KEEYASK PROJECT

Generating Station

March 2008 Report # 06-08

Aquatic Habitat Utilization Studies in Stephens Lake: Macrophyte Distribution and Biomass, Epiphytic Invertebrates, and Fish Catch-Per-Unit-Effort in Flooded Habitat

Draft

ENVIRONMENTAL STUDIES PROGRAM

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Aquatic Habitat Utilization Studies in Stephens Lake: Macrophyte Distribution and Biomass, Epiphytic Invertebrates, and Fish Catch-Per-Unit-Effort in Flooded Habitat

Draft Report Prepared for Manitoba Hydro

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OVERVIEW

Manitoba Hydro and its potential partners (Tataskweyak Cree Nation, War Lake First Nation, Fox Lake Cree Nation, and York Factory First Nation) are currently looking into building a hydroelectric generating station at Gull Rapids on the Nelson River. Studies are being done to support predictions of possible effects of this generating station on the environment. This information is required to prepare an Environmental Impact Statement (EIS), a document required by government for its consideration when deciding about licensing the generating station. The aquatic part of these studies is looking at the water, algae (microscopic plants in the water), weeds, bugs, and fish. The area being studied includes Split, Stephens, Clark, Gull, and Assean lakes and adjoining parts of the rivers (Burntwood, Nelson, Aiken, and Assean) and the streams that flow into them. Separate reports are being issued on each topic and for each different area.

This report presents the results of the fish habitat use study sampling in Stephens Lake during 2005-2006. Sampling for aquatic plants and fish was undertaken at the same time along the western side of Stephens Lake. The purpose of the surveys was to describe the types of species and their distribution to help understand their habitat preferences in a reservoir. This information is needed to develop models to predict aquatic plant distribution in the proposed Keeyask forebay, to understand which groups of invertebrates are associated with which plant species, and to provide data from which to infer fish species distribution in the proposed forebay.

TECHNICAL SUMMARY

Manitoba Hydro and its potential partners (Tataskweyak Cree Nation, War Lake First Nation, Fox Lake Cree Nation, and York Factory First Nation) are currently investigating the feasibility of developing a **hydroelectric generating station*** at Gull Rapids located at the upstream end of Stephens Lake on the Nelson River (Figure 1). An Environmental Studies Program has been developed to provide the data and information required for an **environmental impact assessment** of the above-mentioned hydroelectric **Project**, should a decision be made to proceed with a licensing submission to **regulatory authorities**. Manitoba Hydro and the potential partners have established a cooperative approach to assessing the potential effects of future development on the **environment** and for producing the information required for regulatory review and impact **monitoring**.

The Keeyask **aquatic monitoring** and impact assessment program was designed to investigate and document interrelated components of the Burntwood, Nelson, Aiken, and Assean rivers as well as the associated lake (Split, Stephens, Clark, Gull, and Assean) aquatic **ecosystems**. Investigations of physical **habitat**, **water quality**, **detritus**, **algae**, aquatic **macrophytes**, **aquatic invertebrates**, and fish were to be undertaken. Individual reports are being prepared and issued on each topic and for specific waterbodies.

The following report presents information collected from the fish habitat utilization study conducted on Stephens Lake during 2005-2006. Specific objectives of the program were to:

1) Document the species composition, abundance, and distribution of vascular macrophytes and the variables that influence habitat preference; i.e., water depth, slope, and substratum.

2) Document the species composition and biomass of **vascular** and **nonvascular** macrophytes and the species composition of epiphytic invertebrates at select sites.

3) Document the species composition, abundance, distribution, and habitat preferences of fishes captured within the flooded main basin and flooded bays.

* *Definitions for words appearing in bold are provided in the glossary (see Section 6.0).*

Objective 1:

A total of 525 sampling sites were visited in the western side of Stephens Lake where data on species (presence or absence), depth, substratum, and slope were collected using an echosounder, aluminum probe, and a ponar sampler.

Two of the nine species of macrophytes were observed frequently in standing water areas of Stephens Lake, and each of the two species exhibited markedly different habitat preferences. *Potamogeton richardsonii*, the most frequently observed species, showed a strong affinity for cohesive clay substrata, and was found at depths mainly below the intermittently exposed zone (IEZ). In contrast, *Myriophyllum sibiricum* showed a preference for inhabiting areas with fine organic deposits. While *Myriophyllum sibiricum* was observed as deep as *Potamogeton richardsonii* (i.e., 3.4 m below the 95th percentile water level) the depth distributions of these species differed significantly. The center of the frequency vs. depth distribution of *Myriophyllum sibiricum* was more shallow than *Potamogeton richardsonii*, and was found at about the depth boundary between the IEZ and predominantly wetted zone. This finding suggests that not only did *Myriophyllum sibiricum* inhabit part of the draw down zone of the reservoir, but the markedly different substratum preferences of these two species indicated that each tends to be found in very different flooded ecotypes.

Objective 2:

Macrophyte biomass and epiphytic invertebrate sampling was attempted at 36 sites in Stephens Lake during 2005 and 2006 using a 0.42 m^2 macrophyte sampler with a collection bag constructed of 400 µm mesh.

Macrophytes were absent at seven of these sites. In 2005 the mean total macrophyte dry weight was 25.87 g/m^2 and 19.57 g/m^2 in 2006. Epiphytic invertebrates were collected in conjunction with aquatic macrophyte sampling. Insecta (primarily Chironomidae) were the dominant epiphytic invertebrate found in 2005. The mean total eipiphytic invertebrate abundance in the 400 µm mesh was 123 individuals/m^2 and accounted for 82% of epiphytic invertebrates. Hydrozoa were the dominant epiphytic invertebrate collected in 2006. The mean total epiphytic invertebrate abundance was 591 individuals/m^2 and accounted for 48% of epiphytic invertebrates.

Objective 3:

Sampling in 2005 and 2006 within flooded habitat located in the main basin or bays of Stephens Lake resulted in the capture of 5, 609 fish, using small mesh (16-25 mm stretched mesh) nets for forage fish and larger mesh nets (38-51 mm stretched mesh) for large bodied species.

Total catch rates of 16 species of fish in flooded bay habitats were greater than that observed in the offshore areas of the main basin, although fish species richness in the flooded main basin habitat exceeded that of the flooded bays. Walleye and trout-perch showed a preference for main basin habitat, whereas northern pike, yellow perch, and shiners demonstrated a strong preference for flooded bay habitat. Rainbow smelt were found in all habitats studied in the main basin and flooded bays. Many of the fish species found in the main basin were not abundant.

In flooded bay habitat, northern pike showed a clear preference for habitat structure (i.e., macrophyte or wood) with a preference for use of macrophyte habitat. Shiners and yellow perch demonstrated a preference for shallow water habitat. Rainbow smelt, trout-perch, and walleye all preferred the open deep habitat within the flooded bays; a habitat that appeared to be a nearshore extension of the main basin habitat.

ACKNOWLEDGEMENTS

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Chief and Council of Tataskweyak Cree Nation (TCN) is gratefully acknowledged for their support of this program. We thank Douglas Kitchekeesik and Victor Spence of TCN for arranging logistic support and identifying personnel needed to conduct the field work.

Kelvin Kitchekeesik, George Flett, Leslie Flett, Dean Kitchekeesik, and Howard Flett assisted with the field surveys. Randy Naismith Sr. assisted the surveys by providing a boat and accommodation on Stephens Lake.

The collection of biological samples described in this report was authorized by Manitoba Conservation, Fisheries Branch under terms of Scientific Collection Permit # 05-47 and 23-06.

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TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

LIST OF APPENDICES

1.0 INTRODUCTION

Manitoba Hydro and its potential partners (Tataskweyak Cree Nation [TCN], War Lake First Nation [WLFN], Fox Lake Cree Nation [FLCN], and York Factory First Nation [YFFN]) are currently investigating the feasibility of developing a **hydroelectric generating station**[*] at Gull Rapids located at the upstream end of Stephens Lake on the Nelson River. An Environmental Studies Program has been developed to provide the data and information required for an **environmental impact assessment** of the above-mentioned hydroelectric **Project** (hereafter referred to as the Project), should a decision be made to proceed with a licensing submission to **regulatory authorities**. Manitoba Hydro and the potential partners have established a cooperative approach to assessing the potential effects of the Project on the **environment** and for producing the information required for regulatory review and impact **monitoring**.

The broad objectives of the Environmental Studies Program are the following:

- to describe the **existing environment** of the Study Area using an **ecosystem**-based approach;
- to provide data and information to assist in the planning of the Project;
- to provide data and information to enable assessment of the potential adverse effects that may result from the Project; and
- to provide the basis for monitoring environmental change resulting from development, should the Project proceed.

The following report describes the results of macrophyte and fish habitat utilization studies in Stephens Lake, and is one of the reports produced from the Keeyask Environmental Studies Program.

1.1 AQUATIC ECOSYSTEMS MONITORING AND ASSESSMENT

The collection of **baseline information** on the **aquatic environment** was initiated at the Project site in 1999. Manitoba Hydro expanded the program in 2001, and again in 2002, in response to concerns raised by the Cree Nations to include a broader geographic area to better characterize all aspects of the environment that may be affected by development at Gull Rapids. This included the **reach** of the Nelson River between, and including, Split Lake to Stephens Lake, the Burntwood, Aiken, and Assean rivers, as well as the associated lake

[*] *Definitions for words appearing in bold are provided in the glossary (see Section 6.0).*

(Split, Clark, Gull, and Assean) aquatic ecosystems. Biological investigations included measurements of physical **habitat**, **water quality**, **detritus**, **algae**, aquatic **macrophytes**, **aquatic invertebrates**, and fish.

Individual reports are being prepared and issued on each of these topics and for specific waterbodies. These reports will describe the existing environment, provide information to assist in Project planning, and provide the basis for predicting and assessing the significance of potential adverse effects that may result from construction and operation of the Project.

The following report presents information collected from the fish habitat utilization study conducted on Stephens Lake during 2005-2006. Specific objectives were as follows:

- Document the species composition, abundance, and distribution of vascular macrophytes and the variables that influence habitat preference; i.e., water depth, slope, and substratum. This information is needed to develop a model to predict the distribution of macrophytes in the proposed Keeyask forebay.

- Document the species composition and biomass of vascular and nonvascular macrophytes and the species composition of epiphytic invertebrates at select sites. This information describes how epiphytic invertebrates use macrophyte stands in flooded habitat.

- Document the species composition, abundance, distribution, and habitat preferences of fishes of domestic or commercial importance within the flooded main basin and flooded bays. Fish stomach contents are also described. This information is needed to base inference regarding species composition and use of flooded habitat by fishes in the proposed forebay.

2.0 THE KEEYASK STUDY SETTING

2.1 STUDY AREA

The Keeyask Study Area includes the reach of the Nelson River from Kelsey Generating Station (GS) to Kettle GS, including Split, Clark, Gull, and Stephens lakes; the Burntwood River downstream of First Rapids; the Grass River downstream of Witchai Lake Falls; the Assean River **watershed**, including Assean Lake; and all other tributaries to the above stated reach of the Nelson River (Figure 1).

The entire Study Area lies within the High **Boreal** Land Region characterized by a mean annual temperature of –3.4ºC and an annual precipitation range of 415 to 560 mm. **Topography** is bedrock controlled overlain with fine-grained **glacio-lacustrine deposits** of clays and gravels. Depressional areas have **peat** plateaus and patterned **fens** with **permafrost** present. Black spruce/moss/sedge associations are the dominant vegetation (Canada-Manitoba Soil Survey 1976).

Split Lake, which is immediately downstream of the Kelsey GS at the confluence of the Burntwood and Nelson rivers, is the second largest waterbody in the Study Area. Due to the large inflows from the Nelson and Burntwood rivers, the lake has detectable current in several locations. Split Lake has maximum and mean depths of 28.0 m and 3.9 m, respectively, at a water surface elevation of 167.0 m **ASL** (Lawrence et al. 1999). The surface area of Split Lake was determined to be 26,100 ha (excluding islands), with a total shoreline length, including islands, of 940.0 km (Lawrence et al. 1999). The numerous islands in Split Lake represent 411.6 km of the total shoreline.

The reach of the Nelson River between Split Lake and Stephens Lake is characterized by: i) narrow sections with swiftly flowing water (including Birthday and Gull rapids); and ii) wider more **lacustrine** sections, including Clark and Gull lakes. Mean winter flow in the reach is 3,006 m^3/s and mean summer flow is 2,812 m^3/s (Manitoba Hydro 1996a).

The Assean River system is north of Split Lake and drains into Clark Lake (Figure 1). Except for the mouth of the Assean River, the hydrology of the watershed has not been affected by hydroelectric development.

Stephens Lake, the largest lake in the Study Area, is located downstream of Gull Rapids and was created through the development of the Kettle GS. Stephens Lake has a surface area of 29,930 ha (excluding islands) and a total shoreline length, including islands, of 740.8 km. The numerous islands encompass an area of 3,340 ha and 336.2 km of shoreline. There is no detectable current throughout most of this large lake, except for the old Nelson River channel.

Communities in the Study Area include the First Nations communities of Split Lake (TCN) and York Landing (YFFN), both located on Split Lake (Figure 1). Members of WLFN reside in Ilford south of the Nelson River while some members of FLCN reside in Gillam on the south shore of Stephens Lake. Gillam, the largest community in the Study Area, is the regional headquarters for Manitoba Hydro's northern operations.

The names assigned to some of the features described in Section 2.3 and illustrated in Figure 1 may be inconsistent with local names, topographic maps, and/or the Gazetteer of Canada. When field programs were initiated in spring, 2001, names of several features within the Study Area were unknown to North/South Consultants Inc. (NSC) biologists and First Nation assistants. Therefore, some features for which no name was known were assigned names by field personnel. Chief and council of TCN, YFFN, WLFN, and FLCN or the Canadian Permanent Committee on Geographical Names have not approved names of features described within this document.

2.2 PREVIOUS HYDROELECTRIC DEVELOPMENT

The Study Area is bounded by two Manitoba Hydro hydroelectric generating stations on the Nelson River: the Kelsey GS just upstream of Split Lake and Kettle GS downstream of Stephens Lake. The Kelsey GS came into service in 1961 and is operated as a **run-of-river plant** with very little storage or re-regulation of flows (Manitoba Hydro 1996a).

The Kettle GS was completed in 1974, which raised the water level at the structure by 30.0 m and created a backwater effect upstream to Gull Rapids. Approximately 22,055 ha of land were flooded in creating Stephens Lake (Manitoba Hydro 1996a). Kettle GS is operated as a **peaking-type plant**, cycling its **forebay** on a daily, weekly, and seasonal basis. The forebay is operated within an annual water level range of 141.1 m to 139.5 m ASL (Manitoba Hydro 1996a).

Since 1976, two water management projects, the Churchill River Diversion (CRD) and Lake Winnipeg Regulation (LWR), have influenced water levels and flows within the Study Area. These two projects augment and alter flows to generating stations on the lower Nelson River by diverting additional water into the drainage from the Churchill River (CRD) (Manitoba Hydro 1996b) and managing outflow from Lake Winnipeg (LWR). The CRD and LWR projects reversed the Nelson River pre-Project seasonal water level and flow patterns in the Keeyask Study Area by increasing water levels and flow during periods of ice cover and reducing flows during the open-water period. Overall, there has been a net increase of 246 m^3/s in mean annual flow at Gull Rapids since CRD and LWR (Manitoba Hydro 1996a). The historic and current flow regimes are described in “History and First Order Effects, Split Lake Cree Post-Project Environmental Review”, Volume Two (Manitoba Hydro 1996a).

2.3 REPORT SPECIFIC STUDY AREA

The land bordering Stephens Lake includes areas of poor, moderate, and well-drained soils, dominated by black spruce forest in upland areas and black spruce **bogs**, peatlands, and fens in lowland areas. Trembling aspen occurs **sporadically** along the shoreline of Stephens Lake in areas that are well-drained. Soils are predominantly **organic** along the north shore, but include a section of mineral soil surrounding the north arm, and both mineral and organic soils along the south shore. Permafrost is **discontinuous** and sporadic, and exposed bedrock occurs at the west end of the lake (Agriculture and Agri-Food Canada 2003).

As discussed in Section 2.2, construction of the Kettle GS resulted in extensive flooding immediately upstream of the GS. Moose Nose Lake (north arm) and several other small lakes that previously drained into the Nelson River became continuous with the Nelson River to form Stephens Lake. Flooded **terrestrial** habitats compose a large portion of the existing lake **substratum**, and include organic **sediments** as well as areas of clay and **silt**. Woody debris is abundant due to the extensive flooding of treed areas. Outside the flooded terrestrial areas, the substrata are dominated by fine clay and silt. Sand, gravel, and cobble, and areas of organic material dominate the shoreline, with much of the shoreline being prone to **erosion**. **Riparian** vegetation includes willow, alder, black spruce, tamarack, and scattered stands of trembling aspen.

Major tributaries of Stephens Lake include the North and South Moswakot rivers that enter the north arm of the lake. The only other major **tributary** of Stephens Lake was the Butnau River. However, during construction of the Kettle GS, an earth dyke was constructed at the inlet of the Butnau River at Stephens Lake, and a channel developed to divert the Butnau River through Cache Lake into the Kettle River (Manitoba Hydro 1996a). Looking Back Creek is a second order ephemeral stream that drains into the north arm of Stephens Lake. This creek, located directly north of Gull Rapids and Gull Lake, is approximately 35 km in length and a number of small tributaries drain into it.

3.0 METHODS

3.1 OVERVIEW

Aquatic macrophyte distribution and biomass, epiphytic invertebrates, and fish were sampled concurrently during the summer of 2005 and 2006. The methods and data are each provided in three separate sections of the report. The macrophyte model section aims to describe the use of flooded habitat by vascular macrophytes and does so by sampling at many point locations over a wide area of the reservoir. The macrophyte biomass and epiphytic sampling section is presented next. This method uses an areal sampling approach at a relatively small number of sites. Fish capture data are presented in the last section. Samples were collected from July 27 to August 4, 2005 and from August 4 to 13, 2006. All samples in this study were collected from habitats flooded by the Kettle dam at the first full supply level attained in 1971.

3.2 MACROPHYTE MODEL DATA

3.2.1 Distribution of Macrophytes and Habitat Variables

Aerial video frame surveys were undertaken within the study area to locate macrophytes, and to direct sampling from a boat. Aerial video was captured along 72 km of shoreline using a global positioning system (GPS) linked system (Red Hen Systems Inc., Fort Collins, Colorado) mounted on a Bell Jet Ranger helicopter. Aerial frame surveys were conducted at about 100 m above the lake surface.

In 2005, boat-based sampling identified macrophytes by species, and at each location water depth, bottom slope, and substratum type were recorded. Water depth (± 5 cm) was measured at the center of each plant stand using an incremented 5 m aluminum probe. Slope of the substratum was determined using the change in depth over a known distance using the aluminum probe, or using a scientific-grade vertical echosounder operating at 50 kHz (Quester Tangent Corporation, Sydney, British Columbia), coupled with Trimble Pro XR differential (sub-meter) GPS. Substratum type at the location of the macrophyte stand was classified based on texture or compaction with the probe, and/or with a Ponar bottom sampler.

In 2006, sampling was directed to areas where plants were recorded as absent to document the habitat conditions at sites where plants do not exist. Information from the first field survey was used to locate areas where plants were absent and boat-based sampling was used to collect depth, slope, and substratum information. Effort was stratified within the preferred water depth range observed in 2005, as well as above and below this depth range.

All water depth observations were standardized relative to the 95th water level percentile using the mean water level during the survey.

3.2.2 Statistics

The Mann-Whitney test was used to assess differences in depth distribution by testing if the centers of the macrophyte distributions were equivalent in location. The Kolmogorov-Smirnov test was employed to validate the assumption of similar distributions required by the Mann-Whitney test, and to suggest if the use of Mann-Whitney was merited. Differences in the shape of distributions were assessed by centering the data. Centering involves the subtraction of the mean from each observation, and so removes the effect of scale differences between the distributions.

3.3 MACROPHYTE BIOMASS AND ASSOCIATED EPIPHYTIC INVERTEBRATE SAMPLING

3.3.1 Macrophyte Field Sampling

Macrophyte biomass and epiphytic invertebrate sampling was conducted on July 31, 2005 and August 4, 2006. Twenty-two sites were sampled in 2005 and 14 sites were sampled in 2006 (Tables 5 and 6). In 2005, all sites visited were chosen randomly from the sample of sites known to have macrophytes with the intent to provide a relatively large sample. In 2006, sites were chosen by a stratified random sampling design so that half the sample sites were located in areas where plants were not observed (during the helicopter survey). This method was employed to verify that aerial and boat-based observations were in agreement at sites where macrophytes were recorded as absent from the helicopter.

Macrophyte locations were assessed from the air with a helicopter survey conducted on July 28, 2005. The locations of the macrophyte beds was recorded on maps from the air and then re-visited by a boat based survey. At each site, UTM coordinates were taken with a hand-held Global Positioning System unit and water depth was measured using an aluminium rod which was graduated to the nearest 1 cm.

Aquatic macrophytes and epiphytic invertebrates were collected with a custom-designed sampler constructed of industrial ABS grade material. The frame measured 0.6 x 0.7 m, with a surface area of 0.42 m^2, and an attached 1.5 m cod-end. The sampler was placed into the water with the retractable cutter blade engaged and lowered to the bottom, disturbing the aquatic plants as little as possible. The cutter blade and attached cod-end were then pulled across the bottom of the sampler, severing the rooted macrophytes above the sediment surface. All plants and associated invertebrates were retained within the sampler.

Once the sampler was pulled to the surface, macrophytes were removed by hand, placed in a ziplock bag and a whole wet weight was taken (+/- 1 g) with a Kilotech PC 2000A digital scale. The macrophytes were then placed in a 400 µm mesh-bottom bucket and rinsed thoroughly to remove epiphytic invertebrates. After rinsing, macrophyte samples were placed in a salad spinner and spun to remove excess moisture, placed in labelled ziplock bags and weighed again. Any water collected from the spinning process was added to the rinse buckets to retain all invertebrates. Macrophyte samples were transported to the field laboratory, frozen and then transported to the North/South Consultants Inc. laboratory in Winnipeg for further processing. Invertebrate samples from the 400 µm mesh-bottom bucket were placed in labelled plastic jars, preserved with 10% formalin, and transported to the North/South Consultants Inc. laboratory in Winnipeg for further processing.

3.3.2 Laboratory and Data Analyses

Macrophytes were thawed in the laboratory in cold water and identified to the lowest **taxonomic** group possible (usually genus or **species**). Macrophyte samples were sorted and identified based on Fassett (1957), Flora of North America Editorial Committee (2000), Johnson et al. (1995) and Lahring (2003). Macrophytes were thoroughly rinsed again in the lab using a 400 µm sieve to collect any epiphytic invertebrates missed during processing in the field.

The wet weight (g) of each macrophyte group was determined by weighing plant material in pre-weighed aluminum pans with a Mettler PM480 Delta Range digital scale to the nearest 0.001 of a gram. Samples were subsequently dried in a Fisher Scientific Isotemp drying oven for approximately 24 hours at a temperature of 106 °C and a dry-weight (g) was determined for each macrophyte group. Dried samples were discarded once processed. Aquatic macrophyte biomass (g/m^2) was determined by dividing the dry weight of the macrophyte group per sample (g) by the surface area of the sampler (0.42 m^2).

Epiphytic invertebrate samples were sorted under a 3x magnifying lamp and invertebrates were transferred to 70% ethanol. Any remaining invertebrates found on macrophytes in the laboratory that were not initially rinsed and placed into bottles in the field were included in the analysis. Invertebrates were identified under an 80-100x stereomicroscope to major group and enumerated with reference texts by Clifford (1991), McCafferty (1998), and Merritt and Cummins (1996). Quality Assurance/Quality Control (QA/QC) procedures were followed for sample processing and invertebrate identification (Appendix 3).

Epiphytic invertebrate abundance (individuals/m^2) was calculated by dividing the number of invertebrates per sample by the surface area of the sampler (0.42 m^2). To determine total number of taxa, epiphytic invertebrate groups were identified to the lowest practical taxonomic level as presented in the following table:

Phylum, Subphylum or Class	**Major Group**	**Taxonomic Level of Identification**
Annelida	Oligochaeta; Hirudinea	Subclass
Crustacea	Ostracoda	Class
	- all other Crustacea	Order
Arachnida	Acarina	Subclass
Mollusca	Bivalvia	Family
	Gastropoda	Class
Hydrozoa	-	Class
Insecta	Megaloptera; Odonata; Coleoptera; Hemiptera; Ephemeroptera; Trichoptera; Diptera	Family

If aquatic macrophytes were absent from randomly pre-selected sites, values of zero were assigned to those sites when calculating overall dry weights and epiphytic invertebrate abundance. Samples were averaged for each site and this value was used to calculate the overall mean, **standard deviation**, and percent composition of aquatic macrophyte and epiphytic invertebrates for each area.

3.4 HABITAT USE BY FISH

3.4.1 Physical Monitoring

Water temperature and depth were recorded at each gillnet sampling site. Depth was measured using decametre graduations and was recorded as one of two categories: deep (over 4.0 m) or shallow (under 4.0 m). Water temperature was recorded using a hand-held thermometer (± 0.5 °C). A GPS receiver was used to record sampling locations using Universal Transverse Mercator, North American Map Datum, 1983.

3.4.2 Fish Capture

Bottom-set gill nets were used to sample the fish community in each of four flooded habitat types. From July 27 to August 4, 2005, 37 sites were sampled in the main basin and bay habitats: 14 in macrophyte habitat; 12 in shallow open-water; eight in deep open-water; and three in shallow, wood debris habitats. Sampling in 2006 focused entirely on bay habitat in order to focus the study to shallow flooded areas and provide a balanced sampling design across habitat types. From August 4 to 13, 2006, 55 sites were sampled in bay habitats: 16 in macrophyte habitat; and 13 sites in each of open shallow, open deep, and wooded habitats.

At all sites, each of which represented a habitat type, one gang of small mesh gill nets and one gang of large mesh gill nets were set. Small mesh gangs consisted of three 10 m long and 1.8 m deep panels of 16, 20, and 25 mm (stretched measure) twisted nylon mesh. Large mesh gangs consisted of a panel of 38 mm and 51 mm twisted nylon mesh (stretched measure) that were 22.9 m in length and 1.8 m deep. Where possible, the large mesh panels were tied together. Set duration at each site was approximately 24 hours.

3.5 FISH DATA

All fish captured were enumerated by species. Fork length, or total length where appropriate, (± 1 mm) and round weight (± 25 g) were recorded for all species captured, with the exception of forage fish. Northern pike, walleye, cisco, sauger, and lake whitefish were examined internally to determine stomach contents.

3.5.1 Data Analyses

Habitat comparisons and standardizing CPUE

Fish data analyses considered first a comparison of catch rates between the main basin and bay habitats, using the 2005 data. Next, the catch rates among the habitats found within the bays was compared using the 2005 and 2006 data. To facilitate direct comparison among the fish catch rates among the main basin and bay habitats, the small mesh and large mesh data from 2005 were each standardized to a single net length; catch-per-unit-effort (CPUE) of the 2005 data was expressed for each species as the number of fish captured in a 100 m net set for a 24 hour period. Catch-per-unit-effort (CPUE) of the 2006 data was expressed for each species as the number of fish captured in a 100 m net set for a 24 hour period for large mesh gear, and 30 m net set for a 24 hour period for small mesh.

Habitat use, central tendency, and dispersion

The temporal variation of fish catch rates (i.e., the consistency from one catch to another) is an important aspect in the interpretation of fish habitat use. A few individuals of one species may use a habitat regularly, whereas large numbers of another species may use the same habitat, but only periodically. To appreciate these two different forms of habitat use, it is necessary to understand the variation in the data, and how effective statistics, such as a mean, are in portraying the trend in the data. To best demonstrate the variability and range in CPUE and how these relate to measures of central tendency and dispersion, the raw CPUE results for each gillnet set are presented with the mean and median CPUE for each species by year of sampling. These scatter plots show the distribution of raw data and the mean and median values are used to show the inter-annual variation of catch rate by species and habitat type. All data for each species and habitat type was then pooled and are shown as box plots to present the main patterns in the data from both years of sampling. The box plots can also be used to contrast against outliers evident only in the scatter plots.

An example may assist interpretation of how the mean and median help to describe habitat use. A species with a mean CPUE value that is much higher than the median value suggests a relatively high temporal variation (i.e., occasional catches can be relatively large) and so the mean CPUE may be biased and may be an overestimate. In such cases, the median is a better estimate of the central tendency. Species with mean and median CPUE values that are similar will tend to be caught more regularly and will have similar counts among surveys. As a result, these catches will have a relatively narrow range in CPUE, and so the mean and median are good estimates of central tendency.

4.0 RESULTS

4.1 ASPECTS OF THE PHYSICAL ENVIRONMENT DURING THE STUDY PERIOD

Water levels in the Stephens Lake reservoir in 2005 and 2006 were near maximum. The surface level of the reservoir during surveys was 140.2 ASL in 2005 and 140.9 ASL in 2006. The range in water levels recorded daily at the Butnau dam on Stephens Lake during 2005 and 2006 was 0.28 m and 2.35 m, respectively. Changes in water level during the period of macrophyte growth (June 1 – August 30) was limited (0.18 m in 2005 and 0.51 m during 2006). Water level variation during field surveys each year was limited. The range in water levels in 2005 and 2006 during field programs was 0.07 m and 0.08 m, respectively.

The intermittently exposed zone (IEZ) for the present study is defined as the range in water depth between the 5th and 95th water level percentiles calculated using the hourly seasonal open water data for the existing environment (1977 – 2003). The seasonal open water 95th percentile water level elevation for the existing environment is 140.9 ASL (Manitoba Hydro, 2005). The 5th seasonal open water percentile is 139.06 ASL, or is equal to a water depth of 1.83 m below the 95th percentile.

In 2005, local drainages had abundant run-off, which was not the case in 2006. Consequently, the water in the bays studied here was cooler and less turbid in 2005 than it was in the relatively turbid main basin of Stephens Lake. Water temperatures in the flooded bays in 2005 were about 16°C, but in the main basin of Stephens Lake was 22 - 23°C. During this period in 2005, temperatures were as cool as 12.0°C at the terminal ends of Ross Wright and O'Neil bays where ephemeral tributaries drain through peat basins underlain by permafrost. In 2006, less inflow from local permafrost drainages enabled greater penetration of turbid water masses from the Nelson River or the main basin of Stephens Lake into the bays, and water temperatures in the flooded bays was warmer (18 - 20°C). The water quality and light extinction of the water masses in this study area during the same period of study is described by Cooley et al. (2008).

4.2 MACROPHYTE MODEL DATA

4.2.1 Macrophyte Species Composition and Abundance, and Distribution in Flooded Habitat

A total of 525 sampling sites were visited where data on species (presence or absence), depth, substratum, and slope were collected (Figure 2). Macrophytes were absent at 186 of these sites. All sampling sites combined represent reservoir water depths of 0.26 m - 10 m.

4.2.1.1 Species Composition

Nine species of vascular macrophytes were observed. Macrophyte stands observed in 2005 were located easily in 2006. There was no apparent change in composition or location of plant stands between the two study years.

4.2.1.2 Abundance

Sampling in 2005 and 2006 resulted in a total sample size of 339 sites where rooted aquatic plants were present (Table 1). The two most frequently observed species were: *Potamogeton richardsonii* (n = 203) and *Myriophyllum sibiricum* (n = 82). The seven other species, which accounted for 22% of the total sample at plant sites, were, in descending order of frequency, *Stuckenia pectinatus*, *Utricularia macrorhiza, Stuckenia vaginatus, Ranunculus aquatilis, Potamogeton gramineus*, *Poacea* sp., and *Polygonum amphibium*.

4.2.2 Use of Flooded Habitat

4.2.2.1 Water Depth

The distribution of frequency vs. water depth for all samples where species were present or absent is shown in Figure 3. Each data group approximates a normal distribution and so measures of central tendency can be used to describe the data. Frequency vs. depth histograms are provided for each species in Figure 4.

Macrophytes were observed in water depths ranging from 0.68 m – 3.48 m with a mean depth of 2.5 m. Eighty-five percent of the macrophytes sampled (n = 294) were observed at depths below the IEZ. Within the IEZ, *Myriophyllum sibiricum* was observed most frequently (n = 31). The four other species, in descending order of frequency, were: *Potamogeton richardsonii, Utricularia macrorhiza, Poacea* sp., *Potamogeton gramineus,* and *Polygonum amphibium*; these species accounted for 31% of the IEZ samples at plant sites.

The permanently wetted zone (PWZ) occupies depths below the IEZ. Within the PWZ, *Potamogeton richardsonii* (n = 198) and *Myriophyllum sibiricum* (n = 51) were observed most frequently. The six remaining species, in descending order of frequency, were: *Stuckenia pectinatus, Stuckenia vaginatus, Ranunculus aquatilis, Utricularia macrorhiza, Potamogeton gramineus,* and *Poacea* sp., and accounted for 15% of the PWZ samples at plant sites. The species that were found only in the PWZ are *Ranunculus aquatilis, Stuckenia pectinata,* and *Stuckenia vaginatus.* The sample size and measures of central tendency and dispersion for use of water depth for each species are listed in Table 1.

Sample sizes are sufficiently large for *Potamogeton richardsonii* and *Myriophyllum sibiricum* to merit statistical tests of the equality of depth distributions. The shape of the depth distributions of these species are similar ($Z = 1.05$, $P>2.12$, $n = 285$), and so there is evidence to suggest that the location of each of the depth distributions is different ($Z=4.89$, $P>0.000$, $n = 285$). The Mann-Whitney U test further confirms that the two depth distributions are statistically different ($Z = -10.23$, $P>0.000$, $n = 285$).

Nearly all *Potamogeton richardsonii* were found in the PWZ (97.5%) at a mean depth of 2.7 m. Conversely, *Myriophyllum sibiricum* can be found in water significantly more shallow; the mean depth was 2.0 m, or just slightly below the lower depth limit of the IEZ. About 38% of the *Myriophyllum sibiricum* sites were within the EIZ.

4.2.2.2 Substratum and Slope

Flooded substrata in the study ranged from organic to mineral materials, and sometimes were layered due to post-inundation depositional processes. Table 2 shows cross tabulation results for surface and sub-surface layers for all sites (i.e., plants present or absent) collected in the study area in 2005 and 2006.

Substratum samples lacking any evidence of layers totalled 74% of the 525 samples. Samples that were mineral-based, including clay or clay/sand/silt combinations totalled 53% of the sample. All other homogenous samples were based from organic materials composed of fibric, mesic, or humic-based layers of peat or organic deposits in the form of detritus or fine organic deposition. The remaining samples showed two layers, including surface layers of detritus or non-cohesive silt resulting from lacustrine depositional processes, except for one sample that contained three layers.

Percent slope information collected at all sites ranged from 0 – 10.8% (Table 3). Sampling at sites where plants were absent spanned a greater range of slope than where they were present. This was done to ensure the full range of environmental conditions was sampled. Table 3 shows, not surprisingly, that low slopes dominated the study area and most plant species inhabited areas less than 4% slope. In particular, 95% of the substrata where *Potamogeton richardsonii* or *Myriophyllum sibiricum* were sampled were slopes that were 2.7% or 1.5% or less, respectively.

4.2.2.3 Substratum Preference of Macrophytes

A strong fidelity to mineral-based substrata was demonstrated by *Potamogeton richardsonii, Potamogeton gramineus, Stuckenia pectinatus,* and *Stuckenia vaginatus* (Table 4). Seventytwo percent of the *Potamogeton richardsonii* samples were taken from clay substratum, and this preference is also evident for *Potamogeton gramineus* (71%; n = 7). While sample sizes are relatively small, between 47 – 75% of the *Stuckenia pectinatus* and *Stuckenia vaginatus* samples were observed on clay substrata. Most of the remaining samples for the preceding four species were also sampled from mineral based substrata, in the form of mixed combinations of sand/clay/silt.

In contrast, *Myriophyllum sibiricum* shows a strong affinity to organic deposition (83 %; n = 82), as does the less frequently observed *Utricularia macrorhiza* (100%; n = 12) and *Ranunculus aquatilis* (63%; n = 8).

Macrophytes were not observed on any type of inundated peat (i.e., O_f, O_h, O_m; n = 61) nor on 96% of the deep detritus areas.

4.3 SPECIES COMPOSITION AND BIOMASS OF MACROPHYTES AND EPIPHYTIC INVERTEBRATES

Aquatic macrophytes and associated epiphytic invertebrates were collected at 22 sites during 2005 (Table 5; Figure 8). Aquatic macrophytes were not present at seven out of 14 sites in Stephens lake during the 2006 sampling period (Table 6; Figure 8). Sampling in 2005 resulted in 14 sites represented by *Potamogeton richardsonii,* eleven sites with either *Stuckenia vaginatus* (n = 1) or *Stuckenia pectinatus* (n = 9), including two sites of *Stuckenia* sp. that were identified only to Genus, and a single site of *Myriophyllum sibiricum*.

4.3.1 Macrophytes

Eight taxa of vascular macrophytes were identified from samples collected at 29 sites in Stephens Lake in 2005 and 2006. Nonvascular macrophytes collected in Stephens Lake included aquatic moss, Cyanophycota, and unidentified macrophytes, each contributing less than 5% of the total dry weight collected at each site (Table 7; Figure 6).

The mean dry weight of macrophyte samples from Stephens Lake was 48.47 g/m^2 in 2005 and 36.00 g/m^2 in 2006. The species composition was primarily *Potamogeton richardsonii* (53.4% in 2005; 54.4% in 2006) and *Myriophyllum sibiricum* (19.4% in 2005; 24.9% in 2006) (Table 7; Figure 6).

4.3.2 Epiphytic Invertebrates

Thirty-six epiphytic invertebrate taxa were collected from aquatic macrophyte samples from Stephens Lake in 2005 and 2006 (Appendices 1 and 2). Insecta, primarily Chironomidae, were the most common invertebrate group collected in 2005 with 123 individuals/m^2

captured in the 400 µm sieve (Appendix1; Table 8). Overall, Insecta accounted for 82% of the dry weight of invertebrates collected from Stephens Lake in 2005 (Figure 7). Hydrozoa was the most common invertebrate group collected in 2006, with 591 individuals/m^2 captured in the 400 µm sieve. The next most common groups were Insecta, (primarily Chironomidae) at 313 individuals/m^2 and Annelida (primarily Oligochaeta) at 260 individuals/m^2 (Appendix 2; Table 8). Overall, Hydrozoa accounted for 48% of the dry weight of invertebrates collected from Stephens Lake in 2006, followed by Insecta with 25% (Figure 7).

4.4 HABITAT USE BY FISH

The distribution of sampling sites in 2005 and 2006 is shown in Figure 9. The common names, scientific names, and abbreviations of the fish species captured during fish community investigations conducted in Stephens Lake during summer 2005 and 2006 are provided in Appendix 4.

4.4.1 Fish Species Composition and Abundance

4.4.1.1 Species Composition

The composition of fish species sampled in both years using both gear types was similar (Figure 10). However, the relative abundance of rainbow smelt and trout-perch was about two fold higher in 2005 when sampling included main basin habitat. Large northern pike (> 300 mm) and yellow perch were captured more frequently in 2006 when samples were collected only from flooded bay habitat.

4.4.1.2 Abundance

Sampling in 2005 and 2006 resulted in a total catch of 5,609 fish. In 2005, sixteen species (n = 2,596 fish) were captured; whereas in 2006, thirteen species were captured (n = 3,013). In both years the most frequently captured species, in descending order were: shiner spp. (mostly spottail shiner and a few emerald shiner), followed by rainbow smelt, trout-perch, northern pike, yellow perch, and walleye. Nine additional fish species accounted for < 3.0 % of the total catch. Table 9 lists the total number of the common fish species captured by year, habitat zone (flooded main basin/flooded bay), and habitat class.

4.4.2 Use of Flooded Habitat

4.4.2.1 Fish Use of the Main Basin and Bay Habitat

Sampling in 2005 showed that the main basin is host to more species of fish, but the total CPUE of all species combined was greater in the bays. The number of fish and CPUE for each species captured in the main basin and bay habitat is shown in Table 10.

Catch rates of walleye and trout-perch collected in the flooded main basin in 2005 were markedly higher than the samples taken from flooded bay habitats in the same year (Table 10). Mean walleye catch rates for both small and large walleye (i.e., shorter or longer than 250 mm) were 10 - 20 times greater in the main basin when compared to relatively low catch rates (mean CPUE of < 0.5) in the bay habitats. Walleye catch rates in the main basin were notably highest in macrophyte stands (small walleye CPUE of 5; large walleye CPUE of 10). The mean rate of catching trout-perch in the main basin was a CPUE of 23, or as much as four times higher than the mean CPUE of bay habitat. Trout-perch in the main basin were sampled most frequently from the open shallow habitat. Fish sampled infrequently and only in the main basin were: mooneye, slimy sculpin, and lake chub.

In contrast, most yellow perch, northern pike, and shiners were caught primarily in the flooded bays. When these species were caught in the main basin these species were caught less often, but mostly from macrophyte habitat. Yellow perch catch rates in the flooded bay habitat were 5 fish per 24 hours, or about 10 times higher than the mean catch rates of 0.5 fish per 24 hours in the aquatic plant beds of the main basin. Small northern pike frequented most of the bay habitat used by large northern pike (i.e., shorter or longer than 300 mm), although the mean catch rate of small pike was about half the large pike CPUE of 10.8. In the main basin, small and large length classes of northern pike were sampled mainly in macrophyte habitat with mean CPUE values of 4.9 and 10.3 fish per 24 hours, respectively. Shiners also used most of the flooded bay habitat (mean CPUE of 48 fish per 24 hours) but used open deep habitat the least (CPUE of 6.3). In the main basin the abundance was lower, with a mean CPUE of about 31 fish per 24 hours. However, shiners caught in macrophyte stands in the main basin had a CPUE of 58, which exceeded the average CPUE for this species in the bays. Rainbow smelt were captured within all flooded habitats sampled in the main basin and the bays. Mean catch rates within the main basin and flooded bays were 36 and 31 fish per 24 hours, respectively.

Longnose sucker and burbot were only captured in the flooded bays, but were infrequent in the catches.

4.4.2.2 Fish Use of Flooded Bay Habitat

This section provides results first by species and year of sampling and secondly as pooled data for each species. The results of each year of study are used to demonstrate the inter-annual variability in catch rates by habitat, whereas the pooled data show the overall trend using box plots. The results for each species range from normally distributed to highly non-normal, and so means and medians are shown.

Shiner spp.

Shiner catch data show a large range in capture rate, with exceptionally high CPUE values from relatively few gillnet sets (Figure 11, upper panel A). The maximum catch rate for these species' (about 200 shiners per 24 hours) was from macrophyte habitat, about four times that of other sets in the same habitat. Median CPUE values for all types of flooded bay habitat in both years were well above zero, which indicates that shiners use all bay habitats to some extent. Inter-annual variation in the shiner catch rates shows that samples in 2005 were higher in habitats with structure (i.e., macrophyte, wood) when compared to samples from habitats with limited structure (i.e., open shallow, open deep). In contrast, samples from 2006 show groups of CPUE from individual net sets in open shallow and open deep sites that were elevated relative to 2005. These elevated catch rates, especially for open shallow habitat, appear to indicate greater use of habitats with limited structure in 2006. However, high CPUE values, i.e., above 75, are present in all bay habitats. Although shiners are abundant and well distributed, with catches expected often at median CPUE values of 10 – 25, infrequent and exceptionally large catches appear to be a trait of their ecology.

The pooled data shown in the box plots (Figure 11, lower panel A) reveal that the mean and median values of shiners in open deep habitat are notably lower than that of the other classes. Shiners are ubiquitous in the flooded bays of Stephens Lake but because open deep habitat is used less; a strong preference is evident for use of shallow water habitat.

Rainbow smelt

Rainbow smelt showed a large range in catch rates, with exceptionally high CPUE values in relatively few gillnet sets (Figure 11, upper panel B). Differences between the annual mean rate of catch by habitat was marked. Fewer smelt were caught in flooded bays during 2006. In 2005, median values from flooded bay habitat ranged between 5 and 25, except for open shallow habitat that had a median CPUE of about 2. In 2006, median CPUE values from flooded bay habitat were all less than 5.

The median CPUE values in the box plots were above zero and similar across all four habitat types, which indicate that smelt are distributed throughout the flooded bays (Figure 11, lower panel B). The difference between the mean and median CPUE values for smelt is greatest in the open shallow and open deep habitats, which is suggestive of a preference for smelt use of open habitat (i.e., structure-less areas, irrespective of depth) but with the important distinction that the temporal variation in catches between structured (W, M) and open (OS, OD) appeared quite different. Because large numbers of smelt were caught on occasion in the open habitat and were not characteristic of the macrophyte and wood habitat, smelt appear to use structured (M, W) and unstructured habitat (OS, OD) differently.

Trout-perch

The median CPUE values for trout-perch were zero, or near zero, for macrophyte, wood, and open shallow in both study years (Figure 12, upper panel A), indicating that the species does not frequent these types of habitats in flooded bays. Although samples of trout-perch collected in 2005 did show occasional use of macrophyte (a single sample) and open shallow (a few samples) habitats, it was only the open deep habitat that consistently showed frequent use by the species. In both years of study, trout-perch had similar mean and median CPUE values (2005: median 8.4, mean 10; 2006: median 9, mean 10) showing a relatively strong measure of central tendency. This means the temporal variation and range in catches was low, and so the use of open deep habitat by trout-perch was relatively consistent (Figure 12, lower panel A).

Yellow perch

The median CPUE values for yellow perch vary by habitat and year of sampling, and are well above zero for all flooded bay habitat, except for open deep habitat (Figure 12, upper panel B). When compared to the rate of catch in the other habitat types, open deep has limited scatter and the mean and median values were equal to, or near, zero (2005: mean 0, median 0; 2006: mean 1.6, median 1.2), indicating limited use of this habitat. Variation in catch rates between gillnet sets within or between years was evident in the other habitats as scatter, or as differences among mean or median values.

The box plots present the pooled data and clearly show that yellow perch demonstrate a strong tendency for use of shallow flooded bay habitat (Figure 12, lower panel B). Further, the relatively large range in catch rates observed implies the use of shallow habitats by yellow perch is frequent (i.e., the species was almost always present in catches) but the number of fish sampled per 24 hour period varied notably; often from a mean of 8 fish to as many as 30.

Walleye

Walleye catch rates were low in all habitat types in the flooded bays (Figure 13, upper panels A and B). Median CPUE values were zero for both length classes in all habitats in both years of sampling, except in 2006 for fish larger than 250 mm in open shallow and open deep habitat (median CPUE of 1.4 in both habitats). Although small walleye were sampled infrequently, the highest catch rate was in macrophyte habitat (CPUE of 3), and was about twice the rate found in wood and open shallow. Small walleye were not sampled in either year within the open deep habitat and as such, when small walleye use flooded bays, they tended to use shallow habitat.

The box plots combine both years of data from the flooded bays and show that the mean catch rates of large walleye were about twice that of small walleye (Figure 13, lower panels A and B). These data suggest that catch rates of walleye were highest in open habitat (OS, OD). Interestingly, the largest walleye CPUE collected in OS and OD approached that found in the main basin, where catch rates were consistently higher than that sampled in flooded bays in 2005. Further, the highest catch rate was found in OD; this suggests that the open deep habitat of the bay could be considered an extension of the main basin habitat.

Northern pike

The CPUE data showed that both length classes of northern pike had a clear preference for macrophyte habitat (Figure 14, upper panels A and B). The highest rates of northern pike capture in macrophyte habitat were between 30 and 40 fish per 24 hour period. The CPUE of large northern pike (>300 mm) was usually between 10 and 25, or about twice that of small northern pike. Mean values were only marginally greater than the median values, indicating that a mean can be considered an unbiased estimator, and is a representative measure of the pattern in the data. The measures of central tendency show that most of the catches within and among sites and sampling years were similar. Consequently, inter-annual variation in the rate of catching northern pike was relatively low. Median CPUE values of pike each year were less than a difference of 2 in all habitats, except for small pike in wood habitat in 2005 when fewer sites of this type were sampled, and large pike sampled within macrophyte habitat in 2006.

Small pike CPUE statistics were higher in macrophyte and wood habitat than in open shallow, and notably above the catch rates in open deep (Figure 14, upper panel A). In the open deep habitat, the mean and median values in 2005 and 2006 was zero, or less than a CPUE of 2, respectively. This indicates that small pike showed limited use of open deep habitat.

The CPUE statistics for large pike show a clear trend of catch rates among the habitat types for both years of sampling (Figure 14, upper panel B). Large pike showed a clear preference for macrophyte habitat, with minimum CPUE rates of about 10, which is at least 2 times higher than minimum catch rate observed in the other habitat. The mean, median, and maximum CPUE values of large northern pike sampled in wood habitat were consistently higher than that found in open shallow or open deep.

The box plots representing the pooled data show that evidence is strong to suggest that small and large northern pike preferred habitat with structure (macrophyte, wood), with a preference for macrophyte habitat (Figure 14, lower panels). The preference for macrophyte habitat was even more clear for large pike. This is evident as a distribution of minimum, median, mean, and maximum CPUE values that were markedly higher when compared to catch rates from the other habitat types. Open deep habitats were seldom used by northern pike and even less by small pike.

4.4.3 Fish Stomach Contents by Habitat

Only northern pike had sufficient stomach content samples to merit discussion. Stomach samples of northern pike were empty from 35% to not less than 60% of the time in both years of sampling across all habitats (Figure 15). The percent frequency of northern pike dietary items is similar among habitat types when both years of data are compared, except for rainbow smelt. In 2005, rainbow smelt were the dominant food item in the diet of northern pike. Smelt were consumed in all habitats, but the percent frequency of smelt in pike stomachs in open shallow (35%) and particularly open deep habitat (54%), was markedly higher than in macrophyte (22%) or wood (24%) samples. Apparently, predation of smelt by pike was higher in structure-less (i.e., open-water) conditions within the flooded bays during August 2005. In contrast, during August 2006, the frequency of occurrence of smelt in the stomachs of northern pike was markedly lower in all habitat types. The frequency that smelt were observed in pike stomachs sampled in open shallow and open deep habitat was 16% and 17%, respectively, which was only about 5% more frequent than was observed in macrophyte and wood habitats.

When the raw frequency data shown in Figure 11, panel B, and Table 9 are also considered, it is clear that a marked change in habitat use by smelt was observed. In 2005, 395 smelt were caught in open deep, or about four times more than were caught in open shallow habitat. In 2006, the reverse occurred; 312 smelt were caught in open shallow habitat, or about seven times more than were caught in open deep habitat that year.

5.0 SUMMARY

Two of the nine species of macrophytes were observed frequently in standing water areas of Stephens Lake, and each of the two species exhibited markedly different habitat preferences. *Potamogeton richardsonii*, the most frequently observed species, showed a strong affinity for cohesive clay substrata, and was found at depths mainly below the IEZ. In contrast, *Myriophyllum sibiricum* showed a preference for inhabiting areas with fine organic deposits. While *Myriophyllum sibiricum* was observed as deep as *Potamogeton richardsonii* (i.e., 3.4 m below the 95th percentile water level) the depth distributions of these species differed significantly. The center of the frequency vs. depth distribution of *Myriophyllum sibiricum* was more shallow than *Potamogeton richardsonii*, and was found at about the depth boundary between the IEZ and PWZ. This finding suggests that not only did *Myriophyllum sibiricum* inhabit part of the draw down zone of the reservoir, but the markedly different substratum preferences of these two species indicated that each tends to be found in very different flooded ecotypes.

Macrophyte biomass and epiphytic invertebrate sampling was attempted at 36 sites during 2005 and 2006. Macrophytes were absent at seven of these sites. In 2005 the mean total macrophyte dry weight was 25.87 g/m^2 and 19.57 g/m^2 in 2006. Epiphytic invertebrates were collected in conjunction with aquatic macrophyte sampling. Insecta (primarily Chironomidae) were the dominant epiphytic invertebrate group found in 2005. The mean total epiphytic invertebrate abundance in the 400 µm mesh was 123 individuals/m^2 and accounted for 82% of epiphytic invertebrates. Hydrozoa were the dominant epiphytic invertebrate group collected in 2006. The mean total epiphytic invertebrate abundance was 591 individuals/m^2 and accounted for 48% of epiphytic invertebrates

Total catch rates of 16 species of fish in flooded bay habitats were greater than that observed in the offshore areas of the main basin, although fish species richness in the flooded main basin habitat exceeded that of the flooded bays. Walleye and trout-perch showed a preference for main basin habitat, whereas northern pike, yellow perch, and shiners demonstrated a strong preference for flooded bay habitat. Rainbow smelt were found in all habitats studied in the main basin and flooded bays. Many of the fish species found in the main basin were not abundant.

In flooded bay habitat, northern pike showed a clear preference for habitat structure (i.e., macrophyte or wood) with a preference for use of macrophyte habitat. Shiners and yellow perch demonstrated a preference for shallow water habitat. Rainbow smelt, trout-perch, and walleye all preferred the open deep habitat within the flooded bays; a habitat that appeared to be a nearshore extension of the main basin habitat.

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6.0 GLOSSARY

Algae (al) − a group of simple plant-like aquatic ***organisms*** possessing ***chlorophyll*** and capable of ***photosynthesis***; they may be attached to surfaces or free-floating; most freshwater ***species*** are very small in size.

ASL − Above Sea Level.

Aquatic – living or found in water.

Aquatic environment − areas that are permanently under water, or that are under water for a sufficient period to support ***organisms*** that remain for their entire lives, or a significant portion of their lives, totally immersed in water.

Aquatic invertebrate (s) − an animal lacking a backbone that lives, at least part of its life, in the water (e.g., aquatic insect, mayfly, clam, aquatic earthworm, crayfish).

Aquatic monitoring – the primary goal of long term ***monitoring*** of lakes and rivers is to understand how ***aquatic*** communities and ***habitats*** respond to natural processes and to be able to distinguish differences between human-induced disturbance effects to aquatic ***ecosystems*** and those caused by natural processes.

Aquatic plants – multi-celled plants living in the water.

Basin (s) – a distinct section of a lake, separated from the remainder of the lake by a constriction.

Baseline information − information about an area, over a period of time, that is used as background for detecting and/or comparing potential future changes.

Bog (s) – wetland ***ecosystem*** characterized by an accumulation of ***peat***, acid conditions, and a plant community dominated by sphagnum moss.

Boreal − of, or relating to, the forest areas of the North Temperate Zone, dominated by coniferous trees such as spruce, fir, and pine.

Chlorophyll – a group of green pigments present in plant and ***algal*** cells that are necessary in the trapping of light energy during ***photosynthesis***

Confluence – the meeting place of two streams or rivers.

Detritus − particulate and dissolved ***organic*** matter that is produced by the decomposition of plant and animal matter.

Discontinuous – the occurrence of ***permafrost*** in 35-85% of a geographic area.

Ecosystem (s) − all living ***organisms*** in an area and the non-living parts of the environment upon which they depend, as well as all interactions, both among living and non-living components of the ecosystem.

Environment − 1) the total of all the surrounding natural conditions that affect the existence of living ***organisms*** on earth, including air, water, soil, minerals, climate, and the organisms themselves; and, 2) the local complex of such conditions that affects a particular organism and ultimately determines its physiology and survival.

Environmental impact assessment − an evaluation of the likely adverse environmental effects of a project that will contribute to decisions about whether to proceed with a project.

Ephemeral − a stream that flows only in direct response to precipitation, and thus ceases flowing during dry seasons.

Epiphytic invertebrate – an ***invertebrate*** found on ***aquatic plants***, using the plant for food or shelter

Existing environment − the present condition of a particular area; generally assessed prior to the construction of a proposed project.

Forebay – the portion of a reservoir immediately upstream of a hydroelectric facility.

Fen (s) – a peatland with the water table usually at or just above the surface; often stagnant and alkaline.

Genus − a division in the classification of plants and animals consisting of a group of related ***species***; a ***taxonomic*** rank below family and above species.

Glacio-lacustrine deposits − soil that originates from lakes that were formed by melting glaciers.

Habitat − the place where a plant or animal lives; often related to a function such as spawning, feeding, etc.

Hydroelectric generating station − a generating station that converts the potential energy of elevated water or the kinetic energy of flowing water into electricity.

Invertebrate (s) – animals without a spinal column.

Lacustrine − referring to freshwater lakes; ***sediments*** generally consisting of stratified fine sand, ***silt***, and clay deposits on a lake bed.

Macrophyte (s) − multi-celled ***aquatic*** and ***terrestrial*** plants.

Monitoring − measurement or collection of data to determine whether change is occurring in something of interest.

Nonvascular − refers to lower plants which lack well developed conducting tissues (xylem and phloem): e.g. moss and ***algae***.

Neuston – small ***organisms*** that occur at or near the surface of the water.

Organic – the compounds formed by living ***organisms***.

Organism (s) – an individual living thing.

Peat − material consisting of non-decomposed and only slightly decomposed ***organic*** matter found in extremely moist areas.

Permafrost − subsoil that remains below the freezing point throughout the year, as in an Arctic environment.

Photosynthesis – a process which occurs in plants and ***algae*** where, in the presence of light, carbon dioxide and water are turned into a useable form of energy (sugar) and oxygen.

Project − proposed ***hydroelectric generating station*** on the Nelson River, ***upstream*** of Stephens Lake.

Reach − any length of stream or river under study, often with similar features along its length.

Regulatory authorities − a decision-making body such as a government department.

Riparian – along the banks of rivers and streams.

Run-of-river plant − a hydroelectric generating station that has no upstream storage capacity and must pass all water flows as they come.

Sediment (s) – material, usually soil or ***organic detritus***, which is deposited in the bottom of a waterbody.

Silt – a very small rock fragment or mineral particle, smaller than a very fine grain of sand and larger than coarse clay; usually having a diameter of 0.002 to 0.06 mm; the smallest soil material that can be seen with the naked eye.

Soil (s) – 1) all loose, unconsolidated, weathered, or otherwise altered rock material above bedrock; and 2) a natural accumulation of ***organic*** matter and inorganic rock material that is capable of supporting the growth of vegetation.

Species – a group of ***organisms*** that can interbreed to produce fertile offspring.

Sporadic (ally) – the occurrence of isolated patches of ***permafrost***, 10-35% of a geographic region.

Standard deviation (SD) – the square root of the variance of a collection of numbers.

Substratum – the material forming the streambed; also solid material upon which an ***organism*** lives or to which it is attached.

Taxon (a) – any valid taxonomic category (e.g., order, family, genus, species) defined according to hierarchical level.

Taxonomic – pertaining to the classification of plants and animals into groups.

Terrestrial – belonging to, or inhabiting the land or ground.

Topography − the general configuration of the land surface including relief and position of natural and man-made features.

Vascular – referring to the higher plants (e.g., flowering plants).

Water quality − measures of substances in the water such as nitrogen, phosphorus, oxygen, and carbon.

Watershed − the area within which all water drains to collect in a common channel or lake.

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TABLES AND FIGURES

Table 1. Water depth (m) statistics for samples of macrophyte species in flooded habitat of Stephens Lake during the period of maximum growth in 2005 and 2006. Water depth has been standardized to the 95th water level percentile.

Species	n	Minimum	Maximum	Mean	Std. Deviation
Polygonum amphibium	1	1.68	1.68	1.68	-
Poacea sp.	3	1.78	1.88	1.81	0.06
Myriophyllum sibiricum	82	1.18	3.38	2.04	0.45
Utricularia macrorhiza	12	1.68	2.88	2.13	0.38
Ranunculus aquatilis	8	2.18	2.48	2.33	0.11
Potamogeton gramineus	7	0.68	3.08	2.56	0.84
Stuckenia pectinatus	15	2.28	3.08	2.62	0.28
Potamogeton richardsonii	204	1.78	3.48	2.74	0.34
Stuckenia vaginatus	8	2.28	3.48	2.87	0.43

Table 2. Cross-tabulation of substratum material type for surface and sub-surface materials in Stephens Lake where macrophytes were either present or absent. One sample contained three layers and is not shown, but is included in the totals. Material types are explained in the text. O_f, O_m, and O_h are organic material derived from pre-flood peatlands in a fibric, mesic, or humic state.

		Surface Material													
		Clay	Detritus	Gravel	O_f	O_m	Organic Deposition	Sand	Sandy/Clay	Sandy/Silt	Silt	Silt/Organic Deposition	Silty/Clay	Silty/Sand	Total
Sub-Surface Material	Clay	154	36	2	0	0	0	0	0	0	28	0	0	0	220
	Detritus	0	27	0	0	0	5	0	0	0	19	3	0	0	54
	Gravel	0	0	0	0	0	0	1	0	0	0	0	0	0	1
	O_f	0	0	0	23	0	3	0	0	0	21	0	0	0	47
	Oh	0	0	0	0	0	1	0	0	0	2	0	0	0	3
	O_m	0	0	0	0	11	0	0	0	0	0	0	0	0	11
	Organic Deposition	0	0	0	0	0	122	0	0	0	2	0	0	0	124
	Sand	0	0	0	0	0	0	0	0	0	13	0	0	0	13
	Sandy/Clay	0	0	0	0	0	0	0	3	0	0	0	0	0	3
	Sandy/Silt	0	0	0	0	0	0	0	0	1	0	0	0	0	1
	Silt	0	0	0	0	0	0	0	0	0	13	0	0	0	13
	Silty/Clay	0	0	0	0	0	0	0	0	0	0	0	14	0	14
	Silty/Sand	0	0	0	0	0	0	0	0	0	1	0	0	19	20
Total		154	63	2	23	11	131	1	3	1	100	3	14	19	525

Table 3. Statistics of percent slope for sites where macrophytes were absent, or where present, by species. Sample totals are consistent with previous tables. Statistics for the slope data include the 5th and 95th and the median to describe slope frequency distributions.

	Percent Slope					
Species	Minimum	Maximum	Percentile 05	Percentile 95	Mean	Median
absent	0.00	10.85	0.30	5.92	2.35	1.89
Myriophyllum sibiricum	0.10	2.93	0.20	1.50	0.60	0.50
Poacea sp	0.20	0.50	0.20	0.50	0.30	0.20
Polygonum amphibium	0.47	0.47	0.47	0.47	0.47	0.47
Potamogeton gramineus	0.67	2.10	0.67	2.10	1.40	1.20
Potamogeton richardsonii	0.15	6.54	0.30	2.70	1.38	1.10
Ranunculus aquatilis	0.25	6.14	0.25	6.14	2.44	1.85
Stuckenia pectinatus	0.65	3.86	0.65	3.86	2.18	2.20
Stuckenia vaginatus	1.10	2.42	1.10	2.42	1.68	1.60
Utricularia macrorhiza	0.20	0.91	0.20	0.91	0.34	0.30

Table 4. Frequency of sub-surface substratum types sampled at each location where macrophytes were either present or absent in Stephens Lake during 2005 and 2006. One sample at a site where macrophytes were absent contained three layers and is not shown, but is included in the totals. O_f, O_m, and O_h are organic material derived from pre-flood peatlands in a fibric, mesic, or humic state.

	Sub-Surface Material													
Species	Clay	Detritus	Gravel	O_f	O_h	O_m	Organic Deposition	Sand	Sandy/Clay	Sandy/Silt	Silt	Silty/Clay	Silty/Sand	Total
absent	38	51	1	47	3	11	9	13	0	0	11	0	1	185
Myriophyllum sibiricum	14	0	0	0	0	0	68	0	0	0	0	0	0	82
Poacea sp.	0	0	0	0	0	0	3	0	0	0	0	0	0	3
Polygonum amphibium	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Potamogeton gramineus	5	0	0	0	0	0	0	0	0	0	0	0	2	7
Potamogeton richardsonii	147	2	0	0	0	0	27	0	3	0	2	11	11	203
Ranunculus aquatilis	2	1	0	0	0	0	5	0	0	0	0	0	0	8
Stuckenia pectinatus	7	0	0	0	0	0	0	0	0	1	0	2	5	15
Stuckenia vaginatus	6	0	0	0	0	0	0	0	0	0	0	1	1	8
Utricularia macrorhiza	0	0	0	0	0	0	12	0	0	0	0	0	0	12
Total	220	54	1	47	3	11	124	13	3	1	13	14	20	525

Table 5. Survey information for macrophytes and epiphytic invertebrates collected in Stephens Lake, summer 2005.

Date	Area Name	Site[1]	Location (UTM/Datum NAD 83)			Water	Sample[1]	
			Zone	Easting	Northing	Depth (m)	Macrophytes	Epiphytic Invertebrates
31-Jul-05	Stephens Lake	1	15V	367088	6250452	1.6	√	√
31-Jul-05	Stephens Lake	2	15V	367070	6250401	1.8	√	√
31-Jul-05	Stephens Lake	3	15V	367089	6250383	1.8	√	√
31-Jul-05	Stephens Lake	4	15V	367090	6250376	1.8	√	√
31-Jul-05	Stephens Lake	5	15V	367091	6250362	1.6	√	√
31-Jul-05	Stephens Lake	6	15V	367067	6250382	1.8	√	√
31-Jul-05	Stephens Lake	7	15V	367207	6250477	1.6	√	√
31-Jul-05	Stephens Lake	8	15V	367179	6250471	1.8	√	√
31-Jul-05	Stephens Lake	9	15V	367172	6250461	1.8	√	√
31-Jul-05	Stephens Lake	10	15V	367165	6250485	1.8	√	√
31-Jul-05	Stephens Lake	11	15V	367182	6250477	1.7	√	√
31-Jul-05	Stephens Lake	12	15V	369079	6251895	1.8	√	√
31-Jul-05	Stephens Lake	13	15V	369026	6251886	1.8	√	√
31-Jul-05	Stephens Lake	14	15V	369023	6251885	1.8	√	√
31-Jul-05	Stephens Lake	15	15V	367875	6252585	2.3	√	√
31-Jul-05	Stephens Lake	16	15V	367893	6252599	2.2	√	√
31-Jul-05	Stephens Lake	17	15V	361704	6252020	1.0	√	√
31-Jul-05	Stephens Lake	18	15V	361700	6252010	1.0	√	√
31-Jul-05	Stephens Lake	19	15V	361715	6252004	1.0	√	√
31-Jul-05	Stephens Lake	20	15V	361777	6251956	1.4	√	√
31-Jul-05	Stephens Lake	21	15V	362775	6255131	2.0	√	√
31-Jul-05	Stephens Lake	22	15V	362770	6255116	2.0	√	√

[1] √ indicates that macrophyte and epiphytic samples were collected

Table 6. Survey information for macrophytes and epiphytic invertebrates collected in Stephens Lake, summer 2006.

Date	Area Name	Site	Location (UTM/Datum NAD 83)			Water	Sample[1,2,3]	
			Zone	Easting	Northing	Depth (m)	Macrophytes	Epiphytic Invertebrates
4-Aug-06	Stephens Lake	1	15V	367655	6249837	1.5	n.m	n.e
4-Aug-06	Stephens Lake	2	15V	367104	6250442	2.0	n.m	n.e
4-Aug-06	Stephens Lake	3	15V	368792	6251922	2.1	n.m	n.e
4-Aug-06	Stephens Lake	4	15V	366376	6250754	2.1	n.m	n.e
4-Aug-06	Stephens Lake	5	15V	363987	6250126	1.9	n.m	n.e
4-Aug-06	Stephens Lake	6	15V	364223	6251521	1.7	n.m	n.e
4-Aug-06	Stephens Lake	7	15V	365150	6252294	1.8	n.m	n.e
4-Aug-06	Stephens Lake	29	15V	363734	6254090	1.2	√	√
4-Aug-06	Stephens Lake	64	15V	362914	6254072	2.5	√	√
4-Aug-06	Stephens Lake	71	15V	362187	6254240	1.0	√	√
4-Aug-06	Stephens Lake	181	15V	362714	6255156	1.5	√	√
4-Aug-06	Stephens Lake	225	15V	363247	6254768	1.9	√	√
4-Aug-06	Stephens Lake	262	15V	372473	6254581	1.6	√	√
4-Aug-06	Stephens Lake	274	15V	373220	6253964	1.9	√	√

[1] √ indicates that macrophyte and epiphytic samples were collected

[2] n.m indicated no macrophytes at that site

[3] n.e indicated no epiphytics collected at that site

Table 7. Summary of mean dry weight (g/m^2), ± one standard deviation (SD), and percent dry weight (%) of vascular and nonvascular aquatic macrophyte samples collected from 29 sites in Stephens Lake during the summer of 2005 and 2006. Individual abundances may not add up to totals due to rounding.

Area	**Stephens Lake**					
Year	**2005**			**2006**		
	Mean	**SD**	**%**	**Mean**	**SD**	**%**
Vascular Macrophytes						
Lemna trisulca	0.00	0.00	0.00	0.00	0.00	0.00
Myriophyllum sibiricum	9.39	25.03	19.37	8.96	25.23	24.90
Polygonum amphibium	0.00	0.00	0.00	4.38	16.38	12.16
Potamogeton gramineus	2.10	5.07	4.34	0.00	0.00	0.00
Potamogeton richardsonii	25.87	35.99	53.38	19.57	48.04	54.37
Stuckenia pectinatus	7.07	16.01	14.59	0.00	0.00	0.00
Stuckenia vaginatus	0.00	0.00	0.00	3.09	11.55	8.57
Utricularia macrorhiza	0.10	0.46	0.20	0.00	0.00	0.00
Nonvascular Macrophytes						
Aquatic moss	0.98	3.56	2.03	0.00	0.00	0.00
Cyanophycota	0.01	0.04	0.02	0.00	0.00	0.00
Unidentified Macrophytes/organic debris	2.94	9.36	6.08	0.00	0.00	0.00
TOTAL MACROPHYTES	**48.47**	**31.41**	**100.00**	**36.00**	**50.09**	**100.00**

Table 8. Summary of mean abundance (individuals/m^2), ± one standard deviation (SD), and overall percent of total epiphytic invertebrates (%) collected from 29 sites in Stephens Lake during the summer of 2005 and 2006. Individual abundances may not add up to totals due to rounding.

Area	**Stephens Lake**					
Year	**2005**			**2006**		
	Mean	**SD**	**% of Total**	**Mean**	**SD**	**% of Total**
Sieve Size	**400 µm**			**400 µm**		
Annelida	0	1	0.3	260	487	21
Crustacea	9	16	5.8	55	104	4.4
Arachnida	1	2	0.6	2	3	0.2
Mollusca	16	24	10.7	21	33	1.7
Hydrozoa	0	0	0.0	591	1801	47.6
Insecta	123	146	82	313	514	25
Terrestrial Invertebrates	0	1	0.2	0	1	0.0
Total Invertebrates	**150**	**146**	**100.0**	**1243**	**2432**	**100.0**

Table 9. Frequency of occurrence for common fish species sampled in small and large mesh gill nets from flooded habitat at Stephens Lake. Macrophyte (M), wood (W), open shallow (OS), and open deep (OD) habitats were sampled in the main basin and bays during August of 2005 and 2006. Fish species name abbreviations are listed in Appendix 1.

Habitat Zone	Habitat	Year	SHINER *sp.*	RNSM	TRPR	YLPR	WALL < 250mm	WALL > 250mm	NRPK < 300mm	NRPK > 300mm
Main	M	2005	226	78	45	2	20	35	21	40
Basin	OS	2005	23	156	139	0	1	5	1	7
	OD	2005	0	15	10	0	0	1	0	0
Total			249	249	194	2	21	41	22	47
Bay	M	2005	329	62	42	34	2	2	22	63
		2006	232	36	0	102	0	8	92	209
	W	2005	150	45	0	15	1	0	7	31
		2006	365	76	0	86	1	5	62	104
	OS	2005	253	98	41	36	0	0	10	40
		2006	544	312	26	115	3	19	36	90
	OD	2005	26	395	42	0	0	0	0	25
		2006	242	44	109	19	0	15	17	44
Total			2141	1068	260	407	7	49	246	606
Grand Total			2390	1317	454	409	28	90	268	653

Table 10. CPUE statistics for small and large gill net sets in the main basin and bay habitats of Stephens Lake in 2005. Habitat types sampled were: macrophyte (M), open deep (OD), open shallow (OS), and wood (W). For each habitat the following information is provided: 1) The number of gill net sets, 2) the number of fish (n), 3) the proportion of the gill net sets each species was captured, and 4) the mean CPUE. Totals for the main basin and bays are also provided. CPUE is expressed as #fish/24 hrs/100 m. Fish species name abbreviations are listed in Appendix 4.

Reservoir Habitat	Habitat Type	Number of Sets in Habitat	Statistic	Shiner *sp.*	RNSM	TRPR	YLPR	SAUG	WALL <250mm	WALL >250mm	NRPK <300mm	NRPK >300mm	CISC	LKWH	WHSC	LNSC	LKCH	MOON	SLSC	BURB	Total
				Small Mesh Gill Net				Large Mesh Gill Net													
Bay	**M**	7	n	329	62	42	34	1	2	2	22	63	1	3	-	-	-	-	-	-	561
			Proportion of sets	0.86	0.71	0.14	0.57	0.14	0.14	0.14	0.86	1.00	0.14	0.14	-	-	-	-	-	-	1.00
			CPUE	68.97	12.99	9.42	7.14	0.22	0.45	0.45	4.37	12.97	0.22	0.65	-	-	-	-	-	-	117.85
	OD	7	n	26	395	42	-	-	-	-	-	25	7	5	-	1	-	-	-	1	502
			Proportion of sets	0.71	1.00	1.00	-	-	-	-	-	0.86	0.71	0.57	-	0.14	-	-	-	0.14	1.00
			CPUE	6.34	87.59	10.46	-	-	-	-	-	5.76	1.69	1.21	-	0.27	-	-	-	0.25	113.56
	OS	6	n	253	98	41	36	-	-	-	10	40	6	1	-	-	-	-	-	-	485
			Proportion of sets	1.00	1.00	0.33	0.83	-	-	-	0.67	1.00	0.67	0.17	-	-	-	-	-	-	1.00
			CPUE	60.80	23.17	9.01	8.45	-	-	-	2.22	9.40	1.46	0.23	-	-	-	-	-	-	114.74
	W	3	n	150	45	-	15	-	1	-	7	31	-	2	1	-	-	-	-	-	252
			Proportion of sets	1.00	1.00	-	1.00	-	0.33	-	1.00	1.00	-	0.67	0.33	-	-	-	-	-	1.00
			CPUE	73.74	21.89	-	7.33	-	0.49	-	3.41	15.12	-	0.99	0.49	-	-	-	-	-	123.46
	Total	23	n	**758**	**600**	**125**	**85**	**1**	**3**	**2**	**39**	**159**	**14**	**11**	**1**	**1**	-	-	-	**1**	**1800**
			Proportion of sets	**0.87**	**0.91**	**0.43**	**0.52**	**0.04**	**0.09**	**0.04**	**0.57**	**0.96**	**0.43**	**0.35**	**0.04**	**0.04**	-	-	-	**0.04**	**1.00**
			CPUE	**48.40**	**39.51**	**8.40**	**5.33**	**0.07**	**0.20**	**0.14**	**2.35**	**10.12**	**0.96**	**0.76**	**0.06**	**0.08**	-	-	-	**0.08**	**116.46**
Main Basin	**M**	7	n	226	78	45	2	-	20	35	21	40	5	1	2	-	3	5	-	-	483
			Proportion of sets	1.00	1.00	0.71	0.29	-	0.86	0.71	0.71	1.00	0.43	0.14	0.29	-	0.43	0.43	-	-	1.00
			CPUE	58.05	20.01	11.42	0.56	-	5.43	9.56	4.88	10.28	1.26	0.25	0.53	-	0.73	1.21	-	-	124.15
	OD	1	n	-	15	10	-	-	-	1	-	-	-	2	-	-	-	-	-	-	28
			Proportion of sets	-	1.00	1.00	-	-	-	1.00	-	-	-	1.00	-	-	-	-	-	-	1.00
			CPUE	-	28.06	18.70	-	-	-	1.87	-	-	-	3.74	-	-	-	-	-	-	52.37
	OS	6	n	23	156	139	0	7	1	5	1	7	2	2	7	0	1	2	1	0	354
			Proportion of sets	0.83	1.00	1.00	0.00	0.67	0.17	0.33	0.17	0.33	0.17	0.33	0.50	0.00	0.17	0.17	0.17	0.00	1.00
			CPUE	6.08	43.68	39.22	0.00	2.08	0.22	1.39	0.22	1.74	0.61	0.56	1.91	0.00	0.27	0.45	0.25	0.00	98.68
	Total	14	n	**249**	**249**	**194**	**2**	**7**	**21**	**41**	**22**	**47**	**7**	**5**	**9**	-	**4**	**7**	**1**	-	**865**
			Proportion of sets	**0.86**	**1.00**	**0.86**	**0.14**	**0.29**	**0.50**	**0.57**	**0.43**	**0.64**	**0.29**	**0.29**	**0.36**	-	**0.29**	**0.29**	**0.07**	-	**1.00**
			CPUE	**31.63**	**30.73**	**23.85**	**0.28**	**0.89**	**2.81**	**5.51**	**2.53**	**5.89**	**0.89**	**0.63**	**1.08**	-	**0.48**	**0.80**	**0.11**	-	**108.10**

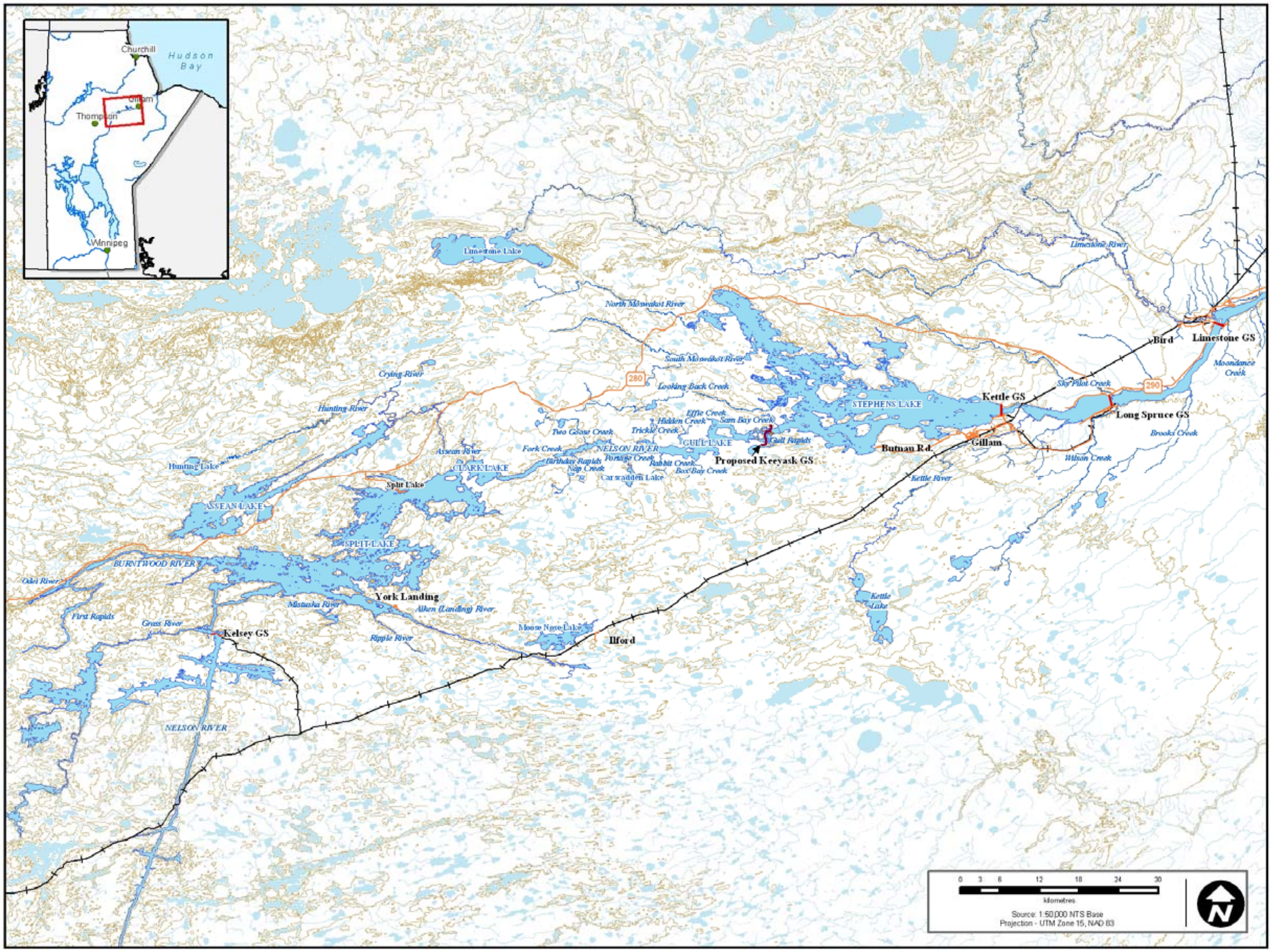


Figure 1. Map of the Keeyask Study Area showing proposed and existing hydroelectric development.

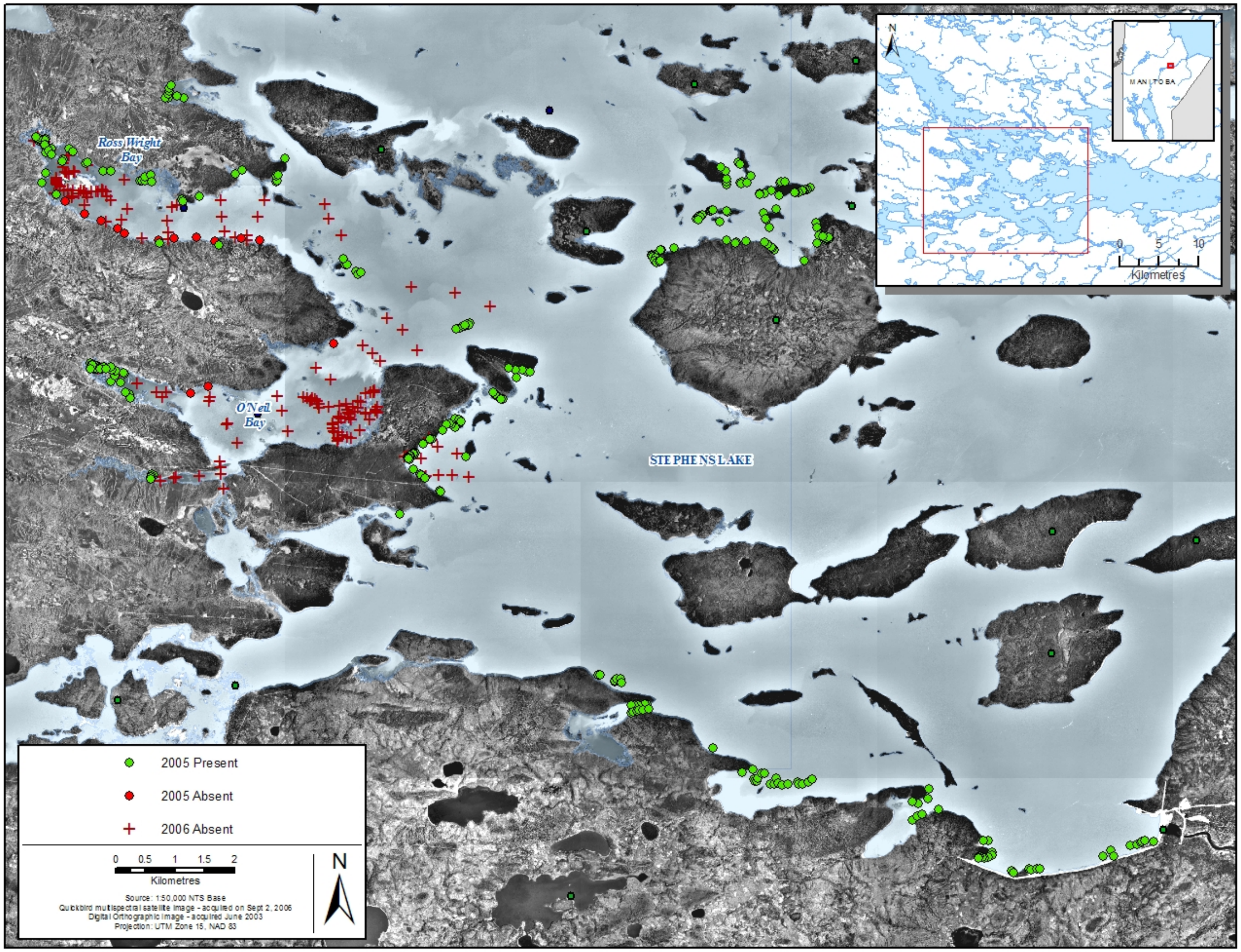
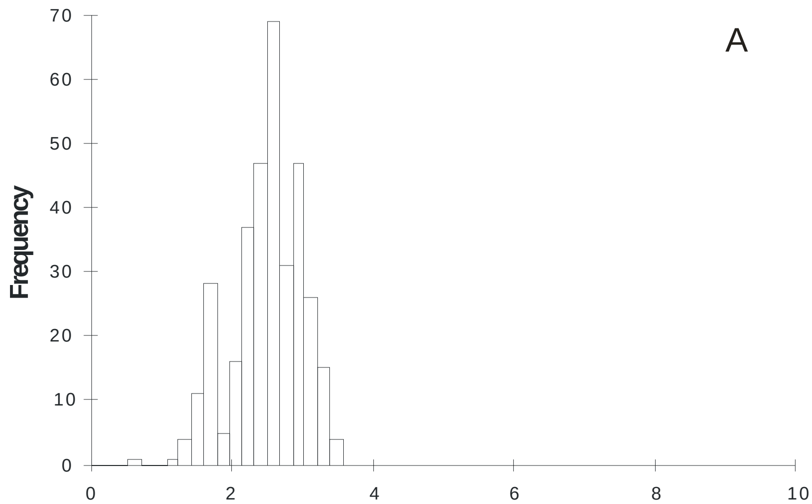


Figure 2. Location of the 525 sampling sites where data on species (presence or absence), depth, substratum, and slope were collected.



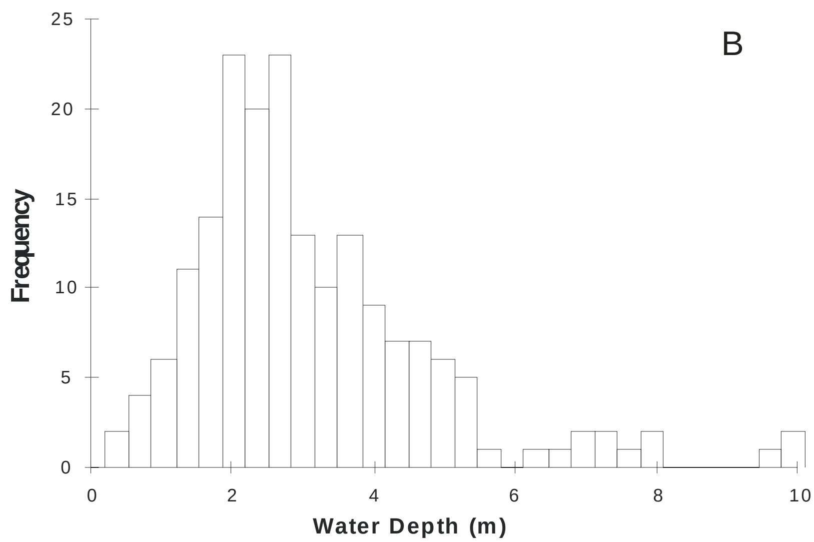


Figure 3. Frequency vs. water depth histograms of all samples where macrophytes were present (A) or absent (B). Water depth has been standardized to the 95th water level percentile.

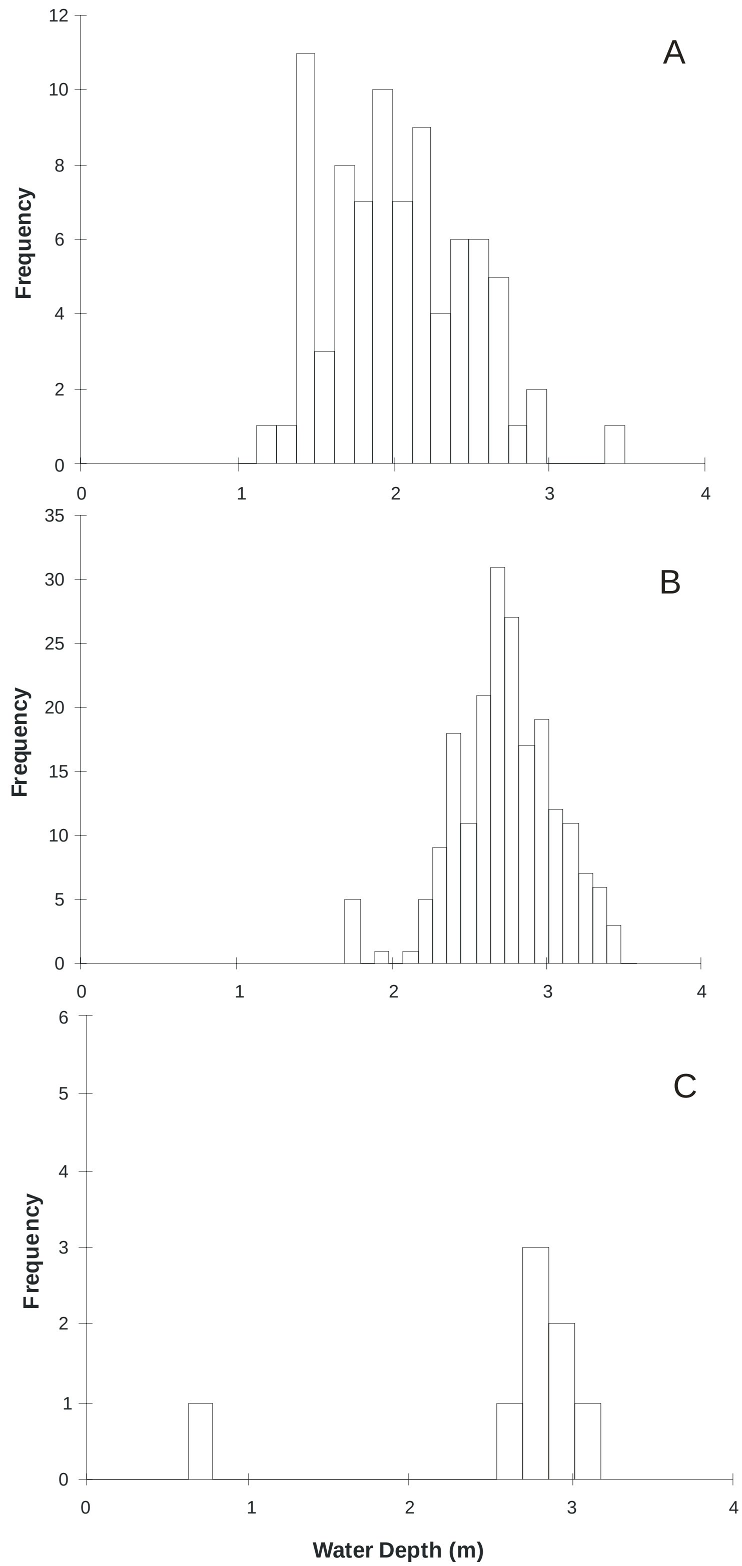


Figure 4. Frequency vs. water depth histogram of *Myriophyllum sibiricum* (A), *Potamogeton richardsonii* (B), and *Potamogeton gramineus* (C). Water depth has been standardized to the 95th water level percentile.

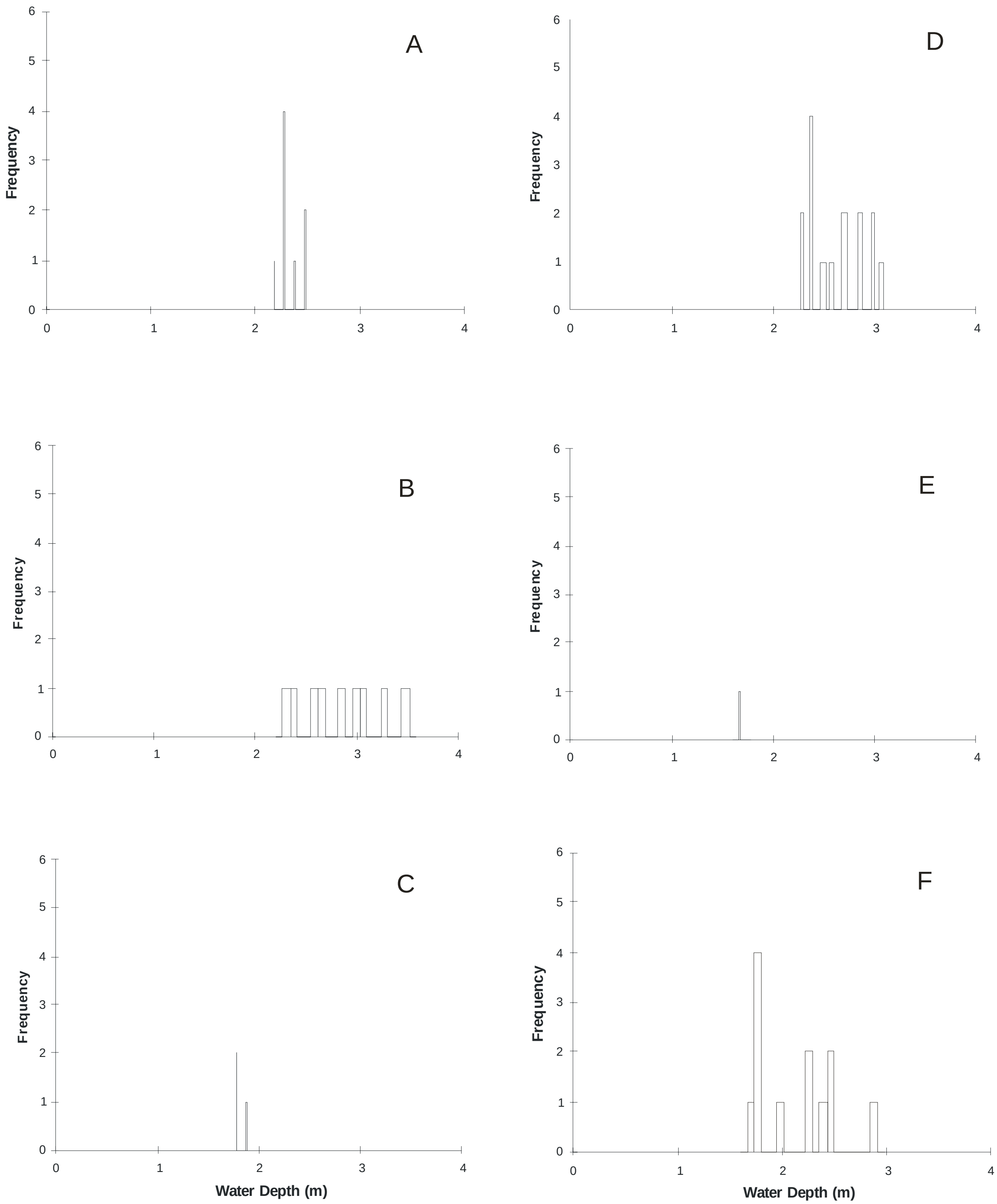


Figure 5. Frequency vs. water depth histogram of *Ranunculus aquatillus* (A), *Stuckenia vaginatus* (B), *Poacea* sp.(C), *Stukenia pectinatus* (D), *Polygonum amphibium* (E), and *Utricularia macrorhiza* (F) . Water depth has been standardized to the 95th water level percentile.

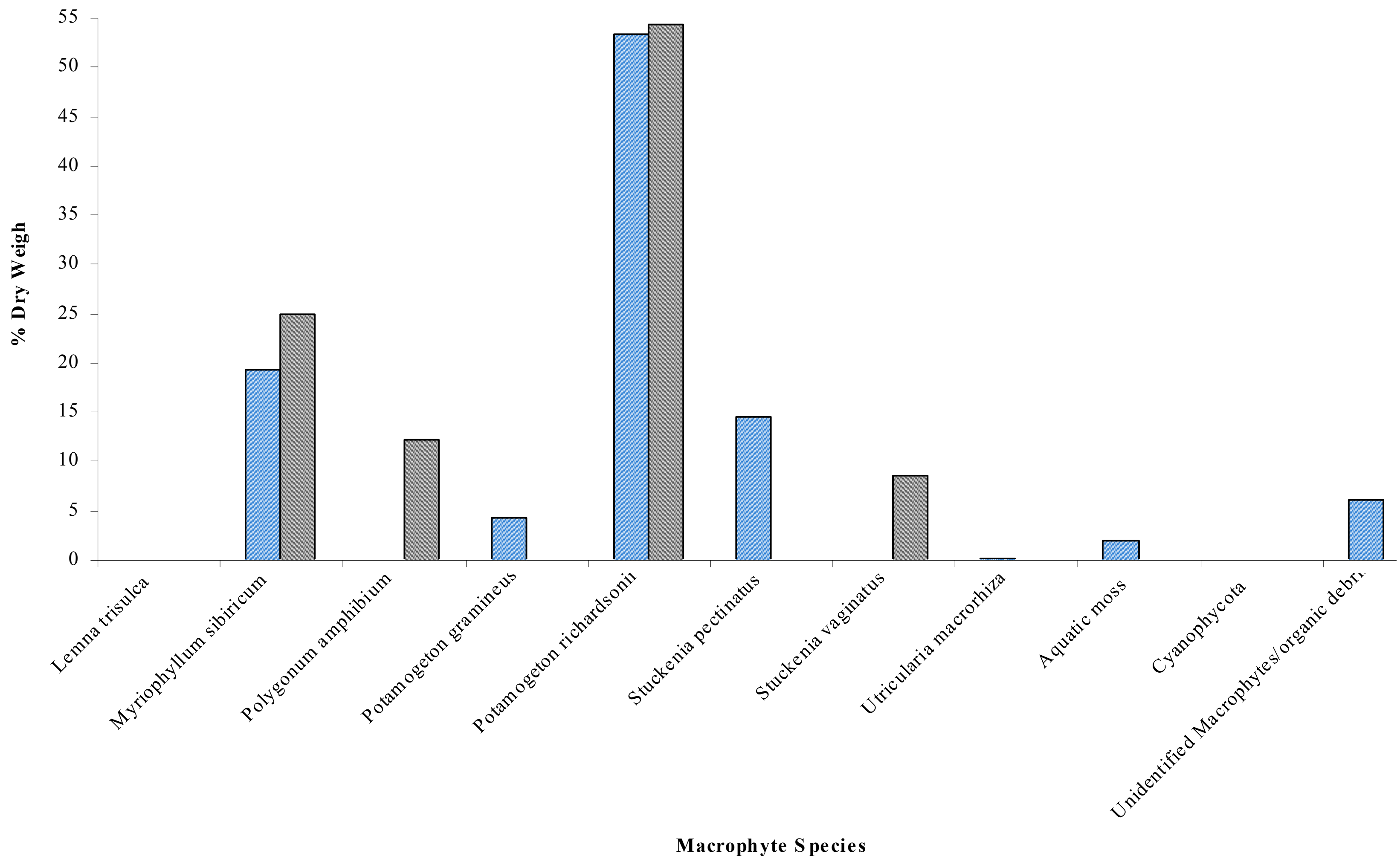


Figure 6. Mean percent dry weight (%) of vascular and nonvascular macrophyte samples collected from 29 sites in Stephens Lake, summer 2005 and 2006.

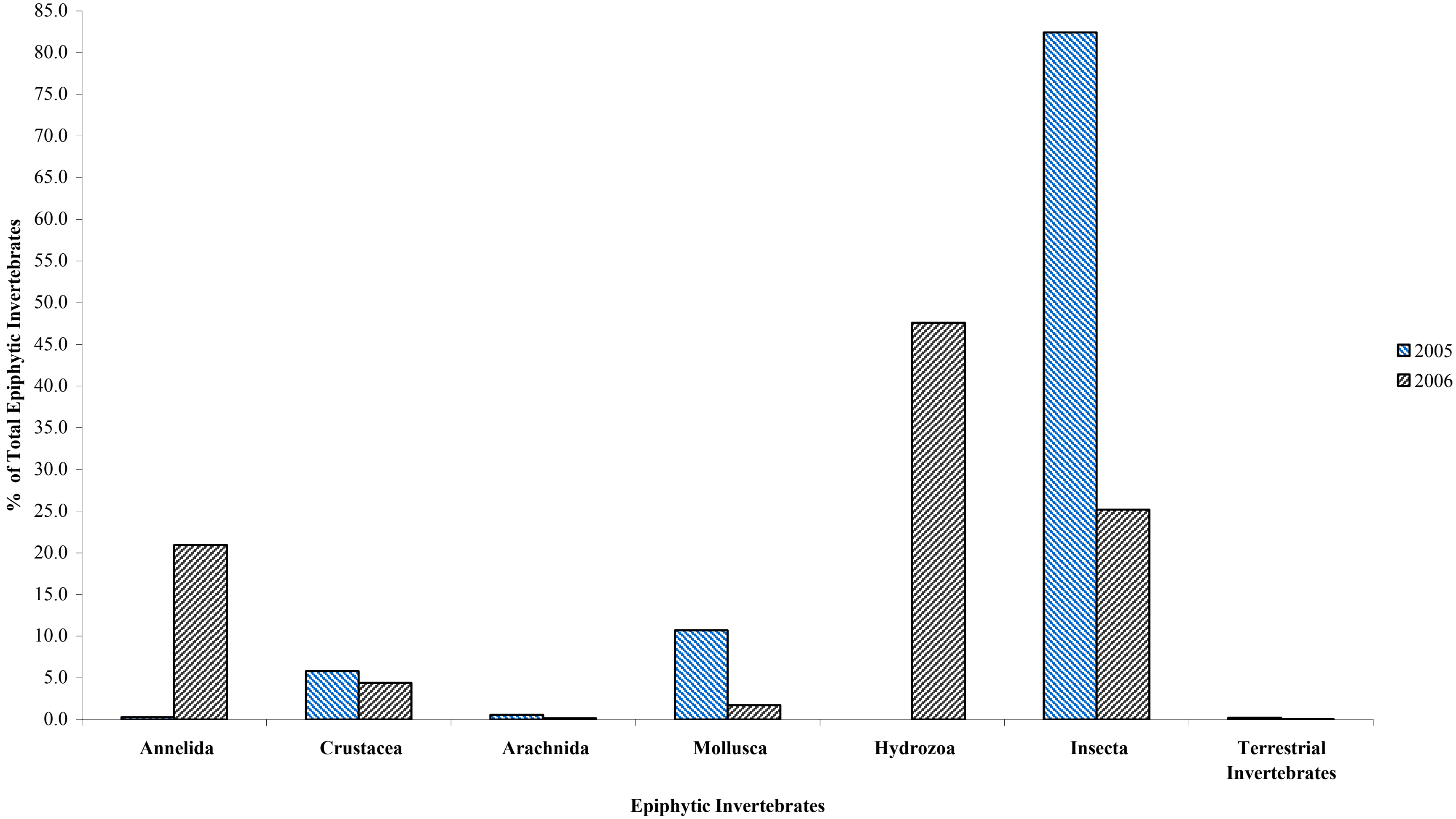


Figure 7. Percent of total epiphytic invertebrates (%) retained in a 400 µm sieve, collected from 29 sites in Stephens Lake, summer 2005 and 2006.

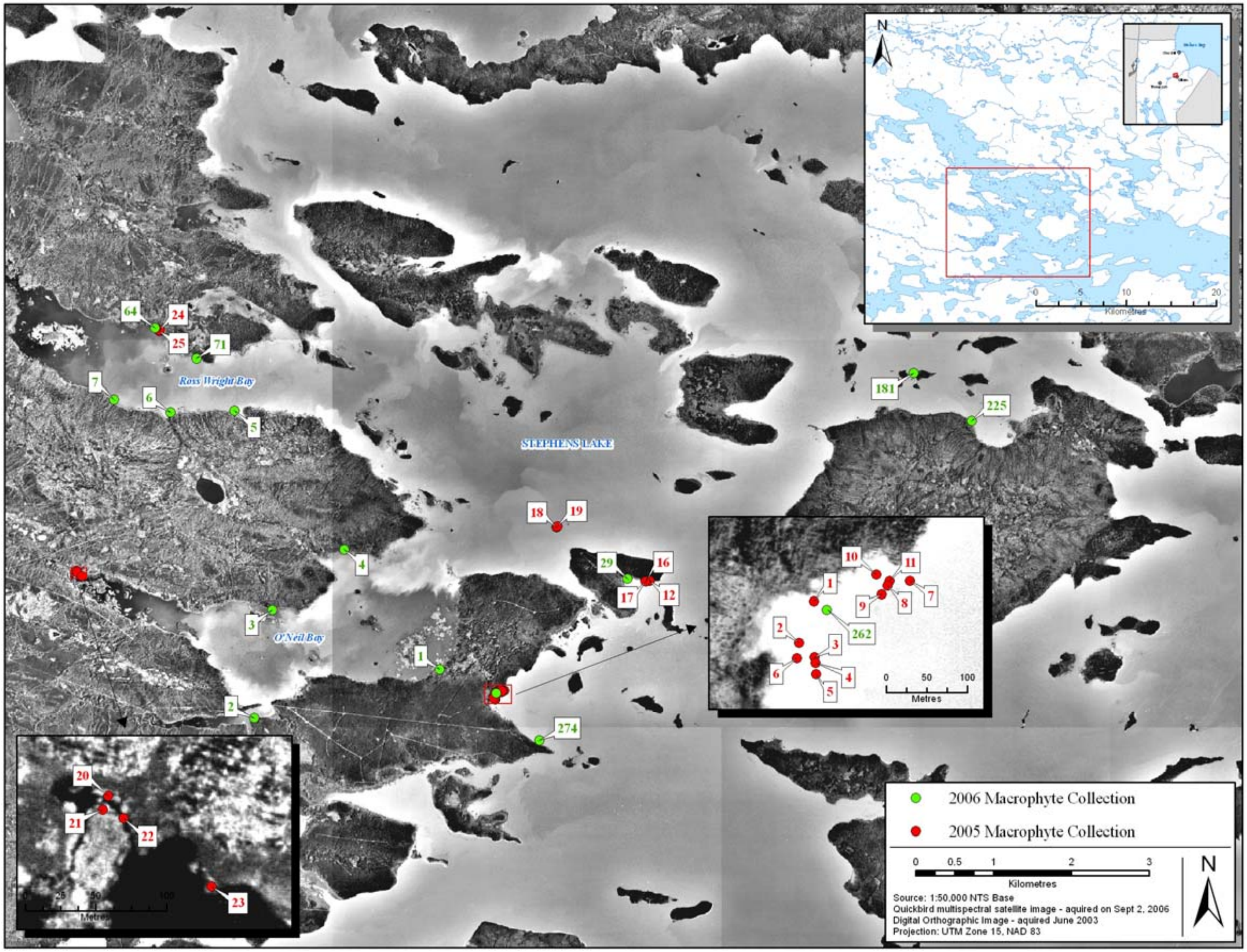


Figure 8. Aquatic macrophyte and associated epiphytic invertebrate sampling sites in Stephens Lake, summers 2005 and 2006.

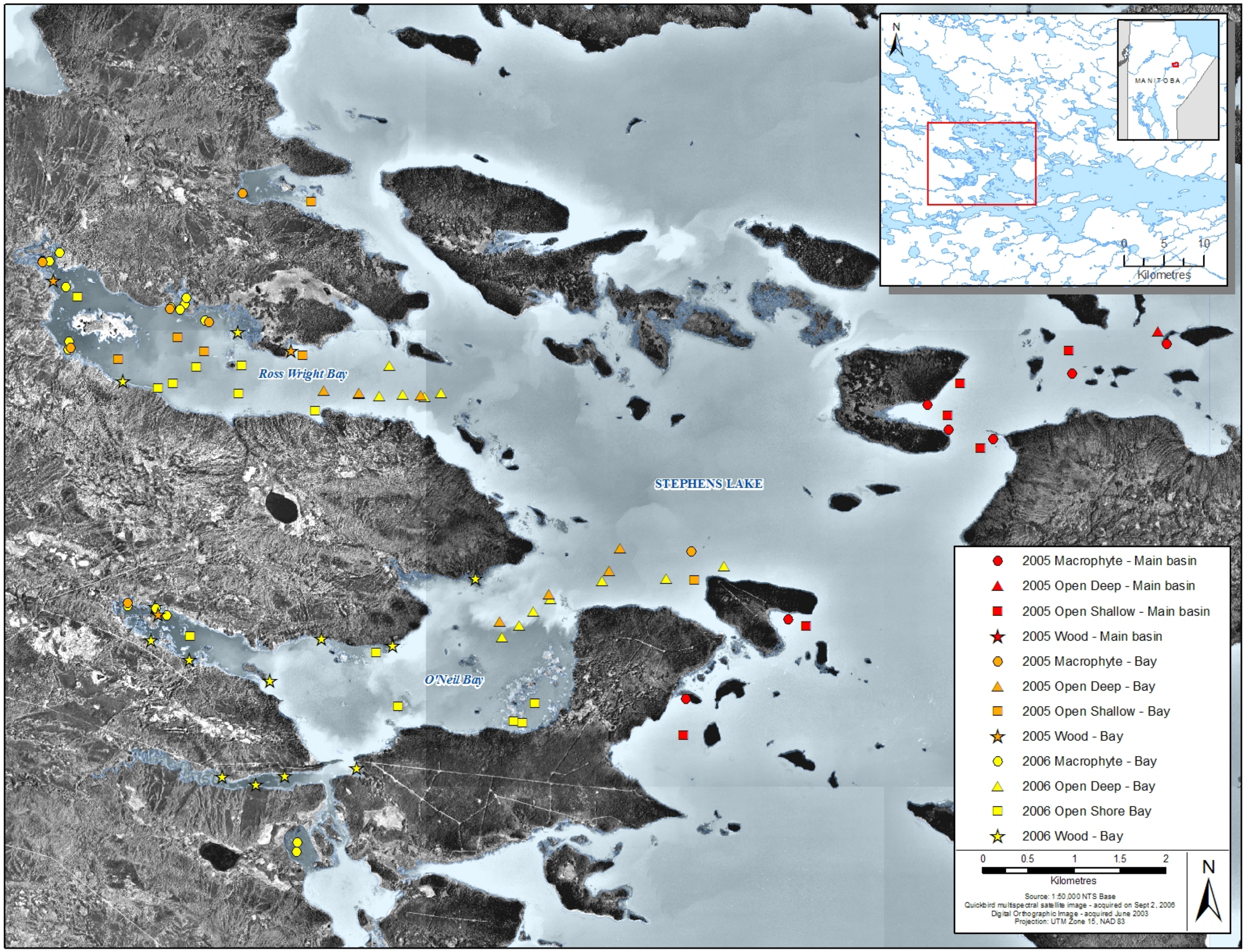


Figure 9. Fish sampling sites visited in Stephens Lake during 2005 and 2006 in macrophyte, wood, open shallow, open deep habitats within bays and the main basin. Each gill net type used was set at each site shown in the map.

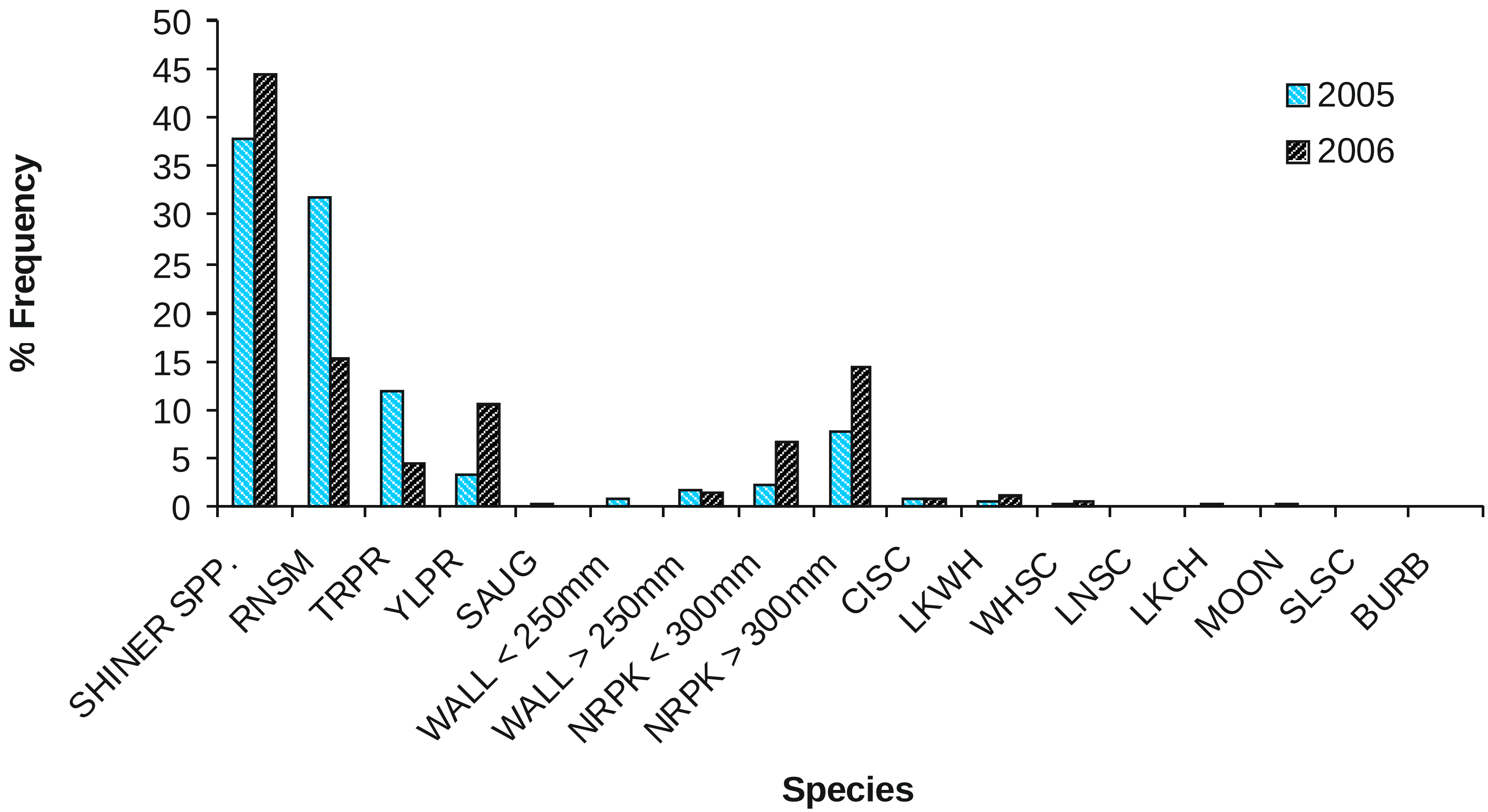


Figure 10. Species composition of all fish collected in the main basin and bays of Stephens Lake during August of 2005 and 2006. Shiner *sp*. catches were almost entirely spottail shiners with incidental emerald shiners. Species abbreviations are listed in Appendix 4.

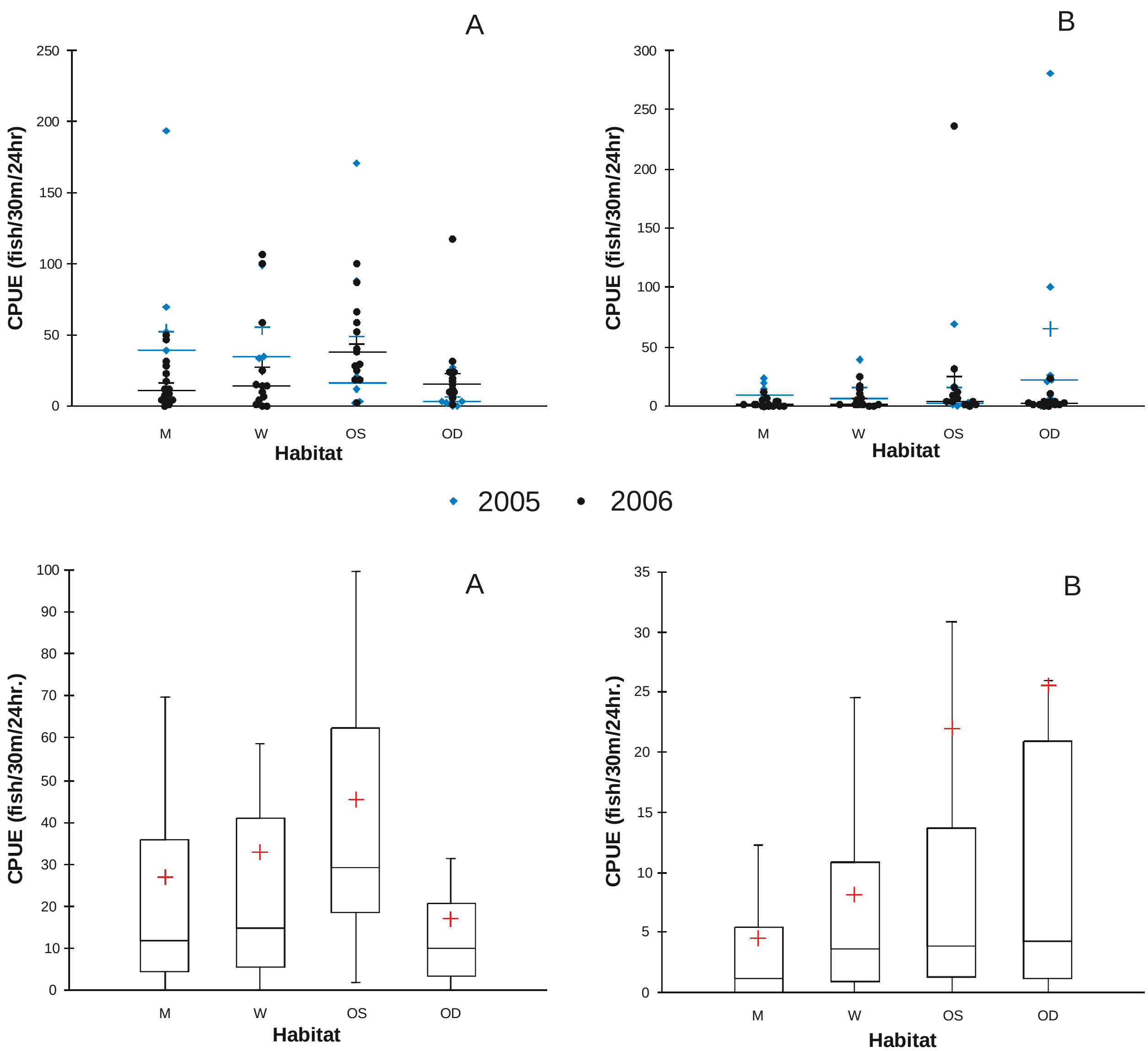


Figure 11. Scatter plots (top) and box plots (bottom) of catch-per-unit-effort (CPUE) for shiner spp. (A) and rainbow smelt (B) at sites in Stephens Lake located in flooded bays with macrophyte (M), wood (W), open shallow (OS), and open deep (OD) habitat types during August of 2005 and 2006. Crosses and horizontal bars show mean and median CPUE for the raw data each year or the pooled data represented by the box plots. Note the difference in y axis scale when the raw data in the scatter plot are compared to the box plots.

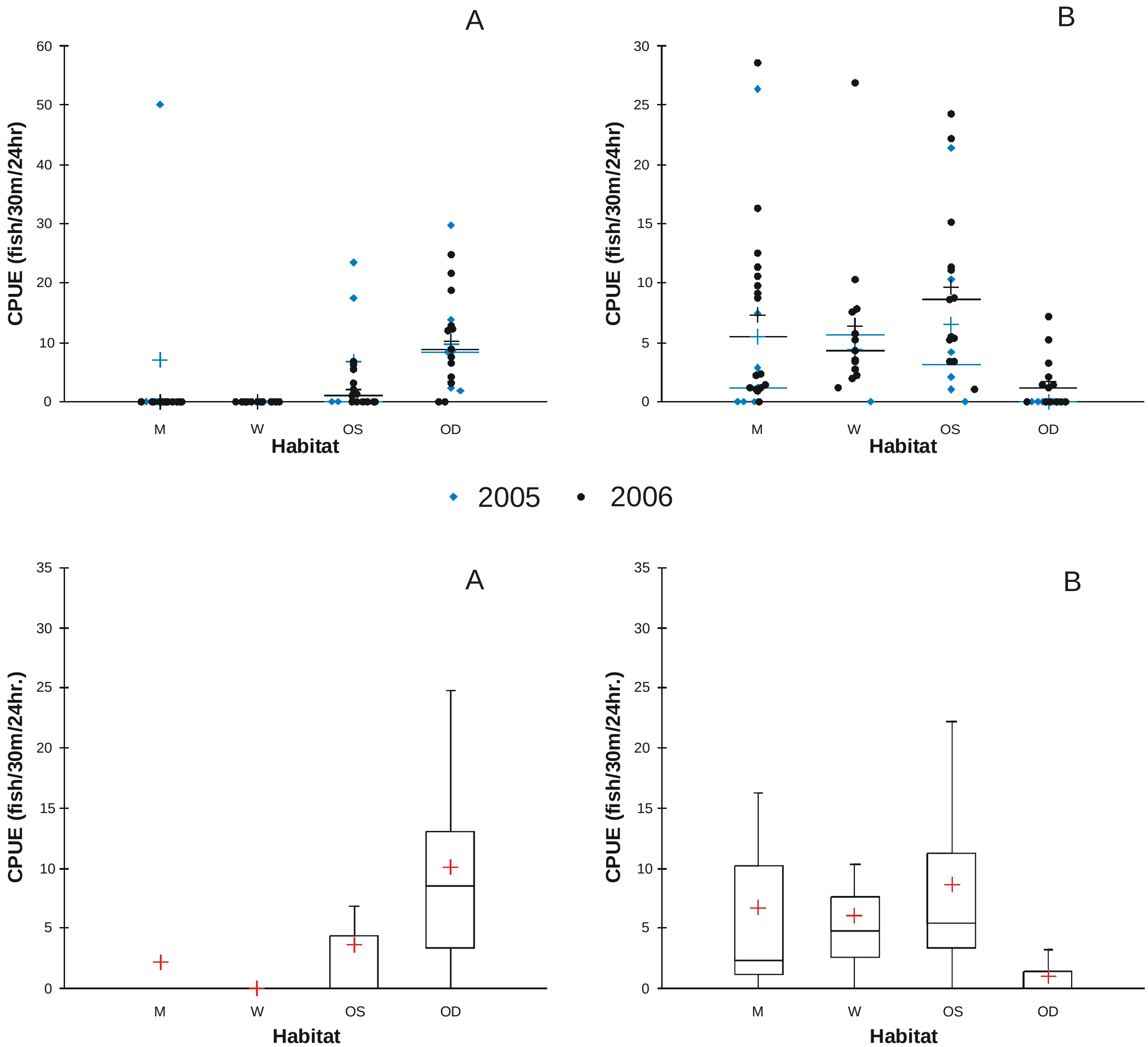


Figure 12. Scatter plots (top) and box plots (bottom) of catch-per-unit-effort (CPUE) for trout-perch (A) and yellow perch (B) sites collected in flooded bays in Stephens Lake during August of 2005 and 2006. Habitat types are: macrophyte (M), wood (W), open shallow (OS), and open deep (OD). Crosses and horizontal bars show mean and median CPUE for the raw data each year or the pooled data represented by the box plots.

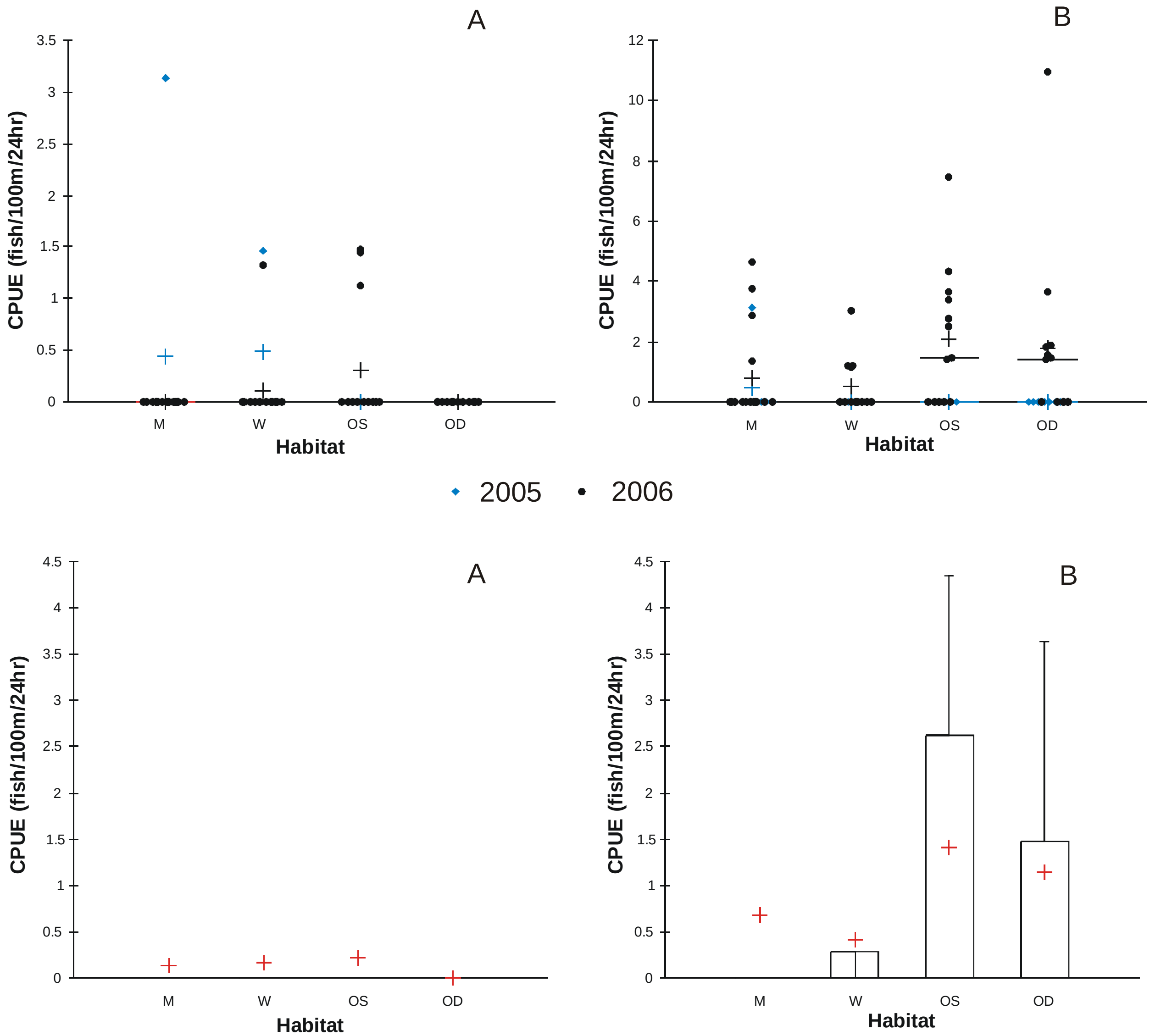


Figure 13. Scatter plots (top) and box plots (bottom) of catch-per-unit-effort (CPUE) for small walleye (<250 mm) (A) and large walleye (>250 mm) (B) sites collected in flooded bays in macrophyte (M), wood (W), open shallow (OS), and open deep (OD) habitat types in Stephens Lake during August of 2005 and 2006. Crosses and horizontal bars show mean and median CPUE for the raw data each year or the pooled data represented by the box plots. Note the difference in y axis scale when the raw data in the scatter plot are compared to the box plots.

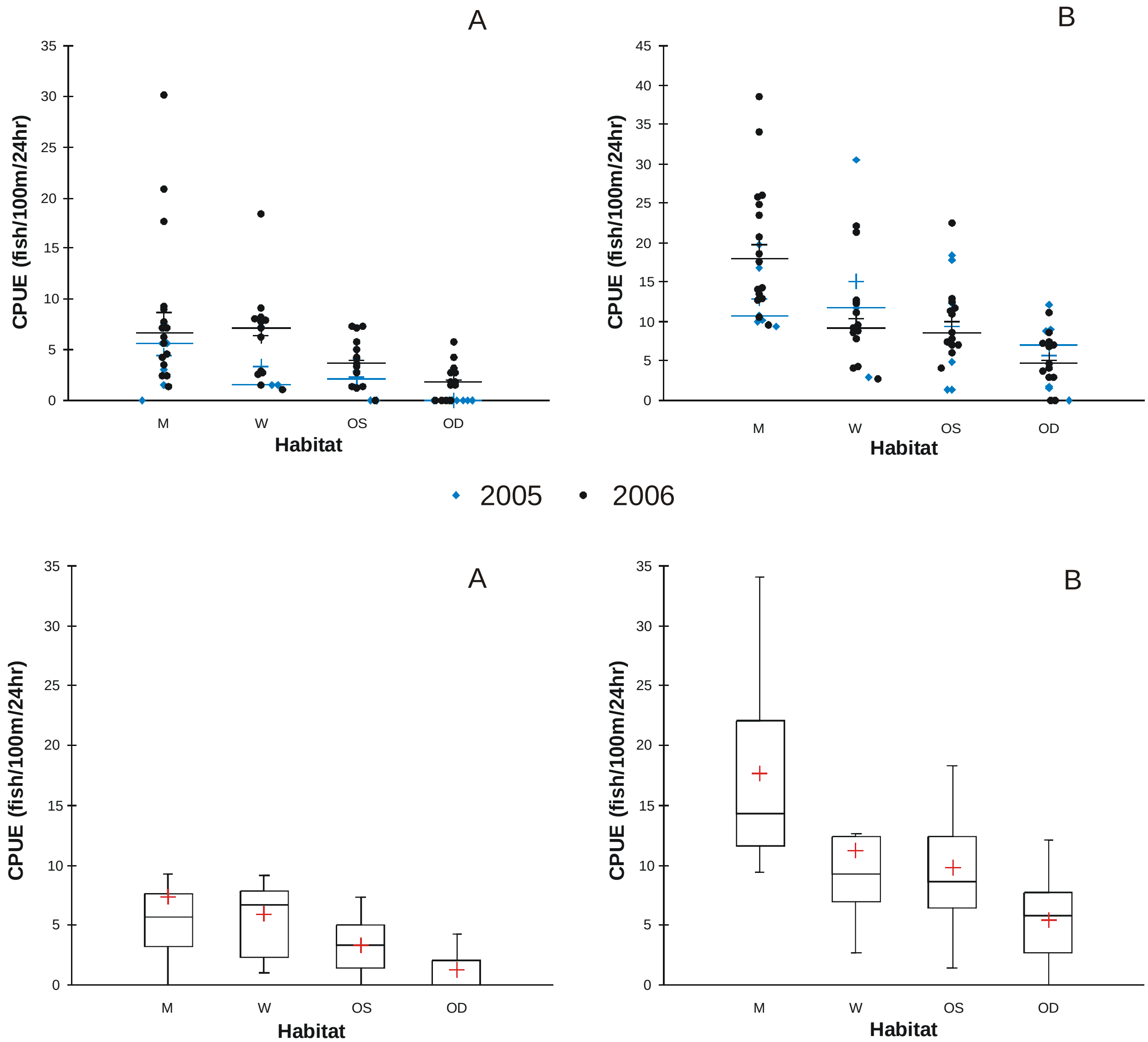


Figure 14. Scatter plots (top) and box plots (bottom) of catch-per-unit-effort (CPUE) for small northern pike (<300 mm) (A) and large northern pike (>300 mm) (B) sites collected in flooded bays in macrophyte (M), wood (W), open shallow (OS), and open deep (OD) habitat types in Stephens Lake during August of 2005 and 2006. Crosses and horizontal bars show mean and median CPUE for the raw data each year or the pooled data represented by the box plots.

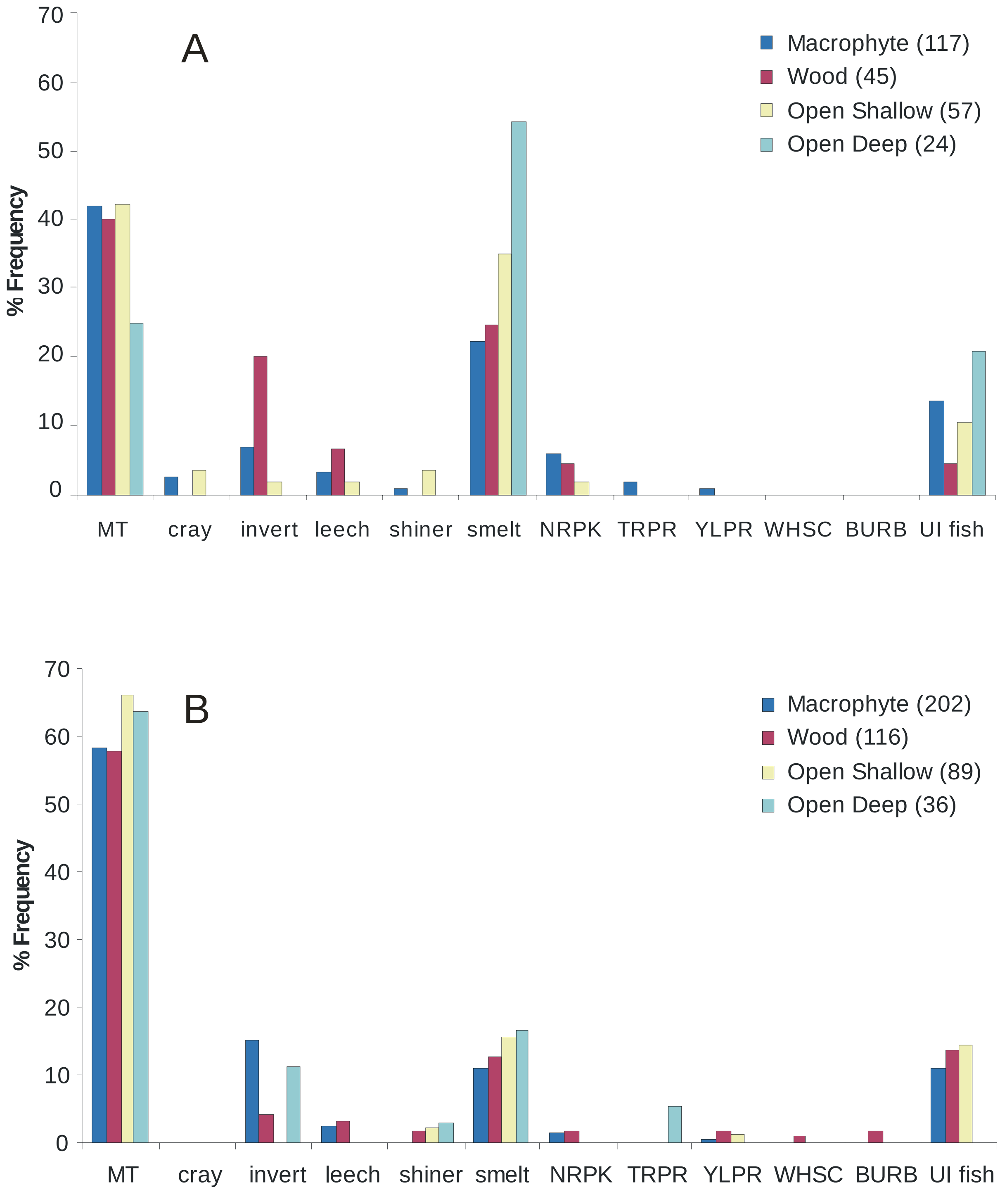


Figure 15. Percent frequency of northern pike stomach contents by prey species and by habitat in Stephens Lake during August of 2005 (A) and 2006 (B). The number of northern pike from which stomach samples were taken is listed in parentheses in the legend. MT = empty, cray = crayfish, UI fish = unidentified fish. All other species name abbreviations are listed in Appendix 4.

APPENDIX 1.

DETAILED ABUNDANCE AND COMPOSITION OF EPIPHYTIC INVERTEBRATES COLLECTED IN STEPHENS LAKE SUMMER, 2005

Table A1-1. Abundance (individuals/m²) , mean +/- one standard deviation (SD) and overall percent of total epiphytic invertebrates (%) collected in Stephens Lake, summer 2005. Individual abundances may not add up to totals due to rounding.

Waterbody	Stephens Lake - 2005		
Site	Overall		
	Mean	SD	%
Annelida			
Oligochaeta	0	0	0
Hirudinea	0	1	0
Total Annelida:	**0**	**1**	**0**
Crustacea			
Ostracoda	2	3	1
Amphipoda			
Gammaridae	0	1	0
Talitridae	6	11	4
Conchostraca	1	4	1
Total Crustacea:	**9**	**16**	**6**
Arachnida			
Acarina	1	2	1
Mollusca			
Bivalvia			
Pisidiidae	0	1	0
Unionidae	0	0	0
Gastropoda - unidentified	0	1	0
Hydrobiidae	0	1	0
Lymnaeidae	0	1	0
Physidae	5	9	3
Planorbidae	7	15	4
Valvatidae	3	4	2
Total Mollusca:	**16**	**24**	**11**
Hydrozoa	0	0	0
Insecta			
Megaloptera			
Sialidae - larva	0	0	0
Coleoptera - larva (unidentified)	0	1	0
Dytiscidae - larva	0	0	0
Gyrinidae - larva	2	3	1
Haliplidae - larva	0	1	0
Hemiptera			
Corixidae - larva	2	4	2
Corixidae - adult	0	0	0
Ephemeroptera			
Baetidae - larva	0	1	0
Baetiscidae - larva	0	0	0
Caenidae - larva	2	6	1
Ephemeridae - larva	0	0	0
Leptophlebiidae - larva	0	0	0
Tricorythidae - larva	0	0	0
Odonata			
Aeshnidae - larva	0	1	0
Coenagrionidae - larva	1	2	0
Trichoptera - larva (unidentified)	0	1	0
Hydropsychidae - larva	0	0	0
Hydroptilidae - larva	0	1	0
Lepidostomatidae - larva	0	1	0
Limnephilidae - larva	1	2	0
Phryganeidae - larva	2	3	1
Polycentropodidae - larva	1	2	0
Diptera			
Ceratopogonidae - larva	2	4	1
Chironomidae - larva	110	146	74
Chironomidae - pupa	1	2	1
Total Insecta:	**123**	**146**	**82**
Terrestrial Invertebrates	**0**	**1**	**0**
Total Invertebrates	**150**	**146**	**100**

APPENDIX 2.

DETAILED ABUNDANCE AND COMPOSITION OF EPIPHYTIC INVERTEBRATES COLLECTED IN STEPHENS LAKE SUMMER, 2006

Table A2-1. Abundance (individuals/m^2), mean +/- one standard deviation (SD) and overall percent of total epiphytic invertebrates (%) collected in Stephens Lake, summer 2006. Individual abundances may not add up to totals due to rounding.

Waterbody	Stephens Lake - 2006		
	Overall		
	Mean	SD	%
Annelida			
Oligochaeta	260	487	21
Hirudinea	0	1	0
Total Annelida:	**260**	**487**	**21**
Crustacea			
Ostracoda	7	21	1
Amphipoda			
Gammaridae	1	2	0
Talitridae	34	58	3
Conchostraca	13	31	1
Total Crustacea:	**55**	**104**	**4**
Arachnida			
Acarina	2	3	0
Mollusca			
Bivalvia			
Pisidiidae	0	0	0
Unionidae	0	0	0
Gastropoda - unidentified	1	1	0
Hydrobiidae	1	2	0
Lymnaeidae	0	1	0
Physidae	8	17	1
Planorbidae	12	20	1
Valvatidae	0	0	0
Total Mollusca:	**21**	**33**	**2**
Hydrozoa	**591**	**1801**	**48**
Insecta			
Megaloptera			
Sialidae - larva	4	13	0
Coleoptera - larva (unidentified)	0	0	0
Dytiscidae - larva	0	0	0
Gyrinidae - larva	2	4	0
Haliplidae - larva	0	0	0
Hemiptera			
Corixidae - larva	3	6	0
Corixidae - adult	1	3	0
Ephemeroptera			
Baetidae - larva	0	1	0
Baetiscidae - larva	0	0	0
Caenidae - larva	0	1	0
Ephemeridae - larva	0	0	0
Leptophlebiidae - larva	0	1	0
Tricorythidae - larva	0	0	0
Odonata			
Aeshnidae - larva	0	0	0
Coenagrionidae - larva	0	1	0
Trichoptera - larva (unidentified)	4	13	0
Hydropsychidae - larva	0	0	0
Hydroptilidae - larva	0	0	0
Lepidostomatidae - larva	0	0	0
Limnephilidae - larva	0	0	0
Phryganeidae - larva	40	125	3
Polycentropodidae - larva	1	4	0
Diptera			
Ceratopogonidae - larva			
Chironomidae - larva	253	431	20
Chironomidae - pupa	4	9	0
Total Insecta:	**313**	**514**	**25**
Terrestrial Invertebrates	**0**	**1**	**0**
Total Invertebrates	**1243**	**2432**	**100**

APPENDIX 3.

QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

Sample Processing

Sorting aquatic invertebrate samples involves removing aquatic macro-invertebrates from the organic and inorganic material within each sample.

Sorting Samples

- All sorting is done using a 3x desktop magnifier with lamp;
- All sorted samples are checked by a second laboratory technician;
- Any additional invertebrates collected during the checking process are combined with the original sample, but counted separately; and
- Sorting efficiency must be $\geq$ 95%. Anything less, and the sample must be re-sorted.

Verification of Taxonomic Identification

To verify the taxonomic identifications and improve consistency among taxonomists, North/South Consultants Inc. communicates with taxonomic specialists on a regular basis.

Sample Identification

- Once samples have been identified to the appropriate taxonomic level by an in-house taxonomist, a sample subset is selected for review by an external taxonomist for accuracy in taxonomic identification and enumeration of individuals;
- For each project, 10% of the identified samples from each in-house taxonomist are randomly selected and sent to a taxonomic specialist for QA/QC;
- All uncertain and unknown organisms are also sent to the specialist;
- Misidentifications and/or enumeration discrepancies are noted on the laboratory datasheet;
- The target overall accuracy objective is 90% for invertebrate identification and enumeration. The taxonomic specialist's identification/enumeration values will be used where deviations (that fall within the acceptable limit) exist; and
- All samples that fall outside the target accuracy objectives will be re-identified and/or re-enumerated.

Data Processing

Data processing involves entering the data from the laboratory data sheet into an excel spreadsheet. Data sheets include: the date of sample, name of waterbody, site location, type of sample, sample sorter, sample verifier, taxonomic identification, and enumeration list. Once raw data has been entered into the template spreadsheet, a second technician checks and verifies entered data and formulae. A final verification or spot-check is conducted by the report author.

APPENDIX 4.

THE COMMON NAMES, SCIENTIFIC NAMES, AND ABBREVIATIONS OF THE 16 FISH SPECIES CAPTURED DURING FISH HABITAT STUDIES AT STEPHENS LAKE DURING AUGUST 2005 AND 2006

Table A4-1. Common name, scientific name, and abbreviation for fish species captured in Stephens Lake during 2005 and 2006.

Common Name	**Scientific Name**	**Abbreviation**
Burbot	*Lota lota*	BURB
Cisco	*Coregonus artedi*	CISC
Emerald shiner	*Notropis atherinoides*	EMSH
Lake chub	*Couesius plumbeus*	LKCH
Lake whitefish	*Coregonus clupeaformis*	LKWH
Longnose sucker	*Catostomus catostomus*	LNSC
Mooneye	*Hiodon tergisus*	MOON
Northern pike	*Esox lucius*	NRPK
Rainbow smelt	*Osmerus mordax*	RNSM
Sauger	*Sander canadensis*	SAUG
Slimy sculpin	*Cottus cognatus*	SLSC
Spottail shiner	*Notropis hudsonius*	SPSH
Trout-perch	*Percopsis omiscomaycus*	TRPR
Walleye	*Sander vitreus*	WALL
White sucker	*Catostomus commersoni*	WHSC
Yellow perch	*Perca flavescens*	YLPR