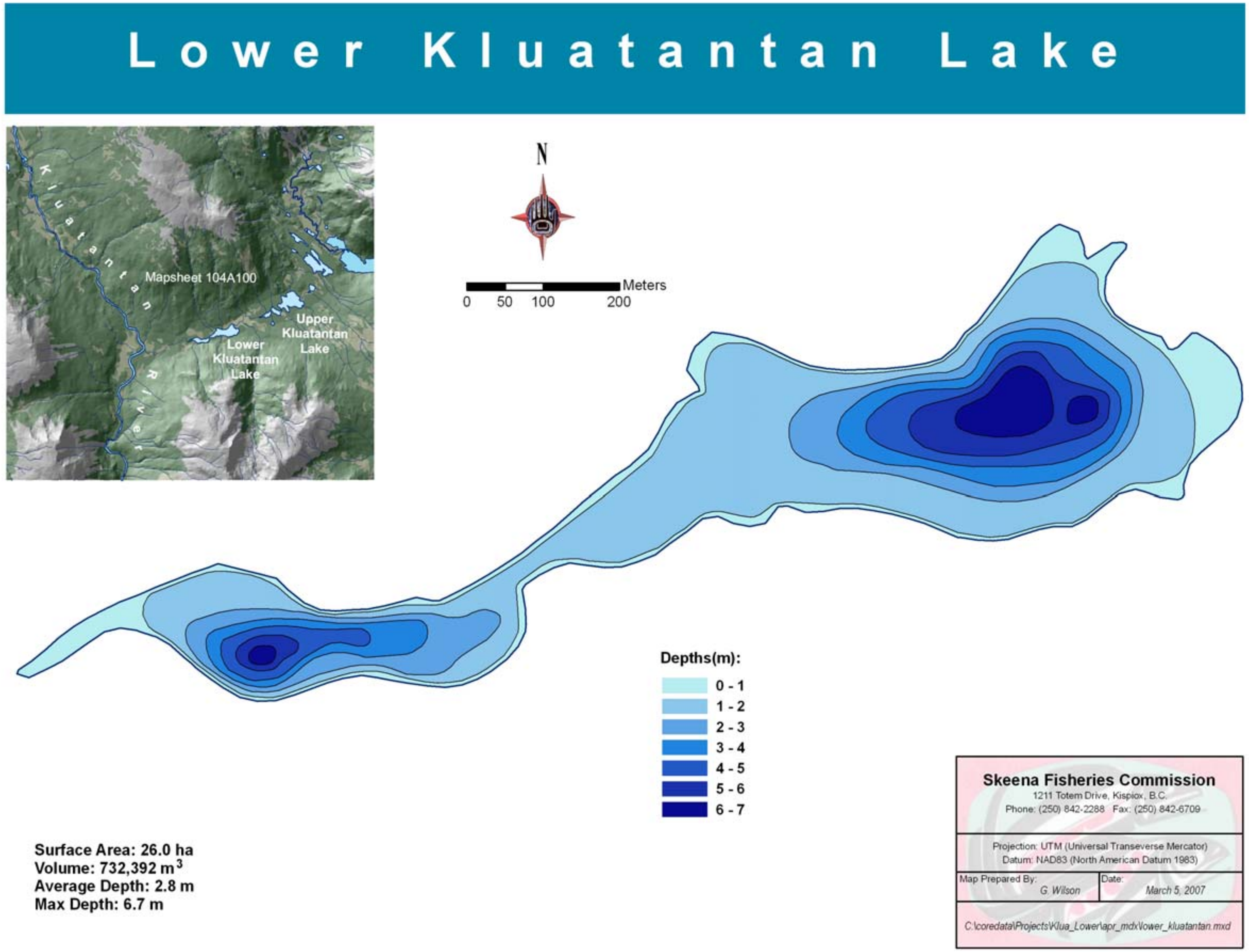

Figure 10. Lower Kluatantan Lake bathymetric map

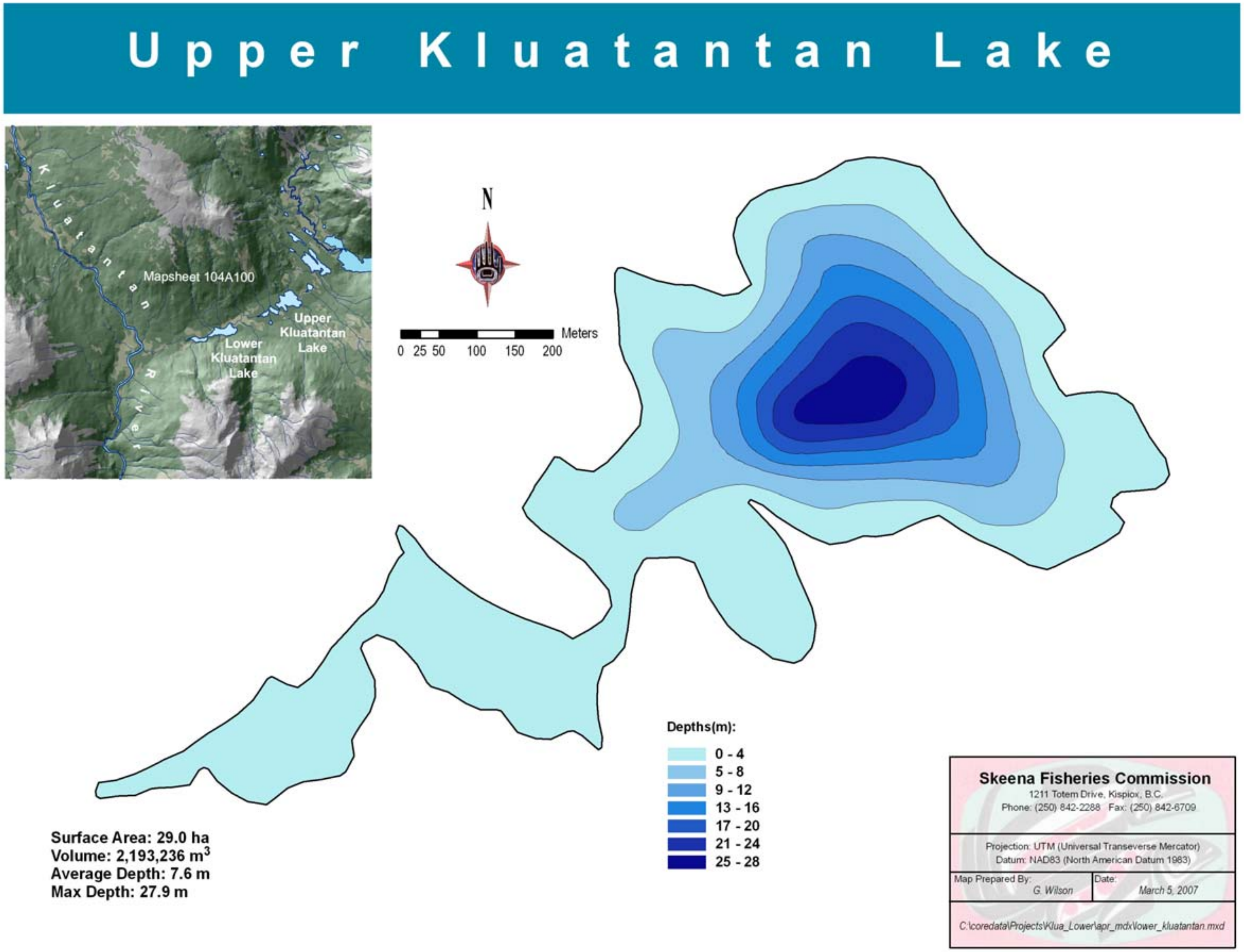

Figure 11. Upper Kluatantan Lake bathymetric map

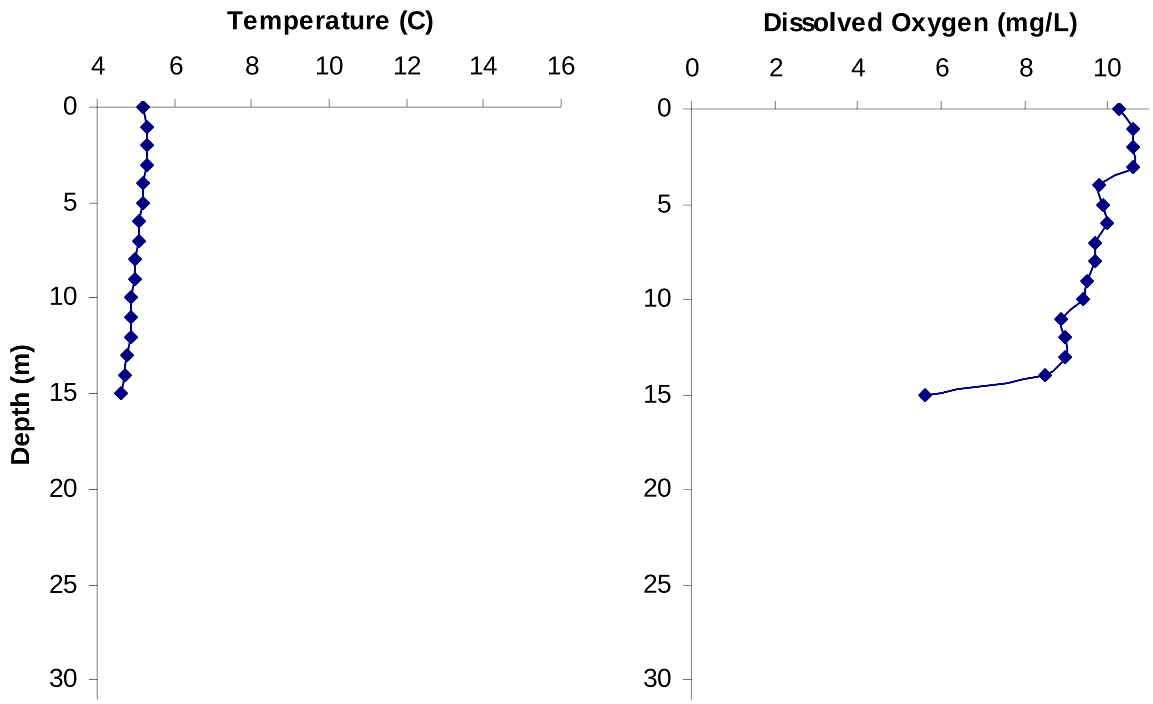

Figure 12. Temperature & oxygen profiles for Kitwanga Lake (north basin)

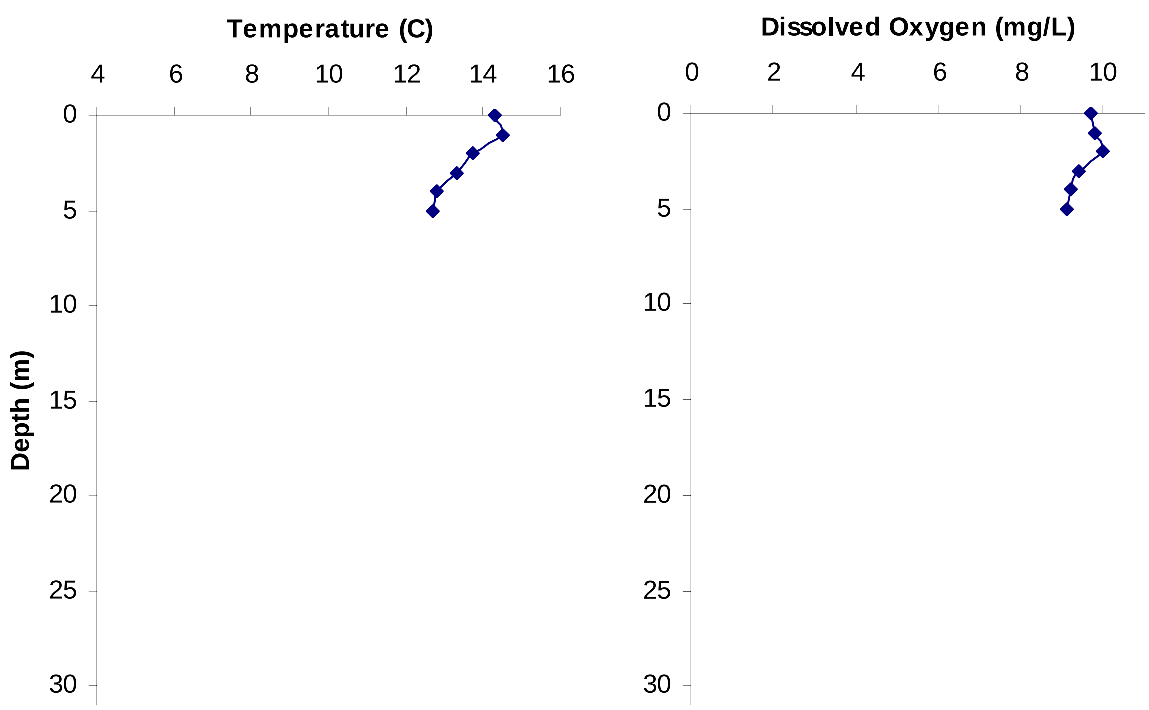

Figure 13. Temperature & oxygen profiles for Lower Kluatantan Lake (west basin)

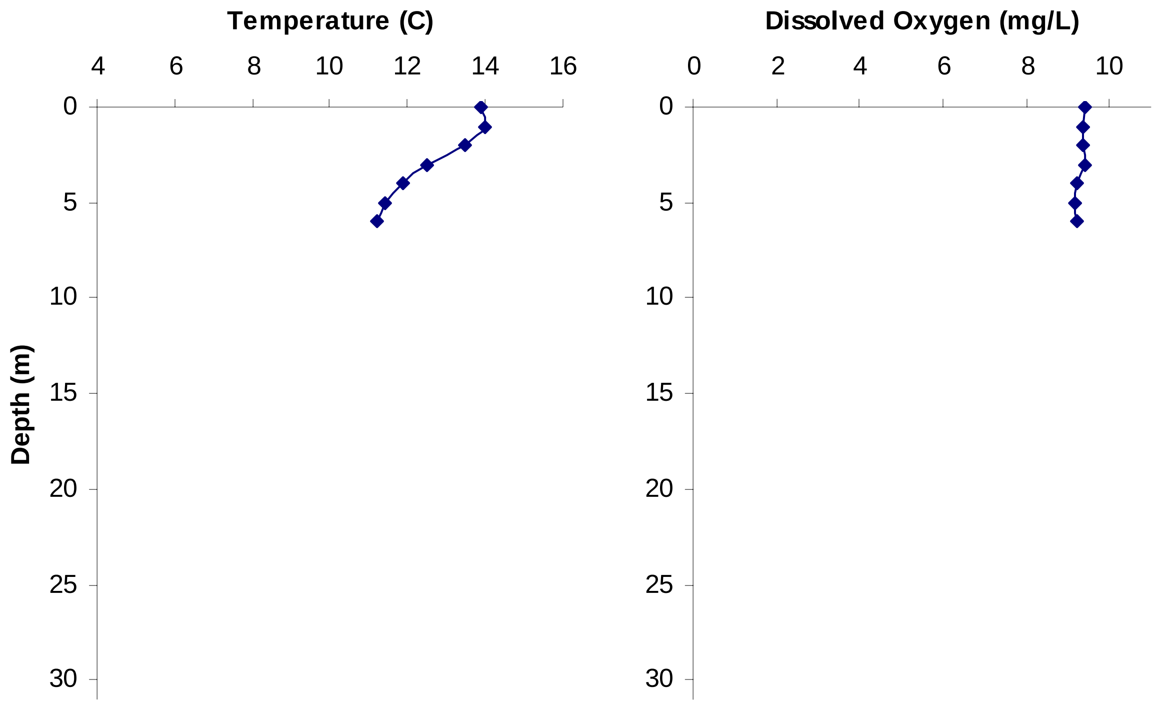

Figure 14. Temperature & oxygen profiles for Lower Kluatantan Lake (east basin)

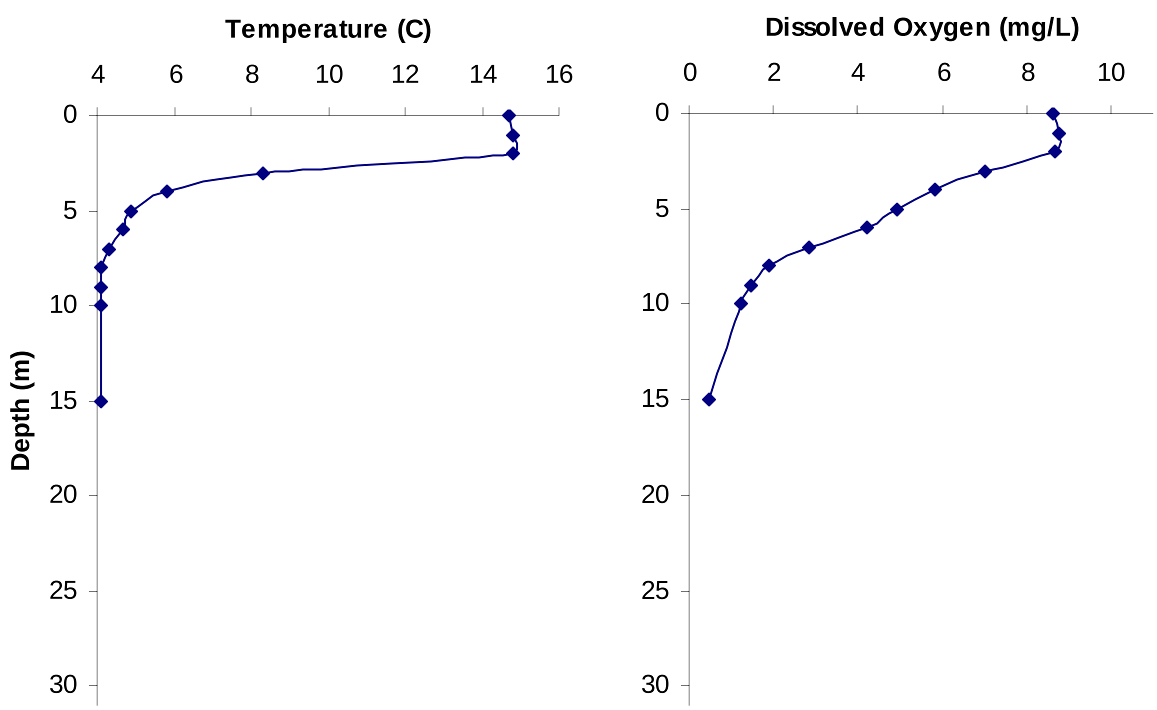

Figure 15. Temperature & oxygen profiles for Upper Kluatantan Lake

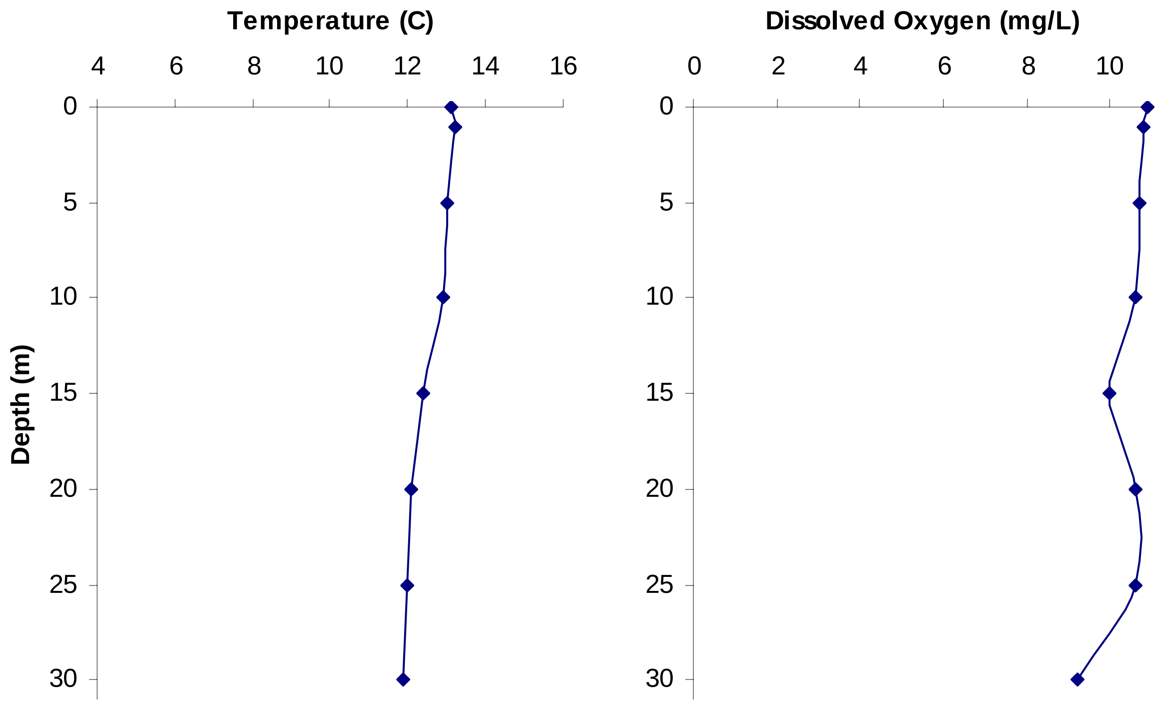

Figure 16. Temperature & oxygen profiles for Lakelse Lake

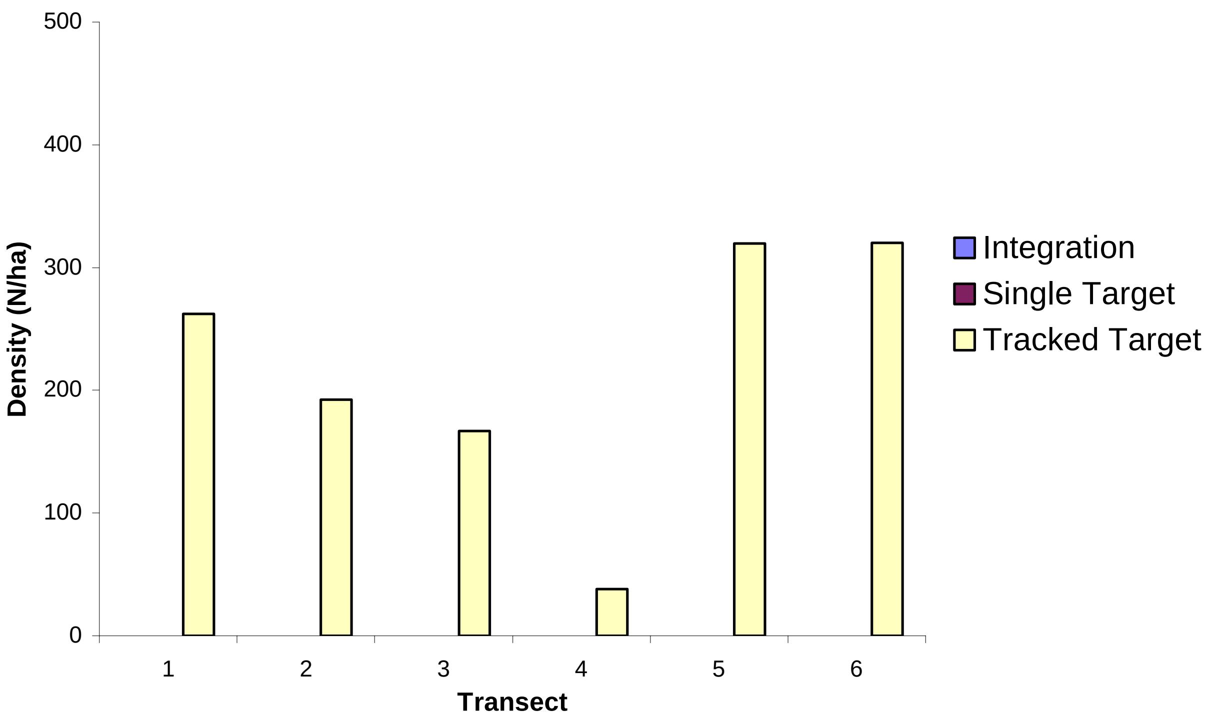

Figure 17. Kitwanga Lake small size class target densities by transect

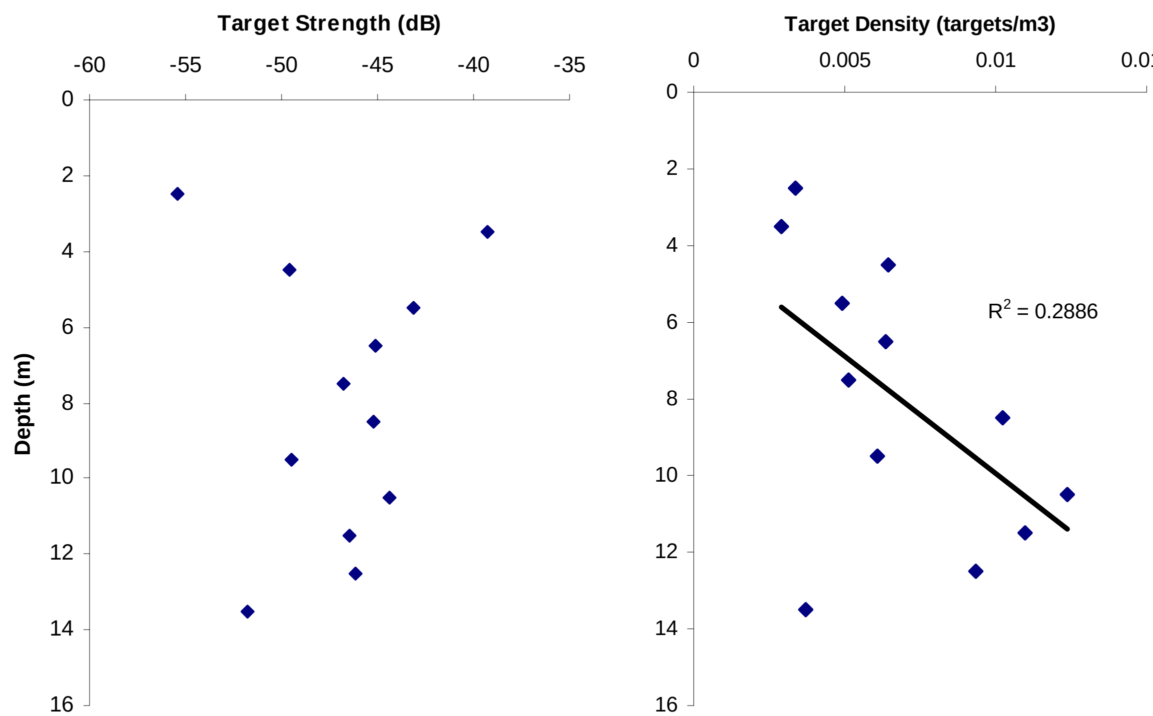

Figure 18. Average TS and target density profiles from all transects of Kitwanga Lake

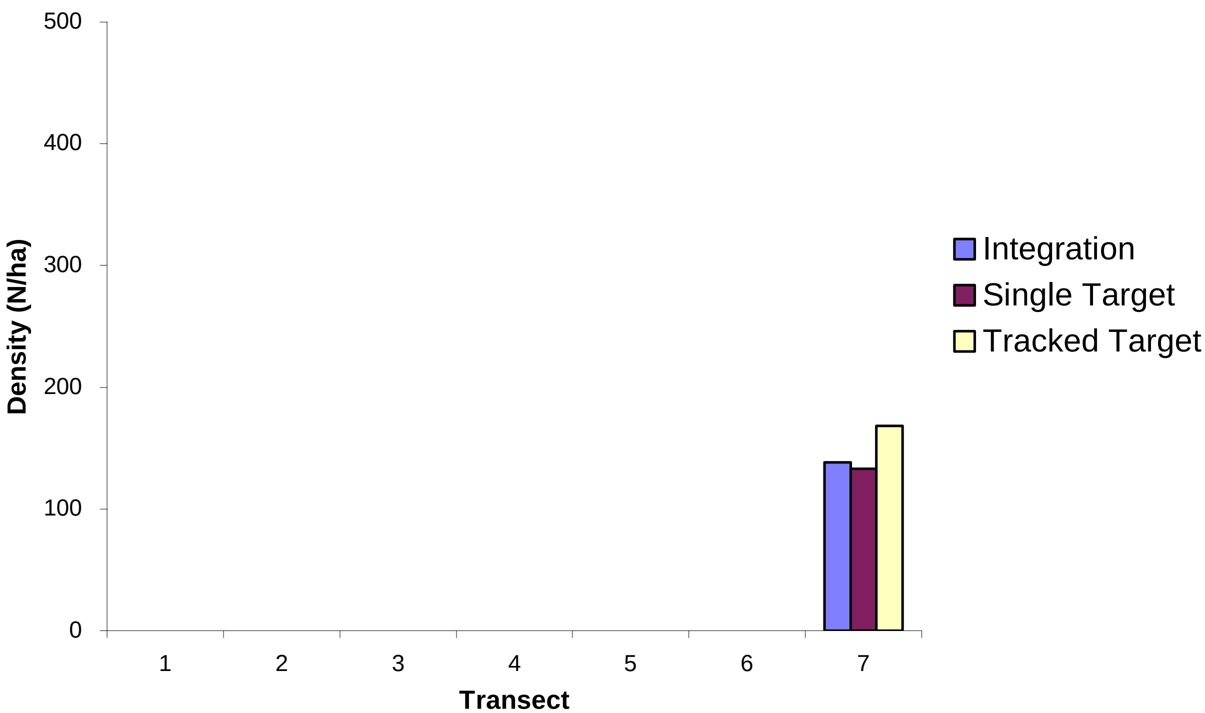

Figure 19. Lower Kluatantan Lake small size class target densities by transect and analysis method

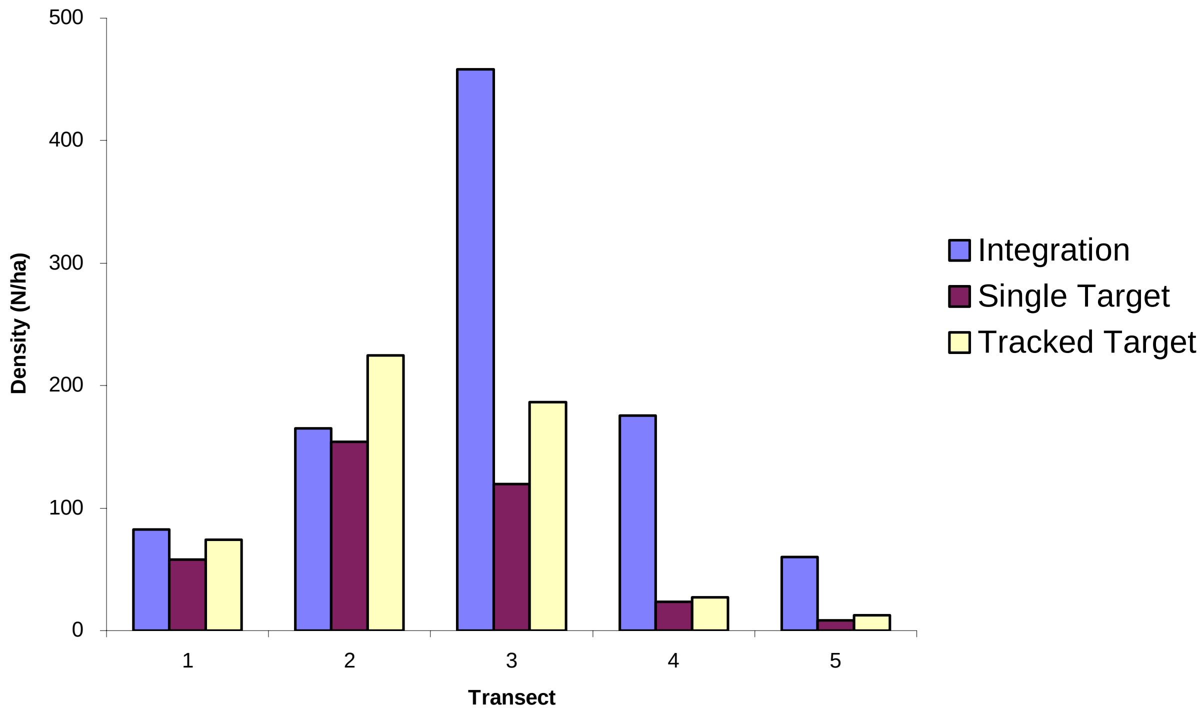

Figure 20. Lakelse Lake small size class target densities by transect and analysis method

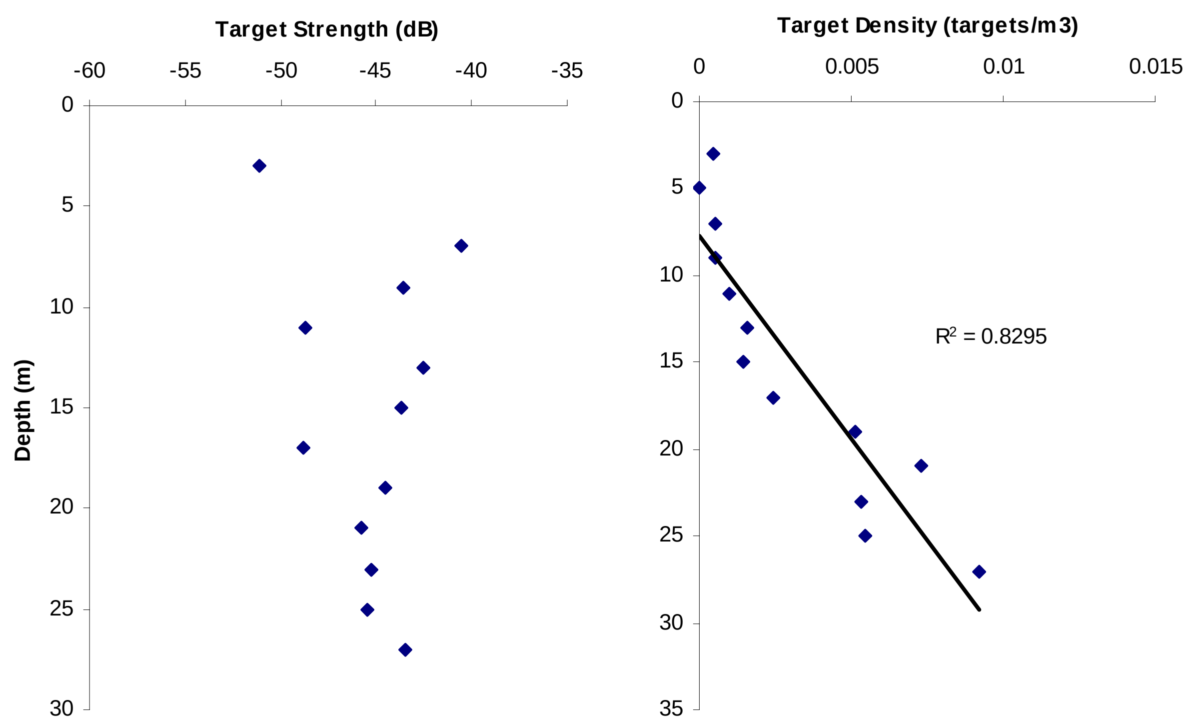

Figure 21. Average TS and target density profiles from transects 1-5 of Lakelse Lake

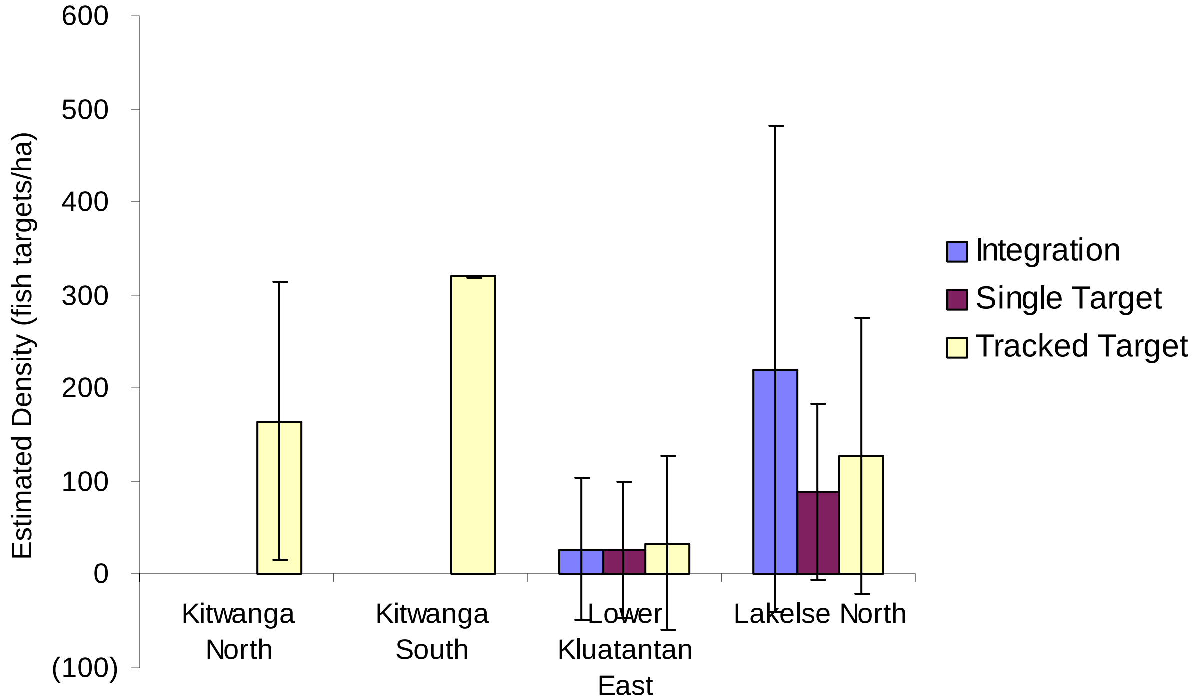

Figure 22. Small size class density estimates by analysis method and lake basin

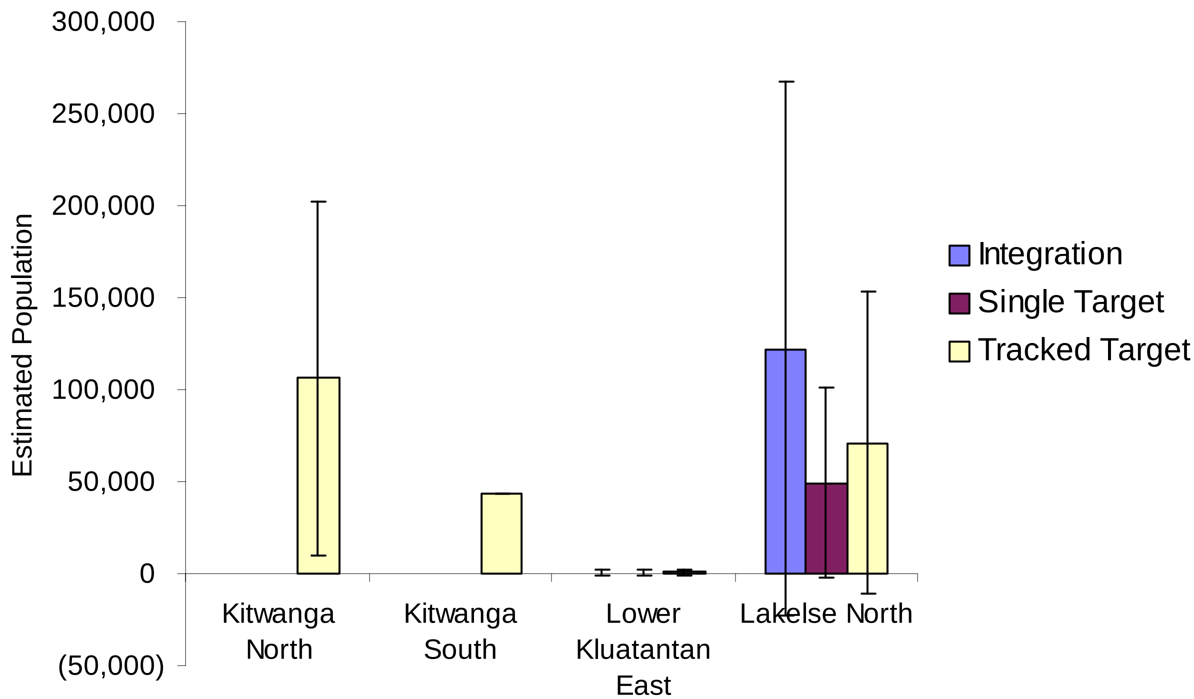

Figure 23. Small size class population estimates by analysis method and lake basin

APPENDIX 1: Kitwanga Lake Transect Echograms

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

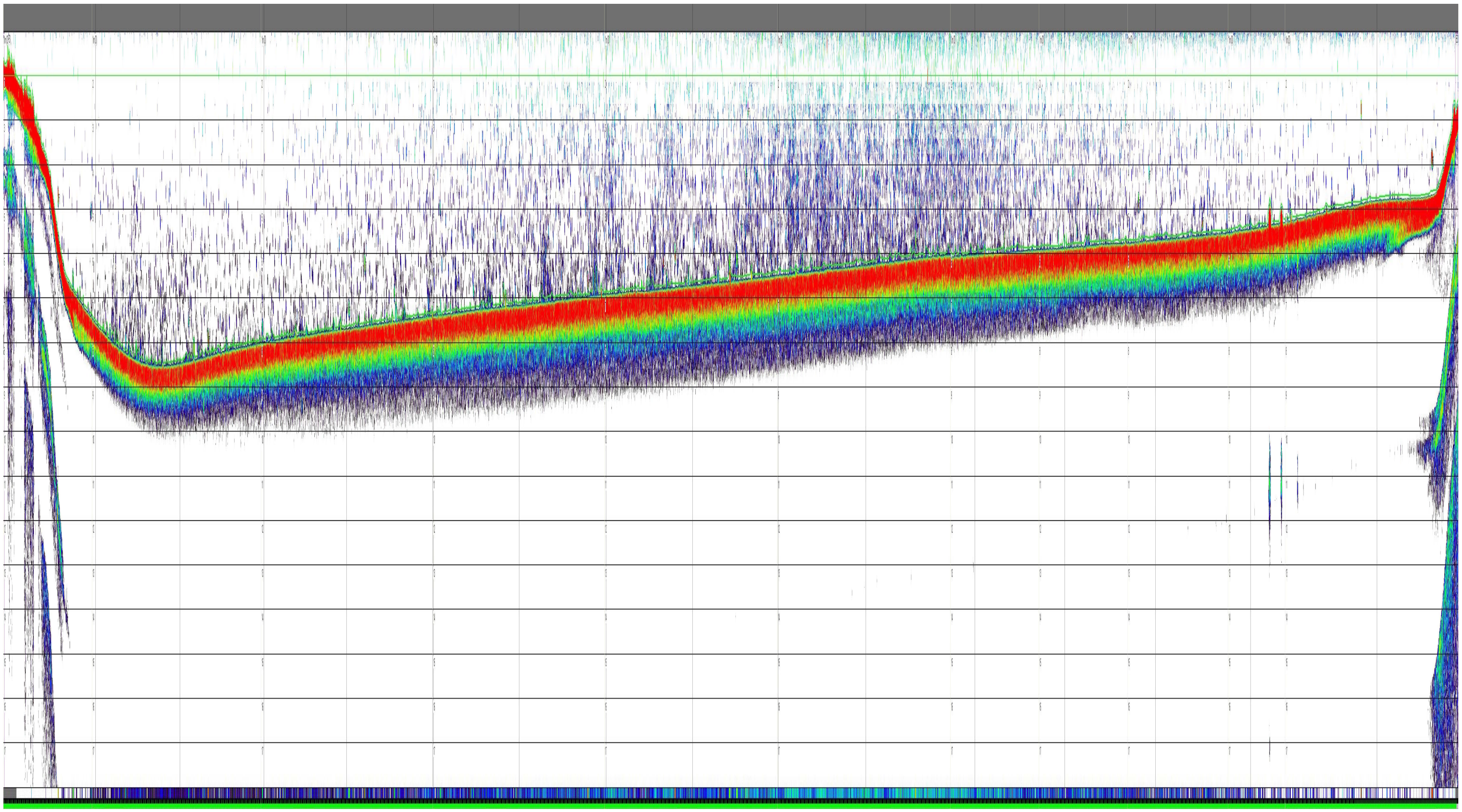

Figure 24. Kitwanga Lake transect 1 echogram

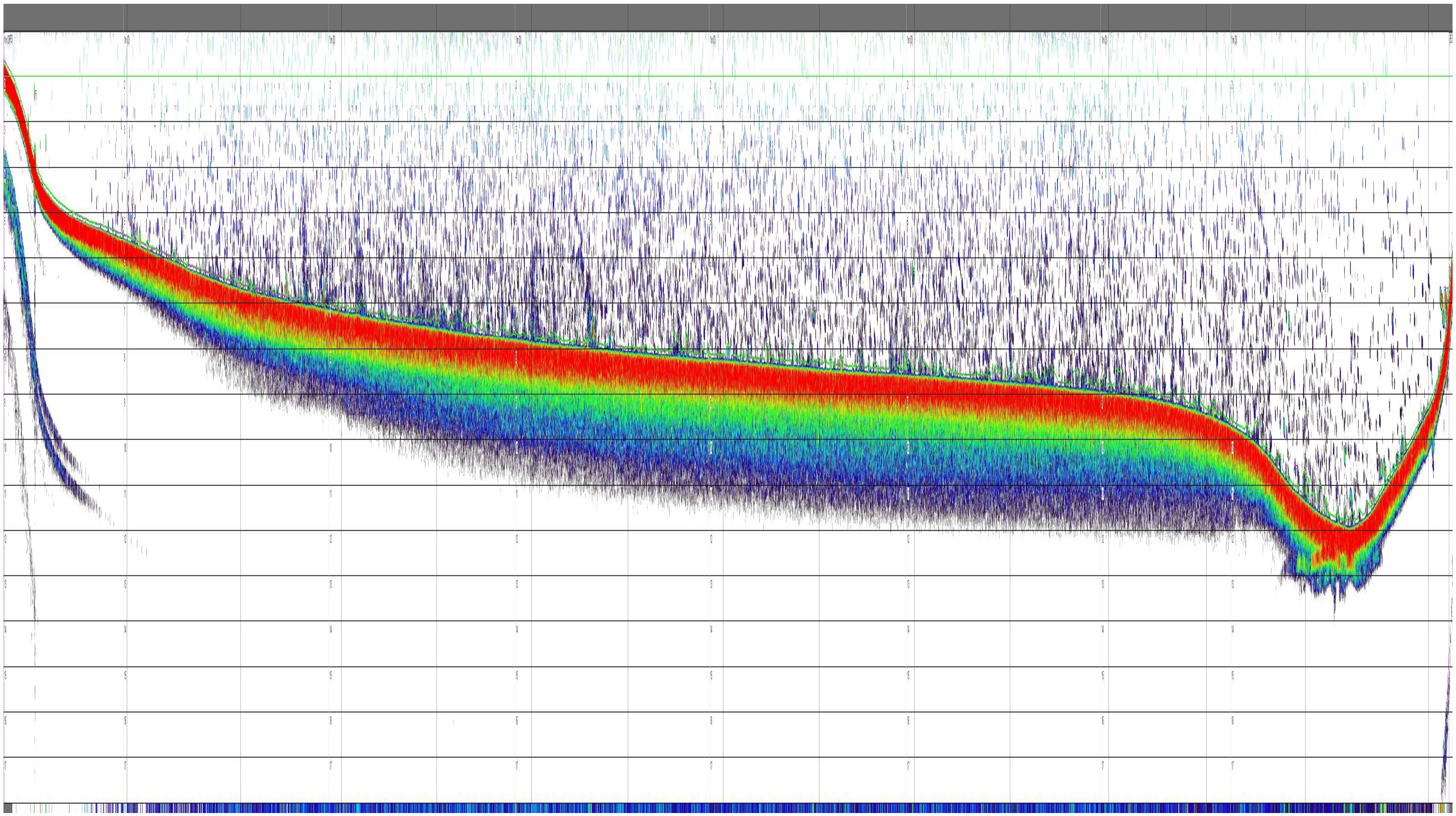

Figure 25. Kitwanga Lake transect 2 echogram

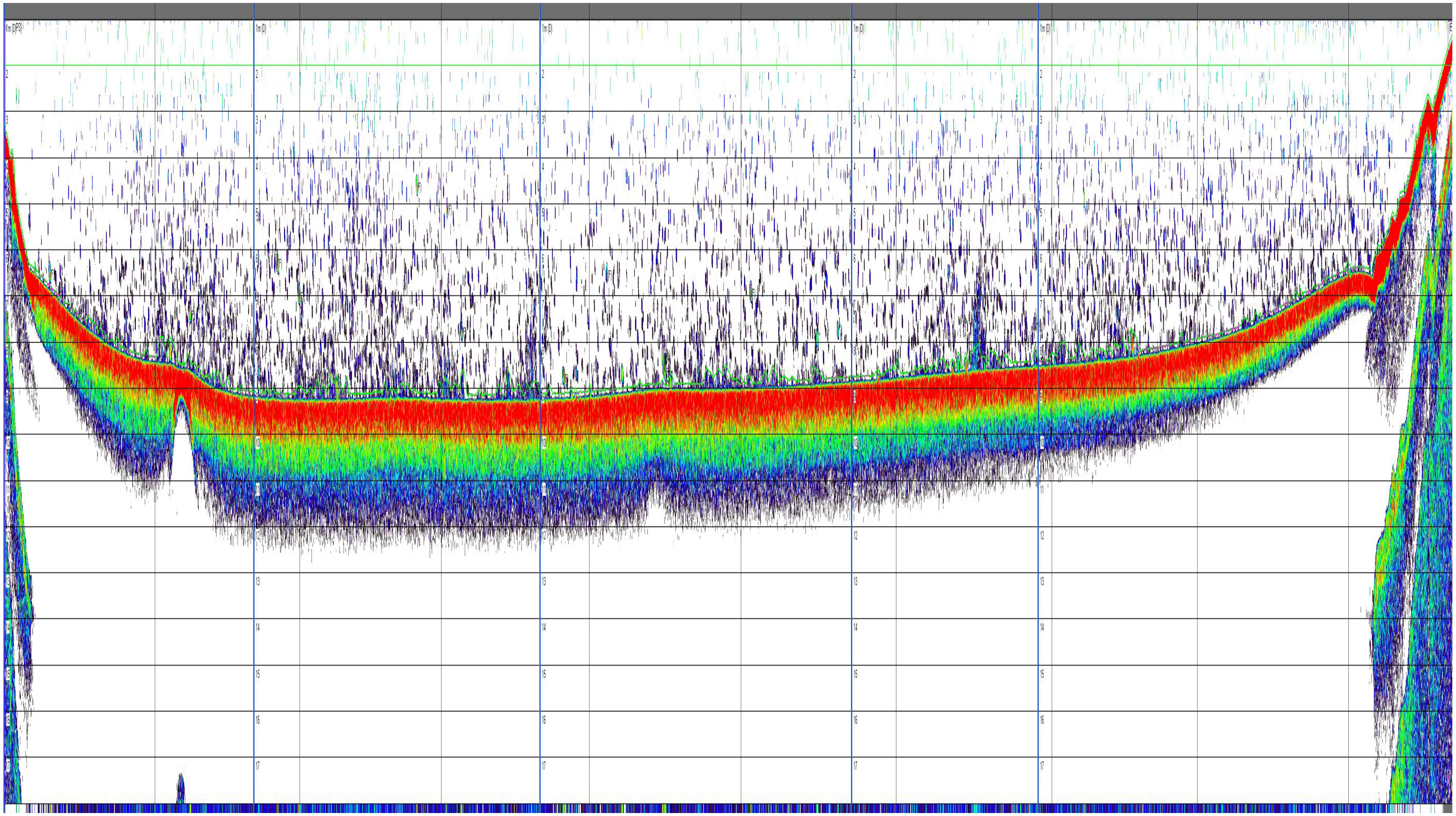

Figure 26. **Kitwanga Lake transect 3 echogram**

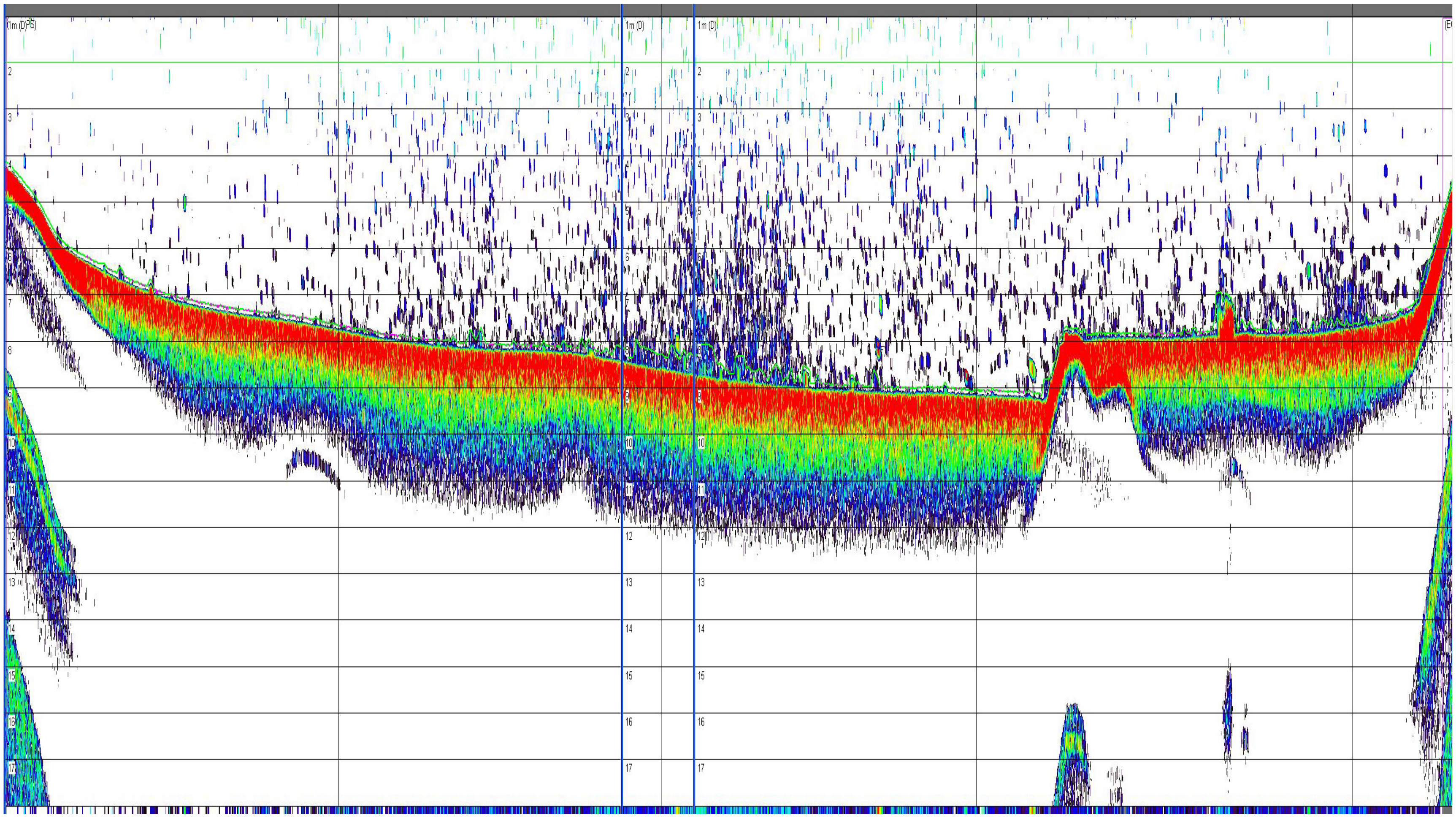

Figure 27. Kitwanga Lake transect 4 echogram

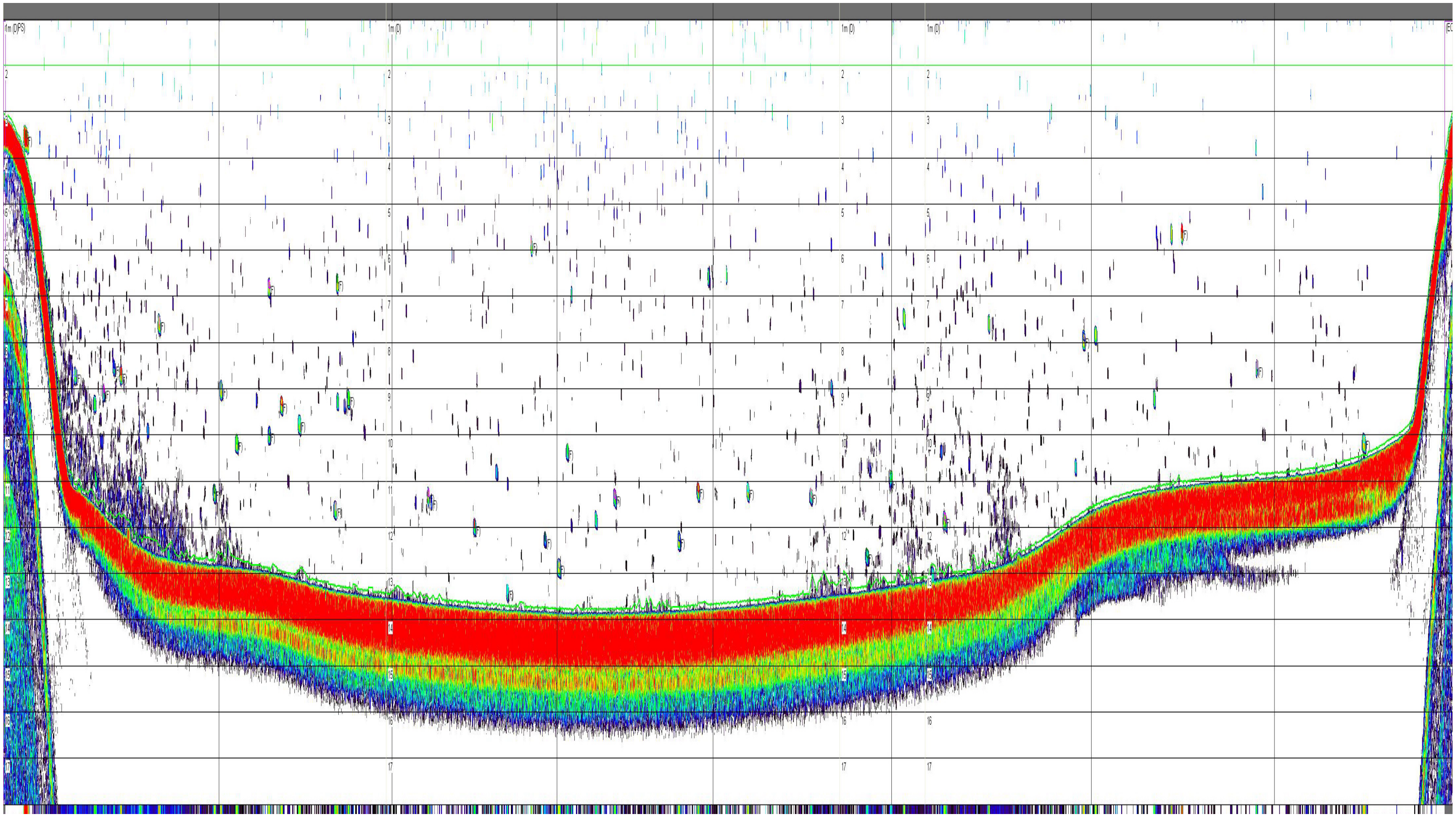

Figure 28. **Kitwanga Lake transect 5 echogram**

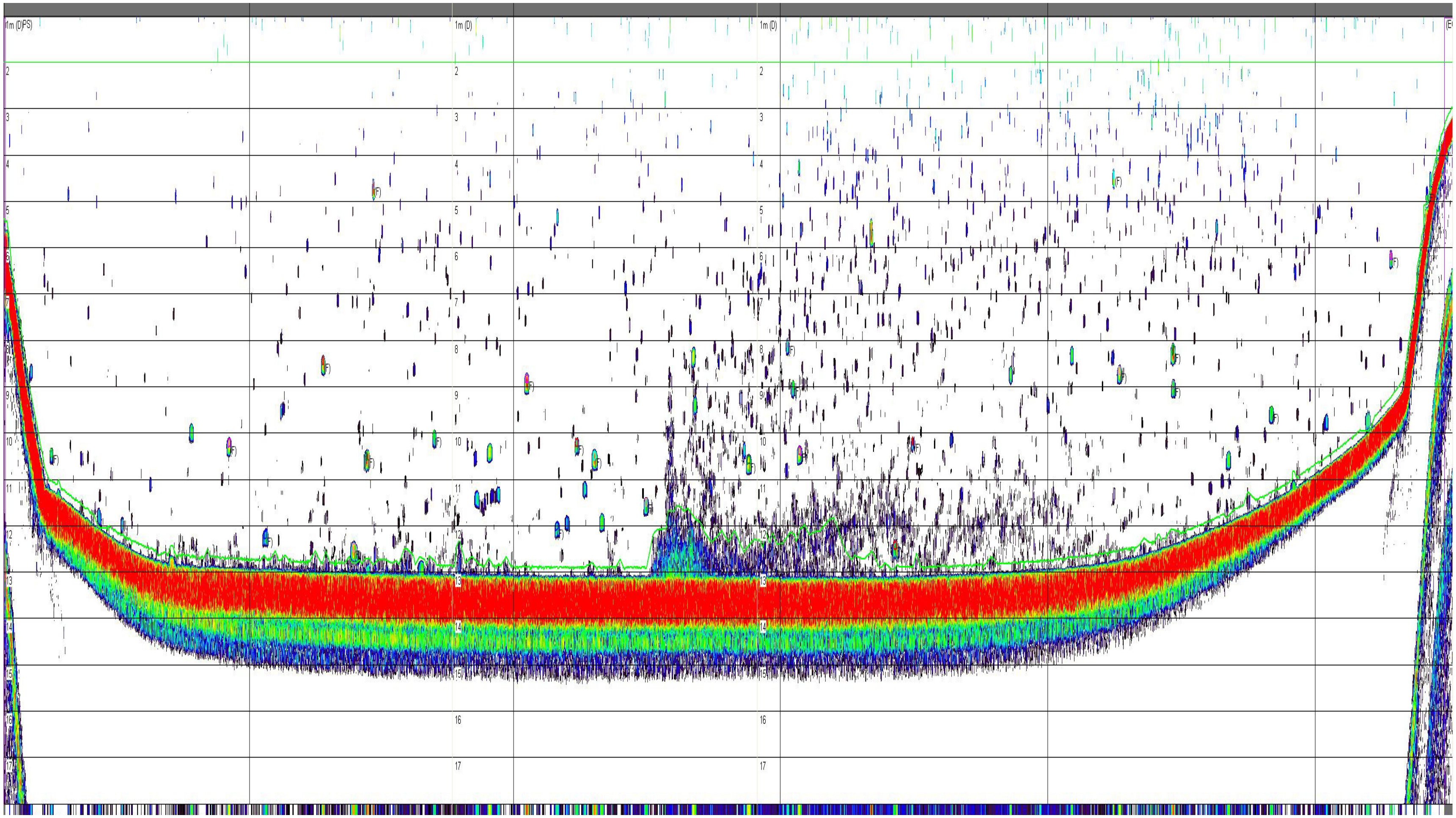

Figure 29. Kitwanga Lake transect 6 echogram

APPENDIX 2: Lower Kluatantan Lake Transect Echograms

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

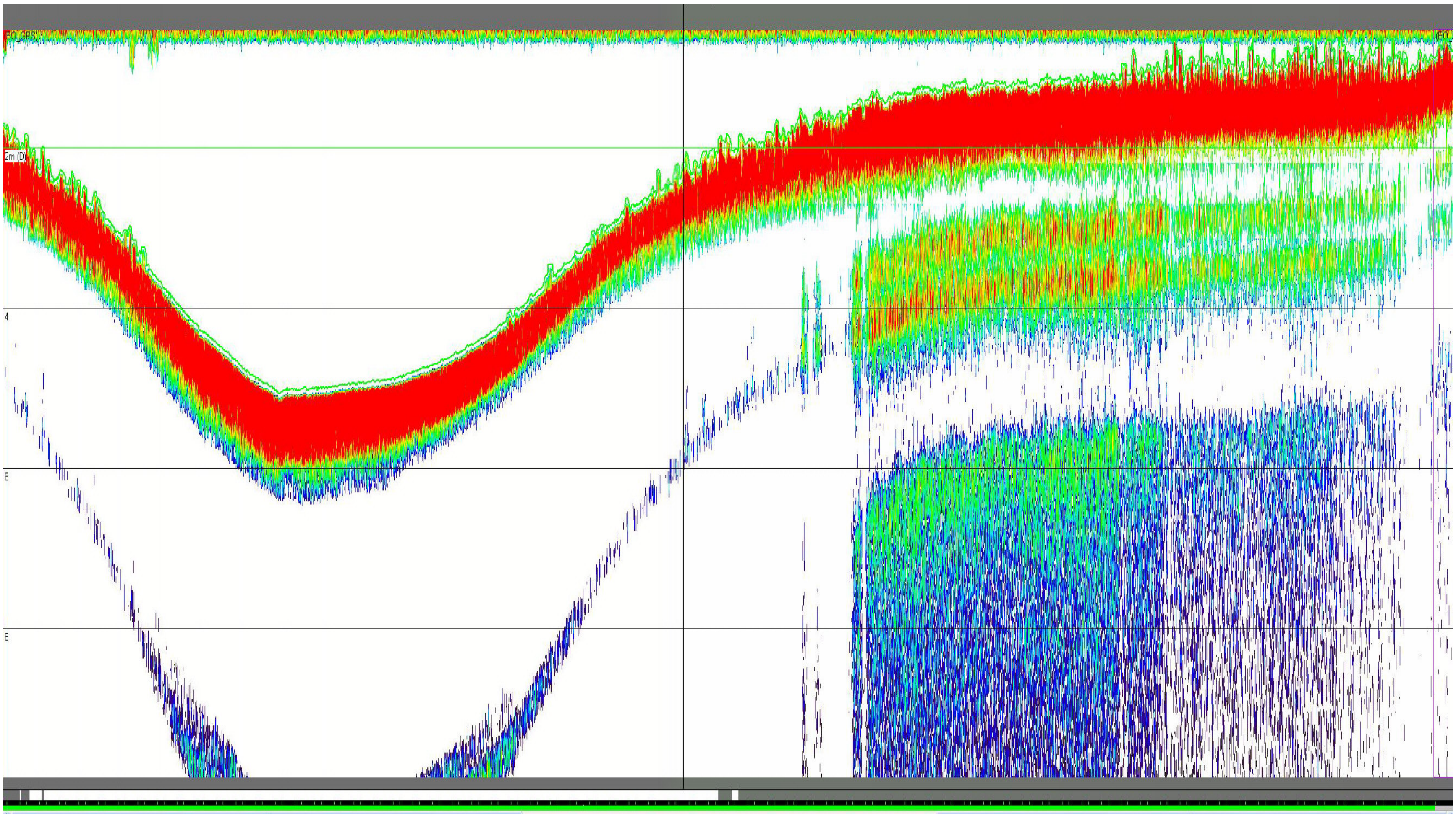

Figure 30. Lower Kluatantan Lake transect 1 echogram

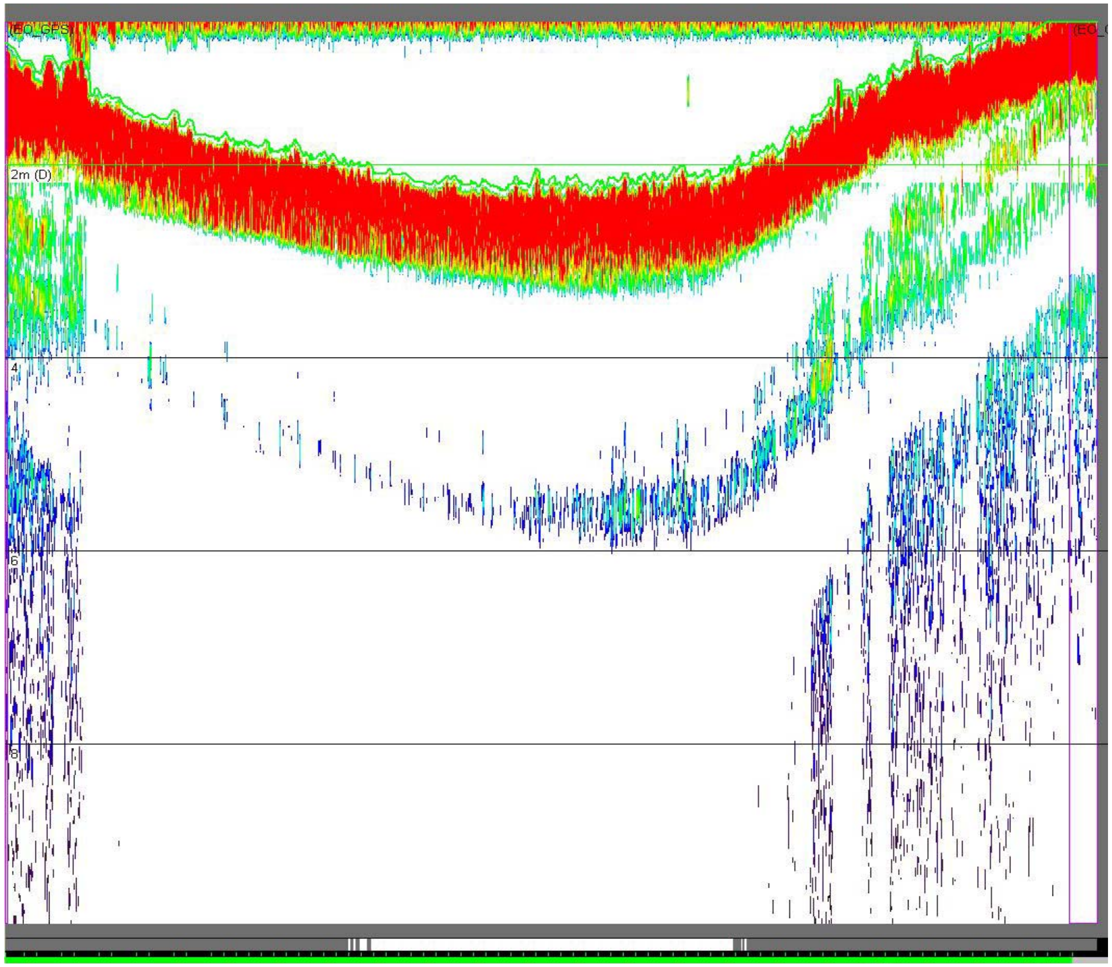

Figure 31. Lower Kluatantan Lake transect 2 echogram

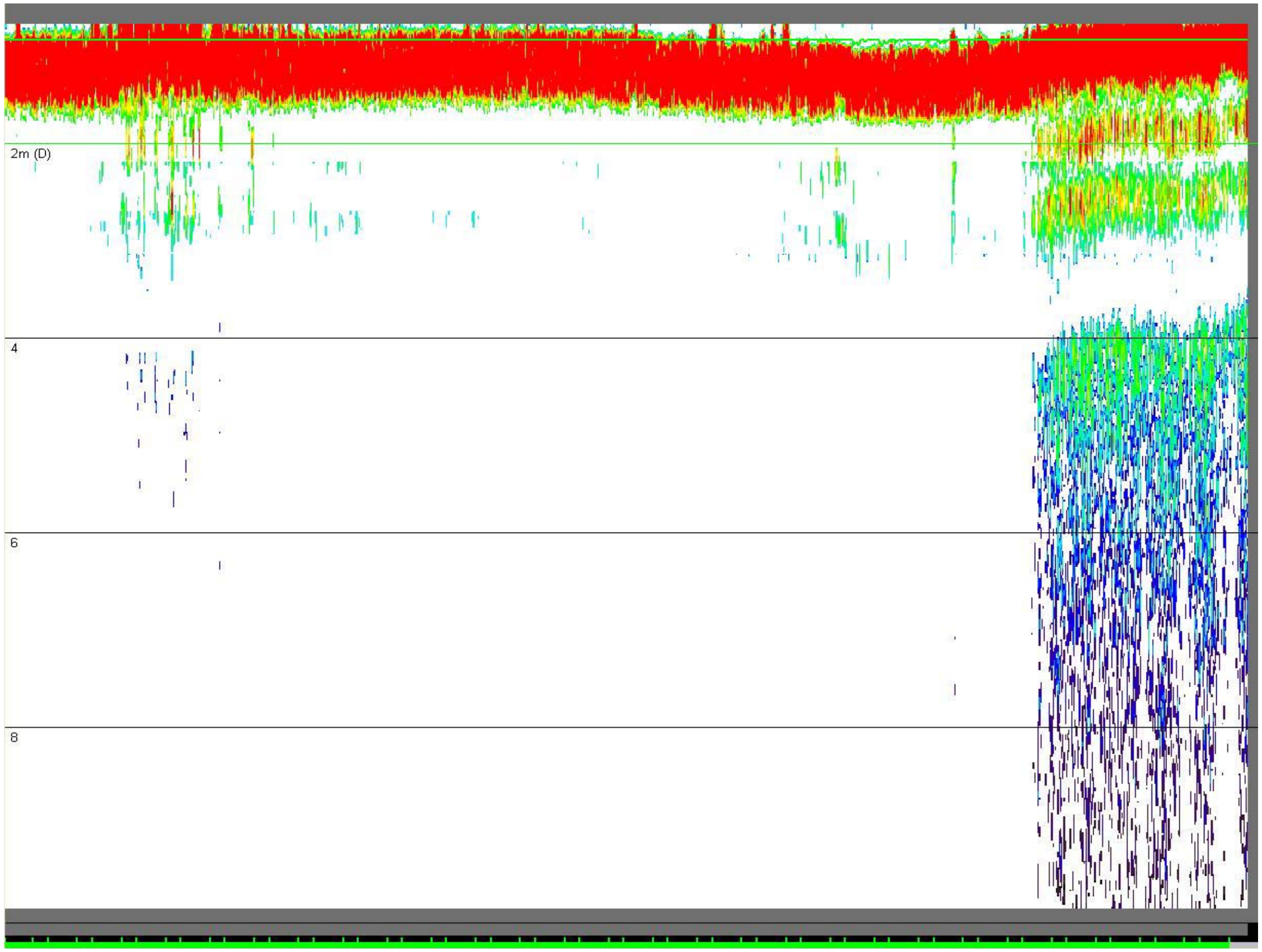

Figure 32. Lower Kluatantan Lake transect 3 echogram

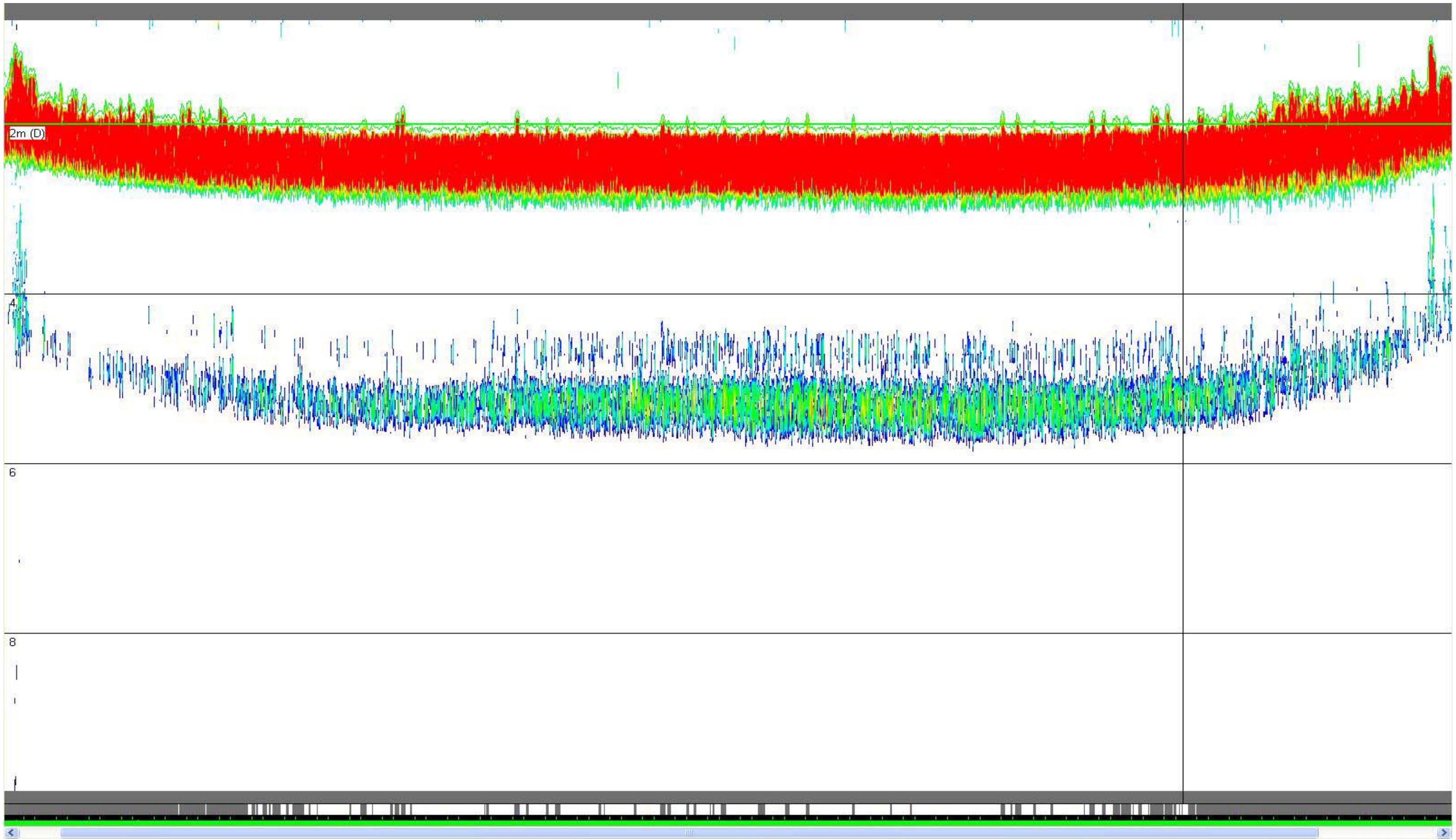

Figure 33. Lower Kluatantan Lake transect 4 echogram

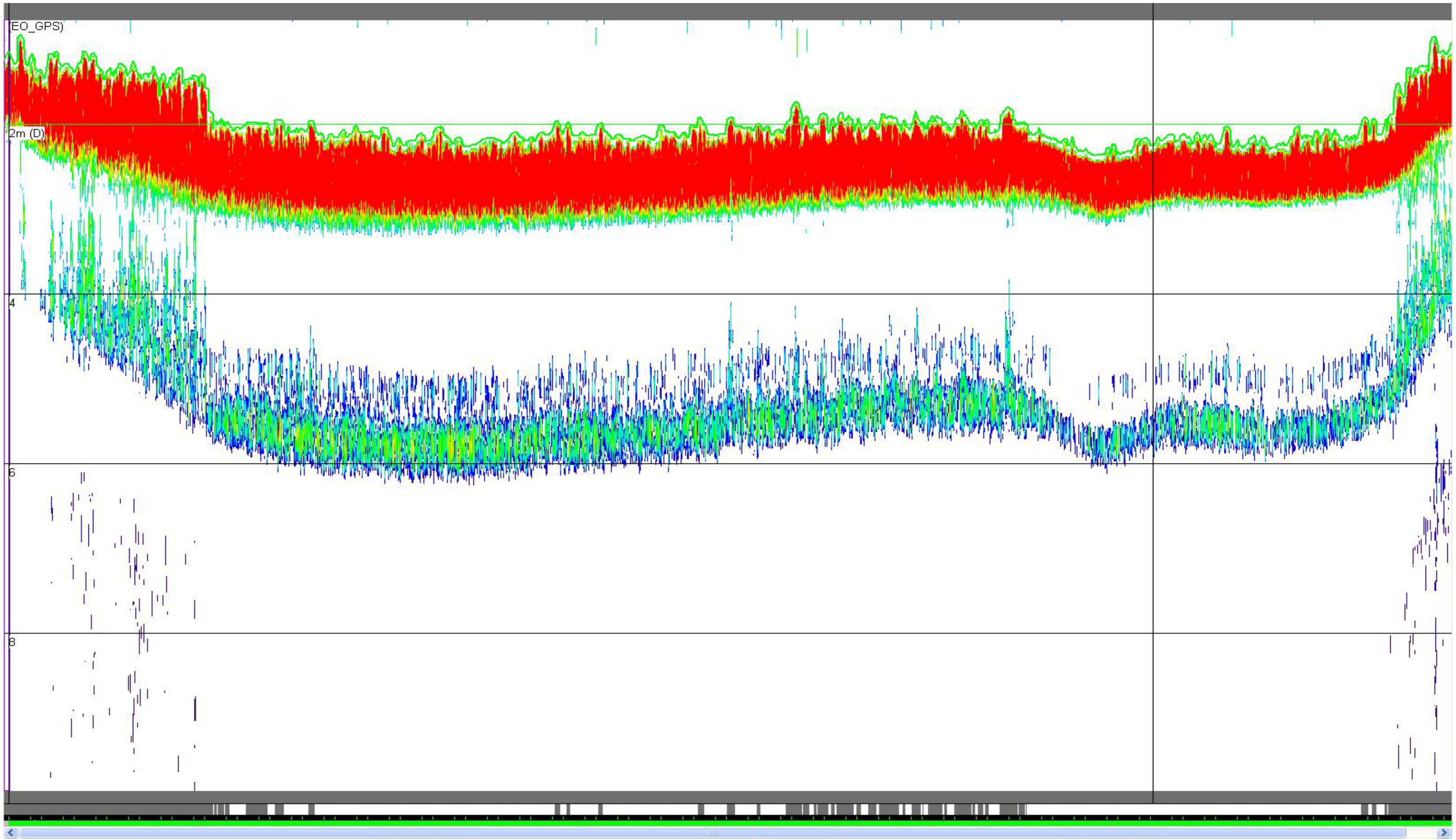

Figure 34. Lower Kluatantan Lake transect 5 echogram

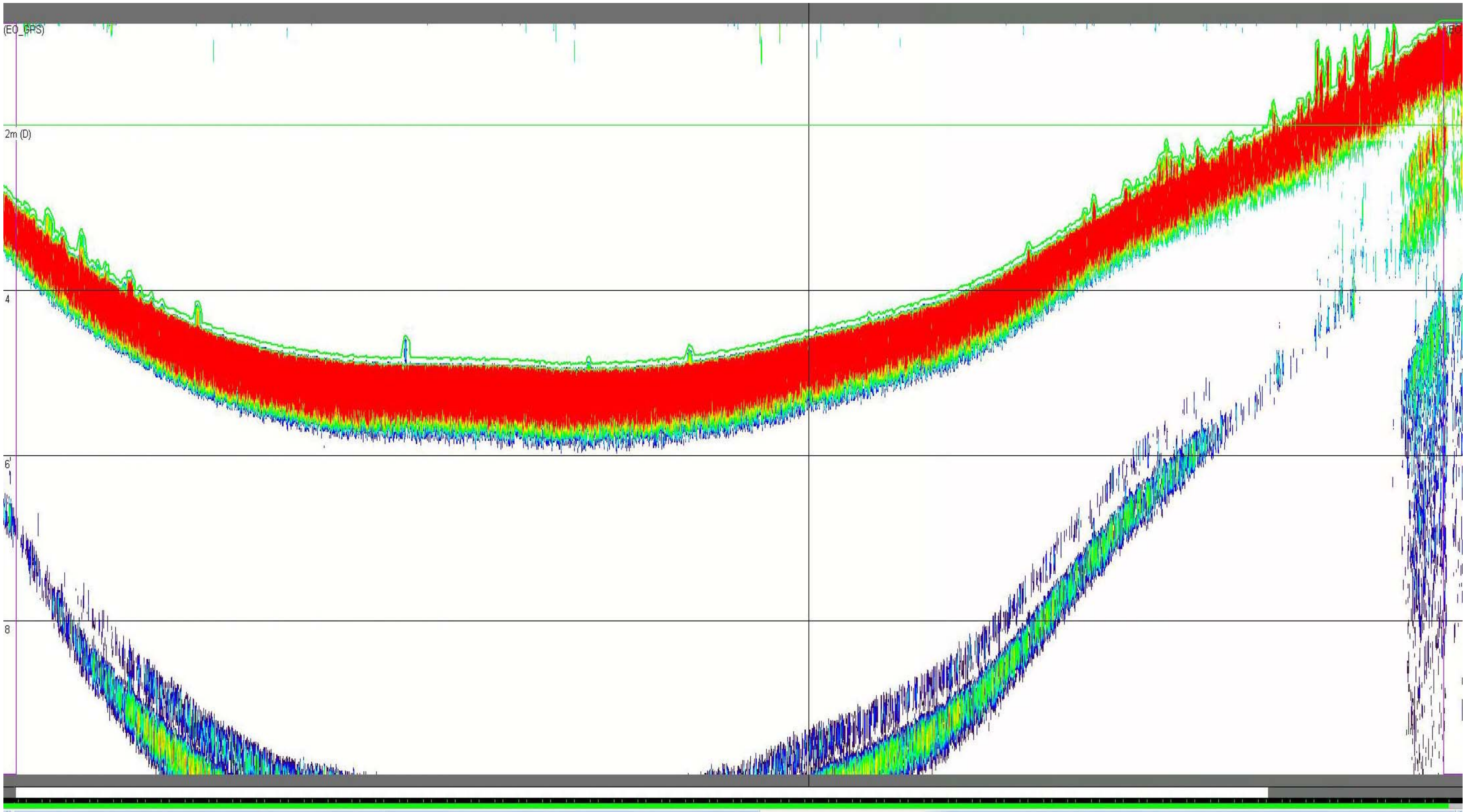

Figure 35. Lower Kluatantan Lake transect 6 echogram

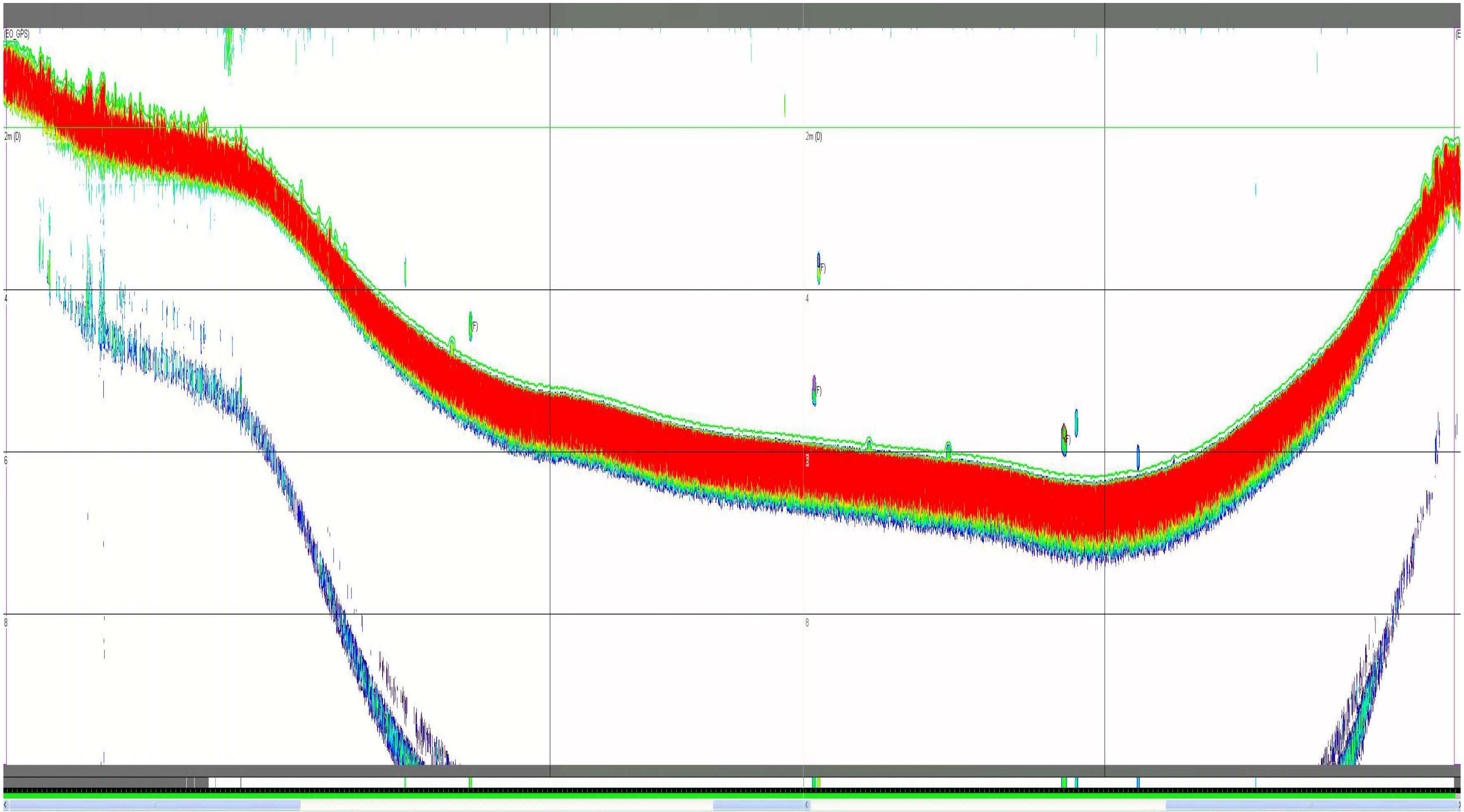

Figure 36. Lower Kluatantan Lake transect 7 echogram

APPENDIX 3: Upper Kluatantan Lake Transect Echograms

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

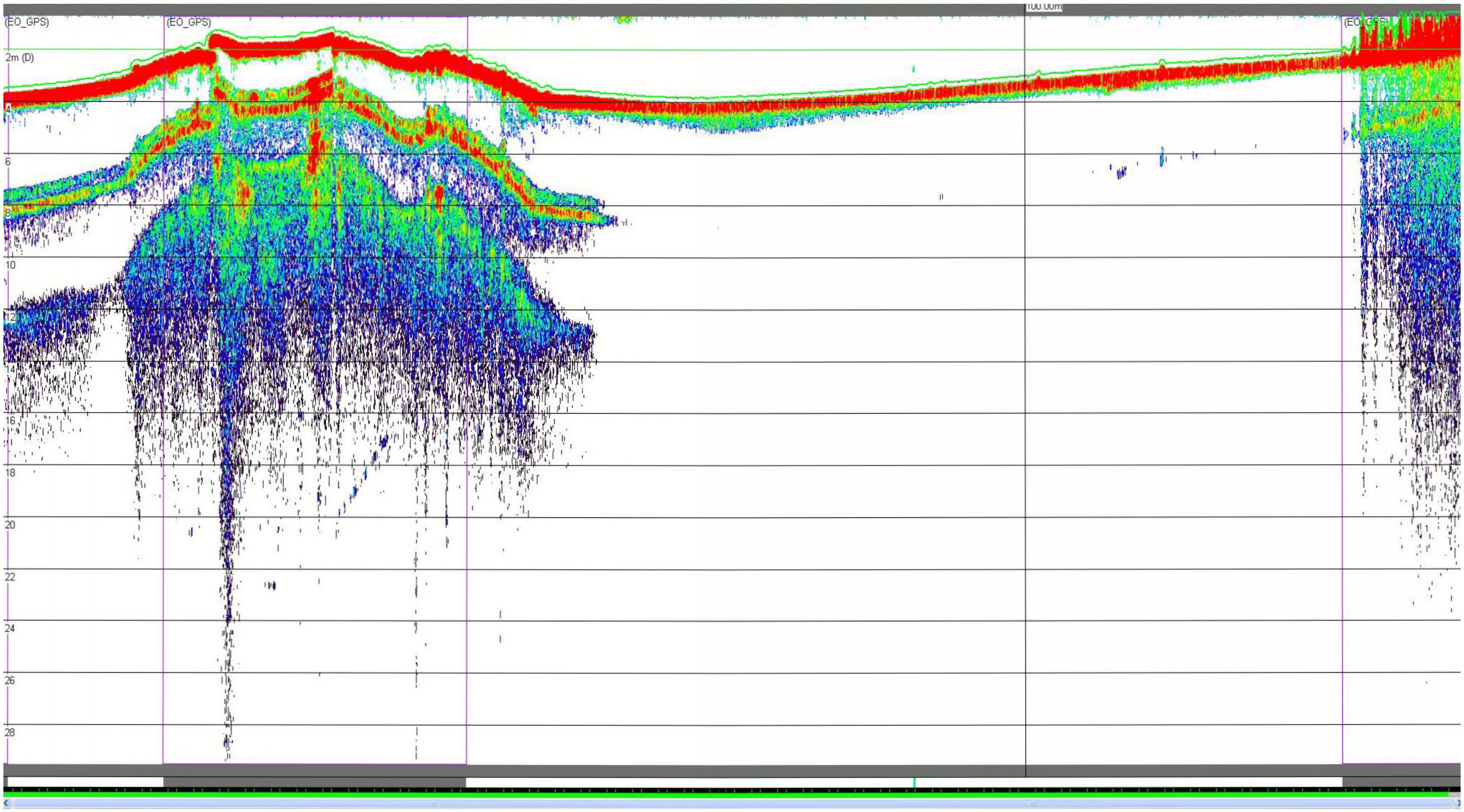

Figure 37. Upper Kluatantan Lake transect 1 echogram

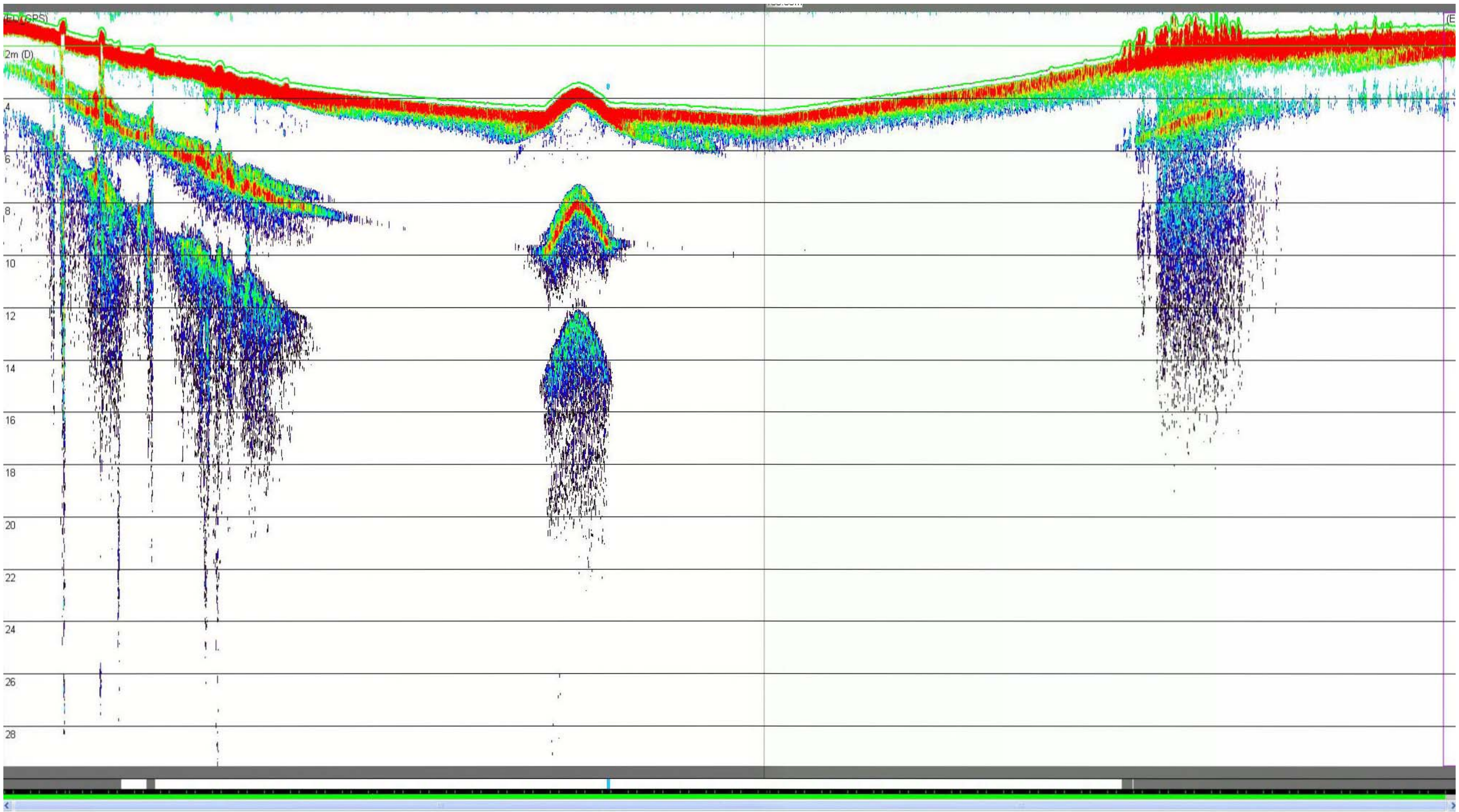

Figure 38. **Upper Kluatantan Lake transect 2 echogram**

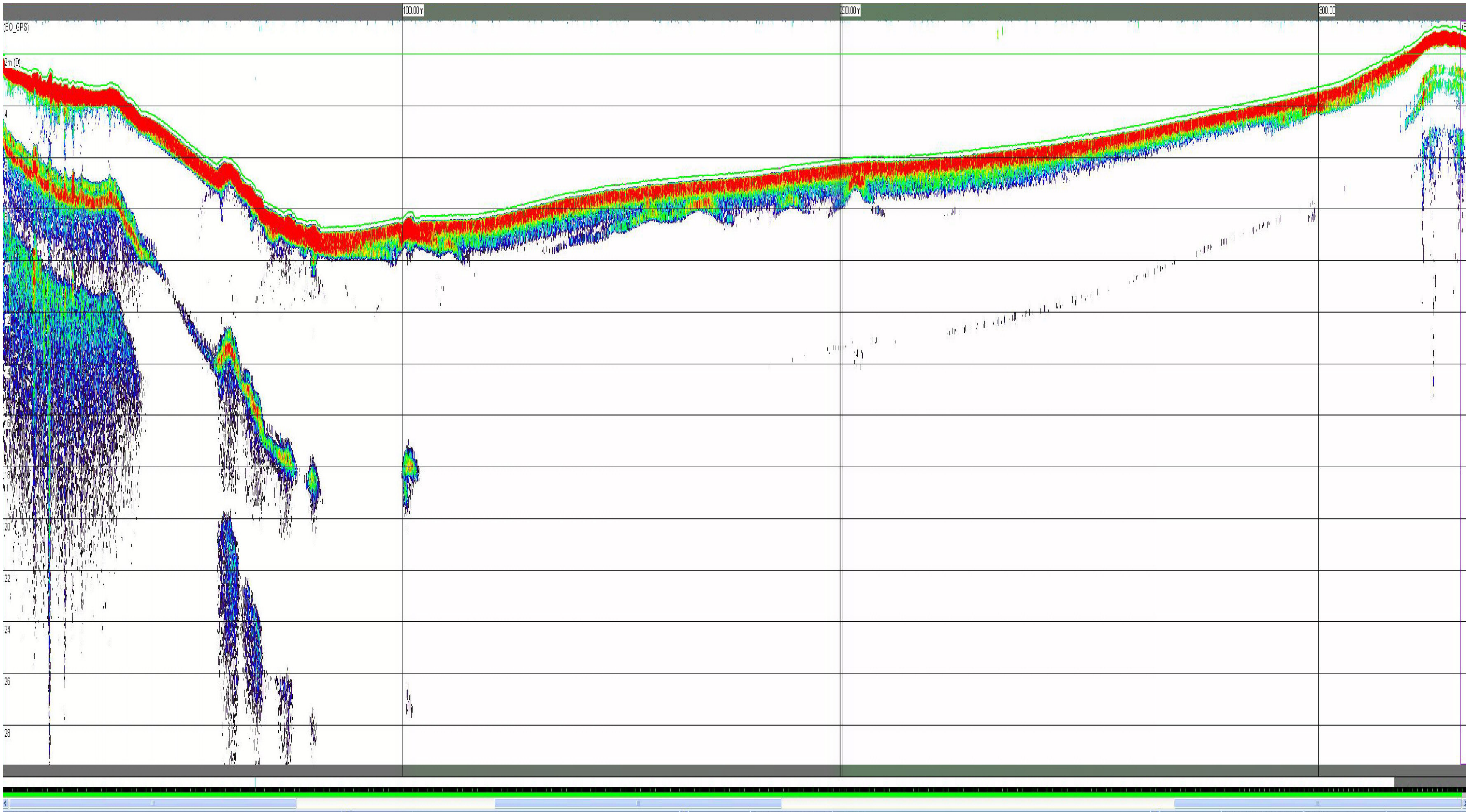

Figure 39. Upper Kluatantan Lake transect 3 echogram

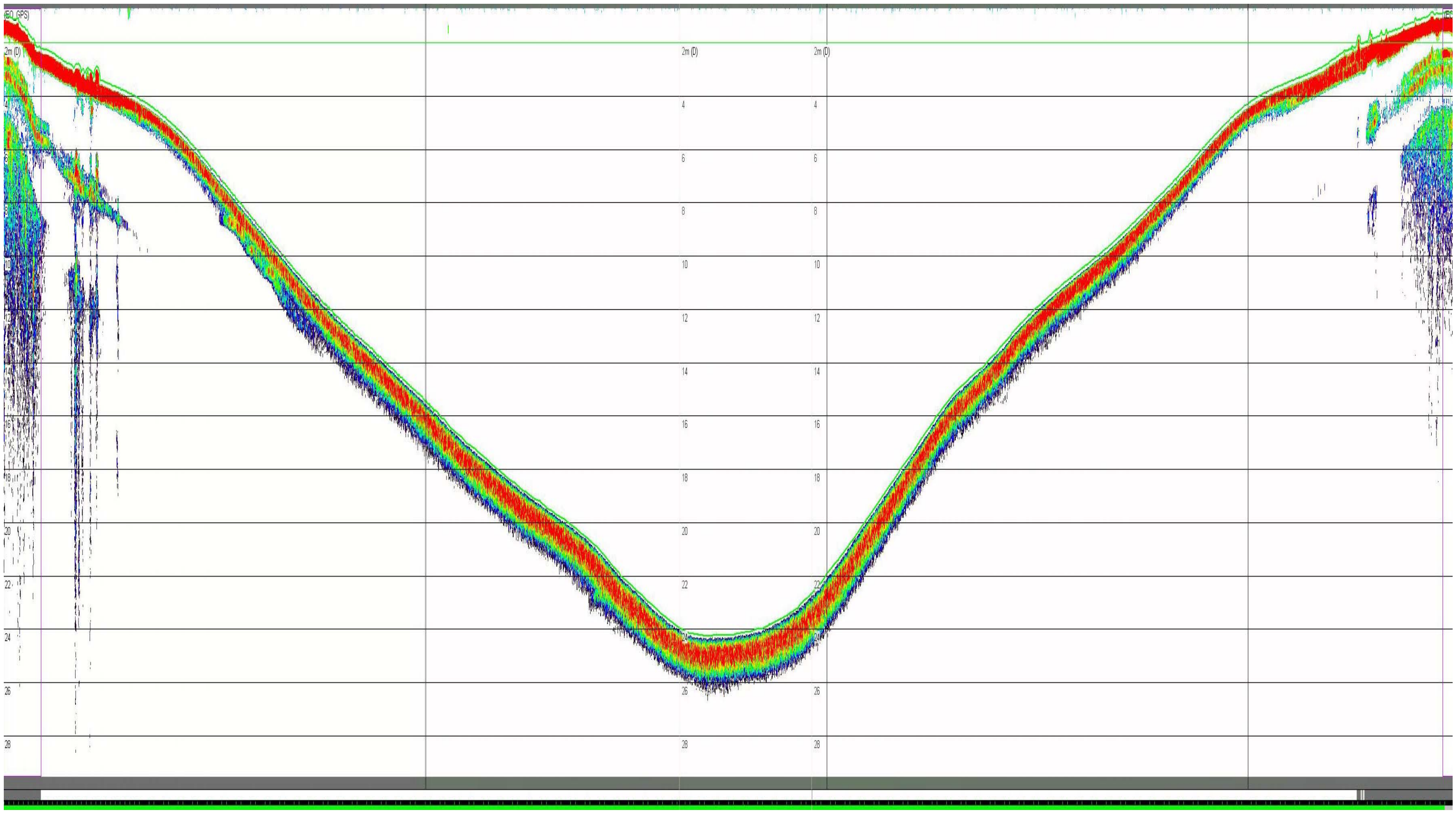

Figure 40. **Upper Kluatantan Lake transect 4 echogram**

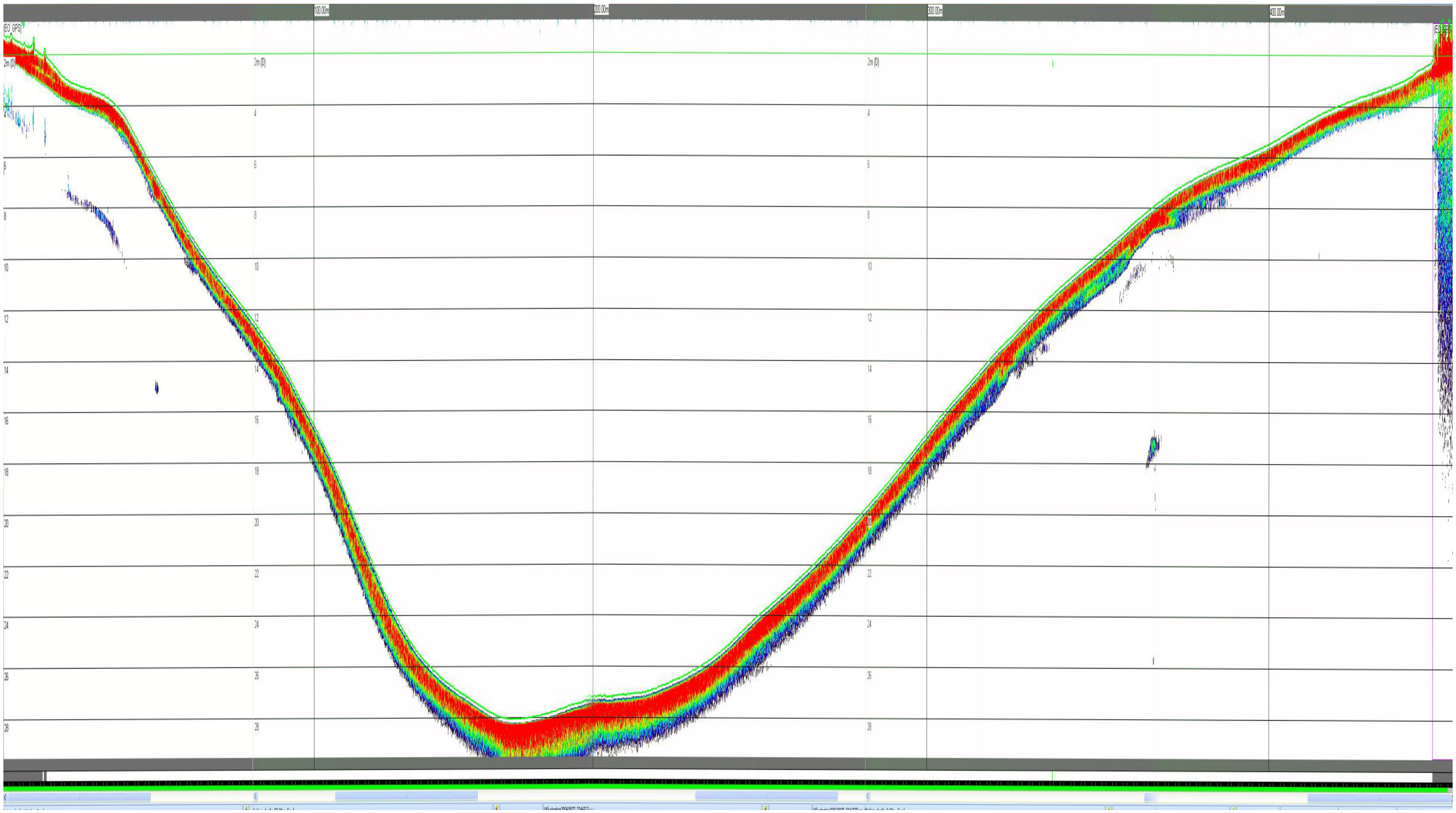

Figure 41. **Upper Kluatantan Lake transect 5 echogram**

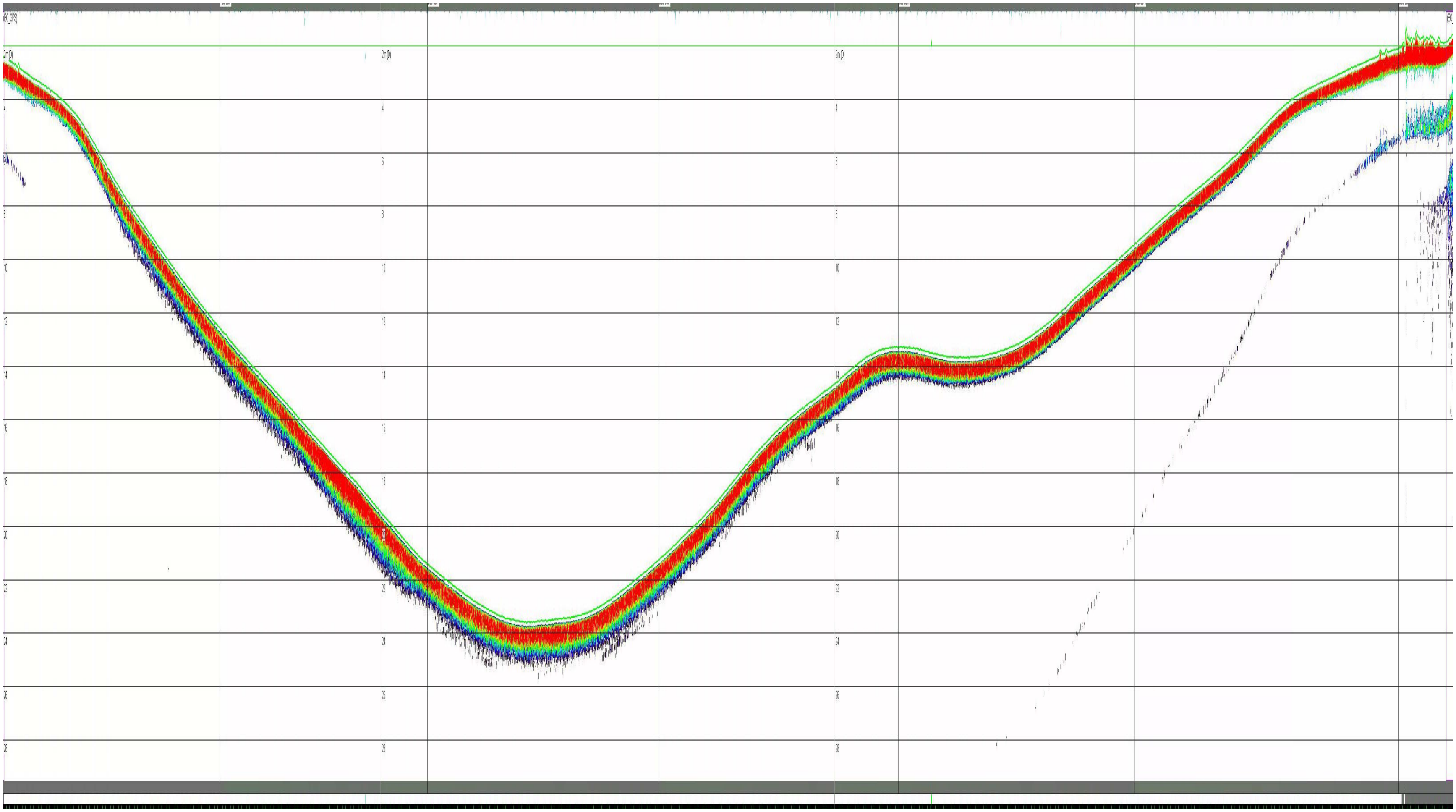

Figure 42. Upper Kluatantan Lake transect 6 echogram

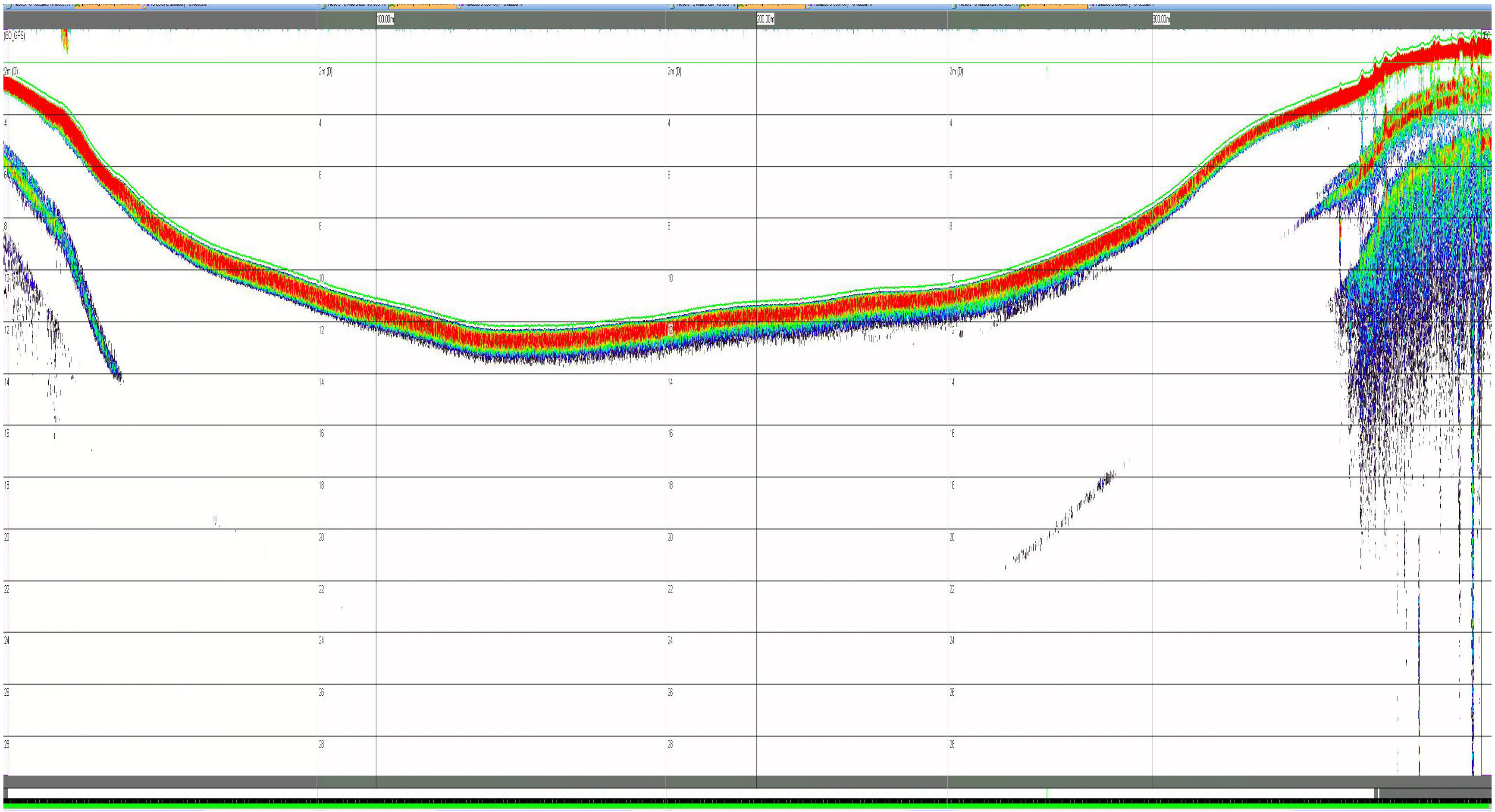

Figure 43. **Upper Kluatantan Lake transect 7 echogram**

APPENDIX 4: Lakelse Lake Transect Echograms

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

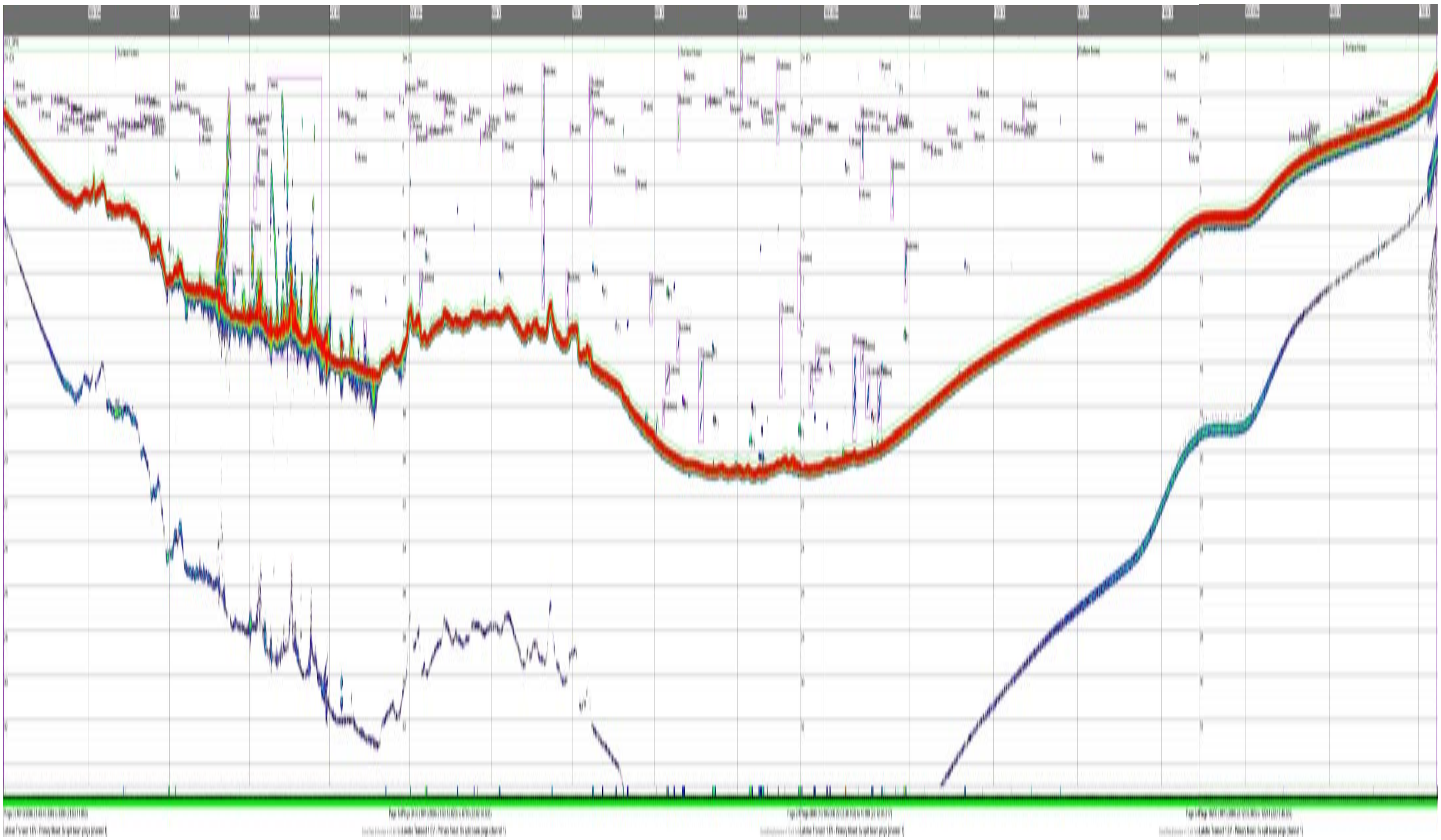

Figure 44. Lakelse Lake transect 1 echogram

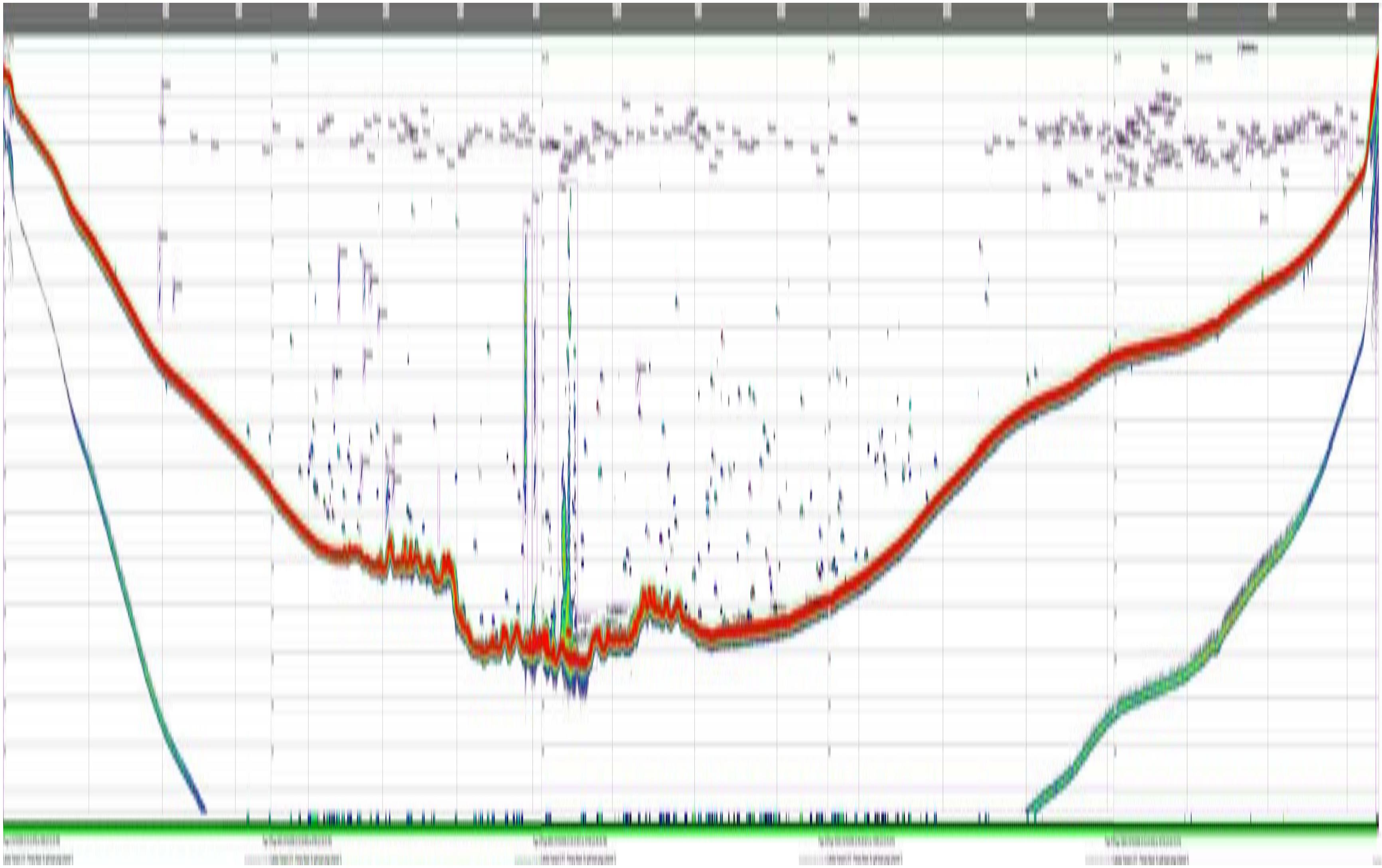

Figure 45. Lakelse Lake transect 2 echogram

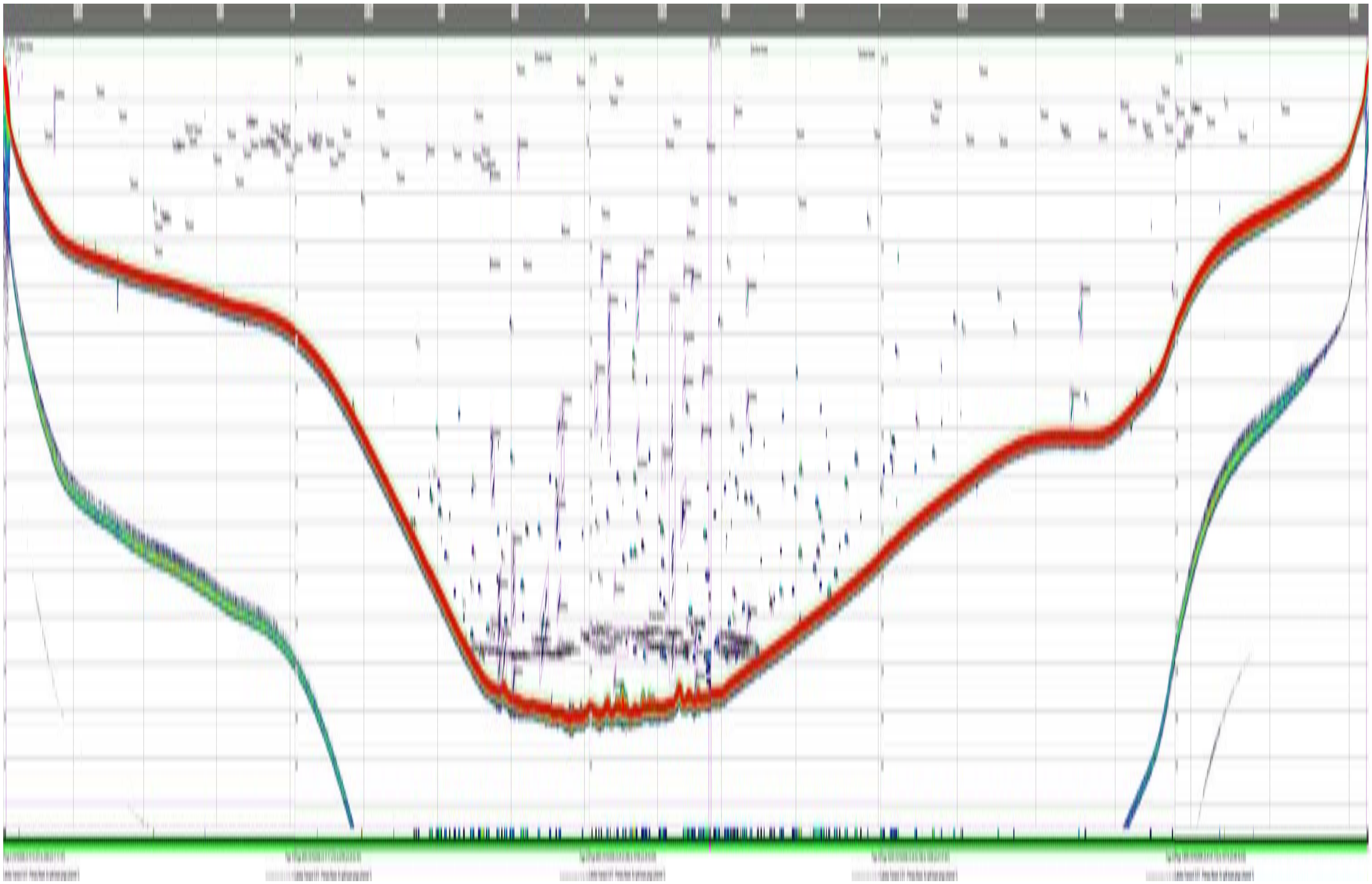

Figure 46. **Lakelse Lake transect 3 echogram**

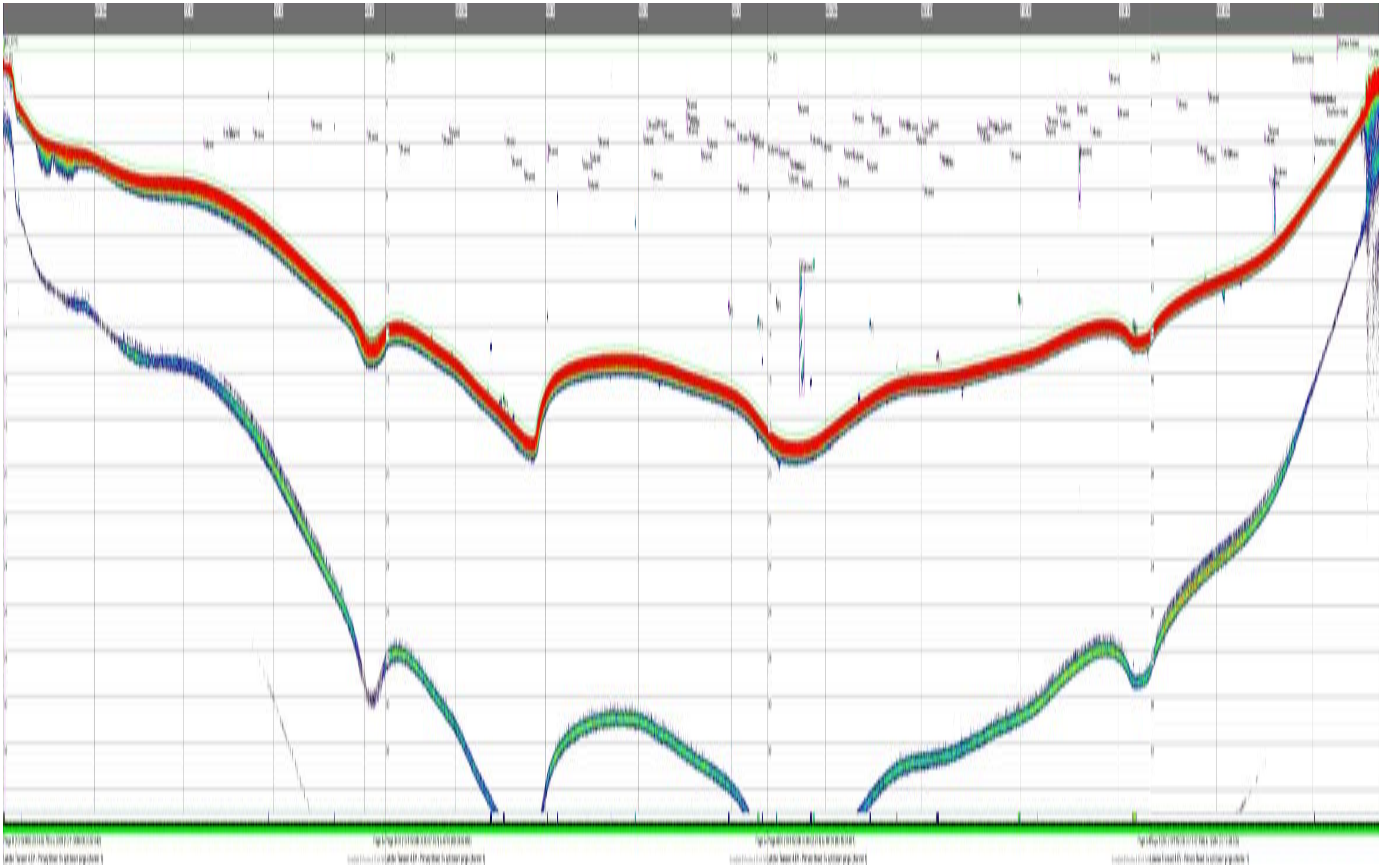

Figure 47. **Lakelse Lake transect 4 echogram**

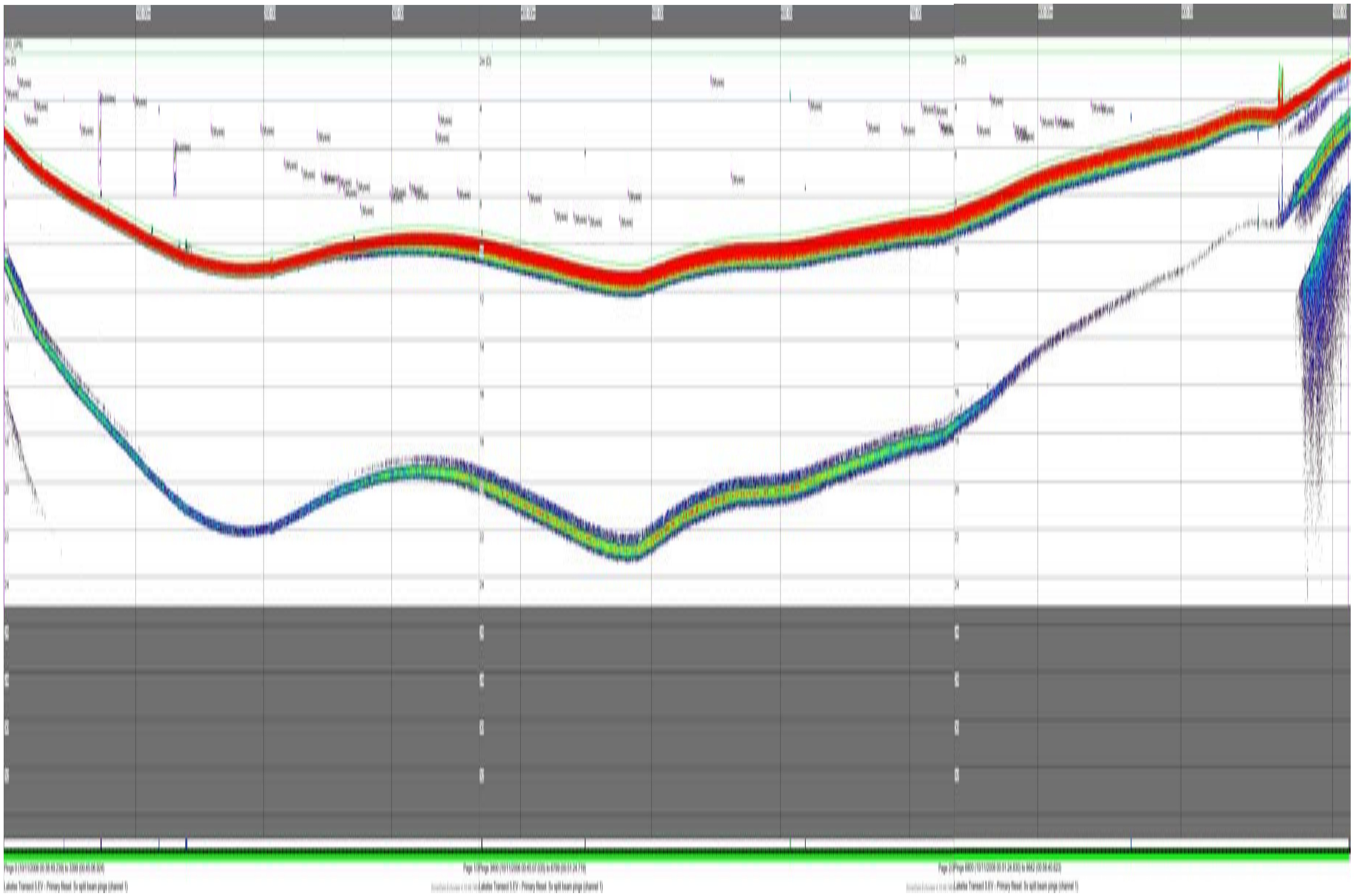

Figure 48. **Lakelse Lake transect 5 echogram**

APPENDIX 5: Kitwanga Lake Fish Catch

Method	#	Species	Lgth. (mm)	Wt. (g)	Comment
Gillnet	2	sockeye	107	14.3	
Gillnet	2	sockeye	107	13.3	
Gillnet	2	sockeye	108	13.9	
Gillnet	2	sockeye	110	14.9	

APPENDIX 6: Lower Kluatantan Lake Fish Catch

Method	#	Species	Lgth. (mm)	Wt. (g)	Comment
Gillnet	1	whitefish	94	9.1	
Gillnet	1	whitefish	95	10.0	
Gillnet	1	coho	137	34.7	
Gillnet	1	coho	122	24.8	
Gillnet	1	coho	112	18.3	
Gillnet	1	coho	87	8.7	
Gillnet	1	sucker	87	9.5	
Gillnet	1	sucker	82	7.2	
Gillnet	2	sucker	87	8.3	
Gillnet	2	coho	103	15.5	

APPENDIX 7: Upper Kluatantan Lake Fish Catch

Method	#	Species	Lgth. (mm)	Wt. (g)	Comment
Gillnet	3	coho	104	17.7	
Gillnet	3	coho	108	19.7	
Gillnet	3	coho			specimen in poor condition
Gillnet	3	coho			specimen in poor condition
Gillnet	4	coho	112	22.1	
Gillnet	4	coho	96	12.0	
Gillnet	4	coho	100	15.8	
Gillnet	4	coho	100	12.2	
Gillnet	4	coho	95		specimen in poor condition
Gillnet	4	coho	125	24.3	
Gillnet	4	coho	120	22.9	
Gillnet	4	coho	124	25.2	
Gillnet	4	coho	107	15.7	
Gillnet	4	whitefish	112	16.6	
Gillnet	4	sucker	76	6.5	
Gillnet	4	sucker	99	13.0	
Gillnet	4	sucker			large sucker escaped

APPENDIX 8: Lakelse Lake Fish Catch

Method	#	Species	Lgth. (mm)	Wt. (g)	Comment
Gillnet	1	peamouth chub	140	30.7	
Gillnet	1	redside shiner	83	6.2	
Gillnet	1	redside shiner	83	6.8	
Gillnet	1	redside shiner			specimen in poor condition
Gillnet	2	n. pikeminnow	136	26.9	
Gillnet	2	redside shiner	118	19.6	
Gillnet	2	redside shiner	103	12.1	
Gillnet	2	redside shiner	86	7.8	
Gillnet	2	redside shiner	89	7.5	
Gillnet	2	redside shiner	88	7.8	
Gillnet	2	redside shiner	86	7.9	
Trawl	1	sockeye	80	6.1	
Trawl	1	sculpin	66		
Trawl	1	sculpin	69		
Trawl	1	sculpin	101		
Trawl	1	sculpin	130		
Trawl	1	sculpin	75		
Trawl	1	sculpin	42		
Trawl	1	sculpin	71		
Trawl	1	sculpin	96		
Trawl	1	sculpin	74		
Trawl	1	sculpin	57		
Trawl	1	sculpin	32		
Trawl	1	sculpin	42		
Trawl	1	sculpin	74		
Trawl	1	sculpin	39		
Trawl	1	sculpin	40		
Trawl	1	sculpin	66		
Trawl	1	sculpin	40		
Trawl	1	sculpin	46		
Trawl	1	sculpin	35		
Trawl	1	sculpin	39		
Trawl	1	sculpin	41		
Trawl	1	sculpin	60		
Trawl	2	sculpin	97		
Trawl	2	sculpin	42		
Trawl	2	sculpin	35		
Trawl	2	sculpin	69		
Trawl	2	sculpin	43		
Trawl	2	sculpin	61		
Trawl	2	sculpin	46		
Trawl	2	sculpin	89		
Trawl	2	sculpin	84		
Trawl	2	sculpin	85		
Trawl	2	sculpin	60		
Trawl	2	sculpin	49		
Trawl	2	sculpin	65		
Trawl	2	sculpin	36		
Trawl	2	sculpin	35		
Trawl	2	sculpin	46		
Trawl	5	sculpin	64		

APPENDIX 9: Hydroacoustic Data By Transect

Table 11. 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	6.61 x10^4	n/a	n/a	262
2	209	n/a	n/a	4.02 x10^4	n/a	n/a	192
3	137	n/a	n/a	2.29 x10^4	n/a	n/a	167
4	45	n/a	n/a	1.73 x10^3	n/a	n/a	38
5	76	n/a	n/a	2.43 x10^4	n/a	n/a	320
6	60	n/a	n/a	1.92 x10^4	n/a	n/a	320
Total	779	n/a	n/a	1.74 x10^5	n/a		

NTG = Integration ST = Single Target TT = Tracked Target

Table 12. 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	252	n/a	n/a	1.17 x10^4	n/a	n/a	46
2	209	n/a	n/a	1.07 x10^4	n/a	n/a	51
3	137	n/a	n/a	5.95 x10^3	n/a	n/a	43
4	45	n/a	n/a	6.91 x10^2	n/a	n/a	15
5	76	n/a	n/a	9.54 x10^3	n/a	n/a	126
6	60	n/a	n/a	7.79 x10^3	n/a	n/a	130
Total	779	n/a	n/a	4.64 x10^4	n/a		

NTG = Integration ST = Single Target TT = Tracked Target

Table 13. Lower Kluatantan 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	4.1	0	0	0	0	0	0
2	2.4	0	0	0	0	0	0
3	1.8	0	0	0	0	0	0
4	2.9	0	0	0	0	0	0
5	2.6	0	0	0	0	0	0
6	3.4	0	0	0	0	0	0
7	8.9	1.23 x10^3	1.18 x10^3	1.49 x10^3	138	133	168
Total	26.0	1.23 x10^3	1.18 x10^3	1.49 x10^3	n/a		

NTG = Integration ST = Single Target TT = Tracked Target

Table 14. 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
1	209	1.73×10^4	1.21×10^4	1.54×10^4	83	58	74
2	92	1.51×10^4	1.41×10^4	2.06×10^4	165	154	225
3	119	5.44×10^4	1.42×10^4	2.22×10^4	458	119	186
4	136	2.39×10^4	3.19×10^3	3.68×10^3	176	23	27
5	105	6.27×10^3	8.96×10^2	1.30×10^3	60	9	12
6	180	n/a	n/a	n/a	n/a	n/a	n/a
7	521	n/a	n/a	n/a	n/a	n/a	n/a
Total	1,360	1.17×10^5	4.45×10^4	6.32×10^4	n/a		

NTG = Integration ST = Single Target TT = Tracked Target

Table 15. 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
1	209	5.84×10^3	4.36×10^3	6.04×10^3	28	21	29
2	92	3.77×10^3	3.40×10^3	5.33×10^3	41	37	58
3	119	3.72×10^4	5.18×10^3	8.57×10^3	313	44	72
4	136	7.68×10^3	8.39×10^2	8.89×10^2	56	6	7
5	105	0	0	0	0	0	0
6	180	n/a	n/a	n/a	n/a	n/a	n/a
7	521	n/a	n/a	n/a	n/a	n/a	n/a
Total	1,360	5.45×10^4	1.38×10^4	2.08×10^4	n/a		

NTG = Integration ST = Single Target TT = Tracked Target