

Appendix C6

**Report: *Meadowbank Gold Project: 2008 Fish-Out of the
Northwest Arm of Second Portage Lake***

***Meadowbank Gold Project: 2008 Fish-Out of the Northwest arm of
Second Portage Lake***

Prepared for

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EXECUTIVE SUMMARY

As part of construction of the Meadowbank Gold Project, a fish-out program was implemented during 2008 in the northwest arm of Second Portage Lake (the “impoundment”). The program was developed and implemented in accordance with a draft Protocol provided by the Department of Fisheries and Oceans.

Removal of fish from a waterbody offers a unique opportunity to gather information on lake productivity and the fish community. Fishing removed a total of 3079 fish from the impoundment weighing 1123 kg. About two-thirds of the fish were lake trout, followed in abundance by arctic char, round whitefish and burbot. Detailed biological data for fish included lengths and weights, sex, maturity, fecundity, stomach contents and aging structures. The fish community consists mainly of fish feeding on zooplankton and benthos, with a group of large lake trout preying on all other fish. The smaller lake trout as well as all whitefish appear to feed predominantly on benthic invertebrates. Arctic char appear to feed primarily on zooplankton in the water column, and the larger lake trout feed on fish (smaller lake trout as well as other species).

The 2008 program, in addition to addressing fish directly, also included collection of data related to water quality, phytoplankton, zooplankton and benthic invertebrates. Analyses of these data confirm that lake productivity is low, and provide a useful data set that will inform future sampling programs developed for monitoring or other purposes. The data set also provides an opportunity to test a range of models predicting fish biomass from various abiotic and biotic lake characteristics. Fish biomass was predicted from ten different models using impoundment data. In general, model predictions were reasonably accurate relative to actual results of the fish-out program.

With regard to fish production, various methods were used to estimate indices of fish abundance or biomass. A two-week mark-recapture study was implemented to develop an index of abundance for lake trout and arctic char. Subsequently, removal of fish began with the “CPUE phase” during which intense gill-netting depleted the fish community and allowed estimation of initial abundance and biomass based on the decline in catch-per-unit-effort (CPUE). Once estimates of initial abundance and biomass based on CPUE had met criteria, a phase of final removal began, during which additional gear types were used and all efforts were made to remove virtually every fish from the impoundment.. Best estimates of the total initial abundance and biomass were 3199 fish and 1258 kg respectively, not including very small fish that would not be susceptible to the gear. These estimates may be biased somewhat low, although recovery of fish that had been marked during the mark-recapture phase indicate that the majority of fish were caught.



Chapter 1

Introduction and Scope of Work

***Meadowbank Gold Project: 2008 Fish-Out of the Northwest arm of
Second Portage Lake***

March 2009

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1. INTRODUCTION

Agnico-Eagle Mines Ltd. (AEM) officially began construction of the Meadowbank Gold Project north of Baker Lake, Nunavut, in July 2008. A major component of the initial work was construction of the East Dike, which bisects Second Portage Lake (**Figure 1-1**). The northwest arm of the lake was to be dewatered as ultimately it will be part of the mine footprint. One of the requirements of the Department of Fisheries and Oceans (DFO) was that a fish-out program be conducted.

This document reports on the fish-out program conducted in 2008 and is organized as follows:

- **Chapter 1** - reviews the requirements of DFO and the major components of the fish-out program.
- **Chapter 2** - reports on findings related to general limnology, trophic dynamics and fish community structure.
- **Chapter 3** - reports on estimates of fish abundance and biomass from limnology and productivity data.
- **Chapter 4** - reports on estimates of fish abundance and biomass from mark-recapture data, catch-per-unit-effort depletion estimators, and final removal data.

2. MANDATE AND OBJECTIVES

In cases where mining or other developments cause lakes to be lost, the Department of Fisheries and Oceans (DFO) currently requires proponents to remove fish as a condition of a *Fisheries Act* authorization. To this end, DFO has developed a General Fish-Out Protocol for Lakes to be Lost Due to Mining Developments (DFO 2008; see **Appendix A**). The stated objectives of the fish-out Protocol are to:

- (i) ensure that all fish are removed from a lake and disposed of in an appropriate manner that minimizes the wasting of fish;
- (ii) determine fish species composition and the abundance and structure of fish populations in Arctic lakes;
- (iii) determine biological, limnological and habitat characteristics of the lakes that are fished out.

3. SCOPE OF THE 2008 FISH-OUT PROGRAM FOR SECOND PORTAGE LAKE

The fish-out program for the northwest arm of Second Portage Lake (**Appendix B**) was developed on the basis of the DFO Protocol, taking into account experience at other fish-



outs associated with northern mines (in particular the fish-out associated with the Diavik Diamond mine - McEachern et al., unpublished) as well as site-specific factors and constraints.

The most intensive requirements of the DFO Protocol relate to understanding the fish community. In particular, the Protocol requires a mark-recapture study; CPUE depletion estimates of abundance, and a final removal phase. The other aspects of the Protocol related primarily to characterizing limnology and habitat are less intensive as they require periodic sampling rather than daily sampling over extended periods.

The fish-out program for the northwest arm of Second Portage Lake took place from August to October 2008. The major components included:

- Mark-recapture phase – Lake trout and arctic char were fished using a single gill net mesh size¹. Set times were short to minimize stress to fish. All trout and char were marked and released. Limited biological data were collected. The mark-recapture phase lasted about two weeks.
- CPUE phase – The lake was fished using gill net gangs consisting of six panels, each of different mesh size. All captured fish were removed from the lake and subjected to biological assessment². Effort data were also collected based on the date and time at which each net was set and pulled. The CPUE phase spanned several weeks until estimates of initial abundance and biomass stabilized.
- Final removal phase – The final removal phase was focused on removing all remaining fish in the lake. Standard gill net gangs were the principal gear given their effectiveness, but overall effort was increased. Detailed biological assessment of a subset of fish continued from the CPUE phase.
- Limnology – Information on physical characteristics of the lake, water quality and nutrients, chlorophyll a, zooplankton, and benthos were collected at three different times (once for benthos) in the three basins of the impoundment.
- Habitat mapping – Habitat (including substrates and bathymetry) in the lake was mapped extensively as part of the environmental assessment documentation for the mine. Confirmation of habitat information is part of the fish-out, but is not yet finalized and will be reported separately.

Results are reported in **Chapters 2 to 4**. The basic data related to fish biology, limnology and productivity, are contained in **Chapter 2**. Given the emphasis placed on estimating abundance and biomass of fish, we dedicate two entire chapters (**Chapters 3 and 4**) to this purpose. **Chapter 3** focuses on relating the data to literature models that predict lake

¹ Trap nets were also used initially but were abandoned as they were ineffective.

² A subset of fish were subjected to detailed biological assessment including ovary weights, liver weights, stomach contents, aging structures, analysis of metals concentrations, etc.



productivity and fish production based on general lake characteristics and water quality parameters. **Chapter 4** estimates total abundance and biomass based on the results of the three phases of the fish-out.

4. REFERENCES

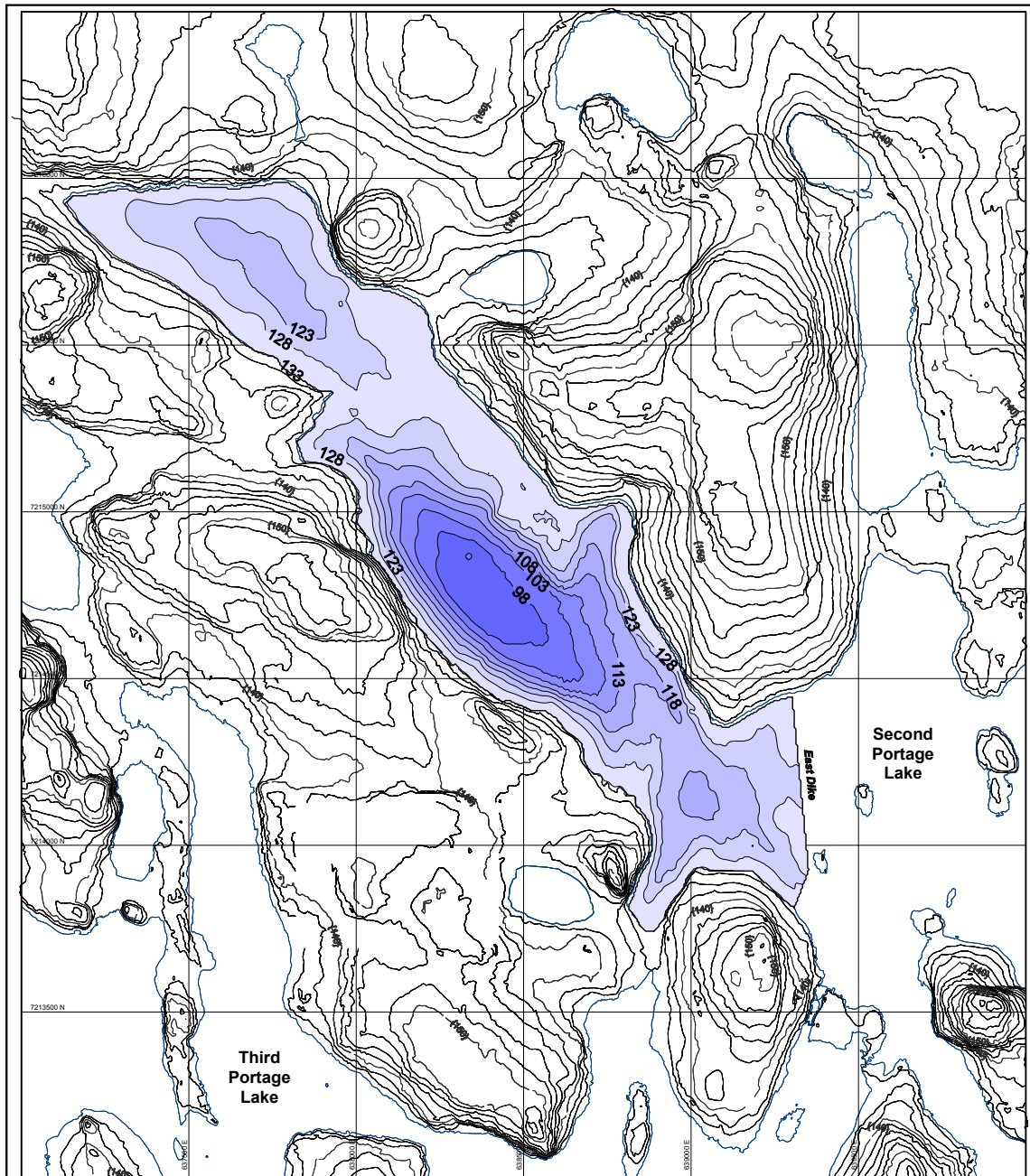
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FIGURES





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FIGURE 1-1
MEADOWBANK GOLD PROJECT - FISHOUT PROGRAM FOR
NORTHWEST ARM OF SECOND PORTAGE LAKE

Northwest Arm of Second Portage Lake showing
East Dike location and bathymetry.

Chapter 2

Limnology and Biology

Meadowbank Gold Project: 2008 Fish-Out of the Northwest Arm of Second Portage Lake

March 2009

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1. INTRODUCTION

1.1. Setting

The Meadowbank study lakes (**Figure 2-1**) are situated about 75 km north of the Hamlet of Baker Lake, Nunavut in the barren-ground central Arctic region within an area of continuous permafrost. The landscape consists of rolling hills and low relief with sparse ground vegetative cover and poor soil development. Numerous lakes with indistinct and complex drainages are interspersed among boulder fields, eskers and bedrock outcrops. The main lakes in the Meadowbank project area include: Third Portage Lake (TP), Second Portage Lake (SP), Tehek Lake (TE), and the Vault Lake system – Vault, Wally (WAL) and Drilltrail lakes.

All lakes in the study area are nutrient poor and unproductive, partly because they are headwater lakes, situated on the watershed boundary that separates two main watershed drainages—the Arctic and Hudson Bay. Only a few hundred meters to the north of Second and Third Portage lakes is the divide between water that flows north to the Arctic Ocean (via the Meadowbank and Back River system) or to Chesterfield Inlet and Hudson Bay (via the Quoich River system).

As is common of headwater lakes, all have small drainage areas relative to the surface area of the lakes themselves. Local inflow from surrounding terrain is the predominant influence on water movement within the system. No rivers enter any of the lakes and only small channels connect the study area lakes. Except during freshet, there is little flow between lakes during most of the year. Movement by fish between the lakes is also rare. The ice-free season on these lakes is very short, with ice break-up in late-June to mid-July and ice-up beginning in late September or early October. Maximum ice thickness is at least 2 m by March/April. Biological productivity of the lakes is limited by nutrient availability, cold water and a short growing season.

1.2. Background

Development of the Meadowbank Gold Project requires that parts of Second and Third Portage lakes be diked, fished out and drained because some of the gold ore deposits are situated adjacent to and beneath these lakes. In order to access these deposits a series of dikes are required to isolate open pit mining activities from the lakes.

The East Dike was the first to be constructed during the open water season of 2008. This dike essentially divided Second Portage Lake in half (**Figure 2-1**). The Western Channel



Dike was constructed in September and October 2008. The water body northwest of the dike (hereafter referred to as the Northwest Arm) or Impoundment is scheduled to be dewatered in 2009.

Second Portage Lake has a total surface area of 4.8 km² and a total volume of 29.7 million cubic meters (Mm³). Surface area northwest of the East Dike is 1.30 km². The northwest arm has a total estimated volume of 14.6 Mm³ divided among three basins separated by shallow sills (**Figure 2-1**). Immediately adjacent to the dike and moving northwest is the southeast basin (1.84 Mm³, maximum depth 17 m), a deep middle basin (10.8 Mm³, maximum depth 40 m) and a northwest basin (2.0 Mm³, maximum depth 11 m).

All of the water from Third Portage Lake drains into Second Portage Lake via three channels. The westernmost channel used to empty into the northwest arm but since September 2008 has been blocked off by the Western Channel dike. Now, all water exiting Third Portage will be via the two remaining channels located southeast of the East Dike. Water from both lakes discharges to Tehek Lake about 1.5 km southeast of the discharge channels (**Figure 2-1**).

See **Chapter 1 Sections 1.3** and **2.2** for details of the Technical Memorandum (**Appendix B**) prepared by Azimuth and accepted by DFO outlines the specific protocols followed for this fish-out program.

1.3. Approach and Objectives

This chapter reports on the following aspects of the Fish-out Program:

- Provision of fish to the community of Baker Lake
- Isolation of the Northwest Arm from Second Portage Lake
- Limnology and water chemistry
- Lower trophic level biota
- Fish community composition and detailed biological analysis.

The limnology component of this chapter consists of basic lake morphometry, limnology, and water and sediment chemistry. Sampling of lower trophic level biota including benthic invertebrates and zooplankton for biomass (mg/m³) and taxonomy was conducted seasonally from each of the three basins. The fisheries section covers species composition, size and condition, gender, maturity, aging, diet and tissue chemistry.



This document does not report on habitat mapping of the dewatered impoundment. Dewatering is scheduled for completion sometime in 2009. Detailed mapping of the subsurface aquatic habitat based on bathymetry, aerial photography and underwater video information was conducted as part of the EIA process. This was an integral part of habitat classification for the No Net Loss Plan (NNLP, 2006). A separate report will be prepared that describes results of quantitative mapping of the dewatered impoundment (to be conducted once dewatering is sufficiently advanced) when compared to the original survey.



2. METHODS

2.1. Quality Assurance / Quality Control

The objective of quality assurance and quality control (QA/QC) is to assure that the chemical and biological data collected are representative of the material or populations being sampled, are of known quality, are properly documented, and are scientifically defensible. Data quality was assured throughout the collection and analysis of samples using specified standardized procedures by experienced, qualified biologists, by the employment of laboratories that have been certified for all applicable methods, and by staffing the program with experienced technicians.

Laboratory QA/QC – Data Quality Objectives (DQOs) are numerically definable measures of analytical precision and completeness. Analytical precision is a measurement of the variability associated with duplicate analyses of the same sample in the laboratory. Completeness for this study is defined as the percentage of valid analytical results. Results that were uncertain due to missed hold times, improper calibration, contamination of analytical blanks, or poor calibration verification results were interpreted with caution.

Results from duplicate laboratory and field samples were assessed using the relative percent difference (RPD) formula between measurements. The equation used to calculate a RPD is:

$$RPD = \frac{(A - B)}{((A + B)/2)} \times 100$$

where: A = analytical result; B = duplicate result.

The laboratory DQOs for this project were:

- Analytical Precision = 25% RPD for concentrations that exceed 10x the method detection limit (MDL).
- Completeness = 95% valid data obtained.

RPD values may be either positive or negative, and ideally should provide a mix of the two, clustered around zero. Consistently positive or negative values may indicate a bias. Large variations in RPD values are often observed between duplicate samples when the concentrations of analytes are very low and approaching the detection limit. The reason for this is apparent if one considers duplicate samples with concentrations of an analyte of 0.0005 and 0.0007 mg/L. In absolute terms, the concentration difference between the



two is only 0.0002 mg/L, a very tiny amount; however, the RPD value is 33.3%. This may sometimes lead to a belief that the level of precision is less than it actually is.

Field QA/QC: Water Sampling – Field QA/QC standards during water sampling were maintained for every sample. The standard QA/QC procedures included thoroughly flushing water collection equipment (i.e., flexible tubing and diaphragm pump) to prevent cross-contamination between stations and thoroughly rinsing the sample containers with site water prior to sample collection.

Equipment blanks were measured at a sub-set of stations by pumping distilled water through the pump and filtering equipment. This ensures that any contamination within the water collection system does not go undetected.

Travel blanks were carried into the field and consisted of samples of distilled water provided by the laboratory that were subjected to field conditions, but never opened. These samples are returned to the laboratory and analyzed for the general suite of analytes to ensure that any inadvertent accidental contamination during transport of sampling containers to and from the site does not go undetected.

A field duplicate at a subset of stations (generally 10% of effort) was collected to assess sampling variability and sample homogeneity; a RPD of 50% for concentrations that are less than 10x the MDL is considered acceptable.

Field QA/QC: Biota Sampling – Standard procedures were used to collect biota samples. All sampling gear was thoroughly rinsed between sampling stations to ensure that there was no inadvertent introduction of biota from one station to another.

With respect to zooplankton and benthos biomass estimates by North/South Consultants, Winnipeg MB, the same technician performed wet and dry weight measurements and conversions and the digital scale was calibrated each time between weights. The QA/QC procedure for data entry consists of technician #1 – data entry; technician #2 – checks every entry; and the senior biologist examines and finalizes the data file before delivery.

ZEAS Biological Consultants Ontario incorporates the following set of QA/QC procedures in all benthic projects undertaken by the company to ensure the generation of high quality and reliable data: Samples were logged upon arrival, inspected, and enumerated; samples were checked for proper preservation; samples were stained to facilitate sorting; taxonomic identifications were based on the most updated and widely used keys; 10% of the samples were re-sorted, documenting 90% recovery; precision and accuracy estimates were calculated; a voucher was compiled; sorted sediments and debris are re-preserved in 10% formalin and are retained for up to three months. For samples subject to subsampling, sorted and unsorted fractions were re-preserved separately.



Data quality objectives (DQO) for replicate counts should be within $\pm 20\%$ of the first count (i.e., the RPD). Field replicate RPD values less than 50% are usually indicative that sampling bias is not excessive and that the resident biota population has been sampled representatively.

2.2. Isolation of the Northwest Arm

The fish-out program was initiated once the northwest arm of Second Portage Lake was isolated from the rest of the lake on July 30 using the cutoff net that extended from the south to the north side of the lake. The net was set immediately upwind (northwest) and directly adjacent to the impoundment-side silt curtain. The top line of the silt curtain was used to attach the cutoff net, functioning as the top line for both.

The cut-off net had the following specifications:

- **Material/mesh** – 210/40 x 1-inch stretched mesh nylon (100-lbs new break strength).
- **Length** – Given the distance across the lake at this location, there are 13 sections of 50 m each for a total of 650 m. Additional panels were included as a contingency.
- **Depth** – Net depth extended to the bottom the entire length of the crossing. Each 50 m section of net was designed to be sufficiently deep taking local bathymetry and predicted wave height into consideration.
- **Weight** – The 50-m sections weighed between approximately 100 and 250 kg depending on the depth.
- **Construction** - All lines were 5/8" Poly Steel, except the bottom line which was lead line. The top line had 6" floats installed one after another for the entire length (50 m). Sections were joined by fastening cable ties every 10 cm top to bottom during deployment.

The net material was of sufficient thickness to ensure good visibility by fish. Although there is a chance that some small fish were trapped should they attempt passage through the net, the thick mesh should prevent incidental entrapment. The 1-inch stretched mesh size was considered a good compromise to address the trade-off between strength and net integrity and incidental capture of small fish. Once the East Dike was constructed, over an approximately two week period, the cutoff net became redundant.



2.3. Limnology and Water Chemistry

Limnological data were collected once during each of July, August and September 2008, from above the deepest locations at each of the three basins of the northwest arm of Second Portage Lake as per the fish-out program (**Appendix B**). Stations were accessed using a 5 m aluminum boat with a four-stroke outboard engine. Depending on wind conditions, the boat was anchored if possible. Anchoring in the deep middle basin was usually not possible and the boat was held on station by using the engine. A hand-held GPS was used to determine UTM coordinates (NAD 83) and to stay on location on windy days. For consistency, the same locations were sampled during each monthly event.

Observations on weather conditions including an estimate of air temperature, cloud cover, wind speed and direction and precipitation (if any) were recorded on the day of water collections. Secchi depth (m) was acquired using a Secchi disk with metered line. Vertical temperature ($^{\circ}\text{C}$), oxygen (mg/L) and conductivity ($\mu\text{S}/\text{cm}$) at 1 m depth intervals was measured using a YSI Model 85 temperature – oxygen meter. Profiles were acquired from each basin at each monthly event to track vertical changes in oxygen and temperature.

Once Secchi depth and vertical temperature/oxygen data were acquired (and always before benthos were collected), the full suite of water samples was collected. Water was collected from two depths; at 1 m below the surface and at mid-water column. This depth differed between basins according to total depth. In all, 18 complete sets of water chemistry (3 seasons x 2 depths x 3 basins) were collected from the northwest arm in 2008.

Water samples were collected by pumping lake water using weighted flexible (food-grade silicone) tubing and a diaphragm pump connected to a 12 volt battery. In general, the procedures were:

- The silicon tubing was weighted (using a plastic-coated lead weight), hung over the side of the boat and the pump was turned on to prime the tubing. Once primed, the pump was allowed to run for at least 2 minutes to thoroughly flush the tubing and to ensure that there was no cross-contamination between stations before water samples were collected.
- For each sampling event water was pumped from 1 m below the surface and from one-half total depth (total depth was determined using a hand held digital depth meter) and pumped directly into the sampling vessels.



Water was analyzed for a broad suite of ‘conventional’ parameters as well as total and dissolved (i.e., filtered) metals. Particular sampling containers were used to collect water for the conventional parameters as follows:

- 1 x 1-L plastic bottle for pH, conductivity, hardness, dissolved anions and nutrients (ammonia, bicarbonate, carbonate, hydroxide, alkalinity, chloride, silicate, sulfate, nitrate, nitrite, total Kjeldahl nitrogen, orthophosphate and total phosphate, sulfate), and total dissolved solids (TDS). No preservative is required.
- 1 x 250-ml amber glass bottle for total organic carbon (TOC) preserved with 1 mL hydrochloric acid.
- 1 x 250-ml amber glass bottle for dissolved organic carbon (DOC) preserved with 1 mL hydrochloric acid. The sample was filtered in the field laboratory through a 45 µm filter supplied by the laboratory and then preserved.
- 1 x 250-mL plastic bottle preserved with 1 mL nitric acid for the analysis of dissolved calcium and magnesium. The dissolved metals sample was filtered in the field using the above method and then preserved.
- Up to 1 L was filtered from a plastic bottle using a plastic hand pump through a Whatman ashless 45 µm filter for analysis of chlorophyll α concentration (mg/m³). A few drops of magnesium carbonate were added to the filter after filtration, then labeled and frozen.

Samples were stored on ice or in a refrigerator before being shipped via Air Freight to ALS Laboratories in Vancouver, B.C. Trip blanks and field duplicates were included as field QA/QC samples (one each per event) to augment the laboratory duplicates conducted routinely by ALS. A completed chain-of-custody form accompanied the samples during transport.

All of the measured water chemistry concentrations were tabulated and compared against each other, and, when available, to the federal Canadian Council of Ministers of the Environment (CCME, 2007) water quality guidelines for the protection of aquatic life. These guidelines are intended to provide a conservative level of protection to freshwater aquatic life from anthropogenic contaminants or other physical changes (suspended solids, temperature).



2.4. Lower Trophic Levels

2.4.1. Zooplankton

As key primary consumers in the lake food web, these planktonic organisms are important for a number of reasons. From an energy cycling perspective, these herbivorous, omnivorous and carnivorous water column animals are an important food source to key life history stages of certain fish species, especially juvenile round whitefish (*Prosopium cylindraceum*) and Arctic char (*Salvelinus alpinus*) as well as adult Arctic char. The seasonal change in biomass (mg/m^3) of zooplankton is also an important indicator of lake productivity, which ultimately drives the productivity and biomass of fish in the study lakes.

Zooplankton were collected using a 70 μm nitex mesh net with a 30 cm diameter mouth opening and total length of 2.2 m. Four replicate vertical tows were made at each station during each of the monthly sampling events ($4 \times 3 \times 3 = 36$ samples) from 1 m off of the bottom to the surface. The four samples were independent field replicates (not composited) in order to give an understanding of variability. After collection, all samples were placed into uniquely labeled plastic jars and preserved in a 10% buffered formalin solution. All jars were screwed tight and taped to prevent leakage. According to the sampling protocol, samples are to be analyzed only for total biomass (mg/m^3).

Taxonomic composition was not assessed as there are considerable taxonomic data from work completed in previous years. Biomass was determined by North/South Consultants, Winnipeg MB. Zooplankton samples were filtered through a pre-dried 45 μm filter, wet weighed and then dried in an oven at 60°C until completely dry. Samples were weighed dry to determine moisture content and dry weight. Dry biomass (mg/m^3) was determined by standardizing the dry sample weight against the volume of water filtered by the net during each vertical tow, which differed by depth according to each basin.

2.4.2. Benthos

Benthic invertebrates are a primary component of the sediment-based food chain. They are an important food source for fish, consumed either directly in their sediment habitat, in the water column just prior to emergence, or at the water-air interface after emergence. Benthic invertebrates are important for all larval and juvenile stages of the major fish species in the study lakes and the main dietary food source for round whitefish. Benthic productivity supplements pelagic secondary productivity and together with zooplankton these two major dietary components of fish determine overall fish production and biomass.



To acquire benthos, sediment samples were collected using a Petite Ponar grab with a total sampling area of $0.152 \text{ m} \times 0.152 \text{ m} = 0.023 \text{ m}^2$. The DFO Protocol calls for use of an Ekman grab, however, in Azimuth's experience, an Ekman grab is too light to work effectively in the often windy conditions prevailing in the project lake area. A Petite Ponar samples the same surface area as an Ekman grab, but is heavier and therefore easier to control at depth prior to deployment in the sediments. While the volume of a Petite Ponar is less than the Ekman (i.e., 2.4 L compared to 3.5 L, respectively), the latter is unlikely to penetrate deeper into sediments than the Petite Ponar, thus making this extra volume inconsequential.

Only those grab samples that met the following acceptability criteria were retained for analysis; grabs that did not satisfy these conditions were not retained:

- Did not contain large foreign objects
- Attained adequate penetration depth (i.e., 6 to 7 cm)
- Was not overfilled (sediment surface not touching the top of sampler)
- Did not leak (there was overlying water present and no visible leaks)
- Was not disturbed (sediment surface was relatively flat)

Acceptable grabs were placed directly into a large stainless steel sorting basin and benthic invertebrates were separated from fine sediment by sifting the contents through a 500- μm mesh screen on the bottom of the basin. The material remaining on the sieve was transferred into 50- mL HDPE containers and preserved in 10% buffered formalin. Labeling included water proof paper labels placed inside the jars as well as permanent marker labeling on the outside of the jars. All jars were screwed tight and taped to prevent leakage prior to shipping.

Sampling of benthic invertebrates was stratified across a range of depth intervals with a subset collected for biomass (mg/m^2) and taxonomic identification. At each of the three basins, up to 15 samples were collected for benthic community biomass analysis: six in the 5 – 10 m depth interval; four in the 10 – 15 m interval; three in the 15 – 20 m interval; and one in each of the 20 – 25 m and >25 m intervals. An additional five samples, one from each of the depth intervals listed above, was collected for taxonomic analysis. Of course only the middle basin is sufficiently deep to collect the entire suite of depth-stratified samples (i.e., all 20 grabs). The southeast and northwest basins are both less than 10 m deep, therefore only six grabs for biomass and one for taxonomy were collected in the 5 – 10 m depth interval. Benthos was collected only during mid- to late August, to be consistent with sampling during previous years.



Benthos samples were preserved in the field with a 10% buffered formalin solution and sent to Zaranko Environmental Assessment Services (ZEAS) (Nobleton, ON) for taxonomic identification and analysis.

Upon arrival at ZEAS, samples were immediately logged and inspected to ensure adequate preservation to a minimum level of 10% buffered formalin and checked for correct labeling. Benthos samples were sorted at a magnification of between 7 and 10 times with the use of a stereomicroscope. To expedite sorting prior to processing, all samples were stained with a protein dye that is absorbed by aquatic organisms but not by organic material, such as detritus and algae.

Prior to sorting, samples were washed free of formalin in a 500- μ m sieve. In samples containing sand, gravel, or rocks, elutriation techniques were used to separate the lighter benthic macroinvertebrates and associated debris from the heavier sand, gravel and rocks. Elutriation techniques effectively removed almost all organisms except some heavy-bodied organisms such as molluscs and caddisflies with rock cases. As such, the remaining sand and gravel fraction was closely inspected. After elutriation, the remaining debris and benthic macroinvertebrates were washed through a series of two sieves, (i.e., 3.36-mm and 500- μ m respectively). The screening of material through a series of sieves is used to facilitate sorting. This procedure separates macroinvertebrates and detritus into a set of size-based fractions that can be sorted under a more constant magnification.

Benthos were enumerated and sorted into major taxonomic groups, (i.e., order and family), placed in glass bottles and re-preserved in 80% ethanol for more detailed taxonomic analysis by senior staff. Each bottle was labeled internally with the survey name, date, station and replicate number.

Abundance of organisms/ m^2 was determined from the total number of organisms enumerated. Nematodes and ostracods were not reported, nor were they included in abundance and richness calculations because they are too small to be reliably retained on a 500- μ m sieve.

The following endpoints were used for assessing benthic community structure, based on sensitivity, objectivity, ease of interpretation and cost-effectiveness:

- Taxa richness (i.e., corresponds to the number of species or taxa per sample and provides a measure of diversity).
- Total abundance (i.e., number of organisms per m^2).
- Abundance and richness of all major taxa (e.g., insects, molluscs, worms).

Samples collected for biomass were sent to North/South Consultants, Winnipeg MB. Individual organisms were picked from each sample, placed in a pre-weighed petri-dish



and weighed for wet weight. Samples were placed in an oven at 60°C until completely dried, weighed again and dry weight (mg) determined for each sample.

2.5. Fish Community

2.5.1. Background

Consistent with the typical species composition of Arctic lakes (Scott and Crossman, 1979) lake trout dominates abundance and biomass in all study lakes (BAER, 2005). In small isolated ponds, lake trout is frequently the only species present. Arctic char and round whitefish were the only other two species most frequently captured in gill net surveys and together comprised about 25% of the abundance and biomass of fish in the study lakes during historic surveys. The only other species captured in very small numbers was burbot (*Lota lota*). Ninespine stickleback (*Pungitius pungitius*) and slimy sculpin (*Cottus cognatus*) are known to be present in unknown numbers based on visual observations and from stomach contents of fish captured from baseline surveys (BAER, 2005).

Fish represent the top of the food chain and in the study lakes and provide a food source for some fish-eating birds such as loons. According to traditional knowledge, local residents of Baker Lake do not fish on the study lakes. Creel surveys conducted during the past three years have not revealed any local Inuit fishing in or near the Meadowbank study lakes (Azimuth, 2009a). Fishing is typically conducted during late winter or early spring through the ice, usually on Baker Lake, Whitehills Lake and infrequently, Schultz Lake. Lake trout are by far the most frequently captured fish species, followed by Arctic char and occasionally, round whitefish.

Arctic lakes typically contain a large biomass of fish, including many large (>5 kg), old (>20 years) lake trout. Despite the apparently large biomass, the productivity of Arctic lakes is very low, that is, the rate at which this biomass is replaced, or turned over, is very small. In oligotrophic systems there are limited amounts of nutrients available to fish and there is great competition for it. Thus, given the short growing season, limited nutrient availability and very cold water, growth rates of Arctic fish are exceedingly slow.

The main food source of lake trout is usually smaller lake trout, because they are highly cannibalistic. If round whitefish are present in the same lake, these species can also compose a significant portion of the diet of trout (Scott and Crossman, 1979). This partly explains why most lakes contain healthy populations of large lake trout of a similar, narrow size range; smaller fish are eaten and the replacement rate into the larger, older cohort of fish is slow.



The Meadowbank study lakes are situated in the extreme headwaters of the Quoich River drainage basin and within the larger region flowing into Chesterfield Inlet and eventually to Hudson Bay. St. Clair Falls near the mouth of the Quoich River is a barrier to upstream migration by fish (MacDonald and Stewart, 1980), and precludes access by anadromous Arctic char from Chesterfield Inlet to upstream lakes. All of the char here are landlocked.

There are no spring spawning species, such as Arctic grayling (*Thymallus arcticus*) or suckers (*Catostomus* sp.) in the Meadowbank study lakes and connecting channels. Although Arctic grayling are present within the Prince River drainage west of Third Portage Lake, they are not known from the Quoich system (MacDonald and Stewart, 1980).

2.5.2. Fish-out Program

Fish-out of the northwest arm of Second Portage Lake was conducted between 3 August and 16 October 2008. Fishing did not take place until after installation of the fish cutoff net on July 31. As per requirements of the *Fisheries Act* Authorization for this project, the overall objective of this project was to remove virtually all fish from the impoundment. The removal program was divided into three phases: a mark/recapture (i.e., catch and release) phase; a catch-per-unit-effort (CPUE) phase and a final fish-out phase. All phases took place in 2008. Detailed analysis of abundance and biomass is contained in **Chapter 4**.

2.5.2.1. Fishing gear

During the CPUE and final removal phases the fish-out program (see **Section 2.5.2.2** for phase descriptions) used multi-mesh gill nets of stretched mesh sizes 126, 102, 76, 51, 38, and 25 mm. This differs slightly from the DFO Protocol in that the 126 mm panel replaced the 22 mm panel; the change was made because of the large size of some fish and to more closely match the mesh size range used in baseline studies. Each panel of gill net was 6 feet (1.8 m) deep by 25 yds (22.7 m) long, so that the maximum length of a six-panel gang was 150 yds (136.4 m). Each mesh size was fished in constant proportions, with an increasing total number of gangs (i.e., from six to 18) deployed as CPUE declined over time. Gill nets were moved every day or two, depending on catch and weather/wind conditions to ensure complete coverage of the entire northwest arm, both spatially and by depth.

The only exception to this was the initial mark/recapture phase where panels of only small mesh (1.5" or 38 mm stretch mesh) nylon gill nets were used. Nets were set for short duration to minimize mortality of fish. See **Section 3.3** for a full description of fishing gear and phases). Trap nets were also used, but yielded very few fish.



Gill net sets were typically about six or 18 hours (i.e., ‘daytime’ and ‘nighttime’ sets) during the initial two weeks of the CPUE phase because of longer day length and high catch. Once day length and catch diminished nets were left in the water for 24 hours and only checked once daily each morning. In some instances, poor weather prevented net collection and on some occasions, net sets were 48 hours.

Fish were captured using multi-mesh bottom set gill nets and trap nets. The trap net design used was modified slightly from the DFO General Fish-Out Protocol, basically to incorporate longer leads and wings. The house and leads were constructed of 6 mm square mesh nylon twine with house dimensions of 1.23 x 1.23 x 1.23 m. The center lead, run perpendicular to shore was 60 m long and 1.83 m deep. Side wings were 10 m long and 1.83 m deep. Two nets were set, one in the north and one in the south end of the impoundment. Trap nets were left to fish for several days before being moved.

Electrofishing was not used as a fish capture method because of the extremely low conductivity of the water and the generally great depth of the impoundment. Gee or minnow traps also were not used as they have not been found to capture fish in either our own surveys or in other fish-out programs, such as Diavik (e.g., McEachern et al., Unpublished).

2.5.2.2. Fish capture phases

The mark/recapture phase of ‘target species’ lake trout and Arctic char took place between 3 and 17 August inclusive. Captured fish were removed from gill or trap nets, measured for length and weight and either fin clipped (adipose or pelvic fin) or Floy (spaghetti) tagged and released as quickly as possible. Those fish that did not survive capture or were presumed not likely to survive long after being released were sacrificed. Non-target species (round whitefish and burbot or trout and char too small to mark) were also sacrificed. Length (mm), weight (g), gender and maturity data were collected from all mortalities. Biological data collected from live, released fish was not included as part of the detailed fish community analysis to avoid double-counting of fish. Only data from fish sacrificed during the mark-recapture, CPUE and final fish-out phases were used.

On August 21, three days following the end of the mark-recapture phase (i.e., to allow marked fish to mix into the general population), the CPUE phase was carried out and lasted until September 27.

The final removal phase took place immediately after the CPUE phase and extended from September 27 and October 16 inclusive. The exact same gear and fishing methods were used as the CPUE phase, supplemented by panels with alternate mesh sizes. During final removal details of net set durations, UTM coordinates and so on (see **Section 2.5.2.3**



below), were not collected because the objective was to set as many nets as possible to remove all remaining fish. However, like the CPUE phase, length, weight, gender and maturity were collected from all fish. A subset of fish was subjected to more detailed data collections as described below.

2.5.2.3. Data collection protocol

The following information was recorded for each net set:

- wind speed and direction and cloud cover
- air and water temperature
- date and duration fished (hr) according to time in and time out of each gang
- depth (m) and UTM coordinate at beginning and end of each gang

All fish captured during the CPUE phase were sacrificed, identified by species and individually measured and weighed for fork length (mm), body weight (g), gender and state of sexual maturity.

2.5.2.4. Detailed biological assessment

In addition to the above basic parameters, a ‘detailed biological assessment’ or DBA was required from a subset of at least 50 fish of the target species lake trout, Arctic char and round whitefish. Actual sample sizes were slightly larger. DBA sampling took place in a manner that stratified collection across the entire size range of the species, from smallest to largest fish. Ultimately, the DBA set consisted of the following data gathered from all, or a subset of the 164 fish (63 Arctic char, 50 lake trout and 51 round whitefish;

Appendix D):

- **Aging structures** – Otoliths were collected from 63 Arctic char, 51 round whitefish and 50 lake trout, across the range of expected size classes. Otoliths were used because fins are not considered a reliable enough structure for ageing large, old fish.
- **Stomach contents and biomass** – Stomachs and contents were preserved in the field for more detailed analysis in Winnipeg by North/South. Stomachs that were obviously empty were not preserved and not sent to North/South. Stomachs with contents were uniquely labeled, and placed in a 10% buffered formalin solution in whirl-pac bags. Stomachs were emptied and examined for contents by major



taxonomic group (e.g., 60% Cladocera, 40% chironomids). Stomach contents were wet weighted and then dried at 60°C until a stable dry weight had been achieved. Mean biomass of important invertebrate groups was averaged across fish within species, but only for those fish whose stomachs contained food. Empty stomachs are reported separately. Only lake trout consumed fish and these are reported separate (wet and dry weight) from invertebrates.

- **Detailed internal and external examinations** – DELT examinations were conducted on each of the DBA fish to determine, parasite presence, and overall apparent health (e.g., DELT - deformities, erosions, lesions or tumors).
- **Gender** was determined according to male, female or immature.
- **Reproductive status** was determined according to the following categories: undeveloped (i.e., immature fish that have never spawned); ripe, running, spent (i.e., all sexually mature, current year fall spawners), resting (i.e., fish that have spawned in previous years but are not current year fall spawners and have undeveloped gonads); and unknown.
- **Gonad weight and fecundity** was measured for all female fish. Ovaries were preserved in buffered formalin and analyzed for fecundity. A subsample of at least 100 randomly selected eggs was weighed (mg) and then used to estimate the total number of eggs per female based on total ovary weight. Gonadosomatic index (GSI) was calculated based on the ratio of ovary weight to body weight.
- **Liver weight** was measured from excised livers (mg) and a hepatosomatic index (HSI) calculated based on the ratio of liver weight to body weight.
- **Tissue metals** concentrations (including mercury) were determined from a subsample of 15 fish per species. Livers and muscle tissue taken from the dorsal musculature was removed and frozen prior to shipping to ALS for analysis of total metals and mercury.

2.5.3. Data analysis

Data analyses are segregated into two major categories: 1) Basic meristic data (length, weight, gender, maturity) from the entire data set of fish; and 2) the DBA which in addition to meristic data, includes GSI, HSI, stable isotopes and tissue metals concentrations.

2.5.3.1. *Basic meristics*

The following analyses were completed for all mortalities from all three phases of the fish-out (i.e., including the DBA fish):



- Species composition will be determined from all fish captured except those captured and released alive during the mark/recapture phase
- Minimum, maximum and mean length (mm) and weight (g) by species
- Length – weight relationship and length-frequency distribution by species
- Minimum, maximum and mean condition factor (K), by species, calculated as $\text{Weight} \times 10^5 / \text{Length}^3$
- Gender ratio – male : female by species
- Relative proportion of fish according to five reproductive status codes: ripe, running, spent, undeveloped, unknown. Undeveloped fish are fish that are immature and will not spawn during the forthcoming year. Unknown fish are almost all immature and are not identifiable as either a male or a female.
- Relative proportion of fish according to three maturity codes: immature, mature, or unknown. Fish categorized as mature would include all fish of ripe, running or spent codes, as well as large fish that are ‘resting’. That is, fish that have spawned in the past and were mature during a previous year. These fish are not immature and are identified as male or female, but the gonads are undeveloped and will not spawn during the forthcoming year.

In some cases, not all fish can be used for all purposes. A small proportion of fish captured in gill nets were partially eaten by other fish. In these instances, these fish were not used to generate length – weight relationships or condition factor. However, these fish were used to determine the relative proportion of species present. If gender and maturity could be positively identified, they were also used for this purpose. Therefore, the number of fish used for different basic meristic analyses may differ according to category.

2.5.3.2. Detailed biological assessment

The following analyses were carried out on all DBA fish:

- Detailed internal and external examinations to determine gender, reproductive status, parasite presence, and overall apparent health (e.g., DELT - deformities, erosions, lesions or tumors). A summary of observations relating to internal and external health and parasite load is presented.



- Gonad weight and fecundity was measured for all female fish and used to calculate gonadosomatic index (GSI) based on the ratio of ovary weight to body weight. Minimum, maximum and mean GSI is presented.
- Liver weight was measured to calculate hepatosomatic index (HSI) based on the ratio of liver weight to body weight. Minimum, maximum and mean HSI is presented.
- Liver and muscle tissue samples were collected for analysis of total metals including mercury. While not required by the DFO Protocol this was deemed a prudent additional step and a good use of the fish. Analysis of tissues was performed by ALS Laboratories, Vancouver. These data will provide a baseline for aquatic environment effects program (AEMP) monitoring.
- A summary of dietary items consumed for each species is presented. Depending on gut contents, they were either identified in the field (e.g., fish remains) or in the North/South Consultants Inc. Winnipeg laboratory if closer examination was required.
- Age-frequency distribution and age-at-length statistics are calculated for the 50 fish from each species. Age and length of first maturity will be determined from the age data.



3. RESULTS AND DISCUSSION

3.1. QA/QC

Laboratory data quality objectives (DQOs) for this project were met, with all RPDs, method blanks and certified reference materials falling within target limits for water samples (**Table 2-1**). Field DQOs were largely met, with a few exceptions. All parameters in travel blanks (distilled water transported to the site, handled as all other water samples and transported back to the laboratory) were below detection except for ammonia in two samples. Ammonia also exceeded detection in an equipment blank sample. Exceedences of the DLs for these samples cannot be easily explained. Field duplicate samples from the north basin in August and September met target limits for RPDs except for nitrate in one sample and ammonia in one sample and a laboratory duplicate (**Table 2-1**). Because ammonia seemed to be the only parameter that exceeded QA/QC objectives, this is being followed up with the laboratory and may be related to their practices (given that ammonia exceeded in a travel blank) and two equipment blanks using distilled water provided by the laboratory.

Laboratory replicate counts were performed on 10% of all samples for benthos. Fish-out benthos were analyzed in the same batch of samples as the Aquatic Effects Monitoring Program (AEMP) samples. Thus, QA data from fish-out samples were included as part of a larger set and are reported in greater detail in the AEMP (Azimuth, 2009c) report. Replicate samples were chosen at random and processed at different times from the original analysis to reduce bias. Of the re-sorted samples, 2/197 (1.0%), 5/201 (2.5%), 5/272 (1.8%), 17/389 (4.4%), 27/370 (7.3%) and 0/136 (0%) of organisms were missed with an overall omission rate of less than 3%. These results suggest that the vast majority of animals observed in benthic samples by the taxonomist were recovered. A reference collection of benthic taxa has been compiled by ZEAS, Ontario.

Duplicate fish tissue samples were collected from randomly chosen Arctic char and lake trout muscle and liver samples for blind analysis of total metals (mg/kg ww) by ALS (**Table 2-2**). Results of analyses of duplicate samples for 25 metals from five tissues samples (3 muscle, 2 liver) showed RPD values below the 25% difference threshold for all metals except for zinc in a single lake trout muscle sample (RPD 26%). Several other metals (molybdenum, barium, nickel and tin) exceeded the RPD threshold of 25% in individual samples, but were for values that were less than 10x of the method detection (DL) limit. At metal concentrations less than 10x DL, differences that are very small (e.g., <0.02 and 0.03 mg/kg = RPD of 40%) can yield RPDs that exceed 25% but relatively speaking are quite small and do not compromise laboratory DQOs.



3.2. Provision of Fish to the Community

Based on specific feedback from the community gathered over a period of several years, especially from the elders, the following protocols were followed for fish preparation and delivery to the community.

- All lake trout and Arctic char of consumable size (i.e., in excess of 250 mm), once processed for basic meristic information (length, weight, gender, maturity) or DBA were completely gutted and frozen in individual bags. A number of the larger round whitefish and burbot were also prepared in this way as some community elders expressed a desire for these species.
- Bags were labeled as either male or female fish as it was expressed to us that female fish were preferred as they taste better.
- A few very large lake trout and small fish not of a size for human consumption, most burbot and fish that died in nets were processed (not gutted) and placed into bags and labeled as ‘dog food’. Fish labeled as ‘dog food’ was shipped and stored in the community freezer separate from human food.
- Frozen fish were delivered to the community every few days and preferentially provided to community elders, the Baker Lake Hospice or more impoverished people. Periodic radio announcements were made to advise people if a delivery of fish to the community freezer had been made.
- All fish guts and offal from daily processing events were placed into plastic bags and incinerated as per the DFO protocol.

By the end of the sampling program all fish delivered to the community, whether as ‘people food’ or as ‘dog food’ was picked up and we presume, used appropriately.

3.3. Sampling Locations and Weather

Sampling coordinates (UTM NAD83) and weather conditions at the time of sampling during July 20 (spring), August 18 (summer) and September 12 (fall) are reported in **Table 2-3**. Samples for water chemistry, vertical temperature/oxygen profiles, Secchi depth, and vertical zooplankton tows were collected on the same day, with the location of sampling depicted in **Figure 2-1**. Because of the large number of benthic grabs required from multiple depths and locations sampling was spread out over several days during late summer (August) within the southeast, middle and northwest basins, which is consistent



with historic benthic sampling events. Exact locations of benthic grab stations are not depicted on the map; however, UTM coordinates are provided (**Table 2-6**).

3.4. Limnology

Vertical temperature and oxygen profiles measured from mid-basin at the northwest, middle and southeast portions of the impoundment area showed distinct differences (**Figure 2-2**) both between seasons and basins. The shallower southeast and northwest basins were temporarily stratified in spring (July 20, one week after ice-off), with a 5°C difference between surface (12°C) and deep (7°C) water. However, this vertical stratification had been broken down prior to the summer (August) and fall (September) monitoring periods with no significant difference in water temperature between surface and bottom waters. Both basins remained isothermal with no evidence of stratification. In previous surveys strong wind events promote vertical mixing and typically prevent stratification for more than a few days or a week (BAER, 2005).

The deep (>40 m) middle basin was well stratified in spring and summer, with a sharp thermocline at 8 m in July and 18 m in August. Surface water temperature on July 20 was 14°C extending to 8 m where water temperature rapidly declined to 7°C and eventually less than 5°C at 27 m. By August, the epilimnion had deepened to 18 m (12 - 13°C) when temperature rapidly declined to 6°C at 20 m and 5°C at 27 m (**Figure 2-2**). By September 12 stratification had broken down completely in all basins with isothermal temperatures near 7°C from top to bottom. Stratification had become established early in spring and was maintained until eventually eroded probably by late August or early September when the entire lake became isothermal.

Thermal stratification had not been recorded before in Second Portage Lake or in any other project lake in the past (BAER, 2005; Azimuth, 2008a; b). Occasionally stratification can become established for brief periods during windless periods in summer with temperature differences of 3 – 4°C. However, stratification is quickly broken down over a short time because of high, sustained winds that blow along the axis of Second Portage Lake from the northwest ensuring that vertical mixing takes place throughout the entire open water season. However, it is possible that due to the relatively great depth of the middle basin that stratification was not always detected during routine limnology surveys.

Oxygen concentrations (mg/L) were always high, correlated with temperature and near saturation at all depths and seasons (**Figure 2-2**). Oxygen was higher in the hypolimnion than at surface in summer because oxygen concentrations in colder water temperatures are greater. Hypolimnetic oxygen can become reduced because of respiration by biota and lack of oxygen recharge from the air. However, because biological productivity and

rate of breakdown of organic matter in the Meadowbank study lakes is so low, there is no risk of oxygen depletion at any time. In spring and fall oxygen concentrations are high and unstratified in all basins. Late winter water quality monitoring (March) in previous work has revealed high oxygen concentrations under the ice (BAEAR, 2005)

Secchi depth (m) in Second Portage Lake in all basins was high, being greater than 7 m, which is consistent with previous work (BAER, 2005). Secchi depth dropped substantially in summer (<1 m) and fall (1.25 m) in all basins because of elevated suspended solids concentrations introduced to the impoundment as a result of sediment loss from East Dike construction. Although the flow direction and the predominant wind direction is from north to south, wind mixing eventually introduced suspended sediments throughout Second Portage Lake. This has affected some chemistry parameters such as total dissolved and suspended solids concentrations.

3.5. Water Chemistry

Water samples (see **Table 2.3** for collection depths by season) were measured for pH, conductivity, total suspended solids (TSS), total dissolved solids (TDS), anions, nitrogen nutrients, dissolved organic carbon (DOC), chlorophyll α and dissolved calcium and magnesium, common salts that are important nutrients (**Table 2-4**).

Conductivity (20 – 24 $\mu\text{S}/\text{cm}$) was low and consistent across all stations and depths, except a slight elevation (30 $\mu\text{S}/\text{cm}$) at the surface of the southeast basin in fall that is correlated with elevated TDS and TSS (9 mg/L). TSS was below detection limits (DLs) in spring (<3 mg/L) but was above detection in the southeast and middle basins in summer and in all basins in fall, as TSS had spread throughout the impoundment by September. pH was circumneutral (7.2) with low hardness (7 – 9 mg/L) and alkalinity (6 – 7 mg/L) dominated by bicarbonate (**Table 2-4**).

Nutrient concentrations (nitrate/nitrite), Kjeldahl nitrogen (0.1 mg/L), phosphate, dissolved and total organic carbon (DOC/TOC; 1.6 – 2.6 mg/L) and sulfate were low or below detection in spring, but were slightly higher in summer and fall. Phosphate increased in August and September in both surface waters and at depth and was correlated with increases in TDS and TSS. Increased phosphorus may offset diminished light penetration with respect to productivity and chlorophyll α concentrations, which did not vary substantially over the open water season, despite the TSS increase.

DOC was unusually elevated in fall from the southeast basin (22 – 37 mg/L) at 1 m and 6 m depth respectively. DOC typically originates via photosynthetic processes; given that chlorophyll α was low (0.25 $\mu\text{g}/\text{L}$), this result is atypical and suggests contamination of this sample.

Chlorophyll α concentrations were low (0.22 – 0.56 ug/L) at all stations and depths throughout the open water season in Second Portage Lake which is characteristic of very low productivity ultra-oligotrophic lakes (Wetzel, 1983). There were no differences in chlorophyll α concentrations among basins or over seasons as there did not appear to be a discernable pattern or trend. Higher TSS concentrations may have suppressed productivity in the southeast basin in later summer, but this would have also coincided with declining daylight and colder water temperatures at this time of year.

There were no vertical differences in water chemistry parameters over the course of the year in any basin. For example, despite strong stratification of the deep middle basin in August, water quality parameters at 1 m and 16 m were very similar with no meaningful differences between depths (**Table 2-4**).

Dissolved calcium (2.0 – 2.5 mg/L) and magnesium (0.7 – 0.8 mg/L) concentrations were low and uniform across seasons and basins and are typical of nutrient poor systems. The low concentrations of calcium and magnesium may limit whole lake productivity, independent of other nutrients.

Low hardness and alkalinity, low TOC/DOC concentrations and low nitrogen nutrients, combined with very low chlorophyll α concentrations confirm the oligotrophic or ultra-oligotrophic nature (Wetzel, 1983) of Second Portage Lake, which is known from previous baseline work (BAER, 2005)

3.6. Lower Trophic Levels

3.6.1. Zooplankton

Zooplankton biomass (mg/m³ dw) from vertical tows (4 replicates) ranged from 4.8 mg/m³ dw to 126 mg/m³ dw (**Table 2-5**). Note that dry weight biomass is approximately 5% wet weight biomass (i.e., 95% moisture). Although dry weight density in most tows was similar, some values varied widely within stations, illustrating the potentially large variation, perhaps due to patchiness of animals in the water column. There were no obvious trends within basins as biomass did not increase nor decrease consistently from month to month. Comparisons between basins cannot easily be made because tow depth differed between basins. The majority of zooplankton biomass is usually distributed within the upper 10 m of water where their food source, phytoplankton are most abundant. Because the middle basin is quite deep, tows were made from up to 30 m deep, so that water depths where zooplankton biomass is assumed to be low (i.e., 10 – 30 m) was mixed with water depths where zooplankton biomass is assumed to be high (0 – 10 m). This may explain why mean biomass of zooplankton from the deep middle basin (17.2

mg/m³ dw; mean tow depth 30 m) was lower than biomass in the northwest (24.7 mg/m³ dw; mean tow depth 10 m) and southeast basins (38.5 mg/m³ dw; mean tow depth 13 m).

3.6.2. Benthos

The number of benthic invertebrate community samples collected for biomass and taxonomy (one sample per 5 m depth interval) in late August from each basin was dictated by total depth. Ten biomass samples were taken from the shallow north basin (maximum depth 12 m), 16 from the deep middle basin (maximum depth 42 m) and 13 from the shallow southeast basin (maximum depth 18 m)(**Table 2-6**). Details on depth zone, actual sampling depth and UTM coordinates for each station for biomass and taxonomy are also provided in **Table 2-6**.

Mean dry weight biomass of invertebrates contained within single grab sample (i.e., 0.023 m²) was 0.005 g dw in the northwest basin. The deeper southeast and middle basins both had a mean dry weight biomass of 0.003 g dw/sample (**Table 2-7**). Within basins, biomass was greater at shallower depths than deeper depths. In the northeast basin, mean biomass was higher between 5 and 10 m depth (0.006 g dw) than 10 – 15 m, 15 – 20 m (0.002 g dw), and greater than 20 m (0 g) where no benthic invertebrates were recovered.

Single grab samples were also acquired from each 5 m depth interval for taxonomic purposes in addition to biomass (**Table 2-8**). Insects (F. Chironomidae larvae) dominated abundance in the northwest basin at both depth intervals. In the deep middle basin abundance was split between insects and mollusks (Sphaeriidae clams) with approximately equal numbers (278/m² and 261/m² respectively). There did not appear to be any pattern with increasing depth. In the southeast basin at 7 m insects and mollusks co-dominated while mollusks were more abundant at deeper depths (>15 m) (**Table 2-8**). Other taxa including mites (O. Acarina) and annelid worms were present in very low abundance and comprised only a small portion of total abundance, usually less than 5% (**Appendix C**).

Total richness was low, with an average of 7.5 species from the north basin, 6.4 from the middle basin and 4.0 from the southeast basin, not including ostracods or nematodes (**Table 2-9**). Chironomids dominated richness with *Heterotrissocladius* sp., *Zalutschia* sp. and *Procladius* sp. being most common. The bivalve clam genera (*Cyclocalyx*/*Neopisidium* sp.) were present at all stations and depths (**Appendix C**).

3.7. Fish Community

This section explores the basic meristic characteristics of the fish community of the northwest arm impoundment area of Second Portage Lake including species composition,



gender, sexual maturity, reproductive status, mean size, and length-frequency distribution by species. This is followed by a more detailed analysis (i.e., DBA) of a subset of fish of lake trout, Arctic char and round whitefish where fecundity, gonad and liver weights, internal condition and parasite load and tissue metals concentrations were measured.

3.7.1. General Meristic Characteristics

3.7.1.1. Species composition

A total of 3,073 fish were removed from the northwest arm of Second Portage Lake in summer/fall of 2008 (**Table 2-10**). Lake trout dominated the fish community, comprising 66% of all fish captured, followed by Arctic char (16% of all fish enumerated) and equal percentages of round whitefish and burbot (10% and 9% respectively). Species composition was similar to the 1997 survey (EVS, 1998) when lake trout also dominated (74%), followed by Arctic char (15%) and round whitefish (5%). In a brief survey of Second Portage Lake conducted in 1999 (EVS, 1999), composition was again dominated by lake trout (76%), followed by round whitefish (22%) and Arctic char (6%). Burbot were not captured during either survey. These data suggest that brief (2 – 3 day) surveys provide only gross indications of relative species composition, but do not reveal the true composition of the fish population as during a complete fish-out, where for example, burbot were much more numerous, and Arctic char were relatively more numerous than round whitefish from fish-out data than baseline surveys suggested.

3.7.1.2. Size and condition

Mean length, weight and condition factor (K) of lake trout, Arctic char, round whitefish and burbot for which both length and weight data were available (2996 fish) is presented in **Table 2-11**. Length – weight relationships for each species are presented in **Table 2-12**.

Lake trout are typically much larger than all other fish species in Arctic lakes as well as being more numerous (**Table 2-11**). Maximum size of lake trout (12.7 kg) was much greater than Arctic char (2.5 kg), round whitefish and burbot. Burbot can also reach large sizes, up to 10 kg or more (Scott and Crossman, 1979) however, although numerous, they were quite small with the largest fish just over 1 kg. Maximum size of round whitefish was reported as 1.9 kg; however the next largest fish was just less than 1 kg and we suspect that there was an error in measurement of this unusually large fish. However, we could not eliminate this record from the dataset because we could not rule out the inaccuracy of this data record. This fish also had the highest condition factor (2.68), which is unusually high.



Mean size of lake trout was much smaller in the current study (250 mm; 359 g) than in all previous surveys (n=173 fish from 1997, 1999, 2002, 2005; BAER, 2005) in Second Portage Lake (452 mm; 1240 g). A similar trend was also observed for Arctic char (n=39; length 475 mm, weight 1136 g) and round whitefish (n=26; length 327 mm, weight 497 g) as historic means were considerably higher than in the present survey (**Table 2-11**). This is because larger fish are preferentially captured in brief surveys (See Chapter 4 for further discussion of size-related catchability) lasting only a few days, as large fish are more susceptible to capture by gillnets. Thus mean length, weight and age data will be skewed towards larger, older fish in short surveys. Obviously, the fish-out data are more accurate and representative of true species composition and size distribution data for each species.

On average, Arctic char were larger than lake trout, which has been seen in past surveys (EVS, 1997; 1999). In the current study, this is because a large number of quite small lake trout were captured, which drove the average size downwards. On the other hand, relatively few small Arctic char were captured, so mean size tended to be larger. Although Arctic char in this system are non-anadromous (BAER, 2005) they do grow to a large size, in excess of 2 kg with very red flesh.

Condition factor of all species was high (**Table 2-11**) but slightly lower than in historic surveys. This is because of the large number of very small fish included in the overall mean, which tend to naturally have lower K factors because small fish do not have much fat, they have undeveloped gonads and do not have the capacity to consume a large fish, all of which can add considerably to K. Note that maximum K factors reported here are unusually high. This is because a very few fish could not be excluded from the dataset because we could not categorically determine that either length or weight from specific data records were erroneous due to a reporting, transcription or other error.

Examination of the length-frequency distributions of the fish captured reveal some interesting trends (**Figure 2-3**). A large number of small lake trout were captured with an exponential decline in numbers with increasing fish size, which is to be expected in most ecological systems where young and juvenile members of a population outnumber mature adults, even in long-lived species such as lake trout. The same is not true however, for Arctic char and, to a lesser extent, round whitefish, where a distinctly bi-modal distribution in length is evident. Both of these species had relatively large numbers of small, juvenile fish, but equivalent numbers of large fish with a distinct absence of medium size fish. In the case of round whitefish, some of the very small fish were captured in 'Swedish' nets and therefore might be excluded from the distribution, making it less bi-modal.

Although it may seem difficult to explain why the size distribution of Arctic char is so distinctly and so consistently bimodal, this is not unusual for nutrient limited high Arctic lakes that are lake trout dominated. In this case, because the impoundment was virtually completely fished out, these bi-modal distributions cannot be explained by gill net selectivity. Using a single mesh size of gill net produces a bell shaped length-frequency distribution, and that the larger the mesh size, the larger the mean length of the distribution. However, there is considerable overlap in size of fish captured by different mesh sizes used during fish-out (37 mm – 127 mm stretch mesh), which would virtually eliminate this problem. Furthermore, there was no size class of fish that was consistently missed among species, which might suggest gill net selectivity.

The bi-modal size pattern of char in Arctic lakes is related to food-web dynamics and ‘top-down’ pressure from the dominant predator, lake trout. Because lake trout are highly piscivorous, the main food source of lake trout is usually smaller lake trout, because of their abundance. However, if whitefish and/or Arctic char are also present in the same lake, these species can also compose a significant portion of the diet of trout (Scott and Crossman, 1979). In such systems, Johnson (1976) has postulated that bi-modal size distributions remain very constant over time and that the observed bimodality is not a function of the sampling procedure, but is real and is best explained by an ecological feedback mechanism. This mechanism, which is based on fish size and the limited productivity or energy availability of the system, limits steady recruitment of fish from the small size mode to the large size mode. Arctic lakes dominated by large lake trout populations contain a number of large fish that have very low annual growth and mortality rates. Therefore, in stable systems (i.e., no fishing or other environmental perturbations, as exist here), fish from small size classes can only be recruited into larger size classes through a period of rapid growth (i.e., they need to attain a certain minimum size in order to avoid predation and the longer they take to achieve that size, the more likely they are to eventually become prey). In low productivity lakes, smaller fish simply take too long to grow beyond the gape range of larger lake trout. Furthermore, growth of smaller fish is also suppressed because the lake is not productive enough to support the rapid growth of all of the fish in the small size mode into the larger size mode.

Large lake trout consume small lake trout or when available, small Arctic char or whitefish. These fish are most vulnerable until the fish reach a size where larger fish can no longer easily prey upon them (i.e., larger fish are more difficult to capture and eat). It is at this point that a critical threshold is reached (i.e., at the upper end of the small size mode), where these fish have become large enough that they cannot be consumed by fish in the large size mode. Therefore, these fish may grow very rapidly through this intermediate size. Note that there is not necessarily a good relationship between size and age. The age of intermediate size fish can vary widely (Johnson, 1976) because of growth suppression of older fish. Thus, the combination of limited nutrient availability combined

with top-down suppression of growth and predation by large lake trout explains why there are relatively fewer fish in intermediate size classes of Arctic char and, to a lesser extent, round whitefish.

3.7.1.3. Gender and maturity

Female fish were more common than males for lake trout (58%), Arctic char (54%) and round whitefish (58%) of fish for which gender could positively be identified (**Table 2-10**). Male burbot were more common (53%) than females.

With respect to maturity, many more fish were immature (i.e., fish that have never spawned before) than mature, especially lake trout (79%) because small, juvenile fish made up such a large proportion of the fish captured (**Table 2-10; Figure 2-3**). Note that fish that are ‘resting’ were considered ‘mature’. Resting fish are fish that have spawned in the past but are not mature to spawn in the current year. Thus, mature fish include resting fish and not all will spawn in the current year. These fish are broken out in the reproductive status category of **Table 2-10**.

Only 18% of lake trout were categorized as ‘mature’ fish. This includes current year spawners, but also resting fish (about 9%). The vast majority (79%) were immature. For round whitefish, 37% of fish captured were immature while a relatively larger proportion of fish were sexually mature, current year spawners (58%). Forty-seven percent of Arctic char were mature or resting adults, which may partially be explained by the relatively large number of large individuals captured.

Reproductive status was more relevant to identifying the number of fish that are sexually mature to spawn during the current year, because sexually mature fish also lumped in resting fish. Given that all of the fish identified are fall spawners (except burbot – winter spawners), ripe, running and spent fish represent the proportion of fish that spawned or would have spawned in fall 2008. Undeveloped fish include all immature fish, but not resting fish that we have separated out of this category. This deviates from the original DFO protocol but we feel that better information is provided because the number of resting fish is very important. In nutrient limited systems it is very common for mature fish to skip one or more years between spawning events because it may take several years to sequester a sufficient amount of energy to produce gametes.

Undeveloped or immature (i.e., never have spawned before) fish was the most common among lake trout, char and burbot, especially lake trout (79%). Only 9% of lake trout were sexually mature, current year spawners. However, most round whitefish captured were mature to spawn the current year (51%). Despite the large number of small fish captured, this suggests that the majority of mature fish skip at least one year, and

probably more between spawning events. Twenty-one percent of Arctic char captured were current year spawners.

Resting fish comprised an important component of fish reproductive status, accounting for 23% of char and 8% of lake trout, but a small percentage of younger, smaller round whitefish and burbot (3%). Resting fish were as or more abundant as current year spawners.

3.7.2. Detailed Biological Assessment

A subset of fish spread out over the entire size range of fish captured during the fish-out was selected for more detailed biological assessment (DBA). Therefore, some of the categories discussed below are not representative of the overall population (e.g., age, size, maturity), because only a subset of fish was selected and autopsied. Length (mm), weight (gm), condition factor (K) and age (years) of DBA fish is presented in **Table 2-13**. The DBA data set consisted of 163 fish comprised of 63 Arctic char, 50 lake trout and 51 round whitefish spread across the size range of fish captured during fish-out. Full details are presented in **Appendix D**. Mean size data will be different – higher for lake trout and lower for Arctic char, than overall size data (**Table 2-11**).

3.7.2.1. DELT

All fish selected for DBA analysis were subjected to a detailed examination of the external body and internal body cavity for any obvious deformities, erosions, lesions, or tumors (DELT) as well as evidence of parasite load, cysts, scars or other evidence of disease or injury. The vast majority of fish of each species were classified as healthy with very few deformities, erosions, lesions or tumors (**Table 2-14**). Two of 63 Arctic char were identified as having internal cysts; five of 50 lake trout and 2 of 51 round whitefish. One Arctic char had an external lesion on the chin area. Otherwise, external condition of all other fish was excellent with no scars or tumors evident.

Internally, it is typical for fish to contain gut parasites, in or around the gut (e.g., *Diphyllbothrium*, air bladder nematodes or other common parasites). Low levels of parasites have been identified in previous surveys of all lakes in the project area, especially *Diphyllbothrium* sp. that appeared to be a relatively common and widespread parasite that was present in most fish (Azimuth, 2008b). All fish appeared to be in good health, regardless of the parasite load that they were carrying. During the current survey each species had a low level of parasite load including tapeworms in a single Arctic char, and brain parasites in two char. *Diphyllbothrium* sp. cysts were most commonly attached to the gut and pyloric caeca within the body cavity. Twelve of 63 Arctic char and 14 of 50 lake trout were identified as having few parasites in the gut cavity. Six



Arctic char and six trout were identified as having many parasites. Mountain whitefish had a very low body burden of parasites with only two cysts observed (**Table 2.14**).

Within the stomachs of lake trout and Arctic char in particular, two cestode parasite species, *Bothriocephalus* sp. and *Schistocephalus* sp. were common. Tapeworms, including these two species were found in 27 of 63 Arctic char (43%) and 26 of 46 lake trout (56%), but in only 1 of 41 (~1%) round whitefish (**Table 2-14**). In some cases, infestation was relatively heavy as these parasites comprised a greater proportion of wet weight biomass in the gut than did food items.

3.7.2.2. Gender and maturity

Of the subset of fish retained for DBA, like the greater population, there was a greater percentage of female fish than male fish processed, with about 60% females and 40% males (**Table 2-15**). Because fish were selected over a wide size range, there were disproportionately more fish that fell into the large and therefore, mature category than immature. Thus, at least 67% of fish were mature, which also includes resting (i.e., fish that have spawned in the past but will not spawn in the current year) fish, which comprised 21% of Arctic char and 16% of lake trout. Sexually mature current year spawners (i.e., ripe, running, spent) fish comprised 42% of Arctic char, 38% of lake trout and 55% of round whitefish, which is proportionally higher than for the total population as described in Section 3.4.3 and in **Table 2-10**. For example, only 9% of lake trout were current year spawners. Fewer than 20% of fish from any species were immature fish that had undeveloped gonads.

3.7.2.3. Age

Mean age of lake trout aged was 18 years, with a range from 4 – 36. Mean age of Arctic char (8 years; range 2 – 16 years) and round whitefish (8 years; range 2 – 19 years) was similar (**Table 2-13**). These age data are consistent with previous surveys (BAER, 2005). For example mean age of lake trout from Second Portage Lake was 16 years, while maximum age ranged from 26 – 38 years among all study lakes. Mean age of Arctic char was 9.3 years in Second Portage Lake, ranging from 2 – 13 years.

Age-frequency distributions were plotted for Arctic char, lake trout and round whitefish (**Figure 2-4**). At all but the upper and lower ends of the age spectrum, age categories were more or less equivalent because equivalent numbers of fish within particular length categories across the size spectrum were chosen for DBA. Of course, the very young and very old fish are not represented to the same degree as the intermediate ranges. So, the

trends observed in length-frequency distributions for these species are not as evident in the age-frequency distributions, especially for lake trout.

According to Johnson (1976 and 1980) bi-modality in age distributions of Arctic char and round whitefish can exist, despite the fact that equivalent numbers of fish were taken from discrete size-categories. This is related to the reasons why bi-modality exists, as described in **Section 3.7.1.2**. Many small fish within smaller size modes may have a wide size range. Because of growth suppression by larger lake trout many ‘older’ fish may still reside within the small size mode – until such time as they can overcome this and move (rapidly) into the larger size mode. This trend will be explored further in length-at-age relationships.

3.7.2.4. Gonadosomatic index

Gonadosomatic indices (GSI) were calculated for a subset of the female Arctic char (7), lake trout (8) and round whitefish (16) from the DBA fish (**Table 2-16**). Only ripe or running fish (i.e., fish that were going to spawn in the current fall) were included in the GSI calculation. **Photos 1 and 2 (Appendix E)** show images of mature, ripe lake trout and Arctic char females. We did not include immature fish, fish that had partially developed ovaries, which were maturing to spawn the next year, nor fish that were ‘resting’. Resting fish had ovaries with residual and developing eggs (**Photo 3**).

One interesting aspect of this work arose from autopsies of very small (<7 gm) round whitefish that were not captured directly, but came from gut contents of lake trout. During processing it was noticed that in the guts of some lake trout, many partially digested round whitefish appeared to have mature gonads, both males and females. Upon further investigation it was discovered that male and female fish weighing 5 – 7 gm (~90 mm) were sexually mature, ripe fish with large testes and ovaries with large eggs (~150 eggs total). Photographs of mature female round whitefish (age 3 or 4) showing ripe eggs (**Photos 4 and 5**) and mature testes (**Photo 6**) are presented in **Appendix E**. These fish had GSI indices of 10 – 18%, which is very high; larger (300 – 800 g) sexually mature females had GSI values between 6% and 8%. The small precociously mature ~5 gm fish were 3 or 4 years of age and are devoting all energy towards production of gonads and not towards growth.

3.7.2.5. Hepatosomatic index

Hepatosomatic indices (HSI) as a ratio of liver to body weight are presented in **Table 2-16** for Arctic char, lake trout and round whitefish from DBA fish. Mean HSI was similar for all fish at about 1.1% of body weight. HSI data have not been collected from



Meadowbank study lakes in the past. Typical HSI values for fish range between 1 to 2 % and can vary seasonally according to condition factor and overall health of fish with respect to glycogen stores. Exposure to certain environmental contaminants (e.g., cadmium, zinc) can cause liver size to increase and therefore cause HSI to become elevated.

3.7.2.6. Diet

Of the autopsied DBA fish, stomachs of most fish were dissected from the intestines and sent to North/South Consultants (Winnipeg) for analysis. Note that some stomachs that were obviously empty were not sent. The data reported in **Table 2-17** does not represent the true ratio of empty stomachs to stomachs containing food. Despite the initial ‘screening’ of stomachs, some stomachs analyzed in the laboratory were empty. Of the 46 lake trout stomachs examined, 13 were empty, as well as 7 of 63 Arctic char stomachs and 1 of 41 round whitefish stomachs. Mean wet and dry biomass of major taxonomic invertebrate groups showed large differences between species (**Table 2-17**), which was not unexpected. Lake trout diet was dominated by fish on a dry weight basis, when food was present. Invertebrates comprised a small portion of the diet as only 3 gm of dry weight biomass was present in 33 stomachs. Stomachs containing invertebrates were dominated by Laevicaudata (69% of dry weight biomass), or clam shrimp, small crustaceans within the Class Branchiopoda. Laevicaudata are primarily benthic dwelling animals, up to 1 cm in length, are patchy in abundance and when present, can comprise a significant component of the diet, occurring in 25% of all trout examined. Cladocera (9%), leeches (Hirudinea 5%) and Trichoptera larvae (6%) comprised minor components of the diet on a dry weight basis. There did not appear to be a meaningful difference between small and large lake trout with respect to dietary preference, as larger lake trout also appeared to eat invertebrates. Lake trout was the only species where fish and fish eggs were identified in stomach contents. Twelve of 33 lake trout stomachs contained fish, including slimy sculpin. Total wet weight biomass of fish was 450 gm, or approximately 112 gm dw, about 150 times greater than total invertebrate biomass.

Diet of Arctic char was dominated by Cladocera, which is a group of small crustaceans commonly referred to as water fleas and includes *Daphnia*. Cladocera were present in 54% of Arctic char stomachs and comprised 83% of dry weight biomass (**Table 2-17**). Trichoptera (8%) and other taxa (5%) comprised the remainder of dry weight biomass. These data suggest that Arctic char are feeding almost exclusively in the water column from pelagic zooplankton species, primarily Cladocera. Total wet weight biomass of invertebrates in Arctic char stomachs was 60 gm or 3 gm dry weight biomass (95% moisture content).



Laevicaudata were found in 65% of all round whitefish stomachs and were by far (68%) the most important organism consumed by dry weight biomass (4 gm dw). Trichoptera (especially Limnephilidae and Hydropsychidae) were the next most commonly consumed organism and contributed ~30% of dry weight consumed. Total wet weight biomass of food consumed was 69 gm, or 5 gm dry weight. All other organisms comprised a minor component of the diet. These data indicate that round whitefish have an exclusive benthivorous diet.

As noted above, lake trout and Arctic char stomachs commonly contained cestode parasites (e.g., *Bothriocephalus* sp. and *Schistocephalus* sp.)(**Table 2-14**). Infestation was common (~50% of fish lake trout and Arctic char examined) and in some cases comprised a significant component of the gut contents (note that weight of parasites was not measured) and may have posed a significant constraint on energetic efficiency of some fish that were heavily infested.

3.7.2.7. Tissue chemistry

Total metals concentrations data were measured from a subset of 15 Arctic char, 18 lake trout and 13 round whitefish from muscle and liver tissue (**Appendix F**). Mean concentrations and ranges for each species are provided in **Table 2-18**. Metals data were not analyzed from all DBA fish because metals concentrations do not tend to vary much and, with the exception of mercury, do not increase in concentration with increasing fish size. Nevertheless, fish were analyzed across the size spectrum, to incorporate data from small and large fish.

Of the 25 metals analyzed, 10 – 12 metals in muscle (e.g., antimony, cadmium, lead, thallium, vanadium, were consistently below laboratory detection limits) (**Table 2-18**). Calcium, magnesium and strontium are important constituents of bone and concentrations can vary greatly depending upon whether bone fragments are inadvertently analyzed with part of the muscle. Other metals including copper, cobalt, selenium and zinc are essential elements and concentrations are regulated within the body. Mercury, cadmium and lead have no known biological function and can be potentially harmful to aquatic organisms if present at elevated concentrations. Besides consumption guidelines for mercury, there are no other commonly known guidelines for any other metal with the possible exceptions for arsenic (3.5 ppm; BC Ministry of Environment and Health and Welfare Canada) and cadmium (3.6 ppm; World Health Organization). Concentrations of these two metals in fish from Second Portage Lake were at least 100 x less than guideline values. In general, metals concentrations did not differ among species as concentrations of nearly all metals (except mercury) were very similar.

Mercury, like other metals, is naturally found in the environment and is always present in small concentrations at all levels of the food web. However, mercury is unique among metals in animal tissue in that it tends to increase in concentration at progressively higher levels of the food chain, with highest concentrations being found in large, carnivorous fish, such as lake trout. Thus, larger older fish tend to have higher mercury concentrations than small and young fish. The amount of mercury in top predator fish, such as lake trout is almost always higher than in fish species that feed lower on the food web, such as Arctic char and round whitefish. Although mean mercury concentrations were not adjusted according to fish size, this trend was also evident in the current study. Arithmetic mean mercury concentrations of lake trout (0.47 mg/kg; maximum 1.37 mg/kg) were much higher than mean mercury concentrations in Arctic char (0.09 mg/kg; maximum 0.24 mg/kg) and round whitefish (0.05 mg/kg; maximum 0.09 mg/kg)(**Table 2-18**).

Metals concentrations in liver tissue samples were undetectable for only 9 of 25 metals, with some (e.g., uranium, cobalt, cadmium) detectable in liver tissue that were undetectable in muscle. In general, liver tissue metals concentrations are on average 2 – 10 x higher than muscle metals concentrations, with only a few metals (cadmium and strontium), up to 100 x higher (**Table 2-18**).

3.7.2.8. Stable isotopes

Carbon and nitrogen stable isotopes were measured in muscle tissue from a subsample of Arctic char, lake trout and round whitefish and compared to stable isotopes of copepod zooplankton and benthic invertebrates from Second and Third Portage lakes (**Figure 2-5; Appendix G**). Raw data for individual fish are also presented in **Appendix D**. These stable isotope data are used to determine the trophic structure of the food web and identify the relative position of each fish species based on its diet. This parameter was added to investigate the support the Second Portage Lake turbidity investigation and is presented herein as being useful to interpret food web dynamics of the study lakes and for future results. This aspect of our investigation is further explored in the Dike Construction Monitoring Report (Azimuth, 2009b).

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TABLES



Table 2-1. QA/QC data for water parameters, NW Arm of Second Portage Lake, July, August and September 2008.

	Northwest Basin			Northwest Basin			Various Basins / Depths		
	NB-1m 18-Aug-08	Field Dup 18-Aug-08	RPD (%)	NB-1m 12-Sep-08	Field Dup 12-Sep-08	RPD (%)	Original July	Laboratory Duplicate	RPD (%)
CONVENTIONAL PARAMETERS									
Physical Tests									
Conductivity (µS/cm)	21.8	21.9	-0.5	23.7	23.8	-0.4	20.1	20.1	0
Hardness (mg/L)	8.7	8.62	0.9	9.49	9.51	-0.2	-	-	-
pH	7.26	7.24	0.3	7.14	7.21	-1.0	7.14	7.14	0
Total Suspended Solids (mg/L)	<3.0	<3.0	0	3.2	<3.0	6.5	-	-	-
Total Dissolved Solids (mg/L)	17	11	43	20	16	22	-	-	-
Anions & Nutrients (mg/L)									
Alkalinity - Bicarbonate (as CaCO ₃)	6.6	7.1	-7.3	7.3	7.3	0	-	-	-
Alkalinity - Carbonate (as CaCO ₃)	<2.0	<2.0	0	<2.0	<2.0	0	-	-	-
Alkalinity - Hydroxide (as CaCO ₃)	<2.0	<2.0	0	<2.0	<2.0	0	-	-	-
Alkalinity - Total (as CaCO ₃)	6.6	7.1	-7.3	7.3	7.3	0	-	-	-
Ammonia (as N)	0.063	0.022	96	0.024	0.027	-12	0.033	0.023	36
Chloride	<0.50	<0.50	0	<0.50	<0.50	0	-	-	-
Nitrate (as N)	0.0353	0.0147	82	0.0361	0.0366	-1.4	-	-	-
Nitrite (as N)	<0.0010	<0.0010	0	<0.0010	<0.0010	0	-	-	-
Total Kjeldahl Nitrogen	0.10	0.13	-28	0.083	0.074	11	0.065	0.068	-4.5
Ortho Phosphate (as P)	<0.0010	<0.0010	0	<0.0010	0.0011	9.5	-	-	-
Total Phosphate (as P)	0.0055	0.0049	12	0.0071	0.0061	15	-	-	-
Sulfate (SO ₄)	1.82	1.83	-0.5	1.91	1.92	-0.5	-	-	-
ORGANIC / INORGANIC CARBON									
Dissolved Organic Carbon (mg/L)	2.11	1.96	7.4	2.46	2.05	18	-	-	-
Total Organic Carbon (mg/L)	1.57	1.60	-1.9	1.66	1.86	-11	-	-	-
PLANT PIGMENTS									
Chlorophyll-a (µg/L)	0.347	0.451	-26	0.275	0.255	7.5	-	-	-
DISSOLVED METALS (mg/L)									
Calcium	2.27	2.23	1.8	2.45	2.46	-0.4	-	-	-
Magnesium	0.74	0.74	0	0.82	0.82	0	-	-	-

Notes:

RPD = Relative Percent Difference (%) = ((original - duplicate) / (original + duplicate)/2) x 100.

Shaded RPDs exceed 25% (lab duplicates) or 50% (field duplicates).

Shaded travel and equipment blanks exceed laboratory method detection limits.

Table 2-1 con't. QA/QC data for water parameters, NW Arm of Second Portage Lake, July, August and September 2008.

	Various Basins / Depths			Various Basins / Depths			Travel Blanks			Equipment Blanks		
	Original August	Laboratory Duplicate	RPD (%)	Original September	Laboratory Duplicate	RPD (%)	20-Jul-08	18-Aug-08	12-Sep-08	25-Jul-08	18-Aug-08	12-Sep-08
CONVENTIONAL PARAMETERS												
Physical Tests												
Conductivity (µS/cm)	19.8	19.8	0	-	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Hardness (mg/L)	-	-	-	-	-	-	-	<0.70	<0.50	<0.70	<0.50	<0.50
pH	-	-	-	-	-	-	5.63	5.76	5.50	5.62	5.73	5.36
Total Suspended Solids (mg/L)	-	-	-	3.2	3.2	0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Total Dissolved Solids (mg/L)	-	-	-	20	20	0	<10	<10	<10	<10	<10	<10
Anions & Nutrients (mg/L)												
Alkalinity - Bicarbonate (as CaCO ₃)	-	-	-	-	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Alkalinity - Carbonate (as CaCO ₃)	-	-	-	-	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Alkalinity - Hydroxide (as CaCO ₃)	-	-	-	-	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Alkalinity - Total (as CaCO ₃)	-	-	-	7.3	7.4	-1.4	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Ammonia (as N)	-	-	-	-	-	-	0.054	-	0.074	<0.020	0.053	<0.020
Chloride	<0.50	<0.50	0	<0.50	<0.50	0	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Nitrate (as N)	0.0159	0.0162	-1.9	<0.0050	<0.0050	0	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Nitrite (as N)	0.0015	0.0014	6.9	<0.0010	<0.0010	0	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Kjeldahl Nitrogen	-	-	-	-	-	-	0.055	<0.050	<0.050	<0.050	<0.050	<0.050
Ortho Phosphate (as P)	<0.0010	<0.0010	0	-	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Phosphate (as P)	0.0095	0.010	-7.1	-	-	-	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Sulfate (SO ₄)	1.85	1.82	1.6	<0.50	<0.50	0	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
ORGANIC / INORGANIC CARBON												
Dissolved Organic Carbon (mg/L)	3.06	3.20	-4.5	-	-	-	-	-	-	-	-	-
Total Organic Carbon (mg/L)	<0.50	<0.50	0	-	-	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
PLANT PIGMENTS												
Chlorophyll-a (µg/L)	-	-	-	-	-	-	-	-	-	-	-	-
DISSOLVED METALS (mg/L)												
Calcium	-	-	-	-	-	-	-	-	<0.050	-	-	<0.050
Magnesium	-	-	-	-	-	-	-	-	<0.10	-	-	<0.10

Notes:

RPD = Relative Percent Difference (%) = ((original - duplicate) / (original + duplicate)/2) x 100.

Shaded RPDs exceed 25% (lab duplicates) or 50% (field duplicates).

Shaded travel and equipment blanks exceed laboratory method detection limits.

Table 2-2. QA/QC data for fish tissue moisture, lipid content, and total metals concentrations (mg/kg ww), NW Arm of Second Portage Lake, 2008.

Sample Type	Arctic char muscle tissue			Lake trout muscle tissue			Lake trout muscle tissue			Lake trout liver tissue			Lake trout liver tissue		
	Original	Duplicate	RPD (%)	Original	Duplicate	RPD (%)	Original	Duplicate	RPD (%)	Original	Duplicate	RPD (%)	Original	Duplicate	RPD (%)
PHYSICAL PARAMETERS															
Moisture content (%)	75.7	76.6	-1.2	-	-	-	-	-	-	79.3	79.5	-0.3	82.1	81.8	0.4
Lipid content (%)	0.90	0.60	40	-	-	-	2.4	2.4	0	-	-	-	-	-	-
TOTAL METALS (mg/kg ww)															
Aluminum	4.30	3.20	29	3.30	3.10	6.2	<2.0	2.60	-26	<4.0	<4.0	0	<4.0	<4.0	0
Antimony	<0.010	<0.010	0	<0.010	<0.010	0	<0.010	<0.010	0	<0.020	<0.020	0	<0.020	<0.020	0
Arsenic	<0.010	<0.010	0	<0.010	<0.010	0	<0.010	<0.010	0	<0.020	<0.020	0	<0.020	<0.020	0
Barium	0.011	0.027	-84	0.036	0.035	2.8	0.023	0.030	-26	<0.020	0.020	0	0.033	0.030	9.5
Beryllium	<0.10	<0.10	0	<0.10	<0.10	0	<0.10	<0.10	0	<0.20	<0.20	0	<0.20	<0.20	0
Bismuth	<0.030	<0.030	0	<0.030	<0.030	0	<0.030	<0.030	0	<0.060	<0.060	0	<0.060	<0.060	0
Cadmium	<0.005	<0.005	0	<0.005	<0.005	0	<0.005	<0.005	0	0.216	0.237	-9.3	0.084	0.086	-2.4
Calcium	61.3	58.9	4.0	109	132	-19	38.8	37.5	3.4	56.2	63.3	-12	78.4	82.0	-4.5
Chromium	<0.10	<0.10	0	0.190	0.250	-27	0.120	0.120	0	<0.20	<0.20	0	<0.20	<0.20	0
Cobalt	<0.020	<0.020	0	0.021	0.024	-13	<0.020	<0.020	0	0.041	0.043	-4.8	<0.040	<0.040	0
Copper	0.211	0.182	15	0.272	0.296	-8.5	-	-	-	4.19	4.43	-5.6	1.13	1.15	-1.8
Lead	<0.020	<0.020	0	<0.020	<0.020	0	<0.020	<0.020	0	<0.040	<0.040	0	<0.040	<0.040	0
Lithium	<0.10	<0.10	0	<0.10	<0.10	0	<0.10	<0.10	0	<0.20	<0.20	0	<0.20	<0.20	0
Magnesium	276	249	10	135	159	-16	178	192	-7.6	115	126	-9.1	98.6	102	-3.4
Manganese	0.038	0.043	-12	0.063	0.089	-34	0.102	0.130	-24	0.681	0.728	-6.7	0.600	0.618	-3.0
Mercury	0.079	0.080	-1.3	0.220	0.269	-20	1.37	1.49	-8.4	0.606	0.626	-3.2	2.86	2.94	-2.8
Molybdenum	<0.010	<0.010	0	0.020	0.030	-40	0.012	0.011	8.7	0.058	0.059	-1.7	0.033	0.035	-5.9
Nickel	<0.10	<0.10	0	<0.10	0.140	-33	<0.10	<0.10	0	<0.20	<0.20	0	<0.20	<0.20	0
Selenium	0.300	0.280	6.9	0.540	0.620	-14	0.460	0.480	-4.3	3.50	3.75	-6.9	1.17	1.26	-7.4
Strontium	0.052	0.057	-9.2	0.109	0.137	-23	0.031	0.031	0.0	0.090	0.098	-8.5	0.086	0.090	-4.5
Thallium	<0.010	<0.010	0	<0.010	<0.010	0	<0.010	0.012	-18	0.058	0.063	-8.3	0.045	0.045	0
Tin	<0.050	<0.050	0	<0.05	0.067	-29	<0.050	<0.050	0	<0.10	<0.10	0	<0.10	<0.10	0
Uranium	<0.002	<0.002	0	<0.002	<0.002	0	<0.002	<0.002	0	<0.004	<0.004	0	<0.004	<0.004	0
Vanadium	<0.10	<0.10	0	<0.10	<0.10	0	<0.10	<0.10	0	<0.20	<0.20	0	<0.20	<0.20	0
Zinc	3.58	3.20	11	3.87	4.54	-16	3.33	4.31	-26	24.1	25.7	-6.4	17.1	17.5	-2.3

Notes:

RPD = Relative Percent Difference = ((original - duplicate) / ((original + duplicate)/2)) * 100.

RPDs are shaded when in exceedance of 25% but only if the original and duplicate concentrations exceed 10 x MDL.

Table 2-3. Location (UTM, NAD 83) and details of field data collections, NW Arm of Second Portage Lake, 2008.

Season:		SPRING - July 20					SUMMER - August 18					FALL - September 12				
Weather ¹ :		Clear, ~25°C, ~20 km/h SW winds					Cloudy, ~15°C, ~10 km/h SW to SE winds					Cloudy, ~2°C, ~20 km/h N winds				
Basin (depth)	UTM Coordinates (14W)	Parameters Collected	Collection Details			UTM Coordinates (14W)	Parameters Collected	Collection Details			UTM Coordinates (14W)	Parameters Collected	Collection Details			
			Depth (m)	QA/QC ²				Depth (m)	QA/QC				Depth (m)	QA/QC		
				Field	Lab				Field	Lab				Field	Lab	
Northwest (8-12m)	E 0637654	Water Quality	1 & 3	no	dups	E 0637750	Water Quality	1 & 5	dups	dups	E 0637783	Water Quality	1 & 6	dups	dups	
	N 7215794	Temp/O ₂ Cond.	0 - 10	NA	NA	N 7215770	Temp/O ₂ Cond.	0 - 10	NA	NA	N 7215727	Temp/O ₂ Cond.	0 - 10	NA	NA	
		Secchi Depth	7.4	NA	NA		Secchi Depth	1.1	NA	NA		Secchi Depth	1.25	NA	NA	
		Zooplankton	5.5 - 6	4 reps	no		Zooplankton	11	4 reps	no		Zooplankton	11.9	4 reps	no	
		Benthos	No	-	-		Benthos ³	6.8 - 12.4	reps	yes		Benthos	No	-	-	
Middle (30-35m)	E 0638403	Water Quality	1 & 7	no	dups	E 0638300	Water Quality	1 & 16	no	dups	E 0638553	Water Quality	1 & 14	no	dups	
	N 7214840	Temp/O ₂ Cond.	0 - 27	NA	NA	N 7214875	Temp/O ₂ Cond.	0 - 30	NA	NA	N 7214778	Temp/O ₂ Cond.	0 - 29	NA	NA	
		Secchi Depth	7.9	NA	NA		Secchi Depth	0.6	NA	NA		Secchi Depth	1.25	NA	NA	
		Zooplankton	30	4 reps	no		Zooplankton	30	4 reps	no		Zooplankton	28	4 reps	no	
		Benthos	No	-	-		Benthos ³	6.7 - 28.9	reps	yes		Benthos	No	-	-	
Southeast (13-15m)	E 0638970	Water Quality	1 & 7	no	dups	E 0639000	Water Quality	1 & 7	no	dups	E 0639001	Water Quality	1 & 6	no	dups	
	N 7214243	Temp/O ₂ Cond.	0 - 14	NA	NA	N 7214220	Temp/O ₂ Cond.	0 - 14	NA	NA	N 7214279	Temp/O ₂ Cond.	0 - 11	NA	NA	
		Secchi Depth	7.2	NA	NA		Secchi Depth	0.5	NA	NA		Secchi Depth	1.25	NA	NA	
		Zooplankton	9 - 14	4 reps	no		Zooplankton	14.5 - 15	4 reps	no		Zooplankton	12.8	4 reps	no	
		Benthos	No	-	-		Benthos ³	4.6 - 16.4	reps	yes		Benthos	No	-	-	

Notes:

¹ Weather descriptions are for July 20, August 18 and September 12 sampling days in 2008.

² Reps = sample repetitions were collected; dups = duplicates were collected (field) or made for internal QA (lab); NA = not applicable.

³ Benthos were collected in 2008 on September 1: Northwest basin; August 20-31: Middle basin; August 21-29: Southeast basin.

Table 2-4. Conventional water chemistry and dissolved metals (mg/L), NW Arm of Second Portage Lake, July, August and September 2008.

Basin		Northwest						Middle						Southeast					
Depth	CCME (2007)	1m	3m	1m	5m	1m	6m	1m	7m	1m	16m	1m	14m	1m	7m	1m	7m	1m	6m
Date	Guideline ¹	20-Jul-08	20-Jul-08	18-Aug-08	18-Aug-08	12-Sep-08	12-Sep-08	20-Jul-08	20-Jul-08	18-Aug-08	18-Aug-08	12-Sep-08	12-Sep-08	20-Jul-08	20-Jul-08	18-Aug-08	18-Aug-08	12-Sep-08	12-Sep-08
CONVENTIONAL PARAMETERS																			
Physical Tests																			
Conductivity (µS/cm)	NG	20.1	20.1	21.8	22.0	23.7	23.6	20.5	20.1	22.1	22.6	23.2	23.5	20.0	20.0	19.8	22.3	30.3	23.3
Hardness as CaCO ₃ (mg/L)	NG	7.98	8.01	8.70	8.66	9.49	9.49	7.87	7.94	8.47	8.83	9.46	9.38	7.89	7.85	7.09	8.77	9.37	9.46
pH	6.5 - 9.0	7.15	7.14	7.26	7.25	7.14	7.16	7.13	7.14	7.25	7.27	7.17	7.19	7.10	7.13	6.85	7.27	7.44	7.19
Total Suspended Solids (mg/L)	NG	<3.0	<3.0	<3.0	<3.0	3.2	3.2	<3.0	<3.0	7.6	12	3.7	4.7	<3.0	<3.0	4.1	9.1	4.2	<3.0
Total Dissolved Solids (mg/L)	NG	13	<10	17	23	20	22	14	<10	19	21	18	16	<10	<10	11	19	15	16
Anions & Nutrients (mg/L)																			
Alkalinity - Bicarbonate (as CaCO ₃)	NG	6.0	5.7	6.6	6.6	7.3	7.3	5.4	6.4	6.3	6.8	7.2	7.3	5.9	5.5	5.7	6.5	7.1	6.5
Alkalinity - Carbonate (as CaCO ₃)	NG	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Alkalinity - Hydroxide (as CaCO ₃)	NG	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Alkalinity - Total (as CaCO ₃)	NG	6.0	5.7	6.6	6.6	7.3	7.3	5.4	6.4	6.3	6.8	7.2	7.3	5.9	5.5	5.7	6.5	7.1	6.5
Ammonia (as N) ²	25.9 @ pH6.5; 8.24 @ pH7.0; 2.61 @ pH7.5	0.040	0.039	0.063	0.034	0.024	0.045	0.033	0.059	0.080	0.074	0.039	<0.020	0.030	<0.020	0.089	0.11	0.057	<0.020
Chloride	NG	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.62	<0.50	<0.50	<0.50
Nitrate (as N)	2.9	<0.0050	<0.0050	0.035	0.016	0.036	0.034	<0.0050	<0.0050	0.025	0.022	0.039	0.041	<0.0050	<0.0050	0.030	0.027	0.045	0.041
Nitrite (as N)	0.06	<0.0010	<0.0010	<0.0010	0.0015	<0.0010	<0.0010	<0.0010	<0.0010	0.0013	0.0011	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0012	<0.0010	<0.0010
Total Kjeldahl Nitrogen	NG	0.084	0.079	0.10	0.11	0.083	0.12	0.068	0.065	0.11	0.11	0.094	0.089	0.089	0.065	0.26	0.11	0.10	0.10
Ortho Phosphate (as P)	NG	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0011	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Phosphate (as P)	NG	0.0021	0.0026	0.0055	0.0044	0.0071	0.0056	0.0031	0.0024	0.0064	0.0090	0.0050	0.0051	0.0046	0.0035	0.0040	0.0095	0.0055	0.0054
Sulfate (SO ₄)	NG	1.84	1.84	1.82	1.85	1.91	1.92	1.86	1.86	1.78	1.82	1.93	1.93	1.83	1.83	1.53	1.84	1.93	1.93
ORGANIC / INORGANIC CARBON (mg/L)																			
Dissolved Organic Carbon	NG	1.68	1.66	2.11	1.82	2.46	1.74	1.64	1.59	3.06	2.63	1.71	1.89	1.64	1.61	1.83	1.81	37.1	22.7
Total Organic Carbon	NG	1.57	1.55	1.57	1.58	1.66	1.68	1.47	1.50	1.60	1.83	1.90	1.66	1.62	1.55	1.36	1.76	1.79	1.65
PLANT PIGMENTS																			
Chlorophyll-a (µg/L)	NG	0.394	0.337	0.347	0.476	0.550	0.468	0.420	0.366	0.409	0.364	0.536	0.558	0.366	0.417	0.522	0.395	0.438	0.486
DISSOLVED METALS (mg/L)																			
Calcium	NG	2.06	2.07	2.27	2.25	2.45	2.46	2.02	2.05	2.19	2.32	2.47	2.43	2.00	2.00	1.78	2.30	2.43	2.48
Magnesium	NG	0.69	0.69	0.74	0.74	0.82	0.81	0.69	0.68	0.73	0.74	0.80	0.80	0.71	0.69	0.64	0.73	0.80	0.80

Notes:
NG = no guideline.
¹CCME (Canadian Council of Ministers of the Environment) Canadian Water Quality Guidelines for the Protection of Aquatic Life, 1999, updated December 2007.
²Ammonia guidelines are for 10°C.
Shaded concentrations exceed the CCME guideline.

Table 2-5. Seasonal zooplankton biomass per vertical tow and mg/m³ dry weight, NW Arm of Second Portage Lake, July, August & September 2008.

Station	Date	Tow Depth (m)	Wet biomass (g ww)	Dry biomass (g dw)	Dry biomass/tow (mg/m ³ dw)
Northwest Basin					
2PLNB-1	20-Jul-08	5.5	0.13	0.011	28.3
2PLNB-2	20-Jul-08	6.0	0.13	0.010	23.6
2PLNB-3	20-Jul-08	6.0	0.16	0.010	23.6
2PLNB-4	20-Jul-08	6.0	0.08	0.007	16.5
Mean					23.0
NB-001	18-Aug-08	11.0	0.50	0.016	20.6
NB-002	18-Aug-08	11.0	0.81	0.018	23.1
NB-003	18-Aug-08	11.0	1.02	0.056	72.0
NB-004	18-Aug-08	11.0	0.86	0.022	28.3
Mean					36.0
2PL-NB-01	12-Sep-08	11.9	0.28	0.013	15.5
2PL-NB-02	12-Sep-08	11.9	0.24	0.014	16.6
2PL-NB-03	12-Sep-08	11.9	0.08	0.004	4.8
2PL-NB-04	12-Sep-08	11.9	0.35	0.020	23.8
Mean					15.2
Middle Basin					
2PLMB-1	20-Jul-08	30.0	0.87	0.044	20.7
2PLMB-2	20-Jul-08	30.0	1.05	0.038	17.9
2PLMB-3	20-Jul-08	30.0	1.42	0.050	23.6
2PLMB-4	20-Jul-08	30.0	0.91	0.064	30.2
Mean					23.1
MB-001	18-Aug-08	30.0	0.92	0.033	15.6
MB-002	18-Aug-08	30.0	0.59	0.025	11.8
MB-003	18-Aug-08	30.0	0.55	0.026	12.3
MB-004	18-Aug-08	30.0	0.60	0.026	12.3
Mean					13.0
2PL-MB-01	12-Sep-08	28.0	0.63	0.033	16.7
2PL-MB-02	12-Sep-08	28.0	0.58	0.031	15.7
2PL-MB-03	12-Sep-08	28.0	0.54	0.031	15.7
2PL-MB-04	12-Sep-08	28.0	0.52	0.027	13.6
Mean					15.4
Southeast Basin					
2PLSB-1	20-Jul-08	9.0	0.42	0.020	31.4
2PLSB-2	20-Jul-08	13.0	1.28	0.116	126
2PLSB-3	20-Jul-08	14.0	0.62	0.036	36.4
2PLSB-4	20-Jul-08	14.0	0.65	0.030	30.3
Mean					56.1
SB-001	18-Aug-08	14.5	1.13	0.058	56.6
SB-002	18-Aug-08	14.5	1.51	0.054	52.7
SB-003	18-Aug-08	15.0	1.46	0.043	40.5
SB-004	18-Aug-08	14.5	1.29	0.032	31.2
Mean					45.3
2PL-SB-01	12-Sep-08	12.8	0.26	0.013	14.4
2PL-SB-02	12-Sep-08	12.8	0.25	0.012	13.3
2PL-SB-03	12-Sep-08	12.8	0.30	0.014	15.5
2PL-SB-04	12-Sep-08	12.8	0.23	0.012	13.3
Mean					14.1

Table 2-6. Documentation of benthic samples, NW Arm of Second Portage Lake, August & September 2008.

Station ID ¹	Date	Depth Zone (m)	Actual Depth (m)	GPS (UTM 14W, NAD 83)		Sample Analysis	Collection Notes
				Easting	Northing		
Northwest Basin							
NW-Z1-B1	1-Sep-08	5-10	6.8	637912	7215441	Biomass	Grey clay, some sand
NW-Z1-B2	1-Sep-08	5-10	9.4	637849	7215513	Biomass	
NW-Z1-B3	1-Sep-08	5-10	10.0	637842	7215811	Biomass	
NW-Z1-B4	1-Sep-08	5-10	8.0	637528	7215771	Biomass	
NW-Z1-B5	1-Sep-08	5-10	7.4	637453	7215808	Biomass	
NW-Z1-B6	1-Sep-08	5-10	7.7	637345	7215854	Biomass	
NW-Z1-T1	1-Sep-08	5-10	8.4	637625	7215629	Taxonomy	
NW-Z2-B1	1-Sep-08	10-15	10.4	637767	7215823	Biomass	
NW-Z2-B2	1-Sep-08	10-15	11.3	637530	7215858	Biomass	
NW-Z2-B3	1-Sep-08	10-15	10.5	637668	7215801	Biomass	
NW-Z2-B4	1-Sep-08	10-15	12.4	637577	7215792	Biomass	
NW-Z2-T1	1-Sep-08	10-15	10.9	637628	7215812	Taxonomy	
Middle Basin							
MB-Z1-B1	20-Aug-08	5-10	10.0	638667	7214891	Biomass	Brown clay; black specs Clay and gravel Grey mud; 0.5% sand
MB-Z1-B2	20-Aug-08	5-10	8.6	638290	7215152	Biomass	
MB-Z1-B3	20-Aug-08	5-10	7.4	638118	7215211	Biomass	
MB-Z1-B4	20-Aug-08	5-10	9.7	638585	7214836	Biomass	
MB-Z1-B5	29-Aug-08	5-10	8.2	638587	7214877	Biomass	
MB-Z1-B6	29-Aug-08	5-10	6.7	638278	7215225	Biomass	
MB-Z1-T1	29-Aug-08	5-10	7.9	637968	7215216	Taxonomy	
MB-Z2-B1	29-Aug-08	10-15	12.8	638285	7215110	Biomass	
MB-Z2-B2	29-Aug-08	10-15	11.4	638354	7215054	Biomass	
MB-Z2-B3	31-Aug-08	10-15	13.1	638136	7215123	Biomass	
MB-Z2-B4	31-Aug-08	10-15	13.2	638542	7214891	Biomass	
MB-Z2-T1	31-Aug-08	10-15	11.9	638830	7214622	Taxonomy	
MB-Z3-B1	29-Aug-08	15-20	19.5	638516	7214918	Biomass	Clay; 1% sand Clay wit sand/small gravel Orange clay
MB-Z3-B2	29-Aug-08	15-20	15.2	638419	7214959	Biomass	
MB-Z3-B3	31-Aug-08	15-20	18.9	638517	7214540	Biomass	
MB-Z3-T1	31-Aug-08	15-20	19.4	638542	7214850	Taxonomy	
MB-Z4-B1	29-Aug-08	20-25	22.1	638741	7214454	Biomass	
MB-Z4-T1	31-Aug-08	20-25	20.8	638642	7214758	Taxonomy	
MB-Z5-B1	29-Aug-08	>25	28.9	638395	7214970	Biomass	
MB-Z5-T1	31-Aug-08	>25	27.2	638583	7214497	Taxonomy	

Table 2-6 con't. Documentation of benthic samples, NW Arm of Second Portage Lake, August & September 2008.

Station ID ¹	Date	Depth Zone (m)	Actual Depth (m)	GPS (UTM 14W, NAD 83)		Sample Analysis	Collection Notes
				Easting	Northing		
<i>Southeast Basin</i>							
SE-Z1-B1	21-Aug-08	5-10	10.0	639183	7214049	Biomass	Redish fine sand; 90% clay
SE-Z1-B2	21-Aug-08	5-10	9.8	639106	7214041	Biomass	Red/grey; 80%clay; 20%sand
SE-Z1-B3	21-Aug-08	5-10	4.6	639069	7214123	Biomass	Grey; 90% clay; 10% sand
SE-Z1-B4	28-Aug-08	5-10	8.0	639195	7214154	Biomass	Orange clay; 15%sand
SE-Z1-B5	28-Aug-08	5-10	7.0	639095	7214282	Biomass	Mixed clear; nearly all clay
SE-Z1-B6	28-Aug-08	5-10	9.6	639137	7214017	Biomass	
SE-Z1-T1	28-Aug-08	5-10	7.1	639042	7214275	Taxonomy	
SE-Z2-B1	21-Aug-08	10-15	11.6	638923	7213947	Biomass	Red; 90%clay; 10% sand
SE-Z2-B2	28-Aug-08	10-15	11.0	638661	7214435	Biomass	90% brown clay; 10% sand
SE-Z2-B3	28-Aug-08	10-15	12.6	638996	7214062	Biomass	10% sand; 90% clay
SE-Z2-B4	28-Aug-08	10-15	10.4	639123	7214038	Biomass	1% sand; 99% clay
SE-Z2-T1	28-Aug-08	10-15	13.7	639075	7214210	Taxonomy	
SE-Z3-B1	29-Aug-08	15-20	15.5	639029	7214282	Biomass	
SE-Z3-B2	29-Aug-08	15-20	15.2	639062	7214238	Biomass	Orange sand
SE-Z3-B3	29-Aug-08	15-20	16.4	638849	7214513	Biomass	Orange sand
SE-Z3-T1	29-Aug-08	15-20	16.4	638896	7214524	Taxonomy	

Notes:

¹ Station IDs are as follows:

NW=northwest, MB=middle basin, SE=southeast; represent basins.

Z1=5-10m, Z2=10-15m, Z3=15-20m, Z4=20-25m, Z5=>25m; represent depth zones.

B=biomass, T=taxonomy; represent analysis types.

Numbers 1 through 6; represent rep samples.

Table 2-7. Benthic invertebrate biomass results (per grab sample), NW Arm of Second Portage Lake, August & September 2008.

Station	Date	Depth Zone (m)	Actual Depth (m)	Number of Invertebrates	Wet biomass (g ww)	Wet biomass/grab (g/m ² ww)	Dry biomass (g dw)	Dry biomass/grab (g/m ² dw)
Northwest Basin								
NW-Z1-B1	1-Sep-08	5-10	6.8	4	0.002	0.09	0	0
NW-Z1-B2	1-Sep-08	5-10	9.4	0	0	0.00	0	0
NW-Z1-B3	1-Sep-08	5-10	10.0	47	0.119	5.17	0.009	0.39
NW-Z1-B4	1-Sep-08	5-10	8.0	19	0.014	0.61	0.001	0.04
NW-Z1-B5	1-Sep-08	5-10	7.4	3	0.008	0.35	0.001	0.04
NW-Z1-B6	1-Sep-08	5-10	7.7	24	0.047	2.04	0.007	0.30
NW-Z2-B1	1-Sep-08	10-15	10.4	32	0.035	1.52	0.004	0.17
NW-Z2-B2	1-Sep-08	10-15	11.3	101	0.125	5.43	0.011	0.48
NW-Z2-B3	1-Sep-08	10-15	10.5	115	0.084	3.65	0.007	0.30
NW-Z2-B4	1-Sep-08	10-15	12.4	58	0.069	3.00	0.008	0.35
Basin Mean					0.050	2.19	0.005	0.21
Middle Basin								
MB-Z1-B1	20-Aug-08	5-10	10.0	1	0.001	0.04	0	0
MB-Z1-B2	20-Aug-08	5-10	8.6	17	0.042	1.83	0.007	0.30
MB-Z1-B3	20-Aug-08	5-10	7.4	4	0.011	0.48	0.002	0.09
MB-Z1-B4	20-Aug-08	5-10	9.7	34	0.080	3.48	0.007	0.30
MB-Z1-B5	29-Aug-08	5-10	8.2	10	0.009	0.39	0.001	0.04
MB-Z1-B6	29-Aug-08	5-10	6.7	55	0.054	2.35	0.008	0.35
MB-Z2-B1	29-Aug-08	10-15	12.8	11	0.016	0.70	0.005	0.22
MB-Z2-B2	29-Aug-08	10-15	11.4	13	0.016	0.70	0.002	0.09
MB-Z2-B3	31-Aug-08	10-15	13.1	0	0	0	0	0
MB-Z2-B4	31-Aug-08	10-15	13.2	5	0.004	0.17	0.001	0.04
MB-Z3-B1	29-Aug-08	15-20	19.5	6	0.006	0.26	0.001	0.04
MB-Z3-B2	29-Aug-08	15-20	15.2	6	0.006	0.26	0.001	0.04
MB-Z3-B3	31-Aug-08	15-20	18.9	15	0.027	1.17	0.004	0.17
MB-Z4-B1	29-Aug-08	20-25	22.1	0	0	0	0	0
MB-Z5-B1	29-Aug-08	>25	28.9	2	0	0	0	0
Basin Mean					0.018	0.79	0.003	0.11

Table 2-7 con't. Benthic invertebrate biomass results (per grab sample), NW Arm of Second Portage Lake, August & September 2008.

Station	Date	Depth Zone (m)	Actual Depth (m)	Number of Invertebrates	Wet biomass (g ww)	Wet biomass/grab (g/m ² ww)	Dry biomass (g dw)	Dry biomass/grab (g/m ² dw)
<i>Southeast Basin</i>								
SE-Z1-B1	21-Aug-08	5-10	10.0	21	0.030	1.30	0.003	0.13
SE-Z1-B2	21-Aug-08	5-10	9.8	36	0.055	2.39	0.007	0.30
SE-Z1-B3	21-Aug-08	5-10	4.6	22	0.070	3.04	0.008	0.35
SE-Z1-B4	28-Aug-08	5-10	8.0	13	0.009	0.39	0.001	0.04
SE-Z1-B5	28-Aug-08	5-10	7.0	0	0	0	0	0
SE-Z1-B6	28-Aug-08	5-10	9.6	8	0.015	0.65	0.002	0.09
SE-Z2-B1	21-Aug-08	10-15	11.6	12	0.028	1.22	0.006	0.26
SE-Z2-B2	28-Aug-08	10-15	11.0	5	0.010	0.43	0.001	0.04
SE-Z2-B3	28-Aug-08	10-15	12.6	10	0.021	0.91	0.003	0.13
SE-Z2-B4	28-Aug-08	10-15	10.4	1	0	0	0	0
SE-Z3-B1	29-Aug-08	15-20	15.5	6	0.023	1.00	0.002	0.09
SE-Z3-B2	29-Aug-08	15-20	15.2	1	0	0	0	0
SE-Z3-B3	29-Aug-08	15-20	16.4	11	0.022	0.96	0.005	0.22
<i>Basin Mean</i>					<i>0.022</i>	<i>0.95</i>	<i>0.003</i>	<i>0.13</i>

Table 2-8. Benthic invertebrate taxonomy results (total abundance/m²), NW Arm of Second Portage Lake, August & September 2008.

Station	Date	Depth (m)	Total Abundance (#/m ²)				Total
			Oligochaetes	Insects	Molluscs	Other Taxa	
Northwest Basin							
NW-Z1-T1	1-Sep-08	8.4	0	565	217	43	826
NW-Z2-T1	1-Sep-08	10.9	0	261	87	0	348
Basin Mean			0	413	152	22	587
Middle Basin							
MB-Z1-T1	29-Aug-08	7.9	130	391	609	43	1174
MB-Z2-T1	31-Aug-08	11.9	0	478	43	130	652
MB-Z3-T1	31-Aug-08	19.4	0	217	435	0	652
MB-Z4-T1	31-Aug-08	20.8	0	43	87	43	174
MB-Z5-T1	31-Aug-08	27.2	0	261	130	0	391
Basin Mean			26	278	261	43	609
Southeast Basin							
SE-Z1-T1	28-Aug-08	7.1	0	217	261	0	478
SE-Z2-T1	28-Aug-08	13.7	0	0	43	0	43
SE-Z3-T1	29-Aug-08	16.4	0	43	174	0	217
Basin Mean			0	87	159	0	246

Table 2-9. Benthic invertebrate taxonomy results (total richness per grab), NW Arm of Second Portage Lake, August & September 2008.

Station	Date	Total Richness (#taxa/grab)				Total
		Oligochaetes	Insects	Molluscs	Other Taxa	
Northwest Basin						
NW-Z1-T1	1-Sep-08	0	7	1	1	9
NW-Z2-T1	1-Sep-08	0	5	1	0	6
	Basin Mean	0	6.0	1.0	0.5	7.5
Middle Basin						
MB-Z1-T1	29-Aug-08	2	7	1	1	11
MB-Z2-T1	31-Aug-08	0	7	1	1	9
MB-Z3-T1	31-Aug-08	0	4	1	0	5
MB-Z4-T1	31-Aug-08	0	2	1	1	4
MB-Z5-T1	31-Aug-08	0	2	1	0	3
	Basin Mean	0.4	4.4	1.0	0.6	6.4
Southeast Basin						
SE-Z1-T1	28-Aug-08	0	6	1	0	7
SE-Z2-T1	28-Aug-08	0	1	1	0	2
SE-Z3-T1	29-Aug-08	0	2	1	0	3
	Basin Mean	0	3.0	1.0	0	4.0

Table 2-10. Gender, maturity code and reproductive status, of fish-out fish, NW Arm of Second Portage Lake, 2008.

		Arctic char		Lake trout		Round whitefish		Burbot	
		#	%	#	%	#	%	#	%
Total Catch		485	16	2015	66	294	10	279	9.1
Gender	Female	227	58	752	54	129	58	122	47
	Male	166	42	629	46	95	42	137	53
	Unknown	92		634		70		20	
Maturity	Immature	243	50	1600	79	108	37	137	49
	Mature	226	47	363	18	170	58	115	41
	Unknown	16	3	52	3	16	5	27	10
Reproductive Status	Undeveloped	243	50	1600	79	108	37	137	49
	Ripe	27	6	71	4	60	20	100	36
	Running	39	8	70	3	91	31	9	3
	Spent	32	7	45	2	1	0	0	0
	Resting	113	23	152	8	9	3	5	2
	Unknown	31	6	77	4	25	9	28	10

Table 2-11. Length (mm), weight (g) and condition factor (K) of fish-out fish, NW Arm of Second Portage Lake, 2008.

Fish Species	n	LENGTH (mm)		WEIGHT (g)		CONDITION FACTOR ¹ (K)	
		range	mean	range	mean	range	mean
Arctic char	474	100 - 600	333	11 - 2550	622	0.23 - 3.2	1.08
Lake trout	1991	90 - 975	250	5.5 - 12700	359	0.29 - 3.8	1.06
Round whitefish	258	79 - 420	250	2 - 1900	289	0.34 - 2.68	1.02
Burbot	273	120 - 563	239	7 - 1150	109	0.35 - 1.9	0.68

Notes:

¹ Fish Condition Factor: calculated as $K = (\text{Weight} \times 10^5) / (\text{Length}^3)$

Table 2-12. Weight-length relationships of fish-out fish, NW Arm of Second Portage Lake, 2008.

Fish Species	Sample Size	R ²	p-Value	Significant Relationship	Weight (W) on Length (L) Relationship $\text{Log}_{10}W = a + b (\text{Log}_{10}L)$
Arctic char	474	0.99	<0.001	yes	$\text{Log}_{10}W = -5.16 + 3.08 (\text{Log}_{10}L)$
Lake trout	1991	0.99	<0.001	yes	$\text{Log}_{10}W = -5.07 + 3.04 (\text{Log}_{10}L)$
Round whitefish	258	0.99	<0.001	yes	$\text{Log}_{10}W = -5.75 + 3.32 (\text{Log}_{10}L)$
Burbot	273	0.94	<0.001	yes	$\text{Log}_{10}W = -5.23 + 3.02 (\text{Log}_{10}L)$

Notes:

R² = coefficient of determination.

p-Value = probability value; not significant at $p \geq 0.05$.

Table 2-13. Length (mm), weight (g), condition factor (K) and age (yr) of DBA¹ fish, NW Arm of Second Portage Lake, 2008.

Fish Species	n	LENGTH (mm)		WEIGHT (g)		CONDITION FACTOR ² (K)		n	AGE (yr)	
		range	mean	range	mean	range	mean		range	mean
Arctic char	63	117 - 600	382	27 - 2550	884	0.49 - 1.7	1.09	63	2 - 16	8
Lake trout	50	174 - 975	512	50 - 12700	2756	0.95 - 3.0	1.18	49	4 - 36	18
Round whitefish	51	80 - 414	247	3 - 1900	315	0.59 - 2.7	1.04	51	2 - 19	8

Notes:

¹ DBA = detailed biological assessment.

² Fish Condition Factor: calculated as $K = (\text{Weight} \times 10^5) / (\text{Length}^3)$

Table 2-14. Summary of DELT observations of DBA¹ fish in the field and during stomach autopsies², 2008.

Field Observations

	Arctic char	Lake trout	Round whitefish
<i>n</i>	63	50	51
Healthy	41	19	40
No Comments	12	14	11
Few parasites	12	14	0
Many parasites	6	6	0
Brain parasites	2	0	0
Tapeworms	1	3	0
Cysts	2	5	2
Lesions	1 (on chin)	0	0

Stomach Autopsies

	Arctic char	Lake trout	Round whitefish
<i>n</i>	63	46	41
Tapeworms	27	20	1
<i>Bothriocephalus</i> parasite	--	5	--
<i>Schistocephalus</i> parasite	--	1	--

Notes:

¹ DBA = detailed biological assessment.

² Results from stomach contents analyses conducted by North-South Consultants, Winnipeg, MB.

Table 2-15. Gender, maturity code and reproductive status of DBA¹ fish, NW Arm of Second Portage Lake, 2008.

		Arctic char		Lake trout		Round whitefish	
		#	%	#	%	#	%
Total Catch		63	38	50	30	51	31
Gender	Female	35	60	28	58	27	61
	Male	23	40	20	42	17	39
	Unknown	5		2		7	
Maturity	Immature	19	30	15	30	17	33
	Mature	43	68	35	70	34	67
	Unknown	1	2	0	0	0	0
Reproductive Status	Undeveloped	19	30	15	30	17	33
	Ripe	15	24	8	16	11	22
	Running	10	16	9	18	17	33
	Spent	1	2	2	4	0	0
	Resting	13	21	8	16	0	0
	Unknown	5	8	8	16	6	12

Notes:

¹ DBA = detailed biological assessment.

Table 2-16. Gonadosomatic (GSI) and hepatosomatic (HSI) indices of DBA¹ fish,
NW Arm of Second Portage Lake, 2008.

Fish Species	GSI ² (%)			HSI ² (%)		
	n	range	mean	n	range	mean
Arctic char	7	11 - 18	14.9	63	0.66 - 2.0	1.08
Lake trout	6	1.3 - 15	9.13	48	0.55 - 1.6	1.06
Round whitefish	16	3.9 - 18	8.39	40	0.31 - 2.0	1.08

Notes:

¹ DBA = detailed biological assessment.

² GSI = gonadosomatic index; calculated as: ovary weight/body weight.

HSI = hepatosomatic index; calculated as: liver weight/body weight.

Table 2-17. Results of stomach autopsies showing total biomass (g wet and dry) and percent composition (% dry weight) of dietary items.

Species (n = # with contents)	Lake trout (n=33)			Arctic char (n=56)			Round whitefish (n=40)		
# Empty Stomachs	13			7			1		
	Summed ¹ Biomass	Summed Biomass	Percent of diet	Summed Biomass	Summed Biomass	Percent of diet	Summed Biomass	Summed Biomass	Percent of diet
Diet Items	(g wet)	(g dry) ²	(% dw)	(g wet)	(g dry)	(% dw)	(g wet)	(g dry)	(% dw)
INVERTEBRATES									
Cladocera	5.4	0.3	9.5	53	2.2	83	0.02	0.001	0.02
Copepoda	0.2	0.02	0.5	1.3	0.08	2.9	0	0	0
Laevicaudata	37	2.1	69	0.2	0.01	0.4	52	4	68
Hirudinea	2.7	0.2	5.3	0	0	0	0	0	0
O. Trichoptera	2.2	0.2	5.9	3.9	0.2	8.4	1.2	0.2	2.9
F. Limnephilidae	0.3	0.02	0.6	0	0	0	11	1.2	23
F. Hydropsychidae	0	0	0	0	0	0	2.0	0.2	2.9
F. Chironomidae	0.2	0.01	0.4	0.05	0.003	0.1	0.4	0.03	0.7
Other ³	0.4	0.02	0.8	1.9	0.1	4.7	0.6	0.04	0.9
Unidentifiable	3.1	0.2	8.0	0	0	0	1.1	0.1	2.0
Total	52	3		60	3		69	5	
FISH									
Salvelinus (eggs)	2.8	0.7	0.6						
Fish ⁴	450	112	99						
Total	453	113							

¹ Summed biomass is calculated as the total biomass of the dietary item for all stomachs autopsied.

² For fish diet items only -- assumes 75% moisture content.

³ Other = Ostracoda, *Lepidurus* sp., Acarina, Pisidiidae, Empididae and Dytiscidae.

⁴ Fish found in LKTR stomachs include: salmonids, Coregoninae, Slimy sculpin, Arctic char, Ninespine stickleback and unidentifiable fish parts.

Table 2-18. Mean fish tissue moisture, lipid content, and total metals concentrations (mg/kg ww) of DBA¹ fish, NW Arm of Second Portage Lake, 2008.

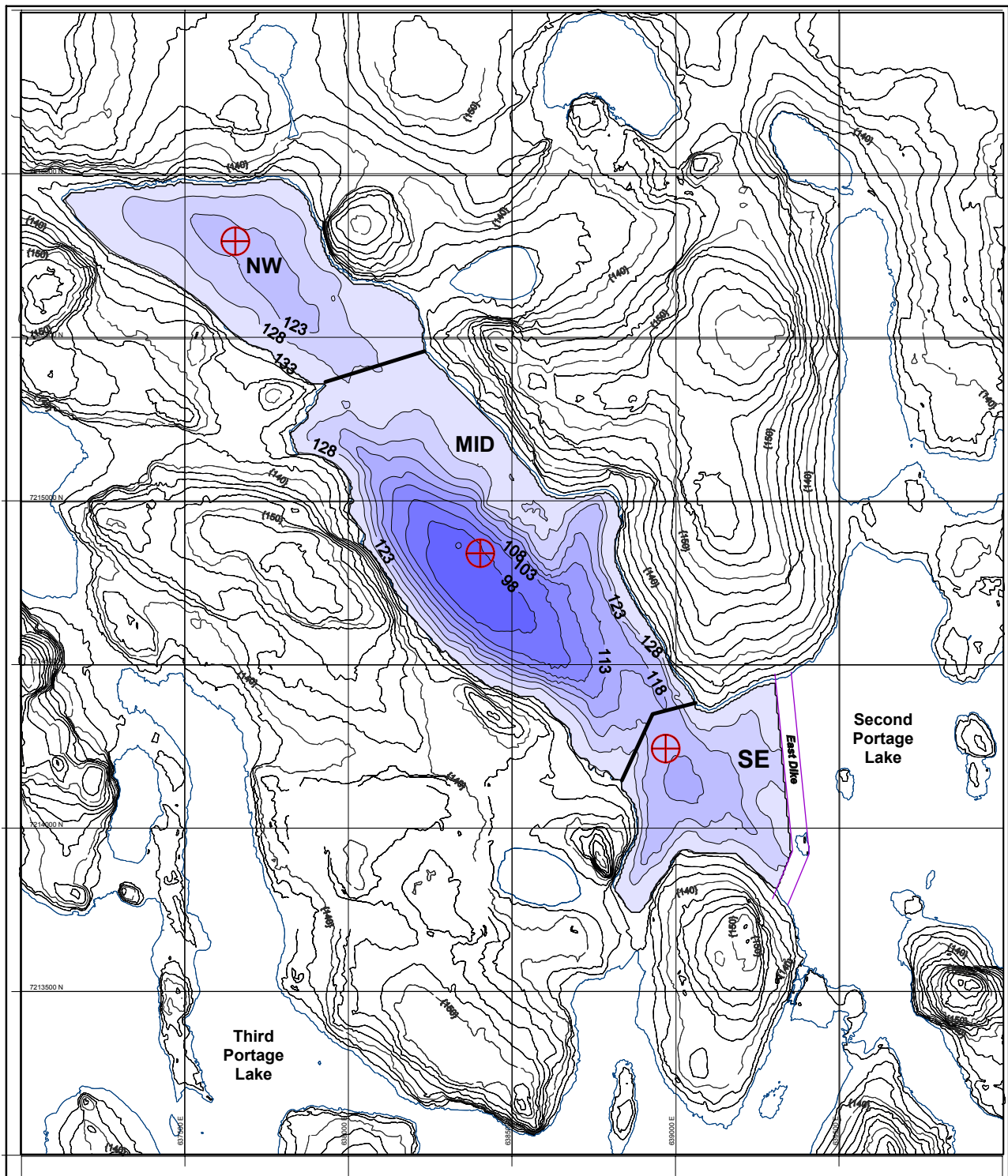
Fish Species Tissue Type Statistic	Arctic Char						Lake Trout						Round Whitefish					
	Muscle			Liver			Muscle			Liver			Muscle			Liver		
	n	Range	Mean	n	Range	Mean	n	Range	Mean	n	Range	Mean	n	Range	Mean	n	Range	Mean
PHYSICAL PARAMETERS																		
Moisture content (%)	15	74.7 - 80.5	76.9	11	71.1 - 79.2	75.2	17	73.3 - 83.9	78.5	16	70.0 - 82.1	77.3	12	72.4 - 83.4	76.6	7	74.1 - 77.8	75.5
Lipid content (%)	15	0.80 - 2.4	1.3	-	-	-	17	0.70 - 6.3	1.8	-	-	-	9	0.90 - 1.9	1.4	-	-	-
TOTAL METALS (mg/kg ww)																		
Aluminum	15	<2.0 - 5.90	3.37	15	<4.0 - 34.2	6.57	18	<2.0 - 6.20	2.72	18	<4.0 - 8.40	4.63	13	<2.0 - 6.00	3.52	12	<4.0 - 26.6	7.61
Antimony	15	<0.010 - <0.020	0.011	15	<0.020 - <0.030	0.0220	18	<0.010 - <0.020	0.011	18	<0.020	0.020	13	<0.010 - <0.020	0.015	12	<0.020 - <0.040	0.025
Arsenic	15	<0.010 - 0.020	0.012	15	<0.020 - 0.174	0.065	18	<0.010 - 0.041	0.014	18	<0.020 - 0.178	0.040	13	<0.010 - 0.032	0.020	12	<0.020 - 0.053	0.033
Barium	15	0.011 - 0.287	0.059	15	<0.020 - 0.082	0.036	18	0.018 - 0.058	0.033	18	<0.020 - 0.440	0.031	13	0.018 - 0.837	0.138	12	0.035 - 0.899	0.135
Beryllium	15	<0.10 - <0.20	0.107	15	<0.20 - <0.30	0.220	18	<0.10 - <0.20	0.111	18	<0.20	0.200	13	<0.10 - <0.20	0.146	12	<0.20 - <0.40	0.250
Bismuth	15	<0.030 - <0.060	0.032	15	<0.060 - <0.090	0.066	18	<0.030 - <0.060	0.033	18	<0.060	0.060	13	<0.030 - <0.060	0.044	12	<0.060 - <0.12	0.075
Cadmium	15	<0.0050 - <0.010	0.005	15	0.046 - 0.813	0.188	18	<0.005 - <0.010	0.006	18	0.068 - 0.508	0.238	13	<0.005 - <0.010	0.007	12	0.019 - 0.091	0.056
Calcium	15	31.8 - 162	65.9	15	26.1 - 126	72.1	18	32.4 - 143	54.1	18	38.1 - 510	111	13	56.5 - 575	160	12	39.5 - 198	94.8
Chromium	15	<0.10 - 0.340	0.162	15	<0.20 - <0.30	0.220	18	<0.10 - 0.840	0.233	18	<0.20	0.200	13	<0.10 - <0.20	0.147	12	<0.20 - <0.40	0.250
Cobalt	15	<0.020 - <0.040	0.021	15	<0.040 - 0.204	0.142	18	<0.020 - <0.040	0.023	18	<0.040 - 0.225	0.094	13	<0.020 - <0.040	0.029	12	<0.048 - 0.158	0.080
Copper	15	0.211 - 0.637	0.385	15	0.860 - 34.0	12.5	18	0.221 - 0.722	0.440	18	1.13 - 14.5	6.71	13	0.114 - 0.890	0.366	12	0.869 - 3.36	2.16
Lead	15	<0.020 - <0.040	0.021	15	<0.040 - <0.060	0.044	18	<0.020 - <0.040	0.022	18	<0.040	0.040	13	<0.020 - <0.040	0.029	12	<0.040 - <0.080	0.050
Lithium	15	<0.10 - <0.20	0.107	15	<0.20 - <0.30	0.220	18	<0.10 - <0.20	0.111	18	<0.20	0.200	13	<0.10 - <0.20	0.146	12	<0.20 - <0.40	0.250
Magnesium	15	199 - 311	257	15	112 - 267	177	18	135 - 326	201	18	93.2 - 334	154	13	160 - 289	254	12	120 - 276	185
Manganese	15	0.038 - 0.132	0.079	15	0.889 - 3.67	1.56	18	0.063 - 0.185	0.112	18	0.554 - 4.17	1.38	13	0.068 - 0.543	0.204	12	1.42 - 4.53	2.68
Mercury	15	0.050 - 0.243	0.090	15	0.080 - 0.284	0.154	18	0.080 - 1.37	0.474	18	0.060 - 3.20	0.857	13	0.021 - 0.090	0.047	12	0.031 - 0.072	0.050
Molybdenum	15	<0.010 - 0.049	0.019	15	0.083 - 0.359	0.216	18	<0.010 - 0.110	0.026	18	0.033 - 0.197	0.107	13	<0.010 - <0.020	0.015	12	0.070 - 0.205	0.155
Nickel	15	<0.10 - 0.200	0.124	15	<0.20 - <0.30	0.220	18	<0.10 - 0.510	0.159	18	<0.20	0.200	13	<0.10 - <0.20	0.146	12	<0.20 - <0.40	0.250
Selenium	15	0.200 - 1.07	0.385	15	0.600 - 3.20	1.68	18	0.30 - 1.25	0.610	18	0.860 - 4.88	2.46	13	<0.40 - 1.41	0.790	12	1.24 - 2.31	1.74
Strontium	15	0.027 - 0.211	0.070	15	0.047 - 0.289	0.145	18	0.026 - 0.207	0.057	18	0.046 - 1.00	0.172	13	0.055 - 1.17	0.291	12	0.069 - 0.448	0.201
Thallium	15	<0.010 - <0.020	0.011	15	0.022 - 0.102	0.048	18	<0.010 - <0.020	0.011	18	<0.020 - 0.108	0.049	13	<0.010 - <0.020	0.015	12	<0.020 - 0.081	0.037
Tin	15	<0.050 - 0.110	0.056	15	<0.10 - <0.15	0.110	18	<0.050 - 0.190	0.071	18	<0.10	0.100	13	<0.050 - <0.10	0.077	12	<0.10 - <0.20	0.125
Uranium	15	<0.002 - <0.004	0.002	15	<0.004 - 0.084	0.010	18	<0.002 - <0.004	0.002	18	<0.004 - 0.010	0.006	13	<0.002 - <0.004	0.003	12	<0.004 - 0.028	0.013
Vanadium	15	<0.10 - <0.20	0.107	15	<0.20 - <0.30	0.220	18	<0.10 - <0.20	0.111	18	<0.20	0.200	13	<0.10 - <0.20	0.146	12	<0.20 - <0.40	0.250
Zinc	15	3.49 - 9.36	5.12	15	16.8 - 84.9	34.7	18	2.77 - 5.36	3.65	18	17.1 - 57.3	28.2	13	2.30 - 9.69	4.78	12	14.4 - 31.7	22.7

Notes:

¹ DBA = detailed biological assessment.

FIGURES





Azimuth Consulting Group Inc.

FIGURE 2-1
MEADOWBANK GOLD PROJECT - FISHOUT PROGRAM FOR
NORTHWEST ARM OF SECOND PORTAGE LAKE

Northwest Arm of Second Portage Lake showing
East Dike location, bathymetry, basin divisions and
sampling locations for 2008.

Figure 2-2. Vertical temperature (°C) and dissolved oxygen (mg/L) profiles, NW Arm of Second Portage Lake, 2008.

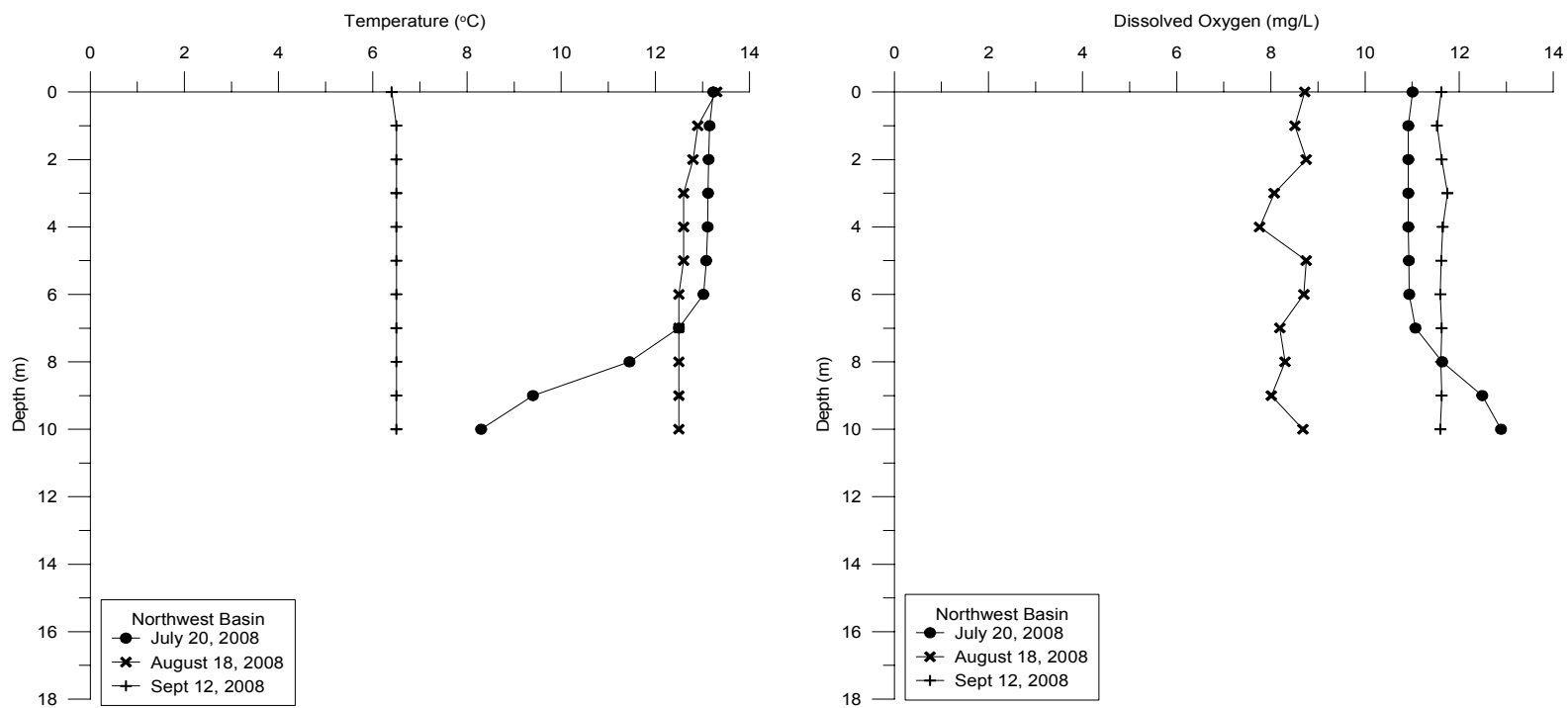


Figure 2-2 con't. Vertical temperature (°C) and dissolved oxygen (mg/L) profiles, NW Arm of Second Portage Lake, 2008.

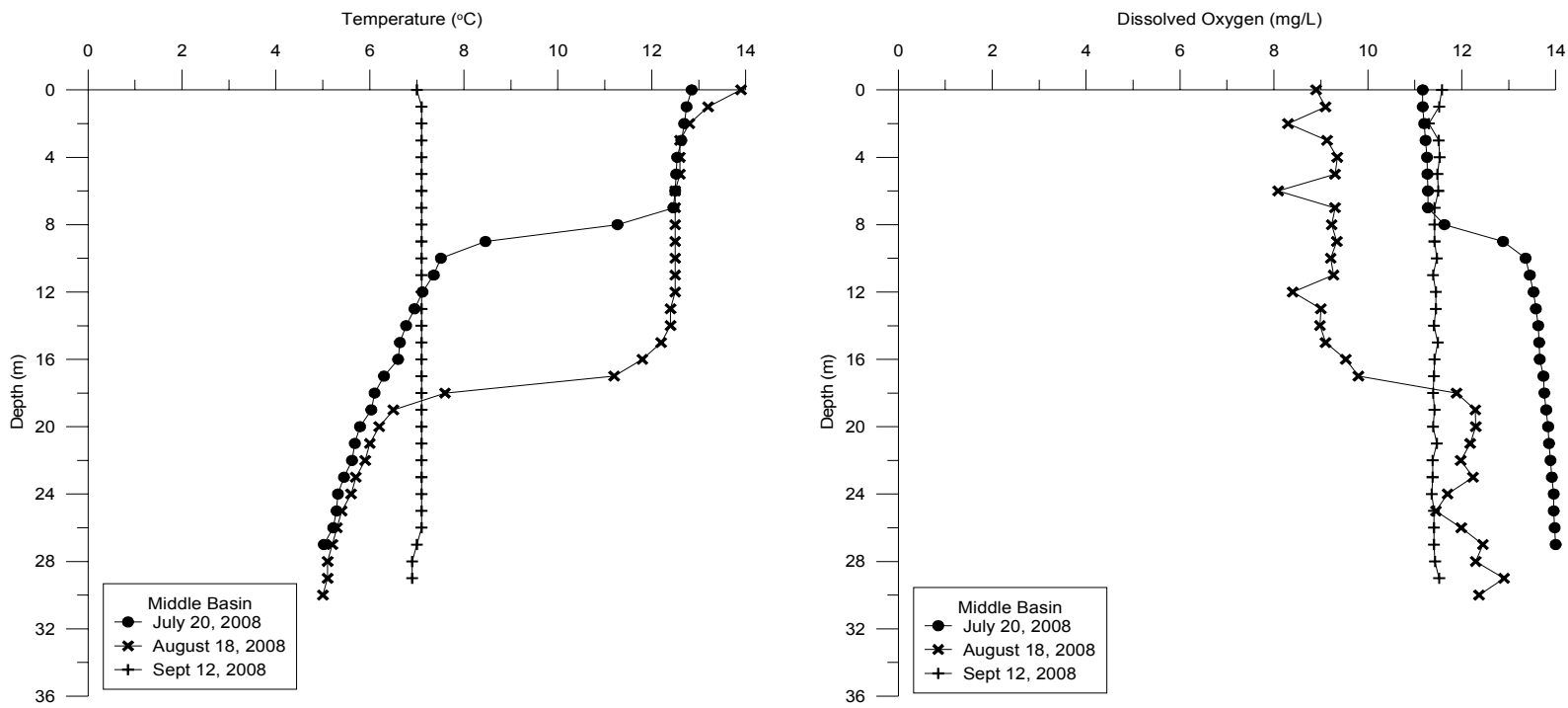


Figure 2-2 con't. Vertical temperature ($^{\circ}\text{C}$) and dissolved oxygen (mg/L) profiles, NW Arm of Second Portage Lake, 2008.

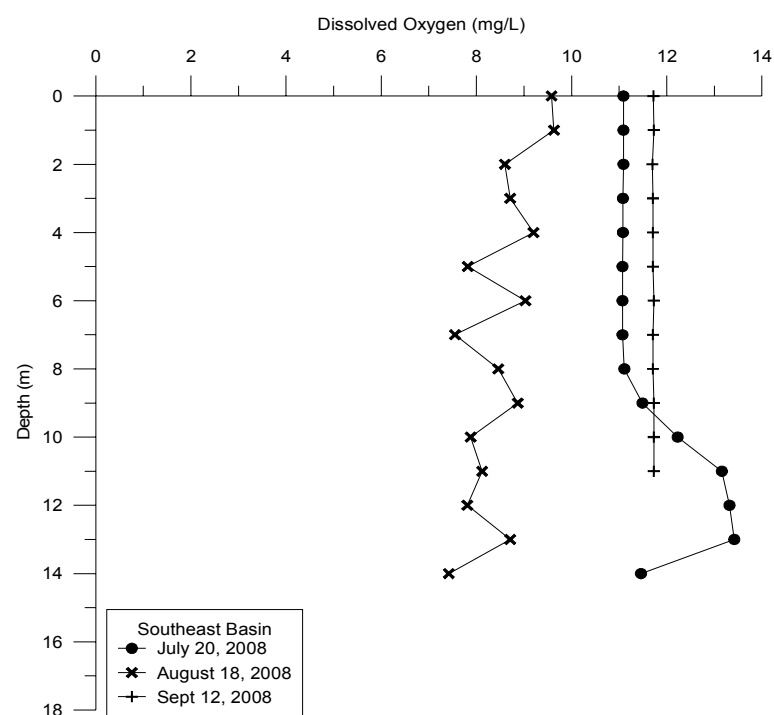
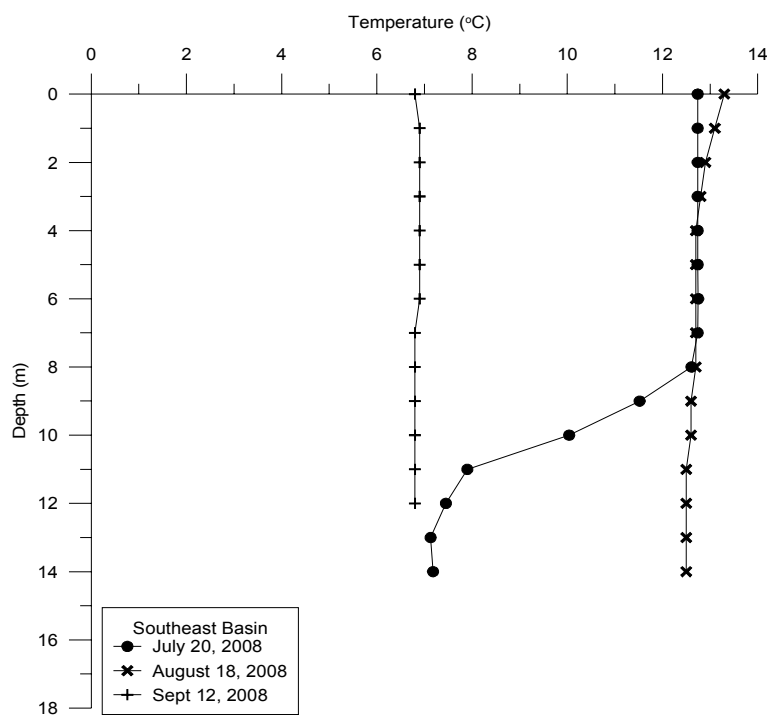


Figure 2-3. Length-frequency distributions of fishout Arctic char, lake trout, round whitefish and burbot, NW Arm of Second Portage Lake, 2008.

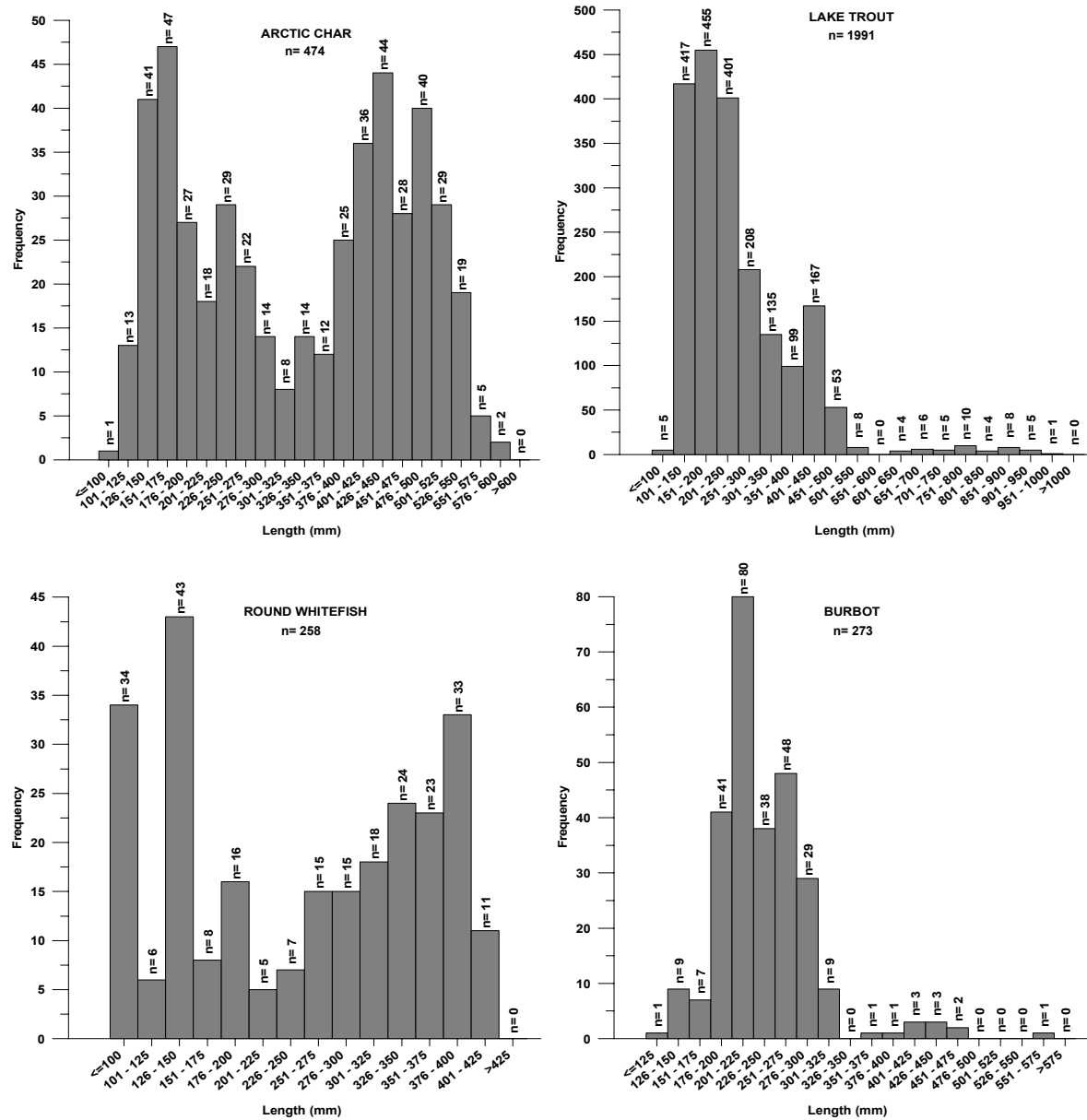
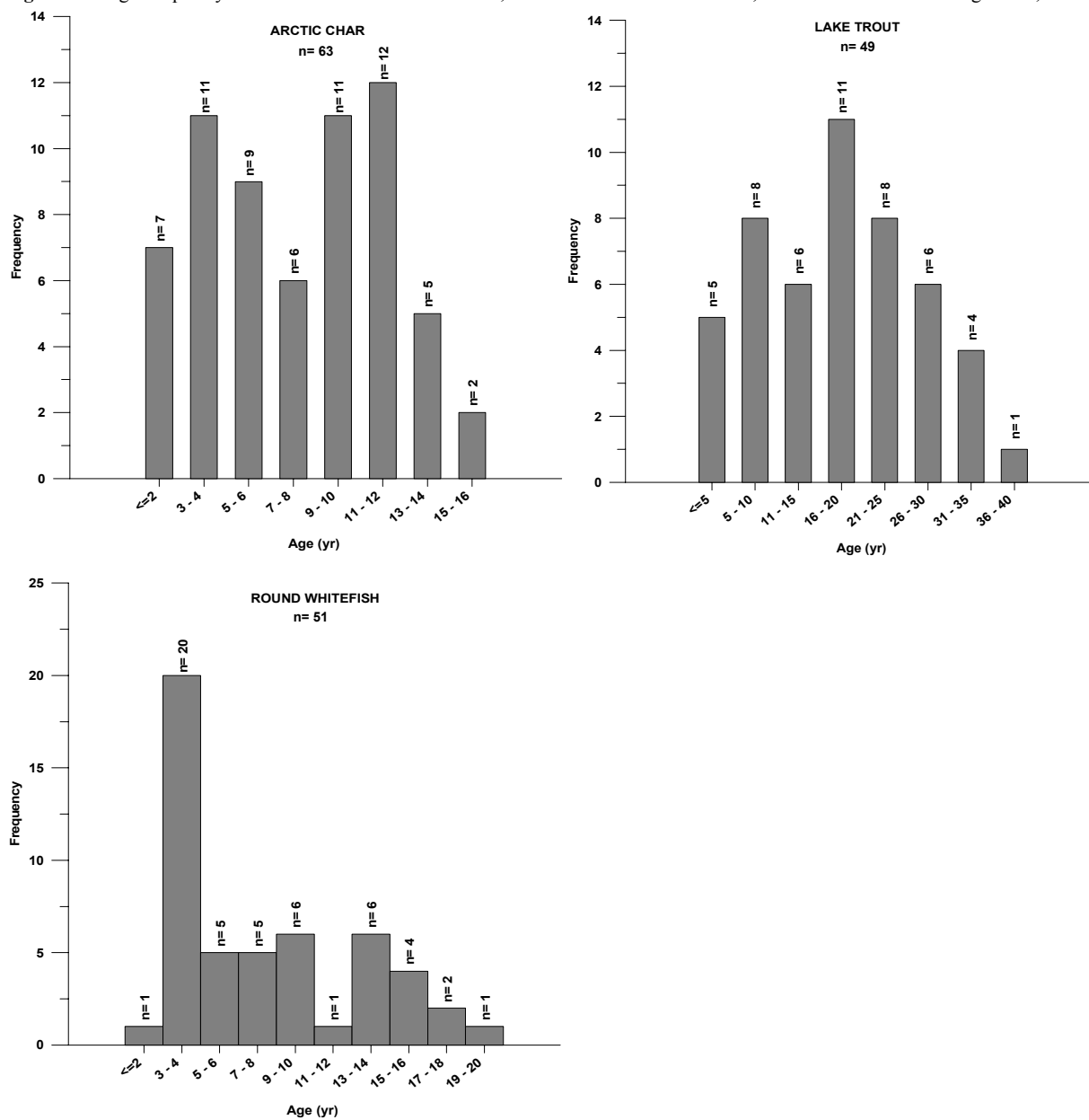


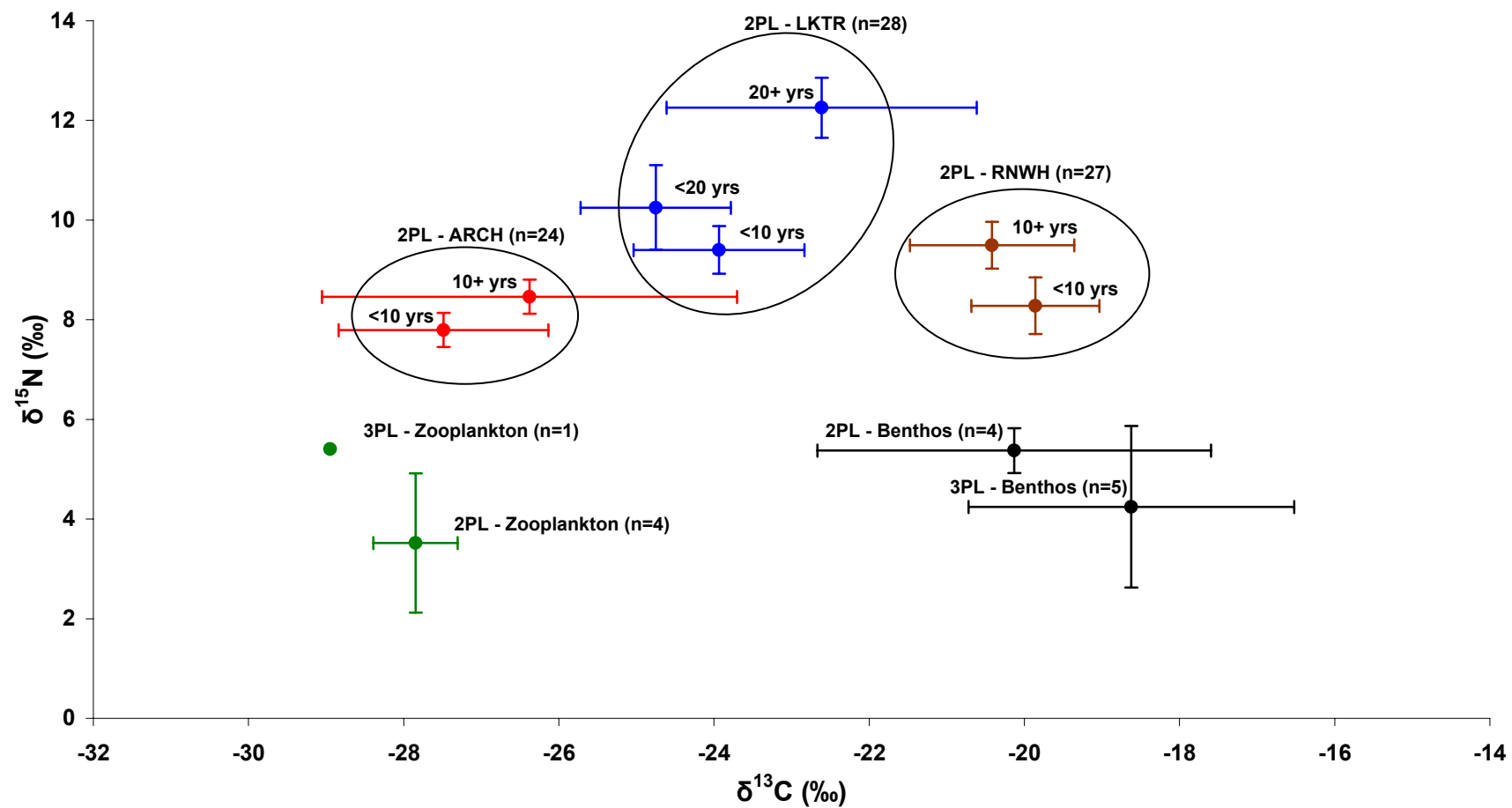
Figure 2-4. Age-frequency distributions of DBA¹ Arctic char, lake trout and round whitefish, NW Arm of Second Portage Lake, 2008.



Notes:

¹ DBA = detailed biological assessment.

Figure 2-5. Mean ($\pm$ SD) benthos, zooplankton and fish $\delta^{15}\text{N}$ (‰) and $\delta^{13}\text{C}$ (‰) value plots for Second & Third Portage Lakes, 2008.



Notes:

2PL=Second Portage Lake; 3PL=Third Portage Lake; ARCH=arctic char; LKTR=lake trout; RNWH=round whitefish.

Chapter 3

Estimates of Fish Biomass using Limnology and Productivity Data

***Meadowbank Gold Project: 2008 Fish-Out of the Northwest arm of
Second Portage Lake***

March 2009

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1. INTRODUCTION

Removing all fish from the northwest arm of Second Portage Lake (impoundment) provides a unique opportunity to better understand the ecology of hyperoligotrophic northern lakes. As outlined in **Chapter 1**, the intent of DFO's fish-out protocol requirement to conduct limnological, chemical and biological sampling of the impoundment (details described in **Chapter 2**) was to explore linkages between fish populations and the biotic and abiotic characteristics of northern lakes.

While there are many possible linkages to explore, the most common, and most immediately relevant to this study, are the relationships between biotic and abiotic factors and fish biomass. These range from simple empirically derived indices to comprehensive ecosystem models. The fish-out provides a unique opportunity to validate the accuracy of a range of methods by comparing their predictions to the actual results of the fish-out. This chapter takes a cursory look at several simple models for predicting fish biomass from the data collected during the fish-out program; the validation of more comprehensive predictive models is beyond the scope of this study.

2. BACKGROUND

Estimating the production and biomass of fish populations and communities has been of interest to fisheries scientists and resource managers for over half a century. Rawson (1952, 1955; as cited in Matuszek, 1978) and Ryder (1965) identified watershed geology (edaphic conditions) and lake morphology as important abiotic factors affecting general lake productivity. Phosphorus, typically limiting in freshwater systems relative to other nutrients, has been shown to be a fairly good edaphic indicator for predicting primary (Wetzel, 1975) and secondary (Oglesby, 1977) productivity. Total dissolved solids (TDS) has been recommended as an edaphic index, first advocated by Rawson (as cited in Matuszek, 1978). The main assumption made using TDS is that it is proportional to one or more of its component parts (e.g., carbon, phosphorus, nitrogen) and therefore a good indicator of the nutrient supply in a lake. TDS was shown to be the best index of general lake productivity of the 100 lakes studied by Northcote and Larkin (1956; as cited in Matuszek, 1978) and the best single environmental correlate of the total fish biomass in U.S. reservoirs (Jenkins and Morais, 1968; as cited in Matuszek, 1978). Ryder (1965) coupled TDS with mean depth to form his morphoedaphic index (MEI): TDS/z , where z equals mean depth. Depth is important for several reasons: (1) the hypolimnion essentially acts as a nutrient sink during periods of thermal stratification, (2) deep lakes tend to be colder and (3) deep lakes tend to have less extensive, less productive littoral zones. Productivity estimates for benthic invertebrates, phytoplankton and fish have all been shown to be negatively correlated to mean depth for a range of lakes (Matuszek, 1978). There are also several biotic factors that have been used to estimate fish biomass or



production. These include biomass or productivity estimates for phytoplankton (e.g., Downing et al., 1990), benthic invertebrates (e.g., Matuszek, 1978; Hanson and Leggett, 1981) and zooplankton (Leach et al., 1987). As expected, the theory behind the use of biotic factors is that they essentially integrate all the abiotic factors. Consequently, these biotic factors should be positively correlated to fish biomass or production (e.g., higher benthic invertebrate biomass should sustain higher fish biomass). These factors are either used independently to predict fish biomass (or production) or are used in conjunction with one or more abiotic factors.



3. METHODS AND RESULTS

3.1. Model Selection Process

As discussed previously, a range of models exist for predicting fish biomass, either directly or indirectly from fish production estimates. From a management perspective, simplicity and precision/accuracy are two main attributes of useful models. A literature search was conducted to identify a number of model options. Selection criteria for application in this chapter included the following:

- *Simplicity* – only linear regression models with parameters readily available from the fish-out data set were considered. A greater emphasis was placed on papers which had evaluated a number of model types relative to those proposing single models.
- *Precision/accuracy* – only statistically-significant (i.e., $p \text{ value} \leq 0.05$) models explaining most of the variability (i.e., $r^2 \geq 0.5$) in fish biomass (or production) were selected.

The following models were used to directly predict fish biomass:

- **Model 1: $FB = 5.692 M/z + 28.7$** (Hanson and Leggett, 1982) – where FB is fish standing crop (kg/ha, wet weight), M is macrobenthos standing crop (kg/ha, wet weight) and z is mean depth (m). This model was developed using a data set of 20 lakes and ponds (general locations not specified) for which surface area (ha), mean depth (m), macrobenthos standing crop (kg/ha, wet weight), and fish standing crop (kg/ha, wet weight) had been estimated. The model was highly significant ($p < 0.001$) and explained 83% of variability in fish standing crop among lakes (i.e., $r = 0.83$).
- **Model 2: $\log FB = 0.708 \log TP + 0.774$** (Hanson and Leggett, 1982) – where FB is fish standing crop (kg/ha, wet weight) and TP is mean total phosphorus ($\mu\text{g/L}$). The model was developed using a data set of 14 lakes and ponds plus four pairs of averages for Minnesota lakes that each contained estimates of fish standing crop (kg/ha, wet weight) and mean epilimnetic total phosphorus concentrations ($\mu\text{g/L}$). The model was highly significant ($p < 0.001$) and explained 75% of variability in fish standing crop among lakes in the data set.

The following models were used to predict fish yield (i.e., annual harvest [kg/ha] from catch data) or production (i.e., net fish community production) for subsequent conversion to fish biomass:

- **Model 3: $\log FY = 0.487 \log M - 0.580$** (Hanson and Leggett, 1982) – where FY is average fish yield (kg/ha yr^{-1}) and M is macrobenthos biomass (kg/ha, wet weight). The model was developed using a data set of 26 north-temperate lakes



for which surface area (km²), mean depth (m), TDS (mg/L), macrobenthos standing crop (kg/ha, wet weight), average fish yield (kg/ha, wet weight), and MEI (mg/L m⁻¹) were known. The model was highly significant (p<0.001) and explained 53% of variability in fish yield among lakes in the data set.

- **Model 4: $FY = 0.007 M + 0.018 TDS - 0.053 z + 0.00007 Ao + 0.793$** (Hanson and Leggett, 1982) – where FY and M are as described in the previous model and TDS is total dissolved solids (mg/L), z is mean depth (m) and Ao is lake surface area (km²). The model was developed using the same data set used for Model 3. The model was highly significant (p<0.001) and explained 66% of variability in fish yield among lakes in the data set.
- **Model 5: $\log FY = 1.021 \log TP - 1.148$** (Hanson and Leggett, 1982) – where TP is total phosphorus (µg/L) and all parameters log-transformed. This model was developed using a data set of 21 north-temperate lakes for which surface area (km²), TDS (mg/L), and mean epilimnetic total phosphorus (µg/L) were known. The model was highly significant (p<0.001) and explained 87% of variability in fish yield among lakes in the data set.
- **Model 6: $FY = 0.091 TDS - 1.161$** (Hanson and Leggett, 1982) – where parameters are as Model 4. This model was developed using the same data set as Model 5. The model was highly significant (p<0.001) and explained 62% of variability in fish yield among lakes in the data set.
- **Model 7: $FY = 0.066 TP + 0.141 z + 0.013 TDS - 1.513$** (Hanson and Leggett, 1982) – parameters as described previously. This model was developed using the same data set as Model 5. The model was highly significant (p<0.001) and explained 97% of variability in fish yield among lakes in the data set.
- **Model 8: $\log FY = 1.17 \log Chla - 1.92$** (Oglesby, 1977) – where FY is fish yield (g/ m² y⁻¹ on a dry weight basis) and Chla is chlorophyll-a (mg/m³). This model was developed using a data set of 46 lakes, ponds and reservoirs located from tropical to north temperate latitudes where data were available for chlorophyll (mg/m³), primary productivity (g C m⁻² yr⁻¹), fish yield, mean depth (m), and morphoedaphic characteristics (mg/L m⁻²). The model was highly significant (p<0.001) and explained 84% of the variability in fish yield among lakes in the data set.
- **Model 9: $\log FP = 0.531 \log TP + 0.332$** (Downing et al., 1990) – where FP is net fish community production (kg/ha yr⁻¹) and TP is total phosphorus (µg/L), both log-transformed. This model was developed using a data set of 20 international lakes (three of which were measured twice, so n = 23) each with whole fish community production data and lake characteristics. The model was highly significant (p<0.001) and explained 67% of the variability in predicted fish community production among the lakes.



Model 10: $\log FY = 0.446 \log MEI + 0.168$ (Ryder, 1965; shown using metric units for parameters in Downing et al. [1990]) – where FY is fish yield (kg/ha yr⁻¹) and MEI is morphoedaphic index (TDS [mg/L]/mean depth [m]). The model was developed using a data set of 23 north-temperate lakes of known area, mean depth, TDS (mg/L), and annual fish yield. The model was highly significant ($p < 0.001$) and explained 86% of the variability in fish yield among lakes.

3.2. Fish Yield and Production Conversions to Biomass

Only two of the models selected in **Section 3.1** directly predict fish biomass, or standing crop. The other models predict either fish yield (i.e., average annual catch weight) or actual annual production (i.e., incremental increase in biomass), both of which can be used to estimate fish biomass.

Many of the early predictive models, such as Ryder's (1965) MEI are based on average annual yield data, which is assumed to be correlated to total annual production. However, the exact relationship between the two is not generally known for most systems. Downing et al. (1990) compared both over a range of primary productivity and suggest that fishing yields are about 10% of net fish community production, suggesting the following conversion factor:

$$(1) \quad FP = 10 \times FY$$

where FP is fish production (kg/ha yr⁻¹) and FY is field yield (kg/ha yr⁻¹).

The data set of 20 international lakes (three lakes measured in separate years, so $n = 23$) used by Downing et al. (1990) to test a number of models contained estimates for both annual fish production and fish biomass. The relationship between the two ($\log FP = 1.084 \log FB - 0.42$) was highly significant ($p < 0.001$) and explained 67% of the variability in fish production among the study lakes. The equation was solved for FB to convert estimates of fish production to fish biomass, as follows:

$$(2) \quad \log FB = (\log FP + 0.42)/1.084$$

These two equations were used where necessary to convert model predictions to fish biomass.

3.3. NW Arm of Second Portage Lake – Abiotic and Biotic Characteristics

Morphological characteristics of the impoundment are shown in **Table 3-1**. Volume and area estimates were derived using Surfer v8 (Golden Software Inc.) and an elevation grid file for the project area (Golder, 2008). Elevation of Second Portage Lake was assumed to be 133 m (AMEC, 2005). The proportion of surface area within specific depth zones,



either by basin or as a whole, shows that a third of the impoundment is less than 5 m deep. It also shows that about a quarter of the lake is deeper than 15 m.

Key water quality parameters and the estimated MEI values for the impoundment are presented in **Table 3-2**. The TP, TDS and Chl a values for each basin are the means of the values reported in **Chapter 2**. The means for the impoundment were calculated by weighting the basin values by their surface areas. Due to the influence of construction-related sediment introductions, measured values for TP and TDS were considered high based on review of previous monitoring data (2007, 2006, 2003, 2002, 1998, 1997, 1996; reporting in Azimuth, 2005; 2008a; 2008b), so “typical” values were proposed for use in an alternate model scenario using those parameters. The MEI was also recalculated using the typical TDS value.

Benthic community biomass results are summarized in **Table 3-3**. Mean biomass per depth zone within each basin and area-weighted (by depth zone areas) means for each basin are presented on a “/m²” basis. Values are converted to kg/ha and the basin values area-weighted (by basin areas) to estimate mean benthic biomass for the whole impoundment area.

3.4. Model Predictions

The ten models described in **Section 3.2** were run using one or more of the parameters shown in **Tables 3-1 through 3-3**. The results are presented in **Table 3-4**. Initial output is shown for each model, as well as the conversions required to standardize predictions to fish biomass (kg/ha, wet weight). Finally, the per-hectare predictions are extrapolated to the whole impoundment to estimate total fish biomass.

As discussed in **Chapter 4**, the total biomass of fish removed from the impoundment by the end of the final removal phase of the fish-out was 1123 kg (i.e., the landed biomass); the Leslie depletion estimate of total fish biomass was 1258 kg (i.e., the Leslie biomass). Model-predicted fish biomass using the measured water quality parameters (i.e., “measured” scenario) ranged from 554 kg (Model 8) to 4400 (Model 10). Models using parameters thought to have been affected by construction-related sediment inputs (i.e., Models 2, 4, 5, 6, 7, 9, 10) were also run with the “typical” values in **Table 3-2**; predicted fish biomass values for this “typical” scenario were closer to the actual biomass in all cases except Models 5 and 6, which already under predicted actual biomass using the observed values (Model 6b actually results in a negative initial output, so no predictions are shown). Overall, predictions were reasonably accurate, with most model estimates within a factor of two or less of the landed and Leslie fish-out biomass values (**Figure 3-1**).

4. DISCUSSION

The results show that most of the models evaluated were reasonably accurate (i.e., within a factor of two) in their predictions of fish biomass for the impoundment. However, the following should be kept in mind:

- *Range of Parameter Values Used to Develop the Model* – the parameter values (both measured and estimated “typical”) for the impoundment are often at the extreme low end of the ranges used to develop the various models. Many of the models were derived using data sets from large lakes with established fisheries, due to the availability of long-term catch data and a keen interest in these lakes by resource managers. Not only does uncertainty in model predictions increase at the ends of the regression, but the models may have little relevance outside the parameter ranges used in their development. The “typical” scenario run for Model 6 (i.e., 6b) is a case in point, where the initial output was actually negative due to the low TDS value. Ryder (1965) comments that his results can be extrapolated to large, north-temperate, intensively fished lakes with no anomalous environmental conditions.
- *Construction-related Changes to Water Quality* – the measured water quality values for certain parameters increased in the impoundment due to sediment inputs from the construction of the East Dike. However, while increases were seen for total phosphate and TDS relative to previous years, more representative values were used for a “typical” scenario based on over a decade of baseline monitoring results for Second Portage Lake. This approach is logical since the standing stock of fish biomass in 2008 in the lake was amassed over many years rather than just 2008. Interestingly, measured chlorophyll-*a* values were within the baseline range, suggesting little to no reduction of primary productivity associated with the magnitude of elevated turbidity in the impoundment.
- *Applicability to Northern Lakes* – while many of the models included north temperate lakes in the data sets used for their development, few if any hyperoligotrophic Arctic lakes were included. Although the model predictions appear reasonably accurate for the impoundment, it is difficult to make broad conclusions regarding the robustness of the underlying model relationships (i.e., to they hold in hyperoligotrophic lakes) after only one evaluation.
- *More Detailed Linkages between Habitat and Fish Community* – the detailed information collected during baseline studies (i.e., habitat mapping) and the fish-out program (see **Chapter 2**) could likely support the development of more rigorous and complex models for exploring a range of questions, including predicting fish biomass. Indeed, DFO’s establishment of a database for fish-out programs should facilitate these efforts by allowing research to continue at a higher level, addressing overarching trends across Arctic lakes.



- *Uncertainty in estimate of fish biomass* – as discussed in **Chapter 4**, there is uncertainty about the estimate of actual fish biomass in the impoundment, for several reasons (e.g., fishing gear is not 100% effective at removing all fish).



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Table 3-1. Morphological characteristics of the NW Arm of Second Portage Lake.

Basin	Volume (Mm ³)	Area (km ²)	Max	Mean	Proportion of Area within Depth Zones					
			Depth (m)	Depth (m)	0-5m	5-10m	10-15m	15-20m	20-25m	>25m
Northwest	2.00	0.35	12.2	5.7	0.45	0.40	0.15	-	-	-
Middle	10.82	0.71	39.4	15.2	0.28	0.14	0.13	0.11	0.08	0.25
Southeast	1.84	0.24	17.0	7.8	0.31	0.33	0.31	0.05	-	-
Impoundment	14.66	1.30	39.40	11.2	0.33	0.25	0.17	0.07	0.05	0.14

Table 3-2. Key water quality parameters and morphoedaphic index of the NW Arm of Second Portage Lake.

Basin	Total Phosphate (µg/L)	Total Dissolved		Morphoedaphic Index (MEI) (mg/L m ^{-1**})
		Solids (mg/L)	Chlorophyll-a (mg/m ³)	
Northwest	4.6	18	0.43	3.1
Middle	5.2	16	0.44	1.1
Southeast	5.4	14	0.44	1.7
AW Mean*	5.0	16	0.44	1.4
Typical***	2.7	11	-	1.0

Notes: *Area-weighted means calculated using basin areas reported in **Table 3-1**.

** Mean depth for each basin reported in **Table 3-1**; Mean MEI calculated using mean TDS (above) and the combined mean depth for the impoundment (**Table 3-1**).

*** Typical values provided for parameters likely affected by construction-related sediment inputs from the East Dike; see text for more detail.

Table 3-3. Benthic community biomass for NW Arm of Second Portage Lake.

Basin	Mean Biomass per Depth Zones (g/m ² ww)					Basin AW Mean*	Converted Biomass**
	5-10m	10-15m	15-20m	20-25m	>25m	(g/m ² ww)	(kg/ha ww)
Northwest	1.38	3.40	-	-	-	1.93	19.3
Middle	1.43	0.39	0.57	0.00	0.00	0.44	4.4
Southeast	1.3	0.64	0.65	-	-	0.96	9.6
AW Mean***							9.4

Notes: *AW = Area-weighted; depth zone and basin areas reported in **Table 3-1**.

** Basin AW mean biomass values converted to kg/ha.

*** Area-weighted mean for whole impoundment.

Table 3-4. Fish biomass predictions for the NW Arm of Second Portage Lake using ten models and two water quality scenarios (“measured” and “typical”).

Model*	Key Parameters*	Initial Model Output			Conversions Used***	Fish Biomass Estimates	
		Value	Units	Type**		(kg/ha, ww)	(total kg ww)
1	M, z	33	kg/ha, ww	FB	0	33	4348
2	TP	19	kg/ha, ww	FB	0	19	2430
2b	TP	12	kg/ha, ww	FB	0	12	1561
3	M	0.78	kg/ha/yr, ww	FY	1, 2	16	2116
4	M, TDS, z, Ao	0.55	kg/ha/yr, ww	FY	1, 2	12	1538
4b	M, TDS, z, Ao	0.46	kg/ha/yr, ww	FY	1, 2	10	1299
5	TP	0.37	kg/ha/yr, ww	FY	1, 2	8	1064
5b	TP	0.20	kg/ha/yr, ww	FY	1, 2	5	590
6	TDS	0.31	kg/ha/yr, ww	FY	1, 2	7	894
6b	TDS	-0.16	kg/ha/yr, ww	FY			
7	TP, z, TDS	0.61	kg/ha/yr, ww	FY	1, 2	13	1695
7b	TP, z, TDS	0.39	kg/ha/yr, ww	FY	1, 2	9	1122
8	Chlr-a	0.0046	g/m ² /yr, dw	FY	1, 2, 3, 4	4	554
9	TP	5.1	kg/ha/yr, ww	FP	2	11	1419
9b	TP	3.6	kg/ha/yr, ww	FP	2	8	1045
10	MEI	1.7	kg/ha/yr, ww	FY	1, 2	34	4400
10b	MEI	1.5	kg/ha/yr, ww	FY	1, 2	29	3758

Notes: * M = macrobenthos

z = mean depth

TP = total phosphate

TDS = total dissolved solids

Chlr-a = chlorophyll-a

MEI = morphoedaphic index

Ao = surface area

b = typical

** FB = fish biomass

FP = fish production

FY = fish yield

*** 1 = yield to production

2 = production to biomass

3 = dry to wet weight (75% moisture [Oglesby, 1977])

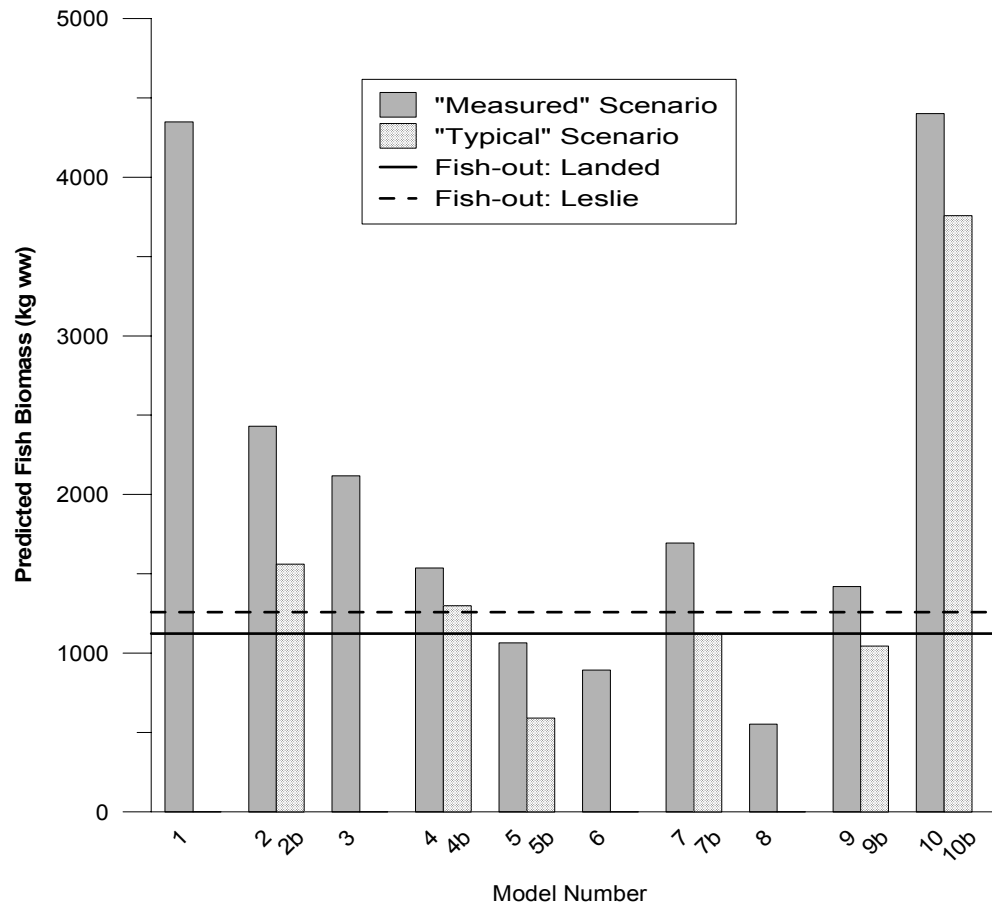
4 = g/m² to kg/ha (multiply g/m² x 10)

0 = none

FIGURES



Figure 3-1. Modeled fish biomass predictions for the NW Arm of Second Portage Lake for two scenarios (“measured” and “typical”) compared to fish-out biomass (landed and Leslie) results.



Chapter 4

Estimates and Indices of Fish Abundance and Biomass

***Meadowbank Gold Project: 2008 Fish-Out of the Northwest arm of
Second Portage Lake***

March 2009

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1. INTRODUCTION

This section describes the quantitative estimation of fish abundance and biomass derived from the three phases of the fish-out program. Mark-recapture information provides an index of abundance or biomass based on recapture rate. CPUE depletion estimators also provide an index of abundance or biomass, using the decline in CPUE over time as the basis. Final removal is intended to provide a near complete census of total abundance or biomass of fish. By using all three of these methods, it is possible to understand the ratio of the indexes (based on mark-recapture or CPUE phases) to ‘true’ abundance or biomass from final removal phase. This ratio would theoretically be applicable to other water bodies with similar characteristics and a similar fish community assemblage.

2. MARK-RECAPTURE

The mark-recapture phase was conducted from 3 to 17 August 2008. The objective for the mark-recapture phase was to achieve a two-day moving average recapture rate of 10% for lake trout, as well as for lake trout / arctic char combined. However, in the event that the recapture rates were not met, it was agreed that the mark-recapture phase would continue for a maximum of 14 days, given the short season and the need to implement the CPUE phase of the fish-out.

2.1. Methods

Two types of gear were used for this phase:

- Trap nets - two trap nets¹ were set perpendicular to shore targeting fairly shallow areas where smaller fish would be expected.
- Gill nets – only 38-mm (1.5 inch) gill nets (1.8m height) were used for this phase.

Set times for gill nets were very short (1 to 4 hours) in order to minimize probability of mortality among marked and released fish. Trap nets were checked daily. Both gear types were moved regularly to cover all available habitats (see **Figure 4-1**). Partial fin clips and/or floy tags were used to mark fish.

Marking applied only to lake trout and char. Round whitefish were not marked because they are known to have low survival after marking, and other species (e.g., burbot) were believed to make up a very small portion of total biomass in the fish community.

¹ Specifications for trap nets: house and leads constructed with 6-mm square mesh, house 1.23 x 1.23 x 1.23 m, center lead 2 x 30.5m pieces for a total of 60m, side leads 9m x 1.83 m depth.



2.2. Results

In-season analysis showed that the objective of a 10% recapture rate was not quite achieved, so the mark-recapture phase was terminated after 14 days. Post-season review of the data showed that a 10% recapture rate was achieved by the end of the period. Results are shown in **Table 4-1**. Trap net data are not presented, because over the entire period the trap nets only caught one fish. We therefore focus only on gill net data.

Over the mark-recapture period, there were a total of 275 sets of 45.4 m length gill nets. A total of 269 fish were marked and released, though five of those died during later recaptures. By the end of the two weeks, the recapture rate was much higher for arctic char (22.6%) than for lake trout (6.7%).

We estimated an index of abundance for lake trout, arctic char, and both species combined using Chapman's adjustment to Schnabel's method (Ricker 1975):

$$N = \frac{\sum C_t M_t}{1 + \sum R_t}$$

where N = estimate of population abundance

C_t = total catch on day t

M_t = total marked fish at large at the start of the t th day

R_t = number of recaptures in the catch C_t on day t

The estimates of abundance from this method are 1497 lake trout and 58 arctic char. As expected, these numbers underestimate the true abundance in part because the 1.5 inch mesh is very specific and preferentially catches and recaptures those fish that are most vulnerable to that particular mesh size (or to gill nets in general). Nevertheless, these estimates may be useful as indexes of abundance when correlated to the results of final removal reported below.

3. CATCH-PER-UNIT-EFFORT

The CPUE phase of the fish-out program was conducted from August 21 to September 27, 2008. The two objectives for the CPUE phase were to continue fishing until:

- there was a consistent, statistically significant (i.e., $p < 0.10$) decline over a 10-day or greater period (for at least one of the two CPUE methods discussed below) for gill nets and for trap nets; and



- overnight sets were catching very few fish regardless of the location of deployment.

3.1. Methods

The CPUE phase began with both gill nets and the two trap nets that had been used during the mark-recapture phase. The two trap nets were abandoned after only four fish were caught after the first 22 trap-net-days of effort.

Gill nets consisted of six panels – one panel each of stretched mesh sizes 126, 102, 76, 51, 38, and 25 mm (i.e., 5, 4, 3, 2, 1.5 and 1 inch). The mesh sizes were fished in exactly constant proportions during the entire CPUE phase. Each mesh panel was 1.8 m deep by 22.7 m long. Nets were moved every day or two to ensure coverage of the all areas of the northwest arm, as shown in **Figure 4-2**. The duration of sets varied. At the start, there were generally two sets per day – a day set (approximately 6 hours duration) and a night set (approximately 18 hours duration). Beginning with nets pulled on August 27th, sets were generally overnight from morning to morning (approximately 24 hours). The pattern of 24-hour sets was generally maintained for the remainder of the CPUE phase; however, an increasing number of weather days led to a number of 48-hour sets, particularly later in September. Water temperatures dropped from 12 degrees Celsius to 3 degrees over the CPUE phase, so by mid to late September almost all fish survived even the longer 48-hour sets.

We collected detailed information on catch and effort during the CPUE phase. The set date, set time, pull date and pull time was recorded for each net so that we could calculate effort at any resolution. In the field we recorded effort as panel hours, and later converted this to net-days for ease of understanding. Regarding catch, we recorded which net and which mesh size caught every fish. In addition, every captured fish was identified to species, weighed and measured for fork length (total length in the case of burbot). We also noted recovery of any marked fish from the mark-recapture phase. Since we prepared every fish for provision to the local community as food (or as dog food for small fish, whitefish, burbot, or any fish that died in the net), we also identified sex and maturity for every fish. Finally, we also conducted detailed biological assessments on a subset of fish – these are reported on separately (in **Chapter 2**).

Analysis of CPUE data was based on both the Leslie and DeLury methods (Hilborn and Walters 1992; Ricker 1975). These methods are referred to generally as depletion estimators because estimation of initial abundance depends on depletion of a population as fishing progresses.

The Leslie method is as follows:

$$CPUE_t = qN_o - qK_t$$

where $CPUE_t$ = catch-per-unit-effort in time interval t

N_o = original population size

q = catchability – the fraction of the population taken by 1 unit of fishing effort

K_t = cumulative catch to the start of interval t plus half of that taken during the interval

Linear regression of the $CPUE_t$ on K_t should give a line where the slope is equal to q , the y-axis intercept is qN_o , and the x-axis intercept is an estimate of N_o (Ricker 1975). We kept track of the estimate of N_o and the significance of the regression after each day.

The DeLury method of analyzing CPUE is as follows:

$$\text{Log}_e(CPUE_t) = \log_e(qN_o) - qE_t$$

where $CPUE_t$ = catch-per-unit-effort in time interval t

N_o = original population size

q = catchability – the fraction of the population taken by 1 unit of fishing effort

E_t = cumulative effort up to the start of interval t plus half of that during the interval

In the case of the DeLury equation, linear regression of $\log_e(CPUE_t)$ on E_t should give a line where the slope = q and the Y-intercept = $\log_e(qN_o)$. The original population size N_o can then be derived.



3.2. Results

The CPUE phase, after a total effort of 317.18 net-days, caught the following:

Species	Catch (number)	Catch (biomass in kg)
Lake trout	1663	648.31
Arctic char	357	232.14
Round whitefish	184	63.02
Burbot	198	22.91
Unknown	1	0.02
Totals:	2403	966.4

CPUE was initially quite variable and then declined rather steadily (**Figure 4-3**). Both the Leslie regression (**Figure 4-4**) and DeLury regression (**Figure 4-5**) showed very significant decline, and by the end both methods were in close agreement regarding the initial population size – the Leslie method estimated 2710 fish, while the DeLury method estimated 2690 fish.

Our in-season depletion estimates focused initially on abundance rather than biomass. However, we quickly realized that more of the larger fish were caught early in the program, while smaller fish were caught later – consequently, biomass is arguably a preferable measure of catch. The trend in CPUE using biomass as catch is steeper (**Figure 4-6**). The estimates of total initial biomass based on the CPUE data set were 920kg and 921kg according to the Leslie and DeLury methods (**Figures 4-7** and **4-8**). Clearly these estimates for initial biomass were too low because we had already exceeded them by the end of the CPUE phase.

3.3. Bias due to Inconstant Catchability

As noted by Ricker (1975), there are several potential sources of error in using CPUE depletion estimators. Given the short time frame within which the CPUE phase took place, and the fact that the area fished was not connected to any other water bodies at the time of fishing, some common sources of error such as immigration, emigration, recruitment or natural mortality are unlikely to bias our data significantly.

Probably the most significant source of error in our results is related to inconstant catchability (Ricker 1975). For example, if natural fish behaviour varies seasonally then



likelihood of capture may also vary. Our fishing season covered periods before and during spawning for trout and char, so we would expect different behaviour patterns over time.

Potentially more important, however, we noticed that the fish caught were larger on average earlier in the CPUE phase. We hypothesized that the larger fish were more vulnerable to the gill nets and tended to be caught early, leaving a pool of less catchable and generally smaller fish. If this were true, CPUE would be high early, resulting in a steeper line and a lower estimate of initial abundance. To quickly check our assumption, we looked at the average biomass of individual fish caught over the first half of the CPUE phase (August 21 to Sept 7) compared to the second half (Sept 9 to 27). Indeed, the average fish caught in the first half was about 50% larger than the average fish caught in the second half (0.47kg compared to 0.30kg), even though there was no change in relative effort of each gill net mesh size.

To test and possibly correct for the potential impact of this bias, we separated the data into several size classes, conducted the depletion analyses on each size class separately (i.e., separate estimates of catchability, initial abundance and initial biomass for every size class), and then summed across the size classes². Results are shown in **Table 4-2**. Catchability shows no particular pattern among the smaller size classes but is noticeably higher for the one or two largest size classes.

The differences in estimates of abundance and biomass based on the entire data set versus size classes is as follows:

	Leslie Method	DeLury Method
Abundance estimate based on entire data set	2710 fish	2690 fish
Abundance estimated by size class and then summed	3019 fish	2482 fish
Biomass estimate based on entire data set	920 kg	921 kg
Biomass estimated by size class and then summed	1099 kg	845 kg

These results show that the Leslie estimates of abundance and biomass increase when size-dependent catchability is considered, while the DeLury estimates decrease.

² For this analysis, we excluded five records where weight was not recorded, plus three records for large fish where there was inconsistency between length and weight.

3.4. Other Potential Biases

Other sources of error may also bias the depletion estimates of abundance derived during the CPUE phase. First, it is likely that later in the season the fishing crews focused proportionately more effort on spawning areas where they expect to find fish. Although we aimed for random placement, we noticed that crews were more likely to run nets for a couple of days in areas of high catch (i.e., remove fish and leave the net in the same location rather than move it). This bias would overestimate CPUE on the right side of the regressions and therefore result in higher-than-expected estimates of initial abundance or biomass. We believe this error was relatively minor or was at least outweighed by biases operating in the opposite direction.

A second potential source of bias is related to one area that was fished with zero or almost zero effort. This area was a deep (40m) basin in the middle of the impoundment, which was difficult to fish because of shortage of line and the difficulty of pulling nets from depth in high wind. Our depletion estimates of abundance or biomass would not include this area, and if fish there were relatively immobile, abundance estimates would be biased low. However, we noted that during final removal phase when we did fish that deep basin, relatively few fish were caught and they tended to be small.

A third potential source of bias in our results would be removal of fish from the nets by predators. If there was significant removal from the nets, the measured CPUE would be less than the actual CPUE. The overall direction of this bias is difficult to predict – taking the case of the Leslie estimator, we might expect a downward bias in the x-intercept (which is equal to initial abundance or biomass) because the entire line would be shifted down; on the other hand, if net predation is higher early, this would pull the left side of the regression line down, flattening out the line and resulting in a higher x-intercept. Estimates of biomass should be less affected if the predators are also caught in the net at the same time or shortly after. We do not believe this was a significant error because crews did not observe a high rate of freshly eaten prey in gut contents of large fish.

Simulation studies have shown that there is often considerable bias in estimates of abundance based on depletion studies (Hilborn and Walters 1992). Most commonly, estimates of initial population size are too low. In general, the Leslie method is preferred to the DeLury method because errors are less likely with catch data than with effort data (Hilborn and Walters 1992; Ricker 1975). In our case, both catch and effort data were measured meticulously. Nevertheless, catch data would be biased if a large number of fish were undetected because they were eaten by predators while in the nets. In the case of effort we do not know how the effectiveness of nets varied due to placement, weather, length of daylight, changes in fish behaviour or other factors. Our sense is that the uncertainties in effort are likely to be considerably larger than with catch; consequently we have more confidence in the Leslie estimates than the DeLury estimates. The DeLury estimates of abundance and biomass were clearly biased low because they were greatly exceeded by the end of final removal phase.



3.5. Comparison to Historical CPUE Data

Fish have been sampled by gillnets in Second Portage Lake as part of the baseline environmental work for the Meadowbank Project. We converted 1997 CPUE data (Azimuth 2003) to make them comparable to 2008 data³. The 1997 data indicate CPUE of 58 fish per net-day in Second Portage Lake, which is about 2.5 times the highest mean daily CPUE measured during the 2008 fish-out program. However, the 1997 data are based on only five sets (two day sets and three night sets), and variability was high. The 1997 data for Third Portage Lake indicate CPUE of 23 fish per net-day, based on 13 sets (six day sets and seven night sets). Again variability among sets was high. Azimuth (2003) hypothesized that Third Portage Lake, due in part to its large size, may be less productive per unit area than Second Portage Lake. Overall, however, the data were too limited to support any firm conclusions.

Even if historical data were more comprehensive, comparison of 2008 CPUE data to historical data would be challenging. CPUE is known to be a function of visibility and fish movement patterns – given the anomalous conditions during 2008⁴, both of these factors may have been different during 2008 compared to other years.

4. FINAL REMOVAL

4.1. Targets

For final removal phase, the objective was to continue fishing until either:

1. no fish were caught for 48 hours, and then after a 24 hour break, no fish were caught for an additional 48 hours; or
2. catch had declined to near zero and the total catch has reached at least 95% of the estimated initial abundance from the CPUE data.

Given that we had over 100 net panels fishing on most days, we did not expect to be able to fish for two days without catching a single fish. Consequently, determination of whether or not final removal was achieved focused primarily on the second criterion.

³ Net gangs were similar, consisting of several panels ranging from 25m to 125m stretched mesh. However, 1997 CPUE data were standardized to 100m total length whereas 2008 data use the 136.2m length of a net gang. In addition, 1997 CPUE data were estimated separately for day and night sets. We assumed day sets of 8h duration and night sets of 16h duration in order to estimate a mean 24h CPUE equivalent for the 1997 data.

⁴ During the 2008 fishing season, suspended sediment concentrations in the water column were higher than normal due to construction of the East Dike.



4.2. Methods

The final removal phase of the 2008 fish-out began with nets set on September 27, 2008 and continued until October 16, 2008. During final removal phase, we had no restrictions on gear types. However, since the gill nets were extremely effective during the CPUE phase, we continued to use those as the principal gear, and increased the number of standard gangs to between 15 and 19. We also added two panels of larger mesh size (8 inch or 312 mm), as well as some fine mesh “Swedish” gill nets (one panel each of 8-mm, 10-mm and 12.5-mm mesh). We did not use trap nets or minnow traps as they had been shown previously to be almost completely ineffective. During the final removal phase, we continued to process catch for biological information, but did not record details regarding which net or mesh size caught each fish.

4.3. Results

Catch during final removal phase totaled 672 fish weighing 157kg. The total combined catch for CPUE and final removal phases was therefore 3079 fish weighing 1123 kg. The breakdown by species was as follows:

Species	Catch (number)	Catch (biomass in kg) ⁵
Lake trout	2018	721
Arctic char	485	298
Round whitefish	295	74
Burbot	280	30
Unknown	1	0.02
Totals:	3079	1123

In terms of the first element of the second final removal phase termination criterion, which was ‘near-zero’ catch, we estimated catch per unit effort during final removal phase using our approximate estimates of effort as net-days⁶. The catch per unit effort during final removal phase averaged approximately 2.03 fish (at 0.45 kg) per net day. We consider this to be near-zero in comparison to the much higher catch rates experienced earlier in the fish-out (see **Figure 4-3** for abundance and **Figure 4-6** for biomass). The average size of fish caught during final removal phase was 0.23 kg, which was much

⁵ Approximate due to missing weight data for some fish.

⁶ One net-day is defined as one CPUE net gang (i.e., 6 panels) fishing for 24 hours.



smaller than the average size of fish caught during the first half and second half of the CPUE phase (0.47 and 0.30 kg, respectively). The fish that remain in the lake after final removal are mainly very small fish with low catchability.

The second element of the target was to catch at least 95% of the estimated initial abundance from the CPUE phase. As discussed earlier, there are several sources of potential bias in the Leslie and DeLury methods of estimating abundance. Most likely, both depletion estimates are biased low, and the DeLury estimate is more prone to errors than the Leslie method. We assumed initial abundance and biomass as measured by the Leslie method, roughly corrected for size-dependent catchability. That is, we assumed initial abundance of 3019 fish and initial biomass of 1099 kg. Even after correcting for bias due to size-dependent catchability, the total catch of 3079 fish at 1123kg appears to exceed the Leslie estimates for the initial population for both abundance and biomass by 2%.

4.4. Bias due to Inconstant Catchability

Clearly, the depletion estimators of initial population abundance and biomass were biased low, even after correcting for size-dependent catchability. Part of this bias can be attributed to the addition of the fine-mesh “swedish” net panels during final removal, which were able to target small fish that had previously been almost ‘uncatchable’ by the standard CPUE net gangs.

We further explored the potential magnitude of bias in the Leslie depletion estimator using data from the final removal phase. Since we had approximate effort data for the final removal phase, we re-calculated the size-class-specific Leslie estimates of initial population abundance and biomass using CPUE data for both the CPUE phase and final removal phase. These estimates are imprecise not only because effort data were approximate but also because the nature of effort changed (in particular the use of the fine-mesh nets during final removal phase targeted small fish with much more efficiency). Nevertheless, as CPUE flattened out over time during the final removal phase (**Figure 4-9** for abundance, **Figure 4-10** for biomass) we hypothesized that incorporation of final removal data into the Leslie depletion estimator could provide insight into the potential extent of biases in estimates of initial abundance and biomass. Using the same size classes used for earlier analysis of CPUE phase data, the estimates of initial population abundance and biomass based on data from both CPUE and final removal phases increased slightly (to 3199 fish at 1258 kg - **Table 4-3**). These increases were less than we had anticipated, particularly for abundance.

Another source of inconstant catchability could relate to differences among species. As an exploratory analysis (not shown) we fit the Leslie model to each species separately. Analysis of covariance showed significantly different ($p < 0.05$) slopes (i.e., catchability) among species. We also explored stratification of the data set by species and size class,



but this did not have a noticeable effect on estimates of initial abundance and biomass compared to the stratification based on size only. We also regressed $\log_e(\text{catchability})$ on mean fish size and found a significant relationship, indicating that catchability is indeed higher for larger fish, but only for the very largest size classes.

4.5. Recovery of Marked Fish

We can check the potential magnitude of biases in depletion estimates of abundance by considering the rate of recovery of fish that were marked during the mark-recapture phase. There were 264 fish that had been marked during the mark-recapture phase and were ‘at-large’ at the start of the CPUE phase. These were lake trout and arctic char only. During the CPUE and final removal phases, we recovered a total of 50 char and 102 trout. However, only 36 char had been recorded as marked and at large. Obviously a recovery rate of char more than 100% is impossible, and we attribute this to errors by the field crews in distinguishing between the two species (typically more likely for smaller fish) or possibly in misidentifying an eroded adipose fin as clipped (more likely for larger fish). Consequently, we consider only the combined recovery rate of marked fish, which was 58% by abundance and 90% by biomass⁷.

Overall, analysis of recovery of marked fish would suggest that bias in the CPUE depletion estimates of initial biomass is low, because we recovered 90% of the biomass of marked fish. In the case of initial abundance, the data suggest that we probably recovered between 58% and 100%⁸ of true abundance.

However, given earlier findings about size-dependent catchability, there may be some bias in the mark-recapture results. The difference in recovery rates for abundance compared to biomass could be explained by a higher recovery rate for large fish compared to small fish. A plot of the length-frequency distributions for marked fish and recovered fish (**Figure 4-11**)⁹ shows that the recovery rate for smaller fish is low, while

⁷ Biomass estimates of marked fish were approximate only. We did not collect weight data during mark-recapture, only length data. Weights were derived from weight-length regressions based on data from the CPUE phase. In addition, the length data for the 264 fish at large at the end of the CPUE phase were not distinguished from the length data of recaptures (i.e., some fish were double-counted), so we had to scale estimates of total char and trout biomass accordingly.

⁸ This does not include fish that are not susceptible to the gear at all (i.e., catchability = 0), which is probably the case for fingerlings or small species that are relatively stationary (e.g., sculpins). We did not catch any sculpins, but did find one in the gut of a larger fish.

⁹ Some size groups show fewer marks than recaptures, which is not possible. The data for marked fish is based on 279 fish, rather than the 264 that were at large at the end of the mark-recapture phase. The extra 15 fish were recaptures and are therefore double-counted, but we have included them in the analysis because we don’t know which 15 fish were double-counted. This could be avoided in future fish-outs by using numbered Floy tags so that all marked fish have unique identifiers.

recovery rates of larger fish were very high. A low rate of recovery of marks in the smaller size ranges could be due to a combination of several factors including post-marking mortality, failure of crews to detect fin-clip marks, size-dependent behaviour of fish that made them less susceptible to the gear later in the season, and, to a lesser extent, predation off of nets. However, given our earlier findings, the most important factor may be size-related catchability. The gillnets tend to preferentially catch large fish, and once those fish are marked and released their likelihood of recapture remains high because of their large size.



5. REFERENCES

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- Hilborn, R., and C.J. Walters. 1992. Quantitative Fisheries Stock Assessment – Choice, Dynamics and Uncertainty. Chapman and Hall, New York.
- Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191: 382 p.



TABLES



Table 4-1. Gill net mark-recapture results.

Note: All data shown are for Lake Trout / Arctic Char. For the last column (recapture rate, the third number is the combined recapture rate for both species

Date	Ct (Catch)	Rt (# Recaptures)	Mortalities Among Marked Fish	# New Marked Fish Released	Mt (Total Marked Fish at Large at Start of Day)	Recapture Rate (%)
3 Aug	14/1	0/0	0/0	14/1	0/0	0 / 0 / 0
4 Aug	2/0	0/0	0/0	2/0	14/1	0 / 0 / 0
5 Aug	26/7	0/0	0/0	26/7	16/1	0 / 0 / 0
6 Aug	4/1	0/1	0/0	4/0	42/8	0 / 11.1 / 1.8
7 Aug	36/19	1/4	0/0	35/15	46/8	1.2 / 17.9 / 5.5
8 Aug	27/12	1/2	0/0	26/10	81/23	1.8 / 17.5 / 6.0
9 Aug	29/1	4/1	1/0	24/0	107/33	4.4 / 19.5 / 7.8
10 Aug	11/4	0/4	0/1	11/0	130/32	4.1 / 26.1 / 9.2
12 Aug	7/2	2/1	0/0	5/1	141/31	5.2 / 27.7 / 10.3
13 Aug	22/3	1/1	0/1	21/1	146/32	5.1 / 27.5 / 10.0
14 Aug	23/0	1/0	0/0	22/0	167/32	5.0 / 28.0 / 9.6
15 Aug	0/0	0/0	0/0	0/0	189/32	5.0 / 28.0 / 9.6
16 Aug	34/3	3/1	1/0	30/2	189/32	5.6 / 28.3 / 9.7
17 Aug	16/2	4/0	1/0	11/2	218/34	6.9 / 27.3 / 10.4
18 Aug					228/36	



Table 4-2. Estimates of abundance, biomass and catchability by size class¹⁰

				Analysis of Abundance				Analysis of Biomass			
				Abundance		Catchability		Biomass (kg)		Catchability	
Size Range (kg)	Sample Size	Avg Biomass (kg)	Total Biomass	Leslie	DeLury	Leslie	DeLury	Leslie	DeLury	Leslie	DeLury
0.01-0.052	632	0.0287	18.1	806	674	0.00609	0.00667	43	19	0.00463	0.00675
0.053-0.076	302	0.0638	19.3	472	337	0.00403	0.00462	54	21	0.00279	0.00478
0.077-0.125	342	0.1035	35.4	403	355	0.00757	0.00742	60	36	0.00643	0.00755
0.126-0.225	315	0.1703	53.6	408	333	0.00612	0.00726	84	56	0.00584	0.00742
0.23-0.600	307	0.3967	121.8	389	346	0.00592	0.00554	163	135	0.00577	0.00568
0.61-1.2	364	0.869	316.3	381	324	0.01117	0.00769	317	275	0.01204	0.00783
1.225-12.7	133	2.9754	395.7	160	113	0.01213	0.01003	378	303	0.01901	0.0125
Totals:	2395		960	3019	2482			1099	845		

¹⁰ Five fish were excluded from the analysis due to lack of weight data, and three fish from the largest size class were excluded because of inconsistency between length and weight data.



Table 4-3. Estimates of abundance, biomass and catchability by size class¹¹, for combined CPUE and final removal data.

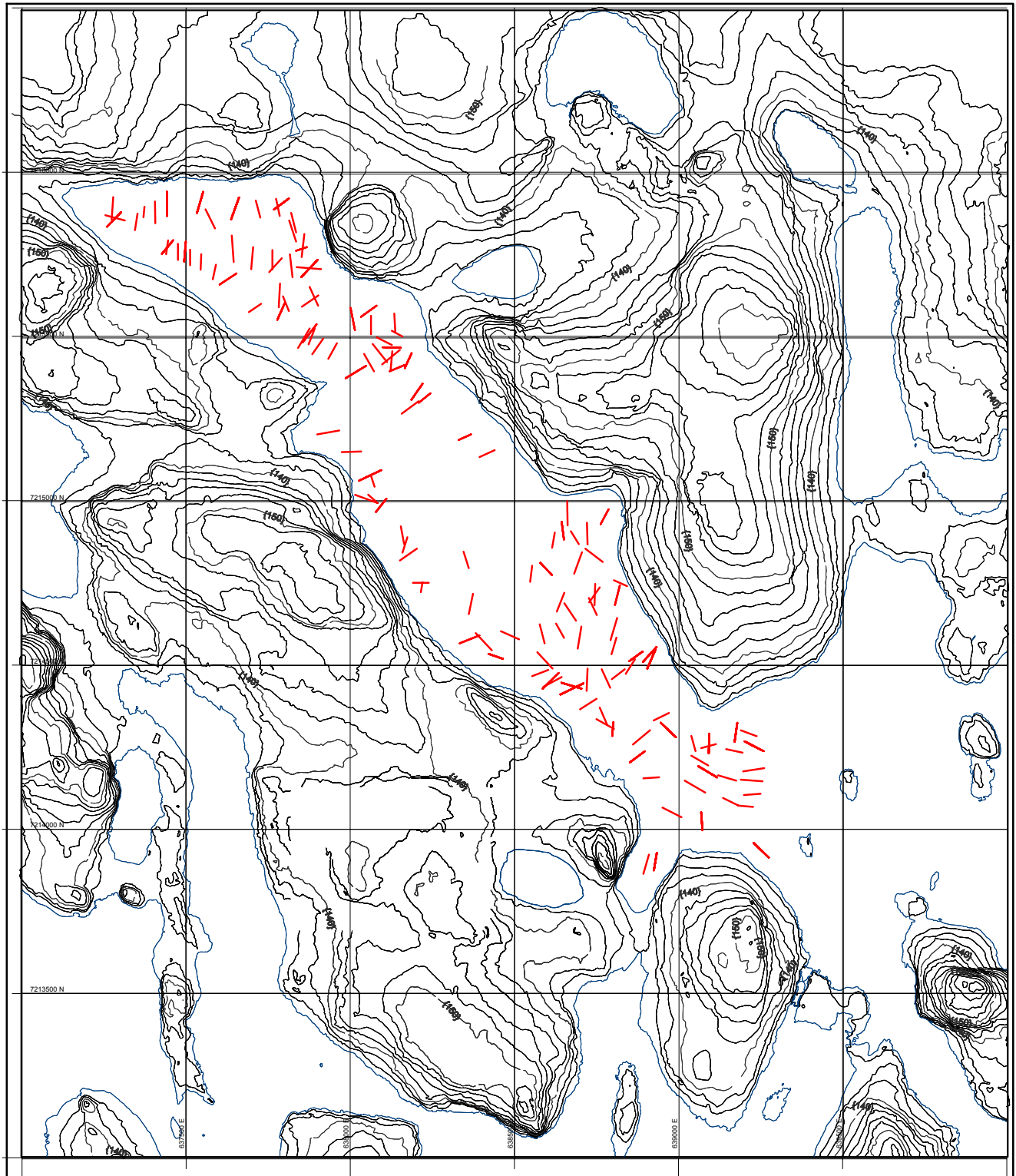
Size Range (kg)	Sample Size	Avg Biomass (kg)	Total Biomass	Leslie Analysis of Abundance		Leslie Analysis of Biomass	
				Abundance	Catchability	Biomass (kg)	Catchability
0.01-0.052	882	0.0272	24.0	893	0.00519	55	0.00417
0.053-0.076	377	0.0631	23.8	430	0.00458	59	0.00322
0.077-0.125	412	0.1035	42.6	426	0.0069	73	0.0058
0.126-0.225	396	0.1702	67.4	424	0.00577	98	0.00543
0.229-0.600	415	0.3941	163.5	437	0.00494	191	0.00485
0.61-1.2	436	0.8701	379.4	423	0.00921	369	0.0096
1.225-12.7	146	2.8531	416.5	166	0.0112	413	0.0167
Totals:	3064		1117	3199		1258	

¹¹ Eight fish were excluded from the analysis due to lack of weight data, and three fish from the largest size class were excluded because of inconsistency between length and weight data.



FIGURES

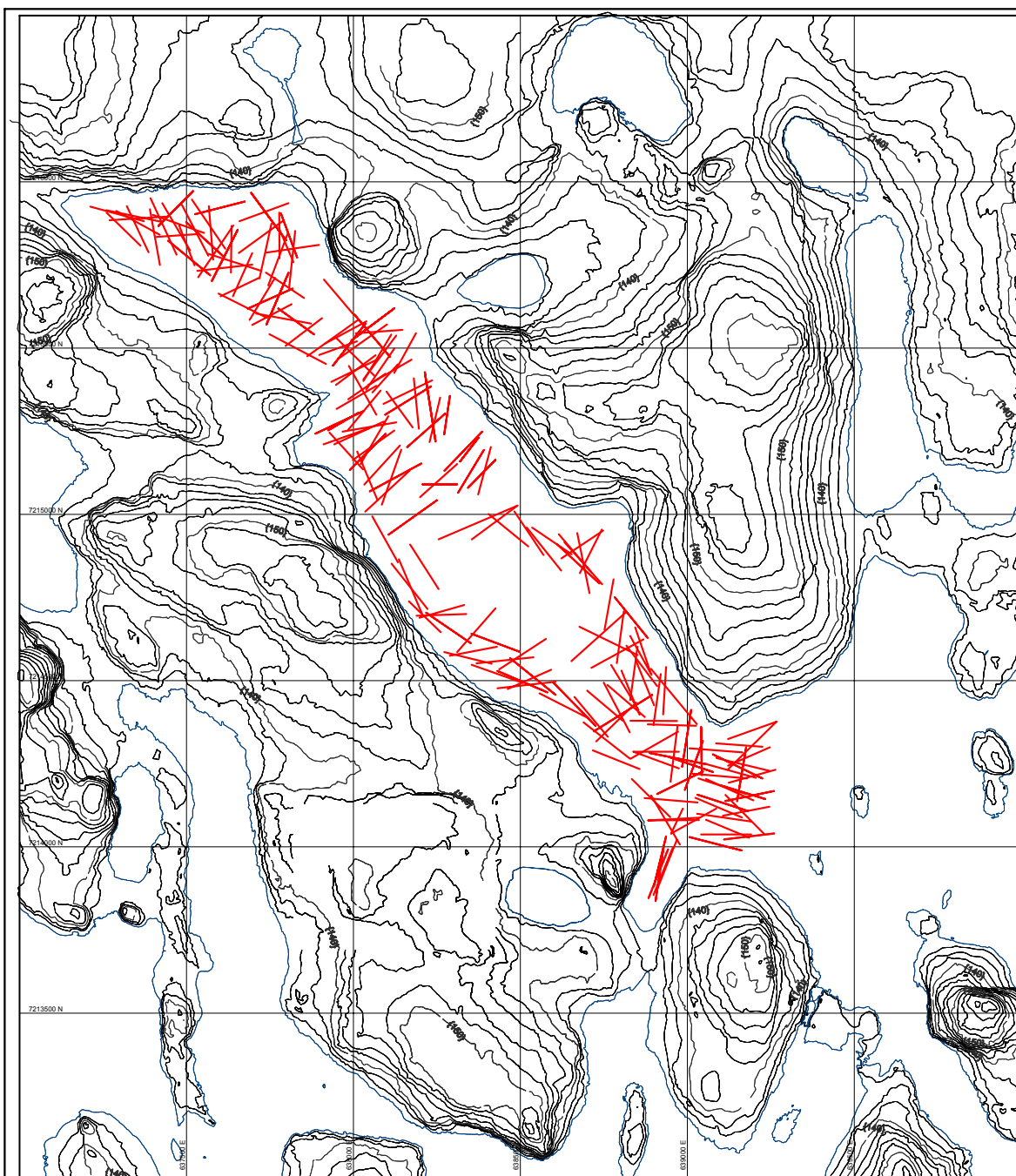




Azimuth Consulting Group Inc.

FIGURE 4-1
MEADOWBANK GOLD PROJECT - FISHOUT PROGRAM FOR
NORTHWEST ARM OF SECOND PORTAGE LAKE

GILL NET LOCATIONS FOR MARK-RECAPTURE PHASE 2008



Azimuth Consulting Group Inc.

FIGURE 4-2
MEADOWBANK GOLD PROJECT - FISHOUT PROGRAM FOR
NORTHWEST ARM OF SECOND PORTAGE LAKE

GILL NET LOCATIONS FOR CPUE PHASE 2008

Figure 4-3. CPUE over time (gill net data)

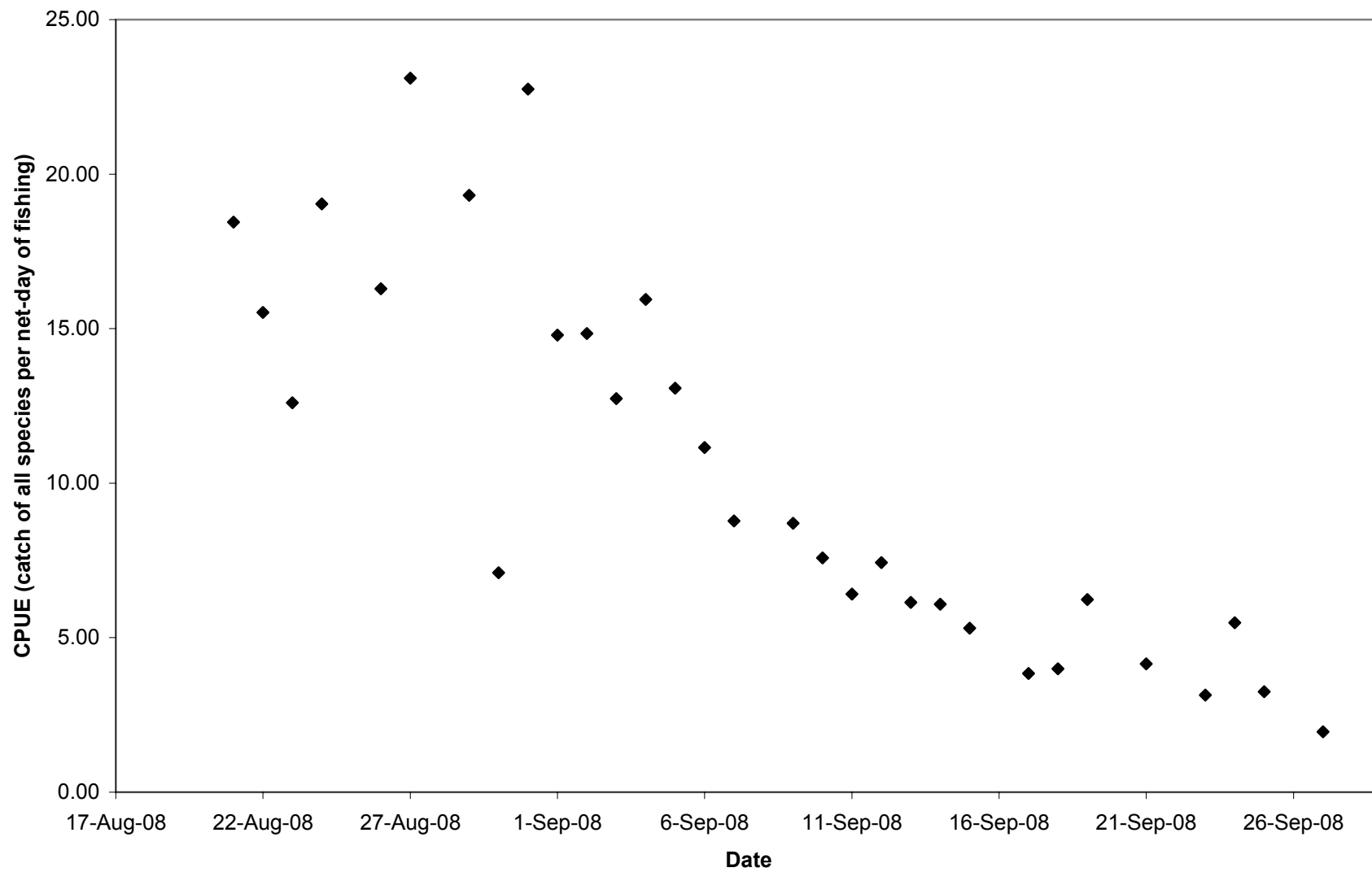


Figure 4-4. Analysis of Gill Net Catch-Per-Unit-Effort - Leslie Method
(note: catchability is the slope of the line)

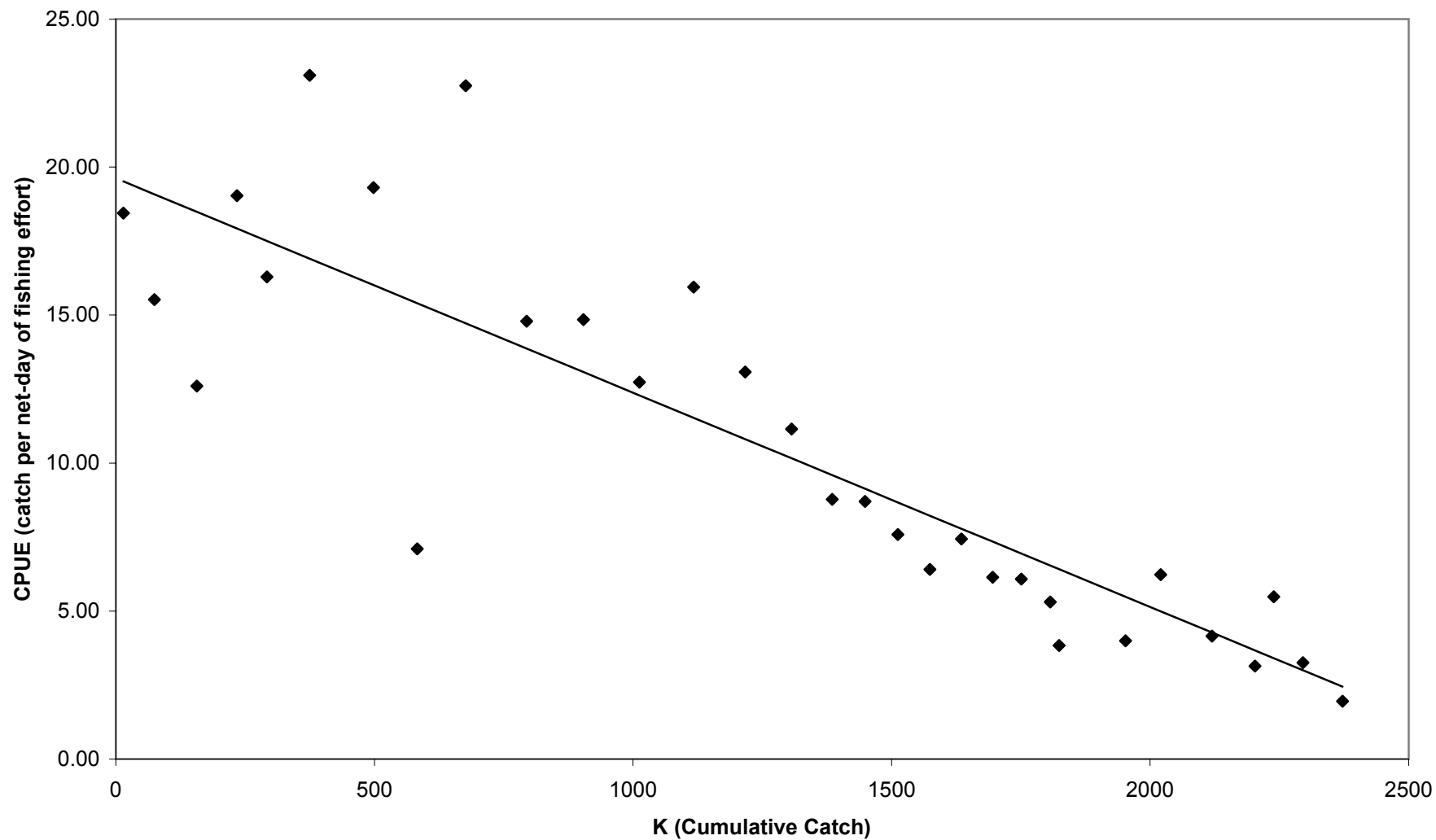


Figure 4-5. Analysis of Gill Net Catch-Per-Unit-Effort - DeLury Method

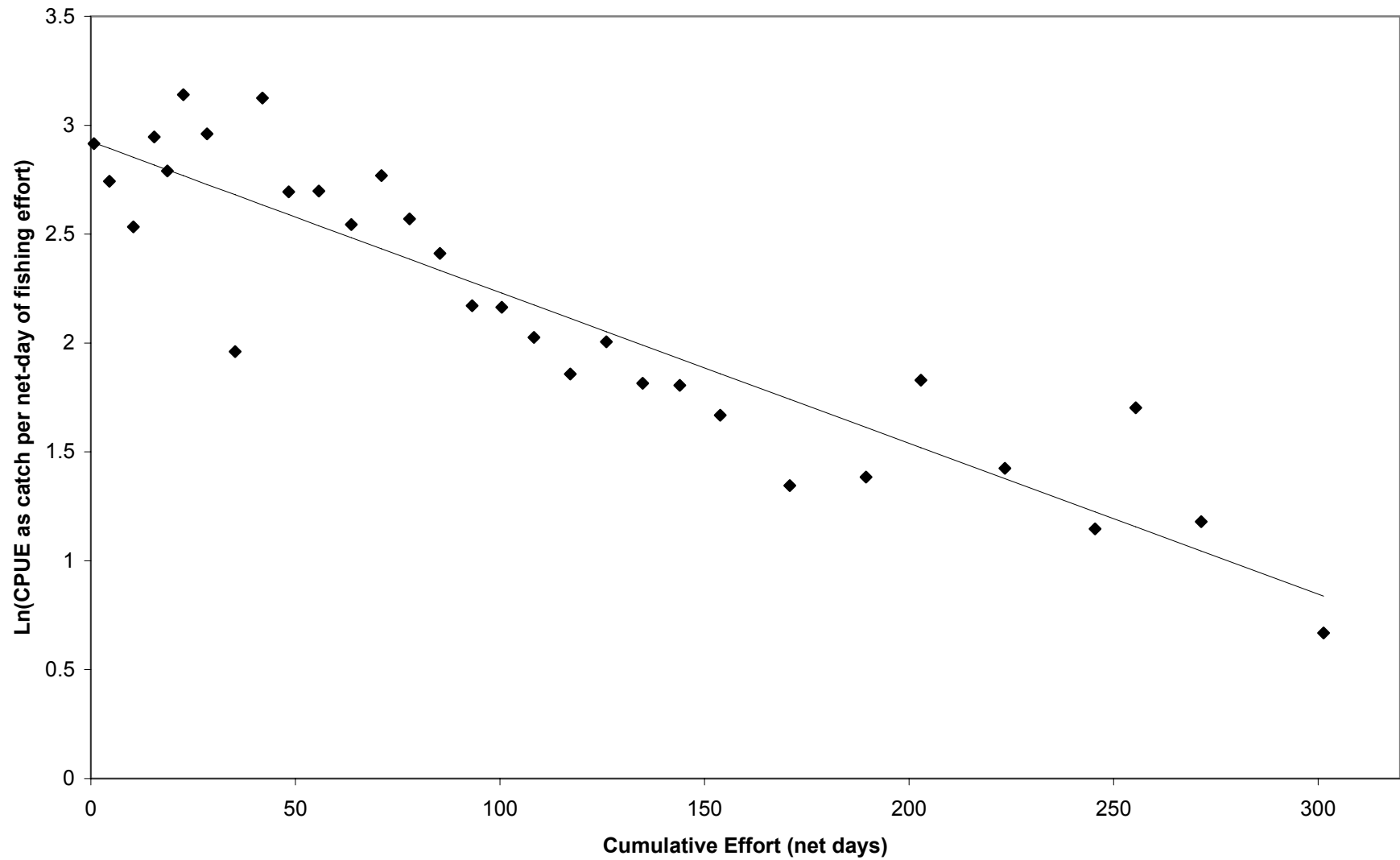


Figure 4-6. Biomass-Based CPUE over time (gill net data)

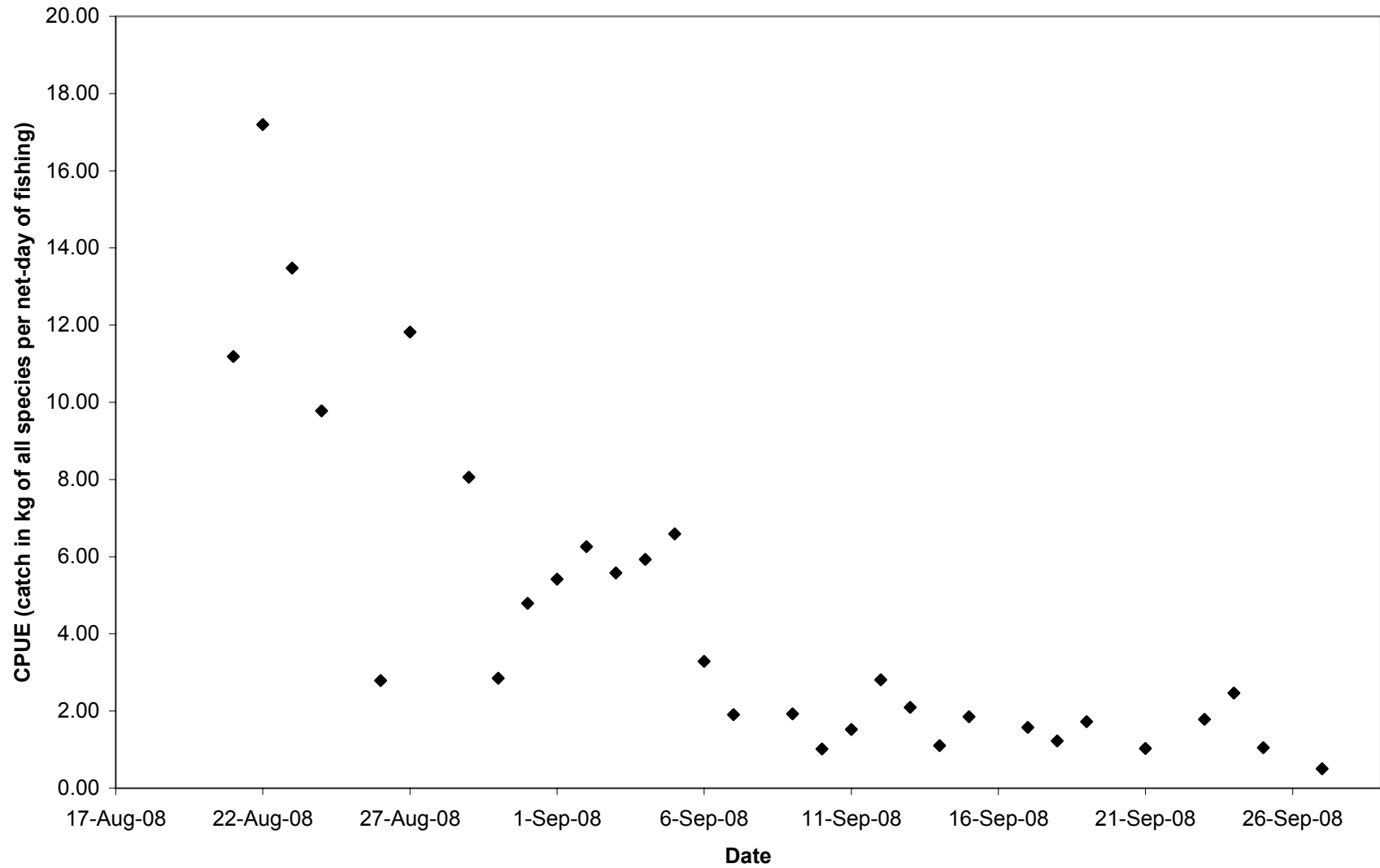


Figure 4-7. Biomass-Based Analysis of Gill Net Catch-Per-Unit-Effort - Leslie Method
(note: catchability is the slope of the line)

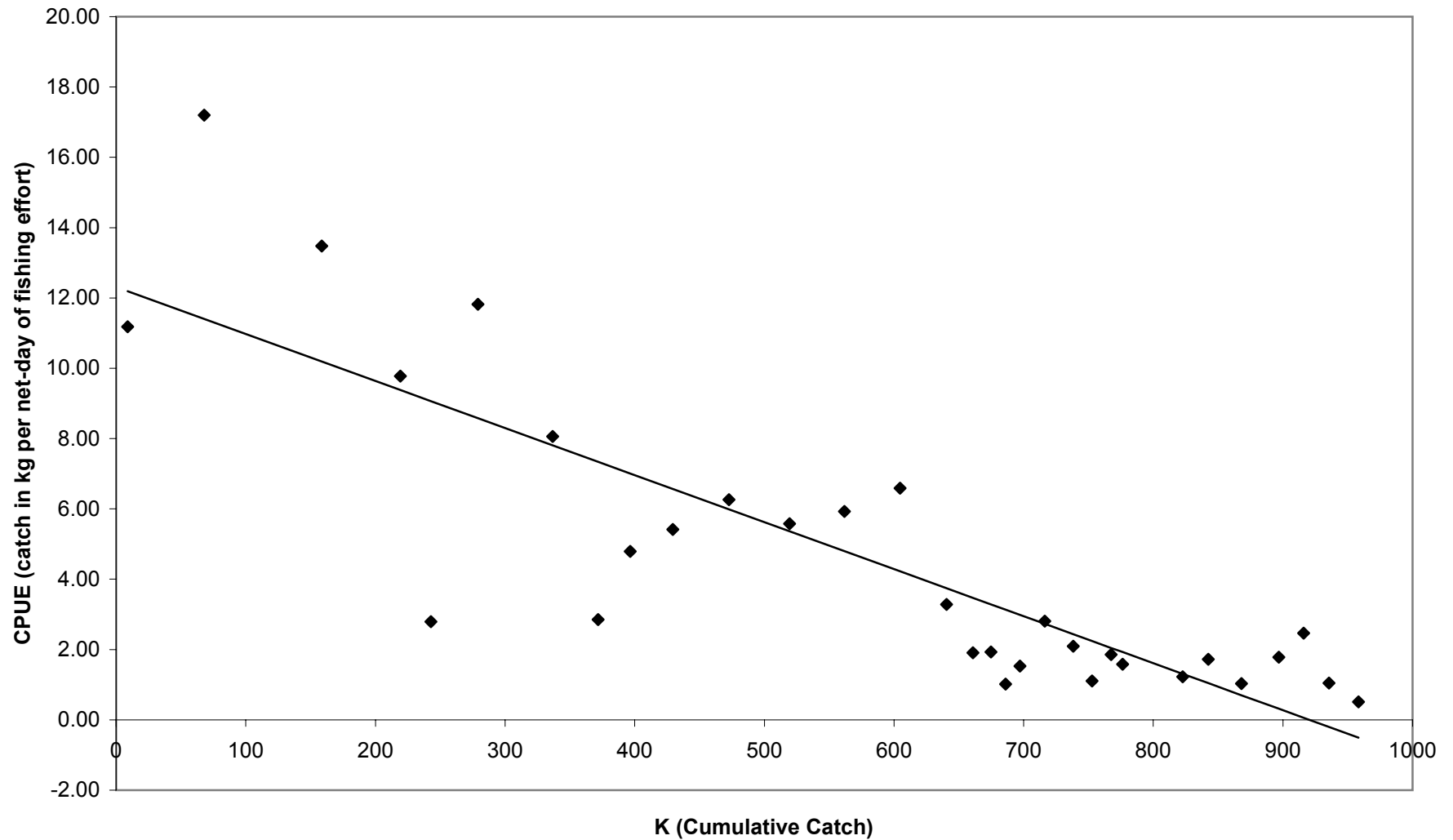


Figure 4-8. Biomass-Based Analysis of Gill Net Catch-Per-Unit-Effort - DeLury Method

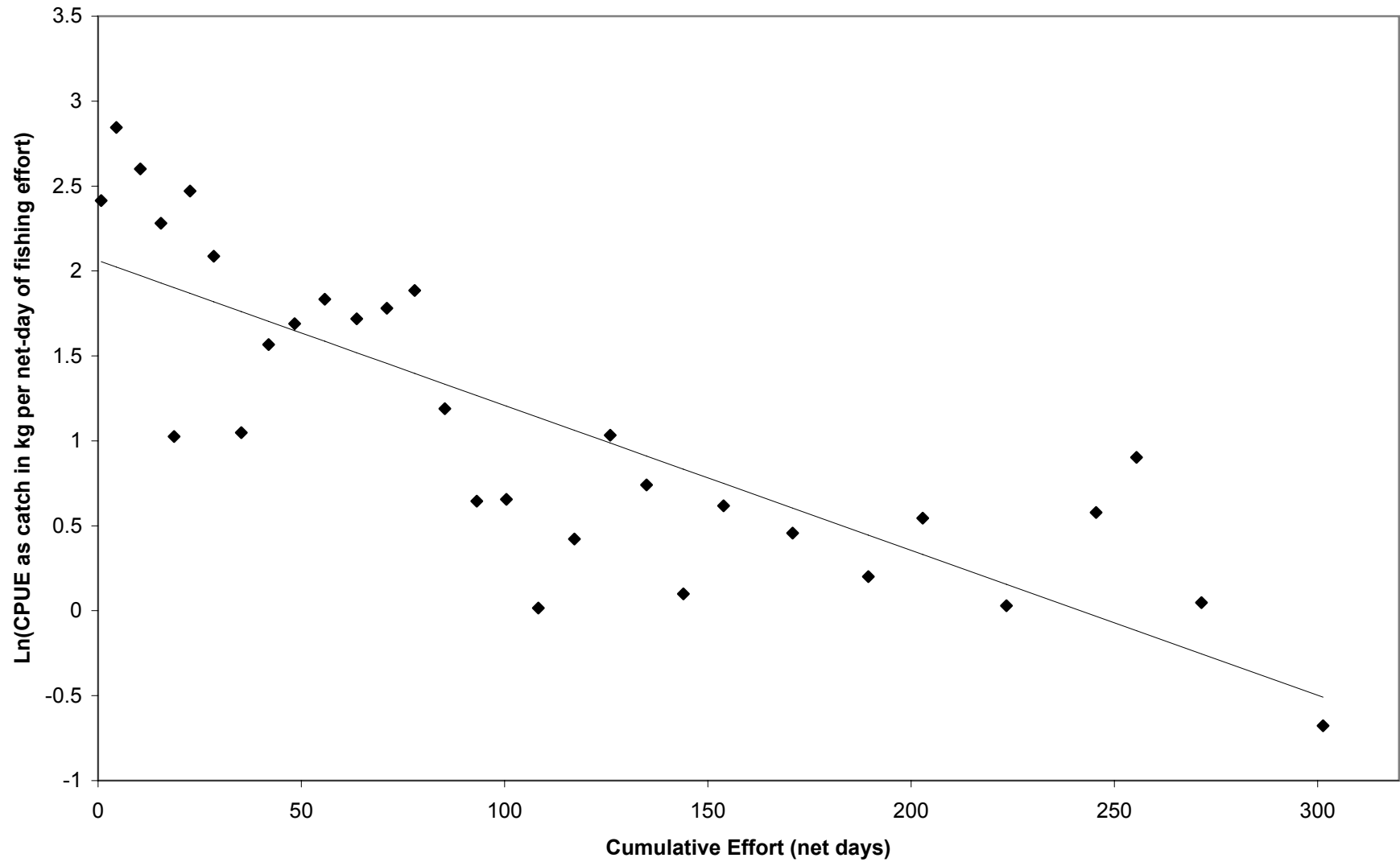


Figure 4-9. CPUE over time including final removal phase (gill net data)

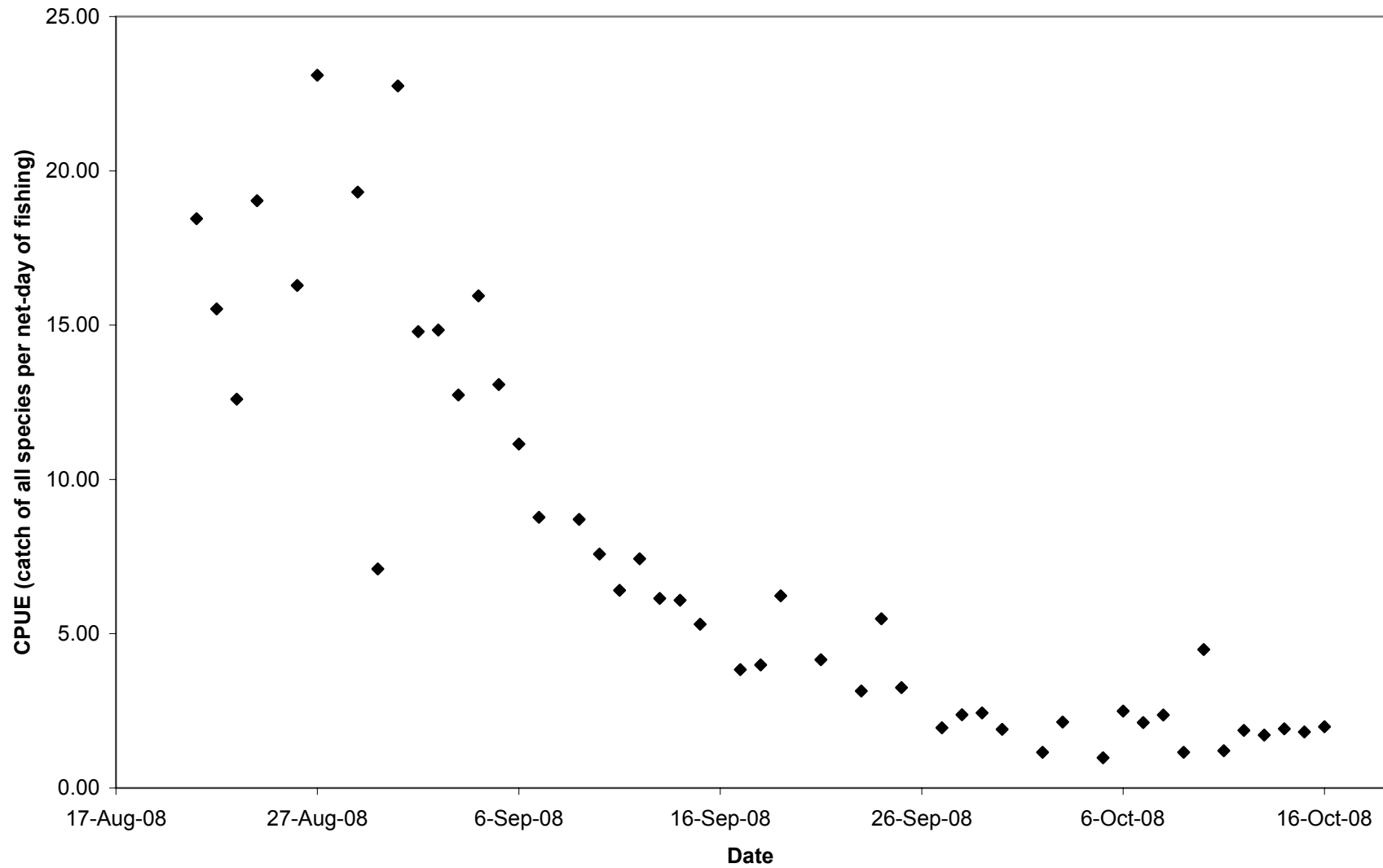


Figure 4-10. Biomass-based CPUE over time including final removal phase (gill net data)

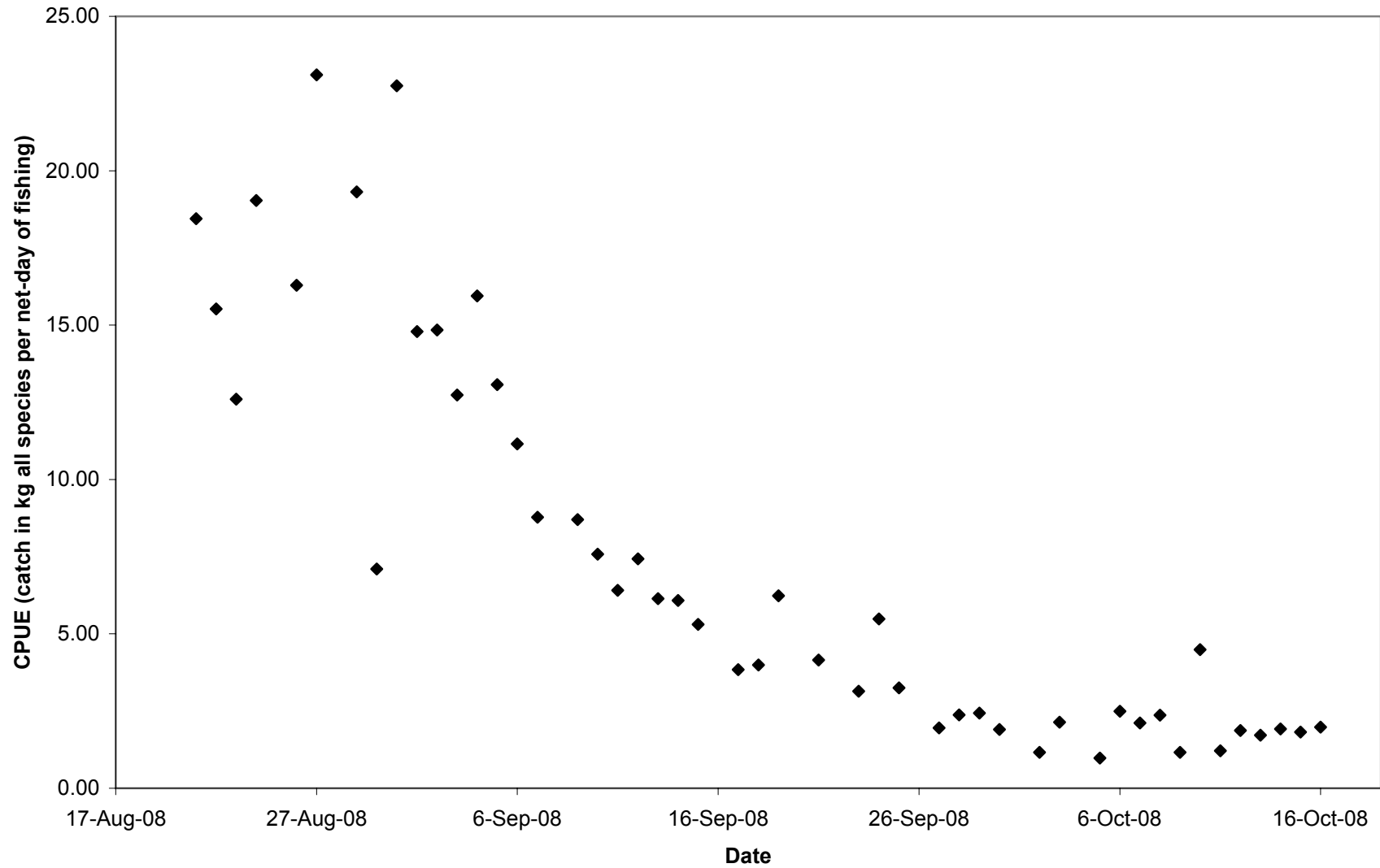
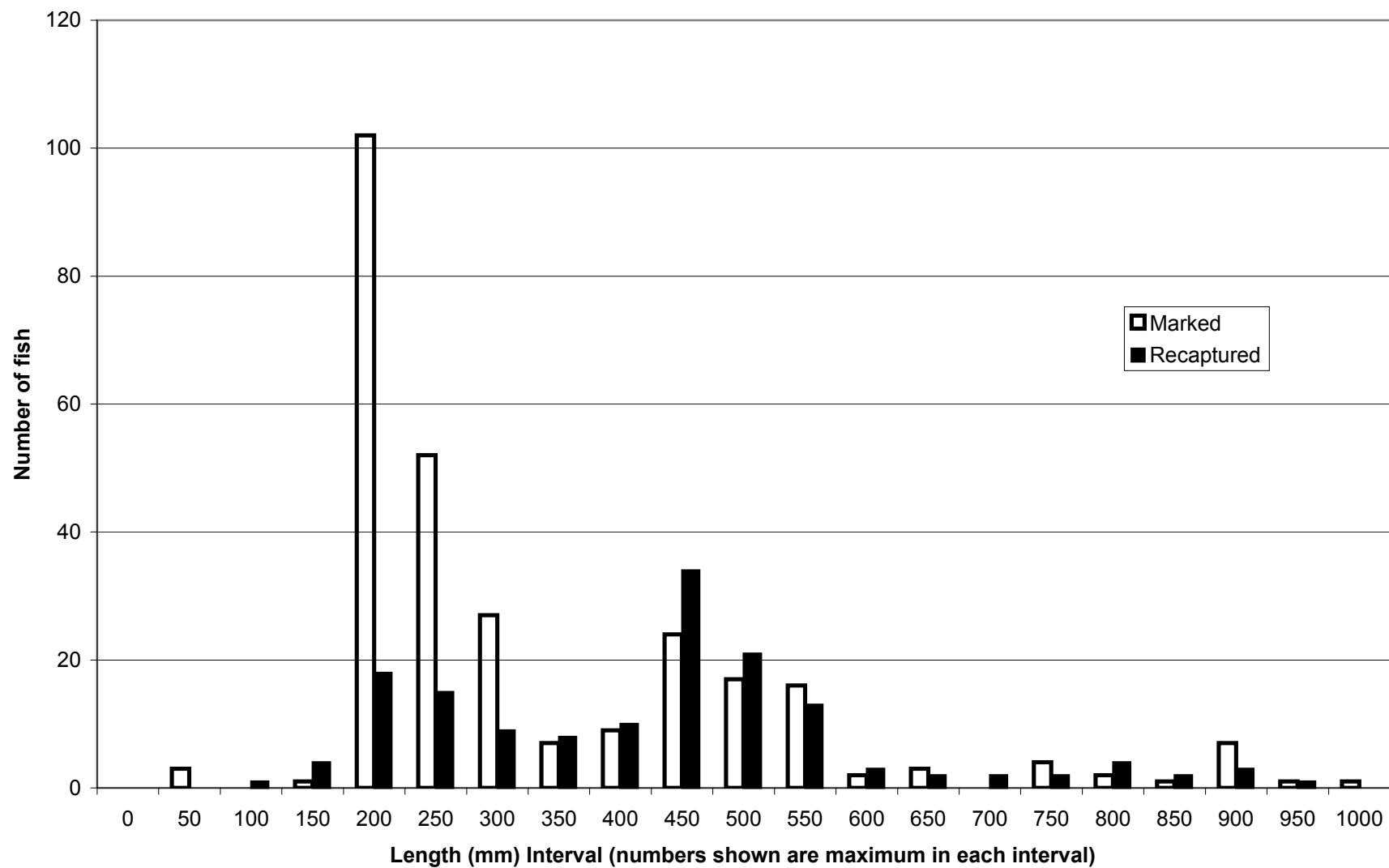


Figure 4-11. Recovery of Marked Fish During 2008 Fishout



APPENDIX A

DFO FISH-OUT PROTOCOL

GENERAL FISH-OUT PROTOCOL FOR LAKES TO BE LOST DUE TO MINING DEVELOPMENTS

The total removal of fish from lakes (i.e., “fish-out”), with or without ‘dewatering’, is often an unavoidable consequence of mining or other developments. All proponents will be required, as a condition of a ss. 35(2) *Fisheries Act* authorization, to conduct a Fish-out Program (Program) on each lake to be lost prior to commencing with the dewatering or other development that requires total fish removal from the lake.

The fish-out of tundra lakes minimizes the wasting of fish, and provides a unique opportunity to collect exceptionally thorough and scientifically defensible data on fish-environment relationships in the North. This document is intended to provide the general protocol for such studies. It is expected that more specific details beyond those contained within this general protocol will be developed and refined as circumstances dictate.

The Program objectives are presented in Section 1. Section 2 presents the management structure of the program. Section 3 provides an overview of the program components and Section 4 describes methods of data collection. Finally, Section 5 describes the reporting requirements.

1. Program Objectives

The intent of the Program is to remove all fish from a lake and distribute/dispose of them in an appropriate manner, determined in consultation with aboriginal communities, that avoids wasting fish and provides scientifically defensible data.

More specifically, the objectives of the Program are to:

- i) ensure that all fish are removed from a lake and disposed of in an appropriate manner that minimizes the wasting of fish,
- ii) determine fish species composition and the abundance and structure of fish populations in Arctic lakes,
- iii) determine biological, limnological, and habitat characteristics of the lakes that are fished out.

These data will be used to:

- 1. assess preliminary sampling program data on fish population and assemblage structure,
- 2. establish a database of biotic and abiotic characteristics of arctic lakes that will be used to determine linkages between fish populations and assemblages and the biotic and abiotic

characteristics of northern lakes, and thereby provide reference data for Aquatic Effects Monitoring Programs and compensation initiatives.

2. Project Management

The proponent's Project Manager will provide a qualified fish biologist to act as the Project Biologist and is encouraged to use aboriginal expertise.

The Project Biologist will be at site during crew training, participate in the collection of data, ensure the quality of data, provide an electronic database consistent with the master database of arctic lakes held by Fisheries and Oceans Canada (DFO), and produce the project report.

To make communications efficient, DFO will have one contact point for the management of the Fish-out Program. This person will be the Project Authority. The Project Authority will be responsible for providing advice to the Project Manager and Project Biologist as the need arises.

3. Components

The capture and processing of fish, including the recording of field data, collection of biological data, and sample analysis, are the responsibility of the proponent based on the components described herein. Rigorous scientific procedures, the details of which are largely beyond this general protocol, are required to provide usable data from the Program. Detailed protocols for all components and procedures, approved by the Project Authority, will be in place prior to initiating the work. Consistency of methods and complete, accurate recording of data are essential.

The Program is divided into three general components based on level of ecosystem organization. These components are:

- 1) Fish Community
- 2) Physical-chemical and biological Limnology
- 3) Habitat Inventory

The Fish Community component can also be broken down into several phases, as outlined in Table 1. (a) A Mark-recapture Phase, using standardized sampling techniques, provides an estimate of the abundance of the resident populations. (b) A CPUE-Removal Phase, also consisting of standardized fishing, provides a second abundance estimate of the fish populations,

as well as biological data on fish in the lake. (c) The Final (total) Removal Phase will consist of every effort to capture all remaining fish in each lake, providing a total census for each fish population. This phase will often be initiated once a lake has been sufficiently dewatered.

The Limnology component (e.g., morphometry, water quality, and samples of lower trophic levels) will be conducted during the Mark-recapture and CPUE phases. Habitat Inventory data (e.g., mapping of lake bathymetry, aquatic vegetation and substrate) will be collected during CPUE and Final Removal phases. Physical habitat data can also be collected during the Final Removal Phase, once a lake has been sufficiently dewatered to expose the habitat.

Table 1: Schematic timeline of the Fish-out Program components.

Program Components	Study Phases		
	Mark-Recapture	CPUE	Final Removal
Mark-recapture	XXXXXXXX		
CPUE		XXXXXXXX	
Final Removal			XXXXXXXX
Limnology	XXXXXXXX	XXXXXXXX	
Habitat Mapping		XXXXXXXX	XXXXXXXX

4. Field Methods

4.1 Fish Community

The goal of the fish community component of the Program is to provide an accurate description of the fish community, and the size and structure of its component populations, in the lakes being studied. This will be accomplished through several complementary phases (Mark-recapture, CPUE, and Final Removal), which are described below. Field gear and deployment methods are also described.

Fishing Gear and General Deployment

Standardized, DFO-approved trap nets and index gill nets will be used to capture fishes during the Mark-recapture and CPUE phases. Additional gear may be added during the Final Removal Phase.

Trap Nets. - DFO has small mesh trap nets that can be used for all phases of the Fish-out Program. The traps are constructed of 6 mm square mesh with a house of 1.23 x 1.23 x 1.23 m. The leads measure 61 m in length and 1.83 m in depth. The trap leads will be anchored to shore and set out perpendicular to the shoreline. Trap nets must be moved regularly (every 2-3 days) around the shoreline to ensure full coverage of the available habitat in the lake.

Gill Nets.- Gill nets of a variety of mesh-sizes will be the primary gear used to capture fish for removal from lakes. Nets should be moved daily such that all available habitat is fished and avoidance behaviour may be minimized. However, since fish abundance and biomass, together with number of species, are generally highest at shallower depths, and because the largest proportion of a lake's volume also occurs in the shallower depth zones, fishing effort should be more intense in (but not exclusive to) shallower depths.

The range of mesh-sizes should be consistent across Fish-out Programs, especially for the Mark-recapture and CPUE phases. For the Mark-recapture Phase, the goal is to release fish back to the lake alive, hence 38mm (1.5") stretched mesh nets should be used in short sets (30 to 60 min) to limit gilling of fish and reduce mortalities. Gill nets used for the purpose of fish removal (CPUE and Final Removal phases) will have stretched mesh-sizes of 102 mm (4"), 76 mm (3"), 51 mm (2"), 38 mm (1½"), 25 mm (1"), and 22 mm (7/8"). During the CPUE Phase, the full range of mesh-sizes must be fished at all times; there should also be a consistent proportion of the different panels used during the CPUE Phase. The total number of panels could be increased for larger lakes and as CPUE decreases. These restrictions are not necessary during the Final Removal Phase. The proponent will ensure that there is a sufficient stock of gill nets of each mesh-size. However, cluttering the lake and having interference affecting catch rates should be avoided in small lakes.

Trap net and gill net site identifications will be drawn on a map of the lake and GPS coordinates (easting/northing) recorded on the field data sheet. Date, time of setting (24 hour clock), and time of retrieval will also be recorded for each trap net and each gill net. Water depths at the start and finish of the trap net leads and gill nets should be recorded, based preferably on field measurements (e.g., fish finder) or from a bathymetric map. Mesh sizes (gill nets) and lengths and heights (trap net leads, gill nets) should also be recorded.

Other gear.- During the Final Removal Phase, additional gear may be used (with approval of the Project Authority), to maximize the likelihood that all fish will be removed. Gill netting could, for example, focus on mesh sizes that best catch the dominant species and sizes. Active fishing methods, such as electrofishing and seining, can be effective at capturing benthic and/or less-active species. Minnow traps can be effective at capturing small-bodied fish, particularly in habitats where it is difficult to use other gear. Baited set lines or baited traps may be effective for catching burbot.

Population Estimates

The Program will provide two different estimates of fish populations, during the Mark-recapture and CPUE phases, respectively. The accuracy of these estimates will be determined from the complete censuses during the CPUE and Final Removal phases. In turn, the marked fish recaptured and removed during the latter two phases will help determining the completeness of the Fish-out Program. Procedures and calculations will follow Ricker (1975).

Mark-recapture Phase

The Mark-recapture Phase of the Program requires that a period of catch, mark, release, and recapture fishing occur prior to the Removal and Fish-out phases (Table 1). As such, mark and recapture procedures occur simultaneously over multiple days. A commonly used method to analyze such data is the Schnabel Method. Note that this method of estimating population size does not require that each individual have a unique mark.

The Mark-recapture phase should commence soon after ice out, before water temperatures above 10°C increase mortality risk. Detailed set data will be recorded for each net and trap and full biological data (see below) will be collected from fish mortalities. Due to low survival rates of whitefishes during netting and marking procedures, the Mark-recapture Phase on a particular lake may be skipped or terminated if previous or current sampling on a lake indicates an abundance of whitefishes and if the fish are not going to be sacrificed.

As described above, small-mesh trap nets and short sets of 38-mm index gill nets will be used in the Mark-recapture phase. Unbaited minnow traps could be added if there are substantial numbers of small fish present. Nets and traps will be moved regularly so that all available habitat in the lake is surveyed, albeit with the shallow-water bias noted earlier.

Partial fin clips, removing $\frac{1}{3}$ to $\frac{1}{2}$ of a fin, can be used to mark fish. It is important to minimize stress on fish and to return the marked fish to the water as soon as possible. However, live wells/holding tanks should be available during the Mark-recapture phase, as needed, to allow stressed fish some recovery time before being returned to the lake. If anaesthetic is being used, fish must be held until they have recovered from the anaesthesia.

Record the counts of all fish captured during this Phase by species and fate category (see Fish count record form). Based on prior information about the fish populations, separate mark-recapture estimates could be made on different size/age-classes (e.g., juveniles vs. adults) or sexes within (some) species; if so, clip different fins to avoid confusion, and record the

distinction. As the phase progresses, more-and-more of the fish being captured will already have been marked (i.e., will be recaptures). Although marking and recapturing a greater proportion of fish in a population will produce more precise estimates of abundance (see Ricker 1975 or Krebs 1999), it is often not practical to maximize precision for all species in a lake. The detailed protocol for the Fish-out Program should indicate *a priori* the recapture rate (e.g., 10%) that will be used as the target objective for the Mark-recapture Phase and whether the Phase will be terminated when all, half, or some other proportion of species reach that target objective.

Note: if a substantial time gap is anticipated between any of the three phases of the Fish-out Program, then a sizeable number of fish should be given more permanent, uniquely numbered marks (tags) during this Phase, which can subsequently be used to assess the effectiveness of the complete censuses during the CPUE and Final Removal phases.

CPUE Phase

The CPUE Phase should commence 3 to 7 days following completion of the Mark-recapture Phase and continue until the CPUE Phase objective is met (see below). During the CPUE Phase, there will be no physical or chemical alterations to the lakes. The “Fishing Success” (Ricker 1975) or “Removal” (Kelso and Shuter 1989) methods for estimating population sizes will be conducted during this Phase of the Program. CPUE estimators are based on the assumption that fishing effort is significant enough to reduce the population and the resulting reduction in fishing success is proportional to the stock present. During this Phase, gear *types*, including mesh-sizes and lengths of individual nets, should remain constant such that a standard “unit of effort” can be defined. However, additional units of this standard unit may be required as stocks, and hence catch rate, decrease. The following methods will be used to determine population estimates for fishes in lakes (Ricker 1975):

- **Leslie Method** - The Leslie method plots CPUE against cumulative catch. The resulting straight line provides the initial population size and catchability estimates.
- **DeLury Method** – The DeLury Method plots the logarithm of the CPUE against cumulative effort. The fitted straight line provides the initial population size and catchability estimates. The DeLury Method can also be modified to allow multiple gear types (e.g., gill nets and trap nets) or to use mark and recapture data.

During the CPUE phase, net checks could be conducted twice per day, later reduced to once per day should the catch-per-unit-effort decline sufficiently. The minimum CPUE objective is achieved when consistent declines in CPUE have been demonstrated over several days of

increasing cumulative fishing effort. There may be rapid 'selection' for net avoidance, however, reducing CPUE disproportionately relative to cumulative effort. Although moving net locations regularly (daily if possible) should help, it may be necessary to insert 1-2 day breaks of no fishing during this Phase. A more rigorous CPUE objective would be achieved when no fish are captured for 24-48 hr of continuous netting, nets are removed for 48 hr, nets are then re-deployed for 24-48 hr of netting and fish are still not captured. At this point, the CPUE Phase should be suspended; if the lake will be dewatered, this would be a time to begin, proceeding to a point where the remaining fish are sufficiently concentrated. The Program may then continue with the Final Removal Phase.

All captured fish should be removed from the lake, and either sacrificed and/or (re)distributed in accordance with any agreements between the proponent and aboriginal communities. Fish from one population should not, however, be stocked into another population. A count of all captured fish, by species (and size-class, if appropriate), must be made and recorded, along with their "fate" or category, e.g., whether the fish had previously been marked or not, and whether it was removed or escaped. The proportion of marked fish (from the Mark-recapture Phase) that was captured and removed during the CPUE Phase can be used as an index of the proportion of all fish in a population captured and removed. Biological data (see "Fish sample record" form) should be taken on every fish, if practical, or on a substantial sub-sample.

Final Removal Phase

To assess the accuracy of the population estimates, as well as to achieve the Program objective of removing all fish from the lake, a total census of the lake's fish community must be completed. Every effort should be made to capture every fish in the lake. During the CPUE Phase, the goal is to capture and remove as many fish as possible while keeping the gear types constant and effort standardized. During the Final Removal Phase, every effort will be made to capture all remaining fish in the lakes, thus, additional capture methods may be added (see "Other gear", above) . Proposed methods will be presented to, and reviewed by, the Project Authority.

After lake volume has been sufficiently reduced for lakes being 'de-watered' (possibly during the winter), the fish-out will resume. As well, the lake must be reduced to such a level that the habitat is exposed and can be photographed. There will be no physical alterations to the lake basins until the photography is completed. Once the photography is completed and the lake levels are sufficiently lowered, the Final Removal Phase can commence.

The Final Removal Phase will continue until the Removal objective is met. The objective should be presented to, and reviewed by, the Project Authority. Possible benchmarks could include the capture and removal of marked fish (fin-clips and/or numbered tags) that exceed a certain percentage (e.g., >99%) of all fish marked by that method. Another Removal objective could be based on CPUE, e.g., no fishes are captured for 48 hr of continuous sampling (with sufficient effort), sampling is halted for 48 hr, sampling then resumes for 48 hr and fish are still not captured.

Captured and removed fish should be treated as in the CPUE Phase: counted and classified, biological data (and tissues) extracted, fish sacrificed, and/or (re)distributed, in accordance with agreements.

Biological Data Collection

During the Mark-recapture Phase of the Program, fish stress and mortality must be minimized. Fish should only be marked and/or examined for marks, before being released, although full biological data should be taken from any mortalities. For each “species” (which may be only a size/age-class of a species), record only the number and category (“fate”) of all fish captured in each trap or net; see “Fish count record” data form.

During the CPUE and Final Removal Phases, however, biological data and/or samples should be collected for each fish captured. Each fish should be identified to “species”, assigned a unique fish number, weighed (0.1 g), and measured for fork length (mm) or, with species such as burbot, slimy sculpin, and sticklebacks, for total length. Record sex, maturity, and reproductive status and take appropriate aging structures from a sub-sample of the smaller, younger fishes and all of the larger, older fishes.

There may be situations where the large number of fish captured on a given day doesn’t allow for collecting complete biological data on all fish. In this case, efforts should be made to measure all fish of each species, and collect the other biological data on subsets from each size-class. Of course, all captured fish should be tallied and given a sample number, even if only measured.

Stomach (and other organ) Samples

During the CPUE phase, take a sub-sample of 50 stomachs from each “species”, distributed evenly across the size ranges of each. All samples should be labelled with the unique sample

number given to the fish from which it came. Freeze stomach samples immediately or preserve them in 10% buffered formalin. Other organs (e.g., liver, gonads) or tissue samples should be taken from these same fish, weighed to allow determination of gonado- and hepatic-somatic indices, and preserved for analyses of fecundity, or contaminant loads.

Aging Structures

Appropriate aging structures (otoliths, scales, cleithra, opercular bones, and/or finrays) should be removed from a sub-sample of the smaller, younger fishes and all of the larger, older fishes.

4.2 Aquatic Biology/Physical Limnology

One of the principle goals of the Fish-out Program is to identify fish community-environment relationships. Therefore, information about other components of the lake ecosystem must be collected. The following ecosystem components will be characterized:

- Physical Limnology
- Water Quality/Nutrients
- Chlorophyll *a*
- Zooplankton
- Benthos
- Habitat Mapping

Ecosystem sampling will be conducted during the open water season of the Program year. Permanent survey sites will be established at the deepest portions of each basin. Samples from these sites will be considered representative of the basin. Except for benthos, sampling surveys will be carried out at each site during three, equally spaced sampling visits. The benthos survey will be conducted once, during mid-August. The information to be collected is presented in the following sections.

Physical Limnology

Record wind (direction and speed), cloud cover, air temperature, and surface water temperature in the field notebook and data form comments box during *every* visit to the lake.

The following components will be carried out at each site during each of the three ecosystem site visits:

- Dissolved oxygen and temperature profiles (1-2 m intervals).
- Secchi depth.

Water Quality/Nutrients

Samples will be taken at a depth of one metre (1 m) and mid-water column. Samples will be analyzed for:

- Total phosphorus
- Total nitrogen
- Total dissolved solids
- Dissolved nutrients – ammonia, nitrate, nitrite, ortho-phosphate, silica
- Total dissolved nitrogen
- Total dissolved organic carbon

Chlorophyll *a*

Samples for Chlorophyll *a*, as an index of primary productivity, will be taken from each of the water quality/nutrient sampling locations. Samples will be handled and analyzed following standard protocols.

Zooplankton

Zooplankton is the dominant group of primary consumers in the pelagic zone and an important component of the diets of fish inhabiting that zone. Zooplankton sampling will be conducted during the water quality/nutrient sampling periods. Sampling will consist of four hauls, bottom to top per station using a 25-30 cm diameter net at least 7x longer than width with 70 to 100 micron mesh. Samples should be preserved and analyzed for total biomass and/or taxonomic composition using standard procedures.

Benthos

Macroinvertebrates are dominant consumers in the littoral and profundal zones of a lake, and important components of fish diets. Benthos samples will be taken once during mid-August. A total of 20 Ekman dredge hauls will be taken below 5 m in each basin, in areas of softer sediments, distributed amongst the following depth intervals: six between 5-10 m; four between 10-15 m; three between 15-20 m; one between 20-25 m; and one deeper than 25 m. Dredge

samples are initially washed through a 250-500 µm mesh and preserved. One dredge haul from each depth interval will be analyzed for taxonomic composition, whereas the remaining fifteen hauls will be used for biomass determinations.

4.3 Habitat Mapping

The objective of this component is to develop a detailed Geographic Information System (GIS) and habitat database for a range of Northern lakes. This component targets physical habitat and augments the data collected in the other components of the Fish-out Program. Combined, these data will provide a description of the structure and distribution of habitat in lakes, used for determining relationships of fish to habitat, and will be invaluable for use in compensation initiatives. All available habitat will be mapped in detail.

Fieldwork for this project will be conducted using ground level shoreline surveys (prior to any lake 'dewatering') and low level photogrammetric aerial photography of exposed pelagic zones (after the lake has been dewatered). Aquatic vegetation, substrate and bathymetry will be mapped during the CPUE Phase as well as during the ground level survey. A suitable habitat classification system will be applied and augmented with geo-referenced coordinates to allow for detailed habitat mapping. From these surveys, GIS maps of substrates, vegetation, depth, slope, and wave energy will be produced through a joint DFO/Proponent project to characterize the lake habitats.

5. Data Reporting

5.1 Data/Sample Analysis

Field data forms, designed to be consistent with DFO's Fish-out data-base, are provided in the Appendix for gear-set data, fish counts, and fish biological data, along with a page of codes for these forms. Data should be entered from these field sheets directly into the MS-Access data-base forms that have been specifically tailored for the Fish-out Program. The analysis of all samples, from water quality to aging structures, are the responsibility of the Proponent. All sample analyses will be conducted by qualified laboratories/personnel.

5.2 Reporting

The Proponent will provide the data resulting from the Fish-out Program in a Data Report Summary. Attempts will also be made to present and discuss the data in relation to the objectives

of the Fish-out Program. In addition to the biological and survey data, sample analyses of results will be provided. Analyses demonstrating the suitability, precision, and accuracy of the data will also be included in the Data Report Summary. The report will also include Mark-recapture and CPUE population estimates.

In addition to the report, the proponent will supply DFO with:

- Photocopies of all field data/notes
- Copies of photographs
- An electronic database in Microsoft Access of all data collected, including the results of all sample analyses.

The report will also include references and comparisons to any baseline data available for these lakes.

6. Literature Cited

- Kelso, J.R.M. and B.J. Shuter 1989. Validity of the removal method for fish population estimation in a small lake. *North American Journal of Fisheries Management* 9:471-476.
- Krebs, C.J. 1999. *Ecological Methodology*, 2nd edition. Benjamin/Cummings, Menlo Park, CA.
- Ricker, W.E. 1975. *Computation and Interpretation of Biological Statistics of Fish Populations*. Bulletin of the Fisheries Research Board of Canada 191.

7. Appendix: Sample Data Forms

Codes

Assess Code	Assessment Type
FO-MR	Fish-out: Mark-Recapture phase
FO-CPUE	Fish-out: CPUE/Removal phase
FO-FREM	Fish-out: Final Removal phase
B-line	Base line sampling
AEMP	Aquatic Effects Monitoring Program

Gear Code	Gear Type
AN	Angling
BS	Beach seine
DN	Dipnet
EF	Electrofisher
GN	Gill net
MN	Minnow trap
TN	Trap net
OT	Other

Length Code	Length
F	Fork
T	Total

Sex Code	Sex
F	Female
M	Male
U	Unknown

Maturity Code	Maturity
IM	Immature
MA	Mature
SD	Seasonal development
UN	Unknown

Reprod Code	Reprod Status
GR	Green
RI	Ripe
RU	Running
SP	Spent
UD	Undeveloped
UN	Unknown

AgeStruct Code	Aging Structure
FR	Finray
OT	Otolith
SC	Scale
NO	None
CL	Cleithrum
OP	Operculum bone

Fate Code	Fate
NR	New, released marked
NM	New, mortality
RR	Recapture, released
RM	Recapture, mortality
E	Escaped unmarked

Tissue Code	Tissue Sample
ST	Stomach
MU	Muscle
LV	Liver
EG	Eggs
GO	Gonad
NO	None

Fin Code	Fin Clip
AD	Adipose
LPc	Left Pectoral
RPc	Right Pectoral
LPv	Left Pelvic
RPv	Right Pelvic
DO	Dorsal
AN	Anal
UC	Upper Caudal
LC	Lower Caudal

Gear set data and fish sample record

Page__ of__

Lake:	Set date:	Net Length (m):	Recorder:
Assessment type:	Set time:	Net Height (m):	Comments:
Gear type:	Lift date:	Net depth (m): /	
Site ID:	Lift time:	Surface temp:	
Easting:		Mesh size(s):	
Northing:	NAD: 83 27		

[illegible]

*Total length (T) for burbot, sculpin, Stickleback sp.; Fork length (F) for all others.

Gear set data and fish sample record

Page ___ of ___

Lake:				Set date:			Net Length (m):				Recorder:			
Assessment type:				Set time:			Net Height (m):				Comments:			
Gear type:				Lift date:			Net depth (m): /							
Site ID:				Lift time:			Surface temp:							
Easting:							Mesh size(s):							
Northing:				NAD: 83 27										
Species Code	Sample No.	Mesh Size (cm)	Length (mm)* F or T	Weight (g)	Sex	Maturity Code	Reprod Status Code	Aging Struct Code	Fin Clip	Fate Code	Tissue Sample Code	Liver Weight (g)	Gonad Weight (g)	Comments

				Set date:			Net Length (m):				Recorder:			
Assessment type:				Set time:			Net Height (m):				Comments:			
Gear type:				Lift date:			Net depth (m): /							
Site ID:				Lift time:			Mesh size(s):							
Easting:				Northing:			NAD: 83 27							

				Set date:			Net Length (m):				Recorder:			
Assessment type:				Set time:			Net Height (m):				Comments:			
Gear type:				Lift date:			Net depth (m): /							
Site ID:				Lift time:			Mesh size(s):							
Easting:				Northing:			NAD: 83 27							

*Total length (T) for burbot, sculpin, Stickleback sp.; Fork length (F) for all others.

Gear set data and fish count record

Page__ of__

Lake:	Set date:	Net Length (m):	Recorder:
Assessment type:	Set time:	Net Height (m):	Comments:
Gear type:	Lift date:	Net depth (m): /	
Site ID:	Lift time:	Surface temp:	
Easting:		Mesh size(s):	
Northing:	NAD: 83 27		

Species Code	Number Captured							Comments
	Fin clip	New, released marked	New, mortality	Recapture, released	Recapture, mortality	Escaped, unmarked	Total	

Biological data for some/all fish have been recorded on Fish Sample Record. Yes__ No__

Gear set data and fish count record

Page ___ of ___

Lake:	Set date:	Net Length (m):	Recorder:
Assessment type:	Set time:	Net Height (m):	Comments:
Gear type:	Lift date:	Net depth (m): /	
Site ID:	Lift time:	Surface temp:	
Easting:		Mesh size(s):	
Northing:	NAD: 83 27		

Species Code	Number Captured							Comments
	Fin clip	New, released marked	New, mortality	Recapture, released	Recapture, mortality	Escaped, unmarked	Total	

Biological data for some/all fish have been recorded on Fish Sample Record. Yes___ No___

	Set date:	Net Length (m):	Recorder:
Assessment type:	Set time:	Net Height (m):	Comments:
Gear type:	Lift date:	Net depth (m): /	
Site ID:	Lift time:	Mesh size(s):	
Easting:	Northing:	NAD: 83 27	

Species Code	Number Captured							Comments
	Fin clip	New, released marked	New, mortality	Recapture, released	Recapture, mortality	Escaped, unmarked	Total	

Biological data for some/all fish have been recorded on Fish Sample Record. Yes___ No___

DRAFT

APPENDIX B

FISH-OUT PROGRAM FOR SECOND PORTAGE LAKE



Technical Memorandum

Date: May 30, 2008

To: Amy Liu, DFO Iqaluit

Cc: Larry Connell and Rachel Gould, Agnico-Eagle Mines Ltd. (AEM)

From: Ryan Hill and Gary Mann (Azimuth Consulting Group Inc.)

Re: Fish-Out Program for the Meadowbank Gold Project

The purpose of this memorandum is to provide details of the fish-out program for the northwest arm of Second Portage Lake (2PL), and to discuss general fish-out plans for the future Bay Zone, Goose Island and Vault Lake impoundments at the Meadowbank Gold Project.

The fish-out program is guided by the draft document “General Fish-out Protocol for Lakes to be Lost Due to Mining Development”, provided by DFO in January 2008. AEM is committed to the collection of key scientific information to help improve the understanding of fish productivity in northern lakes. To this end, and in addition to standard reporting requirements, AEM supports the publishing of relevant results in the peer-reviewed scientific literature to maximize access to the information.

The fish-out program has incorporated inputs from DFO and the local community (public presentation in Baker Lake on 16 April 2008). All dates included herein are estimates and assume that all relevant regulatory permitting is completed by 1 July 2008.

The following elements of the program are elaborated in this document:

1. Community consultation
2. Permitting
3. Personnel
4. Isolation of 2PL northwest arm.
5. Limnology
6. Mark-recapture
7. CPUE phase
8. Habitat mapping
9. Final removal
10. Reporting
11. General planning for Bay Zone, Goose Island and Vault Lake impoundments

The schedule for implementing key elements in 2PL is shown in **Table 1**. Commencement of the fish-out program is directly related to spring breakup.

1.0 Community Consultation

A presentation of the Meadowbank Gold Project Fish-Out Program for the Northwest Arm of Second Portage Lake was given to the community of Baker Lake on 16 April 2008. In addition to general questions regarding the program, one person expressed concerns regarding consuming fin-clipped fish. Informal discussions with other attendees suggested that this was not a general concern, so the program was not modified. No other concerns were raised.

2.0 Permitting

In advance of the fish-out program for the northwest arm of 2PL, AEM will seek permits from DFO (i.e., Authorization and Application for a License to Fish for Scientific Purpose); it is our understanding that a permit will not be required from the Nunavut Research Institute. Permits for the fish-out for the Bay Zone, Goose Island and Vault Lake impoundments will be sought when detailed construction plans are finalized – the fish-out program in these cases will follow the same general approach (pending any DFO-approved improvements resulting from previous fish-out operations) as that for the northwest arm of 2PL.

One of the requirements of the DFO permitting process is an estimation of the fisheries inventory that will be removed during the fish-out. This was looked at in terms of estimated abundance and biomass, as described below:

- **Estimated abundance** - Past gill net surveys in 2PL are summarized in the Baseline Aquatic Ecosystem Report (Cumberland, 2005); catches were dominated by lake trout (*Salvelinus namaycush*) (i.e., two-thirds to three-quarters of total catch), while the remainder of the catch was split between round whitefish (*Prosopium cylindraceum*) and arctic char (*Salvelinus alpinus*). Burbot (*Lota lota*) have been caught in very low numbers. Other species such as lake cisco (*Coregonus artedii*) and arctic grayling (*Thymallus arcticus*), while present in the region, have not been caught in 2PL or nearby project lakes and are not expected to be present. While caught infrequently in gill net surveys due to their small size, both slimy sculpin (*Cottus cognatus*) and nine-spine stickleback (*Pungitius pungitius*) are expected to be present.
- **Biomass** – There are a number of models that have been developed to estimate fish productivity or biomass based on a range of factors (e.g., lake morphology, nutrients, zooplankton biomass, benthos biomass, and/or morphoedaphic index). However, given the published account of the complete fish-out within the dike A154 impoundment at the Diavik mine, we extrapolated those results to derive a reasonable estimate of the potential biomass of fish in the proposed 2PL East dike impoundment. At the Diavik mine¹, the total biomass of fish caught (gill nets, trap

¹ The Diavik data may underestimate fish biomass; some fish may have left the impoundment area due to construction-related disturbance.

nets, and angling) in the impounded area was about 550 kg (McEachern et al. 2002). While not specified by McEachern et al., Azimuth Group estimates the surface area of the A154 impoundment to be roughly 1.5 km². The 2PL East dike impoundment area is 1.3 km², which we can conservatively round up to 1.5 km² to be consistent with the Diavik A154 impoundment area. Assuming a roughly proportionate relationship between surface area and biomass of fish, the estimated biomass in the northwest arm of 2PL would be approximately 550 kg.

Combining both the estimated abundance and biomass parameters together, along with additional information from the Baseline Aquatic Ecosystem Report (Cumberland 2005), we provide the following predicted breakdown of fish biomass/abundance by species:

- Lake trout: 85% of total fish biomass = 468 kg. At mean weight of 1.24 kg, this would be 377 fish. *Note* - Given the large average size of lake trout, their relative contribution to total biomass will be even larger than their contribution to total abundance.
- Arctic char: 10% of total fish biomass = 55 kg. At mean weight of 1.14 kg, this would be 48 fish.
- Round whitefish: 5% of total fish biomass = 28 kg. At mean weight of 0.50 kg, this would be 55 fish.
- Burbot, sculpin and stickleback: probably 1% or less of total biomass.

As mean fish weights were derived from past gill net data, the estimated numbers of fish in the northwest arm of 2PL do not reflect the potential catch of smaller fish in trap nets. Nevertheless, the overall biomass estimates for each species should be reasonable approximations.

3.0 Personnel

The 'Project Manager' role for the fish-out program will be shared by three senior staff from Azimuth Consulting Group. Azimuth's staff have led the aquatic monitoring program at Meadowbank since 1997. Azimuth's senior biologists (i.e., Randy Baker, Gary Mann or Ryan Hill) will be overseeing the fish-out program and at least one will be on site for the majority of its undertaking. The 'Project Biologist'(s) for the fish out program will be fisheries biologists from North/South Consultants Inc. (Winnipeg, Manitoba). All of the Project Biologists from North/South will be experienced personnel, many of which have worked in the arctic and/or previously conducted fish salvage operations. In consultation with the Project Manager, crew training, fish-out implementation, and in-field quality control will be the primary responsibility of the Project Biologist(s). Data analysis, liaison with the DFO Project Authority (i.e., Habitat Biologist, DFO Iqaluit), and reporting will be primarily the responsibility of the Project Manager.

Several field technicians will be needed for water quality sampling, fish-out activities, and boat operations. Azimuth anticipates that these field technicians will be Inuit hired

from the Baker Lake community. Training of technicians will occur during field activities to ensure that future work can occur increasingly under the direction of local people.

4.0 Isolation of 2PL Northwest Arm

The fish-out program can only be initiated once the northwest arm of 2PL has been isolated from the rest of the lake. Barring unforeseen delays, completion of the Western Channel and East dikes to the point where physical isolation has been established (i.e., installation of the rock walls) is anticipated to occur by the first week of August. However, given the short open water season (i.e., mid-July through early October), the chance of construction delays and Azimuth's desire to complete the mark-recapture and CPUE phases of the fish-out program in 2008 prior to the onset of winter weather, Azimuth proposes to use a cut-off net (i.e., barrier net) to contain fish in the northwest arm immediately after ice-out. Azimuth estimates that the additional three weeks (at least) that this strategy provides will allow us to complete the scientific components of the program in 2008 in advance of winter conditions.

Silt curtains will be deployed on both sides of the east dike footprint. The cut-off net will be set immediately upwind (northwest) of the impoundment-side silt curtain. Deployment is currently scheduled to take 8 days and be completed by July 15th 2008. The cut-off net will have the following specifications:

- **Material/mesh** – 210/40 x 1-inch stretched mesh nylon (100-lbs new break strength).
- **Length** – Given the distance across the lake at this location, there are 13 sections of 50m each for a total of 650m. Additional panels will be included as a contingency.
- **Depth** – Net depth will be sufficient to span the entire water column. The 50-m sections will vary in depth (3.5m to 8.5m) according to local bathymetry and predicted wave heights.
- **Weight** – The 50-m sections will weigh between approximately 100 and 250 kg depending on the depth.
- **Construction** - All lines will be 5/8" Poly Steel, except the bottom line which will be lead line. The top line will have 6" floats installed one after another for the entire length (50m). Sections will be joined by fastening cable ties every 10 cm top to bottom during deployment. A 3/4" rope will be used as the main line across the lake.

Net selection involved consideration of several key trade-offs. Larger mesh sizes result in nets that are less susceptible to drag (important in rough conditions), therefore reducing the chances of breaching during storm events. However, while the net material is of sufficient thickness to ensure good visibility, there is a chance that some small fish may be trapped should they attempt passage through the net. Smaller mesh sizes reduce passage or incidental capture of small fish, but result in much higher stress loading on the net structure and anchors, effectively increasing the probability of failure. The 1-inch stretched mesh size was considered a good compromise to address these trade-offs. The

sizing is from knot to knot; given the thickness of the netting material the size of the openings will be smaller (about 3/4 inch). We do not expect significant incidental fish catches (e.g., by acting as a gillnet) because the material will be much thicker, stiffer and visible than material used in gill nets. The cut-off net will be deployed only until the dike walls are completed, at which time the net will be removed.

5.0 Limnology

Limnological data will be collected once per month during July, August and September 2008, in each of the three basins located in the northwest arm of 2PL. Benthos will be collected in August only.

The July and August sampling trips will be conducted by the AEMP monitoring team that will be on-site at those times. The September sampling trip will be conducted by either the Project Manager or a Project Biologist with support from one of the fish-out teams. The fish-out crews may also assist with the benthos sampling in August depending on their availability.

The proposed data collection form for limnological data is attached as Annex B. The data to be collected include:

Water quality parameters measured in the field

- Dissolved oxygen and temperature profiles at 1m intervals in each basin during each sampling period.
- Secchi disk depth at each basin during each sampling period.

Water quality parameters to be sent for analysis to ALS Laboratory Group (ALS)

- total phosphorus
- total nitrogen
- total dissolved solids (TDS)
- dissolved nutrients (ammonia, nitrate, nitrite, ortho-phosphate, silica)
- total dissolved nitrogen
- total and dissolved organic carbon (TOC, DOC)
- chlorophyll a.

These parameters will be collected at both 1m depth and mid-water column. Water samples will be collected using a diaphragm pump with Teflon-lined tubing. Jars types and preservation will be as follows:

- 1 x 1-L plastic bottle for total phosphorus, total nitrogen, TDS, dissolved nutrients, and total dissolved nitrogen (keep cold; no preservative)
- 1 x 250-ml amber glass bottle for TOC (keep cold; preserved with hydrochloric acid).
- 1 x 250-ml amber glass bottle for DOC, unpreserved (keep cold; samples will be filtered and preserved at the lab).

- 1-L plastic bottle filtered in the field with few drops of magnesium carbonate on the filter (prior to filtration); filter to be wrapped in aluminum foil and frozen.

Given that there are three basins, three sampling events, and two depths, there will be 18 samples for each of the parameters. Samples will be sent to ALS in Vancouver, B.C. Trip blanks and field duplicates will be included as field QA/QC samples (one each per event) to augment the laboratory duplicates conducted routinely by ALS.

Zooplankton

Four vertical tows (1m from bottom to surface) for zooplankton will be taken in each of the three basins during each of the three sampling periods. The four samples will be independent field replicate samples (not composited) in order to give an understanding of variability (i.e., a total of 36 zooplankton samples will be collected – 3 basins x 3 time periods x 4 replicates). Samples will be collected using a net conforming to DFO's requirements (i.e., 25-30cm diameter net that is at least 220cm in length with 70 to 100 micron mesh). All samples will be uniquely labeled, and placed in a 10% buffered formalin solution in plastic jars. Labeling will include water proof paper labels (marked with pencil) placed inside the jars as well as permanent marker labeling on the outside of the jars. All jars will be screwed tight and taped to prevent leakage. Samples will be submitted to North/South for analysis of biomass (mg/m^3). Taxonomic composition will not be assessed as there is already considerable taxonomic information in the work completed in previous years.

Benthos

Twenty grab samples will be collected from each of the three basins, in August only. Fifteen samples will be collected for benthic community biomass analysis across a range of depth intervals: six will be collected in the 5-10m depth interval; four in the 10-15m interval; three in the 15-20m interval; and one in each of the 20-25m and >25m intervals. Five samples, one from each of the depth intervals listed above, will be collected for taxonomic analysis. Each grab sample will be washed through a 500-micron sieve, then placed in a 10% buffered formalin solution in plastic jars. Labeling will include water proof paper labels placed inside the jars as well as permanent marker labeling on the outside of the jars. All jars will be screwed tight and taped to prevent leakage. Given that there are three basins, there will be a total of 15 benthos samples for taxonomy, and 45 benthos samples for biomass. The samples for taxonomy will be sent to Zaranko Environmental Assessment Services and the samples for biomass will be sent to North/South.

The DFO Protocol calls for use of an Ekman grab. In Azimuth's experience, an Ekman grab is too light to work effectively in the often windy conditions prevailing in the project lake area. Consequently, Azimuth proposes to use a Petite-Ponar grab, which covers the same surface area (6" x 6") as an Ekman grab, but is heavier and therefore easier to control at depth prior to deployment in the sediments. While the volume of a Petite Ponar is less than the Ekman (i.e., 2.4 L compared to 3.5 L, respectively), the latter is unlikely to penetrate deeper into sediments than the Petite Ponar, thus making this extra volume inconsequential.

6.0 Mark-Recapture

In accordance with the DFO fish-out protocol, Azimuth proposes to begin a mark-recapture phase as soon after ice-out as possible, once the cut-off net is in place (see Section 4).

Azimuth will use two types of fish capture methods for this phase:

- Trap nets - two trap nets² will be set perpendicular to shore targeting fairly shallow areas where smaller fish would be expected.
- Gill nets – only 38-mm index gill nets will be used for this phase. Each boat crew should be able to fish with 4 to 8 net panels, set only for a short time (i.e., 30 to 60 minutes). Gill nets will be moved around to set to cover a range of habitats.

All nets and traps will be moved regularly (every day or two) to cover all available habitats, with an emphasis towards shallow water habitats. Partial fin clips will be used to mark fish, without the use of antiseptic. We propose to mark lake trout (the most abundant species) and arctic char. A consistent series of fins (e.g., adipose then left pelvic then right pelvic) will be clipped to distinguish multiple captures of the same fish. We do not plan to mark slimy sculpin, nine-spine stickleback or burbot as their contribution to total fish biomass is expected to be extremely small (see Section 1). We also do not plan to mark round whitefish because they are known to have reduced survival rates after marking. When necessary, bins or holding tanks will be used to give stressed fish some recovery time prior to release back into the lake.

Details of each set will be recorded using the fields provided in the forms appended to the DFO Protocol. We propose to combine the two forms “Gear Set Data and Fish Sample Record” and “Gear Set Data and Fish Count Record” so that the set data only need to be recorded once. In effect, the form will have 3 elements – an initial section with set data, a second section with fish count data by species, and a third section with detailed biological information for mortalities. In the case of lake trout, we will divide the fish count data into categories based on length (<35cm; 35-65cm; >65cm) in an attempt to gather rough age-class data. Baseline data for 2PL indicated that lake trout have followed a slightly bimodal distribution, with a peak at around 30cm and another around 50cm (Cumberland 2005 – Baseline Aquatic Ecosystem Report). A summary of the changes we propose for the field data collection forms is provided in Annex A.

Fish that do not survive during the mark-recapture phase will undergo a biological assessment (see next paragraph) before being placed in freezers and, later, made available

² DFO's trap nets were unavailable for use in the Meadowbank program. Trap net designs were modified slightly from those described in the DFO General Fish Out Protocol. Specifications for our trap nets: house and leads are to be constructed with the same material (6-mm square mesh), house (1.23 x 1.23 x 1.23 m), center lead (2 x 100 foot pieces for a total of 200 feet; 1.83 m depth), side leads (30 feet x 1.83 m depth).

to the local community. It is anticipated that the community will use larger fish for human consumption and smaller fish for dog food.

Biological assessments will be limited to fish mortalities. This will enable us to limit the physical damage to fish that are designated for distribution within the community (i.e., maintain aesthetics). We will record species; weight; fork length (total length for slimy sculpin, stickleback and burbot) for every fish. We will also physically “milk” each fish to identify, where possible, sexually active males or females. More detailed biological assessment (e.g., aging structures, etc.) of a subset of fish will take place during the CPUE phase.

The mark-recapture phase will continue until the 2-day moving average recapture rate of marked and released fish is 10%, or to a maximum duration of 14 days. After 7 days, if it seems there is a possibility that we will not reach the 10% threshold, we will consider increasing the mark-recapture effort for the remaining 7 days, either by increasing the number of sets, establishing a night shift to capture fish that are more active at night, and (if necessary) bringing in additional staff to allow round-the-clock efforts. The final decision to end the mark-recapture phase will be made in consultation with DFO.

The 10% threshold will apply to the combined data for lake trout and arctic char, as well as to lake trout individually. We do not propose to apply the 10% threshold to arctic char separately – there is likely to be significant imprecision for char as their contribution to total fish biomass is much less than for lake trout.

If for some reason the cut-off net does not work as planned, thus delaying the start of the fish-out until the dike rock walls are completed, we would propose that, in consultation with DFO, the mark-recapture phase be omitted, in order to ensure that the CPUE phase can be completed as planned in 2008.

7.0 CPUE Phase

Following the DFO Protocol’s recommended minimum 3-day break after the completion of the mark-recapture phase, we will begin the CPUE phase of the fish-out program using the same two trap nets, plus gill nets of stretched mesh sizes 126, 102, 76, 51, 38, and 25mm (this differs slightly from the DFO Protocol in that the 126mm panel replaces a 22mm panel; the change was made to more closely match the mesh size range used in baseline studies). The mesh sizes will be fished in constant proportions, with an increasing total number of nets/panels deployed as CPUE declines over time. The panels will be 6 ft (1.8 m) deep by 25 yds (22.7 m) long, so that the maximum length of a six-panel gang would be 150 yds (136.4 m). Nets will be moved every day or two to ensure coverage of the all areas of the northwest arm.

In addition to the two types of nets, angling gear will be on hand, time permitting, to target large lake trout in the deeper basins. Based on the Diavik results (McEachern et al. 2002), we do not expect high catch rates but may be able to catch a few large individuals that provide significant food value per fish.

The Diavik results (McEachern et al. 2002) also found minnow traps to be largely ineffective. Notwithstanding, they will be on hand to use as a supplementary measure to the trap nets if needed.

All data from sets will be recorded using the same form used during the mark-recapture phase. The fish count data will be much simpler since no fish will be released. All captured fish will be identified to species, weighed and measured for fork length (total length in the case of burbot, sculpin and stickleback). We will also physically “milk” each fish to identify reproducing males or females. More detailed biological assessment will be conducted for a subset of fish as:

- **Aging structures**³ will be taken from 150 fish (50 arctic char, 50 round whitefish, 50 lake trout) across a range of expected size classes. These same fish will be subject to more invasive measurements/sampling (see below). Unless deemed acceptable for consumption by the community, these fish will be provided to the Meadowbank camp for use as food (or used as dog food by the community).
- **Stomach contents** will be collected from the same 150 fish. We will either analyze stomach contents in the field (e.g., whole fish can easily be counted) or preserve them if more detailed analysis is needed. In the latter case, samples will be uniquely labeled (and associated with a uniquely identified fish), and placed in a 10% buffered formalin solution in whirl-pac bags. Stomach contents will be processed on site by a biologist or sent to North/South in Winnipeg.
- **Detailed internal and external examinations** will be conducted on each of the 150 fish to determine sex, reproductive status, parasite presence, and overall apparent health (e.g., DELT - deformities, erosions, lesions or tumours).
- **Gonad weights and fecundity** (female only) will also be measured for the same 150 fish. Ovaries will be preserved in buffered formalin (or modified Gilson’s solution) and analyzed for fecundity (on site or at North/South in Winnipeg), where a subsample of at least 100 eggs will be weighed to allow the estimation of the total number of eggs.
- **Liver weights and metals** samples will also be taken. Livers will be weighed in their entirety and a subset of the 150 livers will be frozen for shipment to ALS for analysis.
- **Tissue metals** samples (including mercury), while not required in the DFO Protocol, will be collected from a subset of the 150 fish, frozen and shipped to ALS for analysis.

Fish guts not retained for analytical sampling will be incinerated on site, as requested by DFO.

CPUE data will be analyzed daily using both the Leslie and DeLury methods. Raw data and graphs will be sent to DFO daily (as available) by email or posted to an AEM ftp site.

³ The aging structures will be both otoliths and fins for lake trout and char, and will be otoliths only for burbot and whitefish. No aging structures will be collected from sculpins or sticklebacks.

We propose that the CPUE phase be ended when: (a) there has been a consistent, statistically significant (e.g., $p < 0.10$) decline over a 10-day or greater period (for at least one of the two CPUE methods) for gill nets and for trap nets; and (b) overnight sets are catching very few fish regardless of the location of deployment. This decision will be made in consultation with DFO.

8.0 Habitat Mapping

After dewatering has been sufficient enough to expose the habitat (expected summer 2009), and after snowmelt has occurred, low level photogrammetric aerial photographs will be taken to document the habitat. The aerial photos will enable us to confirm earlier estimates of habitat quality in the impounded area, and will allow derivation of a relationship between habitat area and fish biomass. These relationships could be extrapolated to provide information about the expected value of any reconstructed fish habitat features in terms of fish biomass production.

The aerial photography is expected to occur in July 2009. There will have been no physical alteration of the impounded arm with the exception of the stormwater dike, which will be installed during the early winter months of 2009. The footprint of that dike is relatively small, and occurs in water that is less than 4m below current water levels. The substrate and habitat value of this area (and any areas less than 6m depth) has already been evaluated⁴ by stereoscopic interpretation of pairs of 1:10,000 colour aerial photos, visual observations, and groundtruthed using underwater video cameras.

9.0 Final Removal

Final removal will take place after ice-out in 2009, sometime between July and September (exact dates to be determined). During this phase, gill nets, trap nets, seine nets and/or angling will be used to capture all remaining fish. We will also consider using electrofishing as an option, but will not make a final decision on that until after the catch data from the CPUE phase are evaluated (i.e., depending on the number of fish we expect to remain after the CPUE phase, and their expected distribution spatially and vertically).

We do not expect to be able to recover all marked fish because: (a) smaller marked fish may be eaten by larger fish during the time year between marking and final removal, particularly as fish become more concentrated during dewatering; (b) other natural mortality may occur over the period; and (c) stress-related mortality may occur from the marking event.

⁴ Habitat mapping of the project lakes has already been completed as part of the environmental assessment for the mine (i.e., to support baseline monitoring and the development of habitat compensation plans).

Consequently, although we will track total recovery of marked fish, the removal objective will be based primarily on catch data. That is, we will continue with the removal phase until either:

1. no fish are caught for 48 hours, and then after a 24 hour break, no fish are caught for an additional 48 hours; or
2. catch has declined to near zero and the total catch has reached at least 95% of the estimated initial abundance from the CPUE data.

All captured fish will be identified to species, weighed and measured for fork length (total length in the case of burbot, sculpin and stickleback). We will also physically “milk” each fish to identify reproducing males or females. More detailed biological assessment will be conducted only if the numbers targeted for detailed assessment were not achieved during the CPUE phase.

10.0 Data Analysis and Reporting

According to the DFO Protocol, DFO has developed data input forms to match the data collected during fish-out activities. We will use these forms to enter the field data into an MS Access database. If for some reason the database is not made available, we will enter the data into an MS Access data table directly, using the codes provided in the Protocol. Data entry will not be finalized until all results are available.

Data analysis and reporting will include an interpretative report as well as raw data tables (in appendices) and summary statistics of data (in tables and/or figures). Specifics will include, but not be limited to, the following:

- Introduction and objectives, including inputs from the community
- Review of methodology, including maps showing where gear was placed.
- Analysis of mark-recapture data using the Schnabel method, including best estimates of population sizes and consideration of uncertainty.
- Analysis of CPUE data according to the Leslie and DeLury methods, including best estimates of population sizes and consideration of uncertainty.
- Analysis of limnological data
- Comparison of fish and limnological data to baseline data collected for 2PL and other area lakes
- Copies of field data sheets and photographs (as appendices)
- Copies of lab reports (as appendices)

11.0 General Planning for Other Fish-Outs

Construction scheduling for the Bay Zone, Goose Island and Vault Lake impoundments are not yet finalized. We propose to take the same approach to fish-out at these impoundments as will be used for the northwest arm of 2PL, with the exception of DFO-approved changes incorporated from any previous fish-out activities (i.e., adopting the adaptive management approach integral to managing all aspects of the environment at the

site). While the spirit of this protocol will be followed, specific details may vary depending on the situation; these will be identified and provided to DFO for review once construction schedules are known.

Table 1. Schedule for fish-out of the Northwest Arm of Second Portage Lake, Meadowbank Project.

	Timing							Approximate Dates
	Feb-Jun 2008	July 2008	Aug 2008	Sept 2008	Oct 2008	Nov 2008-Jun 2009	July-Dec 2009	
Permitting	X							As soon as possible
Field gear acquisition	X							As soon as possible
Isolation of 2PL (NW arm)		X						July 7-15, 2008
Mark recapture		X						July 16-28, 2008
Limnology		X	X	X				July – Sep, 2008
Dike construction monitoring		X	X	X				July – Oct, 2008
CPUE phase			X	X				Aug 1 to Sep 30, 2008
Dewatering and monitoring					X	X		Start Oct 10, 2008
Final removal							X	July / August 2009
Habitat mapping							X	July / August 2009
Reporting							X	Sept – Dec 2009

Annex A. Proposed Changes to Field Data Collection Forms

The draft DFO fish out Protocol includes two data forms for recording information on net sets, fish counts and fish samples. We propose to follow the forms as provided with the following modifications:

1. Two forms would be combined into one, to avoid duplication of the information regarding the set. Thus the form would have three sections – one on the set and general information, one on fish count categories, and one on biological data for individual fish.
2. The current form has one field for depth. We propose to add more detail by specifying depth at each end of the set.
3. For fish count data, we will divide lake trout into three size categories (<35cm; 35-65cm; and >65cm).
4. The Protocol recommends using the ‘comments’ box to record wind (direction and speed), cloud cover, air temperature and surface water temperature. We propose to specify individual fields for these parameters to ensure that they are recorded.

In addition, each boat crew will carry a map of the impounded arm (clean copy each day) and indicate the location & direction of each set.

APPENDIX C

BENTHIC INVERTEBRATE ABUNDANCE (NUMBER PER GRAB SAMPLE), NW ARM OF SECOND PORTAGE LAKE, 2008



Appendix C. Benthic invertebrate abundance (number per grab sample), NW Arm of Second Portage Lake, 2008.

Station Replicate	Northwest Basin		Middle Basin					Southeast Basin		
	NW-Z1-T1	NW-Z2-T1	MB-Z1-T1	MB-Z2-T1	MB-Z3-T1	MB-Z4-T1	MB-Z5-T1	SE-Z1-T1	SE-Z2-T1	SE-Z3-T1
ROUNDWORMS										
P. Nemata	1	-	-	10	-	1	1	1	1	-
ANNELIDS										
P. Annelida										
WORMS										
Cl. Oligochaeta										
F. Tubificidae										
immatures with hair chaetae	-	-	1	-	-	-	-	-	-	-
F. Lumbriculidae										
<i>Lumbriculus</i>	-	-	2	-	-	-	-	-	-	-
ARTHROPODS										
P. Arthropoda										
MITES										
Cl. Arachnida										
O. Acarina	1	-	1	3	-	1	-	-	-	-
SEED SHRIMPS										
Cl. Ostracoda	2	-	-	-	-	-	-	-	-	-
INSECTS										
Cl. Insecta										
TRUE FLIES										
O. Diptera										
MIDGES										
F. Chironomidae										
S.F. Chironominae										
<i>Micropsectra</i>	-	2	-	-	1	-	-	1	-	-
<i>Paracladopelma</i>	-	-	-	1	-	-	-	-	-	-
<i>Stictochironomus</i>	-	1	-	-	-	-	-	-	-	-
<i>Tanytarsus</i>	-	-	-	1	-	-	-	-	-	-
S.F. Diamesinae										
<i>Protanypus</i>	-	-	1	1	1	1	-	-	-	-
S.F. Orthocladiinae										
<i>Heterotrissocladius</i>	1	-	1	5	-	-	6	1	-	1
<i>Mesocricotopus</i>	-	-	-	2	-	-	-	1	-	-
<i>Parakiefferiella</i>	1	-	1	-	-	-	-	-	-	-
<i>Psectrocladius</i>	1	-	-	-	-	-	-	-	-	-
<i>Zalutschia</i>	4	2	3	-	-	-	-	1	-	-
S.F. Prodiamesinae										
<i>Monodiamesa</i>	2	1	2	-	-	-	-	-	-	-
S.F. Tanypodinae										
<i>Procladius</i>	4	-	1	1	3	-	-	1	-	-
MOLLUSCS										
P. Mollusca										
CLAMS										
Cl. Bivalvia										
F. Sphaeriidae										
<i>Cyclocalyx/Neopisidium</i>	5	2	14	1	10	2	3	6	1	4
TOTAL NUMBER OF ORGANISMS ¹	19	8	27	15	15	4	9	11	1	5
TOTAL NUMBER OF TAXA ¹	8	5	10	8	4	3	2	6	1	2

Notes:

¹ Number of organisms and taxa totals exclude nematodes and ostracods.

APPENDIX D

DOCUMENTATION OF DETAILED BIOLOGICAL ASSESSMENT (DBA) FISH DATA



Appendix D. Documentation of detailed biological assesement fish data.

Pull Date	Gill Net ID	Species	Sample ID	Length (mm)	Weight (g)	Condition Factor (K)	Sex	Maturity Code	Reproductive Status Code	Age (yr)	Weight Stomach with Contents (g)	Weight Stomach Contents (g)	Weight of food/Weight of fish (%)	Ovary weight (g)	Weight of 100 eggs (g)	Total # eggs	GSI (%)	Liver Weight (g)	HSI (%)	Liver metals sample? Y/N	Tissue metals sample? Y/N	Isotope Analysis		Metals Analysis? Y/N		Comments (incl. results of internal / external examinations incl. DELT)
																						δ ¹³ C (‰)	δ ¹⁵ N (‰)	Muscle	Liver	
22-Aug-08	999PM	ARCH*	10	527	1625	1.11	F	MA	RU	8	13.87	0	0	172.64	6.4	2685	11	32.38	2.0	Y	Y			N	N	heavily parasitized in gut, no stomach contents
22-Aug-08	995PM	ARCH	6	420	675	0.91	F	MA	UD	10	13.68	2.57	0.4	2.54	0.16	1588	0.38	7.39	1.1	Y	Y	-26.32	8.04	Y	Y	lesion on chin, cysts, fat
22-Aug-08	999PM	ARCH	18	500	1500	1.20	F	MA	UD	11	12.13	2.02	0.1	7.69	0.48	1602	0.51	14.26	1.0	Y	Y			N	N	healthy, parasite in brain
22-Aug-08	997PM	ARCH	7	450	1100	1.21	F	MA	UD	12	11.02	1.33	0.1	6.6	0.18	3667	0.60	8.22	0.75	Y	Y			Y	Y	healthy
22-Aug-08	997PM	ARCH	11	445	1100	1.25	F	MA	UD	8	12.83	0	0	6.88	0.27	2548	0.63	9.93	0.90	Y	Y			N	N	healthy, fat, no stomach contents
22-Aug-08	997PM	ARCH	9	485	900	0.79	F	MA	UD	10	10.58	0	0	9.36	0.27	3467	1.0	9.34	1.0	Y	Y	-19.44	9.01	N	N	healthy, no stomach contents
22-Aug-08	997PM	ARCH	8	485	1275	1.12	F	MA	UD	9	12.64	0	0	182.17	7.6	2394	14	24.19	1.9	Y	Y	-29.14	8.06	N	N	healthy, parasite in brain, no stomach contents
23-Aug-08	997AM	ARCH	5	485	1150	1.01	M	MA	UD	9	15.73	0.93	0.1					9.44	0.82	Y	Y	-26.97	7.96	Y	Y	healthy
27-Aug-08	1004AM	ARCH	1	475	1250	1.17	F	MA	RI	10	22.0	4.00	0.3	1.38	9.0	15	0.11	19.00	1.5	Y	Y			N	N	healthy, tapeworm in stomach
27-Aug-08	1002AM	ARCH*	34	174	50	0.95	F	MA	RU	6	1.79	0.26	0.5	8.81			18	0.54	1.1	Y	Y			Y	Y	healthy, only 86 eggs total
27-Aug-08	1002AM	ARCH	21	464	1002	1.00	F	MA	UN	9	39.0	10	1.0	6	0.30	2000	0.60	10	1.0	Y	Y	-28.32	8.10	N	N	healthy, couple of parasites, could be F1, F2, F5
27-Aug-08	1002AM	ARCH	3	445	1100	1.25	F	MA	UN	12	33.0	8.0	0.7	7			0.64	9	0.82	Y	Y	-27.94	8.20	N	N	healthy, ovaries very undeveloped therefore only total weight, could be F1, F2, F5
27-Aug-08	1002AM	ARCH**	16	--	--	--	F	MA	UN	11	32.0	5	0.36	10.76	0.99	1087	0.77	10	0.71	Y	Y			N	N	healthy, weight&length are NOT consistent, could be F1, F2, F5
27-Aug-08	1002AM	ARCH	13	210	100	1.08	M	IM	UD	2	4.52	1.37	1.4					0.98	1.0	Y	Y	-27.01	7.32	Y	Y	healthy, few cysts
27-Aug-08	1002AM	ARCH	32	504	1300	1.02	M	MA	RI	11	28	10	0.8					9	0.69	Y	Y	-27.64	8.43	N	N	healthy
27-Aug-08	1002AM	ARCH	45	550	1850	1.11	M	MA	RI	14	20	3	0.2					14	0.76	Y	Y	-27.64	8.33	Y	Y	healthy, couple of parasites
27-Aug-08	1002AM	ARCH	37	502	1450	1.15	M	MA	RI	10	40	12	0.8					12	0.83	Y	Y			N	N	healthy, parasite in stomach
29-Aug-08	2001AM	ARCH	17	257	180	1.06	F	IM	UD	4	7	3	1.7					1.7	0.94	Y	Y			N	N	healthy
29-Aug-08	2002AM	ARCH*	12	514	1680	1.24	F	MA	RI	13	18	2	0.1	237	6.0	3950	14	32	1.9	Y	Y	-27.85	8.24	N	N	healthy, few parasites
29-Aug-08	1009AM	ARCH*	28	502	1500	1.19	F	MA	RU	12	21	0	0	216	7.0	3086	14	23	1.5	Y	Y			N	N	healthy, no stomach contents
29-Aug-08	2001AM	ARCH	18	330	390	1.09	M	IM	UD	6	15	4	1.0					4	1.0	Y	Y	-28.87	7.83	N	N	healthy, few parasites
29-Aug-08	1008AM	ARCH	12	554	2150	1.26	M	MA	RI	12	32	8	0.4					16	0.74	Y	Y			N	N	healthy
29-Aug-08	1008AM	ARCH	19	172	58	1.14	M	MA	RI	9	1.7	2.3	4.0					0.45	0.78	Y	Y			N	N	some parasites
30-Aug-08	1011AM	ARCH	5	253	200	1.24	F	IM	UD	4	6.5	3.0	1.5	0.27			0.14	2.0	1.0	Y	Y	-27.35	8.01	Y	Y	healthy
30-Aug-08	1012AM	ARCH	5	373	550	1.06	F	IM	UD	7	17.3	3.5	0.6					5.6	1.0	Y	Y	-27.61	7.66	N	N	healthy
30-Aug-08	1011AM	ARCH	20	285	300	1.30	M	IM	UD	4	11.6	5.8	1.9					3.0	1.0	Y	Y	-27.26	7.51	N	N	healthy
30-Aug-08	1011AM	ARCH	10	564	2250	1.25	M	MA	RI	13	27.1	3.45	0.2					15	0.67	Y	Y	-28.32	8.32	N	N	healthy, few parasites
30-Aug-08	1010AM	ARCH	6	565	1975	1.10	M	MA	RI	12	24	4.0	0.2					14	0.71	Y	Y			N	N	healthy
30-Aug-08	2006AM	ARCH	2	521	1650	1.17	M	MA	RU	10	25.2	3.6	0.2					13.5	0.82	Y	Y			N	N	healthy
30-Aug-08	1010AM	ARCH	2	534	1625	1.07	M	MA	RU	16	24.7	4.2	0.3					15.32	0.94	Y	Y			N	N	healthy, lots of parasites
31-Aug-08	1014AM	ARCH	14	198	75	0.97	F	IM	UD	3	2.7	1.7	2.3	0.1			0.13	0.8	1.1	Y	Y			N	N	healthy, some parasites
31-Aug-08	2007AM	ARCH	9	253	150	0.93	F	IM	UD	4	6.5	3.0	2.0	0.2			0.13	1.9	1.3	Y	Y	-27.28	7.49	N	N	healthy
31-Aug-08	2007AM	ARCH	29	155	39	1.05	F	IM	UD	2	1.8	2.1	5.4					0.43	1.1	Y	Y			N	N	healthy
31-Aug-08	1014AM	ARCH	18	200	100	1.25	F	IM	UD	2	5.4	3.3	3.3					1.6	1.6	Y	Y			N	N	healthy
31-Aug-08	1014AM	ARCH	34	525	1700	1.17	F	MA	RI	10	48	9	0.5	11	0.40	2750	0.65	16	0.94	Y	Y	-26.73	8.38	N	N	healthy, 100 eggs were estimated - eggs too small to count
31-Aug-08	2007AM	ARCH	1	295	275	1.07	F	MA	UN	4	9.9	4.1	1.5	0.40			0.15	2.5	0.9	Y	Y	-27.80	7.48	N	N	healthy, some parasites, could be F1, F2, F5
31-Aug-08	1014AM	ARCH	6	287	250	1.06	M	IM	UD	4	10.1	5.4	2.2					2.2	0.88	Y	Y			Y	Y	healthy
31-Aug-08	1015AM	ARCH	7	538	1750	1.12	M	MA	RI	11	22.1	2.8	0.2					11.5	0.66	Y	Y			N	N	healthy
31-Aug-08	1014AM	ARCH	4	232	100	0.80	M	MA	RI	6	4.8	2.4	2.4					1.25	1.3	Y	Y	-23.41	8.60	N	N	healthy
31-Aug-08	1014AM	ARCH	9	244	150	1.03	U	IM	UD	3	3.5	2.0	1.3					1.3	0.87	Y	Y			N	N	healthy
31-Aug-08	2008AM	ARCH	16	117	27	1.69	U	IM	UD	3	2	2	7.4					0.45	1.7	Y	Y			N	N	healthy
1-Sep-08	2011AM	ARCH	4	389	700	1.19	F	MA	UD	6	25.0	7.4	1.1	1.8	0.25	720	0.26	6.0	0.86	Y	Y	-2				

Appendix D. Documentation of detailed biological assesement fish data.

Pull Date	Gill Net ID	Species	Sample ID	Length (mm)	Weight (g)	Condition Factor (K)	Sex	Maturity Code	Reproductive Status Code	Age (yr)	Weight Stomach with Contents (g)	Weight Stomach Contents (g)	Weight of food/Weight of fish (%)	Ovary weight (g)	Weight of 100 eggs (g)	Total # eggs	GSI (%)	Liver Weight (g)	HSI (%)	Liver metals sample? Y/N	Tissue metals sample? Y/N	Isotope Analysis		Metals Analysis? Y/N		Comments (incl. results of internal / external examinations incl. DELT)
																						δ ¹³ C (‰)	δ ¹⁵ N (‰)	Muscle	Liver	
24-Aug-08	004AM	LKTR	29	869	7500	1.14	F	MA	UD		191.87	0	0	116.74	0.45	25942	1.6	101	1.3	Y	Y			N	N	has some larger eggs, no stomach contents
24-Aug-08	006AM	LKTR	18	905	10900	1.47	M	MA	RU	23	260	0	0					137.4	1.3	Y	Y			N	N	parasitic cysts, no stomach contents
27-Aug-08	1005AM	LKTR	9	284	300	1.31	F	IM	UD	9	11.77	4.28	1.4	0.19			0.063	2.95	0.98	Y	Y	-23.32	9.81	N	N	healthy, only 1 undeveloped ovary weighed
27-Aug-08	1005AM	LKTR	2	245	150	1.02	F	IM	UD	8	8.19	3.16	2.1	0.22			0.15	1.42	0.95	Y	Y	-24.17	10.0	Y	Y	undeveloped ovaries, healthy
27-Aug-08	1005AM	LKTR	4	240	150	1.09	F	IM	UD	7	6.45	1.85	1.2					1.34	0.89	Y	Y			N	N	healthy, some parasites
27-Aug-08	1004AM	LKTR	12	235	150	1.16	F	IM	UD	7	9.74	3.86	2.6					1.56	1.0	Y	Y			N	N	some cysts, healthy
27-Aug-08	1002AM	LKTR	1	660	3150	1.10	F	MA	UN	20	211	129	4.1	12	2.0	600	0.38	48	1.5	Y	Y	-20.96	12.2	Y	Y	parasitic cysts, could be F1, F2, F5
27-Aug-08	1004AM	LKTR	13	411	800	1.15	F	MA	UN	15	39	14.7	1.8	6.1	0.80	763	0.76	5.9	0.74	Y	Y			N	N	healthy, ovaries undeveloped so 100 eggs was estimated, could be F1, F2, F5
27-Aug-08	1002AM	LKTR	33	516	1500	1.09	F	MA	UN	23	41.2	0	0	14.4			0.96	14.7	0.98	Y	Y	-20.36	11.1	Y	Y	undeveloped ovary, could be F1, F2, F5
27-Aug-08	2000AM	LKTR	1	435	900	1.09	F	MA	UN	16	17	6	0.7	9	0.71	1268	1.0	8	0.89	Y	Y			N	N	healthy, could be F1, F2, F5
27-Aug-08	1005AM	LKTR	3	240	150	1.09	M	IM	UD	8	5.38	0.88	0.6					1.32	0.88	Y	Y	-25.45	8.87	N	N	healthy
27-Aug-08	1004AM	LKTR	2	245	150	1.02	M	IM	UD	7	11.36	5.10	3.4					1.52	1.0	Y	Y	-22.56	8.89	N	N	a lot of parasites
27-Aug-08	1002AM	LKTR	49	944	9100	1.08	M	MA	RI	36	1000	119	1.3					103	1.1	Y	Y			N	N	
27-Aug-08	1004AM	LKTR	21	435	900	1.09	M	MA	UD	14	29.3	8.3	0.9					6.9	0.77	Y	Y			Y	Y	some parasites
27-Aug-08	1002AM	LKTR	47	695	3650	1.09	M	MA	UD	28	76.4	0	0					33.7	0.92	Y	Y	-23.37	12.2	Y	Y	healthy
27-Aug-08	1002AM	LKTR	2	461	2950	3.01	M	MA	UD	21	226	110	3.7					42	1.4	Y	Y			N	N	healthy, some parasites, weight&length are NOT consistent
27-Aug-08	1005AM	LKTR	10	174	50	0.95	U	IM	UD	6	2.54	0.9	1.8					0.56	1.1	Y	Y	-24.91	9.55	Y	Y	tapeworms & cysts
29-Aug-08	1007AM	LKTR	10	397	625	1.00	F	IM	UD	14	25.5	7.0	1.1	2.65			0.42	5.0	0.80	Y	Y			Y	Y	eggs very undeveloped therefore only total weight, tapeworms in stomach
29-Aug-08	1007AM	LKTR	6	193	78	1.08	F	IM	UD	6	5.3	4.0	5.1					1.0	1.3	Y	Y	-23.23	9.26	N	N	healthy
29-Aug-08	1007AM	LKTR	2	176	65	1.19	F	IM	UD	4	3.5	2.7	4.2					7		Y	Y			N	N	some parasites; liver weight outlier
29-Aug-08	1009AM	LKTR*	4	443	1025	1.18	F	MA	RU	18	21.4	2.5	0.2	47.3	22	211	4.6	9.4	0.92	Y	Y	-23.44	9.17	N	N	eggs spewed in boat too!
29-Aug-08	1009AM	LKTR*	9	482	1125	1.00	F	MA	RU	19	28	3.8	0.3	126.8	12	1075	11	14.6	1.3	Y	Y	-25.26	11.7	Y	Y	
29-Aug-08	1009AM	LKTR*	21	460	1225	1.26	F	MA	RU	14	30.3	7.5	0.6	178.6	11	1624	15	18.0	1.5	Y	Y	-24.90	10.6	Y	Y	healthy
29-Aug-08	2003AM	LKTR	10	449	1050	1.16	F	MA	UN	17	37.0	2.8	0.3	13.7	1.4	1015	1.3	8.5	0.81	Y	Y	-25.25	10.7	Y	Y	stomach parasite, could be F1, F2, F5
29-Aug-08	1008AM	LKTR	9	460	1050	1.08	F	MA	UN	18	42	10.9	1.0	17.5	0.90	1944	1.7	7.45	0.71	Y	Y			N	N	lots of stomach parasites, could be F1, F2, F5
29-Aug-08	2001AM	LKTR	11	450	1070	1.17	F	MA	UN	17	56.2	24.7	2.3	21.0	0.80	2625	2.0	11.0	1.0	Y	Y	-25.36	10.8	N	N	healthy, some parasites, could be F1, F2, F5
29-Aug-08	1007AM	LKTR	1	472	1090	1.04	M	IM	UD	17	36	10	0.9					6	0.55	Y	Y	-24.20	10.4	N	N	healthy, some parasites
29-Aug-08	1009AM	LKTR	3	421	890	1.19	M	MA	RI	15	17	2.6	0.3					5.2	0.58	Y	Y	-23.28	9.54	N	N	healthy, some parasites
29-Aug-08	1009AM	LKTR	8	460	1050	1.08	M	MA	RI	21	29.6	2.5	0.2					7	0.67	Y	Y			N	N	healthy
29-Aug-08	1009AM	LKTR	2	475	1300	1.21	M	MA	RI	16	34.5	4.2	0.3					10	0.77	Y	Y	-24.76	10.3	N	N	parasites & cysts, only ONE otolith
29-Aug-08	1009AM	LKTR	1	417	875	1.21	M	MA	RI	18	21.7	1.9	0.2					7	0.80	Y	Y			N	N	healthy
29-Aug-08	1009AM	LKTR	5	416	800	1.11	M	MA	RI	15	18.5	3.3	0.4					12.8	1.6	Y	Y	-26.31	9.08	N	N	some parasites
29-Aug-08	1007AM	LKTR	3	205	86	1.00	U	IM	UD	5	5.4	3.9	4.5					1.0	1.2	Y	Y			N	N	healthy, lots of parasites
30-Aug-08	1010AM	LKTR	7	785	5950	1.23	M	MA	RI	26	327	121	2.0					84	1.4	Y	Y	-22.22	13.0	Y	Y	lots of parasites
31-Aug-08	1014AM	LKTR	32	451	1100	1.20	F	MA	UN	17	40.6	11.2	1.0					11.5	1.0	Y	Y			N	N	some parasites, could be F1, F2, F5
1-Sep-08	1016AM	LKTR	2	892	8100	1.14	F	MA	UD	27	306	20	0.2	99	0.65	15231	1.2	95	1.2	Y	Y			N	N	stomach parasite
1-Sep-08	2012AM	LKTR	8	657	3325	1.17	M	MA	UD	31	655	469	14.1					54.7	1.6	Y	Y	-20.38	13.1	N	N	small fish in stomach
2-Sep-08	1022AM	LKTR	29	714	4125	1.13	F	MA	UD	21	141.5	15.2	0.4	28.3	0.88	3216	0.69	47.9	1.2	Y	Y	-24.42	11.5	N	N	lots of parasites
2-Sep-08	1022AM	LKTR	13	685	3950	1.23	M	MA	RI	21	152.6	10.7	0.3					52.6	1.3	Y	Y			N	N	very healthy looking
3-Sep-08	2018AM	LKTR*	10	975	12700	1.37	F	MA	RU	31	338.0	15.0	0.1	1561	9.3	16749	12	134.3	1.1	Y	Y	-26.15	11.4	Y	Y	little eggs left over
3-Sep-08	1026AM	LKTR	7	623	2500	1.03	F	MA	SP	29	95	4.2	0.2	15			0.60	29	1.2	Y	Y	-20.47	12.8	Y	Y	healthy, eggs are mostly spent - weighed - in bag
4-Sep-08	1031AM	LKTR	13	753	5575	1.31	M	MA	RU	27	192.7	15.6	0.3					51.7	0.93	Y	Y	-23.79	12.3	N	N	
4-Sep-08	1031AM	LKTR	12	723	4400	1.16	M	MA	RU	23	203.5	18.6	0.4					48.7	1.1	Y	Y	-23.44	12.4	Y	Y	lots of stomach parasites
5-Sep-08	2025AM	LKTR	10	849	7500	1.23	F	MA	UD	34	335	15.3	0.2	139.2	1.5	9469	1.9	82.9	1.1	Y	Y	-24.27	12.2	Y	Y	stomach tapeworms
6-Sep-08	2031AM	LKTR*	8	760	4840	1.10	F	MA	RU	23	132.8	0	0	518	20	2590	11	61	1.3	Y	Y	-19.99	12.2	Y	Y	
6-Sep-08	1037AM	LKTR	12	889	8300	1.18	F	MA	SP	33	269	0	0					117.7	1.4	Y	Y	-24.17	12.9	N	N	female - but spent so no ovary/egg weights
25-Sep-08	4067	LKTR*	4	915	9375	1.22	F	MA	RU	27	128.6	0	0	124.387	20	615	1.3	97	1.0	y	y			Y	Y	most eggs spent, no stomach contents
10-Oct-08	Final Rem	LKTR	38	175	55	1.03	F	IM	UD	4	2.92	1.58	2.9					2.9		Y	Y			N	N	liver weight outlier
10-Oct-08	Final Rem	LKTR	36	177	60	1.08	M	IM	UD	5	6.25	4.76	7.9					0.36	0.60	Y	Y			N	N	sculpins & egg in stomach?
10-Oct-08	Final Rem	LKTR	34	182	68	1.13	M	IM	UD	4	5.49	3.92	5.8					0.79	1.2	Y	Y			Y	Y	sculpins & large eggs in stomach?

Appendix D. Documentation of detailed biological assesement fish data.

Pull Date	Gill Net ID	Species	Sample ID	Length (mm)	Weight (g)	Condition Factor (K)	Sex	Maturity Code	Reproductive Status Code	Age (yr)	Weight Stomach with Contents (g)	Weight Stomach Contents (g)	Weight of food/Weight of fish (%)	Ovary weight (g)	Weight of 100 eggs (g)	Total # eggs	GSI (%)	Liver Weight (g)	HSI (%)	Liver metals sample? Y/N	Tissue metals sample? Y/N	Isotope Analysis		Metals Analysis? Y/N		Comments (incl. results of internal / external examinations incl. DELT)
																						δ ¹³ C (‰)	δ ¹⁵ N (‰)	Muscle	Liver	
22-Aug-08	999PM	RNWH*	13	385	650	1.14	F	MA	RU	14	12.67	4.74	0.7	43.00	1.1	3945	6.6	10.28	1.6	Y	Y			Y	Y	healthy, fat
23-Aug-08	995AM	RNWH*	6	308	300	1.03	F	MA	RI	8	6.11	2.47	0.8	11.77	0.71	1658	3.9	4.95	1.7	Y	Y			N	N	healthy
23-Aug-08	995AM	RNWH	7	327	375	1.07	M	MA	RI	9	6.81	1.18	0.3					3.83	1.0	Y	Y			Y	Y	healthy, female
23-Aug-08	995AM	RNWH	10	305	285	1.00	M	MA	RU	10	8.39	3.88	1.4					3.58	1.3	Y	Y	-20.14	8.64	Y	Y	healthy, female
27-Aug-08	1004AM	RNWH	3	237	125	0.94	F	IM	UD	6	6.9	3.9	3.1					0.95	0.76	Y	Y	-18.51	7.89	Y	Y	healthy, few cysts, ovaries not weighed, only ONE otolith
27-Aug-08	1005AM	RNWH	27	132	20	0.87	F	IM	UD	4	1.2	0.75	3.8					0.21	1.1	Y	Y			N	N	healthy, no cysts
27-Aug-08	1002AM	RNWH*	5	395	725	1.18	F	MA	RI	17	15	2	0.3	40	0.86	4651	5.5	9	1.2	Y	Y	-20.57	9.80	N	N	healthy, few cysts
27-Aug-08	1005AM	RNWH	1	260	125	0.71	M	IM	UD	6	5.8	2.8	2.2					1.6	1.3	Y	Y	-19.21	8.39	N	N	healthy, no parasites
27-Aug-08	1002AM	RNWH	4	385	675	1.18	M	MA	RI	16	11.0	10.0	1.5					6.00	0.89	Y	Y	-19.40	9.74	N	N	healthy, only ONE otolith
27-Aug-08	1005AM	RNWH	12	203	80	0.96	U	IM	UD	5	4.3	1.8	2.3					0.94	1.2	Y	Y	-20.26	8.22	Y	Y	healthy, no cysts
29-Aug-08	1009AM	RNWH	23	268	200	1.04	F	IM	UD	7	7.3	3.7	1.9	0.4			0.20	1.8	0.90	Y	Y	-19.51	8.58	N	N	ovaries underdeveloped therefore only total weight
29-Aug-08	1008AM	RNWH*	7	328	400	1.13	F	MA	UN	10	16	8	2.0	24	0.46	5217	6.0	6	1.5	Y	Y	-19.84	8.61	N	N	healthy, could be F1, F2, F5
29-Aug-08	2001AM	RNWH	14	200	70	0.88	M	IM	UD	4	5.5	4.2	6.0					0.56	0.80	Y	Y			N	N	
29-Aug-08	2001AM	RNWH	25	270	225	1.14	M	IM	UD	8	9	4.6	2.0					2.5	1.1	Y	Y	-19.55	8.47	Y	Y	
29-Aug-08	2001AM	RNWH	24	306	300	1.05	M	MA	RI	7	9	3	1.0					1.78	0.59	Y	Y	-19.54	9.14	N	N	healthy, only ONE otolith
29-Aug-08	1008AM	RNWH	6	361	600	1.28	M	MA	RI	14	22	7	1.2					7	1.2	Y	Y			Y	Y	healthy
29-Aug-08	1008AM	RNWH	22	133	24	1.02	U	IM	UD	4	1	0.28	1.2					0.22	0.92	Y	Y			N	N	healthy
29-Aug-08	2001AM	RNWH	3	130	20	0.91	U	IM	UD	3	10.6	2.5	12.5					0.25	1.3	Y	Y			Y	Y	
30-Aug-08	1011AM	RNWH	18	225	150	1.32	M	IM	UD	6	6.6	3.7	2.5					1.2	0.80	Y	Y	-19.83	8.42	N	N	healthy
30-Aug-08	1012AM	RNWH	2	133	21	0.89	U	IM	UD	3	1.3	2.25	10.7					0.3	1.4	Y	Y			N	N	healthy
31-Aug-08	2007AM	RNWH*	3	295	290	1.13	F	MA	UN	8	14.0	8.0	2.8	15	1.4	1071	5.2	3	1.0	Y	Y	-19.00	8.83	N	N	healthy, could be F1, F2, F5
31-Aug-08	2007AM	RNWH*	2	315	375	1.20	F	MA	UN	9	13.7	6.7	1.8	18.5	0.65	2846	4.9	5.3	1.4	Y	Y	-20.77	9.03	N	N	healthy, could be F1, F2, F5
31-Aug-08	2007AM	RNWH*	21	381	725	1.31	F	MA	UN	14	19.7	4.9	0.7	48.3	0.55	8782	6.7	10.3	1.4	Y	Y			N	N	healthy, could be F1, F2, F5
31-Aug-08	1014AM	RNWH*	2	370	600	1.18	F	MA	UN	12	14.4	3.6	0.6	41.0	1.0	4100	6.8	10.2	1.7	Y	Y	-20.11	9.86	N	N	healthy, could be F1, F2, F5
31-Aug-08	2007AM	RNWH	30	335	440	1.17	M	MA	RI	10	14.8	7.6	1.7					3.4	0.77	Y	Y	-18.70	9.19	N	N	healthy
31-Aug-08	2009AM	RNWH	4	289	225	0.93	M	MA	RI	6	8.3	3.7	1.6					1.9	0.84	Y	Y	-19.69	8.81	N	N	healthy
2-Sep-08	2015AM	RNWH	12	407	700	1.04	M	MA	RI	19	23.1	5.0	0.7					6.5	0.93	Y	Y	-21.03	9.89	N	N	healthy
3-Sep-08	2021AM	RNWH	8	177	60	1.08	F	IM	UD	4	3.2	1.63	2.7					0.55	0.92	Y	Y	-19.50	7.57	N	N	healthy
3-Sep-08	1025AM	RNWH	7	191	71	1.02	U	IM	UD	4	3.33	1.18	1.7					0.71	1.0	Y	Y	-19.28	8.20	N	N	healthy
4-Sep-08	1028AM	RNWH*	17	402	700	1.08	F	MA	UN	13	19.3	3.4	0.5	60.0	1.1	5455	8.6	13.7	2.0	Y	Y			N	N	healthy
4-Sep-08	1031AM	RNWH	7	403	800	1.22	M	MA	RU	16	17.3	1.2	0.2					2.5	0.31	Y	Y	-19.34	9.42	N	N	healthy
4-Sep-08	2022AM	RNWH	3	152	36	1.03	U	IM	UD	3	2.75	1.22	3.4					0.29	0.81	Y	Y	-20.65	7.59	Y	Y	healthy
4-Sep-08	2022AM	RNWH	2	135	20	0.81	U	IM	UD	3	1.16	0.57	2.9					0.25	1.3	Y	Y	-21.50	7.19	N	N	healthy, only ONE otolith
5-Sep-08	2025AM	RNWH	8	182	57	0.95	M	IM	UD	4	2.2	0.23	0.4					0.65	1.1	Y	Y	-21.06	7.89	Y	Y	healthy
6-Sep-08	2029AM	RNWH	12	403	760	1.16	M	MA	RI	13	20.6	7.1	0.9					4.3	0.57	Y	Y	-20.93	9.49	N	N	healthy, only ONE otolith
9-Sep-08	3001AM	RNWH*	11	413	950	1.35	F	MA	RU	15	11.0	6.0	0.6	95.76	0.80	11970	10	14.73	1.6	Y	Y	-22.36	10.1	N	N	healthy.fat
11-Sep-08	3010	RNWH*	7	414	1900	2.68	F	MA	RU	18	15.3	5.1	0.3	76.5	0.46	16630	4.0	19.5	1.0	Y	Y	-20.69	9.59	Y	Y	healthy, lots of fat, no parasites
11-Sep-08	3010	RNWH	11	400	825	1.29	M	MA	RU	13	13.42	4.19	0.5					6.36	0.77	Y	Y			Y	Y	healthy.fat
12-Sep-08	3012	RNWH	1	401	875	1.36	M	MA	RI	15	9.96	0.91	0.1					7.11	0.81	Y	Y	-21.90	9.62	N	N	healthy
29-Sep-08	Final Rem	RNWH	5	86	5	0.79	F	MA	RU	4				0.0222			0.44			N	N			N	N	<100mm, only otoliths and gonad weight, whole fish in own bag
29-Sep-08	Final Rem	RNWH*	1	85	5	0.81	F	MA	RU	3				0.655			13			N	N			N	N	<100mm, only otoliths and gonad weight, whole fish in own bag
29-Sep-08	Final Rem	RNWH	2	80	3	0.59	F	MA	RU	2										N	N			N	N	only otoliths were taken; <100mm and F3, whole fish in own bag
29-Sep-08	Final Rem	RNWH	3	80	3	0.59	F	MA	RU	3										N	N			N	N	only otoliths were taken; <100mm and F3, whole fish in own bag
29-Sep-08	Final Rem	RNWH	4	83	4	0.70	F	MA	RU	4										N	N			N	N	only otoliths were taken; <100mm and F3, whole fish in own bag
29-Sep-08	Final Rem	RNWH	6	93	5	0.62	F	MA	RU	3										N	N			N	N	only otoliths were taken; <100mm and F3, whole fish in own bag
29-Sep-08	Final Rem	RNWH	7	93	6	0.75	F	MA	RU	3										N	N			N	N	only otoliths were taken; <100mm and F3, whole fish in own bag
10-Oct-08	Final Rem	RNWH*	46	92	7	0.90	F	MA	RU	3	0.7	0	0	0.692		86	9.9	0.7		Y	Y			Y	N	healthy, no stomach contents, only 88 eggs; liver weight outlier
10-Oct-08	Final Rem	RNWH*	58	95	6.51	0.76	F	MA	RU	4	0.14	0	0	0.54		76	8.3			N	N			N	N	healthy, only 76 eggs
10-Oct-08	Final Rem	RNWH*	47	88	5.9	0.87	F	MA	RU	4		0	0	1.00		168	17			N	N			N	N	healthy, empty stomach, 168 eggs
10-Oct-08	Final Rem	RNWH*	53	94	6.1	0.73	F	MA	RU	4		0	0	1.08		146	18			N	N			N	N	healthy, empty stomach, 146 eggs
12-Oct-08	Final Rem	RNWH	4	270	250	1.27	F	IM	UD	9	5.126	0.7546	0.3	1.097	0.096	1143	0.44	2.0094	0.80	Y	Y			N	N	healthy

Notes:

* included in summary GSI calculations.

** *not* included in length, weight, condition factor summary calculations.

APPENDIX E

PHOTOS OF DBA FISH, SHOWING MATURITY AND REPRODUCTIVE STATUS





Photo 1: Ripe female lake trout (825 mm).



Photo 2: Ripe female Arctic char.



Photo 3: 'Resting' female lake trout showing old and partially developed eggs.



Photo 4: Mature female round whitefish (85 mm; 7g).



Photo 5: Mature female round whitefish recovered from lake trout gut.



Photo 6: Mature male round whitefish from lake trout gut showing mature testes.

APPENDIX F

FISH TISSUE MOISTURE, LIPID CONTENT, AND TOTAL METALS CONCENTRATIONS (MG/KG WW), NW ARM OF SECOND PORTAGE LAKE, 2008



Appendix F. Fish tissue moisture, lipid content, and total metals concentrations (mg/kg ww), NW Arm of Second Portage Lake, 2008.

Sample ID	2020 AM-ARCH-8	2020 AM-ARCH-4	1002 AM-ARCH-34	1002 AM-ARCH-13	1011 AM-ARCH-5	1014 AM-ARCH-6	FISHOUT-ARCH-41
ALS Sample ID	L701452-02	L701452-04	L701452-06	L701452-08	L701452-10	L701452-12	L701452-14
Matrix	Muscle	Muscle	Muscle	Muscle	Muscle	Muscle	Muscle
PARAMETERS (%)							
Moisture Content	76.2	78	80.5	77.1	75.1	77	79
Lipid Content	1.3	1.4	1.4	1.4	2.4	1.4	1.4
METALS (mg/kg ww)							
Aluminum	5.9	4.2	4.4	2.6	2.4	3	2.8
Antimony	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
Arsenic	<0.010	0.015	<0.020	0.013	0.013	<0.010	0.012
Barium	0.287	0.081	0.022	0.014	0.022	0.035	0.036
Beryllium	<0.10	<0.10	<0.20	<0.10	<0.10	<0.10	<0.10
Bismuth	<0.030	<0.030	<0.060	<0.030	<0.030	<0.030	<0.030
Cadmium	<0.0050	<0.0050	<0.010	<0.0050	<0.0050	<0.0050	<0.0050
Calcium	126	162	78.3	56.3	72.2	72.4	71.7
Chromium	<0.10	<0.10	<0.20	<0.10	0.13	<0.10	<0.10
Cobalt	<0.020	<0.020	<0.040	<0.020	<0.020	<0.020	<0.020
Copper	0.424	0.397	0.453	0.456	0.637	0.452	0.291
Lead	<0.020	<0.020	<0.040	<0.020	<0.020	<0.020	<0.020
Lithium	<0.10	<0.10	<0.20	<0.10	<0.10	<0.10	<0.10
Magnesium	262	311	283	208	252	292	249
Manganese	0.127	0.117	0.132	0.07	0.09	0.078	0.067
Mercury	0.0578	0.0502	0.0679	0.0772	0.0669	0.0767	0.0506
Molybdenum	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
Nickel	<0.10	<0.10	<0.20	<0.10	<0.10	<0.10	<0.10
Selenium	0.31	0.38	0.84	0.2	0.34	0.34	0.26
Strontium	0.163	0.211	0.047	0.061	0.09	0.066	0.097
Thallium	<0.010	<0.010	<0.020	<0.010	<0.010	0.01	<0.010
Tin	<0.050	<0.050	0.11	<0.050	<0.050	<0.050	0.057
Uranium	<0.0020	<0.0020	<0.0040	<0.0020	<0.0020	<0.0020	<0.0020
Vanadium	<0.10	<0.10	<0.20	<0.10	<0.10	<0.10	<0.10
Zinc	6.76	6.38	9.36	6.08	6.24	5.67	4.13

Appendix F. Fish tissue moisture, lipid content, and total metals concentrations (mg/kg ww), NW Arm of Second Portage Lake, 2008.

Sample ID	2020 AM-ARCH-11	2011 AM-ARCH-4	995 PM-ARCH-6	997 PM-ARCH-7	997 AM-ARCH-5	2018 AM-ARCH-9	1002 AM-ARCH-45
ALS Sample ID	L701452-16	L701452-18	L701452-20	L701452-22	L701452-24	L701452-26	L701452-28
Matrix	Muscle	Muscle	Muscle	Muscle	Muscle	Muscle	Muscle
PARAMETERS (%)							
Moisture Content	75.8	75.2	74.7	75.7	75.4	77.4	76.5
Lipid Content	1.1	2.1	0.9	0.8	0.9	0.9	1.3
METALS (mg/kg ww)							
Aluminum	4	3.9	3.6	4.3	<2.0	3	2.5
Antimony	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Arsenic	0.012	<0.010	<0.010	<0.010	<0.010	0.012	0.011
Barium	0.016	0.195	0.048	0.011	0.02	0.038	0.037
Beryllium	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Bismuth	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Cadmium	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Calcium	38.4	41.2	55.1	61.3	41.1	40.5	40.9
Chromium	0.1	<0.10	<0.10	<0.10	0.25	0.34	0.34
Cobalt	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Copper	0.337	0.348	0.283	0.211	0.245	0.365	0.453
Lead	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Lithium	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Magnesium	286	256	284	276	258	216	223
Manganese	0.07	0.058	0.054	0.038	0.056	0.079	0.085
Mercury	0.0732	0.0911	0.0826	0.0794	0.0781	0.243	0.143
Molybdenum	<0.010	<0.010	<0.010	<0.010	0.041	0.043	0.049
Nickel	<0.10	<0.10	<0.10	<0.10	0.14	0.19	0.18
Selenium	0.31	0.28	0.35	0.3	0.28	0.25	0.27
Strontium	0.033	0.028	0.055	0.052	0.047	0.034	0.033
Thallium	<0.010	<0.010	0.01	<0.010	<0.010	<0.010	<0.010
Tin	<0.050	<0.050	<0.050	<0.050	0.061	<0.050	<0.050
Uranium	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Vanadium	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Zinc	4.46	4.33	4.14	3.58	3.6	3.49	4.17

Appendix F. Fish tissue moisture, lipid content, and total metals concentrations (mg/kg ww), NW Arm of Second Portage Lake, 2008.

Sample ID	2022 AM-ARCH-14	1005 AM-LKTR-10	FISHOUT-LKTR-34	1005 AM-LKTR-2	1007 AM-LKTR-10	1004 AM-LKTR-21	2003 AM-LKTR-10
ALS Sample ID	L701452-30	L701452-32	L701452-34	L701452-36	L701452-38	L701452-40	L701452-42
Matrix	Muscle	Muscle	Muscle	Muscle	Muscle	Muscle	Muscle
PARAMETERS (%)							
Moisture Content	79.9	-	77.8	79.8	79.5	79.7	79.9
Lipid Content	0.8	-	1.8	0.7	0.8	0.7	2.1
METALS (mg/kg ww)							
Aluminum	<2.0	<4.0	6.2	2.1	<2.0	4	3.5
Antimony	<0.010	<0.020	<0.020	<0.010	<0.010	<0.010	<0.010
Arsenic	<0.010	0.041	<0.020	<0.010	0.01	<0.010	0.017
Barium	0.024	0.038	0.049	0.018	0.027	0.043	0.058
Beryllium	<0.10	<0.20	<0.20	<0.10	<0.10	<0.10	<0.10
Bismuth	<0.030	<0.060	<0.060	<0.030	<0.030	<0.030	<0.030
Cadmium	<0.0050	<0.010	<0.010	<0.0050	<0.0050	<0.0050	<0.0050
Calcium	31.8	143	85.3	53.5	42.9	44	32.4
Chromium	0.27	<0.20	<0.20	<0.10	<0.10	0.13	0.84
Cobalt	<0.020	<0.040	<0.040	<0.020	<0.020	<0.020	0.023
Copper	0.418	0.599	0.221	0.303	0.279	0.23	0.36
Lead	<0.020	<0.040	<0.040	<0.020	<0.020	<0.020	<0.020
Lithium	<0.10	<0.20	<0.20	<0.10	<0.10	<0.10	<0.10
Magnesium	199	326	270	209	213	209	209
Manganese	0.07	0.185	0.181	0.102	0.068	0.109	0.138
Mercury	0.105	0.0977	0.0798	0.111	0.0867	0.192	0.267
Molybdenum	0.033	<0.020	<0.020	<0.010	<0.010	0.012	0.11
Nickel	0.15	<0.20	<0.20	<0.10	<0.10	<0.10	0.51
Selenium	1.07	0.46	0.47	0.46	0.51	0.31	0.3
Strontium	0.027	0.207	0.067	0.064	0.044	0.045	0.029
Thallium	<0.010	<0.020	<0.020	<0.010	<0.010	<0.010	<0.010
Tin	0.062	0.18	0.19	0.112	<0.050	0.067	0.062
Uranium	<0.0020	<0.0040	<0.0040	<0.0020	<0.0020	<0.0020	<0.0020
Vanadium	<0.10	<0.20	<0.20	<0.10	<0.10	<0.10	<0.10
Zinc	4.48	5.36	4	3.71	3.52	2.79	3.55

Appendix F. Fish tissue moisture, lipid content, and total metals concentrations (mg/kg ww), NW Arm of Second Portage Lake, 2008.

Sample ID	1009 AM-LKTR-21	1009 AM-LKTR-9	1002 AM-LKTR-33M	1026 AM-LKTR-7	1002 AM-LKTR-1	1002 AM-LKTR-47	1031 AM-LKTR-12
ALS Sample ID	L701452-44	L701452-46	L701452-48	L701452-50	L701452-52	L701452-54	L701452-56
Matrix	Muscle	Muscle	Muscle	Muscle	Muscle	Muscle	Muscle
PARAMETERS (%)							
Moisture Content	79	81.3	83.9	78.8	76.7	80.8	76
Lipid Content	1.3	1.3	0.9	0.8	2.3	1.2	2.5
METALS (mg/kg ww)							
Aluminum	2.5	3	3.3	2.2	<2.0	2	<2.0
Antimony	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Arsenic	0.014	<0.010	<0.010	0.016	0.01	0.013	<0.010
Barium	0.034	0.043	0.036	0.018	0.034	0.024	0.023
Beryllium	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Bismuth	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Cadmium	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Calcium	44.8	37	109	36.1	61.9	34.2	36.6
Chromium	0.82	<0.10	0.19	<0.10	0.18	0.12	0.27
Cobalt	0.029	<0.020	0.021	<0.020	<0.020	<0.020	<0.020
Copper	0.407	0.444	0.272	0.324	0.401	0.277	0.712
Lead	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Lithium	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Magnesium	215	202	135	193	195	176	168
Manganese	0.152	0.083	0.063	0.072	0.107	0.082	0.121
Mercury	0.194	0.643	0.22	0.313	0.274	0.421	0.426
Molybdenum	0.098	<0.010	0.02	<0.010	0.018	0.011	0.029
Nickel	0.48	<0.10	<0.10	<0.10	<0.10	<0.10	0.15
Selenium	0.32	0.34	0.54	1.25	0.82	0.62	0.73
Strontium	0.041	0.029	0.109	0.035	0.054	0.026	0.04
Thallium	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Tin	0.065	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Uranium	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Vanadium	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Zinc	2.8	3.48	3.87	3.33	4.45	2.77	4.36

Appendix F. Fish tissue moisture, lipid content, and total metals concentrations (mg/kg ww), NW Arm of Second Portage Lake, 2008.

Sample ID	2031 AM-LKTR-8	1010 AM-LKTR-7	2025 AM-LKTR-10	GN-4067-LKTR-4	2018 AM-LKTR-10	FISHOUT-RNWH-46	2001 AM-RNWH-3
ALS Sample ID	L701452-58	L701452-60	L701452-62	L701452-64	L701452-66	L701452-68	L701452-70
Matrix	Muscle	Muscle	Muscle	Muscle	Muscle	Muscle	Muscle
PARAMETERS (%)							
Moisture Content	75.4	76.8	73.3	79.8	76.8	83.4	-
Lipid Content	2.6	1.8	6.3	1.8	2.4	-	-
METALS (mg/kg ww)							
Aluminum	2.2	<2.0	<2.0	<2.0	<2.0	<4.0	<4.0
Antimony	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.020
Arsenic	0.012	0.012	0.013	0.013	<0.010	<0.020	0.026
Barium	0.057	0.028	0.018	0.028	0.023	0.393	0.837
Beryllium	<0.10	<0.10	<0.10	<0.10	<0.10	<0.20	<0.20
Bismuth	<0.030	<0.030	<0.030	<0.030	<0.030	<0.060	<0.060
Cadmium	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.010	<0.010
Calcium	46.9	45.4	39.6	43.1	38.8	156	69.9
Chromium	0.13	0.18	0.21	0.21	0.12	<0.20	<0.20
Cobalt	<0.020	<0.020	<0.020	<0.020	<0.020	<0.040	<0.040
Copper	0.722	0.397	0.687	0.598	0.686	0.341	0.346
Lead	<0.020	<0.020	<0.020	<0.020	<0.020	<0.040	<0.040
Lithium	<0.10	<0.10	<0.10	<0.10	<0.10	<0.20	<0.20
Magnesium	187	189	182	165	178	160	284
Manganese	0.108	0.098	0.121	0.124	0.101	0.189	0.196
Mercury	0.447	1.18	1.08	1.13	1.37	0.0902	0.0371
Molybdenum	0.012	0.02	0.02	0.023	0.012	<0.020	<0.020
Nickel	<0.10	0.1	0.11	0.11	<0.10	<0.20	<0.20
Selenium	1.02	1.12	0.74	0.51	0.46	<0.40	0.51
Strontium	0.059	0.046	0.052	0.046	0.031	0.231	0.083
Thallium	0.012	<0.010	0.014	<0.010	<0.010	<0.020	<0.020
Tin	<0.050	<0.050	<0.050	<0.050	<0.050	<0.10	<0.10
Uranium	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0040	<0.0040
Vanadium	<0.10	<0.10	<0.10	<0.10	<0.10	<0.20	<0.20
Zinc	3.75	3.54	4.01	3.11	3.33	5.4	5.69

Appendix F. Fish tissue moisture, lipid content, and total metals concentrations (mg/kg ww), NW Arm of Second Portage Lake, 2008.

Sample ID	2022 AM-RNWH-3	2025 AM-RNWH-8	1005 AM-RNWH-12	1004 AM-RNWH-3	2001 AM-RNWH-25	995 AM-RNWH-7	995 AM RNWH-10
ALS Sample ID	L701452-72	L701452-74	L701452-76	L701452-78	L701452-80	L701452-82	L701452-84
Matrix	Muscle	Muscle	Muscle	Muscle	Muscle	Muscle	Muscle
PARAMETERS (%)							
Moisture Content	78.2	77.4	76.1	72.4	75.5	76.4	75.6
Lipid Content	1.9	1.5	-	-	1.7	1.3	1.1
METALS (mg/kg ww)							
Aluminum	<4.0	2.3	3.6	6	5.6	<4.0	<4.0
Antimony	<0.020	<0.010	<0.010	<0.020	<0.010	<0.020	<0.020
Arsenic	0.028	0.032	0.021	0.028	0.018	<0.020	<0.020
Barium	0.161	0.018	0.018	0.096	0.094	0.029	0.031
Beryllium	<0.20	<0.10	<0.10	<0.20	<0.10	<0.20	<0.20
Bismuth	<0.060	<0.030	<0.030	<0.060	<0.030	<0.060	<0.060
Cadmium	<0.010	<0.0050	<0.0050	<0.010	<0.0050	<0.010	<0.010
Calcium	235	155	56.5	575	63.8	113	56.5
Chromium	<0.20	<0.10	<0.10	<0.20	<0.10	<0.20	<0.20
Cobalt	<0.040	<0.020	<0.020	<0.040	<0.020	<0.040	<0.040
Copper	0.304	0.226	0.521	0.642	0.89	0.232	0.114
Lead	<0.040	<0.020	<0.020	<0.040	<0.020	<0.040	<0.040
Lithium	<0.20	<0.10	<0.10	<0.20	<0.10	<0.20	<0.20
Magnesium	281	286	259	289	279	283	194
Manganese	0.38	0.157	0.158	0.543	0.262	0.146	0.068
Mercury	0.0214	0.0482	0.0339	0.0358	0.0379	0.0363	0.0291
Molybdenum	<0.020	<0.010	<0.010	<0.020	<0.010	<0.020	<0.020
Nickel	<0.20	<0.10	<0.10	<0.20	<0.10	<0.20	<0.20
Selenium	<0.40	0.42	0.61	0.82	0.77	1.03	0.71
Strontium	0.413	0.254	0.055	1.17	0.111	0.149	0.069
Thallium	<0.020	<0.010	<0.010	<0.020	<0.010	<0.020	<0.020
Tin	<0.10	0.07	0.083	<0.10	<0.050	<0.10	<0.10
Uranium	<0.0040	<0.0020	<0.0020	<0.0040	<0.0020	<0.0040	<0.0040
Vanadium	<0.20	<0.10	<0.10	<0.20	<0.10	<0.20	<0.20
Zinc	5.79	4.16	6.76	9.69	5.92	3.62	2.3

Appendix F. Fish tissue moisture, lipid content, and total metals concentrations (mg/kg ww), NW Arm of Second Portage Lake, 2008.

Sample ID	1008 AM-RNWH-6	999 PM-RNWH-13	GN-3010-RNWH-7	GN-3010-RNWH-11	2020 AM-ARCH-8	2020 AM-ARCH-4	1002 AM-ARCH-34
ALS Sample ID	L701452-86	L701452-88	L701452-90	L701452-92	L701452-01	L701452-03	L701452-05
Matrix	Muscle	Muscle	Muscle	Muscle	Liver	Liver	Liver
PARAMETERS (%)							
Moisture Content	76.2	75.9	75.8	75.8	-	-	-
Lipid Content	1.5	0.9	0.9	1.9	-	-	-
METALS (mg/kg ww)							
Aluminum	2.1	<2.0	2.2	<2.0	<6.0	<6.0	34.2
Antimony	<0.010	<0.010	<0.010	<0.010	<0.030	<0.030	<0.020
Arsenic	<0.010	0.013	<0.010	<0.010	0.133	0.174	<0.020
Barium	0.033	0.023	0.032	0.034	0.037	0.046	0.082
Beryllium	<0.10	<0.10	<0.10	<0.10	<0.30	<0.30	<0.20
Bismuth	<0.030	<0.030	<0.030	<0.030	<0.090	<0.090	<0.060
Cadmium	<0.0050	<0.0050	<0.0050	<0.0050	0.094	0.154	0.813
Calcium	266	101	98.7	133	82.5	105	114
Chromium	<0.10	<0.10	<0.10	0.11	<0.30	<0.30	<0.20
Cobalt	<0.020	<0.020	<0.020	<0.020	0.122	0.094	0.166
Copper	0.452	0.266	0.192	0.235	9.82	9.67	34
Lead	<0.020	<0.020	<0.020	<0.020	<0.060	<0.060	<0.040
Lithium	<0.10	<0.10	<0.10	<0.10	<0.30	<0.30	<0.20
Magnesium	251	288	225	227	245	267	237
Manganese	0.163	0.109	0.106	0.174	2.06	2.3	3.67
Mercury	0.0838	0.06	0.0557	0.0463	0.0966	0.139	0.137
Molybdenum	<0.010	<0.010	<0.010	0.013	0.263	0.359	0.17
Nickel	<0.10	<0.10	<0.10	<0.10	<0.30	<0.30	<0.20
Selenium	1.41	1.25	0.91	1.03	2.63	2.49	2.69
Strontium	0.796	0.121	0.128	0.201	0.245	0.289	0.172
Thallium	<0.010	<0.010	<0.010	<0.010	0.068	0.102	0.064
Tin	<0.050	<0.050	<0.050	<0.050	<0.15	<0.15	<0.10
Uranium	<0.0020	<0.0020	<0.0020	<0.0020	<0.0060	<0.0060	0.0838
Vanadium	<0.10	<0.10	<0.10	<0.10	<0.30	<0.30	<0.20
Zinc	3.99	3.05	2.7	3.04	42.1	40.4	84.9

Appendix F. Fish tissue moisture, lipid content, and total metals concentrations (mg/kg ww), NW Arm of Second Portage Lake, 2008.

Sample ID	1002 AM-ARCH-13	1011 AM-ARCH-5	1014 AM-ARCH-6	FISHOUT-ARCH-41	2020 AM-ARCH-11	2011 AM-ARCH-4	995 PM-ARCH-6
ALS Sample ID	L701452-07	L701452-09	L701452-11	L701452-13	L701452-15	L701452-17	L701452-19
Matrix	Liver	Liver	Liver	Liver	Liver	Liver	Liver
PARAMETERS (%)							
Moisture Content	-	72.7	72.6	77.9	71.1	73.3	74.1
Lipid Content	-	-	-	-	-	-	-
METALS (mg/kg ww)							
Aluminum	<4.0	6.4	<4.0	<6.0	<4.0	<4.0	<4.0
Antimony	<0.020	<0.020	<0.020	<0.030	<0.020	<0.020	<0.020
Arsenic	0.133	0.065	<0.020	0.041	0.136	0.034	0.062
Barium	<0.020	<0.020	<0.020	<0.030	<0.020	0.031	0.062
Beryllium	<0.20	<0.20	<0.20	<0.30	<0.20	<0.20	<0.20
Bismuth	<0.060	<0.060	<0.060	<0.090	<0.060	<0.060	<0.060
Cadmium	0.046	0.149	0.109	0.186	0.067	0.056	0.104
Calcium	72.6	63.4	43.5	59.5	52.2	26.1	87.7
Chromium	<0.20	<0.20	<0.20	<0.30	<0.20	<0.20	<0.20
Cobalt	0.118	0.151	0.159	0.132	0.136	0.116	0.187
Copper	12.7	12.7	14.7	5.87	14	8.84	11.9
Lead	<0.040	<0.040	<0.040	<0.060	<0.040	<0.040	<0.040
Lithium	<0.20	<0.20	<0.20	<0.30	<0.20	<0.20	<0.20
Magnesium	203	194	145	147	155	112	172
Manganese	1.52	1.26	1.12	1.16	1.46	0.889	1.25
Mercury	0.147	0.0987	0.123	0.0795	0.143	0.107	0.142
Molybdenum	0.28	0.241	0.201	0.147	0.252	0.227	0.243
Nickel	<0.20	<0.20	<0.20	<0.30	<0.20	<0.20	<0.20
Selenium	1.81	1.3	1.07	1.02	1.44	1.11	1.72
Strontium	0.141	0.117	0.097	0.133	0.105	0.047	0.23
Thallium	0.051	0.034	0.022	0.047	0.043	0.044	0.037
Tin	<0.10	<0.10	<0.10	<0.15	<0.10	<0.10	<0.10
Uranium	<0.0040	<0.0040	<0.0040	<0.0060	<0.0040	<0.0040	<0.0040
Vanadium	<0.20	<0.20	<0.20	<0.30	<0.20	<0.20	<0.20
Zinc	34.3	34.6	33	24.1	32.2	21.3	32.9

Appendix F. Fish tissue moisture, lipid content, and total metals concentrations (mg/kg ww), NW Arm of Second Portage Lake, 2008.

Sample ID	997 PM-ARCH-7	997 AM-ARCH-5	2018 AM-ARCH-9	1002 AM-ARCH-45	2022 AM-ARCH-14	1005 AM-LKTR-10	FISHOUT-LKTR-34
ALS Sample ID	L701452-21	L701452-23	L701452-25	L701452-27	L701452-29	L701452-31	L701452-33
Matrix	Liver	Liver	Liver	Liver	Liver	Liver	Liver
PARAMETERS (%)							
Moisture Content	73.1	76.7	79.1	77.5	79.2	-	-
Lipid Content	-	-	-	-	-	-	-
METALS (mg/kg ww)							
Aluminum	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	8.4
Antimony	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Arsenic	0.039	0.038	0.033	0.034	<0.020	0.064	0.178
Barium	0.027	0.022	0.059	0.027	0.041	0.03	0.044
Beryllium	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Bismuth	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060
Cadmium	0.148	0.183	0.123	0.156	0.431	0.317	0.102
Calcium	58.7	48.4	107	35.1	126	338	64.6
Chromium	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Cobalt	0.204	0.169	<0.040	0.147	0.19	0.111	0.051
Copper	21.7	15.1	0.86	1.34	14.3	11.8	8.17
Lead	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
Lithium	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Magnesium	178	140	166	152	144	334	277
Manganese	1.44	1.14	1.33	1.53	1.23	3.13	1.75
Mercury	0.22	0.217	0.233	0.284	0.137	0.0858	0.0601
Molybdenum	0.24	0.214	0.083	0.167	0.153	0.173	0.127
Nickel	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Selenium	1.76	1.24	0.6	1.14	3.2	2.47	4.1
Strontium	0.1	0.082	0.144	0.057	0.209	0.445	0.09
Thallium	0.038	0.026	0.088	0.039	0.024	0.044	0.108
Tin	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Uranium	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
Vanadium	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Zinc	39.7	29.8	16.8	20.9	33.8	57.3	31.5

Appendix F. Fish tissue moisture, lipid content, and total metals concentrations (mg/kg ww), NW Arm of Second Portage Lake, 2008.

Sample ID	1005 AM-LKTR-2	1007 AM-LKTR-10	1004 AM-LKTR-21	2003 AM-LKTR-10	1009 AM-LKTR-21	1009 AM-LKTR-9	1002 AM-LKTR-33M
ALS Sample ID	L701452-35	L701452-37	L701452-39	L701452-41	L701452-43	L701452-45	L701452-47
Matrix	Liver	Liver	Liver	Liver	Liver	Liver	Liver
PARAMETERS (%)							
Moisture Content	72	76.5	76.7	78.6	81.8	77.4	79.7
Lipid Content	-	-	-	-	-	-	-
METALS (mg/kg ww)							
Aluminum	<4.0	6.2	4.1	4.9	6.3	4.4	4.2
Antimony	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Arsenic	0.091	0.023	0.054	0.036	<0.020	0.06	<0.020
Barium	0.04	0.041	0.038	<0.020	0.038	<0.020	0.025
Beryllium	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Bismuth	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060
Cadmium	0.276	0.303	0.368	0.508	0.259	0.403	0.364
Calcium	510	163	65.7	79.6	68.5	89.2	77.1
Chromium	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Cobalt	0.078	0.134	0.138	0.166	0.225	0.04	0.159
Copper	7.11	5.6	5.41	14.5	2.21	4.81	7.72
Lead	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
Lithium	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Magnesium	236	171	126	136	149	175	137
Manganese	2.62	1.64	4.17	1.11	0.984	1.34	1.12
Mercury	0.133	0.188	0.159	0.409	0.227	0.866	0.343
Molybdenum	0.197	0.175	0.134	0.138	0.064	0.08	0.108
Nickel	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Selenium	3.05	2.66	2.04	1.43	0.86	1.38	1.88
Strontium	1	0.243	0.105	0.094	0.079	0.095	0.106
Thallium	0.053	0.062	0.039	0.032	0.091	0.077	0.032
Tin	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Uranium	<0.0040	<0.0040	0.01	0.0096	0.0099	0.01	0.0087
Vanadium	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Zinc	42.7	28.7	25.9	34.8	21	27.6	28.8

Appendix F. Fish tissue moisture, lipid content, and total metals concentrations (mg/kg ww), NW Arm of Second Portage Lake, 2008.

Sample ID	1026 AM-LKTR-7	1002 AM-LKTR-1	1002 AM-LKTR-47	1031 AM-LKTR-12	2031 AM-LKTR-8	1010 AM-LKTR-7	2025 AM-LKTR-10
ALS Sample ID	L701452-49	L701452-51	L701452-53	L701452-55	L701452-57	L701452-59	L701452-61
Matrix	Liver	Liver	Liver	Liver	Liver	Liver	Liver
PARAMETERS (%)							
Moisture Content	76.1	73	77.7	77.7	79.3	78.9	70
Lipid Content	-	-	-	-	-	-	-
METALS (mg/kg ww)							
Aluminum	4.7	<4.0	<4.0	<4.0	<4.0	4.1	<4.0
Antimony	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Arsenic	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Barium	0.032	0.038	0.037	0.022	<0.020	<0.020	0.027
Beryllium	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Bismuth	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060
Cadmium	0.353	0.068	0.119	0.182	0.216	0.118	0.094
Calcium	75.6	74.4	61.8	66.6	56.2	48.7	38.1
Chromium	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Cobalt	0.132	0.066	0.104	0.042	0.041	0.056	0.055
Copper	12.7	4.04	5.58	8.68	4.19	7.98	7.87
Lead	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
Lithium	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Magnesium	127	106	133	108	115	93.2	96.3
Manganese	0.816	0.554	0.83	1.06	0.681	0.683	0.733
Mercury	0.217	0.263	0.892	0.491	0.606	1.86	2.56
Molybdenum	0.118	0.072	0.129	0.108	0.058	0.08	0.078
Nickel	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Selenium	4.88	2.1	2.34	2.35	3.5	3.27	2.38
Strontium	0.147	0.108	0.118	0.107	0.09	0.072	0.059
Thallium	0.023	<0.020	0.031	0.068	0.058	0.025	0.025
Tin	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Uranium	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
Vanadium	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Zinc	29.5	19.2	24.5	27.1	24.1	23.6	23.9

Appendix F. Fish tissue moisture, lipid content, and total metals concentrations (mg/kg ww), NW Arm of Second Portage Lake, 2008.

Sample ID	GN-4067-LKTR-4	2018 AM-LKTR-10	2001 AM-RNWH-3	2022 AM-RNWH-3	2025 AM-RNWH-8	1005 AM-RNWH-12	1004 AM-RNWH-3
ALS Sample ID	L701452-63	L701452-65	L701452-69	L701452-71	L701452-73	L701452-75	L701452-77
Matrix	Liver	Liver	Liver	Liver	Liver	Liver	Liver
PARAMETERS (%)							
Moisture Content	79.5	82.1	-	-	-	-	-
Lipid Content	-	-	-	-	-	-	-
METALS (mg/kg ww)							
Aluminum	<4.0	<4.0	<8.0	<8.0	<4.0	7.9	26.6
Antimony	<0.020	<0.020	<0.040	<0.040	<0.020	<0.020	<0.030
Arsenic	<0.020	<0.020	0.046	0.049	0.053	0.046	0.046
Barium	0.03	0.033	0.899	0.155	0.035	0.077	0.056
Beryllium	<0.20	<0.20	<0.40	<0.40	<0.20	<0.20	<0.30
Bismuth	<0.060	<0.060	<0.12	<0.12	<0.060	<0.060	<0.090
Cadmium	0.147	0.084	0.068	0.042	0.063	0.019	0.091
Calcium	44	78.4	154	148	198	99.6	108
Chromium	<0.20	<0.20	<0.40	<0.40	<0.20	<0.20	<0.30
Cobalt	0.047	<0.040	<0.080	0.089	0.052	0.158	0.12
Copper	1.34	1.13	2.9	2.88	3.36	2.79	2.86
Lead	<0.040	<0.040	<0.080	<0.080	<0.040	<0.040	<0.060
Lithium	<0.20	<0.20	<0.40	<0.40	<0.20	<0.20	<0.30
Magnesium	158	98.6	256	234	191	225	276
Manganese	1.1	0.6	4.53	4.06	2.31	3.02	4.37
Mercury	3.2	2.86	0.057	0.031	0.0718	0.0364	0.0443
Molybdenum	0.061	0.033	0.194	0.185	0.198	0.187	0.205
Nickel	<0.20	<0.20	<0.40	<0.40	<0.20	<0.20	<0.30
Selenium	2.48	1.17	1.55	1.61	1.62	1.75	1.84
Strontium	0.046	0.086	0.346	0.309	0.448	0.208	0.265
Thallium	0.052	0.045	<0.040	0.046	0.081	0.029	0.043
Tin	<0.10	<0.10	<0.20	<0.20	<0.10	<0.10	<0.15
Uranium	<0.0040	<0.0040	<0.0080	<0.0080	<0.0040	0.0099	0.0067
Vanadium	<0.20	<0.20	<0.40	<0.40	<0.20	<0.20	<0.30
Zinc	20.6	17.1	31.7	28	24.4	26.5	27.4

Appendix F. Fish tissue moisture, lipid content, and total metals concentrations (mg/kg ww), NW Arm of Second Portage Lake, 2008.

Sample ID	2001 AM-RNWH-25	995 AM-RNWH-7	995 AM RNWH-10	1008 AM-RNWH-6	999 PM-RNWH-13	GN-3010-RNWH-7	GN-3010-RNWH-11
ALS Sample ID	L701452-79	L701452-81	L701452-83	L701452-85	L701452-87	L701452-89	L701452-91
Matrix	Liver	Liver	Liver	Liver	Liver	Liver	Liver
PARAMETERS (%)							
Moisture Content	74.1	75.5	75.5	75.3	75.5	77.8	74.9
Lipid Content	-	-	-	-	-	-	-
METALS (mg/kg ww)							
Aluminum	5.8	5.6	<6.0	5.1	4.4	<4.0	5.9
Antimony	<0.020	<0.020	<0.030	<0.020	<0.020	<0.020	<0.020
Arsenic	0.022	<0.020	<0.030	<0.020	<0.020	<0.020	<0.020
Barium	0.06	0.085	0.058	0.054	0.04	0.041	0.062
Beryllium	<0.20	<0.20	<0.30	<0.20	<0.20	<0.20	<0.20
Bismuth	<0.060	<0.060	<0.090	<0.060	<0.060	<0.060	<0.060
Cadmium	0.026	0.035	0.059	0.069	0.08	0.067	0.054
Calcium	55.1	54	57.5	130	43.6	49.8	39.5
Chromium	<0.20	<0.20	<0.30	<0.20	<0.20	<0.20	<0.20
Cobalt	0.089	0.077	0.069	0.078	0.049	0.049	0.048
Copper	1.97	1.92	1.51	1.59	1.49	0.869	1.79
Lead	<0.040	<0.040	<0.060	<0.040	<0.040	<0.040	<0.040
Lithium	<0.20	<0.20	<0.30	<0.20	<0.20	<0.20	<0.20
Magnesium	144	140	120	142	198	146	144
Manganese	2.11	2.29	1.45	1.42	2.81	1.73	2.01
Mercury	0.0381	0.0476	0.0412	0.0538	0.0692	0.0505	0.0591
Molybdenum	0.138	0.133	0.125	0.107	0.137	0.07	0.183
Nickel	<0.20	<0.20	<0.30	<0.20	<0.20	<0.20	<0.20
Selenium	1.36	2.31	1.51	2.29	1.57	1.24	2.19
Strontium	0.135	0.11	0.108	0.261	0.069	0.08	0.072
Thallium	0.033	0.035	<0.030	0.021	0.043	<0.020	0.027
Tin	<0.10	<0.10	<0.15	<0.10	<0.10	<0.10	<0.10
Uranium	0.0066	0.0159	0.0178	0.0281	0.0194	0.0168	0.0154
Vanadium	<0.20	<0.20	<0.30	<0.20	<0.20	<0.20	<0.20
Zinc	20.5	21.3	17.9	18.7	20.8	14.4	20.3

APPENDIX G

STABLE ISOTOPES IN NATURE LABORATORY (SINLAB) REPORT



Appendix G. Stable Isotopes in Nature Laboratory (SINLAB) report.

Azimuth ID	SINLAB ID#	Sinlab ID	Date	Position	Wt (mg)	CO2 Amp	N2 Amp	d13C	d15N	% C	% N	C/N	Comments
GN-2008AM #16	GM 014												missing
GN-1002AM #13	GM 015	GM 015	28-Nov-08	7	0.201	2.069	1.315	-27.01	7.32	40.64	12.33	3.30	
GN-1002AM #13	GM 015	GM 015 R	28-Nov-08	24	0.214	2.766	1.709	-27.26	7.31	50.78	14.98	3.39	
GN-2001AM #18	GM 016	GM 016	28-Nov-08	8	0.215	2.477	1.438	-28.87	7.83	45.37	12.58	3.61	
GN-995PM #6	GM 017	GM 017	28-Nov-08	9	0.201	2.304	1.483	-26.32	8.04	45.30	13.90	3.26	
GN-1002AM #32	GM 018	GM 018	28-Nov-08	10	0.207	2.460	1.549	-27.64	8.43	46.83	14.05	3.33	
GN-2020AM #8	GM 019												missing
GN-1014AM #4	GM 020	GM 020	28-Nov-08	11	0.207	1.753	1.137	-23.41	8.60	33.58	10.38	3.23	
GN-2020AM #11	GM 021	GM 021	28-Nov-08	12	0.205	2.467	1.555	-27.88	7.47	47.35	14.23	3.33	
GN-2015AM #10	GM 022	GM 022	28-Nov-08	13	0.190	2.179	1.392	-27.49	7.83	45.29	13.78	3.29	
GN-2002AM #12	GM 023	GM 023	28-Nov-08	14	0.189	2.199	1.342	-27.85	8.24	45.80	13.34	3.43	
GN-2020AM #4	GM 024												missing
GN-1011AM #5	GM 025	GM 025	28-Nov-08	15	0.187	1.829	1.142	-27.35	8.01	38.63	11.50	3.36	
GN-1012AM #5	GM 026	GM 026	28-Nov-08	16	0.194	2.206	1.359	-27.61	7.66	44.95	13.20	3.40	
GN-1002AM #3	GM 027	GM 027	28-Nov-08	17	0.224	2.714	1.634	-27.94	8.20	47.74	13.71	3.48	
GN-1014AM #34	GM 028	GM 028	28-Nov-08	18	0.196	2.487	1.644	-26.73	8.38	50.26	15.80	3.18	
GN-4005 #7	GM 029												missing
GN-2007AM #9	GM 030	GM 030	28-Nov-08	19	0.205	2.500	1.568	-27.28	7.49	48.18	14.39	3.35	
GN-2011AM #4	GM 031	GM 031	28-Nov-08	20	0.219	2.640	1.498	-28.43	7.83	47.56	12.85	3.70	
GN-1002AM #21	GM 032	GM 032	28-Nov-08	21	0.210	2.602	1.541	-28.32	8.10	48.84	13.84	3.53	
GN-1002AM #45	GM 033	GM 033	28-Nov-08	22	0.210	2.424	1.541	-27.64	8.33	45.63	13.83	3.30	
GN-1002AM #34	GM 034												missing
GN-1011AM #20	GM 035	GM 035	28-Nov-08	23	0.208	1.990	1.254	-27.26	7.51	37.91	11.39	3.33	
GN-997PM #8	GM 036	GM 036	28-Nov-08	29	0.223	2.908	1.570	-29.14	8.06	51.15	13.22	3.87	
GN-997PM #8	GM 036	GM 036 R	28-Nov-08	48	0.193	2.619	1.271	-29.99	8.15	53.20	12.43	4.28	
GN-1011AM #10	GM 037	GM 037	28-Nov-08	30	0.203	2.420	1.413	-28.32	8.32	46.91	13.10	3.58	
GN-1014AM #14	GM 038												missing
GN-2007 #1	GM 039	GM 039	28-Nov-08	31	0.224	2.734	1.680	-27.80	7.48	48.08	14.10	3.41	
GN-997PM #9	GM 040	GM 040	28-Nov-08	32	0.222	2.686	1.721	-19.44	9.01	47.66	14.57	3.27	
GN-2022AM #14	GM 041	GM 041	28-Nov-08	33	0.199	2.311	1.419	-24.50	9.09	45.98	13.49	3.41	
GN-997AM #5	GM 042	GM 042	28-Nov-08	34	0.229	2.730	1.718	-26.97	7.96	46.99	14.09	3.34	
GN-1022AM #12	GM 043	GM 043	28-Nov-08	35	0.222	2.590	1.614	-27.39	8.57	45.98	13.65	3.37	
GN-2022 #3	GM 044	GM 044	28-Nov-08	36	0.203	2.408	1.452	-20.65	7.59	46.78	13.47	3.47	
GN-2001AM #5	GM 045												missing
GN-995AM #9	GM 046												missing
GN-3012 #1	GM 047	GM 047	28-Nov-08	37	0.218	2.661	1.638	-21.90	9.62	47.97	14.14	3.39	
GN-2022AM #2	GM 048	GM 048	28-Nov-08	38	0.203	2.414	1.520	-21.50	7.19	46.69	14.08	3.32	
GN-1005AM #12	GM 049	GM 049	28-Nov-08	39	0.208	2.314	1.424	-20.26	8.22	43.80	12.91	3.39	
GN-995AM #10	GM 050	GM 050	28-Nov-08	40	0.223	2.484	1.610	-20.14	8.64	43.80	13.60	3.22	
GN-1028AM #17	GM 051												missing
GN-2021AM #8	GM 052	GM 052	28-Nov-08	41	0.228	2.832	1.746	-19.50	7.57	48.58	14.34	3.39	
GN-1011AM #18	GM 053	GM 053	28-Nov-08	42	0.198	2.466	1.517	-19.83	8.42	48.87	14.44	3.39	
GN-2001AM #24	GM 054	GM 054	28-Nov-08	43	0.207	2.338	1.451	-19.54	9.14	44.26	13.18	3.36	
GN-1031AM #7	GM 055	GM 055	28-Nov-08	44	0.225	2.668	1.599	-19.34	9.42	46.34	13.38	3.46	
GN-2025AM #8	GM 056	GM 056	28-Nov-08	45	0.213	2.304	1.418	-21.06	7.89	42.34	12.54	3.38	
GN-1004AM #3	GM 057	GM 057	28-Nov-08	46	0.220	2.605	1.683	-18.51	7.89	46.36	14.39	3.22	
GN-2007AM #2	GM 058	GM 058	28-Nov-08	47	0.199	2.452	1.394	-20.77	9.03	48.27	13.18	3.66	
GN-2029AM #12	GM 059	GM 059	28-Nov-08	53	0.206	2.398	1.489	-20.93	9.49	45.76	13.64	3.36	
GN-2029AM #12	GM 059	GM 059 R	28-Nov-08	72	0.194	1.908	1.095	-21.23	9.79	38.72	10.75	3.60	
GN-1025AM #7	GM 060	GM 060	28-Nov-08	54	0.214	2.508	1.537	-19.28	8.20	46.03	13.58	3.39	
GN-1005AM #1	GM 061	GM 061	28-Nov-08	55	0.208	2.456	1.565	-19.21	8.39	46.22	14.14	3.27	
GN-1008AM #7	GM 062	GM 062	28-Nov-08	56	0.221	2.634	1.616	-19.84	8.61	46.74	13.76	3.40	
GN-2015AM #12	GM 063	GM 063	28-Nov-08	57	0.220	2.637	1.589	-21.03	9.89	46.96	13.62	3.45	
GN-1009AM #23	GM 064	GM 064	28-Nov-08	58	0.226	2.627	1.565	-19.51	8.58	45.44	13.04	3.49	
GN-2007AM #30	GM 065	GM 065	28-Nov-08	59	0.227	2.665	1.570	-18.70	9.19	45.91	13.00	3.53	
GN-3001AM #11	GM 066	GM 066	28-Nov-08	60	0.201	2.658	1.412	-22.36	10.10	51.78	13.25	3.91	
GN-2009AM #4	GM 067	GM 067	28-Nov-08	61	0.214	2.609	1.620	-19.69	8.81	47.80	14.25	3.35	
GN-1014AM #2	GM 068	GM 068	28-Nov-08	62	0.211	2.544	1.519	-20.11	9.86	47.35	13.59	3.48	
GN-3010 #7	GM 069	GM 069	28-Nov-08	63	0.187	1.974	1.262	-20.69	9.59	41.46	12.74	3.25	
GN-2007AM #3	GM 070	GM 070	28-Nov-08	64	0.210	2.633	1.438	-19.00	8.83	49.21	12.95	3.80	
GN-1002AM #5	GM 071	GM 071	28-Nov-08	65	0.224	2.860	1.657	-20.57	9.80	49.91	13.92	3.59	
GN-3012 #1	GM 072	GM 072	28-Nov-08	66	0.205	2.512	1.490	-22.00	9.91	48.10	13.73	3.50	
GN-1002AM #4	GM 073	GM 073	28-Nov-08	67	0.188	2.315	1.352	-19.40	9.74	48.42	13.58	3.56	
GN-1005AM #10	GM 074	GM 074	28-Nov-08	68	0.191	2.452	1.552	-24.91	9.55	50.39	15.35	3.28	
GN-1002AM #22	GM 075	GM 075	28-Nov-08	69	0.199	2.415	1.493	-24.17	9.17	47.74	14.24	3.35	both whirl paks labelled 22 (23?)
GN-2001AM #11	GM 076	GM 076	28-Nov-08	70	0.209	2.533	1.559	-25.36	10.77	47.34	14.06	3.37	
GN-1026AM #7	GM 077	GM 077	28-Nov-08	71	0.209	2.431	1.560	-20.47	12.78	45.56	14.07	3.24	
GN-1031AM #13	GM 078	GM 078 R	28-Nov-08	92	0.210	2.422	1.436	-23.45	12.40	45.14	12.93	3.49	
GN-1031AM #13	GM 078	GM 078	28-Nov-08	78	0.203	2.372	1.364	-23.79	12.28	45.87	12.74	3.60	
GN-1007AM #6	GM 079	GM 079	28-Nov-08	79	0.196	2.265	1.430	-23.23	9.26	45.39	13.82	3.28	
GN-1002AM #23	GM 080	GM 080	28-Nov-08	80	0.223	2.614	1.699	-21.69	11.55	45.80	14.40	3.18	both whirl paks labelled 22 (23?)
GN-1009AM #21	GM 081	GM 081	28-Nov-08	81	0.219	2.780	1.649	-24.90	10.56	49.59	14.23	3.49	

Appendix G. Stable Isotopes in Nature Laboratory (SINLAB) report.

Azimuth ID	SINLAB ID#	Sinlab ID	Date	Position	Wt (mg)	CO2 Amp	N2 Amp	d13C	d15N	% C	% N	C/N	Comments
GN-2012AM #8	GM 082	GM 082	28-Nov-08	82	0.198	2.589	1.320	-20.38	13.05	51.16	12.64	4.05	
GN-2031AM #8	GM 083	GM 083	28-Nov-08	83	0.221	2.561	1.311	-19.99	12.25	45.41	11.26	4.03	
GN-1005AM #3	GM 084	GM 084	28-Nov-08	84	0.228	2.674	1.698	-25.45	8.87	45.95	14.08	3.26	
GN-1009AM #5	GM 085	GM 085	28-Nov-08	85	0.209	2.634	1.476	-26.31	9.08	49.35	13.36	3.69	
GN-1009AM #9	GM 086	GM 086	28-Nov-08	86	0.225	2.697	1.698	-25.26	11.71	46.91	14.27	3.29	
GN-1002AM #1	GM 087	GM 087	28-Nov-08	87	0.222	2.702	1.626	-20.96	12.15	47.67	13.88	3.43	
GN-1010AM #7	GM 088	GM 088	28-Nov-08	88	0.211	2.799	1.507	-22.22	12.99	51.96	13.54	3.84	
GN-1004AM #2	GM 089	GM 089	28-Nov-08	89	0.212	2.558	1.586	-22.56	8.89	47.31	14.16	3.34	
GN-1009AM #3	GM 090	GM 090	28-Nov-08	90	0.203	2.129	1.269	-23.28	9.54	41.23	11.89	3.47	
GN-1002AM #33	GM 091	GM 091	28-Nov-08	91	0.215	2.590	1.579	-20.36	11.14	47.31	13.93	3.39	
GN-1002AM #47	GM 092	GM 092	15-Dec-08	6	0.222	2.503	1.549	-23.37	12.21	46.50	12.85	3.62	
GN-1002AM #47	GM 092	GM 092 R	15-Dec-08	30	0.194	2.002	1.393	-22.01	11.94	42.67	13.25	3.22	
GN-2025AM #10	GM 093	GM 093	15-Dec-08	7	0.202	2.346	1.508	-24.27	12.22	47.95	13.74	3.49	
GN-1005AM #2	GM 094	GM 094	15-Dec-08	8	0.188	2.216	1.478	-24.17	10.03	48.80	14.49	3.37	
GN-1009AM #4	GM 095	GM 095	15-Dec-08	9	0.215	2.506	1.591	-23.44	9.17	47.88	13.60	3.52	
GN-1009AM #2	GM 096	GM 096	15-Dec-08	10	0.227	2.517	1.771	-24.76	10.29	45.72	14.35	3.19	
GN-1022AM #29	GM 097	GM 097	15-Dec-08	11	0.207	2.424	1.386	-24.42	11.54	48.35	12.35	3.92	
GN-1037AM #12	GM 098	GM 098	15-Dec-08	12	0.216	2.625	1.587	-24.17	12.89	49.99	13.50	3.70	
GN-1005AM #9	GM 099	GM 099	15-Dec-08	13	0.220	2.489	1.684	-23.32	9.81	46.59	14.06	3.31	
GN-2003AM #10	GM 100	GM 100	15-Dec-08	14	0.201	1.925	1.323	-25.25	10.74	39.97	12.19	3.28	
GN-1007AM #1	GM 101	GM 101	15-Dec-08	15	0.196	2.207	1.524	-24.20	10.39	46.43	14.30	3.25	
GN-1031AM #12	GM 102	GM 102	15-Dec-08	16	0.202	2.435	1.394	-23.44	12.40	49.85	12.71	3.92	
GN-2018AM #10	GM 103	GM 103	15-Dec-08	18	0.190	2.283	1.260	-26.15	11.41	49.51	12.21	4.05	
GN-4017 #12	GM 104	GM 104	15-Dec-08	19	0.210	2.574	1.754	-23.15	13.46	50.28	15.31	3.28	took aliquot
2PL-EAS-1	GM 105	GM 105	15-Dec-08	20	0.222	2.252	0.732	-27.87	1.48	42.30	6.19	6.84	took aliquot
2PL-EAS-2	GM 106	GM 106	15-Dec-08	21	0.230	2.275	0.896	-28.39	3.99	40.92	7.22	5.66	took aliquot
2PL-EAS-3	GM 107	GM 107	15-Dec-08	22	0.122	1.204	0.399	-28.03	3.95	40.61	6.16	6.59	took aliquot
2PL-EAS-DT	GM 108	GM 108	15-Dec-08	23	0.233	1.067	0.224	-27.10	4.66	18.91	1.84	10.26	took aliquot
3PL-EAS	GM 109	GM 109	15-Dec-08	24	0.196	1.650	0.539	-28.95	5.41	34.43	5.17	6.66	took aliquot
2PL-EAS-1	GM 110	GM 110	15-Dec-08	25	0.207	1.950	0.843	-20.89	5.80	39.07	7.56	5.17	
2PL-EAS-2	GM 111	GM 111	15-Dec-08	26	0.231	2.189	1.057	-19.62	5.25	39.30	8.49	4.63	
2PL-EAS-3	GM 112	GM 112	15-Dec-08	27	0.218	0.994	0.214	-16.97	4.79	18.78	1.88	9.97	
2PL-EAS-DT	GM 113	GM 113	15-Dec-08	28	0.211	1.749	0.625	-23.04	5.65	34.57	5.54	6.24	
3PL-EAS-1	GM 114	GM 114	15-Dec-08	29	0.197	1.783	0.720	-20.51	5.41	36.84	6.80	5.42	
3PL-EAS-2	GM 115	GM 115	15-Dec-08	36	0.209	2.044	0.900	-21.13	5.88	40.43	8.00	5.06	
3PL-EAS-2	GM 115	GM 115 R	15-Dec-08	42	0.204	1.945	0.861	-21.30	5.95	39.54	7.83	5.05	
3PL-EAS-3	GM 116	GM 116	15-Dec-08	37	0.203	1.842	0.662	-17.71	2.62	37.59	6.08	6.19	
3PL-EAS-4	GM 117	GM 117	15-Dec-08	38	0.210	1.587	0.559	-16.23	4.91	31.50	4.97	6.34	
3PL-EAS-5	GM 118	GM 118	15-Dec-08	39	0.211	2.223	0.821	-17.53	2.40	43.56	7.21	6.04	
ARCH 997-PM-9	GM 119	GM 119	15-Dec-08	40	0.228	2.665	1.754	-28.18	8.13	47.99	14.14	3.39	extra sample
RNWH 2001-AM-25	GM 120	GM 120	15-Dec-08	41	0.205	2.437	1.530	-19.55	8.47	48.75	13.67	3.57	extra sample