2009 Skeena Sockeye Lakes Hydroacoustic Surveys

Prepared for the Skeena Watershed Initiative by:
Charmaine Carr-Harris
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Skeena Fisheries Commission
P.O. Box 166
Hazelton, BC V0J 1Y0

EXECUTIVE SUMMARY

Skeena Fisheries Commission (SFC) conducted hydroacoustic surveys at five sockeye rearing lakes in the Skeena Watershed. Shallow and glacial turbid lakes were selected in order to determine whether a horizontally oriented transducer in conjuction with conventional down-looking hydroacoustic methodolgy would effectively sample the top layers of lakes where fish are thought to be surface oriented. Surveys were conducted at Atna, Azuklotz, Kalum, Motase, and Slamgeesh Lakes. The horizontal transducer proved to be most effective at Atna, Azuklotz and Motase lakes. Overall fish density ranged from 49 fish/hectare at Atna Lake to 1,041 fish/hectare at Azuklotz lake.

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INTRODUCTION

Skeena Fisheries Commission (SFC) has conducted mobile hydroacoustic surveys in small lakes throughout the Skeena Watershed since 2005. The main objectives of these surveys is to enumerate and sample the sockeye fry populations, and to estimate the species composition at each lake. Data of fall fry abundance obtained by hydroacoustic techniques for sockeye in their critical rearing habitat can be directly compared to lake productivity potential (Shortreed *et al.* 2001) so as to provide an unbiased estimate of the status of the sampled conservation unit. This technique is recommended in the recent publication of Holt *et al.* 2009 for determining status and benchmarks for sockeye conservation units.

Between 2005 and 2008 our population estimates were produced using only down-looking hydroacoustic gear . A limitation to vertically oriented gear is that the top 2m of of the water column are excluded from population estimates and all acoustic data to 4m are questionable because of the small sample volume at the top of the conical acoustic beam. While this has not affected previous surveys of clear, deep lakes where the target species are usually found at greater depths, it is problematic in shallow and glacially turbid lakes, where a higher proportion of juvenile salmonids may occupy the upper layers of the water column. Of 29 known sockeye rearing lakes in the Skeena watershed, about one third are shallow or glacially turbid.

In 2009 with the help of a grant from the Skeena Watershed Initiative, the SFC hydroacoustic program was expanded to include five shallow and turbid lakes in the Skeena watershed (Figure 1). Hydroacoustic surveys were conducted at lakes, most of which with the exception of Kalum Lake, had previously been considered unsuitable for conventional hydroacoustic methodology. In order to effectively survey the top 4m of the water column, we acquired a second transducer, which was positioned horizontally at a 90º angle to the vertically oriented transducer.

Atna Lake is a glacially turbid lake located upstream and south of Morice Lake, which drains into the Morice River, a major tributary of the Bulkley River. Morice sockeye are a serious ongoing conservation concern as stocks have been in decline since the 1990s. Atna Lake has a surface area of 416 hectares, average depth of 36 m, and maximum depth of 67 m. This was the first hydroacoustic survey of Atna Lake, which is located in the traditional territory of the Wet’suwet’en First Nation.

Azuklotz Lake is a clear, shallow lake located in the Northeast section of the Skeena watershed adjacent to Bear Lake, which drains into the Bear River then the Sustut River, a tributary of the upper Skeena River. Azuklotz Lake has a surface area of 166 hectares, a maximum depth of 9.5 m and an average depth of 4 m. Azuklotz lake is located within the traditional territories of the Gitxan First Nation and was last surveyed by Fisheries and Oceans’ Cultus Lake Laboratory in 2003.

Kalum Lake is a glacially turbid lake located in the middle reaches of the Kalum River, a 5th order tributary of the lower Skeena river that drains an area of 2,255 km^2. Kalum lake covers a surface area of approximately 1,850 hectares, with an average depth of 75 m and a maximum depth of over 140 m. SFC conducted the last hydroacoustic survey at Kalum Lake in 2007. Kalum Lake is located within the traditional territories of the Kitsumkalum First Nation.

Motase Lake is a glacially turbid lake at the headwaters of the Squingula River, which is a tributary of the upper Skeena. The Cultus Lake laboratory conducted the last survey at Motase Lake in 2003. Motase Lake covers a surface area of 409 hectares with an average depth of 13 m and a maximum depth of 32 m, and is located within the traditional territories of the Gitxsan First Nation.

Slamgeesh Lake is a clear, shallow lake which drains into the Slamgeesh River, a tributary of the upper Skeena river. Gitksan Watershed Authorities have operated a counting weir and full index site at Slamgeesh Lake since 2000. Slamgeesh Lake covers a surface area of 48 hectares, with an average depth of only 3.8 m and a maximum depth of 7.5 m.

METHODS

Hydroacoustic Survey

Our 2009 Azuklotz and Kalum Lake surveys were conducted along previously established transects at both lakes (Figures 3 and 5). New transect designs for Atna, Motase and Slamgeesh Lake (Figures 2, 4, 6) were established for our 2009 surveys. Our surveys consisted of five transects at Azuklotz and Slamgeesh Lakes, seven at Kalum Lake, and eight at Motase and Atna Lakes.

Transects were sampled using a Biosonics DT-X echosounder with a 200 kHz split-beam transducer producing a 6º beam. The downward-pointing transducer was pole-mounted to our inflatable vessel, a Bombard Commando C-4. A second transducer with the same specifications was positioned sideways, at a 6º angle below the horizontal plane. Hydroacoustic data from both transducers were collected to an acoustic threshold of -100 dB using Biosonics Visual Acquisition software as the vessel proceeded along transects at a constant speed. Acoustic data were collected to a maximum depth threshold of 80 m. This depth threshold was greater than the maximum depth of all lakes except for Kalum.

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

Acoustic estimates of the fish populations are based on the volumes of each lake. BC Ministry of Environment (MOE) bathymetric maps were used to calculate volumes for each depth layer and representative transects for Kalum and Azuklotz lakes. Volume calculations for Motase lake was based on geo-referenced bathymetry data collected during our hydroacoustic surveys combined with data from MOE bathymetric maps. The volume calculations for Atna lake were based on bathymetric data collected with our DT-X system at the time of our survey (Figure 7).

Post-processing of hydroacoustic data was performed using Echoview v. 4.80. Target densities were calculated using three different methods for down-looking acoustic data. The integration method divides the average acoustic energy for each depth layer by the average target strength. The single target method divides the sum of only those targets that have specific acoustic characteristics of single fish by the sampled beam volume. The tracked target estimate is produced by grouping single targets into individual fish tracks, then dividing the total number of fish tracks by the sampled wedge volume. Depending on the conditions at each lake, not all estimate methods are available for each survey. Side-looking acoustic data were analyzed using the Tracked target method. Data from the vertically oriented transducer were analyzed in separate 2 m depth layers for each transect. Data from the horizontally oriented transducer were analyzed in a single 18 m wide layer, the range that represented the top 4 m of the water column. The results from the surface and deeper layers were summed to produce an estimate for each transect.

The target densities calculated for each transect layer are multiplied by the layer volume of the lake area represented by that transect to produce a transect layer population estimate. Transect estimates are produced from the sum of layer population estimates. Transect densities are averaged and multiplied by the whole surface area of the lake to produce the total fish estimate for the entire lake or lake section.

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

The fish estimates were divided into “small” fish and “large” fish based on the distribution of target strengths from each transect and each layer. "Small" fish were classified as fish with target strengths between –64 and –46 dB. This target strength is approximately equivalent to salmoniform fish <135 mm, based on Love’s (1977) 45º aspect formula. Small fish were apportioned into “O. nerka” and “other small fish” based on the relative proportion of species in the trawl catch. Kokanee, the resident freshwater form of sockeye are not separable from sockeye at the fry stage without detailed chemical analysis of the otolith cation zonation. We therefore use the field category “O.nerka” for the combined fry of kokanee and sockeye. We assume that all or most of the O. nerka are actually sockeye fry.

Fish Collection

We used different fish capture methods to collect fish samples from near the surface and from deeper layers. Swedish gillnets were used to capture fish between 0-6 m depth at Atna, Azuklotz, Motase, and Slamgeesh lakes. These gillnets consisted of 4 variable mesh sizes between ½” and 1”. The gillnets were set at dusk and allowed to soak for the duration of the survey. We used a 2 x 2 m midwater trawl to sample fish below 2m depth at Atna, Kalum, Motase, and Slamgeesh Lakes. The trawl net was towed behind the boat at a constant speed of approximately 1m/s, and retrieved with a winch. The depth of each tow varied according to the length of the line that was deployed which was calibrated and marked prior to sampling. Generally gillnets proved more effective at sampling shallow lakes such as Azuklotz and Slamgeesh. Trawl sampling was most effective in larger, deeper lakes.

Large fish were counted and released. Small fish were sorted by species and stored in 10% formaldehyde, and weighed and measured after at least 30 days of preservation. Scales were removed and inspected under a compound microscope to determine the age of salmonid fishes.

Temperature and Dissolved Oxygen

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

RESULTS

Atna Lake

Atna Lake was surveyed on September 8-10, 2009. We observed low densities of fish targets and captured few specimens but observed adult spawners in an adjacent creek. Temperature and dissolved oxygen data for all lakes are provided in Figures 8 through 17.

We captured only three juvenile O. nerka during seven trawls with a combined length of 8.7 km We also captured one O. nerka, one coho (*Oncorrhynchus kisutch*), and three large bull trout (*Salvelinus confluentus*) in four gillnets with a combined soak time of 80 hours. Sample data for all lakes are recorded in Table 1. All sockeye were age-0, or young of the year, and the coho was age -1.

We collected bathymetric data from Atna Lake with our DT-X system at the time of our survey. These data were used to produce a bathymetric map for lake volume calculations (Figure 7). Our 2009 fall fry hydroacoustic population estimate for Atna Lake (tracked target method) was 20,208 “small” size fish (Table 2) with a density of 49 fish/hectare. No large fish were observed on our transects, and our sample was not sufficient to apportion the Atna Lake hydroacoustic estimate by species.

Azuklotz Lake

Azuklotz Lake was surveyed on 24 September 2009. Adult sockeye were observed in the lake at the time of the survey. We captured 12 O. nerka fry, 56 redside shiners (*Richardsonious balteatus*), and one large adult sockeye (*Onchorrynchus nerka*) in two gillnets with a combined soak time of 24 hours. All O. nerka juveniles were age-0, or young of the year, with an average length of 68 mm and an average weight of 3.3 grams (Table 1).

Our 2009 hydroacoustic estimate for Azuklotz Lake (tracked target method) was 172,568 “small” size and 7,737 “large” size fish. The overall fish density was 1,041 fish/hectare (Table 2). Juvenile O. nerka comprised 18% of the “small” size population estimate.

Kalum Lake

Kalum lake was surveyed on 1 September 2009. High winds prevented use of the horizontal transducer, so only down-looking acoustic data were available for this survey. Much of Kalum Lake is deeper than the maximum depth threshold of 80 m, which appears to have been deeper than the bottom of the fish layer during our survey.

We captured 8 O. nerka fry and 1 juvenile coho in 5 trawls over a combined distance of 12.6 km. All O. nerka were age-0, with an average length of 54 mm and an average weight of 1.7 grams (Table 1).

Our 2009 Kalum Lake hydroacoustic estimate was 584,842 “small” size and 16,719 “large” size fish. The overall fish density was 325 fish/hectare. Our trawl sample was not sufficient to apportion the Kalum Lake hydroacoustic estimate by species, but it is likely that most of the “small” size fish were sockeye.

Motase Lake

Motase Lake was surveyed on 23 September 2009. We captured 4 O. nerka fry and 2 juvenile Chinook (*Oncorrhynchus tschawytscha*) in five gillnets with a combined soak time of 60 hours, and 3 O. nerka fry and 2 prickly sculpin (*Cottus asper*) in three trawls with a combined distance of 3.2 km. The gillnet captured O. nerka were slightly larger than then trawl-captured O. nerka (Table 1). All O. nerka and one Chinook were age-0, and the remaining Chinook was age-1.

Our 2009 Motase Lake hydroacoustic estimate was 37,893 “small” size fish, with a density of 93 fish/hectare. We observed no “large” size fish in our hydroacoustic sample. Our trawl sample was not sufficient to apportion the Motase lake hydroacoustic estimate by species.

Slamgeesh Lake

Slamgeesh Lake was surveyed on 15 September 2009. We captured 2 juvenile O. nerka, 4 coho, 3 prickly sculpin, and 2 mountain whitefish in 3 trawls with a combined distance of 1.2 km. We captured 49 coho, 1 cutthroat trout (*Oncorrhynchus clarki clarki*), 61 O. nerka fry, and 4 large bull trout in 6 gillnets with a combined soak time of 72 hours. The rainbow trout, 6 coho, and one sockeye were age-1. The remaining O. nerka and coho were age-0.

The Slamgeesh lake hydroacoustic survey was compromised by a high density of larval midge (Chironomids) throughout the water column, which produced too much noise in the acoustic data (Figures 20, 21) for effective analysis. A hydroacoustic population estimate is therefore not available for this survey.

DISCUSSION

The low fish densities observed during most of our 2009 hydroacoustic surveys were the biggest challenge for building population estimates for these lakes, where it was difficult to obtain adequate trawl or gillnet samples because of low fish catchability. We captured O. nerka fry in all of the lakes sampled in 2009 but were unable to obtain an adequate fish sample to apportion the "small" size hydroacoustic estimates by species at Atna, Kalum and Motase lakes.

The horizontal transducer was sucessful in that it enabled more comprehensive hydroacoustic sampling in shallow and turbid lakes. The potential negative effects of boat avoidance are eliminated by using data from greater range in either direction. On the other hand, the use of horizontally oriented gear introduced increased sensitivity to adverse weather conditions. High winds and heavy rain can cause a significant amount of noise in the acoustic data that may compromise data analysis. Down-looking hydroacoustic surveys have the advantage of capturing most targets in uniform dorsal aspect, and there is an established relationship between fish size and target strength (TS) (Love 1977) that is more variable with side-looking data, which may capture fish targets at any angle. Where available, data collected from the side-looking transducer is of value because the sample volume at 0-4 m depth is always greater than that collected from a vertically oriented transducer. Simultaneous ensonification of both upper and deeper layers is an effective means of establishing the presence and number of fish targets in the top layers of the water column.

With the exception of Atna Lake, past hydroacoustic surveys were conducted at all of the lakes surveyed by the SFC in 2009. The 2009 results agreed closely with results from the 2003 survey at Azuklotz Lake (Shortreed and Hume 2004) and from the 2007 survey at Kalum Lake (Hall and Carr-Harris 2008). The 2009 Motase Lake estimate is nearly double the estimate from the 2003 survey, reported by Shortreed and Hume (2004) who observed that the fish appeared to be surface oriented (Shortreed and Hume 2004). Overall fish densities ranged from 49 fish per hectare at Atna Lake to 1,041 fish per hectare at Azuklotz Lake. The low fish densities observed at Atna Lake may suggest that this lake is of conservation concern. Additional surveying of this lake is appropriate, especially if this lake were to be considered a separate conservation unit as proposed by the Canadian Science Advisory Secretariat (2009).

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Table 1. Fish sample data, 2009 hydroacoustic surveys (all lakes). Lengths are in mm, weights in grams.

Lake	Gear	Species	n	Average length	Max. length	Min. length	Std. Dev. Length	Average weight	Max. weight	Min. weight	Std. Dev. Weight
Atna	Gillnet	Coho	1	105				12.0			
Atna	Gillnet	O. nerka	1	74				5.0			
Atna	Trawl	O. nerka	3	56	63	49	7	1.9	2.6	1.1	0.8
Azuklotz	Gillnet	Redside shiner	56	68	75	59	6	3.3	4.2	2.1	0.9
Azuklotz	Gillnet	O. nerka	12	85	105	59	11	8.2	13.7	2.9	2.6
Kalum	Trawl	Coho	1	77				3.3			
Kalum	Trawl	O. nerka	8	54	61	42	6	1.7	2.5	0.9	0.6
Motase	Gillnet	Coho	2	92	100	84	11	9.4	12	6.8	3.7
Motase	Gillnet	O. nerka	4	79	86	73	6	5.4	6.8	4	1.4
Motase	Trawl	O. nerka	5	69	75	51	10	4.0	5.1	1.7	1.3
Motase	Trawl	Prickly Sculpin	2	61	105	17	62	6.9	13.6	0.1	9.5
Slamgeesh	Gillnet	Coho	49	89	118	51	12	7.2	15.5	2.5	2.7
Slamgeesh	Gillnet	Rainbow trout	1	150				33.7			
Slamgeesh	Gillnet	O. nerka	61	88	99	69	7	6.6	10.4	3.1	1.8
Slamgeesh	Trawl	Coho	4	80	98	65	14	4.9	9.2	2.5	2.9
Slamgeesh	Trawl	Prickly Sculpin	3	29	35	26	5	0.2	0.3	0.1	0.1
Slamgeesh	Trawl	O. nerka	2	57	57	56	1	1.4	1.4	1.3	0.1
Slamgeesh	Trawl	Mountain whitefish	2	91	112	70	30	6.1	9.7	2.5	5.1

Table 2. 2009 Hydroacoustic fall fry population and density estimates (all lakes)

Lake	Estimate method	Size class	Density (n/ha)	Population
Atna	Tracked target (2-transducer)	All fish	49	20,208
		"Small" size fish	49	20,208
		"Large" fish	0	0
Azuklotz	Tracked target (2-transducer)	All fish	1,041	172,568
		"Small" size fish	995	164,832
		"Large" fish	47	7,737
		Age-0 Nerka	179	29,670
Kalum	Tracked target (1-transducer)	All fish	325	601,561
		"Small" size fish	316	584,842
		"Large" fish	9	16,719
Motase	Tracked target (2-transducer)	All fish	93	37,893
		"Small" size fish	93	37,893
		"Large" fish	0	0

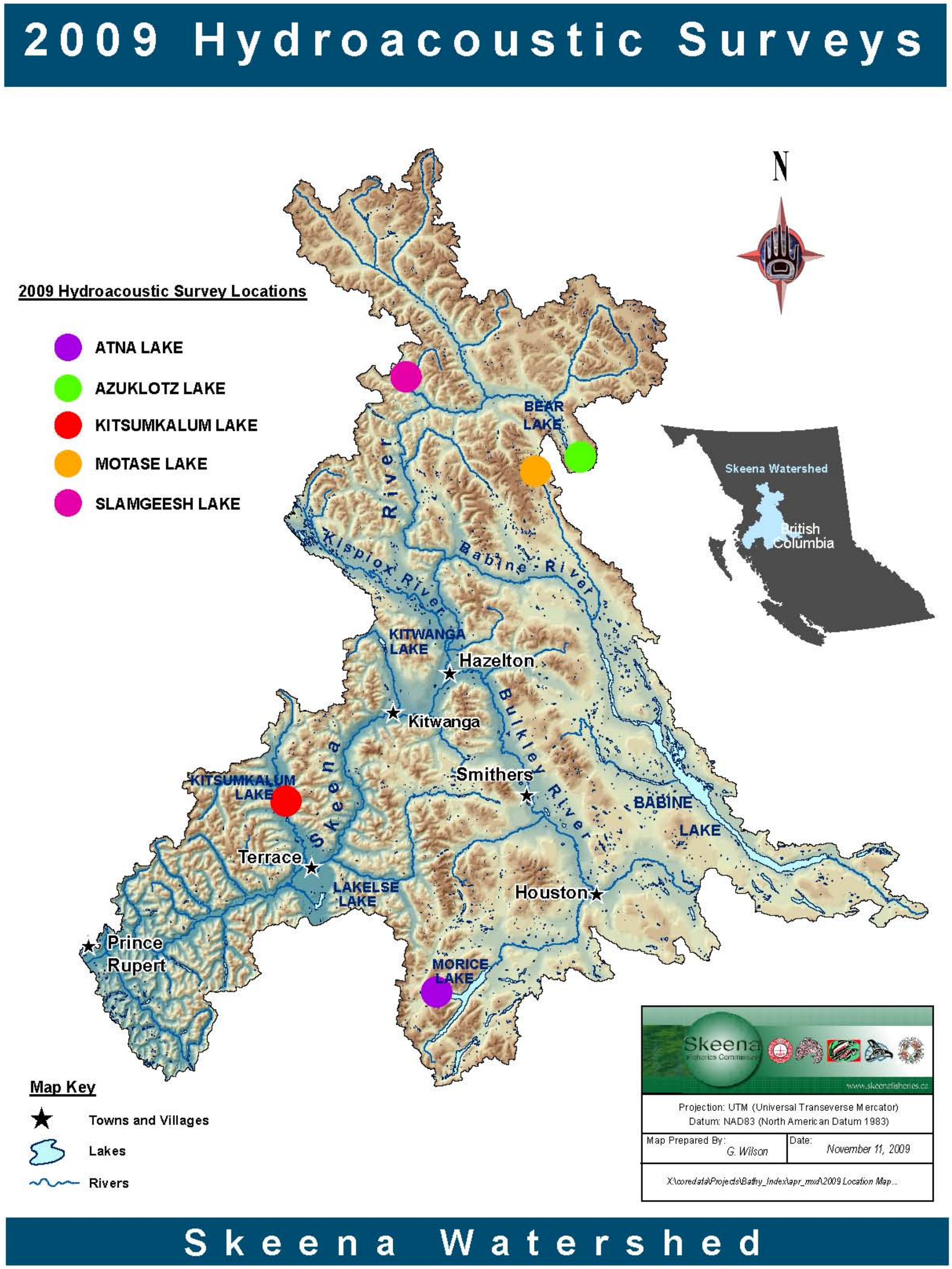


Figure 1. Location of lakes surveyed in the Skeena Watershed

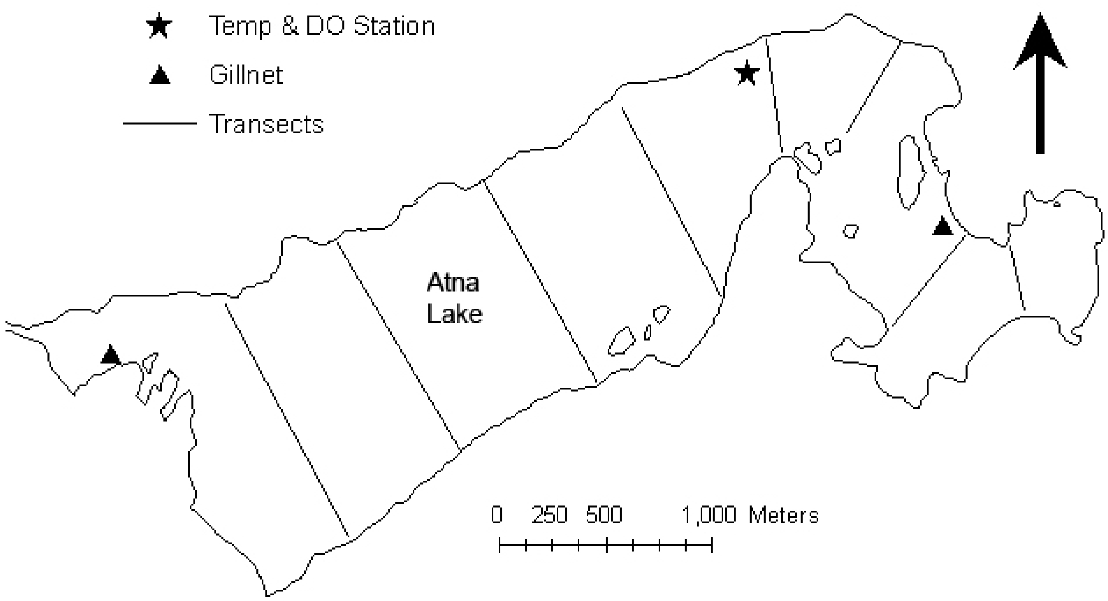


Figure 2. Atna Lake transects

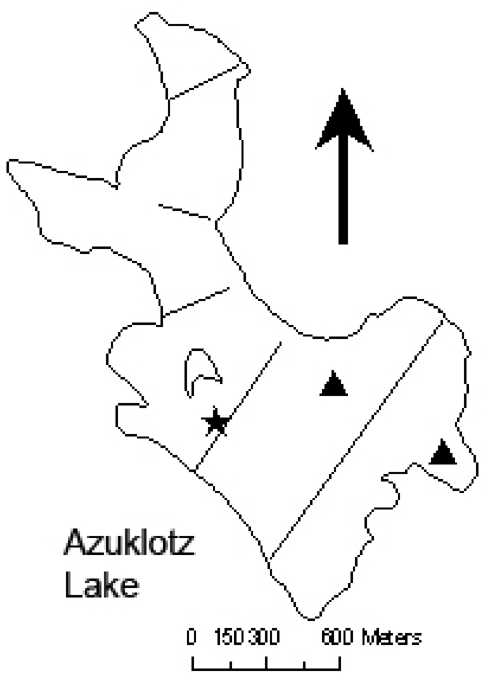


Figure 3. Azuklotz Lake transects

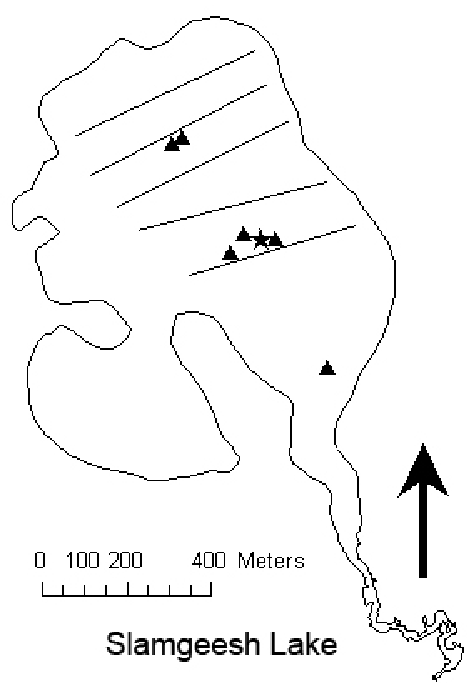


Figure 4. Slamgeesh Lake transects

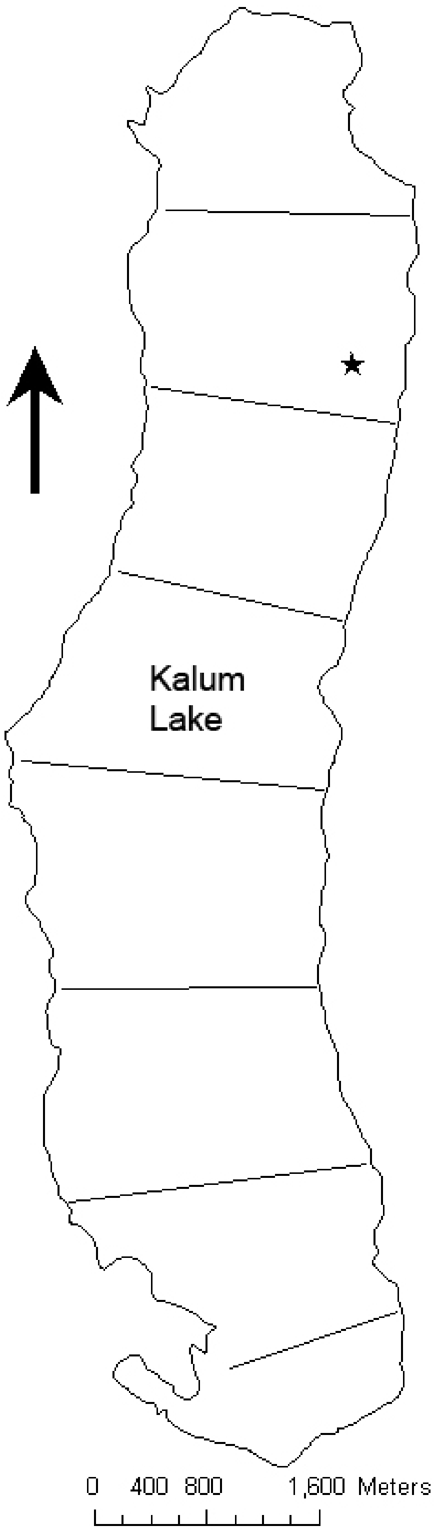


Figure 5. Kalum Lake transects

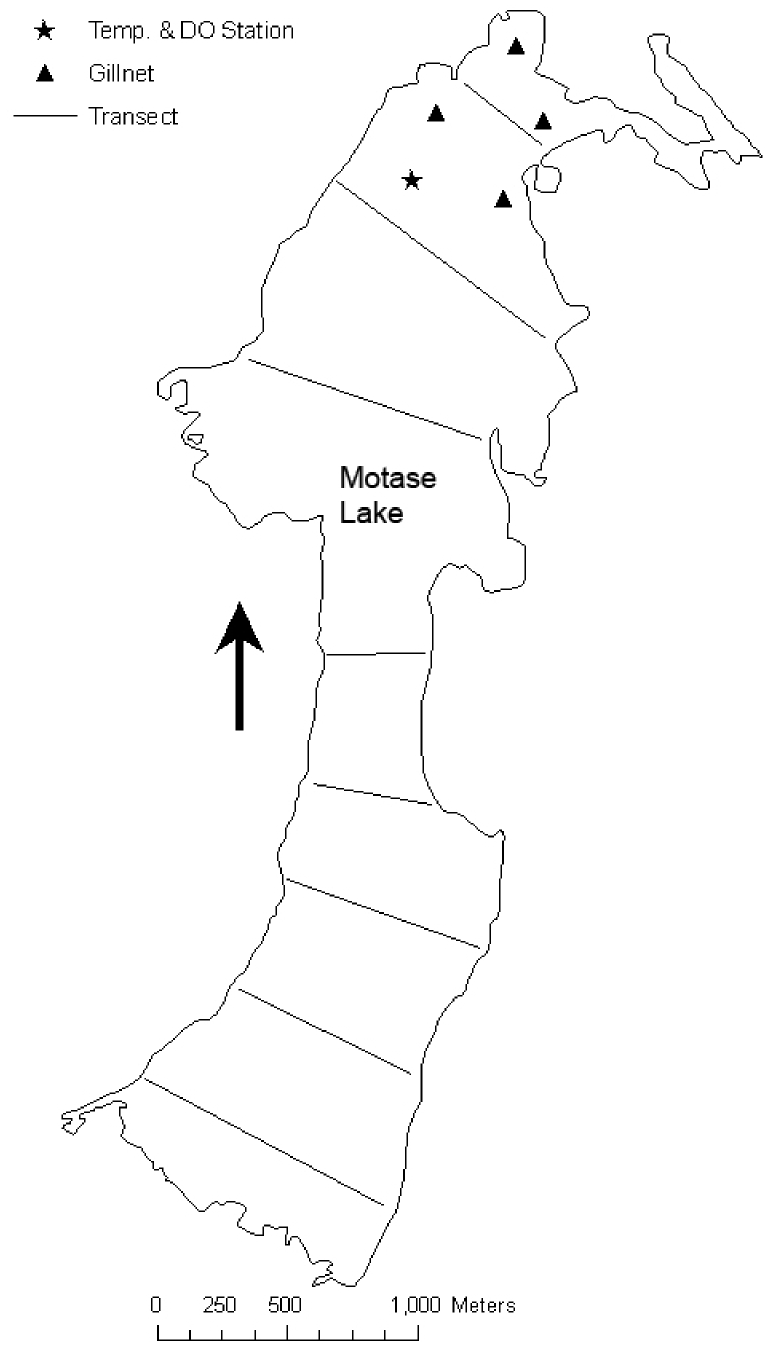


Figure 6. Motase Lake transects

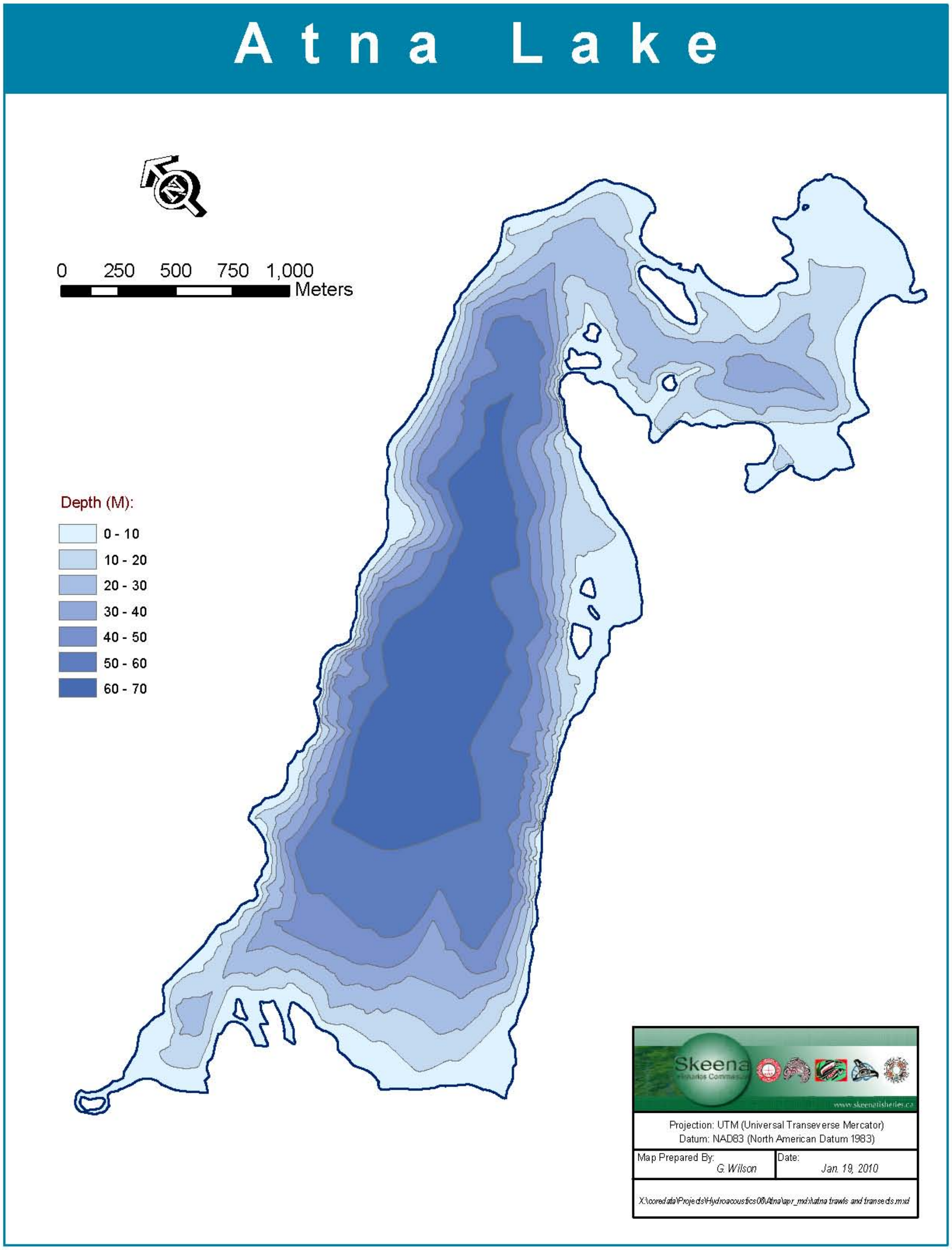


Figure 7. Atna Lake bathymetric map

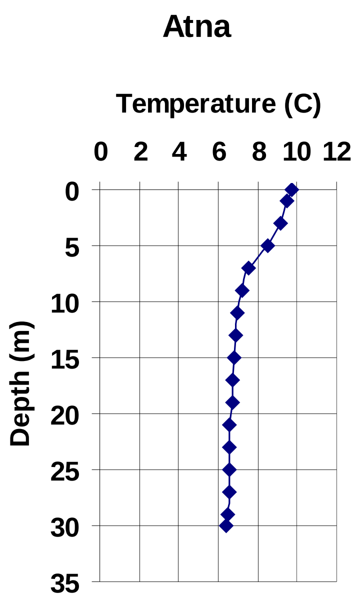
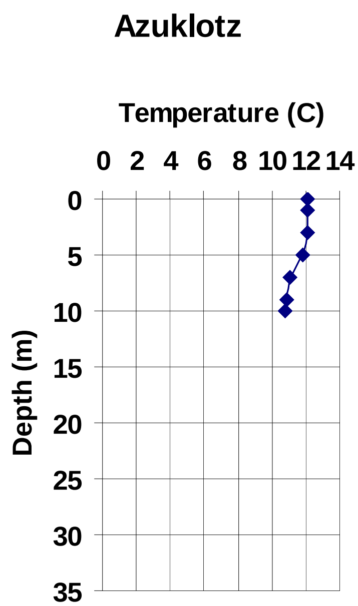


Figure 8



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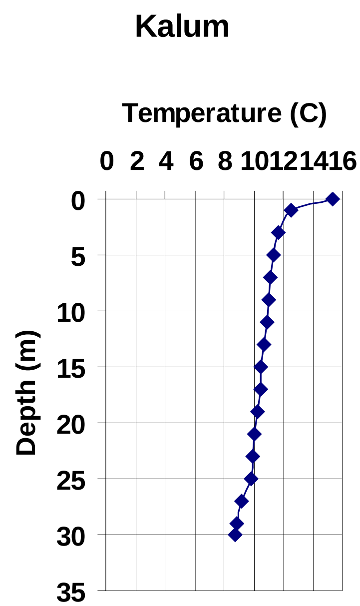

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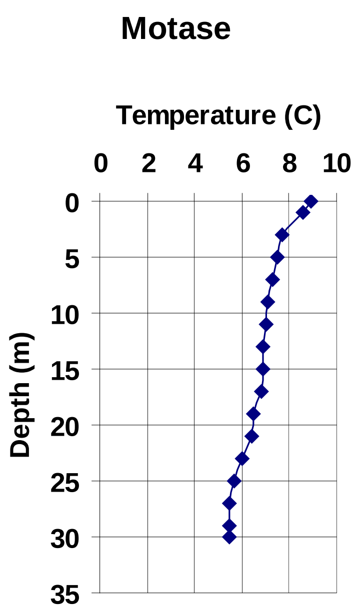

Figure 11

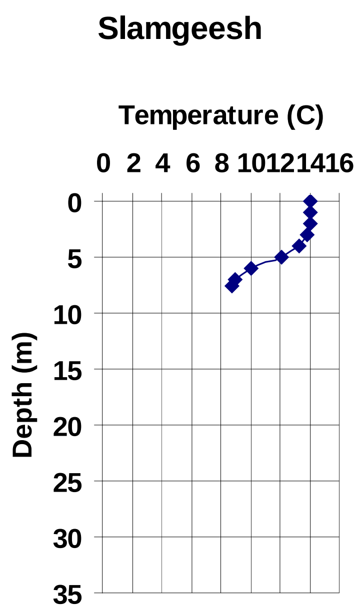

Figure 12

Figures 8 to 12. Temperature profiles for Atna, Azuklotz, Kalum, Motase, and Slamgeesh Lakes, 2009 hydroacoustic surveys

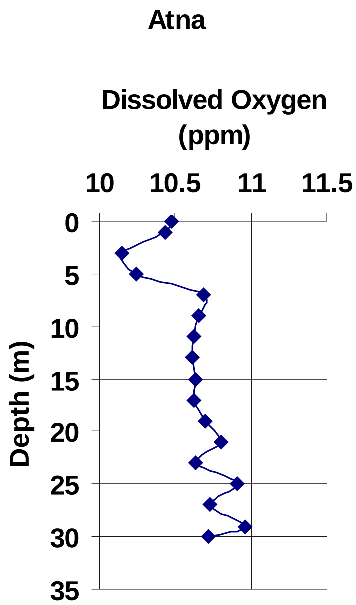

Figure 13

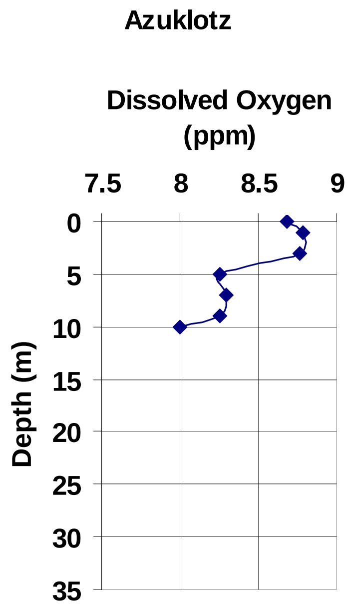

Figure 14

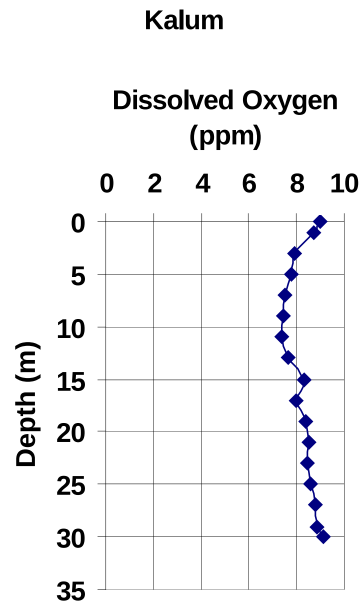

Figure 15

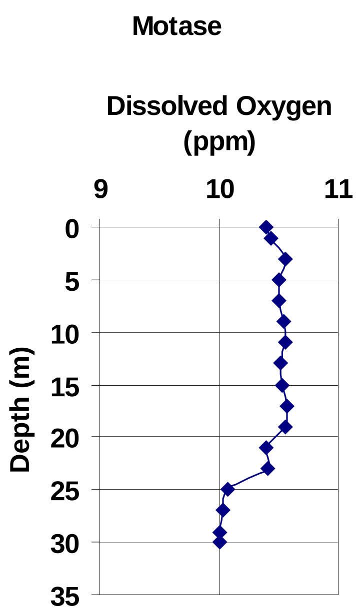

Figure 16

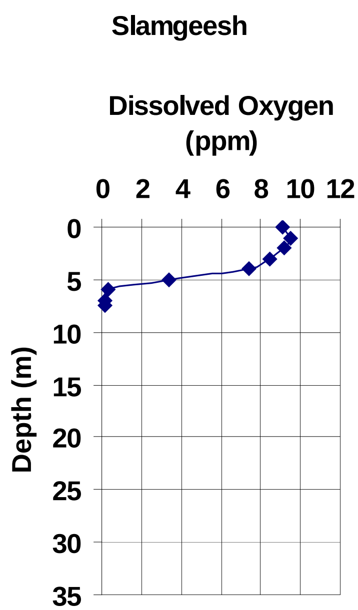

Figure 17

Figures 13 to 17. Dissolved oxygen profiles for Atna, Azuklotz, Kalum, Motase, and Slamgeesh Lakes, 2009 hydroacoustic surveys

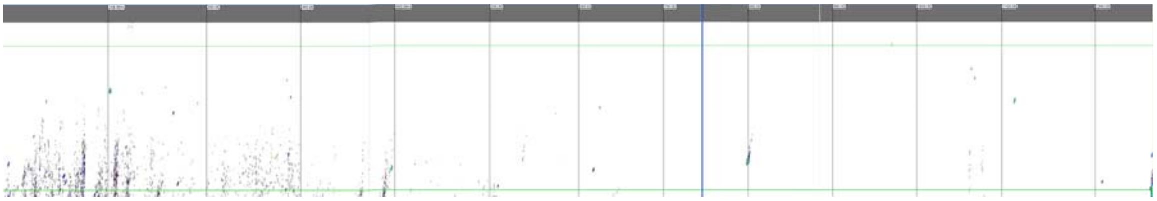
Figure 18. Atna 2009 Transect 3 echogram (horizontal transducer)

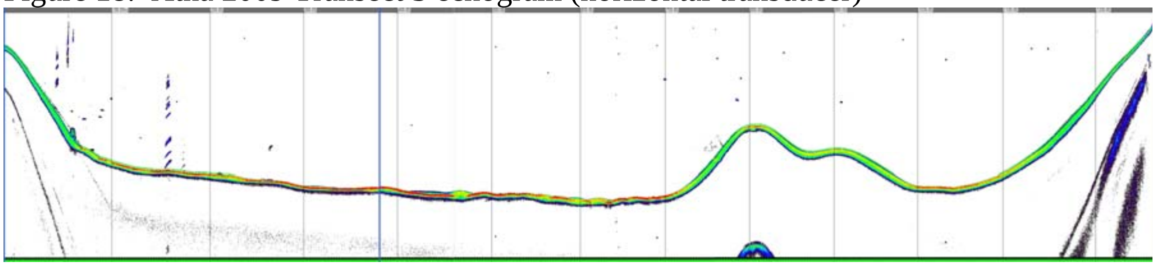
Figure 19. Atna 2009 Transect 3 echogram (vertical transducer)

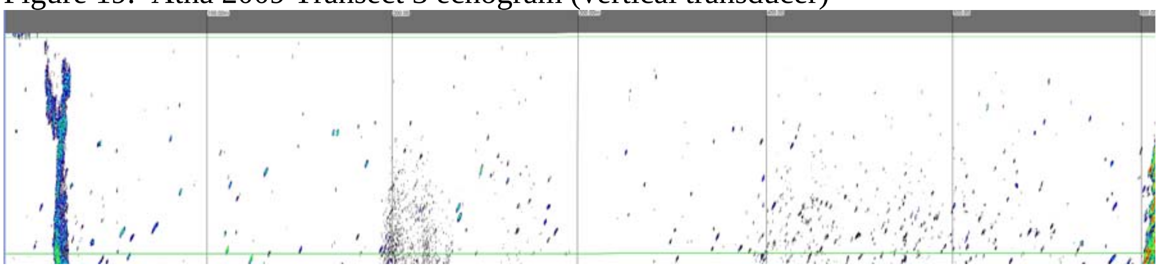
Figure 20. Azuklotz 2009 Transect 4 echogram (horizontal transducer)

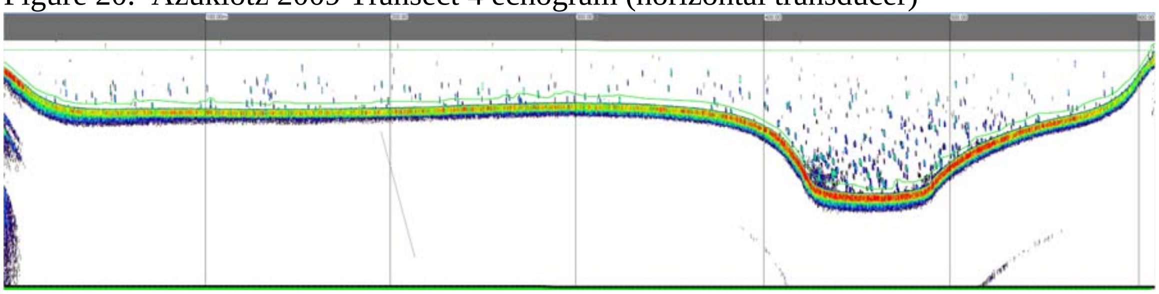
Figure 21. Azuklotz 2009 Transect 4 echogram (vertical transducer)

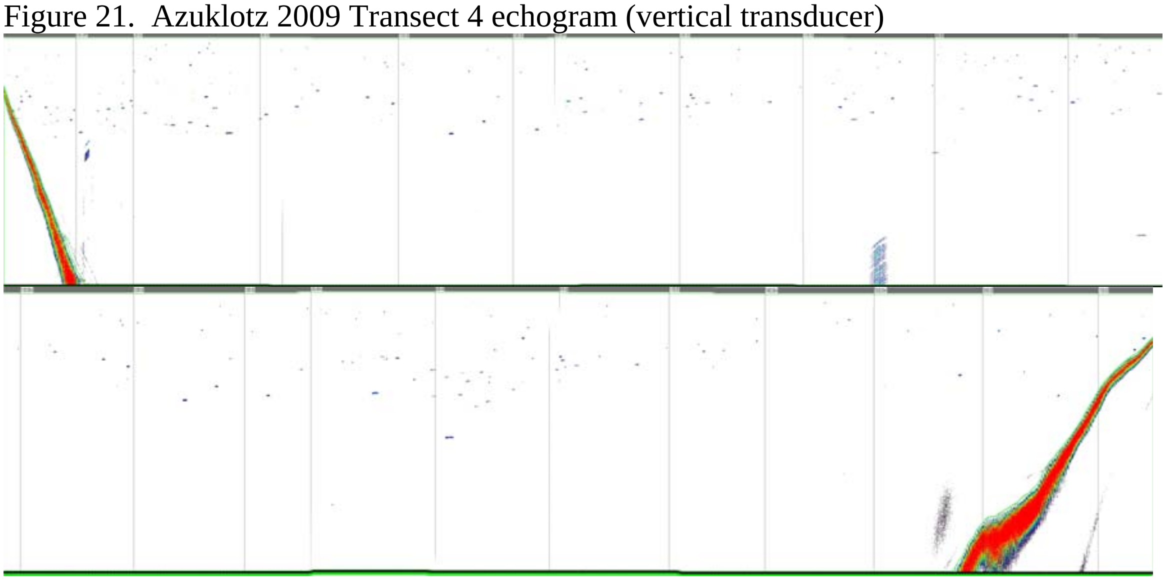
Figure 22. Kalum 2009 Transect 3 echogram (vertical transducer)

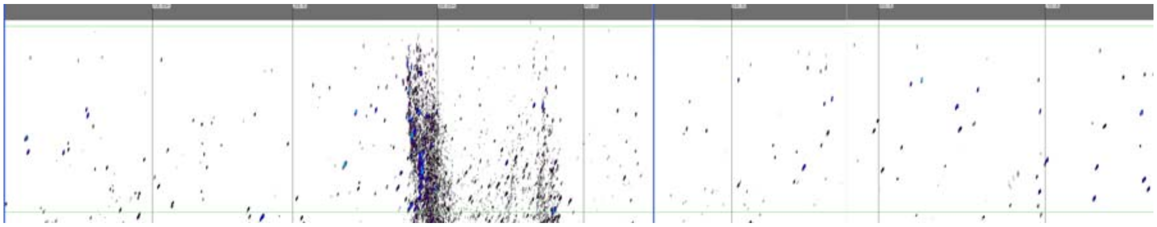

Figure 23. Motase 2009 Transect 7 echogram (horizontal transducer)

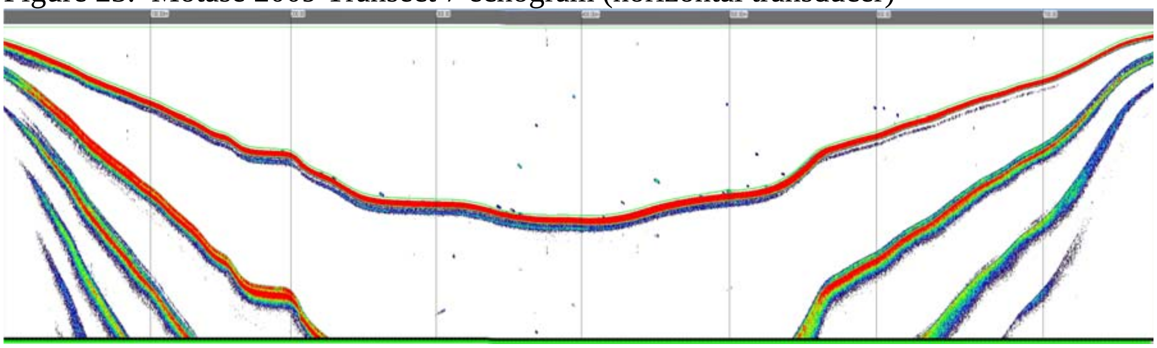

Figure 24. Motase 2009 Transect 7 echogram (vertical transducer)

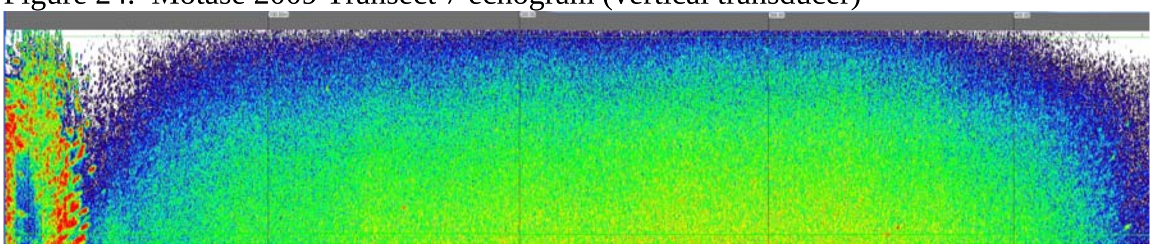

Figure 25. Slamgeesh 2009 Transect 3 echogram (horizontal transducer)

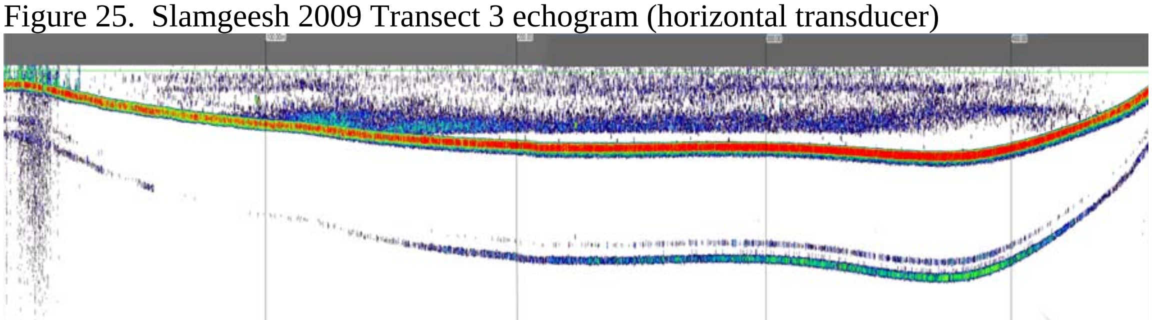

Figure 26. Slamgeesh 2009 Transect 3 echogram(vertical transducer)