12-Year Summary Report

Coordinated Aquatic Monitoring Program

2025

Contents

Abbreviations, Acronyms, and Units

%	Percent
°C	Degrees Celsius
CAMP	Coordinated Aquatic Monitoring Program
CCME	Canadian Council of Ministers of the Environment
cms	Cubic metres per second
CPUE	Catch-per-unit-effort
CRD	Churchill River Diversion
CS	Control structure(s)
DO	Dissolved oxygen
ECCC	Environment and Climate Change Canada
EPT	Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)
FNU	Formazin nephelometric unit
GS(s)	Generating station(s)
m	Metre
m^2	Square metre(s)
µg/L	Micrograms per litre
mg/L	Milligrams per litre
mm	Millimetre
MWQSOGs	Manitoba Water Quality Standards, Objectives, and Guidelines
MWS	Manitoba Water Stewardship
n	Sample size or number of samples
no.	Number
O+C	Oligochaeta and Chironomidae
OECD	Organization for Economic Cooperation and Development
PAL	Protection of aquatic life
ppm	Parts per million
SE	Standard error
T/day	Tonnes per day
TN	Total nitrogen
TP	Total phosphorus
TSS	Total suspended solids

1.0 Preamble

This report is part of the CAMP 12-year reporting package. The package consists of the Data Report, Indicator Report, and Interpretive Summary Report. The Data Report presents the data for the CAMP indicators for the 12-year monitoring period (2008-2019). The Indicator Report describes the indicators included in CAMP reporting. The Interpretive Summary report presents a summary of the results over the monitoring period.

Additional information on CAMP, such as monitoring protocols, previous reports, and newsletters, can be found online at https://www.campmb.ca/.

This summary report includes a description of the program, including changes to the program since the last reporting period. Monitoring results are summarized by region and include information on each CAMP component: physical environment, water quality, benthic macroinvertebrates, fish community, and mercury in fish. The report concludes with observations and next steps.

2.0 Introduction

2.1 Coordinated Aquatic Monitoring Program

The Coordinated Aquatic Monitoring Program (CAMP) is a long-term aquatic monitoring program to study and monitor waterbodies (rivers and lakes) affected by Manitoba Hydro's generating system. CAMP was established in 2006 with a Memorandum of Understanding (MOU) between the Province of Manitoba (MB) and Manitoba Hydro (MH). Monitoring began in 2008, with the first three years serving as a pilot project. CAMP was developed by integrating components from existing MB and MH long-term monitoring programs and incorporating new components and sites to fill necessary gaps.

The need for a coordinated approach was identified during the Section 35 Aboriginal Consultations for the Wuskwatim Generating Station. Long-term aquatic monitoring strengthens the understanding of the effects of hydroelectric activity on the aquatic ecosystem and supports more informed decision making when it comes to water management.

CAMP's mandate is to study and monitor waterbodies affected by Manitoba Hydro's generating system. Its aim is to create synergies between Manitoba Hydro and the Province of Manitoba thereby to:

- Avoid duplication
- Combine critical portions of similar environmental programs
- Assist in developing a more complete understanding of the state of the aquatic environment in areas of Manitoba Hydro operations.

CAMP's objective is to monitor aquatic environments and track conditions over time by:

- Monitoring select physical, chemical, and biological components of waterbodies within Manitoba Hydro's generating system.
- Monitoring waterbodies outside of Manitoba Hydro's hydroelectric generating system. These off-system water bodies will help determine how other factors, like climate, affect the aquatic environment.

The major components currently monitored under CAMP are:

- Physical Environment
- Water Quality
- Benthic Macroinvertebrates
- Fish Community
- Mercury in Fish

Each component is examined through specific indicators, which are measured by defined metrics.

CAMP is in the process of expanding to include additional monitoring components (e.g. shoreline monitoring), opportunities for participation by Indigenous communities and inclusion of both Indigenous and scientific knowledge.

CAMP divides the areas Manitoba Hydro operates in into seven study regions across Manitoba as follows:

- Winnipeg River Region
- Saskatchewan River Region
- Churchill River Diversion Region
- Upper Churchill River Region
- Lower Churchill River Region
- Upper Nelson River Region
- Lower Nelson River Region

On-system waterbodies are those located on, and influenced by, Manitoba Hydro's hydraulic operating system such as reservoirs and areas downstream of hydroelectric generating stations and control structures.

Off-systems waterbodies include lakes and river reaches where water levels and flows are either entirely or largely unaffected by Manitoba Hydro's hydraulic operating system.

2.2 Program Scope

Manitoba Hydro's generating system was developed in the early 1900s for the southern generating stations, while the northern stations were mostly developed in the 1960s and beyond. CAMP cannot compare the current environmental conditions with those before the developments because similar historical data is not available. Moreover, since Manitoba waterbodies differ by geography, drainage type, latitude, species assemblages and societal use, lakes cannot be compared easily to each other, and information collected about one region does not necessarily indicate any broader trend. However, lakes can be compared to themselves over time. As such, CAMP is designed to track each individual CAMP waterbody over time, beginning in 2008 when monitoring was initiated. CAMP also samples off-system waterbodies in the region. These reference waterbodies help determine if environmental parameters, other than water management, have contributed to observed changes in the broader study areas. The off-system waterbodies are intended to provide regional context and are not to be used as direct comparisons.

2.3 Indicator Approach

CAMP monitors a wide range of parameters under each component. For the purpose of reporting, CAMP presents data on select indicators and their associated metrics. The indicators are outlined in Table 1. Descriptions of each indicator can be found in the CAMP Indicator Report (CAMP, 2025).

Table 1: CAMP Indicators

Component	***Indicator***	*Metric*
Physical Environment	**Climate**	Air Temperature
		Precipitation
	Water Regime	Flow
		Water Level and Variability
		Water Temperature
	Sedimentation	Turbidity
		Sediment Load
Water Quality	**Dissolved Oxygen (DO)**	DO concentration and percent saturation
		Temperature Stratification[1]
	Water Clarity	Secchi Disk Depth
		Turbidity
		Total Suspended Solids (TSS)
	Nutrients and Trophic Status	Total Phosphorous
		Total Nitrogen
		Chlorophyll a
Benthic Macroinvertebrates	**Abundance**	Total Invertebrate Abundance
		Total Invertebrate Density

[1] Temperature stratification is a supporting metric for dissolved oxygen and is not tracked for change over time.

Component	***Indicator***	*Metric*
	Community Composition	Proportions of Major Invertebrate Taxa
		EPT Index
		O+C Index
	Taxonomic Richness	Total Richness
		EPT Richness
	Diversity	Hill's Index
Fish Community	**Community Diversity**	Hill's Effective Species Richness
		Relative Species Abundance
	Abundance	Catch-per-unit-effort (CPUE)
	Species Growth	Fork Length-at-Age
	Species Condition	Relative Weight
		Fulton's Condition Factor
	Recruitment	Relative Year-Class Strength
Mercury in Fish	**Mercury in Fish**	Arithmetic mean mercury concentration
		Length-standardized mean mercury concentration of large-bodied species

2.4 Pathway of Effects

CAMP is a system-wide program that monitors a broad range of ecosystem components. Indicators used in CAMP reporting were selected using a pathways of effects approach to explain why the indicators are monitored and how they are connected. The pathway of effects model helps describe the pathways between human activities (in this case, hydroelectric disturbance and associated stressors) and effects on the aquatic environment. Figure 1 shows a pathway of effects diagram, with the indicators included in CAMP reporting highlighted in green. The figure is a simplification of the many complex connections between the development and operation of Manitoba Hydro's hydroelectric system and the aquatic environment.

It should be noted that in addition to hydroelectric disturbance, many external drivers also influence the aquatic environment. These include infrastructure development, industrial and municipal activities, agriculture, climate, invasive species, fish harvesting, and water management outside of the Manitoba Hydro hydraulic operating system. Recognizing the existence of external drivers is important, as they can make it challenging to pinpoint specific causes and effects within a complex ecosystem.

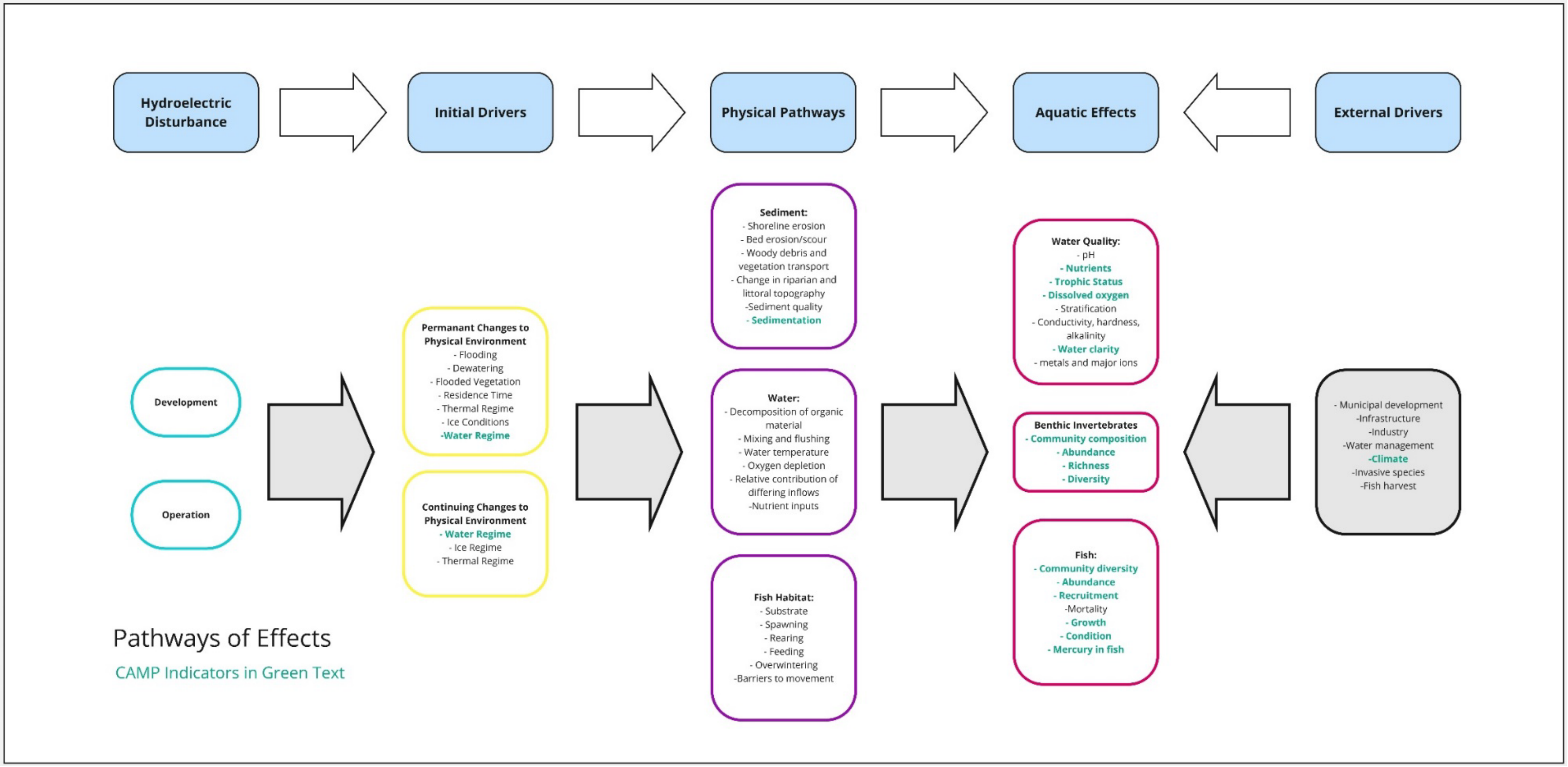


Figure 1: Pathway of Effects

3.0 Program Changes

3.1 Implementation of Recommendations

CAMP is an adaptive monitoring program that evolves based on new learnings and recommendations. Following the completion of the CAMP Six-Year Report, the International Institute for Sustainable Development-Experimental Lakes Area (IISD-ELA) was asked to review the document and provide recommendations on the:

1. Effectiveness of the reporting indicators;
2. Pathways of effects structure and resulting ecosystem hypotheses;
3. Interpretation of observed trends in the context of the ecosystem hypotheses (based on the regional sections).

This third-party review resulted in several recommendations that were endorsed by CAMP. Work is ongoing to prioritize and implement recommendations appropriately. Recommendations implemented to date include:

- Finalizing a formal Pathways of Effects for CAMP incorporating all possible disturbances, drivers, pathways and effects.
- Using a standardized approach to reporting indicators across regions.
- Moving the sampling sites upstream of Notigi Control Station (Rat, Notigi, West Mynarski lakes) from the Churchill River Diversion Region to the Upper Churchill River Region.
- Removing Lake Winnipeg as a separate region for reporting CAMP data.
- Incorporating hydrometric and climate data into reporting.
- Including continuous monitoring data in reporting and making it available publicly on request.
- Incorporating fish mercury reporting into the fish component.
- Redeveloping the website.

3.2 Lake Winnipeg

Prior to this reporting period, Lake Winnipeg was included as a monitoring region under CAMP. From the onset of CAMP, it was recognized that Lake Winnipeg was a large and complex system with many factors influencing its environment. CAMP sampling was not intended to be capable of describing the aquatic ecosystem of the entire Lake. As a result, Lake Winnipeg is no longer included as a monitoring region under CAMP. CAMP sampling on Lake Winnipeg continues but is primarily reported as an inflow or outflow of the study region closest to each specific monitoring location. Sampling at Grand Rapids reflects the outflow of the Saskatchewan River (Saskatchewan River Region) and Mossy Bay reflects the inflow of the Nelson River (Upper Nelson River Region). Comprehensive monitoring of Lake Winnipeg is done by other organizations, such as through the State of Lake Winnipeg Report (ECCC and MARD 2020).

3.3 Addition of Continuous Monitoring

In 2016, continuous monitoring was initiated to collect data on total suspended solids (TSS) and water quality (turbidity, conductivity, dissolved oxygen, and temperature). As of the period covered by this report, data was available from the following continuous monitoring sites: Grand Rapids Generating Station, Missi Falls Control Structure, Wuskwatim Generating Station, Jenpeg Generating Station, and Limestone Generating Station. Since then, additional continuous monitoring sites have been established at Pointe Du Bois Generating Station, Pine Falls Generating Station, Churchill River near Leaf Rapids, and Notigi Control Structure. Data for those newly established sites will be included in future reporting and is available in a raw format upon request.

3.4 CAMP Expansion

CAMP is currently undergoing a program expansion. This will include additional monitoring components (e.g., shoreline monitoring), opportunities for participation by Indigenous communities and inclusion of both Indigenous and scientific knowledge. Manitoba and Manitoba Hydro are currently working to connect with communities in the north in order to collaborate on the expansion of CAMP in the upper Nelson River and lower Churchill/Burntwood/Lower Nelson River areas. Expansion of CAMP monitoring in other regions is being planned.

4.0 Regional Monitoring Results

The following sections present summaries of the data collected for select indicators during the 12-year monitoring period. The summaries include observations including differences between waterbodies and changes over time. Due to limitations in the data set, not all indicators are summarized. For example, mercury in 1-year-old Yellow Perch was excluded due to a lack of data collected over the monitoring period. Complete data under all indicators can be found in the CAMP 12-Year Data Report (2024).

4.1 Winnipeg River Region

4.1.1 Physical Environment Summary

4.1.1.1 Climate

Over the monitoring period, October and November generally experienced warmer than normal conditions (≥ 7 out of 13 months above normal), while April generally experienced below normal conditions (≥ 7 out of 13 months below normal). On an annual basis, no distinct patterns in the data were identified as there was nearly equal number of years below, near, and above normal conditions; 2012 had the warmest annual average temperature at 4.0ºC, while 2014 had the coolest annual average temperature at 0.9ºC. The maximum and minimum monthly average air temperatures during the monitoring period were 21.3ºC (July 2012) and -20.6ºC (January 2014), respectively.

Over the monitoring period, February, April, July, and September generally experienced more than normal precipitation (≥ 7 out of 13 months above normal). On an annual basis, no distinct patterns in the data were identified as there was nearly equal number of years below, near, and above normal conditions; 2010 had the highest annual total precipitation (870.8 mm), while 2011 had the lowest annual total precipitation (389.0 mm). The maximum and minimum monthly total precipitation recorded during the monitoring period were 184.3 mm (September 2019) and 0.5 mm (April 2018), respectively.

4.1.1.2 Water Regime

Water Flows and Levels:

The Winnipeg River's flow is largely controlled by precipitation within its basin and regulated releases from upstream reservoirs in Ontario. Manitoba Hydro operates six generating stations along the river, maintaining stable forebay levels upstream under most flow conditions; downstream levels vary naturally. CAMP monitors forebay water levels on-system at Pointe du Bois, Lac du Bonnet (McArthur Falls), and Pine Falls generating stations, while off-system monitoring targets Manigotagan and Eaglenest lakes.

From 2008 to 2020, on-system flows ranged from very dry (< 10th percentile) to very wet (> 90th percentile), with monthly means between 278 and 2,503 cubic meters per second (cms) with a median value of 982 cms. Very dry conditions occurred in parts of three years, while very wet conditions were observed in seven years. Off-system Manigotagan River flows ranged similarly from 1.1 to 52.4 cms, and a median value of 7cms. Despite flow variability, on-system forebay levels remained stable and close to average, with low variability and occasional moderate fluctuations. Off-system lake levels were inferred from flow data.

Water Temperature:

Continuous water temperature data are not available for this region during the period from 2008 to 2020. Continuous water temperature monitoring was initiated at the Pointe du Bois GS in 2020, after the monitoring period for this report and this data will be presented in the next reporting cycle.

4.1.1.3 Sedimentation

Sedimentation data are not available for this region during the period from 2008 to 2020. Monitoring was initiated at the Pointe du Bois GS in 2020, after the monitoring period for this report and this data will be presented in the next reporting cycle.

4.1.2 Water Quality Regional Summary

Lakes and reservoirs along the Winnipeg River were well-oxygenated, well-mixed, and relatively clear, with moderate to moderately high concentrations of nutrients. All on-system waterbodies were well-oxygenated year-round and dissolved oxygen (DO) concentrations throughout the water column consistently met Manitoba Water Quality Standards, Objectives, and Guidelines (MWQSOGs) instantaneous minimum objectives for cool- and cold-water aquatic life (MWS 2011). Lakes and reservoirs along the Winnipeg River were typically isothermal and DO was similar throughout the water column. This differs from the off-system waterbody, Manigotagan Lake, which though well-oxygenated near the surface, thermally stratified during the summer and fall and DO at depth fell below PAL objectives in each year of monitoring (typically in fall).

Water clarity in the Winnipeg River Region was high as indicated by mean Secchi disk depths greater than 1 m, and low turbidity and total suspended solids (TSS). A slight decrease in water clarity was observed along the Winnipeg River with increasing distance downstream. Additionally, water clarity tended to be higher in winter under the ice than during the open-water season.

The lakes and reservoirs along the Winnipeg River were meso-eutrophic based on total phosphorous (TP) and mesotrophic based on total nitrogen (TN) and chlorophyll *a*. Similarly, Manigotagan Lake was mesotrophic based on TP, TN, and chlorophyll *a*. Seasonal differences in phytoplankton biomass (as indicated by chlorophyll a) were observed throughout the Winnipeg River Region. Chlorophyll *a* typically peaked in the spring and tended to be lower in winter under the ice than during the open-water season.

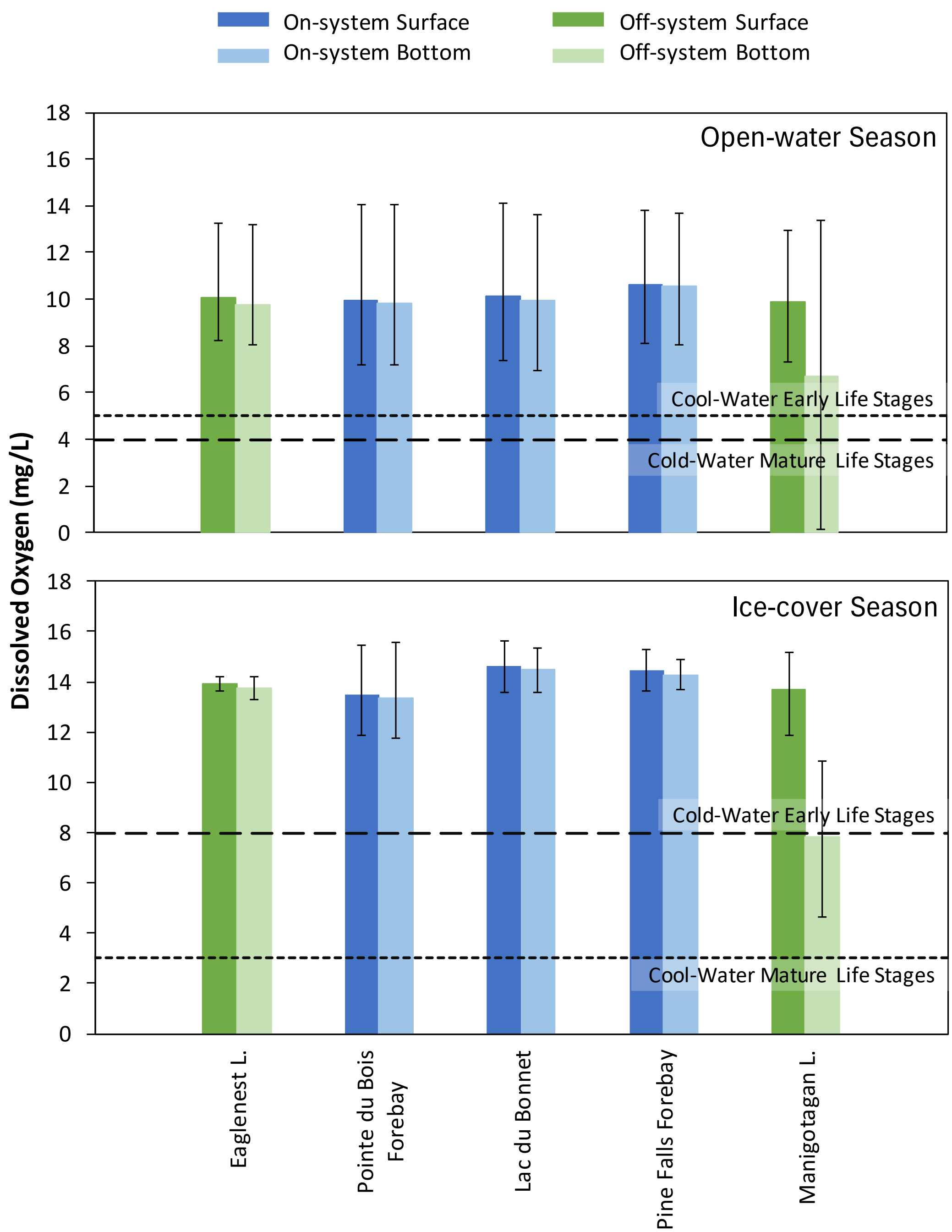


Figure 2. Average dissolved oxygen concentrations in the Winnipeg River Region from 2008-2019 compared to the MWQSOG instantaneous minimum objectives for the protection of cold- and cool-water aquatic life. Error bars show total range of values (i.e., minimum and maximum).

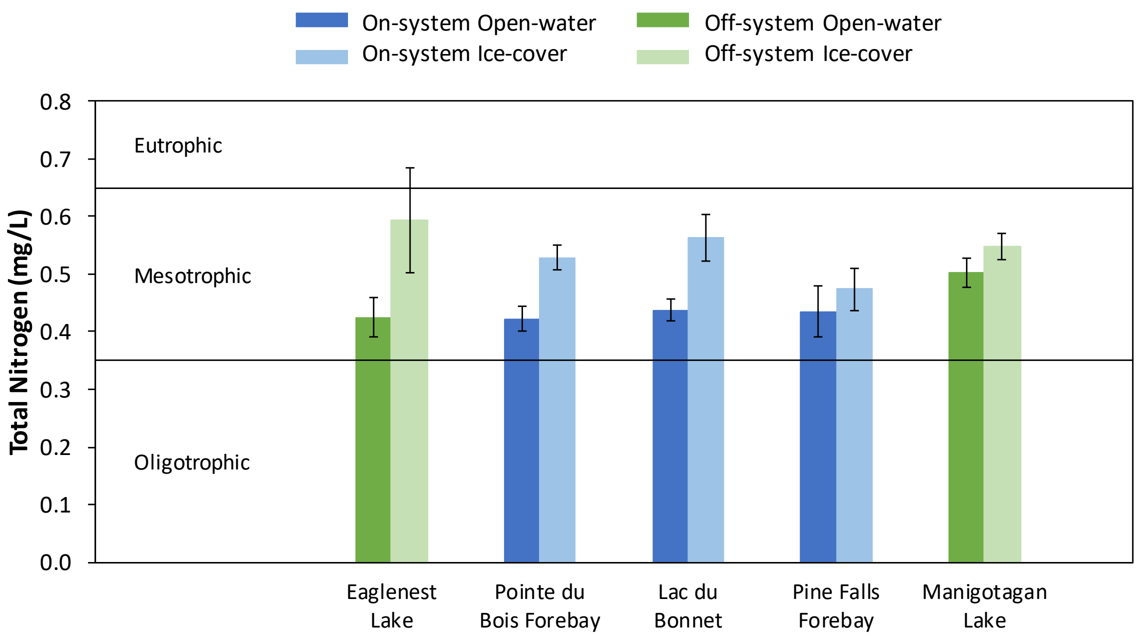


Figure 3. Mean (±SE) total nitrogen concentrations in the Winnipeg River Region from 2008-2019 compared to trophic categories for lakes and reservoirs (OECD 1983).

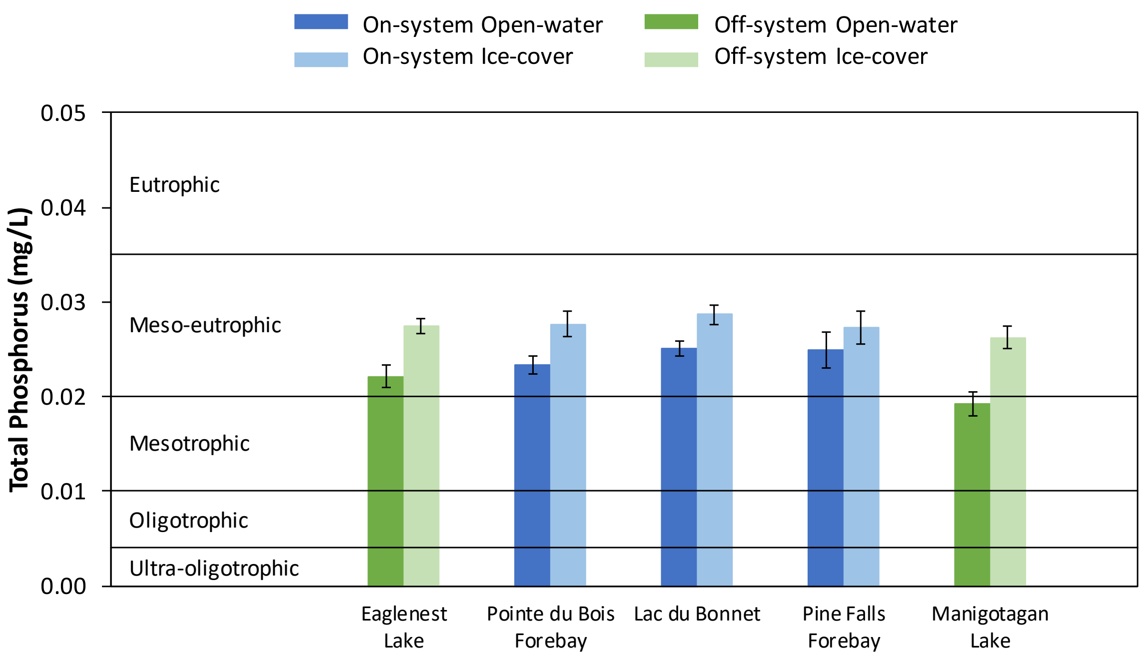


Figure 4. Mean (±SE) total phosphorus concentrations in the Winnipeg River Region from 2008-2019 compared to the CCME Canadian Guidance Framework for Phosphorus (CCME 2004).

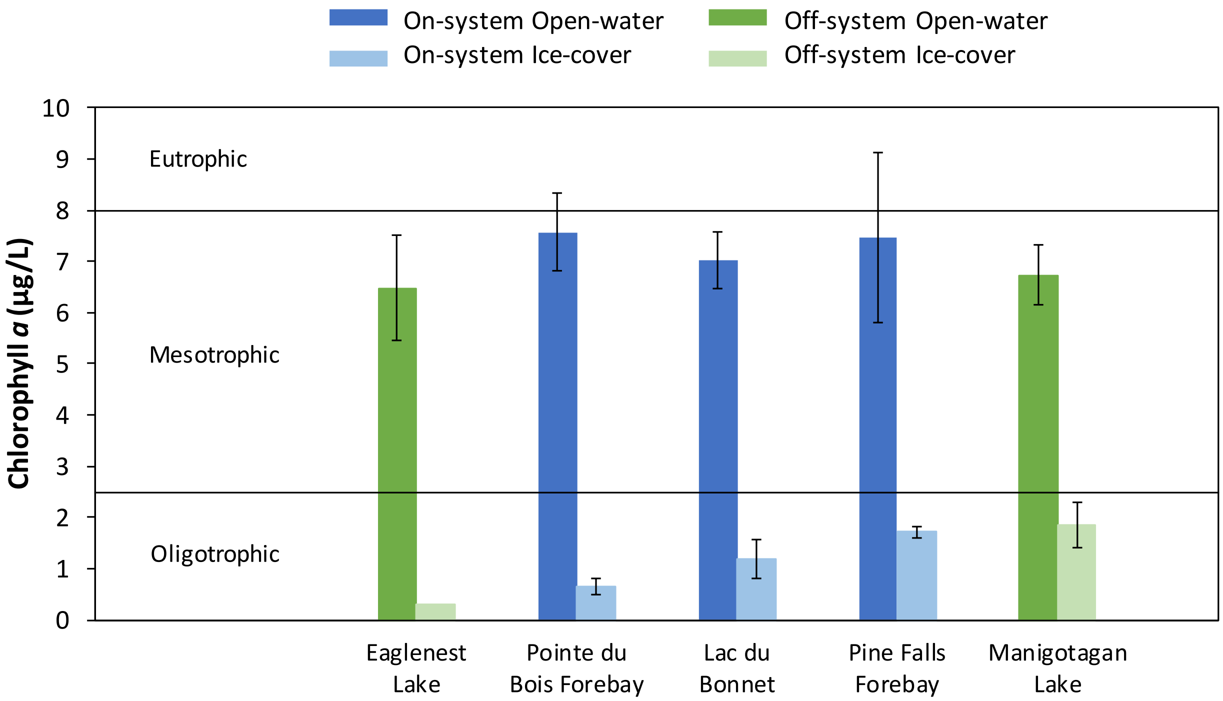


Figure 5. Mean (±SE) chlorophyll *a* concentrations in the Winnipeg River Region from 2008-2019 compared to trophic categories for lakes and reservoirs (OECD 1983).

4.1.3 Benthic Invertebrates Regional Summary

The dominant benthic invertebrate taxa were generally similar at all Winnipeg River Region nearshore sites (Oligochaeta, Amphipoda: Hyallelidae, Chironomidae, and Ephemeroptera: Caenidae and/or Ephemeridae). These taxa are commonly associated with the predominant substrate at all sites (hard/coarse substrates with varying amounts of organic matter and sandy loam substrates). Mean total invertebrate abundances were higher at the sites located on the Winnipeg River (i.e., at the off-system Eaglenest Lake, and the Pointe du Bois Forebay, Lac du Bonnet, and the Pine Falls Forebay) and lowest at the off-system Manigotagan Lake.

The dominant taxa were also generally similar at all offshore sites (Oligochaeta, Bivalvia: Sphaeriidae, Chironomidae, and Ephemeroptera: Ephemeridae). These taxa are commonly associated with the predominant substrate present at all sites (loamy sand). Like the nearshore, mean total abundances (densities; all years combined) were higher at sites on the Winnipeg River (i.e., at the off-system Eaglenest Lake, and the Pointe du Bois Forebay, Lac du Bonnet, and the Pine Falls Forebay) and lowest at the off-system Manigotagan Lake. The alternating life cycle of the burrowing mayfly (Ephemeridae: *Hexagenia*) appeared to contribute to year-to-year differences in invertebrate community metrics at the Pointe du Bois Forebay (total abundance, EPT Index, and Hill's Index), as shown in Figure 10.

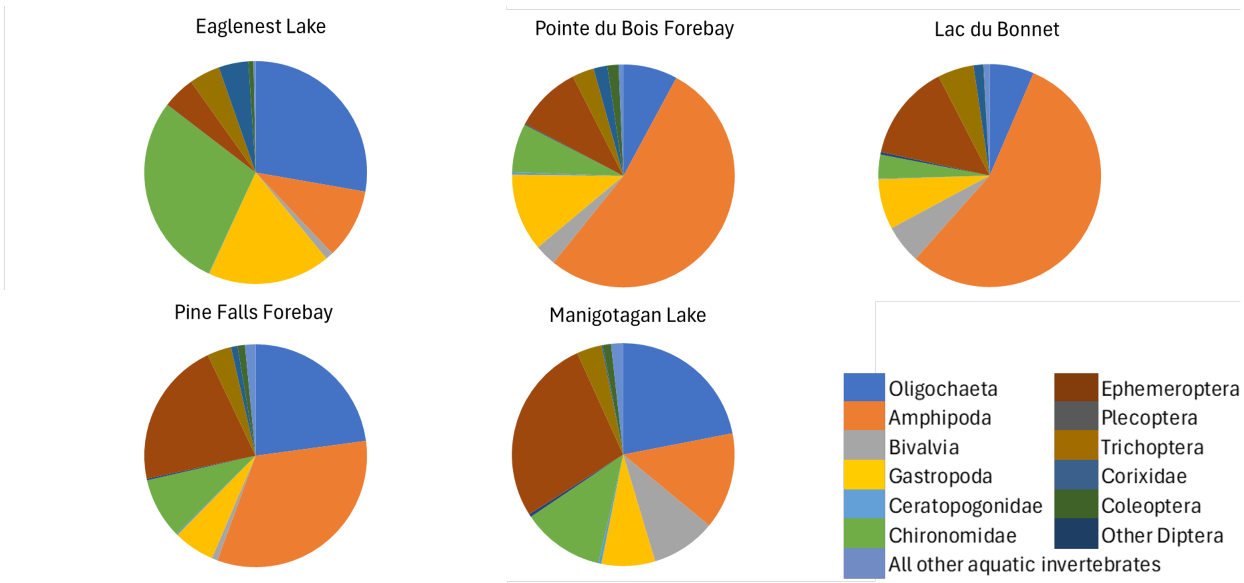


Figure 6. Average relative abundance (% of total) of the benthic invertebrate taxa groups captured at nearshore sites in the Winnipeg River Region from 2010-2019.

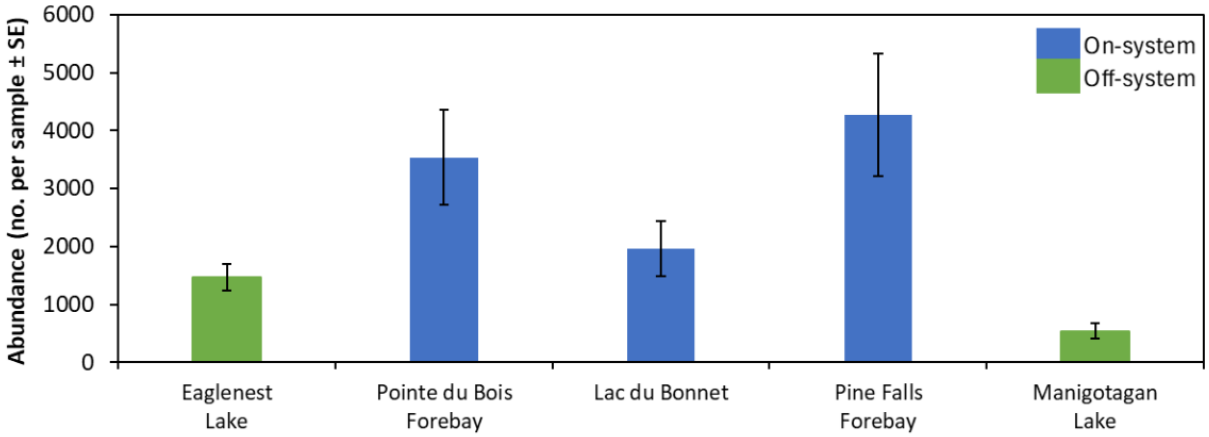


Figure 7. Average total abundance (no. per sample ± SE) of benthic invertebrates captured at nearshore sites in the Winnipeg River Region from 2010-2019.

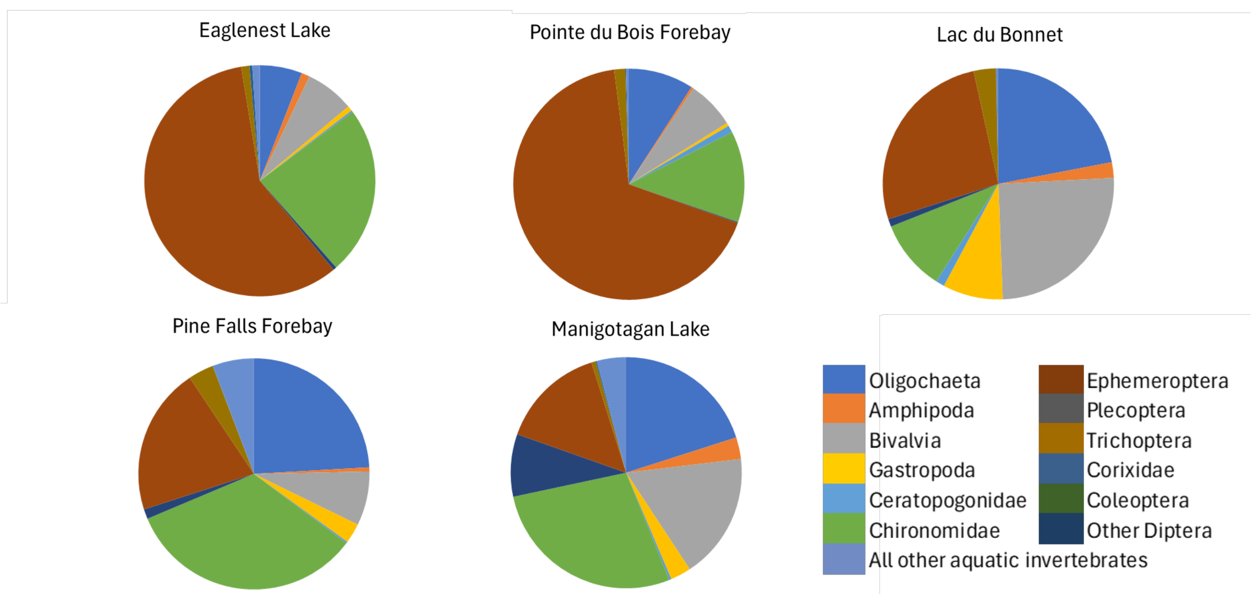


Figure 8. Average relative abundance (density, % of total) of the benthic invertebrate taxa groups captured at offshore sites in the Winnipeg River Region from 2010-2019

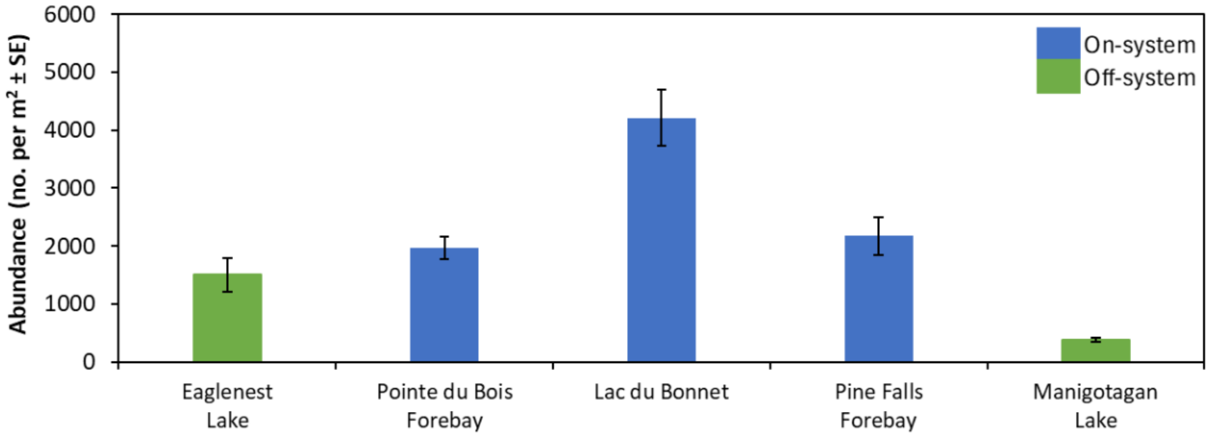


Figure 9. Average total abundance (density, no. per m2 ± SE) of benthic invertebrates captured at offshore sites in the Winnipeg River Region from 2010-2019.

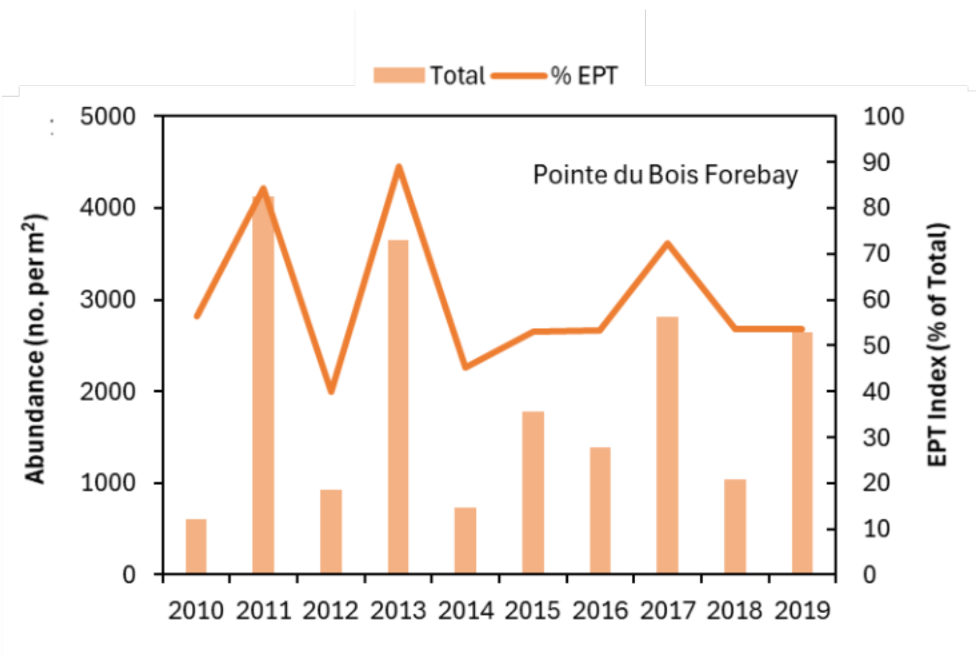


Figure 10. Average total invertebrate abundance (density, no. per m2; bar) and EPT Index (% of total; line) at the Pointe du Bois Forebay offshore site in the Winnipeg River Region from 2010-2019.

4.1.4 Fish Community Regional Summary

The species composition and abundance of fish from the Winnipeg River waterbodies other than Pine Falls Forebay were generally similar with Yellow Perch, Sauger, Walleye, White Sucker, Trout-perch, and Spottail Shiner most commonly captured. Fewer species and a lower abundance of fish were observed at the Pine Falls Forebay where the community composition was dominated by one species (Channel Catfish).

The fish community of the off-system Manigotagan Lake differed from on-system sites in several aspects. Notable differences included:

- the absence of Sauger in the catch;
- lower species diversity; and
- a higher abundance of fish, notably Cisco, Lake Whitefish, and Walleye. This difference may be due in whole or in part to differences in the timing of sampling. Manigotagan Lake is sampled in September, while the majority of the other waterbodies in the Winnipeg River Region, excluding Lac du Bonnet, are sampled in July.

Monitoring results indicated that the invasive Rainbow Smelt, although captured in the region, has not become well established as catches of this species were limited in the waterbodies in which they were observed (Eaglenest Lake, and the Pine Falls and Pointe du Bois forebays). Lake Sturgeon[2] (not a target species for CAMP) were captured infrequently at all on-system sites.

The growth of young Walleye, Northern Pike, and Sauger (age 3 or 4) was generally higher at Manigotagan Lake and Lac du Bonnet compared to the other waterbodies in the region likely because sampling was conducted later in the season at these waterbodies. The growth of young Sauger (3-year-olds) from Lac du Bonnet appear to have slightly increased over the monitoring period. Likewise, slight increases in the

[2] The methodologies used in the Fish Community sampling program are not designed to target Lake Sturgeon or capture them in proportion to their abundance (i.e., larger gill net mesh sizes are excluded from the gear).

condition factor of Northern Pike and White Sucker from Manigotagan Lake occurred over the sampling period.

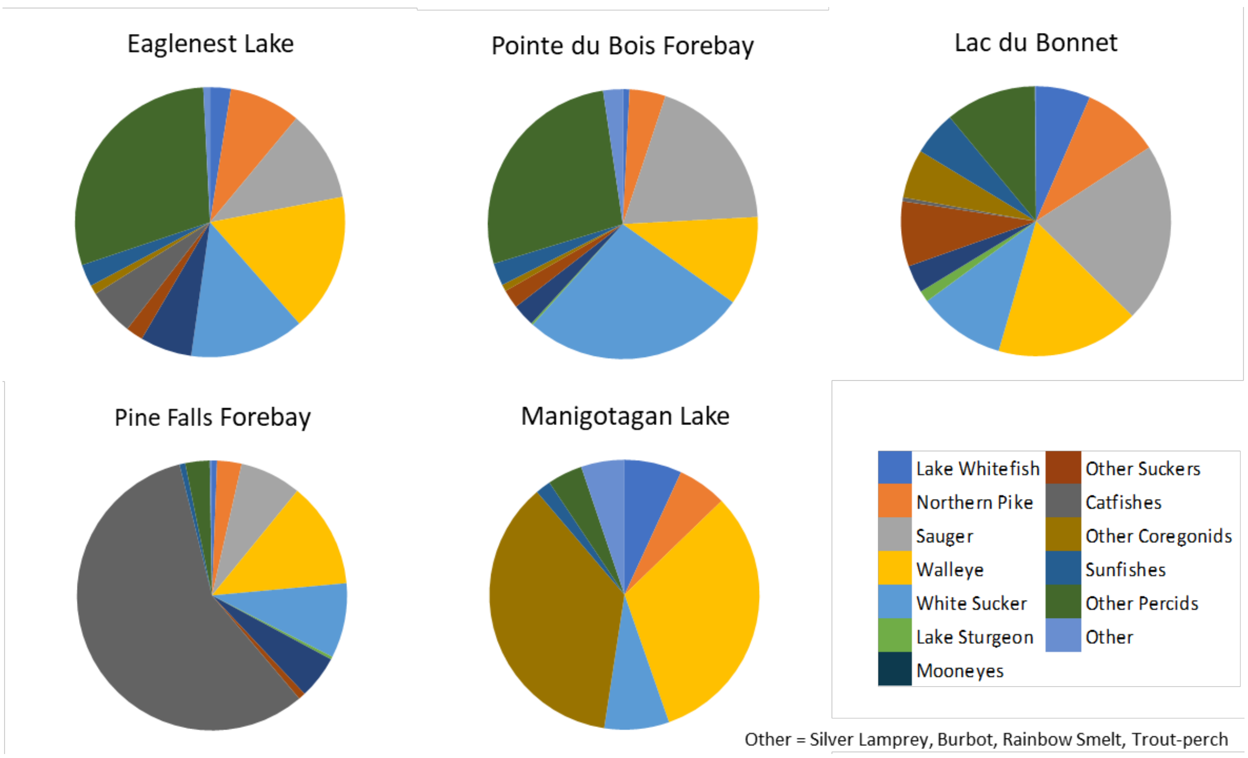


Figure 11. Average relative species abundance of target species and taxa groups captured annually in standard gang gill nets in standard gang gill nets in the Winnipeg River Region from 2008-2019.

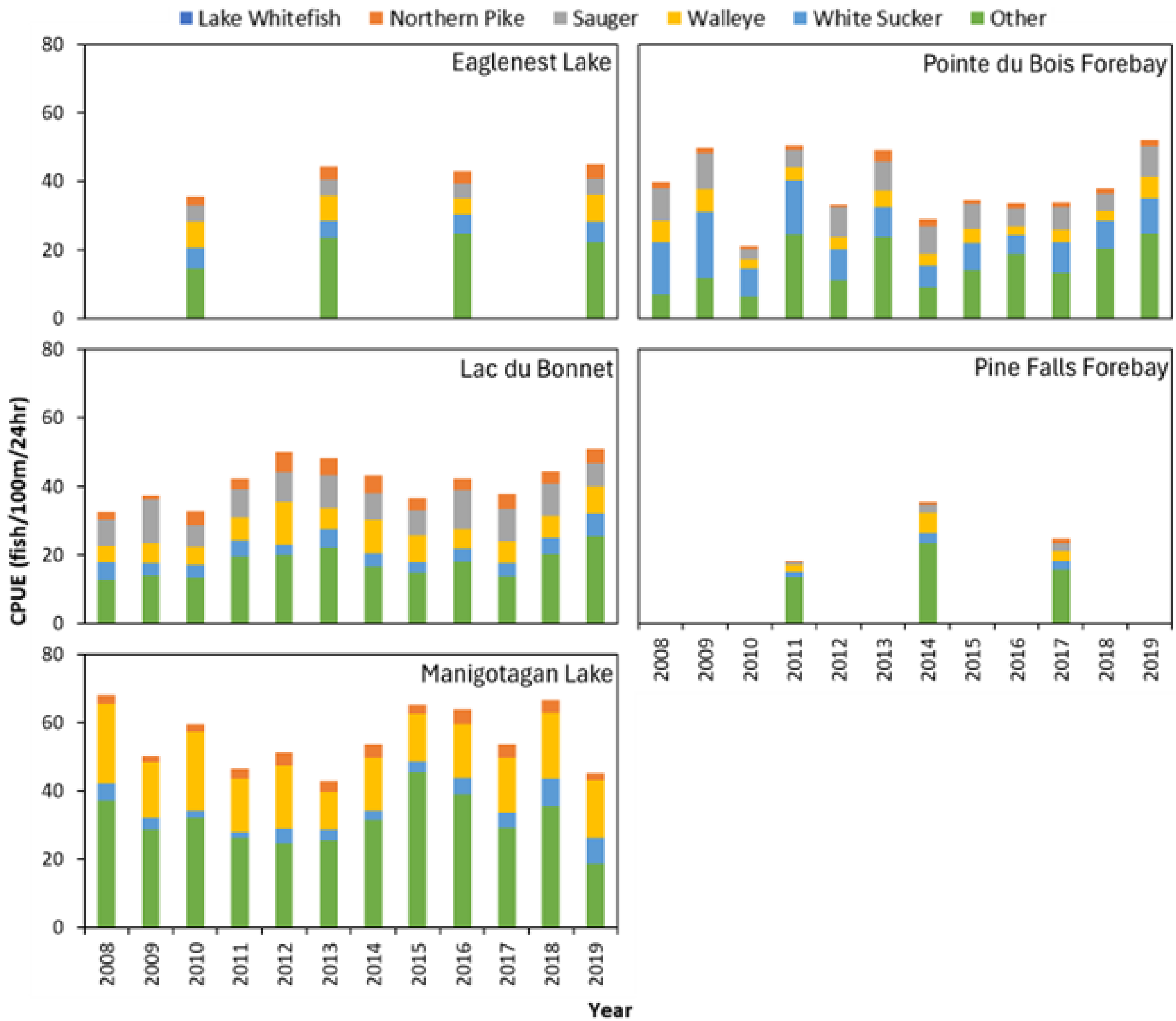


Figure 12. Average catch-per-unit-effort (fish/100 m/24 hr) per year of target species captured in standard gang gill nets in the Winnipeg River Region from 2008-2019

4.1.5 Mercury in Fish Regional Summary

As an ecosystem monitoring program, CAMP does not analyze mercury in fish data in relation to human health. Data collected through CAMP is made available to the relevant experts and authorities for human health analysis.

Standard mean mercury concentrations in a 400 mm Walleye and a 550 mm Northern Pike were relatively similar between sampling years in the on-system Pointe du Bois Forebay (mean in all years sampled: 0.44 and 0.43 ppm, respectively) and off-system Manigotagan Lake (mean in all sampling years: 0.37 and 0.42 ppm, respectively) (Figure 13).

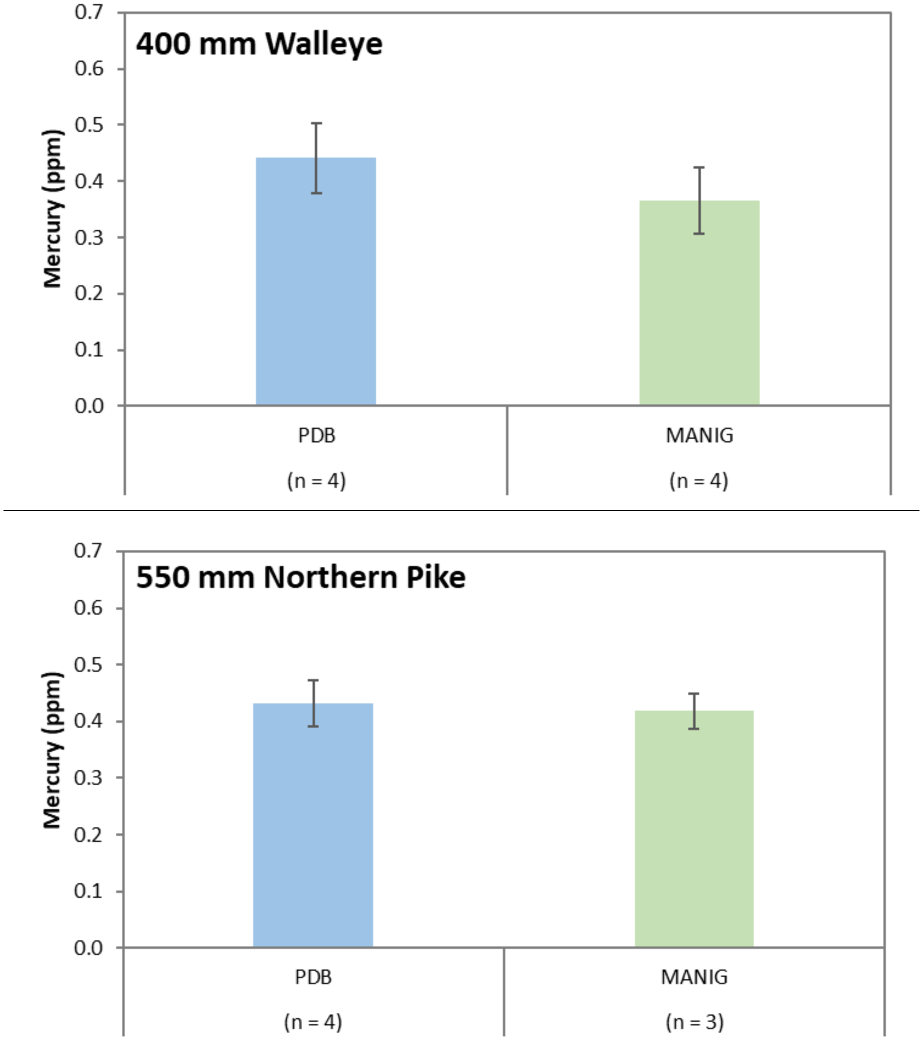


Figure 13. Average length-standardized mercury concentration (± standard error) in fish muscle from Winnipeg River Region waterbodies. Blue = on-system, Green = off-system, n = number of sampling years.

4.2 Saskatchewan River Region

4.2.1 Physical Environment Regional Summary

4.2.1.1 Climate

Over the monitoring period, September generally experienced warmer than normal conditions (≥ 7 out of 13 months above normal), while the months of March and November generally experienced cooler than normal conditions (≥ 7 out of 13 months below normal). On an annual basis, no distinct patterns in the data were identified as there was nearly equal number of years below, near, and above normal conditions; 2016 had the warmest annual average temperature at 2.2°C, while 2014 had the coolest annual average temperature at -0.8°C. The maximum and minimum monthly average air temperatures during the monitoring period were 21.0°C (July 2012) and -25.1°C (December 2013), respectively.

Over the monitoring period, January and July generally experienced more than normal precipitation (≥ 7 out of 13 months above normal), while the months of February, March, April, May, August, and October generally experienced less than normal precipitation (≥ 7 out of 13 months below normal). On an annual basis, no distinct patterns in the data were identified as most years in the monitoring period experienced near normal conditions, and there was nearly an equal number of years with above normal precipitation as there were below normal; 2016 had the highest annual total precipitation (695.0 mm), while 2019 had the lowest annual total precipitation (381.0 mm). The maximum and minimum monthly total precipitation recorded during the monitoring period were 206.2 mm (June 2013) and 1.3 mm (March 2019), respectively.

4.2.1.2 Water Regime

Water Flows and Levels

The Saskatchewan River, entering Manitoba from the Rocky Mountains, is influenced by precipitation and upstream water use. Cedar Lake serves as a hydroelectric reservoir for the Grand Rapids Generating Station, with local tributaries and upstream flows affecting water levels at Cedar Lake and South Moose Lake. CAMP monitors on-system sites including the Saskatchewan River at The Pas, Grand Rapids, Cedar Lake, and South Moose

Lake. Off-system monitoring occurs at Cormorant Lake, primarily driven by local precipitation.

Between 2008 and 2020, flows at The Pas and Grand Rapids ranged from very dry (< 10th percentile) to very wet (> 90th percentile), with above-average flows more common. Monthly flows at The Pas ranged from 257 to 2,215 cms (median 573 cms), and at Grand Rapids from 128 to 2,099 cms (median 723 cms). Water levels at on-system sites reflected reservoir operations and seasonal variations, with monthly deviations exceeding ±0.5 m observed intermittently. South Moose Lake remained relatively stable, while off-system Cormorant Lake levels varied primarily with precipitation.

Water Temperature

Monitoring for the SRR takes place at the Grand Rapids generating station (GS) where equipment is permanently deployed in the generating station and collects data continuously throughout the year. The site has been monitored since June 2019, so the period of record for this report covers approximately 11 months. The data record is not long enough to draw any conclusions about trends at this site.

Water temperature peaked at about 25°C in late July and then decreased to about 0 °C by the beginning of November. It remained near 0°C through winter 2019/2020 until late April when it began to increase during the spring thaw. The duration of ice cover, which is assumed to be when water temperature is below 1°C, was at least 24 weeks, although the start is uncertain due to some missing data.

4.2.1.3 Sedimentation

Monitoring for the SRR takes place at the Grand Rapids GS where equipment is permanently deployed in the generating station and collects data continuously throughout the year. The site has been monitored since June 2019, so the period of record for this report covers approximately 11 months. The data record is not long enough to draw any conclusions about trends at this site.

Average turbidity was quite low as compared with other monitoring regions. It ranged from about 0.3-6.5 Formazin Nephelometric Units (FNU) overall. Turbidity was highest and more variable in summer, being generally above 2 FNU. During winter, from

November through April, it steadily declined from about 1 FNU to the minimum of 0.3 FNU.

Sediment loads varied from about 12-460 tonnes per day (t/d) overall, with peak levels and greater variability in the summer. However, while turbidity was lowest in winter, the winter sediment loads (which varied from about 12-125 t/d) were generally within the range of summer sediment loadings (which at some points were below 100 t/d and as low as 25 t/d). This may be due to differences in Grand Rapids GS discharge, where high winter flows can result in higher sediment loads despite lower turbidity.

4.2.2 Water Quality Regional Summary

Waterbodies along the Saskatchewan River were, with few exceptions, typically well-oxygenated throughout the water column, and moderately turbid to clear with moderate to high concentrations of nutrients. Some changes in water quality conditions were observed from upstream to downstream on the main flow of the Saskatchewan River. Differences were also observed for South Moose Lake, which is located off the main flow of the Saskatchewan River, as well as the off-system Cormorant Lake.

On-system sites in the Saskatchewan River Region were typically well-oxygenated throughout the water column during the open-water season. Although thermal stratification was periodically observed in spring or summer at deeper sites (i.e., Cedar Lake - West is the exception) DO typically met MWQSOGs instantaneous minimum objectives for cool- and cold-water aquatic life (MWS 2011) throughout the water column. However, DO decreased with depth in Lake Winnipeg at Grand Rapids and fell below the MWQSOGs instantaneous minimum objectives for cool- and/or cold-water aquatic life on two occasions in summer.

During the ice-cover season, all on-system waterbodies were well-oxygenated near the surface and DO consistently met MWQSOGs instantaneous minimum objectives near the surface. Thermal stratification and/or changes in temperature with depth occurred in winter, such that, Cedar Lake - Southeast and Lake Winnipeg - Grand Rapids were each stratified in one winter, and South Moose Lake was thermally stratified each of the four winters monitoring was conducted. Along with the changes in temperature, DO decreased with depth but typically met PAL objectives throughout the water column at most sites. However, DO at depth fell below the instantaneous minimum objective for cold-water aquatic life (8.0 mg/L) during two winters in Cedar Lake - Southeast, and in three of the four winters sampling occurred at South Moose Lake. The off-system lake (i.e., Cormorant Lake) was consistently well-oxygenated near the surface but was often thermally stratified during the spring and/or summer and DO at depth occasionally fell below PAL objectives in summer and winter.

Water clarity at on-system sites in the Saskatchewan River Region varied spatially from moderately turbid to relatively clear. Considering sites located on the main flow of the Saskatchewan River, water clarity increased with distance downstream, being lowest in the river and highest in Cedar Lake - Southeast and in Lake Winnipeg. Water clarity in South Moose Lake, which is off the main flow path of the Saskatchewan River, was similar to the farthest downstream sites in the region. This occurrence likely reflects settling of suspended materials within Cedar Lake. The off-system lake (i.e., Cormorant Lake) was exceptionally clear with average Secchi depths greater than 4 m and very low turbidity and TSS. As observed in all CAMP regions, water clarity tended to be higher in winter under the ice than during the open-water season.

On-system lakes in the Saskatchewan River Region were mesotrophic to eutrophic based on TP, TN, and chlorophyll *a*. The Saskatchewan River was eutrophic based on TP and oligotrophic based on TN and chlorophyll *a*. Nutrients (TN and TP) and phytoplankton biomass (as indicated by chlorophyll *a*) tended to be lower in South Moose Lake, which is located off the main flow of the Saskatchewan River, than at the other on-system sites, and higher in the Saskatchewan River and the west basin of Cedar Lake than at sites downstream. Similar to TSS, phosphorus concentrations decreased with distance downstream, being highest in the river and lowest in Cedar Lake - Southeast and downstream in Lake Winnipeg. This spatial trend may reflect, at least in part, settling of particulate material in Cedar Lake. The off-system lake (i.e., Cormorant Lake) was oligotrophic based on TP, TN, and chlorophyll *a*.

A slight increasing trend in chlorophyll *a* was observed in Cedar Lake - Southeast from 2009 (the first full year of monitoring at this site) to 2019. Temporal trends in chlorophyll *a* were not evident at other sites in the region.

Seasonal differences in phytoplankton biomass (as indicated by chlorophyll *a*) were observed for annual on-system monitoring locations including Cedar Lake - Southeast and Lake Winnipeg at Grand Rapids. At these locations, chlorophyll *a* peaked in summer and/or fall when phytoplankton blooms (i.e., chlorophyll *a* ≥ 10 µg/L) frequently occurred. Phytoplankton biomass tended to be lower in winter under the ice than during the open-water season at most sites in the region. However, higher concentrations of chlorophyll *a* occasionally occurred under the ice in Cedar Lake - Southeast and in Lake Winnipeg at Grand Rapids. Chlorophyll *a* tended to be much lower at the off-system lake (i.e., Cormorant Lake) where it followed a similar seasonal pattern to the on-system lakes and was lowest in winter and highest in fall.

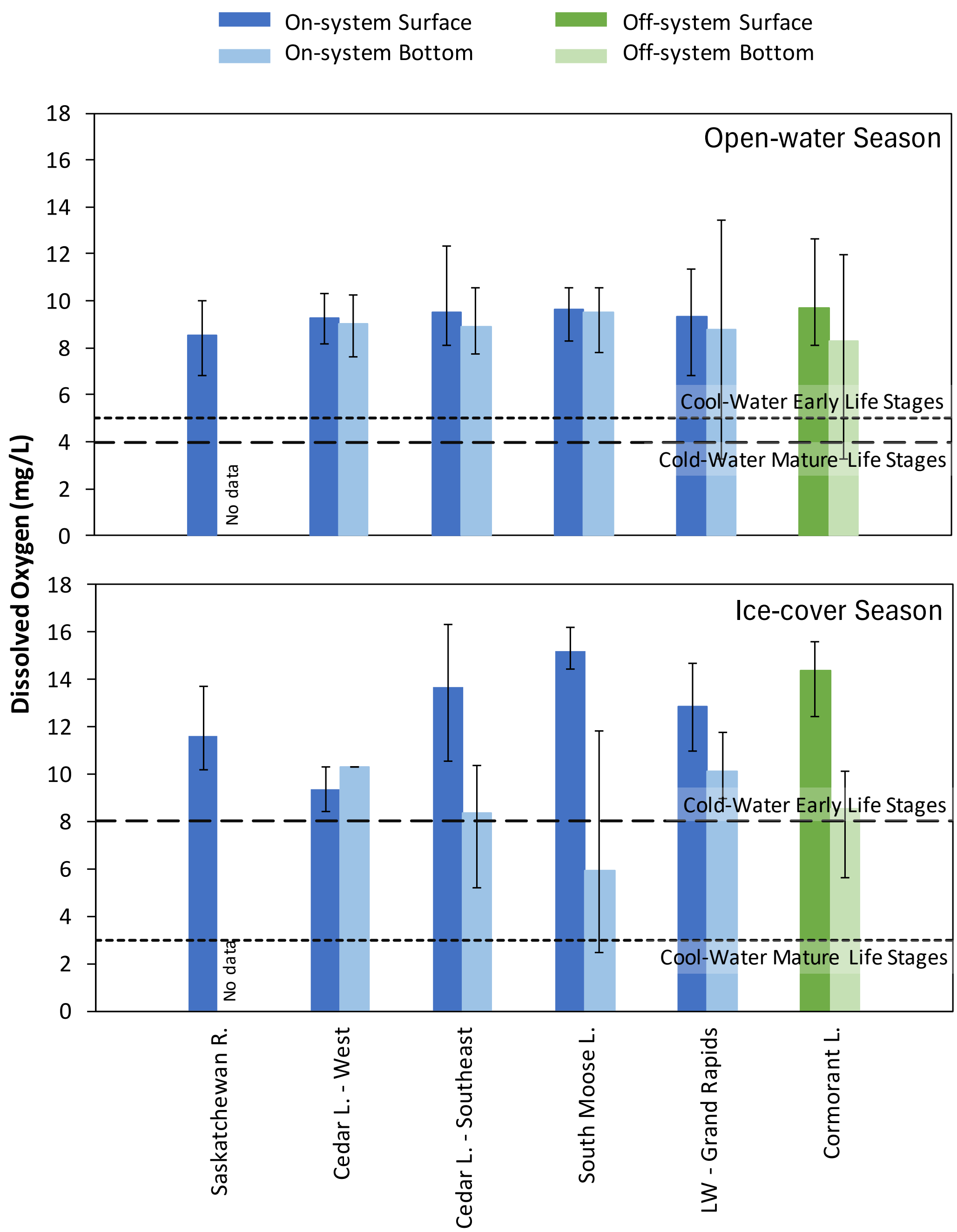


Figure 14. Average dissolved oxygen concentrations in the Saskatchewan River Region from 2008-2019 compared to the MWQSOG instantaneous minimum objectives for the protection of cold- and cool-water aquatic life. Error bars show total range of values (i.e., minimum and maximum).

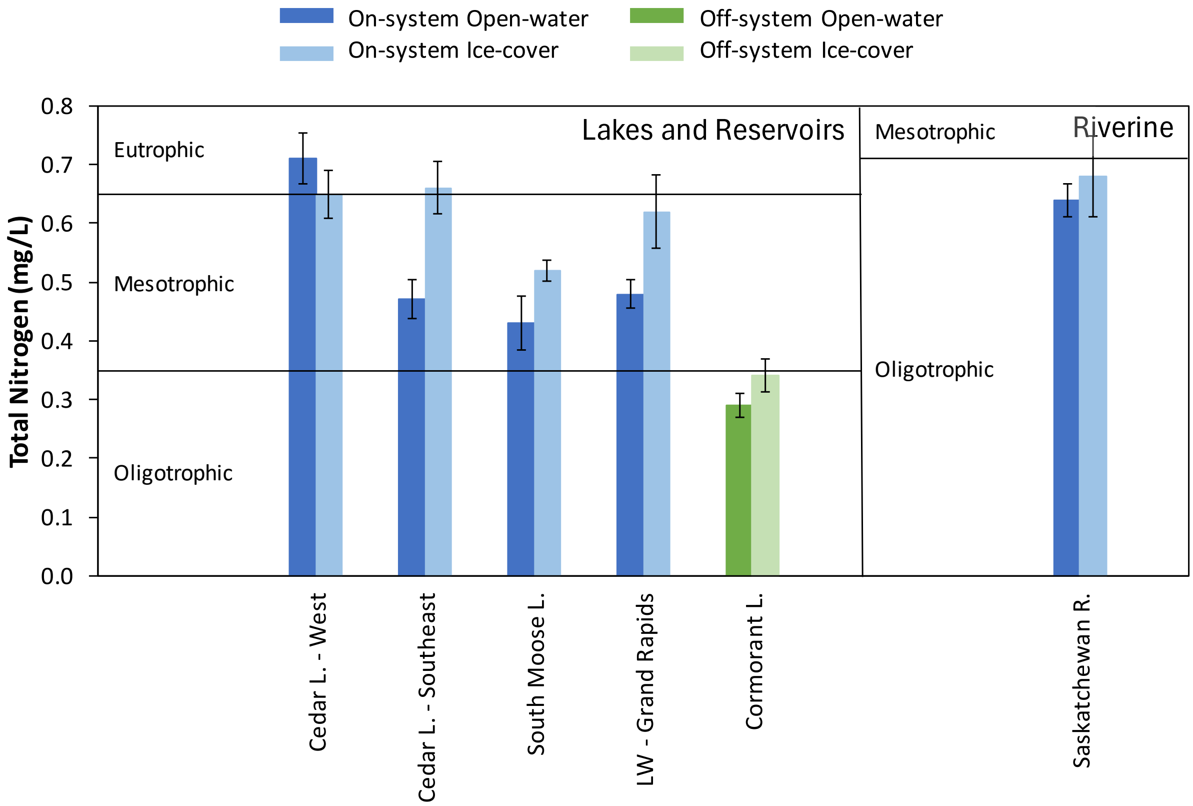


Figure 15. Mean (±SE) total nitrogen concentrations in the Saskatchewan River Region from 2008-2019 compared to trophic categories for lakes and reservoirs (OECD 1983) and riverine sites (Dodds et al. 1998).

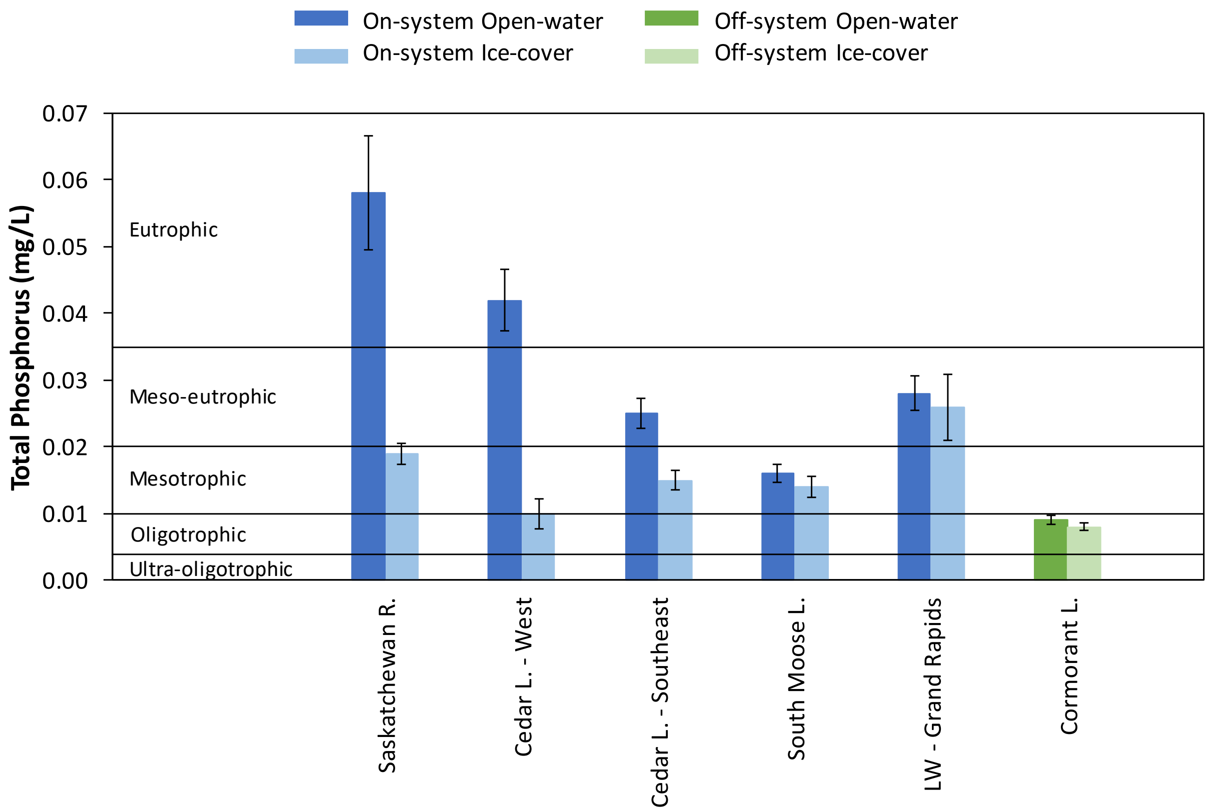


Figure 16. Mean (±SE) total phosphorus concentrations in the Saskatchewan River Region from 2008-2019 compared to the CCME Canadian Guidance Framework for Phosphorus (CCME 2004).

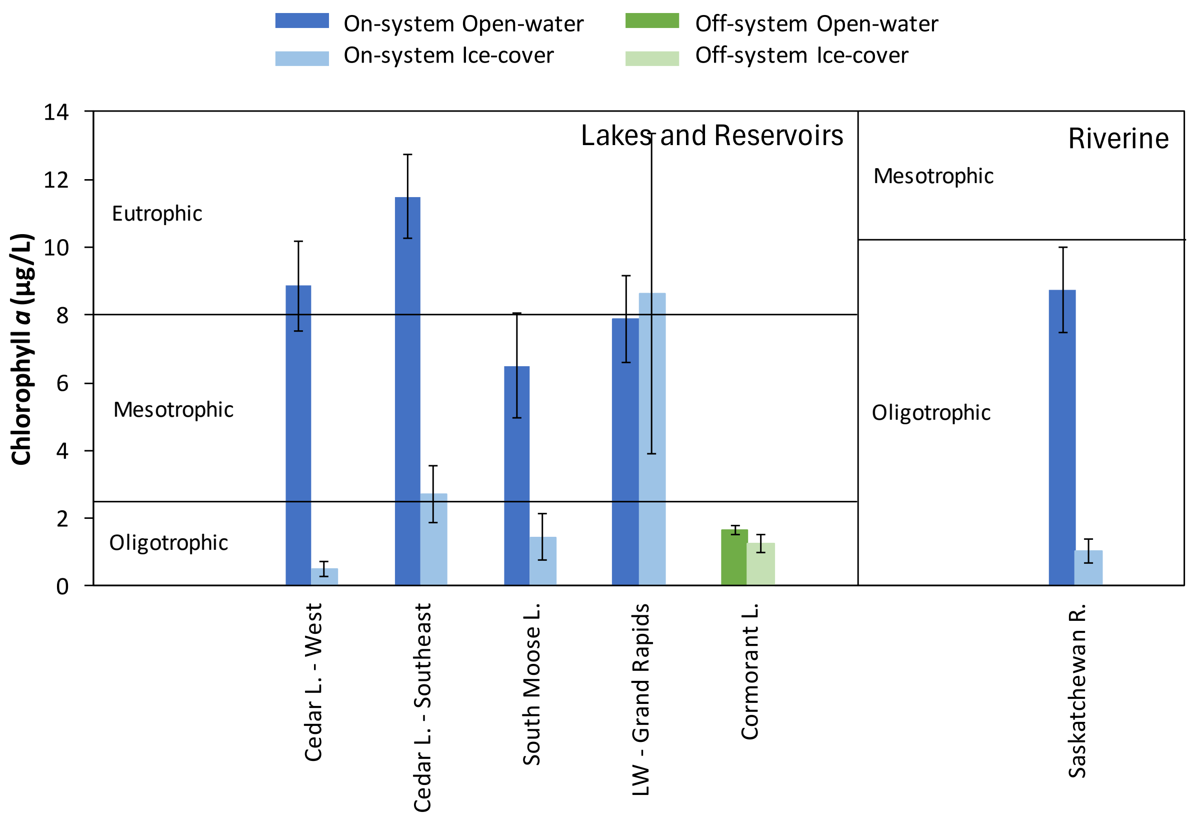


Figure 17. Mean (±SE) chlorophyll *a* concentrations in the Saskatchewan River Region from 2008-2019 compared to trophic categories for lakes and reservoirs (OECD 1983) and riverine sites (Dodds et al. 1998).

4.2.3 Benthic Invertebrates Regional Summary

The nearshore benthic invertebrate community varied between years and across sites in the Saskatchewan River Region. The Saskatchewan River - downstream of The Pas was sampled with a benthic grab sampler as the shoreline was not wadable. The dominant taxa at this site varied year-to-year (Oligochaeta, Bivalvia: Sphaeriidae, and/or Ephemeroptera: Ephemeridae). The South Moose Lake community was mainly comprised of Oligochaeta and/or Amphipoda (Hyalellidae). At Cedar Lake - West, Oligochaeta, Amphipoda (Hyalellidae), and/or Chironomidae were most prevalent in all but one year (the dominant taxon in 2014 was Hydrachnidae (water mites). The community at Cedar Lake - Southeast was mainly comprised of Amphipoda (Hyalellidae) and/or Gastropoda (Lymnaeidae and Valvatidae) in most years. Amphipoda (Hyalellidae) was also the dominant taxon at the Lake Winnipeg - Grand Rapids site. At the off-system Cormorant Lake, the dominant taxa were Chironomidae and/or Amphipoda (Hyalellidae) in most years; Ephemeroptera (Caenidae) and Ceratopogonidae were co-dominant in 2011. These taxa are commonly associated with the predominant substrate at all sites (hard/coarse substrates with varying amounts of organic matter and silty loam substrates). Some observed differences in invertebrate composition appear related to coarser substrates, such as prevalence of Caenidae at Cormorant Lake and Gastropoda at Cedar Lake - Southeast (boulder, cobble, and gravel). Relative to the other sites, mean total invertebrate abundance (all years combined) in the nearshore was very high at the Lake Winnipeg - Grand Rapids site and very low at the off-system Cormorant Lake.

The dominant taxa (Oligochaeta, Amphipoda: Hyalellidae or Pontoporeiidae, Bivalvia: Sphaeriidae, and/or Chironomidae) at the offshore sites were generally similar among sites and years. These taxa are commonly associated with fine substrates present at all sites (silt to silty clay loam). Mean total invertebrate abundance (densities; all years combined) at Cedar Lake - Southeast and Lake Winnipeg - Grand Rapids was very high and at least two times higher than the other sites, including at the off-system Cormorant Lake.

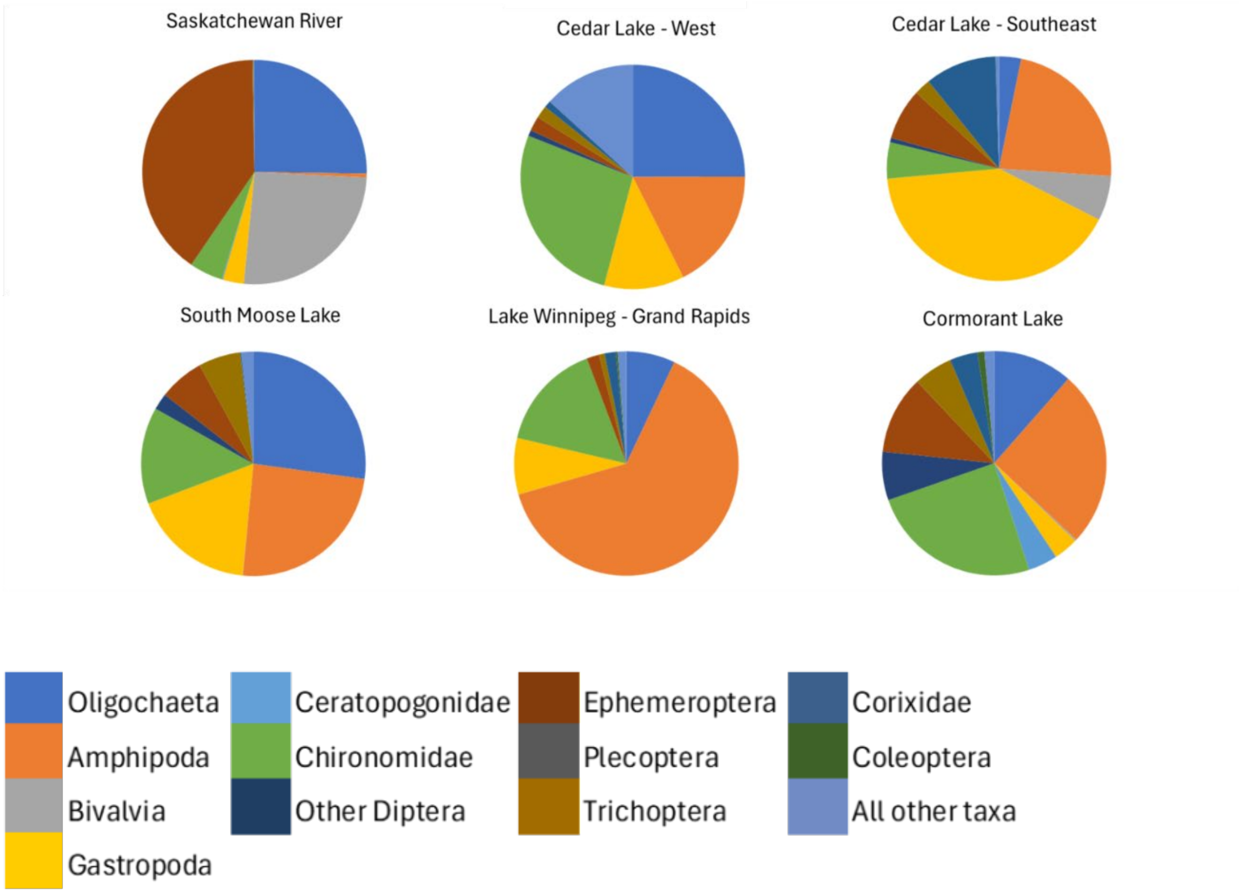


Figure 18. Average relative abundance (% of total) of the benthic invertebrate taxa groups captured at nearshore sites in the Saskatchewan River Region from 2010-2019.

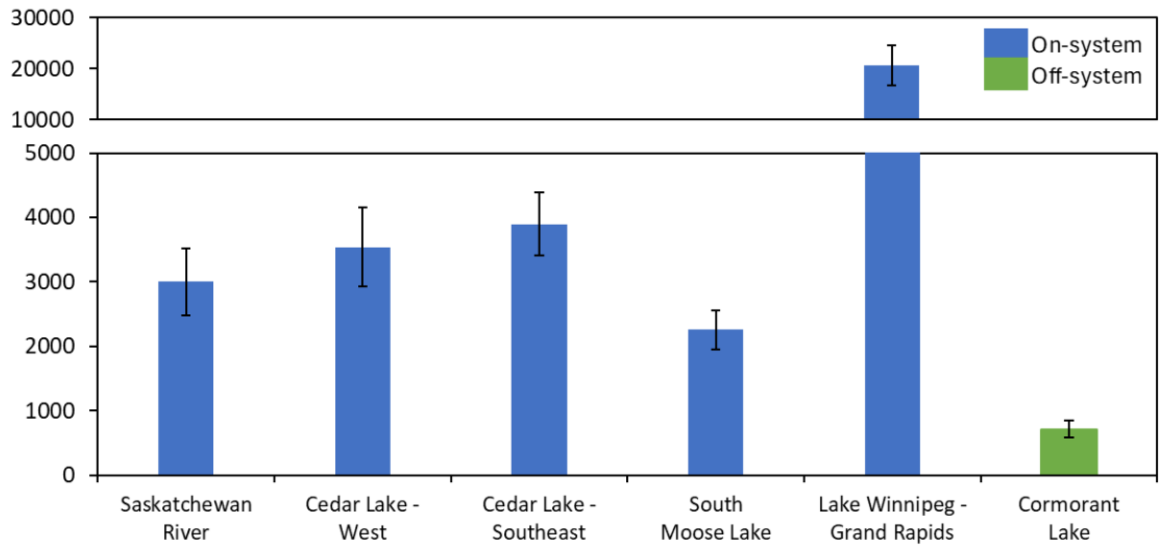


Figure 19. Average total abundance (no. per sample ± SE) of benthic invertebrates captured at nearshore sites in the Saskatchewan River Region from 2010-2019.

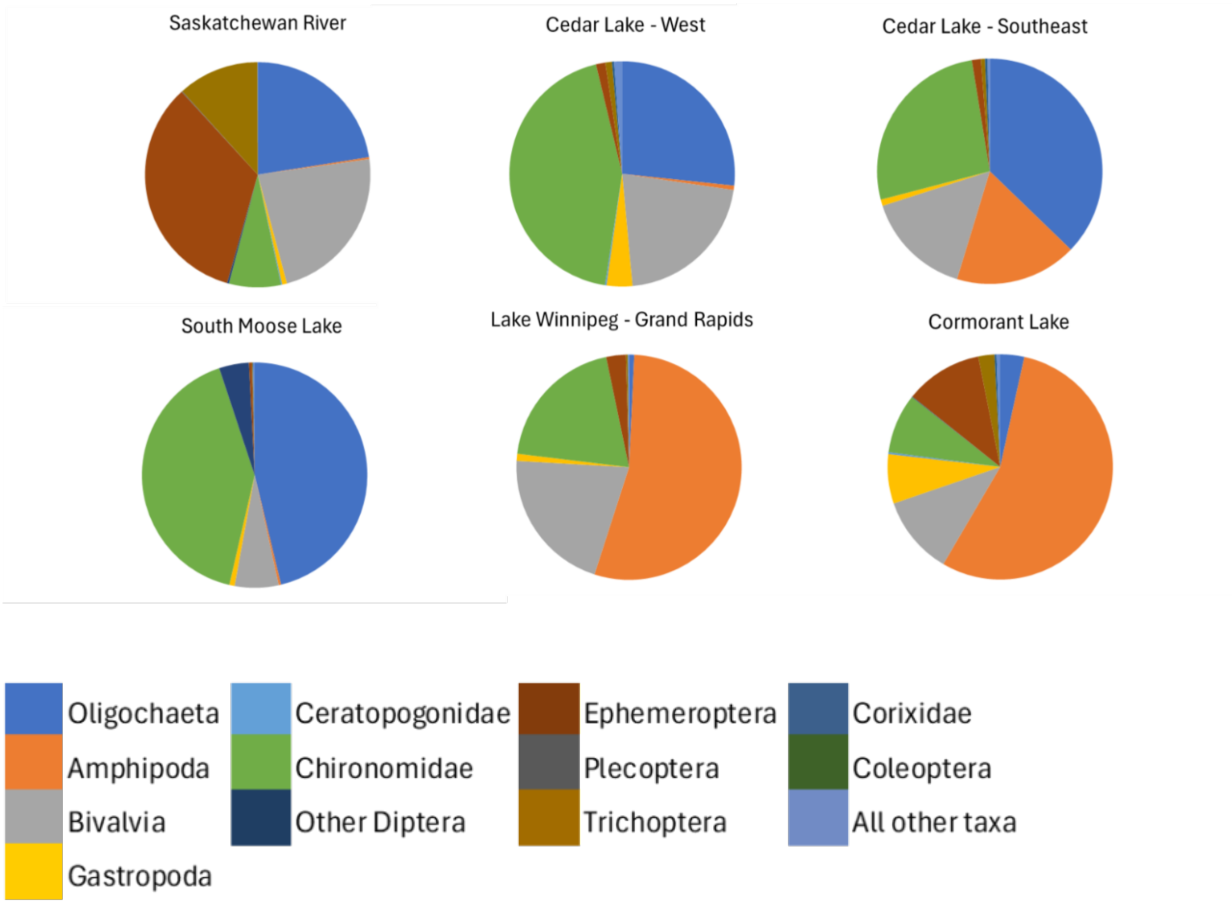


Figure 20. Average relative abundance (density, % of total) of the benthic invertebrate taxa groups captured at offshore sites in the Saskatchewan River Region from 2010-2019.

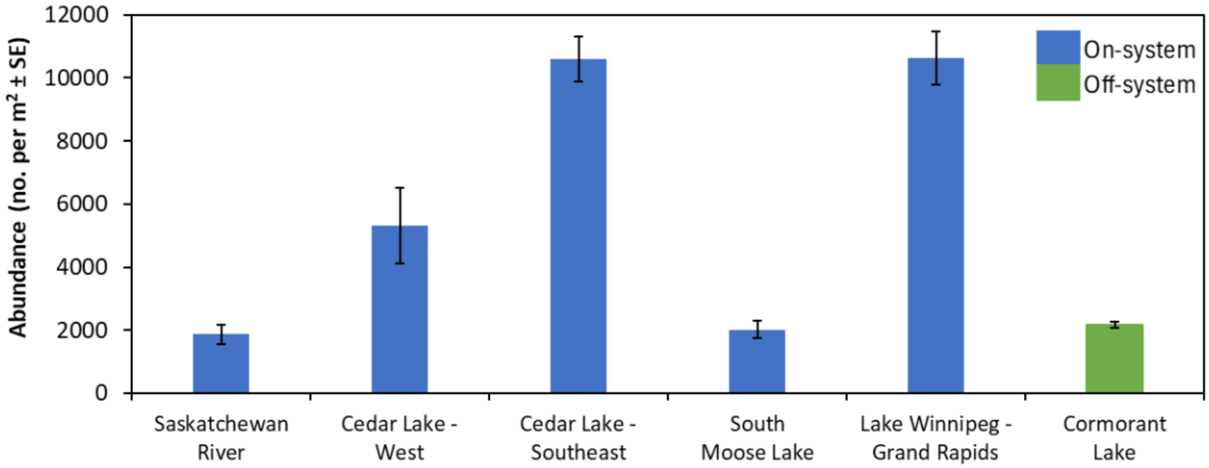


Figure 21. Average total abundance (density, no. per m2 ± SE) of benthic invertebrates captured at offshore sites in the Saskatchewan River Region from 2010-2019.

4.2.4 Fish Community Regional Summary

White Sucker and Walleye were the common species among all on-system waterbodies along the Saskatchewan River. Other frequently caught species were more waterbody-specific: Sauger were more common upstream in the Saskatchewan River and Cedar Lake - west; Cisco were common in Cedar Lake - southeast; Northern Pike were common at South Moose Lake; and Yellow Perch were common in Cedar Lake - southeast, South Moose Lake, and Lake Winnipeg - Grand Rapids. The diversity of the fish community was lower at South Moose Lake and Lake Winnipeg - Grand Rapids compared to the other on-system waterbodies. The species composition of the off-system Cormorant Lake was generally similar to the on-system waterbodies, with catches dominated by Walleye, White Sucker, and Yellow Perch. Lower species diversity in Cedar Lake - southeast and Cormorant Lake observed in 2009 and 2010 and in Lake Winnipeg - Grand Rapids in 2010 are likely related to deviations in the sampling methodology. In both instances, either no small mesh gill net gang or only one was set near the target locations in these years, which may have resulted in fewer species being captured.

Lake Sturgeon[3] were captured in the Saskatchewan River and in Lake Winnipeg - Grand Rapids. Hiodontid species (Mooneye and Goldeye) were captured almost exclusively upstream in the Saskatchewan River, but a small number of Goldeye were also captured farther downstream in Cedar Lake - west. Lake Whitefish were notably absent from the Saskatchewan River and Cedar Lake - west. The invasive Rainbow Smelt was not observed in any of the waterbodies upstream of the Grand Rapids GS (i.e., in the Saskatchewan River). While this species was captured in Lake Winnipeg - Grand Rapids, catches have declined over time, and the species has not been caught under CAMP since 2015.

Catches were lowest in the Saskatchewan River, intermediate in Cedar and South Moose lakes, and highest in Lake Winnipeg - Grand Rapids. The abundance of Walleye was particularly high in Lake Winnipeg - Grand Rapids.

The condition of Walleye, Sauger, and White Sucker and the growth of young Lake Whitefish (age 4 years) from Cormorant Lake were generally lower than fish from the on-system waterbodies. The growth of young Walleye (age 3 years) was higher at South Moose Lake compared to the other lake sites. Two of the metrics showed some notable temporal differences for the fish community at Lake Winnipeg - Grand Rapids:

- the condition and length-at-age-3 of Walleye was lower over the 2015-2019 period relative to the 2008-2014 period. This is similar to the reported decline in the condition of Walleye in the north basin of Lake Winnipeg as a whole in the mid-2010s, which was attributed to a decline in Rainbow Smelt prey (ECCC and MARD 2020); and,
- the length-at-age-3 of Sauger was also lower in the 2015-2019 period relative to the 2008-2014 period.

[3] The methodologies used in the Fish Community sampling program are not designed to target Lake Sturgeon or capture them in proportion to their abundance (i.e., larger gill net mesh sizes are excluded from the gear).

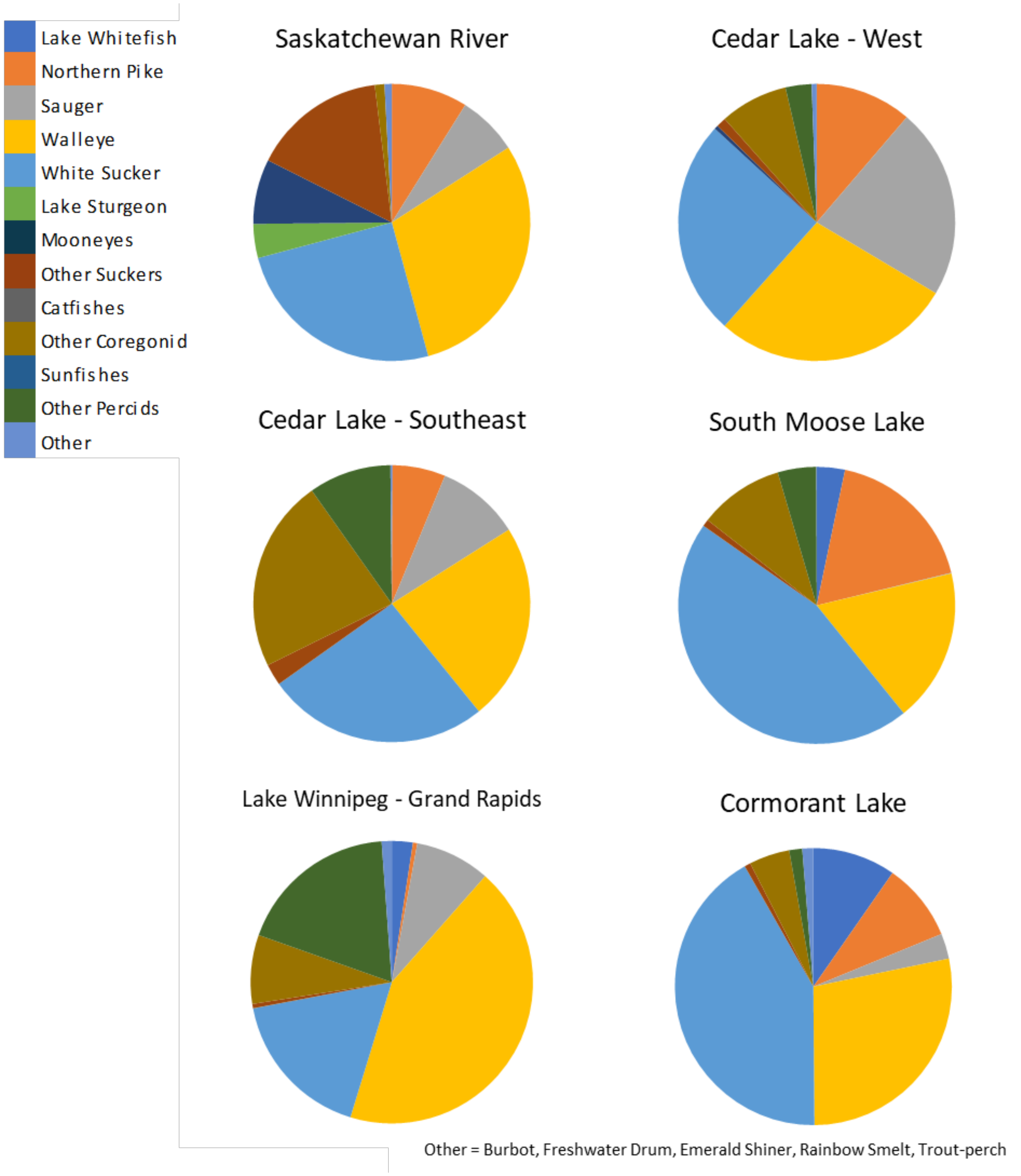


Figure 22. Average relative species abundance of target species and taxa groups captured annually in standard gang gill nets in standard gang gill nets in the Saskatchewan River Region from 2008-2019.

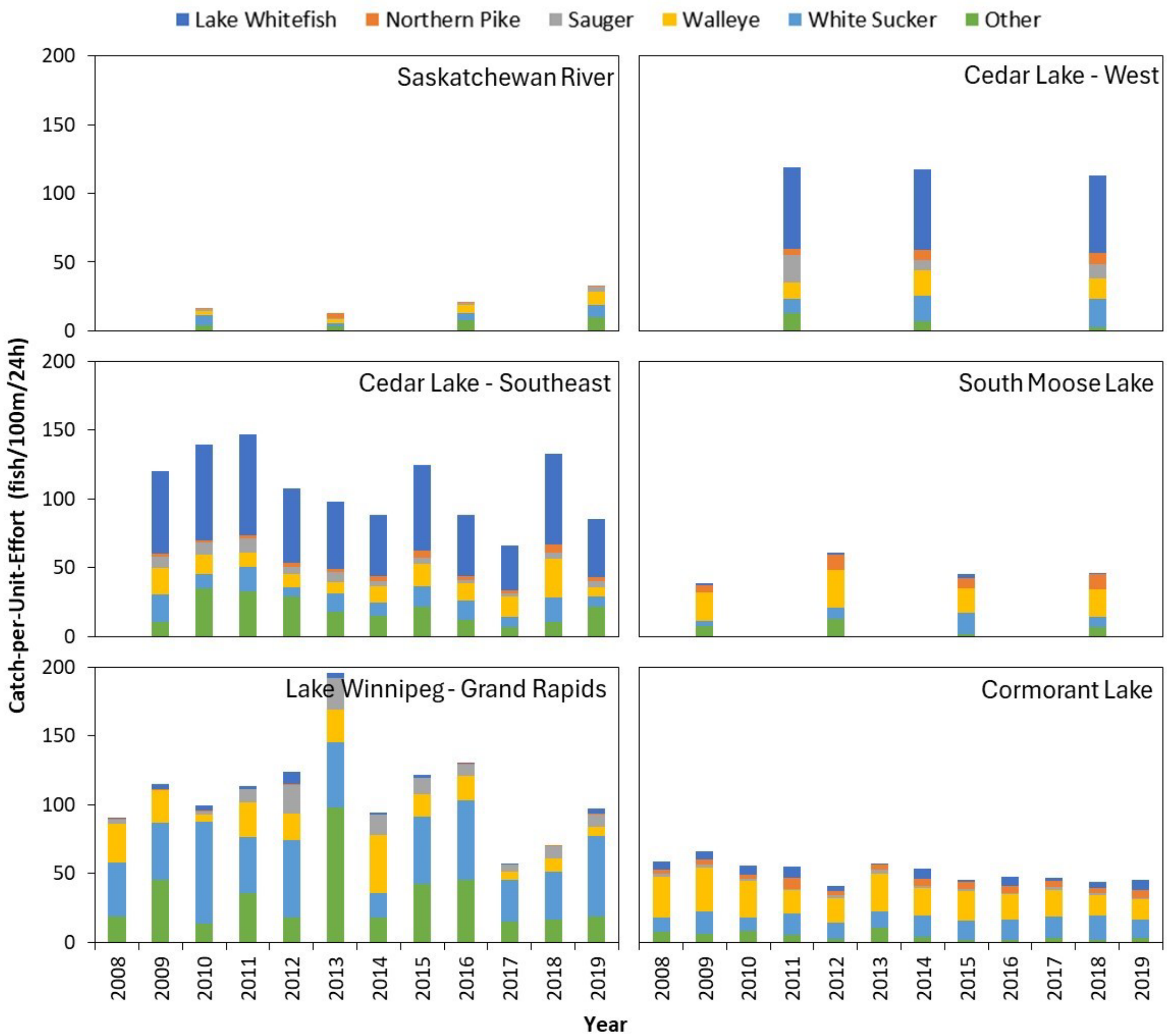
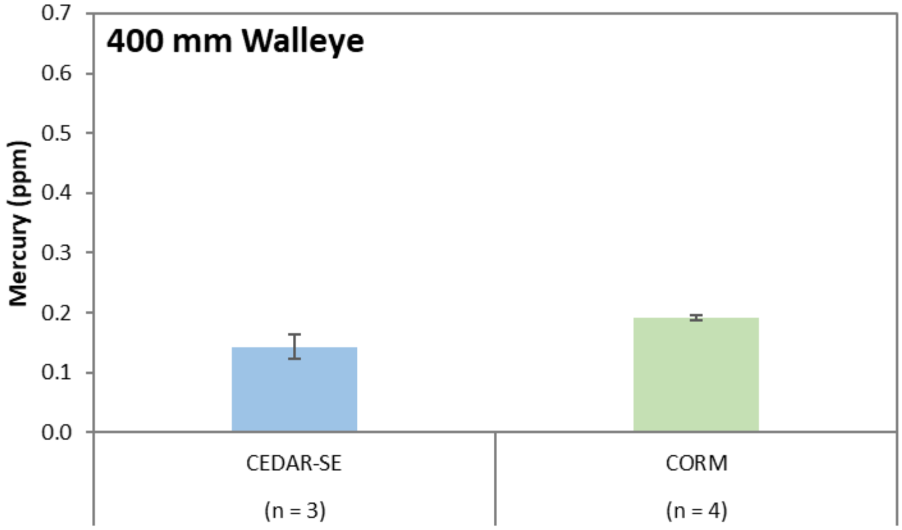


Figure 23. Average catch-per-unit-effort (fish/100 m/24 hr) per year of target species captured in standard gang gill nets in the Saskatchewan River Region from 2008-2019.

4.2.5 Mercury in Fish Regional Summary

As an ecosystem monitoring program, CAMP does not analyze mercury in fish data in relation to human health. Data collected through CAMP is made available to the relevant experts and authorities for human health analysis.

Standard mean mercury concentrations in a 400 mm Walleye and a 550 mm Northern Pike were typically lower in the on-system Cedar Lake - southeast (mean in all years sampled: 0.14 and 0.13 ppm, respectively) compared to the off-system Cormorant Lake (mean in all years sampled: 0.19 and 0.25 ppm, respectively; Figure 1). Lake Whitefish were not analyzed for mercury from Cedar Lake due to a low capture rate.



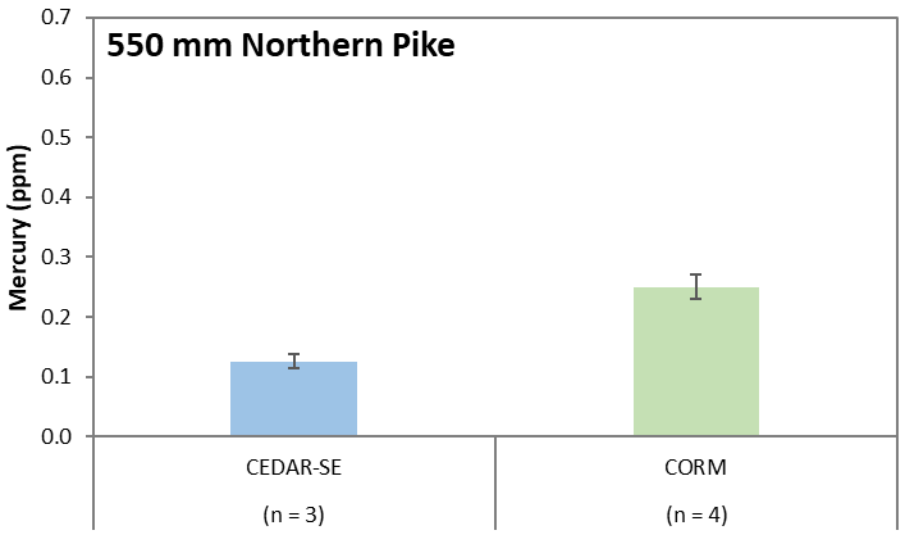


Figure 24. Average length-standardized mercury concentration (± standard error) in fish muscle from Saskatchewan River Region waterbodies.

Blue = on-system, Green = off-system, n = number of sampling years.

4.3 Upper Churchill River Region

4.3.1 Physical Environment Regional Summary

4.3.1.1 Climate

Over the monitoring period, the months of January, September, and December generally experienced warmer than normal conditions (≥ 7 out of 13 months above normal), while March and April generally experienced cooler than normal conditions (≥ 7 out of 13 months below normal). On an annual basis, no distinct patterns in the data were identified as most years in the monitoring period were near normal conditions, however there were more years with above normal temperatures than below normal; 2010 had the warmest annual average temperature at -0.6ºC, while 2014 had the coolest annual average temperature at -4.5ºC. The maximum and minimum monthly average air temperatures during the monitoring period were 18.7ºC (July 2012) and -29.8ºC (December 2013), respectively.

Over the monitoring period, August generally experienced more than normal precipitation (≥ 7 out of 13 months above normal), while February, May, September, and December generally experienced less than normal precipitation (≥ 7 out of 13 months below normal). On an annual basis, no distinct patterns in the data were identified, however there were more years with above normal precipitation than below normal in the monitoring period; 2009 had the highest annual total precipitation (641.9 mm), while 2014 had the lowest annual total precipitation (348.4 mm). The maximum and minimum monthly total precipitation recorded during the monitoring period were 175.0 mm (August 2019) and 0.0 mm (November 2010), respectively.

4.3.1.2 Water Regime

Water Flows and Levels:

The Upper Churchill River, entering Manitoba from the northwestern Saskatchewan, is influenced by snowmelt, precipitation, and regulation of lakes within the basin, notably Reindeer Lake. The Churchill River Diversion (CRD) alters natural flows by redirecting water through Southern Indian Lake (SIL), Notigi, and the Rat and Burntwood rivers, with flow controls at Missi Falls and Notigi. CAMP monitors on-system reservoirs associated with the CRD, including Southern Indian Lake, Opachuanau Lake, Rat Lake, Notigi Lake, and Mynarski Lake Central. Continuous water temperature monitoring near Leaf Rapids began in 2020. Granville Lake, upstream of SIL, serves as an off-system site generally unaffected by SIL backwater except during low flows combined with high lake levels.

From 2008 to 2020, the monthly flows at Granville Falls ranged between 523 and 2,392 cms (median 867 cms). Southern Indian Lake exhibited a stable seasonal water level pattern, with most monthly averages within ±0.5 metres of the long-term mean and low variability. Other reservoirs such as Rat Lake and Notigi Lake showed greater variability due to proximity to control structures. Granville Lake's water levels primarily reflected natural river flow variations, with generally low variability.

Water Temperature:

Continuous water temperature data are not available for this region during the period from 2008 to 2019. Continuous water temperature monitoring was initiated on the upper Churchill River near Leaf Rapids in 2020, after the monitoring period for this report, and this data will be presented in the next reporting cycle.

4.3.1.3 Sedimentation

Sedimentation data are not available for this region during the period from 2008 to 2019. Continuous monitoring was initiated on the upper Churchill River near Leaf Rapids in 2020, after the monitoring period for this report, and this data will be presented in the next reporting cycle.

4.3.2 Water Quality Regional Summary

Waterbodies along the upper Churchill River were well-oxygenated near the surface, and relatively clear, with low to moderately high concentrations of nutrients. Some spatial differences in water quality conditions were observed in the region, including differences between waterbodies on the upper Churchill River and those on the Rat River along the Churchill River Diversion (CRD) route. Conditions also differed between Central Mynarski Lake which is located off the main flow path of the Rat River system and sites located along the main flow of the Churchill and Rat rivers. Water quality conditions in the off-system Granville Lake, located on the upper Churchill River, were relatively similar to those observed downstream in Southern Indian Lake.

Some differences were also observed between the deeper lakes with longer residence times in this region relative to the shallower lakes with shorter residence times located downstream of the Notigi Control Structure (CS) in the CRD Region.

All waterbodies along the upper Churchill River (i.e., Granville and Opachuanau lakes, and Areas 1, 6, and 4 of Southern Indian Lake) were well-oxygenated year-round and dissolved oxygen (DO) concentrations throughout the water column consistently met MWQSOGs instantaneous minimum objectives for cool- and cold-water aquatic life (MWS 2011). Lakes along the upper Churchill River were typically isothermal and DO was similar throughout the water column. Thermal stratification was occasionally observed however the thermocline was typically shallow (0-2 m).

Lakes located on the CRD route downstream of Southern Indian Lake and upstream of the Notigi CS were also consistently well-oxygenated at the surface. However, although typically well-oxygenated across the water column, DO fell below MWQSOGs instantaneous minimum objectives for cool- and/or cold-water aquatic life (MWS 2011) during one summer in Rat Lake and one winter in Notigi Lake - East. Thermal stratification also occurred on occasion in both of these sampling areas. DO consistently met PAL objectives throughout the water column in Notigi Lake - West.

Limnological conditions at Central Mynarski Lake differed notably from lakes located on the main flow path of the Churchill or Rat/Burntwood River systems. Central Mynarski Lake was thermally stratified during all but one sampling event during the open-water season and was thermally stratified during one of three winters sampled. Oxygen depletion occurred coincident with thermal stratification and concentrations below the thermocline frequently fell below PAL objectives during both the open-water and ice-cover seasons.

Water clarity in the Upper Churchill River Region was high as indicated by mean Secchi disk depths greater than 1 m, and relatively low turbidity and TSS. As observed in all

CAMP regions, water clarity tended to be higher in winter under the ice than during the open-water season.

Some spatial differences were noted in water clarity metrics in this region but the differences were not consistently observed for all metrics or across sampling events. In general, water clarity was lower in Opachuanau Lake and Southern Indian Lake - Areas 1 (inflow of the lake) and 6 (area of the lake where the South Bay Diversion Channel is located) than either Southern Indian Lake - Area 4 (area where the Missi Falls CS is located) or the upstream Granville Lake. Additionally, water clarity was higher in Central Mynarski Lake compared to the lakes (i.e., Rat and Notigi lakes) along the CRD route upstream of the Notigi CS.

Lakes in the Upper Churchill River Region were mesotrophic to meso-eutrophic based on total phosphorus (TP), oligotrophic to mesotrophic based on total nitrogen (TN), and with two exceptions, mesotrophic based on chlorophyll *a*. Although Southern Indian Lake - Area 6 was on average oligotrophic based on chlorophyll *a*, concentrations were relatively similar to other on-system sites. Conversely, chlorophyll *a* concentrations were notably higher on average in Central Mynarski Lake and indicative of eutrophic conditions. Similar to the on-system lakes, Granville Lake was mesotrophic based on TP, TN, and chlorophyll *a*.

Nutrients (TN and TP) were lower in Area 4 of Southern Indian Lake compared with the upstream off-system Granville Lake and TN was higher in Central Mynarski Lake than other lakes in the region. Phytoplankton blooms (i.e., chlorophyll *a* ≥ 10) occurred in Central Mynarski Lake during each of the three fall sampling events but were not a regular occurrence elsewhere in the region. Additionally, phytoplankton biomass (as indicated by chlorophyll *a*) tended to be lower in winter under the ice than during the open-water season in all waterbodies.

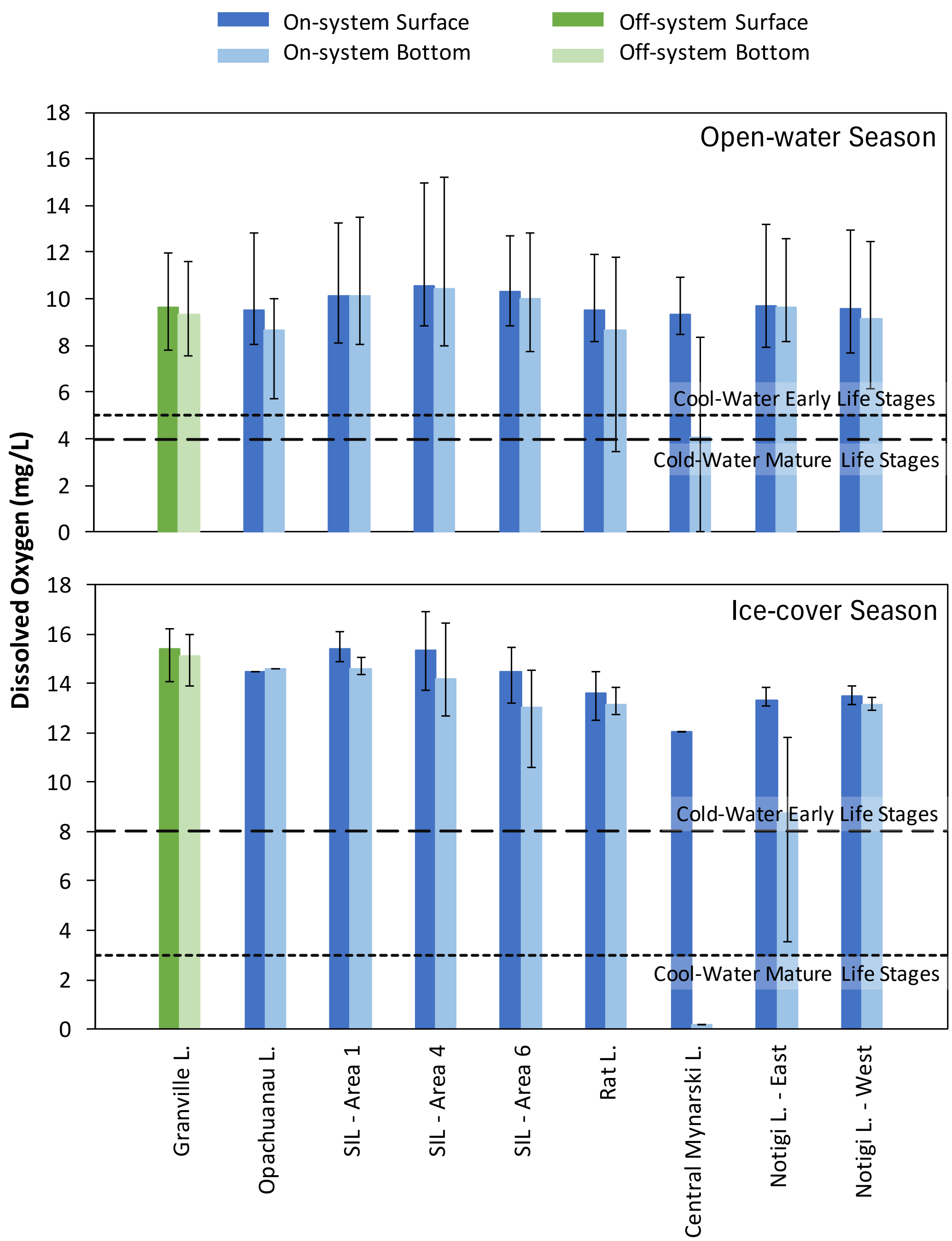
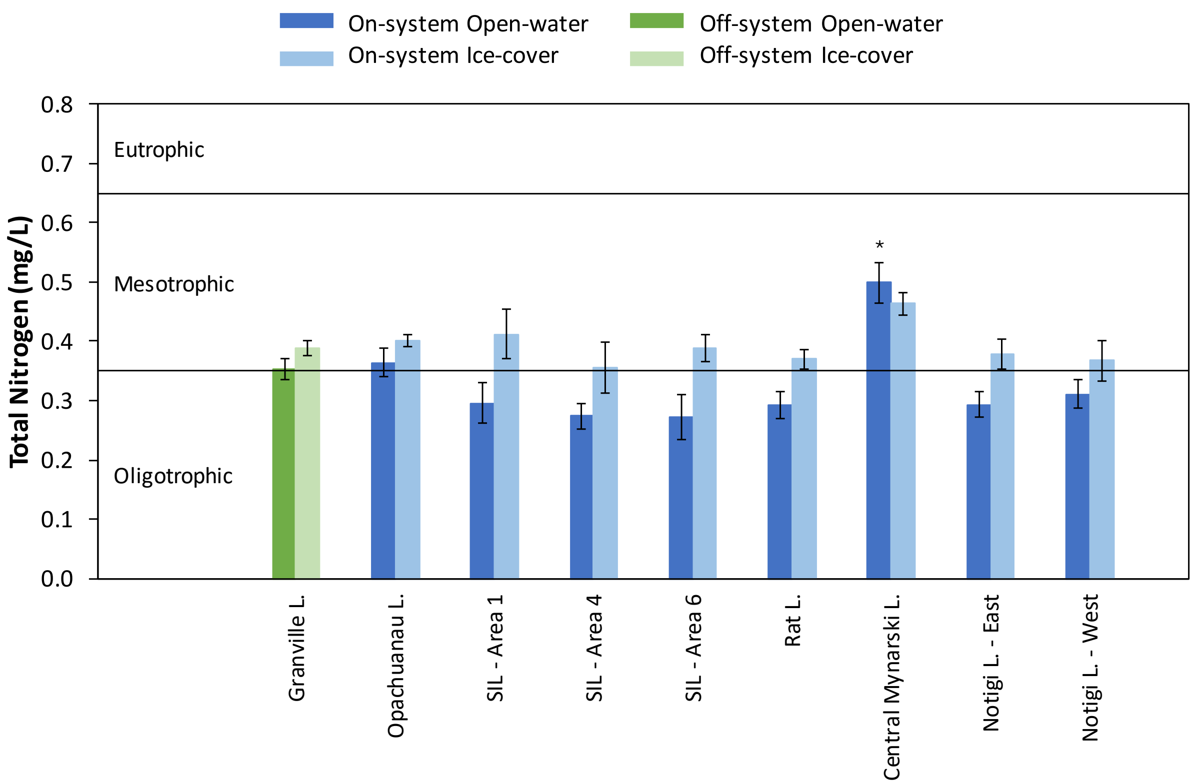


Figure 25. Average dissolved oxygen concentrations in the Upper Churchill River Region from 2008-2019 compared to the MWQSOG instantaneous minimum objectives for the protection of cold- and cool-water aquatic life. Error bars show total range of values (i.e., minimum and maximum).



Notes: * Outlier value of 2.68 mg/L from spring 2014 was excluded from values reported for Central Mynarski Lake.

Figure 26. Mean (±SE) total nitrogen concentrations in the Upper Churchill River Region from 2008-2019 compared to trophic categories for lakes and reservoirs (OECD 1983).

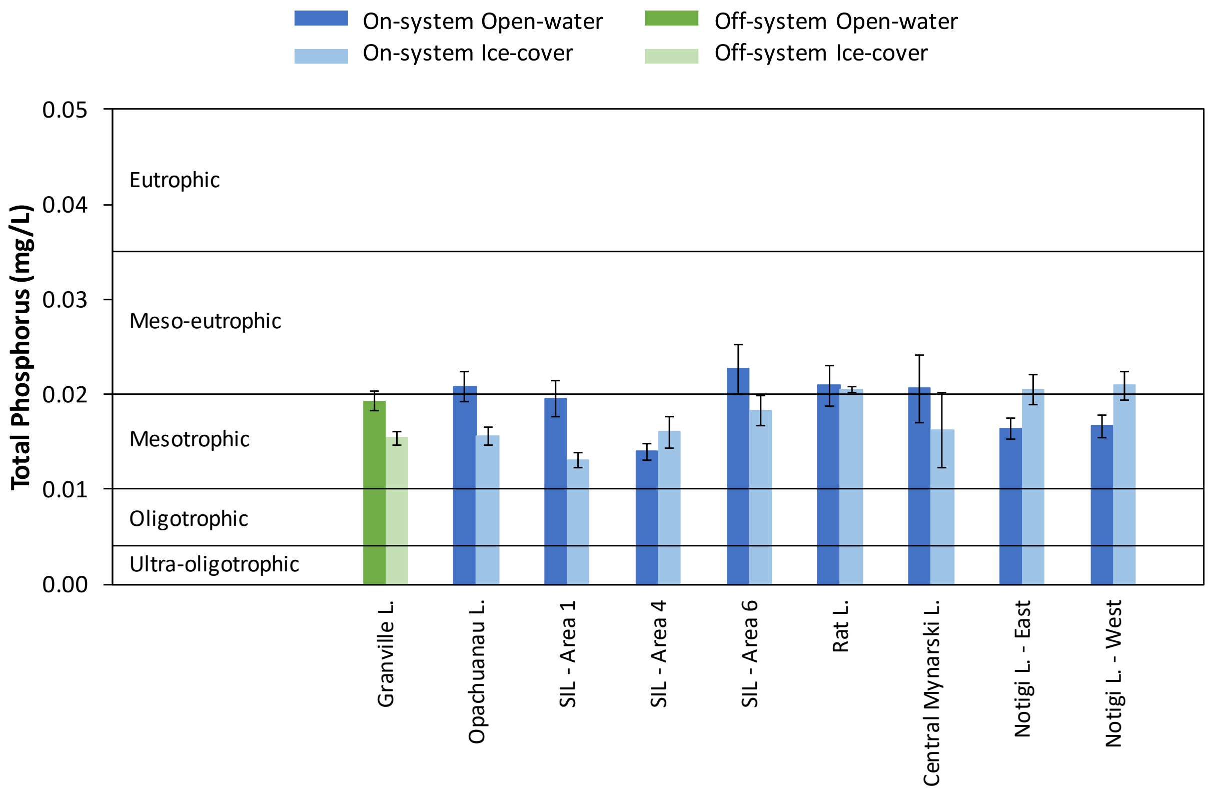


Figure 27. Mean (±SE) total phosphorus concentrations in the Upper Churchill River Region from 2008-2019 compared to the CCME Canadian Guidance Framework for Phosphorus (CCME 2004).

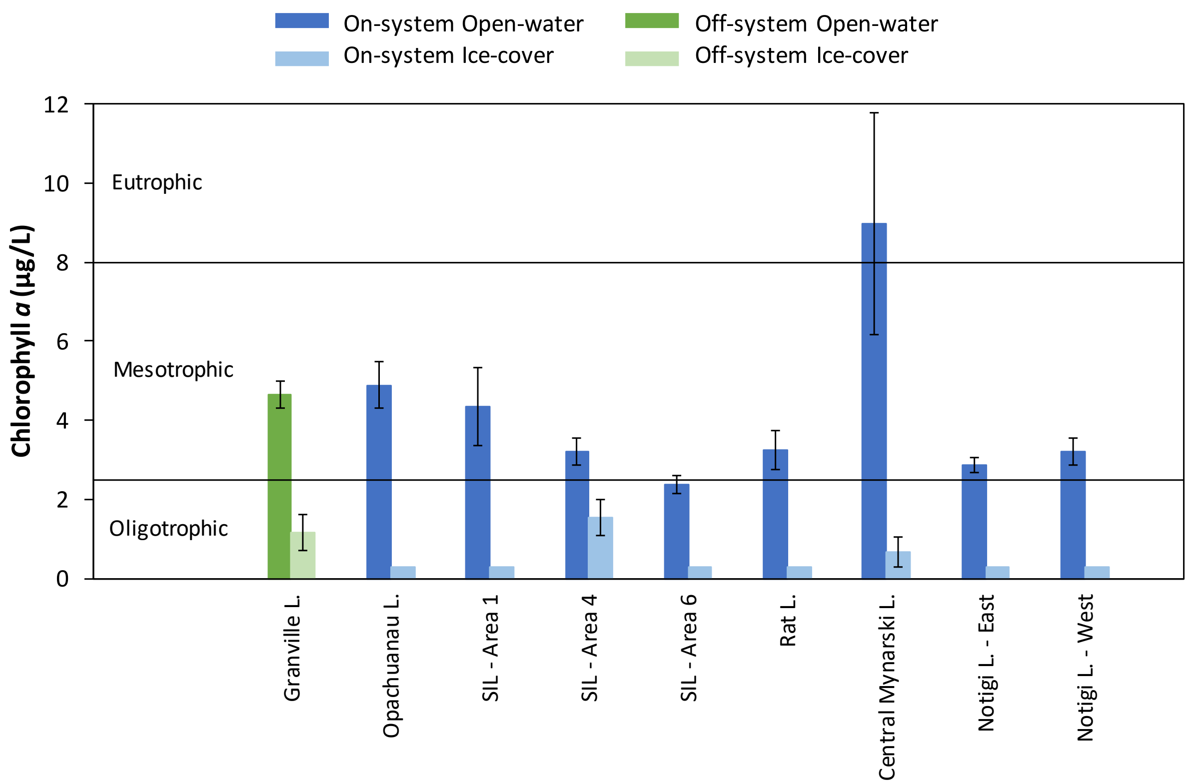


Figure 28. Mean (±SE) chlorophyll *a* concentrations in the Upper Churchill River Region from 2008-2019 compared to trophic categories for lakes and reservoirs (OECD 1983).

4.3.3 Benthic Invertebrates Regional Summary

The dominant benthic invertebrate taxa in the nearshore were similar between one Upper Churchill River Region on-system site (Southern Indian Lake - Area 4) and the off-system Granville Lake (Oligochaeta, Chironomidae, and Corixidae). These taxa were also common at the other on-system sites (Opachuanau Lake, Southern Indian Lake - Areas 1 and 6, and Central Mynarski, Rat, and Notigi lakes), but relative proportions of the dominant taxa varied among sites and years. Mean total invertebrate abundances (all years combined) was highest at Southern Indian Lake - Area 1 and lowest at Southern Indian Lake - Area 6. Observed differences in total invertebrate abundance did not appear related to sediment composition among sites and years. Bedrock and boulder (with little to no fines) dominated the nearshore habitat substrate in Granville Lake.

Hard/coarse substrates with varying amounts of organic matter and sandy loam sediments were prevalent at Opachuanau Lake and Southern Indian Lake - Areas 1, 4, and 6. Conversely, fine sediments (silty clay loam) were the predominant nearshore substrate at Central Mynarski, Rat, and Notigi lakes.

The dominant taxa were generally similar among offshore sites (Amphipoda: Pontoporeiidae, Chironomidae, and/or Ephemeroptera: Ephemeridae). Mean total invertebrate abundance (densities; all years combined) was lowest at Rat Lake and highest at the off-system Granville Lake. Observed differences did not appear related to substrate as sediment composition was relatively similar across sites. Fine sediments (silty clay loam) were the predominant offshore benthic substrate at most sites (Granville and Opachuanau lakes, Southern Indian Lake - Areas 1 and 6, and Rat and Notigi lakes); and sandy loam substrate was prevalent at Southern Indian Lake - Area 4 and Central Mynarski Lake.

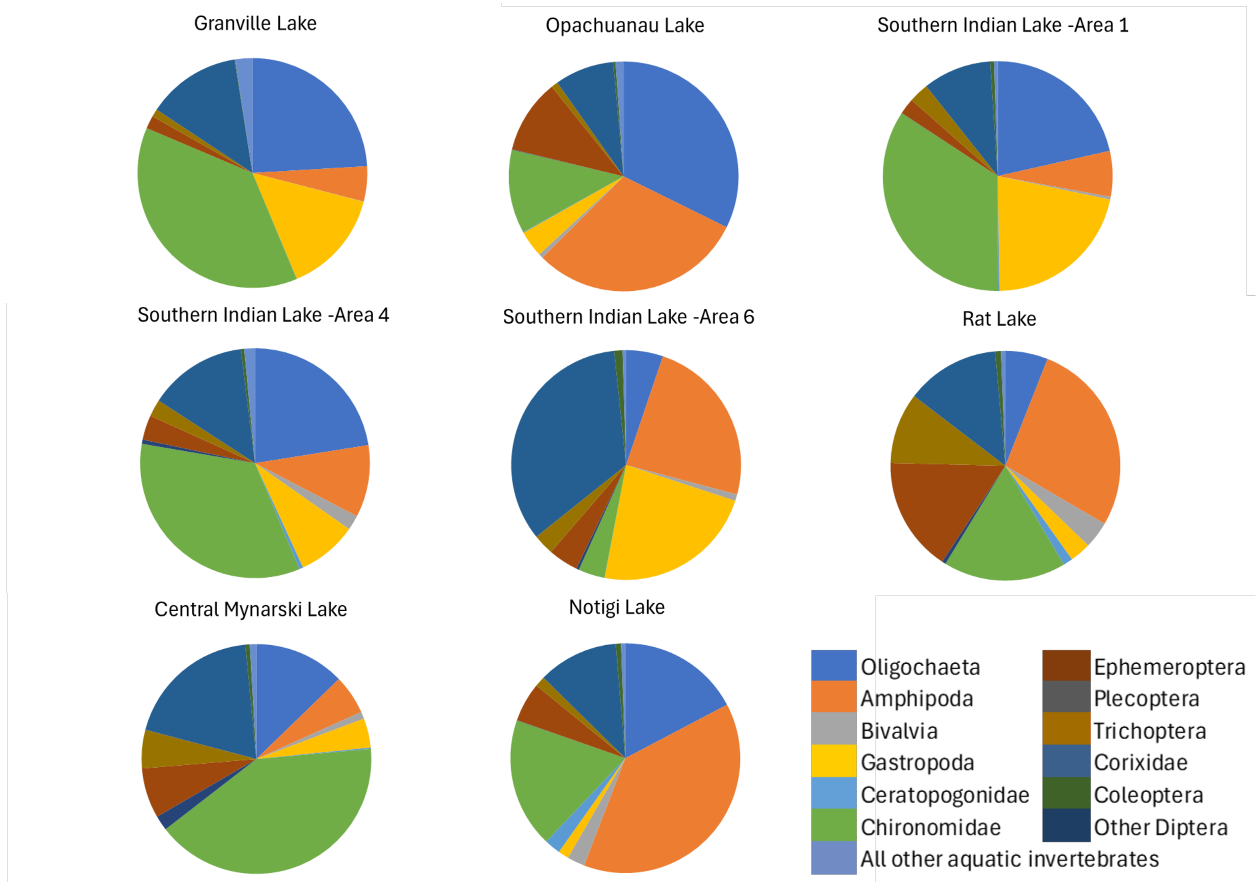


Figure 29. Average relative abundance (% of total) of the benthic invertebrate taxa groups captured at nearshore sites in the Upper Churchill River Region from 2010-2019.

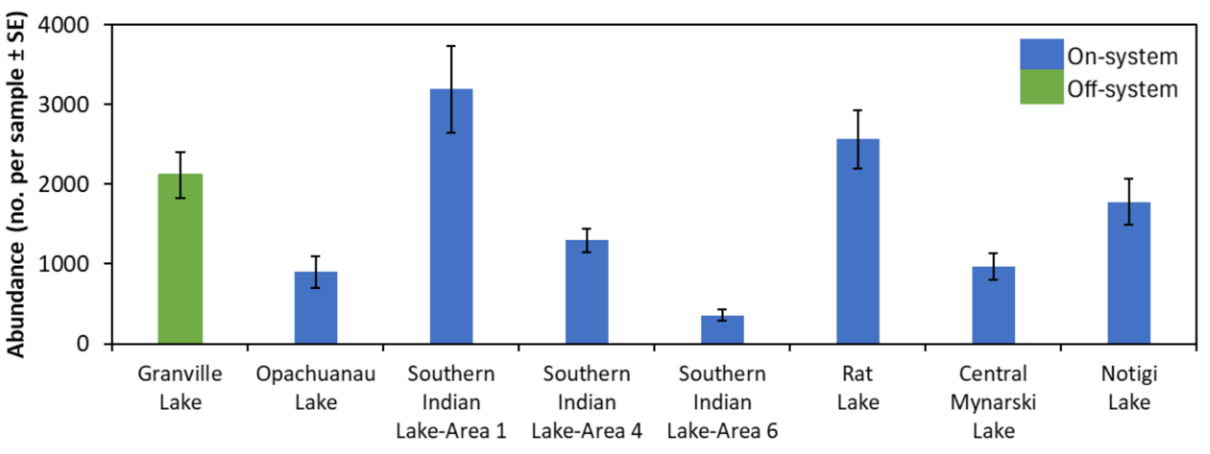


Figure 30. Average total abundance (no. per sample ± SE) of benthic invertebrates captured at nearshore sites in the Upper Churchill River Region from 2010-2019.

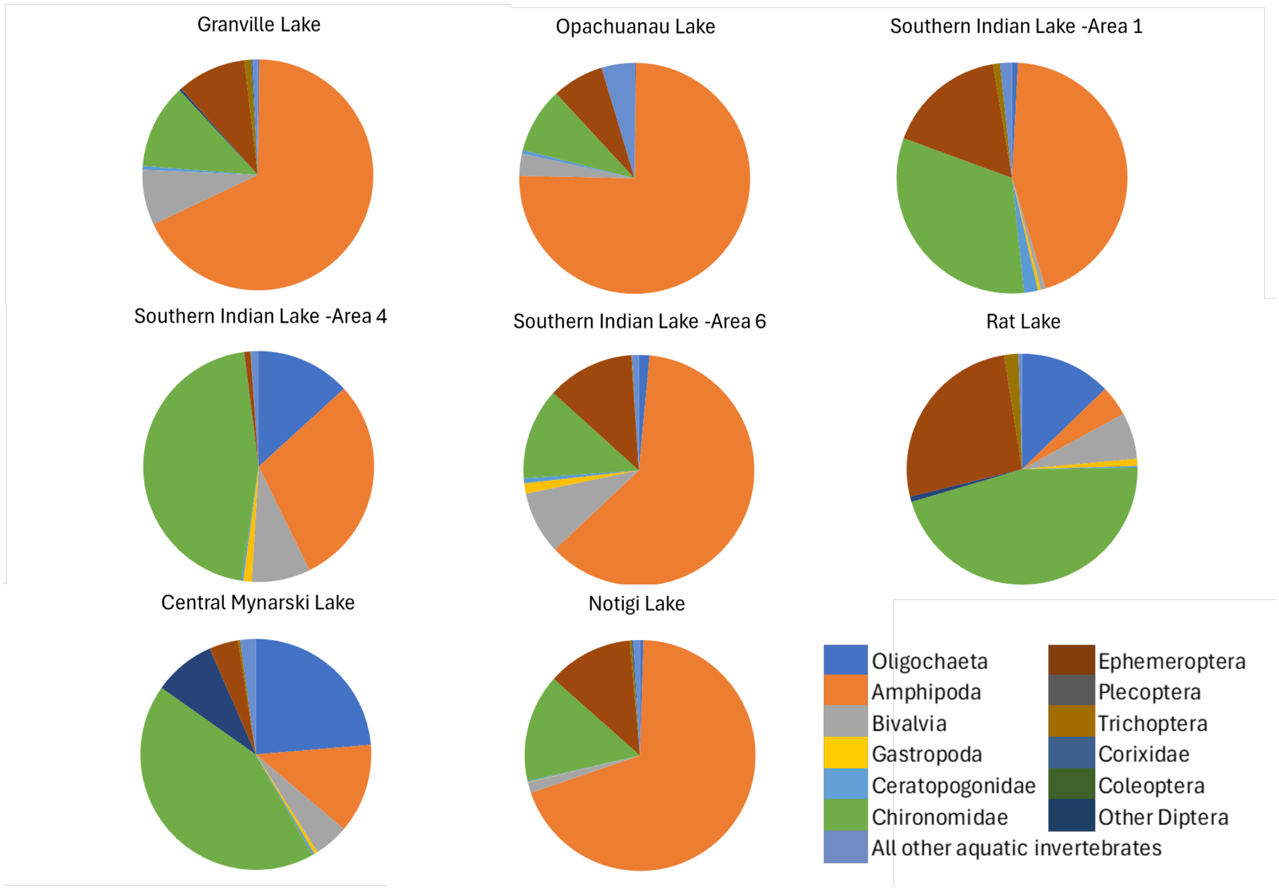


Figure 31. Average relative abundance (density, % of total) of the benthic invertebrate taxa groups captured at offshore sites in the Upper Churchill River Region from 2010-2019.

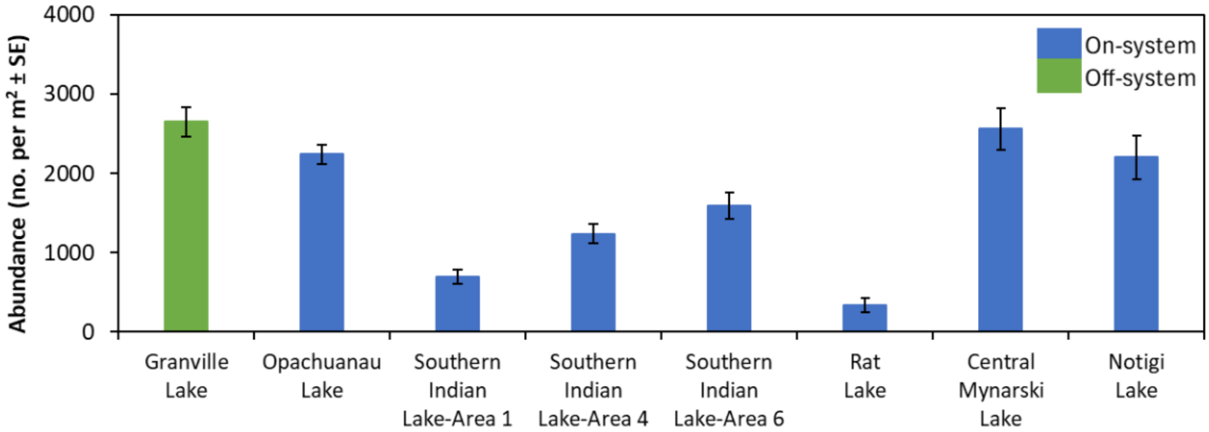


Figure 32. Average total abundance (density, no. per m2 ± SE) of benthic invertebrates captured at offshore sites in the Upper Churchill River Region from 2010-2019.

4.3.4 Fish Community Regional Summary

The fish community in the waterbodies along the upper Churchill River was quite variable. At waterbodies upstream of Southern Indian Lake (Opachuanau and Granville lakes), White Sucker accounted for a large proportion of the catch, and Lake Whitefish, Sauger and Walleye made up a lower proportion. There were also differences in relative species abundance among the areas of Southern Indian Lake: Lake Whitefish and White Sucker were more common in Area 1; Sauger and White Sucker were more common in Area 6; and Lake Whitefish and Longnose Sucker were more common in Area 4. Trout-perch was the forage fish species caught most frequently with Emerald and Spottail shiners caught less frequently.

The fish community of the off-system Granville Lake was notably different in that Mooneye, Goldeye, and Shorthead Redhorse were exclusively captured here, and the abundance of all species combined was typically higher. The diversity of catches was relatively variable at many of the upper Churchill River monitoring areas over the monitoring period but was consistently higher at Opachuanau Lake and lower at Area 1 of Southern Indian Lake.

The composition of catches at the on-system waterbodies along the Rat River was more consistent, with Walleye and White Sucker dominating the catches in Rat, Central Mynarski, and Notigi lakes. Central Mynarski Lake differed from the other two lakes along the Rat River in that neither Sauger nor Longnose Sucker were observed in the catches and the species diversity was considerably lower and total abundance higher; differences may relate to the lake being off the main flow path of the Rat River. The abundance of Lake Whitefish was noticeably lower in the Rat River waterbodies compared to those on the Churchill River. In addition to the three forage species observed in the Churchill River lakes, Yellow Perch were also common in lakes along Rat River.

Invasive fish species were not captured and likely have not become established in the region. Lake Sturgeon[4], although historically known to occur at sites within the region (MEDITNR 2024), were also not captured under the CAMP.

Both condition and growth were generally lower for Lake Whitefish from Area 4 of Southern Indian Lake and condition was generally higher for Lake Whitefish from Rat and Notigi lakes compared to the other waterbodies in the Upper Churchill River Region. The condition of Walleye from Southern Indian Lake - Area 4, and Northern Pike from Granville Lake appears to have decreased over the sampling period. Conversely the growth of young Northern Pike (4-year-old) from Southern Indian Lake - Area 4 and Granville Lake appears to have increased over the sampling period, resulting in lengths similar to what was observed in other waterbodies.

[4] The methodologies used in the Fish Community sampling program are not designed to target Lake Sturgeon or capture them in proportion to their abundance (i.e., larger gill net mesh sizes are excluded from the gear).

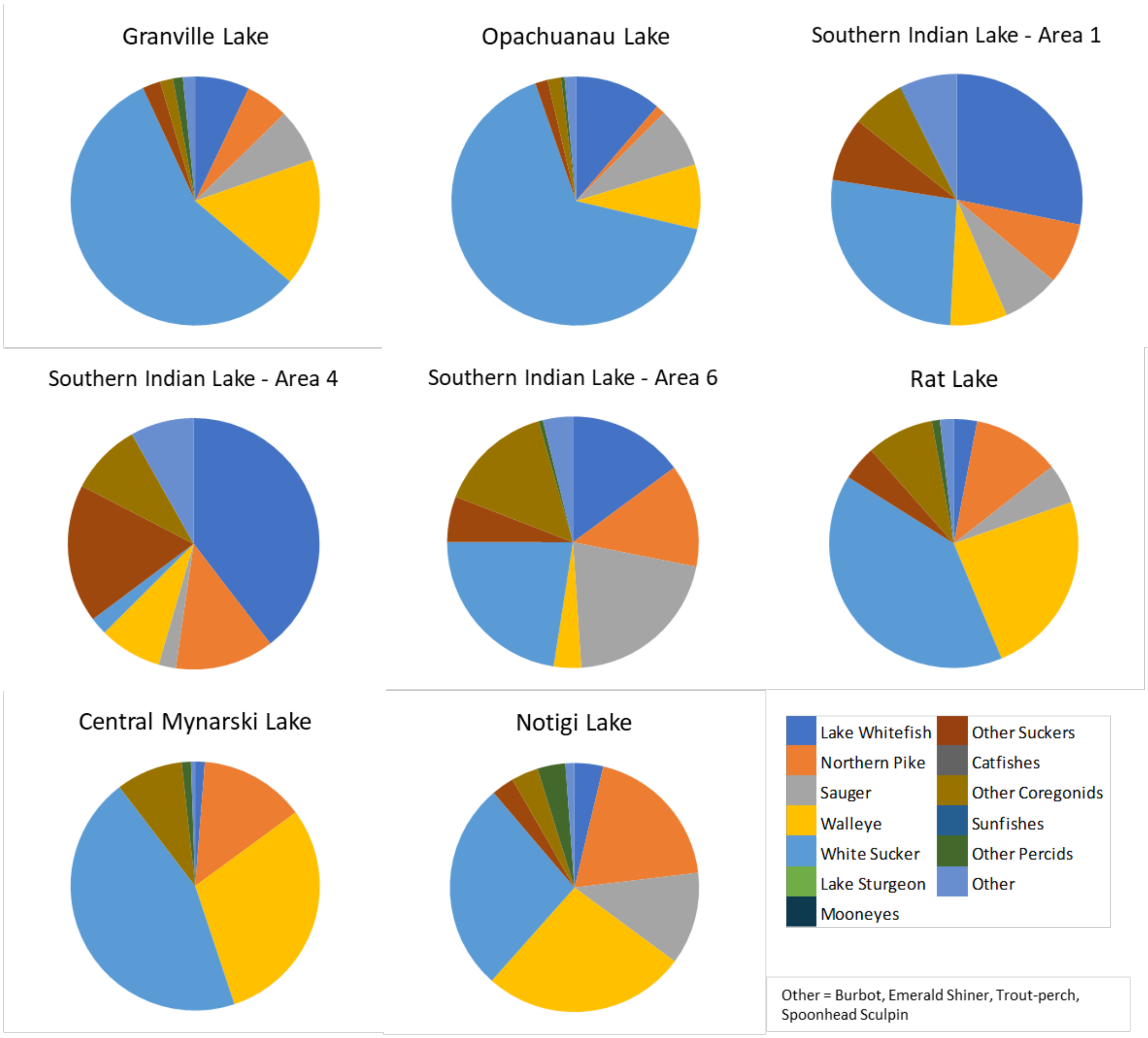


Figure 33. Average relative species abundance of target species and taxa groups captured annually in standard gang gill nets in standard gang gill nets in the Upper Churchill River Region from 2008-2019.

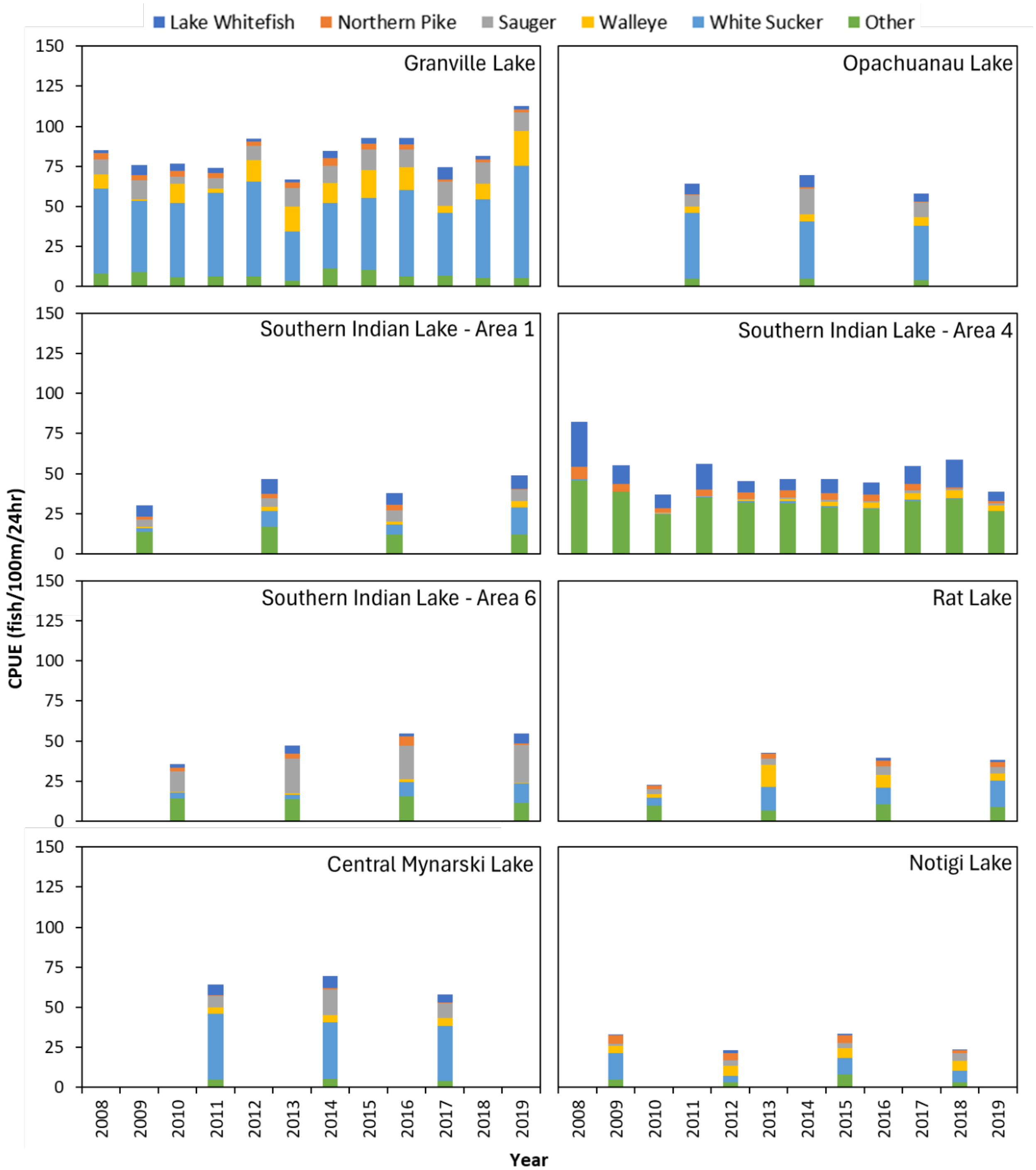
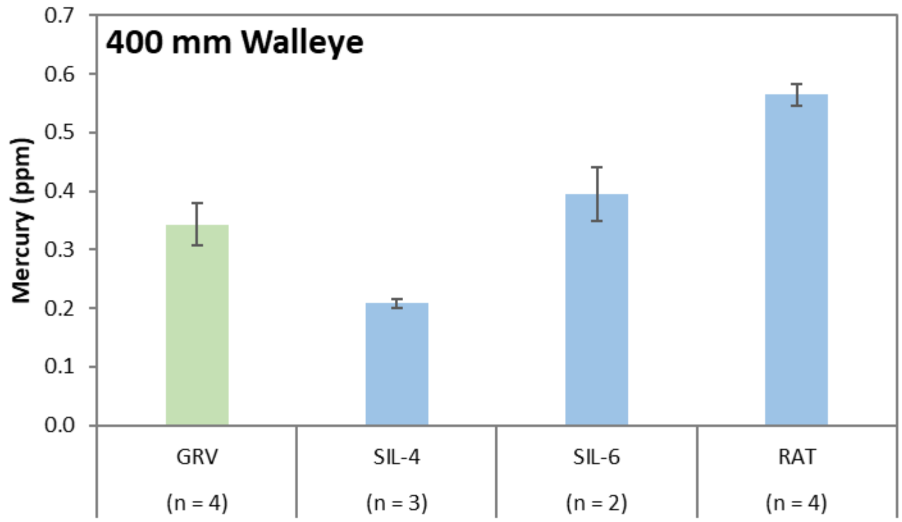


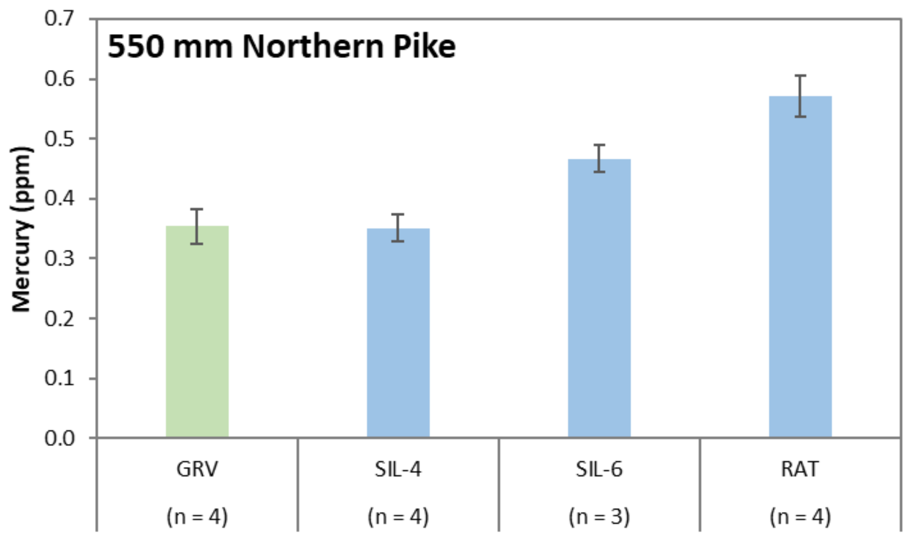
Figure 34. Average catch-per-unit-effort (fish/100 m/24 hr) per year of target species captured in standard gang gill nets in the Upper Churchill River Region from 2008-2019.

4.3.5 Mercury in Fish Regional Summary

As an ecosystem monitoring program, CAMP does not analyze mercury in fish data in relation to human health. Data collected through CAMP is made available to the relevant experts and authorities for human health analysis.

Standard mean mercury concentrations in a 400 mm Walleye and a 550 mm Northern Pike generally showed an increase with increasing distance downstream along the upper Churchill/Rat river system, where concentrations were lowest in Southern Indian Lake - Area 4 (mean in all years sampled: 0.21 and 0.35 ppm, respectively), intermediate at Southern Indian Lake - Area 6 (mean in all years sampled: 0.39 and 0.47 ppm, respectively), and highest in Rat Lake (mean in all years sampled: 0.56 and 0.57 ppm, respectively). The concentration of mercury in a 350 mm Lake Whitefish was considerably higher at Southern Indian Lake - Area 4 (mean in all years sampled: 0.067 ppm) compared to the other two on-system waterbodies (mean in all years sampled: 0.034 and 0.041 ppm). Concentrations of all three species from the off-system Granville Lake fell within the range observed at the on-system waterbodies (mean in all years sampled: 0.34, 0.34, and 0.052 ppm, respectively).


400 mm Walleye
Mercury (ppm)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
GRV
(n = 4)
SIL-4
(n = 3)
SIL-6
(n = 2)
RAT
(n = 4)


550 mm Northern Pike
Mercury (ppm)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
GRV
(n = 4)
SIL-4
(n = 4)
SIL-6
(n = 3)
RAT
(n = 4)

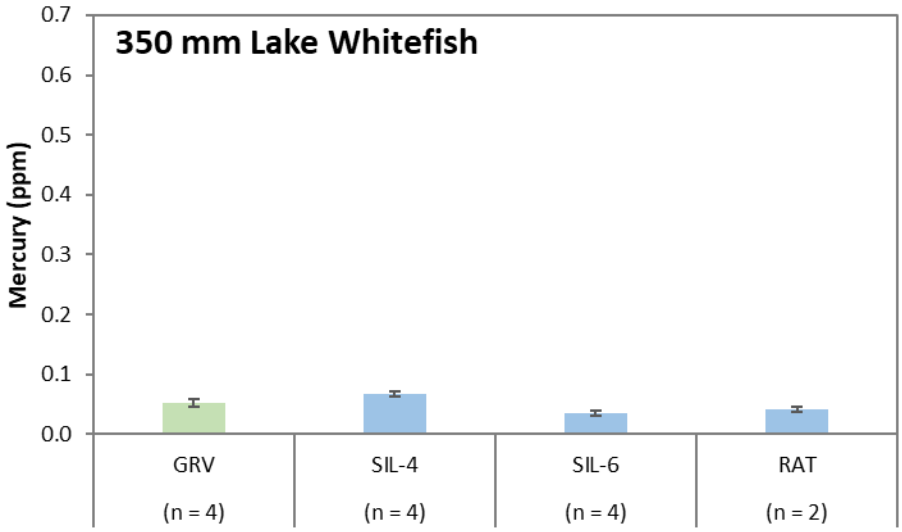


Figure 35. Average length-standardized mercury concentration (± standard error) in fish muscle from Upper Churchill River Region waterbodies.

Blue = on-system, Green = off-system, n = number of sampling years.

4.4 Lower Churchill River Region

4.4.1 Physical Environment Regional Summary

4.4.1.1 Climate

Over the monitoring period, the months of January and September generally experienced warmer than normal conditions (≥ 7 out of 13 months above normal). On an annual basis, no distinct patterns in the data were identified as the majority of years in the monitoring period experienced near normal temperatures, with the exception of 2010 to 2012 which were above normal; 2010 had the warmest annual average temperature at -3.2ºC, while 2013 had the coolest annual average temperature at -6.9ºC. The maximum and minimum monthly average air temperatures during the monitoring period were 14.5ºC (July 2018) and -28.5ºC (January 2013), respectively.

Over the monitoring period, July and August generally experienced more than normal precipitation (≥ 7 out of 13 months above normal), while all other months (with the exception of September) generally experienced less than normal precipitation (≥ 7 out of

13 months below normal). On an annual basis, a pattern of drier conditions was identified as 8 out of 13 years in the monitoring period recorded below normal precipitation; 2017 had the highest annual total precipitation (472.1 mm), while 2018 had the lowest annual total precipitation (317.3 mm). The maximum and minimum monthly total precipitation recorded during the monitoring period were 182.1 mm (August 2010) and 0.6 mm (May 2011), respectively.

4.4.1.2 Water Regime

Water Flows and Levels

The Lower Churchill River flow is regulated primarily by the Missi Falls Control Structure, which releases water downstream after diverting the majority through the Rat-Burntwood system. Local tributaries contribute additional inflows along the river. The Coordinated Aquatic Monitoring Program (CAMP) monitors flow, water levels, and temperature at on-system sites including Northern Indian Lake, Partridge Breast Lake, Billard Lake, and Fidler Lake, among others. Off-system monitoring occurs at Gauer Lake, with flow measured downstream at Thorsteinson Lake.

From 2008 to 2020, flows downstream of Missi Falls ranged from the 10th to above the 90th percentile, with monthly means between 17 and 2,110 cms, with a median value of 121 cms. Flow at Red Head Rapids varied similarly, with monthly means from 82 to 3,830 cms (median 296 cms). Off-system Gauer River flows were generally above average, ranging from below the 10th to above the 90th percentile, with monthly means between 6.1 and 127.3 cms (median 28.1 cms). Water levels at on-system sites mirrored these flow patterns and tributary contributions, with periodic deviations exceeding ±0.5 metres. No direct water level data exist for Gauer Lake; levels are inferred from flow measurements.

Water Temperature:

Monitoring for the LCRR is done at the Missi Falls Control Structure (CS) where equipment is permanently deployed in the CS and collects data continuously throughout the year. Monitoring began at this site in August 2018, so 2019 is the only complete year of monitoring during the reporting period. The data record is not long enough to draw any conclusions about trends at this site.

Water temperatures peaked at about 19°C in July/August both summers. During summer 2019 water temperature readings displayed a couple of rapid decreases and subsequent increases of 7-8°C, but the cause is unclear. The temperature decreased to about 0°C in early November and remained at that level over the winter until about mid-April to mid-May. The duration of ice cover, which is assumed to be when water temperature is below 1°C, was at least 24 weeks both years, but missing data precludes a better estimate.

4.4.1.3 Sedimentation

Monitoring for the LCRR is done at the Missi Falls Control Structure (CS) where equipment is permanently deployed in the CS and collects data continuously throughout the year. Monitoring began at this site in August 2018, so 2019 is the only complete year of monitoring during the reporting period. The data record is not long enough to draw any conclusions about trends at this site.

Between August 2018 and April 2020, average turbidity ranged from about 6-58 FNU (Formazin Nephelometric Units) but was typically less than 20 FNU. Turbidity declines steadily through winter, reaching its annual minimum just before the spring thaw. In 2019, turbidity was variable in summer, with peak levels occurring in August and just before freeze-up in early November. It is typical for turbidity to vary in summer due to flow variability and particularly in response to storm and wind events.

Because Missi Falls CS outflows were typically low during the monitoring period, the corresponding sediment loads were also generally low, between about 10-70 t/d in open water and ice conditions. The sediment loads increase with increasing flows, reaching as much as 400-500 t/d at peak loads.

4.4.2 Water Quality Regional Summary

Lakes and riverine sites in the Lower Churchill River Region were well-oxygenated, and clear, with low to moderate concentrations of nutrients. Water quality conditions along the lower Churchill River were similar to conditions upstream in Southern Indian Lake near Missi Falls, which is located in the Upper Churchill River Region.

All on-system waterbodies were well-oxygenated year-round and dissolved oxygen (DO) concentrations throughout the water column consistently met Manitoba Water Quality Standards, Objectives, and Guidelines instantaneous minimum objectives for cool- and cold-water aquatic life (MWS 2011). Lakes along the lower Churchill River were typically well mixed (isothermal), and DO was similar throughout the water column. Occasionally, Northern Indian Lake was thermally stratified in spring or summer, although it remained well-oxygenated throughout the water column.

The off-system waterbody (i.e., Gauer Lake) was well-oxygenated during the open-water season, and typically isothermal, although Gauer Lake was occasionally thermally stratified in spring or summer. During the ice-cover season, Gauer Lake was well-oxygenated near the surface; however, DO concentrations decreased with depth during most winter sampling events and fell below the MWQSOGs instantaneous minimum objective for cold-water aquatic life (8.0 mg/L) at depth in one winter when a deeper location in the south basin of the lake was sampled. The decrease in DO concentrations with depth occurred despite the lake being isothermal in winter.

Water clarity along the lower Churchill River was high as indicated by mean Secchi disk depths of greater than a meter, and low turbidity and total suspended solids. Water clarity was similar along the lower Churchill River from Partridge Breast Lake to the Churchill Weir and was similar to that observed upstream of Missi Falls. Water clarity was slightly higher in the off-system waterbody (i.e., Gauer Lake). Throughout the region, total suspended solids tended to be lower in winter under the ice than during the open-water season; however, no seasonal differences were observed for turbidity.

The trophic status of lakes and reservoirs along the lower Churchill River were similar to those upstream of Missi Falls; mesotrophic based on total phosphorus (TP) and chlorophyll *a*, and with one exception, oligotrophic based on total nitrogen (TN). The exception was Fidler Lake, which was mesotrophic based on TN. The off-system Gauer Lake was mesotrophic based on TP, TN and chlorophyll *a*.

The lower Churchill River at the Little Churchill River was mesotrophic based on TP and oligotrophic based on TN and chlorophyll *a*. Conditions were similar to the Hayes River – the off-system riverine site monitored as part of the Lower Nelson River Region - which was also mesotrophic based on TP and oligotrophic based on TN and chlorophyll *a*. Phytoplankton biomass (as indicated by chlorophyll *a*) tended to be lower in winter under the ice than during the open-water season.

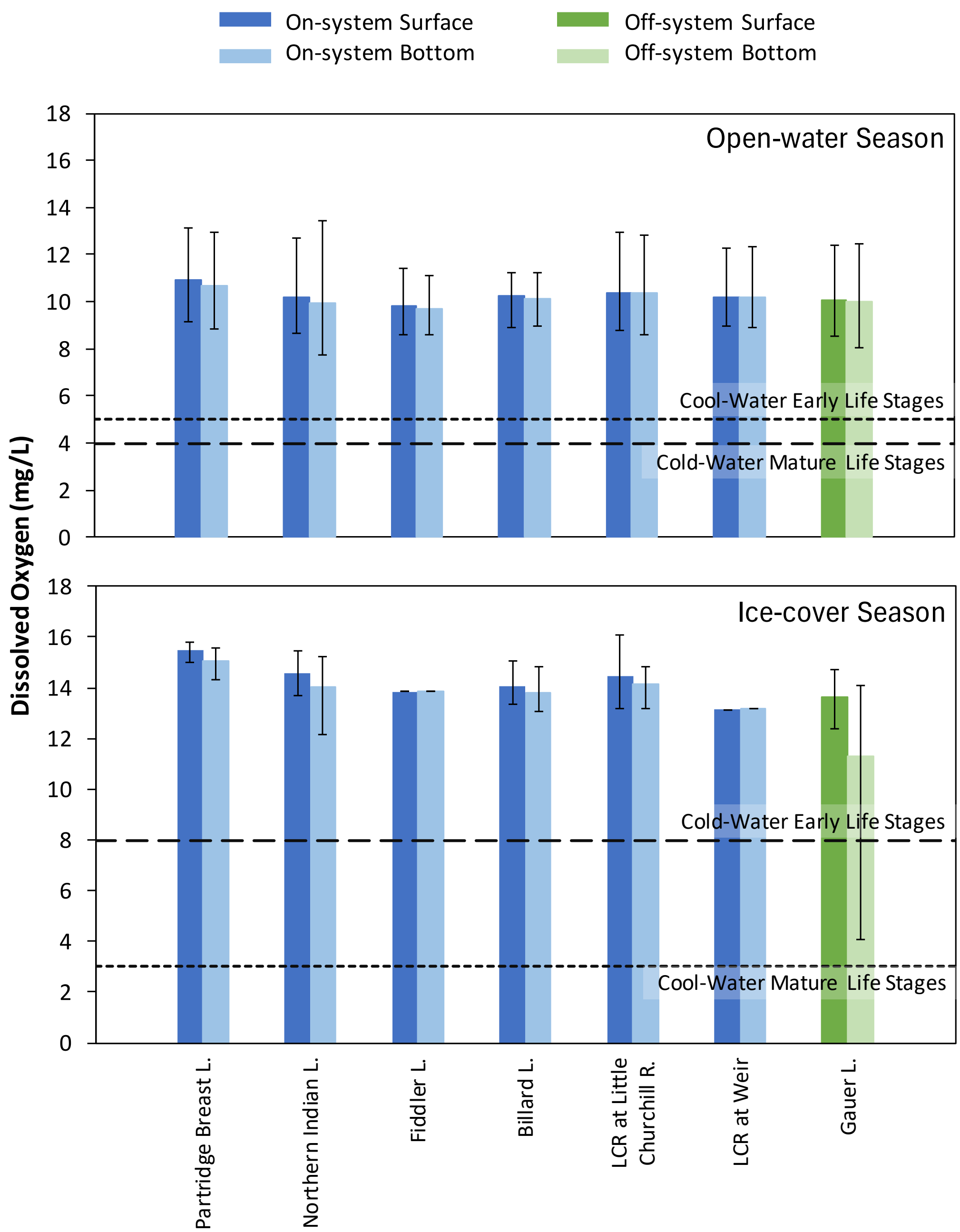


Figure 36. Average dissolved oxygen concentrations in the Lower Churchill River Region from 2008-2019 compared to the MWQSOG instantaneous minimum objectives for the protection of cold- and cool-water aquatic life. Error bars show total range of values (i.e., minimum and maximum).

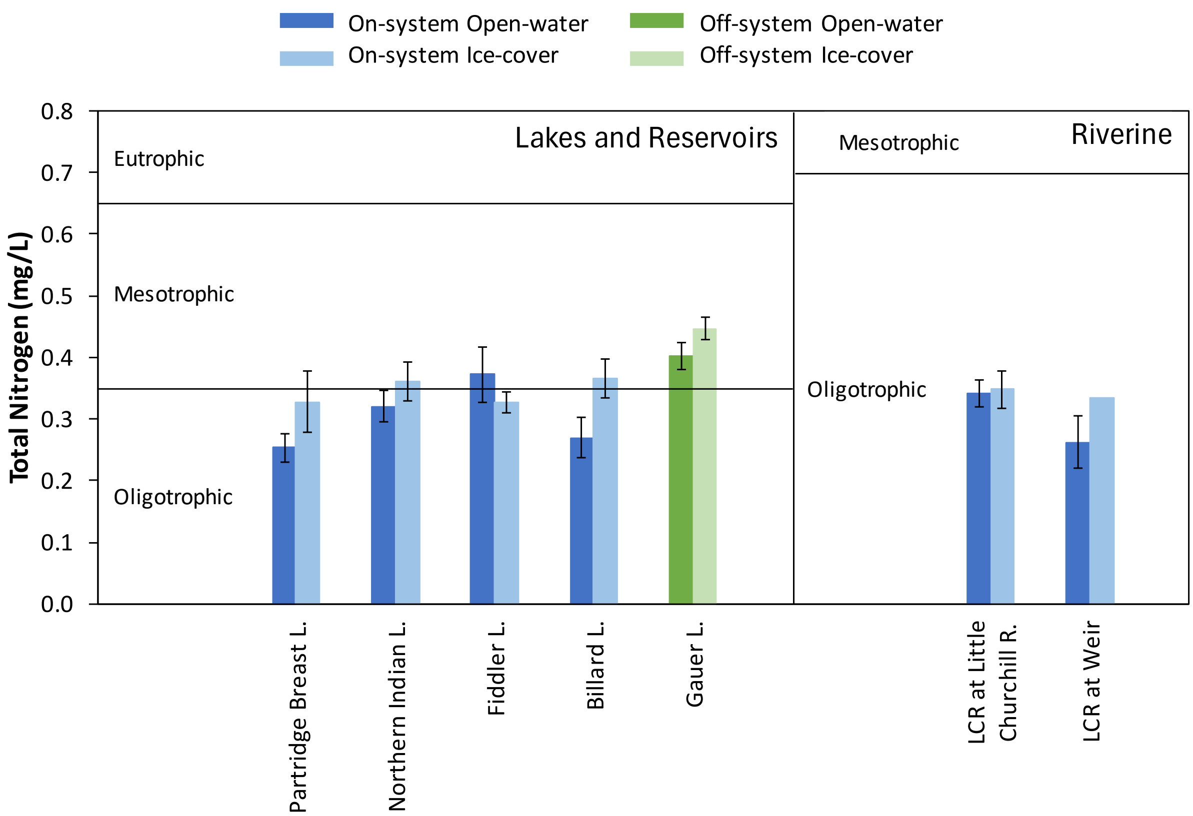


Figure 37. Mean (±SE) total nitrogen concentrations in the Lower Churchill River Region from 2008-2019 compared to trophic categories for lakes and reservoirs (OECD 1983) and riverine sites (Dodds et al. 1998).

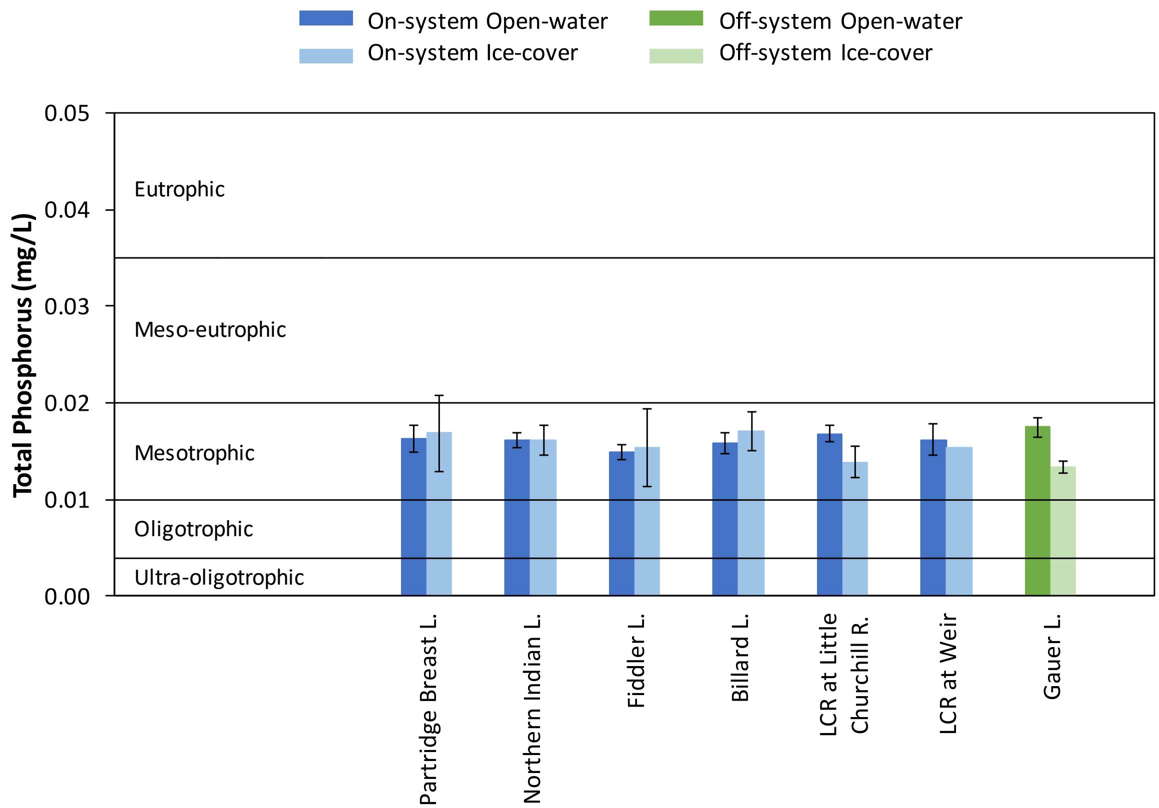


Figure 38. Mean (±SE) total phosphorus concentrations in the Lower Churchill River Region from 2008-2019 compared to the CCME Canadian Guidance Framework for Phosphorus (CCME 2004).

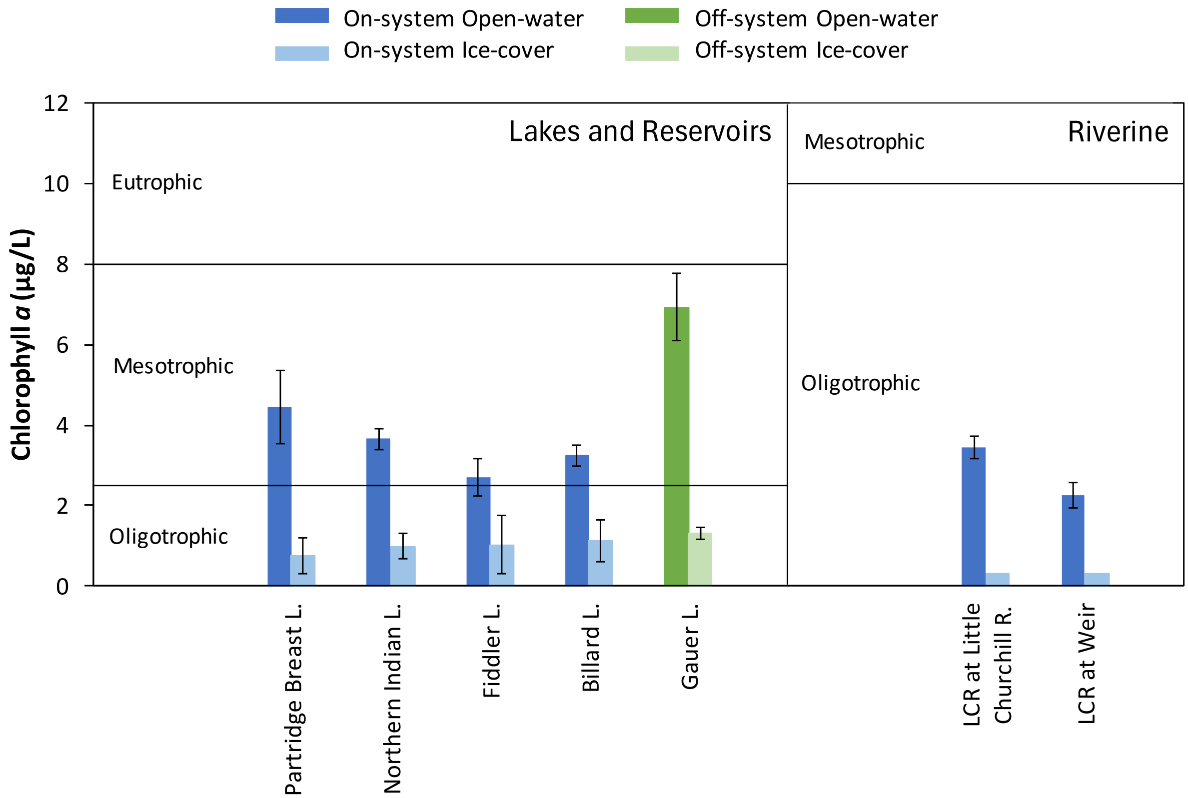


Figure 39. Mean (±SE) chlorophyll *a* concentrations in the Lower Churchill River Region from 2008-2019 compared to trophic categories for lakes and reservoirs (OECD 1983) and riverine sites (Dodds et al. 1998).

4.4.3 Benthic Invertebrates Regional Summary

The dominant benthic invertebrate taxa varied between years and across nearshore sites (all years combined) in the Lower Churchill River Region. Overall, taxa were typical of the substrate composition found at each of the sites. At Northern Indian Lake (silty clay loam) the dominant invertebrate taxa included Oligochaeta, Amphipoda (Hyallelidae), Chironomidae, and/or Tipulidae in different years. At the lower Churchill River at the little Churchill River (sandy loam), some of these taxa as well as others (e.g., Bivalvia: Sphaeriidae and Ephemeroptera: Baetiscidae) were prevalent. Dominant invertebrate taxa also varied between Partridge Breast Lake (Ephemeroptera: Caenidae), Fidler Lake (Gastropoda: Lymnaeidae and Planorbidae), Billard Lake (Ephemeroptera: Caenidae), the lower Churchill River at the Churchill Weir (Ephemeroptera: Leptophlebiidae), and at the off-system Gauer Lake (Gastropoda: Lymnaeidae and Physidae), where the nearshore habitat largely consisted of hard/coarse substrates with varying amounts of fines and organic matter. Mean total invertebrate abundances (all years combined) in the nearshore were at least 2x higher at on-system waterbodies compared to the off-system Gauer Lake. There were peaks in mean total abundance at annual on-system sites (Northern Indian Lake in 2012 and 2017, and in the lower Churchill River at the Little Churchill River in 2014). Although the locations of the Northern Indian Lake and the lower Churchill River at the Little Churchill River nearshore sampling area moved year-to-year relative to water levels at the time of sampling, substrate composition was similar among sampling years.

Dominant taxa were generally similar at the offshore sites in Partridge Breast, Northern Indian, and Fidler lakes (Amphipoda: Pontoporeiidae and/or Chironomidae, with Ephemeroptera: Ephemeridae prevalence varying among years). Dominant taxa were also generally similar among Billard Lake, the lower Churchill River at the Little Churchill River, the lower Churchill River at the Churchill Weir and the off-system Gauer Lake (Oligochaeta, Bivalvia: Sphaeriidae and/or Chironomidae). Mean total abundances (densities; all years combined) in the offshore habitat were more than two times lower at Fidler Lake compared to all other sites. Peaks in mean total abundance were observed at the lower Churchill River at the Little Churchill River and the off-system Gauer Lake in 2013, and at Northern Indian in 2015. Observed differences did not appear related to sediment composition. Finer sediments dominated at Northern Indian, Billard, and Gauer lakes (silt loam to silty clay loam), and sandier substrates dominated at Partridge Breast Lake, Fidler Lake, the lower Churchill River at the Little Churchill River, and the lower Churchill River at the Churchill Weir (sand, sandy loam to loamy sand).

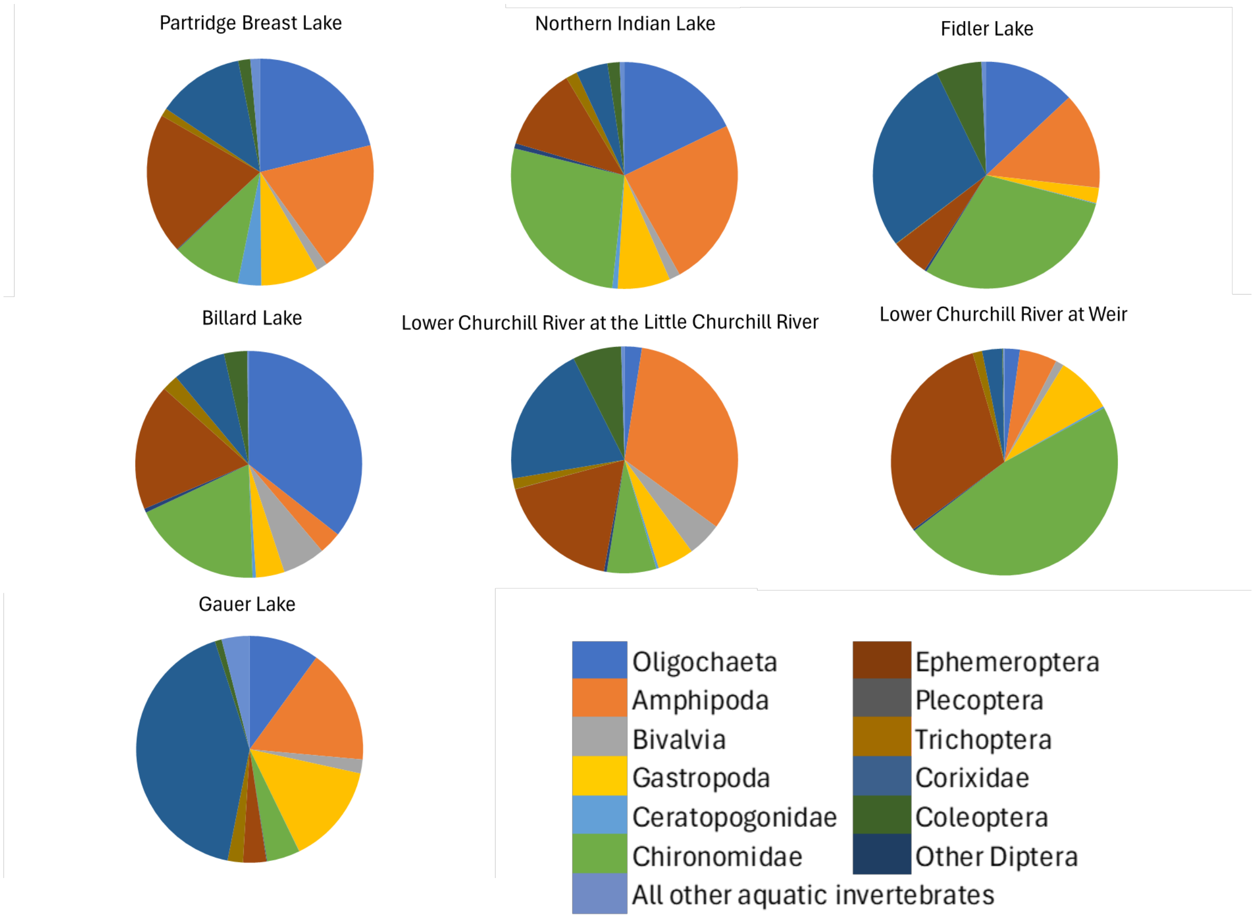


Figure 40. Average relative abundance (% of total) of the benthic invertebrate taxa groups captured at nearshore sites in the Lower Churchill River Region from 2010-2019.

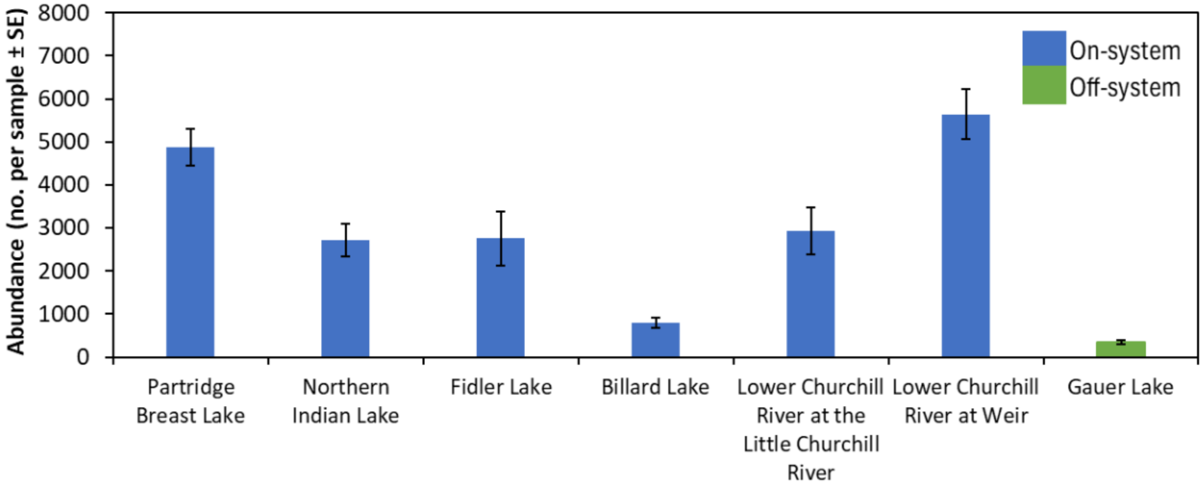


Figure 41. Average total abundance (no. per sample ± SE) of benthic invertebrates captured at nearshore sites in the Lower Churchill River Region from 2010-2019.

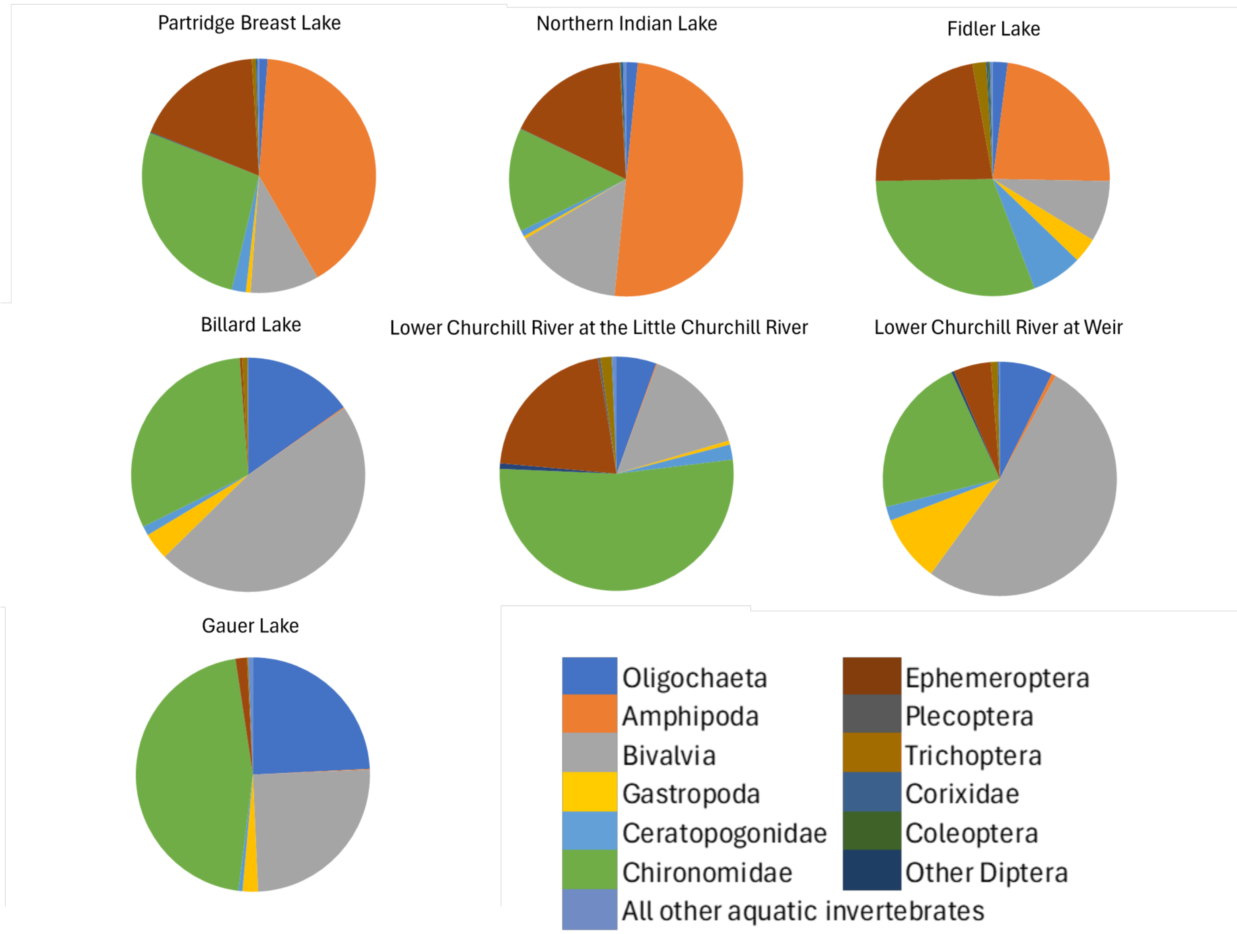


Figure 42. Average relative abundance (density, % of total) of the benthic invertebrate taxa groups captured at offshore sites in the Lower Churchill River Region from 2010-2019.

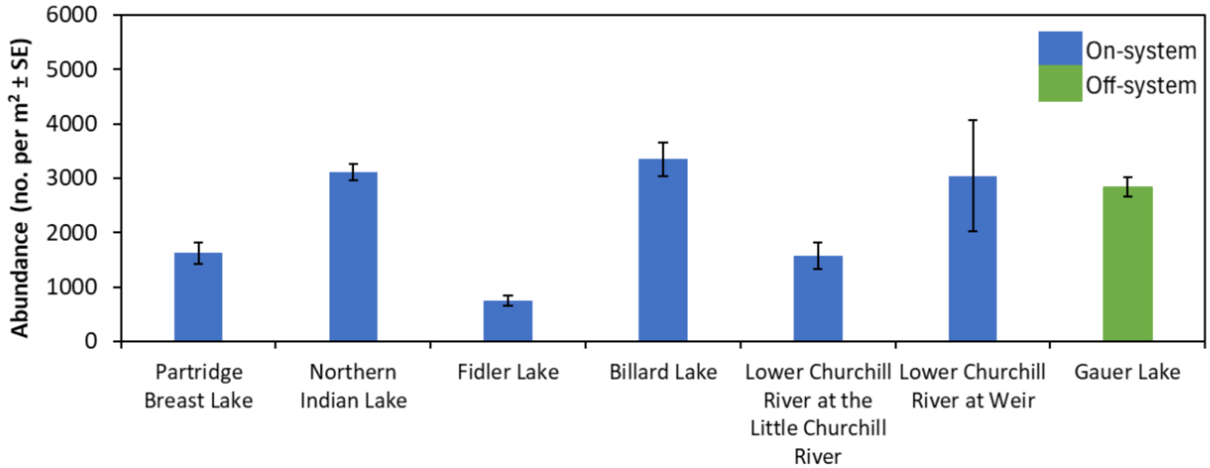


Figure 43. Average total abundance (density, no. per m2 ± SE) of benthic invertebrates captured at offshore sites in the Lower Churchill River Region from 2010-2019.

4.4.4 Fish Community Regional Summary

The fish communities of the Lower Churchill River Region waterbodies were similar in species diversity and abundance, and had a number of fish species in common, including Cisco, Lake Whitefish, Northern Pike, Walleye, and White Sucker. The target species (Lake Whitefish, Northern Pike, Walleye, White Sucker) and Lake Sturgeon[5] comprised most of the standard gang catches from each waterbody making up 87%-99% of the catches over the sampling period. Two shiner species (Spottail and Emerald), Trout-perch and Yellow Perch were the most frequently captured forage species at the on-system waterbodies, with Trout-perch being more abundant at the riverine sites, and Yellow Perch only common at the larger lakes.

The fish community of the lower Churchill River at the Little Churchill River differed from the other sites in several aspects. Notable differences included:

[5] The methodologies used in the Fish Community sampling program are not designed to target Lake Sturgeon or capture them in proportion to their abundance (i.e., larger gill net mesh sizes are excluded from the gear).

- a high relative abundance of Lake Sturgeon in the catches (Lake Sturgeon were also captured in small numbers in Billard Lake and the lower Churchill River at the Churchill Weir sites); and
- several species were only observed at this site, including Arctic Grayling, Longnose Dace, and Northern Redbelly Dace.

There was evidence of a decreasing trend in the diversity and abundance of fish in a downstream direction at the on-system lakes, with catches in Partridge Breast Lake and Northern Indian Lake being greater than in Fidler and Billard lakes. This decreasing trend may be partially explained by the larger size (i.e., surface area) of Northern Indian Lake and Partridge Breast Lake, both of which are located in the upstream area of the region. Catches at the lower Churchill River at the confluence with the Little Churchill River were generally more variable in terms of diversity and abundance than the lakes in the region.

The fish community of the off-system Gauer Lake was generally similar to the on-system Partridge Breast and Northern Indian lakes, particularly in terms of diversity. However, fish abundance was higher at Gauer Lake compared to the on-system waterbodies. In addition, Walleye, in particular, appear to have increased in abundance over the monitoring period in Gauer Lake.

No invasive fish species were captured and likely have not become established in the region.

Northern Pike from the two riverine sites on the lower Churchill River (the Little Churchill River and Weir sites) had higher condition than those captured in lakes. The higher condition at the lower Churchill River at the Churchill Weir site may be, at least in part, attributable to this site being sampled later in the season (typically September) than other sites in the region (typically August). Timing did not explain the higher condition from the lower Churchill River at the Little Churchill River site, however, as the little Churchill River site was often sampled at the same time as the other waterbodies in the region (typically in late-July/August). Likewise, the growth of young Lake Whitefish (4-year-olds) and Northern Pike (4-year-olds) was higher at the lower Churchill River at the

Little Churchill River and lower Churchill River at the Churchill Weir sites compared to Northern Indian Lake (i.e., fish were longer at a standard age). Growth was also higher for Walleye (3-year-olds) from the lower Churchill River at the Little Churchill River site compared to Northern Indian Lake (i.e., fish were longer at a standard age). Insufficient numbers of 3-year-old Walleye were caught at the Weir site to make meaningful comparisons with other sites. The growth of young Lake Whitefish from Northern Indian Lake, and Northern Pike from Northern Indian and Gauer lakes appear to have increased over the sampling period.

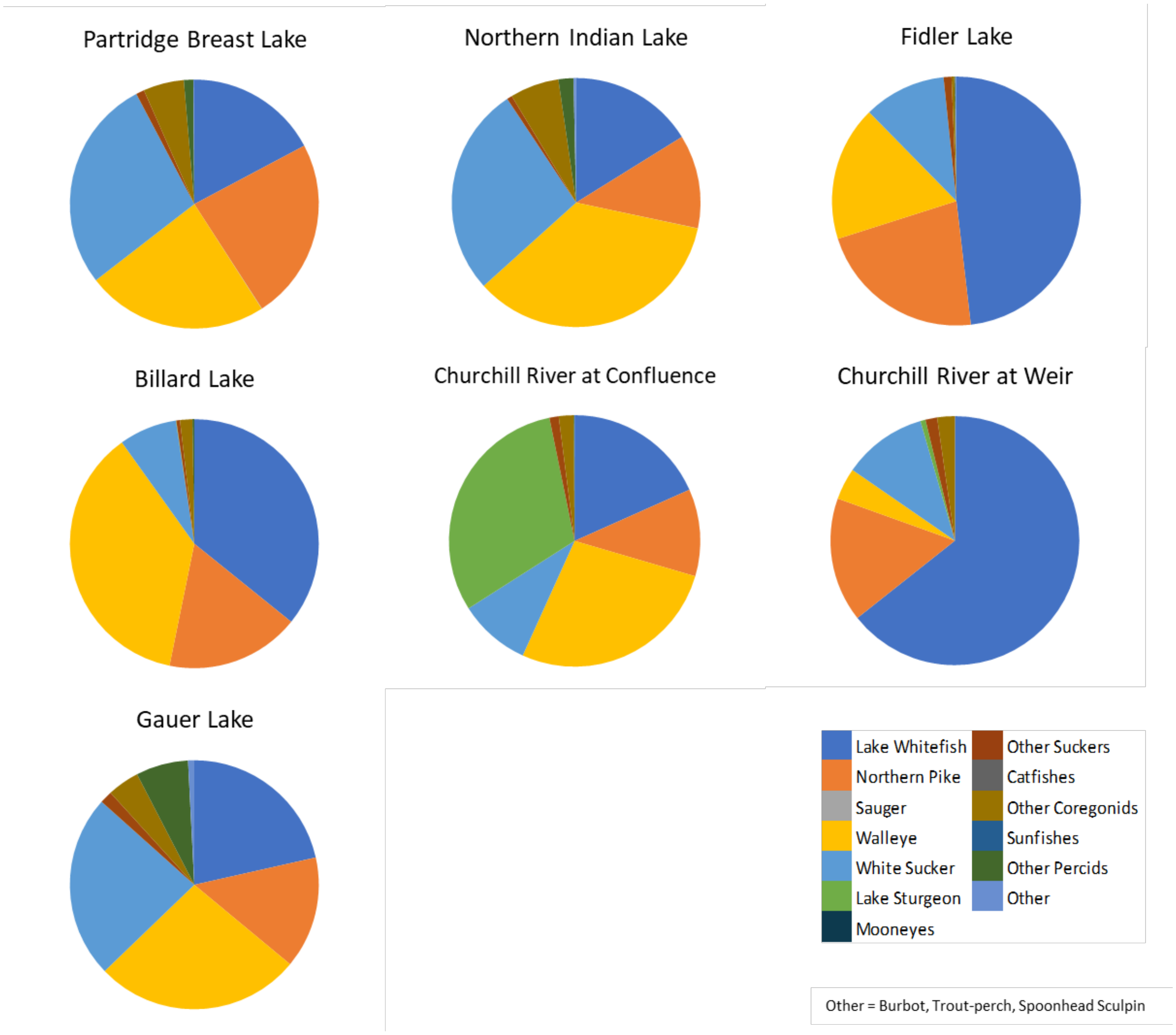


Figure 44. Average relative species abundance of target species and taxa groups captured annually in standard gang gill nets in standard gang gill nets in the Lower Churchill River Region from 2008-2019.

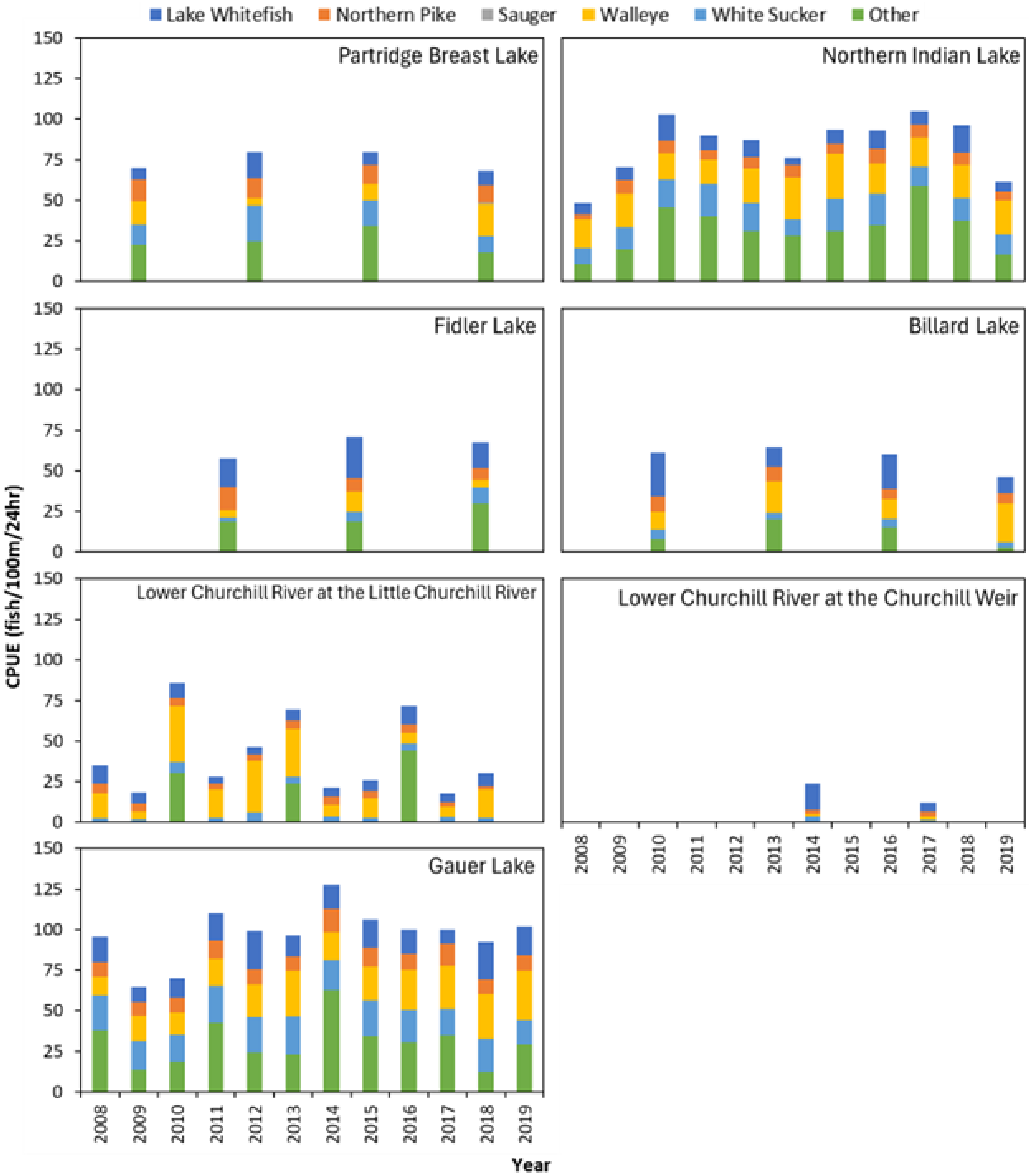
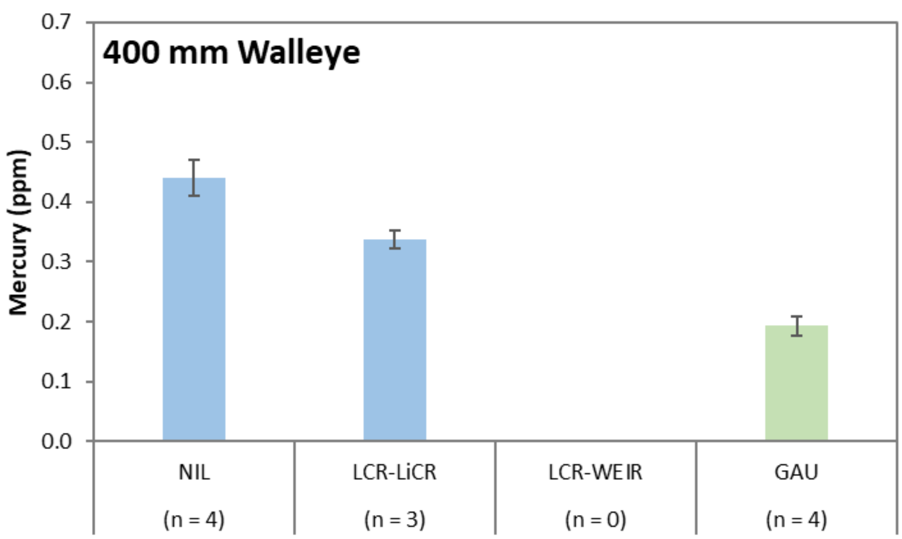


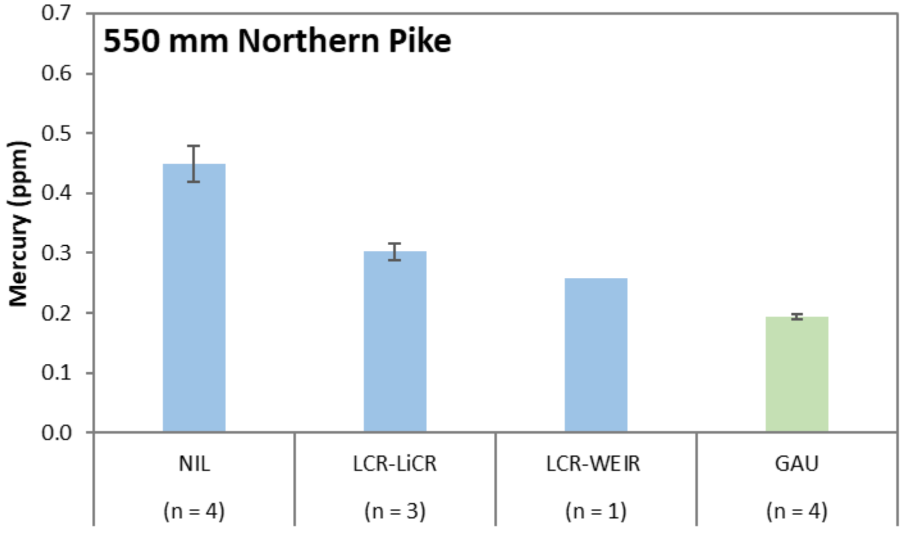
Figure 45. Average catch-per-unit-effort (fish/100 m/24 hr) per year of target species captured in standard gang gill nets in the Lower Churchill River Region from 2008-2019.

4.4.5 Mercury in Fish Regional Summary

As CAMP is an ecosystem monitoring program, it does not analyze mercury in fish data in relation to human health. Data collected through CAMP is made available to the relevant experts and authorities for human health analysis.

Standard mean mercury concentrations in a 400 mm Walleye and a 550 mm Northern Pike were higher at Northern Indian Lake (mean of all years sampled: 0.44 and 0.45 ppm, respectively) compared to the lower Churchill River at the Little Churchill River (mean of all years sampled: 0.34 and 0.30 ppm, respectively; Figure 1). In contrast, the concentration of a 350 mm Lake Whitefish was similar at these two waterbodies (mean of all years sampled: 0.086 and 0.089 ppm, respectively). For all three species, mercury concentrations were lower at the off-system Gauer Lake (mean of all years sampled: 0.033, 0.19, and 0.19 ppm, respectively).





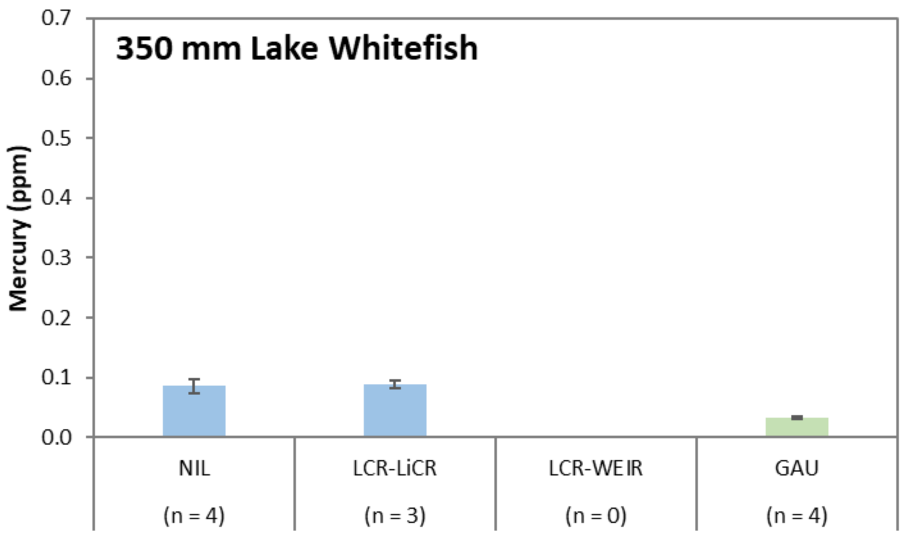


Figure 46. Average length-standardized mean mercury concentration (± standard error) in fish muscle from Lower Churchill River Diversion Region waterbodies.

Blue = on-system, Green = off-system, n = number of sampling years.

4.5 Churchill River Diversion Region

4.5.1 Physical Environment Regional Summary

4.5.1.1 Climate

Over the monitoring period, the months of January and September generally experienced warmer than normal conditions (≥ 7 out of 13 months above normal). On an annual basis, no distinct patterns in the data were identified as most years in the monitoring period were near normal conditions; 2010 had the warmest annual average temperature at -0.2ºC, while 2014 had the coolest annual average temperature at -4.2ºC. The maximum and minimum monthly average air temperatures during the monitoring period were 18.0ºC (July 2012 and July 2020) and -29.5ºC (December 2013), respectively.

Over the monitoring period, July and October generally experienced more than normal precipitation (≥ 7 out of 13 months above normal), while February, April, May, June, November, and December generally experienced less than normal precipitation (≥ 7 out of 13 months below normal). On an annual basis, no distinct patterns in the data were identified as most years experienced near normal conditions, however there were more years with above normal precipitation than below normal in the monitoring period; 2020 had the highest annual total precipitation (746.2 mm), while 2013 had the lowest annual total precipitation (427.4 mm). The maximum and minimum monthly total precipitation recorded during the monitoring period were 236.1 mm (August 2010) and 2.8 mm (April 2008), respectively.

4.5.1.2 Water Regime

Water Flows and Levels

The Churchill River Diversion (CRD) channels most of the Churchill River's flow into the Nelson River through the Rat and Burntwood rivers, regulated at the Notigi Control Structure, with Southern Indian Lake serving as a reservoir. Local inflows also contribute to the Burntwood River. CAMP monitors flow and water levels at on-system sites including Threepoint Lake, Footprint Lake, and Apussigamasi Lake. Leftrook Lake, an off-system site, serves as a natural baseline.

From 2008 to 2020, the monthly flows at Notigi ranged from 523 to 2,392 cms, and median value of 867 cms. Flows did not fall below the 10th percentile in any month, while values above the 90th percentile occurred during parts of eleven years. Water levels at Threepoint and Footprint Lakes reflected these flows, with monthly levels exceeding ±0.5 metres intermittently and mostly low to moderate variability. Apussigamasi Lake, monitored since 2009, showed larger fluctuations and variability ranging from low to high. Leftrook Lake's water levels, primarily influenced by local precipitation, remained stable with mostly low variability.

Water Temperature

Monitoring for the CRD is done at the Wuskwatim Generating Station (GS) where equipment is permanently deployed in the station and collects data continuously throughout the year. Monitoring began at this site in August 2018, so 2019 is the only complete year of monitoring during the reporting period. The data record is not long enough to draw any conclusions about trends at this site.

Water temperature peaked at about 19°C in August in both 2018 and 2019 and decreased to about 0°C in fall and remained at that level over the winter from early November to the latter part of April. The duration of ice cover, which is assumed to be when water temperature is below 1°C , was about 25 and 28 weeks in the two winters of monitoring.

4.5.1.3 Sedimentation

Monitoring for the CRD is done at the Wuskwatim Generating Station (GS) where equipment is permanently deployed in the station and collects data continuously throughout the year. Monitoring began at this site in August 2018, so 2019 is the only complete year of monitoring during the reporting period. The data record is not long enough to draw any conclusions about trends at this site.

Average turbidity ranged from about 7-37 FNU (Formazin Nephelometric Units) between August 2018 and April 2020. Turbidity declines steadily through winter, reaching its annual minimum just before the spring thaw. In 2019, turbidity was variable in summer, with peak levels occurring in late August and just before freeze-up in early

November. It is typical for turbidity to vary in summer due to flow variability and particularly in response to storm and wind events.

As may be expected, sediment load was generally greatest in open water periods and lower during ice covered periods. The open water loads varied from about 450 – 1,100 t/d while winter was much lower at about 150 – 400 t/d, with the lowest loading occurring in April before the thaw.

4.5.2 Water Quality Regional Summary

Some differences in water quality and limnological conditions were observed across waterbodies monitored in the Churchill River Diversion Region - notably between on- and off-system waterbodies. Threepoint and Apussigamasi lakes located on the main flow path of the Rat/Burntwood River are shallower and have shorter water residence times than either Footprint Lake (which is located off the main flow path of the Rat/Burntwood River system) or the off-system Leftrook Lake.

Threepoint and Apussigamasi lakes were well-oxygenated year-round and DO concentrations throughout the water column consistently met the Manitoba Water Quality Standards, Objectives, and Guidelines instantaneous minimum objectives for cool- and cold-water aquatic life (MWS 2011). These two lakes were consistently well mixed (i.e., isothermal) and DO was similar across the water column. This differs from Footprint Lake, which though well-oxygenated near the surface, was thermally stratified during some years of monitoring and DO occasionally fell below PAL objectives at depth. This also differs from lakes located upstream of the Notigi Control Structure on the Rat/Burntwood River system where thermal stratification occurred on occasion and DO occasionally dropped below water quality objectives (see the Upper Churchill River Region for details).

The off-system waterbody in this region, Leftrook Lake, was typically well-oxygenated near the surface, but was thermally stratified in each year of monitoring (either in spring or summer, and/or winter) and DO fell below PAL objectives at depth. In winter, DO concentrations were below the instantaneous minimum PAL objective for early life stages of cold-water aquatic life (8.0 mg/L; e.g., Lake Whitefish) but were generally above the instantaneous minimum PAL objective for cool-water aquatic life (3.0 mg/L e.g., Walleye) throughout much of the water column in Leftrook Lake.

Water clarity at the on-system lakes ranged low to high; Threepoint and Apussigamasi lakes were more turbid compared to Footprint Lake. Although a slight decrease in water clarity was observed from Threepoint Lake downstream to Apussigamasi Lake, both of these lakes had higher turbidity and TSS and lower Secchi Disk depths than lakes located upstream on the Rat/Burntwood River (see the Upper Churchill River Region for additional details). Water clarity was higher in the off-system Leftrook Lake compared to the on-system lakes. Seasonally, water clarity tended to be higher in winter under the ice than during the open-water season as was observed in all CAMP regions.

The on- and off-system lakes in the Churchill River Diversion Region were on average meso-eutrophic based on TP and either mesotrophic (Apussigamasi, Footprint, and Leftrook lakes) or oligotrophic (Threepoint Lake) based on TN. Based on chlorophyll *a*, Threepoint and Apussigamasi lakes were mesotrophic, and Footprint and Leftrook lakes were eutrophic. Phytoplankton biomass (as indicated by chlorophyll *a*) tended to be lower in winter under the ice than during the open-water season. Chlorophyll *a* was higher, and phytoplankton blooms (i.e., chlorophyll *a* > 10 µg/L) frequently occurred in summer and fall at the off-system Leftrook Lake.

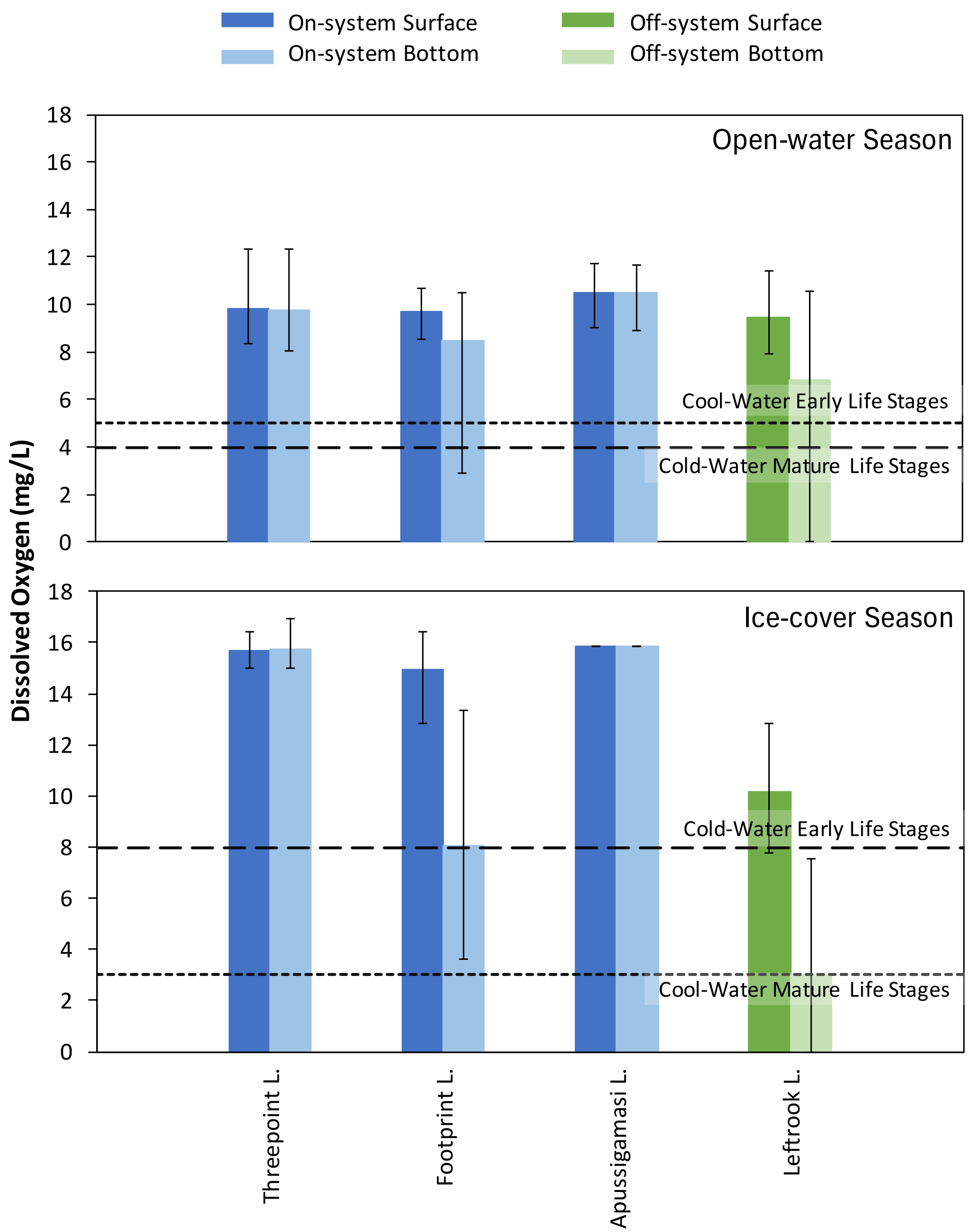
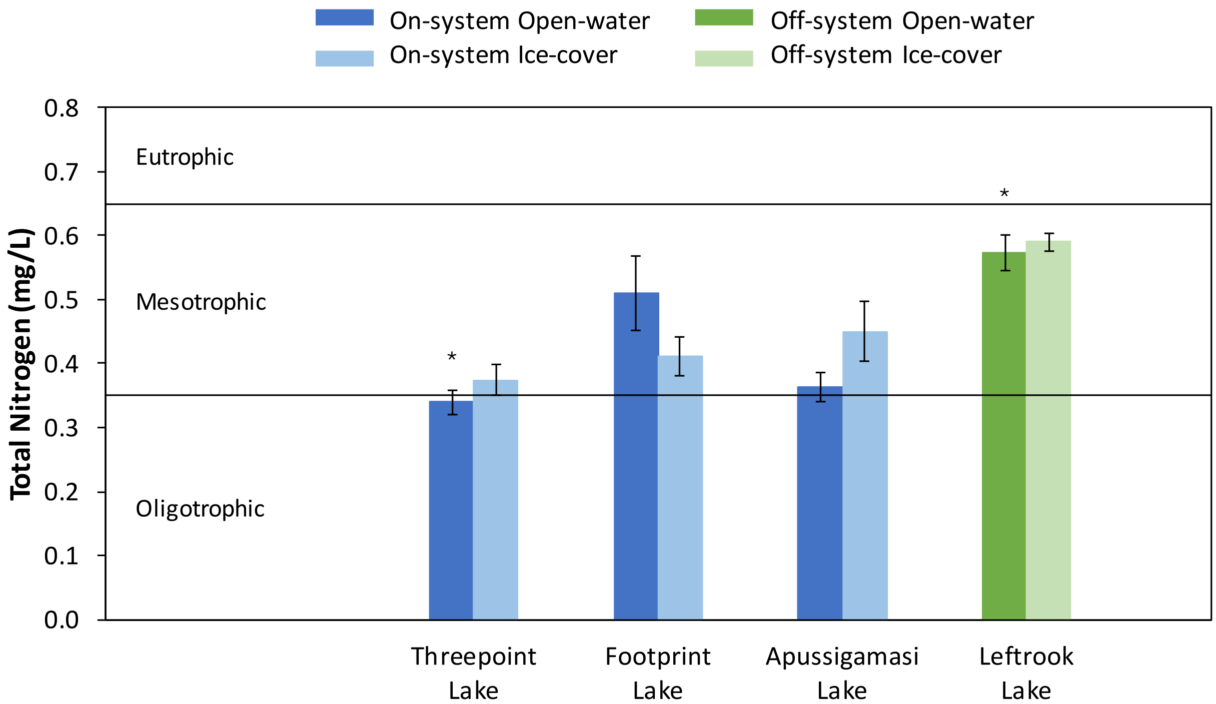


Figure 47. Average dissolved oxygen concentrations in the Churchill River Diversion Region from 2008-2019 compared to the MWQSOG instantaneous minimum objectives for the protection of cold- and cool-water aquatic life. Error bars show total range of values (i.e., minimum and maximum).



Notes: * Outlier values of 3.06 mg/L and 4.33 mg/L from spring 2014 were excluded from values reported for Threepoint Lake and Leftrook Lake, respectively.

Figure 48. Mean (±SE) total nitrogen concentrations in the Churchill River Diversion Region from 2008-2019 compared to trophic categories for lakes and reservoirs (OECD 1983).

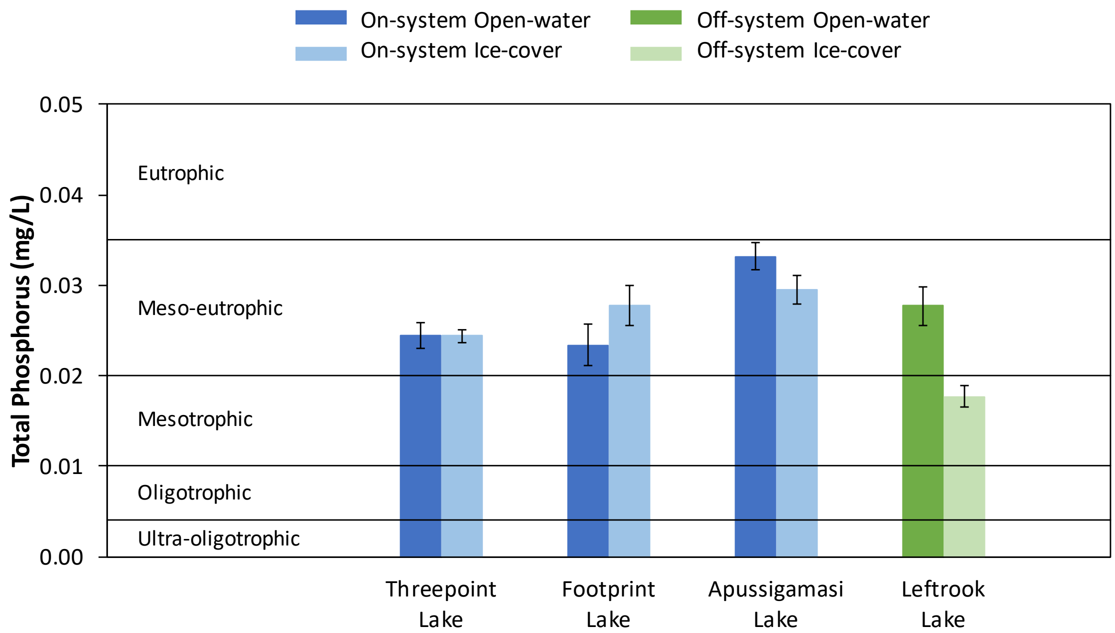


Figure 49. Mean (±SE) total phosphorus concentrations in the Churchill River Diversion Region from 2008-2019 compared to the CCME Canadian Guidance Framework for Phosphorus (CCME 2004).

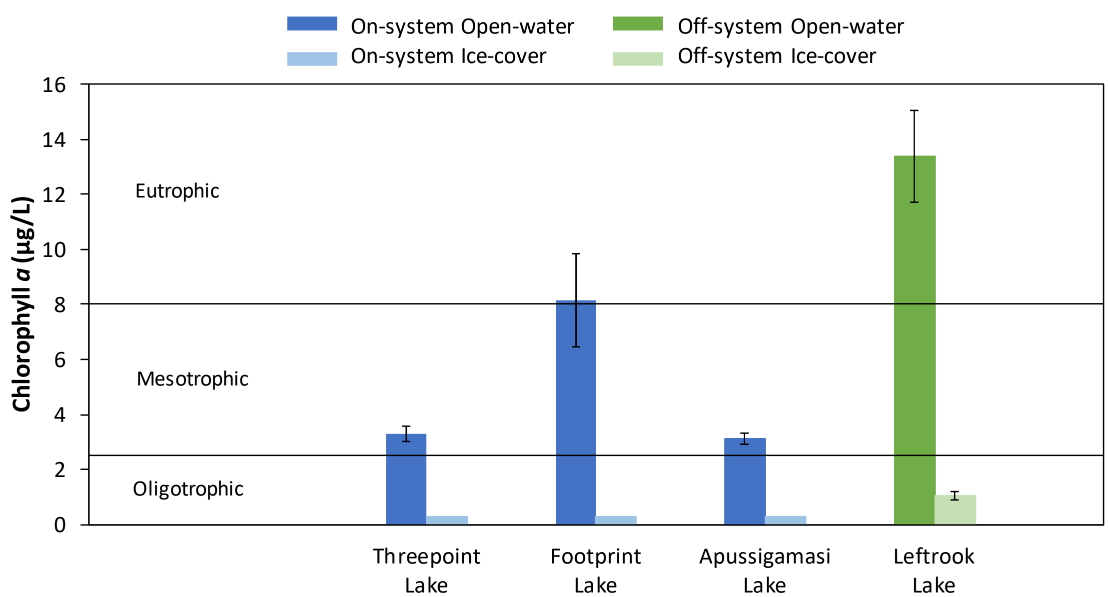


Figure 50. Mean (±SE) chlorophyll *a* concentrations in the Churchill River Diversion Region from 2008-2019 compared to trophic categories for lakes and reservoirs (OECD 1983).

4.5.3 Benthic Invertebrates Regional Summary

The dominant benthic invertebrate taxa were generally similar at all nearshore sites in the Churchill River Diversion Region (Oligochaeta, Amphipoda: Hyallelidae, Chironomidae, and Corixidae). Some of these taxa are common in finer substrates, like at Threepoint, Apussigamasi, and Footprint lakes (silty clay loam). Other nearshore taxa generally associated with the predominant substrate (hard/coarser substrates: boulder, cobble, and gravel) were more abundant at the off-system site Leftrook Lake (Gastropoda: Lymnaeidae, and Ephemeroptera: Caenidae). Mean total invertebrate abundance (all years combined) was lowest at Apussigamasi Lake and highest at the off-system Leftrook Lake. Mean total abundance at Threepoint Lake was 4x lower than Leftrook Lake, and along with other metrics (lower EPT Index, taxonomic richness, and diversity), suggested the Threepoint Lake invertebrate community was less diverse and contained a larger proportion of disturbance -tolerant taxa compared to Leftrook Lake.

The dominant taxa were generally similar at the offshore sites (predominantly Bivalvia: Sphaeriidae), except at Footprint Lake which was dominated by Chaoboridae in 2010; and Amphipoda: Pontoporeiidae and Chironomidae in 2013, 2016, and 2019). Mean total invertebrate abundance (densities; all years combined) was lowest at Footprint Lake and highest at the off-system Leftrook Lake. Observed differences in invertebrate metrics among sites and years did not appear related to sediment composition. Fine sediments (clay to silty clay loam) were predominant at Threepoint, Apussigamasi, and Leftrook lakes. Footprint Lake was sandier, but overall sediment composition (clay loam to sandy clay loam) was generally comparable to the other on-system sites.

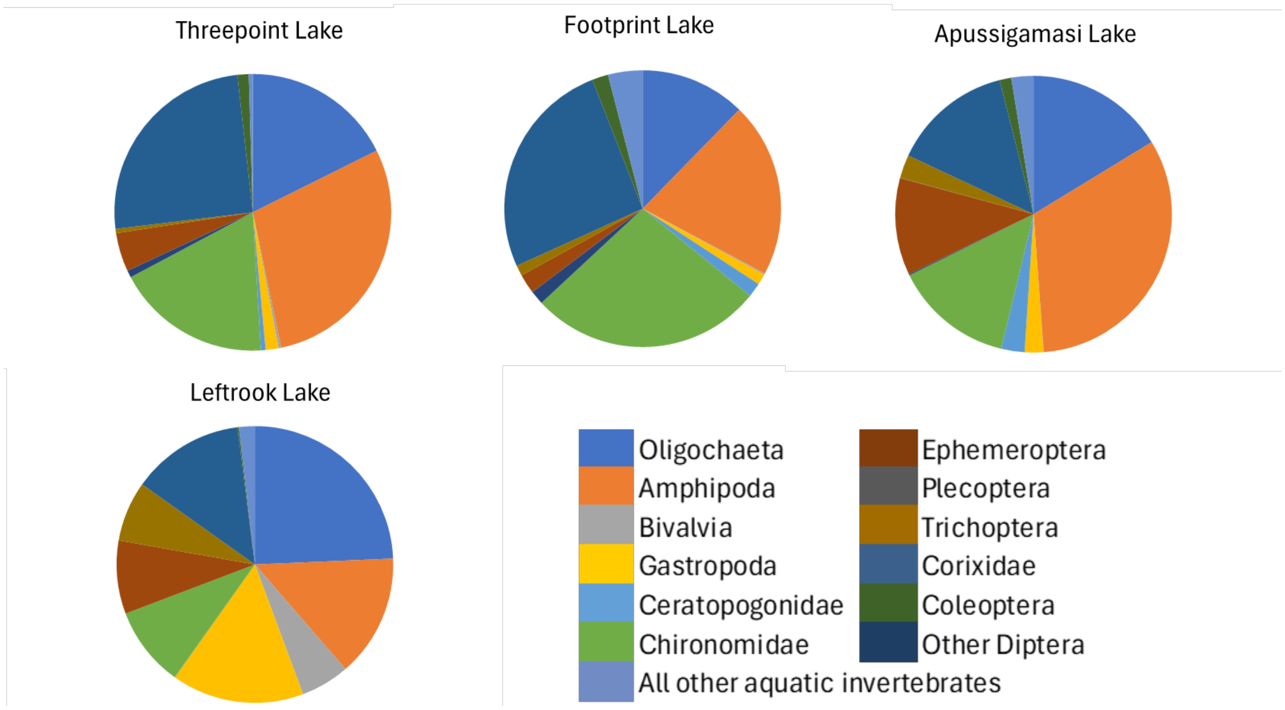


Figure 51. Average relative abundance (% of total) of the benthic invertebrate taxa groups captured at nearshore sites in the Churchill River Diversion Region from 2010-2019.

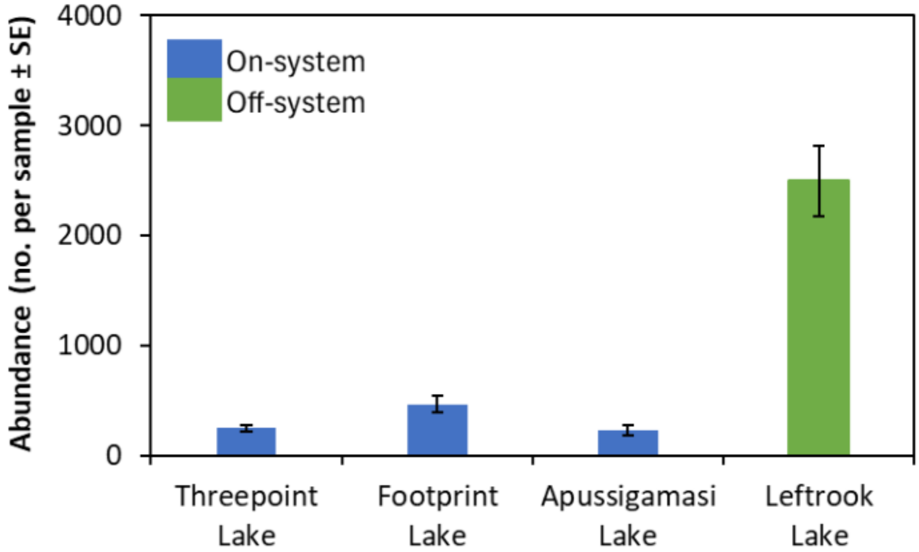


Figure 52. Average total abundance (no. per sample ± SE) of benthic invertebrates captured at nearshore sites in the Churchill River Diversion Region from 2010-2019.

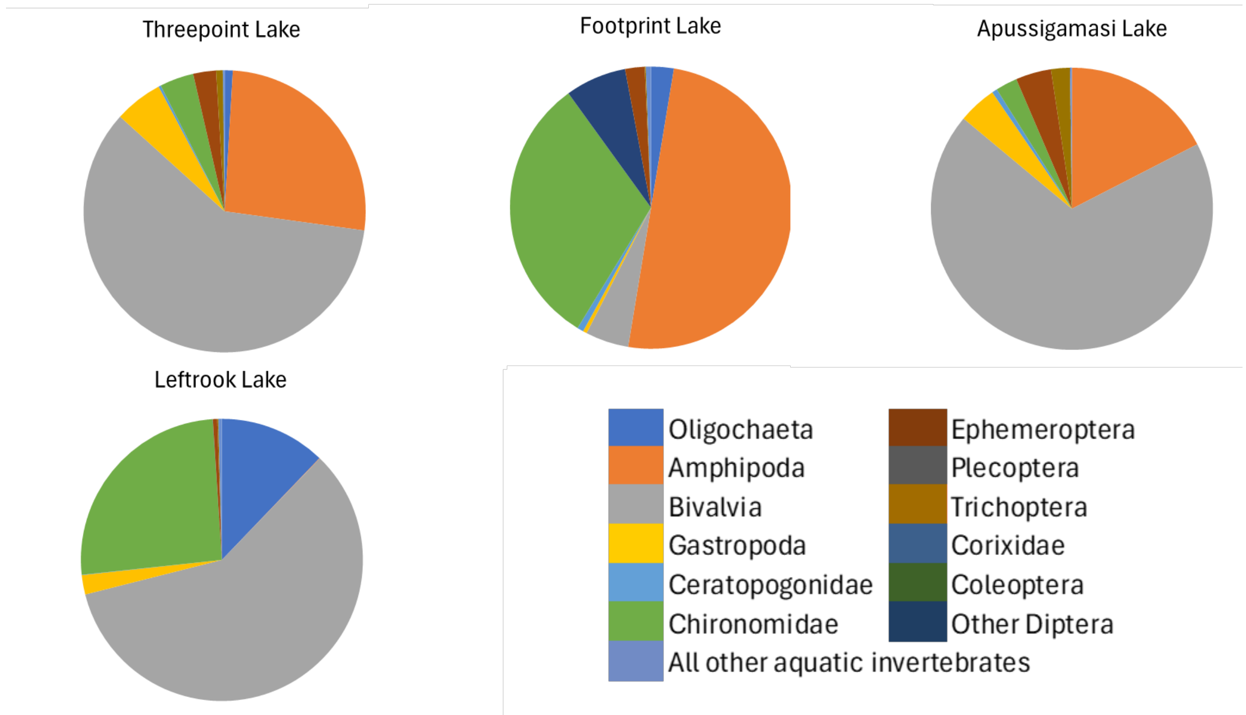


Figure 53. Average relative abundance (density, % of total) of the benthic invertebrate taxa groups captured at offshore sites in the Churchill River Diversion Region from 2010-2019.

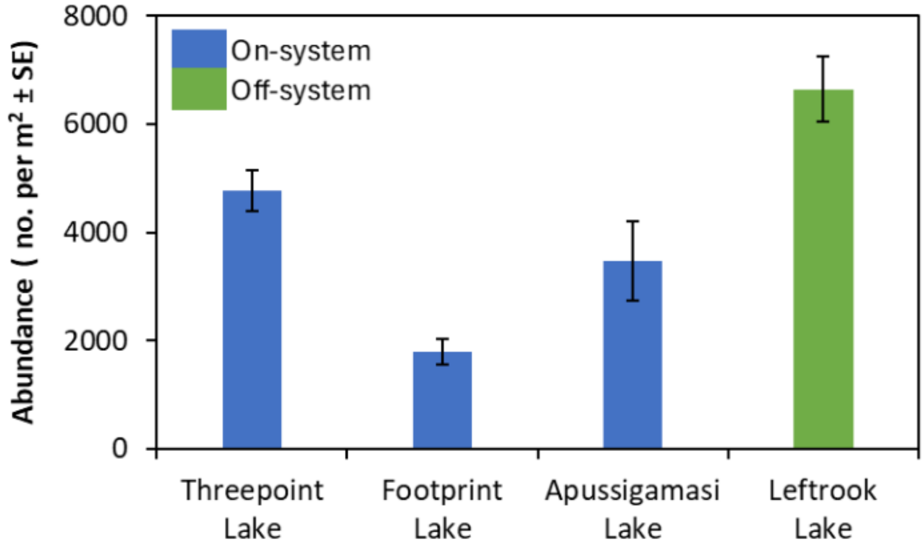


Figure 54. Average total abundance (density, no. per m^2 ± SE) of benthic invertebrates captured at offshore sites in the Churchill River Diversion Region from 2010-2019.

4.5.4 Fish Community Regional Summary

The species composition and abundance of fish from the on-system Churchill River Diversion waterbodies (Threepoint, Footprint, and Apussigamasi lakes), were generally similar, with Walleye, White Sucker, and Sauger most commonly captured. Of these species, Walleye was the most frequently captured, followed by White Sucker and Sauger. Cisco was also particularly abundant in Footprint Lake over the monitoring period and Sauger catches were notably high in Threepoint Lake in 2014 and 2016. Emerald and Spottail Shiner, and less frequently Trout-perch, were the most commonly captured forage species in the region.

The fish community of Apussigamasi Lake differed from the other sites in several aspects. Notable differences included:

- the presence of Mooneye, Goldeye, and Lake Chub in the catch;
- higher species diversity; and
- the condition of Lake Whitefish, Walleye, and White Sucker from Apussigamasi Lake was higher than other waterbodies.

The fish community of the off-system Leftrook Lake differed from the on-system waterbodies in several aspects. Notable differences included:

- the absence of Sauger; and
- higher fish abundance.

No invasive fish species were captured and likely have not become established in the region. In addition, Lake Sturgeon[6] were not captured in the region.

The growth of young Northern Pike (4-year-olds) from Threepoint Lake appears to have increased over the monitoring period.

[6] The methodologies used in the Fish Community sampling program are not designed to target Lake Sturgeon or capture them in proportion to their abundance (i.e., larger gill net mesh sizes are excluded from the gear).

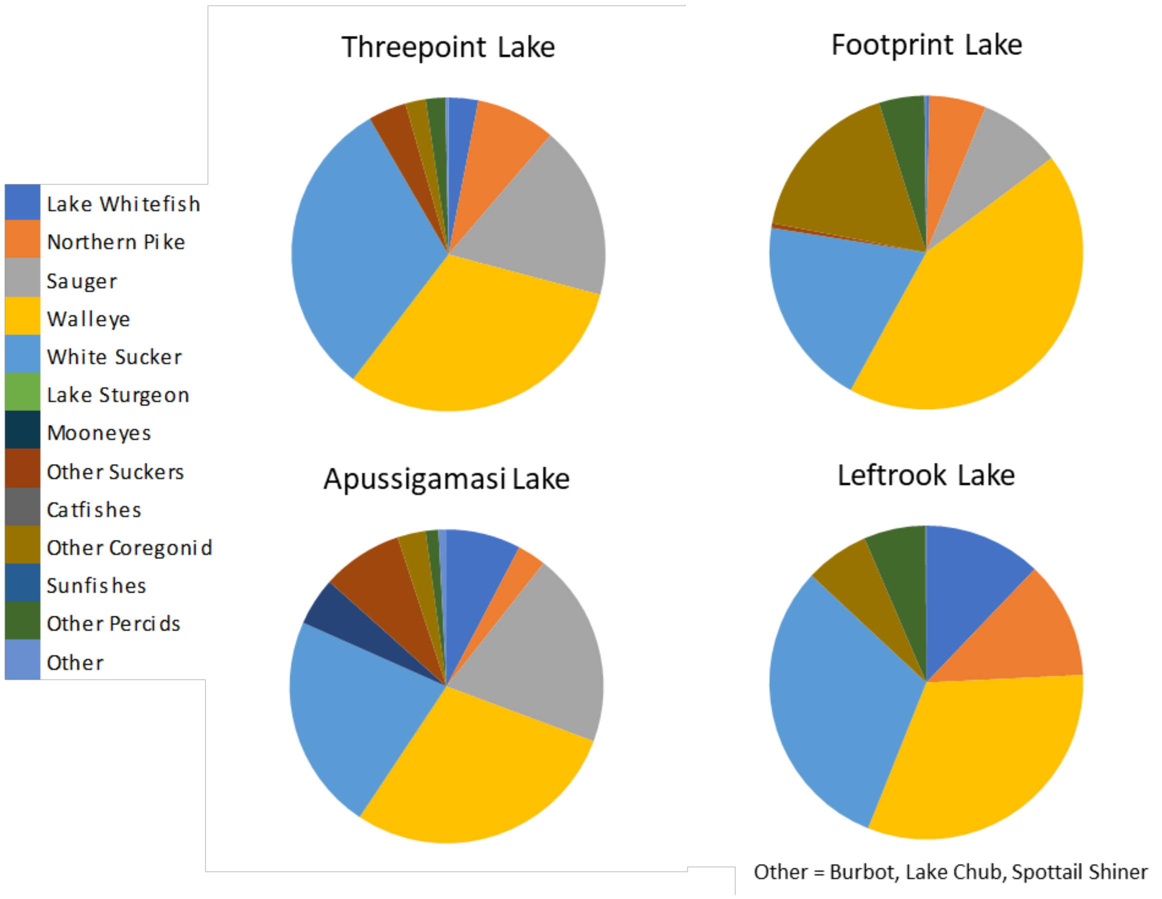


Figure 55. Average relative species abundance of target species and taxa groups captured annually in standard gang gill nets in standard gang gill nets in the Churchill River Diversion Region from 2009-2019.

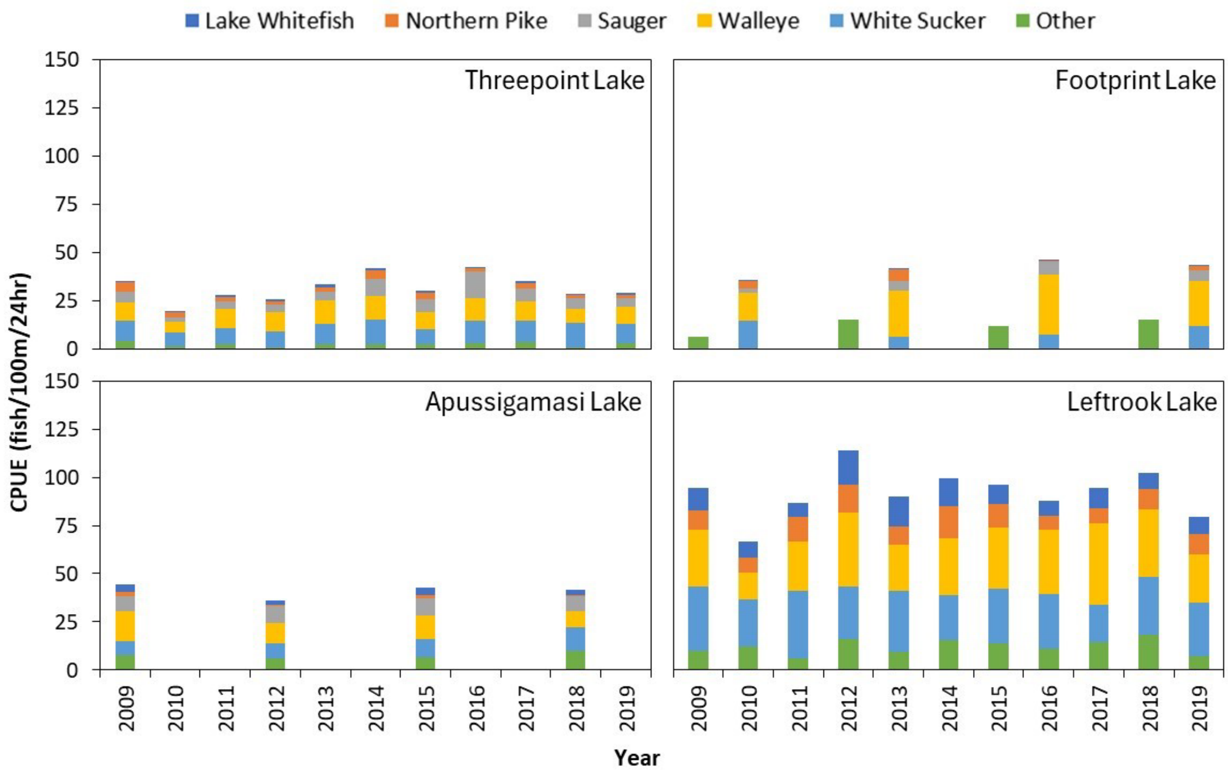
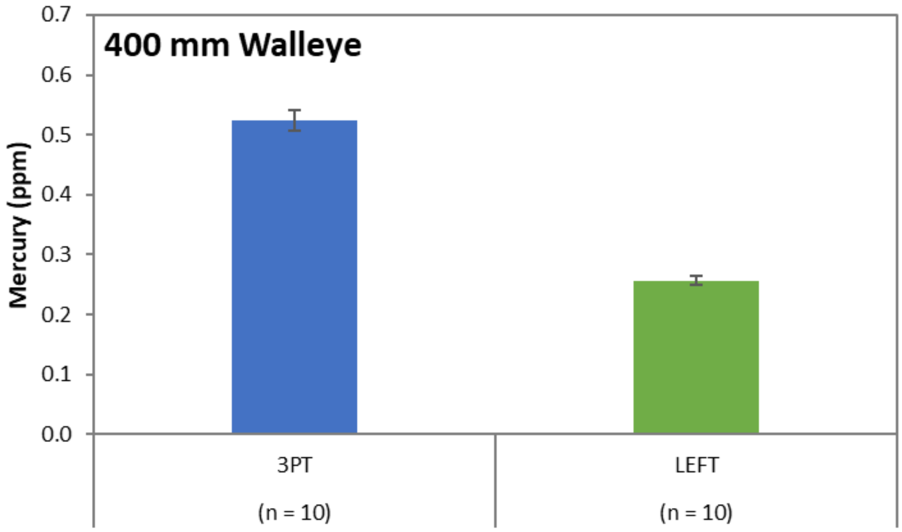


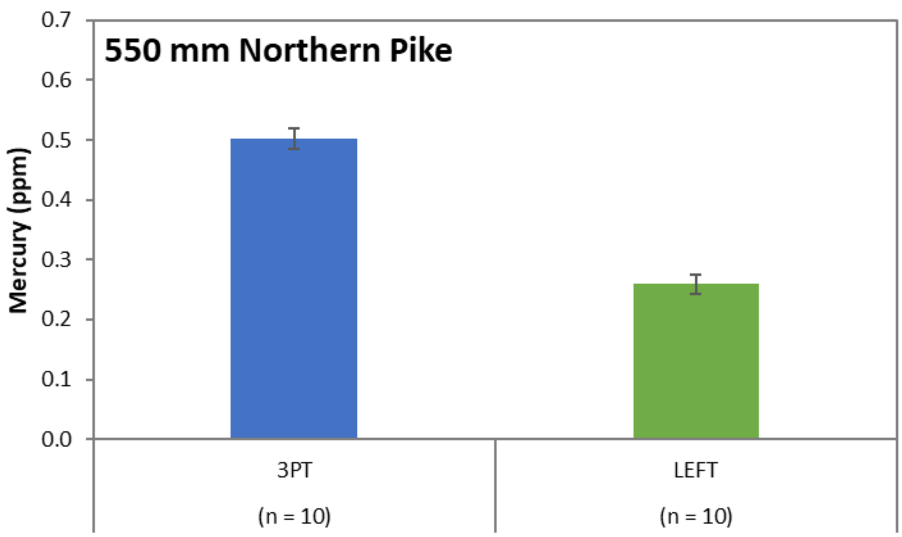
Figure 56. Average catch-per-unit-effort (fish/100 m/24 hr) per year of target species captured in standard gang gill nets in the Churchill River Diversion Region from 2009-2019.

4.5.5 Mercury in Fish Regional Summary

As CAMP is an ecosystem monitoring program, it does not analyze mercury in fish data in relation to human health. Data collected through CAMP is made available to the relevant experts and authorities for human health analysis.

Standard mean mercury concentrations in a 350 mm Lake Whitefish, 400 mm Walleye, and a 550 mm Northern Pike were higher at the on-system Threepoint Lake (mean of all years sampled: 0.059, 0.52, and 0.50 ppm, respectively) compared to the off-system Leftrook Lake (mean of all years sampled: 0.026, 0.26, and 0.26 ppm, respectively; Figure 1). While there was variability in the standard mean concentrations between sampling years, there was no obvious change over the 12-year monitoring period for any species in either waterbody.


400 mm Walleye
Mercury (ppm)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
3PT
(n = 10)
LEFT
(n = 10)


550 mm Northern Pike
Mercury (ppm)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
3PT
(n = 10)
LEFT
(n = 10)

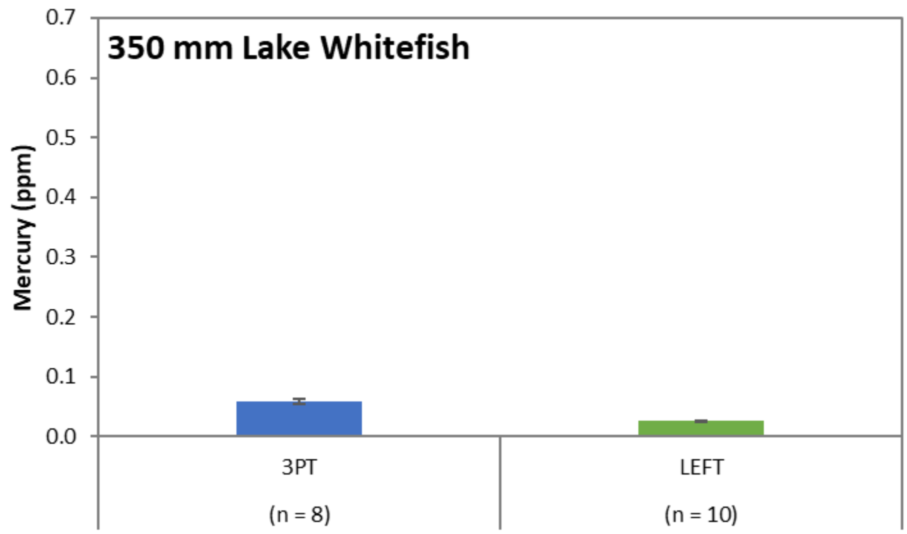


Figure 57. Average length-standardized mean mercury concentration (± standard error) in fish muscle from Churchill River Diversion Region waterbodies.

Blue = on-system, Green = off-system, n = number of sampling years.

4.6 Upper Nelson River Region

4.6.1 Physical Environment Regional Summary

4.6.1.1 Climate

Over the monitoring period, the months of January,

July, September, and December generally experienced warmer than normal conditions (≥ 7 out of 13 months above normal). On an annual basis, 12 out of 13 years in the monitoring period had near or above normal conditions; 2010 and 2016 had the warmest annual average temperature at 1.7ºC, while 2014 had the coolest annual average temperature at -1.7ºC. The maximum and minimum monthly average air temperatures during the monitoring period were 20.5ºC (July 2012) and -26.1ºC (December 2013), respectively.

Over the monitoring period, July generally experienced more than normal precipitation (≥ 7 out of 13 months above normal), while February, April, May, June, September, November, and December generally experienced less than normal precipitation (≥ 7 out of 13 months below normal). On an annual basis, no distinct patterns in the data were identified as the majority of years experienced near normal conditions, however there were more years with below normal precipitation than above normal in the monitoring period; 2016 had the highest annual total precipitation (650.6 mm), while 2019 had the lowest annual total precipitation (184.0 mm). The maximum and minimum monthly total precipitation recorded during the monitoring period were 205.5 mm (July 2008) and 0 mm (April 2012, and June – August 2019), respectively. It should be noted that 0 mm of precipitation recorded over June to August 2019 is suspect and the data should be approached with caution. Compared to a climate station 60 km north, Cross Lake Jenpeg 2 station recorded 15.2 mm of precipitation in June (although had 10 days of missing data), 147.8 mm in July, and 189.8 mm in August (2019); ERA5-Land also showed a notable amount of precipitation over the same three-month period.

4.6.1.2 Water Regime

Water Flows and Levels

The Upper Nelson River flow is mainly governed by precipitation within the Lake Winnipeg Basin and regulated through Jenpeg Generating Station operations. Jenpeg controls the West Channel, carrying most flow for power generation and lake level management, while the unregulated East Channel carries roughly 15% of total flow. CAMP monitors on-system sites including Two Mile Channel, Warren Landing, Playgreen Lake, Little Playgreen Lake, Cross Lake, Sipiwesk Lake, and upstream of the Kelsey Generating Station. Since 2017, continuous water temperature data has been recorded at Jenpeg. Off-system monitoring covers Setting Lake (Grass River system) and Walker Lake, which is influenced by Cross Lake when water levels exceed approximately 207.6 m.

Between 2008 and 2020, the monthly flows at Kelsey Generating Station ranged from 1,486 to 5,450 cms with a median value of 2749 cms. No very dry months (< 10th percentile) were recorded, while very wet conditions (> 90th percentile) occurred sporadically across eight years. Water levels at on-system lakes tracked these flow patterns, with variations mostly within ±0.5 m and low to moderate variability. Off-system lakes exhibited similar stability, with occasional above-average levels.

Water Temperature

Monitoring for the UNRR is done at the Jenpeg GS where equipment is permanently deployed in the generating station and collects data continuously throughout the year. The site has been monitored since August 2017. The data record is not long enough to draw any conclusions about trends at this site.

Water temperatures peaked in late July to mid-August at a temperature of 21-22°C and then generally decrease steadily to about 0°C in early to mid-November. The temperature remains near 0 °C until early May when it begins to increase during the spring thaw. The duration of ice cover, which is assumed to be when water temperature is below 1°C, was about 26-28 weeks.

4.6.1.3 Sedimentation

Monitoring for the UNRR is done at the Jenpeg GS where equipment is permanently deployed in the generating station and collects data continuously throughout the year. The site has been monitored since August 2017. The data record is not long enough to draw any conclusions about trends at this site.

A large peak in turbidity between 30-70 FNU (Formazin Nephelometric Units) occurred in October/November 2017, but in the other years the peaks were much lower at about 25 FNU in November. Turbidity generally declined steadily from the peak to annual lows of about 6 FNU before spring ice breakup in May. After breakup, the turbidity is higher and more variable depending on flow and weather conditions, and ranges from about 10-25 FNU until October/November.

The largest sediment loads of about 5,000-9,300 t/d occurred during the large peak in turbidity in October/November 2017. Sediment loads were much lower in the rest of the reporting period, between about 260-3,000 t/d. Loads were lowest before spring breakup when the lowest turbidity occurs and ranged from about 260-580 t/d. After spring break-up, the loads are higher and more variable, peaking between about 2,000-3,000 t/d.

4.6.2 Water Quality Regional Summary

Lakes, reservoirs, and riverine sites along the upper Nelson River were well-oxygenated, and moderately clear to turbid, with moderate to high concentrations of nutrients. Water quality conditions varied between some sites, notably at the Lake Winnipeg outlets (Two-Mile Channel and the Nelson River at Warren Landing) relative to other on-system waterbodies. Some differences in water quality conditions were also observed between on- and off-system sites.

Lakes and reservoirs along the upper Nelson River were well mixed (i.e., isothermal) and DO was similar throughout the water column. With one exception, DO consistently met Manitoba Water Quality Standards, Objectives, and Guidelines instantaneous minimum objectives for cool- and cold-water aquatic life (MWS 2011) at on-system waterbodies in the region. The exception occurred at Cross Lake in the winter of 2008 when DO was below the instantaneous minimum objective for cold-water aquatic life (8.0 mg/L) one meter below the ice.

Conditions differed at the off-system waterbodies. Setting Lake, which though well-oxygenated near the surface, was thermally stratified each year during spring and/or summer and DO at depth fell below PAL objectives during five of 12 summers of monitoring. Thermal stratification was also observed in Walker Lake during some open-water season sampling periods; however, DO remained above PAL objectives throughout the water column in this lake during the open-water season. Although stratification was not observed in winter, DO at depth often fell below PAL objectives during the ice-cover period in both Setting and Walker lakes.

Water clarity in the Upper Nelson River Region was highly variable both spatially and temporally, most notably within the Lake Winnipeg Outlet Area. Within this part of the region, water clarity was higher in Lake Winnipeg (i.e., Big Mossy Point and Site 22) compared to Two-Mile Channel (both inlet and outlet sites) and the Nelson River at Warren Landing. Turbidity and TSS varied widely between sampling periods in Two-Mile Channel, and to a lesser extent the upper Nelson River at Warren Landing, but were generally higher in fall than in spring and summer.

There is also some evidence of decreasing water clarity along the length of the upper Nelson River. Excluding Playgreen lake, which is susceptible to wind induced resuspension of sediments and erosion, on average, TSS and turbidity were lowest in Lake Winnipeg near the outflows and highest in the upper Nelson River upstream of the Kelsey GS (i.e., the most downstream site). Compared to the on-system sites, water clarity was higher at the off-system waterbodies (i.e., Setting and Walker lakes). Additionally, although not all waterbodies in this region were monitored in winter (i.e., Lake Winnipeg and the outlet channels), water clarity tended to be higher in winter under the ice than during the open-water season similar to all CAMP regions.

The lakes and reservoirs along the upper Nelson River and Lake Winnipeg (i.e., Big Mossy Point and Site 22) were meso-eutrophic to eutrophic based on total phosphorus (TP), mesotrophic based on total nitrogen (TN), and mesotrophic to eutrophic based on chlorophyll *a*. The off-system lakes, Setting and Walker lakes, were mesotrophic to meso-eutrophic based on TP, and mesotrophic based on TN and chlorophyll *a*.

Riverine areas monitored within the region (i.e., Two-Mile Channel and the Nelson River at Warren Landing) were eutrophic based on TP and oligotrophic based on TN and chlorophyll *a*.

Seasonal differences in chlorophyll *a* were observed for annual on-system monitoring locations (with greater than 5 years of data) including the Nelson River at Warren Landing, Two-Mile Channel, and Cross Lake during the open-water season, where chlorophyll *a* was higher in fall than in spring and summer. Similar seasonality was observed at the annual off-system waterbody (i.e., Setting Lake). Although not all waterbodies in this region were monitored in winter, phytoplankton biomass (as indicated by chlorophyll *a*) tended to be lower in winter under the ice than during the open-water season.

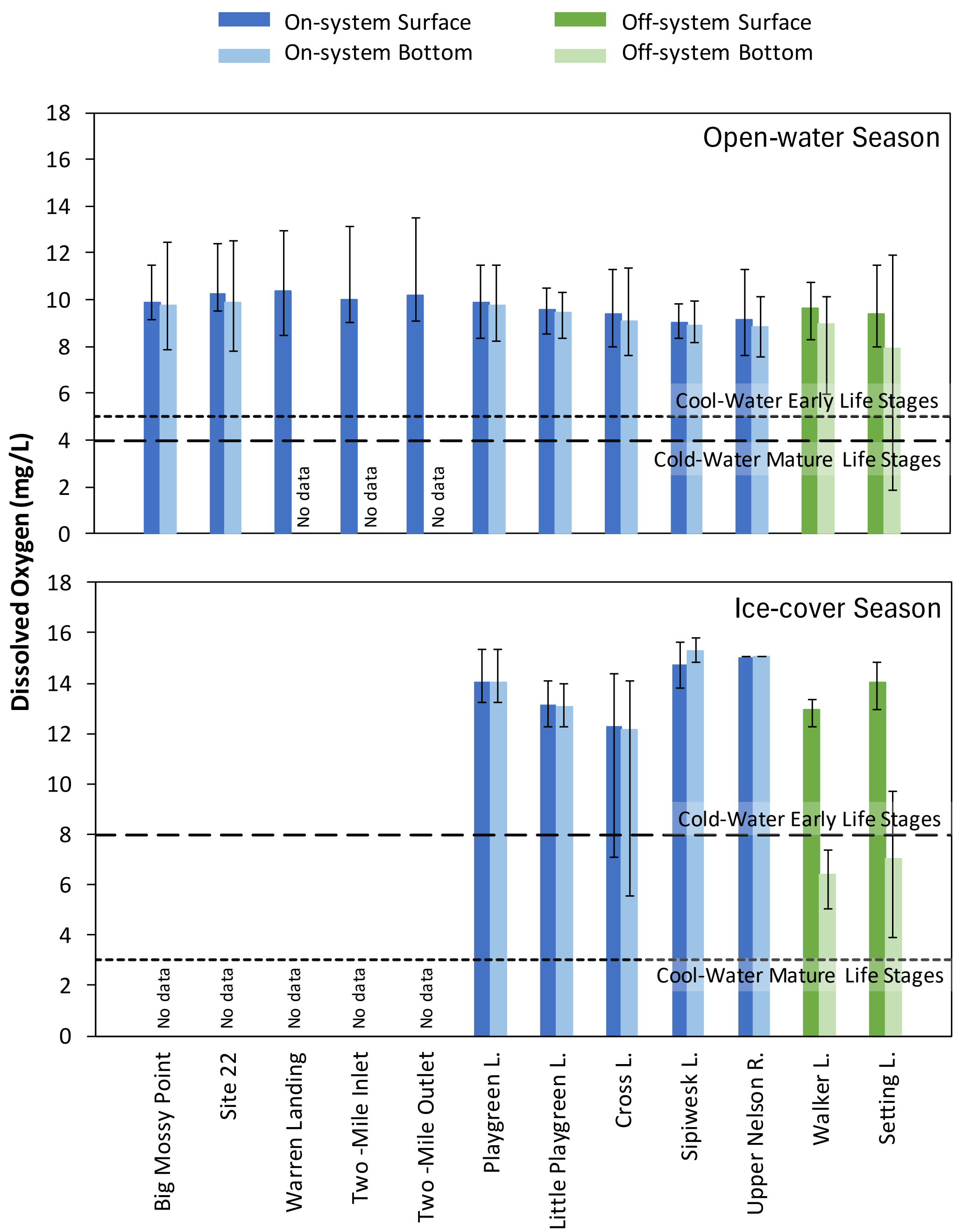
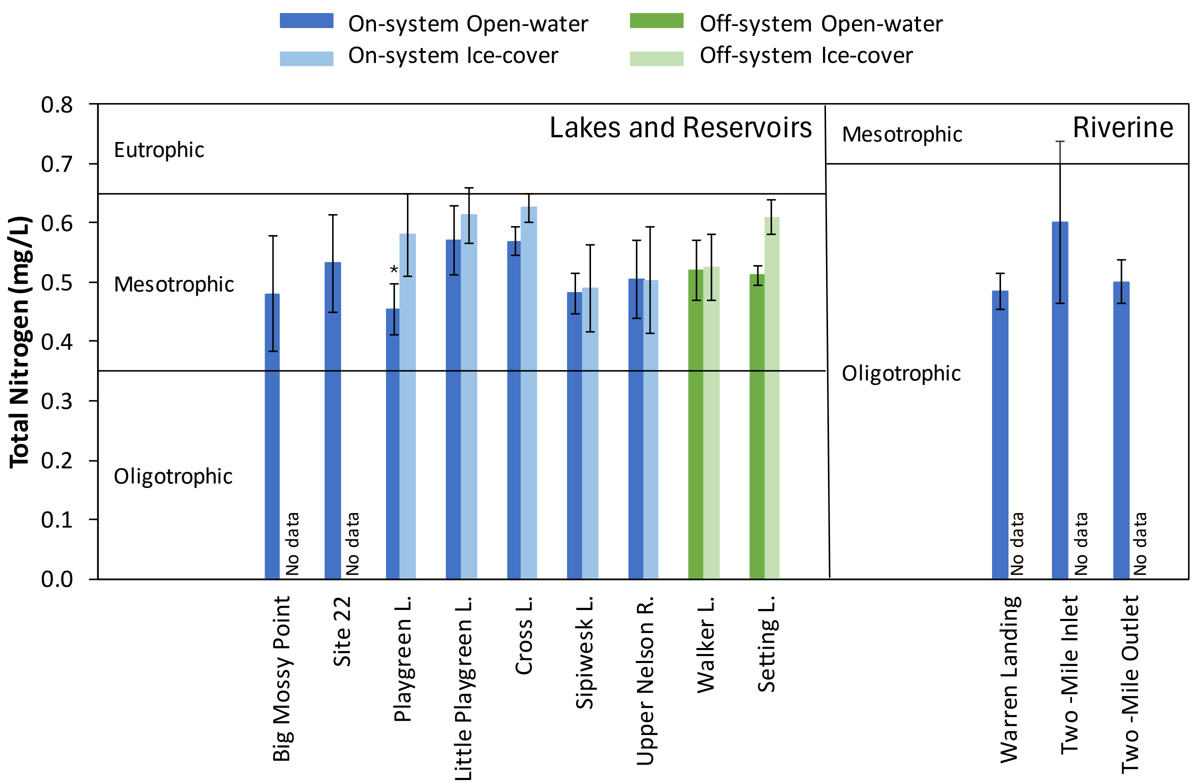


Figure 58. Average dissolved oxygen concentrations in the Upper Nelson River Region from 2008-2019 compared to the MWQSOG instantaneous minimum objectives for the protection of cold- and cool-water aquatic life. Error bars show total range of values (i.e., minimum and maximum).



Notes: * Outlier value of 14.5 mg/L from summer 2012 was excluded from values reported for Playgreen Lake.

Figure 59. Mean (±SE) total nitrogen concentrations in the Upper Nelson River Region from 2008-2019 compared to trophic categories for lakes and reservoirs (OECD 1983) and riverine sites (Dodds et al. 1998).

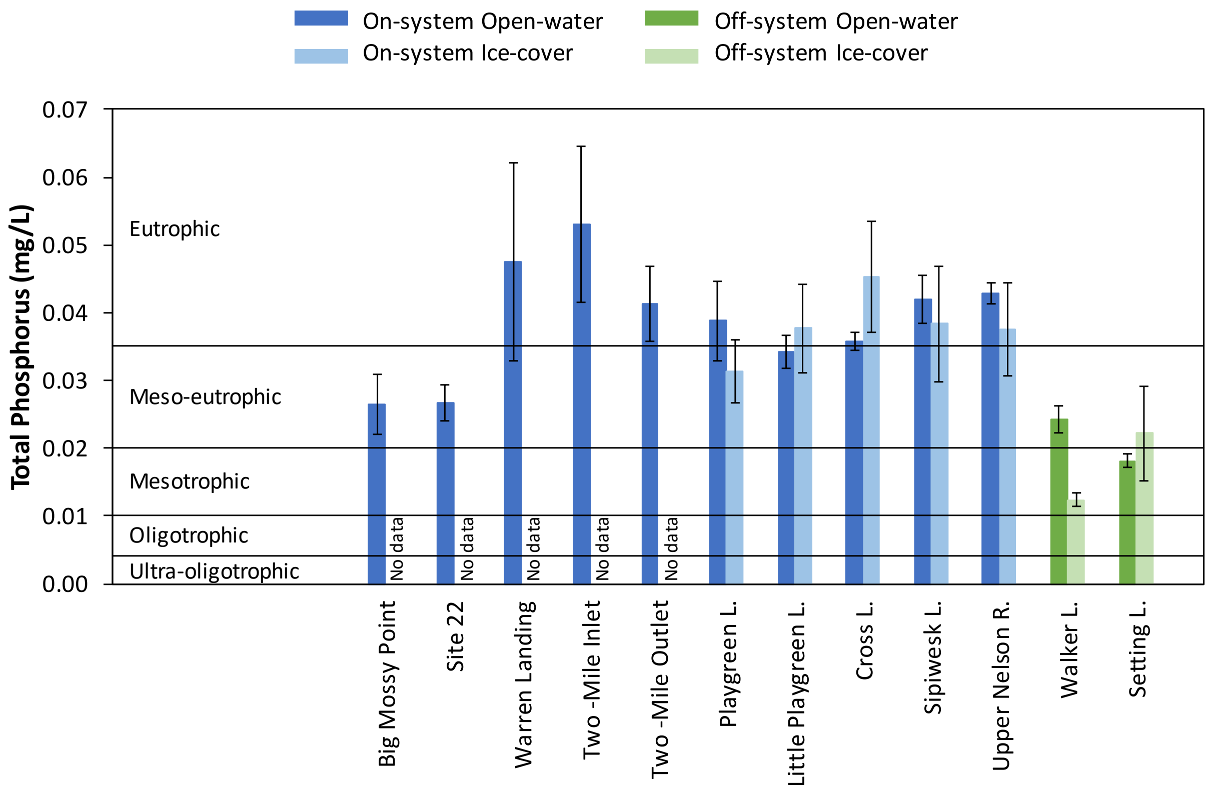


Figure 60. Mean (±SE) total phosphorus concentrations in the Upper Nelson River Region from 2008-2019 compared to the CCME Canadian Guidance Framework for Phosphorus (CCME 2004).

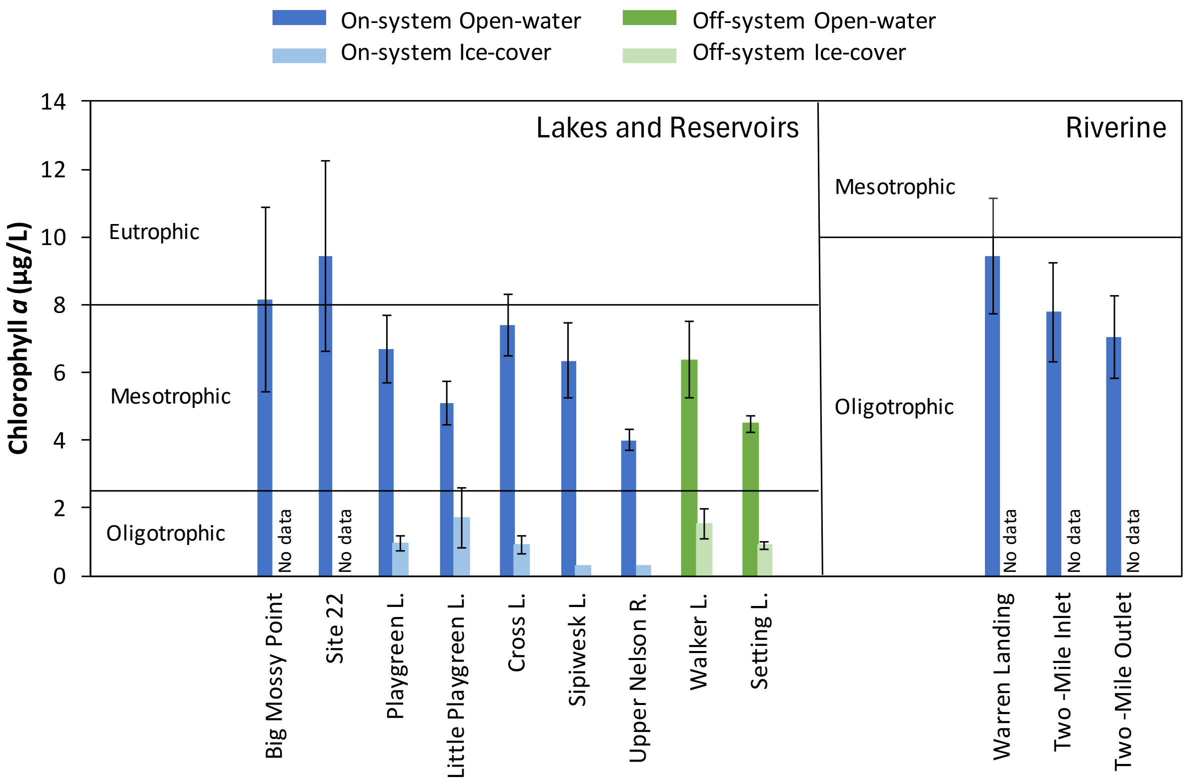


Figure 61. Mean (±SE) chlorophyll *a* concentrations in the Upper Nelson River Region from 2008-2019 compared to trophic categories for lakes and reservoirs (OECD 1983) and riverine sites (Dodds et al. 1998).

4.6.3 Benthic Invertebrates Regional Summary

The nearshore benthic invertebrate community composition varied between years and across sites in the Upper Nelson River Region. Lake Winnipeg - Mossy Bay was mostly comprised of Trichoptera (Hydropsychidae) in 2013, 2015, 2016, and 2019, and then Amphipoda (Pontoporeiidae) in 2017. The dominant taxa in Playgreen Lake were Chironomidae in 2012, Oligochaeta in 2015, and both Bivalvia (Sphaeriidae) and Chironomidae in 2018. Community composition was more consistent among years in Little Playgreen Lake, where Chironomidae, Amphipoda (Hyalellidae), and Gastropoda (Planorbidae) were relatively abundant in most years. The dominant taxa at Cross Lake were Chironomidae and/or Corixidae; except in 2018 when Ephemeroptera

(Ephemeridae and Heptageniidae) and Corixidae were co-dominant. Invertebrate composition varied between years at Sipiwesk Lake, where Corixidae dominated the community in 2011 and 2014, and Chironomidae and Ephemeroptera (Caenidae) were co-dominant in 2017. The dominant taxon at the upper Nelson River - upstream of the Kelsey GS was Amphipoda (Hyalellidae). Taxonomic composition at the off-system Walker Lake also varied year-to-year, where Amphipoda (Hyalellidae) dominated in 2010, Hydrachnidae (water mites) dominated in 2013, Gastropoda (Lymnaeidae and Planorbidae) dominated in 2016, and Oligochaeta and Gastropoda (Lymnaeidae and Planorbidae) dominated in 2019. Community composition at the off-system Setting Lake also varied among years but was mainly comprised of Amphipoda (Hyalellidae) and Chironomidae.

Mean total invertebrate abundance (all years combined) in the nearshore was highest at Little Playgreen Lake. Mean total abundance at Playgreen Lake was within the range of both off-system sites (Walker and Setting lakes), but higher than the remaining on-system sites (Cross Lake, Sipiwesk Lake, and at the upper Nelson River - upstream of the Kelsey GS). Relative to the other nearshore sites, mean total invertebrate abundance (all years combined) was exceptionally low (ranging between 0 and 12 invertebrates) at the Lake Winnipeg - Mossy Bay site (sand, cobble, gravel), where the invertebrate community was comprised of small numbers of Trichoptera (Hydropsychidae) and/or Amphipoda (Pontoporeiidae). Low mean abundance, taxonomic richness, and diversity values at the Lake Winnipeg - Mossy Bay site were attributed to the unstable nearshore habitat from wind fetch (leading to sediment redistribution) and/or ice scouring (causing bank failure).

The dominant taxa were generally similar among offshore sites (Amphipoda: Pontoporeiidae, Bivalvia: Sphaeriidae, Chironomidae, and Ephemeroptera: Ephemeridae). At Lake Winnipeg - Mossy Bay the dominant taxa were Gastropoda and Amphipoda in 2013, and Amphipoda and/or Chironomidae in other years (2014 to 2019). The dominant taxa in Playgreen Lake were Bivalvia in 2012, both Bivalvia and Chironomidae in 2015, and Amphipoda in 2018. Composition was more consistent among years in each of Little Playgreen and Cross Lakes, where Bivalvia, Chironomidae, and/or Ephemeroptera were relatively abundant in most years. The dominant taxa in Sipiwesk

Lake were Amphipoda and Ephemeroptera in all three sampling years (2011, 2014, and 2017). Community composition in the upper Nelson River - upstream of the Kelsey GS varied where Amphipoda dominated in 2011, and Ephemeroptera dominated in 2014 and 2017. The overall taxa structure was similar among years at the off-system Walker Lake where Chironomidae dominated in each sampling year (2010, 2013, 2016, and 2019), and at the off-system Setting Lake where Amphipoda dominated in all years (2010 to 2019).

Mean total invertebrate abundance (densities; all years combined) in the offshore habitat were very low at Lake Winnipeg - Mossy Bay and at the off-system Walker Lake and highest at Playgreen Lake. Mean total abundance at the upper Nelson River – upstream of the Kelsey GS was comparable to the off-system Setting Lake; invertebrate abundance was higher at the remaining on-system sites (Little Playgreen, Cross, and Sipiwesk lakes). Observed differences in invertebrate metrics did not appear related to benthic substrate. Sediments at Cross Lake, Little Playgreen Lake, the upper Nelson River - upstream of Kelsey GS and the off-system Setting Lake were predominantly silty clay, silt, or silt loam, whereas the relative amount of sand was higher in Lake Winnipeg - Mossy Bay, Playgreen Lake, Sipiwesk Lake, and the off-system Walker Lake sediments.

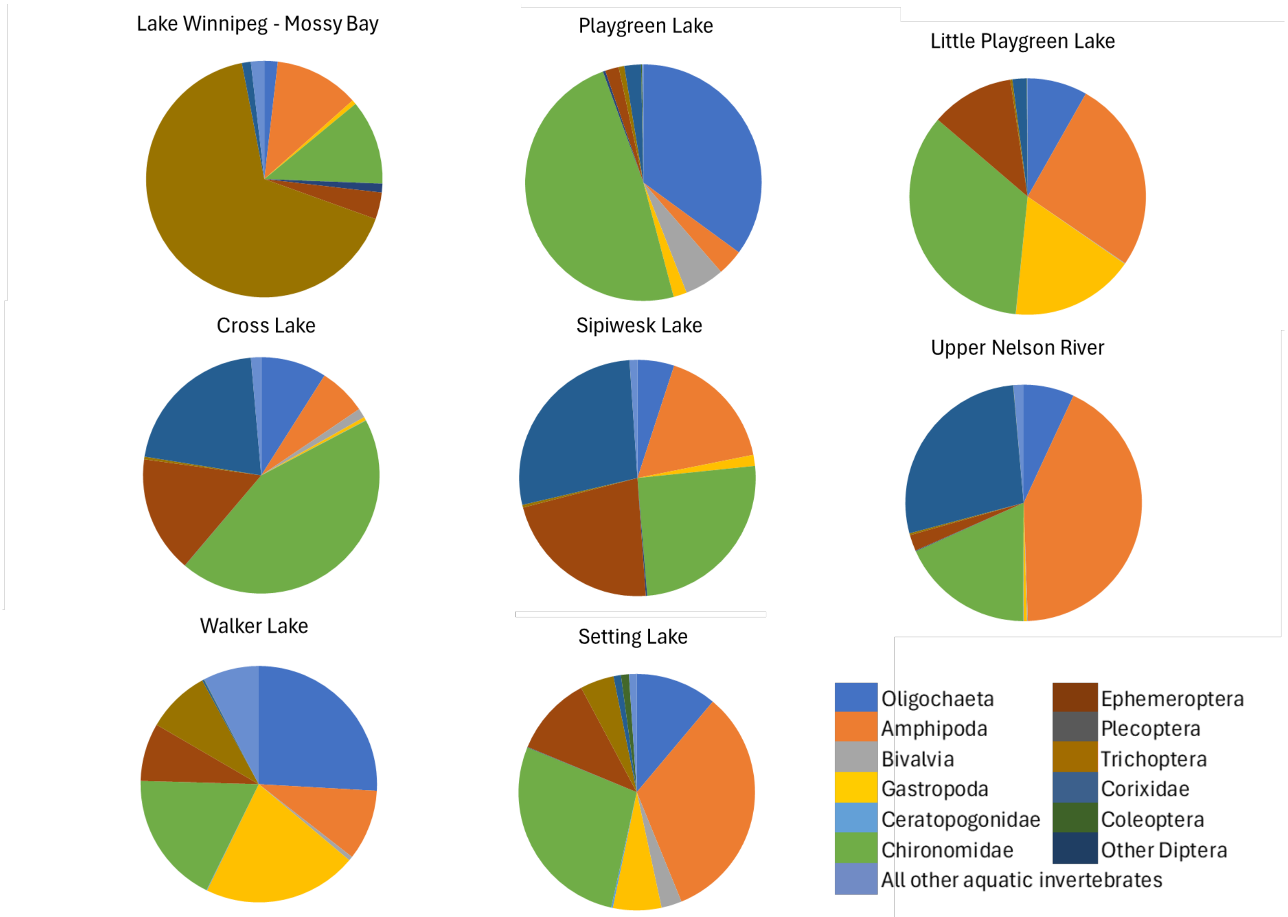


Figure 62. Average relative abundance (% of total) of the benthic invertebrate taxa groups captured at nearshore sites in the Upper Nelson River Region from 2010-2019.

5±1

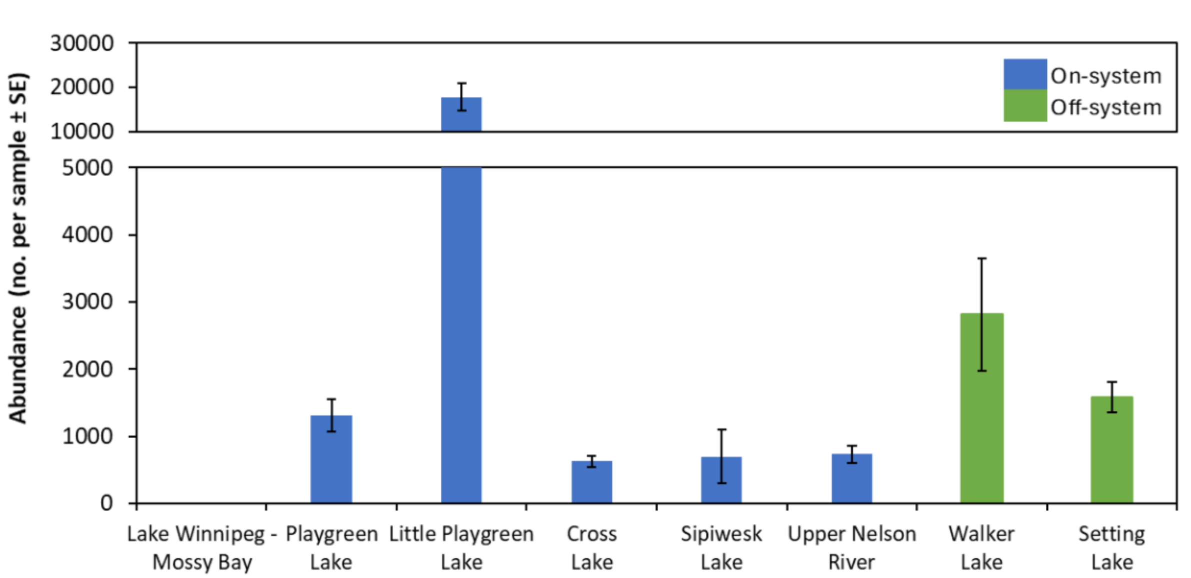


Figure 63. Average total abundance (no. per sample ± SE) of benthic invertebrates captured at nearshore sites in the Upper Nelson River Region from 2010-2019.

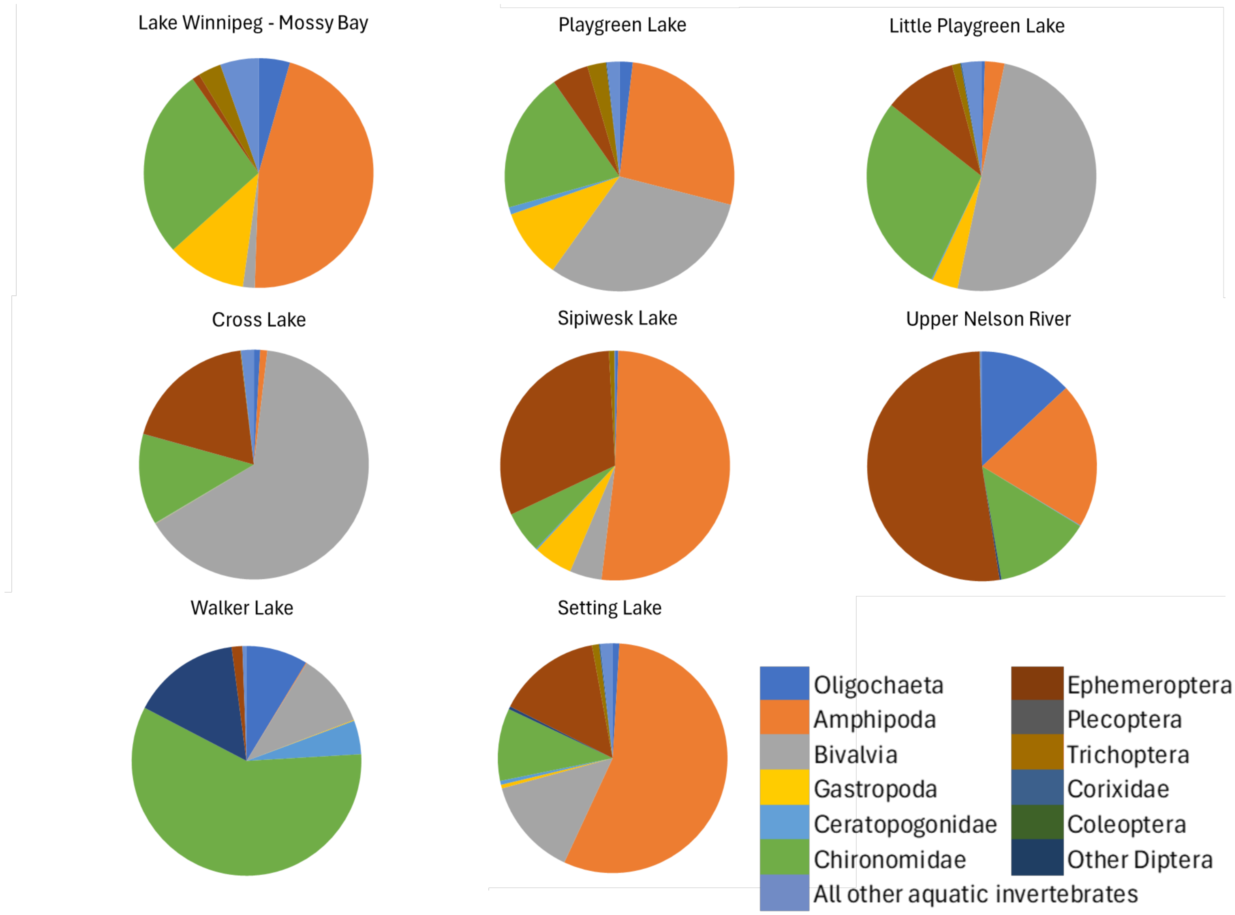


Figure 64. Average relative abundance (density, % of total) of the benthic invertebrate taxa groups captured at offshore sites in the Upper Nelson River Region from 2010-2019

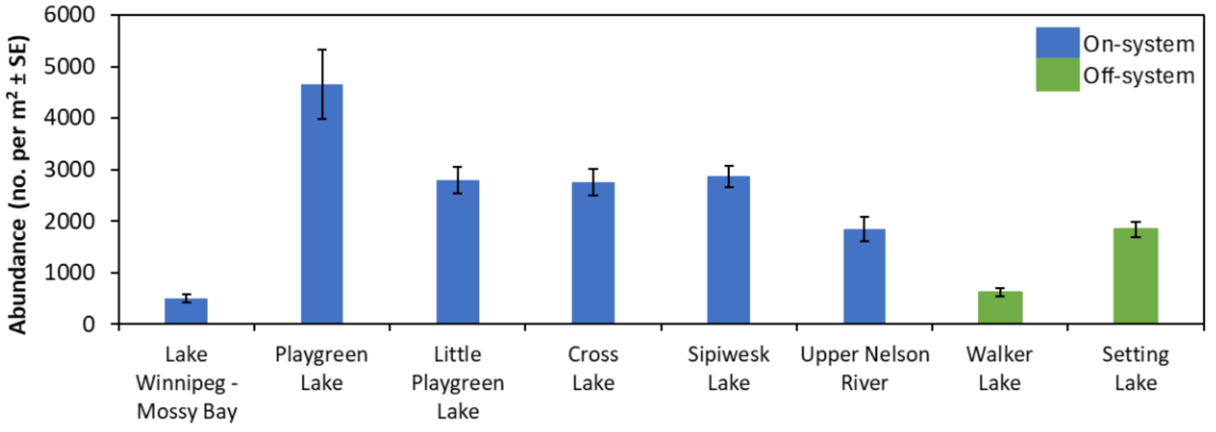


Figure 65. Average total abundance (density, no. per m^2 ± SE) of benthic invertebrates captured at offshore sites in the Upper Nelson River Region from 2010-2019.

4.6.4 Fish Community Regional Summary

The fish species community of the on-system upper Nelson River waterbodies was generally similar in that White Sucker and Walleye were common species at most waterbodies. Sauger, Yellow Perch, Spottail Shiner, and Trout-perch were also common, but their presence in the catch was more location-specific. Silver Redhorse were only captured in Sipiwesk Lake.

The abundance of large-bodied fish catches generally decreased in a downstream direction along the Nelson River; Lake Winnipeg - Mossy Bay and Playgreen Lake typically had higher CPUE, while Little Playgreen Lake, Cross Lake, and Sipiwesk Lake had lower CPUE compared to the upstream waterbodies, and the upper Nelson River downstream of Sipiwesk Lake had considerably lower CPUE than at the lacustrine waterbodies. A decrease in the CPUE of the large-bodied catch overall and specifically of Northern Pike and White Sucker in Little Playgreen Lake may be a result of a change in the timing of sampling, which changed from mid-June in 2010 to mid-July in subsequent years.

The species diversity and abundance of fish at the off-system Walker and Setting lakes generally fell within the range observed at the on-system waterbodies, but Setting Lake had higher diversity and catches compared to Walker Lake. Setting Lake differed from the other waterbodies in that Cisco was a frequently captured species in all years.

Monitoring results indicate that the invasive Rainbow Smelt, which have been observed in the on-system waterbodies but not in either of the off-system waterbodies, has not become well established as catches of this species have declined over time. The other invasive fish species in the region (Common Carp) was captured infrequently; occurrences are limited to incidental captures from Cross Lake in one year (2014). Lake Sturgeon were captured in Cross Lake and the upper Nelson River upstream of the Kelsey GS.[7]

The condition and length-at-age of Northern Pike, Walleye, and White Sucker were generally slightly lower at the off-system waterbodies (Walker and Setting Lakes) than at the on-system waterbodies, despite the off-system sites being sampled later in the open-water season than most on-system sites.

A few of the metrics showed some notable temporal differences for the fish community at Lake Winnipeg - Mossy Bay:

- the CPUE of Sauger was particularly high in 2013 compared to other years;
- the CPUE of White Sucker increased over the 2016-2019 period; and
- the condition and length-at-age-3 of Walleye decreased over the 2015-2019 period. This is similar to the reported decline in the condition of Walleye in the north basin of Lake Winnipeg as a whole in the mid-2010s, which was attributed to a decline in Rainbow Smelt prey (ECCC and MARD 2020).

[7] The methodologies used in the Fish Community sampling program are not designed to target Lake Sturgeon or capture them in proportion to their abundance (i.e., larger gill net mesh sizes are excluded from the gear).

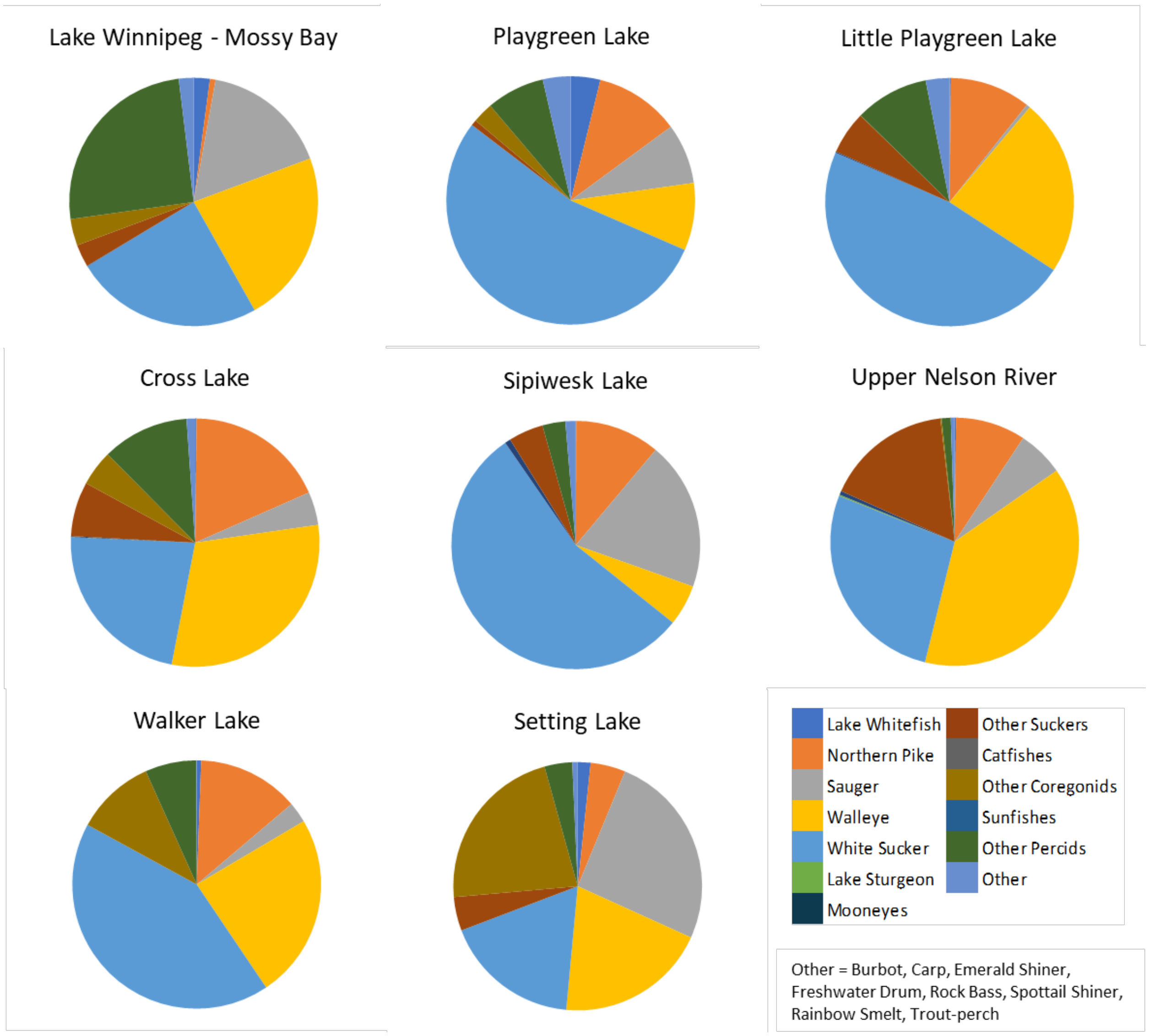


Figure 66. Average relative species abundance (%) of target species and taxa groups captured annually in standard gang gill nets in standard gang gill nets in the Upper Nelson River Region from 2008-2019.

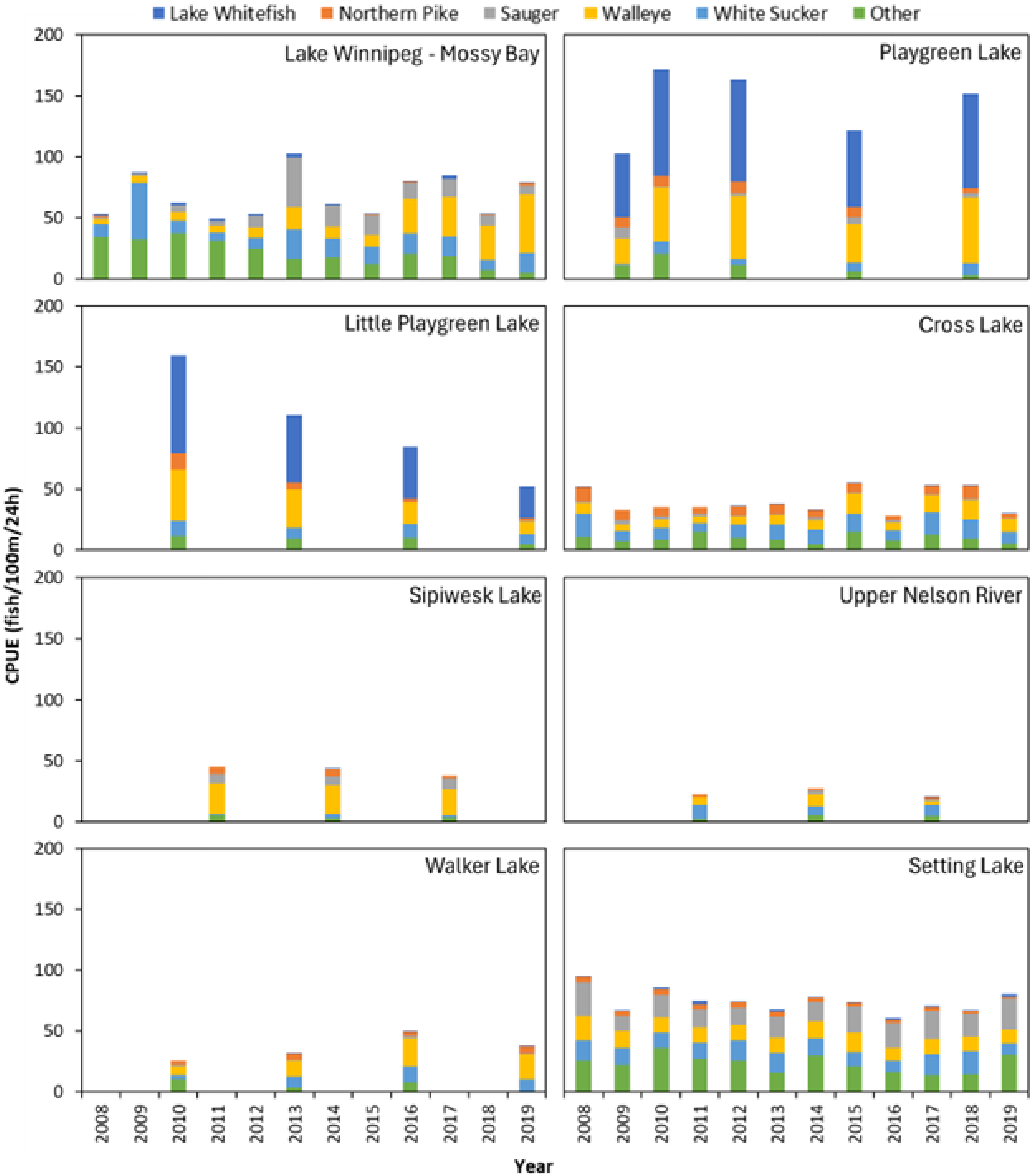


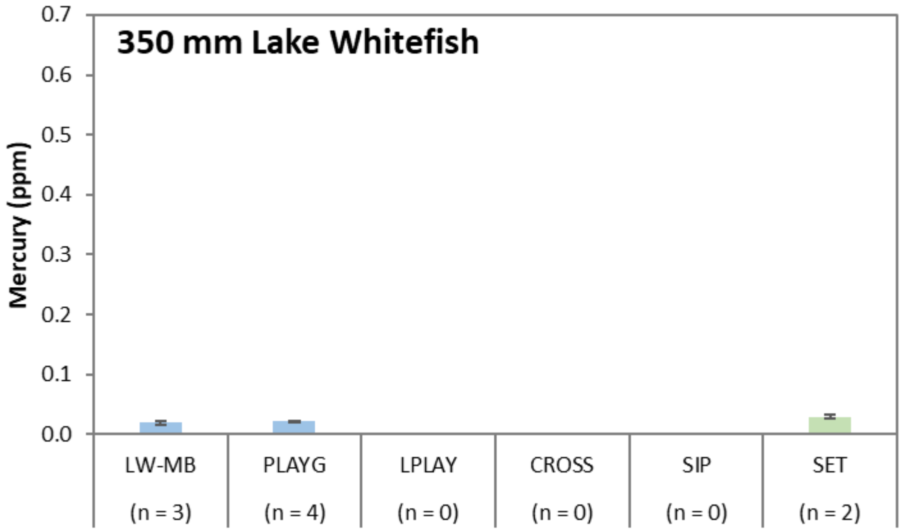
Figure 67. Average catch-per-unit-effort (fish/100 m/24 hr) per year of target species captured in standard gang gill nets in the Upper Nelson River Region from 2008-2019.

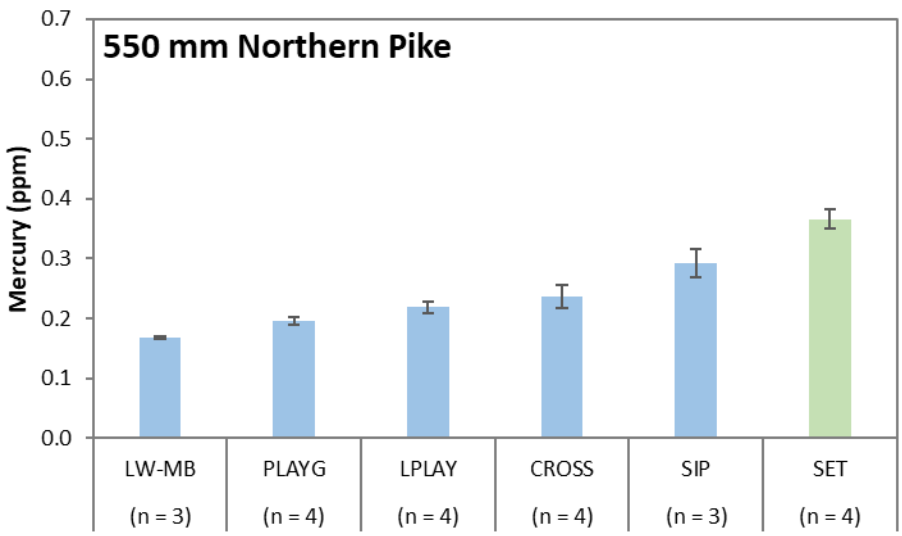
4.6.5 Mercury in Fish Regional Summary

As CAMP is an ecosystem monitoring program, it does not analyze mercury in fish data in relation to human health. Data collected through CAMP is made available to the relevant experts and authorities for human health analysis.

Standard mean mercury concentrations in a 400 mm Walleye and a 550 mm Northern Pike generally increased in a downstream direction along the upper Nelson River, with the lowest concentrations occurring in Lake Winnipeg - Mossy Bay (mean in all years sampled: 0.12 and 0.17 ppm, respectively) and Playgreen Lake (mean in all years sampled: 0.15 and 0.20 ppm, respectively); intermediate concentrations at Little Playgreen Lake (mean in all years sampled: 0.22 and 0.22 ppm, respectively) and Cross Lake (mean in all years sampled: 0.17 and 0.24 ppm, respectively); and the highest concentrations at Sipiwesk Lake (mean in all years sampled: 0.25 and 0.29 ppm, respectively). Concentrations in a 350 mm Lake Whitefish were similar at Lake Winnipeg - Mossy Bay (mean in all years sampled: 0.019 ppm) and Playgreen Lake (mean in all years sampled: 0.21 ppm). Comparisons to other on-system waterbodies are hampered by the low number of whitefish collected at the other on-system waterbodies.

The length-standardized mean mercury concentrations in Lake Whitefish and Northern Pike from the off-system Setting Lake (mean in all years sampled: 0.029 and 0.37 ppm, respectively) were higher than the on-system waterbodies (mean in all years sampled: 0.019-0.021 and 0.16-0.9 ppm, respectively). Concentrations in Walleye were similar between Setting Lake (mean in all years sampled: 0.25 ppm) and Sipiwesk Lake (mean in all years sampled: 0.25 ppm), but higher than the other on-system waterbodies (mean in all years sampled: 0.12-0.22 ppm).


350 mm Lake Whitefish
Mercury (ppm)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
LW-MB (n = 3)
PLAYG (n = 4)
LPLAY (n = 0)
CROSS (n = 0)
SIP (n = 0)
SET (n = 2)


550 mm Northern Pike
Mercury (ppm)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
LW-MB (n = 3)
PLAYG (n = 4)
LPLAY (n = 4)
CROSS (n = 4)
SIP (n = 3)
SET (n = 4)

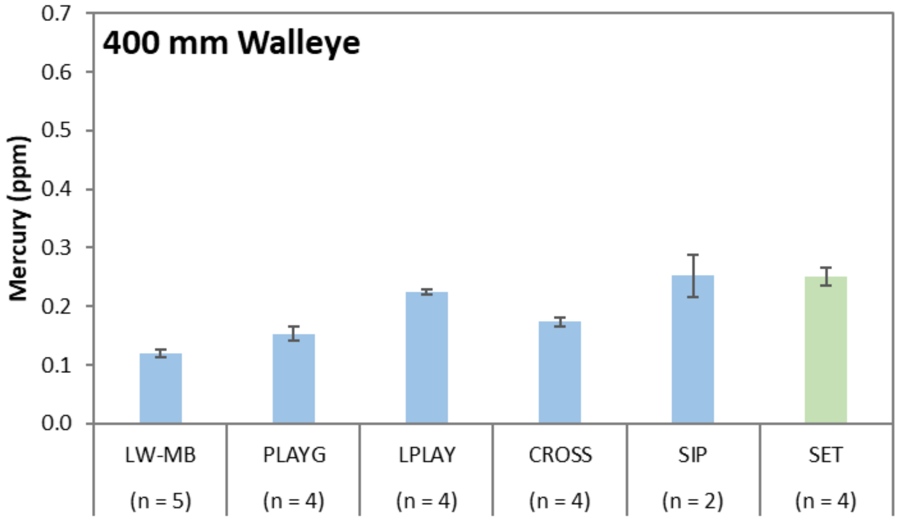


Figure 68. Average length-standardized mean mercury concentration (± standard error) in fish muscle from Upper Nelson River Region waterbodies.

Blue = on-system, Green = off-system, n = number of sampling years.

4.7 Lower Nelson River Region

4.7.1 Physical Environment Regional Summary

4.7.1.1 Climate

Over the monitoring period, the months of January, September, and December generally experienced warmer than normal conditions (≥ 7 out of 13 months above normal). On an annual basis, no distinct patterns in the data were identified as most years in the monitoring period experienced near normal temperatures, with the exception of 2010 to 2012 and 2016 which were above normal; 2010 had the warmest annual average temperature at -0.5ºC, while 2013 had the coolest annual average temperature at -4.6ºC. The maximum and minimum monthly average air temperatures during the monitoring period were 18.3ºC (July 2012) and -28.6ºC (December 2013), respectively.

Over the monitoring period, June, July, August, and October generally experienced more than normal precipitation (≥ 7 out of 13 months above normal), while February, March, May, November, and December generally experienced less than normal precipitation (≥ 7 out of 13 months below normal). On an annual basis, no distinct patterns in the data were identified as most of the years experienced near normal conditions. However, there were more years with above normal precipitation than below normal in the monitoring period; 2020 had the highest annual total precipitation (701.6 mm), while 2013 had the lowest annual total precipitation (429.0 mm). The maximum and minimum monthly total precipitation recorded during the monitoring period were 190.3 mm (August 2019) and 0.2 mm (March 2017), respectively

4.7.1.2 Water Regime

Water Flows and Levels

The Lower Nelson River is influenced by regulated outflows from Lake Winnipeg and the Churchill River Diversion (CRD), which redirects much of the Churchill River's flow into the Nelson via the Rat and Burntwood rivers, with local tributary inflows also contributing. CAMP monitors water levels at key on-system sites including Split Lake, Stephens Lake (Kettle forebay), the Limestone forebay, and reaches downstream of the Limestone Generating Station. Water levels at these locations are inferred from flow data at the Kettle Generating Station and the Burntwood River (Thompson gauge). Off-system monitoring includes Assean Lake, unaffected by hydroelectric operations, and the naturally flowing Hayes River.

Between 2008 and 2020, flows at Kettle Generating Station generally ranged from 2,598 to 6,498 cms, and a median value of 3,865cms. Very dry conditions (< 10th percentile) were not observed, while very wet conditions (> 90th percentile) occurred during parts of nine years. Hayes River flows also tended above average, with monthly values between 113 and 2,209 cms (median 480 cms). Water levels at on-system sites reflected these patterns, with varying degrees of variability and months exceeding ±0.5 metres from average. Off-system, Assean Lake showed low variability with water levels more than 0.5 m above average in 16 months and never more than 0.5 m below average.

Water Temperature

Monitoring for the LNRR is done at the Limestone GS where equipment is permanently deployed in the generating station and collects data continuously throughout the year. The site has been monitored since June 2017. The data record is not long enough to draw any conclusions about trends at this site.

In each of the three summers monitored, the water temperature peaked in late July to mid-August at a temperature of 20-21°C. Data were not available in the first two winters of operation. In winter 2019/2020, the temperature dropped to about 0°C in early November and remained there until early May when it began to increase during the spring thaw. The duration of ice cover, which is assumed to be when water temperature is below 1°C, was about 29 weeks.

4.7.1.3 Sedimentation

Monitoring for the LNRR is done at the Limestone GS where equipment is permanently deployed in the generating station and collects data continuously throughout the year. The site has been monitored since June 2017. The data record is not long enough to draw any conclusions about trends at this site.

Average turbidity ranged from about 7-35 FNU (Formazin Nephelometric Units) overall. Turbidity declined steadily with little variability from peak levels of about 28-35 FNU in late December to annual lows of about 8 FNU before spring ice breakup in May. After ice breakup, the turbidity is higher and more variable depending on flow and weather conditions, and ranges from about 10-25 FNU until September/October. Interestingly, the turbidity increases from about September/October to the peak levels observed around the end of December.

Sediment loads were greatest near the end of December when turbidity peaked, with peak loads of about 4,700-9,000 t/d. The loads were generally lowest from January to May, ranging from about 400-1,400 t/d while the loading in summer between the thaw and September/October were variable along with turbidity and ranged from about 500-2,600 t/d.

4.7.2 Water Quality Regional Summary

Lakes, reservoirs, and riverine sites in the Lower Nelson River Region were well-oxygenated, and moderately clear, with low to high concentrations of nutrients. Spatial differences were observed for some water quality metrics including differences between the Burntwood and lower Nelson River sites, as well as the more isolated northern arm of Stephens Lake and off-system sites.

All waterbodies in the region were well-oxygenated year-round and dissolved oxygen (DO) concentrations throughout the water column consistently met Manitoba Water Quality Standards, Objectives, and Guidelines instantaneous minimum objectives for cool- and cold-water aquatic life (MWS 2011). Lakes and reservoirs along the lower Nelson River (i.e., Split and Stephens lakes and the Limestone Forebay) were well mixed (isothermal) and DO was similar throughout the water column. This differs slightly from the off-system lake, Assean Lake, which though well-oxygenated, and typically isothermal, was occasionally thermally stratified; twice near the surface (thermocline at 0-1 m) during the open-water season, and once in winter.

Water clarity along main flow path of the lower Nelson River was moderate. It was lower in the Burntwood River where TSS and turbidity were higher, and conditions in Split Lake and downstream were more similar to the upper Nelson River than the Burntwood River (the upper Nelson River contributes approximately 75% of the flow to the lower Nelson River on average). Water clarity was higher in the more isolated north arm of Stephens Lake, where TSS and turbidity were lower, than along the main flow path of the lower Nelson River. Compared to on-system sites, water clarity was higher in the off-system waterbodies (i.e., the Hayes River and Assean Lake). Throughout the region, water clarity tended to be higher in winter under the ice than during the open-water season, similar to all CAMP regions.

The lakes and reservoirs along the lower Nelson River were meso-eutrophic to eutrophic based on total phosphorus (TP), and oligotrophic to mesotrophic based on total nitrogen (TN) and chlorophyll *a*. Stephens Lake - North was generally less nutrient-rich and had lower levels of chlorophyll *a* than the southern area of the lake or other sites located along the main flow of the lower Nelson River. The off-system lake (i.e., Assean Lake) was mesotrophic based on TP, TN and chlorophyll *a*.

The Burntwood River and the lower Nelson River downstream of the Limestone GS were eutrophic based on TP and oligotrophic based on TN and chlorophyll *a*. The off-system river site (i.e., the Hayes River) was mesotrophic based on TP and oligotrophic based on TN and chlorophyll *a*. Phytoplankton biomass (as indicated by chlorophyll *a*) was relatively similar in spring, summer, and fall, and tended to be lower in winter under the ice than during the open-water season at all sites in the region.

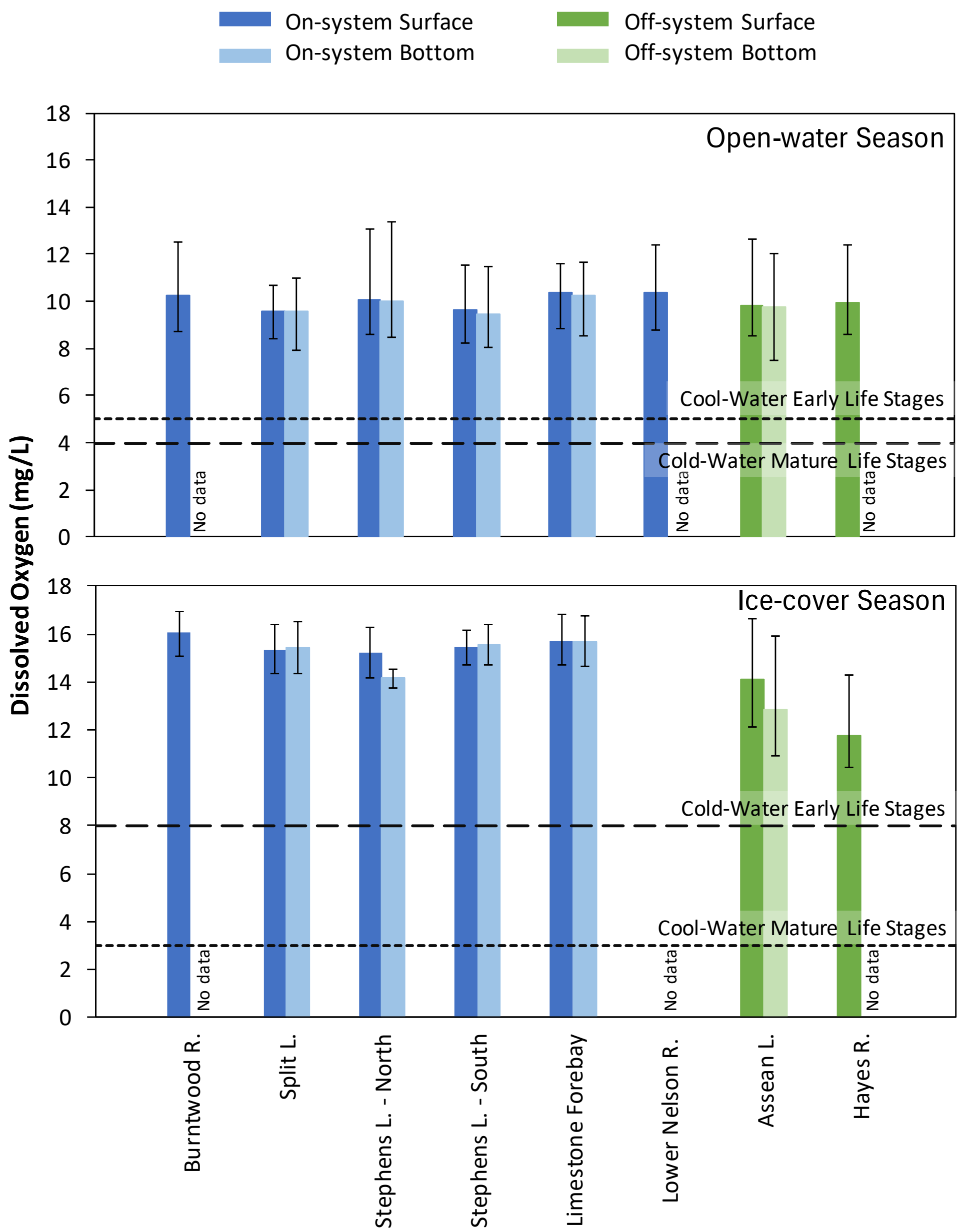
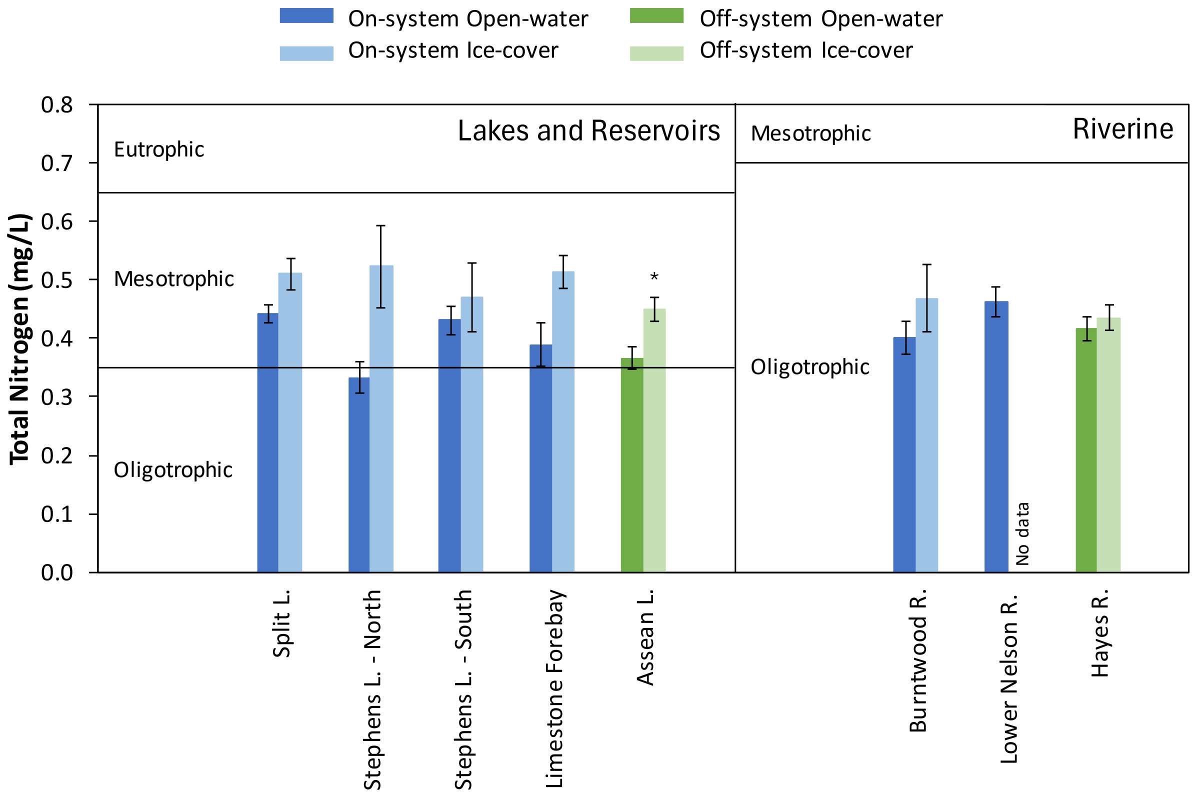


Figure 69. Average dissolved oxygen concentrations in the Lower Nelson River Region from 2008-2019 compared to the MWQSOG instantaneous minimum objectives for the protection of cold- and cool-water aquatic life. Error bars show total range of values (i.e., minimum and maximum).



Notes: * Outlier value of 11.1 mg/L from winter 2015 was excluded from values reported for Assean Lake.

Figure 70. Mean (±SE) total nitrogen concentrations in the Lower Nelson River Region from 2008-2019 compared to trophic categories for lakes and reservoirs (OECD 1983) and riverine sites (Dodds et al. 1998).

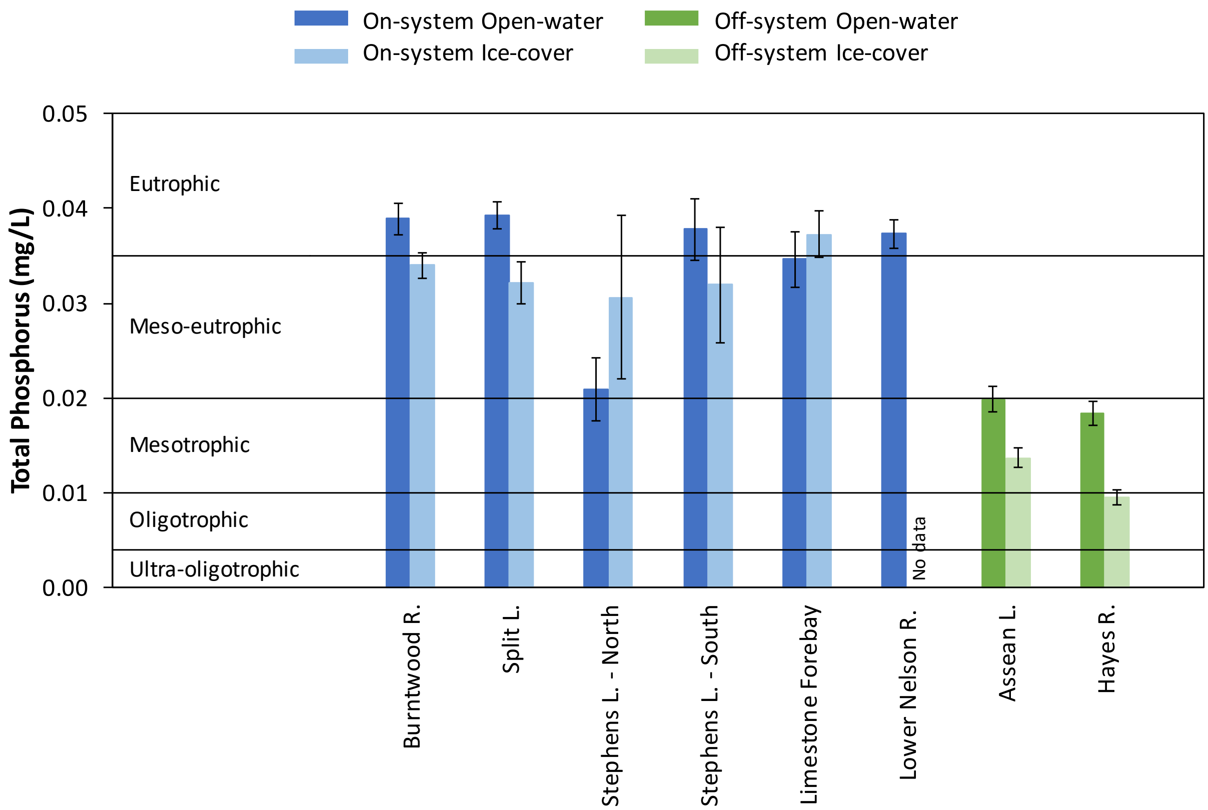


Figure 71. Mean (±SE) total phosphorus concentrations in the Lower Nelson River Region from 2008-2019 compared to the CCME Canadian Guidance Framework for Phosphorus (CCME 2004).

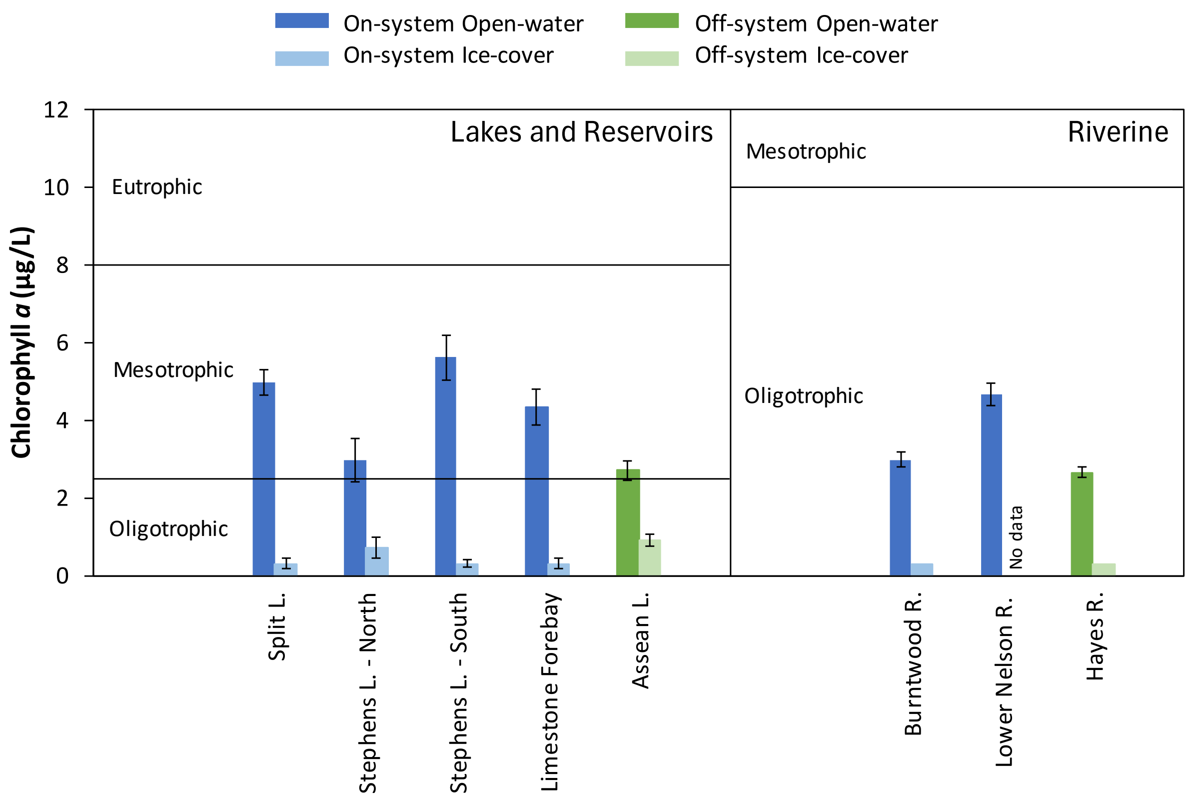


Figure 72. Mean (±SE) chlorophyll *a* concentrations in the Lower Nelson River Region from 2008-2019 compared to trophic categories for lakes and reservoirs (OECD 1983) and riverine sites (Dodds et al. 1998).

4.7.3 Benthic Invertebrates Regional Summary

The nearshore benthic invertebrate community varied between years and across sites in the Lower Nelson River Region. Amphipoda (Hyalellidae), Chironomidae and/or Ephemeroptera (Baetidae) were the dominant taxa in most years at the Burntwood River and Split Lake sites. Oligochaeta dominated the Stephens Lake - South community, whereas in Stephens Lake - North, Chironomidae and/or Corixidae were the dominant taxa. These taxa, along with Amphipoda (Hyalellidae), were also prevalent in the off-system Assean Lake. Oligochaeta, Chironomidae and/or Corixidae were dominant in most sampling years at both lower Nelson River sites (the Limestone GS Forebay and the lower Nelson River - downstream of the Limestone GS). These taxa, along with

Bivalvia (Sphaeriidae), were also common in the off-system Hayes River. Relative to the other nearshore sites, mean total invertebrate abundance (all years combined) was lowest in Stephens Lake (North and South). Mean total abundance was relatively comparable amongst the Burntwood River, Split Lake, both lower Nelson River sites, and both off-system sites (Hayes River and Assean Lake).

The nearshore substrate in the Burntwood River (predominantly silty clay loam) differed from other on-system sites (a greater proportion of sand). Differences between metrics at on-system sites with finer substrates and the off-system Assean Lake with mainly coarse substrates (cobble, boulder) appear related to the different substrate composition. Location of the sampling area at the lower Nelson River - downstream of the Limestone GS site moved year-to-year relative to the water level at the time of sampling. However, substrate composition was similar among sampling years at this site and comparable to the off-system Hayes River nearshore site (sand, mixed with cobble and gravel). The main community differences between these two large river sites were higher taxonomic richness and diversity values (as shown in Figure 75), and the prevalence of Bivalvia (Sphaeriidae), in the Hayes River. By comparison, abundance of Sphaeriidae was negligible at the on-system lower Nelson River site where frequent water level changes may be affecting this group (e.g., benthic habitat instability due to frequent [daily and/or hourly] changes in water levels).

The benthic invertebrate community composition in the offshore varied between years and across sites. Overall, taxa were typical of the substrate composition found at each of the sites. Chironomidae and/or Bivalvia (Sphaeriidae) were the dominant taxa in the Burntwood River. Amphipoda (Pontoporeiidae), Bivalvia (Sphaeriidae), and/or Gastropoda (Hydrobiidae) dominated in Split Lake. Community composition in Stephens Lake – South was mainly comprised of Amphipoda (Pontoporeiidae), whereas in Stephens Lake - North, Chironomidae and/or Ephemeroptera (Ephemeridae) dominated. Community composition in the off-system Assean Lake was mainly comprised of Bivalvia (Sphaeriidae), Chironomidae, and/or Ephemeroptera (Ephemeridae). Oligochaeta, Bivalvia (Sphaeriidae), and/or Chironomidae were dominant at the Limestone Forebay. Community composition was more similar between 2016 and 2019 at the lower Nelson River - downstream of the Limestone GS (Oligochaeta and Gastropoda: Hydrobiidae), when the offshore polygon was re-located to a shallower area (3 to 5 meters) that could be consistently sampled annually.

Mean total invertebrate abundance (densities; all years combined) in the offshore habitat was lowest in Stephens Lake - North and highest in Split Lake. Mean abundance was also relatively high at the lower Nelson River and Stephens Lake - South sites. Mean total abundance was similar between the Burntwood River and the off-system Assean Lake. An offshore sampling area was not established in the Hayes River due to hard/scoured substrate and/or fast water in the 5 to 10 m water depth range. Observed differences in invertebrate metrics at offshore sites did not appear related to sediment composition. Substrates in the Burntwood River and Stephens Lake (South and North) were less sandy compared to Split Lake, the Limestone Forebay, and the off-system Assean Lake but overall composition was relatively similar among these sites (clay to silty clay to silty clay loam). Sediment composition at the lower Nelson River - downstream of the Limestone GS site was much sandier compared to all other sites.

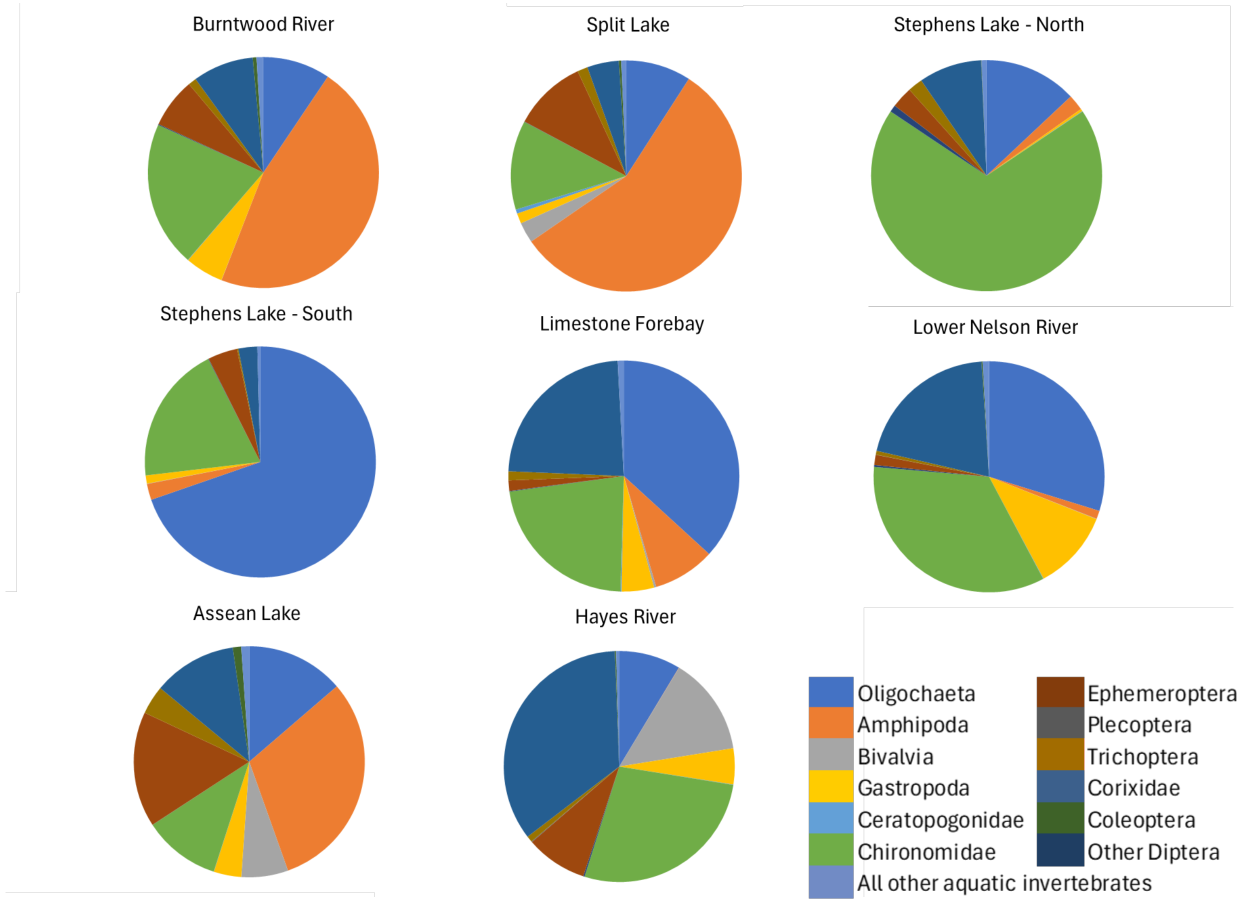


Figure 73. Average relative abundance (% of total) of the benthic invertebrate taxa groups captured at nearshore sites in the Lower Nelson River Region from 2010-2019.

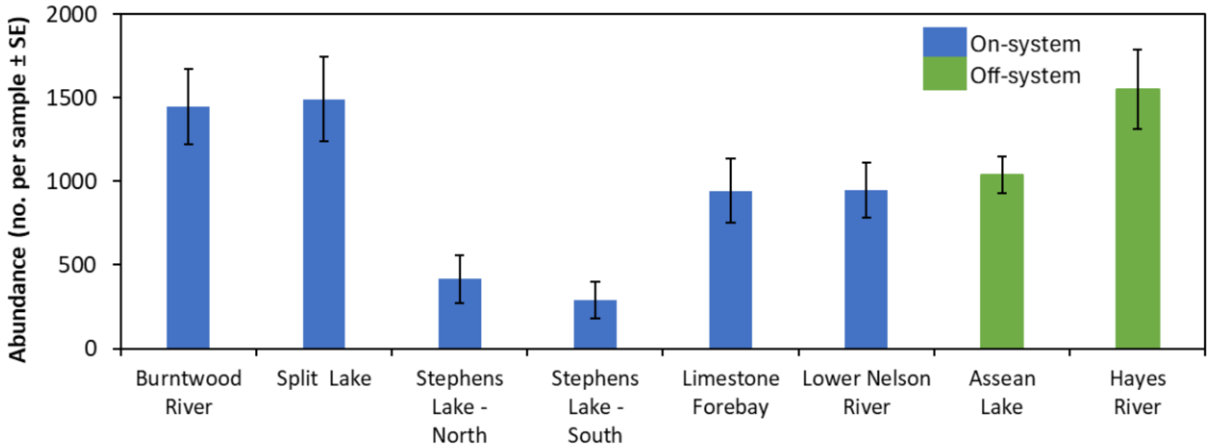


Figure 74. Average total abundance (no. per sample ± SE) of benthic invertebrates captured at nearshore sites in the Lower Nelson River Region from 2010-2019.

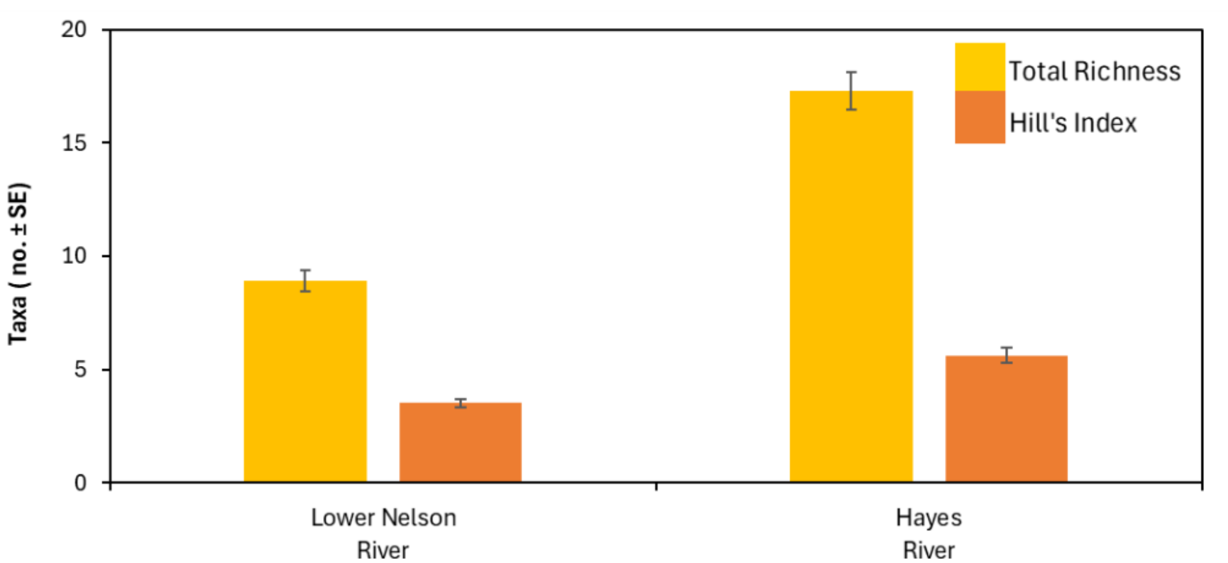


Figure 75. Average number of benthic invertebrate taxa (total richness and Hill's Index ± SE) captured at the lower Nelson River (downstream of Limestone GS) and the Hayes River nearshore sites in the Lower Nelson River Region from 2010-2019.

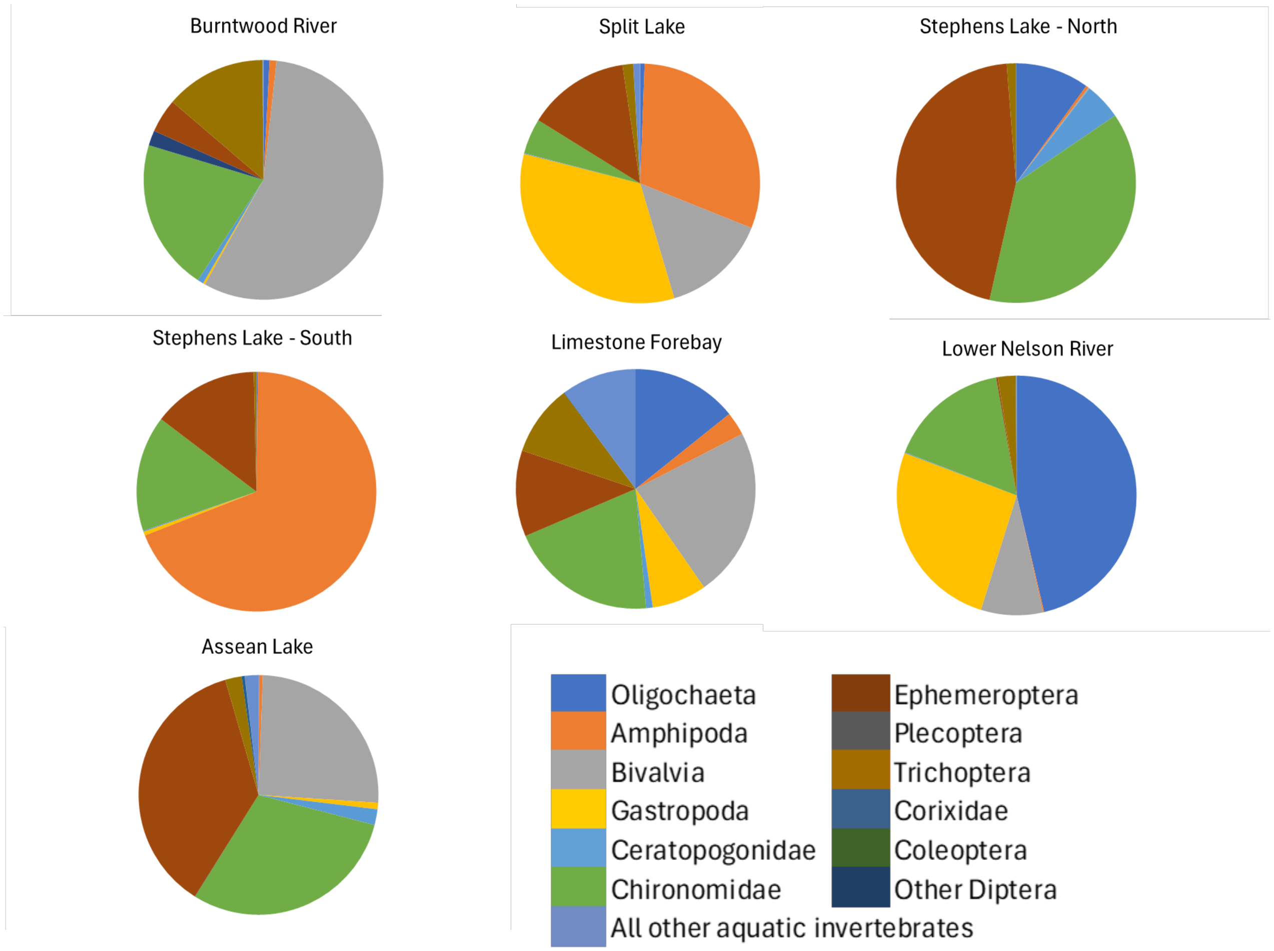


Figure 76. Average relative abundance (density, % of total) of the benthic invertebrate taxa groups captured at offshore sites in the Lower Nelson River Region from 2010-2019.

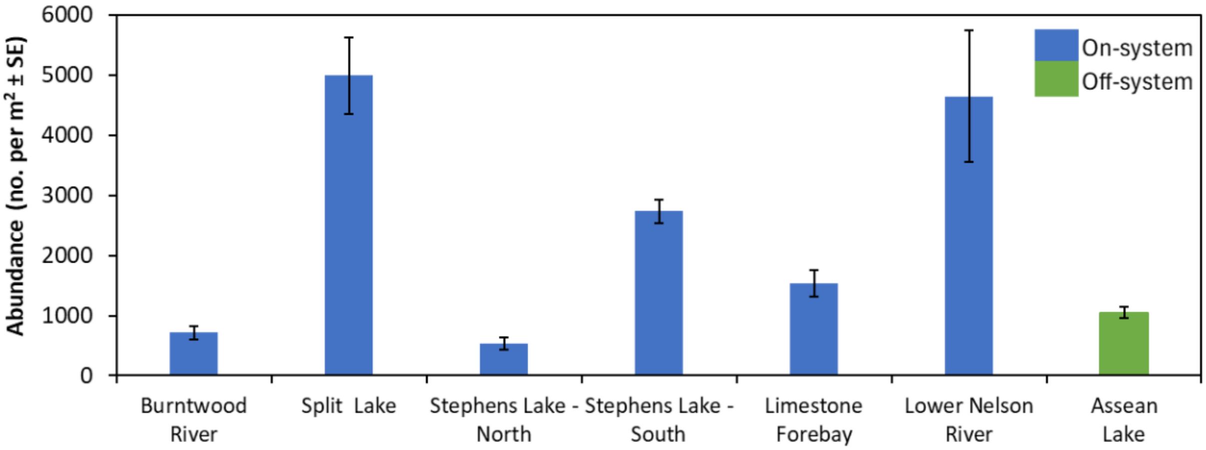


Figure 77. Average total abundance (density, no. per m^2 ± SE) of benthic invertebrates captured at offshore sites in the Lower Nelson River Region from 2010-2019.

4.7.4 Fish Community Regional Summary

There were some key differences in species composition among the on-system waterbodies along the lower Nelson River. Walleye was a common species in waterbodies above the Kettle GS (i.e., the Burntwood River, Split Lake, and both areas of Stephens Lake), while Longnose Sucker was a common species in the two most downstream waterbodies (Limestone Forebay and lower Nelson River downstream of the Limestone GS). Sauger was only common in the two most upstream waterbodies (the Burntwood River and Split Lake), which also had higher overall diversity, and, in the case of Split Lake, the highest total fish abundance. Northern Pike were particularly common in both areas of Stephens Lake and the lower Nelson River downstream of the Limestone GS. The Limestone Forebay generally had the lowest diversity and total fish abundance of the on-system waterbodies. Shiners (Emerald or Spottail) and Trout-perch were typically the most common forage species captured at the on-system waterbodies.

Monitoring results indicate that the invasive Rainbow Smelt, which have been observed in all the on-system waterbodies, have not become well established as catches of this species have typically declined over the monitoring period. Lake Sturgeon were captured at all of the on-system waterbodies except for Stephens Lake - North and were relatively common in catches from the Burntwood River downstream of First Rapids and the lower Nelson River downstream of the Limestone GS[8]. A few species were unique to some of the on-system waterbodies: Silver Redhorse were only captured in Split Lake and Brook Trout were only captured in the waterbodies downstream of the Kettle GS.

The species composition of the off-system Assean Lake was similar to the on-system lakes in that Walleye, White Sucker, and the two shiner species were common species. At the Hayes River, the most frequently captured species were Lake Sturgeon, Walleye, and Trout-perch. There were some notable differences at both off-system waterbodies relative to on-system waterbodies:

- Rainbow Smelt were not captured at either waterbody;
- Sauger were not captured at either waterbody;
- Lake Chub was a common species in the Hayes River; and
- catches, particularly of Walleye, were notably higher at Assean Lake.

The condition of both Northern Pike and Walleye was slightly lower in Assean Lake compared to the on-system waterbodies, while the condition of White Sucker was lower in the rivers (the Hayes and lower Nelson River and, to a lesser extent, the Burntwood River) compared to the lakes and forebays. The condition of Lake Whitefish was particularly high in Stephens Lake - South compared to the other waterbodies and was especially high in 2009 at both Stephens Lake - South and Split Lake.

The condition of Walleye from all on-system waterbodies decreased over the monitoring period. In addition, the condition of Northern Pike from Split Lake decreased over the period of 2012-2019 but were still within the range observed at the off-system waterbodies.

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[8] The methodologies used in the Fish Community sampling program are not designed to target Lake Sturgeon or capture them in proportion to their abundance (i.e., larger gill net mesh sizes are excluded from the gear).

The growth of young Northern Pike (age 4) was generally higher at the two on-system downstream sites (the Limestone Forebay and the lower Nelson River) as well as the off-system Hayes River; whereas young Walleye (age 3) were typically shorter in Stephens Lake - South and the off-system Assean Lake compared to the other waterbodies.

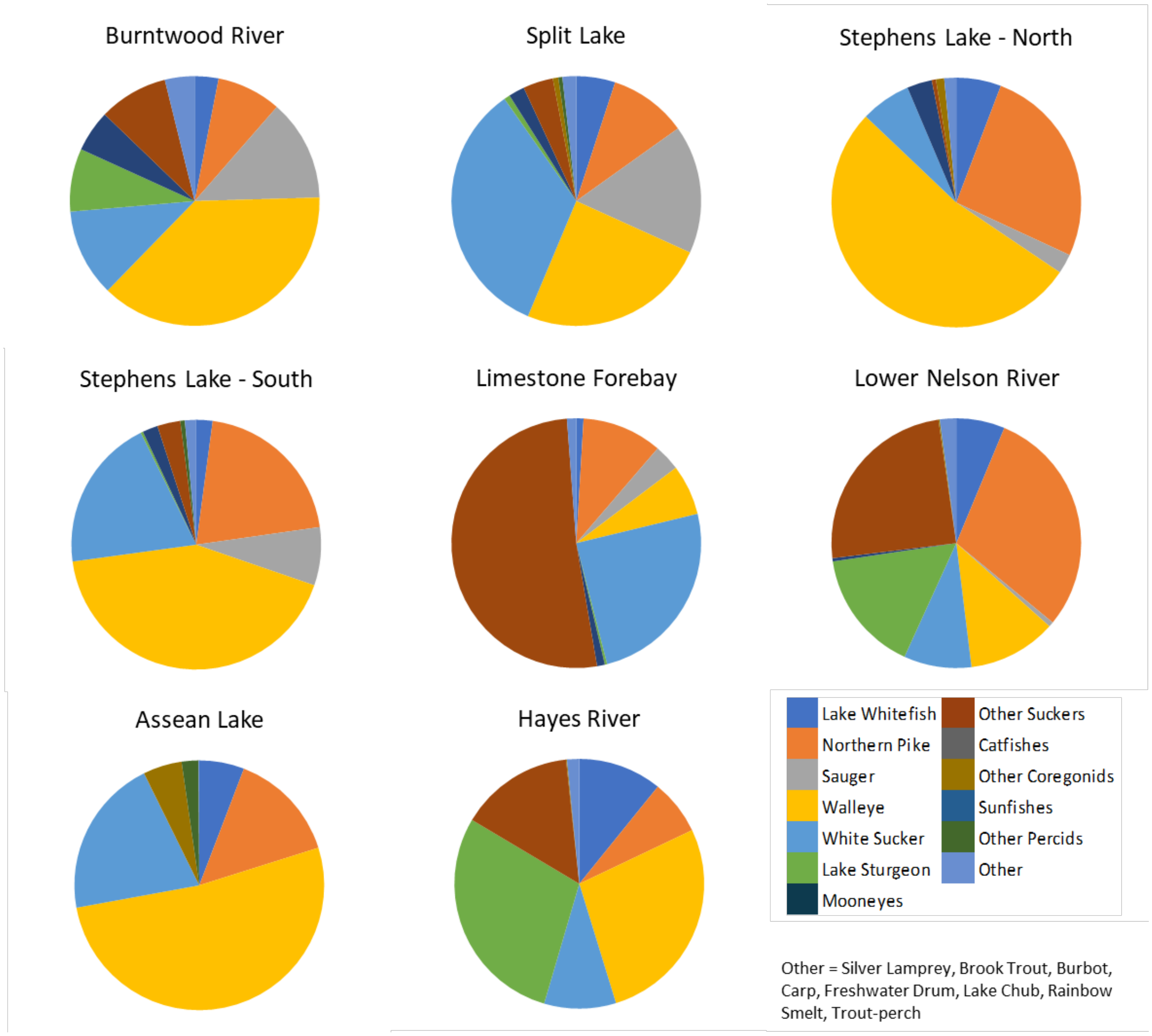


Figure 78. Average relative species abundance of target species and taxa groups captured annually in standard gang gill nets in standard gang gill nets in the Lower Nelson River Region from 2008-2019.

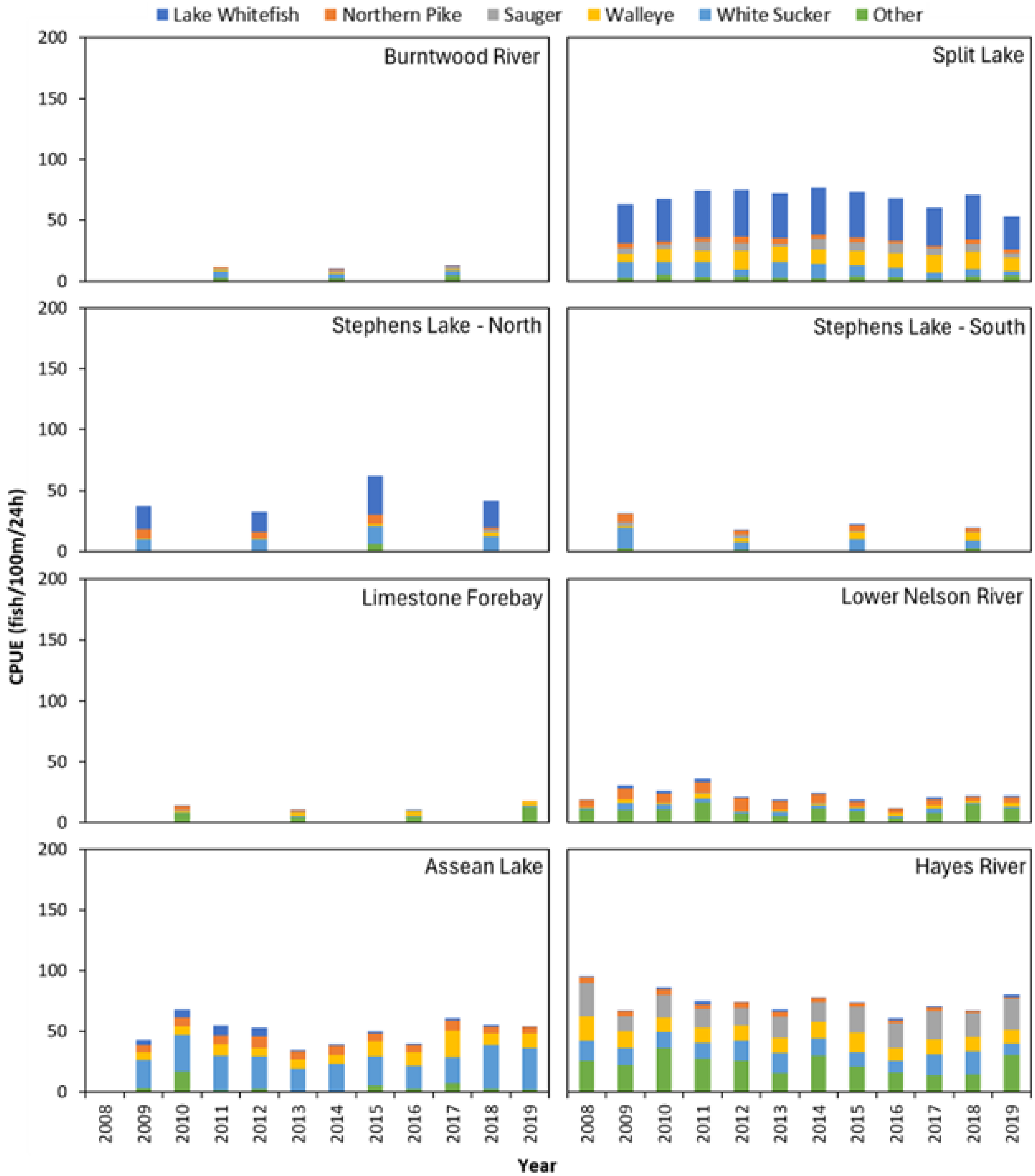


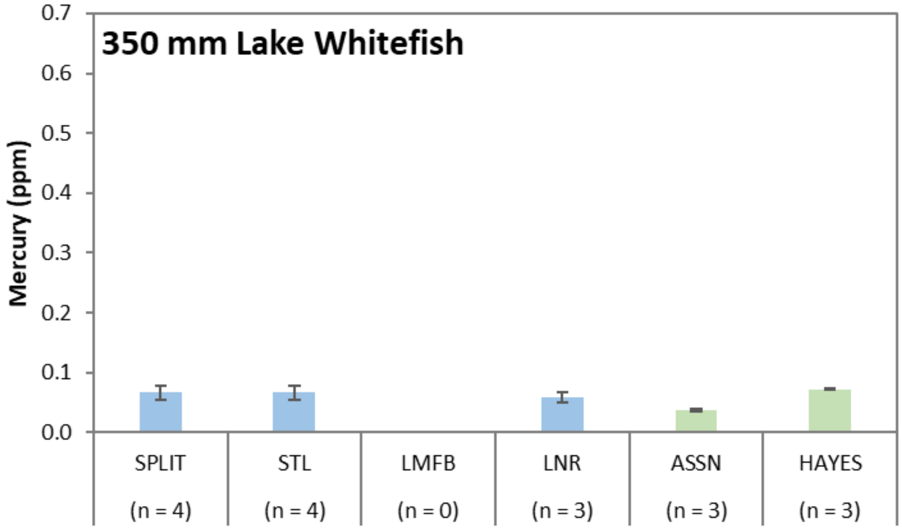
Figure 79. Average catch-per-unit-effort (fish/100 m/24 hr) per year of target species captured in standard gang gill nets in the Lower Nelson River Region from 2008-2019.

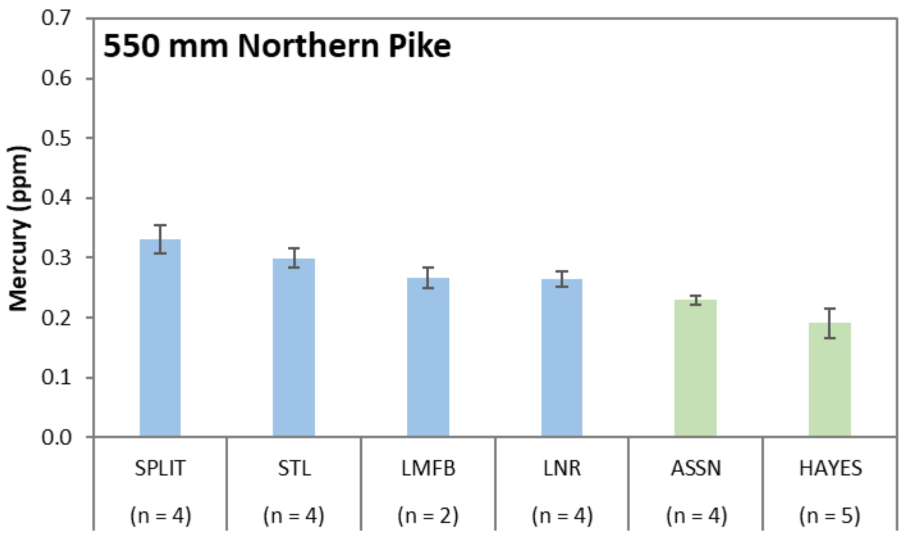
4.7.5 Mercury in Fish Regional Summary

As CAMP is an ecosystem monitoring program, it does not analyze mercury in fish data in relation to human health. Data collected through CAMP is made available to the relevant experts and authorities for human health analysis.

Standard mean mercury concentrations in a 550 mm Northern Pike decreased in a downstream direction along the lower Nelson River, with higher concentrations in Split Lake (mean in all years sampled: 0.33 ppm) and Stephens Lake (mean in all years sampled: 0.30 ppm) and lower concentrations in the Limestone Forebay (mean in all years sampled: 0.27 ppm) and the lower Nelson River below the Limestone GS (mean in all years sampled: 0.26 ppm; Figure 1). This was not observed for mercury concentrations in a 350 mm Lake Whitefish (mean in all years sampled: 0.067, 0.066, and 0.059 ppm, respectively) or 400 mm Walleye (mean in all years sampled: 0.31, 0.36, 0.33, and 0.29 ppm, respectively).

Length-standardized mean mercury concentrations of Walleye and Lake Whitefish from the off-system Hayes River (mean in all years sampled: 0.35 and 0.072 ppm, respectively) were higher than from Assean Lake (mean in all years sampled: 0.26 and 0.037 ppm, respectively) and were similar to the concentrations found in the two species caught in on-system waterbodies (mean in all years sampled: 0.29-0.36 and 0.059-0.067 ppm, respectively) (Figure 1). Length-standardized mercury concentrations in Northern Pike were lowest at the Hayes River (mean in all years sampled: 0.19 ppm) and were lower than concentrations found in Northern Pike caught from the on-system waterbodies (mean in all years sampled: 0.26-0.33 ppm).


350 mm Lake Whitefish
Mercury (ppm)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
SPLIT (n = 4)
STL (n = 4)
LMFB (n = 0)
LNR (n = 3)
ASSN (n = 3)
HAYES (n = 3)


550 mm Northern Pike
Mercury (ppm)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
SPLIT (n = 4)
STL (n = 4)
LMFB (n = 2)
LNR (n = 4)
ASSN (n = 4)
HAYES (n = 5)

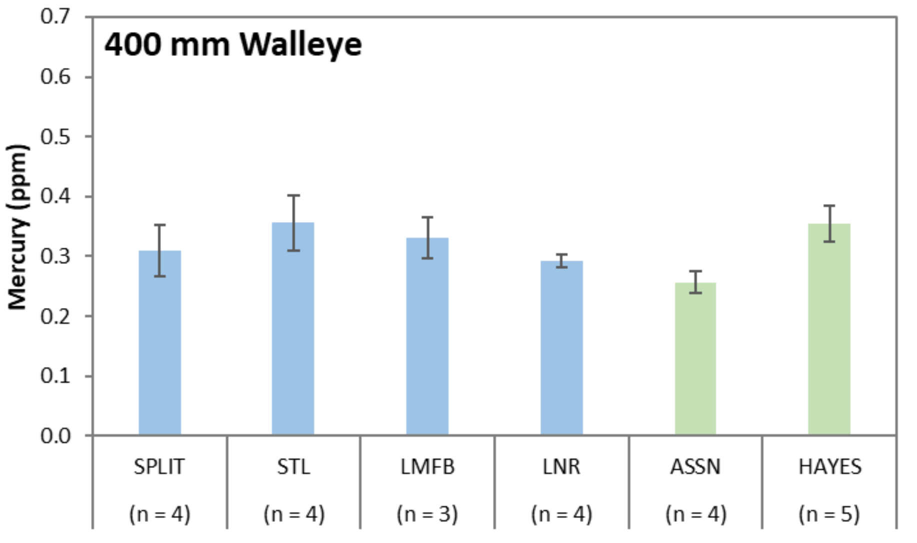


Figure 80. Average length-standardized mercury concentration (± standard error) in fish muscle from Lower Nelson River Region waterbodies.

Blue = on-system, Green = off-system, n = number of sampling years.

5.0 Conclusion

CAMP is a long-term monitoring program that continues to build an extensive data set over time. Establishing a long-term data set through CAMP serves a number of purposes such as informing various decision-making processes and resource management. CAMP data will be essential for future environmental assessments and other processes. As CAMP data is publicly available, it continues to be used by universities, Indigenous communities, consultants, government agencies, students, and others to support a variety of research and other initiatives.

CAMP continues to evolve over time. The program is currently undergoing an expansion to develop a shoreline monitoring component in partnership with Indigenous communities. CAMP's approach to reporting is also being reevaluated with a goal of sharing data more widely in an accessible and timely fashion. This will involve a transition towards a public online data platform where CAMP data can be explored and downloaded. As the platform is developed, all CAMP data remains publicly available by request through the CAMP website (https://www.campmb.ca/request-data).

6.0 Literature Cited

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