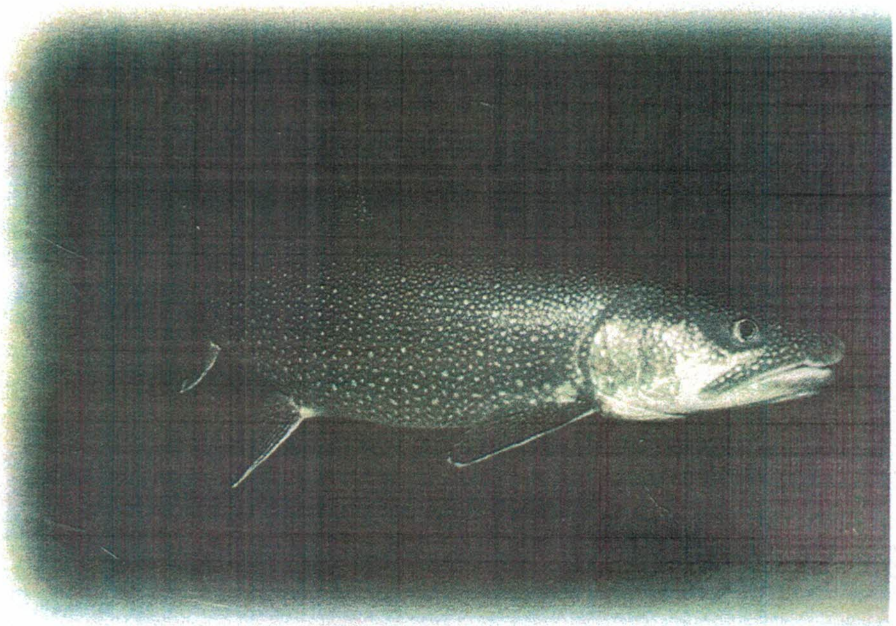
Ministry of Natural Resources

Ontario

Round Lake Trout Report

Summary of Lake Trout (*Salvelinus namaycush*) and Spawning Habitat in Relation to Water Management on Round Lake

May 2010



Renfrew Power Generation

Summary of Lake Trout *(Salvelinus namaycush)* & Spawning Habitat in Relation to Water Management on Round Lake

May 2010

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Executive Summary

Water levels on Round Lake in Renfrew County are maintained in keeping with an operating regime established through the Bonnechere River Water Management Plan (BRWMP 2004, amended in 2005 and 2009). The established operating regime is intended to balance all values on the lake and the river system downstream, including ecological values, power generation, shoreline protection, municipal water use, recreational use, etc.

Round Lake is a cold water lake supporting a naturally reproducing lake trout (*Salvelinus namaycush*) population that is showing signs of poor recruitment. It also hosts both seasonal and permanent residents, commercial businesses and two provincial parks.

One of the constraints that led to the development of the current operating regime for water levels on Round Lake between late fall and the spring freshet, is the need to protect key elevations on lake trout spawning shoals from dewatering or freezing. Lake trout spawn in the fall laying their eggs on rocky shoals in the lake. The eggs then over-winter and hatch in the spring.

In the interest of determining whether some additional water level management flexibility could be achieved on Round Lake, a series of studies were undertaken between 2005 and 2008 to investigate the population and spawning habitat of lake trout.

A bathymetric survey was completed in 2005 to produce water volume and surface area values. This information was further supplemented by detailed mapping in 2006 of spawning habitat on four shoals which provided associated elevations. The identified elevations of spawning habitat ranged between 166.1 m and 170.4 meters above sea level (m asl) for all four shoals combined.

On August 31, 2007 during the middle of the summer stratification period, dissolved oxygen levels were assessed by calculating the Mean Volume Weighted Hypolimnetic Dissolved Oxygen. A value of 8.4 mg/L^{-1} confirmed excellent coldwater oxygen levels for both juvenile and adult lake trout and strongly supported that dissolved oxygen levels is not a contributing factor negatively affecting lake trout recruitment.

A diving survey conducted in 2006 confirmed lake trout eggs on three of the four spawning shoals with the Victoria Island shoal producing the majority of eggs. The diving survey was repeated in 2007 concentrating only on the Victoria Island shoal. Eggs were confirmed between elevations 169.8 m and 167.0 m asl, with the majority of these eggs being deposited between elevations of 169.5 m and 168.7 m asl.

Summer Profundal Index Netting was carried out in September 2007 to estimate the adult (>300 mm) lake trout population and density (adult lake trout/ ha). The adult population estimate (3,783) and density (2.1) was attained with an arithmetic relative standard error (RSE) of 0.54. A target RSE of 0.15 could not be attained due to very low catches of lake trout. Further work needs to be completed to adjust the selectivity correction for lake trout >650 mm in order to confirm the accuracy of this population and density estimate.

DNA analysis confirmed that this population is recognizably distinct from both hatchery strains formerly stocked in Round Lake as well as from all other regionally mixed-ancestry populations. As such, MNR is required to manage this population in accordance to MNR's Strategic Plan for Ontario Fisheries (SPOF II), Ontario's Biodiversity Strategy (Protecting What Sustains Us, 2005) and South Central Ontario Management Plan for Naturally Reproducing Brook Trout and Lake Trout Populations.

Average ice thicknesses over the Victoria Island shoal were measured between 2005 and 2009. The average ice thickness for these years was 0.5m. Since, the majority of eggs are deposited below 169.5 m asl, drawdown could extend to170.1 m asl without directly impacting most of the incubating eggs.

Despite the progress made in answering some information needs about the Round Lake lake trout population, there are still many unknowns including the actual cause of poor recruitment in this population. The work undertaken to this point suggests that water levels, ice thickness and dissolved oxygen are not independently responsible for the absence of young lake trout.

1.0 Introduction

The Bonnechere River Water Management Plan (BRWMP) for the Bonnechere River system was approved under Ontario's *Lakes and Rivers Improvement Act* in September of 2004. As part of a comprehensive planning process, the issue of water level management as it relates to lake trout *(Salvelinus namaycush)* spawning habitat was addressed based on the limited knowledge available at the time. Water level management constraints, intended to protect lake trout eggs, were included in the plan for the Round Lake operating regime.

Approximately one percent of Ontario's lakes support lake trout populations. This represents 20 to 25 percent of all of the lake trout lakes in the world. The province, therefore, has a great responsibility to manage lake trout and lake trout lakes wisely (MNR, 2006).

Lake trout typically spawn at night in late October to early November, generally over windswept shoals. The eggs are deposited over cobble and boulder substrate. Following egg deposition, four to five months are typically required for incubation. Eggs generally hatch sometime in March or April of the following year (Scott and Crossman, 1973).

The existing operating regime for Round Lake includes restrictions on water levels designed to protect lake trout spawning and egg incubation and take into account the life history characteristics mentioned above (see Figure 1, Section 2.0). Specifically, during weeks eight to 13 of the calendar year (late February to the end of March) the water level is held at an elevation 170.41 m or higher with the intention of protecting incubating/developing lake trout eggs/sac fry[1].

There is a provision in the BRWMP which allows the Ministry of Natural Resources (MNR) to give the operator authority to reduce potential for spring flooding by dropping water levels to the lower limit elevation of 170.1 m asl[1]. Spring flooding did occur on Round Lake in 2005, 2008 and 2009. MNR has provided permission each year since 2006 for Renfrew Power Generation (RPG) to drawdown water levels below 170.41 m asl between weeks eight through 13 to reduce the risk of flooding during spring freshet. This risk can only be reduced if Round Lake and Golden Lake are both drawn down to maximize storage capacity.

In October 2006, RPG proposed an amendment to the water management plan that would change the approach taken during weeks one to 19 by eliminating the lower limit during these periods. At the time, MNR raised concerns about the proposed amendment because insufficient information existed to predict the impact of the proposed amendment on lake trout spawning and egg incubation. RPG subsequently withdrew this request.

RPG then retained a fisheries consultant, Natural Resource Solutions Inc. (NRSI), to work with MNR to design a program to collect data to determine what studies/projects should be completed to provide meaningful, relevant information pertaining to hydroelectric operating effects on lake trout reproduction. In May/June of 2007, the fisheries team worked together to develop a program that would address not only the issue of water level management in relation to lake trout

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[1] Note: A recent amendment to the BRWMP (December 2009) changed the winter lower limit to simply 170.1 m asl.

spawning and egg incubation but also other fundamental questions surrounding the community structure of the lake trout population in Round Lake. The result was a work plan that was executed during the field season of 2007 and produced data which is the subject of this report along with results of other fieldwork ongoing since 2005.

1.1 Summary of Objectives

The objectives of this study were determined early on during a working session of biologists representing MNR and RPG. The following specific objectives were identified:

- Confirm the location and timing of lake trout spawning in Round Lake
- Look at the genetic profile of the lake trout population in Round Lake to determine if this population is comprised of the progeny of hatchery fish or are in fact an original native population
- Obtain lake trout density and population estimates using standardized MNR survey techniques
- Determine the population structure of lake trout in Round Lake including age structure and status of the juvenile population
- Determine critical habitat elevations on the lake trout spawning shoals and relate this to present and proposed water level operating regimes

Most of these objectives built on work already being conducted by MNR as part of the lake trout information needs identified in the WMP. This ongoing work consisted of: bathymetry and spawning shoal mapping, dissolved oxygen, diving surveys and spawning assessments.

2.0 Existing Water Management Regime

The Bonnechere River meanders through Bonnechere Provincial Park, forming wetlands and oxbows before entering Round Lake. These areas of slowly moving water provide excellent habitat for various reptiles, amphibians, waterfowl, diverse vegetation, and are important fish nursery areas. Reserve Creek, Jacks Creek, Turners Creek, the Sherwood River (historically referred to as the Little Madawaska) and Byers Creek are the other main tributaries feeding into Round Lake and this part of the upper Bonnechere River.

The water levels on Round Lake and the flows from it are controlled by operation of the Tramore Dam. The Tramore Dam was installed in 1913 to facilitate the production of waterpower for the Town of Renfrew. Operation of the dam has evolved since its construction to address demands for hydroelectricity and various needs and issues created through property development (MNR, 2005).

The operating regime for Round Lake (Figure 1) attempts to accommodate a wide range of values, such as environmental and ecological values, growing concerns of residents and communities, and a need for continued sources of sustainable energy.

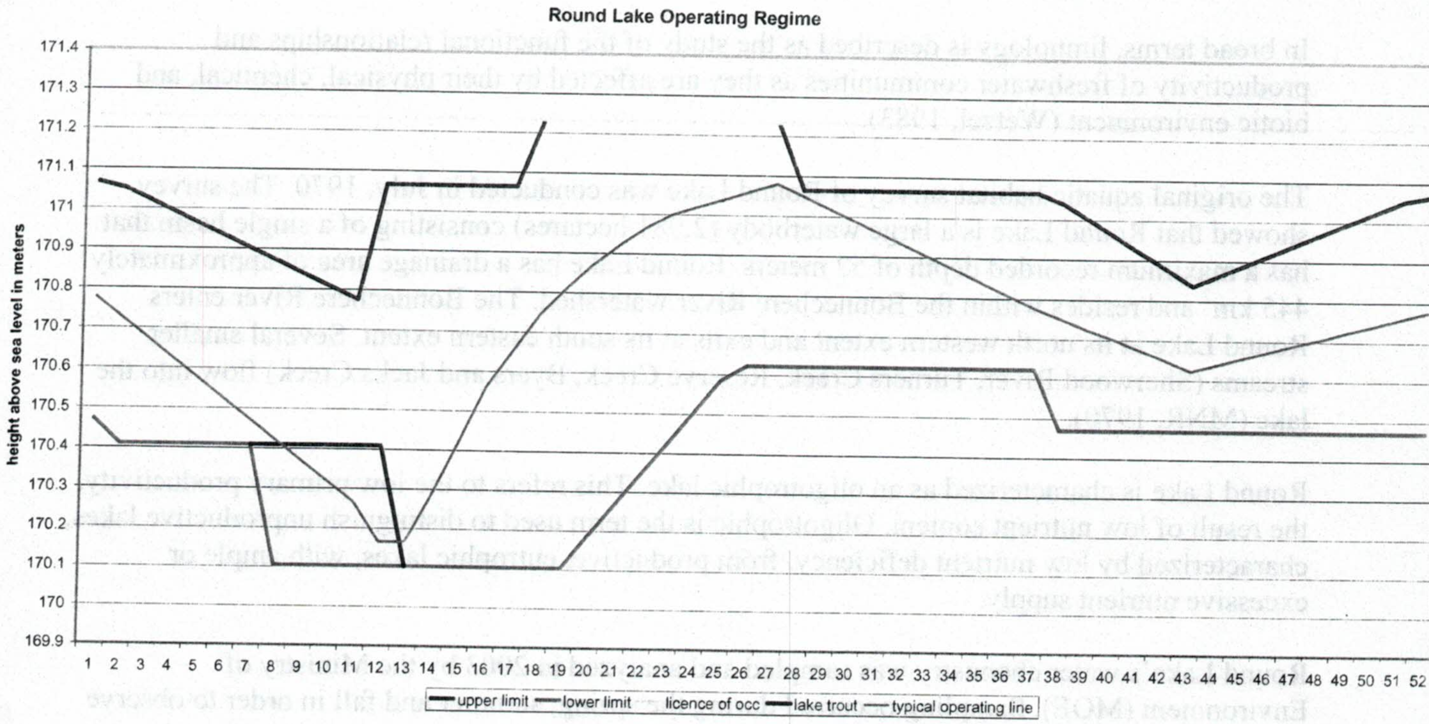


Figure 1. Operating regime on Round Lake, from the BRWMP.

2.1 Typical Operating Line

There is a Typical Operating Line associated with the operating regime for Round Lake. This line was developed using average historical data and plan objectives and is included with the operating regime to provide an indication for the public of where water levels may be under typical conditions. The Typical Operating Line is not a mandatory or enforceable operating requirement in the water management plan.

It is important to note that the typical operating line as indicated above, is shown running through the lower limit established to protect lake trout eggs from weeks eight to 13. Initially the objective of the operating regime was to stay above the 170.41 m level during this period to protect incubating eggs. Since 2006, MNR has allowed operations below 170.41 m asl, to provide increased relief from risk of flooding during spring freshet[2]. A secondary benefit is it allows room for a steady drawdown from freeze-up to the onset of spring freshet, which was a recommendation of a final report on ice-related damages to private properties on Round and Golden Lake by BMT Fleet Technologies (BMT, 2005).

[2] Note: A recent amendment to the BRWMP (December 2009) changed the winter lower limit to simply 170.1 m asl.

3.0 Characteristics of Round Lake Ecosystem

3.1 Limnology

In broad terms, limnology is described as the study of the functional relationships and productivity of freshwater communities as they are affected by their physical, chemical, and biotic environment (Wetzel, 1983).

The original aquatic habitat survey of Round Lake was conducted in July, 1970. The survey showed that Round Lake is a large waterbody (2,981 hectares) consisting of a single basin that has a maximum recorded depth of 52 meters. Round Lake has a drainage area of approximately 445 km^2 and resides within the Bonnechere River watershed. The Bonnechere River enters Round Lake at its north western extent and exits at its south eastern extent. Several smaller streams (Sherwood River, Turners Creek, Reserve Creek, Byers and Jacks Creek) flow into the lake (MNR, 1970).

Round Lake is characterized as an oligotrophic lake. This refers to the low primary productivity, the result of low nutrient content. Oligotrophic is the term used to distinguish unproductive lakes, characterized by low nutrient deficiency, from productive, eutrophic lakes, with ample or excessive nutrient supply.

Round Lake's water chemistry was sampled and analyzed in 2003 by the Ministry of Environment (MOE). Sampling occurred during the spring, summer and fall in order to observe changes in the measurable parameters throughout the open water season (Table 1). Samples were obtained from both the euphotic zone (column of water to which ambient light penetrates) and from one meter above the bottom. Overall, the results of the sampling indicate low phosphorus and nitrogen concentrations, a low sensitivity to acidification, and moderate water clarity (MOE, 2007).

Table 1. Water Chemistry Results in Round Lake, 2003[3]

Parameter	May 27, 2003	July 15, 2003		September 3, 2003	
	Euphotic	Euphotic	Meter off Bottom	Euphotic	Meter off Bottom
Secchi Disk (m)	2.7	3.5		3.4	
Total Phosphorus	0.009	0.006	0.007	0.009	0.006
Ammonia - Nitrogen	0.022	0.008	0.01	0.026	0.029
Nitrite - Nitrogen	0.003	0.003	0.003	0.007	0.007
Nitrate - Nitrogen	0.083	0.005	0.055	0.008	0.143
Total Kjeldahl Nitrogen	0.33	0.35	0.3	0.3	0.22
Dissolved Organic Carbon	5.4	6.2	5.7	7.4	6.2
Dissolved Inorganic Carbon	4.5	4.7	4.9	4.8	4.8
pH	7.91	7.59	7.41	7.56	7.53
Total Alkalinity	43.1	20	20.8	20.9	21.5
Conductivity (uS/cm)	117	64	65	68	69
Calcium		6.5	6.7	6.55	6.65
Magnesium		2.28	2.3	2.32	2.34
Hardness		25.6	26.2	26	26.2

[3] Water Quality Management of Cold Water Lake: County of Renfrew: MOE & MNR, Oct 2007.

3.2 Fish Community

During the 1970 lake survey, an inventory of fish species was conducted. This inventory has since been updated to include native, stocked and a number of invasive species that have become established (Table 2). Of the species in this list, American eel, rainbow trout and brook trout have not been observed in recent times and are likely no longer present. Walleye became indirectly introduced to Round Lake via stocking which occurred downstream in Golden Lake during the 1920's by the Ontario Department of Lands and Forests. Walleye from these stockings migrated into Round Lake and became an established part of the fish community. Rainbow trout is believed to be the only species to be directly introduced to Round Lake via stocking. Each of the other species subsequently stocked by MNR or its predecessor the Department of Lands and Forests, were already present in and native to Round Lake.

Table 2. Native, Stocked and Invasive Species in Round Lake

Native Species		Invasive Species		Historical Stocking		Years Stocked
Lake Trout	*Salvelinus namaycush*	Rainbow Smelt	*Osmerus mordax*	Lake Trout	*Salvelinus namaycush*	1931-32, 34, 36-45, 47, 50-52, 54-55, 58-63, 67-75, 78, 82
Lake Whitefish	*Coregonus clupeaformis*	Rusty Crayfish	*Orconectes rusticus*	Brook Trout	*Salvelinus fontinalis*	1936-42, 44-45, 47-48, 50
Lake Herring (cisco)	*Coregonus artedi*	Spiny Water Flea	*Bythotrephes longimanus*	Rainbow Trout	*Oncorhynchus mykiss*	1948, 50, 52-54, 60
Northern Pike	*Esox Lucius*			Smallmouth Bass	*Micropterus dolomieu*	1937, 40, 52
Smallmouth Bass	*Micropterus dolomieu*			Walleye*	*Sander vitreus*	1946-48, 51-53, 86
Largemouth Bass	*Micropterus salmoides*					
White Sucker	*Catostomus commersonii*					
Brown Bullhead	*Ameiurus nebulosus*					
Trout-perch	*Percopsis omiscomaycus*					
Fallfish	*Semotilus corporalis*					
American Eel	*Anguilla rostrata*					
Burbot	*Lota lota*					
Rock Bass	*Ambloplites rupestris*					
Pumpkinseed	*Lepomis gibbosus*					
Yellow Perch	*Perca flavescens*					
Common Shiner	*Notropis cornutus*					
Log Perch	*Percina caprodes*					
Blacknose Dace	*Rhinichthys atratulus*					
Pearl Dace	*Semotilus margarita*					
Iowa Darter	*Etheostoma exile*					
Spottail Shiner	*Notropis hudsonius*					

*** Denotes walleye originally migrated into Round Lake from a walleye introduction that occurred downstream in Golden Lake during the 1920's.**

3.3 Bathymetry

Bathymetry is a term used to describe the morphological characteristics of a waterbody. Bathymetric data is most commonly used to construct a map illustrating depth contours and underwater structure. The data can also be used to accurately calculate water volume, mean and maximum depths, and to stratify depths at desired intervals to obtain information specific to those depth strata. Bathymetric information is important for evaluating habitats for various aquatic species, locating critical habitat features (e.g. spawning shoals) and selecting sampling sites for various aquatic surveys (e.g. index netting).

3.3.1 Methodology and Technology

The standard software program used in data acquisition in the field is the Bathymetric Automated Survey System (BASS). When used in conjunction with a Global Positioning System (GPS) enabled depth sounder, the collection of position (x,y) and depth (z) is acquired and matched to provide corresponding position and depth (x,y,z) data. When a sufficient amount of data points are collected, an interpolation can be run using Geographic Information System (GIS) software to produce a full surface profile of the lake bottom including shoals.

Within MNR, a manual of instructions for bathymetric surveys was developed to set out the standards for bathymetric data collection in terms of pattern and intensity for different size lakes (Levec, 2004). To process the collection of bathymetric data points, a manual for the GIS analysis of bathymetry data was also developed (Levec, 2003). During execution of this project both these manuals were used to guide the collection and analysis of bathymetric data on Round Lake.

3.3.2 Results of Bathymetry

The bathymetric survey of Round Lake was carried out over four days between September 9 and 19, 2005. Each day of data collection referenced the daily average water level reading from the Tramore Dam water level gauge. Since slight water level changes each day would ultimately affect the actual depth (z) readings, the data was corrected to a single water level elevation (see Table 3). This prevented daily changes in water levels from creating errors in depth from one day of data collection to the next. This correction was essential for the purpose of merging the various data sets together in order to generate a lake-wide bathymetric map of Round Lake and associated contours (Figure 2).

Table 3. Daily average Water Levels and Adjustments to Standardize Data Sets

Bathymetric Data Collection Date	Daily Average Water Level Reading (meters asl)	Adjustment to 170.70
September 9, 2005	170.68	0.02
September 13, 2005	170.65	0.05
September 14, 2005	170.65	0.05
September 19, 2005	170.64	0.06

The collection of bathymetric data also provided a means of calculating both water volumes and areas of depth for Round Lake (Table 4). The analysis of these parameters also facilitated the study of other information needs such as lake trout population assessment and calculation of dissolved oxygen values.

Table 4. Volume and Surface Area Values vs. Depth for Round Lake

Depth Range	Volume		Surface Area	
	$m^3 \times 10^4$	Percentage	Hectares	Percentage
0 to -10m	1026.96	35.84	1179.89	39.58
-10 to -15m	384.38	13.41	384.13	12.89
-15 to -20m	368.08	12.84	369.65	12.40
-20m to -25m	484.9	16.92	508.57	17.06
-25 to -30m	459.96	16.05	428.95	14.39
-30 to -35m	93.34	3.26	64.1	2.15
-35 to -40m	27.35	0.95	26.81	0.90
> -40m	20.68	0.72	18.91	0.63
Totals >	**2865.65**	**100.00**	**2981.01**	**100.00**

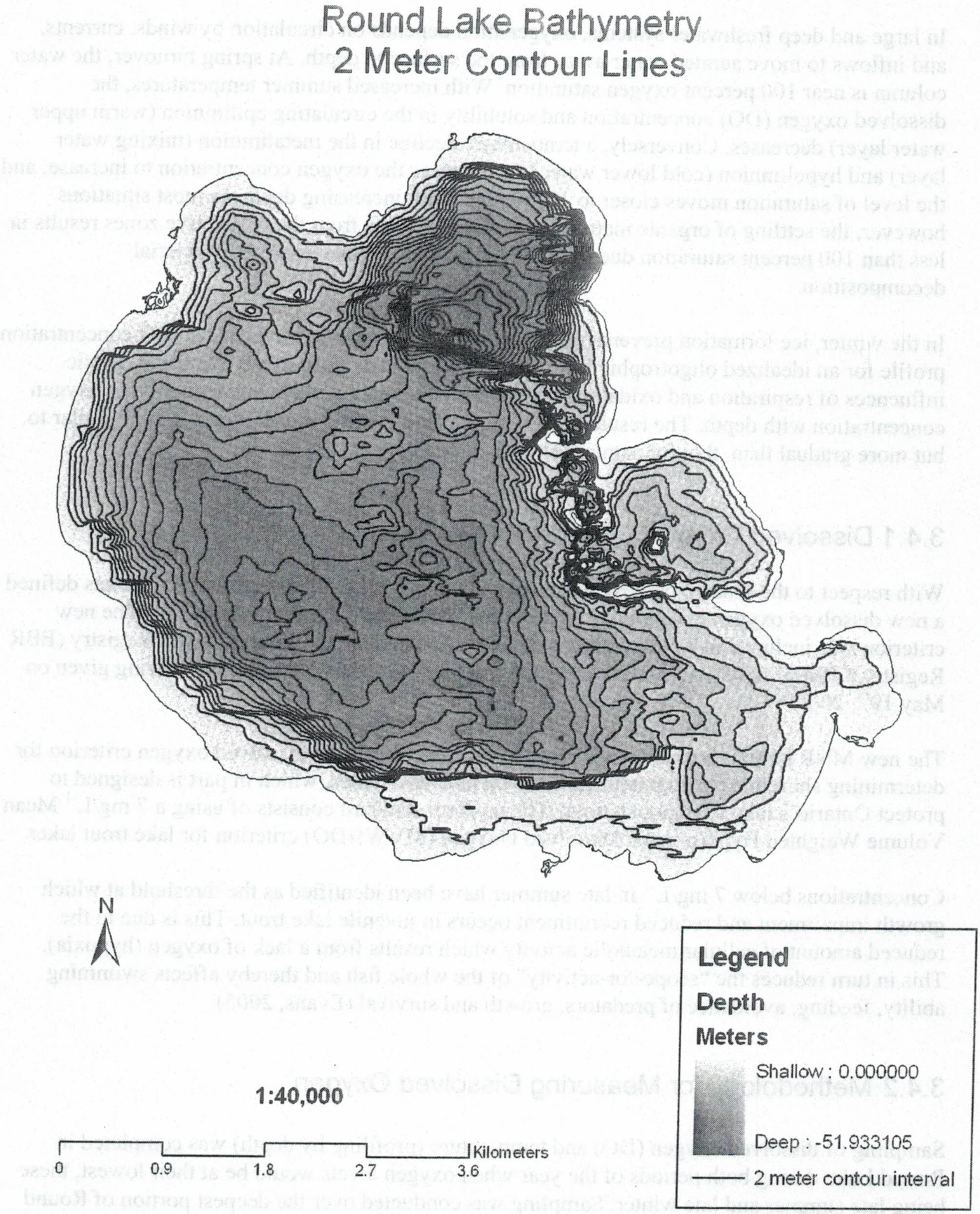


Figure 2. Round Lake bathymetry map with two meter contour lines overlaid.

3.4 Dissolved Oxygen & Temperature

In large and deep freshwater systems, oxygenation depends on circulation by winds, currents, and inflows to move aerated water away from the surface to depth. At spring turnover, the water column is near 100 percent oxygen saturation. With increased summer temperatures, the dissolved oxygen (DO) concentration and solubility in the circulating epilimnion (warm upper water layer) decreases. Conversely, a temperature decline in the metalimnion (mixing water layer) and hypolimnion (cold lower water layer) causes the oxygen concentration to increase, and the level of saturation moves closer to 100 percent with increasing depth. In most situations however, the settling of organic matter into the deeper areas from the productive zones results in less than 100 percent saturation due to oxidation processes associated with bacterial decomposition.

In the winter, ice formation prevents the exchange of atmospheric oxygen. The DO concentration profile for an idealized oligotrophic lake is at a constant saturation relative to depth. Biotic influences of respiration and oxidation are normally present and there is a reduction in oxygen concentration with depth. The resultant oxygen profile showing depletion at depth is similar to, but more gradual than, that for summer stratification (Wetzel, 1983).

3.4.1 Dissolved Oxygen Criteria for Lake Trout

With respect to the linkage between lake trout and dissolved oxygen, recent research has defined a new dissolved oxygen criterion for protection of lake trout habitat (Evans 2006). The new criterion was included in a policy proposal that was posted on the Environmental Registry (EBR Registry # PB06E6807) on January 19, 2006, with a favourable decision notice being given on May 19th, 2006.

The new MNR policy recommends the use of a uniform standard dissolved oxygen criterion for determining shoreline development capacity on lake trout lakes, which in part is designed to protect Ontario's lake trout populations. The uniform standard consists of using a 7 mg/L^{-1} Mean Volume Weighted Hypolimnetic Dissolved Oxygen (MVWHDO) criterion for lake trout lakes.

Concentrations below 7 mg/L^{-1} in late summer have been identified as the threshold at which growth impairment and reduced recruitment occurs in juvenile lake trout. This is due to the reduced amount of cellular metabolic activity which results from a lack of oxygen (hypoxia). This in turn reduces the "scope-for-activity" of the whole fish and thereby affects swimming ability, feeding, avoidance of predators, growth and survival (Evans, 2005).

3.4.2 Methodology for Measuring Dissolved Oxygen

Sampling of dissolved oxygen (DO) and temperature (profiling by depth) was completed in Round Lake during both periods of the year when oxygen levels would be at their lowest, these being late summer and late winter. Sampling was conducted over the deepest portion of Round Lake on August 31, 2007 and again on March 10, 2008 using an YSI 600XLM multi-parameter probe linked to a Panasonic ToughBook laptop for continuous data logging.

Testing and calibration of the multi-parameter probe was conducted prior to sampling in the field according to the manufacturers testing and calibration instructions. Sampling was a simple process of lowering the probe slowly (0.5 meter per second or slower), which allowed the probe to equilibrate and collect sufficient readings throughout the water column. The data logging/collection rate was also set to collect both oxygen (mg/L^{-1}) and temperature (°C) measurements every one (1) second.

3.4.3 Results of Dissolved Oxygen

Figure 3 illustrates the dissolved oxygen and temperature profiles on Round Lake on August 31, 2007. This date was chosen as it is the mid-point in the sampling window (Aug 15 to Sept 15) for calculation of the MVWHDO (Section 3.4.4). Dissolved oxygen concentrations above 7 mg/L^{-1} are displayed throughout all depths at the sampling site. Based on this information, lake trout could utilize any depth below the thermocline. A thermocline is generally defined as the thin layer of water, in which temperature changes more rapidly with depth than it does in the layers above or below.

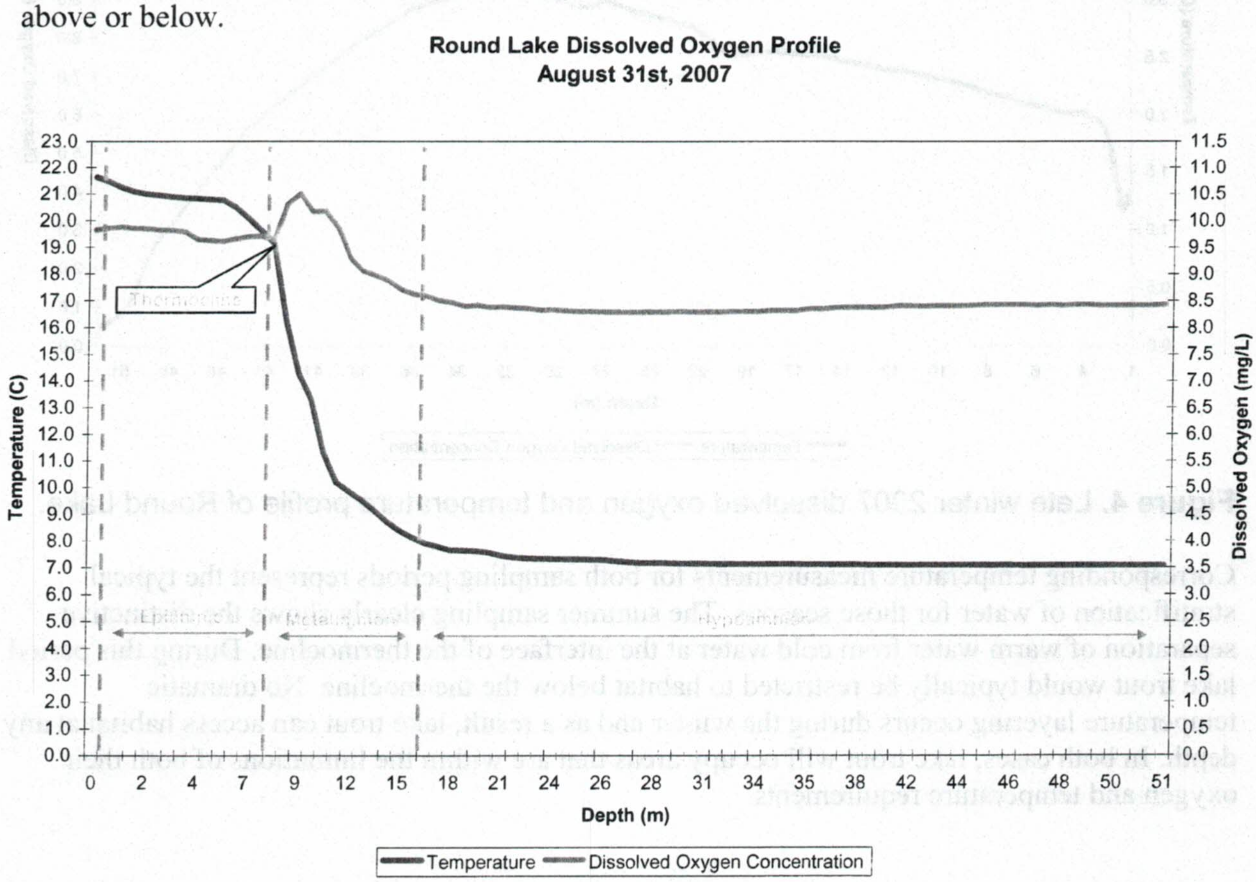


Figure 3. Late summer 2007 dissolved oxygen and temperature profile of Round Lake.

Figure 4 illustrates a dissolved oxygen and temperature profile taken on Round Lake on March 10, 2008. It shows the gradual reduction of oxygen concentration with depth that is typical of oligotrophic lakes during the late-winter period.

During this late-winter period, habitat with dissolved oxygen below 7 mg/L^{-1} begins at approximately 41 m of depth and extends to the bottom of the lake. Based on the lake volume and area calculation (Appendix I), the area of Round Lake with less than optimal conditions (<7 mg/L^{-1}) for adult and juvenile lake trout only represents a volume of 15.33 m^{3}x10^4 or approximately 0.53 percent of the total lake volume. This limited volume of less than ideal oxygen concentration during the late-winter period is normal in oligotrophic lakes and is not considered to be significant enough to impair lake trout recruitment considering lake trout are not restricted to these depths at this time of the year.

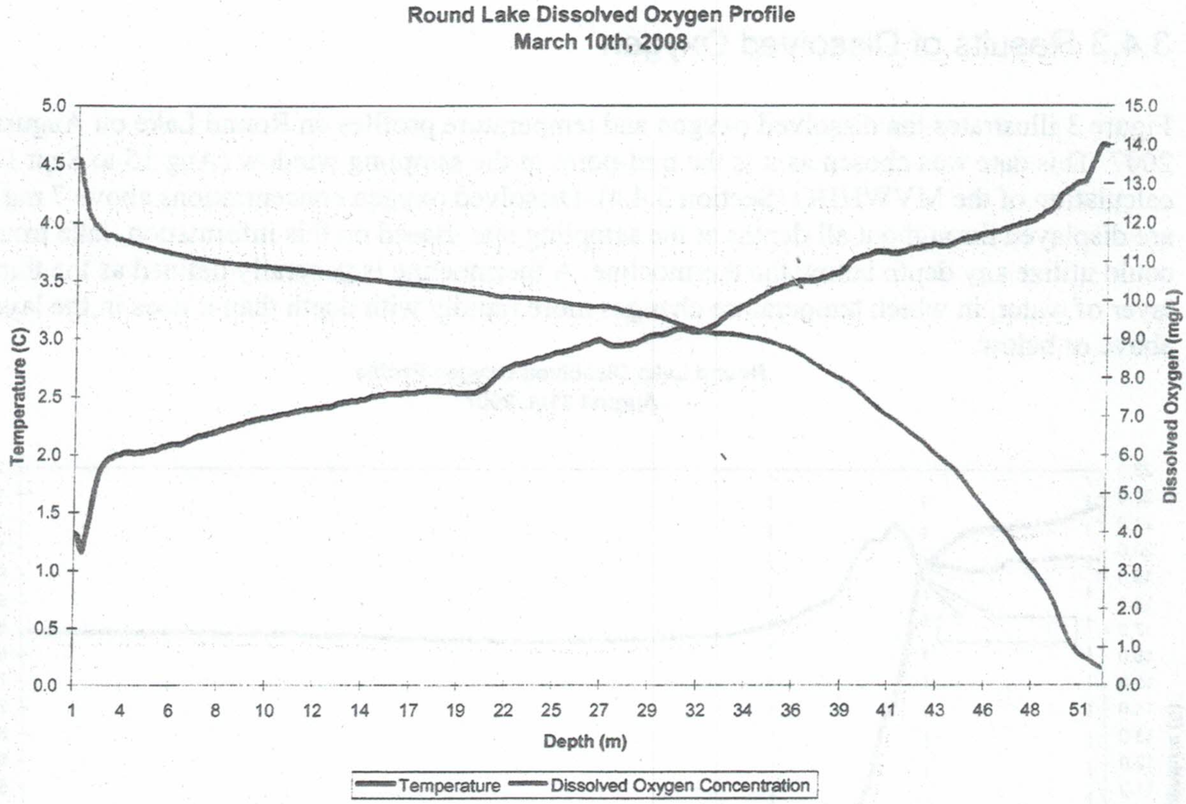


Figure 4. Late winter 2007 dissolved oxygen and temperature profile of Round Lake.

Corresponding temperature measurements for both sampling periods represent the typical stratification of water for those seasons. The summer sampling clearly shows the distinctive separation of warm water from cold water at the interface of the thermocline. During this period lake trout would typically be restricted to habitat below the thermocline. No dramatic temperature layering occurs during the winter and as a result, lake trout can access habitat at any depth. In both cases, lake trout will occupy areas that are within the limitations of both their oxygen and temperature requirements.

3.4.4 Comparison to Provincial Dissolved Oxygen Policy

Volume-weighted oxygen is calculated as the measured dissolved oxygen at each depth stratum (below the thermocline) multiplied by the proportion of the hypolimnetic volume represented by that stratum. It is important to note that only measurements taken during the late-summer period (August 15 to September 15) are used to calculate the Mean MVWHDO and not the late winter period. This is due to the fact that, during the winter months, lake trout are not thermally restricted to the hypolimnion and can access other habitat not available during the thermal stratification period.

The volume of each depth stratum is calculated from bathymetric data using the following formula:

$$V = \frac{m}{3}(A_t + A_b + \sqrt{A_t} * A_b)$$

where

V is volume in m^3 x 10^4
A_t is the area in ha of the top of the stratum
A_b is the area in ha of the bottom of the stratum
m is the depth of the stratum in meters

Once volume is calculated for each stratum it is then expressed as a fraction of the total hypolimnetic volume that is multiplied by the dissolved oxygen concentration observed for each stratum. These individual concentrations are summed to yield volume-weighted average oxygen.

Volume-weighted oxygen concentrations above 7 mg/L^{-1} are desirable for strong juvenile survival and optimal conditions for adults. Evans' (2006) research described the limiting effects of hypoxia on daily life processes of juvenile lake trout and recruitment limitations once volume-weighted oxygen concentrations start to fall below 7 mg/L^{-1}.

The MVWHDO dissolved oxygen value that was calculated from the Aug 31, 2007 dissolved oxygen profiling in Round Lake was 8.401 mg/L^{-1}. This is above the minimum criterion described by Evans' research, which was subsequently adopted into MNR policy. The calculations used to determine this value are included in Appendix 1.

As indicated by this MVWHDO value, Round Lake appears to provide optimal habitat conditions for both juvenile and adult lake trout. These results strongly suggest that dissolved oxygen is not a contributing factor with respect to perceived or measured poor recruitment of juvenile lake trout in Round Lake.

3.5 Spawning Shoal Mapping

In 2002, an assessment of the spawning shoals was conducted manually by physically wading into the water and using measuring sticks to record water depth on top of the shoal and at its drop-offs (Côté, 2003). This survey resulted in an approximation of the amount of habitat present and at what elevation. This effort led MNR to conclude, on the basis of the information available at the time, that impacts to incubating eggs would occur if water levels dropped below 104.8 m local datum (170.4 m asl).

3.5.1 2006 Mapping Methodology

The mapping of habitat is a challenging task even under the best of conditions. The accurate mapping of lake trout habitat underwater created a unique challenge. This mapping is critical in describing the location, quantity and elevation of suitable spawning habitat for lake trout in Round Lake. This information is key to implementing water management regimes that do not negatively impact on fish reproduction.

A more comprehensive mapping exercise than the 2002 effort was carried out in 2006 to not only map the elevations and shoals in detail, but to also identify and quantify suitable spawning substrate and associated elevations.

The same equipment used to collect bathymetric data (Section 3.3) was used to collect spawning habitat data. However, the addition of an underwater video camera system (AquaView) was utilized in accurately identifying and mapping of spawning substrate.

The first question considered was to identify what constituted suitable spawning substrate for lake trout so it could be mapped and identified. Figure 5 shows the actual substrate material in Round Lake (AquaView photograph) that was defined as suitable spawning substrate for the purposes of mapping the spawning habitat. This material consisted predominantly of rounded rubble with periodic distribution of larger cobble sized materials. The substrate was found to be clean and not armoured. It provided the necessary interstitial spaces for eggs to be deposited and be protected during the winter incubation period. The presence of interstitial spaces was the primary indicator for suitable habitat.

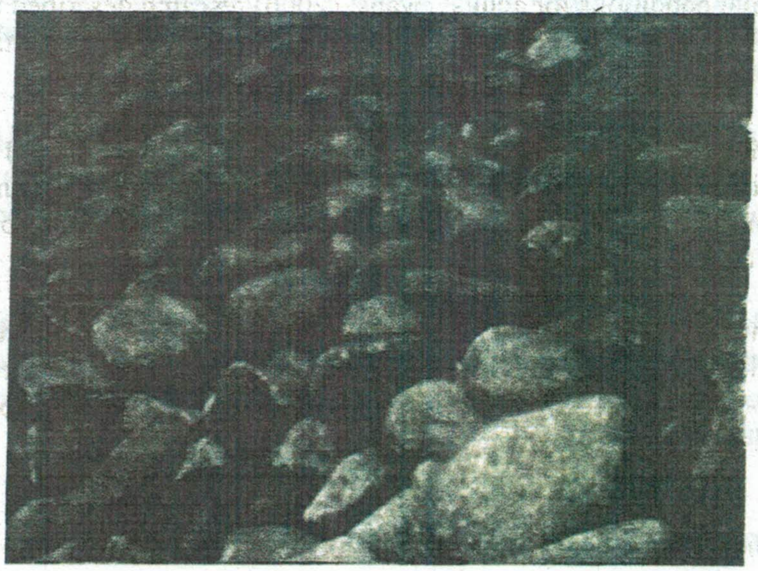


Figure 5. View of substrates considered as spawning habitat.

Marsden et al (1995) emphasized the importance of interstitial spaces between the substrates to provide protection from predation and scour caused by wind and wave action. Kelso *et al* (1995) noted that areas of the spawning shoals with a slope of greater than 15° tended to have greater interstitial depths as less fine material settled in these areas.

Unsuitable substrate consisted of rubble and cobble material that was embedded with sand or gravel, and contained no interstitial spaces for eggs to fall into and be protected (Figure 6).

The suitability of spawning habitat was classified in this manner due to the ease of viewing substrate via the underwater camera. Substrate size was not used for defining suitable vs. unsuitable spawning habitat in this mapping exercise simply due to the difficulty and workload involved in measuring substrate sizes throughout each of the four shoals. Presence of interstitial spaces remained the key parameter for suitable spawning habitat regardless of what size the substrate was.

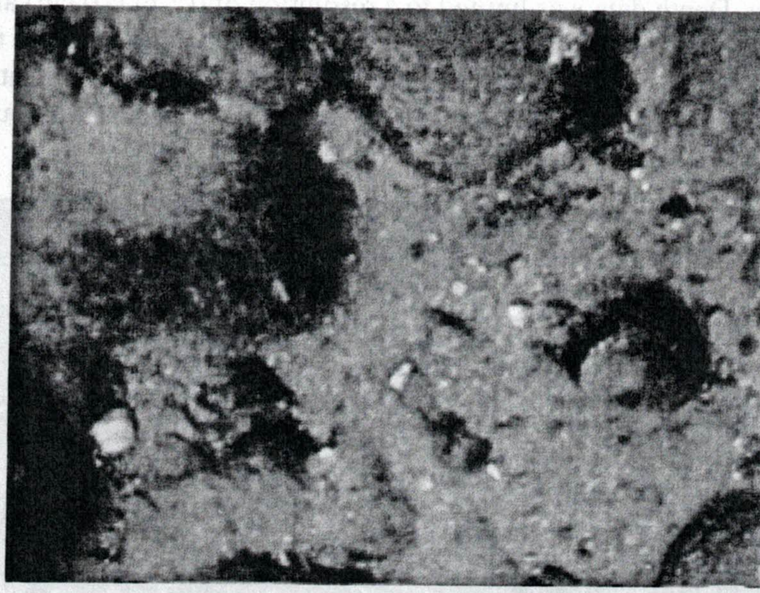


Figure 6. Example of substrates considered unsuitable for spawning.

To our knowledge, a formal methodology or manual of instruction had not been developed describing the process of identifying and collecting spawning substrate information using bathymetry equipment and under water cameras. As a result, a methodology was developed by Darwin Rosien, Senior Fish & Wildlife Technical Specialist, MNR Pembroke District.

In short, the process for mapping suitable lake trout spawning material involved deploying the underwater video camera next to the sonar transducer. The camera was mounted on a 3 m fibreglass pole that could be manoeuvred up or down in the water column and rotated to view the bottom as the boat slowly moved across the entire shoal surface. Images being captured by the camera could be viewed in real time on the connected display monitor. Habitat deeper than three meters was not targeted as this is outside the typical spawning depth range for lake trout and whitefish (Scott and Crossman, 1973). However, if visibility on the display monitor allowed the identification of suitable habitat deeper than 3m, then it was mapped as well.

This method worked best with a two person crew. One person would operate the camera and control its depth and position while observing the display monitor while the other crew person would navigate the boat across all areas of the shoal using the information from the underwater camera, laptop and GPS sonar.

The BASS program on the laptop provided the navigator a visual display of where they were positioned, where they had been (via tracks) and where they needed to go in order to cover all areas of the shoal. The program has a toggle switch that allows the user to easily turn on/off data logging (x,y,z data) based on what was being viewed on the display monitor.

The combination of using the BASS program and observing the bottom substrate from the underwater camera allowed the navigator to selectively collect or not collect bathymetry information (x,y,x) depending on whether they were navigating over suitable or unsuitable substrates for lake trout spawning . Turning the BASS system on only when passing directly over suitable habitat allowed the accurate collection of position (x,y) and depth (z) data of suitable spawning substrate. Depth data was limited to a resolution of 0.1 m (10 cm) and could not be defined at a finer scale due to limitations of the depth sounder. This data was then mapped using a Geographic Information System (GIS) and analyzed to calculate the amount of habitat at various elevations. This method of data collection was used on each of the four shoals (off each of the four islands) identified in Round Lake (Figure 7).

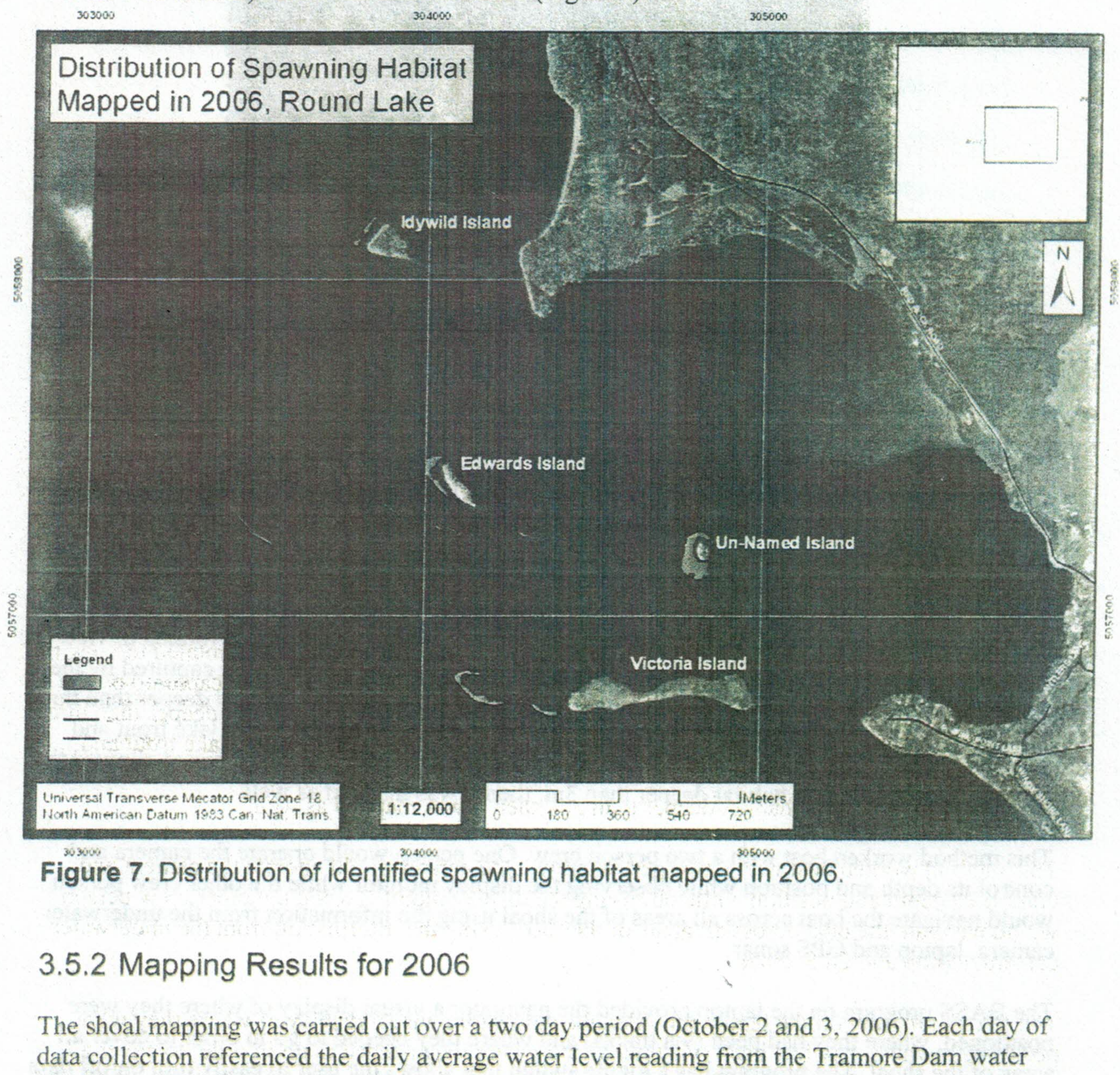


Figure 7. Distribution of identified spawning habitat mapped in 2006.

3.5.2 Mapping Results for 2006

The shoal mapping was carried out over a two day period (October 2 and 3, 2006). Each day of data collection referenced the daily average water level reading from the Tramore Dam water level gauge. The water level readings were 170.87 m and 170.85 m asl respectively, which represented a water level difference of only 0.02 m between each day. This difference was insignificant as the resolution at which the sonar could detect a depth change was 0.1 m (10 cm) or greater.

Once the collection of depth and position (x,y,z) for each shoal was completed using the above methodology, the data was imported into ArcMap (Version 9.1) to display and analyze the collected data points.

3.5.2.1 Victoria Island Shoal

Figure 8 illustrates the distribution of data points that were collected on the Victoria Island Shoal using the BASS system in combination with an underwater video camera. Data points are displayed over the one meter contour lines and depth shading that was produced from the 2005 bathymetric survey. A polygon was generated from the data points to illustrate and quantify the extent of suitable spawning habitat.

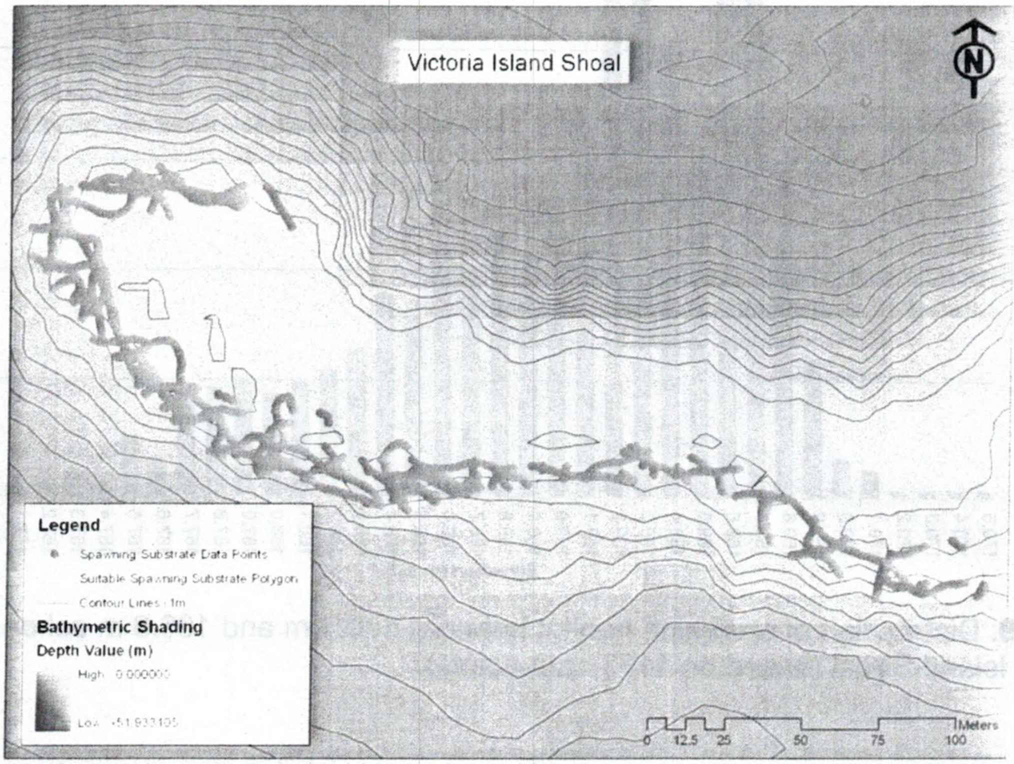


Figure 8. Distribution of spawning habitat on Victoria Island Shoal in relation to bathymetric contours.

The collected data points (x,y position and z, depth) represent suitable spawning substrate and are useful in quantifying the frequency or amount of habitat at a specific elevation or a range of elevations. The data points were randomly collected and were not intended to be collected in a manner that equally distributed their collection spatially. Data points were collected automatically at an interval of every second while over top of suitable spawning substrate.

Figure 9 illustrates the number of data points that represent spawning habitat at specific elevations on the Victoria Island shoal. These elevations were derived from subtracting the depth (z) data from the average daily water level for the days the data was collected. Both data sets were referenced to the daily average water level reading of 170.8 m asl (which represented 170.87 m and 170.85 m) for October 2 and 3, 2006.

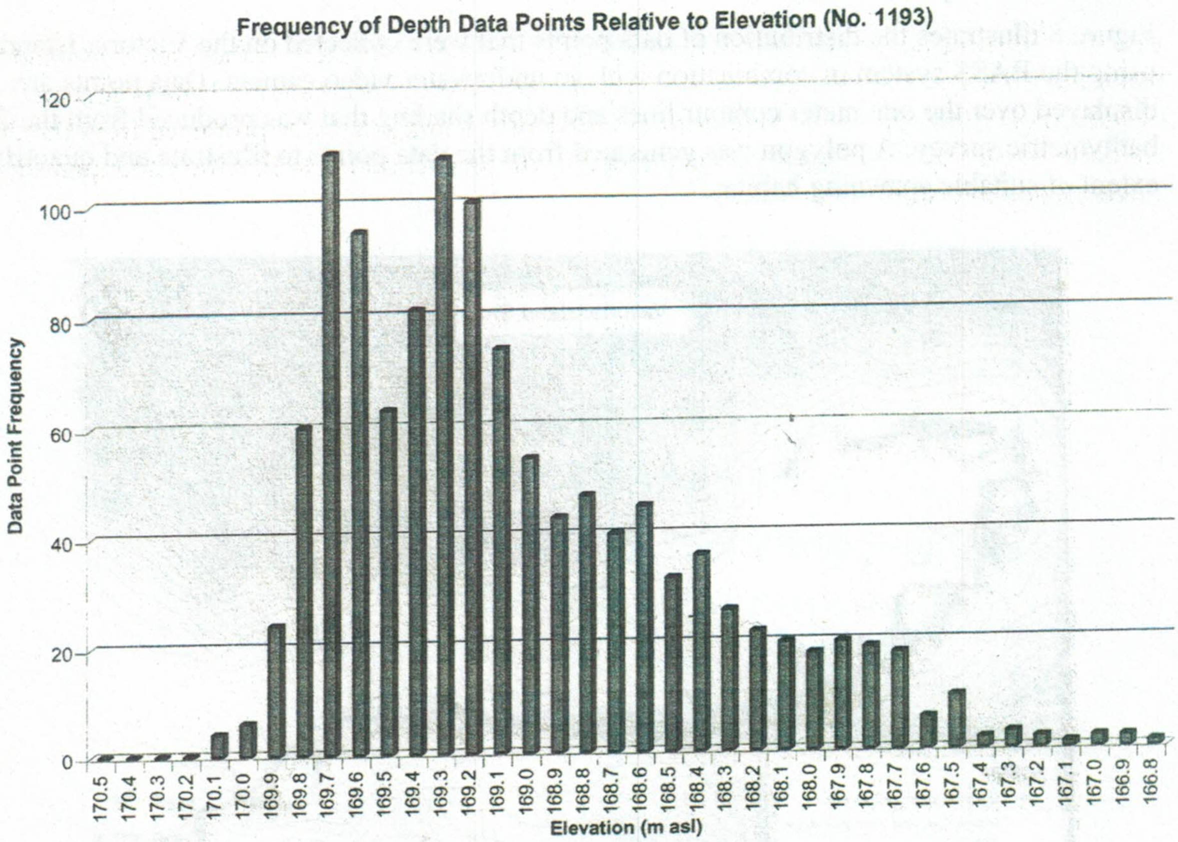


Figure 9. Distribution of spawning habitat between 170.1 m and 166.8 m asl on the Victoria Island Shoal (based on 1193 data points).

Table 5 provides a summary of spawning habitat and associated elevation ranges. Approximately 37 percent of the data points represent habitat that exists between 170.5 m and 169.5 m asl. Another 28 percent of data points are represented immediately below this in the elevation range of 169.4 m to 169.1 m asl. The quantity of data points below these elevations begin to drop off substantially as depth increases. However, habitat deeper than what was observable by the underwater camera could not be mapped.

Table 5. Habitat Elevation Summary - Victoria Island Shoal

Depth	Elevation Range	Data Point Frequency	Percentage
0.3 to 0.6	170.5 to 170.2	0	0.0%
0.7 to 1m	170.1 to 169.8	94	7.9%
1.1 to 1.3m	169.7 to 169.5	348	29.2%
1.4 to 1.7m	169.4 to 169.1	336	28.2%
1.8 to 2.1m	169.0 to 168.7	175	14.7%
2.2 to 2.5m	168.6 to 168.3	116	9.7%
2.6 to 2.9m	168.2 to 167.9	77	6.5%
3 to 3.3m	167.8 to 167.5	36	3.0%
3.4 to 3.7m	167.4 to 167.1	8	0.7%
3.8 to 4.1m	167.0 to 166.7	3	0.3%
	Total	1193	100.0%

A calculation of the total amount of suitable habitat in terms of area was performed using a polygon feature that was created from the outline/outside edge of all the data points representing suitable substrate for spawning (Figure 7). Although not a flat feature, this was interpreted by the GIS as being a flat surface and calculated one area measurement for the entire zone occupied by the data points regardless of elevation. Based on calculating the area as described above, the Victoria Island shoal consists of approximately 5618 m^2 (0.56 ha) of spawning habitat with suitable substrate size for lake trout.

3.5.2.2 Edwards Island Shoal

Figure 10 and 11 show the distribution of mapped spawning habitat for the Edwards Island Shoal. Table 6 summarizes the percentage of spawning habitat associated with various elevation ranges. Approximately 44 percent of the data points represent habitat that exists between 170.5 and 169.5 m asl. Another 36 percent of data points are represented immediately below this in the elevation range of 169.4 m to 169.1 m asl. Similarly to Victoria Island shoal, the quantity of data points below these elevations begin to drop off substantially as depth increases.

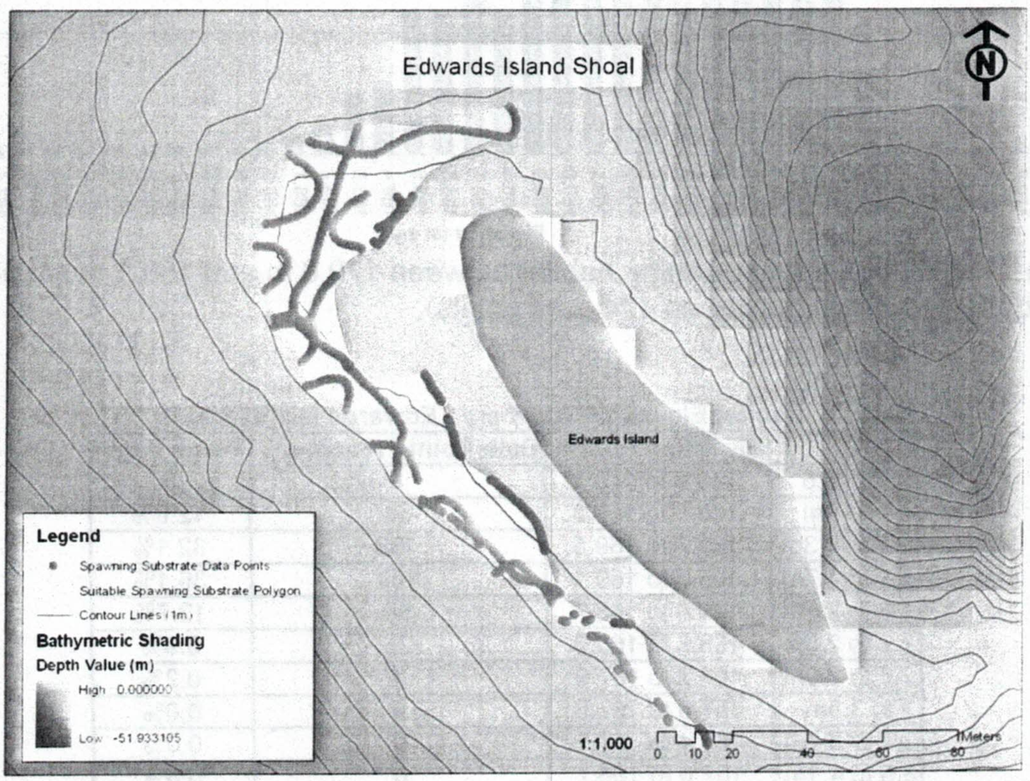


Figure 10. Distribution of spawning habitat on Edwards Island Shoal in relation to bathymetric contours.

Although the data points were not equally spaced (spatially), the primary intent was to identify spawning substrate and their random distribution accurately describes the location of spawning habitat. The depth (and conversion to elevation) should also be considered accurate, however it should be noted that the density of data points collected was not equal across all areas being mapped. This was an expected outcome, as the intent was to map spawning habitat as it was being identified and not on tracking the density of data points.

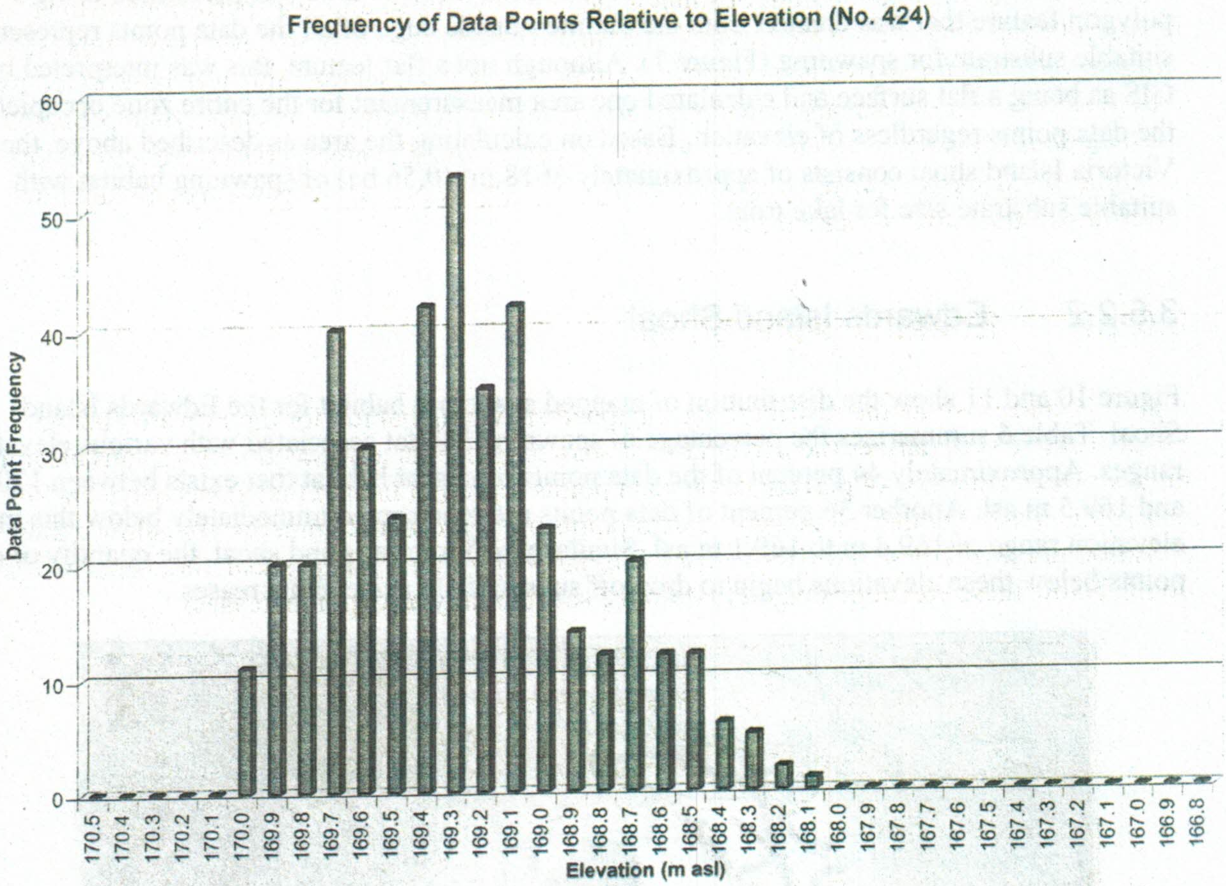


Figure 11. Distribution of spawning habitat between 170.0 m and 168.1 m asl on the Edwards Island Shoal (based on 424 data points).

Table 6. Habitat Elevation Summary - Edwards Island Shoal

Depth	Elevation Range	Data Point Frequency	Percentage
0.3 to 0.6	170.5 to 170.2	0	0
0.7 to 1m	170.1 to 169.8	51	12.0%
1.1 to 1.3m	169.7 to 169.5	136	32.1%
1.4 to 1.7m	169.4 to 169.1	153	36.1%
1.8 to 2.1m	169.0 to 168.7	58	13.7%
2.2 to 2.5m	168.6 to 168.3	25	5.9%
2.6 to 2.9m	168.2 to 167.9	1	0.2%
3 to 3.3m	167.8 to 167.5	0	0.0%
3.4 to 3.7m	167.4 to 167.1	0	0.0%
3.8 to 4.1m	167.0 to 166.7	0	0.0%
	Total	424	100.0%

The amount of suitable spawning substrate for lake trout was calculated to be approximately 3490 m^2 (0.34 ha) using the polygon defined from the data points that represented spawning habitat.

3.5.2.3 Idywild Island Shoal

Figures 12 and 13 show the distribution of mapped spawning habitat for the Idywild Island Shoal. Table 7 summarizes the percentage of spawning habitat associated with various elevation ranges. Approximately 36 percent of the data points represent habitat that exists between 170.5 m and 169.5 m asl. Another 18 percent of data points are represented immediately below this in the elevation range of 169.4 m to 169.1 m asl. A total of 1516 m^2 (0.15 ha) of suitable spawning substrate exists for lake trout on the Idywild Island shoal.

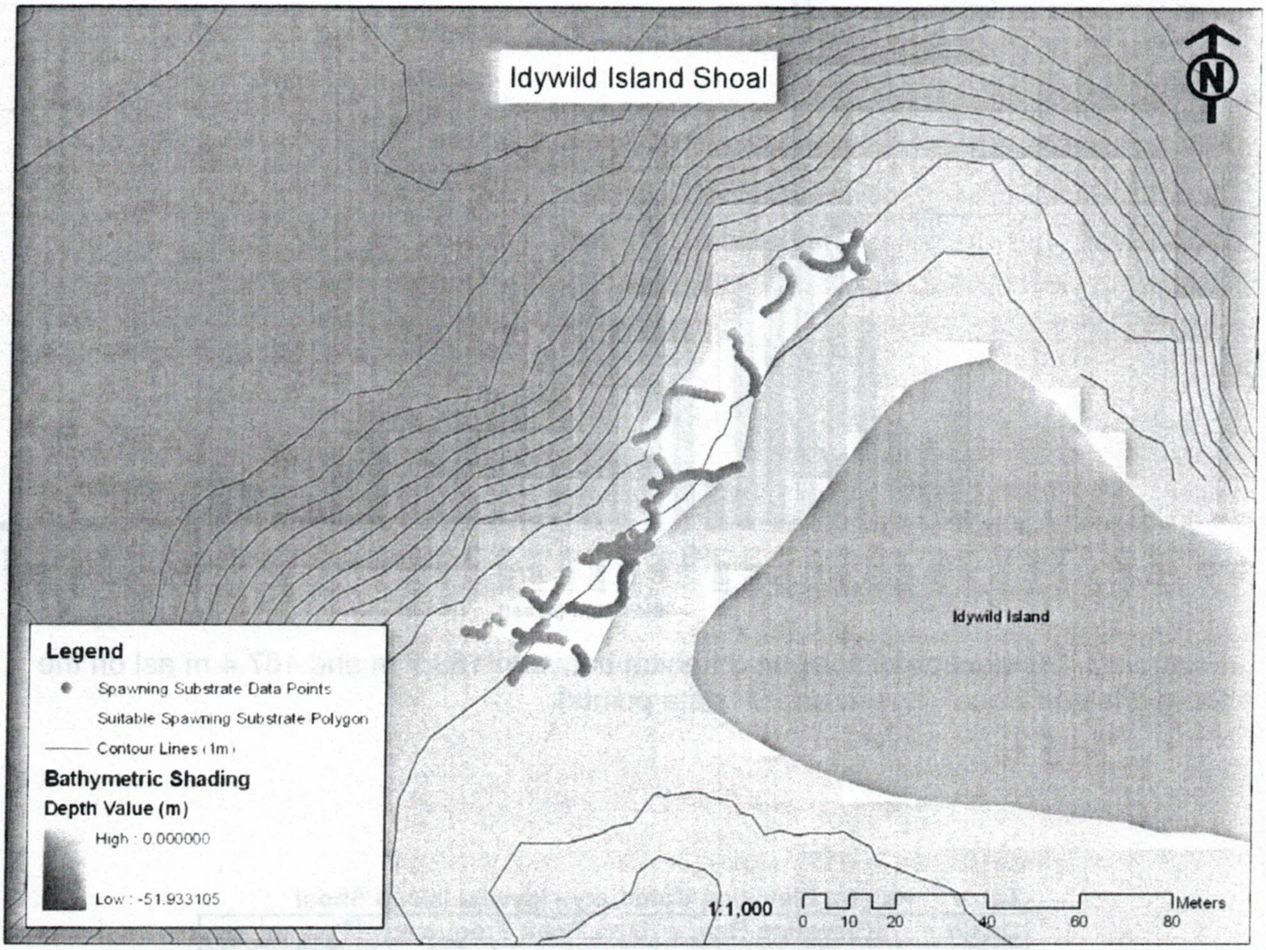


Figure 12. Distribution of spawning habitat on Idywild Island Shoal in relation to bathymetric contours.

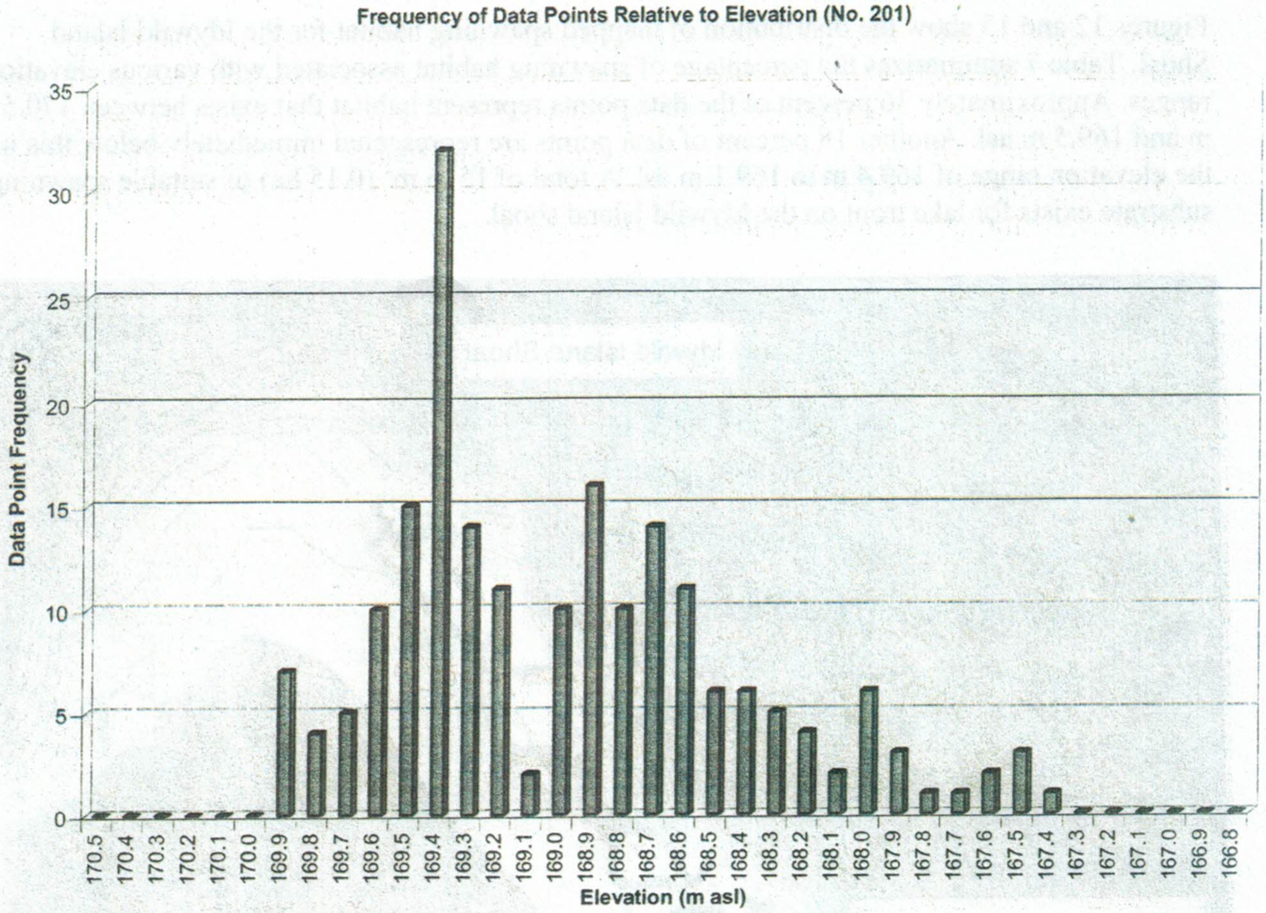


Figure 13. Distribution of spawning habitat between 169.9 m and 167.4 m asl on the Idywild Island Shoal (based on 201 data points).

Table 7. Habitat Elevation Summary - Idywild Island Shoal

Depth	Elevation Range	Data Point Frequency	Percentage
0.3 to 0.6	170.5 to 170.2	0	0.0%
0.7 to 1m	170.1 to 169.8	11	5.5%
1.1 to 1.3m	169.7 to 169.5	62	30.8%
1.4 to 1.7m	169.4 to 169.1	37	18.4%
1.8 to 2.1m	169.0 to 168.7	51	25.4%
2.2 to 2.5m	168.6 to 168.3	21	10.4%
2.6 to 2.9m	168.2 to 167.9	12	6.0%
3 to 3.3m	167.8 to 167.5	7	3.5%
3.4 to 3.7m	167.4 to 167.1	0	0.0%
3.8 to 4.1m	167.0 to 166.7	0	0.0%
	Total	**201**	**100.0%**

3.5.2.4 Un-named Island Shoal

Figure 14 and 15 show the distribution of mapped spawning habitat on the Un-named Island shoal. Table 8 summarizes the percentage of spawning habitat associated with various elevation ranges. Approximately 50 percent of the data points represent habitat that exists between 170.5 and 169.5 m asl. Another 24 percent of data points are represented immediately below this in the elevation range of 169.4 m to 169.1 m asl. This shoal has a calculated total area of 7396 m^2 (0.73 ha) of spawning habitat for lake trout, which is larger than that found on the Victoria Island Shoal.

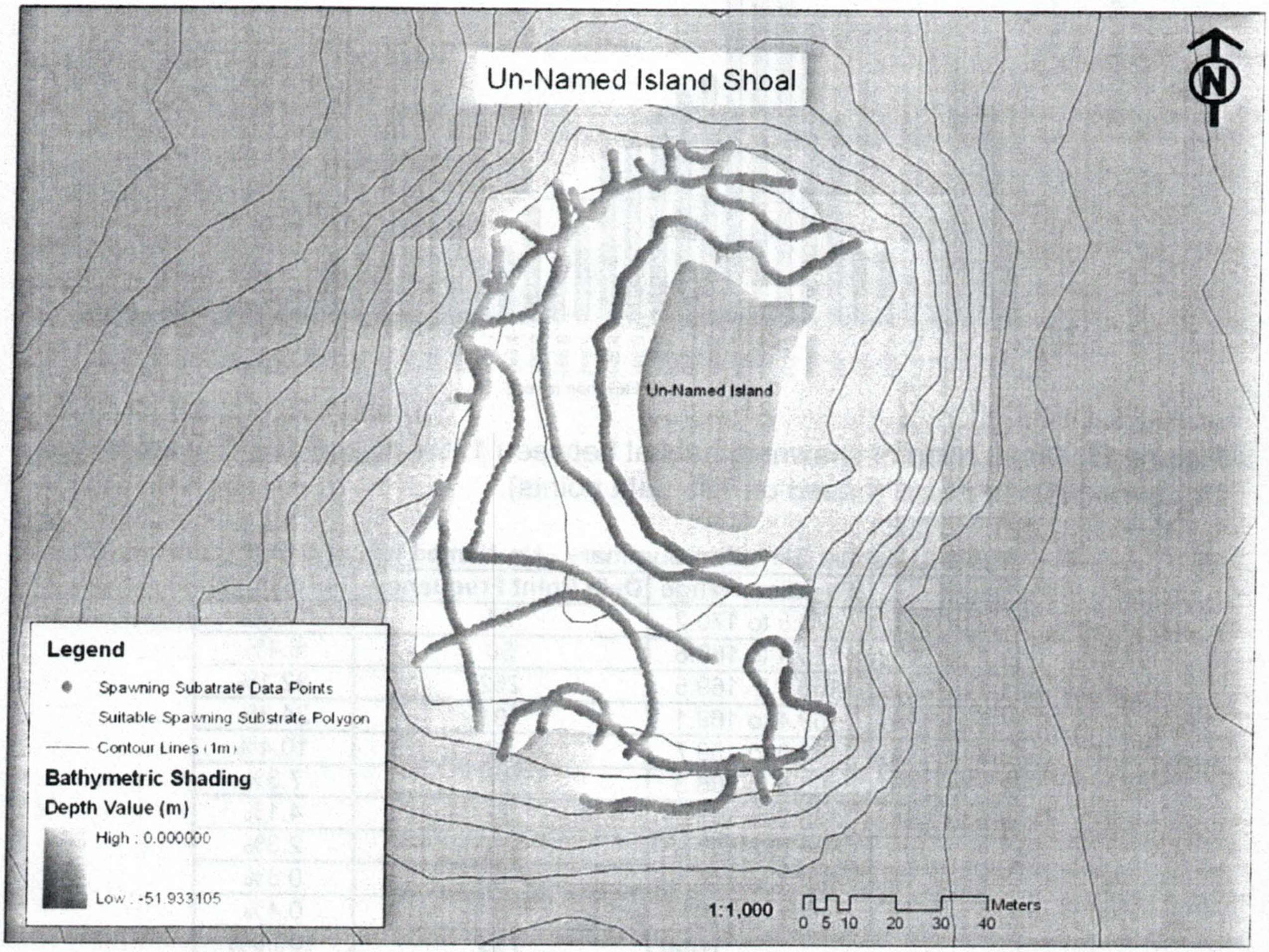


Figure 14. Distribution of spawning habitat on Un-named Island Shoal in relation to bathymetric contours.

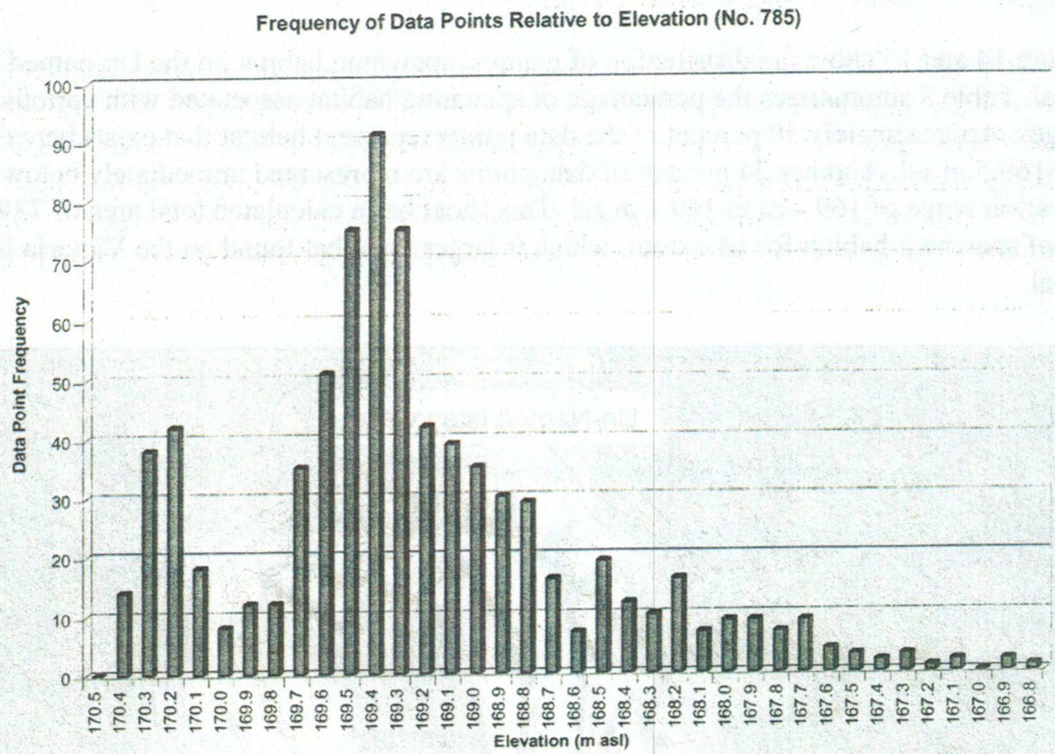


Figure 15. Distribution of spawning habitat between 170.4 m and 166.8 m asl on the Un-named Island Shoal (based on 785 data points).

Table 8. Habitat Elevation Summary - Un-Named Island Shoal

Depth	Elevation Range	Data Point Frequency	Percentage
0.3 to 0.6	170.5 to 170.2	94	12.0%
0.7 to 1m	170.1 to 169.8	50	6.4%
1.1 to 1.3m	169.7 to 169.5	252	32.1%
1.4 to 1.7m	169.4 to 169.1	191	24.3%
1.8 to 2.1m	169.0 to 168.7	82	10.4%
2.2 to 2.5m	168.6 to 168.3	57	7.3%
2.6 to 2.9m	168.2 to 167.9	32	4.1%
3 to 3.3m	167.8 to 167.5	18	2.3%
3.4 to 3.7m	167.4 to 167.1	6	0.8%
3.8 to 4.1m	167.0 to 166.7	3	0.4%
	Total	785	100.0%

3.5.2.5 Spawning Habitat Mapping Summary

The methodology and equipment used to identify and accurately map spawning habitat for lake trout in Round Lake proved to be successful compared to previous attempts. The technological changes have enabled spatial measurements and mapping using GPS and GIS software that otherwise would prevent such analysis. The addition of an underwater camera allowed us to identify substrate material and map only what is suitable for lake trout spawning. Table 9 shows a summary of each shoal's measurements.

Table 9. Quantitative Summary of Spawning Habitat by Shoal in Round Lake

Shoal Name	Area		Area %	# of Data Points	Data Pt Density pts /m2	Min Habitat Depth (m)	Min Habitat Elevation (m asl)	Max Habitat Depth (m)	*Max Habitat Elevation
	Meters Squared	Hectares							
Victoria	5618	0.56	31.2%	1193	0.21	-0.7	170.1	-4	166.8
Edwards	3490	0.34	19.4%	424	0.12	-0.8	170.0	-2.7	168.1
Idywild	1516	0.15	8.4%	201	0.13	-0.9	169.9	-3.4	167.4
Un-named	7396	0.73	41.0%	785	0.10	-0.4	170.4	-4	166.8
Totals >	**18,020**	**1.78**	**100.0%**	**2603**					

* Note: The underwater video camera was only able to observe to these depths. Habitat may continue to deeper depths.

The information summarized in Table 9 is entirely from the data points representing suitable spawning habitat on each of the shoals. Although the density of data points (# of data points per m^2 of identified habitat) was not equal across each shoal, similar densities were successfully collected on each shoal.

It could be argued that the intensity of data collection was not equal for all shoals and thus would possibly influence the minimum and maximum statistics; however, the attribute information obtained from the data points was an artefact or secondary product of the primary goal (mapping suitable habitat). This primary goal was to complete and accurately describe the location of suitable spawning substrate for lake trout in Round Lake.

3.6 Confirmation of Timing and Location of Spawning

In 2006 MNR identified four possible shoals where lake trout might be spawning, based on suitable substrates. These were shoals at Victoria Island, Idywild Island, Edwards Island and an unnamed Island (Location = NAD83, Z18 E304820, N5057200). A short-duration gill netting exercise was used to confirm the relative importance of these habitats for spawning as well as to confirm the time of spawning.

In 2007 MNR and NRSI repeated the gill net exercise focusing exclusively on the Victoria Island Shoal, as it is considered to be the primary spawning area in Round Lake based on 2006 gill netting conducted the previous year.

3.6.1 Methodology for Spawning Assessment

Lake trout are autumn broadcast spawners, meaning they do not create a redd, or nest, but instead release reproductive products while slowly swimming along slopes of cobble and rubble during the fall (Tibbits, 2003, Dawson *et al*, 1997, Gunn, 1995, Scott and Crossman, 1973). Choice of location favours regions with stronger currents or wave action, which reduces particulate accumulation on incubation sites (Gunn, 1995). There may be some influence by site and kin recognition, as well as chemosensory cues (Gunn, 1995). Water temperature, wind direction and intensity, and the rate of temperature decline all influence the timing and duration of the spawning period (Gunn, 1995, Scott and Crossman, 1973). Determination of the lake trout spawning period in 2006 and 2007 was confirmed by gill net census directly over mapped spawning substrate. Also, visual observations and timing trends closely followed those stated in peer-reviewed literature.

Bottom-set gill nets targeting spawning lake trout tend to be successful when deployed over windward ridges of suitable spawning substrate (Janssen *et al,* 2006) and adjacent to deep water (Bronte *et al*, 2007, Janssen *et al,*2006, Kelso *et al,* 1995, Bronte, 1993).

Three nets, each with 4.5 inch mesh, 50 m long and 2 m in height were tied together to form a gang. These connected panels of sinking mesh monofilament were deployed at a depth of about 2 m along Victoria Island Shoal to target spawning activity. The short set gill net method was employed on three nights between 26 September and 18 October, 2006 and four nights between October 11 and November 2, 2007 from 1900 to 2130 hours. Duration of each set was between 20 to 100 minutes in order to minimize mortalities. The duration of sets were shortened as weather conditions worsened.

3.6.2 Gill Netting Results for 2006

Sampling was conducted on the nights of September 26, October 10 and 18, 2006 over mapped spawning substrate located on each of the four identified shoals. As indicated in Table 10, the majority (19) of the lake trout were captured on Victoria Island shoal, while the Un-named Island shoal produced three lake trout and Edwards Island shoal produced one. No lake trout were captured on the Idywild Island shoal.

Table 10. 2006 Short Duration Gill Netting Results

Netting Attributes								Species							
Date	Net #	Shoal Name	Mesh Size	Set Time	Lift Time	Temp	Duration (hours)	Lake Trout	Whitefish	Rainbow Smelt	White Sucker	Rock Bass	Smallmouth Bass	Walleye	Comments
Sept 26,06	1	Victoria	2"	19:00	19:50	13.8	0.83	0	0	0	0	1	0	0	mesh size could be too small
Sept 26,06	2	Un-named	2"	19:25	20:15	14.0	0.83	0	0	1	0	0	0	0	
10-Oct-06	1	Victoria	4"	18:40	19:30	11.1	0.83	7	10	0	3	0	1	1	
10-Oct-06	2	Un-named	5"	18:50	20:15	11.3	1.41	0	0	0	2	0	0	0	1 LT escaped off net
10-Oct-06	3	Edwards	4"	20:30	21:30	11.4	1	0	0	0	0	0	0	0	
10-Oct-06	4	Idywild	5"	20:40	21:20	11.4	0.66	0	0	0	0	0	0	0	
18-Oct-06	1	Victoria	4"	18:30	19:05	9.3	0.58	12	9	0	3	0	0	0	
18-Oct-06	2	Un-named	5"	18:43	20:00	9.3	1.28	3	2	0	3	0	0	0	
18-Oct-06	3	Edwards	4"	20:39	21:05	9.4	0.43	1	1	0	2	0	0	1	
18-Oct-06	4	Idywild	5"	20:50	21:30	9.4	0.66	0	0	0	0	0	0	0	
						Totals >>	8.51	23	22	1	13	1	1	2	

The gill netting effort produced a limited number of female lake trout to judge the progression of the spawning period (Table 11). However, the increasing quantity of lake trout being observed on the shoals during each night of gill netting seemed to provide a general indication of pre and peak spawning. Based on the 2006 gill netting results, the Victoria Island shoal appeared to attract the most lake trout compared to the other three identified shoals. This attraction may be a function of the shoals orientation to the prevailing winds or possible homing tendency common in lake trout.

Table 11. Lake Trout Catch Attributes - Round Lake, 2006

Date	Net #	Shoal	Total Length (mm)	Fork Length (mm)	Weight (grams)	Sex	Clips	Comments
10-Oct-06	1	Victoria Island	783	716	4000	M	none	Ripe
10-Oct-06	1	Victoria Island	811	745	5200	M	none	Ripe
10-Oct-06	1	Victoria Island	867	788	5700	M	none	Ripe
10-Oct-06	1	Victoria Island	845	768	5600	M	none	Ripe
10-Oct-06	1	Victoria Island	795	735	5600	M	none	Ripe
10-Oct-06	1	Victoria Island	831	764	6700	M	none	Ripe
10-Oct-06	1	Victoria Island	802	732	7100	F	none	Green
18-Oct-06	1	Victoria Island	788	720	4900	M	none	Ripe
18-Oct-06	1	Victoria Island	750	687	4550	M	none	Ripe
18-Oct-06	1	Victoria Island	780	706	5100	M	none	Ripe
18-Oct-06	1	Victoria Island	782	715	5500	M	none	Ripe
18-Oct-06	1	Victoria Island	833	766	6400	M	none	Ripe
18-Oct-06	1	Victoria Island	762	701	5200	M	none	Ripe
18-Oct-06	1	Victoria Island	765	708	5100	M	none	Ripe
18-Oct-06	1	Victoria Island	841	770	5300	M	none	Ripe
18-Oct-06	1	Victoria Island	783	718	4800	M	none	Ripe
18-Oct-06	1	Victoria Island	789	730	5750	M	none	Ripe
18-Oct-06	1	Victoria Island	788	730	5300	M	none	Ripe
18-Oct-06	1	Victoria Island	821	754	5700	M	none	Ripe
18-Oct-06	2	Un-Named Island	757	695	4400	F	none	Ripe
18-Oct-06	2	Un-Named Island	790	729	5500	M	none	Ripe
18-Oct-06	2	Un-Named Island	713	653	3400	M	none	Ripe
18-Oct-06	3	Edwards Island	807	745	5100	M	none	Ripe
		MIN	*713*	*653*	*3400*			
		MAX	*867*	*788*	*7100*			
		AVG	*794.91*	*729.35*	*5300.00*			

3.6.3 Gill Netting Results for 2007

Sampling was conducted on the nights of October 11, 15, 22, and November 2, 2007 over mapped spawning habitat on the Victoria Island Shoal only. Since the 2006 spawning assessment revealed that the majority of the spawning was occurring on this shoal, it was decided that sampling should be more focused to this shoal in order to maximize limited resources within the available timeframe. Gill net catch results are shown in Table 12.

Table 12. 2007 Short Duration Gill Netting Results

Date	Male Green	Male Ripe	Male Spent	Unknown	Female Green	Female Ripe	Female Spent	Total Lake Trout
11-Oct-07	0	3	0	0	0	0	0	3
15-Oct-07	0	8	0	0	0	0	0	8
22-Oct-07	0	10	0	2	3	3	0	18
02-Nov-07	0	1	4	0	0	0	2	7

In total, 36 lake trout were collected of which 26 were males, 8 were females and 2 were unknown (Table 12). Determination of sex was confirmed by a sample of the reproductive products (i.e. milt and eggs). Total length for each fish was not recorded due to inclement weather and/or field efforts being preferentially dedicated to the activities for the time-sensitive preparation of the egg incubators (Section 5). Clipping the adipose fin for genetic samples provided a means to identify fish collected previously in the gill netting program or during the 2007 Summer Profundal Index Netting (SPIN) study. Only two fish caught during the short set gill netting program had been fin clipped during earlier handling. Genetic samples from adipose fins were taken from all trout except those caught on October 11, 2007.

The following describes the nightly results from the 2007 gillnet program.

October 11, 2007: *Early arrivals.* Only male lake trout were caught onsite. Weather conditions on the night of October 11th consisted of drizzle with total cloud cover, progressing to strong winds and high waves. Temperatures were taken at 21:10 for air and water, and were respectively, 12.8° Celsius and 10° Celsius. The crew set four nets of 2-3 panels each, over two hours. The fish collected (Table12) were three ripe male lake trout, one lake whitefish (*Coregonus clupeaformis*), one white sucker (*Catostomus commersoni*) and two smallmouth bass (*Micropterus dolomieu*). It was evident from the catch that the male lake trout appeared on the shoal prior to the females. This is consistent with observations by Gunn (1995) and Scott and Crossman (1973).

October 15, 2007: *Staging.* Sampling efforts resulted in the collection of eight ripe male lake trout that had not been previously caught (no fin clip) (Table12). The weather was rough, with high winds and waves during the sets. The combination of observations and netting results indicated the mass assembling of lake trout on Victoria Island Shoal. Martin (1956) identified this phenomenon as a key indication of pre-spawning congregation, or staging, which leads to active spawning.

October 22, 2007: *Spawning.* This was the most successful night of netting with a total catch of six female, and 10 male lake trout. The females were found to be in the following spawning condition: three ripe, two green and two undetermined. All ten males were in ripe condition (Table 12). Males had been on the spawning grounds about 10 days prior to the arrival of the females which is consistent with the observations of Gunn (1995). Two lake trout were missing portions of their adipose fins, evidence of previous handling (DNA samples). Both males and females were in ripe condition and present over suitable spawning substrate.

November 2, 2007: *Activity waning*. The night was cloudy with an air temperature of 9.1° Celsius at 1900 hours. A collection of 16 fish were retrieved from the single gang set. The fish were identified as four spent male lake trout, two spent female lake trout and one ripe male lake trout (7 lake trout total), and nine lake whitefish, all green with hard bellies and no eggs observed (Table 12). All lake trout adipose fins were clipped prior to release. Spawning was almost over as evidenced by six spent lake trout (four male, two female) and one ripe male. Gunn (1995) also found that the male lake trout remain at the spawning sites for a time after the females had left. The presence of pre-spawn lake whitefish at the shoal was also an indication that lake trout spawning activity was ending. Pre-spawn accumulation of lake whitefish usually only begins at the tail end of lake trout reproduction as water temperature continues to drop (Scott and Crossman, 1973).

3.6.4 2007 Observation Results of Spawning

Congregations of lake trout were first noted along the south western slope of Victoria Island Shoal during the evening of October 11, 2007. An estimated 12 fish were seen in about 1 to 2 m of water, with groups of two and three fish swimming close together. Janssen *et al* (2006) observed this close swimming as well and considered it evidence of the onset of the staging period and initiation of spawning period. On the evening of October 26, 2007, approximately 30 trout were seen by spotlight in the murky water. The pale white/silver sheen occasionally observed on reproducing lake trout, and reported by Gunn (1995), reflected distinctly in the spotlights. Fish swam mainly along the windward precipice of the shoal consistent with descriptions by other observers (Janssen *et al*, 2006, Weatherley *et al*, 1996). An attempt to videotape the lake trout on the shoal was unsuccessful. This night was considered to be the peak of spawning activity. It was noted that there was little aggression displayed by the fish, even during peak activity. Gunn (1995) also had similar notes.

Only two lake trout were observed on the evening of November 2, 2007. Both lake trout had lost the white/silver sheen and regained a darker colouration. Additionally the arrival of whitefish on Victoria Island Shoal was also observed at the time. This was noted as the end of lake trout spawning and the beginning of the whitefish spawn.

3.6.5 Timing of the 2007 Spawning Period

The lake trout spawning period typically lasts for five to 13 days, with an average of 10 days, during the months of September to November (Dawson *et al*, 1997). The timing tends to be delayed in more northern locations (Dawson *et al,* 1997), occasionally even taking place in the spring (Bronte, 1993). It was observed on Round Lake, that congregation of ripe trout began the week of October 11 in Round Lake. Spent lake trout were caught in gill nets on November 2 and so determined the end of the 2007 spawning period. The 2007 spawning period was therefore considered to have lasted approximately three weeks. This was further confirmed by the ripe lake whitefish that were caught in the same nets, as whitefish traditionally begin their spawning activity on the heels of lake trout (Scott and Crossman, 1973)

3.7 Summer Profundal Index Netting (SPIN)

Several information needs related to lake trout have been identified in the Bonnechere River Water Management Plan, including the overall "Status of Lake Trout Population in Round Lake". Little baseline information existed on the impacts of current waterpower operations on the long-term sustainability of the naturally reproducing lake trout population in Round Lake (MNR, 2005). Given this information need, a suitable assessment method was sought to help answer questions around the lake trout population in Round Lake.

Lake Trout are known to occupy a wide range of lake sizes which often require a different approach and intensity of sampling. This species is known to exhibit several life history strategies resulting in divergence of possible adult sizes. Even within a given lake, this species occupies neither a predictable nor constant distribution. To further increase this variability; lake trout are a highly prized sportfish occupying deep clear lakes, ideal for recreation. Populations are often in a degraded state, real or perceived, which calls for a cautious sampling method. This level of variability limits the ability to develop a "one method fits all" approach to lake trout assessment in Ontario (Sandstrom *et al*, 2007). To address the above sampling issues, Summer Profundal Index Netting (SPIN) was developed by the Science and Information and Aquatic Research and Development Sections of the MNR. This methodology allows some degree of flexibility, while maintaining comparability, to suit the specific conditions of the intended lake and population.

3.7.1 SPIN Methodology

The SPIN field methodology was conducted in accordance to the Manual of Instructions and with the direct assistance and expertise of Steve Sandstrom of the Aquatic Science Unit (ASU) of the MNR. Having a biologist who developed the SPIN protocol assist in the Round Lake SPIN ensured existing local staff and consultants were trained to properly and effectively complete the survey. Prior to this survey, no other SPIN work had been conducted within Pembroke District. However, the SPIN methodology and supporting baseline data to derive estimates from was developed and tested from lakes across the province including controlled test lakes.

3.7.1.1 Lake Stratification

Data from the bathymetric mapping of Round Lake was used to stratify and calculate stratum areas prior to field work. This data was also invaluable in calculating the area weighted density estimate and simplifying the site selection process. Figure16 illustrates the distribution of depths in Round Lake. Warm water above the thermocline (not typically utilized by lake trout during the summer) occupies approximately the first 10 meters of depth, after which, depths are reported at five meter intervals until a depth of 40 meters. Depths beyond 40 meters are categorized in 20 meter intervals. Round Lake has a maximum documented depth of 52 meters.

For the purpose of determining sample sizes for each individual strata and subsequent calculation of the area weighted density estimation, areas of each stratum were calculated by standard GIS processes. Table 13 describes the area (hectare), percentages, quantity of sample sites, and nets within each stratum. It should be noted that in most cases, nets were doubled up (two nets connected together) as a means of increasing biological sample size.

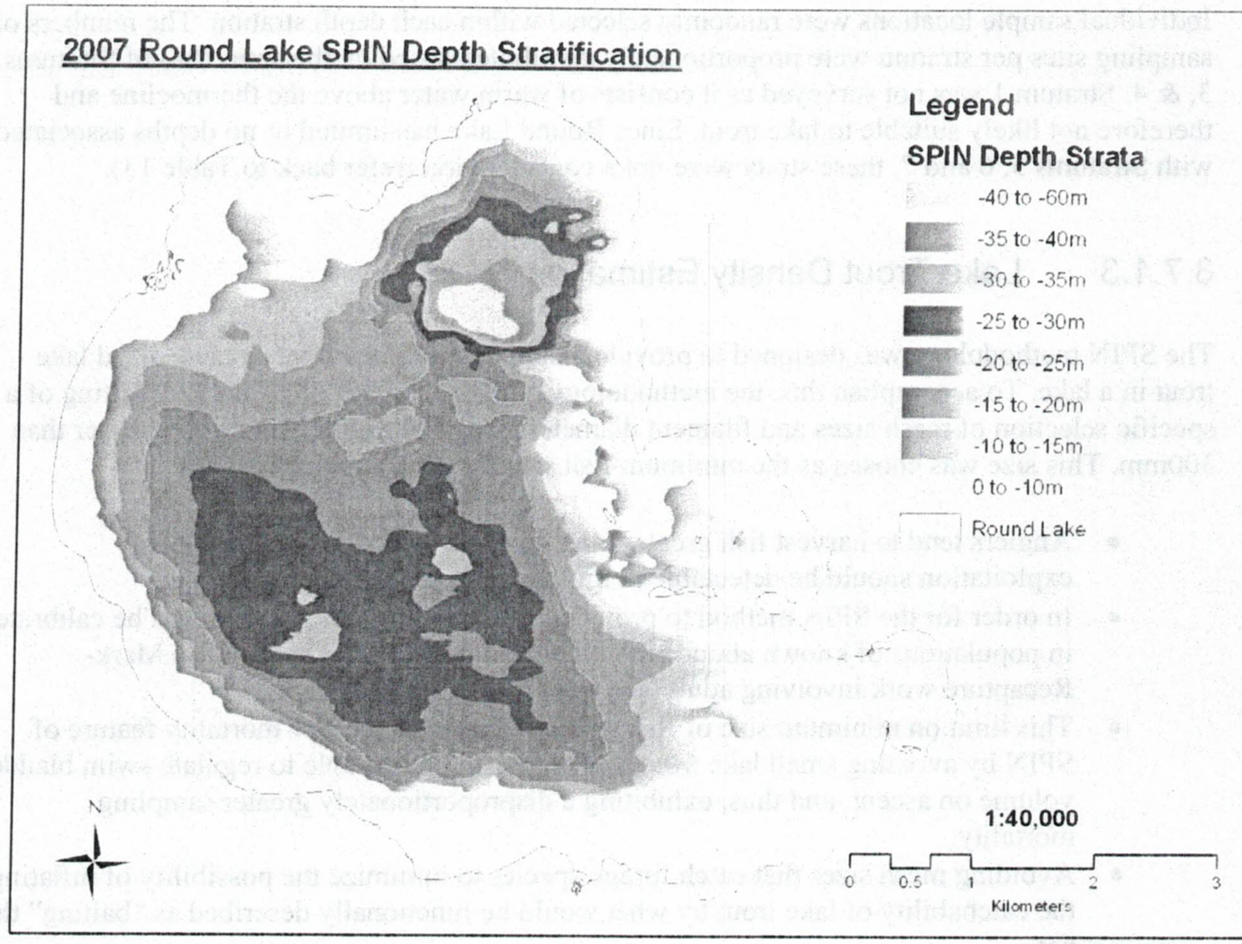


Figure 16. Distribution of depth strata in Round Lake.

Table 13. Distribution of stratum areas, percentages, sample sites and nets.

Stratum Info	Depth Ranges (meter)	Volume $m^3 \times 10^4$	Volume %	Surface Area (ha)	Surface Area (%)	Core Stratum Areas (ha)	Core Stratum Areas (%)	# of Sample Sites	Total # of Nets
Stratum 1	0 to 10	1026.96	35.84	1179.89	39.58	Excluded			
Stratum 2	10 to 15	384.38	13.41	384.13	12.89	753.78	25.28	12	24
	15 to 20	368.08	12.84	369.65	12.40				
Stratum 3	20 to 25	484.9	16.92	508.57	17.06	937.52	31.44	10	16
	25 to 30	459.96	16.05	428.95	14.39				
Stratum 4	30 to 35	93.34	3.26	64.10	2.15	90.91	3.04	3	6
	35 to 40	27.35	0.95	26.81	0.90				
Stratum 5	40 to 60	20.68	0.72	18.91	0.63	18.91	0.63	0	0
	Total	**2865.65**	**100.00**	**2981.01**	**100.00**	**1801.12**	**60.4**	**25**	**46**

3.7.1.2 Random Sample Site Selection

Individual sample locations were randomly selected within each depth stratum. The numbers of sampling sites per stratum were proportionately distributed based on the areas (ha) of Stratums 2, 3, & 4. Stratum 1 was not surveyed as it consists of warm water above the thermocline and therefore not likely suitable to lake trout. Since Round Lake has limited or no depths associated with Stratums 5, 6 and 7, these strata were not a consideration (refer back to Table 13).

3.7.1.3 Lake Trout Density Estimation

The SPIN methodology was designed to provide a density estimate of harvestable sized lake trout in a lake. To accomplish this, the methodology employs the use of gillnets consisting of a specific selection of mesh sizes and filament diameters that will capture lake trout greater than 300mm. This size was chosen as the minimum fish size for the following reasons:

- Anglers tend to harvest fish greater than this size; hence, consequences of exploitation should be detectable in this segment of the population.
- In order for the SPIN method to provide an estimation of density it must be calibrated in populations of known abundance. Calibration of SPIN was done via Mark-Recapture work involving adult lake trout (>300mm in Ontario).
- This limit on minimum size of fish selected improves the low mortality feature of SPIN by avoiding small lake trout that appear to be less able to regulate swim bladder volume on ascent, and thus, exhibiting a disproportionately greater sampling mortality.
- Avoiding mesh sizes that catch forage species to minimize the possibility of inflating the catchability of lake trout by what would be functionally described as "baiting" the net.

Lake Trout density estimations are determined by calculating the selectivity corrected area weighted mean arithmetic catch per net. The calculation of density does not require a large biological sample and it is guided by the appropriate number of nets (samples) within each depth stratum. Essentially, nets should be allocated equally to all regions of the lake utilized by lake trout (i.e., water below the thermocline).

3.7.1.4 Duration of Sets

SPIN provides some options with regards to the duration of sets using the Large Mesh gear. Either 2-hour ($SPIN_{(L2)}$, daytime sets) or 18-hour ($SPIN_{(L18)}$, overnight sets) options are available. Or, both $SPIN_{(L2)}$ and $SPIN_{(L18)}$ sets can be used concurrently in a lake. The 2007 survey utilized the $SPIN_{(L2)}$ option.

Calibration of index Catch-Per-Unit-Effort (CUE) with density has only been completed for the $SPIN_{(L2)}$ method. This means that only the $SPIN_{(L2)}$ method has an established relationship between CUE and density. Future work by the ASU is focused on calibration of the $SPIN_{(L18)}$ method and will be included in a later version of SPIN (Sandstrom *et al*, 2007).

3.7.1.5 Lake Trout Biological Indicators

Through the use of nets, SPIN is able to obtain a representative sample of adult lake trout across the range of lake depths and area. The objective was to evaluate the biological integrity of the population and monitor for effects of exploitation on life history characteristics.

The key diagnostic parameters to evaluate would include:

- Size and / or age at maturity for both sexes
- Estimate of survival (length or age based)
- Growth parameters (if otoliths collected)

In order to make reliable interpretations on a population, a sample size (live or dead) of approximately 75 lake trout is required. Smaller samples may provide some insight into the life history characteristics of a population, but sample sizes smaller than 30 fish will not provide reliable information. It should be noted that the biological component of SPIN is independent of the density estimation and therefore does not influence the population estimation derived for a given waterbody.

3.7.1.6 Small Fish and Lake Trout Recruitment Assessment

With lake trout being a piscivore (predator of forage fish), it's important to have an understanding of forage species composition in the lake. A survey of the resident fish community was obtained using SPIN gillnets consisting of a series of smaller mesh sizes and filament diameters that dovetail into the small end of the SPIN Large Mesh series without repetition of mesh size. This gear is designed to sample small (i.e., forage) fish less than 300 mm.

This Small Mesh gear was fished separately of the SPIN Large Mesh gear and at a much lower intensity and only in a few key stratums. The gear was not intended to provide an inclusive list of species mainly due to the lower sampling intensities, but rather provide a complementary list of species found in association with the resident lake trout population.

Small Mesh gear can also be used to evaluate recruitment success and early life history growth of lake trout. However, in order to accomplish this, the gear must be sampled at higher intensities within the hypolimnion (Sandstrom *et al*, 2007). The timeframes of the 2007 survey did not permit this high intensity sampling for evaluation of recruitment. Only two double sets of Small Mesh gear were deployed in the deep-water portions (Stratum 3 and 4) of Round Lake to sample for recruitment.

Each of the Small Mesh gear used to assess forage species and lake trout recruitment was set for 18 hour span over night. This duration covers two crepuscular periods (sunset and sunrise), which prevents possible under sampling of species that may only be active during one of the crepuscular periods.

3.7.2 SPIN Results

The 2007 Round Lake SPIN was conducted on September 10 and 11, 2007 with the expertise and equipment from the ASU of the MNR and assistance from biologists from NRSI. A total of 25 different sampling locations were surveyed to assess adult lake trout. Refer back to Table 13 for stratum related information on these sample locations. Juvenile lake trout were assessed with two Small Mesh nets set below the thermocline, while forage species were examined via one Small Mesh net set above the thermocline for a total of 28 separate efforts.

During the SPIN survey it became evident that lake trout were not evenly distributed throughout the different depth strata in Round Lake. Catches were only occurring within the vicinity of the islands, presumably due to more underwater structure than other areas of the lake, or possibly due to pre-staging prior to spawning.

In addition to the random sample locations, a series of "Targeted" sample locations were netted to determine if the area occupied by lake trout could be better defined. This would provide additional data to compare results. Table 14 describes the stratums that were "targeted" and the number of samples situated in each. It is important to note that this targeted effort cannot be included in the actual density and population estimation because of the bias of targeting lake trout. However, this additional biological data can be looked at independent of the density and population estimation.

Table 14. Targeted Stratums, Percentages, Sample Sites and Nets

Stratum Info	Depth Ranges (meter)	Volume $m^3 \times 10^4$	Volume %	Surface Area (ha)	Surface Area (%)	Core Stratum Areas (ha)	Core Stratum Areas (%)	# of Sample Sites	Total # of Nets
Stratum 2	10 to 15	384.38	13.41	384.13	1288.6%	753.78	25.28	4	8
	15 to 20	368.08	12.84	369.65	1240.0%				
Stratum 3	20 to 25	484.9	16.92	508.57	1706.0%	937.52	31.44	1	1
	25 to 30	459.96	16.05	428.95	1438.9%				

Figure 17 illustrates the distribution of both random and targeted $SPIN_{(L2)}$ sampling locations throughout Round Lake as well as the locations in which lake trout were captured.

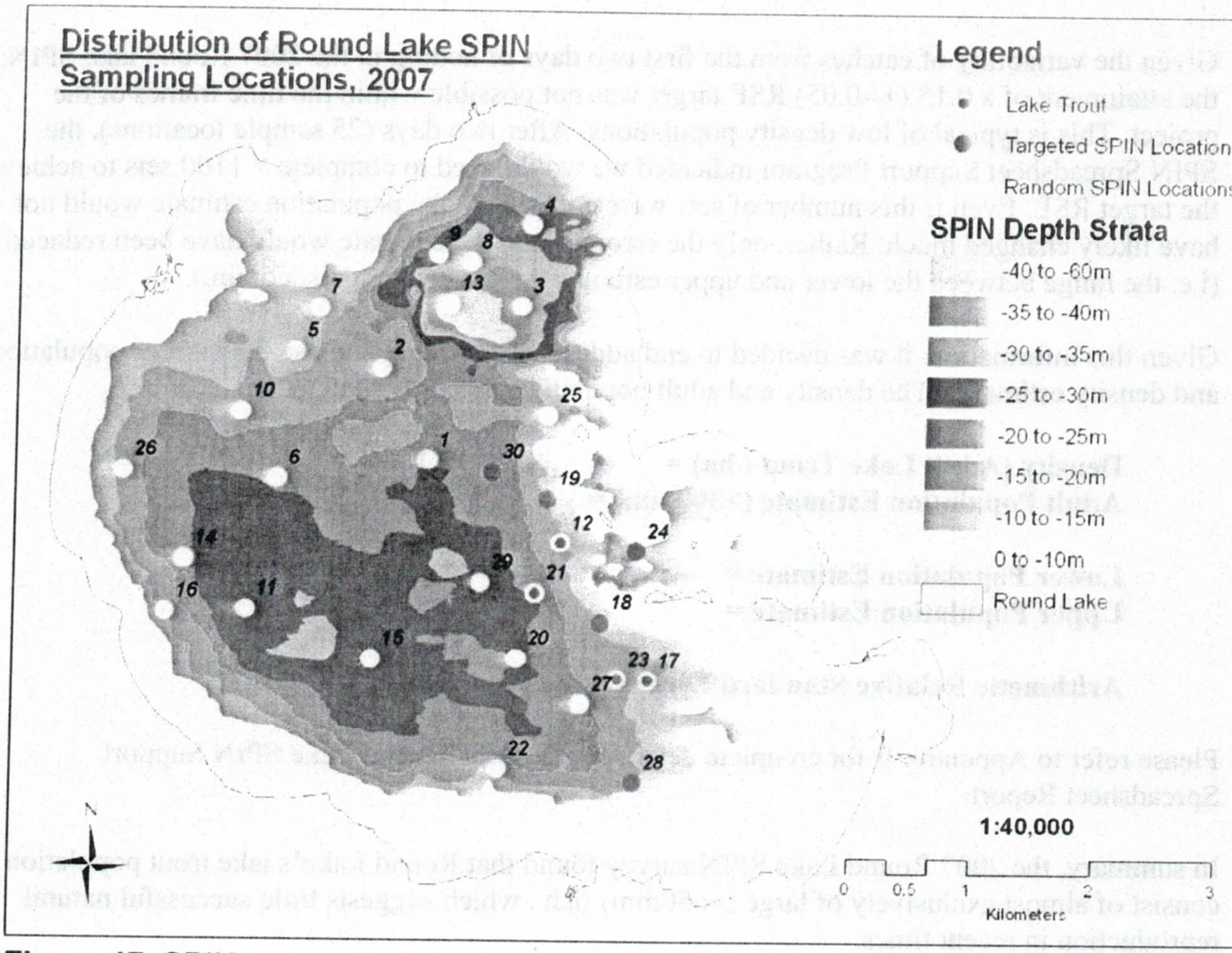


Figure 17. $SPIN_{(L2)}$ sampling (including targeted sets) and lake trout capture locations in Round Lake.

3.7.3 Lake Trout Density and Population Estimate ($SPIN_{(L2)}$)

The calculations used in deriving densities and population estimates for lakes are complex and beyond the scope of this report. These calculations are described in detail within the Manual of Instructions for SPIN. Again, it is important to note that only the $SPIN_{(L2)}$ has an established relationship between CUE and density (Sandstrom *et al*, 2007).

To aid in eliminating errors during the numerous calculations, a spreadsheet support program was developed by the Science and Information Section, Aquatic Science Unit of the Ministry of Natural Resources. This program has embedded all the necessary formulas and automates the calculations as the user inputs SPIN data directly. This program was created by Steve Sandstrom and is called SPIN Support Spreadsheet Version 8.3.

This program was used at the end of each day to calculate the Relative Standard Error (RSE). The RSE is a measure of an estimate's reliability. It is useful to track the daily changes in RSE during the course of a survey, to permit the exploration (i.e., extrapolation) of whether further sampling will be analytically advantageous.

Given the variability of catches from the first two days of netting in the 2007 Round lake SPIN, the attainment of a 0.15 (+/-0.05) RSE target was not possible within the time frames of the project. This is typical of low density populations. After two days (25 sample locations), the SPIN Spreadsheet Support Program indicated we would need to complete > 1100 sets to achieve the target RSE. Even if this number of sets were completed, the population estimate would not have likely changed much. Rather, only the error around the estimate would have been reduced (i.e. the range between the lower and upper estimates) (Sandstrom, pers. comm.).

Given this information, it was decided to end additional sampling and use the current population and density estimates. The density and adult population was estimated to be:

Density (Adult Lake Trout / ha) =	**2.1**
Adult Population Estimate (>300mm) =	**3,783**
Lower Population Estimate =	**169**
Upper Population Estimate =	**7,458**
Arithmetic Relative Standard Error (RSE) =	**0.54**

Please refer to Appendix II for complete details on the 2007 Round Lake SPIN Support Spreadsheet Report.

In summary, the 2007 Round Lake SPIN survey found that Round Lake's lake trout population consist of almost exclusively of large (>650mm) fish , which suggests little successful natural reproduction in recent times.

Interestingly, the density of these large sized lake trout is actually greater than some densities of the same size class of lake trout in many of what is considered Ontario's healthy lake trout lakes, where the piscivorous biomass is shared between many smaller size classes (Sandstrom, pers. comm.).

3.7.4 Adult Lake Trout Biological Indicators

A preferred sample of 75 lake trout (>300 mm) is required to evaluate the biological integrity of the population. During the 2007 Round Lake SPIN, a total of 15 lake trout were captured and sampled from both the random and targeted sample locations. This limited number is insufficient to produce reliable results on life history. The low lake trout catch confirmed a low lake trout population density dominated by asymptotically large lake trout.

Thirteen of the 15 lake trout captured were released in good condition after measurements and clipping of the adipose fin. The fin clip was collected as a source of DNA should the need to analyze it arise. The clip also served as a distinct mark should the fish be captured again in the future. By all accounts, these lake trout appeared to be healthy and robust. The two mortalities (one female, one male) were examined and determined to be in excellent shape. Visceral fat within the body cavities was abundant indicating good health and abundance of forage supplies. Stomachs were examined for forage species but were found to be empty.

3.7.5 Small Fish and Lake Trout Recruitment Assessment

One Small Mesh net was deployed in Stratum 2 overnight for duration of 18 hours to obtain a representative sample of forage-sized fish found in association with lake trout in Round Lake. Table 15 compares the fish species detected in the 2007 SPIN for both the Small and Large Mesh SPIN nets.

Table 15. Small Mesh Assessment with Comparison to Large Mesh Catches

Species Detected		Small Mesh SPIN Gear	Quantity Caught	Large Mesh SPIN Gear	Quantity Caught
Common Name	Scientific Name				
Spottail Shiner	*Notropis hudsonius*	X	1		
Trout Perch	*Percopsis omiscomaycus*	X	1		
Rainbow Smelt	*Osmerus mordax*	X	25		
Yellow Perch	*Perca flavescens*	X	36		
White Sucker	*Catostomus commersonii*	X	1	X	12 (*5)
Lake Trout	*Salvelinus namaycush*			X	8 (*7)
Lake Whitefish	*Coregonus clupeaformis*			X	1 (*2)
Burbot	*Lota lota*			X	4
Cisco (Lake Herring)	*Coregonus artedi*			X	9 (*1)
Northern Pike	*Esox lucius*			X	(*1)

* indicates additional quantity caught using targeted sets

Both Cisco and Rainbow Smelt have been well documented as being the preferred natural food of adult lake trout although many other fish species like whitefish, perch, sculpins, shiners, sticklebacks and other lake trout have been observed in lake trout stomachs (Scott and Crossman, 1973).

Rainbow Smelt, a recent invader, were first reported in Round Lake on January 10th, 1989 by MNR Fish and Wildlife Technician, Pat Sloan. This report came from a stomach sample from a walleye that contained one partially digested adult rainbow smelt. Another stomach sample from a lake trout caught in Round Lake on January 17th, 1990 confirmed the establishment of rainbow smelt in to Round Lake's fish community (MNR, 1990). Despite the fact that studies have not exposed rainbow smelt as a heavy predator of other fish species, it is still regarded with suspicion by biologists and fishermen as a species that preys upon young fry. No direct evidence of predation on young lake trout has been demonstrated, however, it can't be ruled out that rainbow smelt may have an influence on recruitment. Lake trout on the other hand, will prey heavily on rainbow smelt when large enough to do so (Scott and Crossman, 1973).

Two double sets of Small Mesh gear were deployed in Stratum 3 and 4 of Round Lake to sample for recruitment. These sets failed to detect any lake trout <300mm. This may be a consequence to the small sample size, but does support the speculation that recruitment is low in Round Lake. Figure 18 illustrates the distribution of sample locations for both small forage fish and recruitment assessment.

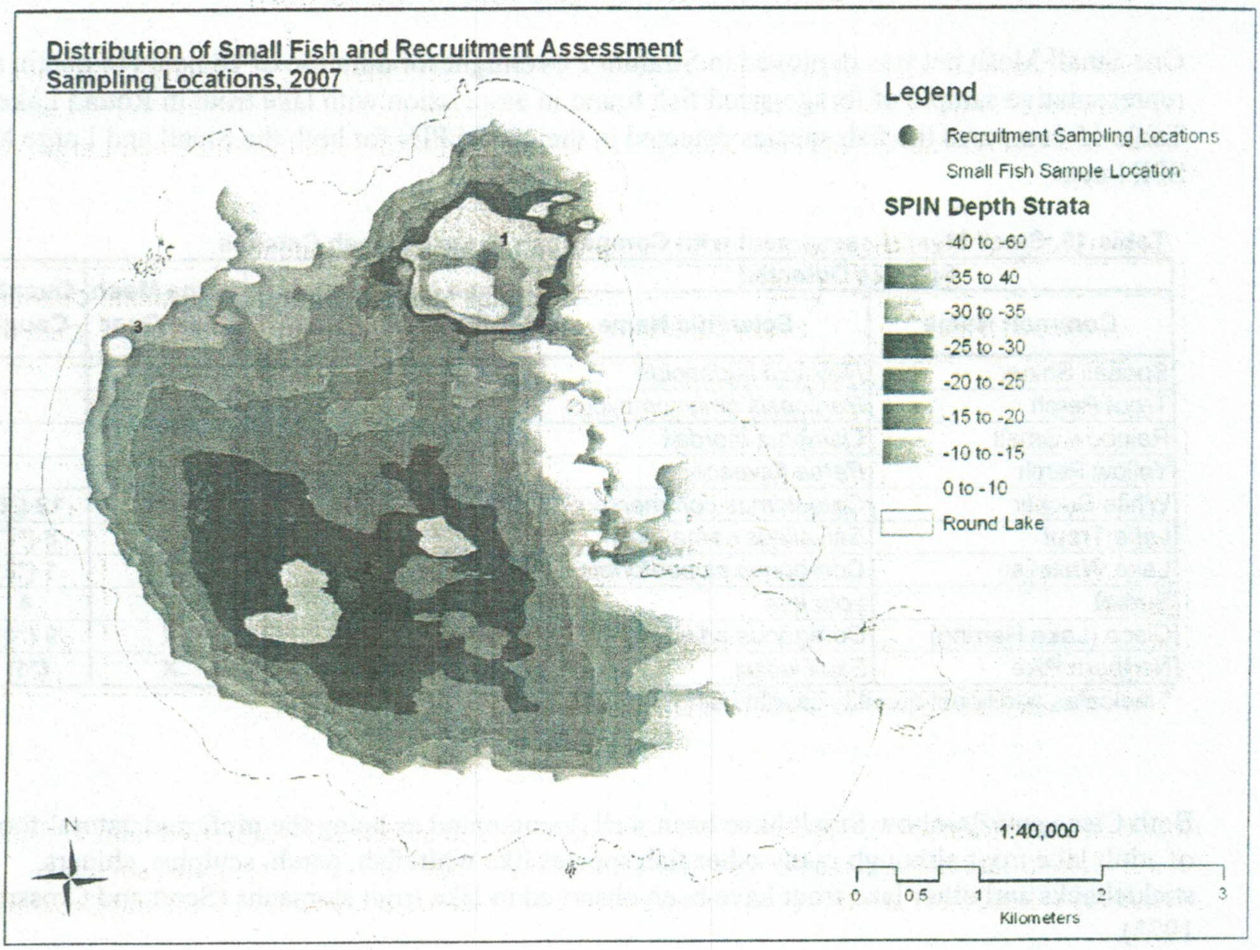


Figure 18. Sample locations for forage fish and juvenile lake trout assessment.

3.7.6 Discussion

The difficulty in measuring a lake trout population from one that exists in very low density (lake trout/ha) is the ability to actually capture specimens to derive data and subsequent population estimates from. To complicate the matter further, the catchability of large fish, such as those in Round Lake is not fully understood due to the lack of large fish available during the development of the SPIN protocol. In essence, we do not fully understand whether large lake trout are more or less susceptible to nets, which hampers SPINs ability to accurately estimate their true density.

The ASU is currently working to answer this specific question. Their ongoing preliminary work suggests that very large lake trout (>650mm) are highly vulnerable to nets even though there are few, possibly no, mesh sizes that they can physically become wedged/gilled in. The current working hypothesis is that they are attracted by scent (looking for food and lingering around nets) and become entangled in the nets increasing their catchability.

Is the selectivity correction (amount of adjustment) for large bodied lake trout in fact accurate given their vulnerability to nets? This question had never been an issue, until Round Lake was sampled using the SPIN protocol. The reason being large lake trout made up such a small proportion of the catches from all of the other lakes that had SPIN surveys. Round Lake's lake trout catch comprise entirely of fish >650mm, which creates a problem around selectivity correction. If the current selectivity correction for lake trout >650mm is too low it will result in overestimating density and the population. The opposite would occur if it is too high. Work is currently underway to evaluate the accuracy of SPIN results in Round Lake by examining the size selective catchability of these large lake trout.

Regardless, the limited size classes of lake trout in the 2007 SPIN strongly indicates small or failed year classes for the past decade or more. Since no fin clips were observed on any of the fish captured during the SPIN, fall spawning assessment or from angler reports, the existing population in Round Lake is clearly derived from successful natural recruitment in the lake at one time or another. Any stocked lake trout would have been identifiable by fin clips. Unfortunately, insufficient numbers of lake trout were captured in the 2007 SPIN to assess specific individual ages and identify the specific spawn years where recruitment was successful.

However, lake trout data obtained from Round Lake in 2006 from Michael Rennie, a Postdoctoral Researcher studying lake whitefish *(Coregonus clupeaform)* provided some age structure information for lake trout incidentally caught during his work. A total of 24 lake trout were obtained and submitted to MNR. Both fin rays and otoliths were collected from each fish and aged. From this small sample of lake trout, age results ranged from seven to 16 years. From the individual ages the identification of specific hatch years was possible. The resulting hatch years for these fish ranged between the years of 1990 and 1999 (Figure 19). This provides strong evidence that natural recruitment has been occurring in Round Lake long after any stocking events which ceased in 1982.

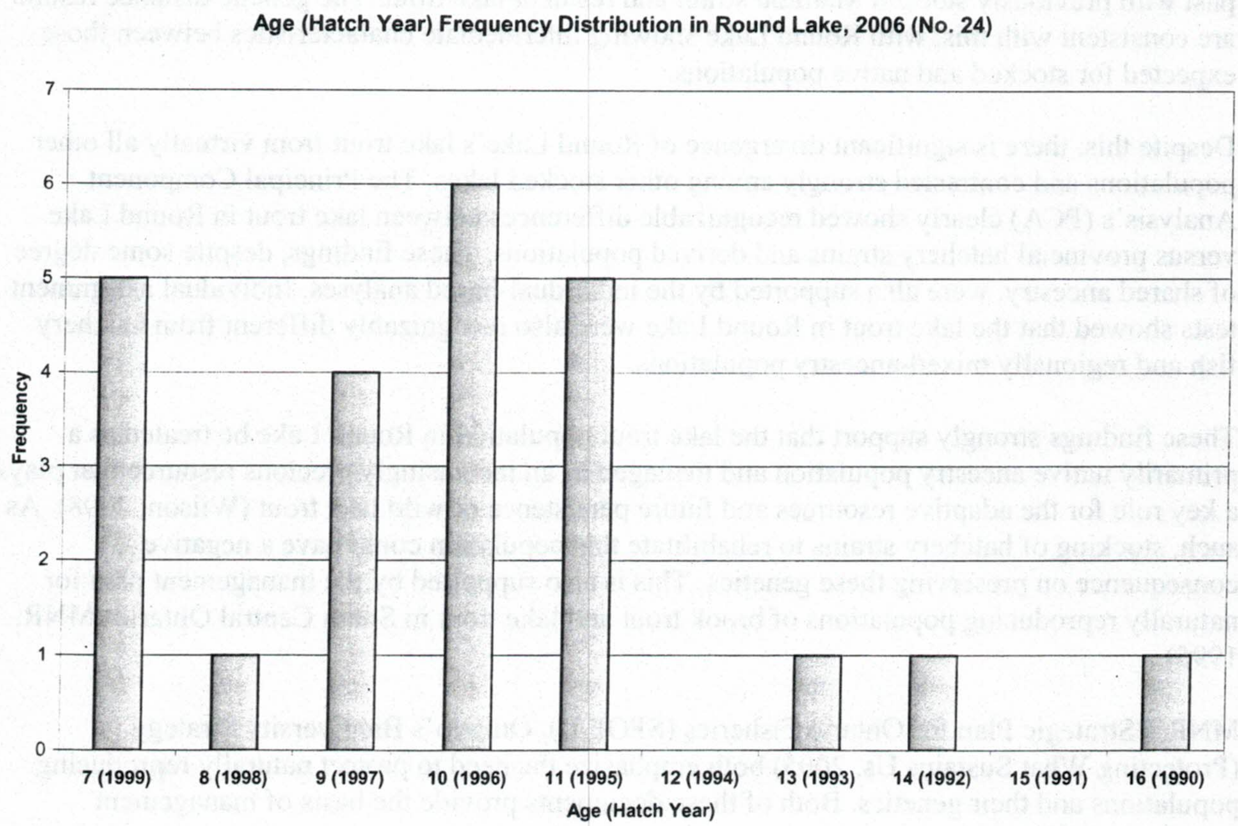


Figure 19. Ages and originating hatch years of lake trout caught in Round Lake, 2006.

Again, these fish were all large bodied fish that had total length measurements ranging between 704 and 847 mm. The absence of smaller sized lake trout indicates that something has changed within the past decade which is preventing lake trout from successfully completing their life cycle in detectable amounts.

4.0 DNA Results

The genetic ancestry of the lake trout in Round Lake has significant implications as to how water levels on Round Lake might be managed. The options for management can be quite different for stocked versus native/naturalized populations.

To ascertain the ancestry of the Round Lake population, flesh samples were collected from lake trout in the fall of 2006 and sent to the Ministry of Natural Resources DNA Profiling & Forensic Centre in Peterborough for analysis. The detailed methods and results of this testing has been published in a separate report authored by Chris Wilson and titled: "Genetic assessment of ancestry of wild-caught lake trout (*Salvelinus namaycush*) in Round Lake.

The combined population and individual-based analyses indicate that the lake trout in Round Lake have been minimally influenced by past stocking, but are still recognizably distinct from previously and currently stocked populations. Some degree of interbreeding has occurred in the past with previously stocked Manitou strain and resident lake trout. The genetic distance results are consistent with this, with Round Lake showing intermediate characteristics between those expected for stocked and native populations.

Despite this, there is significant divergence of Round Lake's lake trout from virtually all other populations and contrasted strongly among other stocked lakes. The Principal Component Analysis's (PCA) clearly showed recognizable differences between lake trout in Round Lake versus provincial hatchery strains and derived populations. These findings, despite some degree of shared ancestry, were also supported by the individual-based analyses. Individual assignment tests showed that the lake trout in Round Lake were also recognizably different from hatchery fish and regionally mixed-ancestry populations.

These findings strongly support that the lake trout population in Round Lake be treated as a primarily native ancestry population and managed as an increasingly precious resource that plays a key role for the adaptive resources and future persistence of wild lake trout (Wilson, 2008). As such, stocking of hatchery strains to rehabilitate this population could have a negative consequence on preserving these genetics. This is also supported by the management plan for naturally reproducing populations of brook trout and lake trout in South Central Ontario (MNR, 1995).

MNR's Strategic Plan for Ontario Fisheries (SPOF II), Ontario's Biodiversity Strategy (Protecting What Sustains Us, 2005) both emphasize the need to protect naturally reproducing populations and their genetics. Both of these documents provide the basis of management principles for Ontario resources.

5.0 Incubation and Egg Studies

During the 2006 field season using diver observations, MNR documented the presence of lake trout eggs and the pattern of deposition, on three of the four spawning shoals in Round Lake. Due to a limited number of divers and exposure limitations from the cold water, only the shoals that produced lake trout during previous netting were explored. Idywild Island Shoal was the only shoal structure that was not searched for lake trout eggs as no lake trout were captured on it during netting of the fall spawning assessment in 2006.

Although this method provides a good general indication of where eggs are being deposited on the shoals, it is limited from the perspective that eggs that have settled into interstitial spaces are not visible to the divers. Divers were instructed to flip over substrate and look for eggs that may have settled down within the interstitial spaces. Despite this, an effort was made to find a passive method that might allow an unbiased observation of a greater number of deposited eggs. A literature review was conducted to determine other methods of documenting egg deposition. Some methods have involved the burial of containers filled with substrates (Perkins and Kreuger, 1994, Stauffer, 1981). Other methods have employed suction to extract eggs from the substrate (Dorr *et al*, 1981, Wagner, 1981). These methods have achieved varying rates of success in collecting eggs but are typically labour intensive and very time consuming.

Schreiner *et al* (1995) evaluated the use of disk traps developed by Marsden *et al* (1991) for investigation of lake trout egg deposition. The disk traps were successful when used on shallow, protected reefs but were relatively ineffective on unprotected offshore or shoreline reefs. Dorr *et al* (1981) observed extreme movement of eggs as a result of wind induced wave action during heavy storms. Similar egg drift has been documented by Marsden and Krueger (1991) and Perkins and Kreuger (1994). Given the exposed nature of the shoal at Victoria Island, similar egg movement can be expected on Round Lake.

5.1 Observation of Egg Deposition by Divers

5.1.1 Methods

Diving surveys to mark locations of egg deposition were carried out on October 21, 2006 and October 27, 2007. The methodology used for observation of eggs was identical in both years. However, only the Victoria Island shoal was surveyed in 2007. This decision was made because the Victoria Island shoal was now considered as the primary spawning shoal and the diving effort should be focused here. Also, the cold water greatly reduced exposure times for the divers which directly influenced the amount of survey work that could be completed.

Divers were deployed in survey teams to identify and mark locations of egg deposition along the Victoria Island shoal. A "contour search pattern" was applied by the dive teams, with each team using a length of rope (tether) to keep the divers at consistent horizontal spacing's (see Figure 20). In this manner, it was possible to survey the full surface area of the spawning bed from approximately elevation 170m asl (top of spawning habitat) to elevation 167m asl (bottom of shoal). This effectively covered all of the underwater terrain from the top of the rocky shoal to the deeper edge of the shoal where the substrate changed to sand/silt and was unsuitable for spawning. Where clusters of eggs were observed during the dive, small marker floats were released from the bottom, leaving a trail of floats behind the dive teams. These floats were anchored into the substrate so as not to drift away from the egg cluster location. Once divers were out of the water, MNR staff in boats recorded the locations and depths of the anchored floats using Wide Area Augmentation System (WAAS) enabled GPS sonar.

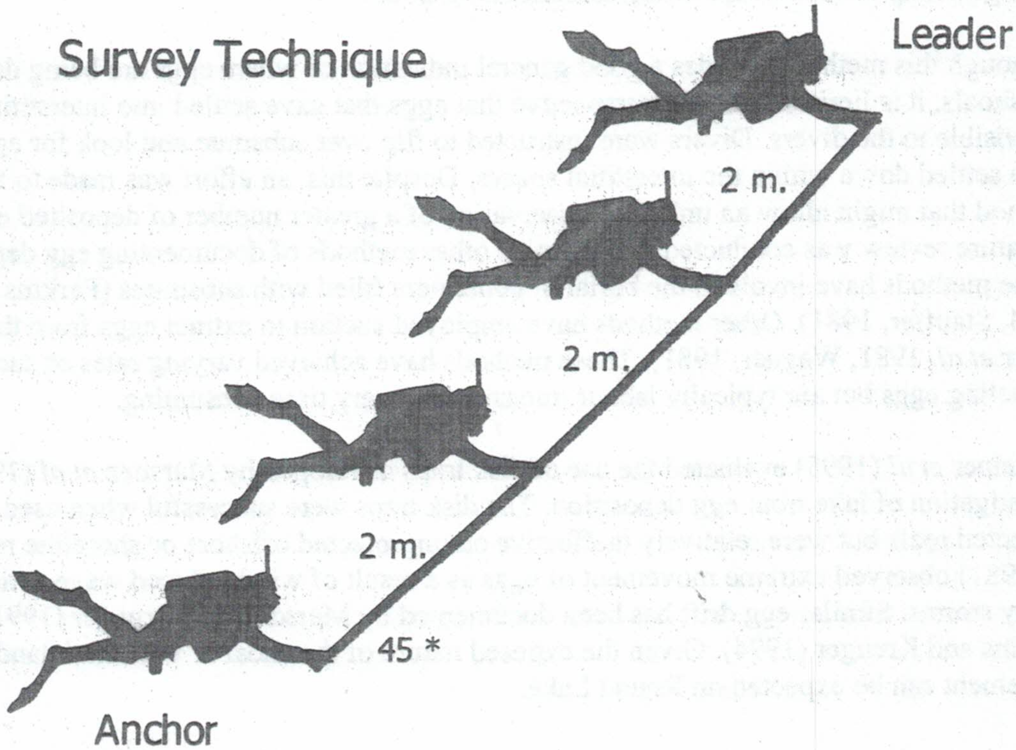


Figure 20. Depiction of survey spacing and technique used by divers.

The 2006 survey was confined to the western half of the Victoria Island shoal, due to manpower constraints and time limitations. Due to the 2006 results, the survey in 2007 was focused solely on the Victoria Island shoal and was expanded to include the entire length of the shoal.

Where a significant number of eggs were seen (i.e. indicating a particularly productive spawning area), the upper and lower depth limits of the spawn area were checked, (i.e. the minimum and maximum depths).

Measurements of egg densities were not taken, as the primary objective of the survey was not to quantify egg deposition but rather to establish the range of elevation in which the eggs were being deposited.

It should also be noted that divers were briefed on the size differences between lake trout and lake whitefish *(Coregonus clupeaformis)* eggs prior to diving. Lake trout eggs are comparably larger (5-6 mm) than that of whitefish (3.0 to 3.2 mm). Also, whitefish eggs were not expected to be observed on the shoal as their spawning typically occurs after lake trout when water temperatures are below 7.8°C (Scott and Crossman, 1973).

5.1.2 Results

The results of egg deposition are shown in Figure 21. This figure depicts the distribution of egg clusters on the Victoria Island Shoal for both 2006 and 2007. The range of the eggs for both years are between elevations from 169.85 and 167.09 meters above sea level (m asl). Within this range of elevation, the majority of eggs for both years were located between 169.5 and 168.7 m asl.

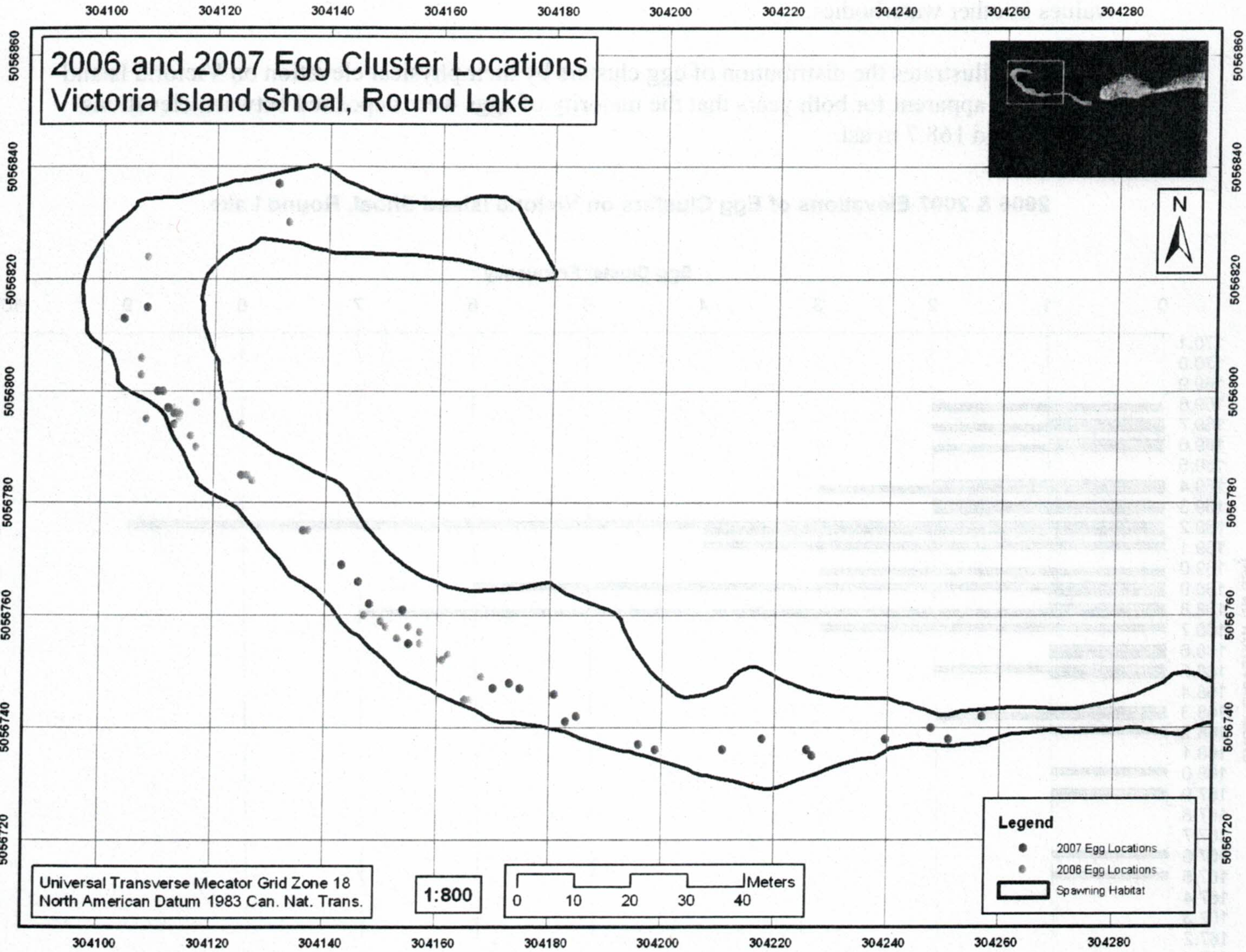


Figure 21. Distribution of observed egg deposition by divers on Victoria Island Shoal in 2006 and 2007.

All of the 39 egg clusters located in 2006 were situated between elevations of 167.09 and 169.79 m asl. Not all of the Victoria Island Shoal habitat was searched in 2006 as divers spent time searching for eggs on other shoals off Edwards Island and Un-Named Island. Only the western half of Victoria Island shoal to an easting of 304170 was surveyed by divers in 2006.

In 2007, the entire Victoria Island Shoal was surveyed by the divers. This search resulted in 30 egg clusters being located between elevations 168.35 and 169.85 m asl.

For both years, egg cluster locations were strongly correlated to the habitat that was identified and mapped using the underwater camera and bathymetry equipment (Section 3.5). This egg distribution for both years supports that the developed methodology for mapping lake trout habitat in Round Lake was accurate and that this method could be applied to capture habitat values in other waterbodies.

Figure 22 illustrates the distribution of egg clusters by their physical elevation on Victoria Island Shoal. It is apparent for both years that the majority of eggs were deposited between elevations of 169.5 and 168.7 m asl.

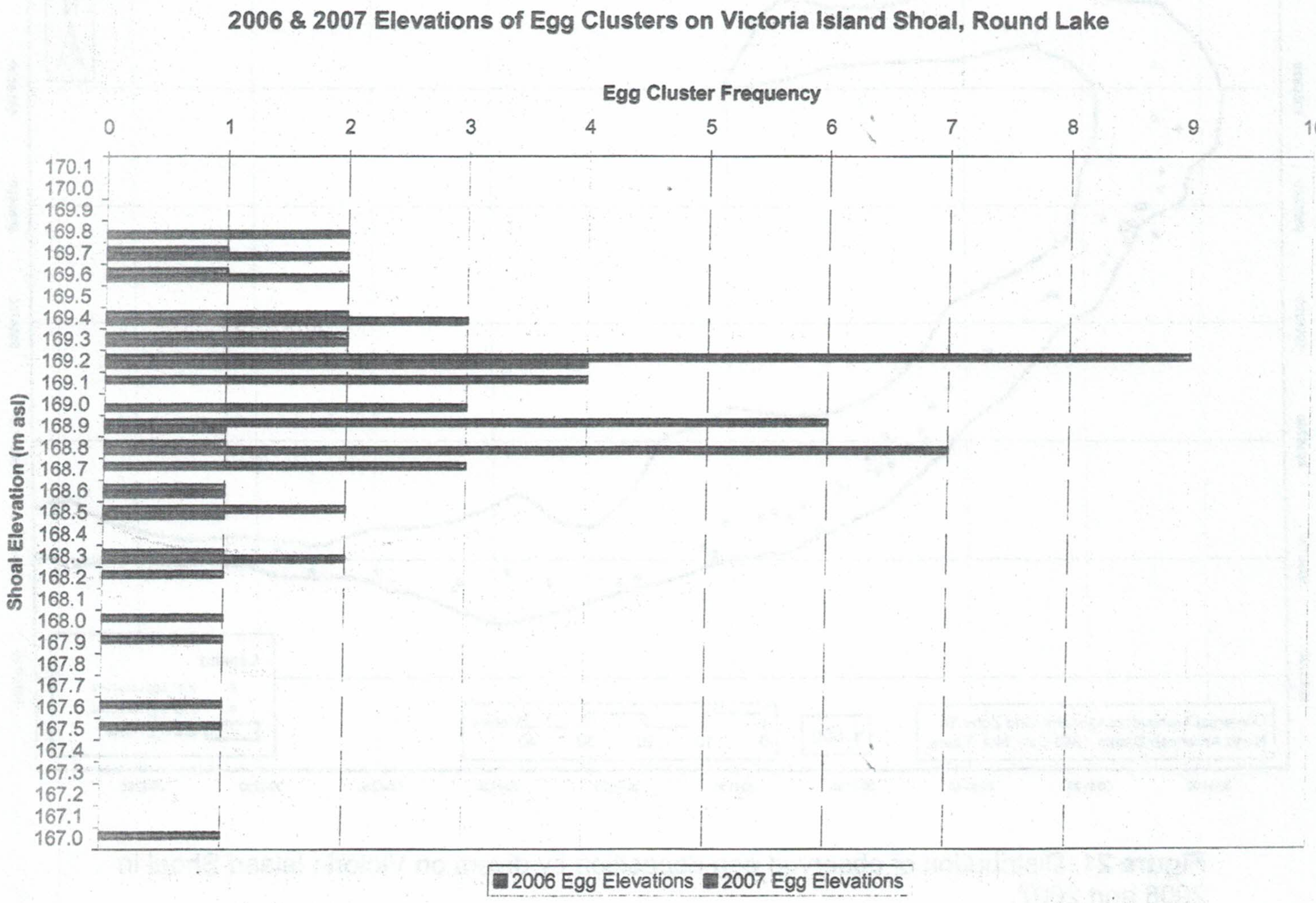


Figure 22. Elevational distribution of egg clusters observed during 2006 and 2007 diving surveys.

5.2 Egg Mat Experiment

An egg mat experiment was undertaken to help supplement the efforts and observations by divers and assist in further defining the areas eggs were being deposited. The primary goal of the mats was to collect eggs to compare the results of the diver observations. In short, were the diver's observations adequately detecting eggs or were eggs being missed? A secondary goal of the egg mats was to collect substrate size information and shoal angle at each mat location. Spawning substrate size would be classified using a scale described by Edsall *et al* (1992) called Modified Wentworth Scale (Table 16). This information could be used to describe the transition of substrate type/size along a cross-sectional profile of the shoal.

Table 16. Modified Wentworth Scale (Edsall 1992)

Substrate Discription	Size (mm)
Boulder	>999
Cobble	257-999
Rubble	65-256
Gravel	2-64
Sand	0.5-1.9
Fines	<0.5

Ideally, this experiment should have involved egg traps buried in the substrate. However, the resources of this project did not allow the deployment of such gear as they were not available to the study team. As a result, the team chose to experiment using egg mats in an attempt to collect deposited eggs. Egg mats have proven successful in the past for collecting spawned walleye eggs in flowing streams by NRSI in 2008. To our knowledge, egg mats had not been used before to collect lake trout eggs. This effort was therefore viewed as highly experimental.

5.2.1 Methods

<u>Egg Mat Construction -</u> In total, 40 egg mats were prepared for the experiment. Each unit consisted of a 35.5 cm square of 0.635 cm thick steel plate with three 2.5 cm bolts welded onto one side, all oriented the same way along a center line with furnace filter fabric prepared in lengths to wrap around the steel plate (Figure 23). Three holes were cut out of the fabric to allow for the bolts to be accessed. The filter was held onto the steel by four butterfly clips, two at each corner where the filter edges connected. The fabric of the furnace filter that was used came in two colours, blue and green. The two suppliers carried the same grade and type of filter but different dye lots.

A length of 3/16 gauge wire was tied at each of the two edge bolts. This "handle" provided a grip during handling, and media to attach the numbered identification tags of duct tape and orange flagging tape. The trap number was written on both sides of the duct tape and flagging tape with an indelible marker. Seven colours of cable ties were also used to identify unique vertical transects of the egg mats. The cable tie colours utilized were: green, blue, red, yellow, white, black and green & white.

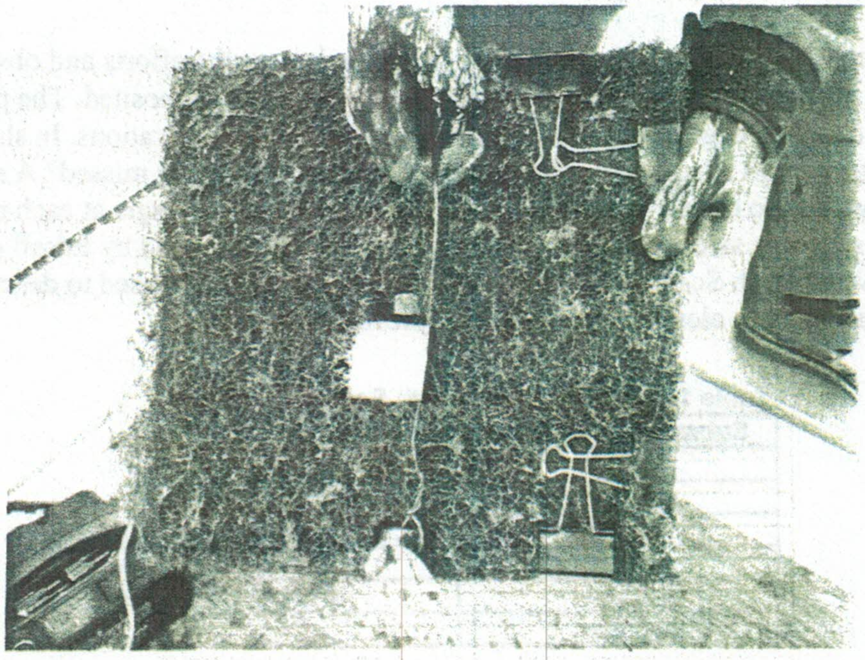


Figure 23. Assembled egg mat.

Egg Mat Deployment - Each egg mat was deployed from a boat using a top rope released immediately beside the sonar depth sounder transducer for accurate depth measurement. A GPS waypoint was collected for each egg mat upon launching. A length of rope measuring at least twice as long as the anticipated depth, was looped through the wire handle or center bolt of the egg mat and both ends of the rope were held in hand. When the boat reached the desired depth and location the egg mat was lowered and one end of the rope was released while the other end of the rope was pulled back into the boat. There were three crew members available for the launch of all 40 egg mats. One acted as boat handler and alternate record keeper, one released the egg mats and one labelled and prepared the egg mats and kept notes during the activity.

An attempt was made to set the egg mats on horizontal transects across the shoal, originating in shallow water (1.25 m depth), on top of the shoal, and extending at 0.5 meter depth intervals on a line perpendicular to the shoal orientation. The goal of deploying egg mats in this manner was that information on depth and substrate type (based on Wentworth Scale) could be used to develop a series of cross sectional profiles of the shoal detailing substrate size and slope angle.

Egg Mat Observations - On Oct. 27, 2007, members of the Deep River Underwater Club provided diving services, on a volunteer basis, to the project. The divers were divided into two teams of two divers and one instructor/dive master. Each team and the dive master was provided with carpenter pencils tied with corded nylon twine to sanded lexan slates (approximately 10 x 15 cm each) and a slope measuring device (Figure 24).

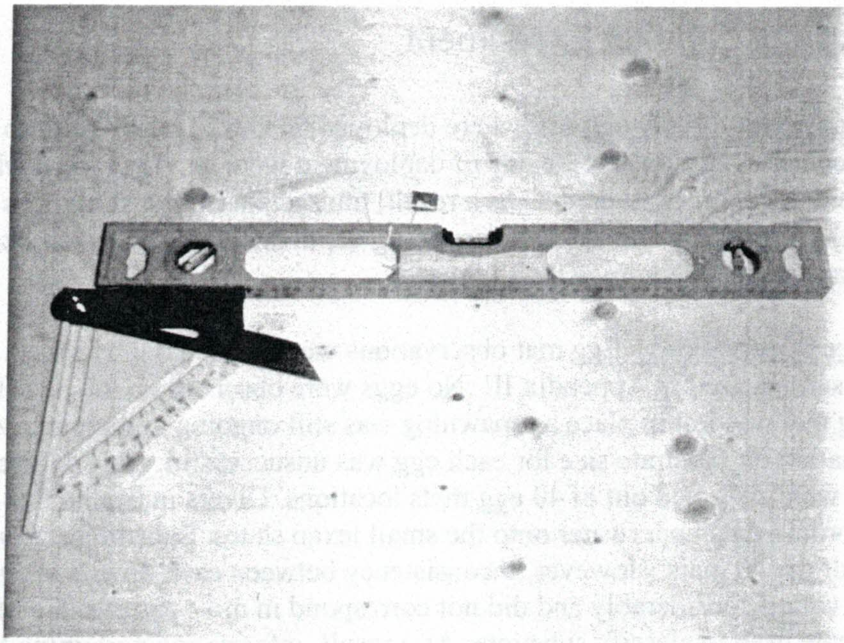


Figure 24. Slope measuring device used by divers to measure and record substrate size and slope angle of egg mats.

The slope measuring device consisted of a carpenter's level constructed of red, hardened Styrofoam with three vials and incremental markings in centimetres, and a sliding T square glued and bolted at one end to allow for immediate onsite measurement. Upon measuring the slope, the diver used a wing nut to fix the device in position for subsequent measurement of the angle, at the surface. A yellow embossed protractor was used to determine the slope in degrees. The device also had a 3 cm by 10 cm lexan slate bolted near one end that listed the various categories and observations to be conducted for each egg mat. This allowed divers to record their observations.

The dive teams recorded egg mat sample number, slope of mat as it lay on the shoal, dominant type and size of substrate, secondary substrate types, condition of mat and a count of eggs on each mat. This information was written onto the slates and passed to crew members on the boat. The crew members then transcribed the data onto data forms or field books, scrubbed off the graphite with a scour pad and returned the slates to the next dive team.

The divers also attached an orange float to each of the egg mats using a length of rope and a carabineer. The rope length for each float was shortened just enough to keep the float below the water surface (so not to attract attention and tampering), but long enough to enable reaching into the water to retrieve it and the attached egg mat. Since dive services would not be available for the retrieval this provided an easy way for spotting and retrieving the egg mats from a boat.

<u>Egg Mat Retrieval -</u> Egg mats were retrieved by a two person crew on Nov 3, 2007. One person manoeuvred the boat, using the GPS to locate the egg mats. Once in close proximity to the egg mats, the orange floats below the surface became visible enabling the other person to hook the float with an extendable pike pole. The rope was drawn to the surface and into the boat in a way that maintained the horizontal plane of the egg mat as much as possible to reduce the chance of washing eggs off the egg mat. Each egg mat was inspected for eggs and mat condition.

5.2.2 Results of Egg Mat Experiment

Egg Mat Deployment – Forty egg mats were deployed on Oct 11, 2007 prior to peak spawning of lake trout. Weather conditions on the day of deployment were less than ideal which resulted in deviations from the planned transects. As a result, transects were not straight as intended (Figure 25). Wind and wave action also made determining depth difficult and which likely contributed to some inaccuracy in depth readings for egg mats.

Egg Mat Diver Observations - Egg mat observations were carried out by divers on October 27, 2007 and are summarized in Appendix III. No eggs were observed on the mats by the divers that day. Each egg mat was left in place as spawning was still ongoing at that time. An attempt to record information on substrate size for each egg was unsuccessful. Only 11 measurements of substrate size were collected out of 40 egg mats locations. Divers indicated that they had difficulty recording data underwater onto the small lexan slates. Substrate size was noted by divers for 36 of the 40 mats. However, inconsistency between each diver's interpretations of substrate size varied considerably and did not correspond in most cases to the Modified Wentworth Scale used to classify substrate. As a result, information pertaining to substrate size at each egg mat location should be considered unreliable.

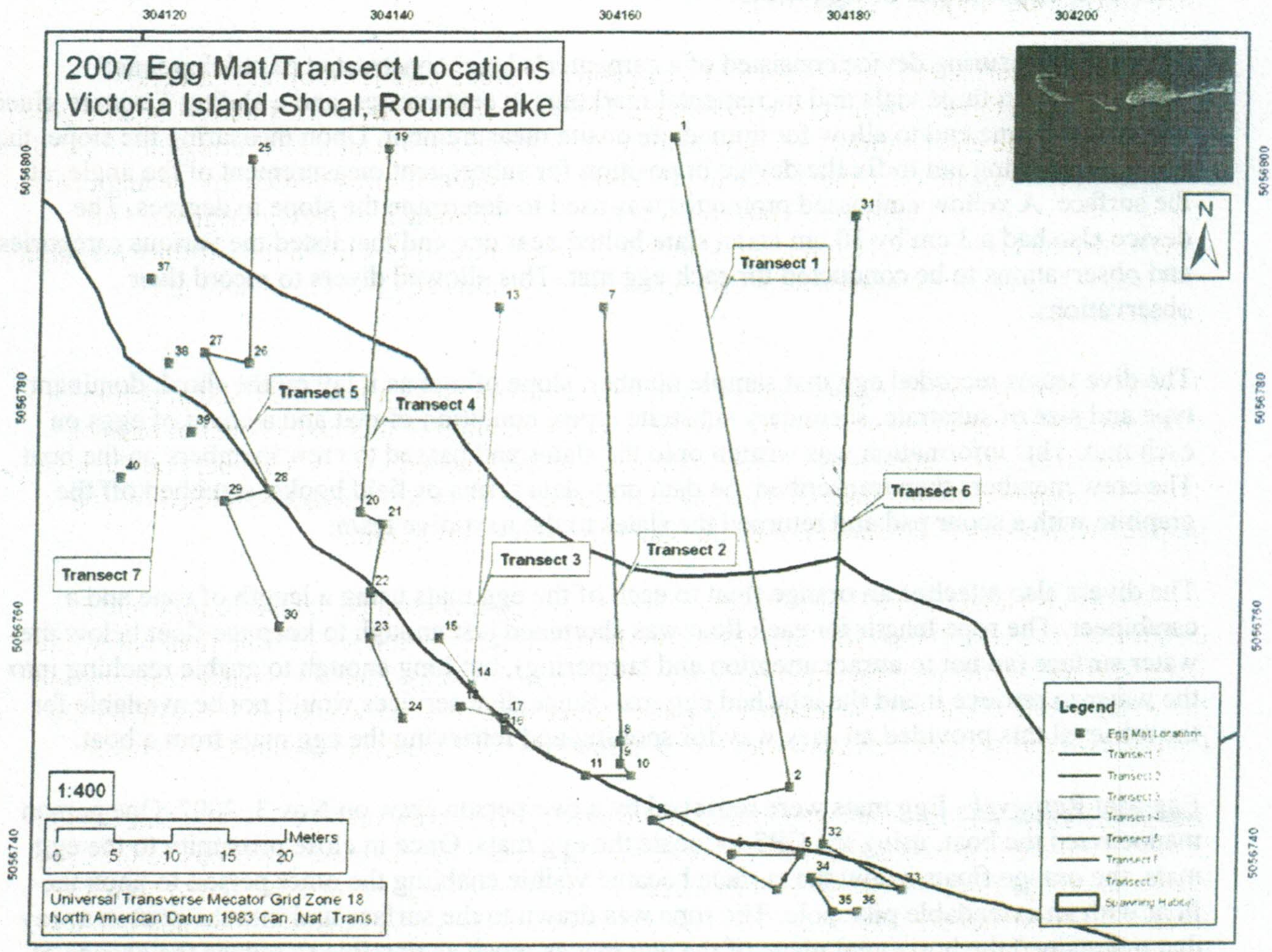


Figure 25. Distribution of egg mats and resulting transects on Victoria Island spawning shoal.

Divers were successful in obtaining angle measurements from 38 of the 40 egg mats. Shoal angles at the egg mat locations ranged from 0 degrees (flat) to 60 degrees with an average slope angle of 16 degrees from the 38 measurements. Divers also noted the depths using their dive indicators in an effort to confirm egg mat depths to what was recorded on the day of deployment (very wavy day). However, these instruments were not designed for precise readings in shallow water. As a result, depth information pertaining to egg mat locations should be considered unreliable. The combination of inaccurate egg mat depth readings and lack of substrate measurements prevented the creation of cross-sectional profiles that showed the types of substrate.

Egg Mat Retrieval - Upon retrieval of the mats on Nov 3, 2007 no eggs were captured except for a single egg on one egg mat. The reasons for the egg mats not capturing eggs remain unknown; however the following may be plausible explanations:

- The larger diameter lake trout eggs may have been too large for the mesh openings in the furnace fibre (mesh openings are ideal for smaller walleye eggs).
- Lake trout eggs are not adhesive unlike walleye eggs.
- The egg mats may have been spread too thinly. When compared with the egg deposition locations shown in Figure 25 it appears that many of the egg mats were deeper or shallower than the zone of egg deposition.
- Egg mats that were deployed on the steep slopes of the spawning bed may have been relatively ineffective as eggs may have rolled off the mats and the mats would not have sampled as large a surface area as those placed on a flat area.
- The orientation of the spawning bed to the prevailing southwest winds, with no protection from wave action was likely a significant factor in preventing eggs from being deposited on mats or scouring eggs from the mats.
- Eggs may have washed off the mat during the retrieval.
- An avoidance response by lake trout to the egg mats may also have occurred as indicated by Figure 26. Very few eggs were located in close proximity to egg mats.

In short, limited data and conclusions could be drawn from the egg mat experiment to assist with further describing the lake trout spawning habitat off Victoria Island. The failure of the mats to capture eggs prevented any comparisons to the observations made by divers in both 2006 and 2007. In addition, the inability to accurately classify substrate type and depth at each egg mat location prevented analysis of each cross-sectional transect.

In lieu of not being able to create representative cross-sectional profiles using the egg mat data, original bathymetry data was used to illustrate the profile of Victoria Island shoal from four different locations. This data would not provide substrate information, except for what was identified through mapping, but would provide an accurate account of the shoal profile and corresponding elevation.

Bathymetry data was referenced to the Tramore data water level in order to generate the elevation readings from the depth data (z). GIS analysis then measured the distance of each data point (x,y) in order to provide an accurate measurement of the shoal profile between the start and end of each cross-section. Cross section locations were arbitrarily selected from relatively straight bathymetric collection points from four representative locations across the length of the shoal (Figure 27).

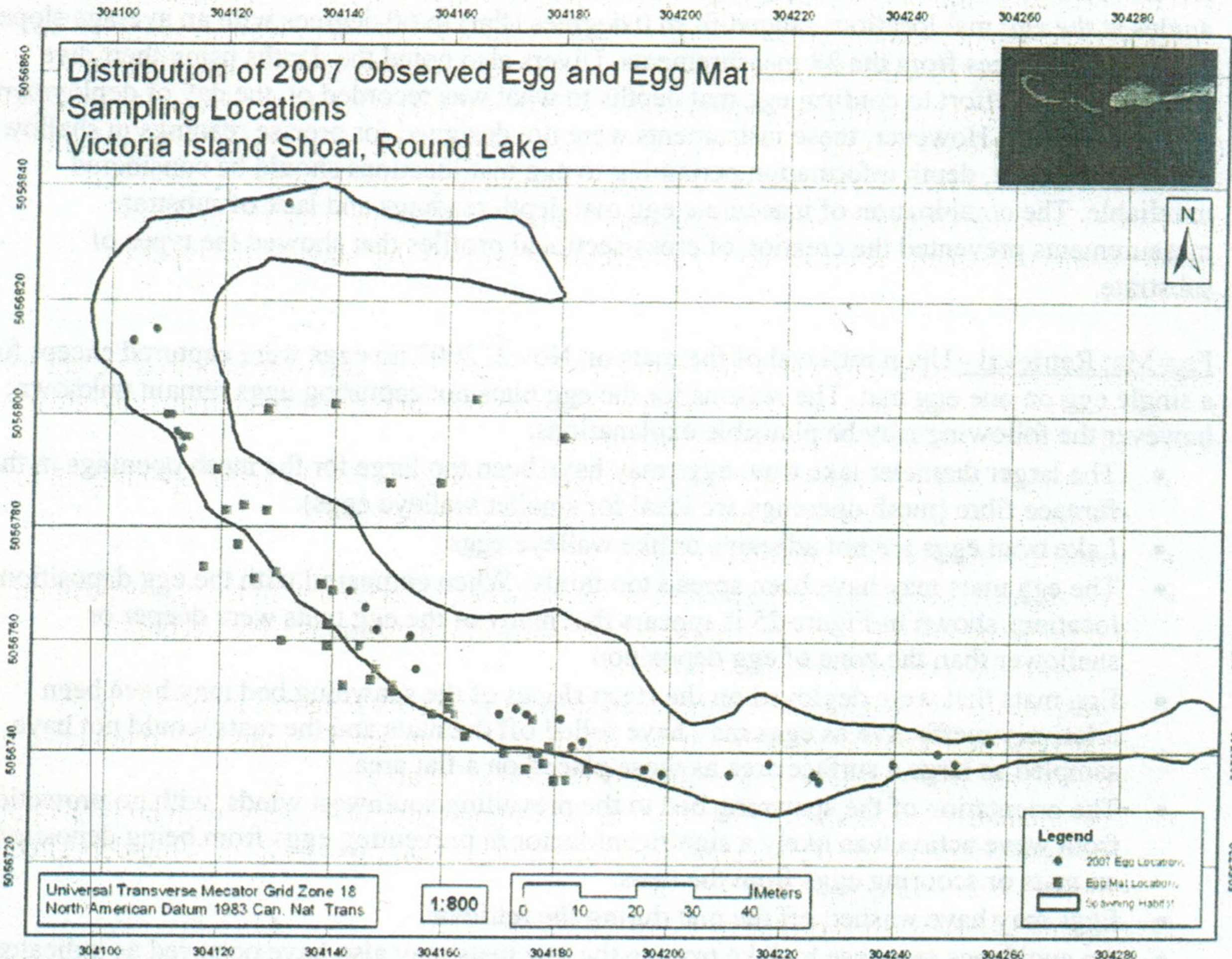


Figure 26. Distribution of observed egg clusters and egg mat sampling locations on the Victoria Island spawning shoal.

Figures 28 through 31 illustrate each individual cross section as they appear in Figure 27. Spawning habitat which was identified through mapping (section 3.5) was also included in each profile. This habitat is only illustrated to the depths and elevations that were visible to the underwater camera during the mapping process. Additional spawning habitat does exist beyond what is illustrated in each cross sectional profile based on diver observations and limited egg mat data.

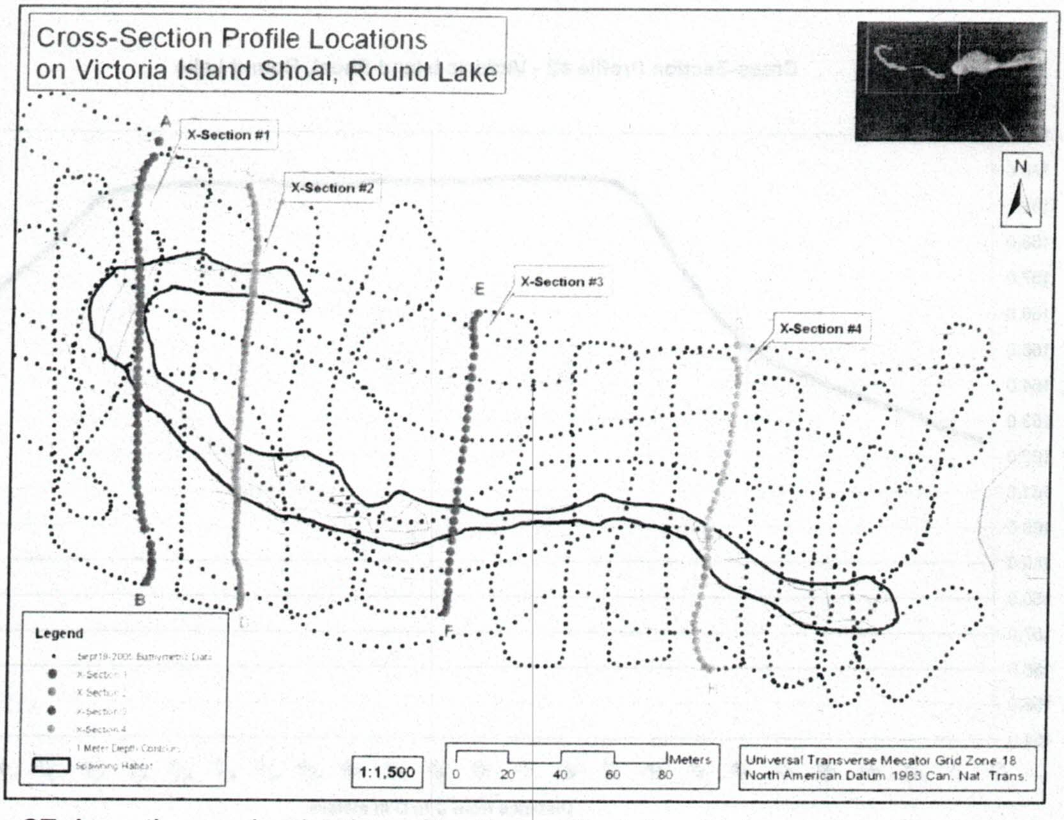


Figure 27. Location and selection of bathymetric data points used to create four cross sectional profiles along Victoria Island shoal, Round Lake.

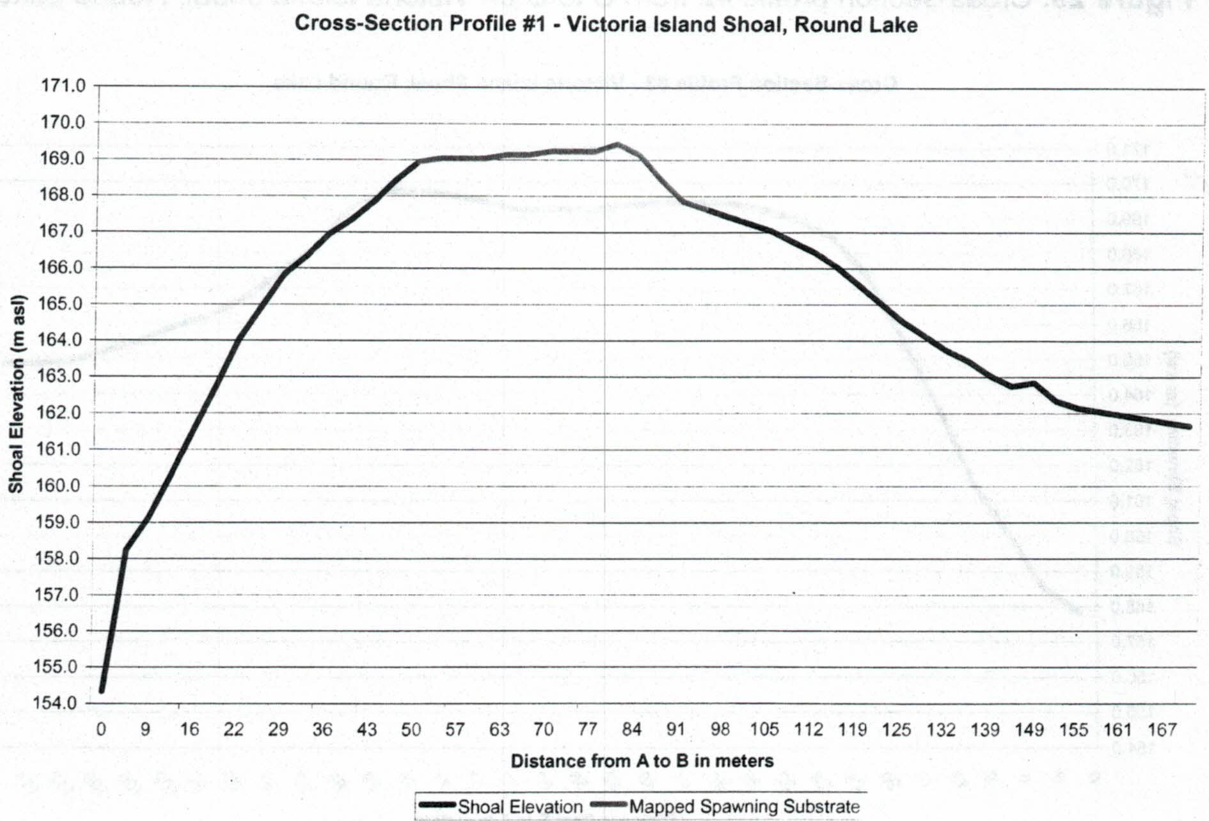


Figure 28. Cross-section profile #1 from A to B on Victoria Island shoal, Round Lake.

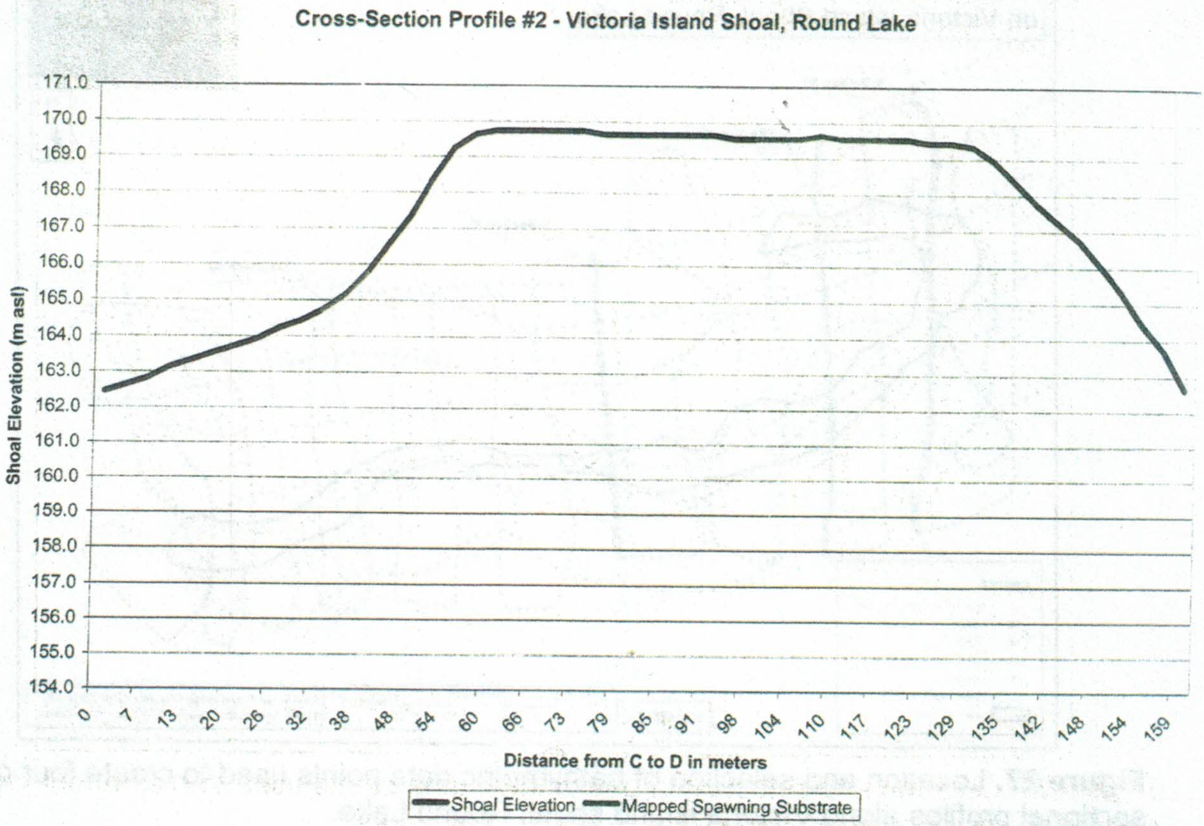


Figure 29. Cross-section profile #2 from C to D on Victoria Island shoal, Round Lake.

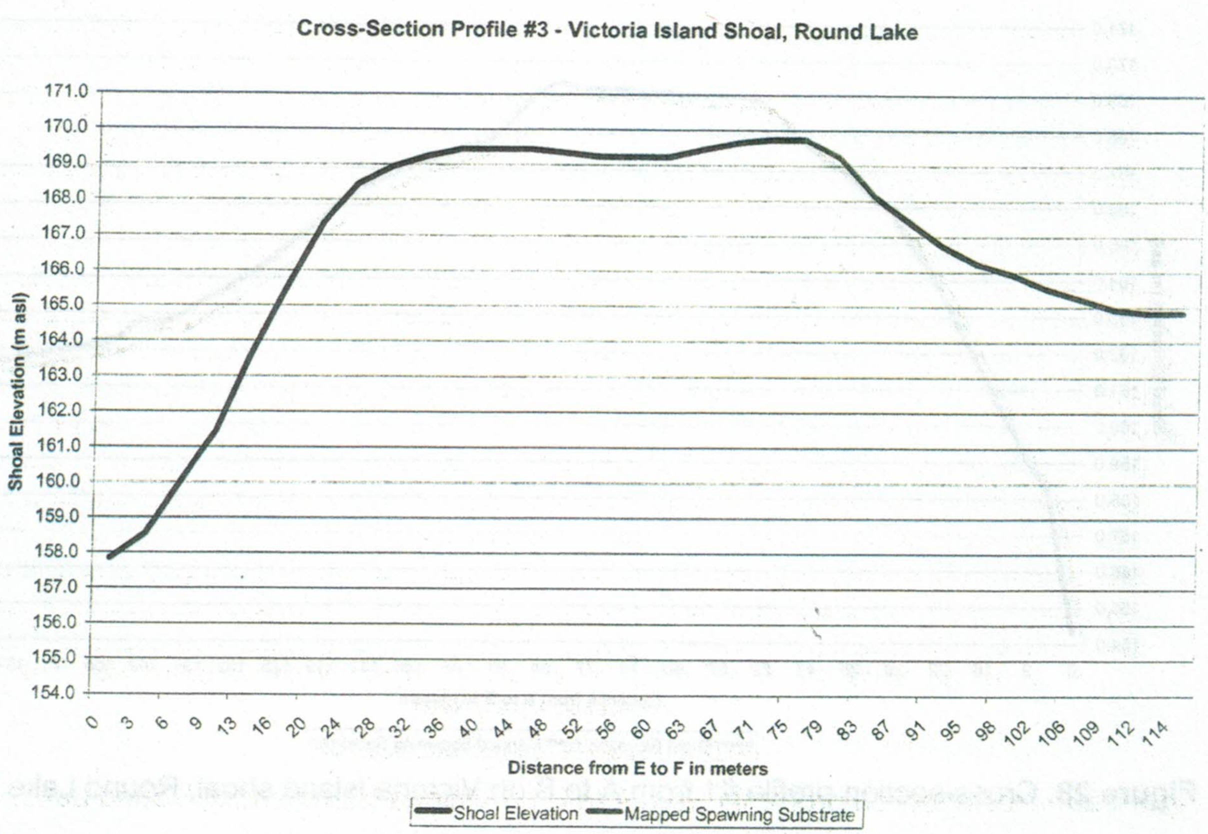


Figure 30. Cross-section profile #3 from E to F on Victoria Island shoal, Round Lake.

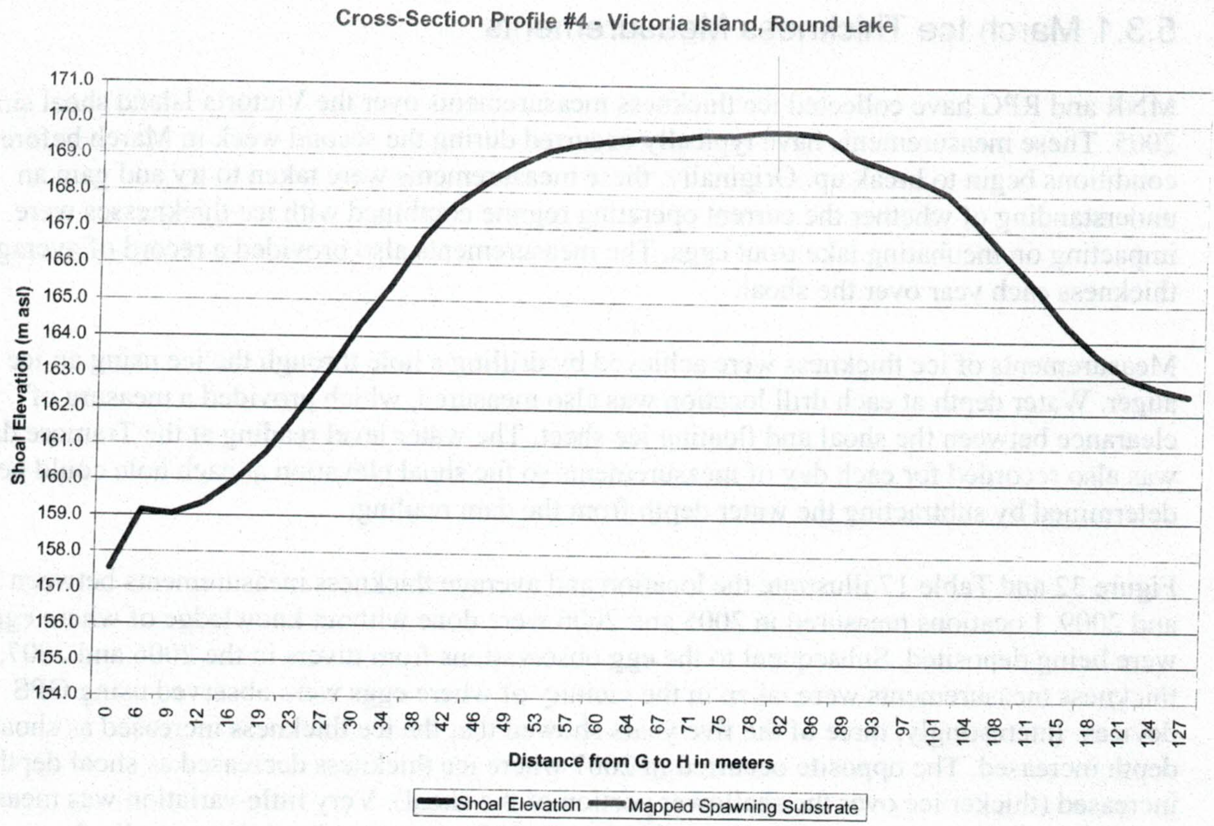


Figure 31. Cross-section profile #4 from G to H on Victoria Island shoal, Round Lake.

5.3 Lake Trout Egg Incubation Study

During the initial project planning, it became apparent that there was a need to gather specific data pertaining to the incubation of lake trout eggs on the Victoria Island Shoal and whether water/ice levels were affecting eggs during the egg incubation and sac fry stage.

The duration of incubation at various elevations on the shoal was of particular interest in order to determine if incubation duration was influenced by elevation (i.e. faster incubation in deeper sites compared to slower incubation in shallower sites). Furthermore, the subsequent analysis of the data would indicate if a particular stage of development was being impacted (i.e. egg vs. sac fry stage). To supplement this work, ice thickness data on Victoria Island Shoal from previous winters (2005 to 2009) was included to determine the effects of ice on the incubation and sac fry stage.

Artificial incubators (Scotty Boxes) were also used to carry out a study aimed at answering some of these questions. It was also hoped that this study might shed some light on the suitability of using artificial incubators to supplement the amount of naturally deposited fertilized eggs on the shoal and therefore the reproductive potential of lake trout in Round Lake (Section 5.3.5). Furthermore, it was hoped that the incubators would provide some evidence of survivorship when retrieved in March by visual observation of sac fry within the incubators.

5.3.1 March Ice Thickness Measurements

MNR and RPG have collected ice thickness measurements over the Victoria Island shoal since 2005. These measurements have typically occurred during the second week in March before ice conditions begin to break up. Originally, these measurements were taken to try and gain an understanding of whether the current operating regime combined with ice thicknesses were impacting on incubating lake trout eggs. The measurements also provided a record of average ice thickness each year over the shoal.

Measurements of ice thickness were achieved by drilling a hole through the ice using an ice auger. Water depth at each drill location was also measured, which provided a measure of clearance between the shoal and floating ice sheet. The water level reading at the Tramore dam was also recorded for each day of measurements so the shoal elevation at each hole could be determined by subtracting the water depth from the dam reading.

Figure 32 and Table 17 illustrate the location and average thickness measurements between 2005 and 2009. Locations measured in 2005 and 2006 were done without knowledge of where eggs were being deposited. Subsequent to the egg observations from divers in the 2006 and 2007, ice thickness measurements were taken in the vicinity of where eggs were observed using GPS devices. Interestingly, three of the five years showed that the ice thickness increased as shoal depth increased. The opposite occurred in 2007 where ice thickness decreased as shoal depth increased (thicker ice over the shallower portion of the shoal). Very little variation was measured in 2009. Actual measurements between 2005 and 2009 are summarized in Appendix 4.

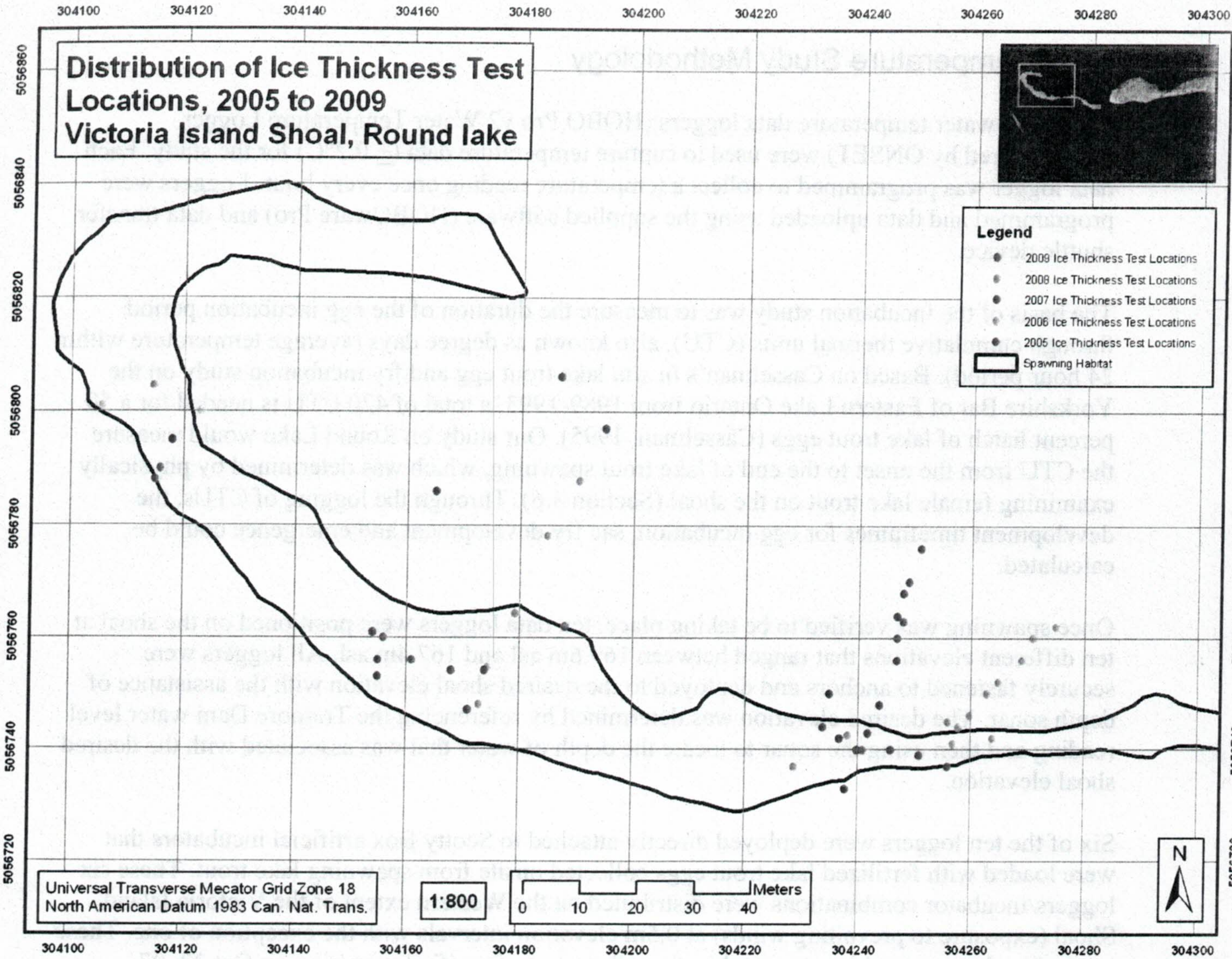


Figure 32. Distribution of drill locations for measuring ice thicknesses between 2005 and 2009.

Table 17. Average Ice Thickness over Victoria Island Shoal, 2005 to 2009

Date	Tramore Dam Reading	# of Test Holes	Average Ice Thickness (meters)	Minimum Observed Thickness (meters)	Maximum Observed Thickness (meters)	General Comments on Measurements
March 9, 2005	170.49	19	0.58	0.40	0.71	Ice thickness increased as shoal depth increased
March 15, 2006	170.18	10	0.43	0.30	0.53	Ice thickness increased as shoal depth increased
March 9, 2007	170.33	8	0.47	0.38	0.55	Ice thickness decreased as shoal depth increased
March 11, 2008	170.60	10	0.52	0.43	0.55	Ice thickness increased as shoal depth increased
March 11, 2009	170.30	7	0.52	0.48	0.55	No significant changes in thickness

5.3.2 Temperature Study Methodology

Electronic water temperature data loggers (HOBO Pro v2 Water Temperature Logger, manufactured by ONSET) were used to capture temperature data ($\pm$ 0.2°C) for the study. Each data logger was programmed to collect a temperature reading once every hour. Loggers were programmed and data uploaded using the supplied software (HOBOware Pro) and data transfer shuttle device.

The basis of the incubation study was to measure the duration of the egg incubation period through cumulative thermal units (CTU), also known as degree days (average temperature within 24 hour period). Based on Casselman's *in situ* lake trout egg and fry incubation study on the Yorkshire Bar of Eastern Lake Ontario from 1989-1993, a total of 420 CTU is needed for a 50 percent hatch of lake trout eggs (Casselman, 1995). Our study on Round Lake would measure the CTU from the onset to the end of lake trout spawning, which was determined by physically examining female lake trout on the shoal (Section 3.6). Through the logging of CTUs, the development timeframes for egg incubation, sac fry development and emergence could be calculated.

Once spawning was verified to be taking place, ten data loggers were positioned on the shoal at ten different elevations that ranged between 169.6m asl and 167.4m asl. All loggers were securely fastened to anchors and deployed to the desired shoal elevation with the assistance of depth sonar. The desired elevation was determined by referencing the Tramore Dam water level reading and then using the sonar to locate the depth of water that was associated with the desired shoal elevation.

Six of the ten loggers were deployed directly attached to Scotty Box artificial incubators that were loaded with fertilized lake trout eggs collected onsite from spawning lake trout. These six loggers/incubator combinations were distributed on the Western extent of the Victoria Island Shoal (exposure to prevailing winds) at 0.5m elevation intervals with the exception of one. These logger/incubators would represent data from the onset of verified spawning on Oct 22, 07.

An additional four loggers (no incubators attached) were also deployed on Nov 3, 2007 to represent data from the end of the spawning period. These loggers were also deployed at 0.5m elevation intervals that staggered the previous six logger/incubator elevations (see Figure 33 & Table 18). The first five loggers/incubators were retrieved during ice thickness measurements on March 11, 2008, while the remaining loggers were left to collect data well into the summer of 2008.

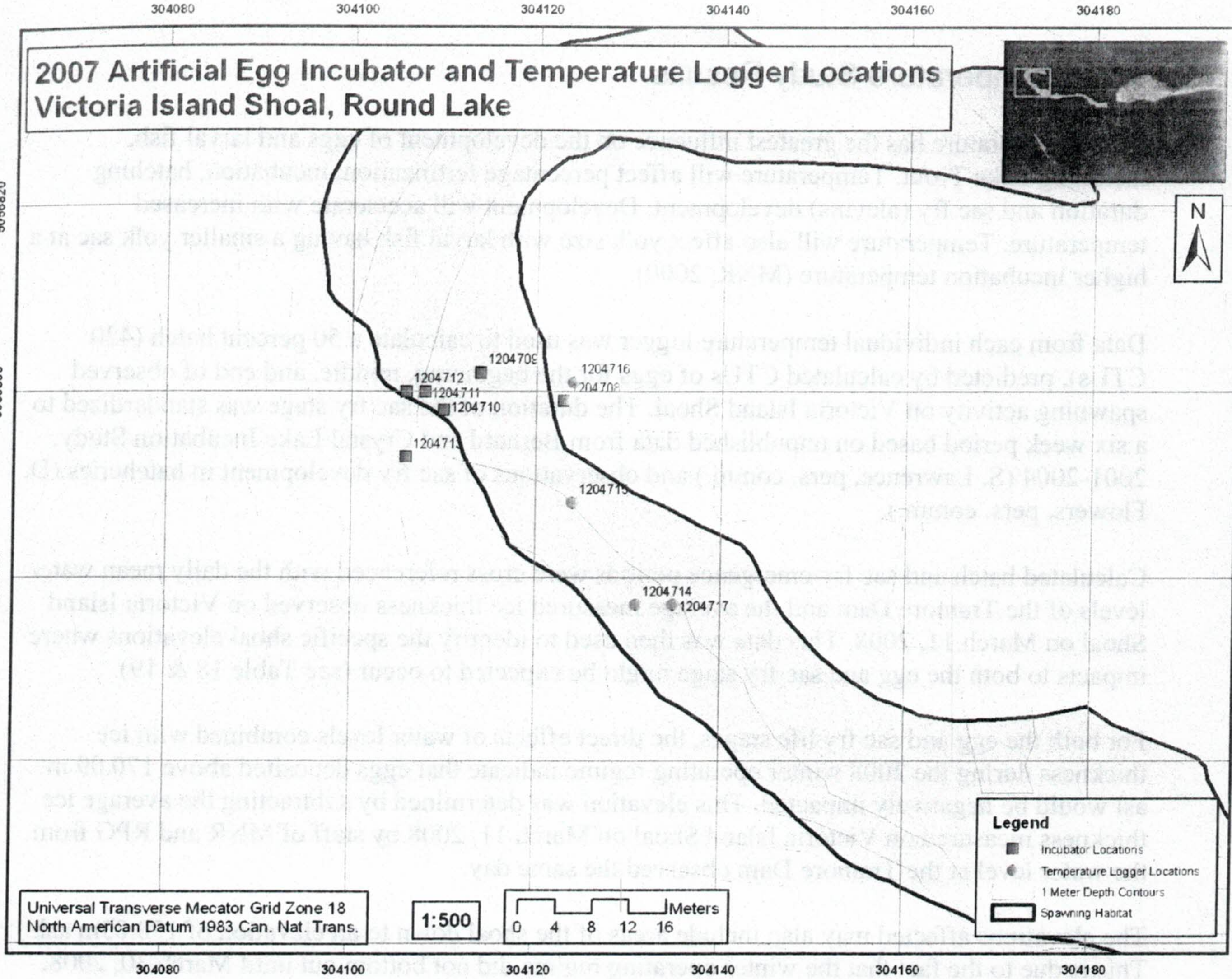


Figure 33. Distribution of temperature data loggers and egg incubators.

Table 18. Distribution by Elevation of Data Loggers and Scotty Box Incubators

Logger I.D.	Description	Tramore Dam Water Level	Depth (m)	Shoal Elevation m asl	Easting	Northing	Deployed
1204708	Logger/Incubator #1	170.6	1	169.6	18T 0304123	5056799	22-Oct-07
1204709	Logger/Incubator #2	170.6	1.2	169.4	18T 0304114	5056802	22-Oct-07
1204710	Logger/Incubator #3	170.6	1.7	168.9	18T 0304110	5056798	22-Oct-07
1204711	Logger/Incubator #4	170.6	2.2	168.4	18T 0304108	5056800	22-Oct-07
1204712	Logger/Incubator #5	170.6	2.7	167.9	18T 0304106	5056800	22-Oct-07
1204713	Logger/Incubator #6	170.6	3.2	167.4	18T 0304106	5056793	22-Oct-07
1204717	Logger #7	170.6	1.4	169.2	18T 0304135	5056777	03-Nov-07
1204715	Logger #8	170.6	1.6	169.0	18T 0304124	5056788	03-Nov-07
1204716	Logger #9	170.6	1.9	168.7	18T 0304124	5056801	03-Nov-07
1204714	Logger #10	170.6	2.0	168.6	18T 0304131	5056777	03-Nov-07

5.3.3 Temperature Study Results

Water temperature has the greatest influence on the development of eggs and larval fish, including Lake Trout. Temperature will affect percentage fertilization, incubation, hatching duration and sac fry (alevins) development. Development will accelerate with increased temperature. Temperature will also affect yolk size with larval fish having a smaller yolk sac at a higher incubation temperature (MNR, 2000).

Data from each individual temperature logger was used to calculate a 50 percent hatch (420 CTUs), predicted by calculated CTUs of eggs for the beginning, middle, and end of observed spawning activity on Victoria Island Shoal. The duration of the sac fry stage was standardized to a six week period based on unpublished data from Bernard and Crystal Lake Incubation Study, 2001-2004 (S. Lawrence, pers. comm.) and observations of sac fry development in hatcheries (D. Flowers, pers. comm.).

Calculated hatch and sac fry/emergence periods were cross referenced with the daily mean water levels of the Tramore Dam and the average measured ice thickness observed on Victoria Island Shoal on March 11, 2008. This data was then used to identify the specific shoal elevations where impacts to both the egg and sac fry stage might be expected to occur (see Table 18 & 19).

For both the egg and sac fry life stages, the direct effects of water levels combined with ice thickness during the 2008 winter operating regime indicate that eggs deposited above 170.09 m asl would be negatively impacted. This elevation was determined by subtracting the average ice thickness measured on Victoria Island Shoal on March 11, 2008 by staff of MNR and RPG from the water level at the Tramore Dam observed the same day.

The elevations affected may also include areas of the shoal down to an elevation of 170.03m asl. This is due to the fact that the winter operating regime did not bottom out until March 30, 2008. However, ice thickness at this time was not measured and may not have been the same as on March 11, 2008. Therefore, the 170.09m asl elevation should be used to define the impact to eggs/alevins during 2008.

The data from each temperature logger was also analyzed to see if there were any differences in temperature based on the elevational location on the shoal. Differences in temperature would directly affect the accumulation of CTUs, which directly influences the rate of development in both eggs and sac fry.

As illustrated by Figure 34, the temperature differences between elevations were very small except during two periods. The first period being from mid-December and mid-January and the second being from late-January and early-April. The differences between each logger/elevation during these periods are distinct and partially account for the wide duration of hatching and subsequent sac fry periods. The other obvious contributing factor to these lengthy periods is the differences in temperature between the start and end of spawning.

Table 19. Calculated lake trout hatch and associated water level/ice impacts on Victoria Island Shoal.

		Egg Stage of Development on Victoria Island Shoal											
		A	B	C	D	E		F	G		H	I	J
Logger I.D.	Description	Date Deployed	Tramore Dam Water Level on Date of Deployment	Water Depth(m) on Deployment Date	Shoal Elevation m asl where Logger is Located	Date which 420 CTUs is reached (50% Hatch)	Total Days to Reach "E" (Hatch)	Tramore Dam Water Level on Date of "E"	Meter of Water over Shoal at "E" excluding Ice Thickness	Change in Depth (m) Between A and E	Minimum Tramore Dam Water Level Between A and E	*170.60 minus 0.51m	Impact to egg stage of Development
1204708	Logger/Incubator #1	22-Oct-07	170.65	1	169.6	18-Jan-08	88	170.93	1.33	+0.28	170.61 on Nov 5, 07	Unknown ice thickness in mid Jan	Unknown
1204709	Logger/Incubator #2	22-Oct-07	170.65	1.2	169.4	14-Jan-08	84	170.91	1.51	+0.26			
1204710	Logger/Incubator #3	22-Oct-07	170.65	1.7	168.9	19-Jan-08	89	170.93	2.03	+0.28			
1204711	Logger/Incubator #4	22-Oct-07	170.65	2.2	168.4	14-Jan-08	84	170.92	2.52	+0.27			
1204712	Logger/Incubator #5	22-Oct-07	170.65	2.7	167.9	16-Jan-08	86	170.94	3.04	+0.29			
1204713	Logger/Incubator #6	22-Oct-07	170.65	3.2	167.4	13-Jan-08	83	170.91	3.51	+0.26			
1204717	Logger #7	03-Nov-07	170.62	1.4	169.2	25-Apr-08	174	171.69	2.49	+1.07	170.54 on Mar 30, 08	170.09	**Impacts to all eggs deposited above 170.09m asl
1204715	Logger #8	03-Nov-07	170.62	1.6	169.0	27-Apr-08	176	171.66	2.66	+1.04			
1204716	Logger #9	03-Nov-07	170.62	1.9	168.7	23-Apr-08	172	171.71	3.01	+1.09			
1204714	Logger #10	03-Nov-07	170.62	2	168.6	15-Apr-08	164	171.38	2.78	+0.76			

* denotes the Tramore Dam Water Level and Average Ice Thickness measured on Victoria Island Shoal on March 11th, 2008.

** denotes that another 6 cm of impact may have occurred as drawdown continued until Mar 30th, but ice thickness at that time is unknown (170.54 minus 0.51 = 170.03).

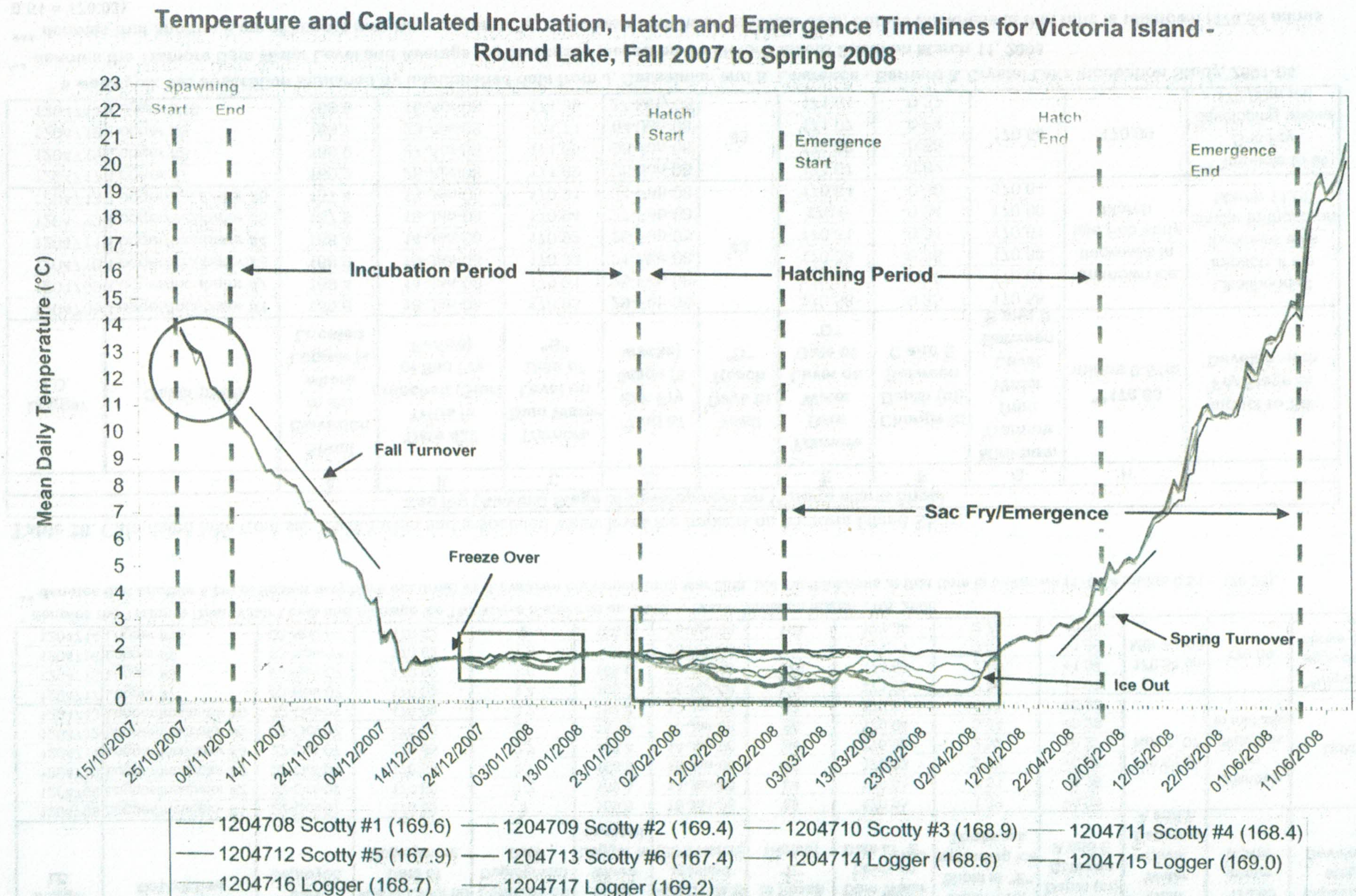
Table 20. Calculated lake trout sac fry duration and associated water level/ice impacts on Victoria Island Shoal.

		Sac Fry (Alevins) Stage of Development on Victoria Island Shoal									
		A	B	C	D		E	F	G	H	I
Logger I.D.	Description	Shoal Elevation m asl where Logger is Located	Date 420 THUs is reached (Start of Sac Fry Period)	Tramore Dam Water Level on Date of "B"	*End of Sac Fry Stage (6 weeks)	Total Days to Reach "D"	Tramore Dam Water Level on Date of "D"	Change in Depth (m) Between C and E	Minimum Tramore Dam Water Level Between B and D	**170.60 minus 0.51m	Impact to Sac Fry Stage of Development
1204708	Logger/Incubator #1	169.6	18-Jan-08	170.93	29-Feb-08	43	170.58	-0.35	170.58	Unknown ice thickness in late Feb early March	Likelihood of impacts if ice thickness was similar to those on March 11,08
1204709	Logger/Incubator #2	169.4	14-Jan-08	170.91	25-Feb-08		170.61	-0.30	170.61		
1204710	Logger/Incubator #3	168.9	19-Jan-08	170.93	01-Mar-08		170.58	-0.35	170.58		
1204711	Logger/Incubator #4	168.4	14-Jan-08	170.92	25-Feb-08		170.61	-0.31	170.61		
1204712	Logger/Incubator #5	167.9	16-Jan-08	170.94	27-Feb-08		170.6	-0.34	170.60		
1204713	Logger/Incubator #6	167.4	13-Jan-08	170.91	24-Feb-08		170.61	-0.30	170.61		
1204717	Logger #7	169.2	25-Apr-08	171.69	06-Jun-08	43	171.07	-0.62	170.54	170.09	***Impacts to all Sac Fry developing above 170.09m asl
1204715	Logger #8	169.0	27-Apr-08	171.66	08-Jun-08		171.08	-0.58			
1204716	Logger #9	168.7	23-Apr-08	171.71	04-Jun-08		171.07	-0.64			
1204714	Logger #10	168.6	15-Apr-08	171.38	27-May-08		171.01	-0.37			

* 6 week yolk sac absorbtion indicated by unpublished data from J. Casselman and S. Lawrence - Barnard & Crystal Lake Incubation Study, 2001-04.

/** denotes the Tramore Dam Water Level and Average Ice Thickness measured on Victoria Island Shoal on March 11, 2008.

*** denotes that another 6 cm of impact may have occurred as drawdown continued until Mar 30th, but ice thickness at that time is unknown (170.54 minus 0.51 = 170.03).



Notes: The red circle indicates the differences in water temperature during the spawning period. Red rectangles indicate areas of temperature variation due to elevation (depth) differences on the shoal. The combination of these will result in varying durations of incubation, hatch and subsequent fry swim-up.

Figure 34. Incubation, hatch and emergence times predicted from temperature logger data.

Temperature readings from the six loggers on Oct 23, 07 (the day after deployment) ranged from 13.81°C to 13.92°C (mean = 13.87°C). Twelve days later (end of observed spawning), temperatures from all 10 loggers ranged from 10.22°C to 10.34°C (mean = 10.27°C). Mid-spawning temperatures from six loggers ranged from 12.37°C to 12.45°C (mean = 12.41°C).

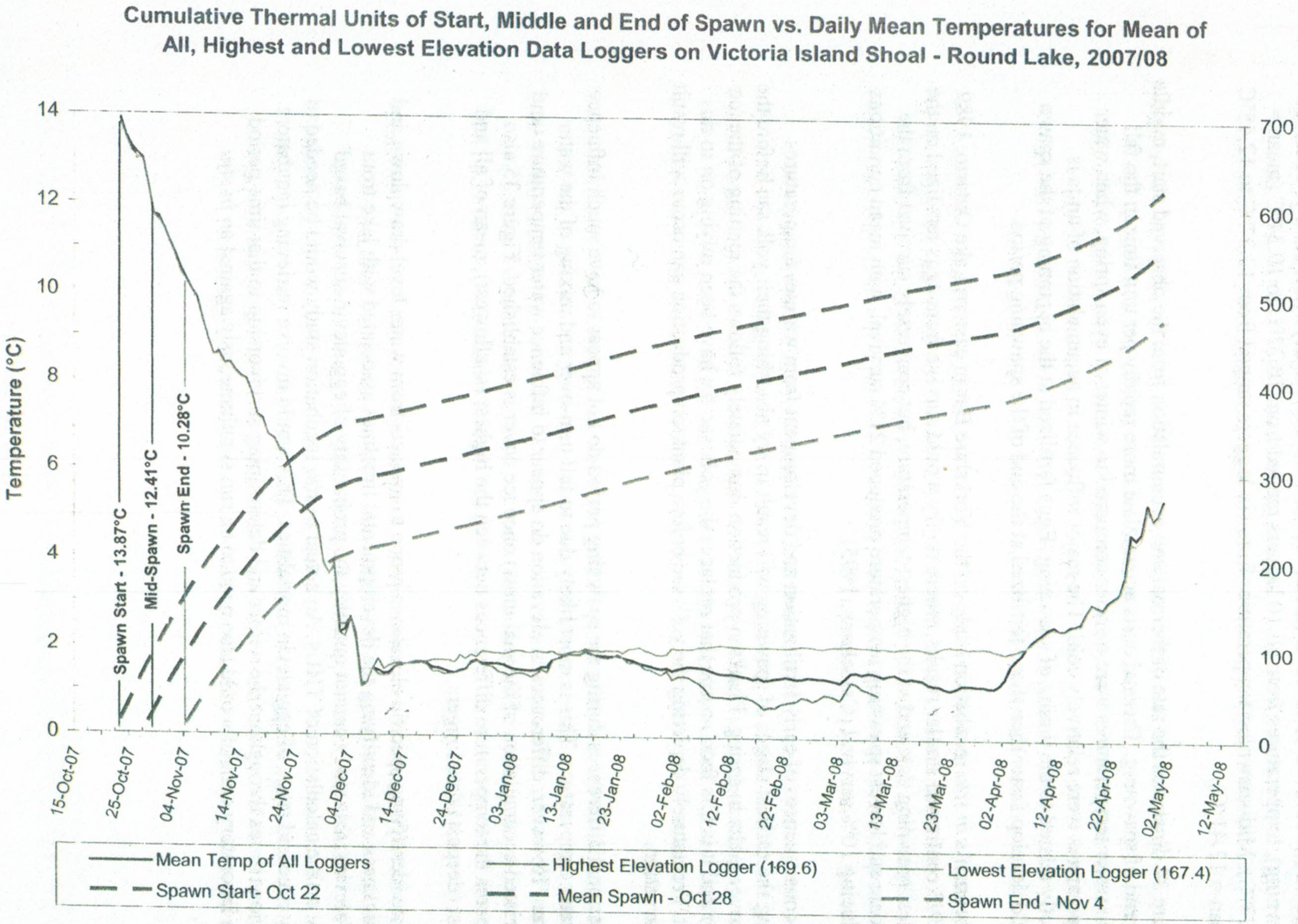
Figure 34 illustrates the rate of thermal unit accumulation from the observed start, middle and end of spawning. Thermal units accumulate more rapidly per unit time in the fall when water temperatures were warmer compared to winter or even spring, when water temperatures were relatively cold. The major influence in accumulation of units is directly related to the timing of spawning. Eggs fertilized at the beginning of the spawn would develop faster then those fertilized at the end of the spawning period.

Casselman's *in situ* incubation study on the Yorkshire Bar in eastern Lake Ontario, 1989 to 1993 confirmed similar results, where no fry would survive from eggs fertilized on the earliest spawning date and at the highest temperature, but conversely survival from the last date and lowest spawning temperature produced 21% survival, with mean conditions producing 10% survival (Casselman, 1995).

The consequences of early fertilization and development from warmer temperatures during the earliest stages of spawning will result in fry absorbing their yolk sac before the ice cover melts in spring. Plankton production immediately follows the melting of the ice cover and it is this food source that replaces the yolk sac fry have been relying on to this point. Prematurely depleting the yolk sac before plankton production can occur will result in starvation.

Elevational differences during the spawning period do not appear to have much influence on water temperature. This is most likely due to fall turn-over and mixing of the water column. However, differences in elevation do appear to influence water temperature (and associated accumulation of thermal units) once ice cover is established. Figure 35 also compares the temperature differences between the highest (shallowest), mean of all and lowest (deepest) data loggers.

Despite identifying specific elevations prone to impacts from water level draw down and ice thickness and identifying the developmental timelines associated with lake trout eggs/alevins; this study cannot quantify the probability of egg/alevin survival based solely on the calculation of THUs. An actual *in situ* incubation study would be needed to verify time and stage of egg/alevin mortalities. This would involve retrieving incubators at various times throughout the winter and determining survivorship to that time period. An in laboratory control would also need to be run simultaneously against an *in situ* study.



Mean daily water temperatures associated with lake trout spawning period in Round Lake are delineated by the vertical solid lines falling on the appropriate dates for beginning, middle and end of spawning. These dates mark important times when incubation would begin for naturally deposited and fertilized eggs. Curves (dashes) illustrate the CTUs commencing on each of these dates. Coloured solid lines indicated daily mean temperatures of loggers located at the highest (shallowest) vs. lowest (deepest) elevations. Black solid line indicated the average daily mean temperatures of all 10 loggers combined.

Figure 35. Thermal unit accumulation and mean daily temperatures of data loggers.

5.3.4 Temperature Study Discussion

In the absence of a detailed *in situ* study, the analysis of CTUs from the 10 data loggers situated at various elevations on the Victoria Island shoal should provide relatively close predictions of incubation, hatch, and emergence timelines for 2007/08. When combined with water level and ice thickness data, the identified elevations impacted and to what life stage the impacts occur should provide enough information to develop a water management regime that will minimize impacts to lake trout eggs.

Again, the analysis is only specific to the operating regime and ice thicknesses observed in 2008. Years with different water levels and ice thicknesses will ultimately have different results. In the case of 2008, the entire observed winter operating level was higher than the typical operating line. For example, the operating level ranged approximately 20 to 40cm higher than the typical operating line between weeks eight through 13. With the 2008 winter operating levels being higher than typical, one can acknowledge that the calculated effects of water levels and ice thickness on incubating egg/fry in 2008 would have been less than what would have occurred if the operating regime followed the typical operating line. If typical operating line is a reflection of past operations (and desired levels), it is reasonable to conclude that in years where the winter operation regime follows the typical line, increased impacts to incubating egg/sac fry will occur.

These impacts are perceived to be minimal as most eggs observed in 2006 and 2007 were documented below 169.5 m asl, beyond the elevation impacted by 0.5m of ice thickness.

5.3.5 Scotty Box Experiment

Methodology - In the absence of being able to conduct an *in situ* incubation study on Round Lake due to funding limitations and manpower, a small scale experiment using artificial egg incubators (Scotty Boxes) was used instead (Figure 36). This experiment was run simultaneous to the egg incubation study previously described.

Artificial egg incubators (Scotty Boxes, manufactured by Scotty Plastics Ltd.) were used to house fertilized eggs that were collected and fertilized from captured lake trout that were using Victoria Island shoal. These incubators were scientifically designed and tested plastic incubation units that were developed to provide an efficient aid in the stream incubation of salmon eggs. Their unique design either eliminates or minimizes most of the problems experienced by natural incubation. Fungus infection is virtually eliminated and eggs are protected from predators and silt suffocation. Pilot testing by the company indicates survival rates from egg to fry are often better than 90 percent as compared to natural spawning survival rates of between five percent and 20 percent.

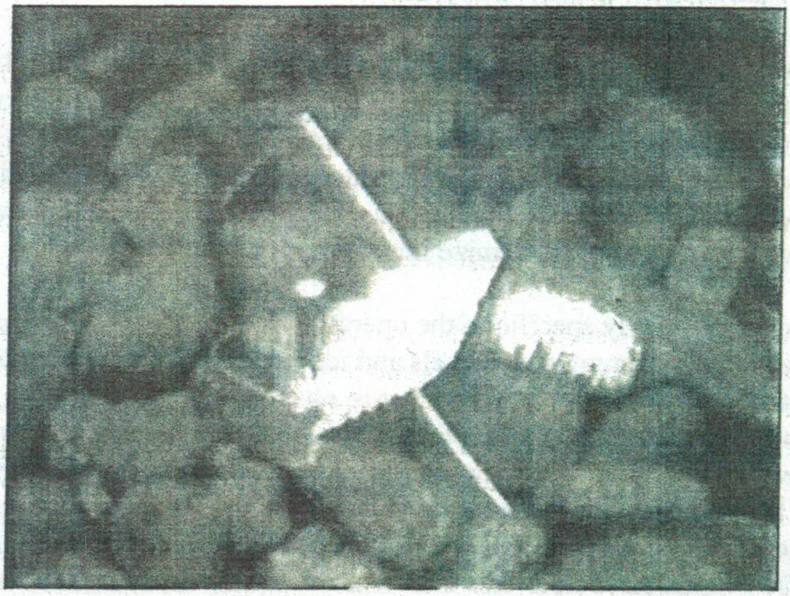


Figure 36. Under water photograph of Scotty Box and data logger situated on spawning substrate.

Although these incubators were designed for river systems, it was thought their use for incubating lake trout eggs in a lake environment would be worthy of trying. Several sizes of incubators were available. The incubator size refers to the size of the egg chambers and the exit hole for the fry to emerge from. We ordered our Scotty Boxes with the appropriate size of chambers and exit holes to accommodate lake trout egg sizes of 5-6 mm. Each individual box contained a total of 200 individual incubation chambers.

Egg collection occurred on Oct 22, 2007 during spawning assessment (Section 3.6) on Victoria Island Shoal. Both females and males were captured and held in floating mesh cage for use in the fertilization procedure. Dry fertilization (eggs and milt applied in the absence of water) was used to fertilize eggs in accordance to the hand spawning procedure outlined in the MNR Fish Culture Manual (MNR, 2000).

The procedure is a non-lethal technique used to obtain eggs and milt from ripe fish. Eggs and milt are collected separately and only mixed using one female to no more than two or three males for each female lot of eggs. After fertilization, eggs were loaded into incubators using the supplied loading tray and boxes were securely closed using the supplied hardware.

Each box containing fertilized eggs was immediately immersed in a tub of water to begin the water hardening phase and to prevent the eggs from drying out. Once a sufficient number of boxes were filled with eggs, temperature data loggers and anchors were wired to each immersed incubator box. Each incubator box was not removed from the tub of water until it was ready to be deployed at the desired depth using the onboard sonar.

A length of rope measuring at least twice as long as the desired depth was looped through the center bolt of the egg incubator, and both ends of the rope were held in hand. When the boat was positioned at the desired depth and location, the incubator was lowered to the bottom; one end of the rope was released and the other end of the rope was pulled back into the boat. This resulted in each incubator being deployed at precisely the correct depth and elevation.

Scotty Box Experiment Results and Discussion - Six incubators were deployed on Oct 22, 2007 at six different elevations along the western extent of Victoria Island Shoal (refer back to Figure 24). Elevations ranged from 169.6m asl to 167.4m asl (Table 21).

Table 21. Elevational Distribution of Scotty Box Incubators

Logger I.D.	Description	Tramore Dam Water Level	Depth (m)	Shoal Elevation m asl	Easting	Northing	Deployed
1204708	Logger/Incubator #1	170.6	1	169.6	18T 0304123	5056799	22-Oct-07
1204709	Logger/Incubator #2	170.6	1.2	169.4	18T 0304114	5056802	22-Oct-07
1204710	Logger/Incubator #3	170.6	1.7	168.9	18T 0304110	5056798	22-Oct-07
1204711	Logger/Incubator #4	170.6	2.2	168.4	18T 0304108	5056800	22-Oct-07
1204712	Logger/Incubator #5	170.6	2.7	167.9	18T 0304106	5056800	22-Oct-07
1204713	Logger/Incubator #6	170.6	3.2	167.4	18T 0304106	5056793	22-Oct-07

All incubators were left to incubate until March 11, 2008 when MNR and RPG retrieved five of the six incubators. The deepest incubator could not be reached and was retrieved along with the other data loggers later in the summer.

The five incubators that were retrieved in March resulted in the following observations or combination thereof:

- Incubator was empty with the exception of a few dead eggs. This likely means that eggs hatched successfully and fry migrated out of incubator once their yolk sac was absorbed.

- Incubator was full of dead eggs in a state of decomposition. Decomposition prevented determination of whether eggs were not fertilized properly or died partway through incubation. Most likely, improper selection of eggs of correct ripeness contributed to unsuccessful fertilization.

The results for the empty Scotty Boxes are inconclusive. It was hoped that the incubators when opened would provide some evidence of sac fry or successful incubation. Since we had no prior data to determine when incubation would end and therefore how long the fish would be in sac fry life stage, we were unsuccessful in confirming whether eggs were incubated, hatched, and developed to the sac fry stage.

Based on the accumulation CTU from the data loggers attached to the incubators, March 11, 2008 put the retrieval of the incubators beyond the sac fry stage. Meaning, the sac fry would have absorbed their yolk sac and migrated out of the incubators as swim up fry by late-February. In short, we missed the sac fry stage of development by retrieving the incubators too late.

The incubators that still had the majority of eggs present did not seem to develop whatsoever. This is most likely due to unsuccessful fertilization from the very beginning.

The unsuccessful fertilization is most likely the result of selecting fish that were not fully ripened. Inexperience in determining the degree of ripeness of both female and male fish will inadvertently result in underdeveloped eggs being used, which for the most part are infertile. In addition, the egg collection occurred at the start of observed spawning activity and was not conducted throughout the spawning period. This likely contributed to inadvertently selecting early spawning lake trout, which may not have been fully ripened.

If future egg collections and incubator are to be used, the egg collection should be broadened to include eggs from throughout the spawning season. In addition, collections should be conducted with the help of hatchery staff who have the experience to determine the spawning readiness of individual fish.

6.0 Conclusions

In addition to the orignal project objectives summarized in Section 1.1, several additional information items were addressed through one or a combination of the study results above. The following conclusions have been reached for the various studies.

6.1.1 Bathymetry

The quantitative and spatial data obtained from automated electronic bathymetry survey of Round Lake and its shoals provided a basis from which other survey work and studies could be drawn from. Numerical data of both water volumes and areas for all depths have supported calculations for cold water habitat, dissolved oxygen, lake trout population and density estimates, spawning habitat location and elevation. This information will continue to provide value in terms of supporting future work and mapping products. In conclusion, the bathymetry work completed on Round Lake was a success.

6.1.2 Dissolved Oxygen

The Mean Volume Weighted Hypolimnetic Dissolved Oxygen measurement of 8.4 mg/L^{-1} confirmed excellent coldwater oxygen levels for both juvenile and adult lake trout. This measurement was above the minimum criteria of 7 mg/L^{-1} described by Evans' research, which was subsequently adopted into MNR policy. In conclusion, these findings strongly support that dissolved oxygen in Round Lake is not a contributing factor negatively effecting lake trout.

6.1.3 Shoal Mapping

The shoal mapping methodology and results successfully provided detailed information pertaining to the quantity (area) and elevation ranges of suitable spawning substrate for lake trout for each of the identified shoals in Round Lake. This data supported egg incubation, egg mat studies, and diving operations. The accuracy of this data was also validated by the strong correlation of eggs observed by divers in both 2006 and 2007 within the area mapped. In conclusion, the shoal mapping exercise should be considered a success as it helped determine critical habitat elevations related to present water management regimes, which was identified as a project objective (Section 1.1).

6.1.4 Confirm location and timing of lake trout spawning in Round Lake.

The 2007 spawning assessment supplemented and confirmed similar spawning locations and times as observed in 2006. The timing was also consistent with peer reviewed literature for other regional lakes. The documentation of lake trout spawning also supported other studies which depended on knowing when spawning started and ended. In addition, the spawning assessment enabled the handling and observations of spawning lake trout which added to the knowledge of where and what habitat lake trout were utilizing. In conclusion, the confirmation of timing and location of lake trout spawning in Round Lake was successfully executed to supplement the various studies. This was also a project objective (Section 1.1). One recommendation related to lake trout spawning would be to further investigate the use of lake trout on the three other identified shoals adjacent to Edwards, Idywild and Un-named Islands in Round Lake. Suitable habitat exists on these shoals and further assessment to confirm their use should be completed (refer to Section 7.1).

6.1.5 Summer Profundal Index Netting

This netting exercise was tasked with addressing several project objectives (Section 1.1). These being, the lake trout population and density estimates, as well as population age structure and status of the juvenile population. In conclusion, the SPIN was able to determine an adult lake trout population and density estimate, but at a higher RSE than desired. The limited catches prevented the minimum 75 samples required to produce reliable results on life history so no age analysis could be performed. Strictly based on the total length measurements, the current lake trout population appears to consist of individuals >650 mm. The large size of these fish further complicated the density and population estimates as the selectivity correction for fish of this size is largely unknown due their rarity when the SPIN protocol was developed and tested. Assessment of juvenile lake trout unfortunately could not be conducted given the time constraints and difficulty of capturing juvenile lake trout. The primary objective of SPIN was to determine the population and density estimates for the adult population. Given the exceedingly low catches, the decision was made to cease sampling as there was no analytical advantage gained from continued netting since the target RSE of 0.15 would not be attained. To supplement and further refine these SPIN results, a series of recommendations are provided in Section 7.2 and 7.4.

6.1.6 Genetic Profile of Lake Trout in Round Lake

Genetic testing of lake trout samples collected in 2006 concludes that the current lake trout population in Round Lake is derived from natural recruitment and not from stocking events between 1931 and 1982. Despite some interbreeding with some fish from these past stocking events, lake trout in Round Lake are recognizably different from both hatchery strains historically stocked in Round Lake and regionally mixed-ancestry populations. In conclusion, the genetic profile of lake trout in Round Lake was successfully determined (Section 1.1). These results recognize lake trout in Round Lake are a natural and native population and as such, MNR must consider the policies of SPOF II and Ontario's Biodiversity Strategy for managing these fish. These findings are also supported by the management plan for naturally reproducing brook trout and lake trout populations in South Central Ontario.

6.1.7 Incubation and Egg Studies

Several exercises were undertaken to study lake trout eggs, their location and incubation. Divers confirmed egg locations in both 2006 and 2007. These locations were strongly matched to the habitat that was identified and mapped using bathymetry and underwater camera equipment. The elevations for these two years of egg observations confirmed preferred spawning depths (elevations) of lake trout occur between elevations 169.85 down to 167.09 meters asl, with the majority of eggs occurring between 169.5 and 168.7m asl. In conclusion this information, along with the average ice thickness (0.5 m) for the last five winters measured over the Victoria Island shoal, indicates that water levels would need to be maintained above 170.35m asl in order to prevent any impacts to lake trout eggs or 170.1 m asl (or current lower limit) to prevent impacts to eggs 169.5 m asl and below. It is acknowledged that in some years ice thickness may be less over the shoal than the surrounding depths, which would decrease risks to eggs. However, the 2007 data shows that ice thickness can actually increases over the shoal, which would increase risks to eggs. In light of this fact, the overall (2005 to 2009) ice thickness average should be considered to determine potential impacts to eggs when considering lower drawdown levels. It is recommended that ice thickness measurements be continued. Refer to section 7.3 for recommendations.

An egg mat experiment was conducted to help supplement diver observations of egg disposition across the Victoria Island Shoal. In addition, collection of information on substrate size and slope angle of the shoal was attempted. In conclusion, this experiment failed to provide sufficient data to provide conclusions on egg disposition, substrate size and slope angle. In lieu of this attempt, cross-sectional profiles were then created using bathymetric data that successfully illustrated four profiles across Victoria Island shoal.

A temperature study was also included to study the effects of temperature on incubating eggs and to determine timelines for the various stages of egg and fry development. To supplement and verify these timelines, artificial egg incubators were simultaneously deployed with fertilized lake trout eggs. In conclusion, the temperature study revealed that the duration of egg incubation, sac fry stage and emergence was not only directly influenced by temperature, but by both the timing of fertilization (start vs. end of spawning period) and elevation (shallow vs. deep) on the shoal. The accumulation of CTUs was greatest for loggers deployed at the start of spawning compared to the end of spawning. Accumulation was also greater for loggers deployed at lower elevations on the shoal once a solid ice sheet had formed over the lake. In conclusion, the temperature study suggested that eggs fertilized earlier in the spawning period had a less likelihood of surviving (due to accelerated development from warmer water) compared to those fertilized near the end of spawning. Elevational temperature differences were evident but only once an ice sheet had formed. The calculated timeframes for incubation, sac fry and emergence in conjunction with water level and ice thickness data enabled the identification of specific elevations susceptible to ice/water level impacts in 2008. An elevation of 170.09m asl was identified as the elevation during the winter of 2008 to which impact would occur down to. Again, the amount of impact on eggs is dependant on annual ice thickness and water levels.

The egg incubator portion of the study was inconclusive due to the fact that incubators were retrieved too late in the season and thus missing the sac fry stage of development. This prevented confirming the calculated developmental timelines of fry development. Since the retrieval of the incubators were beyond what the calculated sac fry stage would be, empty incubators may have been successful in producing lake trout. Incubators that were still full of eggs are most likely due to selecting unsuitable lake trout for the fertilization process. Refer to section 7.3 for recommendations on incubators.

7.0 Recommendations

7.1 Lake Trout Spawning Locations

- Further investigate lake trout spawning on Round Lake's three additional shoals located adjacent to Edwards, Idywild and Un-named Islands. Since the amount of spawning habitat adjacent to Un-named Island is greater than that found adjacent to Victoria Island, further assessment is needed to confirm whether these habitats are being utilized as they are on Victoria Island Shoal.

7.2 Lake Trout Population and Density Estimates

- Conduct a Mark-Recapture study to confirm the SPIN population estimate and CUE catchability of the Large Fish Gear for lake trout over 650mm. The Mark-Recapture study would be easiest completed during the fall spawning period. It would consist of capturing and tagging (Identifiable Floy Tag) as many lake trout as possible during the normal spawning assessment (short-duration gillnets). Subsequent netting the following summer when fish are dispersed will allow comparison of tagged lake trout vs. untagged. A population estimate will be determined from these results to confirm the SPIN estimate and selectivity correction of large bodied lake trout >650mm.
- Evaluate the best population estimate technique to monitor population trends in 5-year intervals. Mark-Recaptures would provide an overall population estimate. However, SPIN would provide a population estimate and possibly life history information pending sufficient catches.
- Closure of the lake trout season in Round Lake should be evaluated to help protect and recover this population. The present fishing regulations for lake trout consist of a slot size (400-550mm) where lake trout within that slot must be

released. The current size structure of the population largely consists of fish over this slot. In essence, the current slot does not protect young lake trout below the slot size, nor the prime breeders above the slot.

7.3 Recruitment

- Examine possible causes linked to low recruitment for the past decade or more. Investigation of food resources available to juvenile lake trout may also reveal links to reduced recruitment.

- If work with artificial incubators occurs in the future it is recommended that MNR hatchery staff be involved in the egg collection and fertilization procedure due to their highly extensive experience in identifying readiness of spawning fish.

- Egg collections should also be spread evenly across the entire spawning period to promote selection of a wide variety of specimens and not inadvertent selection of individuals for early spawning.

- Explore feasibility of collecting eggs from Round Lake and rearing them in a private facility for stocking back into Round Lake. Bancroft District currently has several hatcheries that may be able to accommodate the rearing of lake trout to the yearling stage if funding is provided (D. Flowers, pers. comm.).

7.4 Ice Thickness Measurements

- Annual measurements of ice thickness should continue to assist in gaining understanding what conditions influence ice thickness over the shoal. A systematic method, such as a grid pattern should be used to obtaining a representative sample of measurements. Corresponding snow depth over the ice sheet should also be collected to see if snow or the lack of influences the formation of ice.

7.5 Annual Work

- Consider a meeting each spring between representatives from MNR, RPG, Round Lake Property Owners Association and other stakeholders to discuss proposed fisheries work on Round Lake in order to communicate and increase fisheries understanding and allow opportunity for broader participation/partnerships where feasible.

8.0 References

BMT, 2005. Investigation of ice-related damages to private properties on Round and Golden Lake. Final Report. October 2005. BMT Fleet Technologies, Kanata, Ontario. 126 p.

Bronte et al. 2007. Relative abundance, site fidelity, and survival of adult lake trout in Lake Michigan from 1999 to 2001: implications for future restoration strategies. N Am J Fish Mgmt 27:137-155

Bronte, C.R. 1993. Evidence of spring spawning lake trout in Lake Superior. J Great Lakes Res. 19(3):625-629

Burr, J.M. 1993. Maturity of lake trout from eleven lakes in Alaska. Northwest Science, 67(2):78-87

Casselman, J. 1995. Survival and development of lake trout eggs and fry in Eastern Lake Ontario – *in situ* Incubation, Yorkshire Bar, 1989 to 1993. Journal of Great Lakes Research. 21 (Suppliment 1):384-399.

Casselman, J. 2005. Effects of climate and climate change on lake trout populations and fisheries. Queen's University. Kingston, Ontario. 11p.

Côté, J. 2003. Lake trout spawning shoal assessment report – Round Lake, 2002. Ontario Ministry of Natural Resources.

Dawson, K.A.; Eshenroder, R.L.; Holey, M.E.; and Ward, C. 1997. Quantification of historic lake trout (Salvelinus namaycush) spawning aggregations in Lake Michigan. Can J fish Aquat Sci 54:2290-2302

Dorr, JA III; Jude DJ; Heufelder GR; Klinger SA; Noguchi GE. 1981. Preliminary investigation of spawning habitat conditions and reproduction of LT in Easter L. Michigan near Port Sheldon, Michigan. Michigan University, Ann Arbor (USA). Sea Grant Program.

Ellrott, B.J. and Marsden, J.E. 2004. Lake trout reproduction in Lake Champlain. Transactions of the American Fisheries Society. 133:252-264
Fish Soc 86:231-244

Evans, D.O., J.M. Cassellman and C.C. Willox.1991. Effects of exploitation, loss of nursery habitat and stocking on the dynamics and productivity of lake trout populations in Ontario lakes. Lake Trout Synthesis, Response to Stress Working Group Report. Ontario Ministry of Natural Resources. Toronto, Ontario. 193 p.

Evans, D.O., Nicholls, K.H., Allen, Y.C. and McMurty, M.J. 1996. Historical land use, phosphorus loading and loss of fish habitat in Lake Simcoe, Canada. Can. J. Fish. Aquat. Sci. 53 (Suppl. 1): 194-218.

Evans, D. 2006. Effects of Hypoxia on scope-for-activity of lake trout: defining a new dissolved oxygen criterion for protection of lake trout habitat. Tech. Rep. 2005-01 Habitat & Fisheries Unit, Aquatic Research & Development Section, Aquatic Research & Development Branch, Peterborough, Ontario. 21 p.

Evans, D. 2005. Effects of Hypoxia on scope-for-activity of lake trout: defining a new dissolved oxygen criterion for protection of lake trout habitat. Tech. Rep. 2005-01 Habitat & Fisheries Unit, Aquatic Research & Development Section, Aquatic Research & Development Branch, Peterborough, Ontario. 18 p.

Evans, D. 2006. Effects of Hypoxia on scope-for-activity and power capacity of lake trout. Can. J. Fish. Aquat. Sci. 64: 345-361 (2007)

Gunn, J.M. 1995. Spawning behaviour of lake trout: effects on colonization ability. J Great Lakes Res 21 (Supp. 1):323-329

Janssen, J.; Jude, D.J.; Edsall, T.A.; Paddock, R.W.; Wattrus, N.; Toneys, M.; McKee, P. 2006. Evidence of lake trout reproduction at Lake Michigan's mid-lake reef complex. J Great Lakes Res 32:749-763

Kelso, J.R.M.; MacCallum, W.R.; and Thibodeau, M.L. 1995. Lake trout spawning at five sites in Ontario waters of Lake Superior. J Great Lakes Res. 21(Supp.1):202-211

Levec, F. 2003. GIS Analysis for Bathymetric Surveys. Inventory, Monitoring & Assessment Section. Peterborough, Ontario. 21 p.

Levec, F. 2004. B.A.S.S. 2.4 User Manual. Inventory, Monitoring and Assessment, Peterborough. 21 p. + appendices.

MacLean, J.A.; Evans, D.O.; Martin, N.V. 1981. Survival, growth, spawning distribution, and movements of introduced and native lake trout (Salvelinus namaycush) in two inland Ontario lakes. Can J Fish Aquat Sci 38:1685-1700

Marsden , J.E. and Kreuger, C.C. 1991. Spawning by hatchery-origin lake trout in Lake Ontario:data from egg collections, substrate analysis and diver observations. Can. J. Fish> Aquat. Sci. 48:2377-2384.

MNR. 1970. Lake Survey Files.

MNR, 1992. Strategic Plan for Ontario Fisheries – SPOF II. An Aquatic; Ecosystem Approach to Managing Fisheries. Queen's Printer for Ontario.

MNR, 1995. Management Plan for Naturally Reproducing Populations of Brook Trout and Lake Trout in South Central Ontario. The Brook Trout/Lake Trout Management Committee, February, 1995.

MNR, 2000. Fish Culture Course 2000 Manual. University of Guelph, August 14-18, 2000.

MNR. 2005. Bonnechere River Water Management Plan. Pembroke, Ontario. 98 p. + appendices.

MNR, 2005. Ontario's Biodiversity Strategy – Protecting What Sustains Us. Queen's Printer for Ontario 53 pp.

MNR, 2006. Inland Ontario Lakes Designated for Lake Trout Management. Fisheries Section, Fish & Wildlife Branch. Peterborough. 58 pp.

OMOE, 2007. Water Quality Management of Coldwater Lakes; County of Renfrew. Water Resources Unit, Eastern Region. 207 p.

Perkins and Krueger 1994. Assessment of lake trout spawning: evaluation of traps for measurement of egg abundance. J. Great Lakes Res. 20:385-389

Sandstrom, S. J. and N. Lester. 2007. Summer Profundal Index Netting Protocol; a Lake Trout Assessment Tool. Ontario Ministry of Natural Resources. Peterborough, Ontario. Version 2007.2. 25 p. + appendices.

Schreiner, D.R., Bronte, C.R., Payne, N, R., Fitzsimmons, J.D. and Casselman, J.M. 1995. Use of egg traps to investigate lake trout spawning in the Great Lakes. J. Great Lakes Res. 21 (Supplement): 433-444 International. Association. Great Lakes Res.

Scott, W.B.; and Crossman, E.J. 1973. Freshwater fishes of Canada. Fish. Res. Board of Can. Bull. No. 184.

Stauffer, T.M. 1981. Collecting gear for lake trout eggs and fry. Prog. Fish-Cult. 43:186-193.

Tibbits, W. 2003. An update on lake trout (Salvelinus namaycush) spawning activities in Otsego Lake. (SUNY Oneonta, Biological Field Station, Cooperstown, NY).

Weatherley, A.H.; Kaseloo, P.A.; Gare, M.D.; Gunn, J.M.; and Lipicnik, B. 1996. Field activity of lake trout during the reproductive period monitored by electromyogram radiotelemetry. J Fish Biol 48:675-685

Wetzel, R.G. 1983. Limnology. 2d ed. Saunders College Publishing, Philadelphia.

Wilson, C. 2008. Genetic assessment of ancestry of wild-caught lake trout (Salvelinus namaycush) in Round Lake. Aquatic Research and Development Section, Ontario Ministry of Natural Resources / Trent University, Peterborough ON

Appendix I - Mean Volume Weighted Hypolimnetic Dissolved Oxygen (MVWHDO) Calculations

Round Lake – August 31, 2007

Calculation of Volume Weight Average Oxygen (MVWHDO)

						A	B		
Depth (m)	Temperature	Area Top of Strat (ha)	Area Bottom of Strata (ha)	Volume	Volume Percentage	Volume as a fraction of Total Hypolimnetic Volume	D.O. (mg/L)	A*B	Comment
0 to 1	21.2		191.49				9.8		
1 to 2	20.9	191.49	226.72	208.83	7.29		9.8		
2 to 3	20.8	226.72	200.58	211.38	7.38		9.8		
3 to 4	20.8	200.58	80.30	134.57	4.70		9.6		
4 to 5	20.7	80.30	63.65	71.09	2.48		9.6		
5 to 6	20.4	63.65	88.57	75.01	2.62		9.6		
6 to 7	19.6	88.57	93.38	90.05	3.14		9.6		
7 to 8	18.6	93.38	71.37	81.3	2.84		9.9		
8 to 9	14.2	71.37	77.53	73.68	2.57		10.5		Start of Thermocline
9 to 10	11.3	77.53	86.30	81.05	2.83		10.1		
10 to 11	10.2	86.30	72.90	78.81	2.75		9.2		
11 to 12	9.6	72.90	74.96	73.18	2.55	0.0416	9.1	0.378	Start of Hypolimnion
12 to 13	9.1	74.96	78.79	76.09	2.66	0.0432	8.9	0.385	
13 to 14	8.7	78.79	79.50	78.35	2.73	0.0445	8.8	0.392	
14 to 15	8.4	79.50	77.98	77.95	2.72	0.0443	8.7	0.385	
15 to 16	8.1	77.98	72.29	74.36	2.59	0.0423	8.6	0.363	
16 to 17	7.9	72.29	72.46	71.65	2.50	0.0407	8.5	0.346	
17 to 18	7.6	72.46	80.71	75.78	2.64	0.0431	8.4	0.362	
18 to 19	7.6	80.71	70.77	74.92	2.61	0.0426	8.4	0.358	
19 to 20	7.5	70.77	73.42	71.37	2.49	0.0406	8.3	0.337	
20 to 21	7.4	73.42	106.66	88.62	3.09	0.0504	8.3	0.418	
21 to 22	7.3	106.66	94.37	99.44	3.47	0.0565	8.3	0.469	
22 to 23	7.3	94.37	94.76	93.61	3.27	0.0532	8.3	0.441	
23 to 24	7.3	94.76	103.15	97.93	3.42	0.0556	8.3	0.462	
24 to 25	7.3	103.15	109.63	105.3	3.67	0.0598	8.3	0.497	
25 to 26	7.2	109.63	112.61	110	3.84	0.0625	8.2	0.513	
26 to 27	7.2	112.61	144.72	127.04	4.43	0.0722	8.2	0.592	
27 to 28	7.1	144.72	83.19	111.41	3.89	0.0633	8.2	0.519	
28 to 29	7.1	83.19	55.59	68.23	2.38	0.0388	8.2	0.318	
29 to 30	7.1	55.59	32.84	43.28	1.51	0.0246	8.2	0.202	
30 to 31	7.1	32.84	18.66	25.16	0.88	0.0143	8.2	0.117	
31 to 32	7.1	18.66	15.60	16.93	0.59	0.0096	8.2	0.079	
32 to 33	7.1	15.60	12.38	13.81	0.48	0.0078	8.3	0.065	
33 to 34	7.1	12.38	11.00	11.56	0.40	0.0066	8.3	0.055	
34 to 35	7.1	11.00	6.46	25.88	0.90	0.0147	8.3	0.122	
35 to 36	7.1	6.46	6.22	6.27	0.22	0.0036	8.3	0.030	
36 to 37	7.1	6.22	4.79	5.43	0.19	0.0031	8.3	0.026	
37 to 38	7.1	4.79	5.23	4.95	0.17	0.0028	8.3	0.023	
38 to 39	7.1	5.23	5.86	5.48	0.19	0.0031	8.3	0.026	
39 to 40	7.1	5.86	4.71	5.22	0.18	0.0030	8.3	0.025	
40 to 41	7.1	4.71	6.13	5.35	0.19	0.0030	8.3	0.025	
41 to 42	7.1	6.13	2.60	4.19	0.15	0.0024	8.4	0.020	
42 to 43	7.1	2.60	2.05	2.29	0.08	0.0013	8.4	0.011	
43 to 44	7.1	2.05	1.91	1.95	0.07	0.0011	8.4	0.009	
44 to 45	7	1.91	2.08	1.97	0.07	0.0011	8.4	0.009	
45 to 46	7	2.08	1.39	1.7	0.06	0.0010	8.4	0.008	
47 to 48	7	1.39	1.01	1.18	0.04	0.0007	8.4	0.006	
48 to 49	7	1.01	0.66	0.82	0.03	0.0005	8.4	0.004	
49 to 50	7	0.66	0.42	0.53	0.02	0.0003	8.4	0.003	
50 to 51	7	0.42	0.36	0.38	0.01	0.0002	8.4	0.002	
51 to 52	7	0.36	0.30	0.32	0.01	0.0002	8.4	0.002	

Total Hypolimnetic Volume > 1759.88

8.401 **< Volume-Weighted Average Oxygen Concentration**

Total Lake Volume > 2865.65

Appendix II – 2007 Round Lake SPIN Data Entry Screen (Version 8.3)

SPIN DATA ENTRY SCREEN (VERSION 8.3)

Lake	Round Lake
Date	2007 (Year) 9 (Month)
TDS	
Office	MLFAU
Target Species	Lake Trout
Gear	SPIN

	Area	
Stratum 1 (3-10m)	1179.9	ha
Stratum 2 (10-20m)	753.8	ha
Stratum 3 (20-30m)	937.5	ha
Stratum 4 (30-40m)	90.9	ha
Stratum 5 (40-60m)	0	ha
Stratum 6 (60-80m)		ha
Stratum 7 (80+m)		m
Total Lake Area	2981.01	
Maximum Depth	52	

ALL YELLOW BOXES MUST BE FILLED IN

CUE for LT >< ?	300 / 1500
Min Sets before CUE wt	12
No. Sets per Day	10
Mean wt (catch)	kg
Confidence for Density Est.	0.68
Large Body?	Yes
request mean size >=	400

Est. # Sets Required	57
Est. # Days Required	6
Target RSE	0.15
alpha	0.1
No. of Tails	2
Desired Power	80%
Change Detectable	20%

Calculating Change

Previous Mean ______

Previous Stdev ______

Previous n= ______

Lake Trout Only	
Est Area (ha)	
0-10m	
10-20m	
20-30m	
30-40m	
40+ m	

write down areas before entering

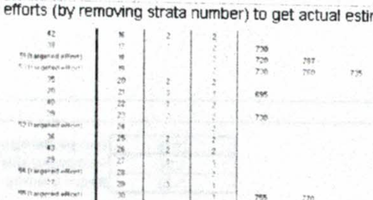
Strata Used	
1	X
2	X
3	X
4	X
5	X
6	X
7	X

SPIN Two Hour Daytime Sets Only

Lake Trout Fork Lengths (lengths caught in each set NOT net; ie. If nets strapped enter catch from both nets)

Use for Notes	Set	Strata	# of nets	Lth 1	Lth 2	Lth 3	Lth 4	Lth 5	Lth 6	Lth 7	Lth 8	Lth 9	Lth 10	Lth 11	Lth 12	Lth 13	Lth 14	Lth 15	Lth 16	Lth 17	Lth 18	Lth 19	Lth 20	Lth 21	Lth 22
19	1	3	2																						
34	2	2	2																						
4	3	4	2																						
13	4	3	2																						
44	5	2	2																						
30	6	3	2																						
31	7	2	2																						
11	8	4	2																						
12	9	3	2																						
33	10	2	2																						
26	11	3	2																						
37	12	2	2	780	710	780	715	795																	
3	13	4	2																						
22	14	3	2																						
24	15	3	1																						
42	16	2	2																						
38	17	2	2	730																					
51 (targeted effort)	18		2	720	787																				
53 (targeted effort)	19		2	730	760	735																			
35	20	2	2																						
20	21	3	1	695																					
40	22	2	2																						
39	23	2	2	730																					
52 (targeted effort)	24		2																						
36	25	2	2																						
43	26	2	2																						
29	27	3	1																						
54 (targeted effort)	28		2																						
27	29	3	1																						
55 (targeted effort)	30		1	755	770																				

Note: Delete all targeted efforts (by removing strata number) to get actual estimate. Should look like this:



Red values are those sets within area called "Little Round Lake"

Appendix II continued – 2007 Round Lake SPIN Support Sheet Report

SUMMER PROFUNDAL INDEX NETTING REPORT

Lake: Round Lake Office: MLFAU Target Sp: Lake Trout SPIII

Date: 2007 9 Total Area: 2981.01 Sampled Area: 1702 TDS: ____

Area Wt. Selectivity Adj Values	Total Catch	Arith CUE	Arith Stdev	Arith RSE
Lake Trout >=300 and <=1500mm	11	0.43	1.18	0.54

Using Large Body Conversion

Density (ha)	Pop Est	Low Est	Upper Est	Pred. Level
2.1	3,783	160	7,458	68%

Sel. Corr. Length Summary (mm)

	Mean	Std
Total Catch	752	37
For LT >400	748	31

Stratum Info	Sites #	Total # Nets	% Sites	% Samp Area	Tot Catch #	Tot Catch %	Mean CUE	Std	RSE
Stratum 1 (3-10m)	0	0			0				
Stratum 2 (10-20m)	12	24	48%	42%	10	84%	0.40	2.09	1.50
Stratum 3 (20-30m)	10	16	40%	53%	2	16%	0.11	0.56	1.60
Stratum 4 (30-40m)	3	6	12%	5%	0		0.00	0.00	#DIV/0!
Stratum 5 (40-60m)	0	0			0				
Stratum 6 (60-80m)	0	0			0				
Stratum 7 (80+m)	0	0			0				
Total	25	46	100%	100%	11	100%			
				actual	8				

No. of Sets Next Day	
Stratum 1	
Stratum 2	0
Stratum 3	2
Stratum 4	0
Stratum 5	
Stratum 6	
Stratum 7	

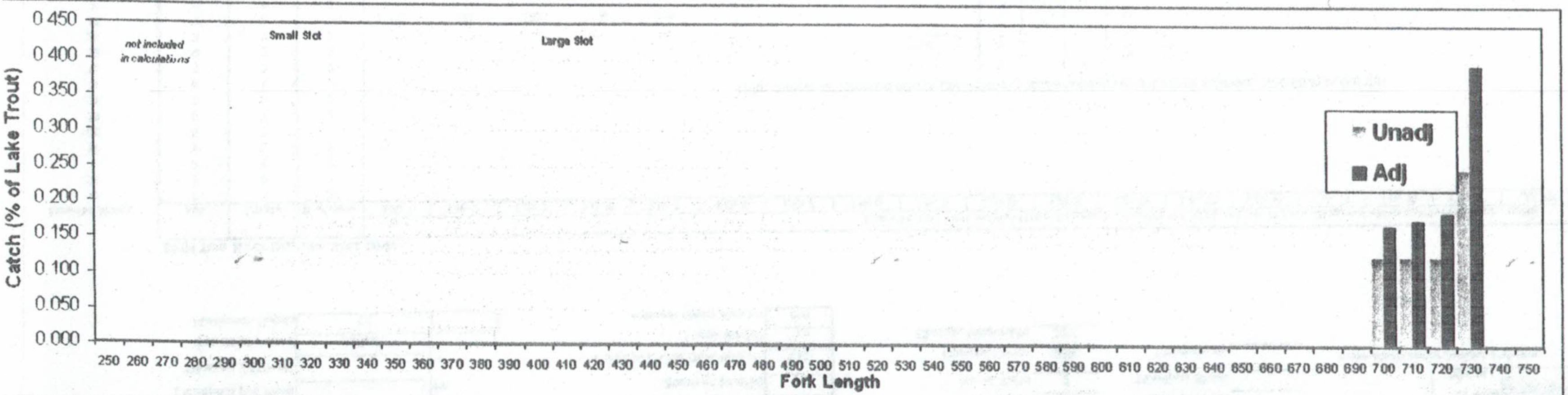
Previous Arith Mean ____
Previous Arith Stdev ____
Previous n= ____

p-Value ____ (Previous Mean, Stdev, n not specified)

Power Observed: 12% (using current n and std)

Power Desired	80%
Change Detectable	20%
Sets Required (n=)	1147

Thermocline(top): n/a m
Thermocline(bottom): 0 m



omega ____
Linf 66
M ____
S ____

% zero S1 ____
% zero S2 75%
% zero S3 94%
% zero S4 100%
% zero S5 ____
% zero S6 ____
% zero S7 ____
Area Wt % zero 88%

Report generated with SPIII SUPPORT SYSTEMS (ver 8.3) Print Date 02/07/2009

<u>Explanation of Tot Catch #:</u> The reason why catches don't add up is due to rounding, which is hidden in the spreadsheet.

The SPIN model assumes that very large lake trout are less vulnerable to the net because there are fewer panels that specifically select for that size. Because of this, the actual catch gets adjusted (up in this case) to account for this by dividing each fish by its retention coefficient. The final number caught per stratum may include fractions of fish. For example, one 500mm lake trout would be the fish = 1 divided by its retention coefficient – 0.91 = 1.1. These adjusted individual fish catches are then summed for effort and then these effort are averaged for each stratum to calculate the stratum CUE.

Appendix III – Egg Mat Observations by Divers. October 27, 2007

SAMPLE ID	TRANSECT COLOUR	OBSERVED DEPTH (m)	SLOPE OF MAT	DOMINANT TYPE	SUBSTRATE AVG SIZE(cm)	CONDITION OF MAT	EGG COUNT SP1 SP2
1	green	0.91	0	gravel, cobble	20.32-35.56	Fine	0
2	green	2.44	22	rubble	25.4	Fine	0
3	green	2.74	30	boulder	20.32	Fine	0
4	green	3.35	25	silt	25.4	Fine	0
5	green	3.05	40	boulder	20.32-40.64	Fine	0
6	green	3.35	5	silt		Fine	0
7	blue	0.91	0	gravel		Fine	0
8	blue	2.74	0	boulder		Fine	0
9	blue	2.74	20			Fine	0
10	blue	2.74	15			Fine	0
11	blue	3.35	25	boulder	20.32	Fine	1
12	blue	3.05	0	boulder	25.4	Fine	0
13	red	0.91	0	gravel, cobble		Fine, flipped, reset	0
14	red	2.74	45	boulder	30.48	Fine	0
15	red		60	boulder		Fine	0
16	red	2.74	27	boulder	25.4	Fine	0
17	red	3.35	10	boulder	25.4	Fine	0
18	red	3.35	10	sand		Fine	0
19	yellow		0	gravel, cobble		Fine	0
20	yellow		45	boulder		Fine	0
21	yellow		25	boulder		Fine	0
22	yellow		20	sand to cobble		Fine	0
23	yellow	3.05	0	gravel, sand		Fine	0
24	yellow	3.96	21	silt		Fine	0
25	white	1.07	0	rubble, silt		Fine	0
26	white		15	boulder		Fine	0
27	white		0	boulder		Fine	0
28	white		0	boulder		Fine	0
29	white		0	cobble		Fine	0
30	white	3.35	20	silt		Fine	0
31	black		level	sand, cobble		Fine	0
32	black		24	boulder		Fine, flipped, reset	0
33	black		20				0
34	black	3.05	25				0
35	black	3.35		rubble, sand	20.32	Fine	0
36	black	3.96		silt		Fine	0
37	green&white		20	boulder		Fine	0
38	green&white		40	boulder, rubble		Fine	0
39	green&white	2.74	15	silt		Fine	0
40	green&white	3.05	LEVEL	silt		Fine	0

Appendix IV – Victoria Island Ice Thickness Measurements, 2005 to 2009

March 9, 2005 Round Lake Ice Thickness Data

ID	Easting	Northing	Ice Thickness (m)	Total Water Depth (m)	Clearance (m)	Elevation on shoal	Comments
13	304241	5056740	0.48	0.27	-0.21	170.22	
12	304242	5056743	0.53	0.3	-0.23	170.19	
17	304237	5056742	0.55	0.35	-0.2	170.14	
16	304240	5056740	0.53	0.38	-0.15	170.11	
18	304234	5056744	0.55	0.48	-0.07	170.01	
5	304244	5056748	0.53	0.53	0	169.96	
2	304248	5056763	0.63	0.61	-0.02	169.88	
19	304235	5056750	0.63	0.63	0	169.86	
10	304247	5056764	0.68	0.68	0	169.81	
4	304247	5056756	0.68	0.71	0.03	169.78	
14	304239	556736	0.5	0.71	0.21	169.78	
6	304246	5056740	0.4	0.73	0.33	169.76	
1	304251	5056776	0.68	0.76	0.08	169.73	
9	304248	5056768	0.68	0.76	0.08	169.73	
11	304249	5056770	0.63	0.82	0.19	169.67	
3	304247	5056760	0.63	0.83	0.2	169.66	
7	304251	5056739	0.48	0.93	0.45	169.56	
8	304256	5056737	0.71	1.01	0.3	169.48	
15	304238	5056733	0.61	1.42	0.81	169.07	
		Average	0.58				
		Min	0.4				
		Max	0.71				

Dam elevation is 170.49
Generally the ice was thicker over areas of the shoal that were deeper.

March 16, 2006 Round Lake Ice Thickness Data

ID	Easting	Northing	Ice Thickness (m)	Total Water Depth (m)	Clearance (m)	Elevation on shoal	Comments
7	304258	5056744	0.35	0.2	-0.15	169.98	
8	304257	5056741	0.35	0.3	-0.05	169.88	
6	304260	5056746	0.38	0.33	-0.05	169.85	
10	304264	5056742	0.3	0.36	0.06	169.82	
9	304256	5056745	0.43	0.38	-0.05	169.8	
5	304263	5056750	0.43	0.45	0.02	169.73	
3	304269	5056756	0.53	0.61	0.08	169.57	
4	304265	5056752	0.53	0.61	0.08	169.57	
2	304275	5056762	0.53	0.68	0.15	169.5	
1	304271	5056760	0.5	0.71	0.21	169.47	
		Average	0.43				
		Min	0.3				
		Max	0.53				

Dam elevation is 170.184
Generally the ice was thicker over areas of the shoal that were deeper.

Appendix IV continued – Victoria Island Ice Thickness Measurements, 2005 to 2009

March 9, 2007 Round Lake Ice Thickness Data

ID	Easting	Northing	Ice Thickness (m)	Total Water Depth (m)	Clearance (m)	Elevation on shoal	Comments
7	304161	5056756	0.55	0.6	0.05	169.73	
5	304156	5056760	0.53	0.8	0.27	169.53	
8	304165	5056786	0.45	0.95	0.5	169.38	
3	304118	5056795	0.43	1.29	0.86	169.04	
4	304155	5056756	0.53	1.36	0.83	168.97	
1	304116	5056790	0.38	1.97	1.59	168.36	
6	304155	5056753	0.45	2.43	1.98	167.9	
2	304116	5056789	0.45	2.58	2.13	167.75	

Average 0.47
Min 0.38
Max 0.55

Dam elevation is 170.33
Generally the ice was thinner over areas of the shoal that were deeper.

March 11, 2008 Round Lake Ice Thickness Data

ID	Easting	Northing	Ice Thickness (m)	Total Water Depth (m)	Clearance (m)	Elevation on shoal	Comments
10	304229	5056737	0.43	0.48	0.05	170.12	
6	304174	5056755	0.52	0.58	0.06	170.02	
8	304185	5056778	0.51	0.6	0.09	170	
9	304190	5056788	0.5	0.64	0.14	169.96	
4	304154	5056761	0.55	0.66	0.11	169.94	
2	304115	5056804	0.55	0.68	0.13	169.92	
1	304123	5056800	0.53	0.71	0.18	169.89	
7	304179	5056764	0.54	0.86	0.32	169.74	
5	304173	5056748	0.53	0.88	0.35	169.72	
3	304106	5056801	0.52	2.19	1.67	168.41	

Average 0.52
Min 0.43
Max 0.55

Dam elevation is 170.603
Generally the ice was thicker over areas of the shoal that were deeper.

March 11, 2009 Round Lake Ice Thickness Data

ID	Easting	Northing	Ice Thickness (m)	Total Water Depth (m)	Clearance (m)	Elevation on shoal	Comments
6	304195	5056797	0.53	0.96	0.43	169.34	
7	304187	5056806	0.5	1.01	0.51	169.29	
2	304168	5056754	0.53	1.04	0.51	169.26	
1	304154	5056761	0.55	1.11	0.56	169.19	
4	304174	5056754	0.48	1.14	0.66	169.16	
5	304188	5056762	0.53	1.14	0.61	169.16	
3	304171	5056747	0.55	2.54	1.99	167.76	

Average 0.52
Min 0.48
Max 0.55

Dam elevation is 170.301
No real difference in ice thickness