CAMP

Coordinated Aquatic Monitoring Program

CAMP Twelve Year Data Report (2008-2019)

Technical Document 6:

Churchill River Diversion Region

Prepared by

Manitoba Hydro

And

North/South Consultants Inc.

2024

Coordinated Aquatic Monitoring Program

Report Citation

Coordinated Aquatic Monitoring Program (CAMP). 2024. CAMP Twelve Year Data Report (2008-2019). Report prepared for Manitoba/Manitoba Hydro CAMP Steering Committee by Manitoba Hydro and North/South Consultants Inc., Winnipeg, MB.

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TECHNICAL DOCUMENT 6: CHURCHILL RIVER DIVERSION REGION

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CAMP

EXECUTIVE SUMMARY

This report presents the results of monitoring conducted under the Coordinated Aquatic Monitoring Program (CAMP) for years 1 through 12 (i.e., 2008/2009 through 2019/2020) in the Churchill River Diversion Region. The Churchill River Diversion Region is composed of the Rat/Burntwood River system from downstream of Notigi Lake and the Notigi Lake Control Structure (CS) to First Rapids on the Burntwood River, approximately 20 km upstream of Split Lake. Waterbodies and sites monitored in this region over this period included three on-system and one off-system waterbodies as follows:

- Threepoint Lake;
- Apussigamasi Lake;
- Footprint lake; and
- Leftrook Lake (off-system).

Monitoring on-system waterbodies addresses the primary objective of CAMP – to monitor aquatic ecosystem health along Manitoba Hydro's hydraulic operating system. The off-system waterbodies were included in CAMP to provide regional information collected in a manner consistent with monitoring of on-system waterbodies that will assist in interpreting any observed environmental changes over time. Such comparisons are intended to help distinguish between hydroelectric-related effects and other external factors (e.g., climate change) in each CAMP region.

Monitoring was conducted annually at some waterbodies and river reaches and on a three-year rotation at other sites. Components monitored under CAMP in the Churchill River Diversion Region presented in this report include water regime, water quality, benthic macroinvertebrates, fish community, and mercury in fish. Results of sedimentation monitoring conducted at the Wuskwatim Generating Station (GS) are also included. Climatological data for the region are also included to provide supporting information to assist with interpretation of CAMP monitoring results.

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ABBREVIATIONS, ACRONYMS, AND UNITS

ANN	Annual
CAMP	Coordinated Aquatic Monitoring Program
CCME	Canadian Council of Ministers of the Environment
CL(s)	Confidence limit(s)
cms	Cubic metres per second
CONT	Continuous
CPUE	Catch-per-unit-effort
CRD	Churchill River Diversion
CS	Control structure(s)
DELTs	Deformities, Erosion, Lesions, and Tumours
DL(s)	Detection limit(s)
DO	Dissolved oxygen
ECCC	Environment and Climate Change Canada
EPT	Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)
FLA	Fork length-at-age
FNU	Formazin nephelometric unit
GN	Standard gang index gill net
GS(s)	Generating station(s)
h	hour
IC	Ice-cover season
IQR	Interquartile range
KF	Fulton's Condition Factor
m	Metre
m^2	Metre squared
Max	Maximum
µg/L	Micrograms per litre
mg/L	Milligrams per litre
Min	Minimum
mm	Millimetre
MWQSOGs	Manitoba Water Quality Standards, Objectives, and Guidelines
MWS	Manitoba Water Stewardship
n	Sample size or number of samples
n_F	Number of fish
no.	Number
ND	No data

n_S	Number of sites
NS	Nearshore
n_{spp}	Number of species caught in standard and small mesh gill nets
NTU	Nephelometric turbidity units
O+C	Oligochaeta and Chironomidae
OECD	Organization for Economic Cooperation and Development
OS	Offshore
OW	Open-water season
PAL	Protection of aquatic life
ppm	Parts per million
RCEA	Regional cumulative effects assessment
ROT	Rotational
RSA	Relative species abundance
RYCS	Relative year-class strength
SD	Standard deviation
SE	Standard error
SN	Small mesh index gillnet gang
SP	Spring
SU	Summer
spp.	species
T/day	Tonnes per day
TN	Total nitrogen
TOC	Total organic carbon
TP	Total phosphorus
TSS	Total suspended solids
unid.	unidentified
WI	Winter
Wr	Relative weight
°C	Degree Celsius

WATERBODY ABBREVIATIONS

Abbreviation	Waterbody
3PT	Threepoint Lake
FOOT	Footprint Lake
APU	Apussigamasi Lake
LEFT	Leftrook Lake

FISH SPECIES LIST

Abbreviation	Common Species Name	Species Name
BURB	Burbot	*Lota lota*
CISC	Cisco	*Coregonus artedi*
EMSH	Emerald Shiner	*Notropis atherinoides*
GOLD	Goldeye	*Hiodon alosoides*
LKCH	Lake Chub	*Couesius plumbeus*
LKWH	Lake Whitefish	*Coregonus clupeaformis*
LNSC	Longnose Sucker	*Catostomus catostomus*
MOON	Mooneye	*Hiodon tergisus*
NRPK	Northern Pike	*Esox lucius*
SAUG	Sauger	*Sander canadensis*
SHRD	Shorthead Redhorse	*Moxostoma macrolepidotum*
SPSH	Spottail Shiner	*Notropis hudsonius*
TRPR	Trout-perch	*Percopsis omiscomaycus*
WALL	Walleye	*Sander vitreus*
WHSC	White Sucker	*Catostomus commersonii*
YLPR	Yellow Perch	*Perca flavescens*

1.0 INTRODUCTION

This report presents the results of monitoring conducted under the Coordinated Aquatic Monitoring Program (CAMP) for years 1 through 12 (i.e., 2008/2009 through 2019/2020) in the Churchill River Diversion Region. The Churchill River Diversion Region is composed of the Rat/Burntwood River system from downstream of Notigi Lake and the Notigi Lake Control Structure (CS) to First Rapids on the Burntwood River, approximately 20 km upstream of Split Lake. Waterbodies and sites monitored in this region over this period included three on-system and one off-system waterbodies as follows:

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- Footprint Lake; and
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Monitoring on-system waterbodies addresses the primary objective of CAMP – to monitor aquatic ecosystem health along Manitoba Hydro's hydraulic operating system. The off-system waterbodies were included in CAMP to provide regional information collected in a manner consistent with monitoring of on-system waterbodies that will assist in interpreting any observed environmental changes over time. Such comparisons are intended to help distinguish between hydroelectric-related effects and other external factors (e.g., climate change) in each CAMP region.

A summary of monitoring conducted by waterbody or river reach presented in this data report is provided in Table 1-1 and monitoring areas are shown in Figure 1-1. As noted in Table 1-1, monitoring was conducted annually at some waterbodies and river reaches and on a three-year rotation at other sites. Components monitored under CAMP in the Churchill River Diversion Region presented in this report include the physical environment (water regime and sedimentation), water quality, benthic macroinvertebrates, fish community, and mercury in fish. Climatological data for the region are also included to provide supporting information to assist with interpretation of CAMP monitoring results.

Table 1-1. Churchill River Diversion Region CAMP monitoring summary.

Waterbody/ Area	Abbreviation	On/Off-System		Component					
		On-System	Off-System	Water Regime	Sedimentation	Water Quality	Benthic Invertebrates	Fish Community	Fish Mercury
Notigi Lake CS	NOT CS	●		CONT					
Threepoint Lake	3PT	●		CONT		ANN	ANN	ANN	ANN
Wuskwatim Generating Station (GS)	WUSK GS	●			CONT				
Apussigamasi Lake	APU	●		CONT		ROT	ROT	ROT	
Footprint Lake	FOOT	●		CONT		ROT	ROT	ROT	
Leftrook Lake	LEFT		●	CONT		ANN	ANN	ANN	ANN

Notes:

1. CONT = site monitored continuously; ANN = site sampled each year; ROT = site sampled every 3 years.

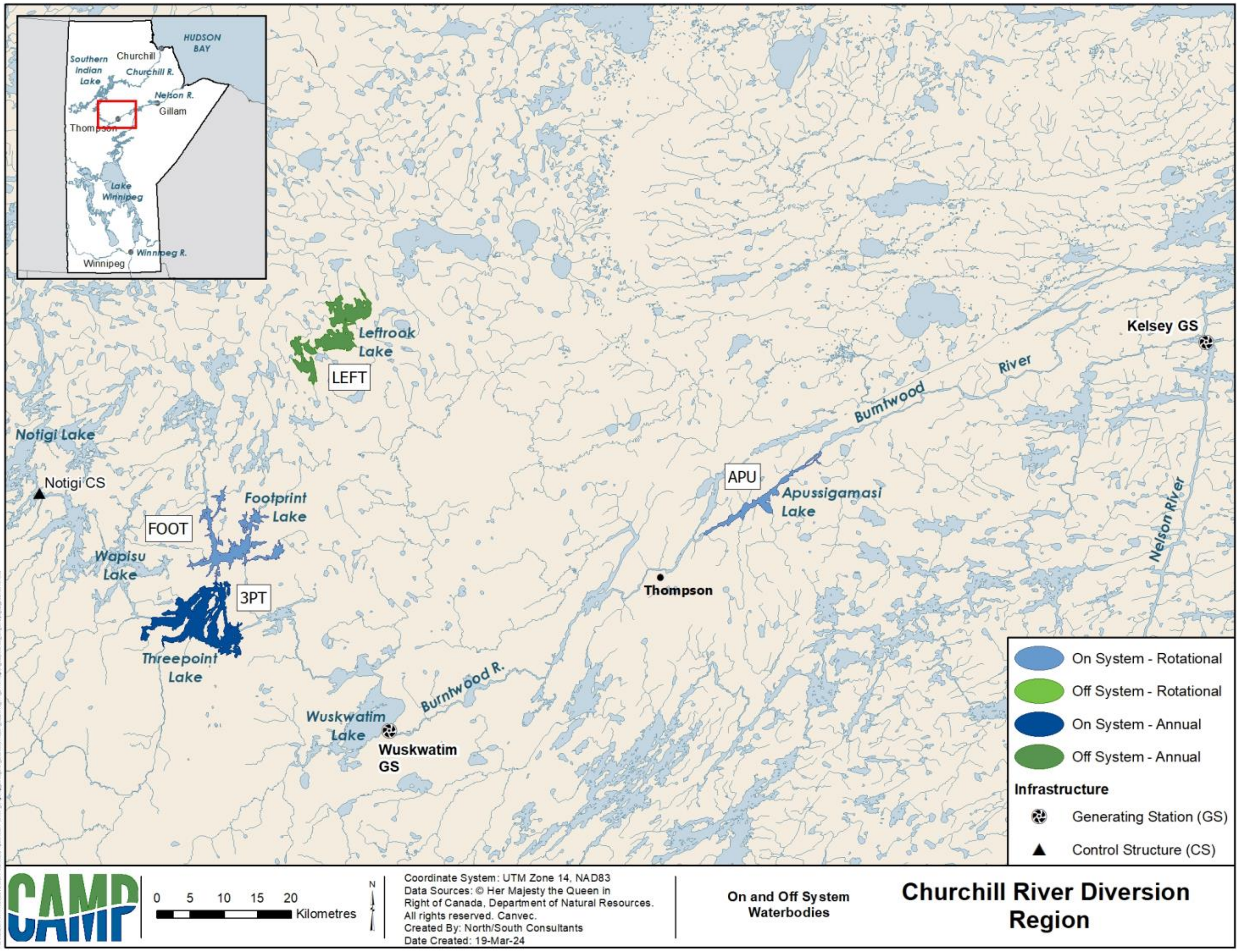


Figure 1-1. On-system and off-system waterbodies and river reaches sampled under CAMP in the Churchill River Diversion Region: 2008-2019.

Photograph 1. Threepoint Lake.

Photograph 2. Apussigamasi Lake.

Photograph 3. Footprint Lake.

Photograph 4. Leftrook Lake.

2.0 PHYSICAL ENVIRONMENT

2.1 INTRODUCTION

The following presents the results of the physical environment monitoring conducted from 2008 to 2019 in the Churchill River Diversion Region. Four waterbodies were monitored in the Churchill River Diversion Region: three on-system sites (Threepoint, Footprint, and Apussigamasi lakes); and one off-system site (Leftrook Lake; Figure 1-1). In addition, a continuous water quality monitoring station is located at the Wuskwatim GS. Though CAMP does not directly monitor climate, data from Environment and Climate Change Canada (ECCC) is included in reporting to contextualize the data collected under each CAMP component. For the Churchill River Diversion Region, meteorological conditions from ECCC's Thompson station are reported.

Three indicators (climate; water regime; and sedimentation) were selected for detailed reporting (Table 2.1-1). Metrics for these indicators include temperature, precipitation, water flow, level and variability, water temperature, continuous turbidity, and suspended sediment load (Table 2.1-1). A detailed description of these indicators in provided in CAMP (2024).

A detailed description of the program design and sampling methods is provided in Technical Document 1, Sections 2.1 and 2.2.

Table 2.1-1. Physical Environment indicators and metrics.

Indicator	Metric	Units
Climate[1]	• Temperature	Degrees Celsius (°C)
	• Precipitation	Millimetres (mm)
Water Regime	• Flow	Cubic meters per second (cms)
	• Water Level and Variability	Metres (m)
	• Water Temperature	Duration of temperature in 5-degree Celsius increments (#days/5 °C)
Sedimentation	• Continuous Turbidity	Formazin nephelometric unit (FNU)
	• Suspended Sediment Load	Tonnes/day (T/day)

Notes:
1. Climate is not monitored through CAMP; data are included for reporting purposes only.

2.2 CLIMATE

In this section, mean monthly air temperatures and total monthly precipitation for each year in the monitoring program (2008-2020) are compared to ECCC climate normals to provide a summary of the Thompson station meteorological conditions. Climate normals are used to summarize the average climatic conditions of a particular location. As recommended by the World Meteorological Organization, ECCC calculates climate normals using a 30-year period (e.g., 1981-2010). The Thompson station is used herein to illustrate climate conditions in the Churchill River Diversion Region.

Historical monthly average air temperature and total monthly precipitation during the monitoring period were calculated based on available daily data from ECCC at multiple stations. It is important to note that the use of multiple stations could introduce inhomogeneities in observations between various stations and the station used for climate normals (Climate ID: 5062922). For instances where datasets were missing more than 10% of the daily data in a month, monthly values were gap-filled using ERA5-Land data (Muñoz Sabater 2019). Seasonal and annual maps derived from ERA5-Land data are also provided in Appendices 2-1 and 2-2 to complement the station data and offer a broader spatial representation of temperature and precipitation conditions across Manitoba. Although the ERA5-Land data correlated reasonably well with the actual observed ECCC data for the Thompson station, it should be noted that ERA5-Land is a gridded reanalysis product, meaning the dataset combines modelled data with observations, and therefore may not provide an entirely accurate representation of observed climate

2.2.1 TEMPERATURE

Figure 2.2-1 illustrates the mean monthly air temperatures (in °C) for each year during the monitoring period compared to the 1981-2010 normal mean temperature. As shown, air temperatures at this location follow a distinct seasonal pattern; warmer in the summer (warmest in July) and cooler in the winter (coldest in January). In general, recorded air temperatures for the monitoring period were consistent with the climate normal pattern. Some deviations can be seen, for example, 2010 recorded considerably warmer temperatures from January to April.

Table 2.2-1 summarizes the mean monthly air temperature data and categorizes each month in the monitoring period as “below normal”, “near normal” or “above normal” conditions. It should be noted that the “near normal” category was subjectively defined as +/- 1°C of the ECCC climate normal. Months “below normal” are highlighted in blue, “near normal” are highlighted in grey, and “above normal” are highlighted in orange. 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.

Table 2.2-1. Thompson mean monthly and annual air temperature (in ˚C) compared to 1981-2010 normal.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2008	-22.4	-24.9	-17.2	-3.0	4.9	13.0	15.7	16.5	6.3	2.8	-9.6	-27.5	-3.8
2009	-22.4	-21.0	-16.6	-2.2	1.6	11.9	13.9	13.3	12.1	-0.6	-5.8	-22.9	-3.2
2010	-18.1	-16.6	-4.9	3.5	5.8	13.2	17.8	14.2	7.2	2.7	-8.9	-18.7	-0.2
2011	-24.8	-20.3	-16.0	-2.1	5.8	13.7	16.5	15.5	11.3	3.1	-9.7	-16.6	-2.0
2012	-20.6	-16.2	-9.6	-1.3	6.9	13.4	18.0	15.0	8.9	-0.5	-14.1	-22.9	-1.9
2013	-25.6	-20.0	-14.4	-6.4	7.7	15.1	16.1	14.9	11.2	-0.1	-14.5	-29.5	-3.8
2014	-25.4	-23.4	-19.5	-7.5	6.9	12.6	15.8	15.0	7.0	1.6	-14.9	-17.9	-4.2
2015	-23.2	-25.2	-12.7	-2.5	5.3	13.0	16.0	14.2	9.3	1.5	-7.3	-13.3	-2.1
2016	-19.0	-21.4	-10.5	-4.0	8.1	13.3	16.4	14.1	10.1	-0.9	-3.5	-21.5	-1.6
2017	-18.1	-18.4	-13.0	-4.3	5.9	12.2	16.7	15.1	9.9	1.0	-15.5	-23.2	-2.6
2018	-24.1	-23.3	-12.0	-5.7	7.4	14.3	16.3	13.2	4.0	-3.2	-15.6	-17.3	-3.8
2019	-25.5	-24.2	-9.7	-2.5	4.6	12.8	16.0	13.8	8.1	0.4	-12.4	-20.8	-3.3
2020	-19.4	-18.9	-13.5	-7.1	4.5	11.8	18.0	15.1	7.2	-2.5	-13.0	-18.8	-3.0
1981-2010 Normal	-23.9	-20.1	-12.5	-2.2	6.1	12.6	16.2	14.5	7.8	0.1	-12.0	-20.9	-2.9

Below Normal	Near Normal	Above Normal

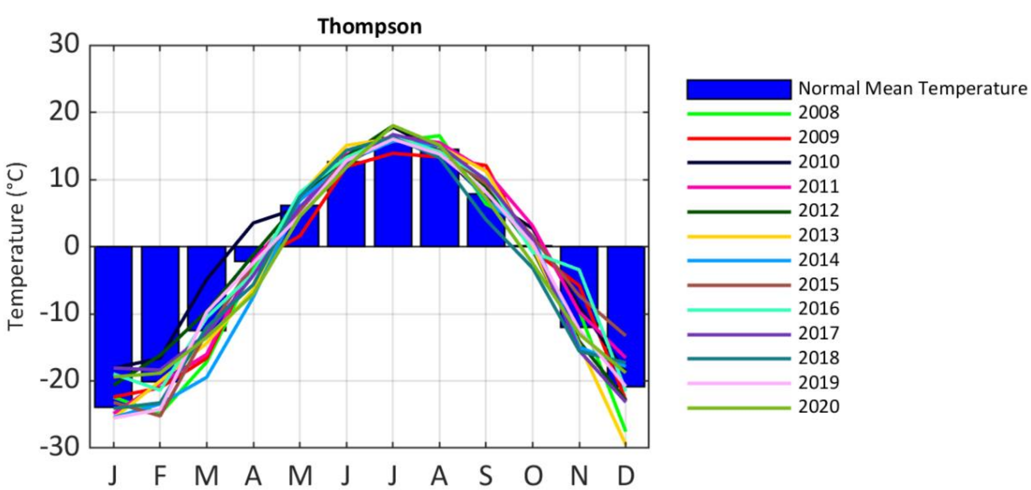


Figure 2.2-1. Thompson mean monthly air temperature (in °C) compared to 1981-2010 normal.

2.2.2 PRECIPITATION

Figure 2.2-2 illustrates the monthly total precipitation (in mm) for each year during the monitoring period compared to the 1981-2010 normal total precipitation. Total precipitation refers to the water equivalent of all types of precipitation. The total precipitation at Thompson follows a noticeable seasonal pattern, where generally the highest amounts of precipitation fall during the summer months (July and August) and the lowest amounts fall during the winter months (January and February). Overall, recorded precipitation for the monitoring period followed similar patterns to the climate normal, although deviations can be seen, such as 2018, where the recorded total precipitation for June and July was much higher than normal and for 2017 (August), which recorded total precipitation well below the normal condition.

Table 2.2-2 summarizes the total monthly precipitation data and categorizes each month in the monitoring period as “below normal”, “near normal” or “above normal” conditions. It should be noted that the “near normal” was subjectively defined as +/- 10% of the ECCC climate normal. Months “below normal” are highlighted in light brown, “near normal” are highlighted in grey, and “above normal” are highlighted in green. 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.

Table 2.2-2. Thompson total monthly and annual precipitation (in mm) compared to 1981-2010 normal.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2008	35.2	27.2	35.2	2.8	21.4	46.5	150.7	108.7	52.6	23.2	17.0	13.6	534.1
2009	21.1	45.4	35.0	16.8	46.2	49.4	146.0	41.8	44.1	51.0	14.9	10.2	521.9
2010	32.5	10.8	14.2	13.4	39.0	9.1	91.1	236.1	59.8	60.0	26.2	31.8	624.0
2011	9.4	14.0	7.4	13.2	17.0	53.0	133.5	185.4	35.0	44.3	18.6	20.5	551.3
2012	32.7	8.4	45.0	18.6	19.2	117.1	43.7	108.1	62.0	55.4	16.4	25.8	552.4
2013	10.7	9.4	9.4	9.6	18.0	33.6	77.4	59.4	63.0	63.4	65.4	8.1	427.4
2014	34.4	15.6	27.0	15.4	42.6	94.6	62.8	131.8	26.6	43.8	22.7	16.2	533.5
2015	18.9	8.8	23.6	24.0	25.6	65.6	114.2	52.3	113.8	33.3	11.1	17.0	508.2
2016	12.6	13.2	20.1	3.0	47.1	44.3	112.9	38.1	98.4	114.6	19.1	23.0	546.4
2017	19.0	23.6	72.4	40.4	24.2	60.4	46.5	17.2	39.8	82.2	50.9	31.5	508.1
2018	52.0	14.7	7.8	13.2	7.6	161.6	171.6	47.6	67.6	50.4	25.4	14.6	634.1
2019	28.4	12.2	9.3	38.2	47.9	59.6	102.8	72.9	31.1	39.6	37.3	19.6	498.9
2020	20.1	11.6	23.1	72.1	16.2	117.8	173.6	117.7	61.2	33.7	62.5	36.6	746.2
1981-2010 Normal	19.5	16.5	22.5	29.0	47.4	67.8	80.9	70.7	62.1	37.1	32.9	22.8	509.2

Below Normal	Near Normal	Above Normal

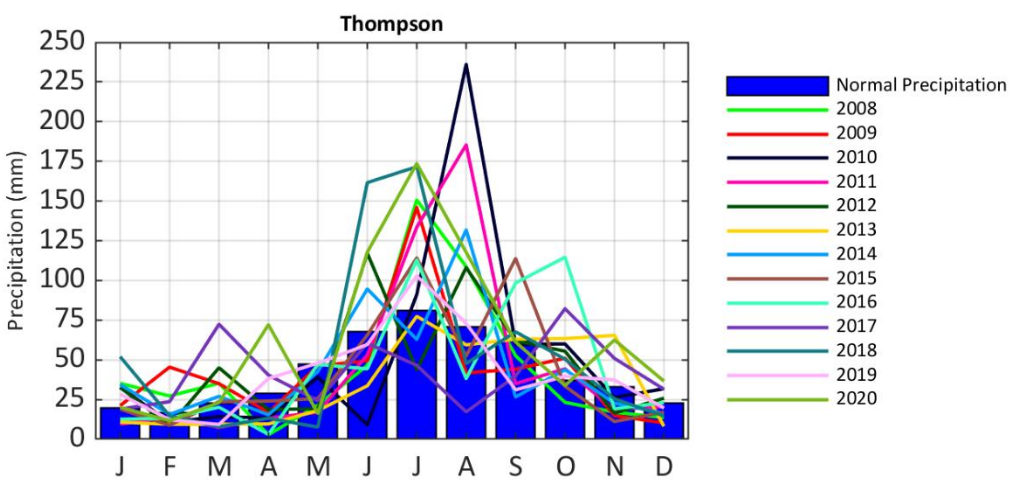


Figure 2.2-2. Thompson total monthly precipitation (in mm) compared to 1981-2010 normal.

2.3 WATER REGIME

The Churchill River Diversion (CRD) improves downstream hydropower generation by transferring the majority of the water flow from the Churchill River to the Nelson River via the Rat River and the Burntwood River. The amount of water diverted to the Nelson River is regulated by the Notigi CS, while Southern Indian Lake is used as a reservoir. Local inflows also contribute to the total water flowing from the Burntwood River into the Nelson River. Additional information on the Churchill River Diversion water regime can be found in the Physical Environment Part IV section of the Regional Cumulative Effects Assessment (RCEA) – Phase II Report (RCEA 2015).

On-System Sites

On-system CAMP monitoring occurred on Threepoint Lake, Footprint Lake, and Apussigamasi Lake (Figure 2.3-1).

Continuous water temperature is measured at the Wuskwatim GS continuous water quality monitoring site. Monitoring started in 2018 and consists of measuring water temperature every 5 minutes and monthly site visits to verify the data. For the water temperature indicator, the continuous water temperature and the duration, in days, that water is below 1 ˚C and five-degree increments is reported.

Off-System Sites

CAMP monitors Leftrook Lake as the off-system waterbody for this region (Figure 2.3-1).

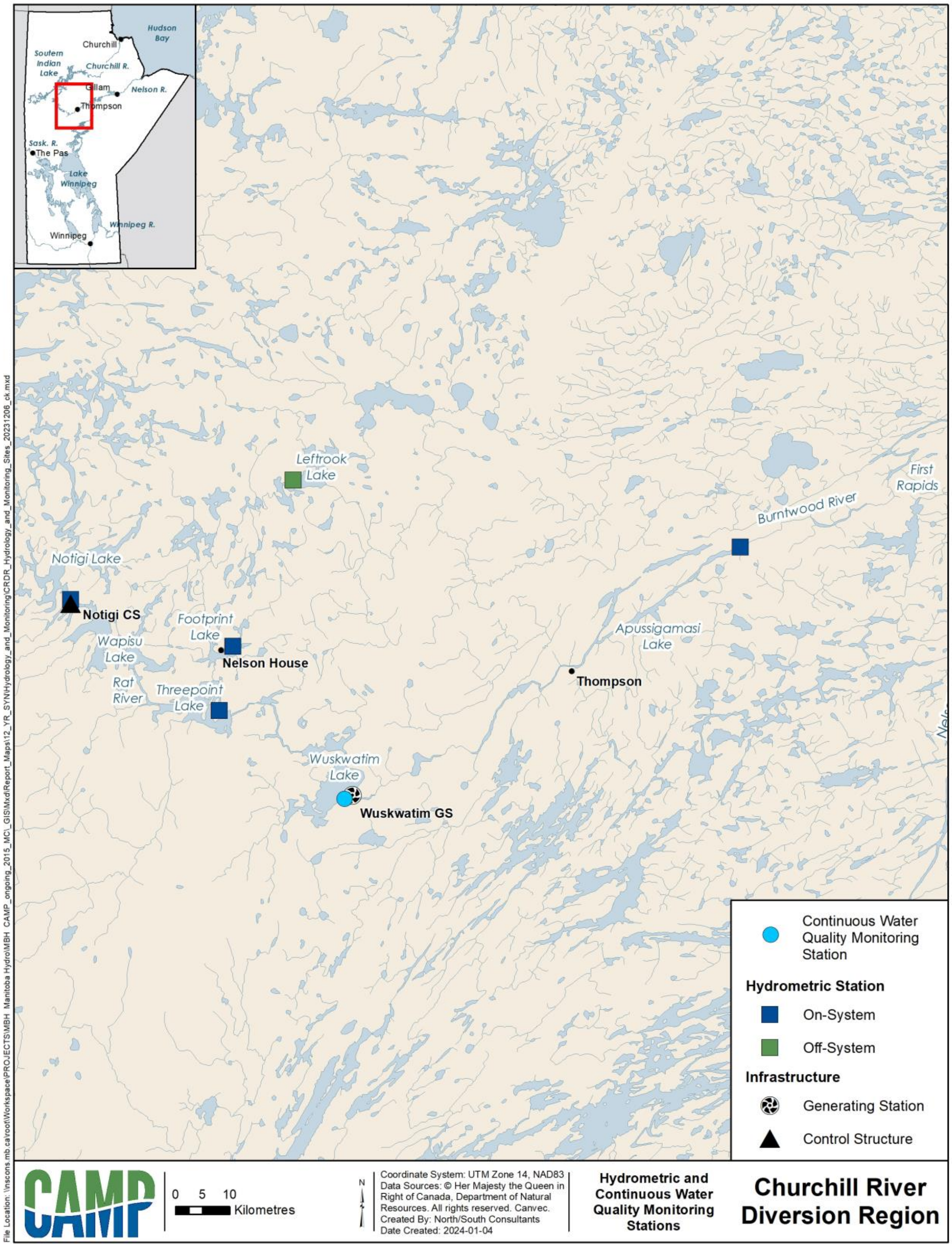


Figure 2.3-1. Hydrometric and continuous water quality monitoring stations in the Churchill River Diversion Region.

2.3.1 FLOW

2.3.1.1 ON-SYSTEM SITES

Notigi Control Structure

From 2008 to 2020, Churchill River Diversion flow conditions ranged from dry to very wet and were more frequently above average than below average compared to the reference period from 1986 to 2015 (Figure 2.3-2 and Table 2.3-1). Monthly mean flow ranged from 523 to 2,392 cms with the overall mean from 2008 to 2020 at 954 cms. Very dry flow conditions, defined as lower than 10^{th} percentile, did not occur in any months during the 2008 to 2020 CAMP monitoring period (Table 2.3-1). Flow conditions were very wet, defined as above the 90^{th} percentile, in parts of eleven years during CAMP, during the following months; July to August 2008, June to December 2009, January 2010, September 2011, June to August and November to December 2012, January, August and October 2013, June to July 2014, May to December 2017 and 2018, January, May to July and November to December 2019, and May to December 2020 (Table 2.3-1).

2.3.1.2 OFF-SYSTEM SITES

There are no off-system flows reported for this region.

Table 2.3-1. Churchill River Diversion at the Notigi CS monthly average flow (cms).

Year	Annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	836	717	719	727	727	836	1029	1251	1100	780	686	708	741
2009	1095	709	699	727	734	889	1138	1177	1465	1667	1527	1291	1099
2010	787	1010	951	900	879	822	768	653	638	761	738	675	657
2011	782	722	735	657	621	732	727	697	951	1103	926	791	717
2012	945	785	770	737	751	970	1139	1228	1037	935	926	1015	1040
2013	896	977	901	843	789	800	781	891	1030	967	1048	903	822
2014	831	794	800	793	693	881	983	997	955	840	805	725	702
2015	710	717	706	709	732	818	741	763	742	698	662	629	601
2016	670	568	543	523	525	685	668	704	851	718	599	764	883
2017	1210	861	836	818	798	1282	1654	1760	1634	1473	1252	1087	1030
2018	1239	957	912	859	819	1155	1231	1275	1568	1670	1562	1258	1092
2019	965	989	923	871	861	1004	1046	1006	943	875	950	1078	1025
2020	1490	972	928	887	862	1046	1331	1827	2392	2254	2029	1817	1502

Very Dry	Dry	Average	Wet	Very Wet
Lower than 10th percentile	10th to 30th percentile	30th to 70th percentile	70th to 90th percentile	Higher than 90th percentile

Notes:

1. Percentiles calculated using 1986-2015 as the reference period.

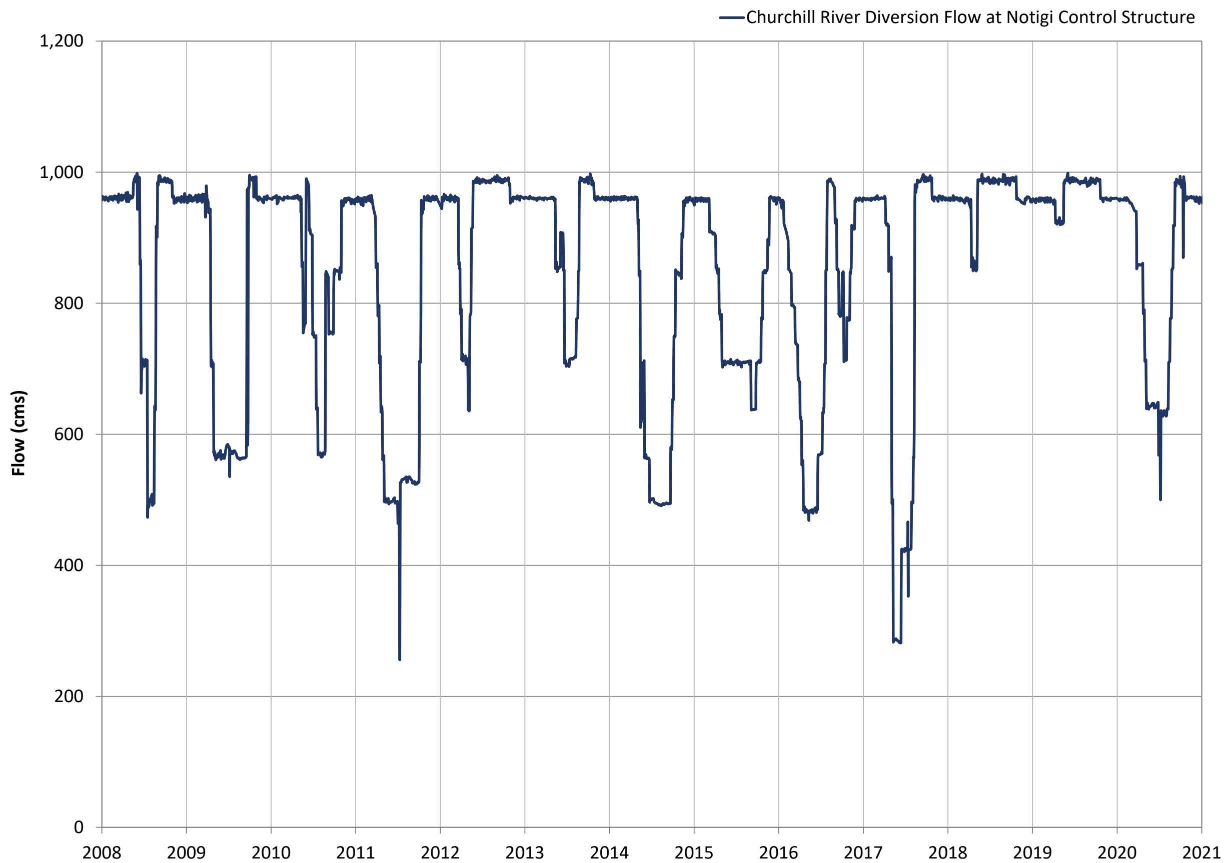


Figure 2.3-2. 2008-2020 Churchill River Diversion at the Notigi CS daily mean flow.

2.3.2 WATER LEVEL AND VARIABILITY

2.3.2.1 ON-SYSTEM SITES

Threepoint Lake

Threepoint Lake is located along the Burntwood River between Notigi and Wuskwatim Lake. Water levels generally follow the pattern set by the CRD flow at Notigi (Figure 2.3-3). During the period from 2008-2020, Threepoint Lake monthly average water levels were more than 0.5 m above the 2008-2020 average in 14 months and were lower than 0.5 m below the 2008-2020 average in 34 months (Table 2.3-2). Threepoint Lake monthly water level variability was lower (below 0.25 m) in 87 months, moderate (between 0.25 and 0.75 m) in 48 months and higher (above 0.75 m) in 20 months (Table 2.3-3).

Footprint Lake

Footprint Lake is located along the Footprint River and is affected by backwater effects of CRD. Water levels generally follow the pattern set by the CRD flow at Notigi (Figure 2.3-4), and closely follow water levels on Threepoint Lake (Figure 2.3-3). During the period from 2008-2020, Footprint Lake monthly average water levels were more than 0.5 m above the 2008-2020 average in 14 months and were lower than 0.5 m below the 2008-2020 average in 34 months (Table 2.3-4). Footprint Lake monthly water level variability was lower (below 0.25 m) in 87 months, moderate (between 0.25 and 0.75 m) in 49 months and higher (above 0.75 m) in 20 months (Table 2.3-5).

Apussigamasi Lake

Apussigamasi Lake is located on the Burntwood River, just downstream from the City of Thompson. The water level gauge on Apussigamasi Lake was established in 2009 as part of CAMP. Water levels generally follow the pattern set by the CRD flow at Notigi (Figure 2.3-5). During the period from 2009-2020, Apussigamasi Lake monthly average water levels were more than 0.5 m above the June 2009-2020 average in 43 months and lower than 0.5 m below the June 2009-2020 average in 30 months (Table 2.3-6). Apussigamasi Lake monthly water level variability was lower (below 0.25 m) in 45 months, moderate (between 0.25 and 0.75 m) in 73 months, and higher (above 0.75 m) in 21 months (Table 2.3-7).

2.3.2.2 OFF-SYSTEM SITES

Leftrook Lake

Water levels on Leftrook Lake vary with precipitation in the local drainage basin (Figure 2.3-6). During the period when data is available from 2010-2020, Leftrook Lake monthly average water levels were more than 0.5 m above the 2010-2020 average in 1 month and not lower than 0.5 m below the 2010-2020 average in any months (Table 2.3-8). Leftrook Lake monthly water level variability was lower (below 0.25 m) in 107 months, moderate (between 0.25 and 0.75 m) in 6 months, and higher (above 0.75 m) in 1 month (Table 2.3-9).

Table 2.3-2. Threepoint Lake monthly average water level (m).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	243.41	243.49	243.49	243.50	243.52	243.20	242.42	242.13	243.23	243.40	243.32	243.31
2009	243.52	243.52	243.50	243.29	242.25	242.16	242.12	241.91	241.84	243.12	243.33	243.33
2010	243.47	243.41	243.34	243.31	243.16	243.09	242.49	241.84	242.84	242.96	243.26	243.42
2011	243.66	243.76	243.62	243.02	241.84	241.34	241.32	241.63	241.61	242.22	243.22	243.27
2012	243.32	243.39	243.33	242.73	242.88	243.55	243.46	243.35	243.36	243.34	243.31	243.42
2013	243.68	243.76	243.48	243.38	243.28	242.99	242.43	242.38	243.21	243.52	243.40	243.32
2014	243.42	243.54	243.51	243.46	243.57	242.52	241.82	241.45	241.29	242.04	242.88	243.27
2015	243.42	243.73	243.65	243.23	242.74	242.48	242.47	242.65	242.51	242.45	242.86	243.27
2016	243.55	243.52	242.98	242.22	241.59	241.59	241.93	243.23	243.21	242.82	242.93	243.36
2017	243.48	243.37	243.41	243.37	243.24	241.80	241.58	241.84	243.26	243.39	243.31	243.29
2018	243.42	243.56	243.44	243.37	243.38	243.52	243.52	243.48	243.45	243.41	243.34	243.33
2019	243.62	243.90	243.54	243.34	243.47	243.56	243.46	243.37	243.42	243.40	243.29	243.25
2020		243.31	243.30	243.11	242.93	242.75	242.79	242.51	243.18	243.51	243.44	243.46

Lower	Average	Higher
Lower than 0.5 m below average	Within 0.5 m below and above average	More than 0.5 m above average

Notes:

1. Blank cell indicates no data.

Table 2.3-3. Threepoint Lake monthly water level range (m).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	0.09	0.05	0.02	0.04	0.12	0.95	0.67	0.93	0.58	0.04	0.09	0.13
2009	0.15	0.06	0.05	0.95	0.37	0.24	0.19	0.37	0.84	0.82	0.06	0.15
2010	0.12	0.06	0.07	0.07	0.55	0.43	1.11	0.82	0.36	0.27	0.37	0.11
2011	0.43	0.29	0.14	1.08	0.89	0.17	0.37	0.28	0.30	1.61	0.17	0.07
2012	0.13	0.06	0.21	0.58	0.68	0.32	0.21	0.04	0.09	0.09	0.11	0.23
2013	0.27	0.28	0.16	0.09	0.34	0.33	0.44	0.61	0.51	0.21	0.15	0.08
2014	0.14	0.07	0.09	0.04	0.85	0.97	0.46	0.25	0.09	1.27	0.44	0.19
2015	0.23	0.37	0.51	0.35	0.50	0.11	0.37	0.25	0.13	0.18	0.46	0.29
2016	0.29	0.33	0.62	0.95	0.16	0.11	0.92	0.79	0.51	0.28	0.53	0.21
2017	0.10	0.05	0.11	0.24	1.26	1.15	0.44	1.62	0.40	0.07	0.13	0.04
2018	0.23	0.07	0.13	0.15	0.16	0.14	0.10	0.13	0.12	0.04	0.10	0.10
2019	0.45	0.23	0.33	0.12	0.22	0.11	0.13	0.08	0.10	0.07	0.10	0.15
2020		0.03	0.04	0.31	0.23	0.34	0.31	0.29	0.82	0.11	0.02	0.29

Lower Variability	Moderate Variability	Higher Variability
Below 0.25 m	0.25 to 0.75 m	Above 0.75 m

Notes:

1. Blank cell indicates no data.

Table 2.3-4. Footprint Lake monthly average water level (m).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	243.39	243.47	243.48	243.50	243.52	243.23	242.43	242.08	243.21	243.38	243.30	243.30
2009	243.49	243.49	243.48	243.29	242.24	242.15	242.11	241.89	241.84	243.12	243.34	243.32
2010	243.45	243.41	243.33	243.28	243.13	243.06	242.46	241.81	242.80	242.93	243.24	243.40
2011	243.64	243.74	243.60	243.02	241.83	241.35	241.35	241.61	241.60	242.20	243.20	243.27
2012	243.31	243.36	243.31	242.71	242.84	243.50	243.43	243.34	243.36	243.36	243.32	243.41
2013	243.65	243.74	243.45	243.36	243.26	242.97	242.41	242.36	243.19	243.49	243.37	243.30
2014	243.40	243.52	243.48	243.43	243.54	242.48	241.77	241.40	241.26	242.01	242.86	243.24
2015	243.39	243.71	243.63	243.19	242.70	242.44	242.40	242.62	242.47	242.43	242.84	243.24
2016	243.53	243.49	242.96	242.19	241.55	241.56	241.89	243.19	243.17	242.78	242.91	243.34
2017	243.45	243.33	243.38	243.36	243.23	241.78	241.56	241.82	243.24	243.37	243.30	243.27
2018	243.40	243.54	243.42	243.35	243.34	243.49	243.48	243.44	243.41	243.37	243.31	243.31
2019	243.59	243.86	243.52	243.33	243.45	243.53	243.42	243.34	243.39	243.36	243.26	243.25
2020	243.35	243.31	243.28	243.09	242.91	242.72	242.75	242.48	243.14	243.48	243.41	243.43

Lower Lower than 0.5 m below average	**Average** Within 0.5 m below and above average	**Higher** More than 0.5 m above average

Table 2.3-5. Footprint Lake monthly average water level (m).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	0.09	0.05	0.02	0.04	0.11	0.95	0.66	0.92	0.56	0.03	0.08	0.13
2009	0.15	0.05	0.06	0.94	0.38	0.23	0.19	0.36	0.84	0.79	0.06	0.14
2010	0.13	0.06	0.08	0.04	0.52	0.43	1.11	0.80	0.35	0.26	0.37	0.11
2011	0.43	0.29	0.14	1.08	0.90	0.16	0.26	0.27	0.27	1.61	0.18	0.07
2012	0.12	0.05	0.21	0.58	0.68	0.31	0.17	0.05	0.06	0.09	0.12	0.21
2013	0.27	0.28	0.16	0.08	0.34	0.32	0.45	0.60	0.50	0.21	0.14	0.08
2014	0.14	0.05	0.10	0.04	0.85	1.00	0.46	0.22	0.11	1.29	0.44	0.19
2015	0.23	0.37	0.51	0.36	0.50	0.10	0.38	0.25	0.12	0.17	0.47	0.29
2016	0.28	0.32	0.63	0.96	0.16	0.12	0.91	0.79	0.50	0.28	0.54	0.21
2017	0.11	0.06	0.12	0.24	1.25	1.16	0.42	1.59	0.40	0.06	0.13	0.04
2018	0.23	0.07	0.14	0.15	0.16	0.13	0.09	0.14	0.11	0.04	0.09	0.10
2019	0.45	0.22	0.31	0.11	0.21	0.11	0.13	0.07	0.09	0.06	0.08	0.16
2020	0.06	0.09	0.03	0.30	0.22	0.35	0.31	0.29	0.80	0.11	0.02	0.29

Lower Variability	**Moderate Variability**	**Higher Variability**
Below 0.25 m	0.25 to 0.75 m	Above 0.75 m

Table 2.3-6. Apussigamasi Lake monthly water average level (m).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008												
2009						186.39	186.33	185.94	185.75	186.67	187.11	187.80
2010	188.33	188.09	187.72	187.28	187.06	186.81	186.53	185.89	186.68	186.78	187.11	187.91
2011	187.90	188.10	187.94	187.25	186.11	185.43	185.37	185.83	185.77	185.87	187.06	188.20
2012	188.02	187.90	187.58	187.02	186.74	187.31	187.26	187.11	187.13	187.12	187.45	188.07
2013	187.98	187.85	187.55	187.44	187.27	186.82	186.36	186.17	186.83	187.32	187.38	187.95
2014	187.80	187.82	187.76	187.56	187.83	186.69	185.96	185.51	185.32	185.81	186.93	187.86
2015	187.79	187.81	187.86	187.41	186.75	186.44	186.36	186.66	186.56	186.40	186.74	187.72
2016	188.12	188.11	187.43	186.59	185.67	185.70	185.82	186.89	187.04	186.82	186.74	187.61
2017	188.00	187.90	187.77	187.62	187.73	186.17	185.67	185.55	186.87	187.13	187.41	187.69
2018	187.98	188.06	187.73	187.50	187.42	187.35	187.46	187.30	187.25	187.18	187.39	187.92
2019	187.93	187.95	187.82	187.41	187.36	187.37	187.27	187.15	187.23	187.16	187.34	187.78
2020	188.01	187.89	187.61	187.23	187.10	186.87	186.91	186.53	186.93	187.31	187.79	187.86

Lower	Average	Higher
Lower than 0.5 m below average	Within 0.5 m below and above average	More than 0.5 m above average

Notes:

1. Blank cell indicates no data.

Table 2.3-7. Apussigamasi Lake monthly water level range (m).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008												
2009						0.04	0.09	0.24	0.25	1.11	0.06	1.26
2010	0.32	0.30	0.36	0.44	0.14	0.21	0.71	0.39	0.64	0.17	0.87	0.28
2011	0.18	0.38	0.44	0.81	1.16	0.33	0.29	0.57	0.47	1.13	1.16	0.53
2012	0.07	0.27	0.29	0.75	0.25	0.61	0.30	0.15	0.07	0.17	0.61	0.45
2013	0.34	0.17	0.24	0.07	0.54	0.23	0.57	0.33	0.58	0.40	0.68	0.15
2014	0.05	0.07	0.17	0.12	0.97	1.04	0.49	0.25	0.19	1.13	1.11	0.47
2015	0.23	0.25	0.47	0.30	0.73	0.24	0.46	0.37	0.30	0.17	1.01	0.76
2016	0.10	0.47	0.74	1.04	0.36	0.21	0.73	0.76	0.23	0.35	0.35	1.10
2017	0.61	0.48	0.29	0.28	1.11	1.55	0.39	1.10	0.61	0.15	0.72	0.27
2018	0.29	0.17	0.40	0.11	0.71	0.32	0.23	0.25	0.20	0.10	0.82	0.45
2019	0.33	0.38	0.57	0.18	0.26	0.14	0.10	0.20	0.10	0.10	0.66	0.38
2020	0.14	0.21	0.35	0.35	0.49	0.43	0.41	0.53	0.71	0.22	1.00	0.62

Lower Variability	Moderate Variability	Higher Variability
Below 0.25 m	0.25 to 0.75 m	Above 0.75 m

Notes:

1. Blank cell indicates no data.

Table 2.3-8. Leftrook Lake monthly average water level (m).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008												
2009												
2010						253.68	253.59					
2011			253.77	253.75	253.88	253.83	253.81	254.01	254.13	253.98	253.92	253.91
2012	253.89	253.86	253.83	253.86	254.07	254.10	254.04	253.88	253.95	253.96	253.99	253.95
2013	253.88	253.83	253.80	253.77	253.87	253.87	253.80	253.79	253.78	253.98	254.12	254.05
2014	253.96	253.90	253.86	253.82	253.88							253.93
2015	253.91	253.87	253.82	253.82	254.00	253.96	253.93	254.18	254.22	254.23	254.14	254.05
2016	253.98	253.94	253.91	253.89	254.00	254.11	254.02	253.99	253.92	254.12	254.10	254.06
2017	253.99	253.95	253.97	253.96	254.39	254.67	254.22	253.96	253.83	253.80	253.86	253.87
2018	253.86	253.84	253.79	253.77	254.04	254.01	254.04	254.03	253.92	253.87	253.87	253.84
2019	253.81	253.79	253.77	253.78	253.93	253.95	253.90	253.87	253.87	253.88	253.85	253.83
2020	253.82	253.80	253.78	253.81	254.03	254.27	254.42	254.37	254.21	254.13	254.06	253.99

Lower Lower than 0.5 m below average	**Average** Within 0.5 m below and above average	**Higher** More than 0.5 m above average

Notes:

1. Blank cell indicates no data.

Table 2.3-9. Leftrook Lake monthly water level range (m).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008												
2009												
2010						0.11	0.02					
2011			0.04	0.06	0.11	0.12	0.12	0.35	0.19	0.08	0.04	0.02
2012	0.02	0.05	0.02	0.08	0.18	0.15	0.19	0.08	0.09	0.05	0.03	0.06
2013	0.06	0.04	0.03	0.03	0.19	0.11	0.06	0.04	0.06	0.31	0.03	0.10
2014	0.06	0.05	0.04	0.04	0.20							0.01
2015	0.04	0.04	0.05	0.20	0.05	0.04	0.22	0.06	0.15	0.08	0.10	0.08
2016	0.05	0.03	0.03	0.04	0.15	0.10	0.08	0.10	0.01	0.00	0.00	0.07
2017	0.05	0.03	0.06	0.02	0.97	0.50	0.34	0.18	0.10	0.08	0.03	0.02
2018	0.01	0.04	0.05	0.11	0.22	0.04	0.09	0.14	0.05	0.03	0.02	0.03
2019	0.02	0.02	0.02	0.09	0.12	0.04	0.07	0.03	0.09	0.05	0.02	0.03
2020	0.02	0.02	0.01	0.04	0.45	0.15	0.23	0.27	0.10	0.07	0.05	0.07

Lower Variability Below 0.25 m	**Moderate Variability** 0.25 to 0.75 m	**Higher Variability** Above 0.75 m

Notes:

1. Blank cell indicates no data.

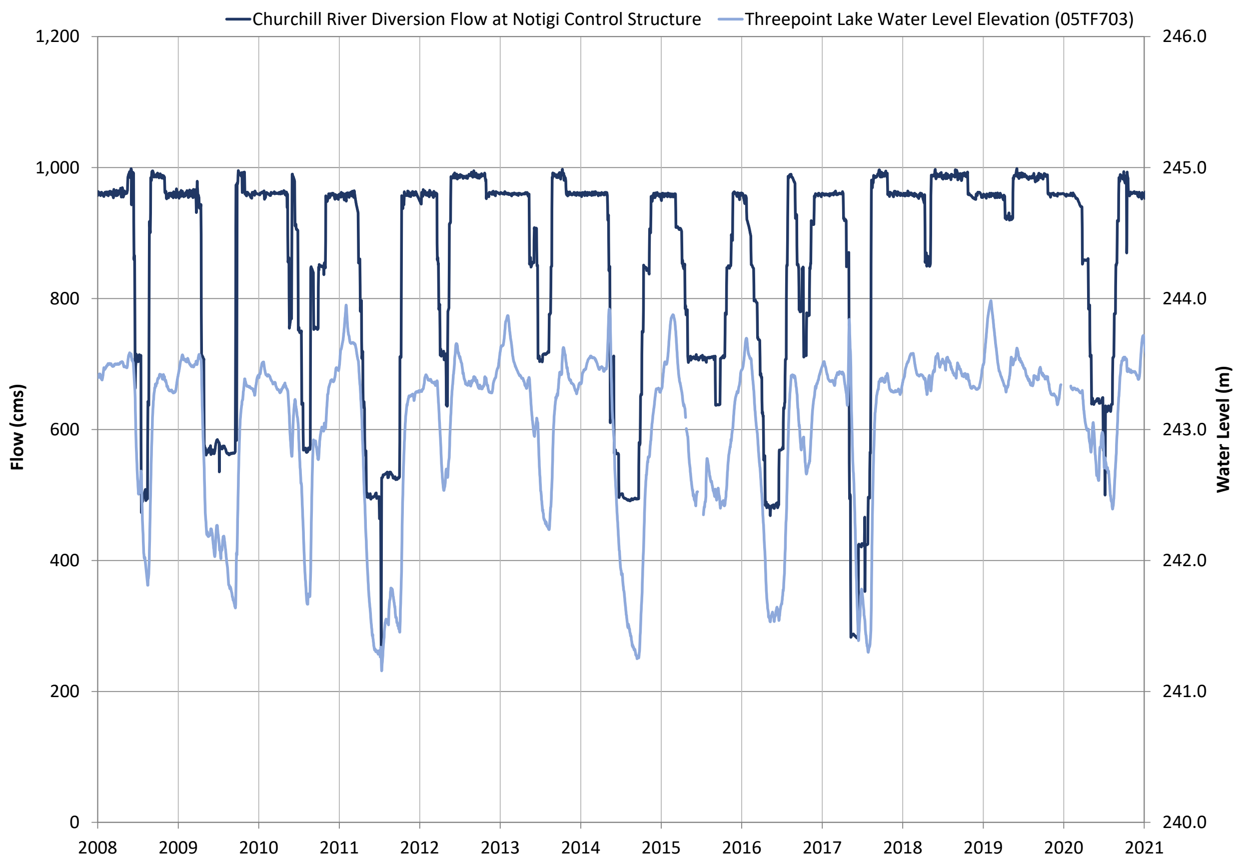


Figure 2.3-3. 2008-2020 Upper Churchill at the Notigi CS daily mean flow and Threepoint Lake daily mean water level.

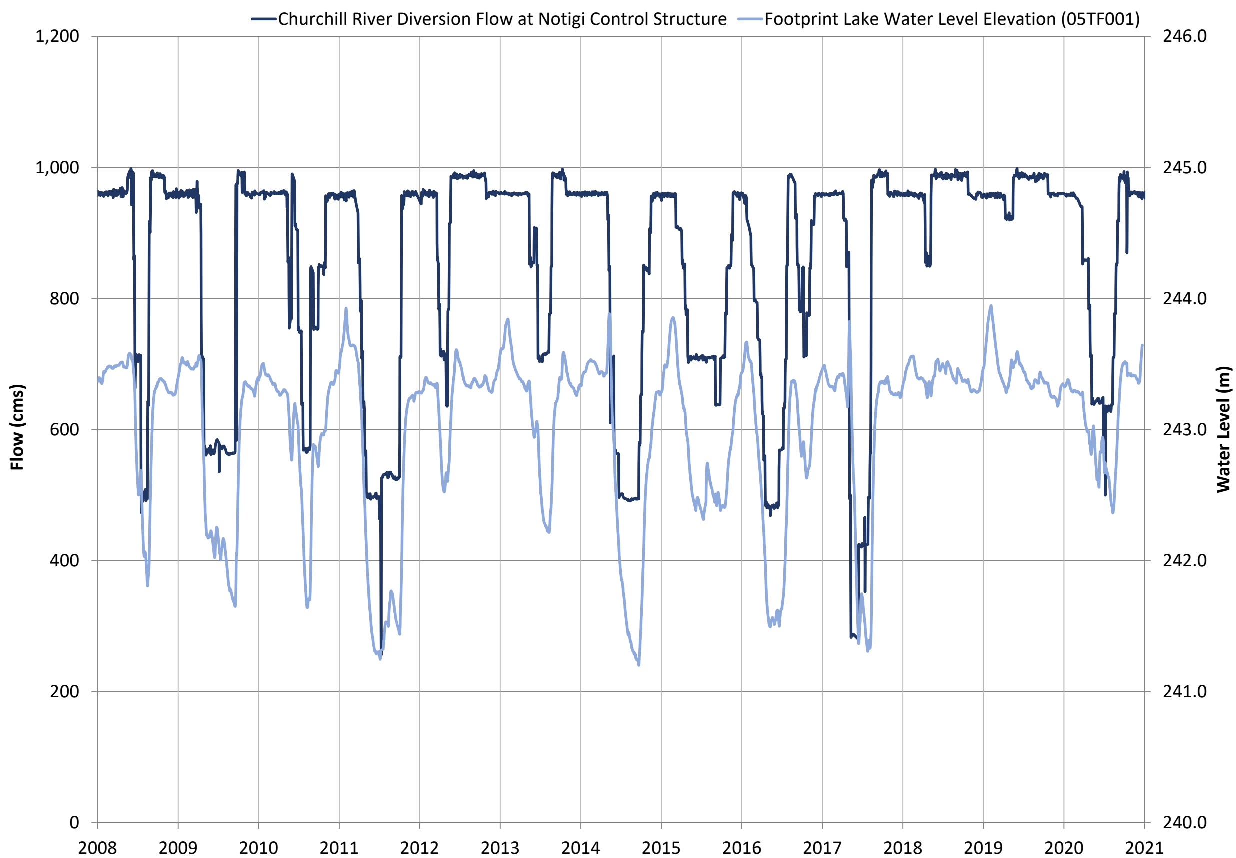


Figure 2.3-4. 2008-2020 Upper Churchill River at the Notigi CS daily mean flow and Footprint Lake daily mean water level.

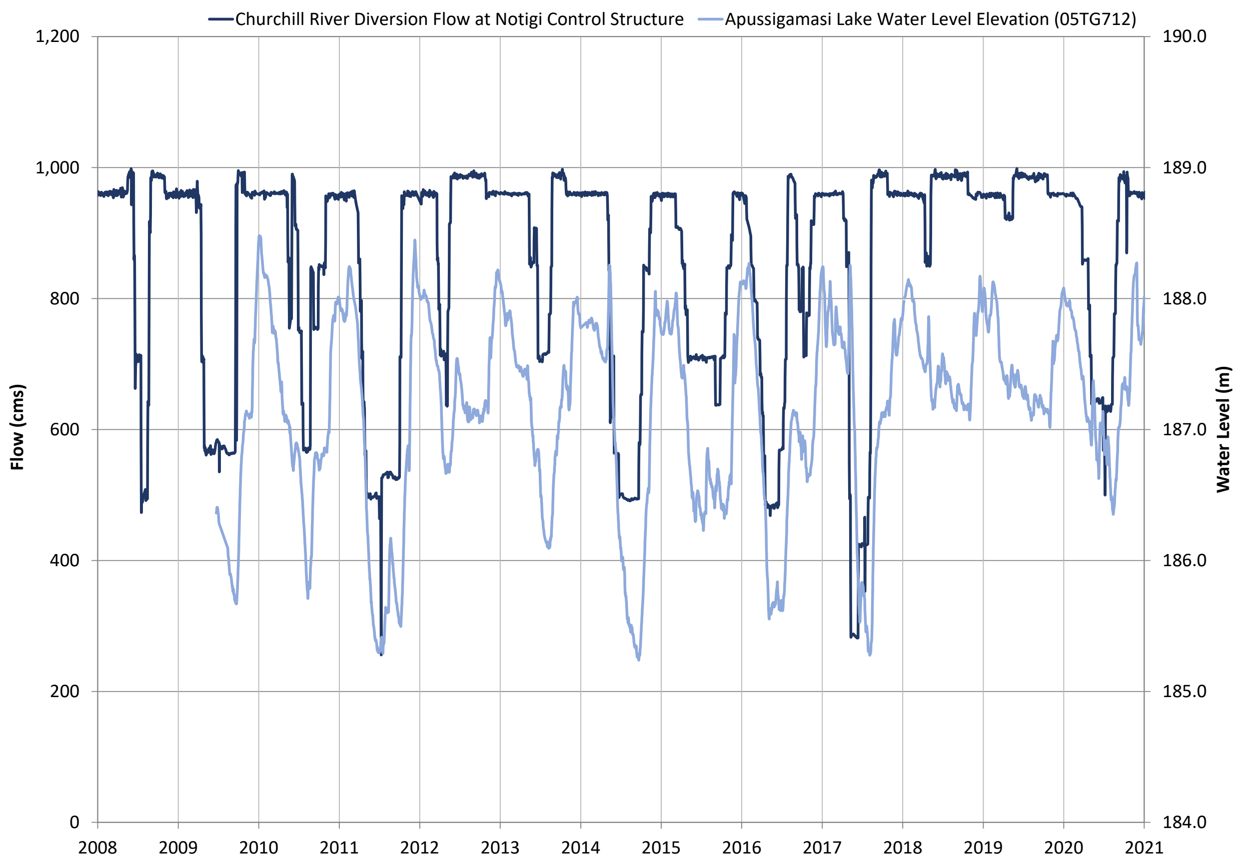


Figure 2.3-5. 2008-2020 Upper Churchill River at the Notigi CS daily mean flow and Apussigamasi Lake daily mean water level.

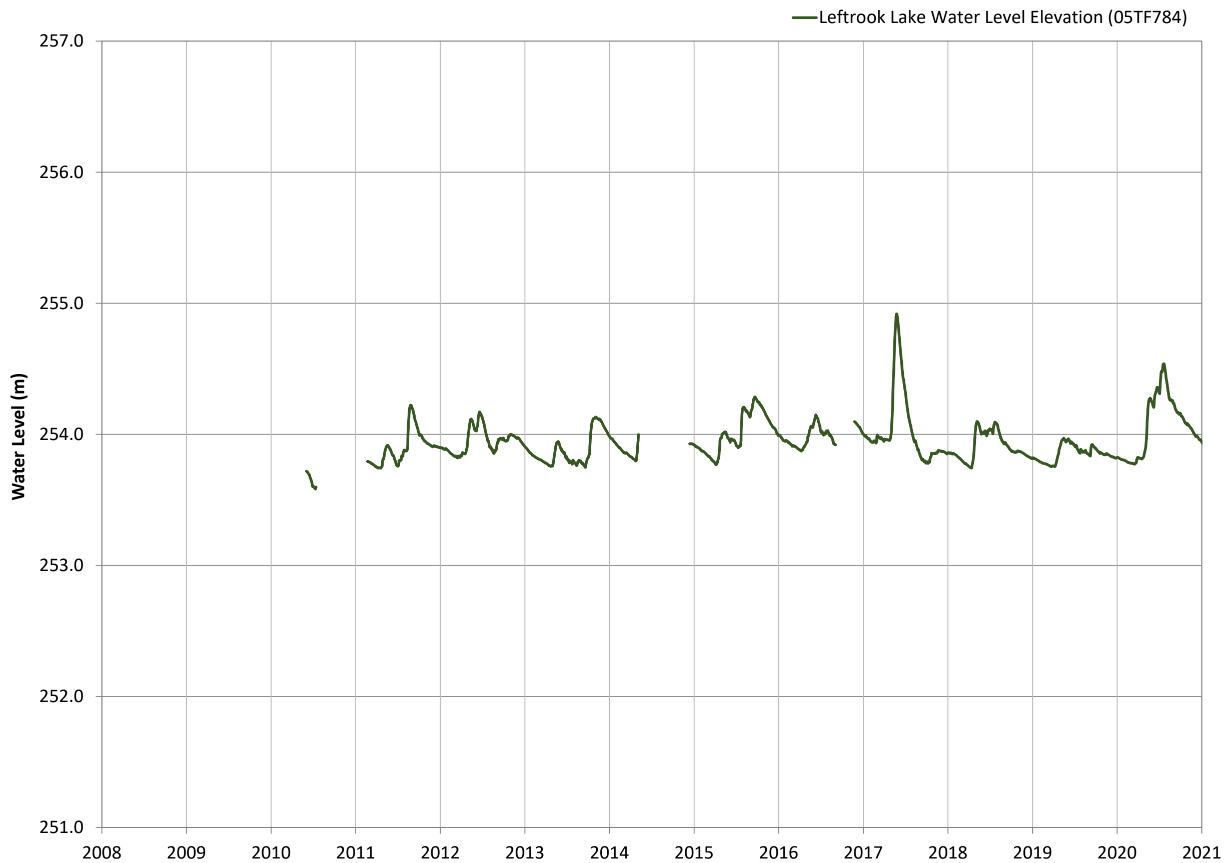


Figure 2.3-6. 2008-2020 Leftrook Lake daily mean water level.

2.3.3 WATER TEMPERATURE

2.3.3.1 ON-SYSTEM SITES

Wuskwatim Generating Station

Water temperature in the Churchill River Diversion Region is monitored at the continuous water quality monitoring station located at the Wuskwatim GS (Figure 2.3-1). Water temperatures drop to near 0 ˚C during the winter period and begin to increase in April (Figure 2.3-7). Temperatures peaked around 19 ˚C in August during the two summers since monitoring has started, returning to near 0 ˚C in early November.

The duration, in days, that water temperature is within different temperature ranges is used as a metric (Table 2.3-10). The number of days that the water temperature was below 1 ˚C, which is used as a proxy-metric for the duration of the ice-cover period, ranged from 176 to 193 days. In summer, the there were no days above 20 ˚C in the two years of monitoring.

2.3.3.2 OFF-SYSTEM SITES

There are no continuous monitoring off-system sites in this region.

Table 2.3-10. 2017-19 Wuskwatim GS water temperature ranges.

Monitoring Year[1]	Number of Days in Temperature Range[2]					
	<1 ºC	1-5 ºC	5-10 ºC	10-15 ºC	15-20 ºC	>20 ºC
2017						
2018	176					
2019	193	38	42	46	66	0

Notes:

1. Period <1ºC is for the entire winter period (e.g., 2017 monitoring year is from Nov 2017 to May 2018).
2. The duration has been estimated using data from nearby gauging stations to infill missing data when available.

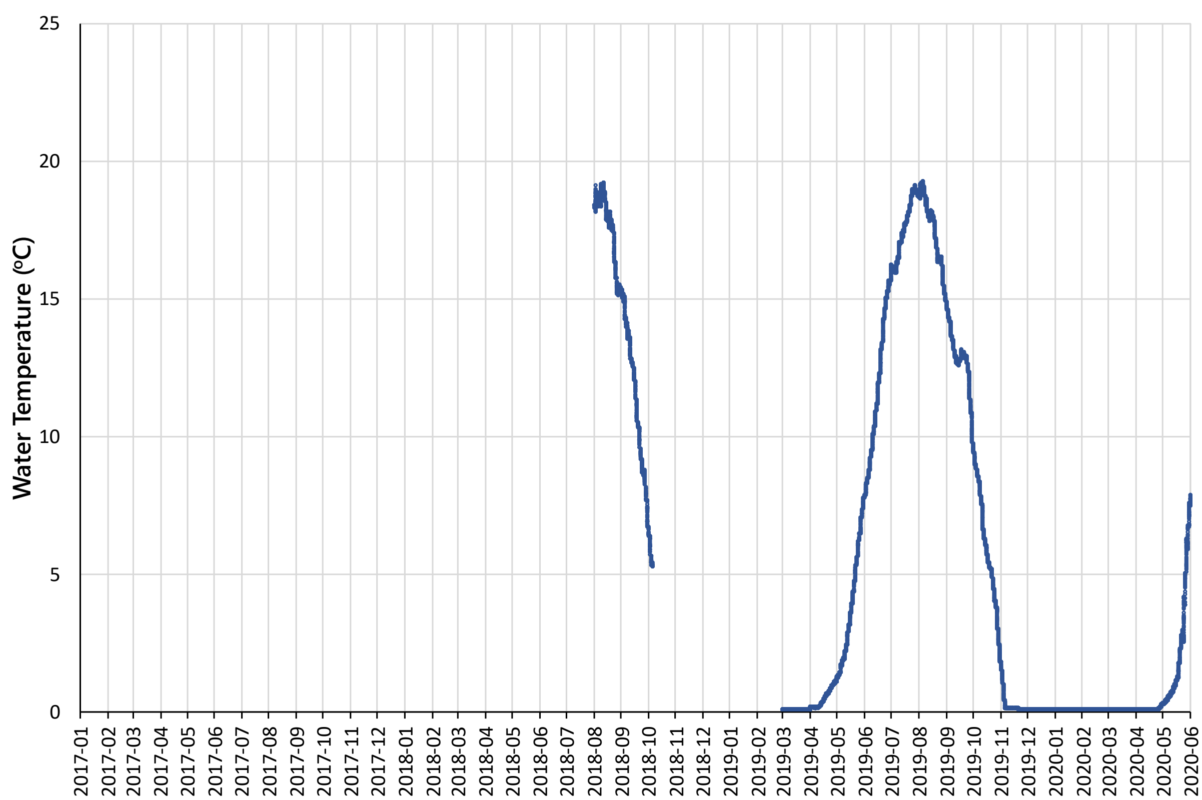


Figure 2.3-7. 2017-2019 Wuskwatim GS continuous water temperature.

2.4 SEDIMENTATION

The following presents the results of sedimentation monitoring conducted in the Churchill River Diversion Region. Monitoring occurred on-system at the continuous water quality monitoring site located at the Wuskwatim GS (Figure 2.3-1). Monitoring started in 2018 (Table 2.4-1) and consists of measuring turbidity every 5 minutes and monthly site visits to verify the data and collect water samples for measuring total suspended solids (TSS) used in calculating the sediment load. For the sedimentation indicator, two metrics (continuous turbidity and suspended sediment load) were selected for detailed reporting (Table 2.4-2).

Table 2.4-1. 2008-2019 sedimentation sampling inventory.

Waterbody/ Area	Sampling Year											
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Wuskwatim GS											●	●

Table 2.4-2. Sedimentation indicators and metrics.

Indicator	Metric	Units
Sedimentation	Continuous turbidity	FNU
	Suspended sediment load	T/day

2.4.1 CONTINUOUS TURBIDITY

2.4.1.1 ON-SYSTEM SITES

Wuskwatim Generating Station

Turbidity in the Churchill River Diversion Region is monitored at the continuous water quality monitoring station located at the Wuskwatim GS. The average monthly turbidity ranged from 8.0 to 30.7 FNU (Table 2.4-3, Figure 2.4-1) with the hourly turbidity ranging from 7 to 38 FNU (Figure 2.4-2).

The continuous data set at the Wuskwatim GS is relatively short and will take more data to confirm patterns and trends in the data. The data set shows greater variability and higher turbidity during the open water period and declining trends during the ice-cover months. During the two summers monitored, peak turbidity was over 30 FNU with the highest occurring in 2019 when it reached over 35 on several occasions. Minimum turbidity reached 7–9 FNU during the two winters monitored.

2.4.1.2 OFF-SYSTEM SITES

There are no continuous monitoring off-system sites in this region.

Table 2.4-3. 2017-2019 Wuskwatim GS average monthly turbidity.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017												
2018								20.7	19.0			19.5
2019			9.8	8.0	10.5	14.0	20.4	23.4	24.2	29.0	30.7	26.5
2020	17.8	13.0	10.0	8.1								

Notes:

1. Monthly data only shown for months with more than 15 days of data.

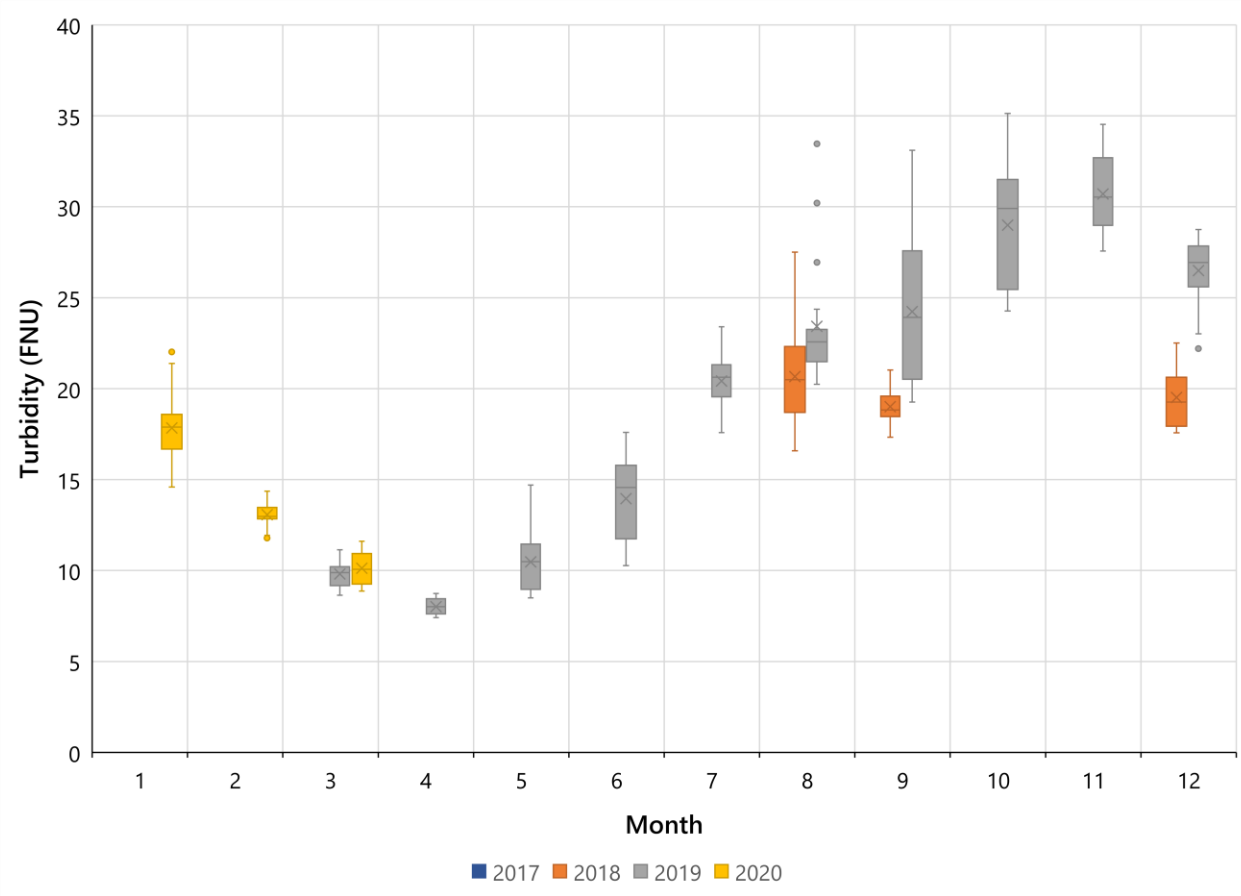


Figure 2.4-1. 2017-2019 Wuskwatim GS monthly turbidity.

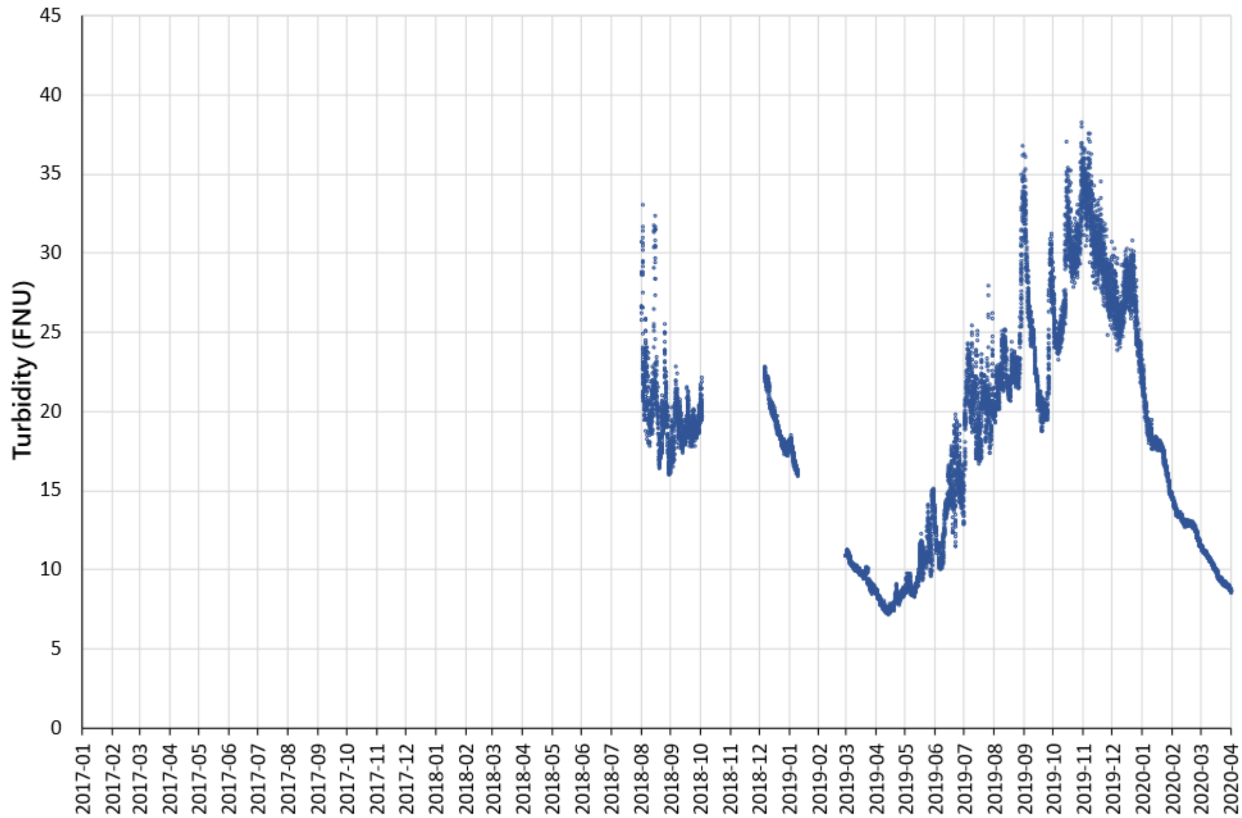


Figure 2.4-2. 2017-2019 Wuskwatim GS continuous turbidity.

2.4.2 SUSPENDED SEDIMENT LOAD

2.4.2.1 ON-SYSTEM SITES

Wuskwatim Generating Station

Sediment load is estimated using the discharge data, continuous turbidity data (Figure 2.4-2) and water samples collected to correlate the turbidity to TSS. The average monthly sediment load ranged from 158 to 836 T/day (Table 2.4-4, Figure 2.4-3). While there is limited data to make observations from, the open-water sediment load was several magnitude times higher than the ice-cover period. There were two peak periods during the 2019 open-water period, occurring in June and November (Figure 2.4-4).

2.4.2.2 OFF-SYSTEM SITES

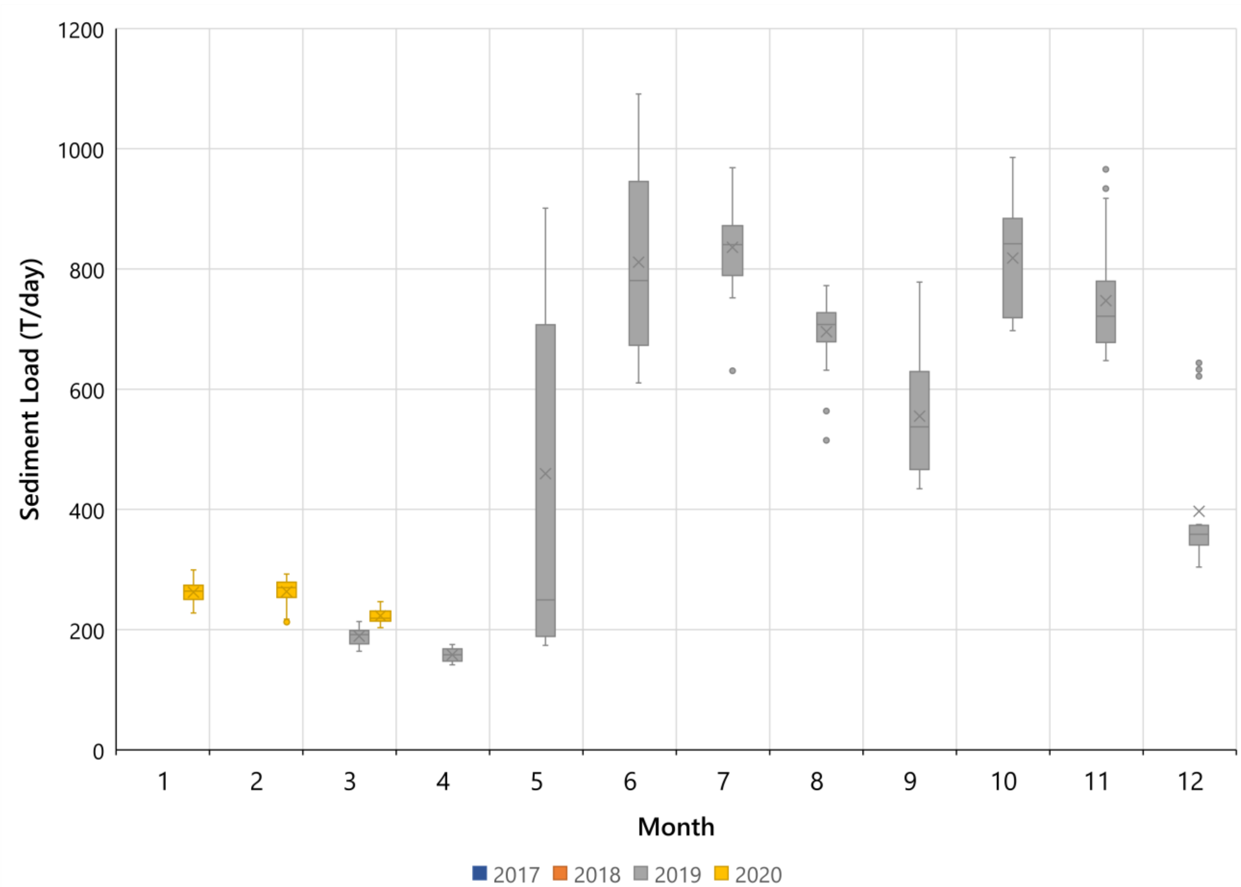
There are no continuous monitoring off-system sites in this region.

Table 2.4-4. 2017-19 Wuskwatim GS average monthly sediment load.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017												
2018												
2019			189	158	459	811	836	695	555	818	747	397
2020	262	263	221	200								

Notes:

1. Monthly average only shown for months with more than 15 days of data.
2. Some months are missing TSS measurements to estimate the load.



*Monthly data only shown for months with more than 15 days of data.

Figure 2.4-3. 2017-2019 Wuskwatim GS monthly sediment load.

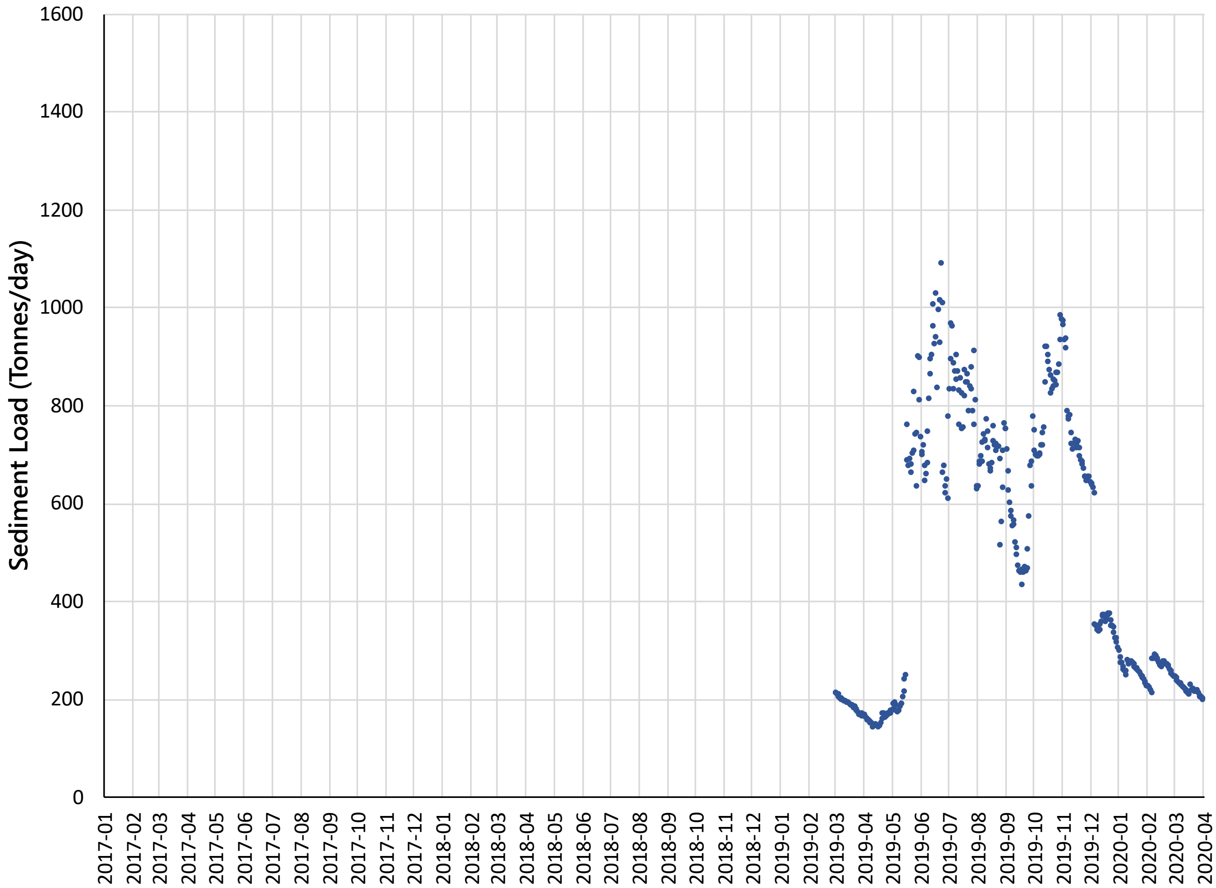
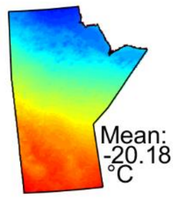
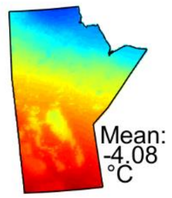
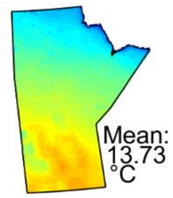
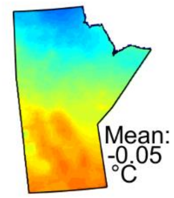
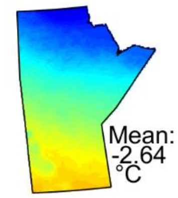
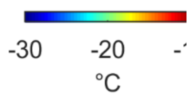
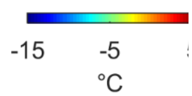
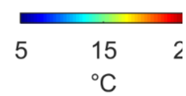
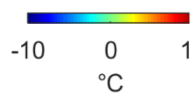
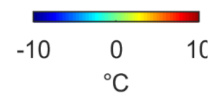
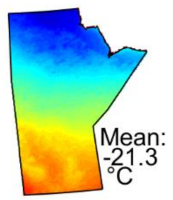
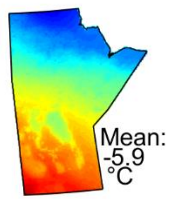
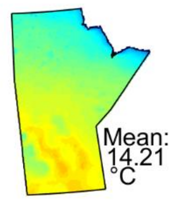
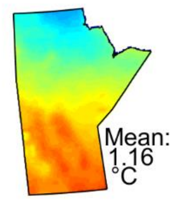
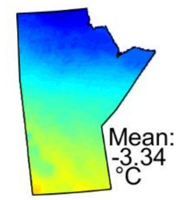
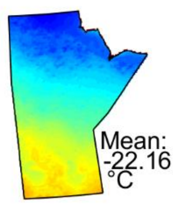
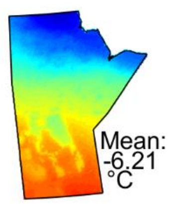
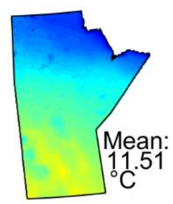
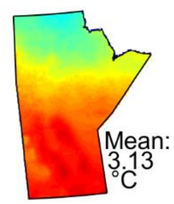
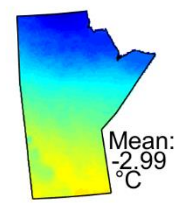
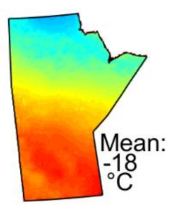
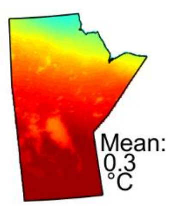
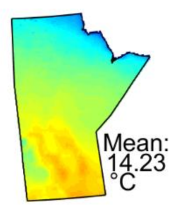
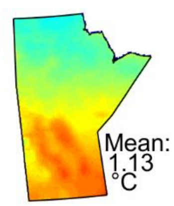
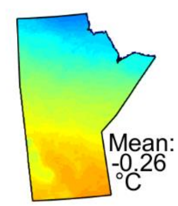
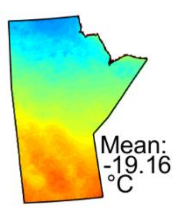
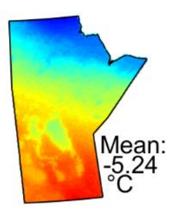
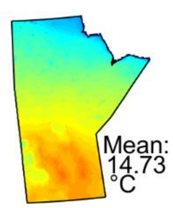
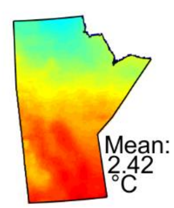
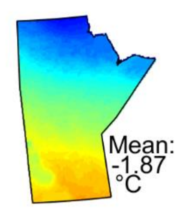
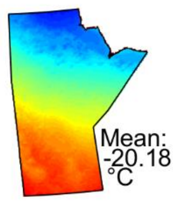
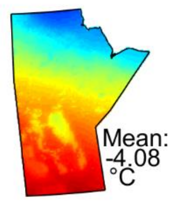
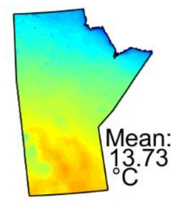
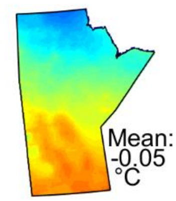
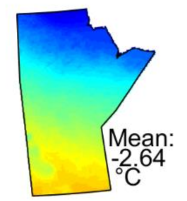
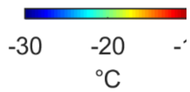
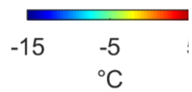
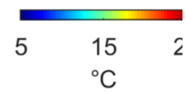
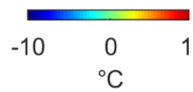
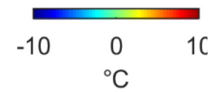
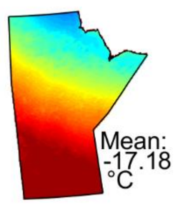
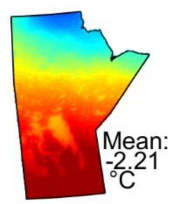
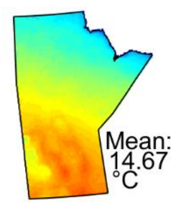
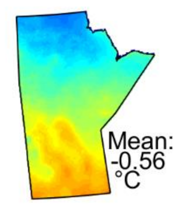
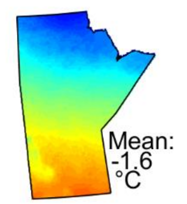
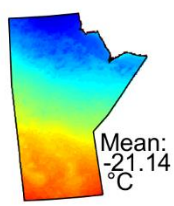
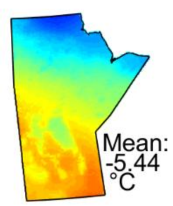
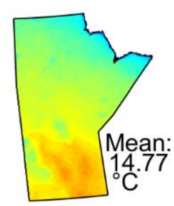
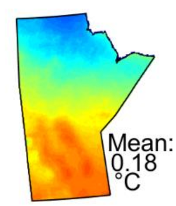
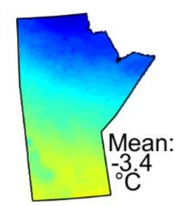
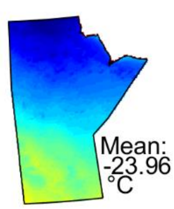
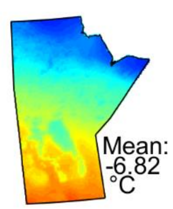
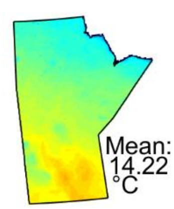
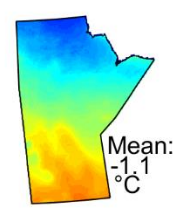
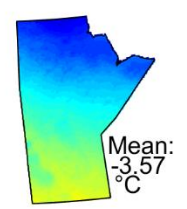
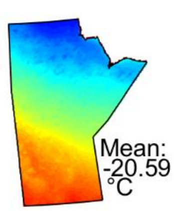
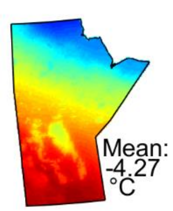
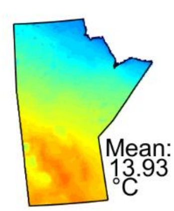
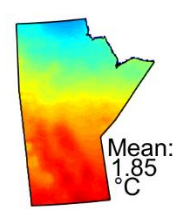
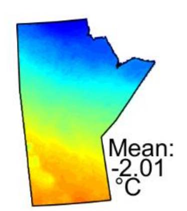
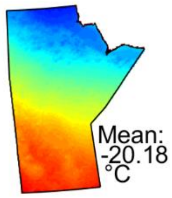
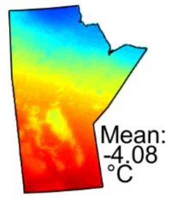
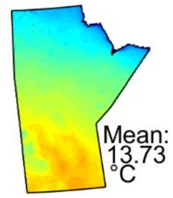
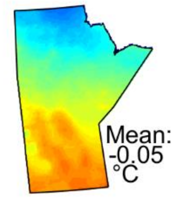
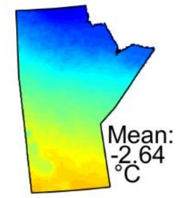
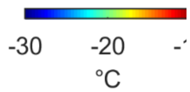
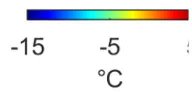
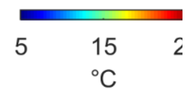
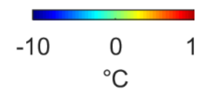
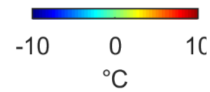
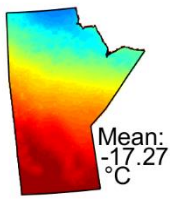
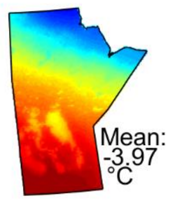
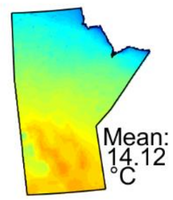
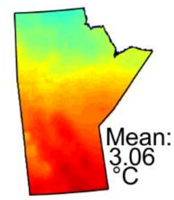
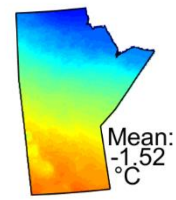
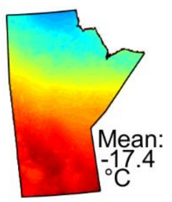
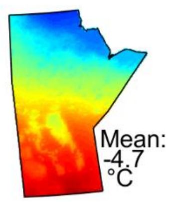
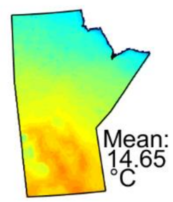
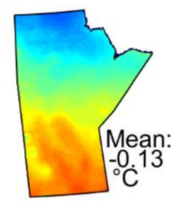
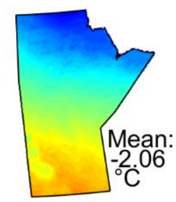
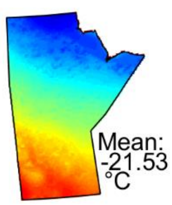
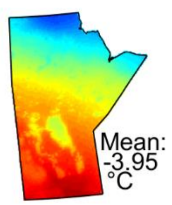
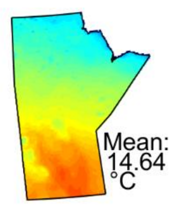
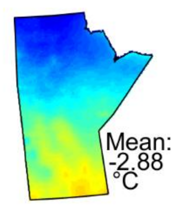
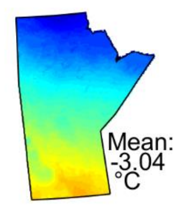
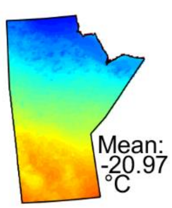
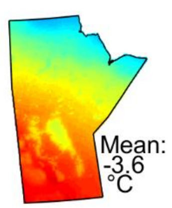
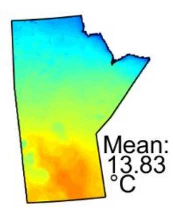
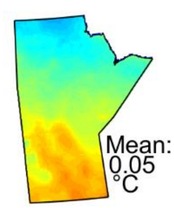
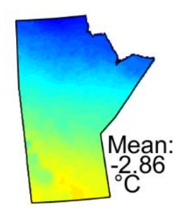
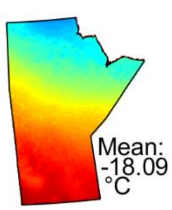
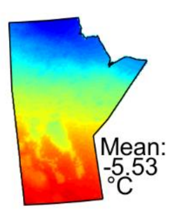
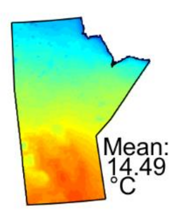
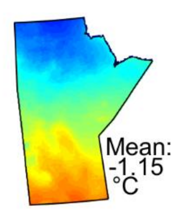
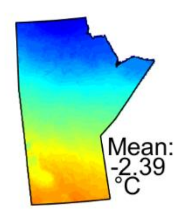


Figure 2.4-4. 2017-2019 Wuskwatim GS daily sediment load.

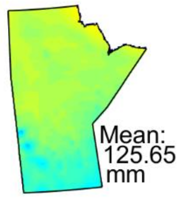
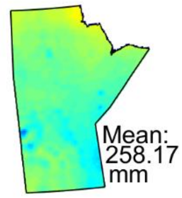
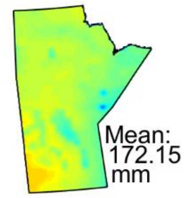
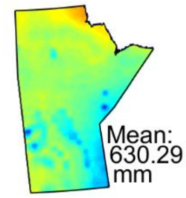
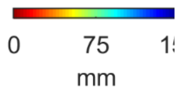
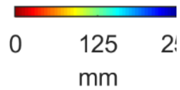
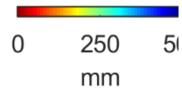
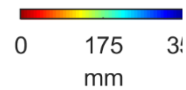
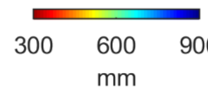
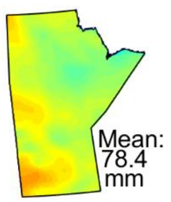
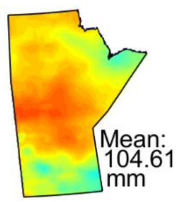
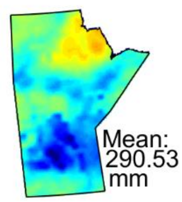
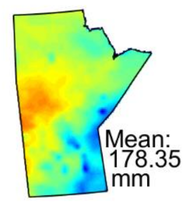
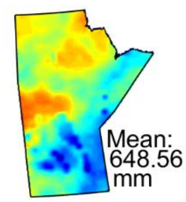
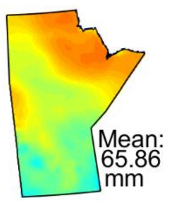
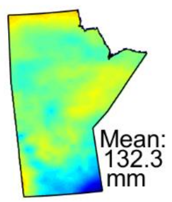
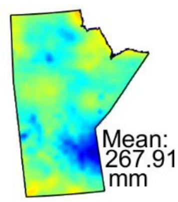
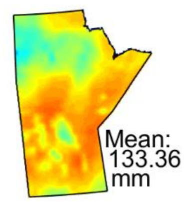
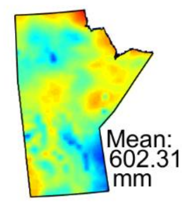
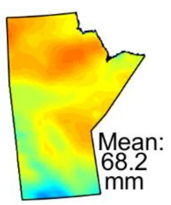
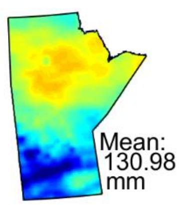
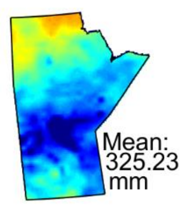
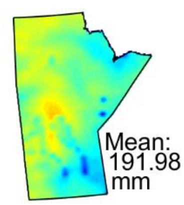
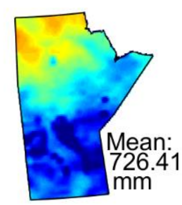
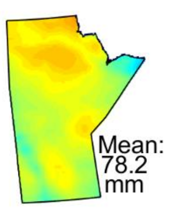
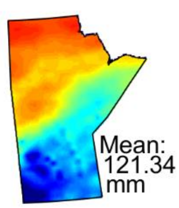
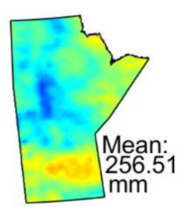
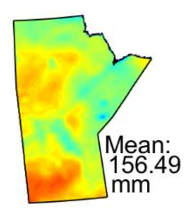
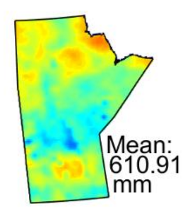
APPENDIX 2-1. SEASONAL AND ANNUAL TEMPERATURE NORMALS DERIVED FROM ERA5-LAND DATA

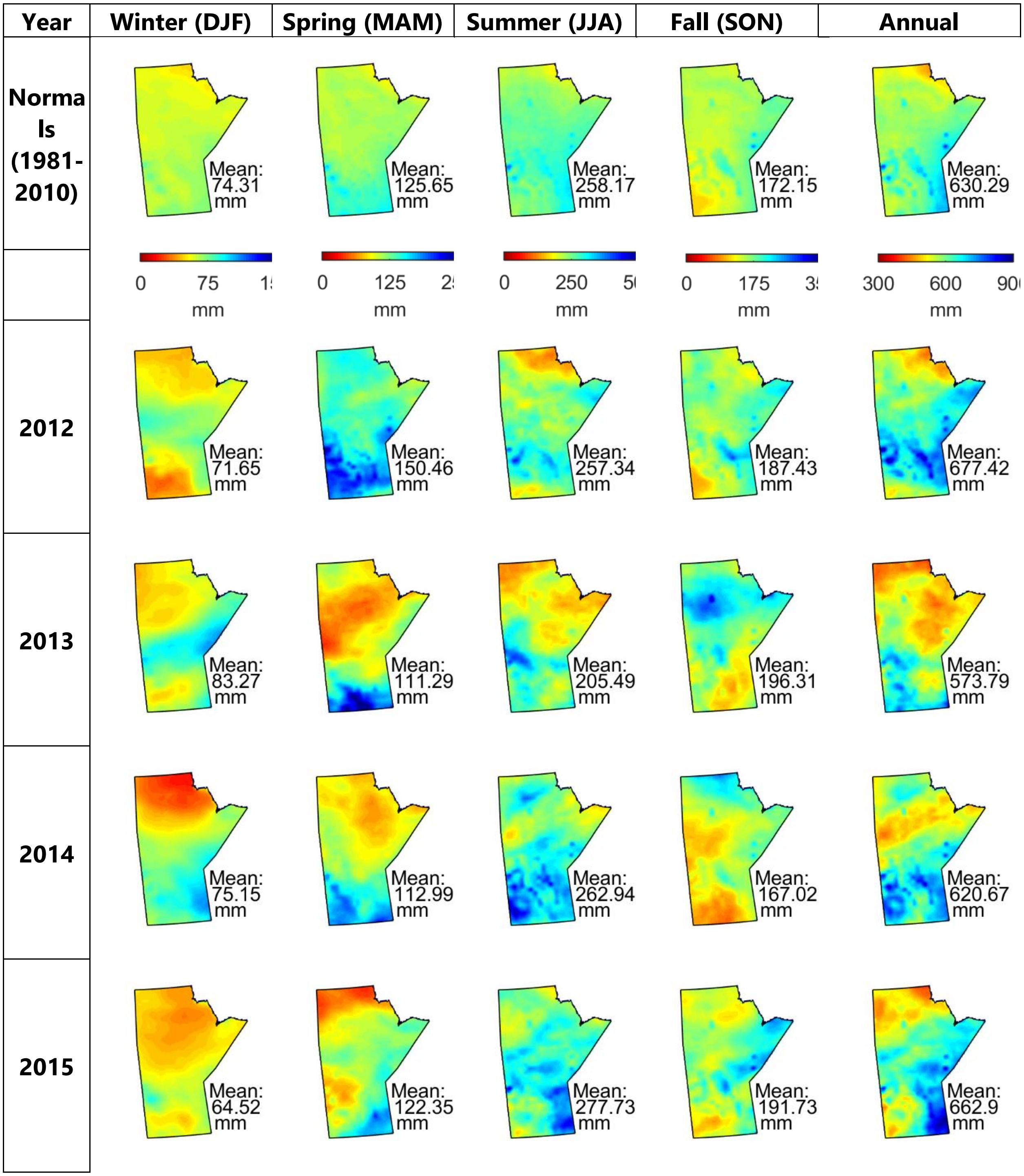
Year	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)	Annual
Normals (1981-2010)					
					
2008					
2009					
2010					
2011					

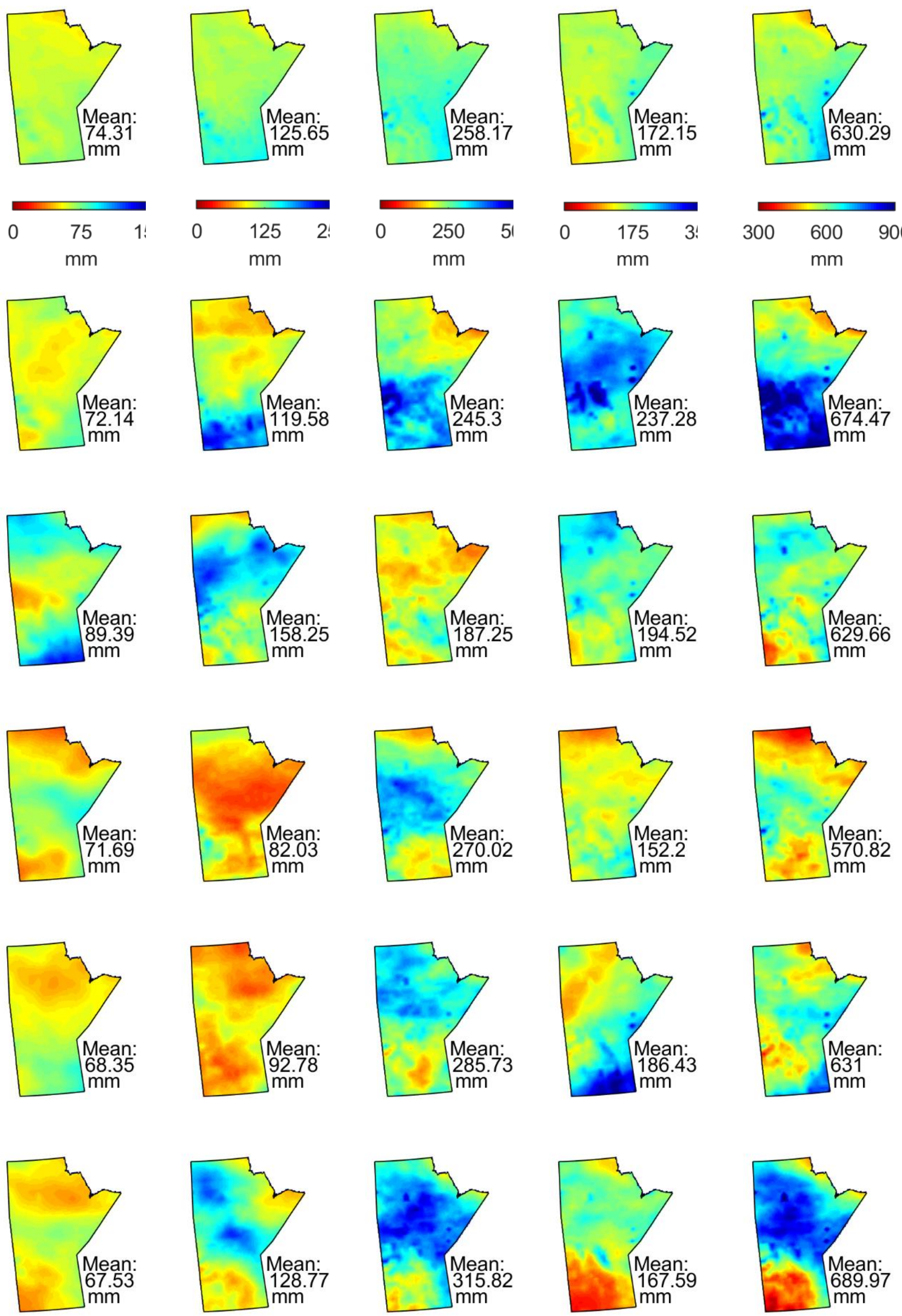
Year	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)	Annual
Normals (1981-2010)					
					
2012					
2013					
2014					
2015					

Year	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)	Annual
Normals (1981-2010)					
					
2016					
2017					
2018					
2019					
2020					

APPENDIX 2-2. SEASONAL AND PRECIPITATION NORMALS DERIVED FROM ERA5-LAND DATA

Year	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)	Annual
Normals (1981-2010)					
					
2008					
2009					
2010					
2011					


Year
Winter (DJF)
Spring (MAM)
Summer (JJA)
Fall (SON)
Annual
Normals (1981-2010)
Mean: 74.31 mm
Mean: 125.65 mm
Mean: 258.17 mm
Mean: 172.15 mm
Mean: 630.29 mm
0 75 1!
mm
0 125 2!
mm
0 250 5(
mm
0 175 3!
mm
300 600 90(
mm
2012
Mean: 71.65 mm
Mean: 150.46 mm
Mean: 257.34 mm
Mean: 187.43 mm
Mean: 677.42 mm
2013
Mean: 83.27 mm
Mean: 111.29 mm
Mean: 205.49 mm
Mean: 196.31 mm
Mean: 573.79 mm
2014
Mean: 75.15 mm
Mean: 112.99 mm
Mean: 262.94 mm
Mean: 167.02 mm
Mean: 620.67 mm
2015
Mean: 64.52 mm
Mean: 122.35 mm
Mean: 277.73 mm
Mean: 191.73 mm
Mean: 662.9 mm



Year	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)	Annual
Normals (1981-2010)	Mean: 74.31 mm	Mean: 125.65 mm	Mean: 258.17 mm	Mean: 172.15 mm	Mean: 630.29 mm
	0 75 1! mm	0 125 2! mm	0 250 5(mm	0 175 3! mm	300 600 90(mm
2016	Mean: 72.14 mm	Mean: 119.58 mm	Mean: 245.3 mm	Mean: 237.28 mm	Mean: 674.47 mm
2017	Mean: 89.39 mm	Mean: 158.25 mm	Mean: 187.25 mm	Mean: 194.52 mm	Mean: 629.66 mm
2018	Mean: 71.69 mm	Mean: 82.03 mm	Mean: 270.02 mm	Mean: 152.2 mm	Mean: 570.82 mm
2019	Mean: 68.35 mm	Mean: 92.78 mm	Mean: 285.73 mm	Mean: 186.43 mm	Mean: 631 mm
2020	Mean: 67.53 mm	Mean: 128.77 mm	Mean: 315.82 mm	Mean: 167.59 mm	Mean: 689.97 mm

3.0 WATER QUALITY

3.1 INTRODUCTION

The following presents the results of water quality monitoring conducted from 2008 to 2019 in the Churchill River Diversion Region. Four waterbodies were monitored in the Churchill River Diversion Region: one on-system annual site (Threepoint Lake); two on-system rotational sites (Footprint and Apussigamasi lakes); and, one off-system annual site (Leftrook Lake; Table 3.1-1 and Figure 3.1-1). Annual sites are sampled each year, whereas rotational sites are sampled once every three years on a rotational basis and are therefore limited to three or four years of data for the 12-year period.

The CAMP water quality program includes four sampling periods (referred to as spring, summer, fall, and winter) per monitoring year (i.e., April-March) typically at a single location within each waterbody or area of a waterbody/river reach. Sampling in the Churchill River Diversion Region was initiated in 2009 and therefore there are only 11 years of monitoring over the 12-year period. During this time, water quality sampling was conducted at each sampling location during each sampling period (i.e., n=44 for annual sites) with two exceptions (Table 3.1-1; Appendix 3-1):

- sampling could not be completed in Threepoint Lake due to slush and thin ice in the winter of 2019 therefore only 10 winter samples were collected over the 12-year period (i.e., n=43); and,
- sampling could not be completed in Apussigamasi Lake due to thin ice in the winter of 2012, therefore only three winter samples were collected over the 12-year period (i.e., n=15).

A detailed description of the program design and sampling methods is provided in Technical Document 1, Section 2.3.

Three indicators (dissolved oxygen [DO]; water clarity; and nutrients/trophic status) were selected for detailed reporting (Table 3.1-2). Metrics for these indicators include DO and its supporting metric temperature/stratification, Secchi disk depth, turbidity, TSS, total phosphorus (TP), total nitrogen (TN), and chlorophyll *a* (Table 3.1-2). A detailed description of these indicators is provided in CAMP (2024).

Table 3.1-1. 2008-2019 Water quality sampling inventory.

Waterbody/ Area	Sampling Year [1]											
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
3PT		●	●	●	●	●	●	●	●	●	●	●[2]
FOOT			●			●			●			●
APU		●			●[2]			●			●	
LEFT		●	●	●	●	●	●	●	●	●	●	●

Notes:

1. Sampling year is from April-March.
2. No winter sample collected due to unsafe ice conditions.

Table 3.1-2. Water quality indicators and metrics.

Indicator	Metric	Units
Dissolved Oxygen	• Dissolved oxygen (DO)	milligrams per litre (mg/L) and percent (%) saturation
	• Temperature/stratification [1]	°C
Water Clarity	• Secchi disk depth	m
	• Turbidity	Nephelometric turbidity units (NTU)
	• Total suspended solids (TSS)	mg/L
Nutrients and Trophic Status	• Total phosphorus (TP)	mg/L
	• Total nitrogen (TN)	mg/L
	• Chlorophyll *a*	micrograms per litre (µg/L)

Notes:

1. Supporting metric.

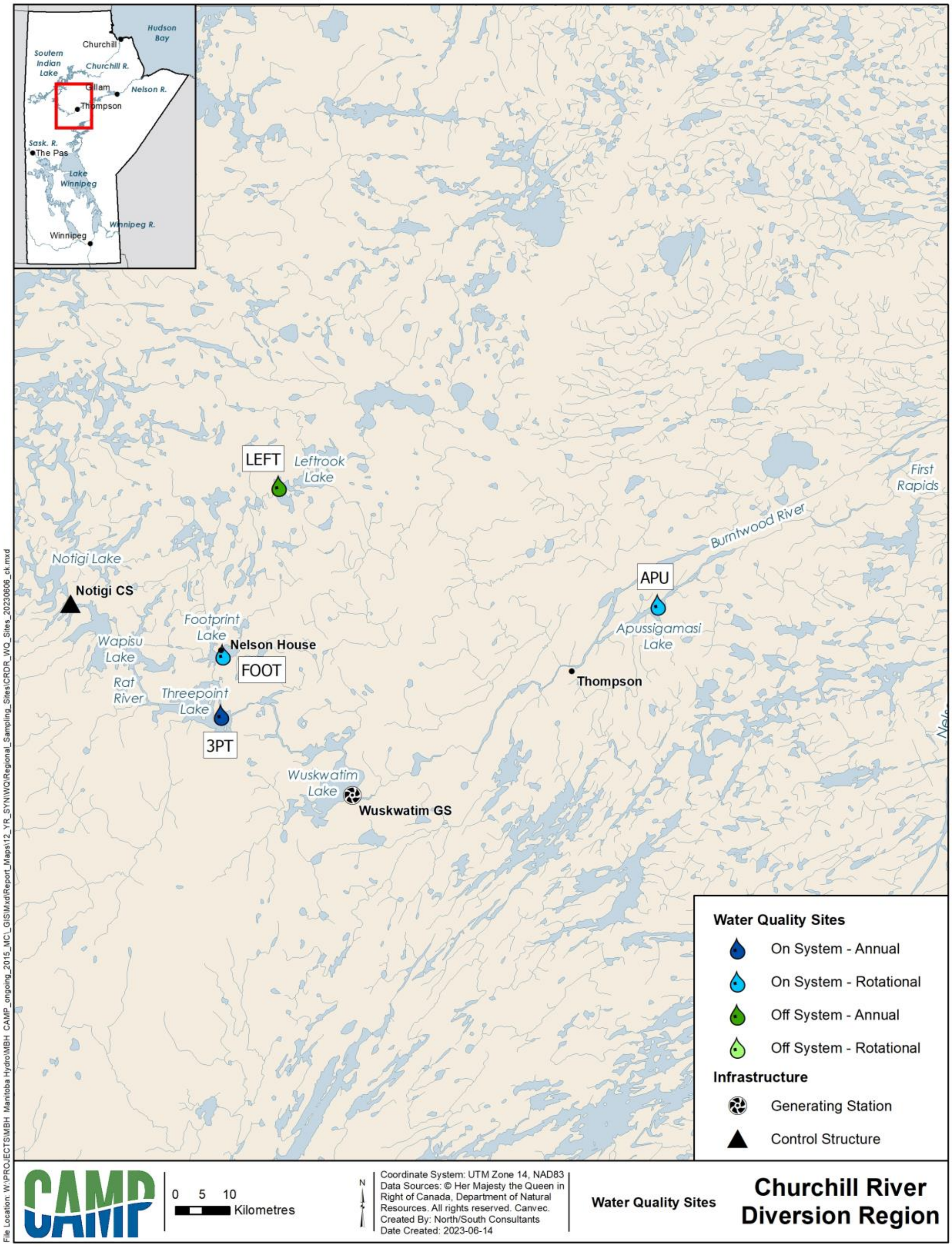


Figure 3.1-1. 2008-2019 Churchill River Diversion Region water quality sites.

3.2 DISSOLVED OXYGEN

3.2.1 DISSOLVED OXYGEN

3.2.1.1 ON-SYSTEM SITES

ANNUAL SITES

Threepoint Lake

Threepoint Lake was well-oxygenated year-round and DO concentrations throughout the water column consistently met the Manitoba Water Quality Standards, Objectives, and Guidelines (MWQSOGs) instantaneous minimum objectives for cool- and cold-water aquatic life during the open-water and ice-cover seasons (Manitoba Water Stewardship [MWS] 2011; Table 3.2-1).

Threepoint Lake was isothermal (i.e., thermal stratification was not observed) and DO concentrations were similar throughout the water column during each sampling period (Table 3.2-1, and Figures 3.2-1 and 3.2-2). During the open-water season, DO concentrations ranged from 8.38 to 12.31 mg/L at the surface and 8.06 to 12.32 mg/L near the bottom (maximum site water depth = 8.0 m). During the ice-cover season, DO concentrations ranged from 15.03 to 16.42 mg/L at the surface and 15.03 to 16.91 mg/L near the bottom (Table 3.2-2 and Figure 3.2-3).

DO concentrations varied between seasons with seasonal mean DO concentrations being higher in winter and spring when the water was cooler, and lower in the summer and fall when the water was warmer (Figure 3.2-4).

DO saturation was near 100% at both the surface and near the bottom during each season sampled (Figure 3.2-5). During the open-water season, surface DO saturation ranged from 91.2 to 115.3% with a mean of 100.5% and a median of 100.6% over the 11 years of monitoring. Mean surface DO saturation levels in the open-water season were similar from year to year ranging from 94.6 to 105.3% and were within or near the interquartile range (IQR) of 95.9 to 102.8%. Bottom DO saturation during the open-water season ranged from 89.5 to 113.0% with a both a mean and median of 99.5% over the 11 years of monitoring. Mean bottom DO saturation levels in the open-water season were similar from year to year ranging from 93.9 to 104.1% and were within or near the IQR of 94.6 to 103.6% (Table 3.2-2 and Figure 3.2-6).

During the ice-cover season, DO saturation at the surface ranged from 105.6 to 121.6% with a mean of 113.2% and a median of 113.7%. The IQR was 107.9 to 117.3%. Bottom DO saturation during the ice-cover season ranged from 105.8 to 119.6% with a mean of 113.6% and a median of 115.5%. The IQR was 108.6 to 118.0% (Table 3.2-2 and Figure 3.2-7).

ROTATIONAL SITES

Footprint Lake

Footprint Lake was well-oxygenated near the surface and DO concentrations near the surface met the MWQSOGs during all sampling periods. DO concentrations decreased with water depth and fell below the MWQSOGs instantaneous minimum objective for cool- and/or cold-water aquatic life in both the open-water and ice-cover seasons in some years.

Footprint Lake was isothermal with the exception of two spring sampling events and one summer sampling event over the four years of monitoring. Specifically, stratification was observed in spring 2010, spring 2013, and summer 2019 (Table 3.2-1 and Figure 3.2-1).

During the open-water season Footprint Lake was well-oxygenated near the surface. Typically DO concentrations were similar throughout the water column; however, DO decreased with water depth during some sampling events (Figure 3.2-2). Specifically, DO concentrations were lower near the bottom than at the surface in summer 2013 and 2019. DO concentrations near bottom met MWQSOGs instantaneous minimum objectives for cool- and cold-water aquatic life (5.0 and 4.0 mg/L, respectively) in summer 2013 but were below both of these objectives in summer 2019 (Table 3.2-1). During the open-water season, DO concentrations ranged from 8.54 to 10.70 mg/L at the surface and 2.93 to 10.48 mg/L near the bottom (maximum site water depth = 14.1 m; Table 3.2-2, and Figure 3.2-8).

During the ice-cover season, Footprint Lake was well-oxygenated near the surface while DO concentrations decreased with water depth and fell below the MWQSOGs instantaneous minimum objectives for cold-water aquatic life near the bottom of the water column in some winters (Figure 3.2-2). Specifically, DO concentrations near the bottom were below the MWQSOGs instantaneous minimum objectives for cold-water aquatic life (8.0 mg/L) in the winters of 2010 and 2019 (Table 3.2-1). In the ice-cover season, DO concentrations ranged from 12.82 to 16.42 mg/L at the surface and 3.60 to 13.33 mg/L near the bottom (Table 3.2-2 and Figure 3.2-8) The decrease in DO concentrations with depth occurred despite the lake being isothermal in winter (Table 3.2-1 and Figure 3.2-1).

During the open-water season, surface DO saturation ranged from 90.2 to 109.7% with a mean of 98.8% and a median of 98.4% over the four years of monitoring. Mean surface DO saturation levels in the open-water season ranged from 96.5 to 101.3% and were within or near the IQR of 95.9 to 100.2%. Bottom DO saturation during the open-water season ranged from 26.7 to 98.4% with a mean of 83.5% and a median of 91.9% over the four years of monitoring. Mean bottom DO saturation levels in the open-water season ranged from 70.2 to 94.4% and were within or near the IQR (88.5 to 94.3%) in two of four years. Mean DO saturation levels near the bottom were below the IQR in 2013 and 2019 (Table 3.2-2 and Figure 3.2-6).

During the ice-cover season, DO saturation at the surface ranged from 89.7 to 122.4% with a mean of 107.4%. Bottom DO saturation during the ice-cover season ranged from 27.0 to 97.2% with a mean of 60.5% (Table 3.2-2 and Figure 3.2-7).

Apussigamasi Lake

Apussigamasi Lake was well-oxygenated year-round and DO concentrations throughout the water column consistently met the MWQSOGs instantaneous minimum objectives for cool- and cold-water aquatic life during the open-water and ice-cover seasons (Table 3.2-1).

Apussigamasi Lake was isothermal and DO concentrations were similar throughout the water column during each sampling period (Table 3.2-1, and Figures 3.2-1 and 3.2-2). During the open-water season, DO concentrations ranged from 9.02 to 11.70 mg/L at the surface and 8.90 to 11.68 mg/L near the bottom (maximum site water depth = 11.6 m). During the ice-cover season, the DO concentration was 15.86 mg/L both near the surface and near the bottom in 2018 (Table 3.2-2 and Figure 3.2-9).

DO saturation in Apussigamasi Lake was near 100% at both the surface and near the bottom of the water column during each season sampled. During the open-water season, surface DO saturation ranged from 99.0 to 112.0% with a mean of 106.5% and a median of 107.5% over the four years of monitoring. Mean surface DO saturation levels in the open-water season were similar from year to year ranging from 101.2 to 109.2% and were within or near the IQR of 102.7 to 109.6%. Bottom DO saturation during the open-water season ranged from 97.5 to 111.7% with a mean of 106.3% and median of 108.6% over the four years of monitoring. Mean bottom DO saturation levels in the open-water season were similar from year to year ranging from 100.2 to 110.0% and were within or near the IQR of 101.8 to 109.6% (Table 3.2-2 and Figure 3.2-6).

During the ice-cover season, DO saturation at the surface was 111.6% both near the surface and near the bottom in 2018 (Table 3.2-2 and Figure 3.2-7).

3.2.1.2 OFF-SYSTEM SITES

ANNUAL SITES

Leftrook Lake

Leftrook Lake was well-oxygenated near the surface and DO concentrations met the MWQSOGs during all open-water sampling periods. However, DO concentrations decreased with water depth and fell below the MWQSOGs instantaneous minimum objectives for cool- and cold-water aquatic life during some open-water sampling events. DO concentrations below the MWQOSOGs instantaneous minimum objectives for cool- and cold-water aquatic life were observed throughout the water column during the ice-cover season.

Leftrook Lake was thermally stratified during the spring or summer sampling events in eight open-water periods as well as approximately half the ice-cover sampling events over the 11 years of monitoring (Figure 3.2-1). Stratification was observed in two spring sampling events (2010 and 2013), six summer sampling events (2011, 2012, 2014, 2017, 2018, and 2019), and five winter sampling events (2009, 2011, 2012, 2015, and 2016; Table 3.2-3).

During summer of most years, DO concentrations decreased down the water column to levels below one or more of the MWQSOGs instantaneous minimum objectives for cool- and cold-water aquatic life (5.0 and 4.0 mg/L, respectively) at approximately 6-9 m from the surface (Table 3.2-3 and Figure 3.2-2). Specifically, DO concentrations near the bottom were below at least one of these objectives in the summers of 2011, 2012, 2013, 2014, 2016, 2017, 2018 and 2019. Additionally, DO concentrations near the bottom were below both objectives in spring 2010 (Table 3.2-3). During the open-water season, DO concentrations ranged from 7.94 to 11.40 mg/L at the surface and from 0.00 to 10.54 mg/L near the bottom (maximum site water depth = 11.6 m; Table 3.2-4 and Figure 3.2-10).

During the ice-cover season, DO concentrations in Leftrook Lake decreased rapidly and fell below the MWQSOGs instantaneous minimum objectives for cold- and cool-water aquatic life at approximately 0.3-4 m below the ice (Figure 3.2-2). DO concentrations near the surface were below the MWQSOGs instantaneous minimum objective for cold-water aquatic life (8.0 mg/L) in winter of 2017, and DO concentrations near the bottom were below this objective in the winters of 2009, 2010, 2012, 2016, 2017, 2018, and 2019. Additionally, DO concentrations near the bottom were below the MWQSOGs instantaneous minimum objective for cool-water aquatic life (3.0 mg/L) in the winters of 2009, 2010, 2012, 2017 and 2018 (Table 3.2-3). In the ice-cover season, DO concentrations ranged from 7.80 to 12.82 mg/L at the surface and from 0.00 to 7.54 mg/L near the bottom (Table 3.2-4 and Figure 3.2-10).

Surface DO concentrations varied between seasons with seasonal mean DO concentrations being higher in spring and fall when the water was colder, and lower in the summer when the water was warmer. Despite colder water in winter, DO concentrations in winter were similar to those in spring and fall (Figure 3.2-11).

DO saturation was near 100% at the surface during the open-water season; however, surface DO saturation was lower in winter (mean = 73.6%; Figure 3.2-12). In the open-water season, surface DO saturation ranged from 86.6 to 121.3% with a mean of 98.5% and a median of 97.2% over the 11 years of monitoring. Mean surface DO saturation levels in the open-water season ranged from 89.9 to 103.4% and were within or near the IQR of 93.3 to 101.9%. During the ice-cover season, surface DO saturation ranged from 56.1 to 89.1% with a mean of 73.6% and a median of 74.5%. The IQR for the ice-cover season was 70.0 to 77.9% (Table 3.2-4 and Figure 3.2-13).

Seasonal differences in both DO concentration and percent saturation occurred near the bottom of the water column where, over the 11 years of monitoring, mean DO saturation was lower in summer and winter (30.0 and 23.1%, respectively) than in spring and fall (84.1 and 92.9%, respectively; Figures 3.2-11 and 3.2-12). During the open-water season, bottom DO saturation ranged from 0.0 to 103.0% with a mean of 68.5% and a median of 88.4% over the 11 years of monitoring. Mean bottom DO saturation levels ranged from 60.1 to 88.1% and were within the IQR for the open-water season (32.1 to 93.3%); however, bottom DO saturation in summer tended to be below the IQR for the open-water season. During the ice-cover season, bottom DO saturation ranged from 0.0 to 56.7% with a mean of 23.1% and a median of 19.4%. The IQR for the ice-cover season was 11.5 to 31.5% (Table 3.2-4 and Figure 3.2-13).

ROTATIONAL SITES

There are no off-system rotational sites in this region.

Table 3.2-1. 2008-2019 On-system sites summary of thermal stratification and DO concentrations.

Metric	Sampling Year	Surface or Bottom	3PT				FOOT				APU			
			Open-Water			Ice-Cover	Open-Water			Ice-Cover	Open-Water			Ice-Cover
			SP	SU	FA	WI	SP	SU	FA	WI	SP	SU	FA	WI
Thermal Stratification	2008													
	2009		No	No	No	No					No	No	No	No
	2010		No	No	No	No	2010	No	No	No				
	2011		No	No	No	No								
	2012		No	No	No	No					No	No	No	ND
	2013		No	No	No	No	2013	No	No	No				
	2014		No	No	No	No								
	2015		No	No	No	No					No	No	No	No
	2016		No	No	No	No	No	No	No	No				
	2017		No	No	No	No								
	2018		No	No	No	No					No	No	No	No
	2019		No	No	No	ND	No	2019	No	No				
DO met MWQSOGs PAL objectives	2008	Surface												
		Bottom												
	2009	Surface	ND	ND	ND	Yes					ND	ND	ND	ND
		Bottom	ND	ND	ND	Yes					ND	ND	ND	ND
	2010	Surface	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes				
		Bottom	Yes	Yes	Yes	Yes	Yes	Yes	Yes	2010				
	2011	Surface	Yes	Yes	Yes	ND								
		Bottom	Yes	Yes	Yes	ND								
	2012	Surface	Yes	Yes	Yes	Yes					Yes	Yes	Yes	ND
		Bottom	Yes	Yes	Yes	Yes					Yes	Yes	Yes	ND
	2013	Surface	Yes	Yes	Yes	ND	Yes	Yes	Yes	ND				
		Bottom	Yes	Yes	Yes	ND	ND	Yes	Yes	ND				
	2014	Surface	Yes	Yes	Yes	ND								
		Bottom	Yes	Yes	Yes	ND								
	2015	Surface	Yes	Yes	Yes	ND					Yes	Yes	Yes	ND
		Bottom	Yes	Yes	Yes	ND					Yes	Yes	Yes	ND
	2016	Surface	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes				
		Bottom	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes				
	2017	Surface	Yes	Yes	Yes	Yes								
		Bottom	Yes	Yes	Yes	Yes								
	2018	Surface	Yes	Yes	Yes	Yes					Yes	Yes	Yes	Yes
		Bottom	Yes	Yes	Yes	Yes					Yes	Yes	Yes	Yes
	2019	Surface	Yes	Yes	Yes	ND	Yes	Yes	Yes	Yes				
		Bottom	Yes	Yes	Yes	ND	Yes	2019	Yes	2019				

Notes:

1. SP = spring; SU = summer; FA = fall; WI = winter.
2. ND = No data.
3. MWQSOGs = Manitoba Water Quality Standards, Objectives, and Guidelines; PAL = Protection of aquatic life.
4. DO concentrations were compared to the most stringent MWQSOGs instantaneous minimum PAL objectives for each season; i.e., 5 mg/L for cool-water early life for the open-water season and 8 mg/L for cold-water early life the ice-cover season.
5. Cells with a year indicated denote instances of stratification or non-compliance with MWQSOGs instantaneous minimum objectives.
6. [ ] = Sampling did not occur.

Table 3.2-2. 2008-2019 On-system sites DO, water depth, and ice thickness summary statistics.

Site	Statistic	Dissolved Oxygen								Water Depth at Site (m)		Ice Thickness at Site (m)
		DO – Surface (mg/L)		DO – Bottom (mg/L)		DO Saturation - Surface (%)		DO Saturation - Bottom (%)				
		OW	IC	OW	IC	OW	IC	OW	IC	OW	IC	IC
3PT	Mean	9.82	15.70	9.79	15.73	100.5	113.2	99.5	113.6	5.3	5.8	0.71
	Median	9.63	15.72	9.60	15.55	100.6	113.7	99.5	115.5	5.5	5.7	0.70
	Minimum	8.38	15.03	8.06	15.03	91.2	105.6	89.5	105.8	3.2	4.9	0.58
	Maximum	12.31	16.42	12.32	16.91	115.3	121.6	113.0	119.6	8.0	6.5	0.90
	SD	0.972	0.576	1.03	0.731	6.00	6.43	5.94	5.95	0.96	0.56	0.095
	SE	0.177	0.235	0.188	0.298	1.10	2.63	1.08	2.43	0.17	0.18	0.030
	Lower Quartile	9.17	15.21	9.10	15.18	95.9	107.9	94.6	108.6	4.5	5.4	0.66
	Upper Quartile	10.29	16.12	10.47	16.10	102.8	117.3	103.6	118.0	5.9	6.2	0.77
	n	30	6	30	6	30	6	30	6	33	10	10
	% Detections	100	100	100	100	100	100	100	100	-	-	-
FOOT	Mean	9.67	14.95	8.46	8.06	98.8	107.4	83.5	60.5	11.0	11.0	0.80
	Median	9.93	-	9.04	-	98.4	-	91.9	-	10.9	-	-
	Minimum	8.54	12.82	2.93	3.60	90.2	89.7	26.7	27.0	7.9	3.6	0.68
	Maximum	10.70	16.42	10.48	13.33	109.7	122.4	98.4	97.2	13.5	14.1	1.02
	SD	0.713	1.89	2.28	4.92	4.92	16.5	22.4	35.2	2.04	4.94	0.156
	SE	0.206	1.09	0.689	2.84	1.42	9.54	6.75	20.3	0.59	2.47	0.078
	Lower Quartile	9.09	-	8.78	-	95.9	-	88.5	-	9.0	-	-
	Upper Quartile	10.16	-	9.68	-	100.2	-	94.3	-	13.1	-	-
	n	12	3	11	3	12	3	11	3	12	4	4
	% Detections	100	100	100	100	100	100	100	100	-	-	-

Table 3.2-2. continued.

Site	Statistic	Dissolved Oxygen								Water Depth at Site (m)		Ice Thickness at Site (m)
		DO – Surface (mg/L)		DO – Bottom (mg/L)		DO Saturation - Surface (%)		DO Saturation - Bottom (%)				
		OW	IC	OW	IC	OW	IC	OW	IC	OW	IC	IC
APU	Mean	10.51	15.86	10.51	15.86	106.5	111.6	106.3	111.6	8.7	10.9	0.70
	Median	10.63	-	10.77	-	107.5	-	108.6	-	8.7	-	-
	Minimum	9.02	15.86	8.90	15.86	99.0	111.6	97.5	111.6	6.8	10.4	0.65
	Maximum	11.70	15.86	11.68	15.86	112.0	111.6	111.7	111.6	10.1	11.6	0.73
	SD	0.787	-	0.835	-	4.33	-	4.94	-	0.94	0.61	0.042
	SE	0.262	-	0.278	-	1.44	-	1.65	-	0.27	0.35	0.024
	Lower Quartile	10.11	-	10.03	-	102.7	-	101.8	-	8.2	-	-
	Upper Quartile	11.02	-	11.00	-	109.6	-	109.6	-	9.5	-	-
	n	9	1	9	1	9	1	9	1	12	3	3
	% Detections	100	100	100	100	100	100	100	100	-	-	-

Notes:

1. OW = Open-water season; IC = Ice-cover season.
2. SD = standard deviation; SE = standard error; n = number of samples.

Table 3.2-3. 2008-2019 Off-system sites summary of thermal stratification and DO concentrations.

Metric	Sampling Year	Surface or Bottom	LEFT			
			Open-Water			Ice-Cover
			SP	SU	FA	WI
Thermal Stratification	2008					
	2009		No	No	No	2009
	2010		2010	No	No	No
	2011		No	2011	No	2011
	2012		No	2012	No	2012
	2013		2013	No	No	No
	2014		No	2014	No	No
	2015		No	No	No	2015
	2016		No	No	No	2016
	2017		No	2017	No	No
	2018		No	2018	No	No
	2019		No	2019	No	No
DO met MWQSOGs PAL objectives	2008	Surface				
		Bottom				
	2009	Surface	ND	ND	ND	Yes
		Bottom	ND	ND	ND	2009
	2010	Surface	Yes	Yes	Yes	Yes
		Bottom	2010	Yes	Yes	2010
	2011	Surface	Yes	Yes	Yes	ND
		Bottom	Yes	2011	Yes	ND
	2012	Surface	Yes	Yes	Yes	Yes
		Bottom	Yes	2012	Yes	2012
	2013	Surface	Yes	Yes	Yes	ND
		Bottom	ND	2013	Yes	ND
	2014	Surface	Yes	Yes	Yes	ND
		Bottom	Yes	2014	Yes	ND
	2015	Surface	Yes	Yes	Yes	ND
		Bottom	Yes	Yes	Yes	ND
	2016	Surface	Yes	Yes	Yes	Yes
		Bottom	Yes	2016	Yes	2016
	2017	Surface	Yes	Yes	Yes	2017
		Bottom	Yes	2017	Yes	2017
	2018	Surface	Yes	Yes	Yes	Yes
		Bottom	Yes	2018	Yes	2018
	2019	Surface	Yes	Yes	Yes	Yes
		Bottom	Yes	2019	Yes	2019

Notes:

1. SP = spring; SU = summer; FA = fall; WI = winter; DO = dissolved oxygen; MWQSOG = Manitoba Water Quality Standards, Objectives, and Guidelines; PAL = Protection of Aquatic Life.
2. ND = No data.
3. DO concentrations were compared to the most stringent MWQSOGs instantaneous minimum PAL objectives for each season; i.e., 5 mg/L for cool-water early life for the open-water season and 8 mg/L for cold-water early life the ice-cover season.
4. Cells with a year indicated denote instances of stratification or non-compliance with MWQSOGs instantaneous minimum objectives.
5. [ ] = Sampling did not occur.

Table 3.2-4. 2008-2019 Off-system sites DO, water depth, and ice thickness summary statistics.

Site	Statistic	Dissolved Oxygen (DO)								Water Depth at Site (m)		Ice Thickness at Site (m)
		DO – Surface (mg/L)		DO – Bottom (mg/L)		DO Saturation - Surface (%)		DO Saturation - Bottom (%)				
		OW	IC	OW	IC	OW	IC	OW	IC	OW	IC	IC
LEFT	Mean	9.47	10.16	6.84	3.01	98.5	73.6	68.5	23.1	9.2	8.9	0.75
	Median	9.31	9.95	8.76	2.42	97.2	74.5	88.4	19.4	9.7	9.9	0.76
	Minimum	7.94	7.80	0.00	0.00	86.6	56.1	0.0	0.0	4.1	3.9	0.63
	Maximum	11.40	12.82	10.54	7.54	121.3	89.1	103.0	56.7	11.6	11.0	0.85
	SD	0.870	1.59	3.73	2.71	7.75	10.1	37.0	20.2	1.81	2.22	0.067
	SE	0.159	0.60	0.692	1.02	1.41	3.81	6.86	7.6	0.31	0.67	0.020
	Lower Quartile	8.84	9.37	2.84	1.44	93.3	70.0	32.1	11.5	8.6	8.8	0.71
	Upper Quartile	10.07	10.92	9.54	4.11	101.9	77.9	93.3	31.5	10.5	10.0	0.78
	n	30	7	29	7	30	7	29	7	33	11	11
	% Detections	100	100	100	100	100	100	100	100	-	-	-

Notes:

1. OW = Open-water season; IC = Ice-cover season.
2. SD = standard deviation; SE = standard error; n = number of samples.

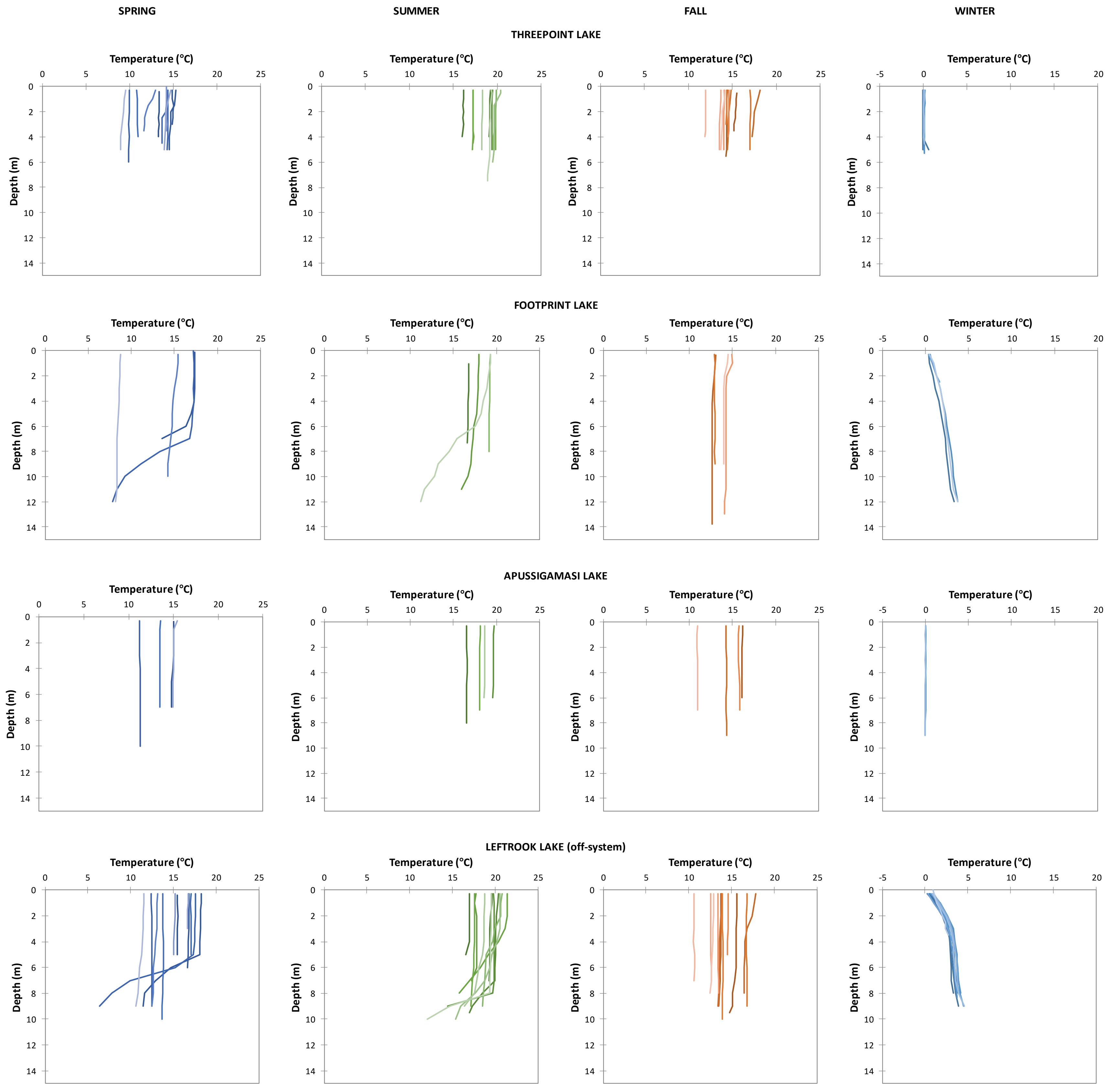


Figure 3.2-1. 2008-2019 On-system and off-system water temperature depth profiles.

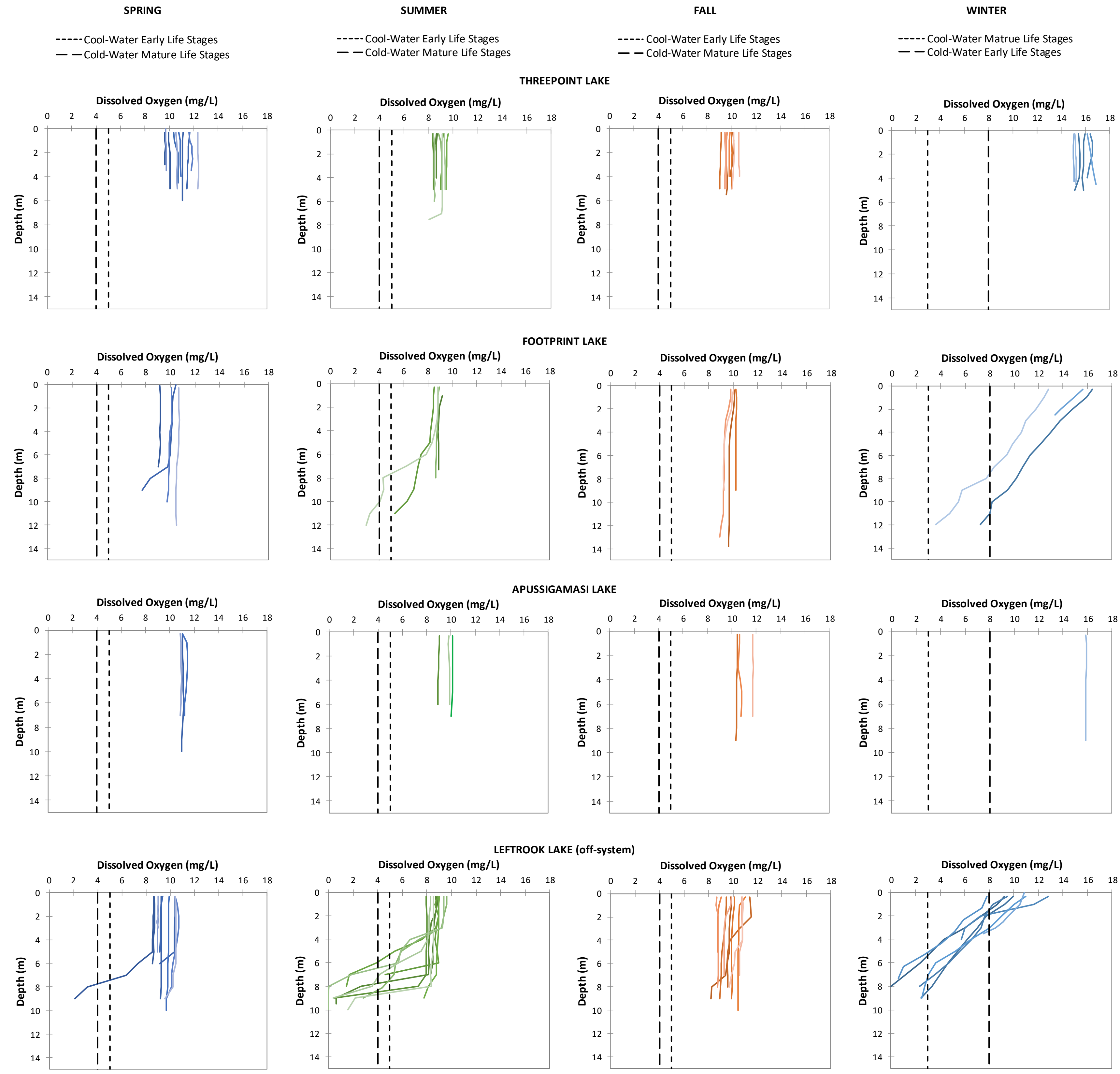


Figure 3.2-2. 2008-2019 On-system and off-system dissolved oxygen depth profiles and comparison to instantaneous minimum objectives for the protection of aquatic life.

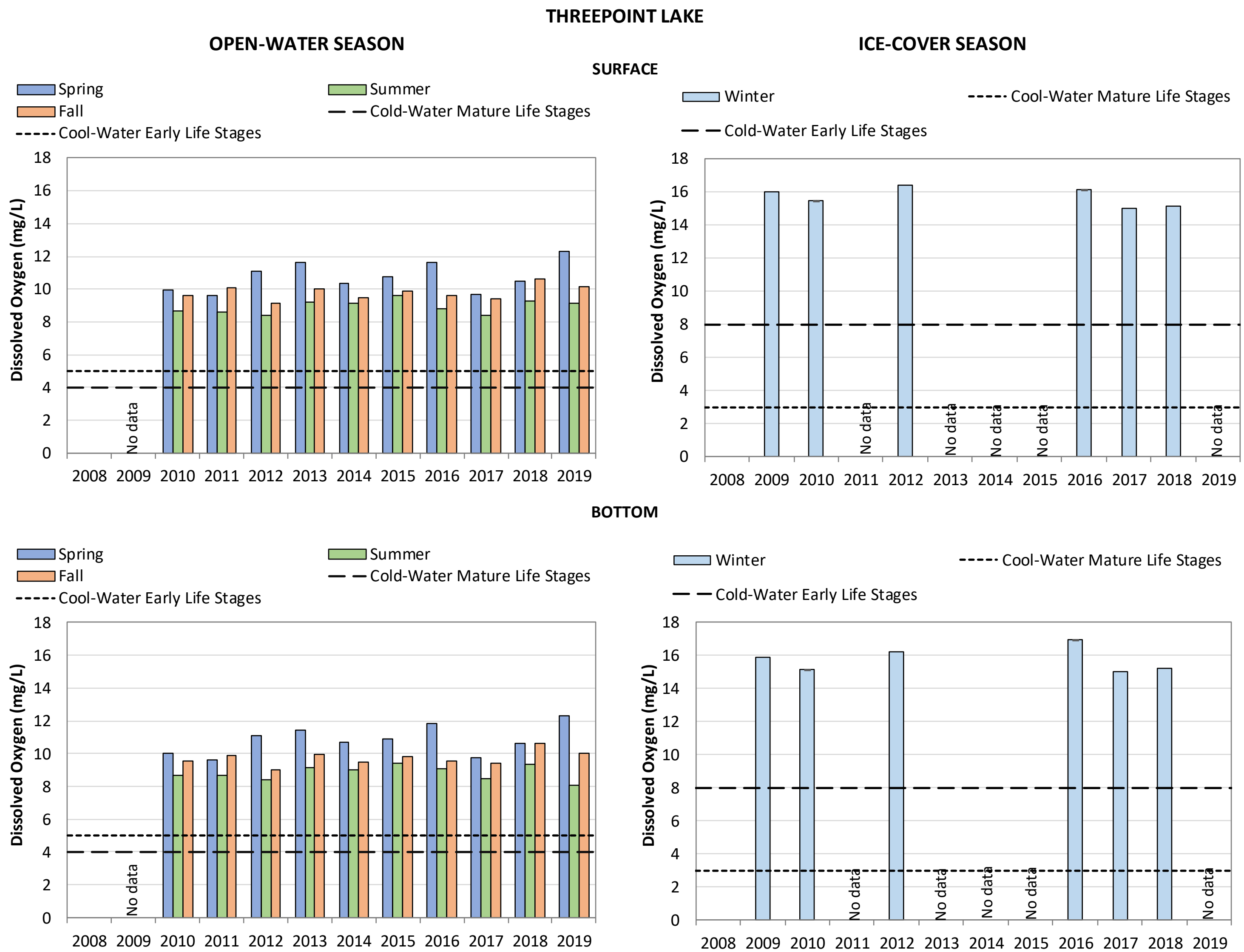


Figure 3.2-3. 2008-2019 Threepoint Lake surface and bottom dissolved oxygen concentrations with comparison to instantaneous minimum objectives for the protection of aquatic life.

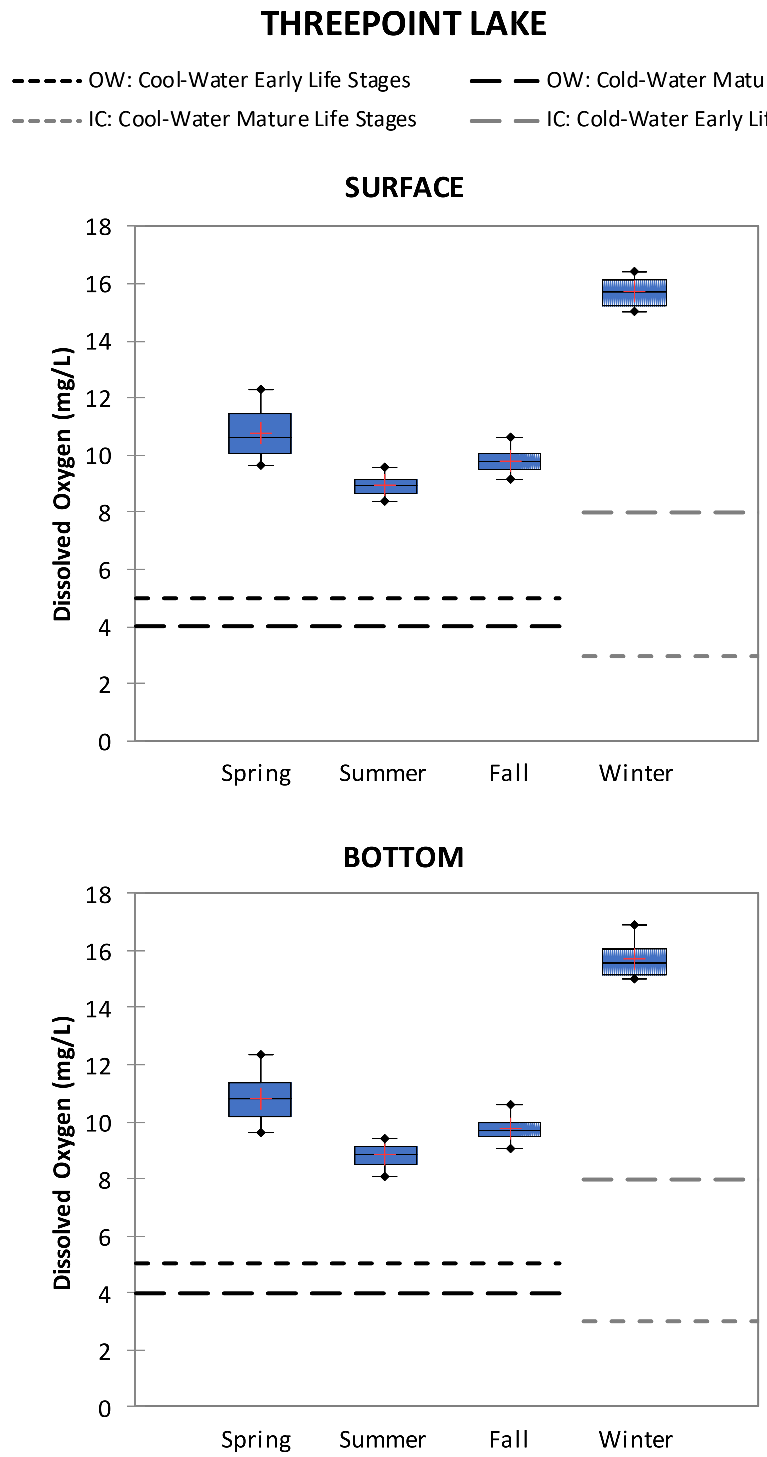


Figure 3.2-4. 2008-2019 On-system seasonal surface and bottom dissolved oxygen concentrations with comparison to instantaneous minimum objectives for the protection of aquatic life.

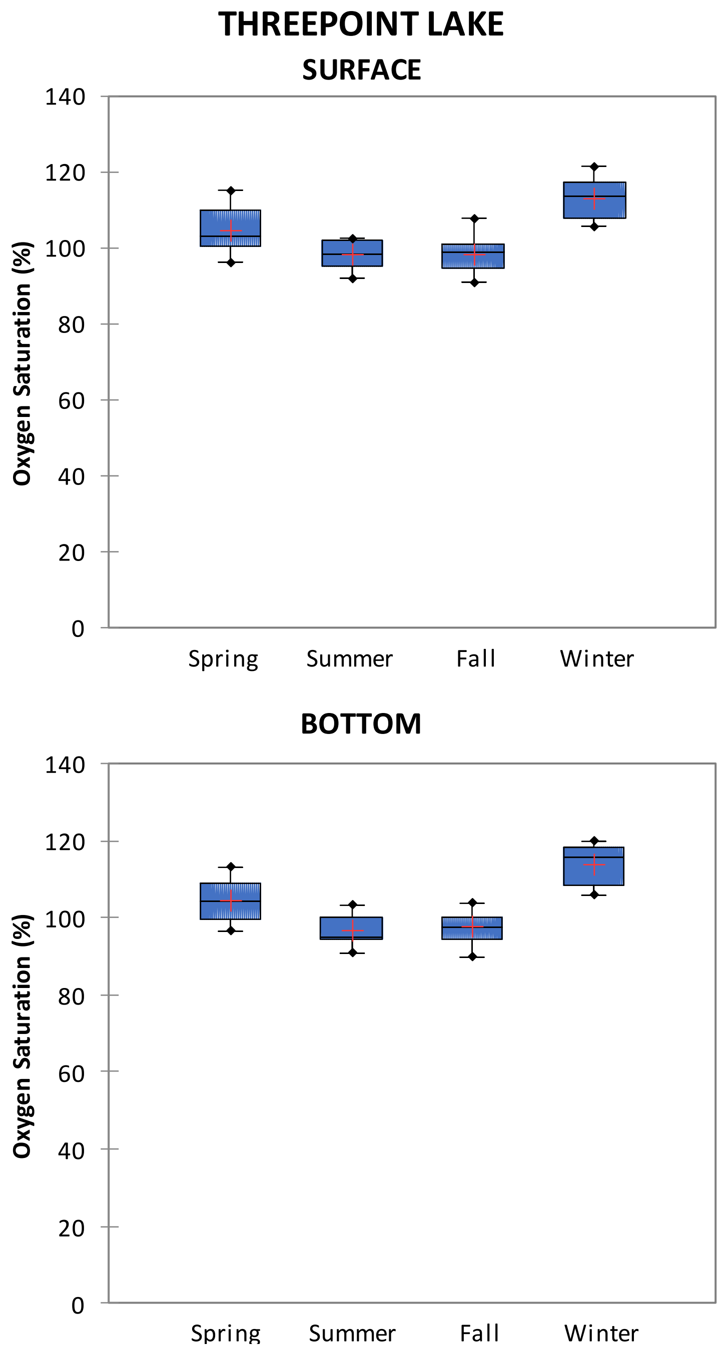


Figure 3.2-5. 2008-2019 On-system seasonal surface and bottom dissolved oxygen saturation.

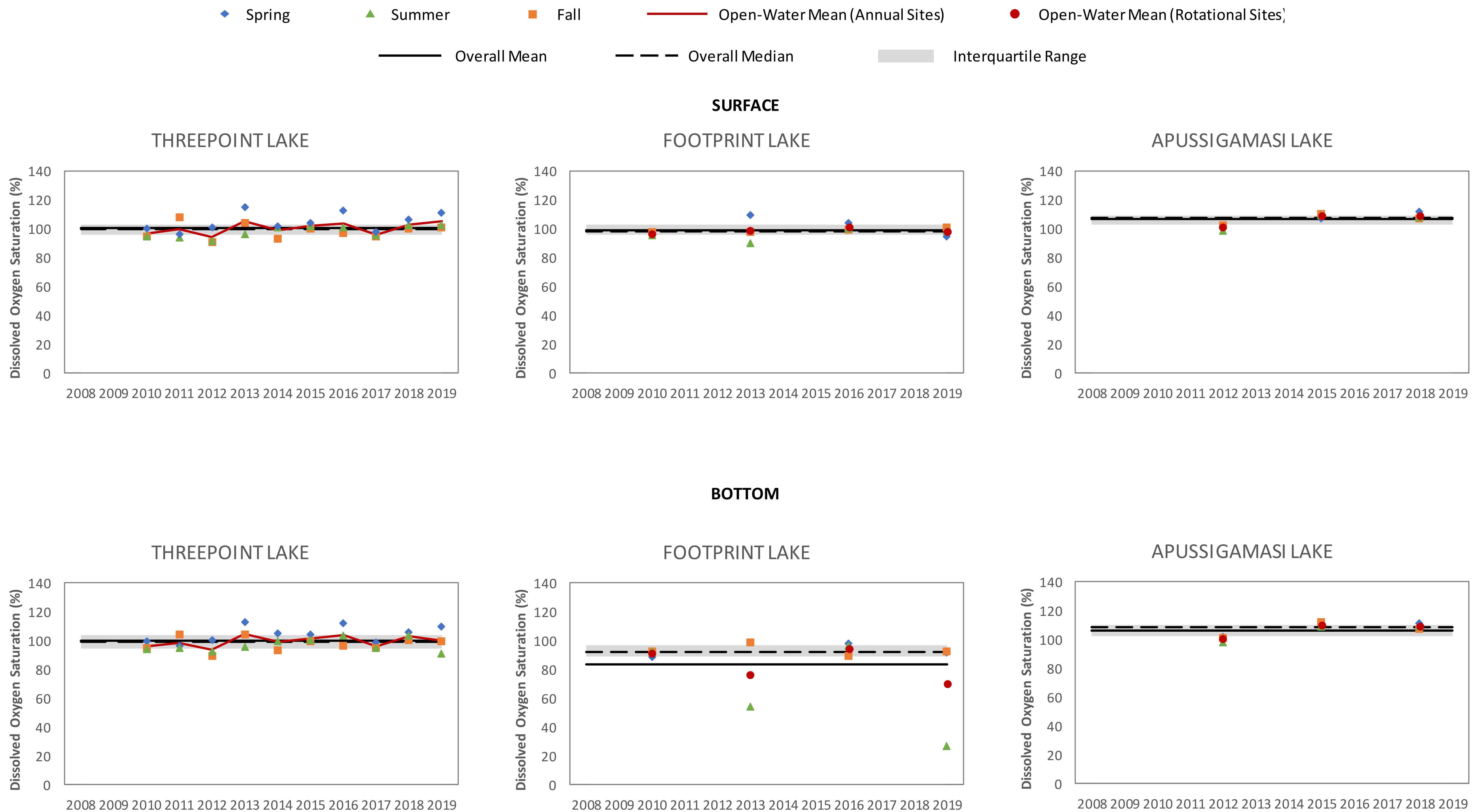


Figure 3.2-6. 2008-2019 On-system open-water season surface and bottom dissolved oxygen saturation.

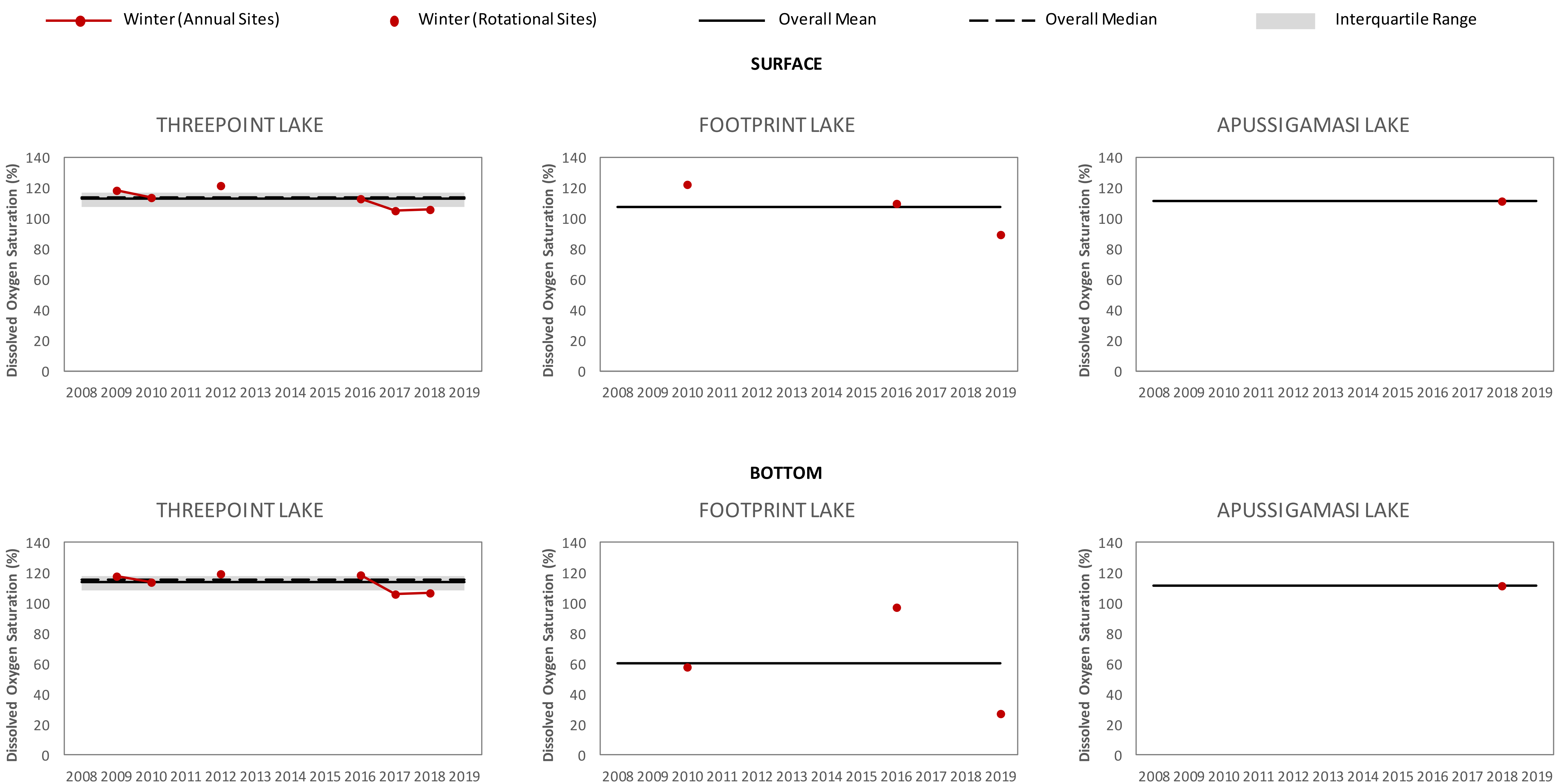


Figure 3.2-7. 2008-2019 On-system ice-cover season surface and bottom dissolved oxygen saturation.

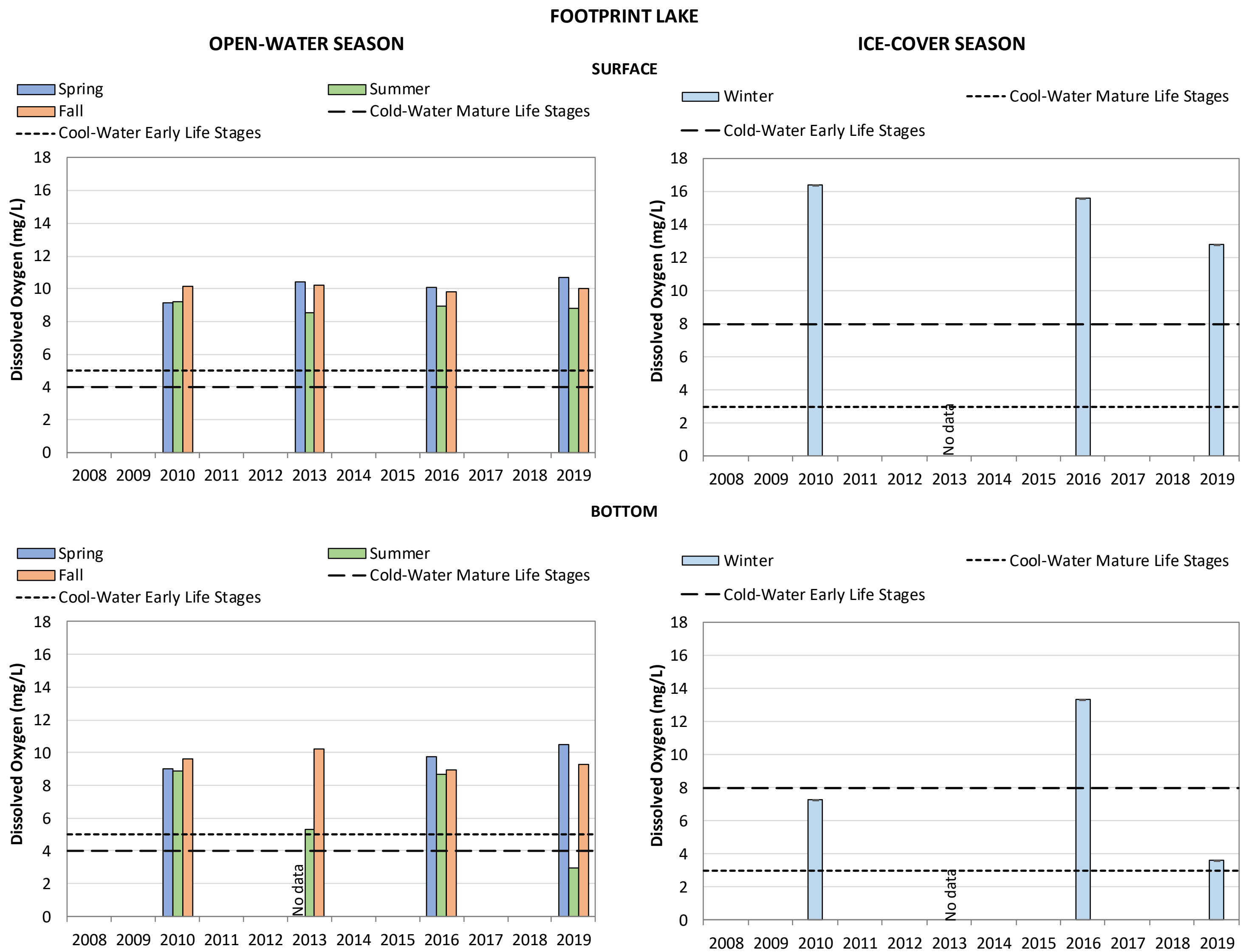


Figure 3.2-8. 2008-2019 Footprint Lake surface and bottom dissolved oxygen concentrations with comparison to instantaneous minimum objectives for the protection of aquatic life.

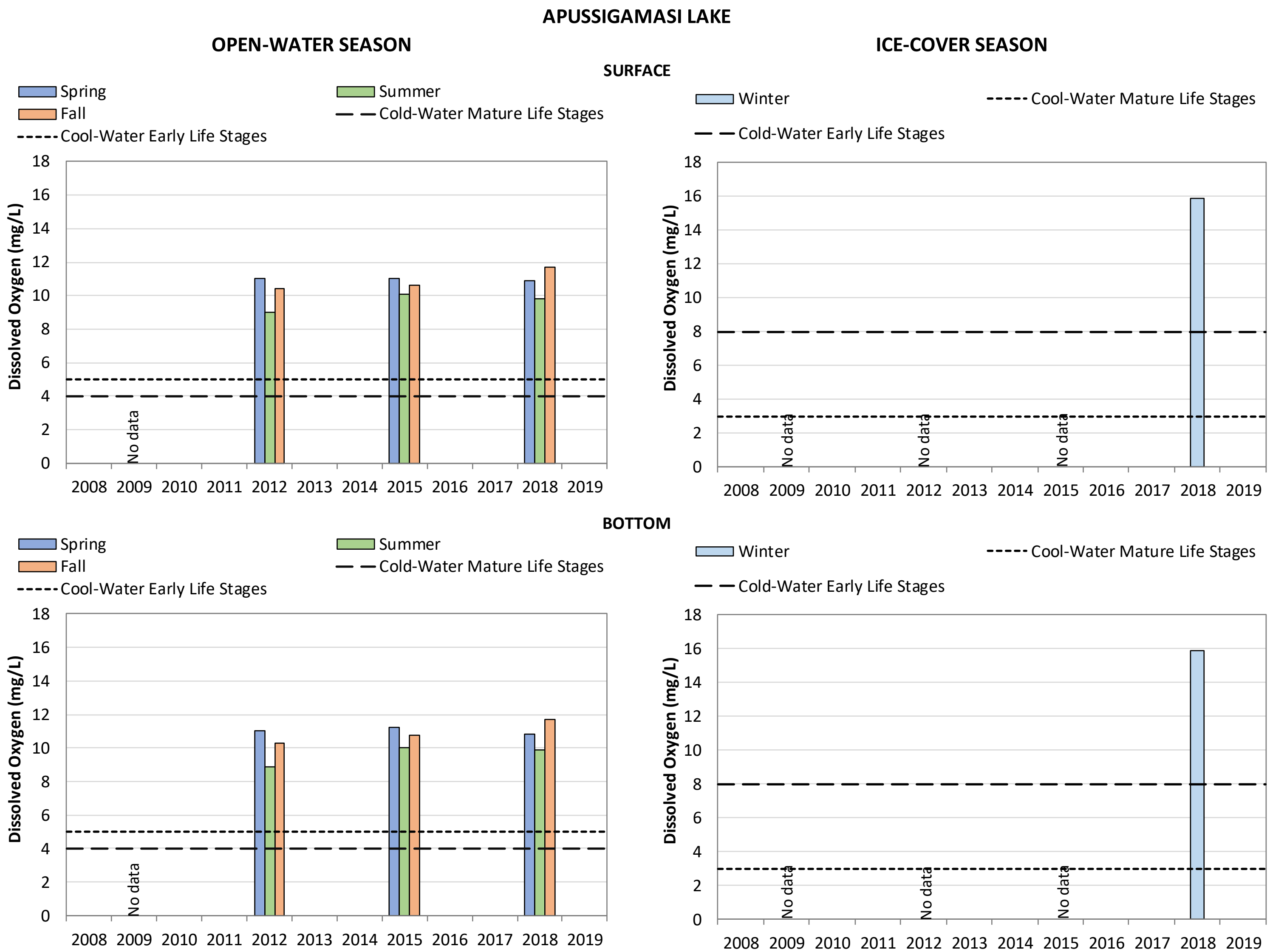


Figure 3.2-9. 2008-2019 Apussigamasi Lake surface and bottom dissolved oxygen concentrations with comparison to instantaneous minimum objectives for the protection of aquatic life.

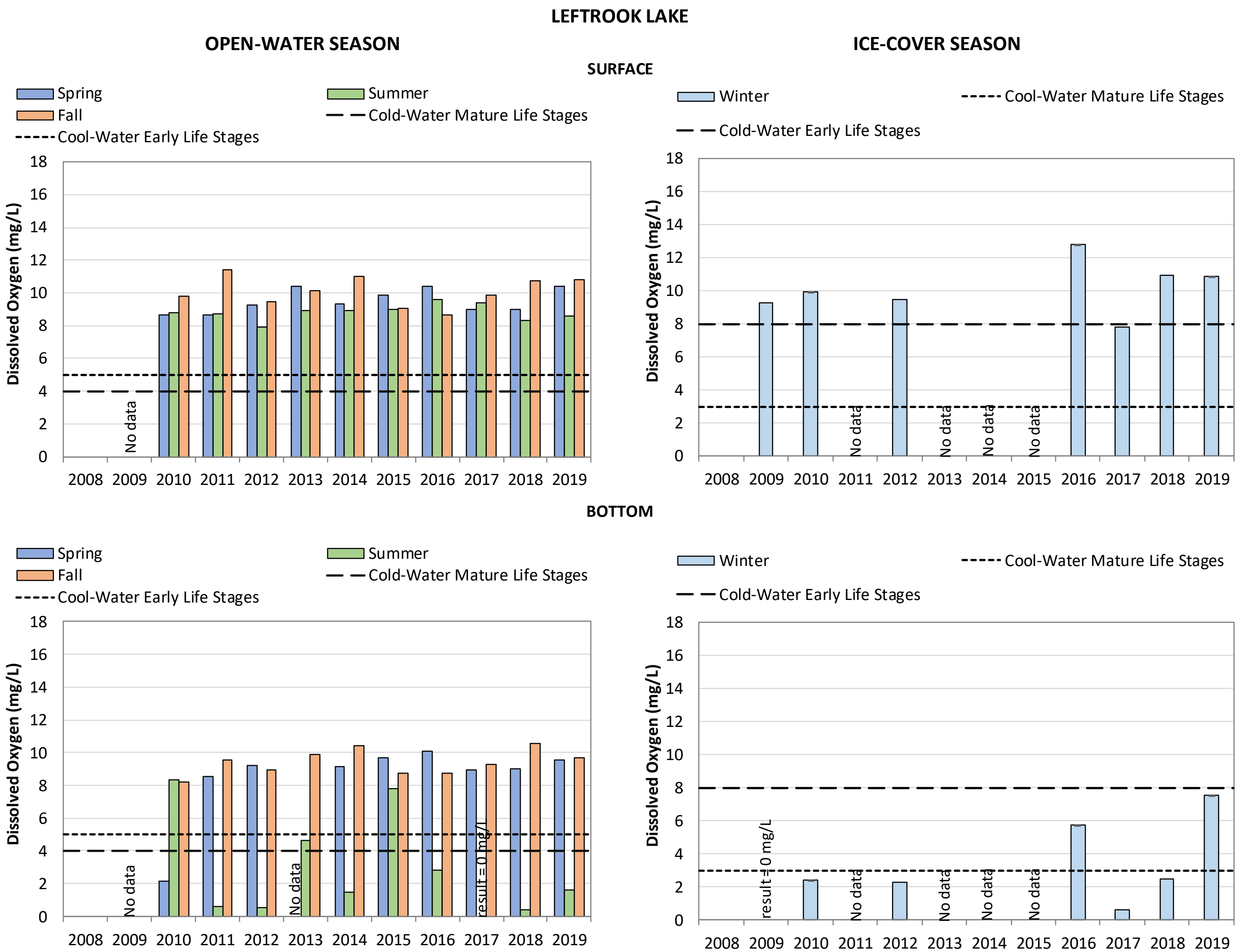


Figure 3.2-10. 2008-2019 Leftrook Lake surface and bottom dissolved oxygen concentrations with comparison to instantaneous minimum objectives for the protection of aquatic life.

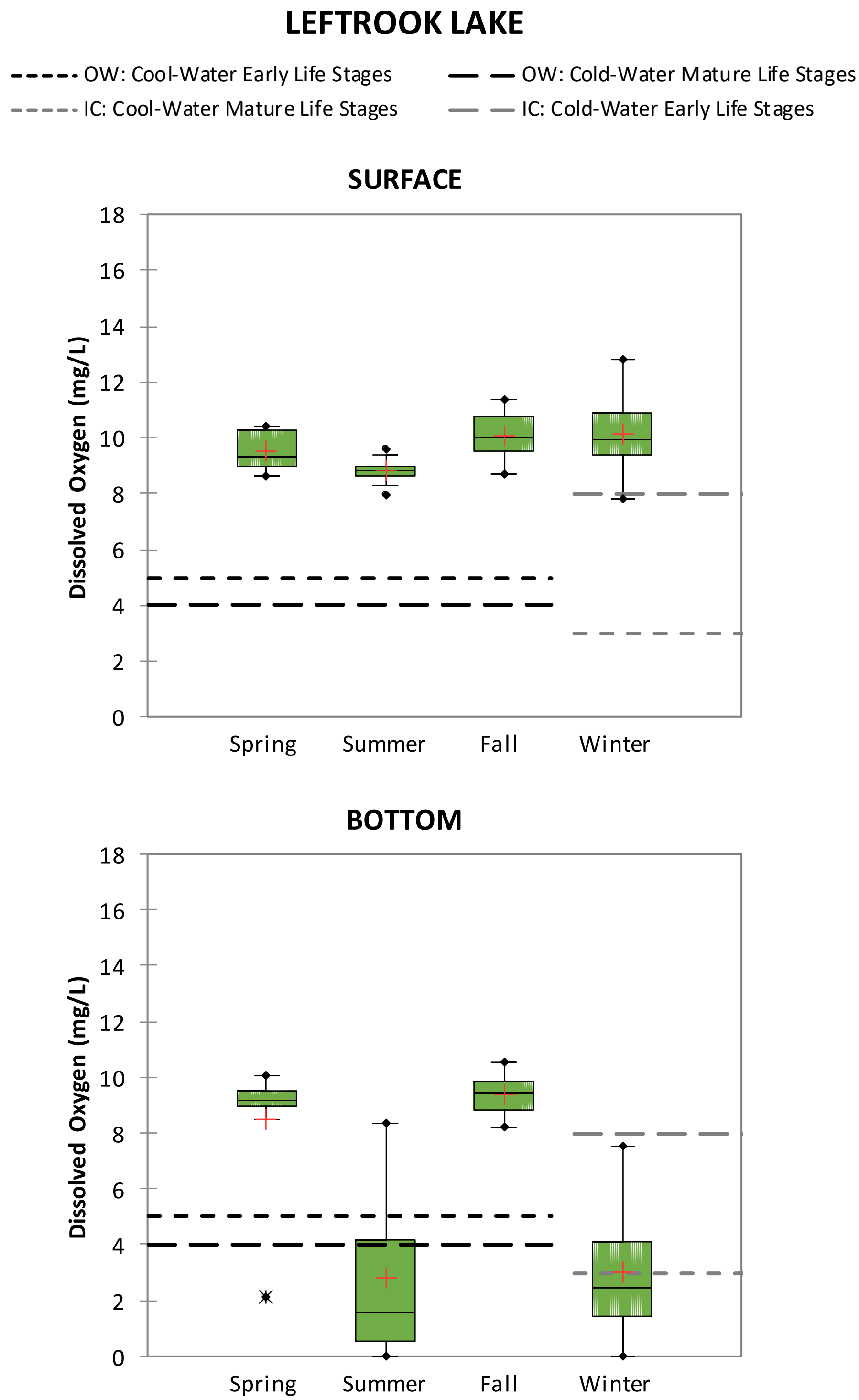


Figure 3.2-11. 2008-2019 Off-system seasonal surface and bottom dissolved oxygen concentrations with comparison to instantaneous minimum objectives for the protection of aquatic life.

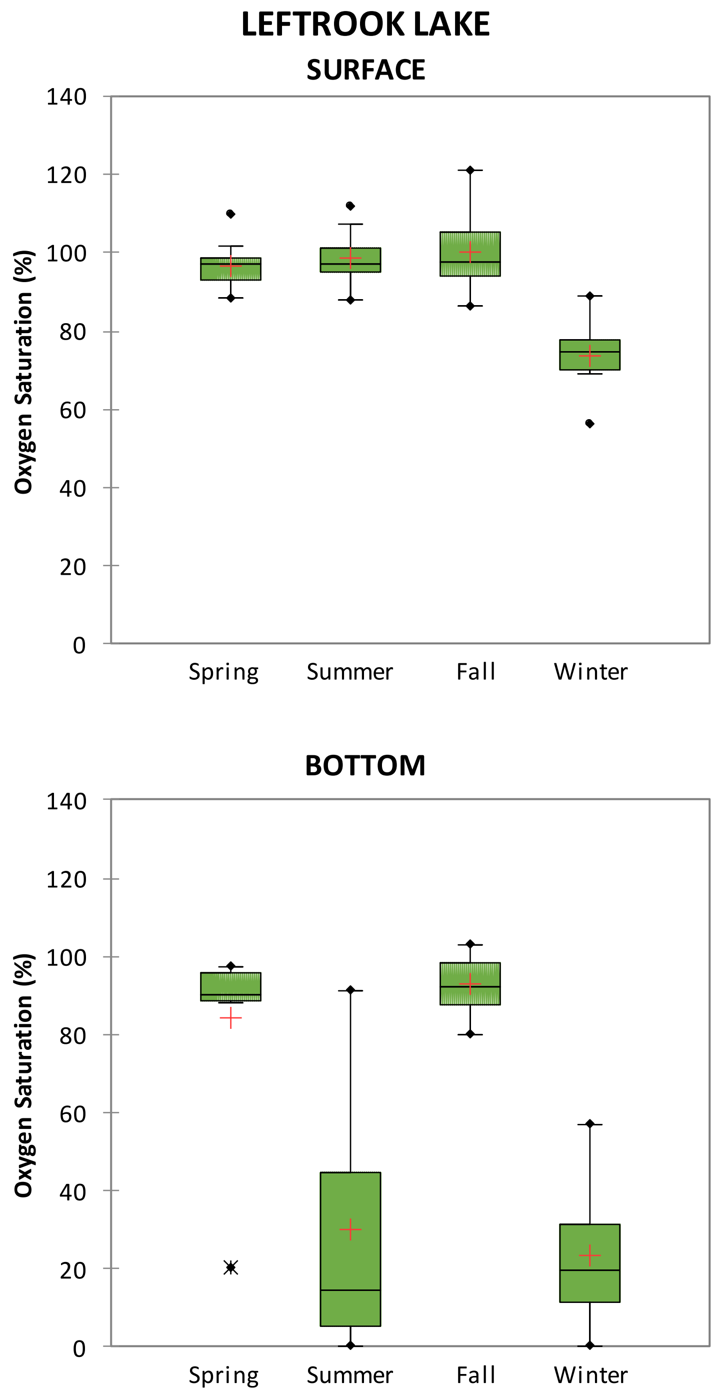


Figure 3.2-12. 2008-2019 Off-system seasonal surface and bottom dissolved oxygen saturation.

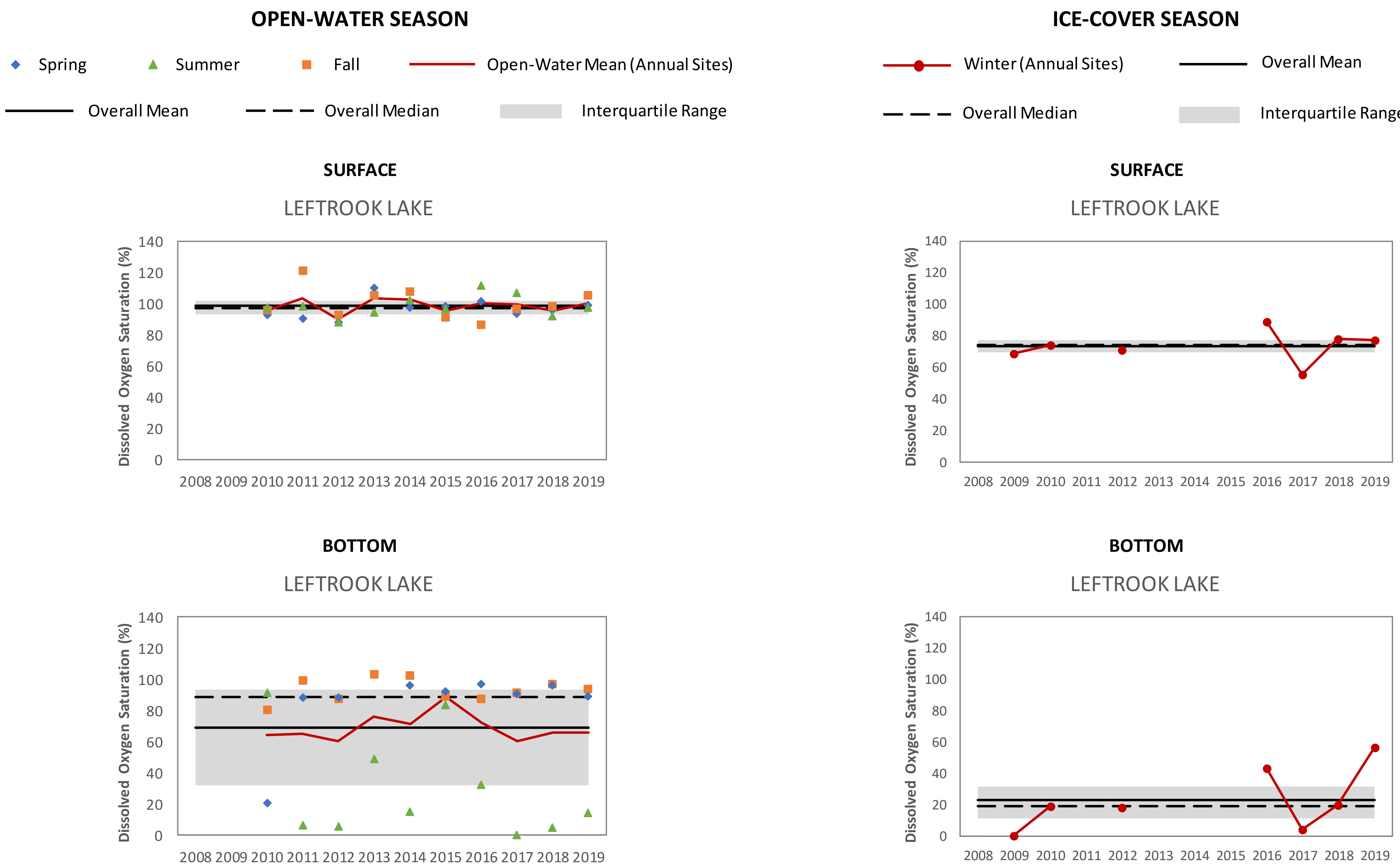


Figure 3.2-13. 2008-2019 Off-system open-water and ice-cover season surface and bottom dissolved oxygen saturation.

3.3 WATER CLARITY

3.3.1 SECCHI DISK DEPTH

3.3.1.1 ON-SYSTEM SITES

ANNUAL SITES

Threepoint Lake

Secchi disk depth in Threepoint Lake ranged from 0.30 to 1.00 m during the open-water season. The mean and median measurements for the 11 years of monitoring were 0.55 and 0.53 m, respectively. Mean annual Secchi disk depths ranged from 0.43 to 0.70 m and were within the IQR (0.45 to 0.59 m) in seven of the 11 years of monitoring. Mean Secchi disk depths were below the IQR in 2014 and above the IQR in 2009, 2012, and 2019 (Table 3.3-1 and Figure 3.3-1).

No clear seasonality was observed for Secchi disk depth in Threepoint Lake over the 11 years of monitoring. However, the mean Secchi disk depth was highest in spring (0.60 m) and lowest in summer and fall (0.52 m for both; Figure 3.3-2).

ROTATIONAL SITES

Footprint Lake

Secchi disk depth in Footprint Lake ranged from 0.65 to 1.90 m during the open-water season. The mean was 1.16 m, the median was 1.05 m, and the IQR was 0.97 to 1.22 m for the four years of monitoring. Mean annual Secchi disk depths ranged from 0.88 to 1.45 m and were within the IQR in 2010, below the IQR in 2016, and above the IQR in 2013 and 2019 (Table 3.3-1 and Figure 3.3-1).

Apussigamasi Lake

Secchi disk depth in Apussigamasi Lake ranged from 0.27 to 0.48 m during the open-water season. The mean and median were both 0.34 m and the IQR was 0.30 to 0.35 m for the four years of monitoring. Mean annual Secchi disk depths ranged from 0.31 to 0.39 m and were within the IQR in 2012, 2015, and 2018 but above the IQR in 2009 (Table 3.3-1 and Figure 3.3-1).

3.3.1.2 OFF-SYSTEM SITES

ANNUAL SITES

Leftrook Lake

Secchi disk depth in Leftrook Lake ranged from 0.80 to 2.80 m during the open-water season. The mean and median measurements for the 11 years of monitoring were 1.63 and 1.55 m, respectively. Mean annual Secchi disk depths ranged from 1.21 to 2.03 m and were within the IQR (1.25 to 1.95 m) in nine of the 11 years of monitoring. Mean Secchi disk depths were below the IQR in 2013 and above the IQR in 2019 (Table 3.3-2 and Figure 3.3-3).

On average, Secchi disk depths were higher in the spring (2.13 m) than in the summer and fall (1.43 and 1.34 m, respectively; Figure 3.3-4).

ROTATIONAL SITES

There are no off-system rotational sites in this region.

Table 3.3-1. 2008-2019 On-system sites water clarity summary statistics.

Site	Statistic	Secchi Disk Depth (m)		Turbidity (NTU)		TSS (mg/L)	
		OW	IC	OW	IC	OW	IC
3PT	Mean	0.55	-	17.9	10.5	7.5	<2.0
	Median	0.53	-	18.2	10.5	7.0	<2.0
	Minimum	0.30	-	8.22	7.52	2.9	<2.0
	Maximum	1.00	-	41.5	13.0	18.6	3.5
	SD	0.137	-	5.42	1.82	3.03	1.04
	SE	0.024	-	0.943	0.576	0.527	0.330
	Lower Quartile	0.45	-	16.2	9.09	5.6	<2.0
	Upper Quartile	0.59	-	19.7	11.8	8.6	2.8
	n	33	-	33	10	33	10
	% Detections	100	-	100	100	100	50
FOOT	Mean	1.16	-	7.33	11.4	5.1	<2.0
	Median	1.05	-	7.36	-	4.9	-
	Minimum	0.65	-	5.30	6.98	2.9	<2.0
	Maximum	1.90	-	11.5	15.1	7.0	2.4
	SD	0.368	-	1.80	3.45	1.27	0.712
	SE	0.106	-	0.520	1.72	0.368	0.356
	Lower Quartile	0.97	-	5.75	-	4.5	-
	Upper Quartile	1.22	-	8.08	-	5.8	-
	n	12	-	12	4	12	4
	% Detections	100	-	100	100	100	50
APU	Mean	0.34	-	29.5	16.4	13.6	8.2
	Median	0.34	-	30.8	-	12.7	-
	Minimum	0.27	-	21.0	14.1	7.6	6.5
	Maximum	0.48	-	35.0	19.4	24.4	9.6
	SD	0.052	-	4.47	2.69	5.23	1.55
	SE	0.015	-	1.29	1.55	1.51	0.897
	Lower Quartile	0.30	-	27.1	-	9.4	-
	Upper Quartile	0.35	-	32.1	-	15.5	-
	n	12	-	12	3	12	3
	% Detections	100	-	100	100	100	100

Notes:

1. OW = Open-water season; IC = Ice-cover season.
2. SD = standard deviation; SE = standard error; n = number of samples.

Table 3.3-2. 2008-2019 Off-system sites water clarity metric summary statistics.

Site	Statistic	Secchi Disk Depth (m)		Turbidity (NTU)		TSS (mg/L)	
		OW	IC	OW	IC	OW	IC
LEFT	Mean	1.63	-	3.25	0.90	4.3	<2.0
	Median	1.55	-	2.58	0.85	3.9	<2.0
	Minimum	0.80	-	1.00	0.42	<2.0	<2.0
	Maximum	2.80	-	6.55	1.53	16.8	<2.0
	SD	0.574	-	1.55	0.357	3.15	-
	SE	0.100	-	0.274	0.108	0.548	-
	Lower Quartile	1.25	-	2.06	0.71	2.4	<2.0
	Upper Quartile	1.95	-	4.38	1.12	4.8	<2.0
	n	33	-	32	11	33	11
	% Detections	100	-	100	100	82	0

Notes:

1. OW = Open-water season; IC = Ice-cover season.
2. SD = standard deviation; SE = standard error; n = number of samples.
3. Turbidity statistics for LEFT exclude suspect value of 19.5 NTU from summer 2011.

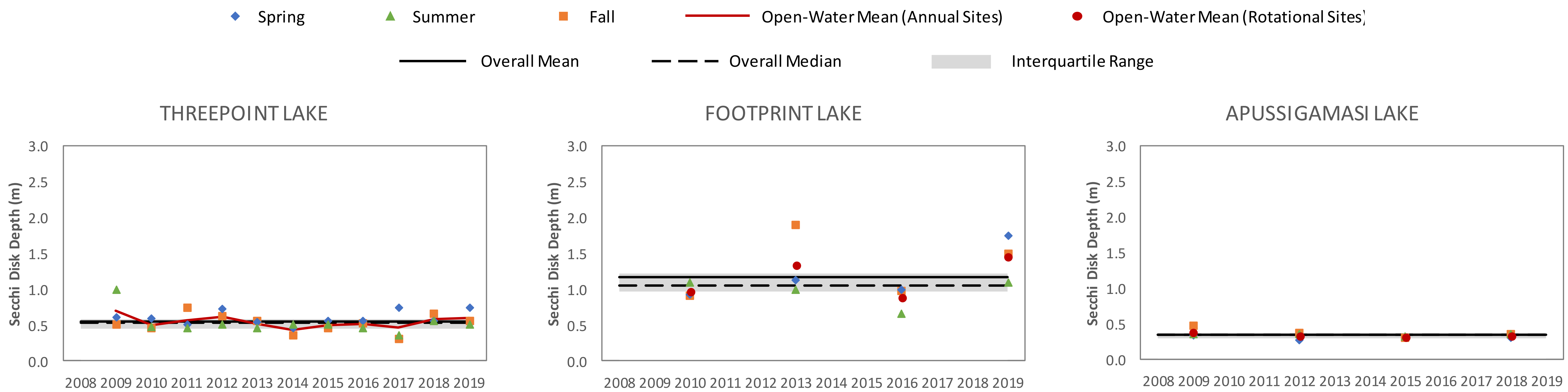


Figure 3.3-1. 2008-2019 On-system open-water season Secchi disk depths.

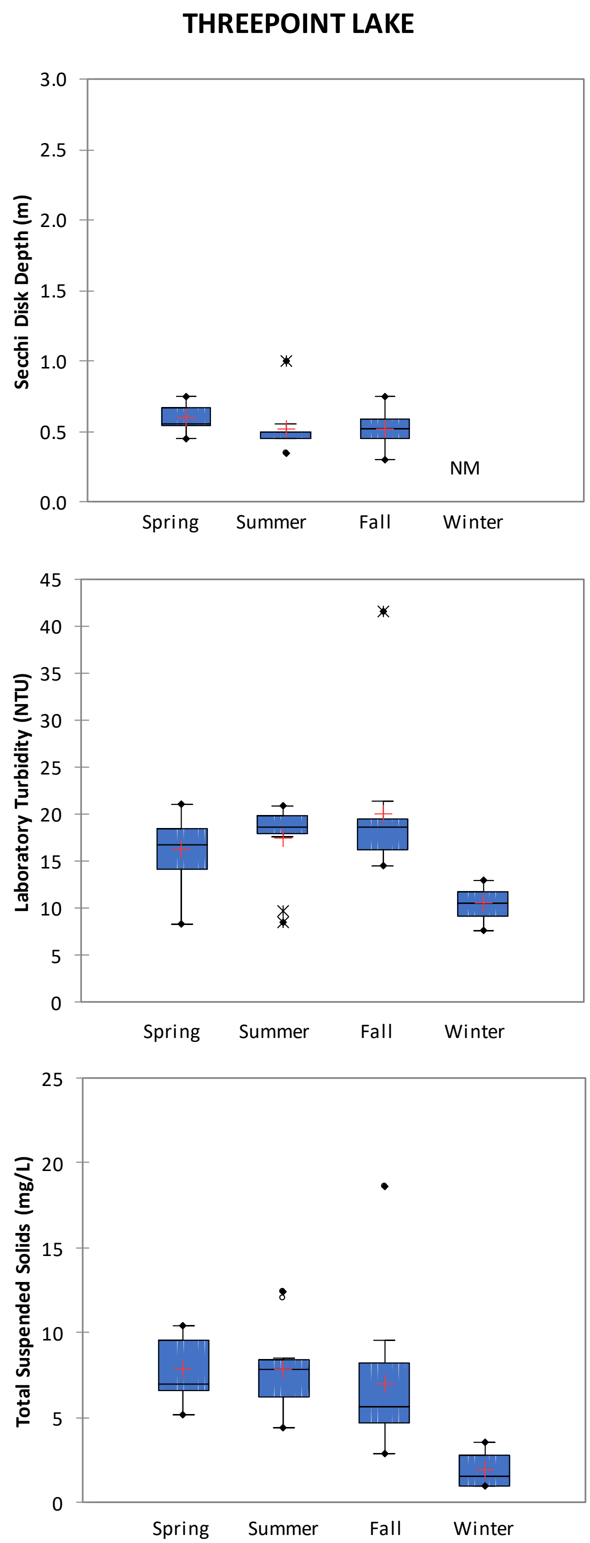


Figure 3.3-2. 2008-2019 On-system seasonal Secchi disk depth, turbidity, and TSS concentrations.

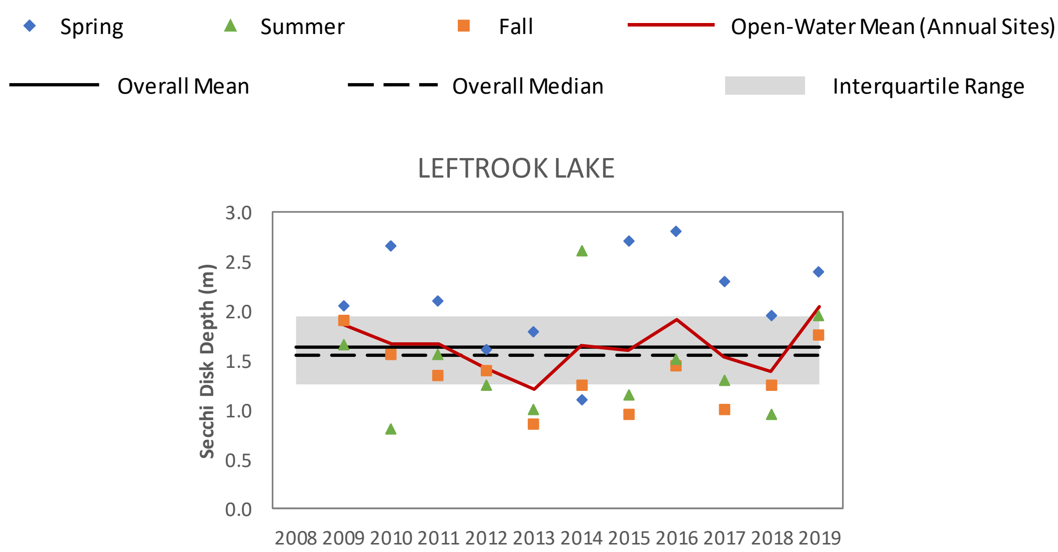
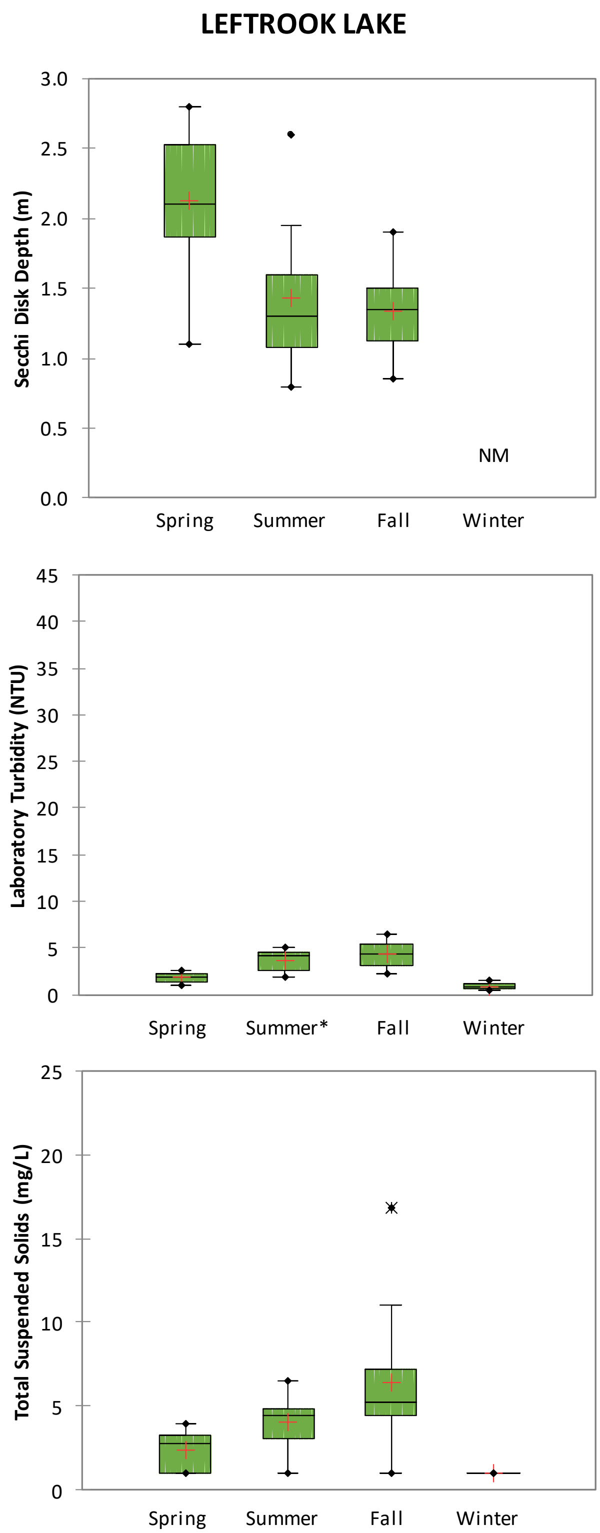


Figure 3.3-3. 2008-2019 Off-system open-water season Secchi disk depths.



*Excludes suspect turbidity value of 19.5 NTU from summer 2011.

Figure 3.3-4. 2008-2019 Off-system seasonal Secchi disk depth, turbidity, and TSS concentrations.

3.3.2 TURBIDITY

3.3.2.1 ON-SYSTEM SITES

ANNUAL SITES

Threepoint Lake

Turbidity in Threepoint Lake ranged from 8.22 to 41.5 NTU during the open-water season. The mean and median turbidity for the 11 years of monitoring were 17.9 and 18.2 NTU, respectively. Open-water season mean annual turbidity ranged from 14.0 to 25.5 NTU and was within the IQR (16.2 to 19.7 NTU) in six of the 11 years. Mean turbidity was below the IQR in 2010, 2011, and 2012 and above the IQR in 2016 and 2017 (Table 3.3-1 and Figure 3.3-5).

Turbidity in the ice-cover season ranged from 7.52 to 13.0 NTU, with both a mean and median of 10.5 NTU for the 10 years of monitoring. The IQR was 9.09 to 11.8 NTU (Table 3.3-1 and Figure 3.3-5).

Turbidity was lower in winter (mean = 10.5 NTU) than the open-water season over the 11 years of monitoring. No clear seasonality was observed for turbidity during the open-water season; however, the lowest mean turbidity occurred in spring (16.2 NTU) and the highest in fall (19.9 NTU; Figure 3.3-2).

ROTATIONAL SITES

Footprint Lake

Turbidity in Footprint Lake ranged from 5.30 to 11.5 NTU during the open-water season. The mean was 7.33 NTU, the median was 7.36 NTU, and the IQR was 5.75 to 8.08 NTU for the four years of monitoring. Mean annual turbidity in the open-water season ranged from 6.51 to 8.90 NTU and was within the IQR in 2010, 2013, and 2019 but above the IQR in 2016 (Table 3.3-1 and Figure 3.3-5).

During the ice-cover season, turbidity ranged from 6.98 to 15.1 NTU, with a mean of 11.4 NTU (Table 3.3-1 and Figure 3.3-5).

Apussigamasi Lake

Turbidity in Apussigamasi Lake ranged from 21.0 to 35.0 NTU during the open-water season. The mean was 29.5 NTU, the median was 30.8 NTU, and the IQR was 27.1 to 32.1 NTU for the four years of monitoring. Mean annual turbidity in the open-water season ranged from 26.7 to 31.3 NTU and was within the IQR in 2009, 2015, and 2018 but below the IQR in 2012 (Table 3.3-1 and Figure 3.3-5).

During the ice-cover season, turbidity ranged from 14.1 to 19.4 NTU, with a mean of 16.4 NTU (Table 3.3-1 and Figure 3.3-5).

3.3.2.2 OFF-SYSTEM SITES

ANNUAL SITES

Leftrook Lake

Turbidity in Leftrook Lake ranged from 1.00 to 6.55 NTU during the open-water season. The mean and median turbidity for the 11 years of monitoring were 3.25 and 2.58 NTU, respectively. Open-water season mean annual turbidity ranged from 2.14 to 4.53 NTU and was within the IQR (2.06 to 4.38 NTU) in 10 of the 11 years. The exception was 2015 when mean turbidity was above the IQR (Table 3.3-2 and Figure 3.3-6). [1]

Turbidity in the ice-cover season ranged from 0.42 to 1.53 NTU, with a mean of 0.90 NTU and median of 0.85 NTU for the 11 years of monitoring. The IQR was 0.71 to 1.12 NTU (Table 3.3-2 and Figure 3.3-6).

Seasonally, turbidity was lower in winter (mean = 0.90 NTU) than during the open-water season over the 11 years of monitoring. Additionally, mean turbidity was lower in spring (1.84 NTU) than in summer and fall (3.67 and 4.28 NTU, respectively; Figure 3.3-4).

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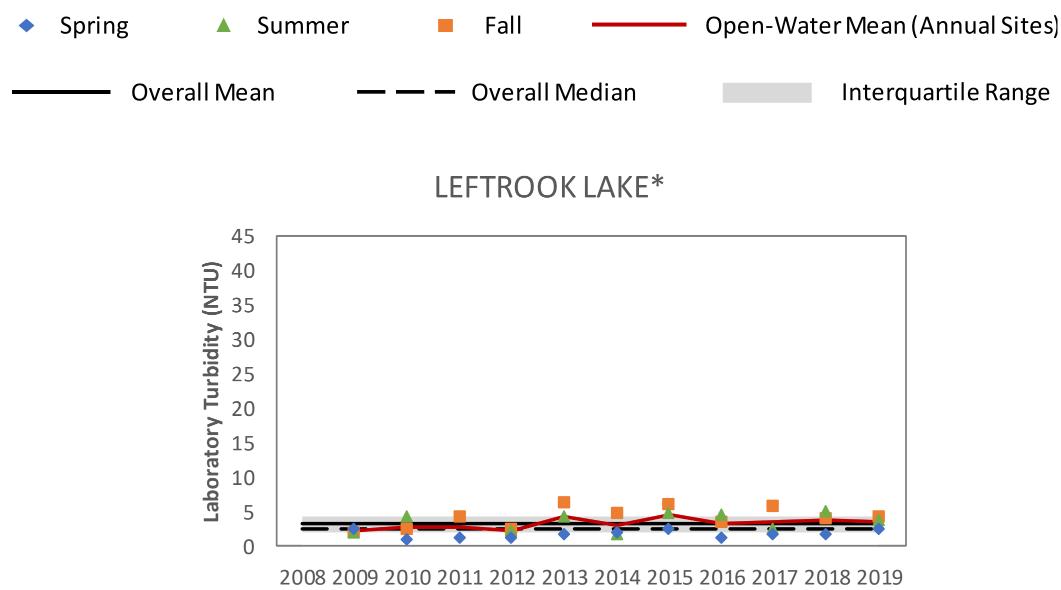
[1] A suspect value of 19.5 NTU from summer 2011 has been excluded from the data reported for the open-water season. This value is unusually high for Leftrook Lake and does not correspond to the *in situ* turbidity measurement nor the TSS concentration reported for the sample.

ROTATIONAL SITES

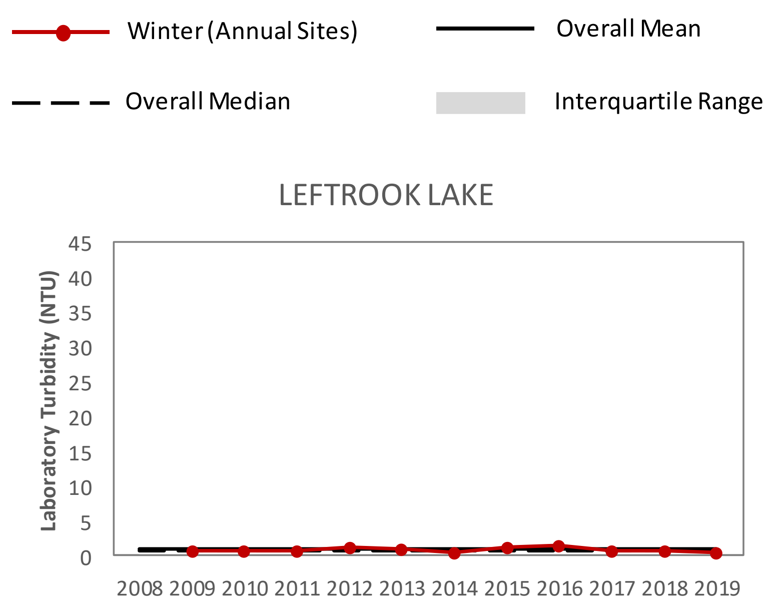
There are no off-system rotational sites in this region.

Figure 3.3-5. 2008-2019 On-system open-water and ice-cover season turbidity levels.

OPEN-WATER SEASON



ICE-COVER SEASON



*Excludes suspect value of 19.5 NTU from summer 2011.

Figure 3.3-6. 2008-2019 Off-system open-water and ice-cover season turbidity levels.

3.3.3 TOTAL SUSPENDED SOLIDS

3.3.3.1 ON-SYSTEM SITES

ANNUAL SITES

Threepoint Lake

TSS concentrations in Threepoint Lake ranged from 2.9 to 18.6 mg/L during the open-water season. The mean and median concentrations for the 11 years of monitoring were 7.5 and 7.0 mg/L, respectively. Open-water season mean annual TSS concentrations ranged from 5.4 to 10.7 mg/L and were within the IQR (5.6 to 8.6 mg/L) in seven of the 11 years. Mean TSS concentrations were below the IQR in 2019 and above the IQR in 2013, 2014, and 2017. TSS concentrations were consistently above the detection limit (DL; 2.0 mg/L) during the open-water season (percent detections = 100; Table 3.3-1 and Figure 3.3-7).

TSS concentrations in the ice-cover season ranged from <2.0 to 3.5 mg/L, both the mean and median were <2.0 mg/L, and the IQR was <2.0 to 2.8 mg/L for the ten years of monitoring. TSS concentrations were below the DL (2.0 mg/L) in half the samples collected during the ice-cover season (percent detections = 50; Table 3.3-1 and Figure 3.3-7).

TSS concentrations in Threepoint Lake were lower in winter (mean <2.0 mg/L), and more frequently below the DL, compared to the open-water season. No clear seasonality was observed for TSS concentrations in the open-water season; however, the lowest mean TSS concentration occurred in fall (7.0 mg/L) and the highest in spring (7.9 mg/L; Figure 3.3-2).

ROTATIONAL SITES

Footprint Lake

TSS concentrations in Footprint Lake ranged from 2.9 to 7.0 mg/L during the open-water season. The mean was 5.1 mg/L and median was 4.9 mg/L, and the IQR was 4.5 to 5.8 mg/L for the four years of monitoring. Mean annual TSS concentrations in the open-water season ranged from 3.6 to 6.5 mg/L and were within the IQR in 2013 and 2016 but below the IQR in 2019 and above the IQR in 2010. TSS concentrations were consistently above the DL (2.0 mg/L) during the open-water season (Table 3.3-1 and Figure 3.3-7).

During the ice-cover season, TSS concentrations ranged from <2.0 to 2.4 mg/L, with a mean of <2.0 mg/L. TSS concentrations were below the DL (2.0 mg/L) in two of four samples collected in winter (i.e., percent detections = 50; Table 3.3-1 and Figure 3.3-7).

Apussigamasi Lake

TSS concentrations in Apussigamasi Lake ranged from 7.6 to 24.4 mg/L during the open-water season. The mean was 13.6 mg/L and median was 12.7 mg/L, and the IQR was 9.4 to 15.5 mg/L for the four years of monitoring. Mean annual TSS concentrations in the open-water season ranged from 10.3 to 20.8 mg/L and were within the IQR in 2009, 2015, and 2018 but above the IQR in 2012 (Table 3.3-1 and Figure 3.3-7).

During the ice-cover season, TSS concentrations ranged from 6.5 to 9.6 mg/L, with a mean of 8.2 mg/L (Table 3.3-1 and Figure 3.3-7).

3.3.3.2 OFF-SYSTEM SITES

ANNUAL SITES

Leftrook Lake

TSS concentrations in Leftrook Lake ranged from <2.0 to 16.8 mg/L during the open-water season. The mean and median concentrations for the 11 years of monitoring were 4.3 and 3.9 mg/L, respectively. Open-water season mean annual TSS concentrations ranged from <2.0 to 7.1 mg/L and were within the IQR (2.4 to 4.8 mg/L) in seven of the 11 years. Mean TSS concentrations were below the IQR in 2010 and above the IQR in 2013, 2014, and 2017. TSS concentrations were occasionally below, but typically above, the DL (2.0 mg/L) during the open-water season (percent detections = 82; Table 3.3-2 and Figure 3.3-8).

TSS concentrations in the ice-cover season were consistently below the DL (2.0 mg/L) over the 11 years of monitoring (Table 3.3-2 and Figure 3.3-8).

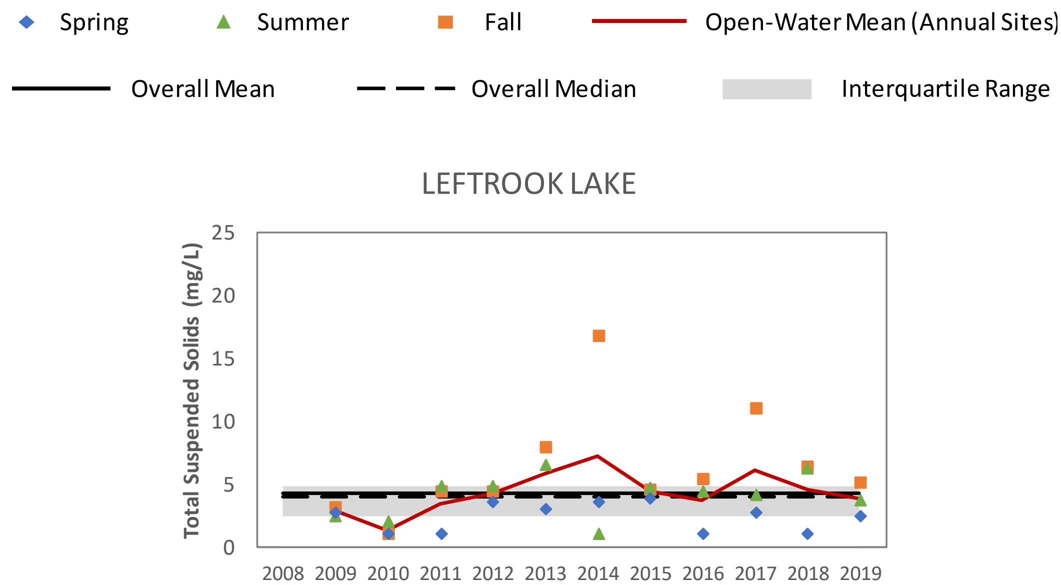
Over the 12-year period, TSS concentrations in Leftrook Lake were lower in winter (mean <2.0 mg/L) than the open-water season. During the open-water season, mean TSS concentrations were lowest in spring (2.4 mg/L) and highest in fall (6.4 mg/L; Figure 3.3-4).

ROTATIONAL SITES

There are no off-system rotational sites in this region.

Figure 3.3-7. 2008-2019 On-system open-water and ice-cover season TSS concentrations.

OPEN-WATER SEASON



ICE-COVER SEASON

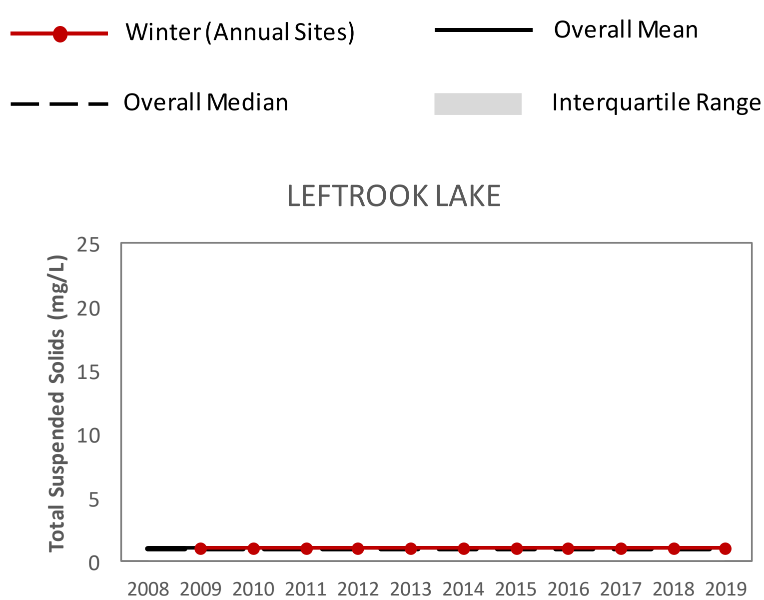


Figure 3.3-8. 2008-2019 Off-system open-water and ice-cover season TSS concentrations.

3.4 NUTRIENTS AND TROPHIC STATUS

3.4.1 TOTAL PHOSPHORUS

3.4.1.1 ON-SYSTEM SITES

ANNUAL SITES

Threepoint Lake

TP concentrations in Threepoint Lake ranged from 0.010 to 0.047 mg/L during the open-water season. The mean and median concentrations for the 11 years of monitoring were both 0.024 mg/L. Open-water season mean annual TP concentrations ranged from 0.016 to 0.035 mg/L and were within the IQR (0.017 to 0.030 mg/L) in eight of the 11 years. Mean TP concentrations were below the IQR in 2013 and above the IQR in 2016 and 2017 (Table 3.4-1 and Figure 3.4-1).

TP concentrations in the ice-cover season ranged from 0.021 to 0.028 mg/L, with a mean of 0.024 mg/L and a median of 0.025 mg/L for the 10 years of monitoring. The IQR was 0.022 to 0.026 mg/L (Table 3.4-1 and Figure 3.4-1).

No clear seasonality was observed for TP in Threepoint Lake over the 11 years of monitoring. Mean TP concentrations were identical in spring, summer, and winter (0.024 mg/L for each season) and the mean TP concentration was only slighter higher in fall (0.025 mg/L; Figure 3.4-2).

Threepoint Lake was meso-eutrophic (0.020 to 0.035 mg/L) on the basis of the 2009-2019 mean open-water season TP concentration (0.024 mg/L). Mean annual TP concentrations (0.016 to 0.035 mg/L) in the open-water season were within the meso-eutrophic range (0.020 to 0.035 mg/L) in eight of the 11 years of monitoring. Mean TP concentrations were in the mesotrophic range (0.010 to 0.020 mg/L) in 2011, 2012, and 2013 (Table 3.4-2).

ROTATIONAL SITES

Footprint Lake

TP concentrations in Footprint Lake ranged from 0.010 to 0.035 mg/L during the open-water season. The mean was 0.023 mg/L, the median was 0.025 mg/L, and the IQR was 0.017 to 0.029 mg/L for the four years of monitoring. Mean annual TP concentrations in the open-water season ranged from 0.019 to 0.027 mg/L and were within the IQR in all four years (Table 3.4-1 and Figure 3.4-1).

During the ice-cover season, TP concentrations ranged from 0.022 to 0.033 mg/L, with a mean of 0.028 mg/L (Table 3.4-1 and Figure 3.4-1).

Footprint Lake was meso-eutrophic (0.020 to 0.035 mg/L) based on the mean of the open-water season TP concentrations for the four years of monitoring (0.023 mg/L). Open-water season mean annual TP concentrations (0.019 to 0.027 mg/L) were also within the meso-eutrophic range in three of the four years of monitoring; however, the open-water mean TP concentration was within the mesotrophic range (0.010 to 0.020 mg/L) in 2013 (Table 3.4-2).

Apussigamasi Lake

TP concentrations in Apussigamasi Lake ranged from 0.023 to 0.044 mg/L during the open-water season. The mean was 0.033 mg/L, the median was 0.034 mg/L, and the IQR was 0.032 to 0.035 mg/L for the four years of monitoring. Mean annual TP concentrations in the open-water season ranged from 0.030 to 0.035 mg/L and were within the IQR in 2009, 2015, and 2018 but below the IQR in 2012 (Table 3.4-1 and Figure 3.4-1).

During the ice-cover season, TP concentrations ranged from 0.027 to 0.032 mg/L, with a mean of 0.030 mg/L for the three years of monitoring (Table 3.4-1 and Figure 3.4-1).

Apussigamasi Lake was meso-eutrophic (0.020 to 0.035 mg/L) based on the mean of the open-water season TP concentrations for the four years of monitoring (0.033 mg/L). Open-water season mean annual TP concentrations (0.030 to 0.035 mg/L) were also within the meso-eutrophic range in each year sampled (Table 3.4-2).

3.4.1.2 OFF-SYSTEM SITES

ANNUAL SITES

Leftrook Lake

TP concentrations in Leftrook Lake ranged from 0.010 to 0.062 mg/L during the open-water season. The mean and median concentrations for the 11 years of monitoring were 0.028 mg/L and 0.024 mg/L, respectively. Open-water season mean annual TP concentrations ranged from

0.019 to 0.038 mg/L and were within the IQR (0.019 to 0.036 mg/L) in 10 of the 11 years. Mean TP concentrations were above the IQR in 2013 (Table 3.4-3 and Figure 3.4-3).

TP concentrations in the ice-cover season ranged from 0.012 to 0.023 mg/L, with a mean of 0.018 mg/L and a median of 0.019 mg/L for the 11 years of monitoring. The IQR was 0.014 to 0.021 mg/L (Table 3.4-3 and Figure 3.4-3).

On average, TP concentrations were lower in spring (0.018 mg/L) and winter (0.018 mg/L) than summer (0.029 mg/L) or fall (0.036 mg/L) over the 11 years of monitoring (Figure 3.4-4).

Leftrook Lake was meso-eutrophic (0.020 to 0.035 mg/L) on the basis of the 2009-2019 mean open-water season TP concentration (0.028 mg/L). Mean annual TP concentrations (0.019 to 0.038 mg/L) in the open-water season were also within the meso-eutrophic range (0.020 to 0.035 mg/L) in eight of the 11 years of monitoring. However, mean annual TP concentrations were within the mesotrophic range (0.010 to 0.020 mg/L) in 2011 and in the eutrophic range (0.035 to 0.100 mg/L) in 2010 and 2013 (Table 3.4-4).

ROTATIONAL SITES

There are no off-system rotational sites in this region.

Table 3.4-1. 2008-2019 On-system sites TP, TN, and chlorophyll *a* summary statistics.

Site	Statistic	TP (mg/L)		TN (mg/L)		Chlorophyll a (µg/L)	
		OW	IC	OW	IC	OW	IC
3PT	Mean	0.024	0.024	0.34	0.37	3.28	<0.60
	Median	0.024	0.025	0.33	0.37	3.05	<0.60
	Minimum	0.010	0.021	<0.20	0.28	0.93	<0.60
	Maximum	0.047	0.028	0.70	0.48	9.16	0.67
	SD	0.0083	0.0024	0.107	0.076	1.61	-
	SE	0.0014	0.0008	0.019	0.024	0.280	-
	Lower Quartile	0.017	0.022	0.30	0.31	2.48	<0.60
	Upper Quartile	0.030	0.026	0.39	0.44	3.82	<0.60
	n	33	10	32	10	33	10
	% Detections	100	100	100	100	100	20
FOOT	Mean	0.023	0.028	0.51	0.41	8.14	<0.60
	Median	0.025	-	0.48	-	7.88	-
	Minimum	0.010	0.022	0.29	0.34	1.55	<0.60
	Maximum	0.035	0.033	1.00	0.48	23.8	<0.60
	SD	0.0081	0.0043	0.198	0.061	5.87	-
	SE	0.0023	0.0022	0.057	0.030	1.69	-
	Lower Quartile	0.017	-	0.40	-	4.25	-
	Upper Quartile	0.029	-	0.54	-	9.54	-
	n	12	4	12	4	12	4
	% Detections	100	100	100	100	100	25
APU	Mean	0.033	0.030	0.36	0.45	3.12	<0.60
	Median	0.034	-	0.34	-	2.92	-
	Minimum	0.023	0.027	0.24	0.38	2.30	<0.60
	Maximum	0.044	0.032	0.47	0.54	4.42	<0.60
	SD	0.0052	0.0026	0.076	0.082	0.703	-
	SE	0.0015	0.0015	0.022	0.047	0.203	-
	Lower Quartile	0.032	-	0.33	-	2.61	-
	Upper Quartile	0.035	-	0.44	-	3.76	-
	n	12	3	12	3	12	3
	% Detections	100	100	100	100	100	67

Notes:

1. OW = Open-water season; IC = Ice-cover season.
2. SD = standard deviation; SE = standard error; n = number of samples.
3. TN statistics for 3PT exclude suspect value of 3.06 mg/L from spring 2014.

Table 3.4-2. 2008-2019 On-system trophic status based on TP, TN, and chlorophyll *a* open-water season mean concentrations.

Trophic Categories	Total Phosphorus (mg/L)			Total Nitrogen (mg/L)			Chlorophyll *a* (µg/L)		
Ultra-oligotrophic	<0.004								
Oligotrophic	0.004-0.010			<0.350			<2.5		
Mesotrophic	0.010-0.020			0.350-0.650			2.5-8		
Meso-eutrophic	0.020-0.035								
Eutrophic	0.035-0.100			0.651-1.20			8-25		
Hypereutrophic	> 0.100			>1.20			>25		
References	CCME (1999; updated to 2024)			Nürnberg (1996)			OECD (1982)		
Sampling Year	**3PT**	**FOOT**	**APU**	**3PT**	**FOOT**	**APU**	**3PT**	**FOOT**	**APU**
2008	-	-	-	-	-	-	-	-	-
2009	0.023	-	0.035	0.35	-	0.43	2.40	-	2.70
2010	0.028	0.026	-	0.33	0.61	-	1.37	3.33	-
2011	0.020	-	-	0.37	-	-	2.42	-	-
2012	0.017	-	0.030	0.33	-	0.31	3.48	-	2.75
2013	0.016	0.019	-	0.24	0.33	-	4.98	8.20	-
2014	0.028	-	-	0.42	-	-	2.76	-	-
2015	0.024	-	0.033	0.40	-	0.38	3.03	-	2.94
2016	0.032	0.027	-	0.32	0.52	-	3.69	7.84	-
2017	0.035	-	-	0.38	-	-	2.53	-	-
2018	0.020	-	0.035	0.28	-	0.33	4.19	-	4.07
2019	0.025	0.022	-	0.35	0.58	-	5.19	13.2	-
Overall (2008-2019)	0.024	0.023	0.033	0.34	0.51	0.36	3.28	8.14	3.12

Notes:

1. CCME = Canadian Council of Ministers of the Environment.
2. OECD = Organization for Economic Cooperation and Development.
3. TN values for 3PT exclude suspect value of 3.06 mg/L from spring 2014.

Table 3.4-3. 2008-2019 Off-system sites TP, TN and chlorophyll *a* summary statistics.

Site	Statistic	TP (mg/L)		TN (mg/L)		Chlorophyll *a* (µg/L)	
		OW	IC	OW	IC	OW	IC
LEFT	Mean	0.028	0.018	0.57	0.59	13.4	1.03
	Median	0.024	0.019	0.58	0.60	10.3	1.15
	Minimum	0.010	0.012	0.24	0.52	0.78	<0.60
	Maximum	0.062	0.023	0.89	0.66	34.0	1.53
	SD	0.0121	0.0041	0.156	0.048	9.61	0.500
	SE	0.0021	0.0012	0.028	0.015	1.67	0.151
	Lower Quartile	0.019	0.014	0.46	0.55	5.35	0.85
	Upper Quartile	0.036	0.021	0.67	0.63	21.3	1.42
	n	33	11	32	11	33	11
	% Detections	100	100	100	100	100	82

Notes:

1. OW = Open-water season; IC = Ice-cover season.
2. SD = standard deviation; SE = standard error; n = number of samples.
3. TN statistics for LEFT exclude suspect value of 4.33 mg/L from spring 2014.

Table 3.4-4. 2008-2019 Off-system trophic status based on TP, TN, and chlorophyll *a* open-water season mean concentrations.

Trophic Categories	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Chlorophyll *a* (µg/L)
Ultra-oligotrophic	<0.004		
Oligotrophic	0.004-0.010	<0.350	<2.5
Mesotrophic	0.010-0.020	0.350-0.650	2.5-8
Meso-eutrophic	0.020-0.035		
Eutrophic	0.035-0.100	0.651-1.20	8-25
Hypereutrophic	> 0.100	>1.20	>25
References	CCME (1999; updated to 2024)	Nürnberg (1996)	OECD (1982)
Sampling Year	**LEFT**	**LEFT**	**LEFT**
2008	-	-	-
2009	0.021	0.50	6.37
2010	0.036	0.61	9.06
2011	0.019	0.66	16.0
2012	0.024	0.53	13.6
2013	0.038	0.63	20.6
2014	0.025	0.60 [1]	12.8
2015	0.030	0.58	14.2
2016	0.028	0.55	7.77
2017	0.030	0.58	14.0
2018	0.030	0.55	17.4
2019	0.023	0.52	15.6
Overall (2008-2019)	0.028	0.57 [1]	13.4

Notes:

1. CCME = Canadian Council of Ministers of the Environment.
2. OECD = Organization for Economic Cooperation and Development.
3. TN values for LEFT exclude suspect value of 4.33 mg/L from spring 2014.

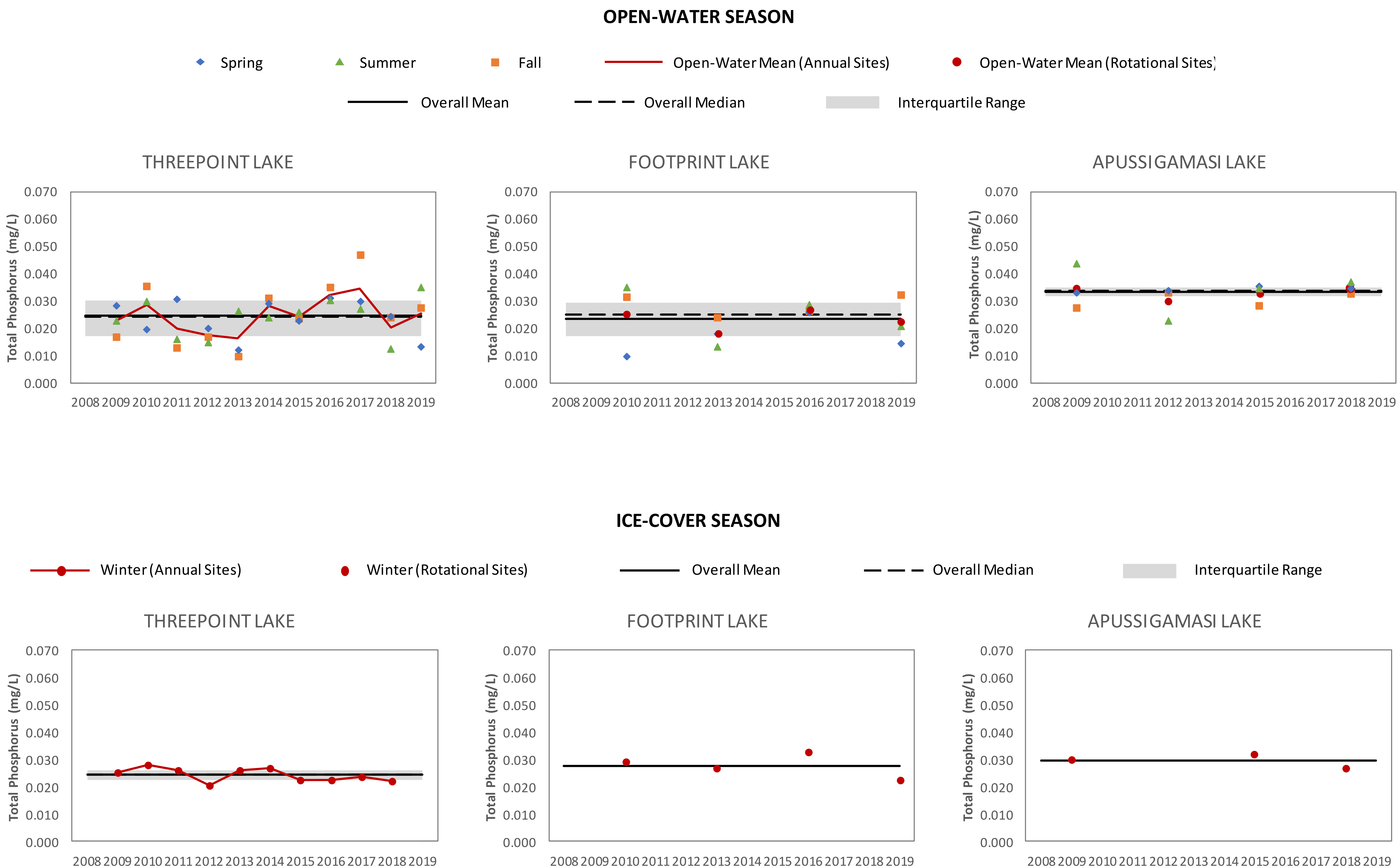
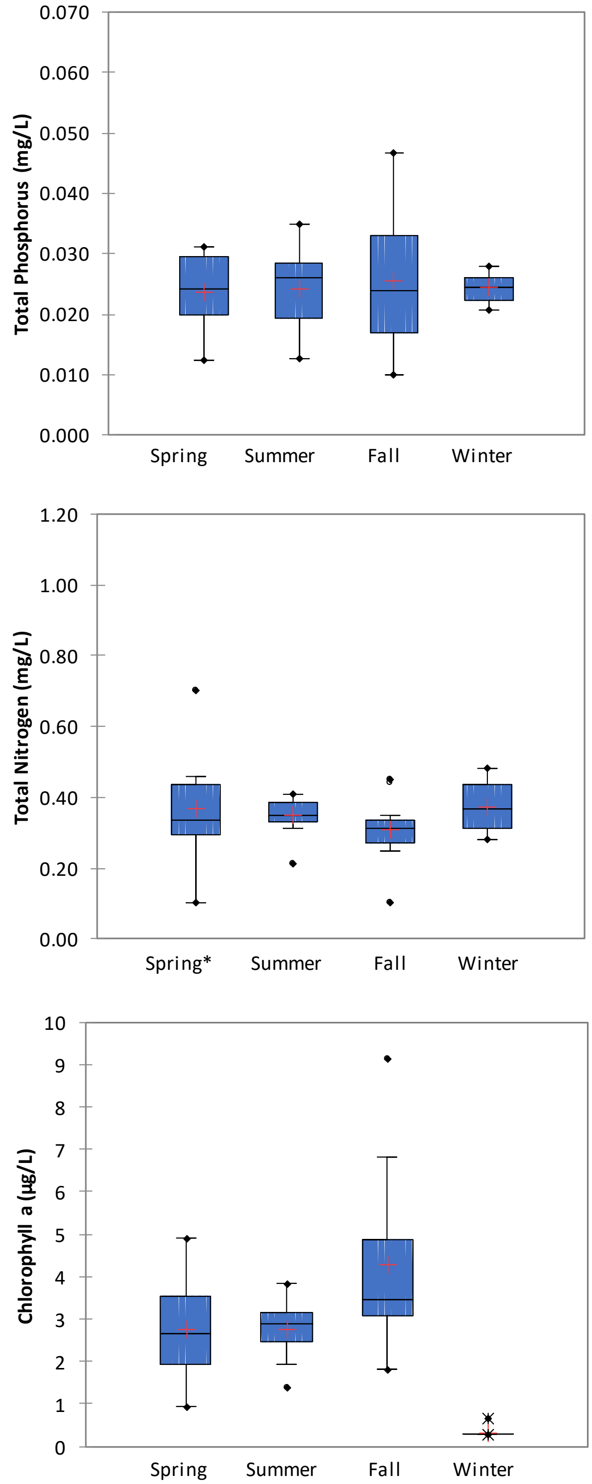


Figure 3.4-1. 2008-2019 On-system open-water and ice-cover season TP concentrations.

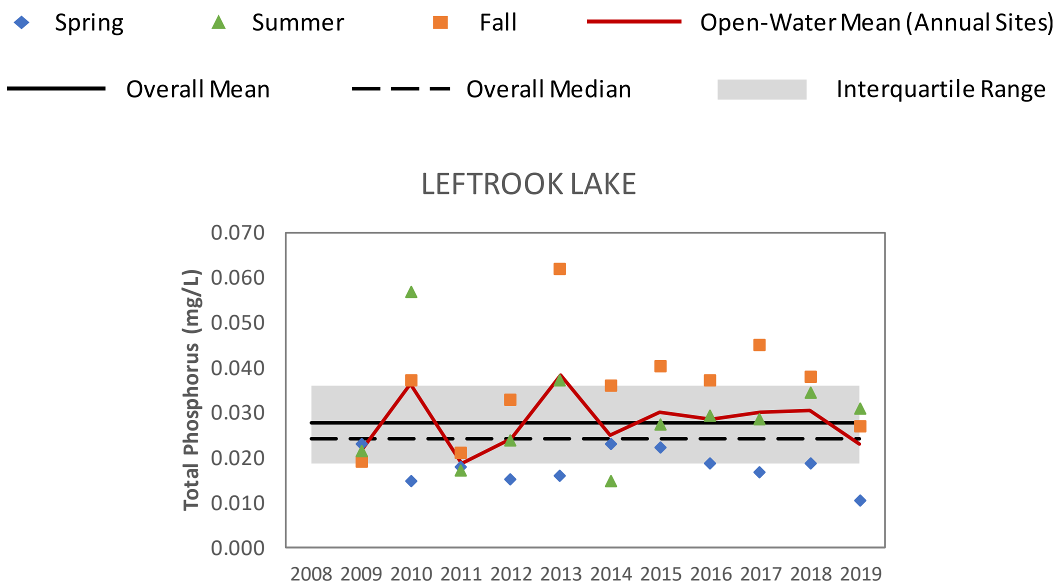
THREEPOINT LAKE



*Excludes suspect TN value of 3.06 mg/L from spring 2014.

Figure 3.4-2. 2008-2019 On-system seasonal total phosphorus, total nitrogen, and chlorophyll *a* concentrations.

OPEN-WATER SEASON



ICE-COVER SEASON

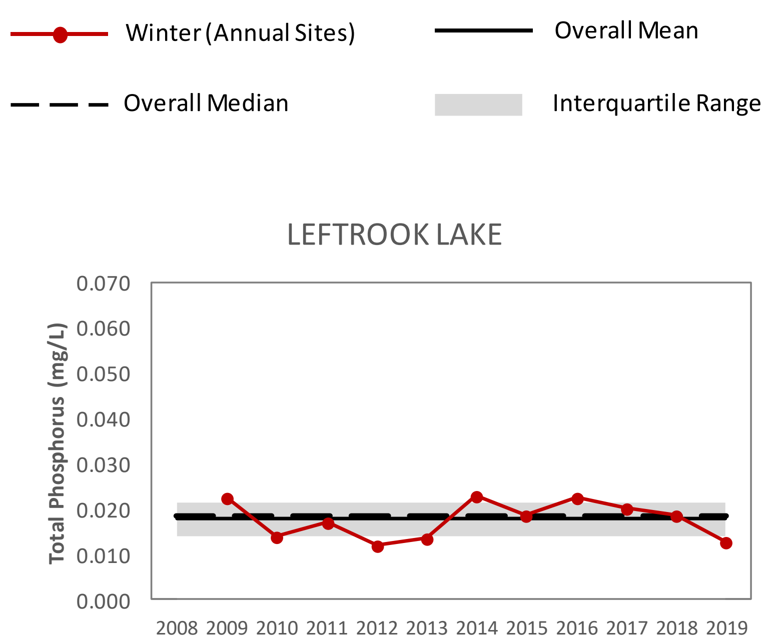
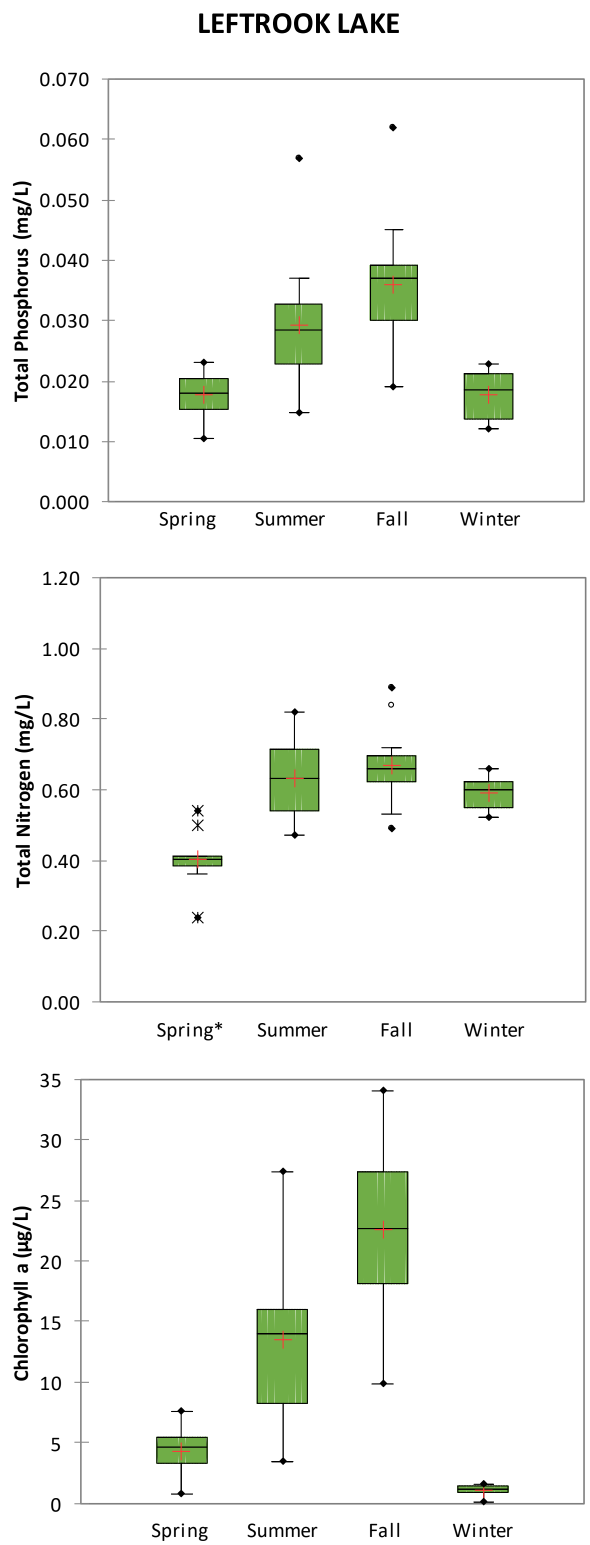


Figure 3.4-3. 2008-2019 Off-system open-water and ice-cover season TP concentrations.



*Excludes suspect TN value of 4.33 mg/L from spring 2014.

Figure 3.4-4. 2008-2019 Off-system seasonal total phosphorus, total nitrogen, and chlorophyll *a* concentrations.

3.4.2 TOTAL NITROGEN

3.4.2.1 ON-SYSTEM SITES

ANNUAL SITES

Threepoint Lake

TN concentrations in Threepoint Lake ranged from <0.20 to 0.70 mg/L during the open-water season. The mean and median concentrations for the 11 years of monitoring were 0.34 mg/L and 0.33 mg/L, respectively. Open-water season mean annual TN concentrations ranged from 0.24 to 0.42 mg/L and were within the IQR (0.30 to 0.39 mg/L) in seven of the 11 years. Mean TN concentrations were below the IQR in 2013 and 2018 and above the IQR in 2014 and 2015 (Table 3.4-1 and Figure 3.4-5).[2]

TN concentrations in the ice-cover season ranged from 0.28 to 0.48 mg/L, with both a mean and median of 0.37 mg/L for the 10 years of monitoring. The IQR was 0.31 to 0.44 mg/L (Table 3.4-1 and Figure 3.4-5).

No clear seasonality was observed for TN in Threepoint Lake over the 11 years of monitoring. However, mean TN concentrations were lowest in fall (0.35 mg/L) and highest in spring and winter 0.37 mg/L for both; Figure 3.4-2).

Threepoint Lake was oligotrophic (<0.350 mg/L) on the basis of the 2009-2019 mean open-water season TN concentration (0.34 mg/L). Mean annual TN concentrations (0.24 to 0.42 mg/L) in the open-water season were also within the oligotrophic range (<0.350 mg/L) in five of the 11 years of monitoring. Mean annual TN concentrations were within the mesotrophic range (0.350 to 0.650 mg/L) in 2009, 2011, 2014, 2015, 2017, and 2019 (Table 3.4-4).

ROTATIONAL SITES

Footprint Lake

TN concentrations in Footprint Lake ranged from 0.29 to 1.00 mg/L during the open-water season. The mean was 0.51 mg/L, the median was 0.48 mg/L, and the IQR was 0.40 to 0.54 mg/L for the

[2] A suspect TN value of 3.06 mg/L from spring 2014 has been excluded from the data reported for the open-water season.

four years of monitoring. Mean annual TN concentrations in the open-water season ranged from 0.33 to 0.61 mg/L and were within the IQR in 2016 but were below the IQR in 2013 and above the IQR in 2010 and 2019 (Table 3.4-1 and Figure 3.4-5).

During the ice-cover season, TN concentrations ranged from 0.34 to 0.48 mg/L, with a mean of 0.41 mg/L (Table 3.4-1 and Figure 3.4-5).

Footprint Lake was mesotrophic (0.350 to 0.650 mg/L) based on the mean of the open-water season TN concentrations for the four years of monitoring (0.51 mg/L). Open-water season mean annual TN concentrations (0.33 to 0.61 mg/L) were also within the mesotrophic range in three of the four years of monitoring; however, the open-water mean TN concentration was within the oligotrophic range (<0.350 mg/L) in 2013 (Table 3.4-2).

Apussigamasi Lake

TN concentrations in Apussigamasi Lake ranged from 0.24 to 0.47 mg/L during the open-water season. The mean was 0.36 mg/L, the median was 0.34 mg/L, and the IQR was 0.33 to 0.44 mg/L for the four years of monitoring. Mean annual TN concentrations in the open-water season ranged from 0.31 to 0.43 mg/L and were within the IQR in three of the four years. The mean annual TN concentration was below the IQR in 2012 (Table 3.4-1 and Figure 3.4-5).

During the ice-cover season, TN concentrations ranged from 0.38 to 0.54 mg/L, with a mean of 0.45 mg/L for the three years of monitoring (Table 3.4-1 and Figure 3.4-5).

Apussigamasi Lake was mesotrophic (0.350 to 0.650 mg/L) based on the mean of the open-water season TN concentrations for the four years of monitoring (0.36 mg/L). Open-water season mean annual TN concentrations (0.31 to 0.43 mg/L) were also within the mesotrophic range in 2009 and 2015; however, the open-water mean TN concentrations were within the oligotrophic range (<0.350 mg/L) in 2012 and 2018 (Table 3.4-2).

3.4.2.2 OFF-SYSTEM SITES

ANNUAL SITES

Leftrook Lake

TN concentrations in Leftrook Lake ranged from 0.24 to 0.89 mg/L during the open-water season. The mean and median concentrations for the 11 years of monitoring were 0.57 mg/L and

0.58 mg/L, respectively. Open-water season mean annual TN concentrations ranged from 0.50 to 0.66 mg/L and were within the IQR (0.46 to 0.67 mg/L) in all years (Table 3.4-3 and Figure 3.4-6).[3]

TN concentrations in the ice-cover season ranged from 0.52 to 0.66 mg/L, with a mean of 0.59 mg/L and a median of 0.60 mg/L for the 11 years of monitoring. The IQR was 0.55 to 0.63 mg/L (Table 3.4-3 and Figure 3.4-6).

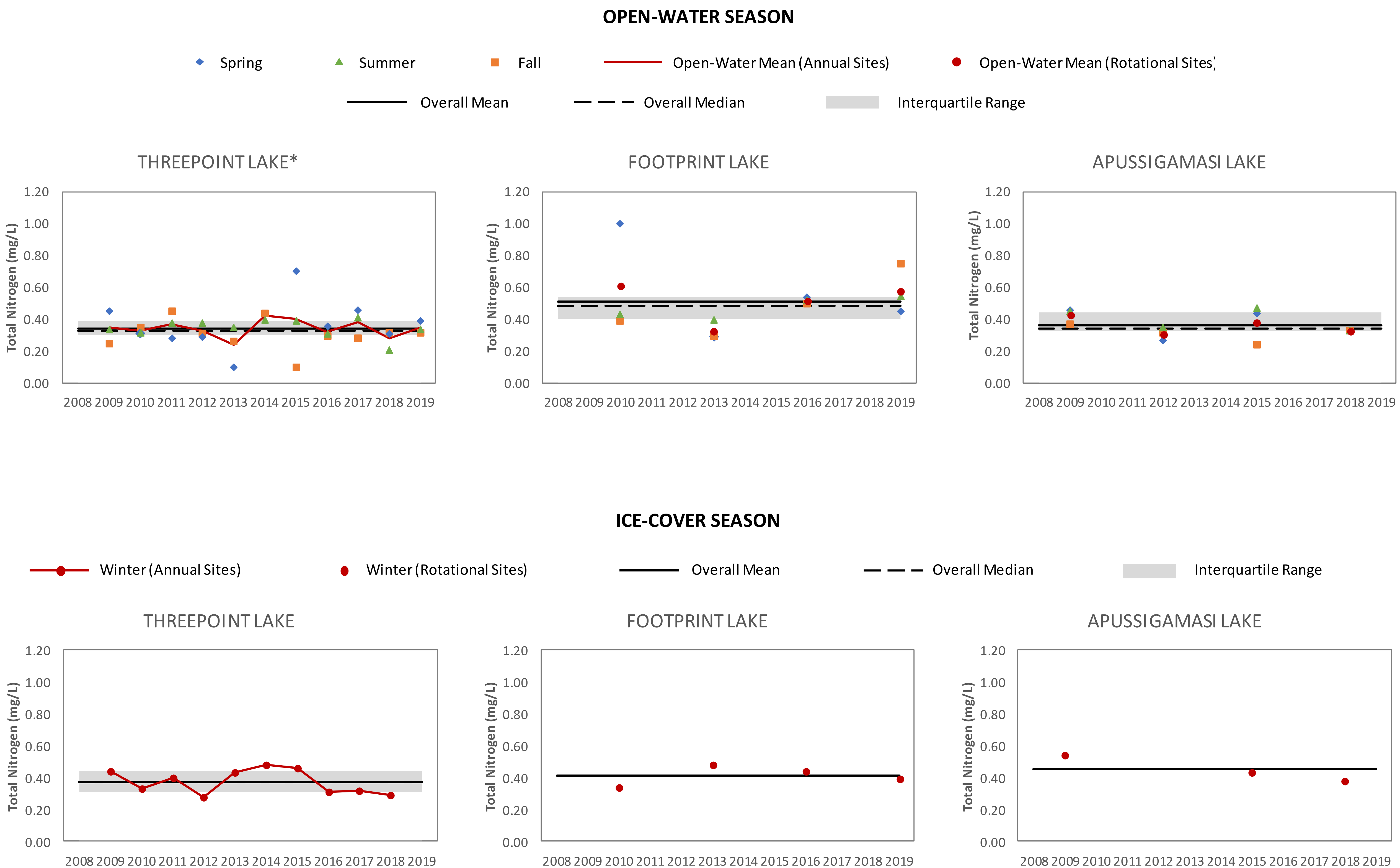
On average, TN concentrations were lower in spring (0.40 mg/L) than in summer (0.63 mg/L), fall (0.67 mg/L) or winter (0.59 mg/L) over the 11 years of monitoring Figure 3.4-4).

Leftrook Lake was mesotrophic (0.350 to 0.650 mg/L) on the basis of the 2009-2019 mean open-water season TN concentration (0.57 mg/L). Mean annual TN concentrations (0.50 to 0.66 mg/L) in the open-water season were also within the meso-eutrophic range (0.020 to 0.035 mg/L) in 10 of the 11 years of monitoring; however, the mean annual TN concentration was within the eutrophic range (0.651 to 1.20 mg/L) in 2011 (Table 3.4-4).

ROTATIONAL SITES

There are no off-system rotational sites in this region.

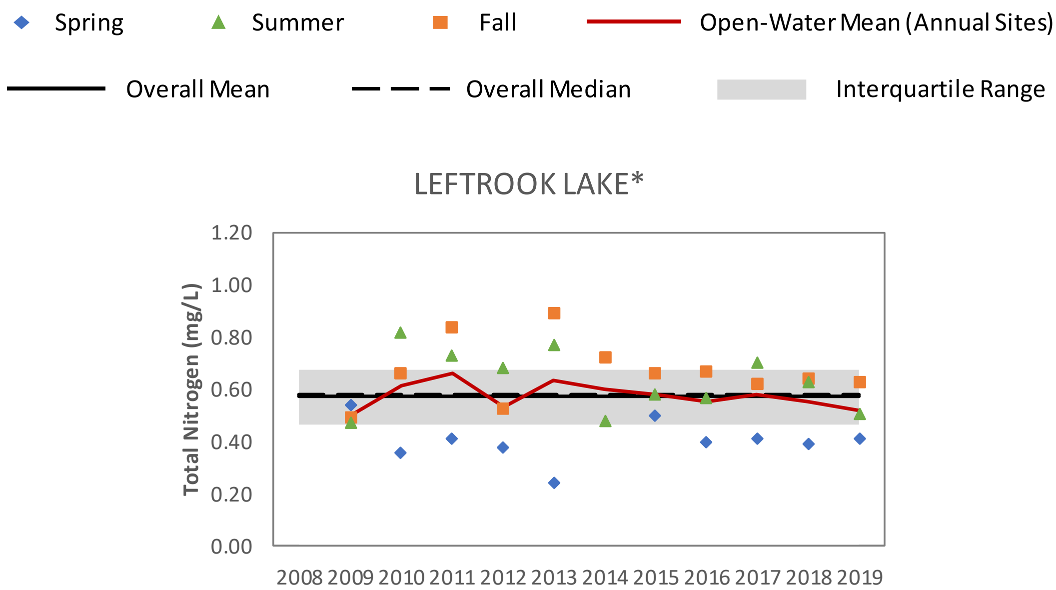
[3] A suspect TN value of 4.33 mg/L from spring 2014 has been excluded from the data reported for the open-water season.



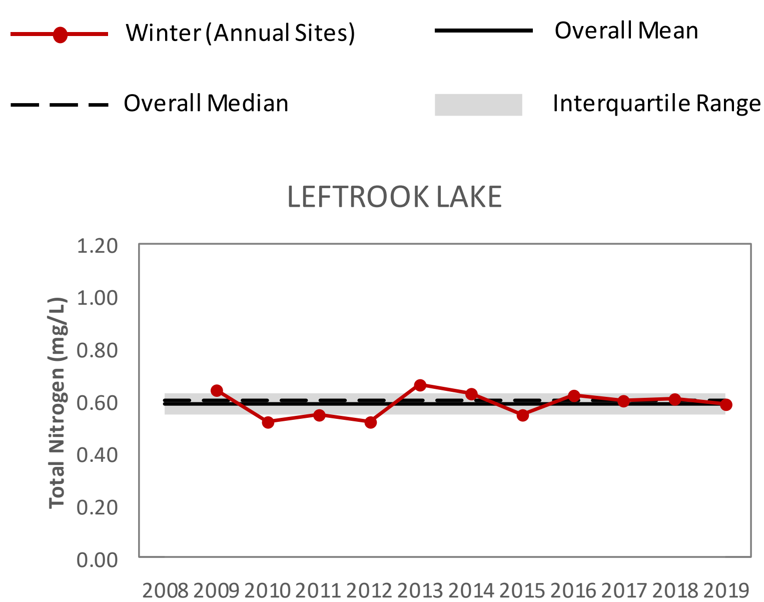
*Excludes suspect value of 3.06 mg/L at 3PT from spring 2014.

Figure 3.4-5. 2008-2019 On-system open-water and ice-cover season TN concentrations.

OPEN-WATER SEASON



ICE-COVER SEASON



*Excludes suspect value of 4.33 mg/L from spring 2014.

Figure 3.4-6. 2008-2019 Off-system open-water and ice-cover season TN concentrations.

3.4.3 CHLOROPHYLL *A*

3.4.3.1 ON-SYSTEM SITES

ANNUAL SITES

Threepoint Lake

Chlorophyll *a* concentrations in Threepoint Lake ranged from 0.93 to 9.16 µg/L during the open-water season. The mean and median for the 11 years of monitoring were 3.28 µg/L and 3.05 µg/L, respectively. Open-water season mean annual chlorophyll *a* concentrations ranged from 1.37 to 5.19 µg/L and were within the IQR (2.48 to 3.82 µg/L) in five of the 11 years. Mean chlorophyll *a* concentrations were below the IQR in 2009, 2010, and 2011 and above the IQR in 2013, 2018, and 2019 (Table 3.4-1 and Figure 3.4-7).

Chlorophyll *a* concentrations in the ice-cover season ranged from <0.60 to 0.67 µg/L, with both a mean and median of <0.60 µg/L for the 10 years of monitoring. The IQR was below the analytical DL of 0.60 µg/L (Table 3.4-1 and Figure 3.4-7).

Chlorophyll *a* concentrations were lower in the winter and frequently below the DL (0.040-0.60 µg/L; percent detection = 20), compared to the open-water season (Table 3.4-1). On average, chlorophyll *a* concentrations during the open-water season were lowest in spring and summer (2.77 and 2.78 µg/L, respectively) and highest in fall (4.28 µg/L; Figure 3.4-2).

Threepoint Lake was mesotrophic (2.5 to 8 µg/L) on the basis of the 2009-2019 mean open-water season chlorophyll *a* concentration (3.28 µg/L). Mean annual chlorophyll *a* concentrations (1.37 to 5.19 µg/L) in the open-water season were also within the mesotrophic range in eight of the 11 years. However, the mean chlorophyll *a* concentration was within the oligotrophic range (<2.5 µg/L) in 2009, 2010, and 2011 (Table 3.4-2).

ROTATIONAL SITES

Footprint Lake

Chlorophyll *a* concentrations in Footprint Lake ranged from 1.55 to 23.8 µg/L during the open-water season. The mean was 8.14 µg/L, the median was 7.88 µg/L, and the IQR was 4.25 to 9.54 µg/L for the four years of monitoring. Mean annual chlorophyll *a* concentrations in the open-water season ranged from 3.33 to 13.2 µg/L and were within the IQR in 2013 and 2016 but were below the IQR in 2010 and above the IQR in 2019 (Table 3.4-1 and Figure 3.4-7).

Chlorophyll *a* concentrations were typically below the DL (0.10-0.60 µg/L) during the ice-cover season (percent detection = 25) and all concentrations were less than 0.60 µg/L. The mean chlorophyll *a* concentration for the four years of monitoring was <0.60 µg/L (Table 3.4-1 and Figure 3.4-7).

Footprint Lake was eutrophic (8-25 µg/L) based on the mean of the open-water season chlorophyll *a* concentrations for the four years of monitoring (8.14 µg/L). Open-water season mean annual chlorophyll *a* concentrations (3.33 to 13.2 µg/L) were also within the eutrophic range in 2013 and 2019 but were within the mesotrophic range (2.5 to 8 µg/L) in 2010 and 2016 (Table 3.4-2).

Apussigamasi Lake

Chlorophyll *a* concentrations in Apussigamasi Lake ranged from 2.30 to 4.42 µg/L during the open-water season. The mean was 3.12 µg/L, the median was 2.92 µg/L, and the IQR was 2.61 to 3.76 µg/L for the four years of monitoring. Mean annual chlorophyll *a* concentrations in the open-water season ranged from 2.70 to 4.07 µg/L and were within the IQR in three of the four years but were above the IQR in 2018 (Table 3.4-1 and Figure 3.4-7).

Chlorophyll *a* concentrations were near or below the DL (0.050-0.60 µg/L) during the ice-cover season (percent detection = 67) and all concentrations were less than 0.60 µg/L. The mean chlorophyll *a* concentration for the three years of monitoring was <0.60 µg/L (Table 3.4-1 and Figure 3.4-7).

Apussigamasi Lake was mesotrophic (2.5 to 8 µg/L) based on the mean of the open-water season chlorophyll *a* concentrations for the four years of monitoring (3.12 µg/L). Open-water season mean annual chlorophyll *a* concentrations (2.70 to 4.07 µg/L) were also within the mesotrophic range in each year of monitoring (Table 3.4-2).

3.4.3.2 OFF-SYSTEM SITES

ANNUAL SITES

Leftrook Lake

Chlorophyll *a* concentrations in Leftrook Lake ranged from 0.78 to 34.0 µg/L during the open-water season. The mean and median for the 11 years of monitoring were 13.4 µg/L and 10.3 µg/L, respectively. Open-water season mean annual chlorophyll *a* concentrations ranged from 6.37 to 20.6 µg/L and were within the IQR (5.35 to 21.3 µg/L) in all years (Table 3.4-3 and Figure 3.4-8).

Chlorophyll *a* concentrations in the ice-cover season ranged from <0.60 to 1.53 µg/L, with a mean of 1.03 µg/L and median of 1.15 µg/L for the 11 years of monitoring. The IQR was 0.85 to 1.42 µg/L (Table 3.4-3 and Figure 3.4-8).

On average, chlorophyll *a* concentrations were lower in winter (1.03 µg/L) and spring (4.30 µg/L) than in summer (13.4 µg/L) and fall (22.5 µg/L; Figure 3.4-4).

Leftrook Lake was eutrophic (8 to 25 µg/L) on the basis of the 2009-2019 mean open-water season chlorophyll *a* concentration (13.4 µg/L). Mean annual chlorophyll *a* concentrations (6.37 to 20.6 µg/L) in the open-water season were also within the mesotrophic range in nine of the 11 years. However, the mean chlorophyll *a* concentration was within the mesotrophic range (2.5 to 8 µg/L) in 2009 and 2016 (Table 3.4-4).

ROTATIONAL SITES

There are no off-system rotational sites in this region.

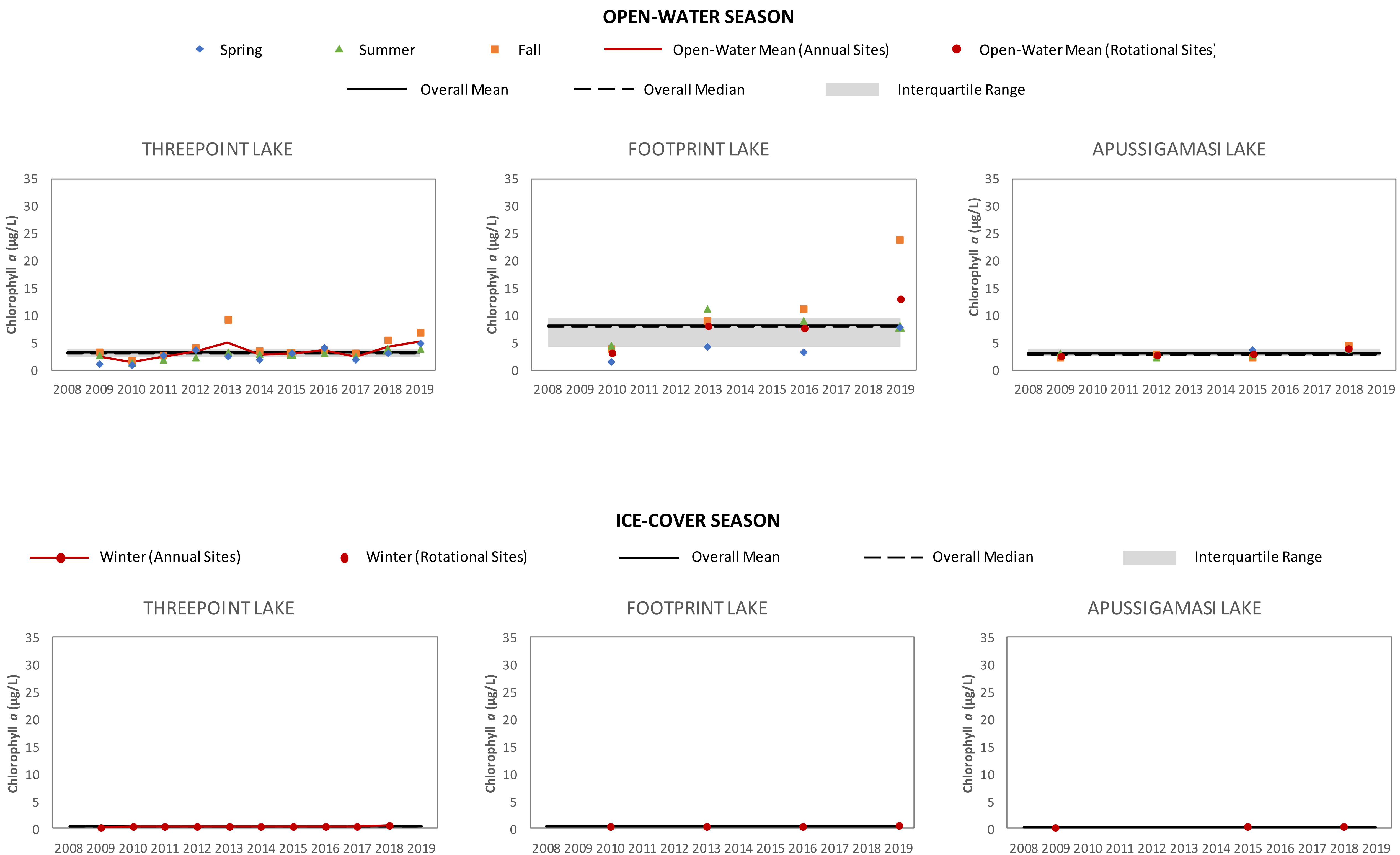
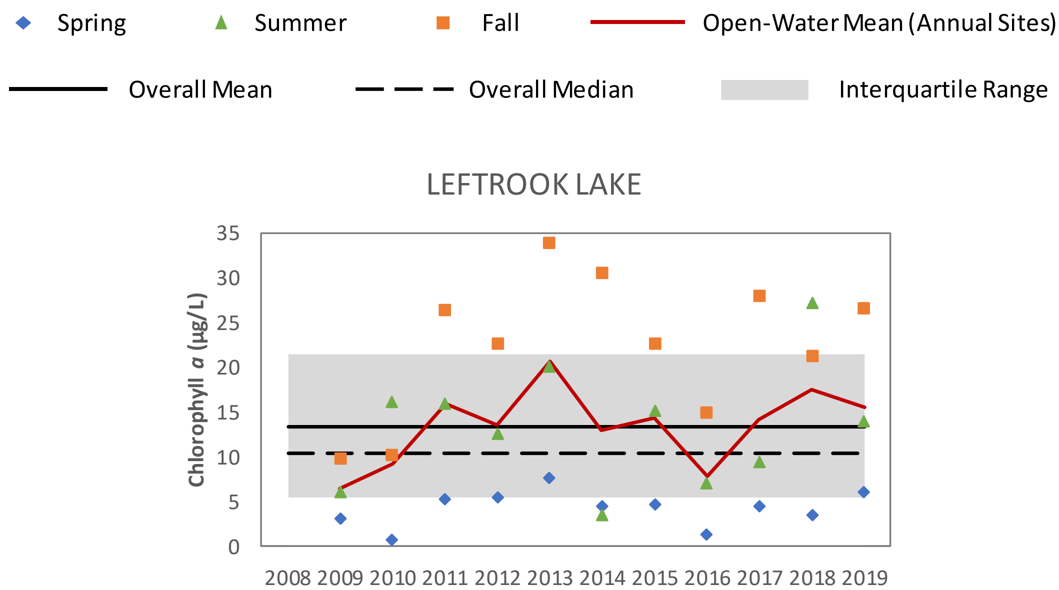


Figure 3.4-7. 2008-2019 On-system open-water and ice-cover season chlorophyll *a* concentrations.

OPEN-WATER SEASON



ICE-COVER SEASON

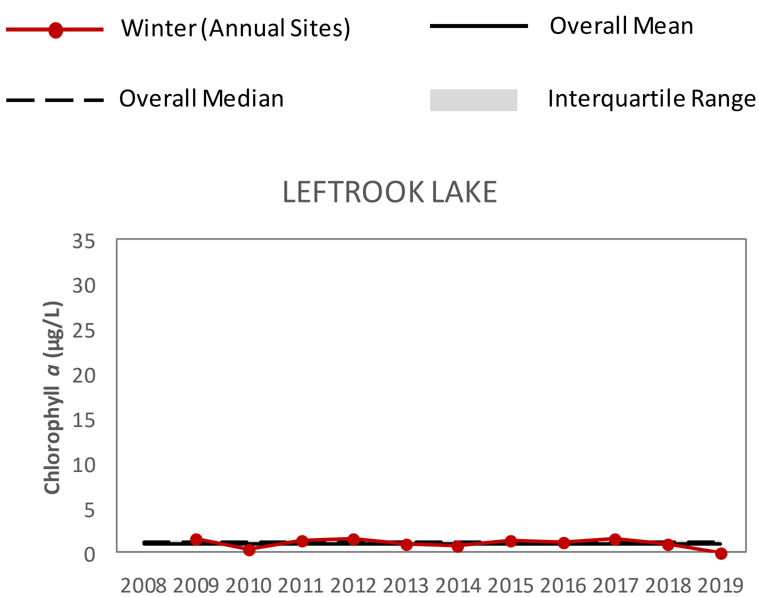


Figure 3.4-8. 2008-2019 Off-system open-water and ice-cover season chlorophyll *a* concentrations.

APPENDIX 3-1. WATER QUALITY SAMPLING SITES: 2008-2019

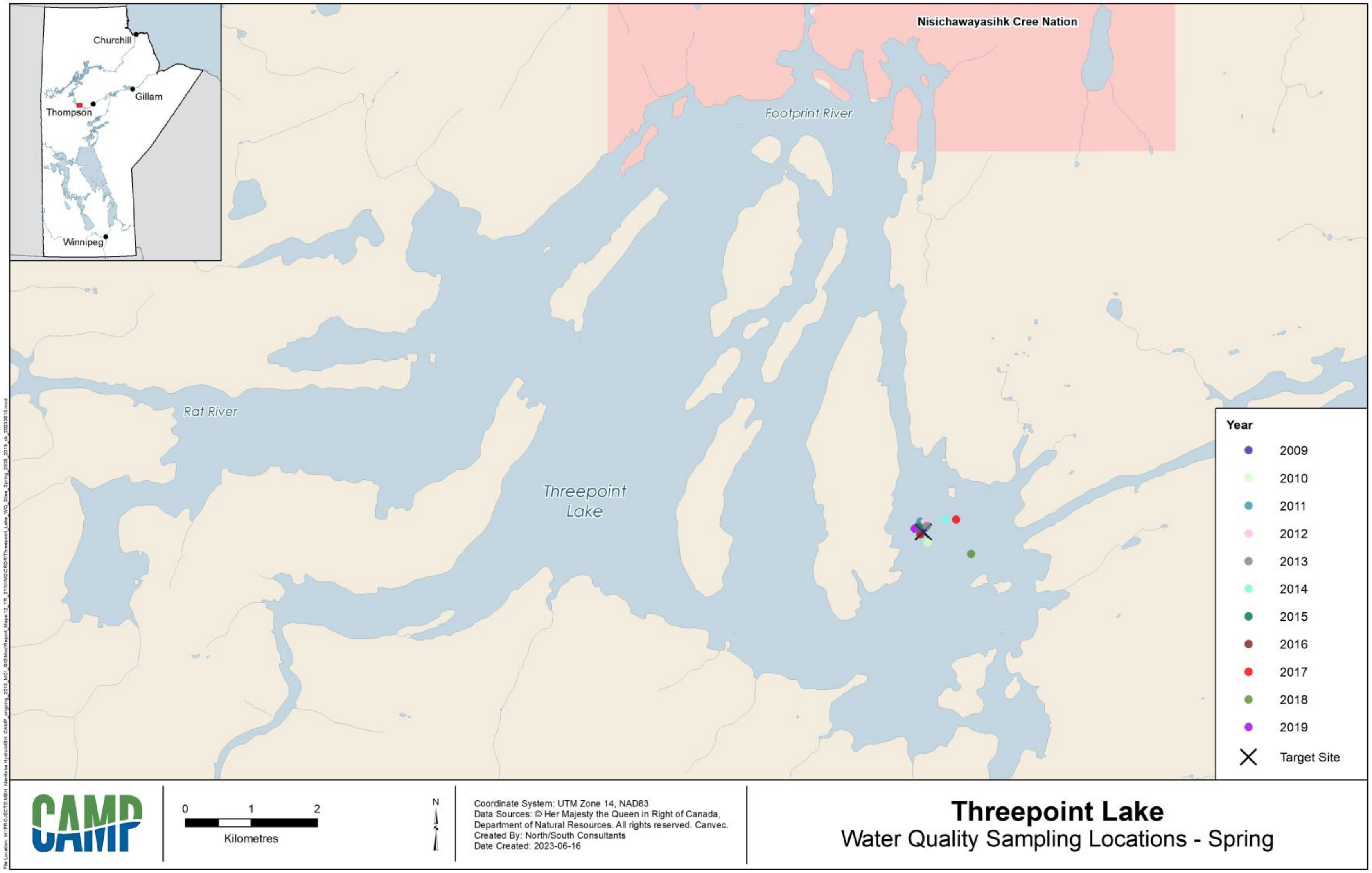


Figure A3-1-1. Spring water quality sampling locations: Threepoint Lake.

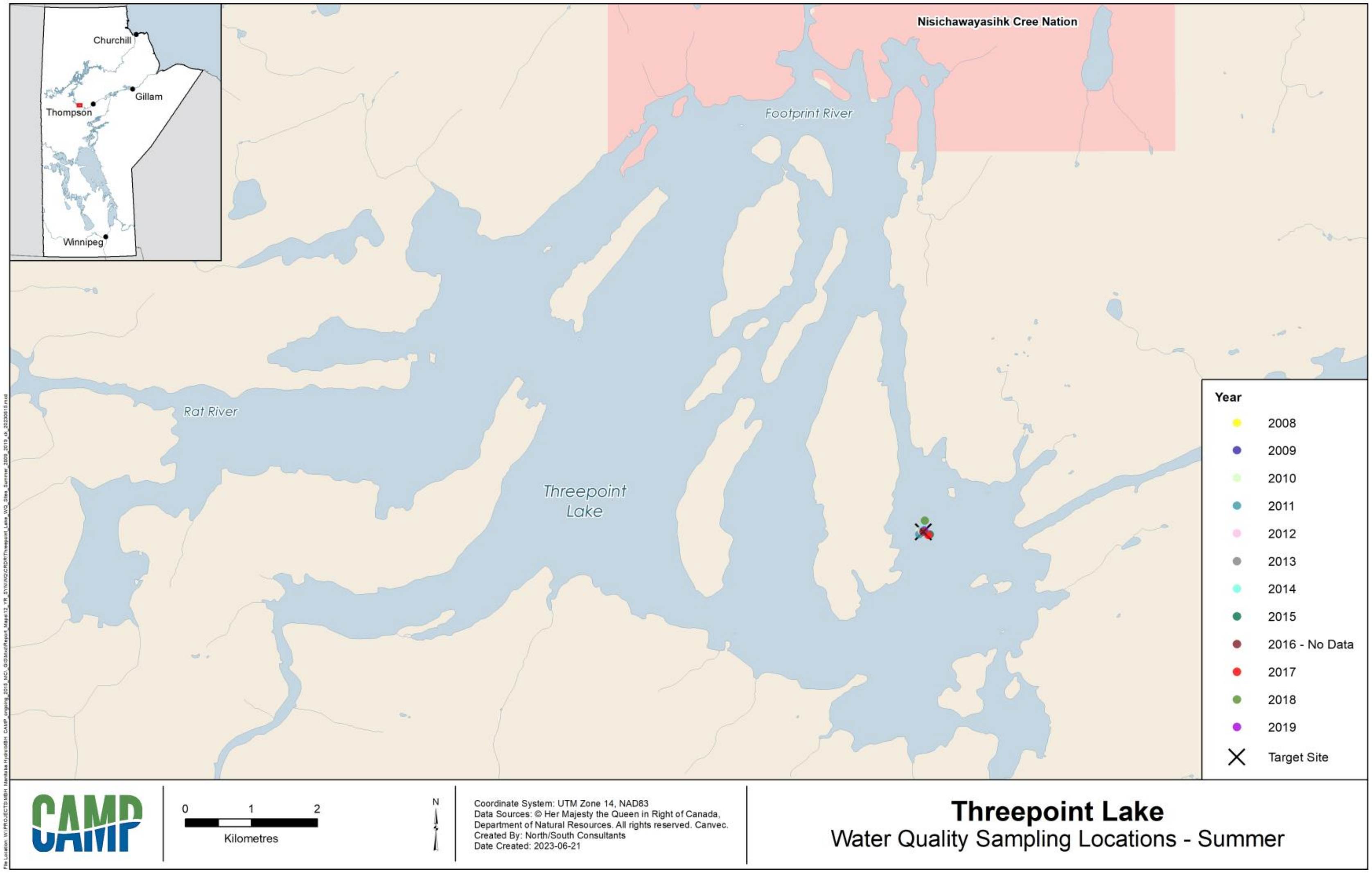


Figure A3-1-2. Summer water quality sampling locations: Threepoint Lake.

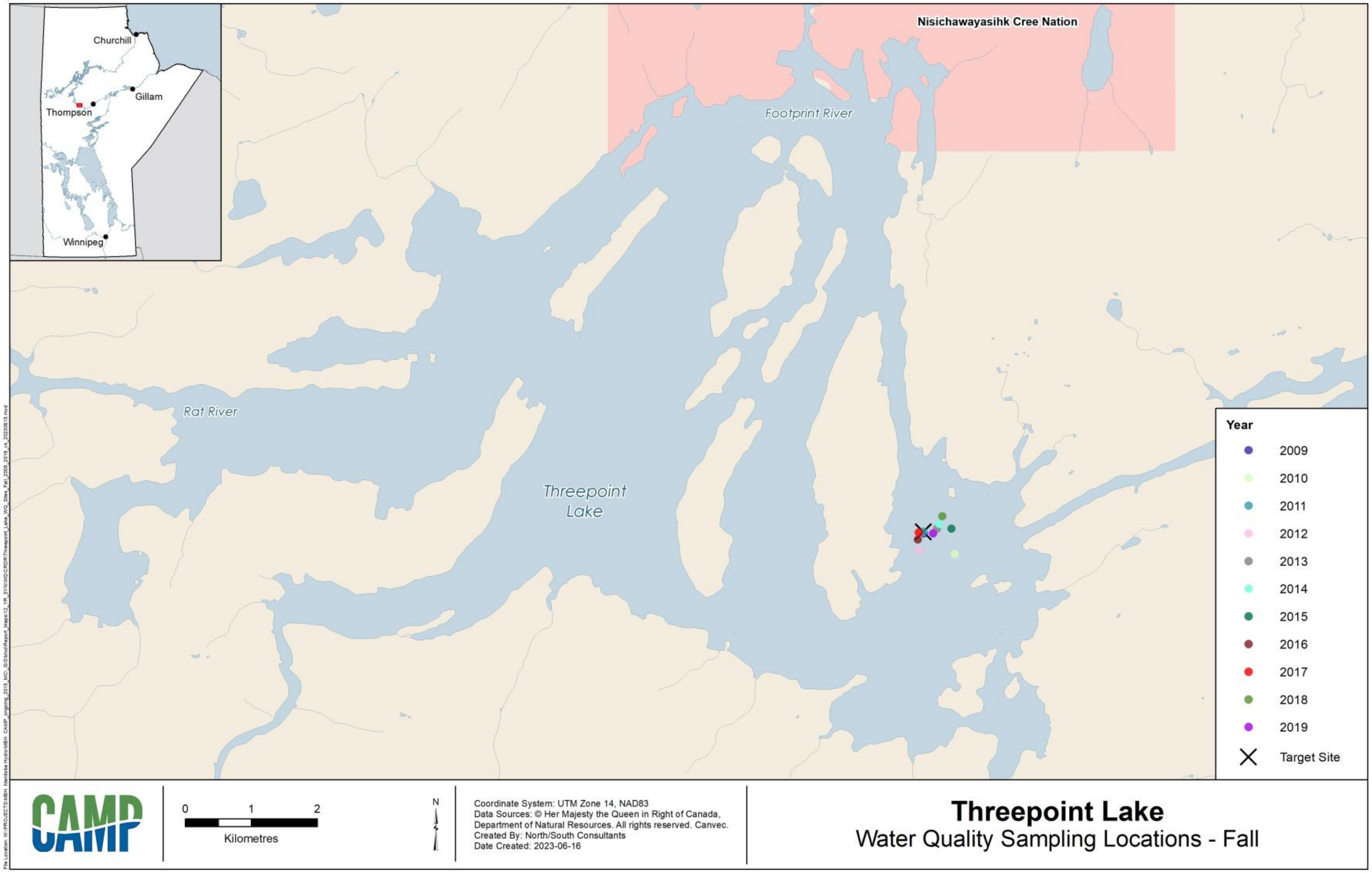


Figure A3-1-3. Fall water quality sampling locations: Threepoint Lake.

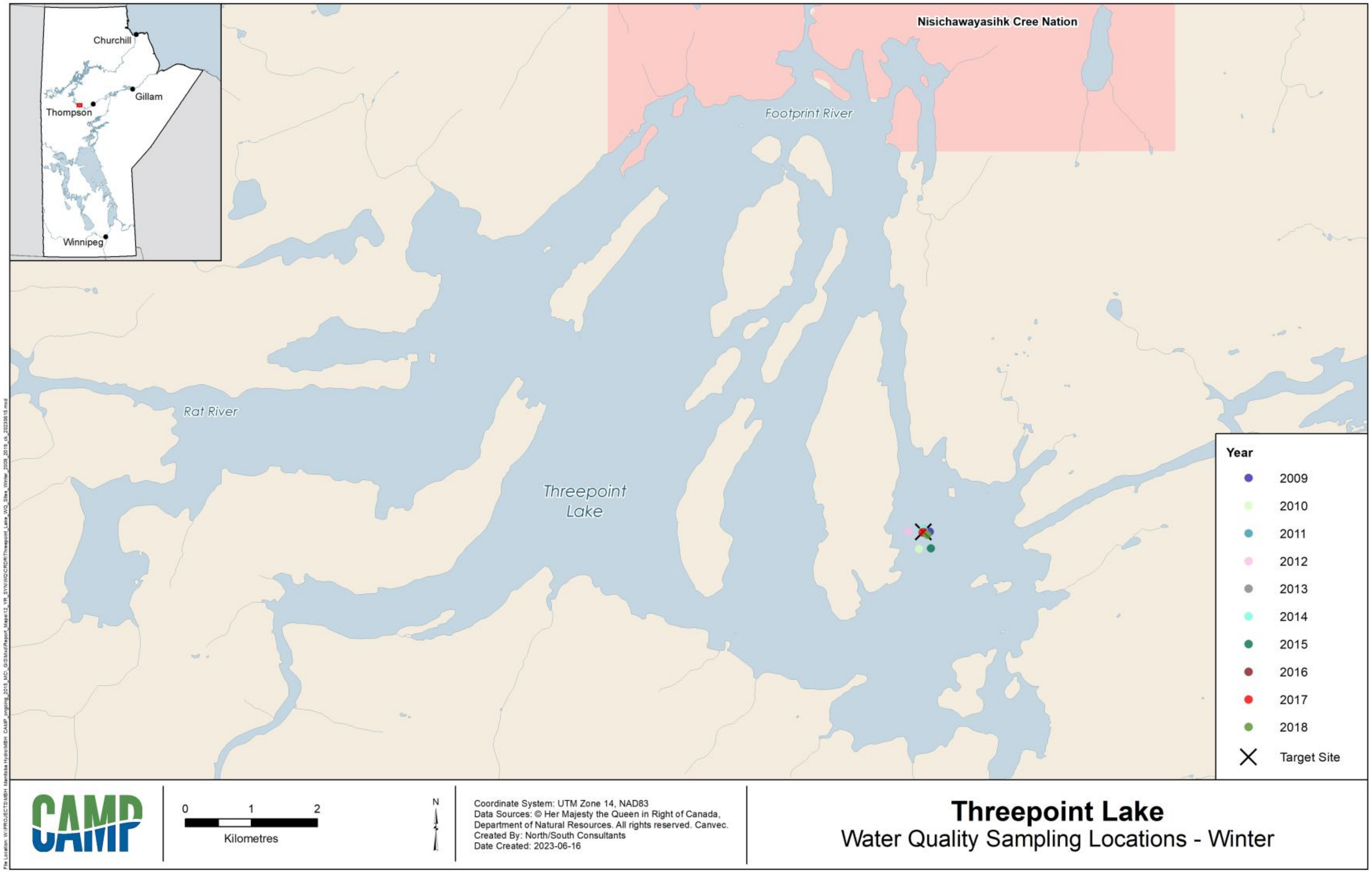


Figure A3-1-4. Winter water quality sampling locations: Threepoint Lake.

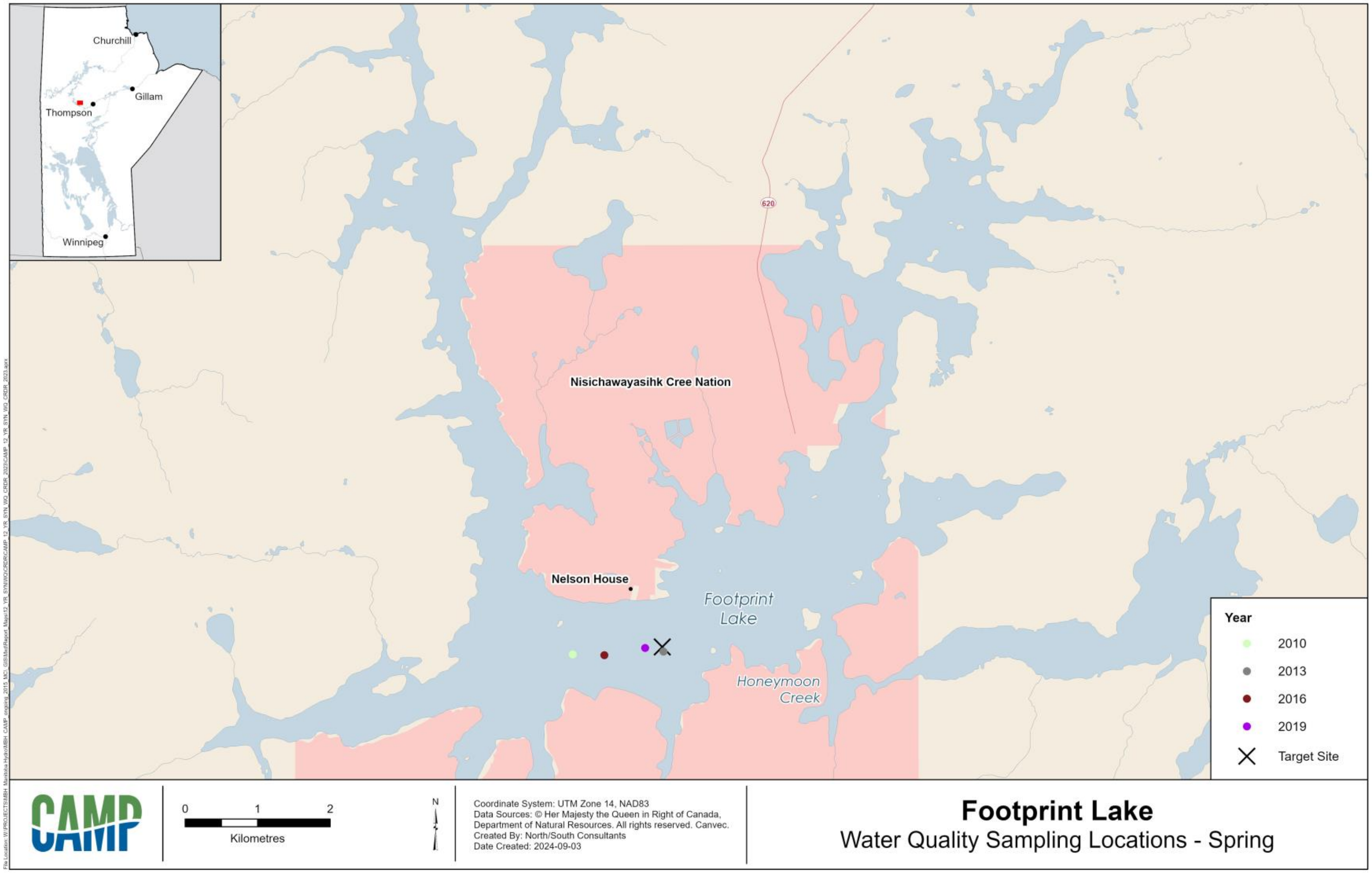


Figure A3-1-5. Spring water quality sampling locations: Footprint Lake.

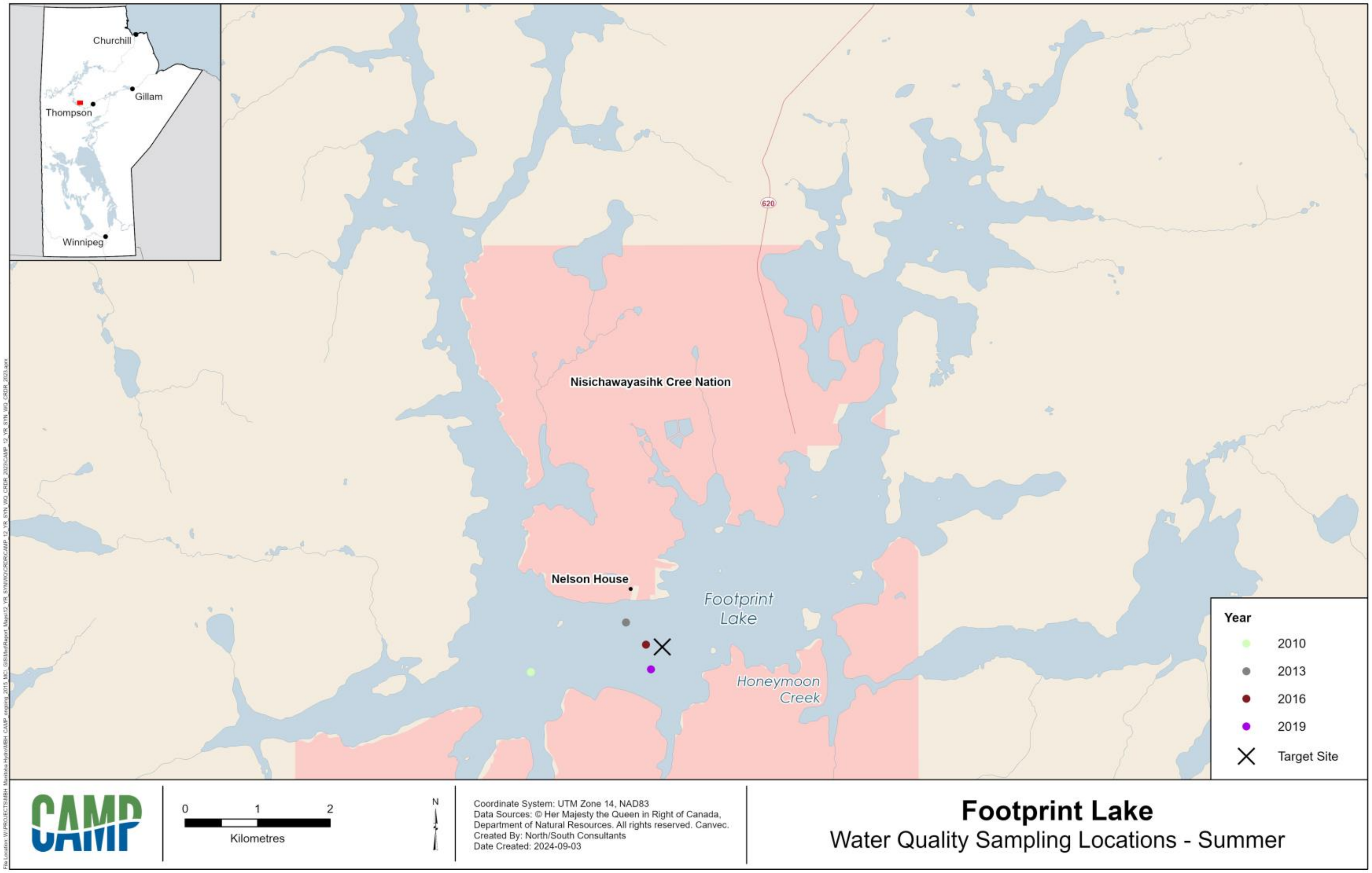


Figure A3-1-6. Summer water quality sampling locations: Footprint Lake.

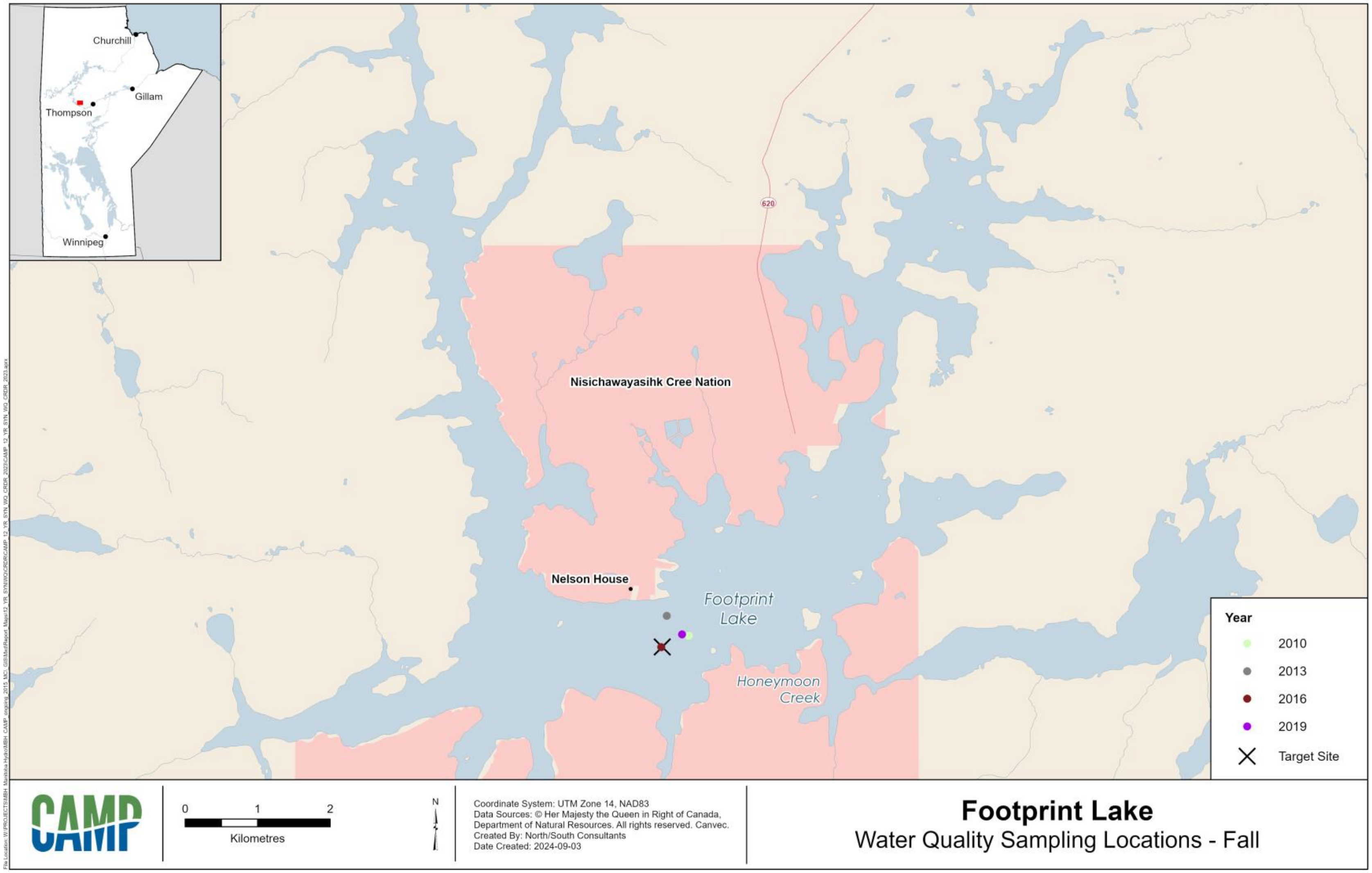


Figure A3-1-7. Fall water quality sampling locations: Footprint Lake.

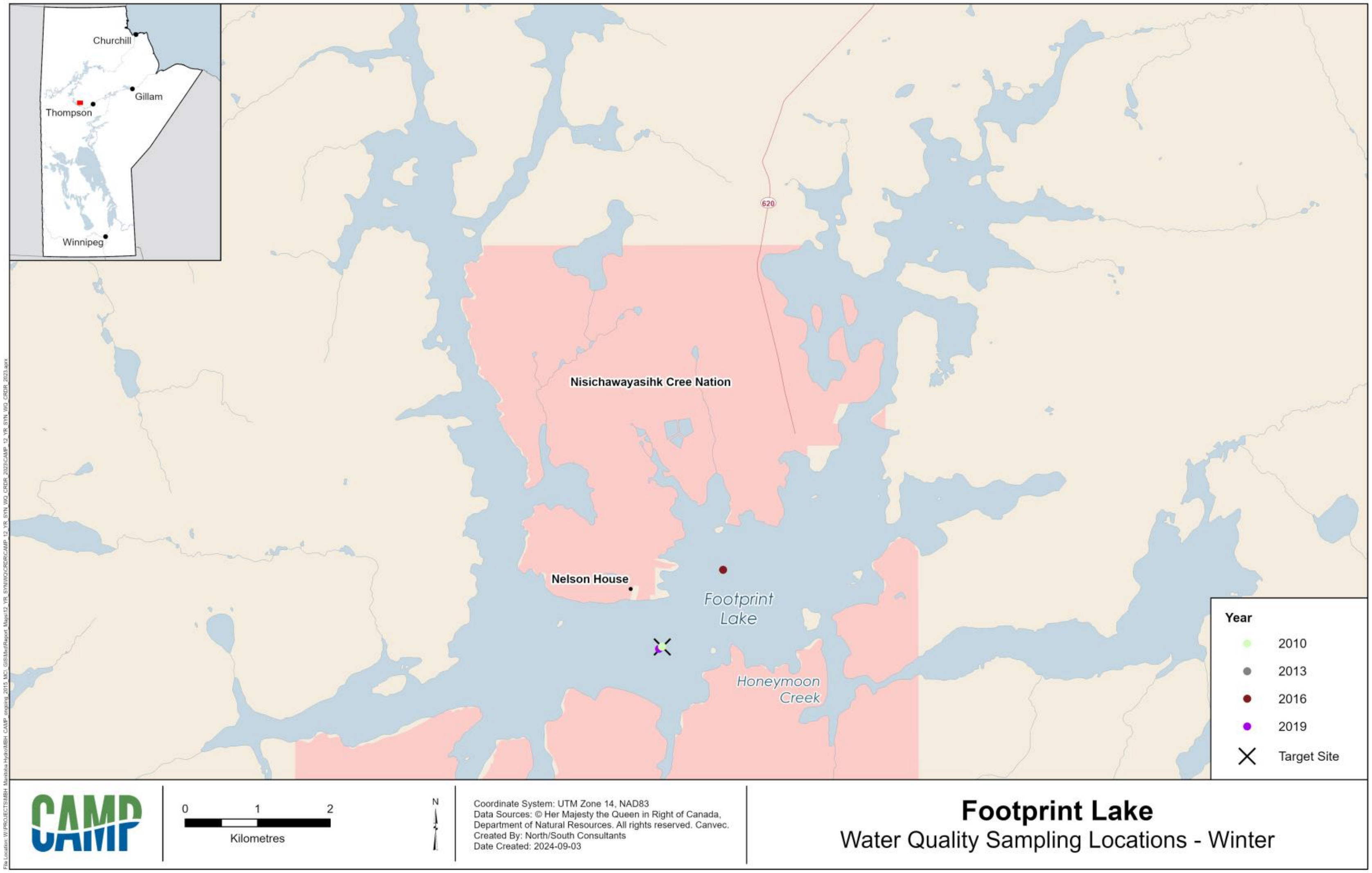


Figure A3-1-8. Winter water quality sampling locations: Footprint Lake.

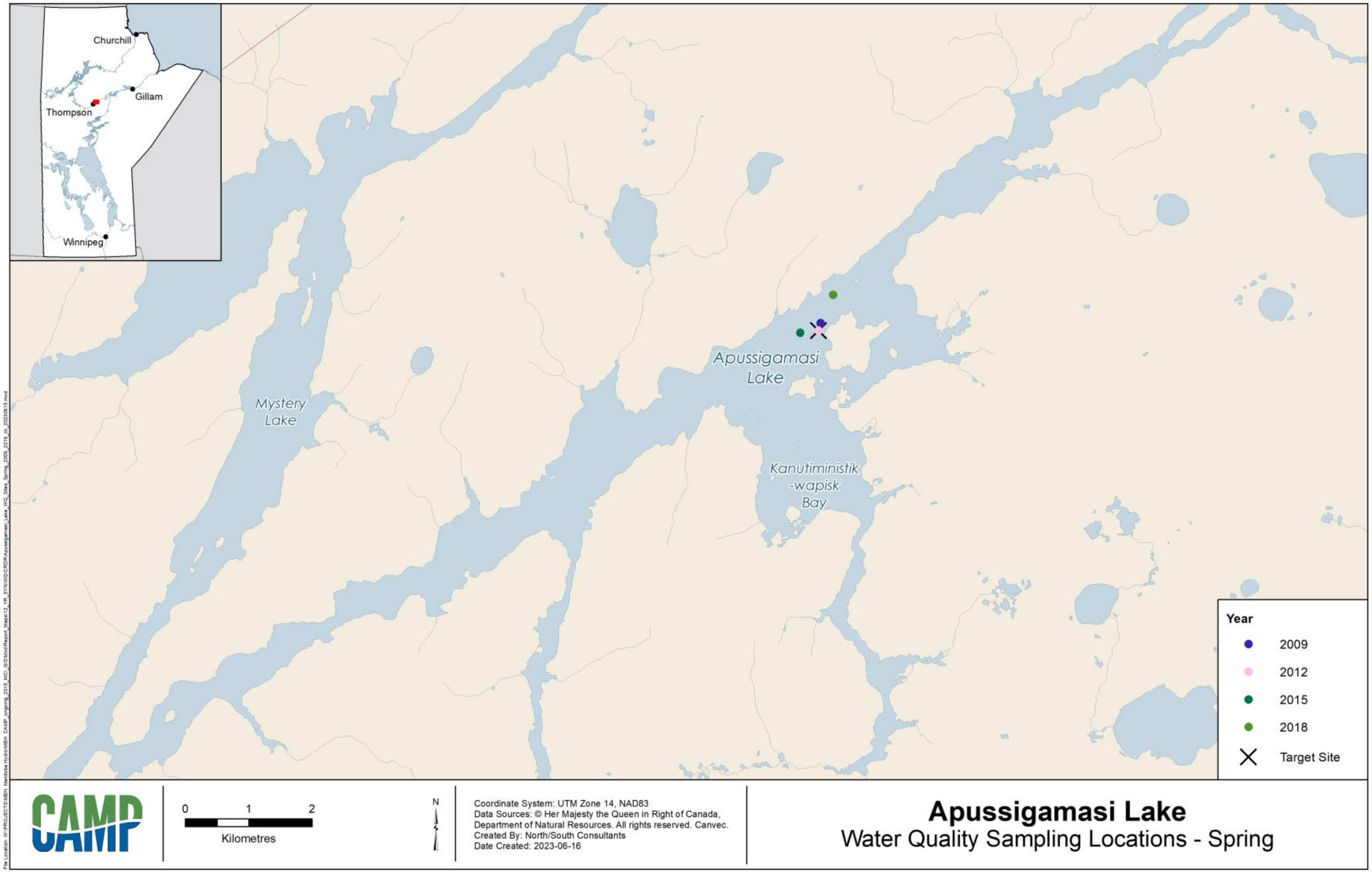


Figure A3-1-9. Spring water quality sampling locations: Apussigamasi Lake.

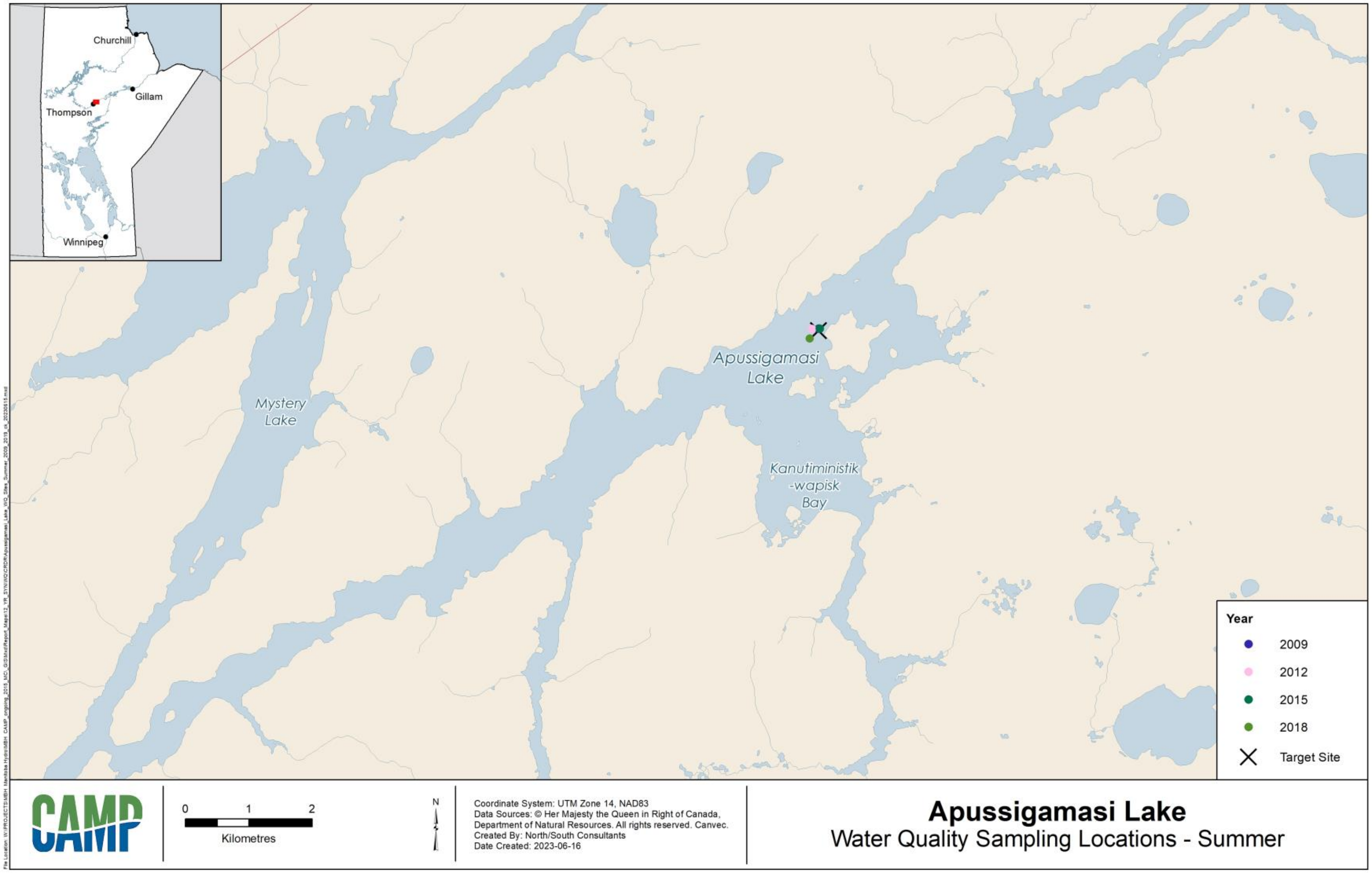


Figure A3-1-10. Summer water quality sampling locations: Apussigamasi Lake.

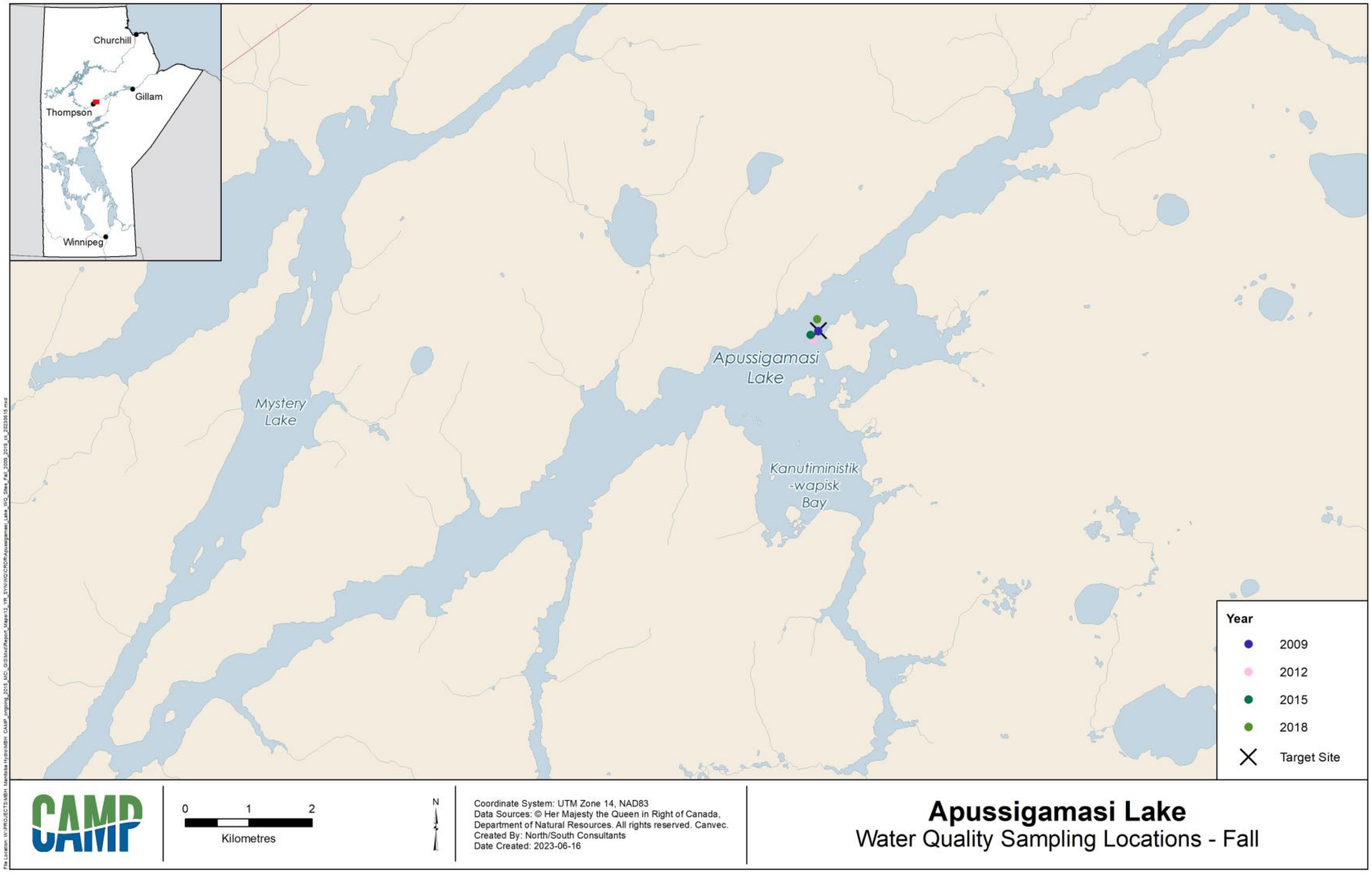


Figure A3-1-11. Fall water quality sampling locations: Apussigamasi Lake.

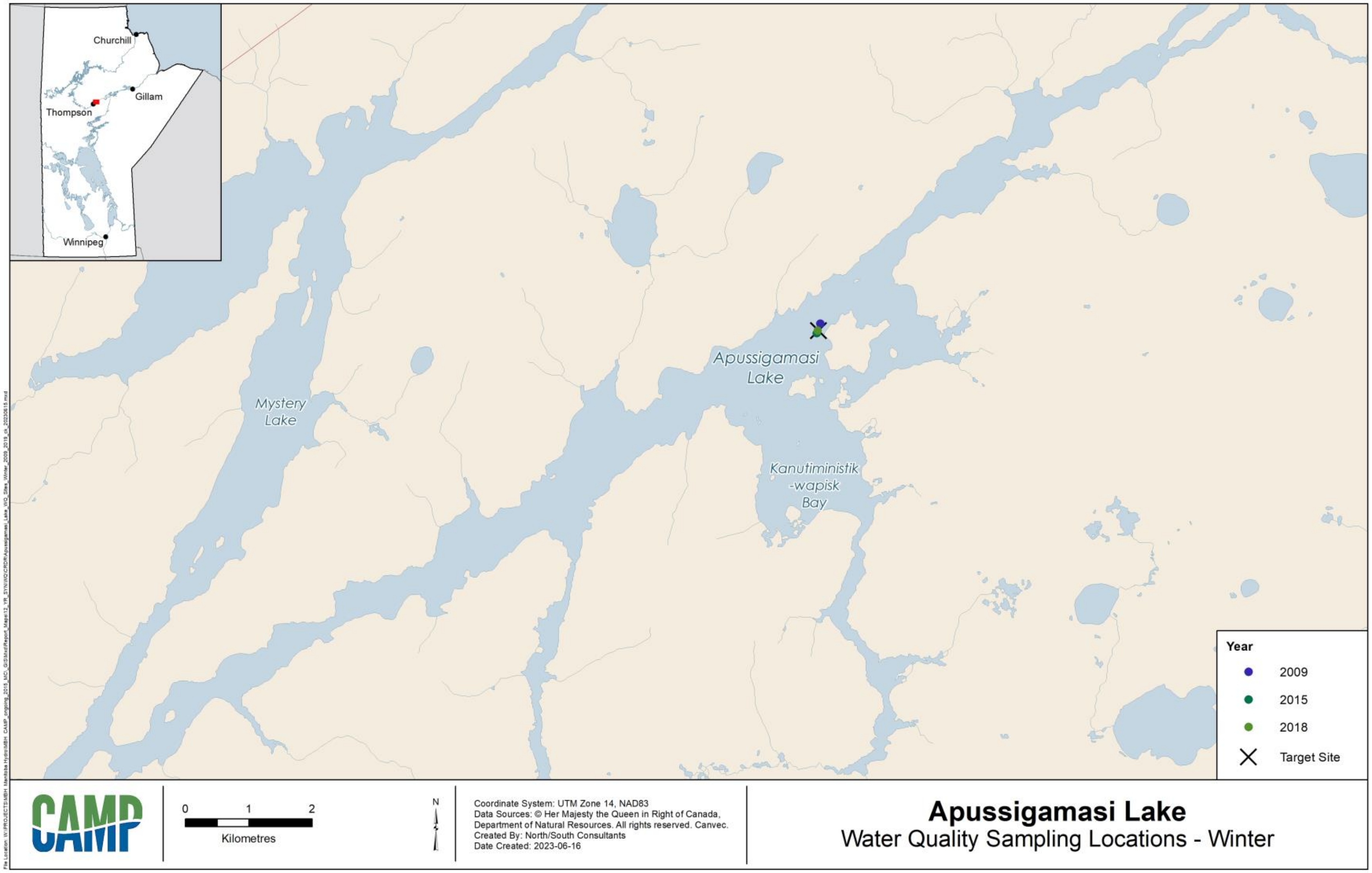


Figure A3-1-12. Winter water quality sampling locations: Apussigamasi Lake.

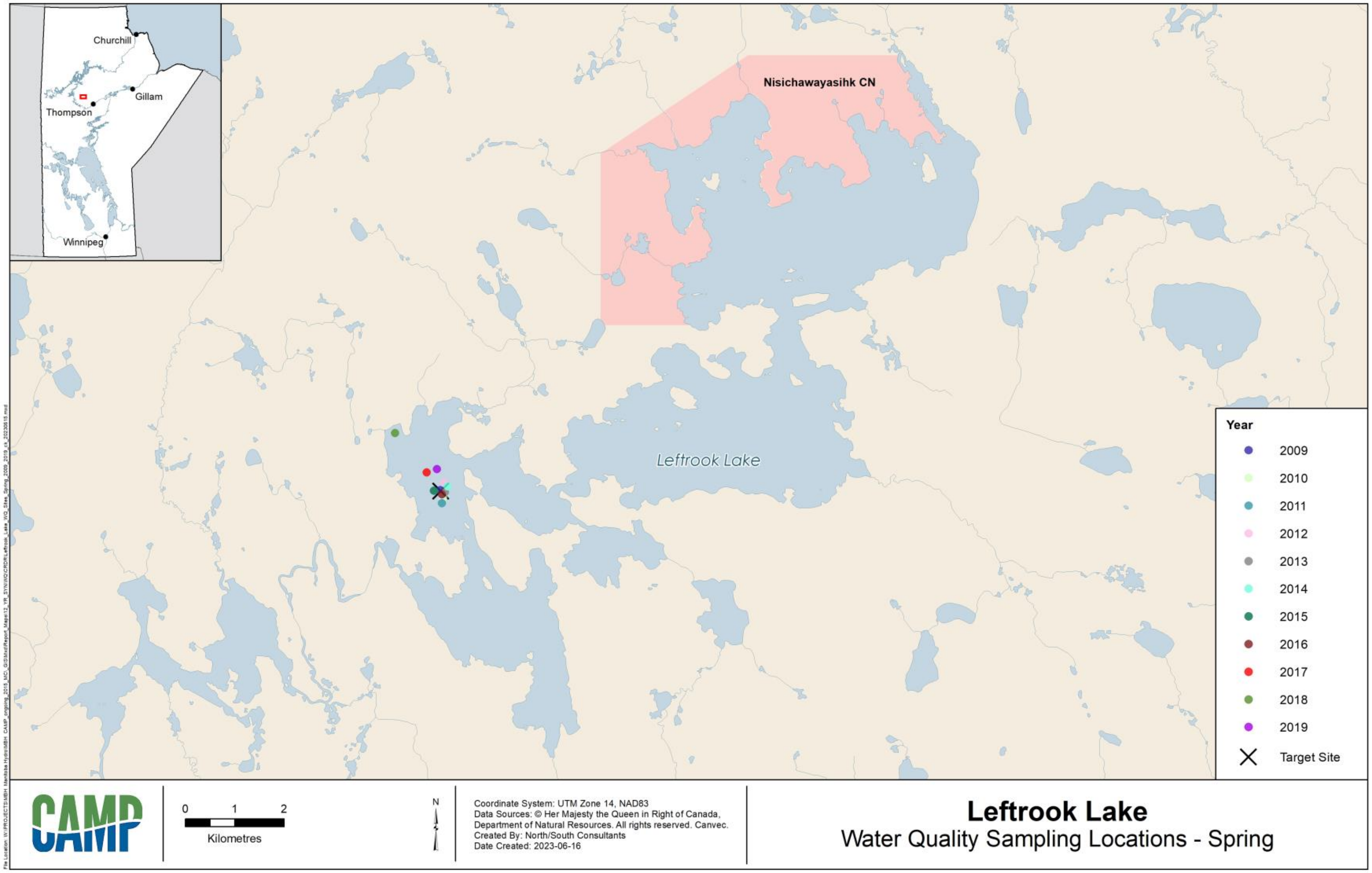


Figure A3-1-13. Spring water quality sampling locations: Leftrook Lake.

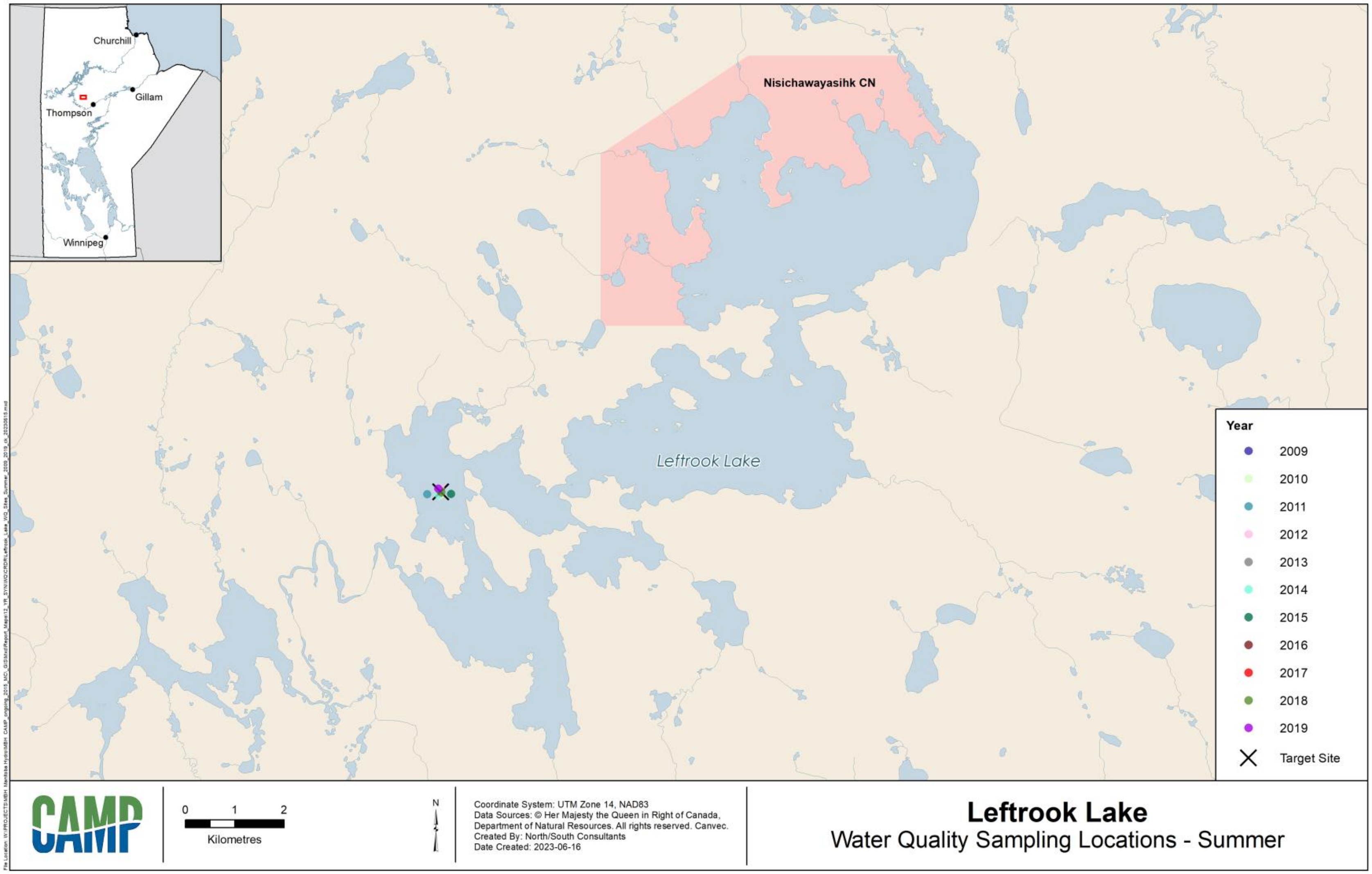


Figure A3-1-14. Summer water quality sampling locations: Leftrook Lake.

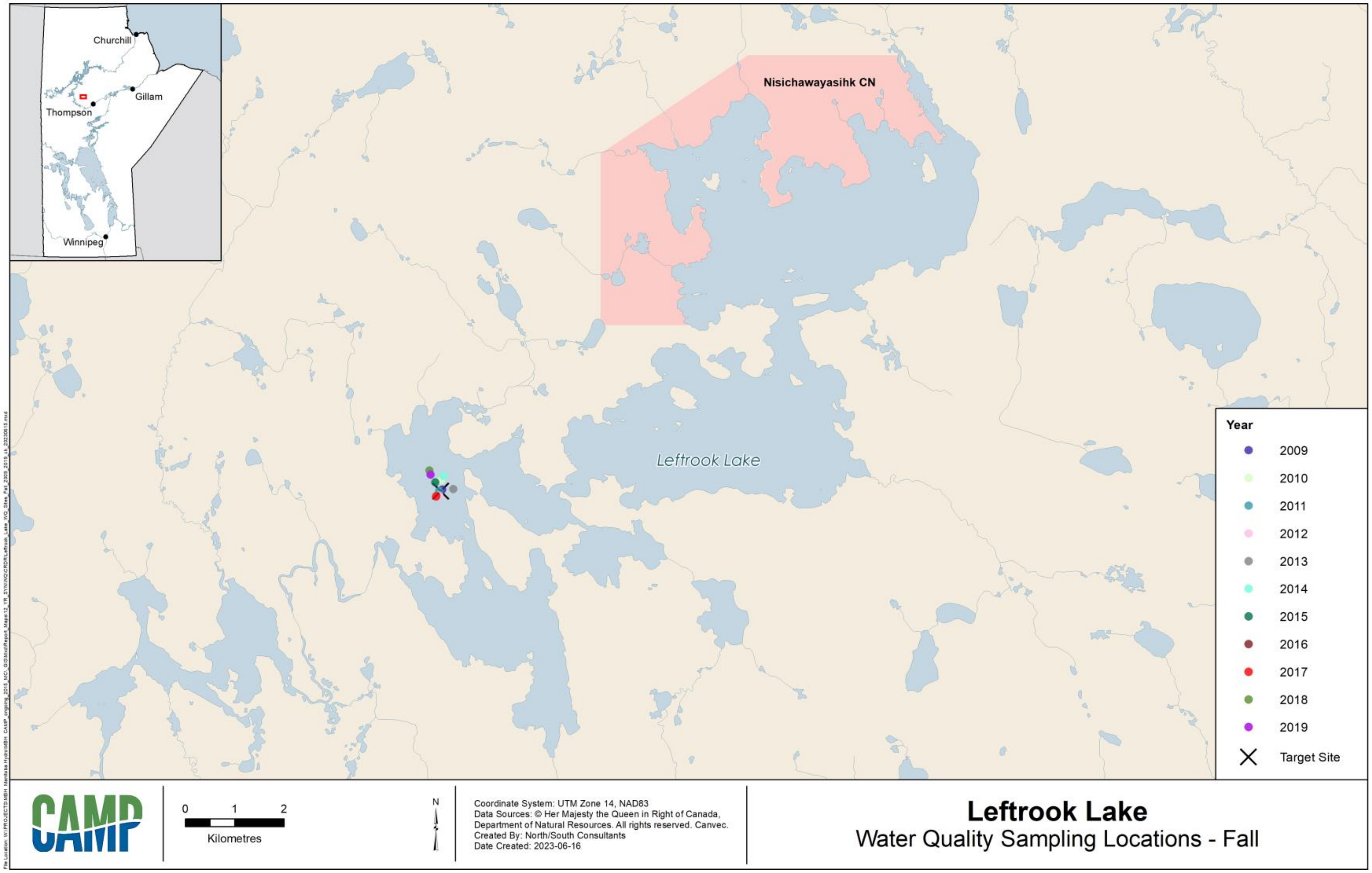


Figure A3-1-15. Fall water quality sampling locations: Leftrook Lake.

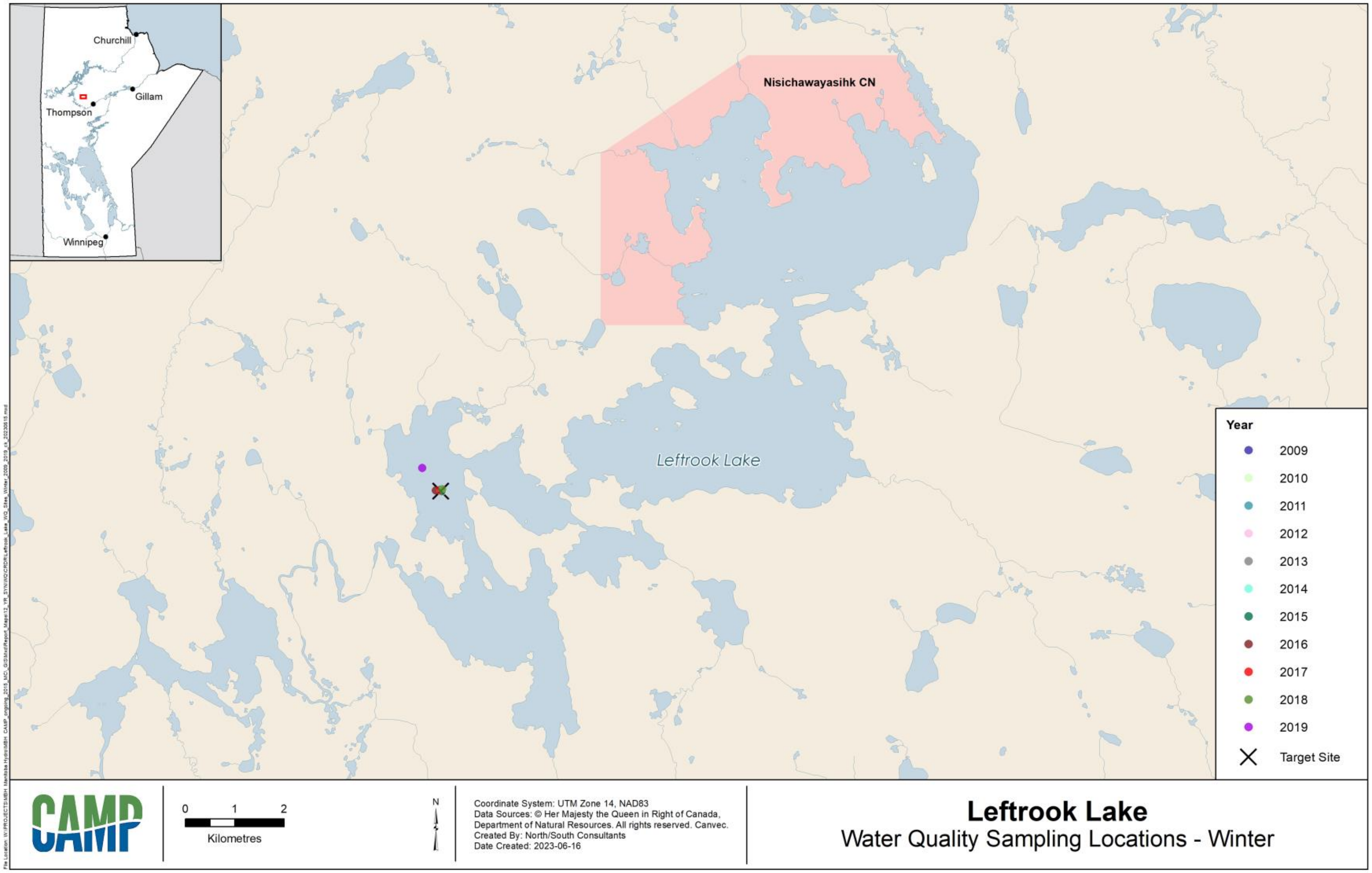


Figure A3-1-16. Winter water quality sampling locations: Leftrook Lake.

4.0 BENTHIC INVERTEBRATES

4.1 INTRODUCTION

The following presents the results of the benthic invertebrate community monitoring conducted from 2010-2019 in the Churchill River Diversion Region. Annual monitoring in this region began in 2009; the 2009 benthic invertebrate dataset was excluded due to a significant change in the sampling design in 2010.

Four waterbodies were monitored in the Churchill River Diversion Region: one on-system annual site (Threepoint Lake), two on-system rotational sites (Footprint Lake and Apussigamasi Lake), and one off-system annual site (Leftrook Lake; Table 4.1-1 and Figure 4.1-1).

Two sampling polygons (nearshore [NS] and offshore [OS]) defined by water depth, flow, and substrate composition were sampled in each waterbody in late summer/fall per year (Appendix 4-1). Five benthic invertebrate samples were collected in each polygon for a total of ten invertebrate samples per waterbody per year. Five sediment samples were also collected in each polygon (where possible) to provide supporting information on substrate composition, total organic carbon (TOC), and texture. Dominant substrate type(s) and sediment analysis results are presented in Appendix 4-2. Sampling was completed at all sites as planned over the period of 2010-2019.

Four benthic invertebrate indicators (abundance, community composition, taxonomic richness, and diversity) were selected for detailed reporting (Table 4.1-2). Metrics for these indicators that are presented herein include: total invertebrate abundance or total invertebrate density; the Ephemeroptera, Plecoptera, and Trichoptera (EPT) Index; the Oligochaeta and Chironomidae (O+C) Index; total taxa richness; EPT taxa richness; and Hill's effective richness (Hill's Index). A detailed description of these indicators is provided in CAMP (2024).

A detailed description of the program design and sampling methods are provided Technical Document 1, Section 2.4.

Table 4.1-1. 2010 to 2019 Benthic invertebrate sampling inventory.

Waterbody/ Area	Sampling Year											
	2008	2009 [1]	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
3PT		-	●	●	●	●	●	●	●	●	●	●
FOOT			●			●			●			●
APU		-			●			●			●	
LEFT		-	●	●	●	●	●	●	●	●	●	●

Notes:

1. Dataset excluded from analysis and reporting due to change in sampling design in 2010.

Table 4.1-2. Benthic invertebrate indicators and metrics.

Indicator	Metric	Units
Abundance	• Total Invertebrate Abundance	Number (no.) per sample
	• Total Invertebrate Density	no. per square metre (m^2)
Community Composition	• Relative Proportions of Major Invertebrate Groups	%
	• EPT Index	%
	• O+C Index	%
Taxonomic Richness	• Total Taxa Richness	no. of families
	• EPT Taxa Richness	no. of families
Diversity	• Hill's Effective Richness (Hill's Index)	value

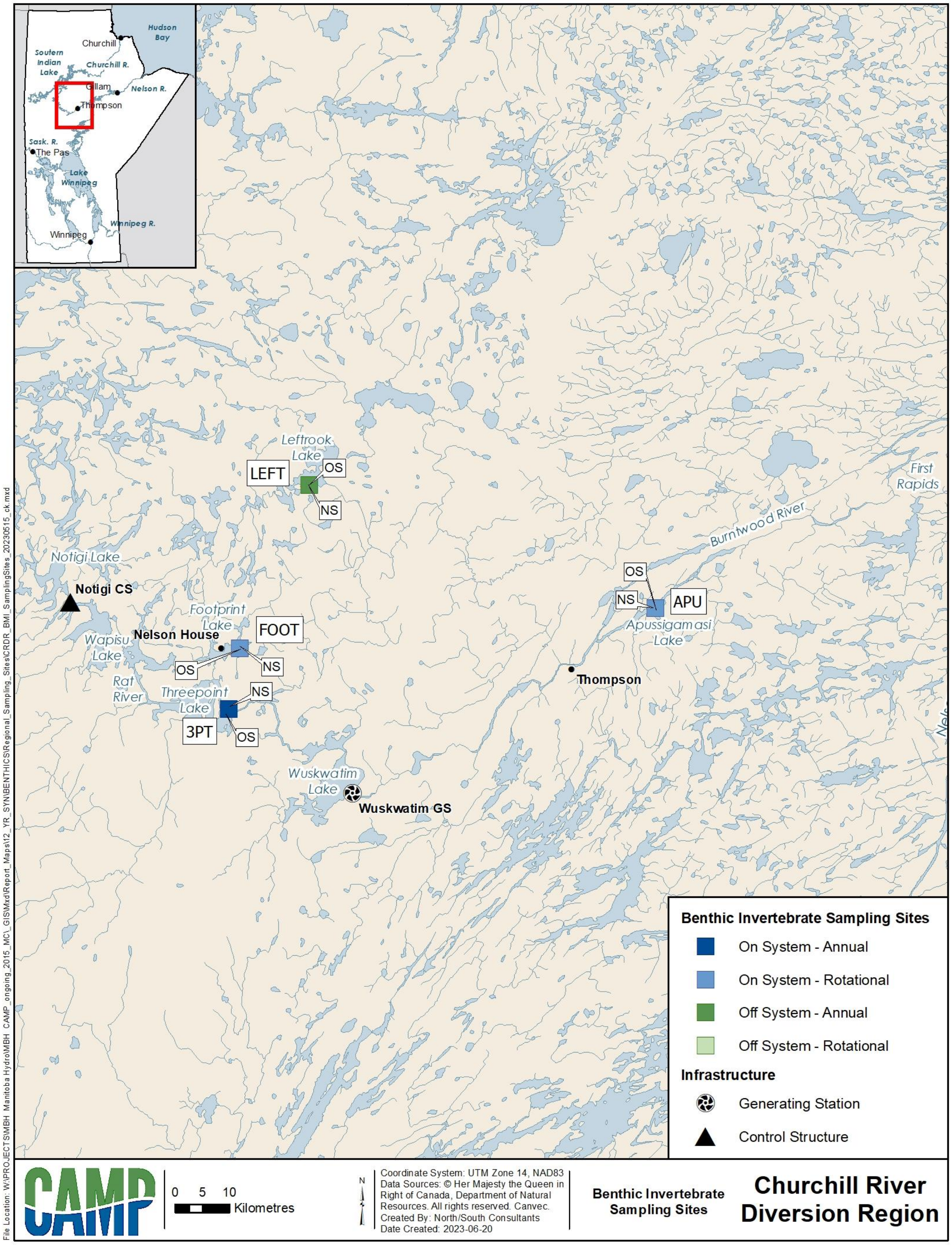


Figure 4.1-1. 2010-2019 Benthic invertebrate nearshore (NS) and offshore (OS) sampling sites.

4.2 ABUNDANCE

4.2.1 TOTAL INVERTEBRATE ABUNDANCE

4.2.1.1 ON-SYSTEM SITES

ANNUAL SITES

Threepoint Lake

Nearshore Habitat

Annual mean abundance over the ten years of monitoring ranged from 138 invertebrates per sample (2010) to 387 invertebrates per sample (2016; Figure 4.2-1). The overall mean abundance was 247 invertebrates per sample, the overall median abundance was 214 invertebrates per sample, and the IQR was 131 to 334 invertebrates per sample. Annual means were within the IQR, except for 2015 and 2016 (above).

Offshore Habitat

Annual mean abundance (density) over the ten years of monitoring ranged from 848 invertebrates per m^2 (2011) to 7,846 invertebrates per m^2 (2014; Figure 4.2-2). The overall mean abundance was 4,777 invertebrates per m^2, the overall median abundance was 5,158 invertebrates per m^2, and the IQR was 2,889 to 6,925 invertebrates per m^2. Annual means were below the IQR in 2010, 2011, and 2012, and above the IQR in 2014, 2015, and 2019.

ROTATIONAL SITES

Footprint Lake

Nearshore Habitat

Annual mean abundance over the four years of monitoring ranged from 104 invertebrates per sample (2010) to 795 invertebrates per sample (2013; Figure 4.2-1). The overall mean abundance was 463 invertebrates per sample, the overall median abundance was 395 invertebrates per sample, and the IQR was 177 to 861 invertebrates per sample. Annual means were within the IQR, except for 2010 (below).

Offshore Habitat

Annual mean abundance (density) over the four years of monitoring ranged from 678 invertebrates per m^2 (2010) to 2,897 invertebrates per m^2 (2019; Figure 4.2-2). The overall mean abundance was 1,802 invertebrates per m^2, the overall median abundance was 1,666 invertebrates per m^2, and the IQR was 927 to 2,543 invertebrates per m^2. Annual means were below the IQR in 2010, and above the IQR in 2013 and 2019.

Apussigamasi Lake

Nearshore Habitat

Annual mean abundance over the three years of monitoring ranged from 87 invertebrates per sample (2012) to 435 invertebrates per sample (2018; Figure 4.2-1). The overall mean abundance was 230 invertebrates per sample, the overall median abundance was 165 invertebrates per sample, and the IQR was 96 to 319 invertebrates per sample. Annual means were below the IQR in 2012, and above the IQR in 2018.

Offshore Habitat

Annual mean abundance (density) over the three years of monitoring ranged from 1,803 invertebrates per m^2 (2015) to 5,944 invertebrates per m^2 (2018; Figure 4.2-2). The overall mean abundance was 3,473 invertebrates per m^2, the overall median abundance was 2,611 invertebrates per m^2, and the IQR was 779 to 5,749 invertebrates per m^2. Annual means were within the IQR, except for 2018 (above).

4.2.1.2 OFF-SYSTEM SITES

ANNUAL SITES

Leftrook Lake

Nearshore Habitat

Annual mean abundance over the ten years of monitoring ranged from 453 invertebrates per sample (2010) to 6,323 invertebrates per sample (2013; Figure 4.2-1). The overall mean abundance was 2,498 invertebrates per sample, the overall median abundance was 1,803 invertebrates per sample, and the IQR was 860 to 3,695 invertebrates per sample. Annual means were below the IQR in 2010, and above the IQR in 2013 and 2018.

Offshore Habitat

Annual mean abundance (density) over the ten years of monitoring ranged from 1,627 invertebrates per m^2 (2012) to 13,109 invertebrates per m^2 (2015; Figure 4.2-2). The overall mean abundance was 6,650 invertebrates per m^2, the overall median abundance was 5,497 invertebrates per m^2, and the IQR was 3,275 to 9,263 invertebrates per m^2. Annual means were below the IQR in 2010 and 2012, and above the IQR in 2013, 2015, and 2018.

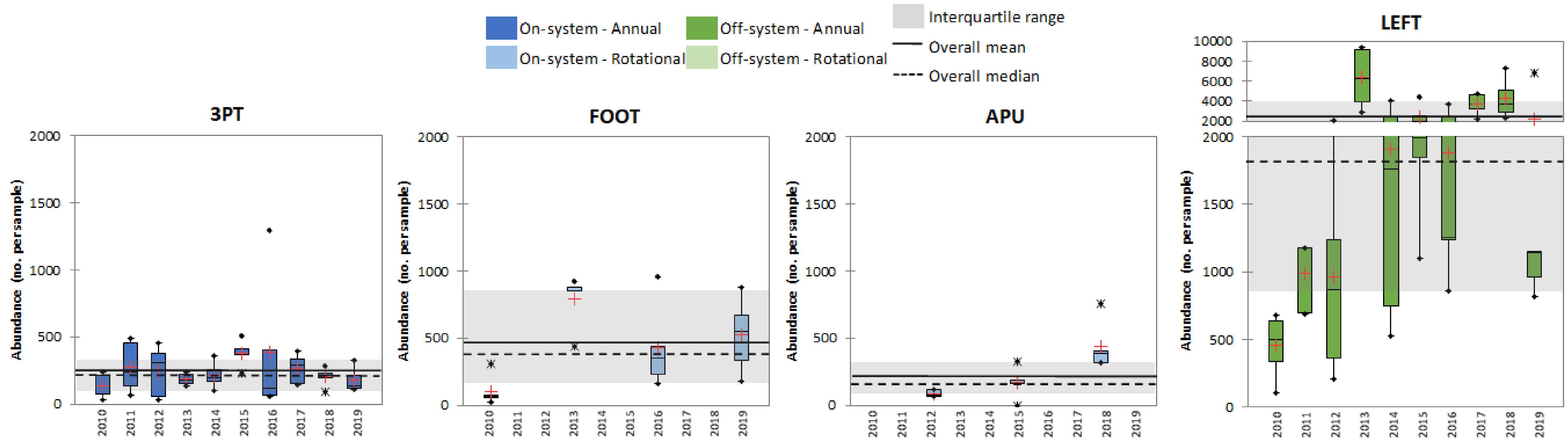


Figure 4.2-1. 2010 to 2019 Nearshore benthic invertebrate abundance (total no. per sample).

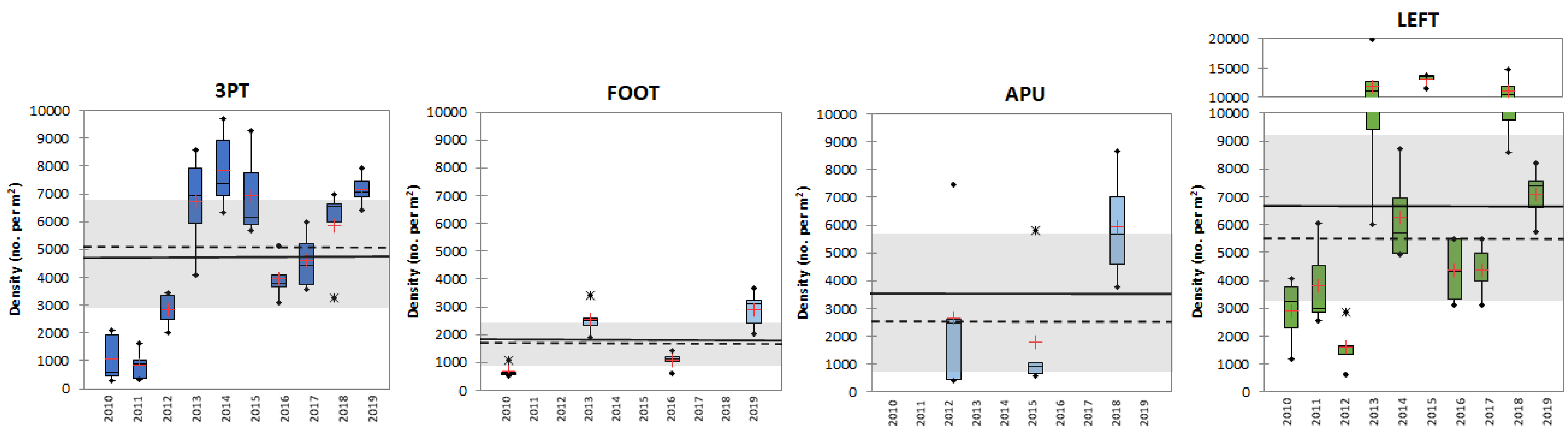


Figure 4.2-2. 2010 to 2019 Offshore benthic invertebrate abundance (density; total no. per m^2).

4.3 COMMUNITY COMPOSITION

4.3.1 RELATIVE ABUNDANCE

4.3.1.1 ON-SYSTEM SITES

ANNUAL SITES

Threepoint Lake

Nearshore Habitat

Benthic invertebrate community composition varied over the ten years of monitoring (2010 to 2019; Table 4.3-1). Corixidae (water boatmen) was the dominant taxon in 2010 (54%), 2015 (48%), and 2018 (41%). Chironomidae (non-biting midges, 29%) and Corixidae (31%) were the dominant groups in 2011. Oligochaeta (aquatic segmented worms, 37%) and Corixidae (26%) dominated in 2012. Oligochaeta (27%), Amphipoda (freshwater shrimps, mainly Hyalellidae, 27%) and Chironomidae (26%) were nearly co-dominant in 2013. Amphipoda (mainly Hyalellidae) was the most abundant taxon in 2014 (73%), 2016 (40%), and 2019 (59%). Oligochaeta (28%) and Chironomidae (31%) were nearly co-dominant in 2017.

Offshore Habitat

Bivalvia (mainly Sphaeriidae, fingernail clams) dominated the benthic invertebrate community over the ten years of monitoring (2010 to 2019; Table 4.3-2). Among those years, mean annual relative abundance of Bivalvia ranged from 48% (2011) to 69% (2019). Aside from 2018, Amphipoda (freshwater shrimps, mainly Pontoporeiidae) was the second most abundant group, with mean relative abundance ranging between 15% (2017) to 39% (2015). The second most abundant taxon in 2018 was Gastropoda (snails, mainly Hydrobiidae,17%).

ROTATIONAL SITES

Footprint Lake

Nearshore Habitat

Benthic invertebrate community composition varied over the four years of monitoring (2010, 2013, 2016, and 2019; Table 4.3-3). Corixidae (water boatmen) was the dominant taxon in 2010 (49%) and 2019 (44%). Chironomidae (non-biting midges) was the dominant taxon in 2013 (38%).

Amphipoda (freshwater shrimps, mainly Hyalellidae, 26%) and Chironomidae (31%) dominated the invertebrate community in 2016.

Offshore Habitat

Benthic invertebrate community composition varied over the four years of monitoring (2010, 2013, 2016, and 2019; Table 4.3-4). One taxon within the "Other Diptera" category (Chaoboridae, phantom midges, 54%) was most abundant in 2010. Amphipoda (freshwater shrimps, Pontoporeiidae) was dominant in 2013 (68%). Amphipoda (41%) and Chironomidae (36%) (non-biting midges) were dominated in 2016. Amphipoda (46%) and Chironomidae (44%) were nearly co-dominant in 2019.

Apussigamasi Lake

Nearshore Habitat

Benthic invertebrate community composition varied over the three years of monitoring (2012, 2015, and 2018; Table 4.3-5). Amphipoda (freshwater shrimps, mainly Hyalellidae) was dominant in 2012 (36%) and 2018 (40%). Oligochaeta (aquatic segmented worms) dominated in 2015 (26%).

Offshore Habitat

Bivalvia (Sphaeriidae, fingernail clams) dominated the benthic invertebrate community in all three years of monitoring (2012, 2015, and 2018; Table 4.3-6). Among those years, mean annual relative abundance of Bivalvia ranged from 60% (2012) to 74% (2018). Amphipoda (freshwater shrimps, Pontoporeiidae) was the second most relatively abundant taxon in 2012 (21%), 2015 (26%), and 2018 (13%).

4.3.1.2 OFF-SYSTEM SITES

ANNUAL SITES

Leftrook Lake

Nearshore Habitat

Benthic invertebrate community composition varied over the ten years of monitoring (2010 to 2019; Table 4.3-7). Amphipoda (freshwater shrimps, Hyalellidae) dominated in 2010 (55%). Oligochaeta (aquatic segmented worms) was dominant in 2011 (44%), 2012 (27%), 2014 (37%), and 2018 (49%). Corixidae (water boatmen) dominated in 2013 (28%). Gastropoda (snails, 28%, mainly Lymnaeidae) and Corixidae (25%) were nearly co-dominant in 2015. Ephemeroptera (mayflies, 42%, mainly Caenidae) was the dominant taxon in 2016. Oligochaeta (22%), Amphipoda (mainly Hyalellidae, 17%), and Bivalvia (mainly Sphaeriidae, 16%) dominated in 2017. Gastropoda was the dominant taxon in 2019 (52%, mainly Lymnaeidae and Planorbidae).

Offshore Habitat

Bivalvia (Sphaeriidae, fingernail clams) dominated the benthic invertebrate community in nine of the ten years of monitoring (2010 to 2014 and 2016 to 2019; Table 4.3-8). Of those years, mean annual relative abundance of Bivalvia ranged from 55% (2013 and 2019) to 74% (2011). Bivalvia (Sphaeriidae, 40%) and Chironomidae (non-biting midges, 38%) were nearly co-dominant in 2015.

Table 4.3-1. 2010 to 2019 Threepoint Lake nearshore benthic invertebrate relative abundance.

0% <1% to 15% >15% to 25% >25% to 50% >50%

Invertebrate Taxa	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Oligochaeta	3%	18%	37%	27%	6%	10%	17%	28%	19%	5%
Amphipoda	5%	12%	21%	27%	73%	12%	40%	24%	24%	59%
Bivalvia	3%	0%	<1%	<1%	1%	<1%	0%	<1%	<1%	0%
Gastropoda	10%	<1%	<1%	1%	2%	2%	1%	<1%	<1%	2%
Ceratopogonidae	<1%	1%	1%	<1%	1%	1%	<1%	0%	<1%	<1%
Chironomidae	16%	29%	6%	26%	5%	19%	25%	31%	7%	4%
Other Diptera	1%	1%	1%	<1%	<1%	2%	<1%	1%	1%	1%
Ephemeroptera	5%	6%	4%	10%	5%	1%	5%	5%	3%	3%
Plecoptera	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Trichoptera	1%	<1%	1%	<1%	<1%	1%	<1%	1%	1%	1%
Corixidae	54%	31%	26%	7%	5%	48%	10%	11%	41%	22%
Coleoptera	1%	2%	1%	1%	1%	2%	1%	<1%	2%	1%
All other taxa	<1%	<1%	1%	1%	<1%	1%	<1%	<1%	1%	1%

Table 4.3-2. 2010 to 2019 Threepoint Lake offshore benthic invertebrate relative abundance.

0% <1% to 15% >15% to 25% >25% to 50% >50%

Invertebrate Taxa	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Oligochaeta	2%	3%	1%	2%	1%	1%	1%	1%	<1%	1%
Amphipoda	29%	24%	16%	31%	33%	39%	36%	15%	9%	21%
Bivalvia	52%	48%	62%	51%	61%	55%	51%	65%	65%	69%
Gastropoda	1%	1%	13%	7%	1%	<1%	1%	7%	17%	5%
Ceratopogonidae	1%	1%	<1%	<1%	<1%	<1%	<1%	<1%	1%	<1%
Chironomidae	7%	9%	4%	7%	2%	2%	5%	6%	5%	2%
Other Diptera	0%	0%	0%	0%	0%	<1%	0%	0%	0%	0%
Ephemeroptera	4%	12%	2%	2%	2%	1%	6%	5%	2%	1%
Plecoptera	0%	0%	0%	0%	0%	0%	0%	0%	<1%	0%
Trichoptera	4%	3%	2%	<1%	<1%	<1%	1%	1%	2%	<1%
Corixidae	0%	0%	<1%	0%	<1%	0%	<1%	<1%	0%	<1%
Coleoptera	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
All other taxa	1%	0%	<1%	0%	<1%	<1%	<1%	0%	<1%	<1%

Table 4.3-3. 2010 to 2019 Footprint Lake nearshore benthic invertebrate relative abundance.

0% | <1% to 15% | >15% to 25% | >25% to 50% | >50%

Invertebrate Taxa	2010	2013	2016	2019
Oligochaeta	8%	13%	14%	10%
Amphipoda	23%	17%	26%	20%
Bivalvia	1%	<1%	0%	<1%
Gastropoda	2%	1%	1%	1%
Ceratopogonidae	1%	1%	1%	4%
Chironomidae	7%	38%	31%	11%
Other Diptera	<1%	2%	<1%	2%
Ephemeroptera	5%	4%	1%	1%
Plecoptera	0%	0%	0%	0%
Trichoptera	1%	1%	1%	2%
Corixidae	49%	12%	23%	44%
Coleoptera	2%	3%	1%	1%
All other taxa	1%	7%	1%	3%

Table 4.3-4. 2010 to 2019 Footprint Lake offshore benthic invertebrate relative abundance.

0% | <1% to 15% | >15% to 25% | >25% to 50% | >50%

Invertebrate Taxa	2010	2013	2016	2019
Oligochaeta	<1%	4%	5%	1%
Amphipoda	15%	68%	41%	46%
Bivalvia	2%	4%	10%	5%
Gastropoda	0%	<1%	1%	<1%
Ceratopogonidae	4%	<1%	<1%	1%
Chironomidae	20%	18%	36%	44%
Other Diptera	54%	1%	2%	3%
Ephemeroptera	5%	4%	1%	1%
Plecoptera	0%	0%	0%	0%
Trichoptera	0%	<1%	1%	0%
Corixidae	0%	0%	0%	0%
Coleoptera	0%	0%	0%	0%
All other taxa	0%	<1%	3%	<1%

Table 4.3-5. 2010 to 2019 Apussigamasi Lake nearshore benthic invertebrate relative abundance.

0% | <1% to 15% | >15% to 25% | >25% to 50% | >50%

Invertebrate Taxa	2012	2015	2018
Oligochaeta	10%	26%	14%
Amphipoda	36%	12%	40%
Bivalvia	0%	<1%	0%
Gastropoda	3%	3%	2%
Ceratopogonidae	<1%	6%	2%
Chironomidae	14%	18%	12%
Other Diptera	0%	<1%	<1%
Ephemeroptera	4%	12%	13%
Plecoptera	0%	<1%	0%
Trichoptera	3%	1%	3%
Corixidae	23%	12%	13%
Coleoptera	3%	3%	<1%
All other taxa	5%	6%	1%

Table 4.3-6. 2010 to 2019 Apussigamasi Lake offshore benthic invertebrate relative abundance.

0% | <1% to 15% | >15% to 25% | >25% to 50% | >50%

Invertebrate Taxa	2012	2015	2018
Oligochaeta	0%	0%	0%
Amphipoda	21%	26%	13%
Bivalvia	60%	63%	74%
Gastropoda	7%	1%	4%
Ceratopogonidae	1%	1%	<1%
Chironomidae	4%	3%	2%
Other Diptera	0%	0%	0%
Ephemeroptera	5%	5%	3%
Plecoptera	0%	0%	0%
Trichoptera	3%	1%	2%
Corixidae	0%	0%	0%
Coleoptera	0%	0%	0%
All other taxa	<1%	0%	<1%

Table 4.3-7. 2010 to 2019 Leftrook Lake nearshore benthic invertebrate relative abundance.

0% | <1% to 15% | >15% to 25% | >25% to 50% | >50%

Invertebrate Taxa	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Oligochaeta	12%	44%	27%	13%	37%	21%	13%	22%	49%	7%
Amphipoda	55%	14%	13%	18%	17%	9%	17%	17%	4%	11%
Bivalvia	6%	1%	3%	6%	2%	1%	4%	16%	4%	6%
Gastropoda	3%	9%	17%	12%	10%	28%	4%	11%	8%	52%
Ceratopogonidae	0%	<1%	<1%	0%	<1%	0%	0%	<1%	0%	0%
Chironomidae	5%	12%	22%	6%	15%	9%	9%	13%	7%	7%
Other Diptera	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Ephemeroptera	4%	4%	3%	6%	1%	1%	42%	8%	12%	1%
Plecoptera	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Trichoptera	8%	4%	4%	9%	2%	4%	5%	12%	8%	6%
Corixidae	2%	9%	10%	28%	15%	25%	2%	1%	5%	8%
Coleoptera	1%	<1%	1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
All other taxa	5%	1%	1%	1%	1%	1%	2%	1%	4%	2%

Table 4.3-8. 2010 to 2019 Leftrook Lake offshore benthic invertebrate relative abundance.

0% | <1% to 15% | >15% to 25% | >25% to 50% | >50%

Invertebrate Taxa	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Oligochaeta	7%	11%	6%	6%	14%	21%	8%	10%	12%	13%
Amphipoda	<1%	0%	0%	<1%	<1%	<1%	0%	<1%	0%	0%
Bivalvia	71%	74%	57%	55%	72%	40%	66%	70%	65%	55%
Gastropoda	1%	1%	1%	2%	2%	1%	3%	4%	4%	3%
Ceratopogonidae	<1%	0%	0%	<1%	0%	0%	0%	<1%	<1%	<1%
Chironomidae	20%	13%	35%	36%	12%	38%	19%	15%	17%	28%
Other Diptera	0%	0%	0%	<1%	<1%	0%	0%	0%	0%	0%
Ephemeroptera	1%	1%	<1%	1%	0%	0%	3%	0%	<1%	<1%
Plecoptera	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Trichoptera	0%	0%	0%	<1%	0%	0%	1%	0%	<1%	<1%
Corixidae	0%	0%	1%	0%	0%	0%	<1%	0%	0%	<1%
Coleoptera	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
All other taxa	1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	1%	<1%

4.3.2 EPT INDEX

4.3.2.1 ON-SYSTEM SITES

ANNUAL SITES

Threepoint Lake

Nearshore Habitat

Annual mean EPT Index over the ten years of monitoring ranged from 2% (2015) to 9% (2013; Figure 4.3-1). The overall mean was 5%, the overall median was 3%, and the IQR was less than 2% to less than 7%. Annual means were within the IQR, except for 2013 (above).

Offshore Habitat

Annual mean EPT Index over the ten years of monitoring ranged from 2% (2014, 2015, and 2019) to 15% (2011; Figure 4.3-2). The overall mean was 5%, the overall median was 3%, and the IQR was 2% to less than 7%. Annual means were below the IQR in 2015 and 2019, and above the IQR in 2011 and 2016.

ROTATIONAL SITES

Footprint Lake

Nearshore Habitat

Annual mean EPT Index over the four years of monitoring ranged from 2% (2016 and 2019) to 4% (2013; Figure 4.3-1). The overall mean was 3%, the overall median was 2%, and IQR was less than 1% to 5%. Annual means were within the IQR in all years.

Offshore Habitat

Annual mean EPT Index over the four years of monitoring ranged from 1% (2016 and 2019) to 5% (2010; Figure 4.3-2). The overall mean was 3%, the overall median was 2%, and the IQR was less than 1% to 5%. Annual means were within the IQR in all years.

Apussigamasi Lake

Nearshore Habitat

Annual mean EPT Index over the three years of monitoring ranged from 7% (2012) to 31% (2015; Figure 4.3-1). The overall mean was 19%, the overall median was 15%, and the IQR was less than 8% to 19%. Annual means were below the IQR in 2012, and above the IQR in 2015.

Offshore Habitat

Annual mean EPT Index over the three years of monitoring ranged from 6% (2018) to 12% (2012; Figure 4.3-2). The overall mean was 9%, the overall median was 7%, and the IQR was 5% to 12%. Annual means were within the IQR in all years.

4.3.2.2 OFF-SYSTEM SITES

ANNUAL SITES

Leftrook Lake

Nearshore Habitat

Annual mean EPT Index over the ten years of monitoring ranged from 4% (2014) to 37% (2016; Figure 4.3-1). The overall mean was 14%, the overall median was 11%, and the IQR was 6% to less than 18%. Annual means were below the IQR in 2014 and 2015, and above the IQR in 2016 and 2017.

Offshore Habitat

Annual mean EPT Index over the ten years of monitoring ranged from 0% (2014, 2015 and 2017) to 3% (2016; Figure 4.3-2). The overall mean and median were less than 1% and IQR was 0% to slightly above 1%. Annual means were above the IQR in 2011 and 2016.

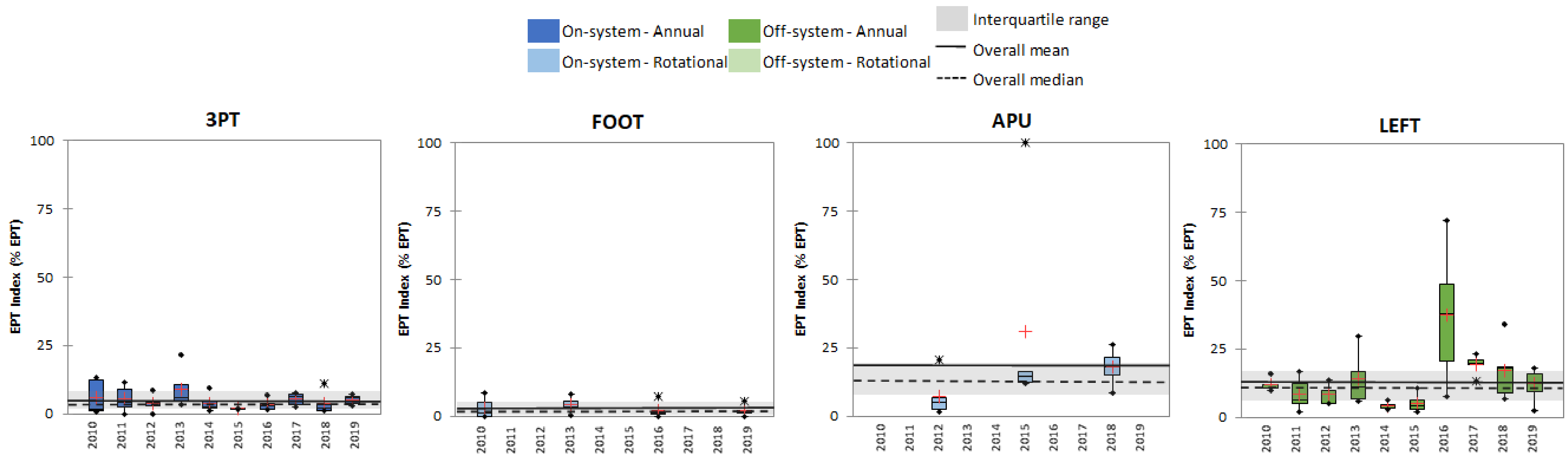


Figure 4.3-1. 2010 to 2019 Nearshore benthic invertebrate EPT Index.

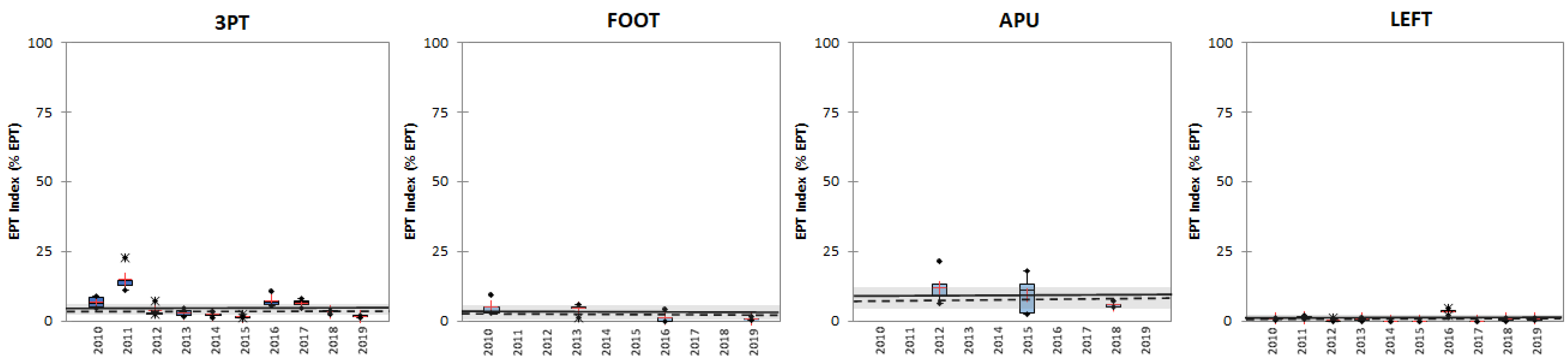


Figure 4.3-2. 2010 to 2019 Offshore benthic invertebrate EPT Index.

4.3.3 O+C INDEX

4.3.3.1 ON-SYSTEM SITES

ANNUAL SITES

Threepoint Lake

Nearshore Habitat

Annual mean O+C Index over the ten years of monitoring ranged from 10% (2019) to 61% (2017; Figure 4.3-3). The overall mean was 35%, the overall median was 34%, and the IQR was 13% to less than 54%. Annual means were below the IQR in 2014 and 2019, and above the IQR in 2013 and 2017.

Offshore Habitat

Annual mean O+C Index over the ten years of monitoring ranged from 3% (2014, 2015, and 2019) to 16% (2011; Figure 4.3-4). The overall mean was 7%, the overall median was 5%, and the IQR was slightly above 3% to less than 8%. Annual means were below the IQR in 2014, 2015 and 2019, and above the IQR in 2010, 2011, and 2013.

ROTATIONAL SITES

Footprint Lake

Nearshore Habitat

Annual mean O+C Index over the four years of monitoring ranged from 21% (2019) to 54% (2013; Figure 4.3-3). The overall mean was 37%, the overall median was 39%, and the IQR was less than 22% to less than 48%. Annual means were below the IQR in 2019, and above the IQR in 2013 and 2016.

Offshore Habitat

Annual mean O+C Index over the four years of monitoring ranged from 23% (2010 and 2013) to 43% (2019; Figure 4.3-4). The overall mean was 33%, the overall median was 29%, and the IQR was 24% to 44%. Annual means were below the IQR in 2010 and 2013.

Apussigamasi Lake

Nearshore Habitat

Annual mean O+C Index over the three years of monitoring ranged from 20% (2012) to 35% (2015; Figure 4.3-3). The overall mean was 28%, the overall median was 30%, and the IQR was less than 12% to less than 42%. Annual means were within the IQR in all years.

Offshore Habitat

Annual mean O+C Index over the three years of monitoring ranged from 2% (2018) to 6% (2012 and 2015; Figure 4.3-4). The overall mean was 4%, the overall median was 2%, and IQR was less than 2% to 4%. Annual means were above the IQR in 2012 and 2015.

4.3.3.2 OFF-SYSTEM SITES

ANNUAL SITES

Leftrook Lake

Nearshore Habitat

Annual mean O+C Index over the ten years of monitoring ranged from 16% (2019) to 55% (2011 and 2018; Figure 4.3-3). The overall mean and median were 36%, and the IQR was less than 20% to less than 49%. Annual means were below the IQR in 2013 and 2019, and above the IQR in 2011 and 2018.

Offshore Habitat

Annual mean O+C Index over the ten years of monitoring ranged from 24% (2011) to 59% (2015; Figure 4.3-4). The overall mean was 35%, the overall median was 31%, and the IQR was less than 25% to less than 42%. Annual means were below the IQR in 2011 and 2017, and above the IQR in 2012, 2013, and 2015.

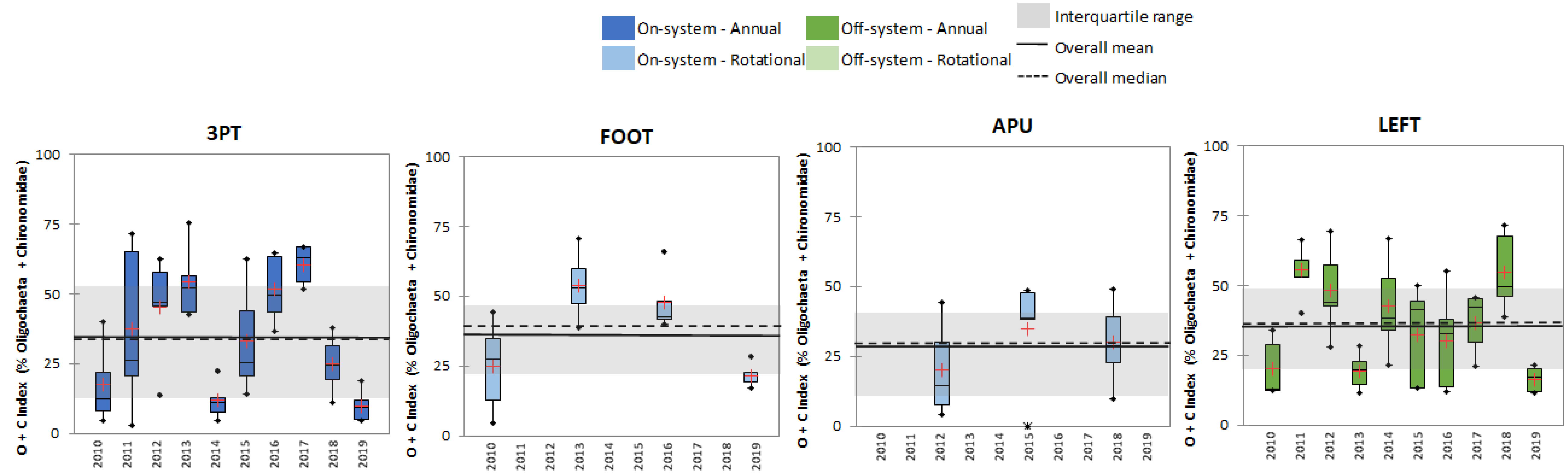


Figure 4.3-3. 2010 to 2019 Nearshore benthic invertebrate O+C Index.

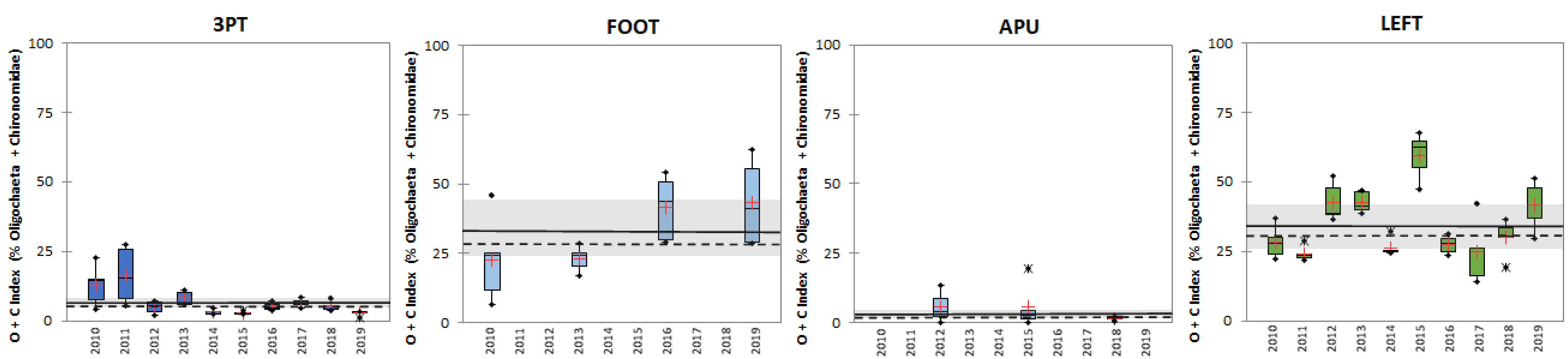


Figure 4.3-4. 2010 to 2019 Offshore benthic invertebrate O+C Index.

4.4 RICHNESS

4.4.1 TOTAL TAXA RICHNESS

4.4.1.1 ON-SYSTEM SITES

ANNUAL SITES

Threepoint Lake

Nearshore Habitat

Annual mean total taxa richness over the ten years of monitoring ranged from ten families (2011, 2012, 2016, and 2017) to 17 families (2015; Figure 4.4-1). The overall mean and median were 12 families, and the IQR was 9 to less than 14 families. Annual means were within the IQR, except for 2015 (above).

Offshore Habitat

Annual mean total taxa richness over the ten years of monitoring ranged from six families (2011) to 11 families (2018; Figure 4.4-2). The overall mean and median were nine families, and the IQR was 8 to 10 families. Annual means were below the IQR in 2010 and 2011, and above the IQR in 2018.

ROTATIONAL SITES

Footprint Lake

Nearshore Habitat

Annual mean total taxa richness over the four years of monitoring ranged from nine families (2010) to 17 families (2013; Figure 4.4-1). The overall mean and median were 13 families, and the IQR was 8 to 17 families. Annual means were within the IQR in all years.

Offshore Habitat

Annual mean total taxa richness over the four years of monitoring ranged from less than six families (2010) to eight families (2019; Figure 4.4-2). The overall mean was seven families, the overall median was six families, and the IQR was 6 to 8 families. Annual means were within the IQR, except in 2010 (below).

Apussigamasi Lake

Nearshore Habitat

Annual mean total taxa richness over the three years of monitoring ranged from nine families (2012) to 18 families (2018; Figure 4.4-1). The overall mean was 14 families, the overall median was 16 families, and the IQR was less than 10 to 17 families. Annual means were below the IQR in 2012, and above the IQR in 2018.

Offshore Habitat

Annual mean total taxa richness over the three years of monitoring ranged from six families (2012 and 2015) to ten families (2018; Figure 4.4-2). The overall mean and median were seven families, and the IQR was 6 to 9 families. Annual means were within the IQR, except in 2018 (above).

4.4.1.2 OFF-SYSTEM SITES

ANNUAL SITES

Leftrook Lake

Nearshore Habitat

Annual mean total taxa richness over the ten years of monitoring ranged from 17 families (2012 and 2016) to 21 families (2018; Figure 4.4-1). The overall mean and median were 18 families, and the IQR was 17 to 20 families. Annual means were below the IQR in 2010, 2013, and 2015, and above the IQR in 2017 and 2018.

Offshore Habitat

Annual mean total taxa richness over the ten years of monitoring ranged from less than five families (2012 and 2015) to more than seven families (2013, 2016 and 2018; Figure 4.4-2). The overall mean and median were six families, and the IQR was 5 to 7 families. Annual means were below the IQR in 2012 and 2015, and above the IQR in 2013, 2016, and 2018.

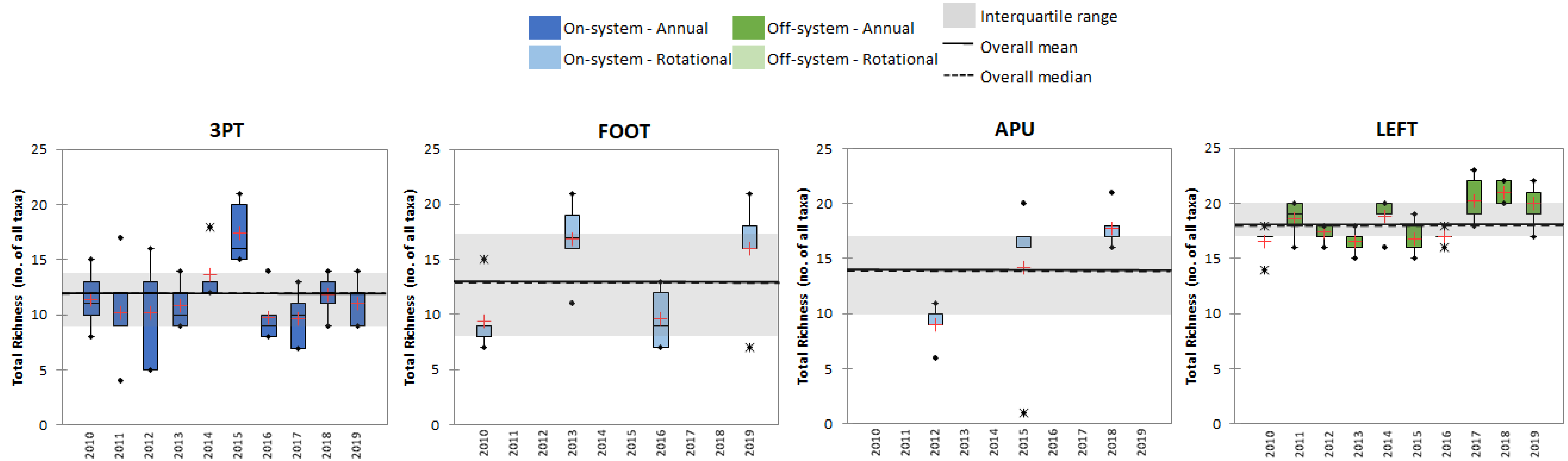


Figure 4.4-1. 2010 to 2019 Nearshore benthic invertebrate total richness (family level).

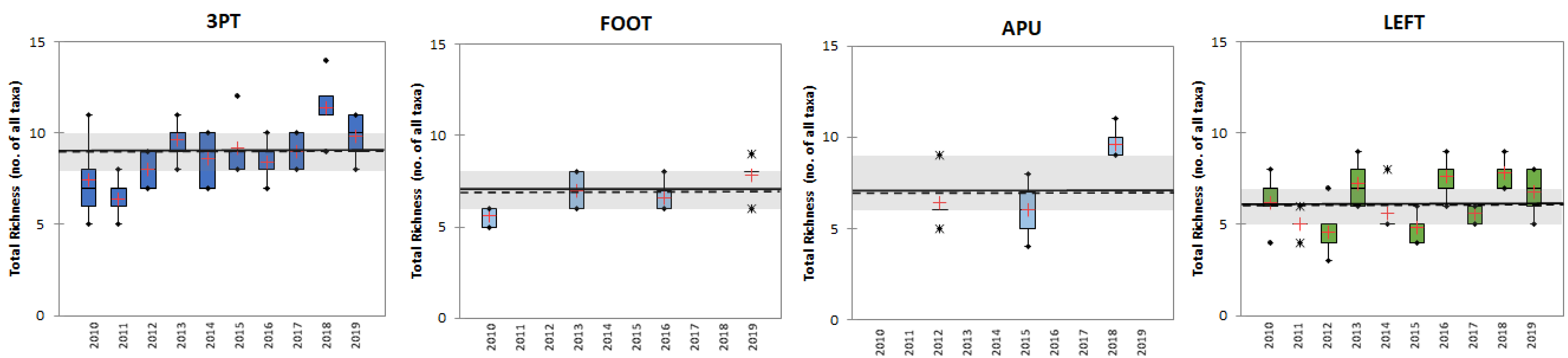


Figure 4.4-2. 2010 to 2019 Offshore benthic invertebrate total richness (family-level).

4.4.2 EPT TAXA RICHNESS

4.4.2.1 ON-SYSTEM SITES

ANNUAL SITES

Threepoint Lake

Nearshore Habitat

Annual mean EPT taxa richness over the ten years of monitoring ranged from two families (2010, 2012, 2013, 2016, and 2017) to four families (2019; Figure 4.4-3). The overall mean and median were three families, and the IQR was 2 to 4 families. Annual means were within the IQR in all years.

Offshore Habitat

Annual mean EPT taxa richness over the ten years of monitoring ranged from one family (2013) to three families (2017, 2018, and 2019; Figure 4.4-4). The overall mean and median were two families, and the IQR was 2 to 3 families. Annual means were below the IQR in 2011 and 2013, and above the IQR in 2018.

ROTATIONAL SITES

Footprint Lake

Nearshore Habitat

Annual mean EPT taxa richness over the four years of monitoring ranged from one family (2010) to five families (2013; Figure 4.4-3). The overall mean and median were three families, and the IQR was 1 to 4 families. Annual means were within the IQR, except in 2013 (above).

Offshore Habitat

Annual mean EPT taxa richness over all four years of monitoring ranged between less than one and slightly greater than one family (2010, 2013, 2016, and 2019; Figure 4.4-4). The overall mean and median were one family, and the IQR was within one family. Annual means were below the IQR in 2016, and above the IQR in 2013.

Apussigamasi Lake

Nearshore Habitat

Annual mean EPT taxa richness over the three years of monitoring ranged from two families (2012) to seven families (2018; Figure 4.4-3). The overall mean was five families, the overall median was six families, and the IQR was 2 to less than 7 families. Annual means were below the IQR in 2012, and above the IQR in 2018.

Offshore Habitat

Annual mean EPT taxa richness over the three years of monitoring ranged from two families (2012 and 2015) to less than three families (2018; Figure 4.4-4). The overall mean and median were two families, and the IQR was less than 2 to 3 families. Annual means were within the IQR in all years.

4.4.2.2 OFF-SYSTEM SITES

ANNUAL SITES

Leftrook Lake

Nearshore Habitat

Annual mean EPT taxa richness over the ten years of monitoring ranged from five families (2012, 2013, and 2015) to eight families (2017, 2018, and 2019; Figure 4.4-3). The overall mean and median were six families, and the IQR was 5 to 8 families. Annual means were below the IQR in 2015, and above the IQR in 2019.

Offshore Habitat

Annual mean EPT taxa richness over the ten years of monitoring ranged from zero families (2014, 2015, and 2017) to less than two families (2016; Figure 4.4-4). The overall mean and median were one family, and the IQR was between zero and 1 family. Annual means were above the IQR in 2013, 2016, 2018, and 2019.

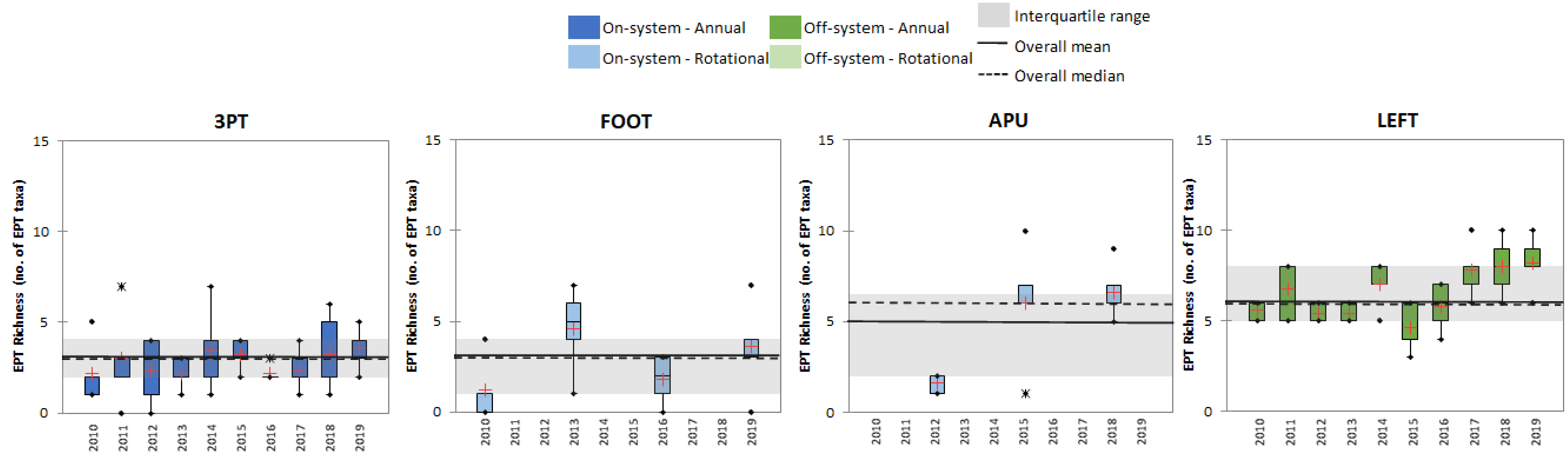


Figure 4.4-3. 2010 to 2019 Nearshore benthic invertebrate EPT richness (family level).

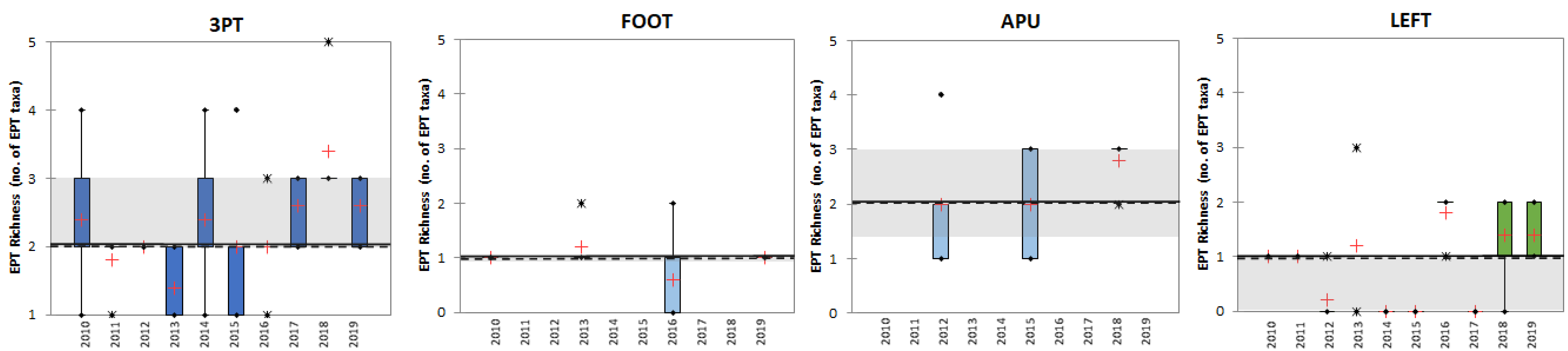


Figure 4.4-4. 2010 to 2019 Offshore benthic invertebrate EPT richness (family level).

4.5 DIVERSITY

4.5.1 HILL'S EFFECTIVE RICHNESS

4.5.1.1 ON-SYSTEM SITES

ANNUAL SITES

Threepoint Lake

Nearshore Habitat

Annual mean Hill's effective richness (Hill's index) over the ten years of monitoring ranged from three (2014) to five (2010, 2013, 2015, 2016, and 2017; Figure 4.5-1). The overall mean and median were four, and the IQR was less than 4 to less than 5. Annual means were within the IQR, except in 2014 (below).

Offshore Habitat

Annual mean Hill's index over the ten years of monitoring ranged from two (2019) to greater than four (2011; Figure 4.5-2). The overall mean and median were three, and the IQR was less than 3 to less than 4. Annual means were below the IQR in 2014, 2015, and 2019, and above the IQR in 2010, 2011, and 2013.

ROTATIONAL SITES

Footprint Lake

Nearshore Habitat

Annual mean Hill's effective richness (Hill's index) over the four years of monitoring ranged from four (2010) to six (2013; Figure 4.5-1). The overall mean and median were five, and the IQR was less than 4 to less than 6. Annual means were within the IQR, except in 2013 (above).

Offshore Habitat

Annual mean Hill's index over the four years of monitoring ranged from three (2013 and 2019) to four (2016; Figure 4.5-2). The overall mean and median were three, and the IQR was between less than 3 and greater than 3. Annual means were above the IQR in 2010 and 2016.

Apussigamasi Lake

Nearshore Habitat

Annual mean Hill's effective richness (Hill's index) over the three years of monitoring ranged from five (2012) to seven (2015 and 2018; Figure 4.5-1). The overall mean was six, the overall median was eight, and the IQR was less than less than 5 to less than 8. Annual means were within the IQR in all years.

Offshore Habitat

Annual mean Hill's index over the three years of monitoring ranged from less than three (2018) to four (2012; Figure 4.5-2). The overall mean and median were three, and the IQR was between less than 3 and greater than 3. Annual means were within the IQR, except in 2012 (above).

4.5.1.2 OFF-SYSTEM SITES

ANNUAL SITES

Leftrook Lake

Nearshore Habitat

Annual mean Hill's effective richness (Hill's index) over the ten years of monitoring ranged from six (2011, 2012, 2014, and 2015) to ten (2019; Figure 4.5-1). The overall mean and median were seven, and the IQR was less than 6 to 8. Annual means were above the IQR in 2017 and 2019.

Offshore Habitat

Annual mean Hill's index over the ten years of monitoring ranged from two (all years except 2015) to slightly more than three (2015; Figure 4.5-2). The overall mean and median were less than three, and the IQR was less than 3 to 3. Annual means were with in the IQR, except in 2011 (slightly below).

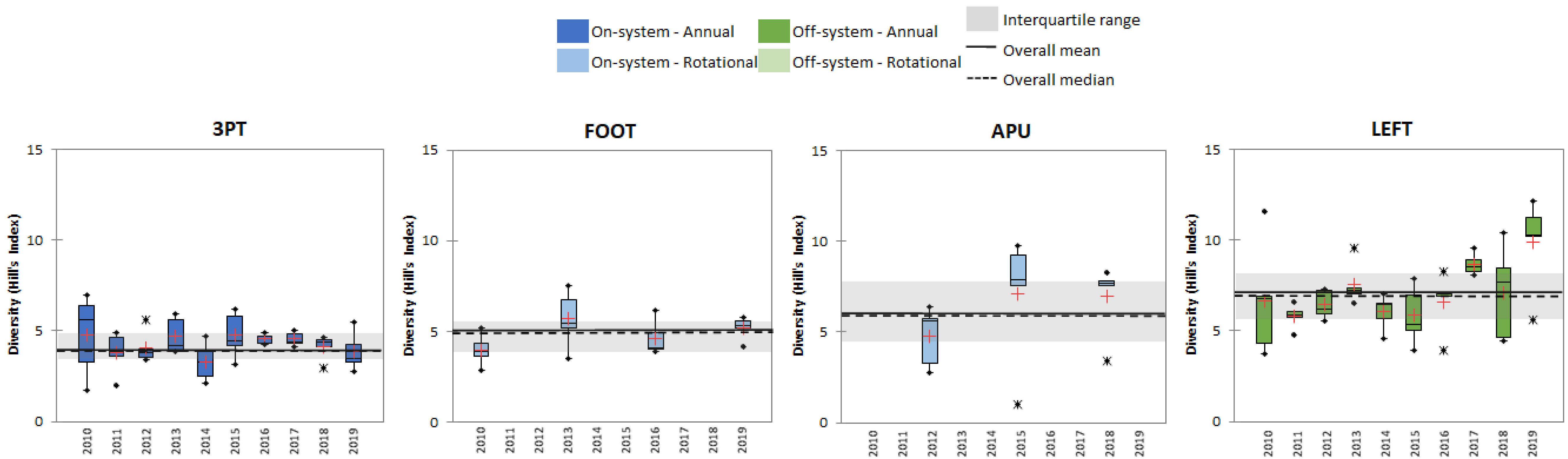


Figure 4.5-1. 2010 to 2019 Nearshore benthic invertebrate diversity (family level).

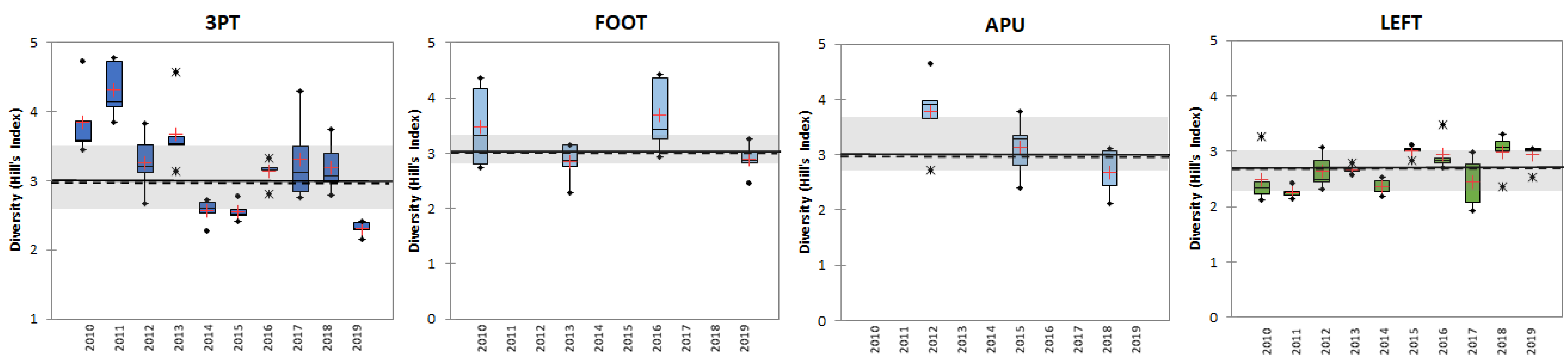


Figure 4.5-2. 2010 to 2019 Offshore benthic invertebrate diversity (family level).

APPENDIX 4-1. BENTHIC INVERTEBRATE NEARSHORE AND OFFSHORE SAMPLING SITES: 2008-2019

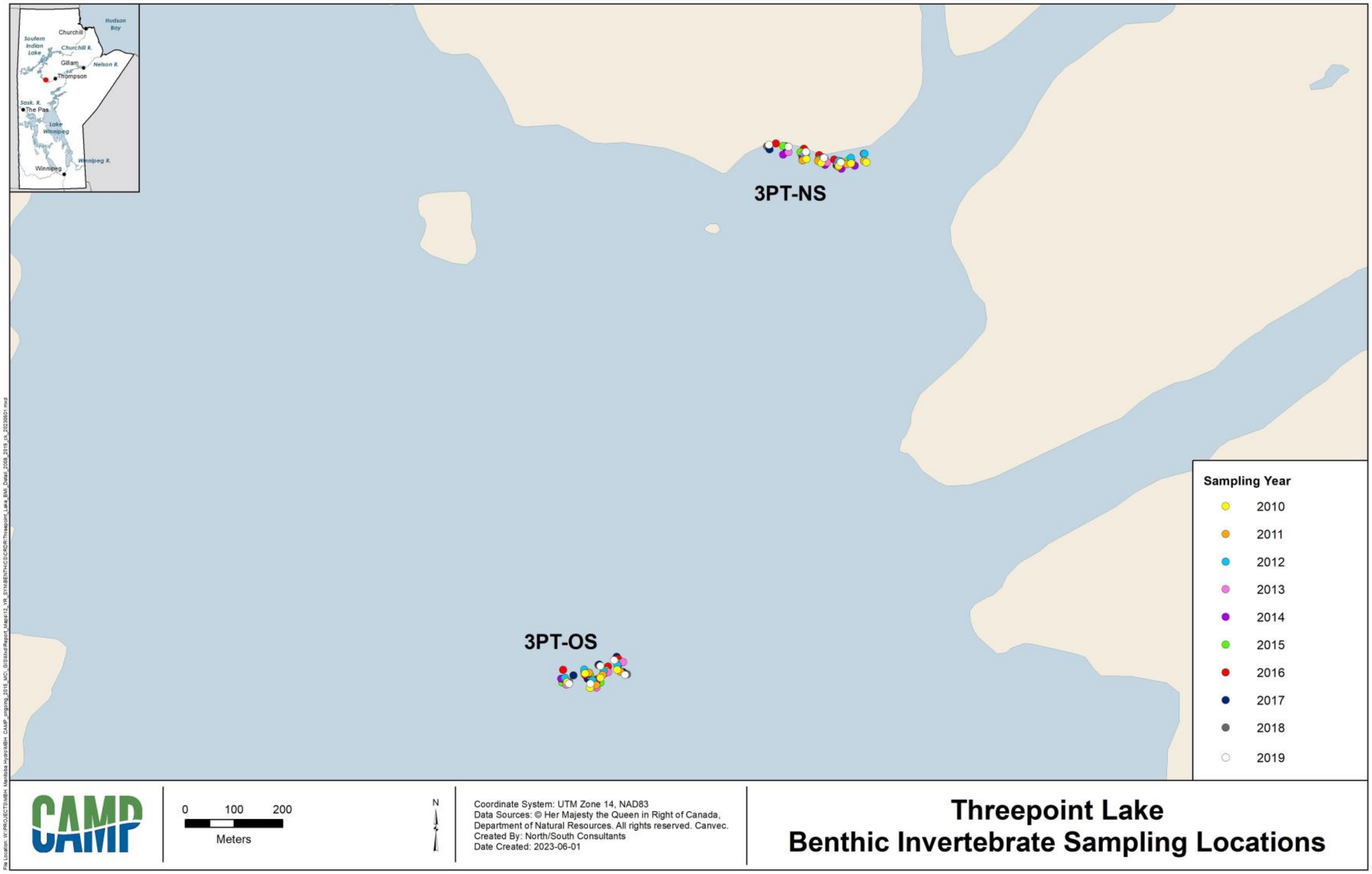


Figure A4-1-1. 2010 to 2019 Threepoint Lake nearshore (NS) and offshore (OS) benthic invertebrate sampling sites.

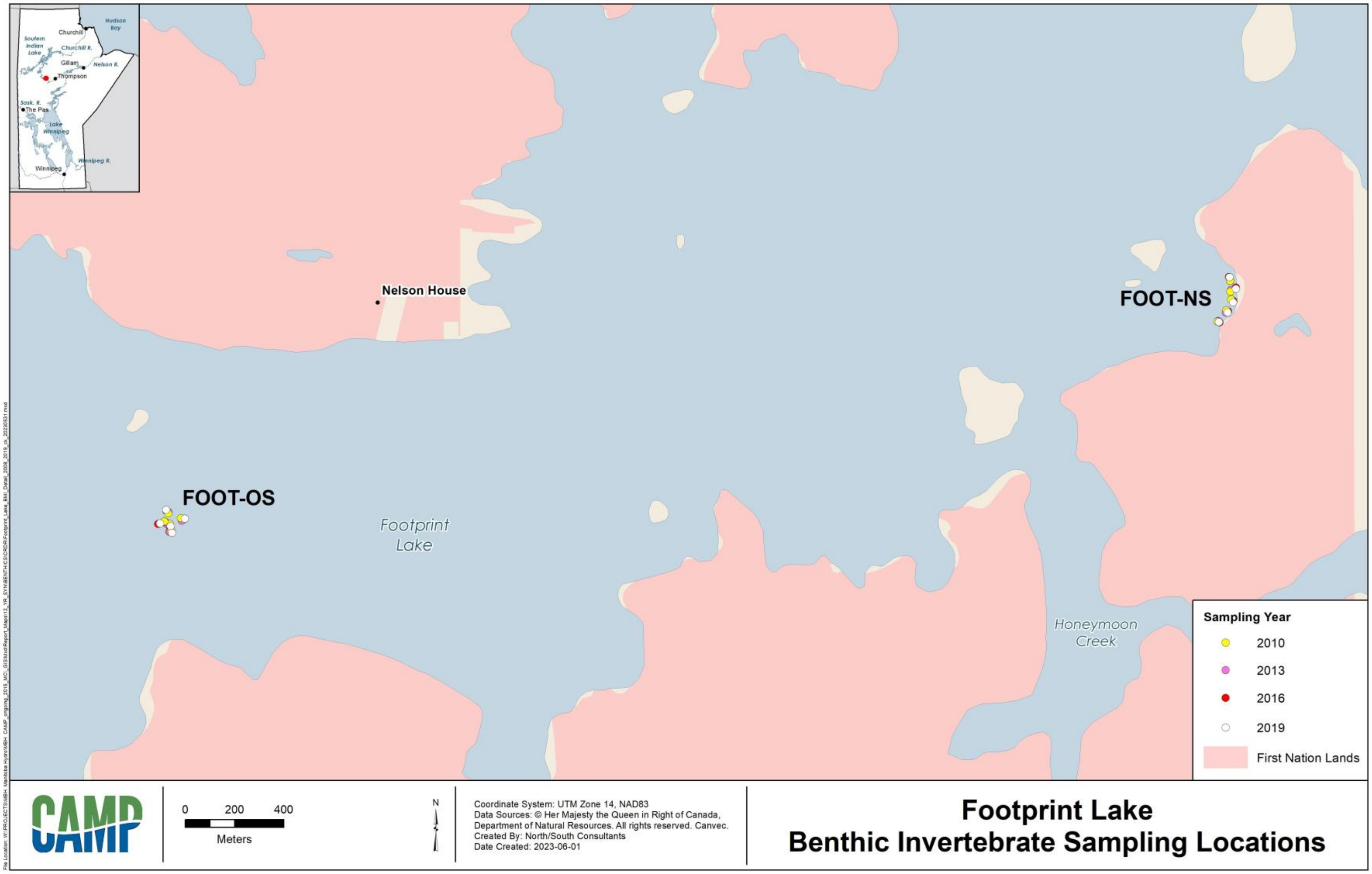


Figure A4-1-2. 2010 to 2019 Footprint Lake nearshore (NS) and offshore (OS) benthic invertebrate sampling sites.

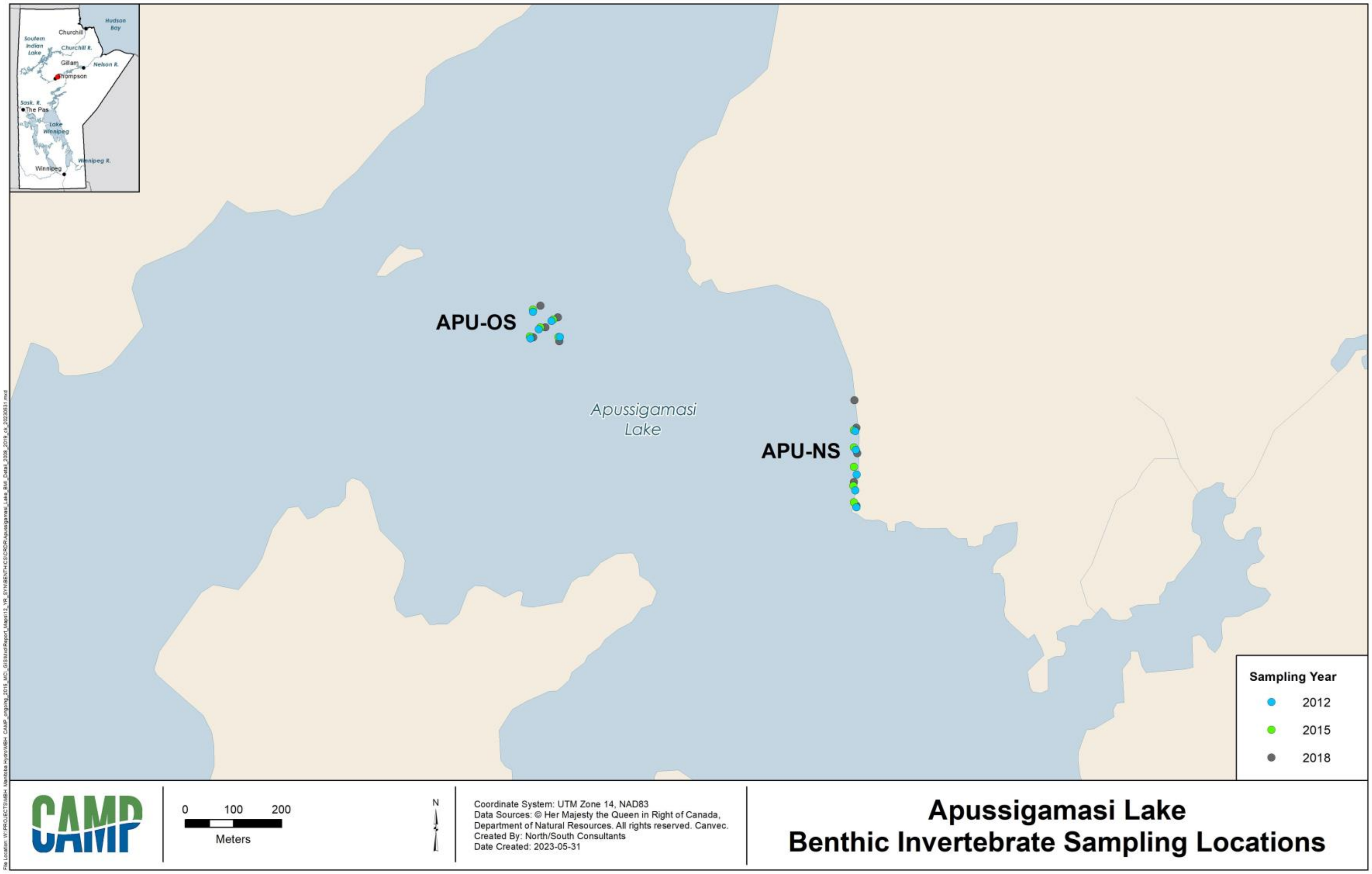


Figure A4-1-3. 2010 to 2019 Apussigamasi Lake nearshore (NS) and offshore (OS) benthic invertebrate sampling sites.

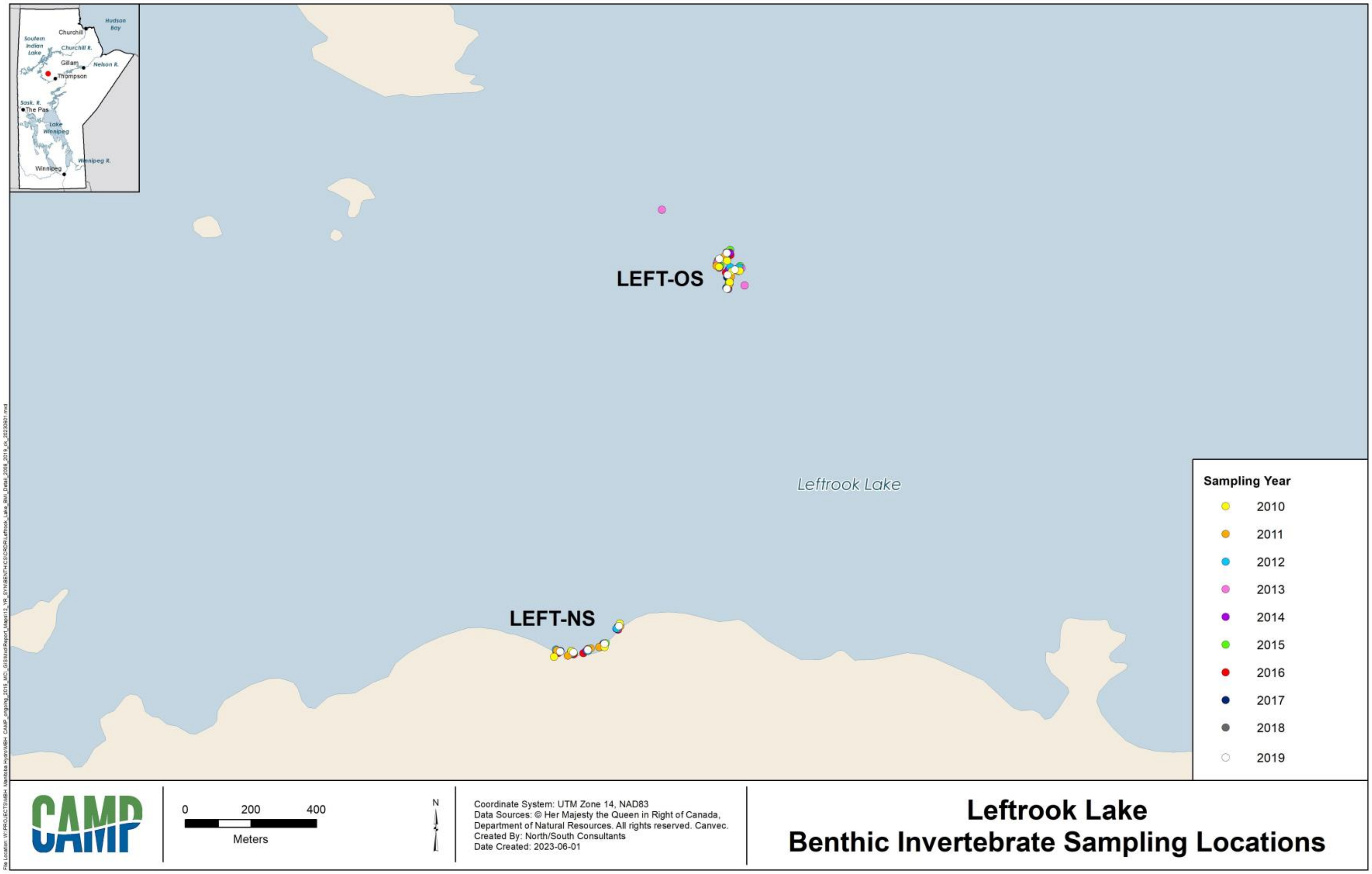


Figure A4-1-4. 2010 to 2019 Leftrook Lake nearshore (NS) and offshore (OS) benthic invertebrate sampling sites.

APPENDIX 4-2. BENTHIC INVERTEBRATE NEARSHORE AND OFFSHORE SUPPORTING SUBSTRATE DATA BY YEAR

Table A4-2-1. 2010 to 2019 Threepoint Lake nearshore supporting benthic substrate data.

Year	Dominant Substrate	Sample Water Depth (m)	Supporting Substrate Analysis				
			Mean Particle Size (%)			Mean TOC (%)	Texture
			Sand	Silt	Clay		
2010	fines and organics	0.4	8.0	45.6	46.5	0.7	Clay
2011	fines	0.7	11.1	18.1	70.8	0.5	Clay
2012	fines	0.6	24.7	39.3	35.9	0.4	Loam
2013	fines	0.9	10.5	22.3	67.1	1.0	Clay
2014	fines and organics	0.4	5.0	31.5	63.6	1.4	Clay
2015	fines, coarse, and organics	0.4	41.5	44.8	13.7	0.3	Loam
2016	fines	0.9	10.6	28.7	60.7	0.8	Clay
2017	fines	0.6	2.8	45.8	51.8	-	Silty clay
2018	fines	0.3	18.0	62.8	19.3	0.5	Silt loam
2019	fines	0.6	9.3	48.2	42.5	0.4	Silty clay loam

Notes:

1. TOC = Total organic carbon.

Table A4-2-2. 2010 to 2019 Threepoint Lake offshore supporting benthic substrate data.

Year	Dominant Substrate	Sample Water Depth (m)	Supporting Substrate Analysis				
			Mean Particle Size (%)			Mean TOC (%)	Texture
			Sand	Silt	Clay		
2010	fines	4.6	9.2	55.9	34.9	1.6	Silty clay loam
2011	fines	4.2	13.1	50.8	36.1	1.5	Silty clay loam
2012	fines	5.9	17.7	52.0	30.3	1.5	Silty clay loam
2013	fines	4.8	12.3	54.2	33.6	1.6	Silty clay loam
2014	fines	3.9	10.7	53.6	35.8	1.7	Silty clay loam
2015	fines	5.3	13.3	54.3	32.3	1.3	Silty clay loam
2016	fines	5.9	16.6	67.8	15.6	1.5	Silt loam
2017	fines	4.5	14.5	60.4	25.0	1.5	Silty clay loam
2018	fines	6.0	17.5	65.4	21.4	1.6	Silt loam
2019	fines and organics	5.9	16.2	55.2	28.6	1.5	Silt loam

Notes:

1. TOC = Total organic carbon.

Table A4-2-3. 2010 to 2019 Footprint Lake nearshore supporting benthic substrate data.

Year	Dominant Substrate	Sample Water Depth (m)	Supporting Substrate Analysis				
			Composition (mean%)			TOC (mean %)	Texture
			Sand	Silt	Clay		
2010	fines, coarse, and organics	0.5	11.1	44.9	43.9	0.9	Silty/Clay
2013	fines	0.4	27.9	19.9	52.2	0.6	Clay loam
2016	coarse and fines	0.7	32.4	46.3	32.0	0.9	Silty clay loam
2019	fines, coarse, and organics	0.4	41.7	41.4	25.1	0.3	Silt loam

Notes:
1. TOC = Total organic carbon.

Table A4-2-4. 2010 to 2019 Footprint Lake offshore supporting benthic substrate data.

Year	Dominant Substrate	Sample Water Depth (m)	Supporting Substrate Analysis				
			Composition (mean%)			TOC (mean %)	Texture
			Sand	Silt	Clay		
2010	fines	6.3	40.1	29.0	30.8	1.2	Clay loam
2013	fines and coarse	6.5	47.1	18.1	34.9	1.1	Clay
2016	fines	7.7	61.4	23.4	15.2	1.2	Sandy loam
2019	fines and coarse	7.7	50.9	17.3	31.8	1.0	Sandy clay loam

Notes:
1. TOC = Total organic carbon.

Table A4-2-5. 2010 to 2019 Apussigamasi Lake nearshore supporting benthic substrate data.

Year	Dominant Substrate	Sample Water Depth (m)	Supporting Substrate Analysis				
			Composition (mean%)			TOC (mean %)	Texture
			Sand	Silt	Clay		
2012	fines	0.7	1.1	14.7	84.2	1.3	Clay
2015	fines	0.9	0.8	53.6	45.6	0.6	Silty clay
2018	fines	0.5	--	53.6	45.8	0.9	Silty clay

Notes:
1. TOC = Total organic carbon.

Table A4-2-6. 2010 to 2019 Apussigamasi Lake offshore supporting benthic substrate data.

Year	Dominant Substrate	Sample Water Depth (m)	Supporting Substrate Analysis				
			Composition (mean%)			TOC (mean %)	Texture
			Sand	Silt	Clay		
2012	fines	7.3	9.4	73.0	17.5	0.8	Silt loam
2015	fines	6.8	5.7	85.0	9.4	0.7	Silt
2018	fines	7.3	8.7	78.4	14.6	1.2	Silt loam

Notes:
1. TOC = Total organic carbon.

Table A4-2-7. 2010 to 2019 Leftrook Lake nearshore supporting benthic substrate data.

Year	Dominant Substrate	Sample Water Depth (m)	Supporting Substrate Analysis				
			Composition (mean%)			TOC (mean %)	Texture
			Sand	Silt	Clay		
2010	hard and coarse	no sample	--	--	--	--	--
2011	hard and coarse	no sample	--	--	--	--	--
2012	hard and coarse	no sample	--	--	--	--	--
2013	hard	no sample	--	--	--	--	--
2014	hard and coarse	no sample	--	--	--	--	--
2015	hard, coarse and organics	no sample	--	--	--	--	--
2016	hard	0.6[2]	98.9	--	--	0.5	Sand
2017	coarse	no sample	--	--	--	--	--
2018	coarse and hard	no sample	--	--	--	--	--
2019	hard and coarse	no sample	--	--	--	--	--

Notes:

1. TOC = Total organic carbon.
2. Surface/interstitial sediment was submitted for analysis.

Table A4-2-8. 2010 to 2019 Leftrook Lake offshore supporting benthic substrate data.

Year	Dominant Substrate	Sample Water Depth (m)	Supporting Substrate Analysis				
			Composition (mean%)			TOC (mean %)	Texture
			Sand	Silt	Clay		
2010	fines	7.9	0.2	26.2	73.7	5.1	Clay
2011	fines	8.7	0.2	26.2	73.6	4.6	Clay
2012	fines	8.2	2.1	47.8	50.1	4.9	Clay
2013	fines	8.3	0.9	49.2	50.0	5.5	Silty clay
2014	fines	8.3	0.1	40.0	59.8	5.1	Silty clay
2015	fines	8.2	0.1	42.7	57.2	4.7	Silty clay
2016	fines	8.4	--	65.7	34.0	4.8	Silty clay loam
2017	fines	8.1	3.6	63.6	34.7	4.7	Silty clay
2018	fines	8.3	--	36.0	63.8	4.9	Silty clay
2019	fines	8.1	1.8	47.0	52.4	4.8	Silty clay

Notes:

1. TOC = Total organic carbon.

5.0 FISH COMMUNITY

5.1 INTRODUCTION

The following presents the results of fish community monitoring conducted from 2008 to 2019 in the Churchill River Diversion Region. Four waterbodies were monitored in the Churchill River Diversion Region starting in 2009: one on-system annual site (Threepoint Lake); two on-system rotational sites (Footprint and Apussigamasi Lake) and one off-system annual site (Leftrook Lake; Table 5.1-1 and Figure 5.1-1). There were no departures from the planned field sampling during the 11-year period.

Monitoring targeted both small-bodied fish species (i.e., forage fish) and large-bodied fish species (e.g., fish targeted in subsistence, commercial, and/or recreational fisheries). Within a given waterbody, sampling was conducted at approximately the same time of year during each year of monitoring. Standard gang index gill nets (GN; 51, 76, 95, 108, and 127 mm stretched mesh panels) were set at each site and a small mesh index gillnet gang (SN; 16, 20, and 25 mm bar measure panels) was attached to the end of the standard gang at approximately every third site (Appendix 5-1). Gill nets were set for approximately 24 hours (h). All fish captured at each site were counted by mesh size and species. Individual metrics (e.g., length, weight, deformities, erosion, lesions, and tumours [DELTs], sex and maturity, and age) were collected for species of management interest (i.e., "target" species). These include: Lake Whitefish (*Coregonus clupeaformis*), Walleye (*Sander vitreus*) and Northern Pike (*Esox lucius*) from all waterbodies in all years; Sauger (*Sander canadensis*) from all waterbodies starting in 2017, except Leftrook Lake where the species has not been caught; and White Sucker (*Catostomus commersonii*) from all waterbodies starting in 2010. All other species were bulk weighed.

Five fish community indicators (abundance, condition, growth, recruitment, and community diversity) were selected for detailed reporting (Table 5.1-2). Metrics for these indicators that are presented herein include: catch-per-unit-effort (CPUE); Fulton's condition factor (KF); relative weight (Wr); fork length-at-age (FLA); relative year-class strength (RYCS); Hill's effective species richness (Hill's index); and relative species abundance (RSA; Table 5.1-2).

A detailed description of the program design and sampling methods is provided in Technical Document 1, Section 2.5.

Table 5.1-1. 2008-2019 Inventory of fish community sampling.

Waterbody/Area	Sampling Year											
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
3PT		●	●	●	●	●	●	●	●	●	●	●
FOOT			●			●			●			●
APU		●			●			●			●	
LEFT		●	●	●	●	●	●	●	●	●	●	●

Table 5.1-2. Fish community indicators and metrics.

Indicator	Metric	Units
Abundance	• Catch-Per-Unit-Effort (CPUE)	# fish/30 m/24 hour (h) # fish/100 m/24 h
Condition	• Fulton's Condition Factor (KF)	-
	• Relative Weight (Wr)	-
Growth	• Fork Length-At-Age (FLA)	mm
Recruitment	• Relative Year-Class Strength (RYCS)	-
Diversity	• Hill's Effective Species Richness	species
	• Relative Species Abundance (RSA)[1]	%

Notes:

1. Supporting metric.

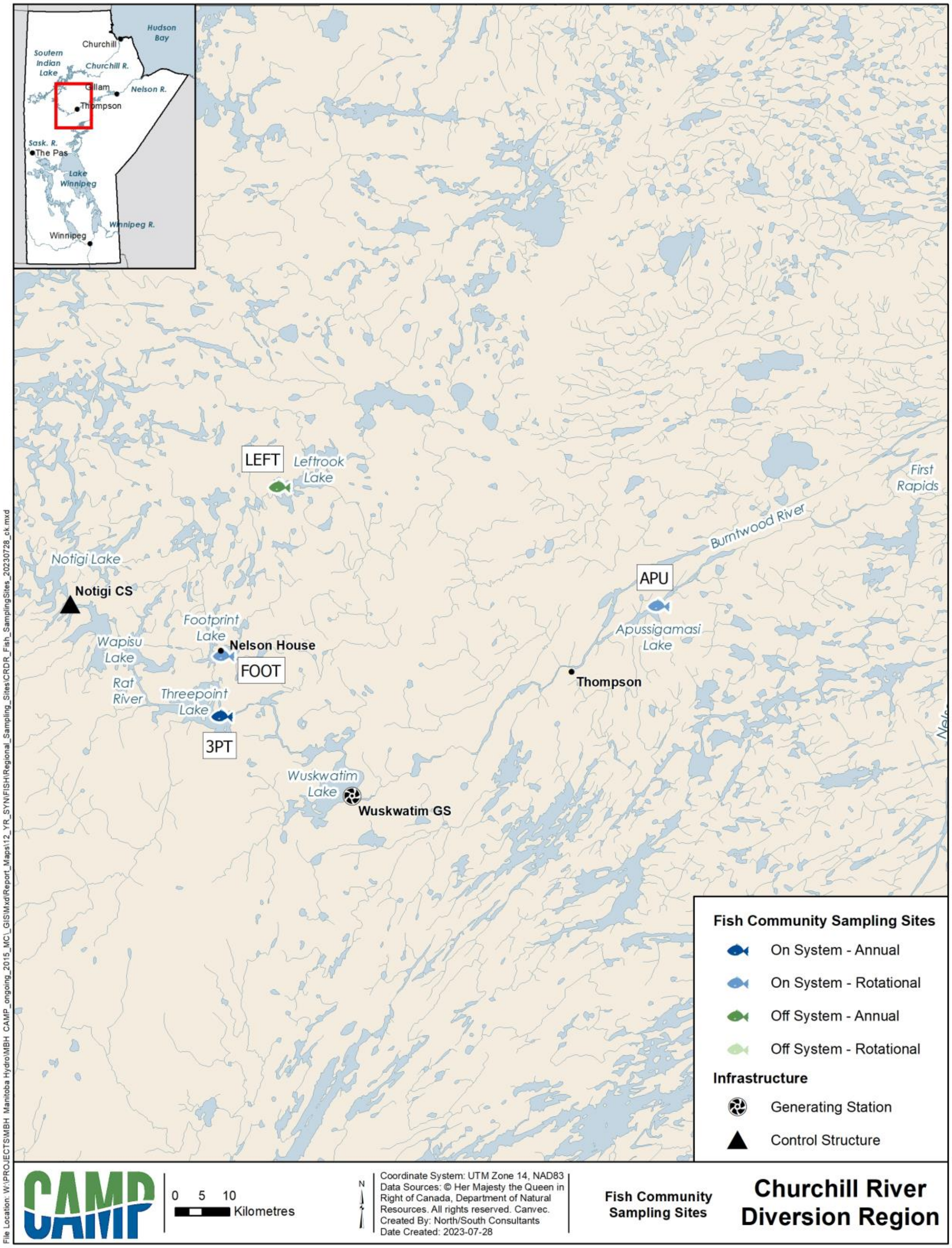


Figure 5.1-1. 2008-2019 Fish community sampling sites.

5.2 ABUNDANCE

5.2.1 CPUE

5.2.1.1 ON-SYSTEM SITES

ANNUAL SITES

Threepoint Lake

Standard Gang Index Gill Nets

The annual mean CPUE varied over the 11 years of monitoring from a low of 19.2 in 2010 to a maximum of 42.6 fish/100 m/24 h in 2016 (Table 5.2-1; Figure 5.2-1).

The overall mean CPUE was 31.9, the median was 30.5, and the IQR was 28.4-35.4 fish/100 m/24 h (Figure 5.2-1). The annual mean CPUE fell within the overall IQR except in 2010, 2011 and 2012 when it was below the IQR and in 2014, 2016 and 2018 when it was above the IQR.

Small Mesh Index Gill Nets

The annual mean CPUE in the small mesh gangs over the 11 years of monitoring was more variable than in the standard gangs, with the mean ranging from a low of 25.9 in 2012 to a high of 448.6 fish/30 m/24 h in 2017 (Table 5.2-1; Figure 5.2-2).

The overall mean CPUE was 128.5, the median was 83.9, and the IQR was 50.0-154.8 fish/30 m/24 h (Figure 5.2-2). The annual mean CPUE fell within the overall IQR except in 2009, 2010, and 2012 when it was below the IQR and in 2015, 2017, and 2018 when it was above the IQR.

Lake Whitefish

Catches of Lake Whitefish were relatively low in Threepoint Lake over the 11 years of monitoring, with the annual mean CPUE ranging from a low of 0.1 in 2010 to a high of 1.5 fish/100 m/24 h in 2013 and 2017 (Table 5.2-1; Figure 5.2-3).

The overall mean CPUE was 1.0, the median was 1.1, and the IQR was 0.6-1.3 fish/100 m/24 h (Figure 5.2-3). The annual mean CPUE fell within the overall IQR except in 2009, 2010, and 2016 when it was below the IQR and in 2017 when it was above the IQR.

Northern Pike

Catches of Northern Pike were relatively consistent in Threepoint Lake over the 11 years of monitoring, with the annual mean CPUE ranging from a low of 1.4 in 2016 to a high of 4.6 fish/100 m/24 h in 2009 (Table 5.2-1; Figure 5.2-4).

The overall mean CPUE was 2.5, the median was 2.3, and the IQR was 1.9-3.0 fish/100 m/24 h (Figure 5.2-4). The annual mean CPUE fell within the overall IQR except in 2016, 2018, and 2019 when it was below the IQR and in 2009, 2014, and 2015 when it was above the IQR.

Sauger

The annual mean CPUE over the 11 years of monitoring varied up to about 12-fold from year-to-year, ranging from a low of 2.5 in 2010 to a high of 14.1 fish/100 m/24 h in 2016 (Table 5.2-1; Figure 5.2-5).

The overall mean CPUE was 6.0, the median was 5.2, and the IQR was 4.2-6.6 fish/100 m/24 h (Figure 5.2-5). The annual mean CPUE fell within the overall IQR except in 2010, 2012, and 2013 when it was below the IQR and in 2014, 2016, and 2017 when it was above the IQR.

Walleye

The annual mean CPUE over the 11 years of monitoring varied by up to about two-fold from year-to-year, ranging from a low of 5.7 in 2010 to a high of 12.5 fish/100 m/24 h in 2013 (Table 5.2-1; Figure 5.2-6).

The overall mean and median CPUE were 9.7, and the IQR was 9.0-11.0 fish/100 m/24 h (Figure 5.2-6). The annual mean CPUE fell within the overall IQR except in 2010, 2015, and 2018 when it was below the IQR and 2014, 2016, and 2017 when it was above the IQR.

White Sucker

The annual mean CPUE over the 11 years of monitoring varied up to about two-fold from year-to-year, with the mean ranging from a low of 7.1 in 2010 to a high of 12.6 fish/100 m/24 h in 2014 (Table 5.2-1; Figure 5.2-7).

The overall mean CPUE was 9.9, the median was 10.6, and the IQR was 8.2-11.3 fish/100 m/24 h (Figure 5.2-7). The annual mean CPUE fell within the overall IQR except in 2010, 2011, and 2015 when it was below the IQR and in 2014, 2016, and 2018 when it was above the IQR.

ROTATIONAL SITES

Footprint Lake

Standard Gang Index Gill Nets

The annual mean CPUE varied over the four years of monitoring from a low of 42.1 in 2010 to a maximum of 58.8 fish/100 m/24 h in 2019 (Table 5.2-1; Figure 5.2-1).

The overall mean CPUE was 53.9, the median was 57.3, and the IQR was 56.7-58.2 fish/100 m/24 h (Figure 5.2-1). The annual mean CPUE fell within the overall IQR except in 2010 when it was below the IQR and in 2019 when it was above the IQR.

Small Mesh Index Gill Nets

The annual mean CPUE in the small mesh gangs over the four years of monitoring was more variable than in the standard gangs, with the mean ranging from a low of 24.7 in 2010 to a high of 182.1 fish/30 m/24 h in 2016 (Table 5.2-1; Figure 5.2-2).

The overall mean CPUE was 99.8, the median was 96.1, and the IQR was 51.3-157.6 fish/30 m/24 h (Figure 5.2-2). The annual mean CPUE fell within the overall IQR in 2019, below the IQR in 2010 and 2013, and above the IQR in 2016.

Lake Whitefish

Catches of Lake Whitefish were relatively low in Footprint Lake over the four years of monitoring, with the annual mean CPUE ranging from a low of 0.1 in 2013 and 206 to a high of 0.3 fish/100 m/24 h in 2019 (Table 5.2-1; Figure 5.2-3).

The overall mean and median CPUE were 0.2, and the IQR was 0.1-0.2 fish/100 m/24 h (Figure 5.2-3). The annual mean CPUE fell within the overall IQR except in 2013 and 2016 when it was below the IQR and in 2019 when it was above the IQR.

Northern Pike

Catches of Northern Pike were relatively low in Footprint Lake over the four years of monitoring, with the annual mean CPUE ranging from a low of 0.4 in 2016 to a high of 5.8 fish/100 m/24 h in 2013 (Table 5.2-1; Figure 5.2-4).

The overall mean and median CPUE were 3.1, and the IQR was 2.3-4.4 fish/100 m/24 h (Figure 5.2-4). The annual mean CPUE fell within the overall IQR in 2010, below the IQR in 2016 and 2019, and above the IQR in 2013.

Sauger

The annual mean CPUE over the four years of monitoring varied up to about four-fold from year-to-year, ranging from a low of 1.9 in 2010 to a high of 7.1 fish/100 m/24 h in 2016 (Table 5.2-1; Figure 5.2-5).

The overall mean CPUE was 4.8, the median was 5.1, and the IQR was 4.2-5.7 fish/100 m/24 h (Figure 5.2-5). The annual mean CPUE fell within the overall IQR except in 2010 when it was below the IQR and in 2016 when it was above the IQR.

Walleye

The annual mean CPUE over the four years of monitoring varied by up to about two-fold from year-to-year, ranging from a low of 14.9 in 2010 to a high of 31.1 fish/100 m/24 h in 2016 (Table 5.2-1; Figure 5.2-6).

The overall mean CPUE was 23.3, the median was 23.7, and the IQR was 23.4-25.8 fish/100 m/24 h (Figure 5.2-6). The annual mean CPUE fell within the overall IQR except in 2010 when it was below the IQR and in 2016 when it was above the IQR.

White Sucker

The annual mean CPUE over the four years of monitoring varied up to about three-fold from year-to-year, with the mean ranging from a low of 6.6 in 2013 to a high of 14.6 fish/100 m/24 h in 2010 (Table 5.2-1; Figure 5.2-7).

The overall mean CPUE was 10.2, the median was 9.9, and the IQR was 7.9-12.8 fish/100 m/24 h (Figure 5.2-7). The annual mean CPUE fell within the overall IQR except in 2013 and 2016 when it was below the IQR and in 2010 when it was above the IQR.

Apussigamasi Lake

Standard Gang Index Gill Nets

The annual mean CPUE varied over the four years of monitoring from a low of 36.1 in 2012 to a maximum of 44.4 fish/100 m/24 h in 2009 (Table 5.2-1; Figure 5.2-1).

The overall mean CPUE was 41.2, the median was 42.2, and the IQR was 40.4-43.0 fish/100 m/24 h (Figure 5.2-1). The annual mean CPUE fell within the overall IQR except in 2012 when it was below the IQR and in 2009 when it was above the IQR.

Small Mesh Index Gill Nets

The annual mean CPUE in the small mesh gangs over the four years of monitoring was more variable than in the standard gangs, with the mean ranging from a low of 42.6 in 2009 to a high of 65.5 fish/30 m/24 h in 2018 (Table 5.2-1; Figure 5.2-2).

The overall mean CPUE was 58.6, the median was 63.2, and the IQR was 58.0-63.8 fish/30 m/24 h (Figure 5.2-2). The annual mean CPUE fell within the overall IQR except in 2009 when it was below the IQR and in 2018 when it was above the IQR.

Lake Whitefish

Catches of Lake Whitefish were relatively low in Apussigamasi Lake over the four years of monitoring, with the annual mean CPUE ranging from a low of 2.3 in 2012 to a high of 4.0 fish/100 m/24 h in 2009 (Table 5.2-1; Figure 5.2-3).

The overall mean and median CPUE were 3.1, and the IQR was 2.6-3.7 fish/100 m/24 h (Figure 5.2-3). The annual mean CPUE fell within the overall IQR except in 2012 when it was below the IQR and in 2009 when it was above the IQR.

Northern Pike

Catches of Northern Pike were relatively low in the Apussigamasi Lake over the four years of monitoring, with the annual mean CPUE ranging from a low of 0.5 in 2012 to a high of 2.1 fish/100 m/24 h in 2009 (Table 5.2-1; Figure 5.2-4).

The overall mean CPUE was 1.3, the median was 1.2, and the IQR was 0.7-1.8 fish/100 m/24 h (Figure 5.2-4). The annual mean CPUE fell within the overall IQR except in 2012 when it was below the IQR and in 2009 when it was above the IQR.

Sauger

The annual mean CPUE over the four years of monitoring varied little from year-to-year, ranging from a low of 7.6 in 2009 to a high of 9.0 fish/100 m/24 h in 2015 (Table 5.2-1; Figure 5.2-5).

The overall mean and median CPUE were 8.2, and the IQR was 7.8-8.7 fish/100 m/24 h (Figure 5.2-5). The annual mean CPUE fell within the overall IQR in 2012, below the IQR in 2009 and 2018, and above the IQR in 2015.

Walleye

The annual mean CPUE over the four years of monitoring varied almost two-fold from year-to-year, ranging from a low of 8.5 in 2018 to a high of 15.6 fish/100 m/24 h in 2009 (Table 5.2-1; Figure 5.2-6).

The overall mean CPUE was 11.8, the median was 11.5, and the IQR was 10.1-13.1 fish/100 m/24 h (Figure 5.2-6). The annual mean CPUE fell within the overall IQR except in 2018 when it was below the IQR and 2009 when it was above the IQR.

White Sucker

The annual mean CPUE over the four years of monitoring varied up to about three-fold from year-to-year, with the mean ranging from a low of 7.4 in 2009 to a high of 11.9 fish/100 m/24 h in 2018 (Table 5.2-1; Figure 5.2-7).

The overall mean CPUE was 9.2, the median was 8.8, and the IQR was 7.9-10.2 fish/100 m/24 h (Figure 5.2-7). The annual mean CPUE fell within the overall IQR except in 2009 when it was below the IQR and in 2018 when it was above the IQR.

5.2.1.2 OFF-SYSTEM SITES

ANNUAL SITES

Leftrook Lake

Standard Gang Index Gill Nets

The annual mean CPUE over the 11 years of monitoring varied by almost two-fold, with the mean ranging from a low of 66.9 in 2010 to a high of 114.1 fish/100 m/24 h in 2012 (Table 5.2-1; Figure 5.2-1).

The overall mean CPUE was 91.9, the median was 94.4, and the IQR was 93.0-97.8 fish/100 m/24 h (Figure 5.2-1). The annual mean CPUE fell within the overall IQR except in in 2010, 2011, 2013, 2016, and 2019 when it was below the IQR and in 2012, 2014, and 2018 when it was above the IQR.

Small Mesh Index Gill Nets

The annual mean CPUE in the small mesh gangs over the 11 years of monitoring was more variable than in the standard gangs, with the mean ranging from a low of 93.2 in 2011 to a high of 1046.9 fish/30 m/24 h in 2014 (Table 5.2-1; Figure 5.2-2).

The overall mean CPUE was 297.4, the median was 169.9, and the IQR was 162.6-404.5 fish/30 m/24 h (Figure 5.2-2). The annual mean CPUE fell within the overall IQR except in 2009, 2011, 2013, 2018, and 2019 when it was below the IQR and in 2012, 2014, and 2017 when it was above the IQR.

Lake Whitefish

Catches of Lake Whitefish were relatively high in Leftrook Lake over the 11 years of monitoring, with the annual mean CPUE ranging from a low of 7.1 in 2011 to a high of 17.8 fish/100 m/24 h in 2012 (Table 5.2-1; Figure 5.2-3).

The overall mean CPUE was 11.0, the median was 10.0 and the IQR was 9.6-13.0 fish/100 m/24 h (Figure 5.2-3). The annual mean CPUE fell within the overall IQR except in 2010, 2011, 2016, 2018, and 2019 when it was below the IQR and in 2012-2014 when it was above the IQR.

Northern Pike

Catches of Northern Pike were relatively high in Leftrook Lake over the 11 years of monitoring, with the annual mean CPUE ranging from a low of 7.0 in 2016 to a high of 16.6 fish/100 m/24 h in 2014 (Table 5.2-1; Figure 5.2-4).

The overall mean CPUE was 10.9, median was 10.4 and the IQR was 10.4-12.4 fish/100 m/24 h (Figure 5.2-4). The annual mean CPUE fell within the overall IQR except in 2009, 2010, 2013, 2016, and 2017 when it was below the IQR and in 2011, 2012, and 2014 when it was above the IQR.

Sauger

Sauger were not captured in Leftrook Lake over the 11 years of monitoring (Table 5.2-1).

Walleye

The annual mean CPUE over the 11 years of monitoring varied by up to about three-fold, with the mean ranging from a low of 13.7 in 2010 to a high of 41.9 fish/100 m/24 h in 2017 (Table 5.2-1; Figure 5.2-6).

The overall mean CPUE was 29.7, the median was 29.5, and the IQR was 29.4-34.2 fish/100 m/24 h (Figure 5.2-6). The annual mean CPUE fell within the overall IQR except in in 2009-2011, 2013, and 2019 when it was below the IQR and in 2012, 2017, and 2018 when it was above the IQR.

White Sucker

The annual mean CPUE over the 11 years of monitoring varied by almost two-fold, with the mean ranging from a low of 19.5 in 2017 to a high of 35.0 fish/100 m/24 h in 2011 (Table 5.2-1; Figure 5.2-7).

The overall mean CPUE was 28.1, the median was 28.0, and the IQR was 28.0-31.1 fish/100 m/24 h (Figure 5.2-7). The annual mean CPUE fell within the overall IQR except in 2010, 2012, 2014, 2017, and 2019 when it was below the IQR and 2009, 2011, and 2013 when it was above the IQR.

Table 5.2-1. 2009-2019 Catch-per-unit-effort.

Waterbody	Year	Small Mesh Catch[1]				Total Catch[2]				LKWH			NRPK			SAUG			WALL			WHSC		
		n_S[3]	n_F[4]	Mean	SE[5]	n_S	n_F	Mean	SE	n_F	Mean	SE	n_F	Mean	SE	n_F	Mean	SE	n_F	Mean	SE	n_F	Mean	SE
3PT	2009	2	77	39.3	33.3	9	366	35.2	15.7	7	0.6	0.5	50	4.6	3.4	56	5.6	4.0	103	9.3	8.8	106	10.7	4.3
	2010	3	120	43.4	16.0	9	263	19.2	7.1	2	0.1	0.3	32	2.4	1.9	31	2.5	1.9	91	5.7	4.0	87	7.1	3.6
	2011	1	210	116.0	-	9	327	28.1	8.0	15	1.1	1.4	24	1.9	1.7	47	4.2	3.1	111	10.2	5.6	96	8.1	2.3
	2012	3	50	25.9	5.6	9	233	25.9	13.1	7	0.8	1.1	17	1.9	1.4	37	4.1	4.2	85	9.7	8.8	76	8.3	3.9
	2013	3	239	83.8	9.4	9	327	33.5	13.3	15	1.5	1.5	22	2.3	2.2	40	4.1	4.5	122	12.5	10.9	104	10.6	5.0
	2014	3	403	151.6	77.4	9	395	42.0	14.0	10	1.1	1.3	39	4.1	2.2	84	9.2	5.7	120	12.3	8.2	117	12.6	9.8
	2015	3	593	210.7	160.2	9	291	30.5	15.8	13	1.4	1.6	32	3.4	3.8	63	6.6	4.5	85	8.9	7.7	70	7.3	5.6
	2016	3	159	56.6	21.1	9	409	42.6	13.4	5	0.5	0.5	14	1.4	1.4	134	14.1	10.8	113	11.6	6.5	114	11.9	6.6
	2017	3	1239	448.6	324.9	9	351	35.6	13.7	15	1.5	2.1	25	2.5	1.5	65	6.7	6.2	102	10.3	5.0	104	10.6	5.5
	2018	3	460	157.9	12.2	9	278	28.8	12.2	6	0.6	0.7	18	1.9	1.4	50	5.2	3.5	73	7.5	5.6	120	12.5	6.7
	2019	3	220	79.6	105.2	9	286	29.3	13.0	12	1.2	0.9	15	1.5	1.6	42	4.3	2.0	88	9.1	8.8	96	9.8	4.2
FOOT	2010	3	72	24.7	12.6	9	480	42.1	17.6	2	0.2	0.4	42	3.9	3.1	20	1.9	2.0	182	14.9	8.5	155	14.6	8.6
	2013	3	127	42.7	20.0	9	565	56.6	27.5	1	0.1	0.3	57	5.8	6.2	51	4.9	9.1	237	24.0	21.0	66	6.6	5.0
	2016	3	526	182.1	29.7	9	563	58.0	26.2	1	0.1	0.3	4	0.4	0.8	69	7.1	5.0	301	31.1	23.6	73	7.5	4.8
	2019	3	434	149.5	49.5	9	578	58.8	20.2	3	0.3	0.5	22	2.2	1.9	51	5.2	5.4	230	23.3	13.7	122	12.2	9.2
APU	2009	3	136	42.6	5.9	9	465	44.4	19.6	41	4.0	5.0	22	2.1	1.3	80	7.6	3.8	165	15.6	13.3	77	7.4	4.4
	2012	3	168	63.3	47.5	9	341	36.1	14.7	22	2.3	1.6	5	0.5	1.0	80	8.6	2.9	99	10.7	8.5	77	8.1	3.5
	2015	3	191	63.1	25.5	9	448	42.5	11.3	38	3.6	3.0	17	1.6	1.4	95	9.0	7.5	129	12.3	5.8	101	9.6	5.3
	2018	3	206	65.5	13.6	9	446	41.8	23.5	31	2.7	3.9	8	0.8	1.0	82	7.7	5.4	95	8.5	8.7	123	11.9	6.6
LEFT	2009	3	329	114.3	23.8	9	983	94.4	27.1	118	11.4	9.6	108	10.3	4.0	0	-	-	299	29.1	16.5	356	33.7	18.0
	2010	3	406	169.9	132.3	9	544	66.9	33.4	88	8.8	15.0	71	7.6	4.5	0	-	-	108	13.7	7.6	191	24.8	19.3
	2011	3	250	93.2	83.9	9	739	86.5	49.3	59	7.1	8.3	112	12.9	9.0	0	-	-	220	25.3	16.6	295	35.0	28.8
	2012	3	816	424.8	504.1	9	824	114.1	46.7	124	17.8	11.3	116	14.9	5.8	0	-	-	273	38.3	20.9	192	26.9	20.3
	2013	3	403	145.5	138.4	9	823	89.8	44.2	141	15.3	7.0	87	9.4	6.1	0	-	-	219	23.9	16.4	292	32.0	22.0
	2014	3	2530	1046.9	1448.7	9	882	99.6	40.4	128	14.5	6.7	150	16.6	6.7	0	-	-	256	29.5	21.1	204	23.2	17.9
	2015	3	560	217.4	181.0	9	852	96.0	36.6	89	10.0	5.6	102	11.9	5.0	0	-	-	283	32.1	12.9	252	28.0	14.1
	2016	3	1052	384.3	203.7	9	809	87.6	22.9	69	7.8	7.1	66	7.0	5.1	0	-	-	307	33.4	15.8	265	28.2	13.6
	2017	3	1160	440.6	173.0	9	855	94.6	40.2	102	10.9	9.4	72	7.8	4.3	0	-	-	379	41.9	27.8	173	19.5	14.8
	2018	3	393	134.1	36.9	9	1027	102.4	35.7	85	8.6	10.1	104	10.4	5.1	0	-	-	354	35.1	20.1	301	30.2	16.2
	2019	3	289	100.8	38.9	9	803	79.5	38.3	92	8.8	11.3	109	10.9	5.1	0	-	-	251	24.9	15.1	279	27.9	15.9

Notes:

1. fish/30 m/24 h.
2. fish/100 m/24 h.
3. n_S = number of sites fished (excludes sets >36 h).
4. n_F = number of fish caught.
5. SE = standard error.

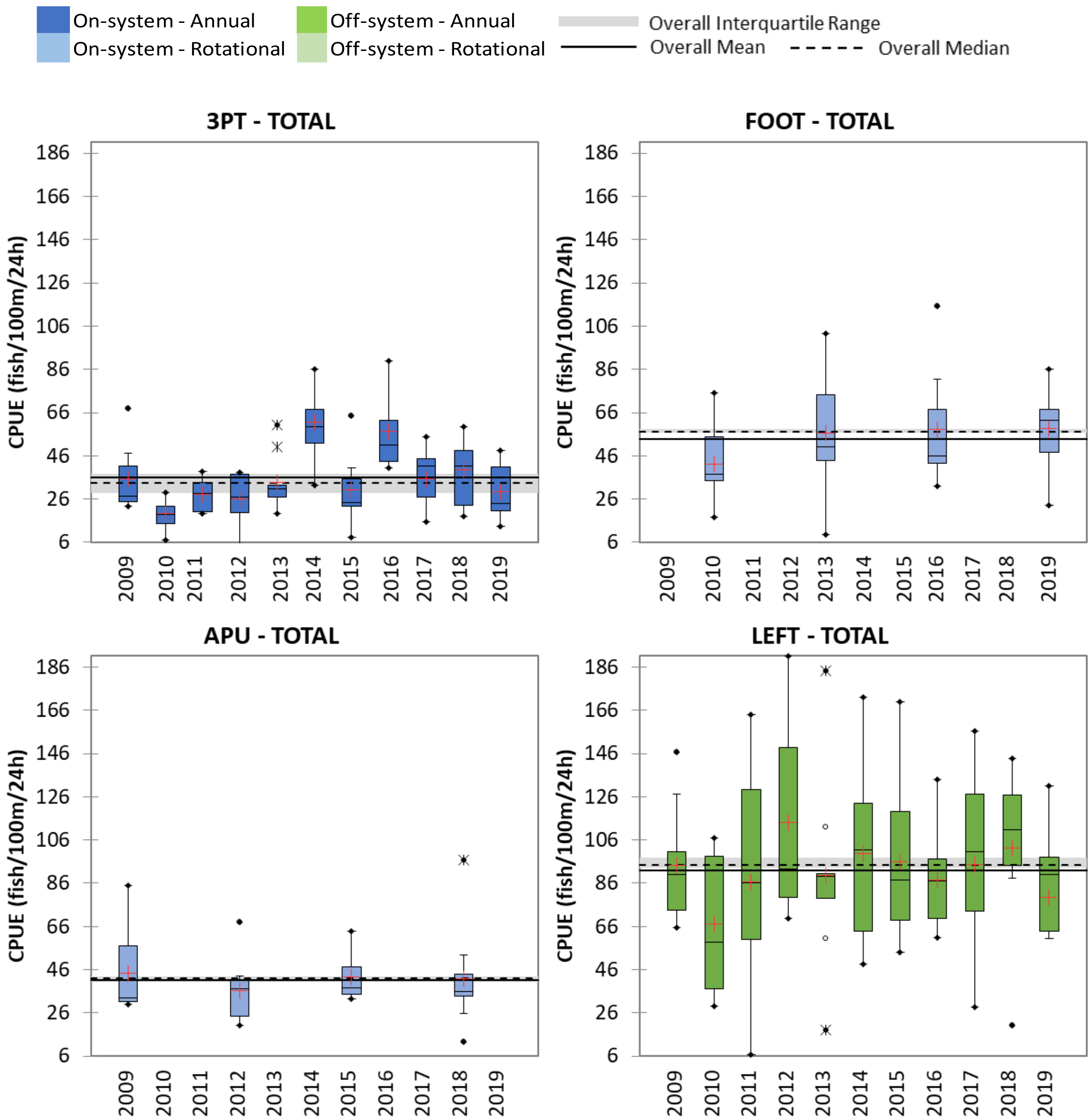


Figure 5.2-1. 2009-2019 Catch-per-unit-effort (CPUE) of standard gang index gill nets.

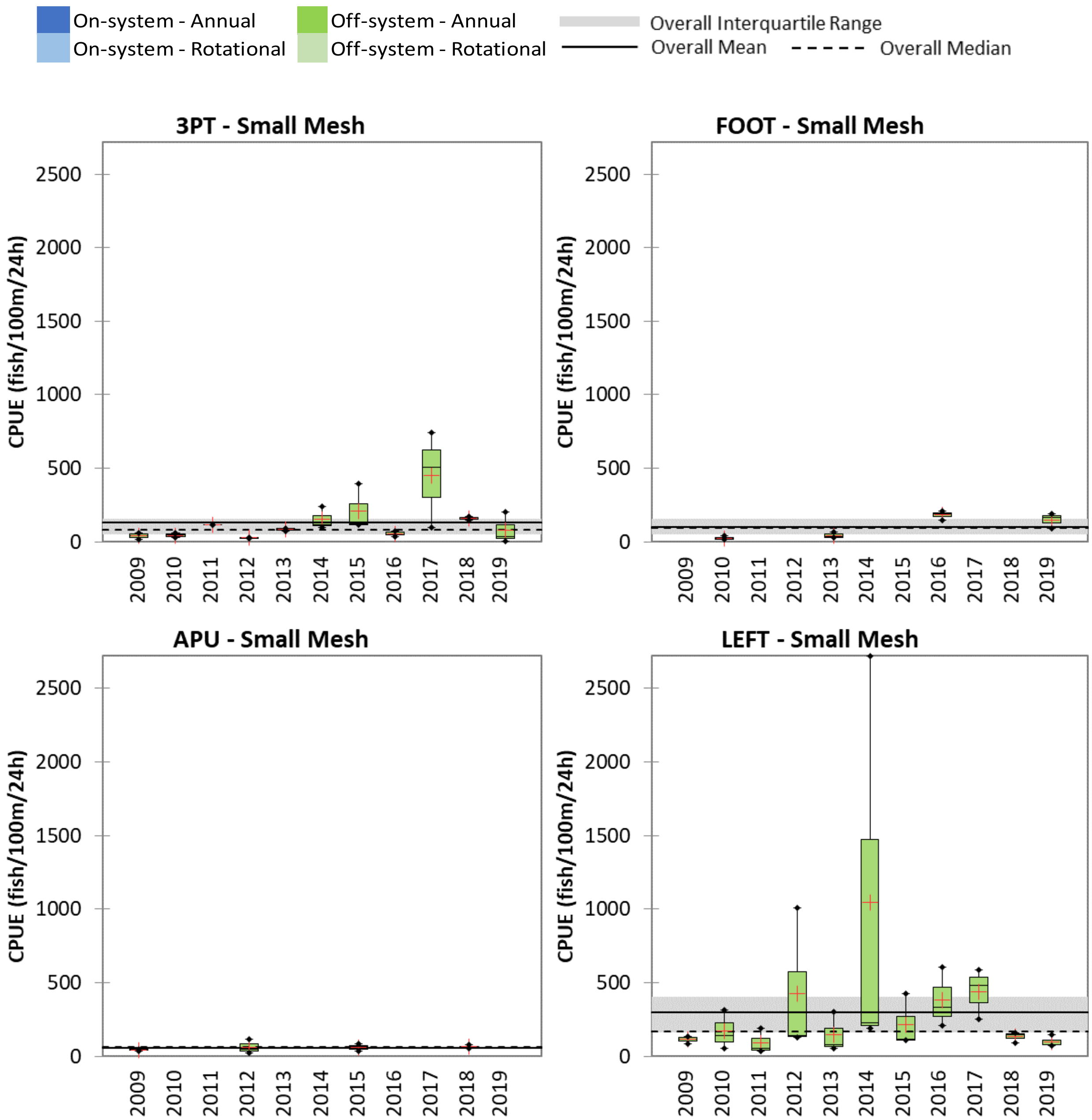


Figure 5.2-2. 2009-2019 Catch-per-unit-effort (CPUE) of small mesh index gill nets.

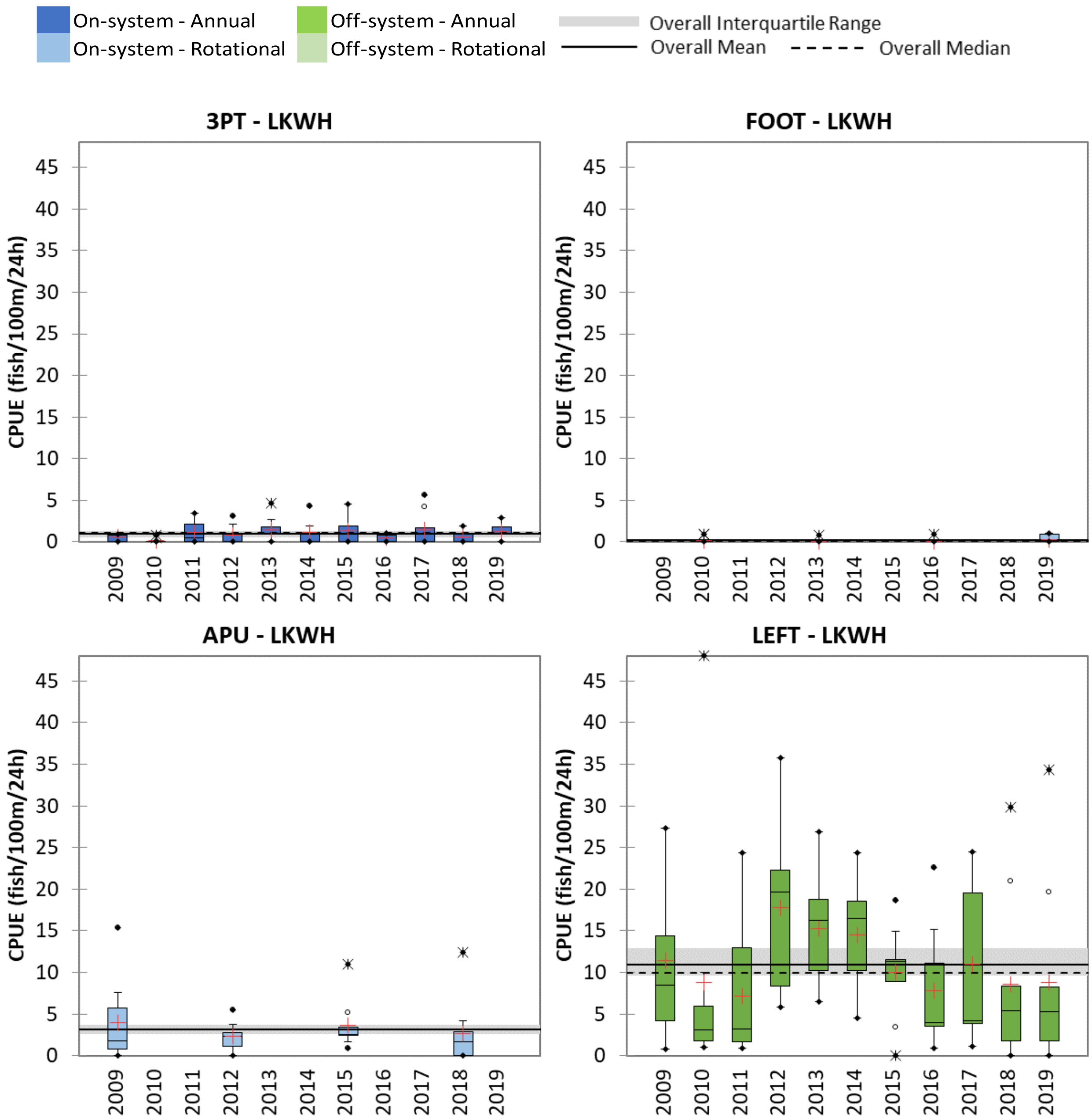


Figure 5.2-3. 2009-2019 Catch-per-unit-effort (CPUE) of Lake Whitefish.

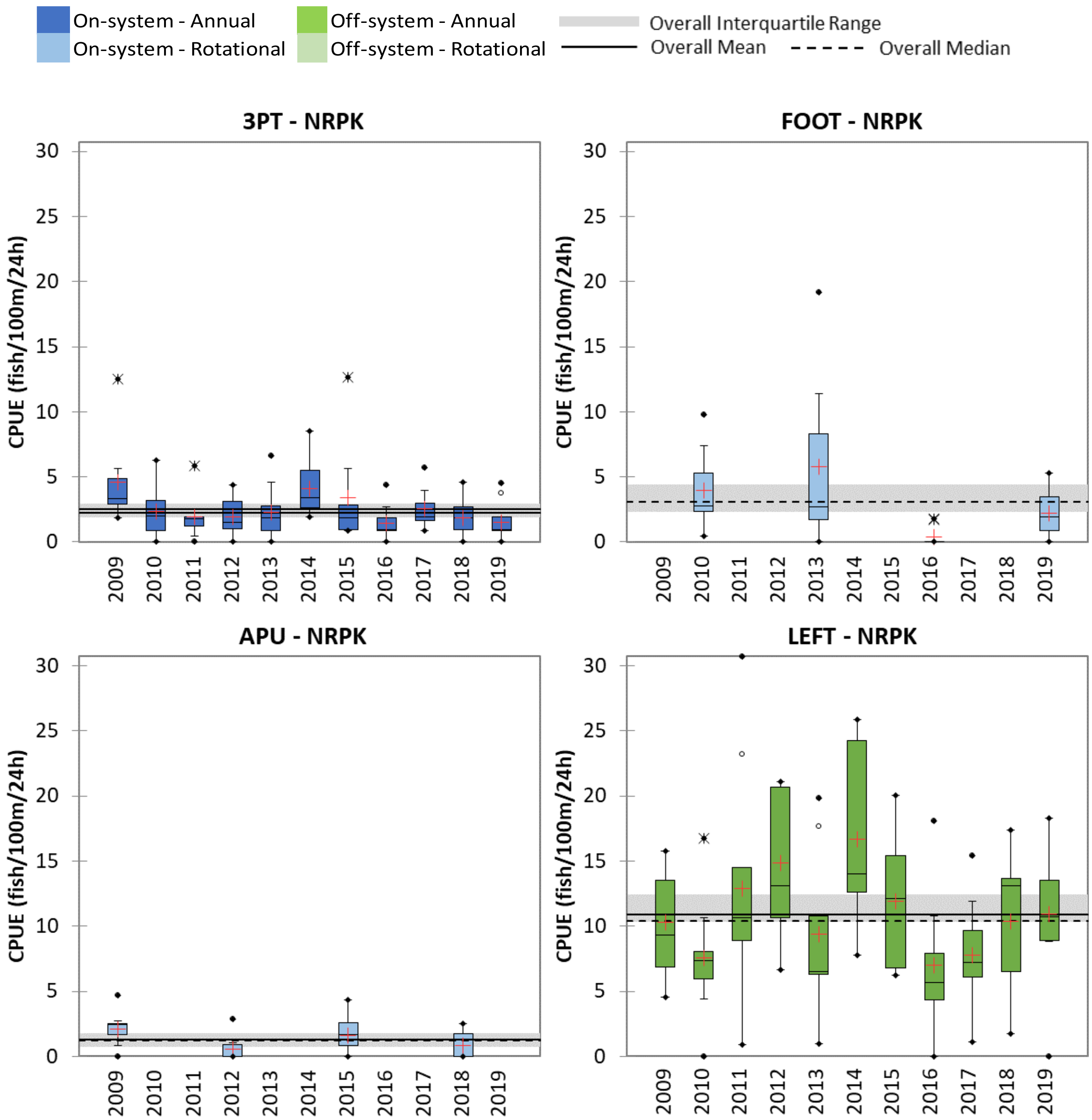


Figure 5.2-4. 2009-2019 Catch-per-unit-effort (CPUE) of Northern Pike.

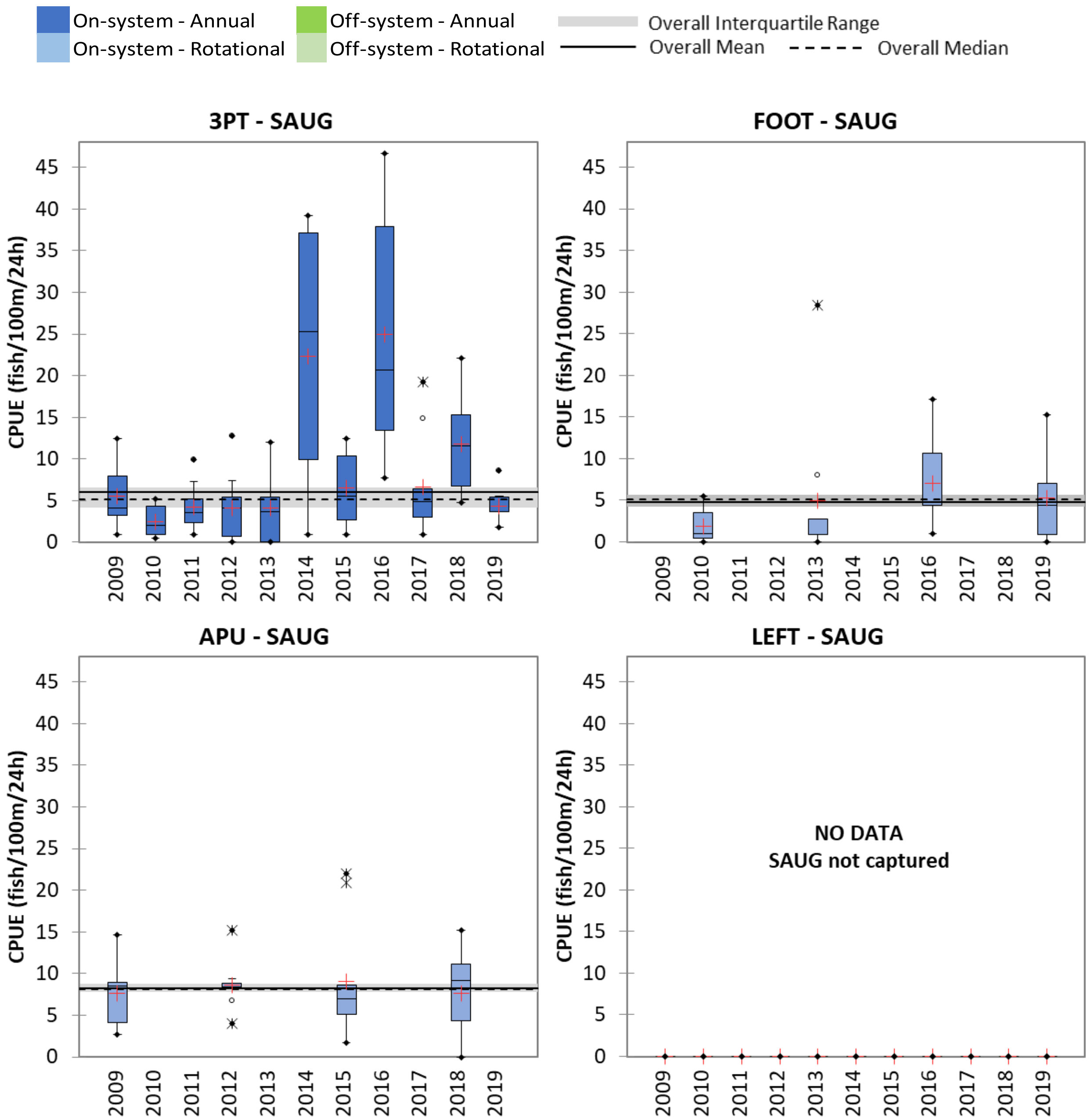


Figure 5.2-5. 2009-2019 Catch-per-unit-effort (CPUE) of Sauger.

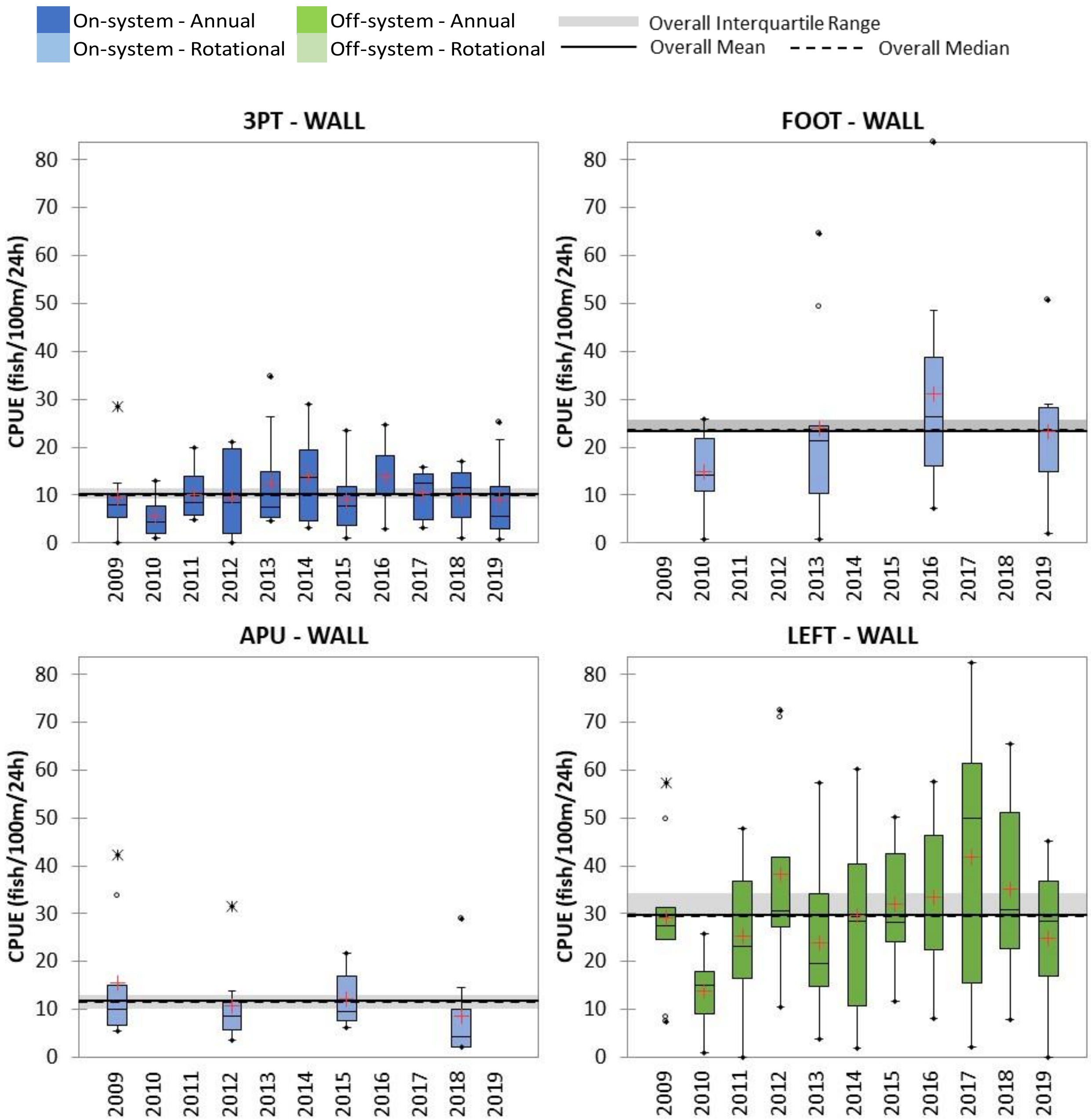


Figure 5.2-6. 2009-2019 Catch-per-unit-effort (CPUE) of Walleye.

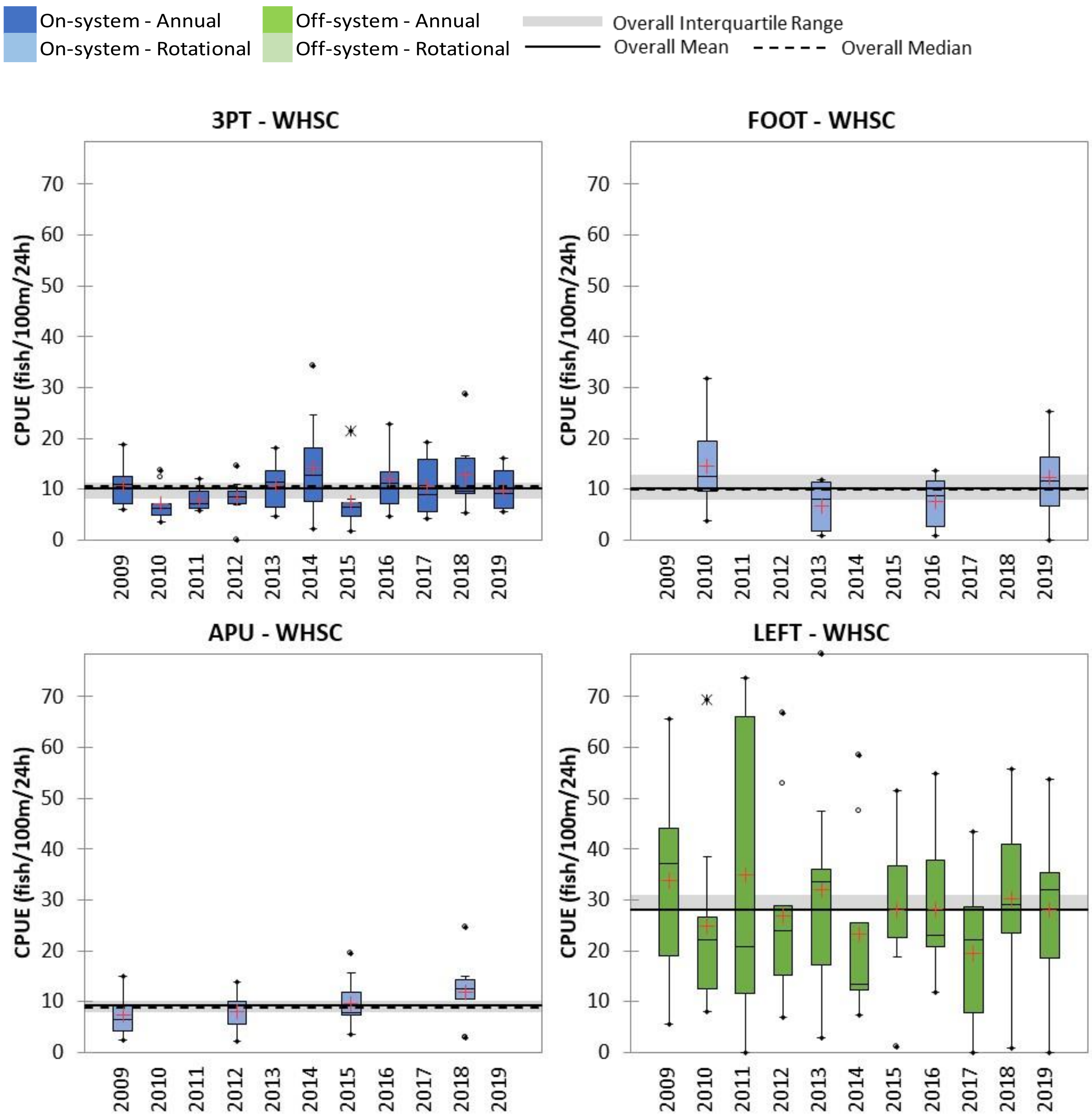


Figure 5.2-7. 2009-2019 Catch-per-unit-effort (CPUE) of White Sucker.

5.3 CONDITION

5.3.1 FULTON'S CONDITION FACTOR

5.3.1.1 ON-SYSTEM SITES

ANNUAL SITES

<u>**Threepoint Lake**</u>

Lake Whitefish

The annual mean KF of Lake Whitefish between 400 and 499 mm in fork length over the 11 years of monitoring ranged from a low of 1.31 in 2017 to a high of 1.63 in 2009 (Table 5.3-1; Figure 5.3-1).

The overall mean KF was 1.43, the median was 1.40, and the IQR was 1.39-1.47 (Figure 5.3-1). The annual mean KF fell within the overall IQR except in 2011, 2013, and 2017 when it was below the IQR and in 2009, 2014, and 2018 when it was above the IQR.

Northern Pike

The annual mean KF of Northern Pike between 400 and 699 mm in fork length over the 11 years of monitoring ranged from a low of 0.64 in 2012 to a high of 0.70 in 2017 (Table 5.3-1; Figure 5.3-2).

The overall mean and median KF was 0.67, and the IQR was 0.66-0.69 (Figure 5.3-2). The annual mean KF fell within the overall IQR except in 2012, 2013, and 2019 when it was below the IQR and in 2009, 2015, and 2017 when it was above the IQR.

Sauger

Sauger was not a target species in Threepoint Lake until 2017; the annual mean KF of Sauger between 200 and 349 mm in fork length over the three years of monitoring ranged from a low of 0.85 in 2019 to a high of 0.91 in 2017 (Table 5.3-1; Figure 5.3-3).

The overall mean KF was 0.87, the median was 0.86 and the IQR was 0.86-0.88 (Figure 5.3-3). The annual mean KF fell within the overall IQR in 2018, below the IQR in 2019 and in above the IQR in 2017.

Walleye

The annual mean KF of Walleye between 300 and 499 mm in fork length over the 11 years of monitoring ranged from a low of 1.00 in 2012 to a high of 1.11 in 2009 (Table 5.3-1; Figure 5.3-4).

The overall mean and median KF were 1.06 and the IQR was 1.05-1.07 (Figure 5.3-4). The annual mean KF fell within the overall IQR except in 2012 and 2016 when it was below the IQR and in 2009, 2013, and 2014 when it was above the IQR.

White Sucker

White Sucker was not a target species in Threepoint until 2010; the annual mean KF of White Sucker between 300 and 499 mm in fork length over the 10 years of monitoring ranged from a low of 1.45 in 2019 to a high of 1.54 in 2010 (Table 5.3-1; Figure 5.3-5).

The overall mean and median KF was 1.50, and the IQR was 1.48-1.51 (Figure 5.3-5). The annual mean KF fell within the overall IQR except in 2011, 2012, and 2019 when it was below the IQR and in 2010 and 2013 when it was above the IQR.

ROTATIONAL SITES

Footprint Lake

Lake Whitefish

The annual mean KF of Lake Whitefish between 400 and 499 mm in fork length over the four years of monitoring ranged from a low of 1.46 in 2016 to a high of 1.58 in 2019 (Table 5.3-1; Figure 5.3-1).

The overall mean KF was 1.53, the median was 1.52 and the IQR was 1.51-1.55 (Figure 5.3-1). The annual mean KF fell within the overall IQR except in 2016 when it was below the IQR and in 2019 when it was above the IQR.

Northern Pike

The annual mean KF of Northern Pike between 400 and 699 mm in fork length over the four years of monitoring ranged from a low of 0.61 in 2019 to a high of 0.69 in 2013 (Table 5.3-1; Figure 5.3-2).

The overall mean KF was 0.66, the median was 0.67 and the IQR was 0.66-0.68 (Figure 5.3-2). The annual mean KF fell within the overall IQR except in 2019 when it was below the IQR and in 2013 when it was above the IQR.

Sauger

Sauger was not a target species in Footprint Lake until 2017 and KF is only available for 2019 (Table 5.3-1). The annual mean KF of Sauger between 200 and 349 mm in fork length in 2019 was 0.90 (Table 5.3-1; Figure 5.3-3).

Walleye

The annual mean KF of Walleye between 300 and 499 mm in fork length over the four years of monitoring ranged from a low of 1.03 in 2016 to a high of 1.09 in 2019 (Table 5.3-1; Figure 5.3-4).

The overall mean and median KF were 1.06 and the IQR was 1.06-1.07 (Figure 5.3-4). The annual mean KF fell within the overall IQR except in 2010 and 2016 when it was below the IQR and in 2019 when it was above the IQR.

White Sucker

The annual mean KF of White Sucker between 300 and 499 mm in fork length over the four years ranged from a low of 1.48 in 2016 to a high of 1.50 in 2013 (Table 5.3-1; Figure 5.3-5).

The overall mean and median KF was 1.49, and the IQR was 1.49-1.50 (Figure 5.3-5). The annual mean KF fell within the overall IQR except in 2016 and 2019 when it was below the IQR, and 2013 when it was above the IQR.

Apussigamasi Lake

Lake Whitefish

The annual mean KF of Lake Whitefish between 400 and 499 mm in fork length over the four years of monitoring ranged from a low of 1.59 in 2012 to a high of 1.74 in 2009 (Table 5.3-1; Figure 5.3-1).

The overall mean KF was 1.68, the median was 1.70, and the IQR was 1.67-1.71 (Figure 5.3-1). The annual mean KF fell within the overall IQR except in 2012 when it was below the IQR and in 2009 when it was above the IQR.

Northern Pike

The annual mean KF of Northern Pike between 400 and 699 mm in fork length over the four years of monitoring ranged from a low of 0.60 in 2012 to a high of 0.71 in 2009 (Table 5.3-1; Figure 5.3-2).

The overall mean KF was 0.68, the median was 0.71 and the IQR was 0.68-0.71 (Figure 5.3-2). The annual mean KF fell within the overall IQR except in 2012 when it was below the IQR and in 2009 when it was above the IQR.

Sauger

Sauger was not a target species in Apussigamasi Lake until 2017 and KF is only available for is only available for 2018 (Table 5.3-1). The annual mean KF of Sauger between 200 and 349 mm in fork length in 2018 was 0.87 (Table 5.3-1; Figure 5.3-3).

Walleye

The annual mean KF of Walleye between 300 and 499 mm in fork length over the four years of monitoring ranged from a low of 1.09 in 2012 and 2018 to a high of 1.13 in 2015 (Table 5.3-1; Figure 5.3-4).

The overall mean and median KF were 1.11 and the IQR was 1.09-1.12 (Figure 5.3-4). The annual mean KF fell within the overall IQR except in 2018 when it was below the IQR and in 2015 when it was above the IQR.

White Sucker

White Sucker was not a target species in Apussigamasi Lake until 2010; the annual mean KF of White Sucker between 300 and 499 mm in fork length over the three years of monitoring ranged from a low of 1.54 in 2015 to a high of 1.59 in 2018 (Table 5.3-1; Figure 5.3-5).

The overall mean KF was 1.56, the median was 1.55, and the IQR was 1.54-1.57 (Figure 5.3-5). The annual mean KF fell within the overall IQR except in 2015 when it was below the IQR and in 2018 when it was above the IQR.

5.3.1.2 OFF-SYSTEM SITES

ANNUAL SITES

Leftrook Lake

Lake Whitefish

The annual mean KF of Northern Pike between 400 and 499 mm in fork length over the 11 years of monitoring ranged from a low of 1.42 in 2010 to a high of 1.63 in 2014 (Table 5.3-1; Figure 5.3-1).

The overall mean KF was 1.51, the median was 1.50, and the IQR was 1.50-1.56 (Figure 5.3-1). The annual mean KF fell within the overall IQR except in 2010 and 2016-2019 when it was below the IQR and in 2009, 2011, and 2014 when it was above the IQR.

Northern Pike

The annual mean KF of Northern Pike between 400 and 699 mm in fork length over the 11 years of monitoring ranged from a low of 0.62 in 2010 and 2015 to a high of 0.68 in 2011 (Table 5.3-1; Figure 5.3-2).

The overall mean and median KF was 0.64, and the IQR was 0.64-0.65 (Figure 5.3-2). The annual mean KF fell within the overall IQR except in 2010, 2013, and 2015 when it was below the IQR and in 2011, 2012, 2014, 2016, and 2017 when it was above the IQR.

Sauger

Sauger became a target species in 2017; it was not captured in Leftrook Lake over the three years of monitoring (Table 5.3-1).

Walleye

The annual mean KF of Walleye between 300 and 499 mm in fork length over the 11 years of monitoring ranged from a low of 0.98 in 2019 to a high of 1.10 in 2011 (Table 5.3-1; Figure 5.3-4).

The overall mean and median KF was 1.03, and the IQR was 1.03-1.04 (Figure 5.3-4). The annual mean KF fell within or was equal to the overall IQR except in 2010, 2012, 2013, 2015, and 2019 when it was below the IQR, and in 2009, 2011, and 2018 when it was above the IQR.

White Sucker

White Sucker became a targe species in 2010; the annual mean KF of White Sucker between 300 and 499 mm in fork length over the ten years of monitoring was 1.42 in 2019 and 1.53 in 2017 (Table 5.3-1; Figure 5.3-5).

The overall mean and median KF was 1.48, and the IQR was 1.48-1.49 (Figure 5.3-5). The annual mean KF fell within or was equal to the overall IQR except in 2010, 2012, 2015, and 2019 when it was below the IQR, and in 2011 and 2017 when it was above the IQR.

Table 5.3-1. 2009-2019 Fulton's condition factor of target species.

Waterbody	Year	LKWH			NRPK			SAUG			WALL			WHSC		
		n_F[1]	Mean	SE[2]	n_F	Mean	SE	n_F	Mean	SE	n_F	Mean	SE	n_F	Mean	SE
3PT	2009	5	1.63	0.06	25	0.69	0.02				80	1.11	0.01			
	2010	2	1.40	0.09	21	0.67	0.02				76	1.06	0.01	82	1.54	0.01
	2011	14	1.39	0.03	15	0.67	0.01				87	1.06	0.01	96	1.47	0.01
	2012	6	1.39	0.04	10	0.64	0.02				68	1.00	0.01	72	1.47	0.01
	2013	14	1.38	0.04	8	0.65	0.04				117	1.10	0.01	98	1.52	0.01
	2014	9	1.50	0.04	38	0.67	0.02				94	1.07	0.01	101	1.50	0.01
	2015	13	1.41	0.03	15	0.69	0.05				69	1.05	0.01	69	1.49	0.01
	2016	4	1.39	0.05	18	0.68	0.01				88	1.04	0.01	112	1.50	0.01
	2017	13	1.31	0.06	16	0.70	0.02	69	0.91	0.01	80	1.06	0.01	95	1.51	0.02
	2018	6	1.49	0.08	19	0.67	0.02	99	0.86	0.01	61	1.06	0.01	112	1.51	0.01
	2019	10	1.46	0.05	10	0.64	0.02	48	0.85	0.01	70	1.05	0.01	85	1.45	0.02
FOOT	2010	2	-	-	22	0.66	0.02				151	1.05	0.01	150	1.49	0.01
	2013	1	1.53	-	37	0.69	0.01				212	1.07	0.00	62	1.50	0.01
	2016	1	1.46	-	4	0.67	0.02				242	1.03	0.00	69	1.48	0.01
	2019	2	1.58	0.02	9	0.61	0.02	58	0.90	0.01	213	1.09	0.01	119	1.49	0.02
APU	2009	32	1.74	0.03	9	0.71	0.02				153	1.12	0.01			
	2012	14	1.59	0.04	2	0.60	0.02				84	1.09	0.01	59	1.55	0.02
	2015	37	1.69	0.03	5	0.70	0.04				115	1.13	0.01	80	1.54	0.02
	2018	28	1.70	0.03	8	0.71	0.02	91	0.87	0.01	72	1.09	0.01	113	1.59	0.01
LEFT	2009	109	1.60	0.01	118	0.64	0.01				348	1.04	0.00			
	2010	83	1.42	0.02	66	0.62	0.01				104	1.02	0.01	190	1.46	0.01
	2011	61	1.59	0.02	100	0.68	0.01				174	1.10	0.01	292	1.51	0.01
	2012	120	1.51	0.01	95	0.67	0.01				227	1.02	0.00	185	1.45	0.01
	2013	140	1.50	0.01	79	0.63	0.01				183	1.01	0.01	283	1.49	0.01
	2014	128	1.63	0.01	141	0.66	0.01				225	1.03	0.01	200	1.48	0.01
	2015	87	1.54	0.02	95	0.62	0.01				293	1.00	0.00	248	1.45	0.01
	2016	71	1.50	0.01	53	0.64	0.01				247	1.03	0.00	261	1.48	0.01
	2017	100	1.46	0.01	79	0.64	0.01	-	-	-	336	1.03	0.00	161	1.53	0.01
	2018	83	1.44	0.02	98	0.64	0.01	-	-	-	360	1.04	0.00	278	1.49	0.01
	2019	94	1.44	0.01	97	0.65	0.01	-	-	-	243	0.98	0.00	257	1.42	0.01

Notes:

1. n_F = number of fish measured for length and weight.
2. SE = standard error.
3. Grey shading indicates a species was not a target species in that year.

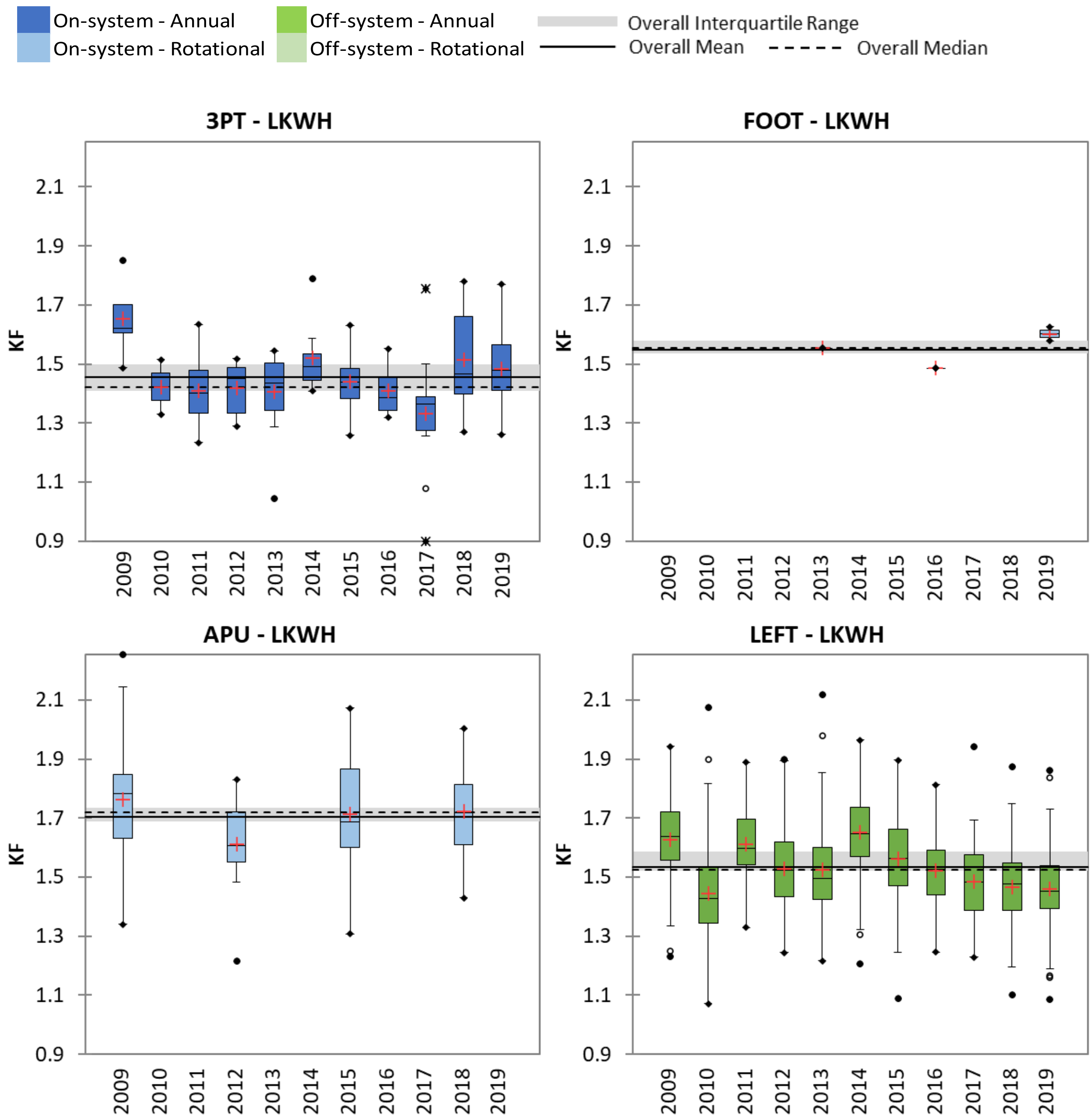


Figure 5.3-1. 2009-2019 Fulton's condition factor (KF) of Lake Whitefish.

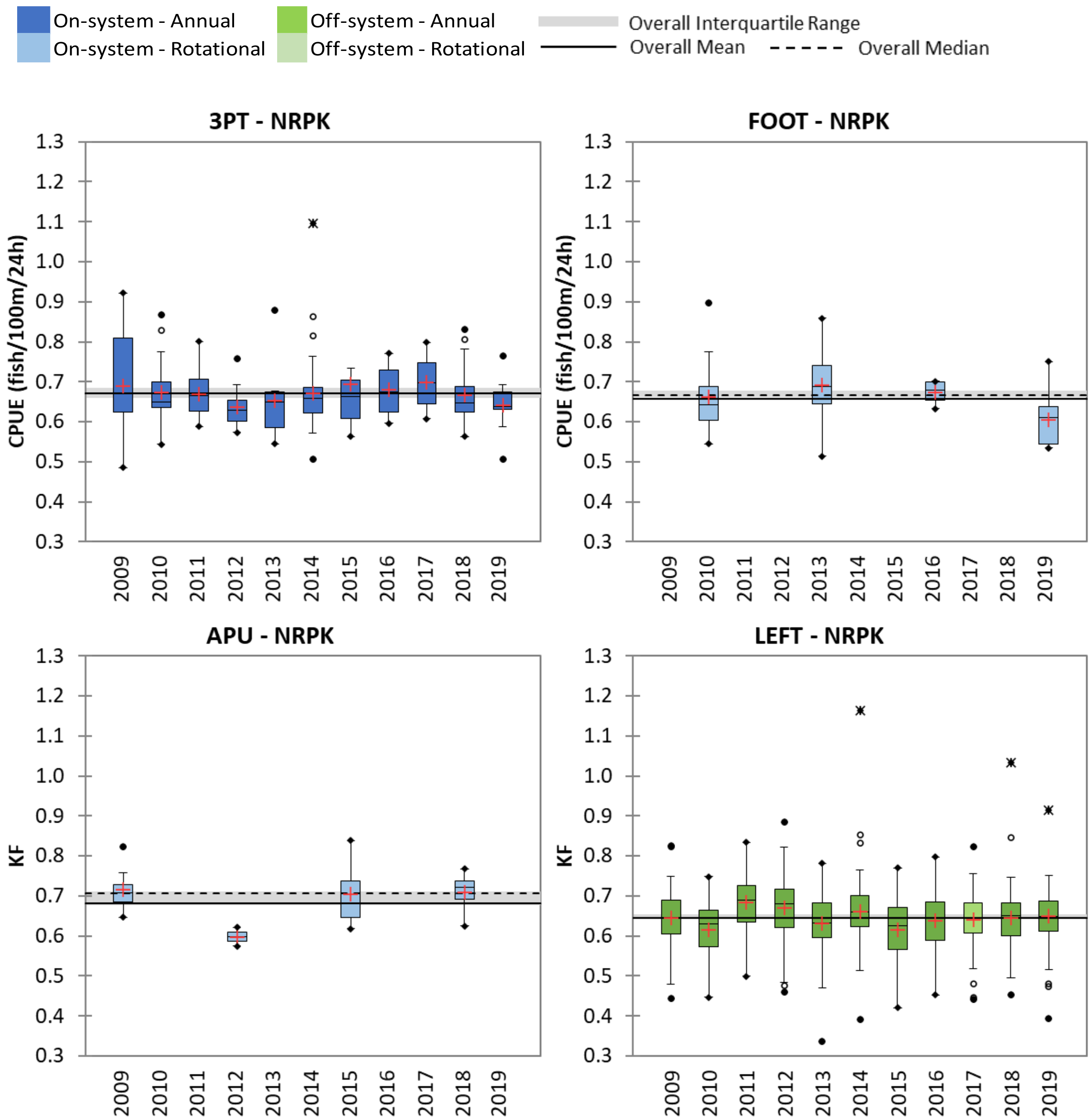


Figure 5.3-2. 2009-2019 Fulton's condition factor (KF) of Northern Pike.

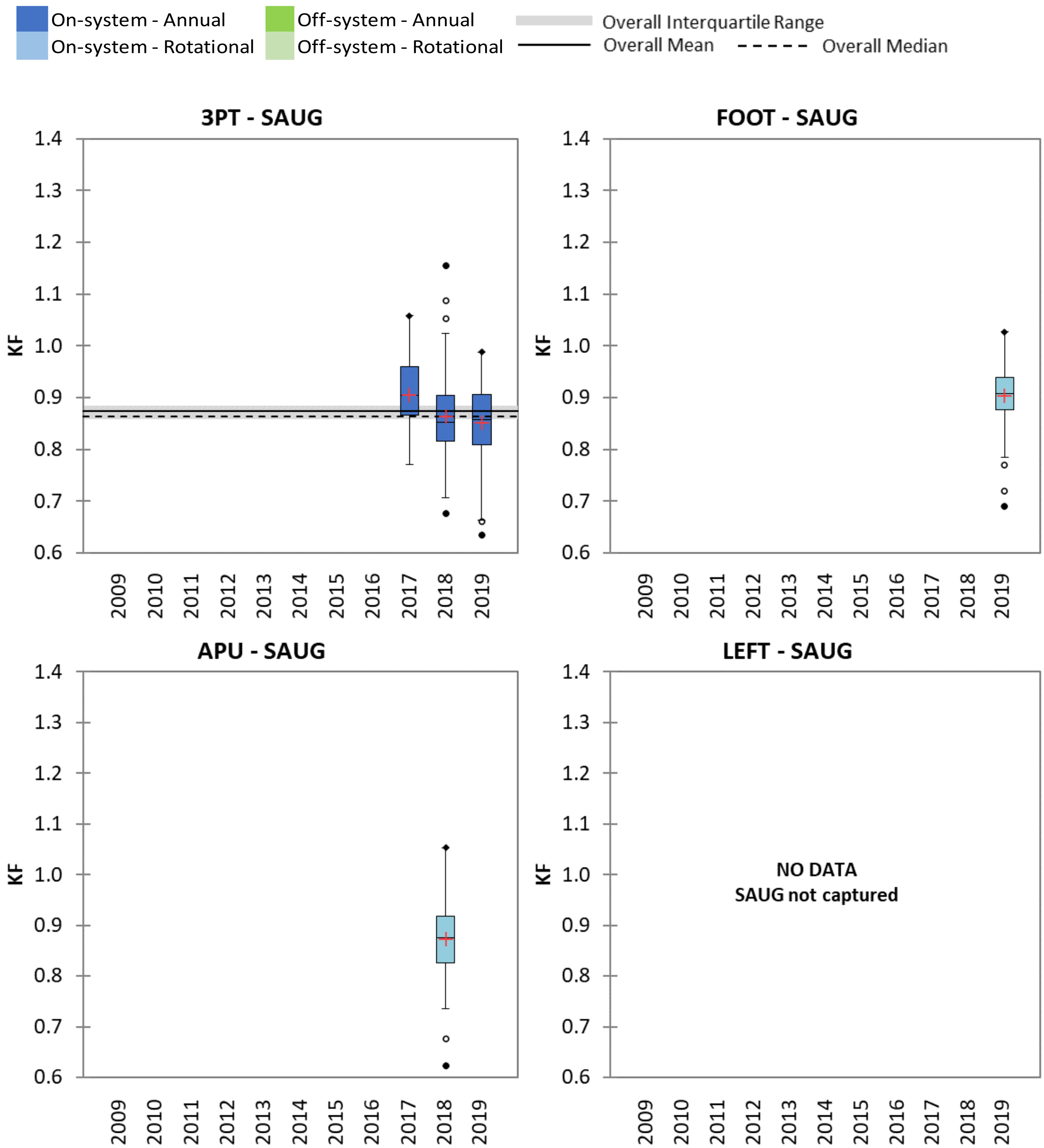


Figure 5.3-3. 2017-2019 Fulton's condition factor (KF) of Sauger.

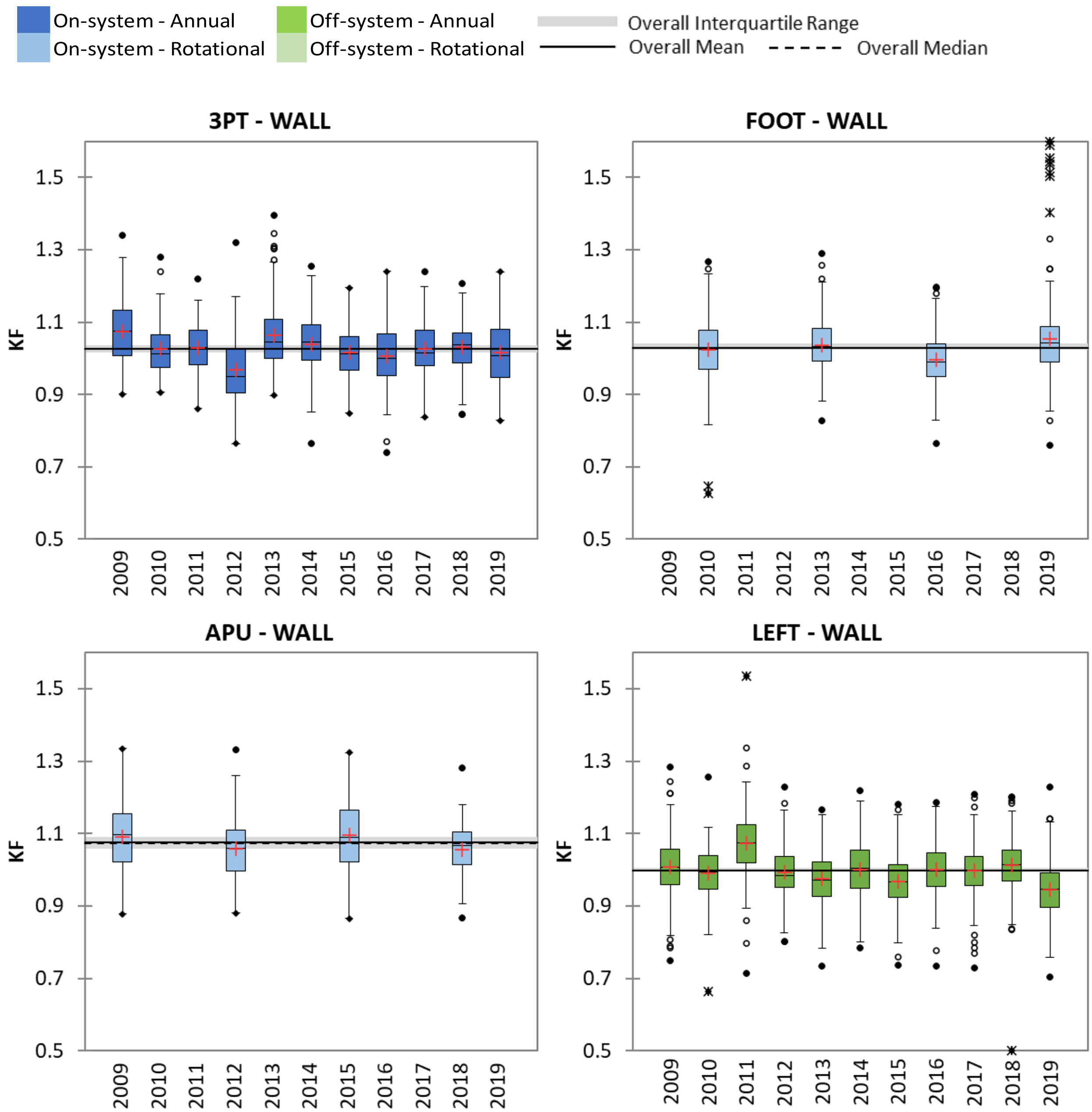


Figure 5.3-4. 2009-2019 Fulton's condition factor (KF) of Walleye.

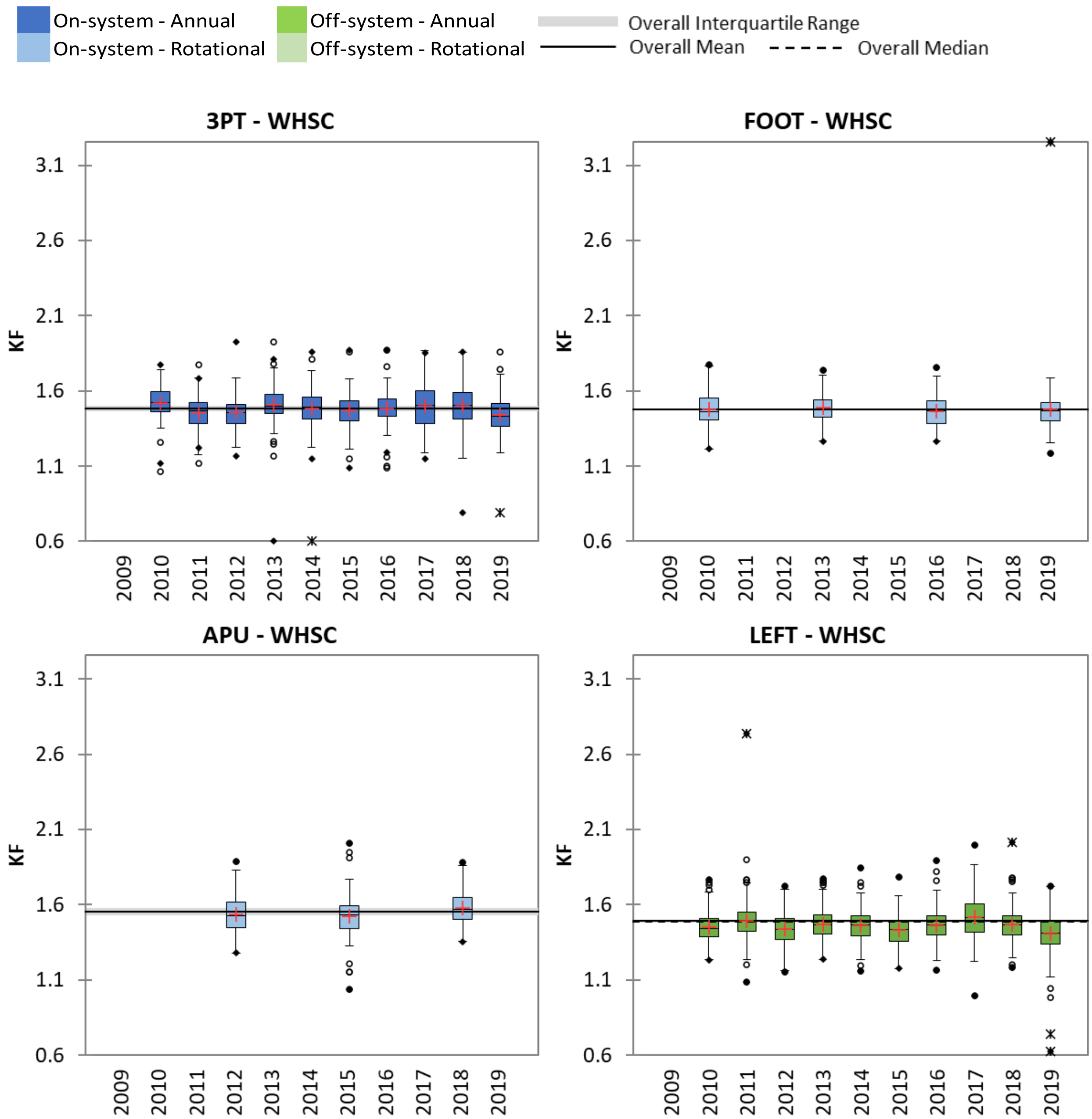


Figure 5.3-5. 2010-2019 Fulton's condition factor (KF) of White Sucker.

5.3.2 RELATIVE WEIGHT

5.3.2.1 ON-SYSTEM SITES

ANNUAL SITES

<u>Threepoint Lake</u>

Lake Whitefish

The annual mean Wr of Lake Whitefish greater than 99 mm and less than 701 mm in total length over the 11 years of monitoring ranged from a low of 91 in 2017 to a high of 118 in 2009 (Table 5.3-2; Figure 5.3-6).

The overall mean Wr was 100, the median was 98, and the IQR was 97-103 (Figure 5.3-6). The annual mean Wr fell within the overall IQR except in 2016 and 2017 when it was below the IQR and in 2009, 2014, and 2018 when it was above the IQR.

Northern Pike

The annual mean Wr of Northern Pike greater than 99 mm in total length over the 11 years of monitoring ranged from a low of 80 in 2012 to a high of 91 in 2016 (Table 5.3-2; Figure 5.3-7).

The overall mean Wr was 84, the median was 83, and the IQR was 81-84 (Figure 5.3-7). The annual mean Wr fell within the overall IQR except in 2012 when it was below the IQR and in 2010, 2016, and 2017 when it was above the IQR.

Sauger

Sauger was not a target species in Threepoint Lake until 2017; the annual mean Wr of Sauger greater than 69 mm in total length over the three years of monitoring ranged from a low of 82 in 2019 to a high of 85 in 2017 (Table 5.3-2; Figure 5.3-8).

The overall mean and median Wr were 83, and the IQR was 82-84 (Figure 5.3-8). The annual mean Wr fell within the overall IQR except in 2009 when it was above the IQR.

Walleye

The annual mean Wr of Walleye greater than 29 mm in total length over the 11 years of monitoring ranged from a low of 78 in 2012 to a high of 88 in 2009, 2013, and 2017 (Table 5.3-2; Figure 5.3-9).

The overall mean and median Wr were 85 and the IQR was 84-87 (Figure 5.3-9). The annual mean Wr fell within the overall IQR except in 2012 and 2015 when it was below the IQR and in 2009, 2013, and 2017 when it was above the IQR.

White Sucker

White Sucker was not a target species in Threepoint until 2010; the annual mean Wr of White Sucker greater than 99 mm in total length over the ten years of monitoring ranged from a low of 93 in 2019 to a high of 99 in 2010 and 2013 (Table 5.3-2; Figure 5.3-10).

The overall mean and median Wr were 97, and the IQR was 95-98 (Figure 5.3-10). The annual mean Wr fell within the overall IQR except in 2019 when it was below the IQR and in 2010 and 2013 when it was above the IQR.

ROTATIONAL SITES

Fooprint Lake

Lake Whitefish

The annual mean Wr of Lake Whitefish greater than 99 mm and less than 701 mm in total length over the four years of monitoring ranged from a low of 100 in 2016 to a high of 110 in 2019 (Table 5.3-2; Figure 5.3-6).

The overall mean and median Wr were 105, and the IQR was 104-107 (Figure 5.3-6). The annual mean Wr fell within the overall IQR except in 2016 when it was below the IQR and in 2019 when it was above the IQR.

Northern Pike

The annual mean Wr of Northern Pike greater than 99 mm in total length over the four years of monitoring ranged from a low of 81 in 2016 to a high of 87 in 2013 (Table 5.3-2; Figure 5.3-7).

The overall mean and median Wr were 84, and the IQR was 83-85 (Figure 5.3-7). The annual mean Wr fell within the overall IQR except in 2016 when it was below the IQR and in 2013 when it was above the IQR.

Sauger

Sauger was not a target species in Footprint Lake until 2017; Wr is only available for 2019 (Table 5.3-1). The annual mean Wr of Sauger greater than 69 mm in total length in 2019 was 86 (Table 5.3-1; Figure 5.3-8).

Walleye

The annual mean Wr of Walleye greater than 29 mm in total length over the four years of monitoring ranged from a low of 83 in 2016 to a high of 88 in 2019 (Table 5.3-2; Figure 5.3-9).

The overall mean and median Wr were 86, and the IQR was 86-87 (Figure 5.3-9). The annual mean Wr fell within the overall IQR except in 2016 when it was below the IQR and in 2019 when it was above the IQR.

White Sucker

The annual mean Wr of White Sucker greater than 99 mm in total length ranged from a low of 95 in 2016 and 2019 to a high of 97 in 2013 (Table 5.3-2; Figure 5.3-10).

The overall mean and median Wr were 96, and the IQR was 95-96 (Figure 5.3-10). The annual mean Wr fell within the overall IQR except in 2013 when it was above the IQR.

Apussigamasi Lake

Lake Whitefish

The annual mean Wr of Lake Whitefish greater than 99 mm and less than 701 mm in total length over the four years of monitoring ranged from a low of 109 in 2012 to a high of 121 in 2009 (Table 5.3-2; Figure 5.3-6).

The overall mean Wr was 116, the median was 117, and the IQR was 115-118 (Figure 5.3-6). The annual mean Wr fell within the overall IQR except in 2012 when it was below the IQR and in 2009 when it was above the IQR.

Northern Pike

The annual mean Wr of Northern Pike greater than 99 mm in total length over the four years of monitoring ranged from a low of 79 in 2012 to a high of 92 in 2009 (Table 5.3-2; Figure 5.3-7).

The overall mean Wr was 87, the median was 88, and the IQR was 85-89 (Figure 5.3-7). The annual mean Wr fell within the overall IQR except in 2012 when it was below the IQR and in 2009 when it was above the IQR.

Sauger

Sauger was not a target species in Apussigamasi Lake until 2017; Wr is only available for 2018 (Table 5.3-2). The annual mean Wr of Sauger greater than 69 mm in total length in 2018 was 83 (Table 5.3-2; Figure 5.3-8).

Walleye

The annual mean Wr of Walleye greater than 29 mm in total length over the four years of monitoring ranged from a low of 87 in 2012 to a high of 91 in 2015 (Table 5.3-2; Figure 5.3-9).

The overall mean and median Wr were 89, and the IQR was 87-90 (Figure 5.3-9). The annual mean Wr fell within the overall IQR except in 2015 when it was above the IQR.

White Sucker

White sucker was not a target species in Apussigamasi Lake until 2010; the annual mean Wr of White Sucker greater than 99 mm in total length over the three years of monitoring ranged from a low of 97 in 2012 to a high of 103 in 2018 (Table 5.3-2; Figure 5.3-10).

The overall mean Wr was 100, the median was 99, and the IQR was 98-101 (Figure 5.3-10). The annual mean Wr fell within the overall IQR in 2015, below the IQR in 2012, and above the IQR in 2018.

5.3.2.2 OFF-SYSTEM SITES

ANNUAL SITES

<u>Leftrook Lake</u>

Lake Whitefish

The annual mean Wr of Lake Whitefish greater than 99 mm and less than 701 mm in total length over the 11 years of monitoring ranged from a low of 98 in 2010 to a high of 112 in 2014 (Table 5.3-2; Figure 5.3-6).

The overall mean Wr was 104, the median was 103, and the IQR was 103-107 (Figure 5.3-6). The annual mean Wr fell within the overall IQR except in 2010 and 2017-2019 when it was below the IQR and in 2009, 2011, and 2014 when it was above the IQR.

Northern Pike

The annual mean Wr of Northern Pike greater than 99 mm in total length over the 11 years of monitoring ranged from a low of 77 in 2010 to a high of 87 in 2011 (Table 5.3-2; Figure 5.3-7).

The overall mean and median Wr were 81, and the IQR was 81-83 (Figure 5.3-7). The annual mean Wr fell within the overall IQR except in 2010, 2013, and 2015 when it was below the IQR and in 2011 and 2012 when it was above the IQR.

Sauger

Sauger was a not a target species in Leftrook Lake until 2017; Sauger were not captured in Leftrook Lake over the three years of monitoring (Table 5.2-2).

Walleye

The annual mean Wr of Walleye greater than 29 mm in total length over the 11 years of monitoring ranged from a low of 80 in 2019 to a high of 91 in 2011 (Table 5.3-2; Figure 5.3-9).

The overall mean and median Wr were 83, and the IQR was 83-84 (Figure 5.3-9). The annual mean Wr fell within the overall IQR except in 2010, 2013, 2015, and 2019 when it was below the IQR and in 2011 and 2018 when it was above the IQR.

White Sucker

White sucker was not a target species in Leftrook Lake until 2010; the annual mean Wr of White Sucker greater than 99 mm in total length over the ten years of monitoring ranged from a low of 92 in 2019 to a high of 98 in 2017 (Table 5.3-2; Figure 5.3-10).

The overall mean and median Wr was 95, and the IQR was 95-96 (Figure 5.3-10). The annual mean Wr fell within the overall IQR except in 2010, 2012, 2015, and 2019 when it was below the IQR and in 2011 and 2017 when it was above the IQR.

Table 5.3-2. 2009-2019 relative weight of target species.

Waterbody	Year	LKWH			NRPK			SAUG			WALL			WHSC		
		n_F[1]	Mean	SE[2]	n_F	Mean	SE	n_F	Mean	SE	n_F	Mean	SE	n_F	Mean	SE
3PT	2009	7	118	4.7	50	84	1.9				103	88	1.2	10	96	1.5
	2010	2	98	4.2	32	85	2.6				91	85	0.6	87	99	0.8
	2011	15	98	2.9	24	81	1.5				111	86	0.9	96	95	0.8
	2012	7	97	2.9	18	80	2.0				109	78	0.8	76	95	0.8
	2013	15	97	2.7	26	84	2.5				127	88	0.7	104	99	0.8
	2014	10	105	2.7	66	83	1.3				127	85	0.8	113	96	0.9
	2015	13	98	2.1	32	81	3.0				91	83	0.7	70	96	0.9
	2016	6	95	2.8	29	91	9.8				142	84	0.6	115	97	0.8
	2017	15	91	3.7	26	86	1.6	77	85	1.0	120	88	1.6	104	98	0.9
	2018	7	104	5.2	21	81	2.0	118	83	0.7	100	86	0.7	123	97	0.8
	2019	12	102	3.2	15	82	2.2	60	82	1.0	96	85	0.7	96	93	1.0
FOOT	2010	0	-	-	42	83	1.2				182	86	0.5	155	96	0.6
	2013	1	105		63	87	1.2				251	87	0.4	66	97	0.7
	2016	1	100		12	81	1.5				331	83	0.3	73	95	0.8
	2019	3	110	0.5	28	85	5.7	70	86	0.8	259	88	0.8	121	95	0.6
APU	2009	41	121	1.9	25	92	2.1	127	83	0.5	179	90	0.5	77	103	0.8
	2012	22	109	2.5	7	79	4.9				113	87	0.7	78	97	1.2
	2015	38	117	1.9	17	88	3.0				156	91	0.8	101	99	1.1
	2018	31	117	2.0	9	88	2.2	103	83	0.7	117	88	1.2	123	103	0.7
LEFT	2009	122	109	0.8	126	80	0.8				393	84	0.3	322	96	0.4
	2010	88	98	1.2	71	77	1.0				108	82	0.6	191	94	0.5
	2011	65	109	1.1	112	87	1.1				220	91	0.7	295	97	0.5
	2012	124	104	0.9	120	85	0.9				287	83	0.4	192	94	0.5
	2013	143	103	0.8	106	80	0.9				245	81	0.4	292	96	0.4
	2014	132	112	0.8	170	83	0.7				277	83	0.4	204	95	0.4
	2015	91	106	1.0	127	79	0.9				354	81	0.3	252	93	0.4
	2016	72	103	1.0	78	81	1.1				344	84	0.4	265	96	0.4
	2017	102	100	0.8	94	81	0.9	0	-	-	419	84	0.3	173	98	0.8
	2018	85	99	1.0	128	82	0.8	0	-	-	434	85	0.3	301	96	0.4
	2019	95	99	1.0	112	81	0.8	0	-	-	313	80	0.4	280	92	0.6

Notes:

1. n_F = number of fish measured for length and weight.
2. SE = standard error.
3. Grey shading indicates a species was not a target species in that year.

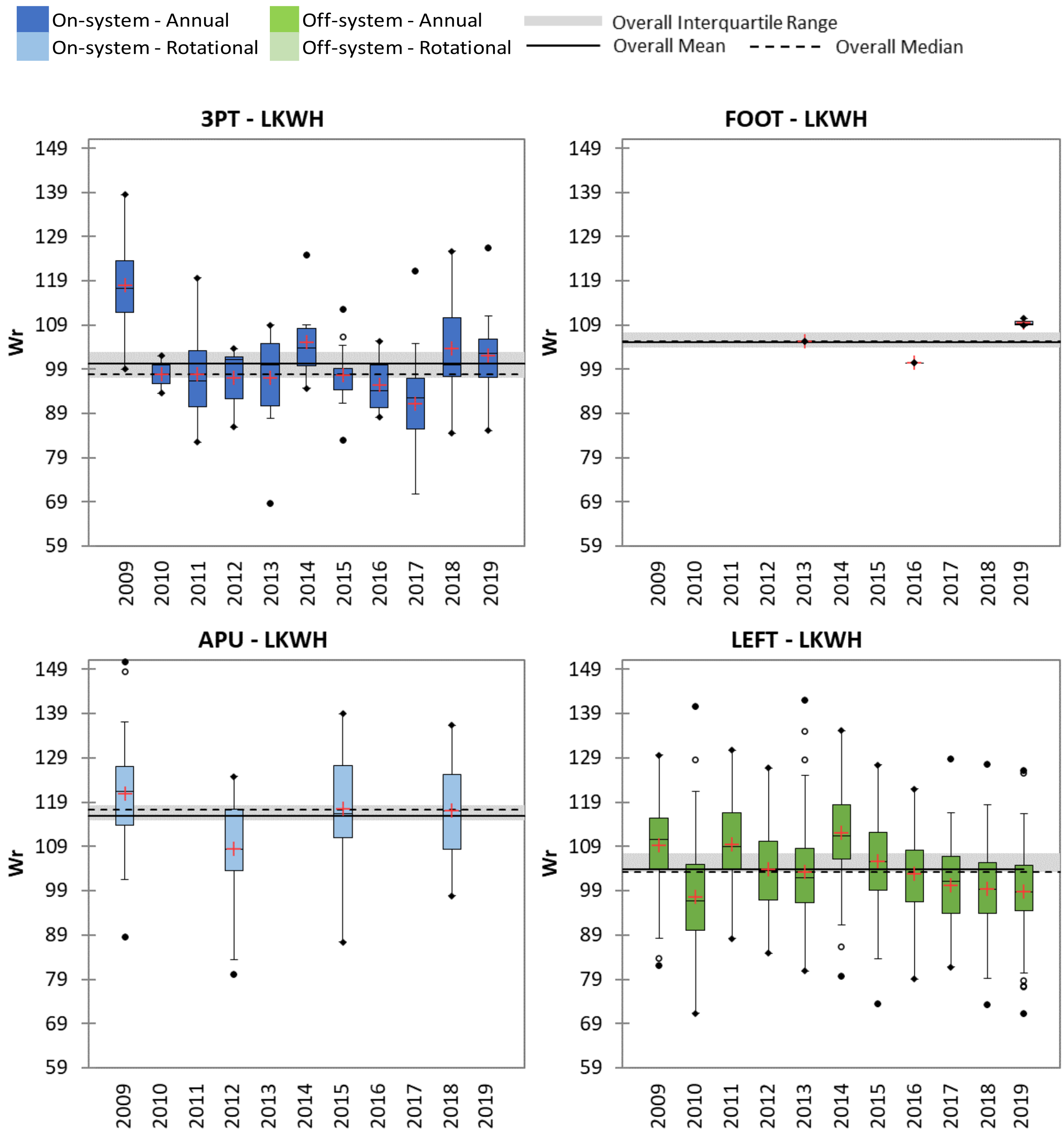


Figure 5.3-6. Relative weight (Wr) of Lake Whitefish.

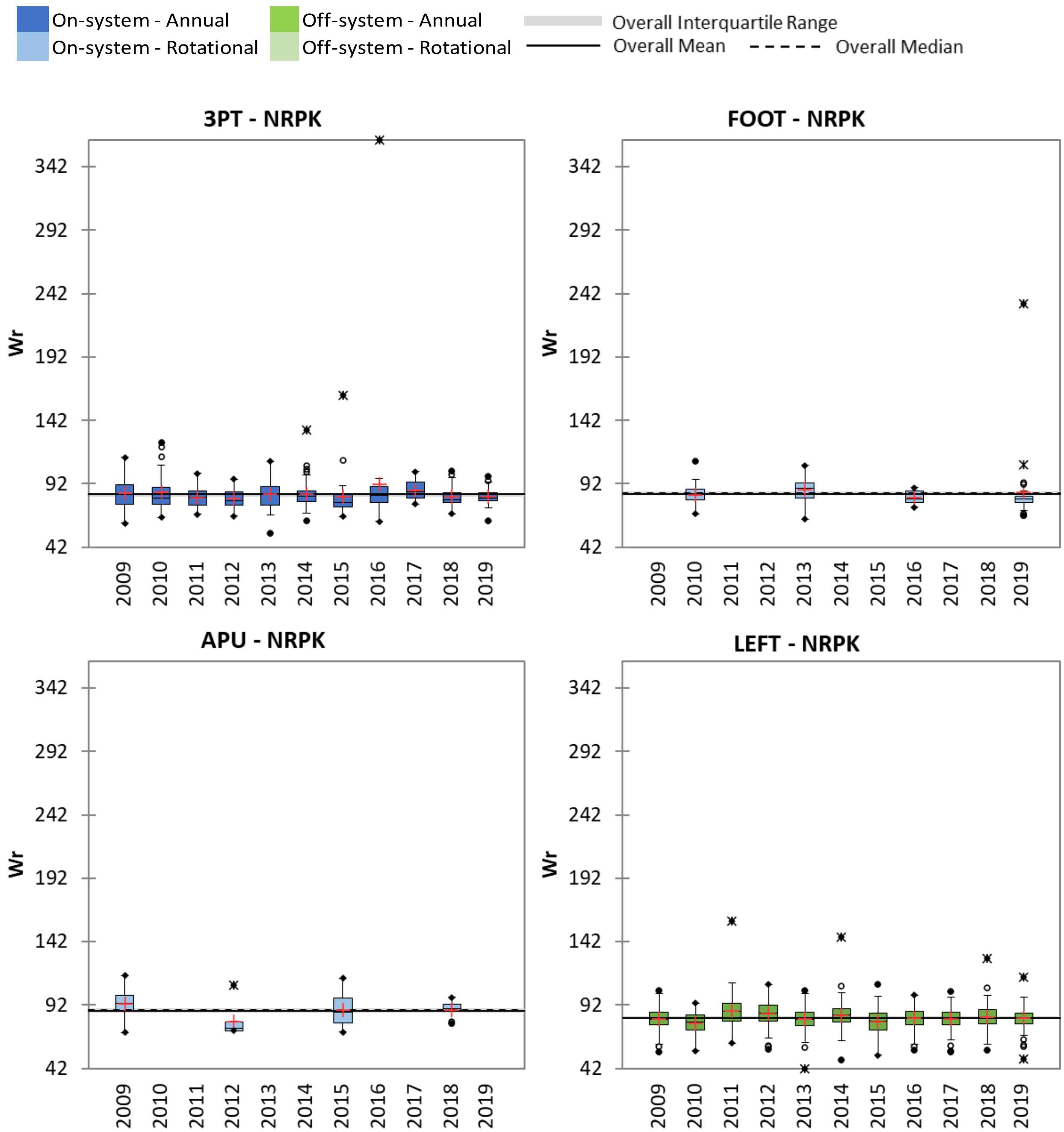


Figure 5.3-7. Relative weight (Wr) of Northern Pike.

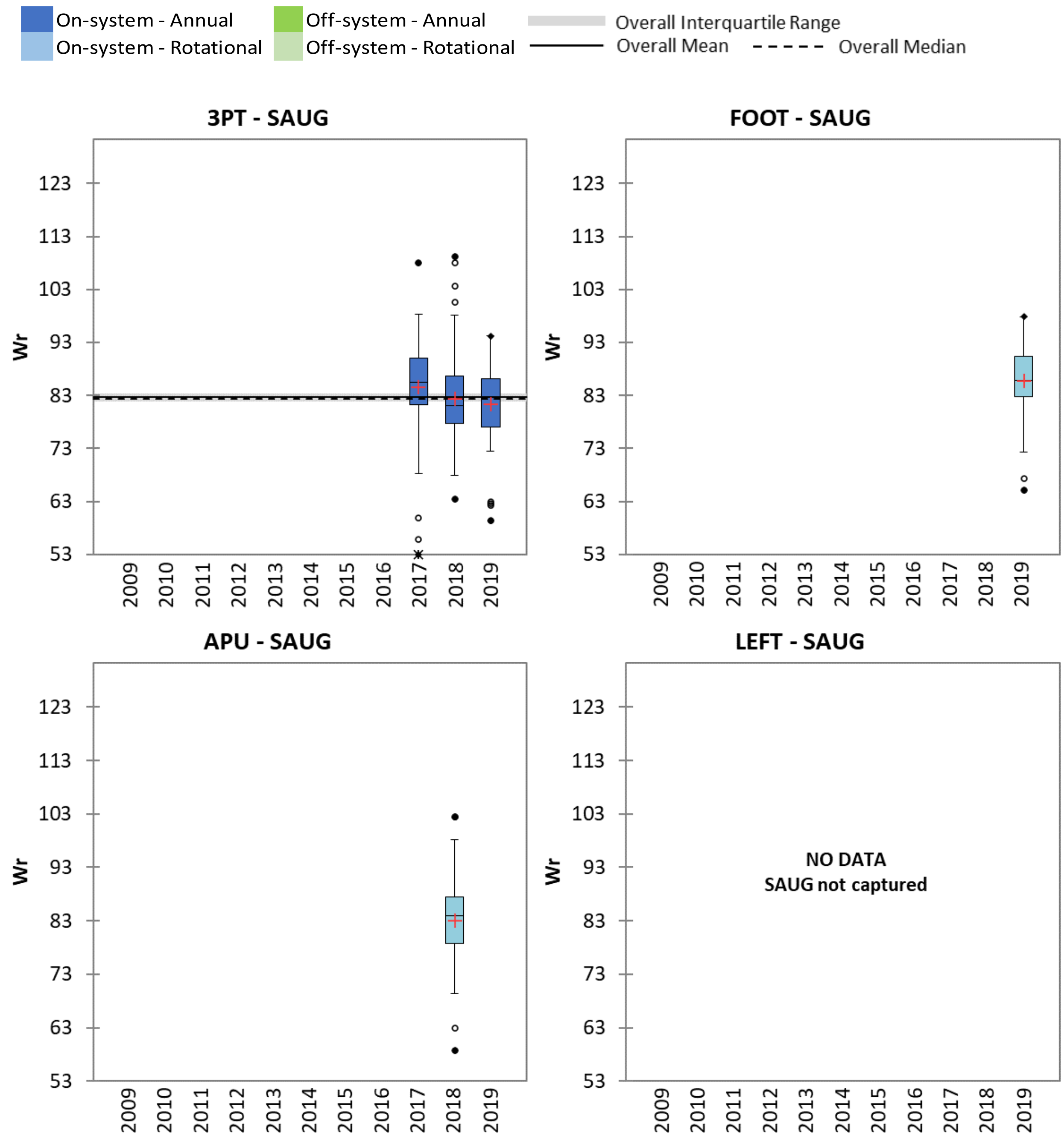


Figure 5.3-8. Relative weight (Wr) of Sauger.

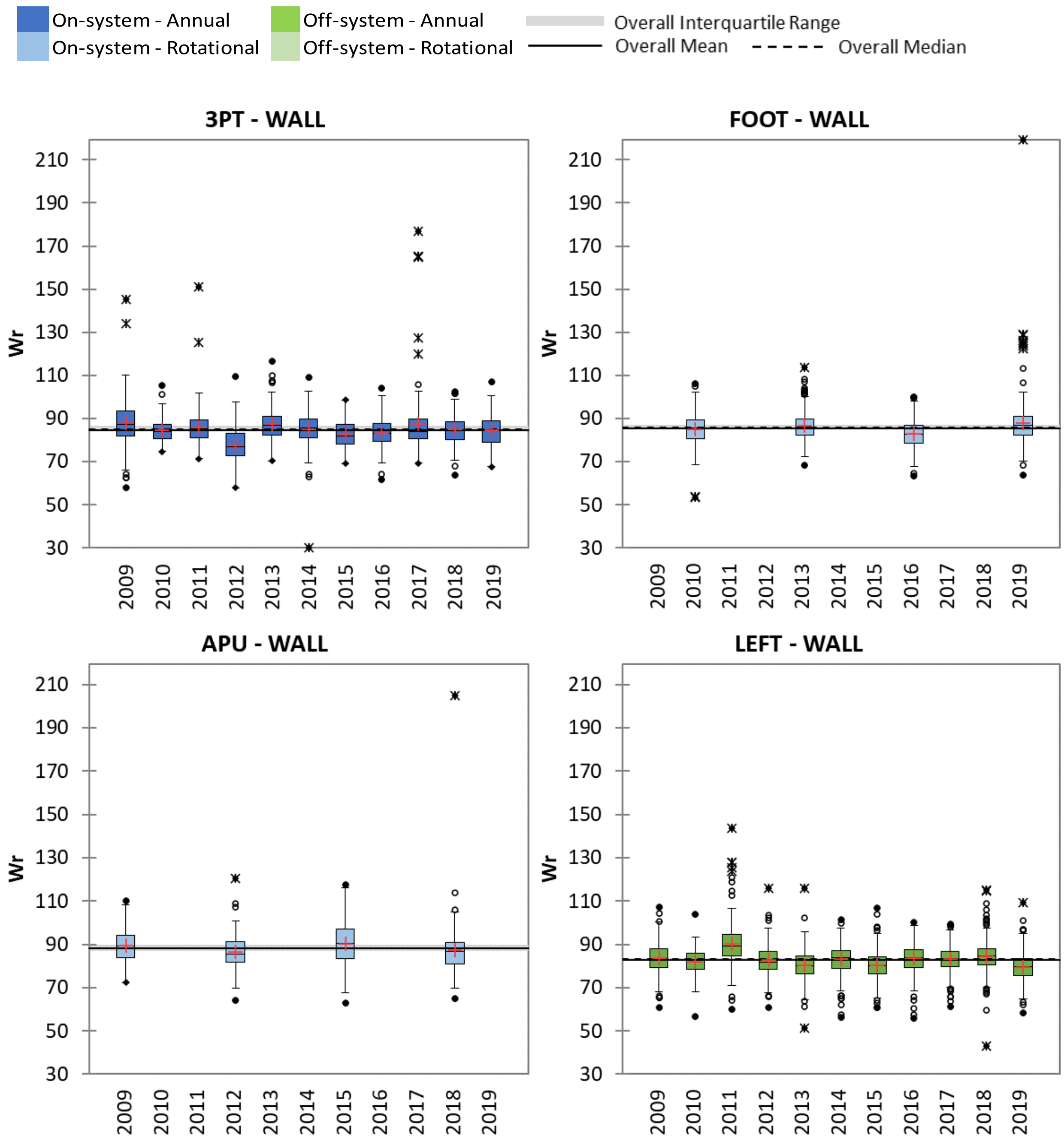


Figure 5.3-9. Relative weight (Wr) of Walleye.

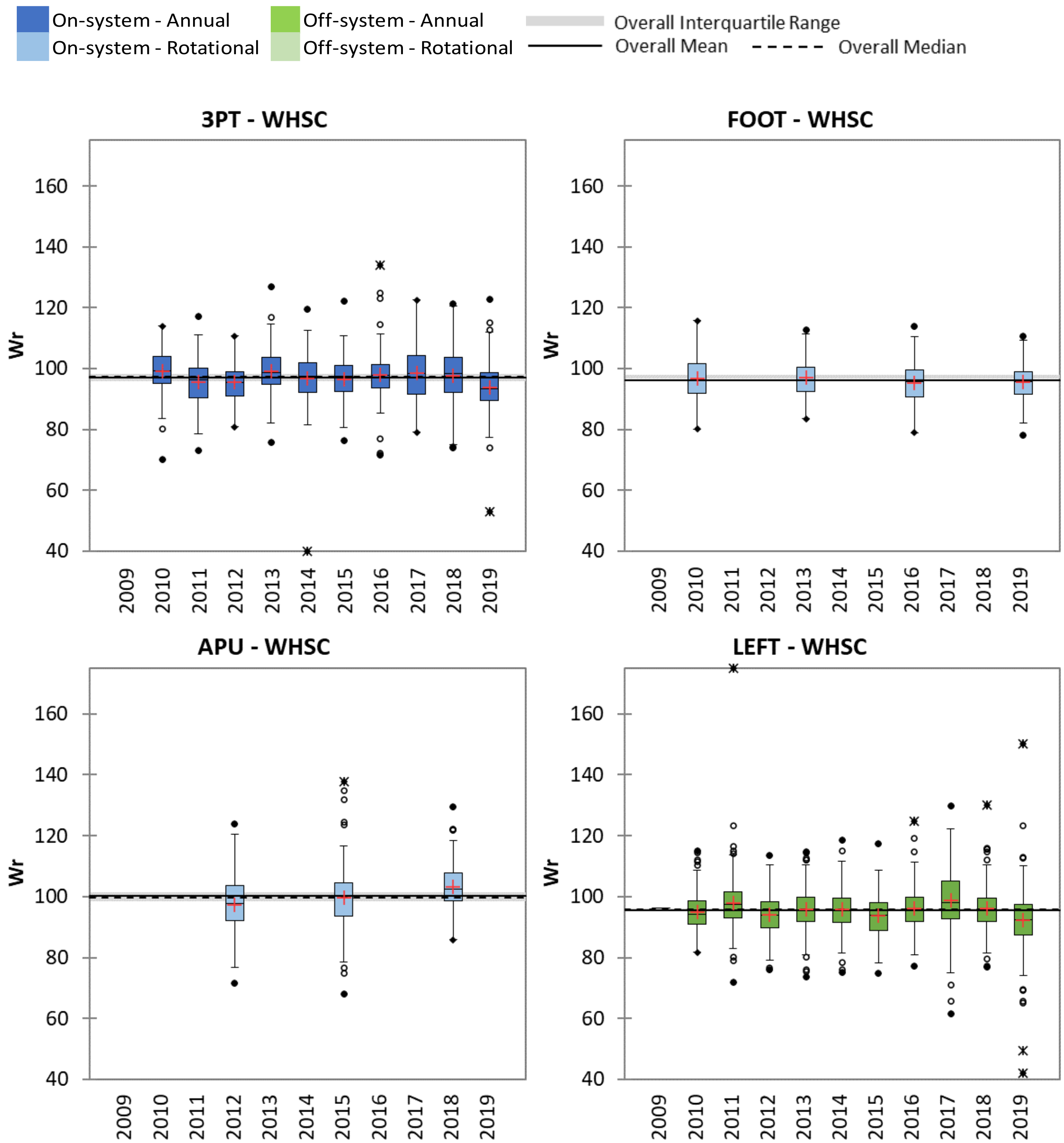


Figure 5.3-10. Relative weight (Wr) of White Sucker.

5.4 GROWTH

5.4.1 LENGTH-AT-AGE

5.4.1.1 ON-SYSTEM SITES

ANNUAL SITES

Threepoint Lake

Lake Whitefish

The annual mean FLA of 4-year-old Lake Whitefish over the 11 years of monitoring ranged from a low of 200 in 2017 to a high of 372 mm in 2015 (Table 5.4-1; Figure 5.4-1).

The overall mean FLA was 299, the median was 309, and the IQR was 270-329 mm (Figure 5.4-1). The annual mean FLA fell within the overall IQR except in 2009 and 2017 when it was below the IQR and in 2013-2015 when it was above the IQR.

Northern Pike

The annual mean FLA of 4-year-old Northern Pike over the 11 years of monitoring ranged from a low of 361 in 2011 to a high of 476 mm in 2019 (Table 5.4-1; Figure 5.4-2).

The overall mean FLA was 418, the median was 429, and the IQR was 396-438 mm (Figure 5.4-2). The annual mean FLA fell within the overall IQR except in 2009, 2011, and 2013 when it was below the IQR and in 2015, 2018, and 2019 when it was above the IQR.

Sauger

Individual Sauger were measured for length and aged at Threepoint Lake starting in 2017 (Table 5.3-1). The annual mean FLA of 3-year-old Sauger over the three years of monitoring ranged from a low of 170 in 2017 to a high of 186 mm in 2018 (Table 5.4-1; Figure 5.4-3).

The overall mean FLA was 179, the median was 181, and the IQR was 175-183 mm (Figure 5.4-3). The annual mean FLA fell within the overall IQR except in 2017 when it was below the IQR and in 2018 when it was above the IQR.

Walleye

The annual mean FLA of 3-year-old Walleye over the 11 years of monitoring ranged from a low of 193 in 2012 to a high of 250 mm in 2013 (Table 5.4-1; Figure 5.4-4).

The overall mean FLA was 227, the median was 230, and the IQR was 221-237 mm (Figure 5.4-4). The annual mean FLA fell within the overall IQR except in 2012 and 2018 when it was below the IQR and in 2013 and 2016 when it was above the IQR.

ROTATIONAL SITES

Footprint Lake

Lake Whitefish

Age-4 Lake Whitefish were not captured in Footprint Lake over the four years of monitoring (Table 5.2-1).

Northern Pike

The annual mean FLA of 4-year-old Northern Pike over the four years of monitoring ranged from a low of 370 in 2010 to a high of 437 mm in 2019 (Table 5.4-1; Figure 5.4-2).

The overall mean FLA was 402, the median was 401, and the IQR was 380-423 mm (Figure 5.4-2). The annual mean FLA fell within the overall IQR except in 2010 when it was below the IQR and in 2019 when it was above the IQR.

Sauger

Sauger was not a target species in Footprint Lake until 2017 and FLA is only available for 2019 (Table 5.3-1). The annual mean FLA of 3-year-old Sauger in 2019 was 297 mm (Table 5.4-1; Figure 5.4-3).

Walleye

The annual mean FLA of 3-year-old Walleye over the four years of monitoring ranged from a low of 217 in 2010 to a high of 250 mm in 2013 (Table 5.4-1; Figure 5.4-4).

The overall mean FLA was 227, the median was 221, and the IQR was 220-229 mm (Figure 5.4-4). The annual mean FLA fell within the overall IQR except in 2010 when it was below the IQR and in 2013 when it was above the IQR.

Apussigamasi Lake

Lake Whitefish

The annual mean FLA of 4-year-old Lake Whitefish over the four years of monitoring ranged from a low of 267 in 2018 to a high of 361 mm in 2015 (Table 5.4-1; Figure 5.4-1).

The overall mean FLA was 318, the median was 321, and the IQR was 301-338 mm (Figure 5.4-2). The annual mean FLA fell within the overall IQR except in 2018 when it was below the IQR and in 2015 when it was above the IQR.

Northern Pike

The annual mean FLA of 4-year-old Northern Pike over the four years of monitoring ranged from a low of 414 in 2012 to a high of 564 mm in 2018 (Table 5.4-1; Figure 5.4-2). No age-4 Northern Pike were captured in 2015.

The overall mean FLA was 468, the median was 426, and the IQR was 423-495 mm (Figure 5.4-2). The annual mean FLA fell within the overall IQR except in 2012 when it was below the IQR and in 2018 when it was above the IQR.

Sauger

Individual Sauger were measured for length and aged at Apussigamasi Lake starting in 2017 when it became a target species. (Table 5.3-1). The annual mean FLA of 3-year-old Sauger in 2018 was 182 mm (Table 5.3-1; Figure 5.3-3).

Walleye

The annual mean FLA of 3-year-old Walleye over the four years of monitoring ranged from a low of 209 in 2009 to a high of 244 mm in 2015 (Table 5.4-1; Figure 5.4-4).

The overall mean FLA was 228, the median was 229, and the IQR was 222-235 mm (Figure 5.4-4). The annual mean FLA fell within the overall IQR except in 2009 when it was below the IQR and in 2015 when it was above the IQR.

5.4.1.2 OFF-SYSTEM SITES

ANNUAL SITES

Leftrook Lake

Lake Whitefish

The annual mean FLA of 4-year-old Lake Whitefish over the 11 years of monitoring ranged from a low of 297 in 2010 to a high of 406 mm in 2016 (Table 5.4-1; Figure 5.4-1).

The overall mean FLA was 349, the median was 350, and the IQR was 349-371 mm (Figure 5.4-1). The annual mean FLA fell within the overall IQR except in 2009-2011, 2015, and 2019 when it was below the IQR and in 2013, 2016, and 2017 when it was above the IQR.

Northern Pike

The annual mean FLA of 4-year-old Northern Pike over the 11 years of monitoring ranged from a low of 422 in 2012 to a high of 477 mm in 2019 (Table 5.4-1; Figure 5.4-2).

The overall mean FLA was 445, the median was 444, and the IQR was 443-454 mm (Figure 5.4-2). The annual mean FLA fell within the overall IQR except in 2010-2012 and 2015 when it was below the IQR and in 2013, 2018, and 2019 when it was above the IQR.

Sauger

Age-3 Sauger were not captured in Leftrook Lake over the 11 years of monitoring (Table 5.2-1).

Walleye

The annual mean FLA of 3-year-old Walleye over the 11 years of monitoring ranged from a low of 191 in 2009 to a high of 245 mm in 2016 (Table 5.4-1; Figure 5.4-4).

The overall mean FLA was 230, the median was 235, and the IQR was 235-237 mm (Figure 5.4-4). The annual mean FLA fell within the overall IQR except in 2009, 2011, 2012 and 2014 when it was below the IQR and in 2015, 2016, and 2018 when it was above the IQR.

Table 5.4-1. 2009-2019 Fork length-at-age of target species.

Waterbody	Year	LKWH			NRPK			SAUG			WALL		
		n_F[1]	Mean	SE[2]	n_F	Mean	SE	n_F	Mean	SE	n_F	Mean	SE
3PT	2009	1	260	-	15	377	7				0	-	-
	2010	0	-	-	5	411	8				2	224	16
	2011	1	307	-	7	361	13				0	-	-
	2012	0	-	-	5	399	12				4	193	26
	2013	1	273	-	4	393	12				2	250	6
	2014	3	343	16	18	432	11				7	232	16
	2015	3	372	20	4	439	37				8	228	6
	2016	1	325	-	10	437	19				17	239	6
	2017	1	200	-	5	429	44	5	170	6	4	236	17
	2018	0	-	-	5	445	36	12	186	4	7	212	13
	2019	1	310	-	2	476	36	6	181	8	0	-	-
FOOT	2010	0	-	-	11	370	13				2	217	1
	2013	0	-	-	22	418	12				14	250	5
	2016	0	-	-	6	383	15				28	222	2
	2019	0	-	-	9	437	27	2	197	24	1	220	-
APU	2009	3	331	33	1	426	-				2	209	9
	2012	3	312	27	2	414	63				9	226	2
	2015	3	361	14	0	-	-				5	244	9
	2018	1	267	-	1	564	-	3	182	7	7	232	11
LEFT	2009	4	338	21	11	444	8				6	191	13
	2010	2	297	81	15	436	8				0	-	-
	2011	7	315	13	23	424	6				9	229	3
	2012	7	352	8	30	422	7				10	228	5
	2013	7	375	5	24	461	8				31	236	3
	2014	14	350	6	44	452	6				12	226	6
	2015	2	318	3	18	433	12				20	238	4
	2016	2	406	6	26	443	10				21	245	3
	2017	6	380	8	34	450	7	0	-	-	16	235	4
	2018	1	367	-	42	456	5	0	-	-	24	241	4
	2019	1	348	-	50	477	6	0	-	-	6	236	6

Notes:

1. n_F = number of fish measured for length and weight.
2. SE = standard error.
3. Grey shading indicates that a species was not a target species in that year.

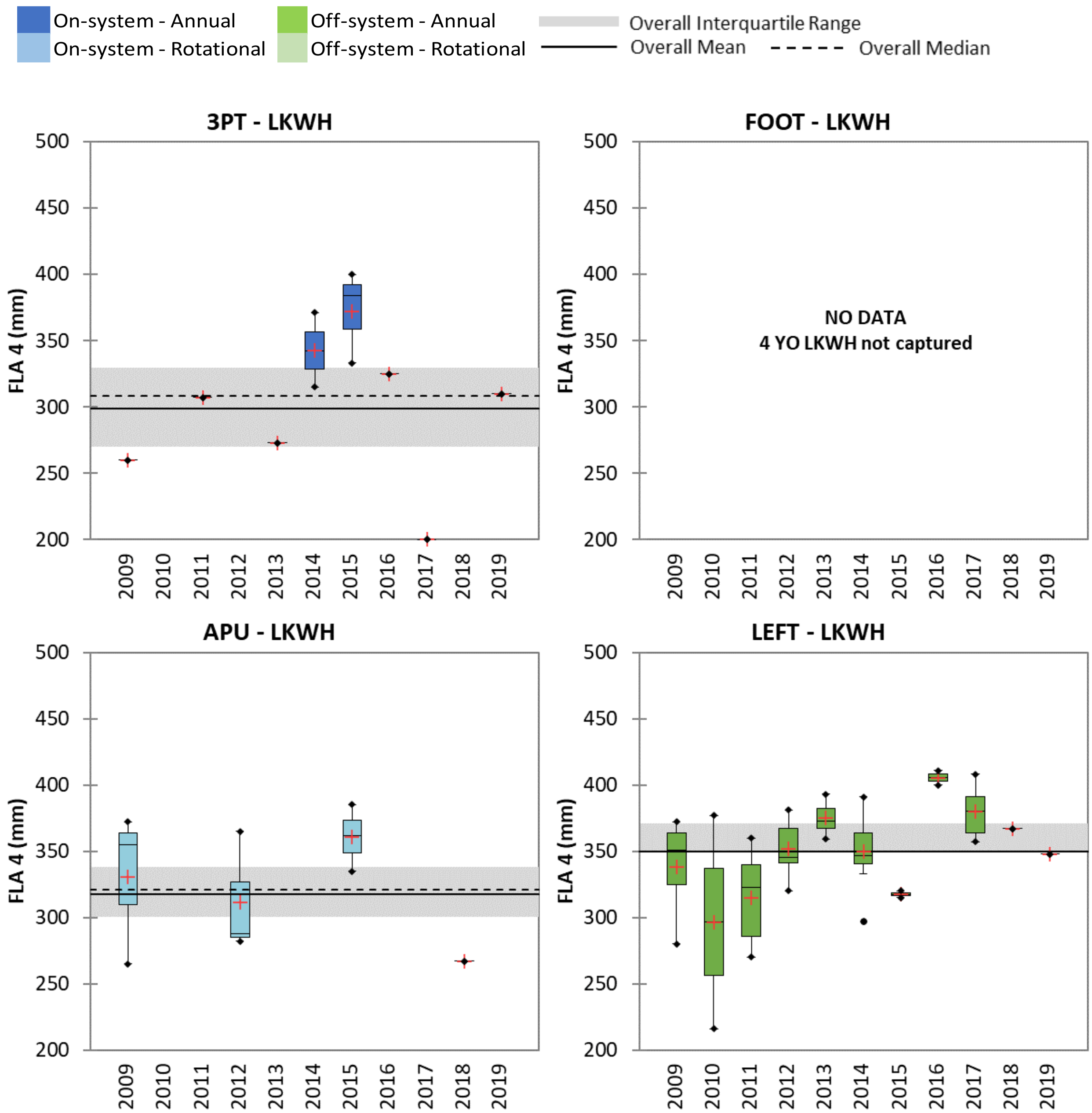


Figure 5.4-1. 2009-2019 Fork length-at-age (FLA) 4 of Lake Whitefish.

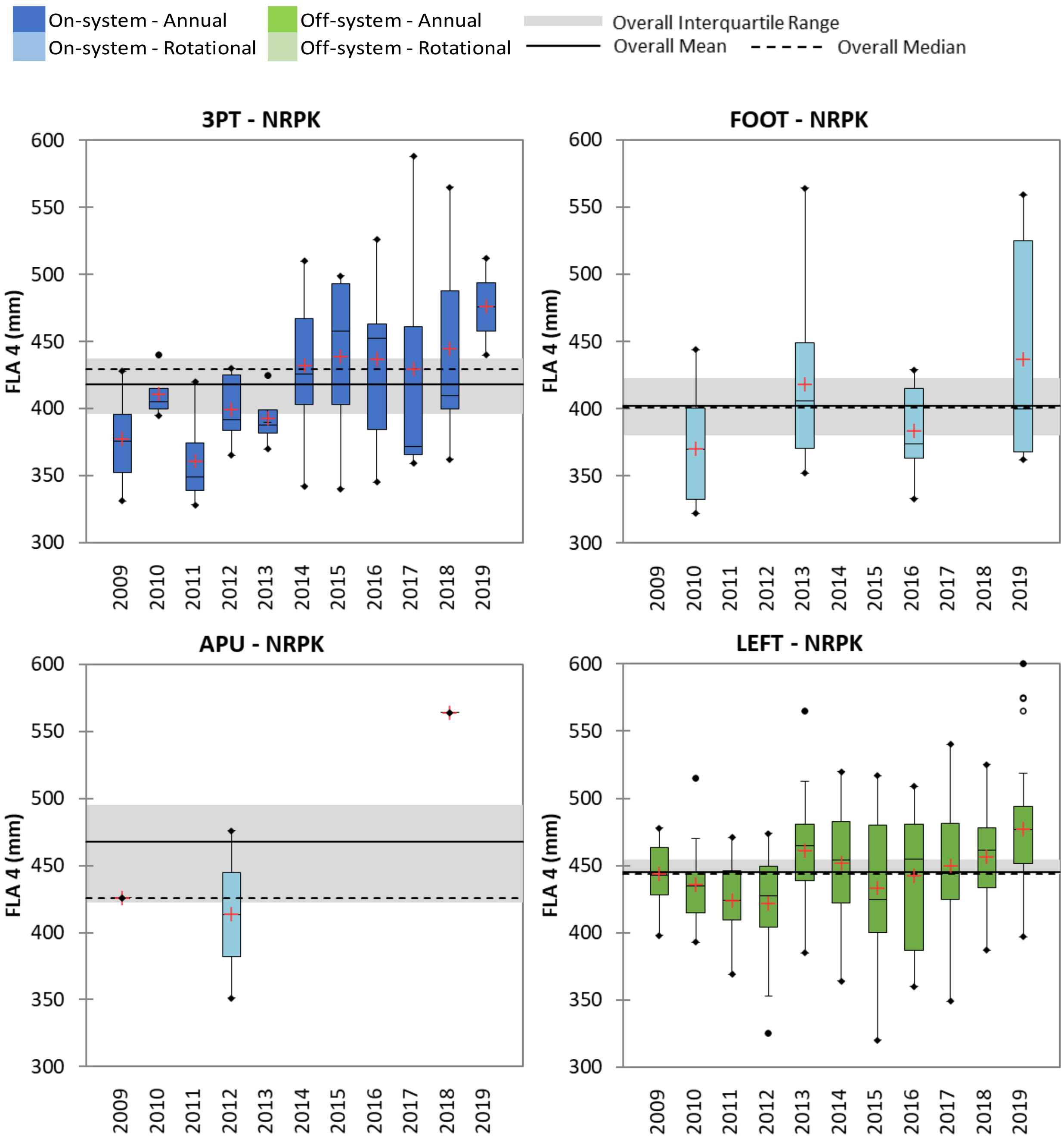


Figure 5.4-2. 2009-2019 Fork length-at-age (FLA) 4 of Northern Pike.

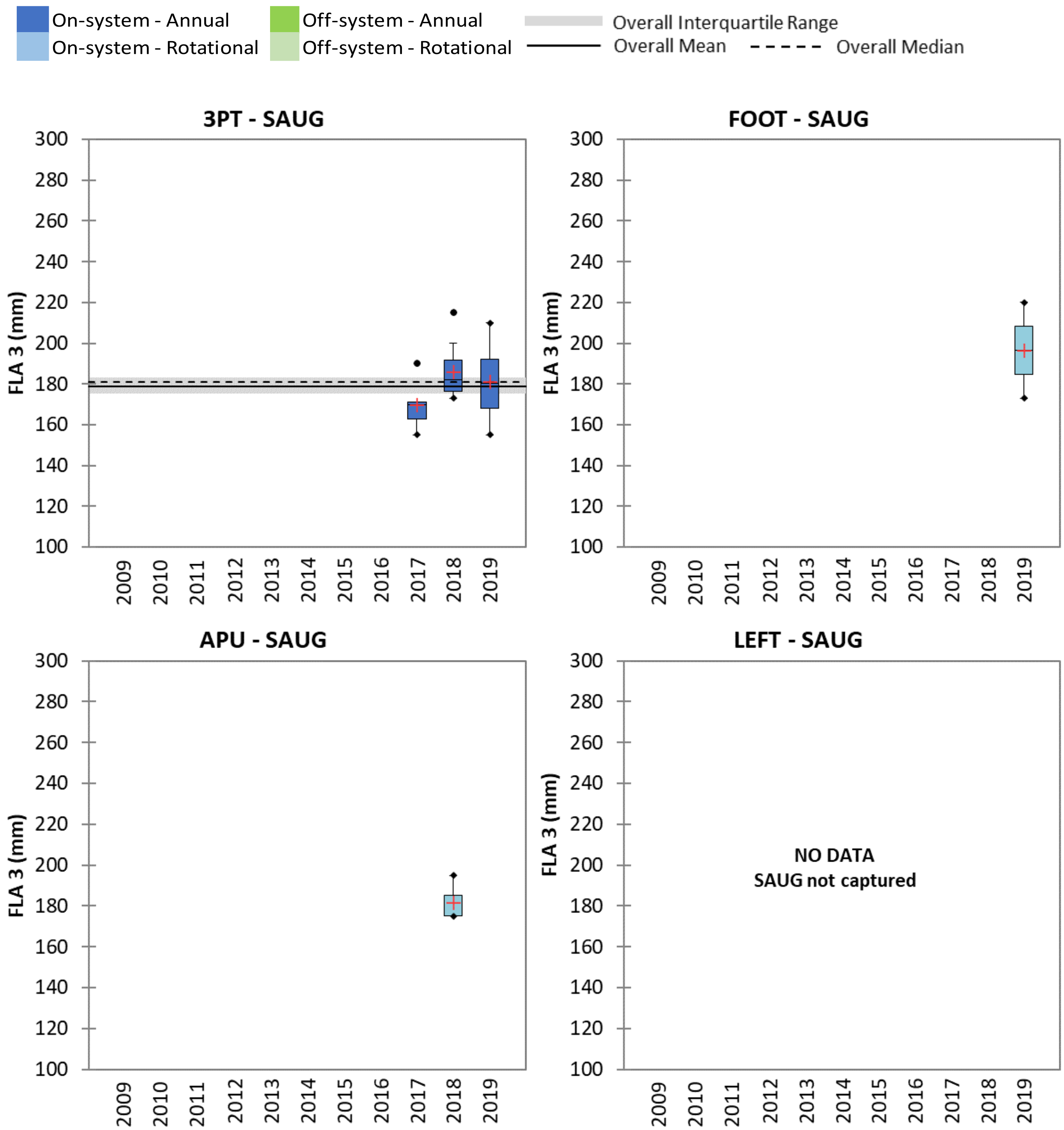


Figure 5.4-3. 2017-2019 Fork length-at-age (FLA) 3 of Sauger.

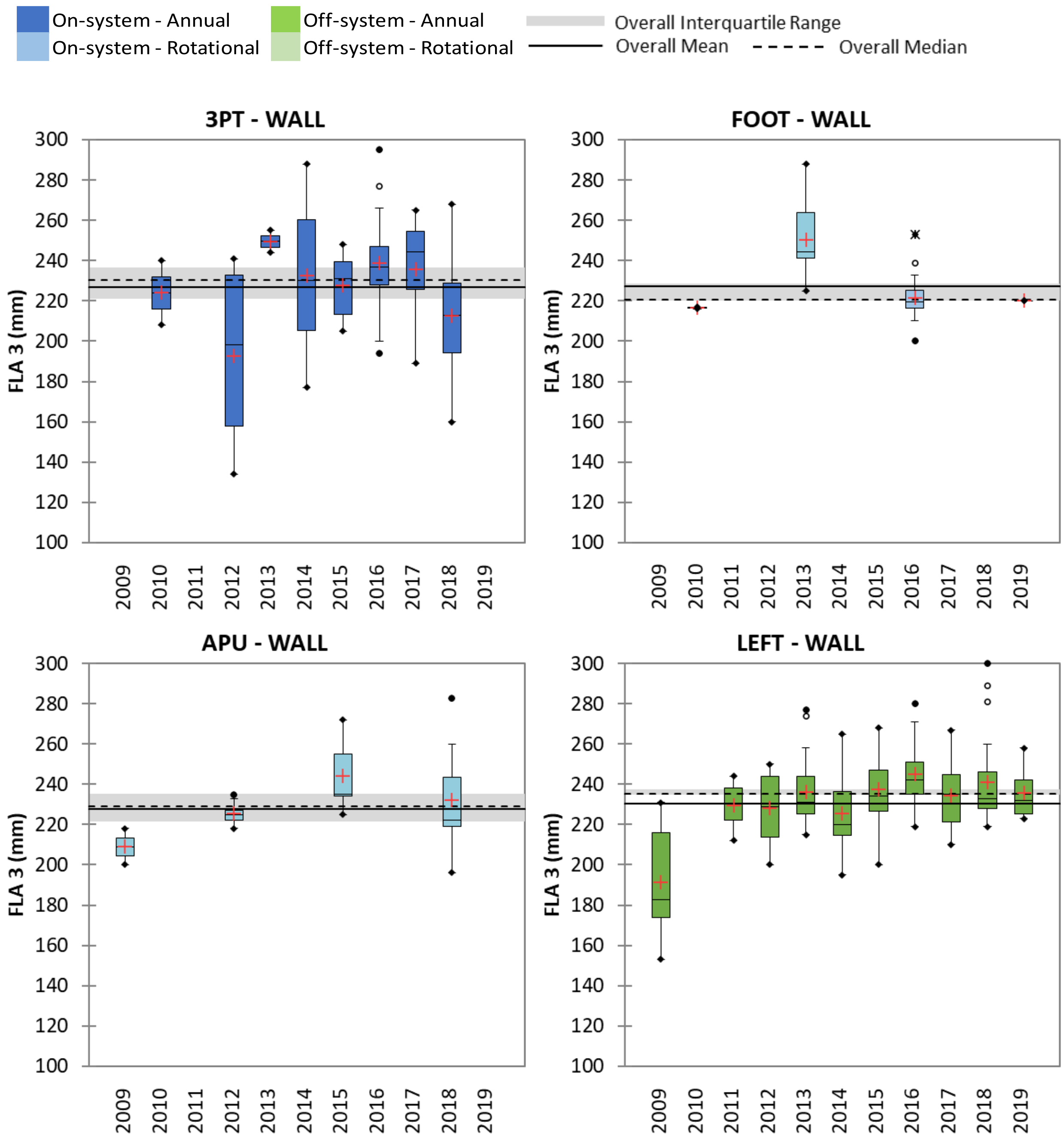


Figure 5.4-4. 2009-2019 Fork length-at-age (FLA) 3 of Walleye.

5.5 RECRUITMENT

5.5.1 RELATIVE YEAR-CLASS STRENGTH

5.5.1.1 ON-SYSTEM SITES

ANNUAL SITES

Threepoint Lake

Lake Whitefish

The RYCS of Northern Pike over the 11 years of monitoring ranged from a low of 0 for the 2000 and 2014 cohort to a high of 238 for the 1999 cohort (Figure 5.5-1). There were four missing cohorts (1997, 1998, 2000 and 2014) from 1997-2014. Particularly weak cohorts (<50) occurred in 2007, 2009, and 2013.

Northern Pike

The RYCS of Northern Pike over the 11 years of monitoring ranged from a low of 23 for the 2002 cohort to a high of 199 for the 2001 cohort (Figure 5.5-2). There were no missing cohorts from 1999-2014. Particularly weak cohorts (<50) occurred in 1999, 2000, and 2002.

Sauger

Individual Sauger from Threepoint Lake were aged starting in 2017 when it became a target species (Table 5.3-1). The RYCS of Sauger over the three years of monitoring ranged from a low of 4 for the 2005 cohort to a high of 41 for the 2007 cohort (Figure 5.5-3). There were no missing cohorts from 2005-2014, but particularly weak cohorts (<50) occurred in all years.

Walleye

The RYCS of Walleye over the 11 years of monitoring ranged from a low of 50 for the 2009 cohort to a high of 168 for the 2013 cohort (Figure 5.5-4). There were no missing cohorts from 1997-2014. There were no particularly weak cohorts (<50), but strong cohorts (>100) were produced in 2001-2003, 2006, and 2010-2014.

ROTATIONAL SITES

RYCS analysis requires data be collected in at least three consecutive years and therefore cannot be conducted for rotational waterbodies.

5.5.1.2 OFF-SYSTEM SITES

ANNUAL SITES

Leftrook Lake

Lake Whitefish

The RYCS of Northern Pike over the 11 years of monitoring ranged from a low of 29 for the 2012 cohort to a high of 215 for the 2007 cohort (Figure 5.5-1). There were no missing cohorts from 1997-2014. Particularly weak cohorts (<50) occurred in 2004, 2012, and 2013.

Northern Pike

The RYCS of Northern Pike over the 11 years of monitoring ranged from a low of 0 for the 1998 cohort to a high of 164 for the 1997 cohort (Figure 5.5-1). The 1998 cohort was the only missing cohort from 2002-2014. Particularly weak cohorts (<50) occurred in 1999, 2001, and 2002.

Sauger

Sauger were not captured in Leftrook Lake over the 11 years of monitoring (Table 5.2-1).

Walleye

The RYCS of Walleye over the 11 years of monitoring ranged from a low of 33 for the 2004 cohort to a high of 189 for the 1999 cohort (Figure 5.5-3). There were no missing cohorts from 1997-2014. Particularly weak cohorts (<50) occurred in 2004 and 2005 and strong cohorts (>100) were produced in 1997-2002, 2008, and 2010-2012.

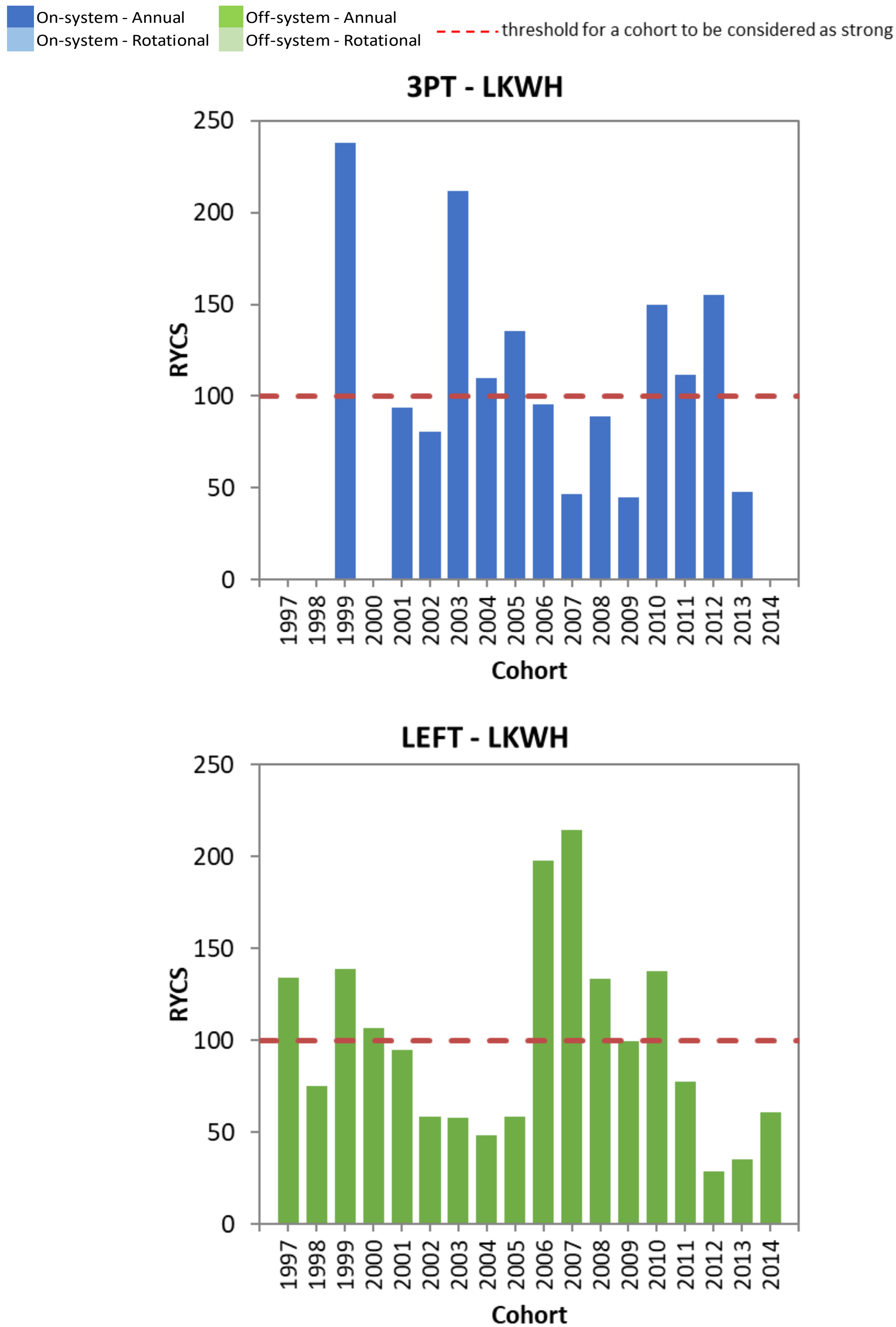


Figure 5.5-1. Relative year-class strength (RYCS) of Lake Whitefish.

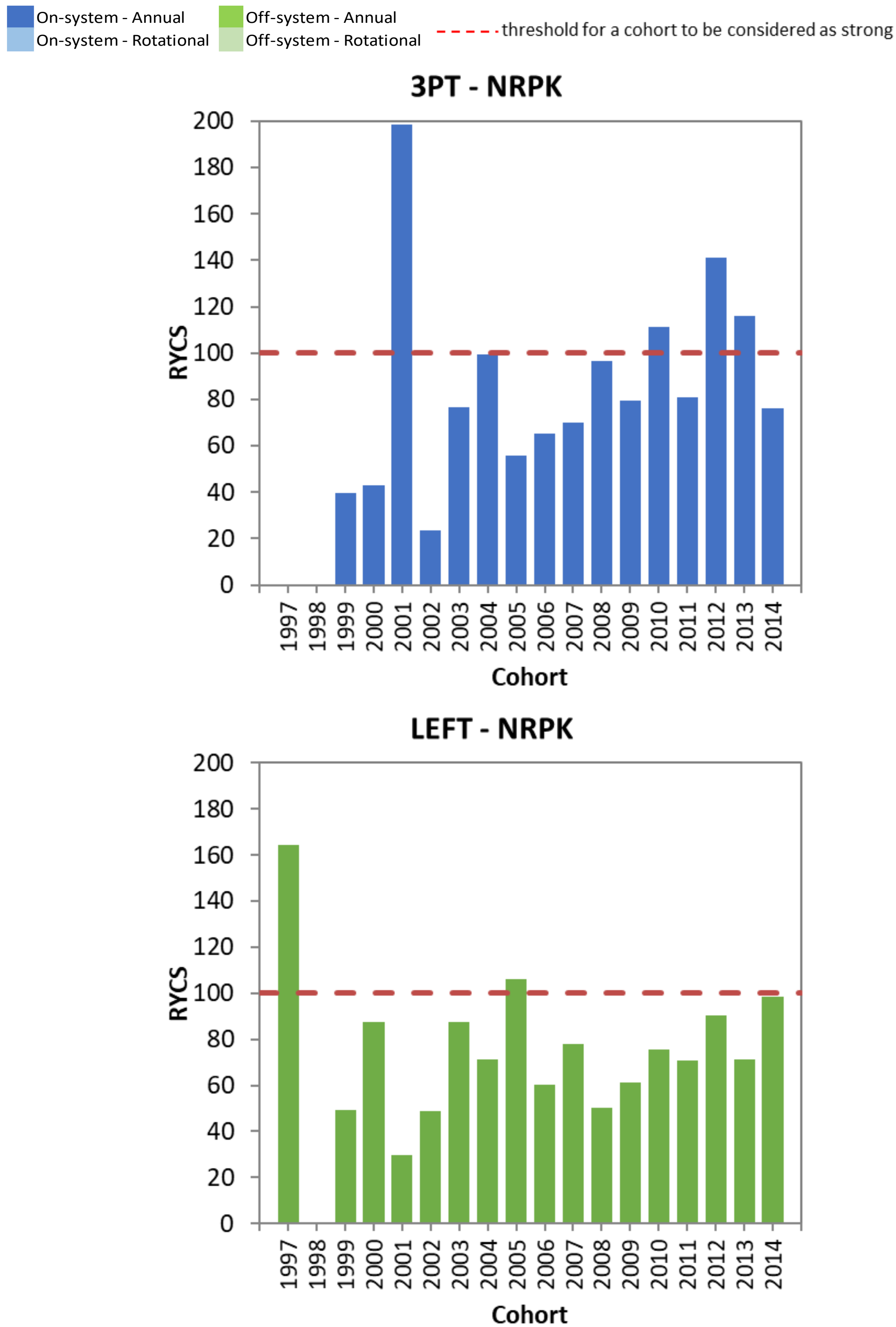
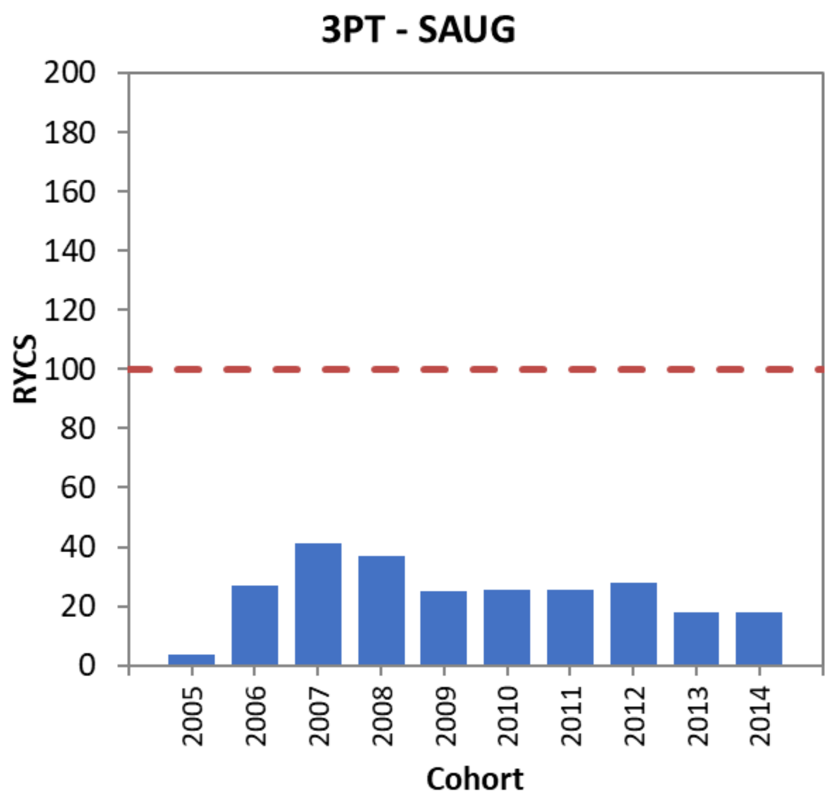


Figure 5.5-2. Relative year-class strength (RYCS) of Northern Pike.



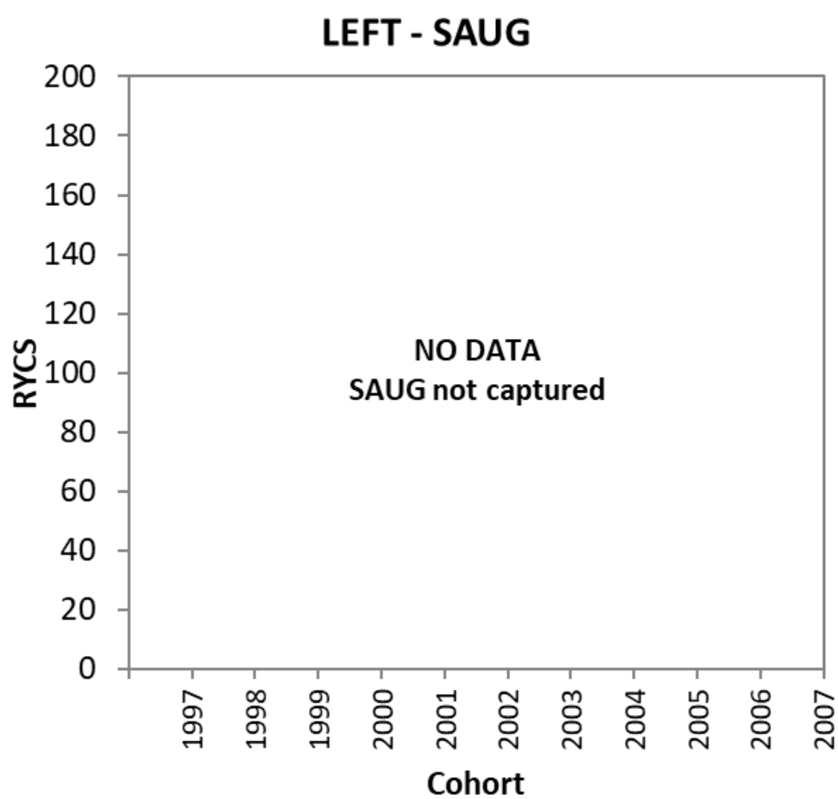


Figure 5.5-3 Relative year-class strength (RYCS) of Sauger.

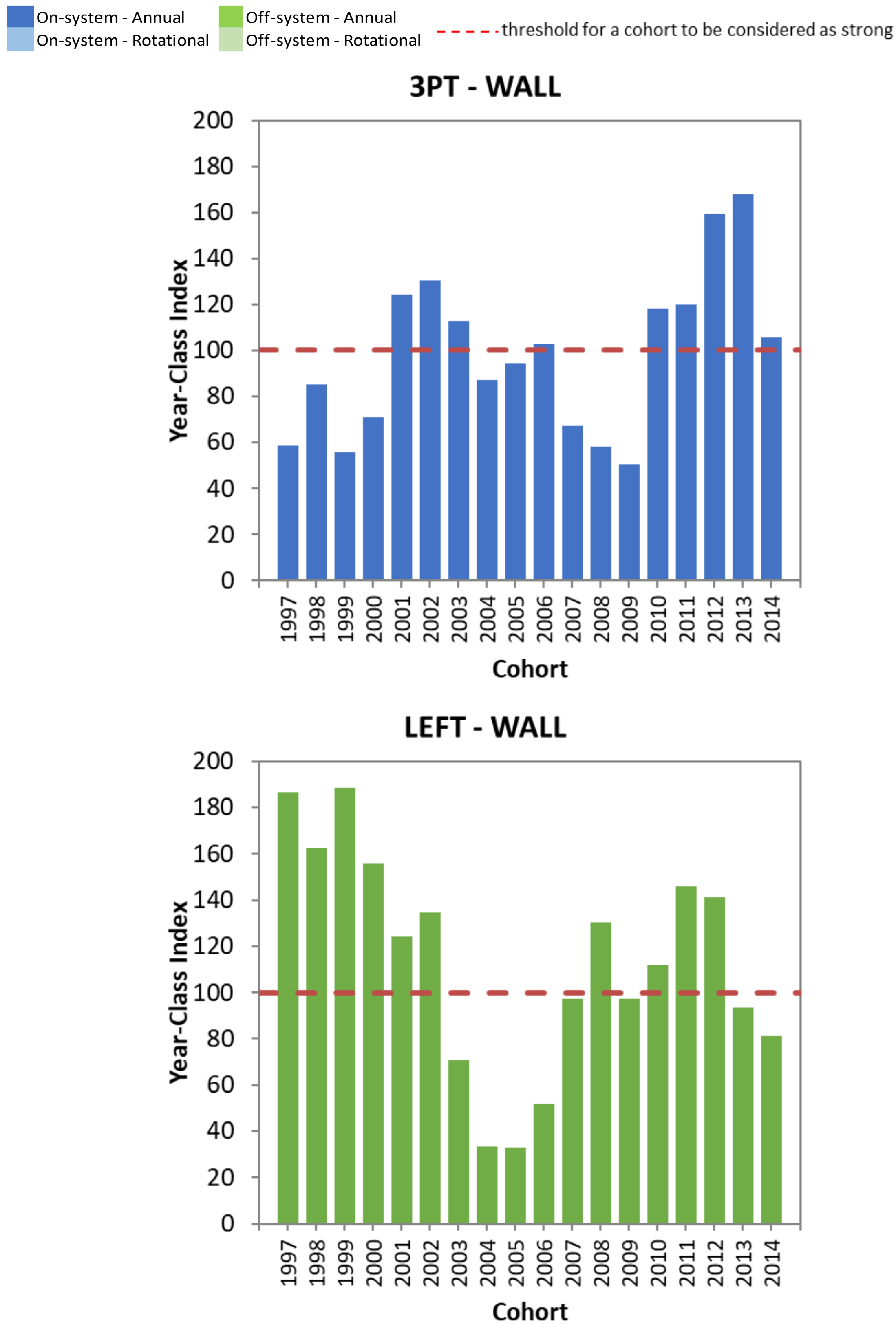


Figure 5.5-4. Relative year-class strength (RYCS) of Walleye.

5.6 DIVERSITY

5.6.1 RELATIVE SPECIES ABUNDANCE

5.6.1.1 ON-SYSTEM SITES

ANNUAL SITES

Threepoint Lake

A total of 13 fish species were captured in the combined standard and small mesh gangs at Threepoint Lake over 11 years of monitoring (Table 5.6-1) with the number of species caught each year ranging from 11-13 species (Tables 5.6-2 and 5.6-3).

Standard Gang Index Gill Nets

White Sucker and Walleye were the most frequently captured species at Threepoint Lake over 11 years of monitoring, each accounting for an average of >30% of the catch (Table 5.6-2). The annual RSA for White Sucker ranged from a low of 24% in 2015 to a high of 43% in 2018. The annual RSA for Walleye ranged from a low of 26% in 2018 to a high of 37% in 2013. Sauger accounted for >25% in one year (2016).

Small Mesh Index Gill Nets

The most common species captured in Threepoint Lake over 11 years of monitoring was Emerald Shiner (*Notropis atherinoides*), which accounted for an average of >25% of the catch (Table 5.6-3). The annual RSA for Emerald Shiner ranged from a low of 0% in 2012 to a high of 68% in 2015. Three other species accounted for >25% of the catch in some years: Sauger in 2009, 2012, and 2016; Walleye in 2012; and Spottail Shiner (*Notropis hudsonius*) in 2010, 2013, 2014, and 2017.

ROTATIONAL SITES

Footprint Lake

A total of 13 fish species were captured in the combined standard and small mesh gangs at Footprint Lake over four years of monitoring (Table 5.6-1), with the number of species caught each year ranging from 11-12 species (Tables 5.6-4 and 5.6-5). In one case, a sculpin was not identified to species (unidentified [unid.] sculpin species [spp.]).

Standard Gang Index Gill Nets

The catch in standard gangs set in Footprint Lake over four years of monitoring was dominated by Walleye, which accounted for an average of ≥38% of the catch (Table 5.6-4). The annual RSA of Walleye ranged from a low of 38% in 2010 to a high of 53% in 2016.

Small Mesh Index Gill Nets

The most common species captured in Footprint Lake over four years of monitoring was Spottail Shiner, which accounted for an average of >25% of the catch (Table 5.6-5). The annual RSA for Spottail Shiner ranged from a low of 28% in 2010 to a high of 60% in 2016. Two other species accounted for >25% of the catch in some years: Emerald Shiner in 2019; and Walleye in 2010.

Apussigamasi Lake

A total of 16 fish species were captured in the combined standard and small mesh gangs at Apussigamasi Lake over four years of monitoring (Table 5.6-1), with the number of species caught each year ranging from 13-16 species (Tables 5.6-6 and 5.6-7).

Standard Gang Index Gill Nets

The catch in standard gangs set in Apussigamasi Lake over four years of monitoring was predominantly Walleye, which accounted for an average of ≥25% of the catch (Table 5.6-6). The annual RSA of Walleye ranged from a low of 21% in 2018 to a high of 35% in 2009. White Sucker also accounted for >25% of the catch in 2018.

Small Mesh Index Gill Nets

The two most common species captured in Apussigamasi Lake over four years of monitoring was Sauger and Spottail Shiner, which both accounted for an average of >25% of the catch (Table 5.6-7). The annual RSA for Sauger ranged from a low of 10% in 2018 to a high of 42% in 2012, while the annual RSA for Spottail Shiner ranged from a low of 13% in 2012 to a high of 45% in 2018. No other species accounted for >25% of the catch in any year.

5.6.1.2 OFF-SYSTEM SITES

ANNUAL SITES

Leftrook Lake

A total of 11 fish species were captured in the combined standard and small mesh gangs at Leftrook Lake over 11 years of monitoring (Table 5.6-1), with the number of species caught each year ranging from 9-10 species (Tables 5.6-8 and 5.6-9). Sauger were not captured at Leftrook Lake.

Standard Gang Index Gill Nets

White Sucker and Walleye were the most frequently captured species at Leftrook Lake over 11 years of monitoring, accounting for an average of >30% of the catch (Table 5.6-8). The annual RSA for White Sucker ranged from a low of 20% in 2017 to a high of 40% in 2011. The annual RSA for Walleye ranged from a low of 20% in 2010 to a high of 44% in 2017.

Small Mesh Index Gill Nets

The most common species captured in Leftrook Lake over 11 years of monitoring was Spottail Shiner, which accounted for an average of >40% of the catch (Table 5.6-9). The annual RSA for Spottail Shiner ranged from a low of 1% in 2019 to a high of 78% in 2014. Three other species accounted for >25% of the catch in some years, Emerald Shiner in 2010, 2013, 2015, 2016, and 2019; Trout-perch (*Percopsis omiscomaycus*) in 2011 and 2019, and Walleye in 2009.

Table 5.6-1. Inventory of fish species.

Family	Species	Abbreviation	Status[1]	Target	3PT	FOOT	APU	LEFT
Hiodontidae	Goldeye	GOLD	Native				●	
	Mooneye	MOON	Native				●	
Cyprinidae	Lake Chub	LKCH	Native				●	
	Emerald Shiner	EMSH	Native		●	●	●	●
	Spottail Shiner	SPSH	Native		●	●	●	●
Catostomidae	Longnose Sucker	LNSC	Native		●		●	
	White Sucker	WHSC	Native	●	●	●	●	●
	Shorthead Redhorse	SHRD	Native		●	●	●	
Esocidae	Northern Pike	NRPK	Native	●	●	●	●	●
Salmonidae	Cisco	CISC	Native		●	●	●	●
	Lake Whitefish	LKWH	Native	●	●	●	●	●
Percopsidae	Trout-perch	TRPR	Native		●	●	●	●
Gadidae	Burbot	BURB	Native		●	●	●	●
Cottidae	unid. Sculpin spp.	-	Native			●		●
Percidae	Yellow Perch	YLPR	Native		●	●	●	●
	Sauger	SAUG	Native	●	●	●	●	
	Walleye	WALL	Native	●	●	●	●	●

Notes:

1. Assigned from Stewart and Watkinson (2004).

Table 5.6-2. 2009-2019 Relative species abundance in standard gang index gill nets in Threepoint Lake.

0%	>0-5%	>5-10%	>10-25%	>25-50%	>50%

Group	Species Code	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Mean
Target	LKWH	2%	1%	5%	3%	5%	3%	4%	1%	4%	2%	4%	3%
	NRPK	14%	12%	7%	7%	7%	10%	11%	3%	7%	6%	5%	8%
	SAUG	15%	12%	14%	16%	12%	21%	22%	33%	19%	18%	15%	18%
	WALL	28%	35%	34%	36%	37%	30%	29%	28%	29%	26%	31%	31%
	WHSC	29%	33%	29%	33%	32%	30%	24%	28%	30%	43%	34%	31%
Mooneyes	GOLD	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	MOON	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Minnows	LKCH	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	EMSH	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	SPSH	0%	0%	0%	0%	0%	0.3%	0%	0%	0%	0%	0%	0.02%
Suckers	LNSC	1%	1%	3%	1%	0.3%	1%	2%	1%	2%	0.4%	2%	1%
	SHRD	2%	0.4%	2%	1%	3%	1%	4%	3%	5%	1%	6%	3%
Coregonids	CISC	2%	5%	3%	1%	2%	1%	2%	1%	3%	2%	2%	2%
Trout-perch	TRPR	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Codfishes	BURB	1%	0.4%	1%	0.4%	0.3%	0%	0.3%	0%	0.3%	0%	0%	0.3%
Sculpins	Sculpin spp.	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Perch	YLPR	6%	1%	2%	1%	2%	3%	1%	1%	2%	1%	1%	2%

Table 5.6-3. 2009-2019 Relative species abundance in small mesh index gill nets in Threepoint Lake.

0%	>0-5%	>5-10%	>10-25%	>25-50%	>50%

Group	Species Code	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Mean
Target	LKWH	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	NRPK	4%	1%	0.5%	2%	2%	0.5%	0%	3%	0.1%	0%	0%	1%
	SAUG	36%	23%	20%	42%	24%	19%	9%	42%	1%	7%	11%	21%
	WALL	5%	13%	17%	48%	2%	1%	1%	6%	1%	1%	4%	9%
	WHSC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.2%	0%	0.02%
Mooneyes	GOLD	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	MOON	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Minnows	LKCH	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	EMSH	34%	14%	19%	0%	26%	28%	68%	29%	56%	62%	58%	36%
	SPSH	10%	38%	21%	0%	40%	44%	18%	4%	38%	24%	18%	23%
Suckers	LNSC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	SHRD	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.5%	0.04%
Coregonids	CISC	1%	4%	10%	0%	1%	3%	1%	0%	1%	2%	1%	2%
Trout-perch	TRPR	9%	7%	14%	8%	5%	3%	3%	17%	2%	3%	8%	7%
Codfishes	BURB	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sculpins	Sculpin spp.	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Perch	YLPR	0%	0%	0%	0%	0.4%	0%	0%	0%	0%	1%	0%	0.1%

Table 5.6-4. 2009-2019 Relative species abundance in standard gang index gill nets in Footprint Lake.

0%	>0-5%	>5-10%	>10-25%	>25-50%	>50%

Group	Species Code	2010	2013	2016	2019	Mean
Target	LKWH	0.4%	0.2%	0.2%	1%	0.3%
	NRPK	9%	10%	1%	4%	6%
	SAUG	4%	9%	12%	9%	9%
	WALL	38%	42%	53%	40%	43%
	WHSC	32%	12%	13%	21%	20%
Mooneyes	GOLD	0%	0%	0%	0%	0%
	MOON	0%	0%	0%	0%	0%
Minnows	LKCH	0%	0%	0%	0%	0%
	EMSH	0%	0%	0%	0%	0%
	SPSH	0%	0%	0%	0%	0%
Suckers	LNSC	0%	0%	0%	0%	0%
	SHRD	0.2%	0%	0.2%	2%	0.5%
Coregonids	CISC	12%	19%	18%	20%	17%
Trout-perch	TRPR	0%	0%	0%	0%	0%
Codfishes	BURB	0.2%	0%	0.4%	0.2%	0.2%
Sculpins	Sculpin spp.	0%	0%	0%	0%	0%
Perch	YLPR	4%	8%	2%	5%	5%

Table 5.6-5. 2009-2019 Relative species abundance in small mesh index gill nets in Footprint Lake.

0%	>0-5%	>5-10%	>10-25%	>25-50%	>50%

Group	Species Code	2010	2013	2016	2019	Mean
Target	LKWH	0%	0%	0%	0%	0%
	NRPK	4%	5%	2%	1%	3%
	SAUG	15%	23%	5%	4%	12%
	WALL	39%	13%	6%	7%	16%
	WHSC	1%	0%	0%	0%	0.3%
Mooneyes	GOLD	0%	0%	0%	0%	0%
	MOON	0%	0%	0%	0%	0%
Minnows	LKCH	0%	0%	0%	0%	0%
	EMSH	4%	1%	23%	40%	17%
	SPSH	28%	39%	60%	43%	43%
Suckers	LNSC	0%	0%	0%	0%	0%
	SHRD	0%	0%	0%	0%	0%
Coregonids	CISC	6%	9%	3%	0.2%	5%
Trout-perch	TRPR	3%	3%	1%	3%	2%
Codfishes	BURB	0%	0%	0%	0%	0%
Sculpins	Sculpin spp.	0%	1%	0%	0%	0.2%
Perch	YLPR	0%	6%	0.4%	1%	2%

Table 5.6-6. 2009-2019 Relative species abundance in standard gang index gill nets in Apussigamasi Lake.

0%	>0-5%	>5-10%	>10-25%	>25-50%	>50%

Group	Species Code	2009	2012	2015	2018	Mean
Target	LKWH	9%	6%	8%	7%	8%
	NRPK	5%	1%	4%	2%	3%
	SAUG	17%	23%	21%	18%	20%
	WALL	35%	29%	29%	21%	29%
	WHSC	17%	23%	23%	28%	22%
Mooneyes	GOLD	0%	0%	0%	0%	0%
	MOON	5%	1%	5%	9%	5%
Minnows	LKCH	0.4%	0%	0%	0%	0.1%
	EMSH	0%	0%	0%	0%	0%
	SPSH	0%	0%	0%	0%	0%
Suckers	LNSC	3%	3%	3%	7%	4%
	SHRD	2%	7%	3%	5%	4%
Coregonids	CISC	3%	3%	3%	2%	3%
Trout-perch	TRPR	0%	0%	0%	0%	0%
Codfishes	BURB	1%	1%	0%	1%	1%
Sculpins	Sculpin spp.	0%	0%	0%	0%	0%
Perch	YLPR	3%	1%	1%	0.2%	1%

Table 5.6-7. 2009-2019 Relative species abundance in small mesh index gill nets in Apussigamasi Lake.

0%	>0-5%	>5-10%	>10-25%	>25-50%	>50%

Group	Species Code	2009	2012	2015	2018	Mean
Target	LKWH	0%	0%	0%	0%	0%
	NRPK	2%	1%	0%	0.5%	1%
	SAUG	40%	42%	27%	10%	30%
	WALL	13%	8%	15%	11%	12%
	WHSC	0%	1%	0%	0%	0.1%
Mooneyes	GOLD	1%	0%	0%	0%	0.2%
	MOON	5%	1%	4%	7%	4%
Minnows	LKCH	0%	0%	0%	0.5%	0.1%
	EMSH	4%	2%	8%	17%	8%
	SPSH	21%	13%	41%	45%	30%
Suckers	LNSC	0%	0%	0%	0%	0%
	SHRD	0%	0%	0%	0%	0%
Coregonids	CISC	1%	10%	4%	3%	5%
Trout-perch	TRPR	13%	22%	2%	6%	10%
Codfishes	BURB	0%	0%	0%	0%	0%
Sculpins	Sculpin spp.	0%	0%	0%	0%	0%
Perch	YLPR	0%	1%	0%	0%	0.1%

Table 5.6-8. 2009-2019 Relative species abundance in standard gang index gill nets in Leftrook Lake.

0%	>0-5%	>5-10%	>10-25%	>25-50%	>50%

Group	Species Code	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Mean
Target	LKWH	12%	16%	8%	15%	17%	15%	10%	9%	12%	8%	11%	12%
	NRPK	11%	13%	15%	14%	11%	17%	12%	8%	8%	10%	14%	12%
	SAUG	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	WALL	30%	20%	30%	33%	27%	29%	33%	38%	44%	34%	31%	32%
	WHSC	36%	35%	40%	23%	35%	23%	30%	33%	20%	29%	35%	31%
Mooneyes	GOLD	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	MOON	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Minnows	LKCH	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	EMSH	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	SPSH	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Suckers	LNSC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	SHRD	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Coregonids	CISC	4%	13%	2%	11%	8%	5%	3%	8%	5%	9%	4%	7%
Trout-perch	TRPR	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Codfishes	BURB	0.3%	0%	0.1%	0%	0%	0.1%	0%	0%	0.1%	0%	0%	0.1%
Sculpins	Sculpin spp.	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Perch	YLPR	6%	2%	5%	4%	2%	11%	12%	5%	10%	9%	5%	6%

Table 5.6-9. 2009-2019 Relative species abundance in small mesh index gill nets in Leftrook Lake.

0%	>0-5%	>5-10%	>10-25%	>25-50%	>50%

Group	Species Code	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Mean
Target	LKWH	1%	0%	2%	0%	0.5%	0.2%	0.4%	0.3%	0%	0%	1%	1%
	NRPK	5%	2%	2%	0.5%	5%	1%	4%	1%	2%	6%	1%	3%
	SAUG	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	WALL	43%	13%	15%	2%	6%	1%	13%	4%	3%	20%	21%	13%
	WHSC	1%	0.5%	0%	0%	0%	0%	0%	0%	0%	1%	1%	0.3%
Mooneyes	GOLD	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	MOON	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Minnows	LKCH	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	EMSH	6%	36%	3%	20%	42%	17%	52%	31%	16%	8%	37%	24%
	SPSH	26%	30%	27%	75%	37%	78%	23%	56%	72%	55%	1%	44%
Suckers	LNSC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	SHRD	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Coregonids	CISC	0%	1%	3%	0%	1%	0%	0%	0%	0%	1%	2%	1%
Trout-perch	TRPR	17%	14%	41%	2%	5%	0.4%	3%	4%	4%	4%	36%	12%
Codfishes	BURB	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sculpins	Sculpin spp.	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.2%
Perch	YLPR	0.3%	2%	7%	0%	3%	3%	4%	3%	3%	4%	0.3%	3%

5.6.2 HILL'S EFFECTIVE RICHNESS

5.6.2.1 ON-SYSTEM SITES

ANNUAL SITES

Threepoint Lake

Hill's effective species richness over the 11 years of monitoring ranged from a low of 4.8 in 2012 to a high of 8.3 species in 2011 (Table 5.6-10; Figure 5.6-1).

The overall mean Hill's index value was 6.6, the median was 6.9, and the IQR was 5.8-7.4 species (Figure 5.6-1). The annual mean Hill's index value fell within the overall IQR except in 2012, 2015, and 2017 when it was below the IQR and in 2011, 2013, and 2019 when it was above the IQR.

ROTATIONAL SITES

Footprint Lake

The Hill's effective species richness over the four years of monitoring ranged from a low of 5.3 in 2010 to a high of 7.2 species in 2019 (Table 5.6-10; Figure 5.6-1).

The overall mean Hill's index value was 6.1, the median was 5.9, and the IQR was 5.8-6.4 species (Figure 5.6-1). The annual mean Hill's index value was below the IQR in 2010 and was above the IQR in 2019.

Apussigamasi Lake

The Hill's effective species richness over the four years of monitoring ranged from a low of 7.7 in 2012 to a high of 9.4 species in 2018 (Table 5.6-10; Figure 5.6-1).

The overall mean Hill's index value was 8.3, the median was 8.1, and the IQR was 7.8-8.6 species (Figure 5.6-1). The annual mean Hill's index value was below the IQR in 2012 and was above the IQR in 2018.

5.6.2.2 OFF-SYSTEM SITES

ANNUAL SITES

Leftrook Lake

Hill's effective species richness over the 11 years of monitoring ranged from a low of 4.3 in 2014 to a high of 8.1 species in 2010 (Table 5.6-10; Figure 5.6-1).

The overall mean and median Hill's index values were 6.4, and the IQR was 6.4-6.7 species (Figure 5.6-1). The annual mean Hill's index value fell within the overall IQR except in 2009, 2012, 2014, and 2017 when it was below the IQR and in 2010, 2013, and 2015 when it was above the IQR.

Table 5.6-10. 2009-2019 Hill's effective species richness.

Waterbody	Year	n_F[1]	n_{spp}[2]	Value
3PT	2009	443	13	7.3
	2010	383	13	6.9
	2011	537	13	8.3
	2012	283	11	4.8
	2013	566	13	7.5
	2014	798	12	7.2
	2015	884	13	5.7
	2016	568	12	6.0
	2017	1590	13	4.8
	2018	738	12	5.9
	2019	506	12	7.6
FOOT	2010	552	12	5.3
	2013	692	11	6.1
	2016	1089	12	5.8
	2019	1012	12	7.2
APU	2009	601	16	8.3
	2012	509	14	7.7
	2015	639	13	7.9
	2018	652	15	9.4
LEFT	2009	1312	10	6.1
	2010	950	10	8.1
	2011	989	10	6.4
	2012	1640	9	6.2
	2013	1226	9	7.2
	2014	3412	10	4.3
	2015	1412	9	6.9
	2016	1861	9	6.4
	2017	2015	10	5.8
	2018	1420	9	6.5
	2019	1092	9	6.4

Notes:

1. n_F = number of fish caught in standard and small mesh gill nets.
2. n_{spp} = number of species caught in standard and small mesh gill nets.

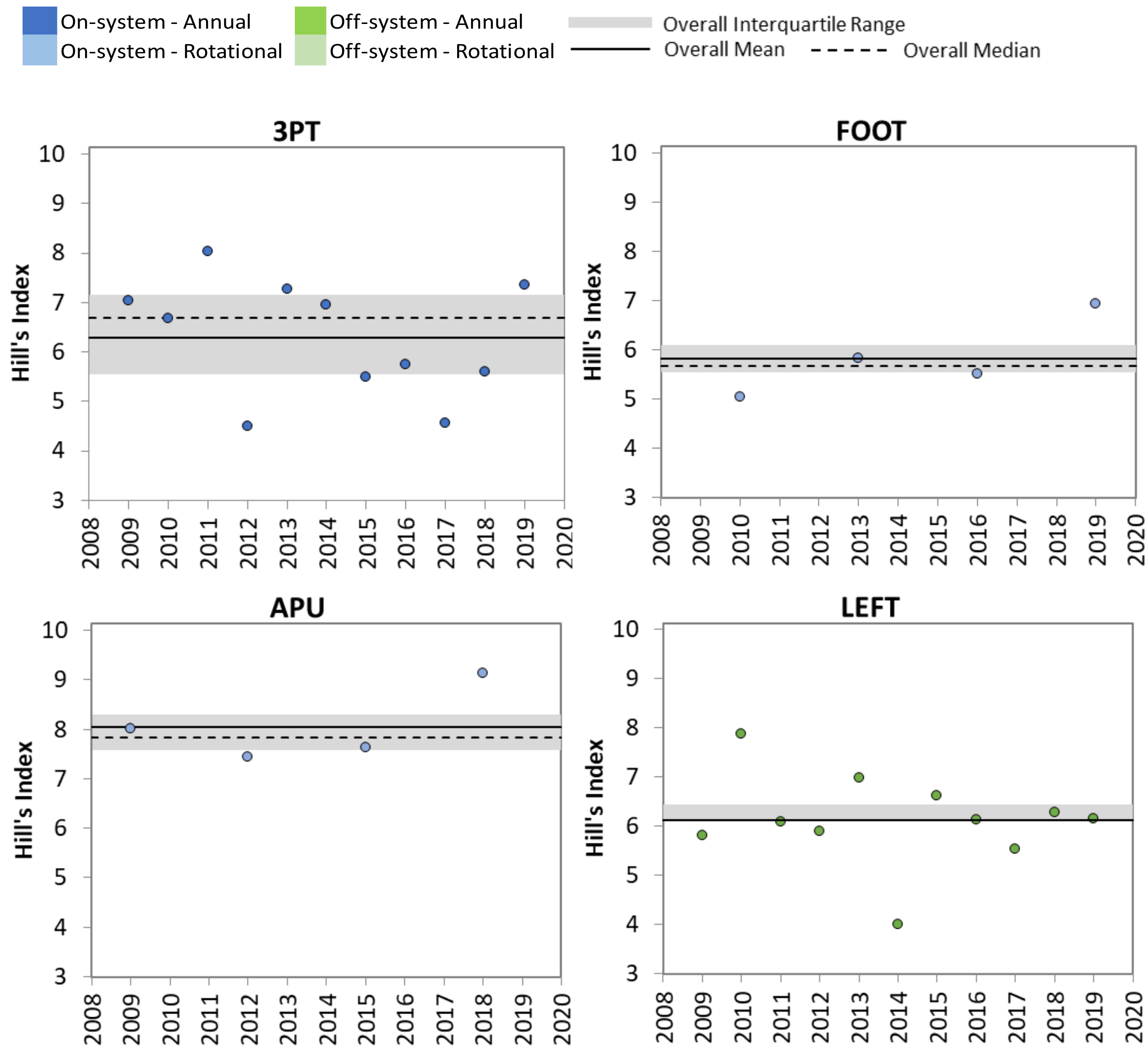


Figure 5.6-1. 2009-2019 Hill's effective species richness.

APPENDIX 5-1. GILLNETTING SITE INFORMATION AND LOCATIONS

The following is a summary of modifications and deviations in sampling locations over the 11 years of monitoring in the Churchill River Diversion Region:

Threepoint Lake

- Gill nets were set at the target locations in all 11 years with the following exceptions:
  - GN-01 was sampled in 2009 and 2011 but was discontinued after the Pilot Program, starting in 2012.
  - GN-09 was not sampled in 2009 or 2011 (the years GN-01 was sampled) but was sampled in 2010 (the year GN-01 was not sampled) and has been sampled every year after the Pilot Program, starting in 2012.
  - SN-02 was sampled in 2009, 2011, and 2012 but was discontinued starting in 2013.
  - SN-09 was not sampled in 2009, 2011, or 2012 (the years SN-02 was sampled) but was sampled in 2010 (the year SN-02 was not sampled) and has been sampled every year starting in 2013.
  - SN-16 was named SN-13 in 2010 but was set at the SN-16 target location.

Footprint Lake

- Gill nets were set at the target locations in all four years.

Apussigamasi Lake

- Gill nets were set at the target locations in all four years.

Leftrook Lake

- Gill nets were set at the target locations in all 11 years.

Table A5-1-1. 2008-2019 Set information for gillnetting sites.

Waterbody	Site	Set Date	UTM Coordinates			Duration (dec. hrs)	Water Depth (m)		Set Water Temperature (°C)
			Zone	Easting	Northing		Start	End	
3PT	GN-01	18-Aug-09	14	504524	6175533	22.2	4.1	3.4	15.0
	GN-02	16-Aug-09	14	503777	6173256	48.3	3.8	0.9	16.0
	GN-04	16-Aug-09	14	501692	6174036	47.7	5.8	5.9	16.0
	GN-05	15-Aug-09	14	501586	6174659	21.2	6.2	6.1	17.0
	GN-06	15-Aug-09	14	500052	6174858	21.8	4.5	1.7	16.0
	GN-13	19-Aug-09	14	508609	6170673	23.5	2.4	3.9	15.0
	GN-15	19-Aug-09	14	507000	6169388	22.9	4.4	3.2	14.0
	GN-16	19-Aug-09	14	507537	6169677	23.7	4.8	4.5	15.0
	GN-17	18-Aug-09	14	505944	6174769	22.4	4.1	3.6	15.0
	SN-02	16-Aug-09	14	503911	6173274	48.3	3.8	0.9	16.0
	SN-15	19-Aug-09	14	506862	6169370	22.9	4.4	3.2	14.0
	SN-16	19-Aug-09	14	507503	6169809	23.7	4.8	4.5	15.0
	GN-02	25-Aug-10	14	503842	6172984	24.5	4.4	1.0	14.0
	GN-04	23-Aug-10	14	502095	6174452	46.9	5.8	6.3	15.0
	GN-05	23-Aug-10	14	501259	6174416	46.3	5.9	5.7	15.0
	GN-06	23-Aug-10	14	500133	6174917	47.3	2.4	4.3	15.0
	GN-09	25-Aug-10	14	503201	6169924	23.5	3.9	4.5	14.0
	GN-13	26-Aug-10	14	508559	6170496	21.0	4.3	0.7	14.0
	GN-15	26-Aug-10	14	507251	6169354	21.1	4.7	4.7	14.0
	GN-16	26-Aug-10	14	507527	6169574	20.9	5.0	5.9	14.0
	GN-17	25-Aug-10	14	505986	6174705	24.0	4.2	1.0	14.0
	SN-09	25-Aug-10	14	503334	6169955	23.5	3.4	3.4	14.0
	SN-15	26-Aug-10	14	507121	6169444	21.1	4.7	4.7	14.0
	SN-16	26-Aug-10	14	507527	6169574	20.9	5.0	5.0	14.0
	GN-01	18-Aug-11	14	504404	6175672	22.0	3.5	3.8	18.0
	GN-02	18-Aug-11	14	503721	6173833	22.1	3.3	2.9	18.0
	GN-04	19-Aug-11	14	501695	6174049	23.1	5.4	5.5	17.0
	GN-05	19-Aug-11	14	501715	6174726	23.3	5.6	5.5	17.0
	GN-06	19-Aug-11	14	500079	6174824	22.8	3.9	3.1	17.0
	GN-13	16-Aug-11	14	507673	6169596	43.6	4.2	4.5	18.5
	GN-15	16-Aug-11	14	506933	6169297	44.2	4.0	3.6	18.5
	GN-16	16-Aug-11	14	507415	6169730	43.1	3.9	4.2	18.5

Table A5-1-1. continued.

Waterbody	Site	Set Date	UTM Coordinates			Duration (dec. hrs)	Water Depth (m)		Set Water Temperature (°C)
			Zone	Easting	Northing		Start	End	
3PT	GN-17	18-Aug-11	14	505969	6174633	21.9	2.5	3.9	18.0
	SN-02	18-Aug-11	14	503721	6173833	22.1	3.3	3.3	18.0
	SN-13	16-Aug-11	14	507673	6169596	43.6	4.2	4.2	18.5
	SN-15	16-Aug-11	14	506933	6169297	43.4	4.0	4.0	18.5
	GN-02	13-Aug-12	14	503956	6172998	19.1	2.8	5.7	19.5
	GN-04	13-Aug-12	14	502081	6174452	19.5	7.1	7.0	19.5
	GN-05	13-Aug-12	14	501191	6174346	19.7	7.1	7.7	19.5
	GN-06	13-Aug-12	14	500138	6174942	19.8	1.9	5.6	19.5
	GN-09	12-Aug-12	14	503374	6169910	27.2	3.9	5.2	19.5
	GN-13	11-Aug-12	14	508542	6170523	20.4	5.3	2.6	21.5
	GN-15	11-Aug-12	14	507214	6169353	20.1	6.0	5.8	21.5
	GN-16	12-Aug-12	14	507644	6169668	27.4	7.1	7.7	19.5
	GN-17	11-Aug-12	14	506032	6174440	20.8	2.3	5.7	21.5
	SN-02	13-Aug-12	14	503968	6173003	19.1	1.2	1.2	19.5
	SN-15	11-Aug-12	14	507231	6169352	20.1	6.0	6.0	21.5
	SN-16	12-Aug-12	14	507638	6169662	27.4	6.8	6.8	19.5
	GN-02	15-Aug-13	14	503958	6173021	23.0	1.3	4.7	20.0
	GN-04	16-Aug-13	14	502034	6174433	22.2	6.0	6.0	19.5
	GN-05	16-Aug-13	14	501264	6174406	22.6	7.1	6.6	19.5
	GN-06	16-Aug-13	14	500140	6174933	22.2	2.4	4.5	20.0
	GN-09	15-Aug-13	14	503183	6169906	22.7	3.4	4.3	19.5
	GN-13	14-Aug-13	14	508663	6170506	23.2	4.3	5.2	19.0
	GN-15	14-Aug-13	14	507064	6169324	22.7	4.7	4.9	19.0
	GN-16	14-Aug-13	14	507700	6169773	23.0	5.4	5.7	19.0
	GN-17	15-Aug-13	14	505965	6174634	23.2	4.5	3.1	20.0
	SN-09	15-Aug-13	14	503343	6169938	22.7	3.2	3.4	19.5
	SN-15	14-Aug-13	14	507232	6169354	22.7	4.9	4.7	19.0
	SN-16	14-Aug-13	14	507615	6169615	23.0	5.2	5.4	19.0
	GN-02	13-Aug-14	14	503958	6173026	24.6	0.8	3.7	19.0
	GN-04	13-Aug-14	14	501956	6174330	23.8	5.2	5.2	19.0
	GN-05	12-Aug-14	14	501241	6174417	21.9	5.8	4.4	19.0
	GN-06	12-Aug-14	14	500160	6174931	21.4	1.8	3.9	19.0
	GN-09	14-Aug-14	14	503214	6170095	23.2	3.7	2.3	20.0
	GN-13	14-Aug-14	14	508528	6170485	19.1	3.6	0.8	20.0
	GN-15	14-Aug-14	14	507184	6169354	19.6	4.3	3.9	20.0

Table A5-1-1. continued.

Waterbody	Site	Set Date	UTM Coordinates			Duration (dec. hrs)	Water Depth (m)		Set Water Temperature (°C)
			Zone	Easting	Northing		Start	End	
3PT	GN-16	14-Aug-14	14	507743	6169625	18.6	4.2	5.5	20.0
	GN-17	14-Aug-14	14	505997	6174766	23.2	3.7	2.2	20.0
	SN-09	14-Aug-14	14	503214	6170095	23.2	3.7	3.7	20.0
	SN-15	14-Aug-14	14	507235	6169364	19.6	4.0	4.3	20.0
	SN-16	14-Aug-14	14	507760	6169600	18.6	4.3	4.2	20.0
	GN-02	16-Aug-15	14	503963	6172988	22.4	1.0	5.0	17.5
	GN-04	15-Aug-15	14	502112	6174443	21.9	6.2	6.3	19.0
	GN-05	15-Aug-15	14	501381	6174493	21.6	7.0	6.8	19.0
	GN-06	15-Aug-15	14	500160	6174936	21.5	1.8	4.9	19.0
	GN-09	16-Aug-15	14	503199	6169857	22.9	4.8	3.8	17.5
	GN-13	17-Aug-15	14	508680	6170515	23.0	4.6	1.4	17.5
	GN-15	17-Aug-15	14	507137	6169440	22.3	5.2	5.2	17.5
	GN-16	17-Aug-15	14	507529	6169553	22.8	5.4	5.9	17.5
	GN-17	16-Aug-15	14	506108	6174601	23.2	1.2	5.0	17.5
	SN-09	16-Aug-15	14	503225	6169893	22.9	3.2	4.8	17.5
	SN-15	17-Aug-15	14	507137	6169440	22.3	5.2	5.2	17.5
	SN-16	17-Aug-15	14	507552	6169573	22.8	5.4	5.4	17.5
	GN-02	11-Aug-16	14	503957	6173038	23.8	2.0	5.2	18.0
	GN-04	10-Aug-16	14	502059	6174428	22.4	6.9	6.9	18.0
	GN-05	10-Aug-16	14	501274	6174450	22.0	7.5	7.5	18.0
	GN-06	10-Aug-16	14	500160	6174941	21.4	1.5	5.5	18.0
	GN-09	11-Aug-16	14	503237	6170078	23.1	5.3	2.6	18.0
	GN-13	12-Aug-16	14	508648	6170557	20.3	1.8	5.3	18.0
	GN-15	12-Aug-16	14	507134	6169383	22.3	5.7	5.9	18.0
	GN-16	12-Aug-16	14	507770	6169672	21.5	6.1	6.0	18.0
	GN-17	11-Aug-16	14	505966	6174630	24.3	3.4	5.5	18.0
	SN-09	11-Aug-16	14	503203	6170085	23.1	5.8	5.3	18.0
	SN-15	12-Aug-16	14	507134	6169344	22.3	5.7	5.7	18.0
	SN-16	12-Aug-16	14	507766	6169597	21.5	5.8	6.1	18.0
	GN-02	16-Aug-17	14	503844	6172959	21.0	3.8	3.8	20.0
	GN-04	17-Aug-17	14	502122	6174456	22.6	5.3	5.1	19.0
	GN-05	17-Aug-17	14	501237	6174420	21.8	5.9	5.7	19.0
	GN-06	17-Aug-17	14	500151	6174913	21.0	3.1	3.8	19.0
	GN-09	16-Aug-17	14	503311	6169982	19.8	2.7	3.8	20.0
	GN-13	15-Aug-17	14	508667	6170467	26.0	2.6	3.5	21.0

Table A5-1-1. continued.

Waterbody	Site	Set Date	UTM Coordinates			Duration (dec. hrs)	Water Depth (m)		Set Water Temperature (°C)
			Zone	Easting	Northing		Start	End	
3PT	GN-15	15-Aug-17	14	507199	6169344	24.8	4.0	3.9	21.0
	GN-16	15-Aug-17	14	507686	6169710	25.8	4.9	4.1	21.0
	GN-17	16-Aug-17	14	505960	6174656	21.8	2.3	3.7	20.0
	SN-09	16-Aug-17	14	503333	6169964	19.8	2.7	2.7	20.0
	SN-15	15-Aug-17	14	507236	6169362	24.8	4.0	3.7	21.0
	SN-16	15-Aug-17	14	507665	6169710	25.8	4.9	5.0	21.0
	GN-02	22-Aug-18	14	503845	6172962	22.8	5.7	5.2	17.0
	GN-04	20-Aug-18	14	502097	6174455	21.9	7.7	7.2	17.5
	GN-05	20-Aug-18	14	501280	6174425	21.9	8.0	7.7	17.5
	GN-06	20-Aug-18	14	500136	6174906	21.6	5.2	5.8	17.5
	GN-09	22-Aug-18	14	503287	6169950	23.5	4.6	5.4	17.0
	GN-13	21-Aug-18	14	508566	6170491	22.7	5.4	5.5	17.0
	GN-15	22-Aug-18	14	507146	6169560	22.8	6.1	6.2	17.0
	GN-16	21-Aug-18	14	507532	6169633	23.6	6.3	7.1	17.0
	GN-17	21-Aug-18	14	505974	6174711	21.9	5.6	5.6	17.0
	SN-09	22-Aug-18	14	503315	6169954	23.5	5.3	4.6	17.0
	SN-15	22-Aug-18	14	507123	6169473	22.8	6.2	6.1	17.0
	SN-16	21-Aug-18	14	507519	6169588	23.6	6.1	6.3	17.0
	GN-02	15-Aug-19	14	503997	6172946	22.6	3.4	5.6	18.0
	GN-04	14-Aug-19	14	502262	6174488	22.9	7.0	6.9	19.0
	GN-05	14-Aug-19	14	501255	6174421	22.5	7.6	7.5	19.0
	GN-06	13-Aug-19	14	500109	6174941	22.3	3.9	5.5	19.0
	GN-09	15-Aug-19	14	503330	6169973	23.4	4.5	5.0	18.0
	GN-13	13-Aug-19	14	508605	6170597	22.3	3.0	5.2	19.0
	GN-15	13-Aug-19	14	507225	6169305	21.9	5.9	5.8	19.0
	GN-16	14-Aug-19	14	507586	6169611	23.1	6.5	6.8	18.0
	GN-17	15-Aug-19	14	506006	6174649	23.3	4.3	5.6	18.0
	SN-09	15-Aug-19	14	503360	6169988	23.4	3.9	4.5	18.0
	SN-15	13-Aug-19	14	507228	6169333	21.9	5.9	5.9	19.0
	SN-16	14-Aug-19	14	507559	6169597	23.1	6.0	6.5	18.0
	GN-02	12-Aug-20	14	503830	6172979	23.1	4.9	4.7	20.0
	GN-04	13-Aug-20	14	502097	6174472	22.7	6.2	6.1	19.0
	GN-05	13-Aug-20	14	501249	6174420	21.9	6.5	6.7	19.0
	GN-06	13-Aug-20	14	500132	6174903	21.0	4.8	3.9	19.0
	GN-09	12-Aug-20	14	503283	6170034	22.6	4.6	3.1	20.0

Table A5-1-1. continued.

Waterbody	Site	Set Date	UTM Coordinates			Duration (dec. hrs)	Water Depth (m)		Set Water Temperature (°C)
			Zone	Easting	Northing		Start	End	
3PT	GN-13	11-Aug-20	14	508573	6170515	25.2	3.3	4.4	19.0
	GN-15	11-Aug-20	14	507247	6169395	24.5	5.0	5.0	19.0
	GN-16	11-Aug-20	14	507696	6169640	24.9	5.2	5.3	19.0
	GN-17	12-Aug-20	14	505993	6174733	23.5	4.7	4.7	20.0
	SN-09	12-Aug-20	14	503306	6170015	22.6	3.1	2.7	20.0
	SN-15	11-Aug-20	14	507249	6169357	24.5	5.0	5.0	19.0
	SN-16	11-Aug-20	14	507722	6169651	24.9	5.3	-	19.0
	GN-02	18-Aug-21	14	503825	6172988	23.1	5.6	5.7	18.0
	GN-04	19-Aug-21	14	502088	6174443	24.6	7.0	7.2	17.0
	GN-05	18-Aug-21	14	501259	6174401	23.8	7.7	7.5	18.0
	GN-06	19-Aug-21	14	500133	6174898	23.1	5.2	5.8	17.0
	GN-09	18-Aug-21	14	503302	6169987	22.8	4.7	5.6	18.0
	GN-13	17-Aug-21	14	508607	6170508	21.3	5.7	5.6	18.0
	GN-15	17-Aug-21	14	507216	6169351	22.8	5.9	5.9	18.0
	GN-16	17-Aug-21	14	507664	6169747	22.2	7.7	5.9	18.0
	GN-17	19-Aug-21	14	505987	6174703	23.1	5.6	5.7	17.0
	SN-09	18-Aug-21	14	503338	6169983	22.8	4.2	4.7	18.0
	SN-15	17-Aug-21	14	507244	6169347	22.8	5.9	5.9	18.0
	SN-16	17-Aug-21	14	507657	6169705	22.2	7.7	7.7	18.0
FOOT	GN-02	21-Aug-10	14	511178	6187513	44.6	3.8	4.6	15.0
	GN-03	21-Aug-10	14	509817	6186051	43.6	4.8	-	15.0
	GN-05	18-Aug-10	14	508121	6182721	23.9	11.2	12.0	15.0
	GN-06	19-Aug-10	14	509547	6181358	23.5	4.8	3.7	14.5
	GN-09	18-Aug-10	14	506107	6180601	23.0	6.2	6.2	15.0
	GN-11	18-Aug-10	14	504994	6179901	21.8	7.7	7.5	15.0
	GN-12	19-Aug-10	14	509639	6183391	23.7	11.2	6.7	15.0
	GN-13	17-Aug-10	14	505945	6189559	22.7	2.9	-	14.0
	GN-14	17-Aug-10	14	504360	6186324	23.7	3.7	5.4	14.0
	SN-06	19-Aug-10	14	509547	6181358	23.5	4.8	4.8	14.5
	SN-09	18-Aug-10	14	506107	6180601	23.0	6.2	6.2	15.0
	SN-14	17-Aug-10	14	504360	6186324	23.7	3.7	3.7	14.0
	GN-02	19-Aug-13	14	511155	6187603	22.1	3.9	4.8	21.0
	GN-03	19-Aug-13	14	509929	6186020	23.0	1.2	5.1	21.0
	GN-05	18-Aug-13	14	508151	6182756	23.7	13.0	12.5	20.0
	GN-06	19-Aug-13	14	509520	6181353	24.3	5.0	2.9	19.0

Table A5-1-1. continued.

Waterbody	Site	Set Date	UTM Coordinates			Duration (dec. hrs)	Water Depth (m)		Set Water Temperature (°C)
			Zone	Easting	Northing		Start	End	
FOOT	GN-09	18-Aug-13	14	506038	6180704	23.4	6.5	6.6	20.0
	GN-11	17-Aug-13	14	504983	6179880	24.4	7.9	8.2	21.0
	GN-12	18-Aug-13	14	509598	6183480	24.6	11.4	12.1	21.0
	GN-13	17-Aug-13	14	505956	6189559	22.6	9.9	5.3	22.0
	GN-14	17-Aug-13	14	504444	6186330	23.1	4.5	6.0	20.0
	SN-06	19-Aug-13	14	509430	6181247	24.3	5.0	5.0	19.0
	SN-09	18-Aug-13	14	506118	6180509	23.4	2.7	6.5	20.0
	SN-14	17-Aug-13	14	504297	6186347	23.1	1.0	4.5	20.0
	GN-02	15-Aug-16	14	511312	6187442	21.5	5.6	5.5	18.0
	GN-03	15-Aug-16	14	509710	6186155	22.1	6.0	6.2	18.0
	GN-05	14-Aug-16	14	508164	6182589	22.4	14.5	13.2	18.0
	GN-06	15-Aug-16	14	509473	6181251	24.1	5.7	6.3	18.0
	GN-09	14-Aug-16	14	506076	6180715	21.8	8.0	7.6	18.0
	GN-11	13-Aug-16	14	505154	6179821	23.2	2.0	9.1	18.0
	GN-12	14-Aug-16	14	509610	6183511	23.3	6.5	12.8	18.0
	GN-13	13-Aug-16	14	505820	6189469	21.6	3.1	6.7	18.0
	GN-14	13-Aug-16	14	504436	6186399	23.6	6.7	6.6	18.0
	SN-06	15-Aug-16	14	509547	6181375	24.1	5.2	5.7	18.0
	SN-09	14-Aug-16	14	506130	6180589	21.8	7.5	8.0	18.0
	SN-14	13-Aug-16	14	504301	6186337	23.6	1.8	6.7	18.0
	GN-02	18-Aug-19	14	511163	6187598	23.7	5.6	5.4	18.0
	GN-03	18-Aug-19	14	509934	6186022	24.1	5.6	6.2	18.0
	GN-05	16-Aug-19	14	508117	6182743	21.0	15.5	12.3	18.0
	GN-06	19-Aug-19	14	509510	6181356	23.1	5.8	5.9	17.0
	GN-09	18-Aug-19	14	506076	6180567	22.3	8.2	7.9	18.0
	GN-11	16-Aug-19	14	505118	6179866	21.9	9.3	7.6	18.0
	GN-12	19-Aug-19	14	509609	6183575	22.4	12.5	11.0	17.0
	GN-13	17-Aug-19	14	505854	6189459	23.0	6.1	5.7	18.0
	GN-14	17-Aug-19	14	504406	6186321	23.9	6.8	6.7	18.0
	SN-06	19-Aug-19	14	509519	6181382	23.1	5.2	5.8	17.0
	SN-09	18-Aug-19	14	506098	6180546	22.3	7.9	8.2	18.0
	SN-14	17-Aug-19	14	504367	6186327	23.9	6.7	6.8	18.0
APU	GN-01	30-Aug-09	14	582102	6186932	22.5	4.3	4.2	15.0
	GN-02	30-Aug-09	14	582543	6186771	23.0	6.5	7.7	15.0
	GN-03	31-Aug-09	14	589045	6191129	25.3	4.4	6.3	15.0

Table A5-1-1. continued.

Waterbody	Site	Set Date	UTM Coordinates			Duration (dec. hrs)	Water Depth (m)		Set Water Temperature (°C)
			Zone	Easting	Northing		Start	End	
APU	GN-04	31-Aug-09	14	589079	6190616	25.7	4.1	4.4	15.0
	GN-05	1-Sep-09	14	587271	6189353	24.3	4.2	4.0	16.0
	GN-06	1-Sep-09	14	587191	6188491	25.5	4.4	4.3	16.0
	GN-07	1-Sep-09	14	585096	6188941	23.3	3.9	4.0	16.0
	GN-08	2-Sep-09	14	584187	6188111	24.8	3.9	3.9	15.5
	GN-09	2-Sep-09	14	583994	6187194	25.8	6.3	7.4	15.5
	SN-03	31-Aug-09	14	589108	6191131	25.3	6.2	6.3	15.0
	SN-06	1-Sep-09	14	587124	6188527	25.5	4.0	4.2	16.0
	SN-09	2-Sep-09	14	583958	6187130	25.8	4.2	4.0	15.5
	GN-01	24-Aug-12	14	581930	6187032	25.8	5.1	5.3	18.0
	GN-02	24-Aug-12	14	582707	6186622	26.7	5.5	4.6	18.0
	GN-03	27-Aug-12	14	589043	6191137	22.5	5.8	5.7	18.0
	GN-04	27-Aug-12	14	589043	6190591	22.0	5.1	5.2	18.0
	GN-05	26-Aug-12	14	587326	6189266	18.6	5.4	5.4	19.0
	GN-06	26-Aug-12	14	587180	6188615	20.0	5.2	5.0	19.0
	GN-07	26-Aug-12	14	585094	6189032	18.0	6.0	7.7	19.0
	GN-08	25-Aug-12	14	583722	6187976	21.3	5.3	5.1	19.0
	GN-09	25-Aug-12	14	583733	6187344	23.0	6.4	6.6	19.0
	SN-03	27-Aug-12	14	589069	6191154	22.5	5.4	5.4	18.0
	SN-06	26-Aug-12	14	587200	6188638	20.3	5.2	5.2	19.0
	SN-09	25-Aug-12	14	583711	6187314	23.0	6.0	6.0	19.0
	GN-01	27-Aug-15	14	581937	6187009	24.0	4.6	4.5	17.0
	GN-02	27-Aug-15	14	582709	6186664	24.7	4.9	4.6	17.0
	GN-03	25-Aug-15	14	589039	6191073	24.1	5.1	4.9	17.0
	GN-04	25-Aug-15	14	589039	6190582	24.3	4.7	4.7	17.0
	GN-05	25-Aug-15	14	587415	6189345	24.4	4.9	4.9	17.0
	GN-06	26-Aug-15	14	587180	6188608	24.0	4.6	4.7	16.0
	GN-07	26-Aug-15	14	585103	6189031	24.8	5.6	7.3	16.0
	GN-08	26-Aug-15	14	583702	6187987	25.7	4.8	4.6	16.0
	GN-09	27-Aug-15	14	583726	6187363	24.8	6.1	7.7	17.0
	SN-03	25-Aug-15	14	589051	6191127	24.1	5.1	5.1	17.0
	SN-06	26-Aug-15	14	587199	6188632	24.0	4.7	4.6	16.0
	SN-09	27-Aug-15	14	583724	6187328	24.8	4.9	6.1	17.0
	GN-01	19-Aug-18	14	581944	6187004	19.7	5.4	5.9	17.0
	GN-02	19-Aug-18	14	582534	6186793	19.9	8.7	5.7	17.0

Table A5-1-1. continued.

Waterbody	Site	Set Date	UTM Coordinates			Duration (dec. hrs)	Water Depth (m)		Set Water Temperature (°C)
			Zone	Easting	Northing		Start	End	
APU	GN-03	17-Aug-18	14	589084	6191115	24.6	5.6	6.2	17.0
	GN-04	17-Aug-18	14	589125	6190730	24.2	5.5	5.3	17.0
	GN-05	17-Aug-18	14	587429	6189350	25.3	5.6	6.1	17.0
	GN-06	18-Aug-18	14	587169	6188550	29.0	5.5	5.5	17.0
	GN-07	18-Aug-18	14	585027	6189049	28.7	5.6	7.9	17.0
	GN-08	18-Aug-18	14	584033	6188114	28.7	7.3	7.5	17.0
	GN-09	19-Aug-18	14	583977	6187159	20.5	5.5	5.8	17.0
	SN-03	17-Aug-18	14	589121	6191122	24.6	5.2	5.6	17.0
	SN-06	18-Aug-18	14	587133	6188533	29.0	5.2	5.5	17.0
	SN-09	19-Aug-18	14	583970	6187131	20.5	5.8	5.5	17.0
	GN-01	19-Aug-21	14	581932	6186901	24.0	5.9	5.4	16.0
	GN-02	19-Aug-21	14	582637	6186864	23.0	8.8	9.0	16.0
	GN-03	17-Aug-21	14	589075	6191159	20.8	6.3	7.6	17.0
	GN-04	17-Aug-21	14	589079	6190617	21.4	5.3	5.5	17.0
	GN-05	17-Aug-21	14	587344	6189455	22.0	5.5	5.8	17.0
	GN-06	18-Aug-21	14	587153	6188481	20.9	5.2	5.2	17.0
	GN-07	18-Aug-21	14	585108	6188952	21.4	7.7	8.2	17.0
	GN-08	18-Aug-21	14	584085	6188065	21.4	7.5	7.4	17.0
	GN-09	19-Aug-21	14	583941	6187190	22.6	5.2	5.4	16.0
	SN-03	17-Aug-21	14	589106	6191149	20.8	4.6	6.3	17.0
	SN-06	18-Aug-21	14	587110	6188519	20.9	5.0	5.2	17.0
	SN-09	19-Aug-21	14	583927	6187160	22.6	5.2	5.2	16.0
LEFT	GN-01	30-Jul-09	14	525846	6217158	24.8	4.0	6.3	17.0
	GN-02	31-Jul-09	14	525373	6216074	24.8	3.5	2.3	16.0
	GN-05	31-Jul-09	14	523426	6217475	23.0	4.0	2.7	16.0
	GN-08	30-Jul-09	14	524030	6213574	25.4	9.8	10.1	17.0
	GN-09	30-Jul-09	14	521582	6213736	26.2	4.4	3.6	17.0
	GN-10	29-Jul-09	14	518299	6210078	25.3	4.1	6.3	17.0
	GN-11	28-Jul-09	14	519799	6209109	22.9	12.7	7.3	17.0
	GN-12	28-Jul-09	14	517146	6213104	21.5	5.2	4.7	17.0
	GN-13	29-Jul-09	14	517898	6212949	24.7	9.4	8.4	17.0
	SN-05	31-Jul-09	14	523453	6217489	23.0	3.9	4.0	16.0
	SN-08	30-Jul-09	14	524004	6213611	25.4	8.8	9.8	17.0
	SN-12	28-Jul-09	14	517142	6213075	21.5	4.8	5.2	17.0
	GN-01	25-Jul-10	14	525927	6216983	14.1	4.5	5.5	21.0

Table A5-1-1. continued.

Waterbody	Site	Set Date	UTM Coordinates			Duration (dec. hrs)	Water Depth (m)		Set Water Temperature (°C)
			Zone	Easting	Northing		Start	End	
LEFT	GN-02	25-Jul-10	14	525506	6216031	14.7	2.5	2.0	21.0
	GN-05	25-Jul-10	14	523396	6217408	15.1	4.5	1.0	21.0
	GN-08	26-Jul-10	14	523809	6213799	27.5	5.0	7.0	21.0
	GN-09	27-Jul-10	14	521700	6213666	20.0	3.0	-	20.0
	GN-10	27-Jul-10	14	518468	6209942	20.8	5.5	5.5	20.0
	GN-11	26-Jul-10	14	519766	6209122	23.7	10.0	1.5	21.0
	GN-12	27-Jul-10	14	517109	6213471	20.8	2.0	4.0	20.0
	GN-13	26-Jul-10	14	517899	6213124	25.0	7.0	2.0	21.0
	SN-05	25-Jul-10	14	523396	6217408	15.1	4.5	4.5	21.0
	SN-08	26-Jul-10	14	523809	6213799	27.5	5.0	5.0	21.0
	SN-12	27-Jul-10	14	517109	6213471	20.8	2.0	2.0	20.0
	GN-01	22-Jul-11	14	525632	6217203	18.8	5.5	2.5	19.0
	GN-02	22-Jul-11	14	525351	6216123	21.7	1.3	2.5	19.0
	GN-05	22-Jul-11	14	523435	6217418	19.8	3.3	0.5	19.0
	GN-08	23-Jul-11	14	524023	6213553	17.8	8.5	6.8	19.0
	GN-09	23-Jul-11	14	521509	6213765	18.4	1.8	3.0	19.0
	GN-10	24-Jul-11	14	518283	6210095	23.1	3.5	5.5	18.0
	GN-11	24-Jul-11	14	519759	6209209	22.5	11.5	12.0	18.0
	GN-12	24-Jul-11	14	517122	6213105	24.4	4.3	5.5	18.0
	GN-13	23-Jul-11	14	517873	6212955	19.7	9.0	7.0	19.0
	SN-05	22-Jul-11	14	523435	6217418	21.4	3.3	3.3	19.0
	SN-08	23-Jul-11	14	524023	6213553	17.8	8.5	8.5	19.0
	SN-12	24-Jul-11	14	517122	6213105	24.4	4.3	4.3	18.0
	GN-01	24-Jul-12	14	525907	6216964	15.8	6.8	6.6	23.5
	GN-02	24-Jul-12	14	525532	6216088	15.1	4.7	1.6	24.0
	GN-05	24-Jul-12	14	523300	6217422	14.5	2.2	3.5	23.5
	GN-08	25-Jul-12	14	523803	6213783	13.8	4.7	6.1	23.0
	GN-09	25-Jul-12	14	521489	6213767	16.0	1.4	2.9	22.0
	GN-10	26-Jul-12	14	518587	6210009	21.7	5.5	5.4	21.0
	GN-11	26-Jul-12	14	519524	6209068	21.3	4.5	6.9	21.0
	GN-12	26-Jul-12	14	517143	6213482	24.2	1.5	4.6	22.0
	GN-13	25-Jul-12	14	517988	6213040	16.9	5.9	3.2	22.5
	SN-05	24-Jul-12	14	523296	6217422	14.5	1.8	1.8	23.5
	SN-08	25-Jul-12	14	523804	6213800	13.8	4.5	4.5	23.0
	SN-12	26-Jul-12	14	517137	6213491	24.2	1.6	1.6	22.0

Table A5-1-1. continued.

Waterbody	Site	Set Date	UTM Coordinates			Duration (dec. hrs)	Water Depth (m)		Set Water Temperature (°C)
			Zone	Easting	Northing		Start	End	
LEFT	GN-01	27-Jul-13	14	525881	6217063	19.4	5.5	5.6	22.0
	GN-02	27-Jul-13	14	525439	6216156	19.9	5.0	1.4	22.0
	GN-05	27-Jul-13	14	523439	6217477	19.0	3.2	3.1	22.0
	GN-08	28-Jul-13	14	523788	6213672	22.6	4.6	5.5	19.0
	GN-09	28-Jul-13	14	521596	6213742	23.4	2.9	3.0	19.0
	GN-10	29-Jul-13	14	518413	6210003	22.6	5.6	5.4	19.0
	GN-11	29-Jul-13	14	519673	6209066	22.2	11.2	4.8	18.0
	GN-12	29-Jul-13	14	517228	6213374	22.6	2.4	4.5	19.0
	GN-13	28-Jul-13	14	517995	6213168	24.3	7.3	3.7	20.0
	SN-05	27-Jul-13	14	523297	6217423	19.0	2.3	3.2	22.0
	SN-08	28-Jul-13	14	523796	6213818	22.6	4.3	4.6	19.0
	SN-12	29-Jul-13	14	517135	6213488	22.6	0.8	2.4	19.0
	GN-01	22-Jul-14	14	525944	6217018	18.8	6.2	5.9	20.0
	GN-02	22-Jul-14	14	525432	6216164	19.8	0.9	4.2	20.0
	GN-05	22-Jul-14	14	523396	6217408	19.0	3.0	3.7	20.0
	GN-08	23-Jul-14	14	523767	6213789	20.3	6.3	6.3	21.0
	GN-09	23-Jul-14	14	521598	6213751	20.4	3.5	3.4	21.0
	GN-10	24-Jul-14	14	518468	6209942	23.3	0.0	0.0	-
	GN-11	24-Jul-14	14	519766	6209122	22.4	0.0	0.0	-
	GN-12	24-Jul-14	14	517109	6213471	22.9	0.0	0.0	-
	GN-13	23-Jul-14	14	517899	6213124	21.6	0.0	0.0	21.0
	SN-05	22-Jul-14	14	523276	6217405	19.0	1.8	3.0	20.0
	SN-08	23-Jul-14	14	523782	6213822	20.3	5.0	5.0	21.0
	SN-12	24-Jul-14	14	517109	6213471	22.9	0.0	0.0	-
	GN-01	23-Jul-15	14	526040	6217019	20.1	6.8	6.9	20.0
	GN-02	23-Jul-15	14	523818	6213805	19.8	0.5	1.0	20.0
	GN-05	23-Jul-15	14	523300	6217428	18.3	3.2	1.3	20.0
	GN-08	22-Jul-15	14	523716	6213908	23.6	3.9	4.2	20.0
	GN-09	22-Jul-15	14	521646	6213690	22.5	3.0	3.0	20.0
	GN-10	21-Jul-15	14	518551	6209958	18.5	5.5	5.7	20.0
	GN-11	21-Jul-15	14	519661	6209062	17.8	8.1	11.1	20.0
	GN-12	21-Jul-15	14	517148	6213472	20.4	2.5	4.3	20.0
	GN-13	22-Jul-15	14	517818	6213217	23.4	7.5	4.1	21.0
	SN-05	23-Jul-15	14	523440	6217456	18.3	3.2	3.2	20.0
	SN-08	22-Jul-15	14	523724	6213915	23.6	4.2	3.9	20.0

Table A5-1-1. continued.

Waterbody	Site	Set Date	UTM Coordinates			Duration (dec. hrs)	Water Depth (m)		Set Water Temperature (°C)
			Zone	Easting	Northing		Start	End	
LEFT	SN-12	21-Jul-15	14	517139	6213489	20.4	1.4	2.5	20.0
	GN-01	22-Jul-16	14	526040	6217019	19.5	5.9	5.3	18.5
	GN-02	22-Jul-16	14	523818	6213805	20.8	4.9	1.7	19.0
	GN-05	22-Jul-16	14	523300	6217428	19.4	2.7	3.4	18.0
	GN-08	23-Jul-16	14	523782	6213838	22.2	4.5	4.2	18.0
	GN-09	23-Jul-16	14	521700	6213662	22.6	3.2	3.0	19.0
	GN-10	24-Jul-16	14	518386	6210016	21.1	5.9	5.6	18.0
	GN-11	23-Jul-16	14	519781	6209076	23.5	11.7	4.9	19.0
	GN-12	24-Jul-16	14	517125	6213454	23.2	2.7	4.9	18.0
	GN-13	24-Jul-16	14	517899	6213127	23.8	6.7	-	19.0
	SN-05	22-Jul-16	14	523440	6217456	19.4	2.2	2.7	18.0
	SN-08	23-Jul-16	14	523774	6213796	22.2	5.1	4.5	18.0
	SN-12	24-Jul-16	14	517111	6213483	23.2	2.4	2.7	18.0
	GN-01	26-Jul-17	14	525932	6216992	21.7	6.1	6.2	20.0
	GN-02	26-Jul-17	14	525442	6216154	23.1	0.9	4.3	21.0
	GN-05	26-Jul-17	14	523319	6217419	19.3	3.0	3.4	20.0
	GN-08	25-Jul-17	14	523756	6213783	23.2	4.7	4.9	20.0
	GN-09	25-Jul-17	14	521713	6213651	21.7	3.0	3.2	19.0
	GN-10	24-Jul-17	14	518466	6209963	19.8	5.9	6.5	20.0
	GN-11	24-Jul-17	14	519765	6209125	19.1	11.9	12.1	20.0
	GN-12	24-Jul-17	14	517125	6213449	21.6	3.2	4.6	20.0
	GN-13	25-Jul-17	14	517986	6213183	20.6	3.4	7.6	20.0
	SN-05	26-Jul-17	14	523296	6217424	19.3	3.0	1.5	20.0
	SN-08	25-Jul-17	14	523787	6213794	23.2	4.7	4.6	20.0
	SN-12	24-Jul-17	14	517108	6213473	21.6	3.2	2.4	20.0
	GN-01	27-Jul-18	14	525931	6216987	23.1	6.7	6.6	18.0
	GN-02	27-Jul-18	14	525437	6216146	24.0	1.8	4.7	18.0
	GN-05	27-Jul-18	14	523423	6217408	21.7	3.6	3.6	18.0
	GN-08	24-Jul-18	14	523790	6213768	23.7	4.9	6.2	19.0
	GN-09	24-Jul-18	14	521695	6213672	23.0	3.0	3.4	18.0
	GN-10	26-Jul-18	14	518466	6209945	23.3	5.9	6.9	18.0
	GN-11	25-Jul-18	14	519764	6209115	24.0	11.3	11.3	18.0
	GN-12	25-Jul-18	14	517118	6213434	25.2	4.8	4.4	18.0
	GN-13	26-Jul-18	14	517898	6213124	22.6	7.8	8.9	18.0
	SN-05	27-Jul-18	14	523394	6217410	21.7	3.5	3.6	18.0

Table A5-1-1. continued.

Waterbody	Site	Set Date	UTM Coordinates			Duration (dec. hrs)	Water Depth (m)		Set Water Temperature (°C)
			Zone	Easting	Northing		Start	End	
LEFT	SN-08	24-Jul-18	14	523802	6213795	23.7	4.5	4.9	19.0
	SN-12	25-Jul-18	14	517110	6213461	25.2	1.6	4.8	18.0
	GN-01	24-Jul-19	14	525806	6216940	23.6	5.9	3.7	22.0
	GN-02	24-Jul-19	14	525498	6216030	26.2	2.3	4.0	21.0
	GN-05	24-Jul-19	14	523389	6217416	21.9	3.3	3.3	21.0
	GN-08	23-Jul-19	14	523763	6213789	23.4	4.4	5.0	21.0
	GN-09	23-Jul-19	14	521716	6213649	22.5	2.9	3.0	20.0
	GN-10	22-Jul-19	14	518463	6209944	23.6	5.7	6.3	19.0
	GN-11	21-Jul-19	14	519775	6209123	22.4	11.2	11.7	19.0
	GN-12	21-Jul-19	14	517140	6213443	23.3	3.7	5.5	19.0
	GN-13	22-Jul-19	14	517906	6213112	22.9	7.4	6.6	20.0
	SN-05	24-Jul-19	14	523359	6217420	21.9	3.6	3.6	21.0
	SN-08	23-Jul-19	14	523795	6213790	23.4	4.5	4.4	21.0
	SN-12	21-Jul-19	14	517120	6213470	23.3	2.3	3.7	19.0
	GN-01	23-Jul-20	14	525901	6216989	24.3	6.2	6.1	21.0
	GN-02	22-Jul-20	14	525462	6216067	21.5	1.8	5.4	21.5
	GN-05	22-Jul-20	14	523305	6217424	23.3	3.8	3.9	21.5
	GN-08	21-Jul-20	14	523846	6213770	22.0	5.5	6.2	22.5
	GN-09	21-Jul-20	14	521623	6213762	20.5	3.5	3.6	22.5
	GN-10	24-Jul-20	14	518385	6210042	21.7	6.0	6.1	22.0
	GN-11	24-Jul-20	14	519675	6209068	20.8	4.6	11.7	22.0
	GN-12	23-Jul-20	14	517135	6213432	24.0	-	-	21.0
	GN-13	24-Jul-20	14	517981	6213159	22.0	6.4	9.0	22.0
	SN-05	22-Jul-20	14	523294	6217430	23.3	2.1	3.8	21.5
	SN-08	21-Jul-20	14	523831	6213770	22.0	5.1	5.5	22.5
	SN-12	23-Jul-20	14	517126	6213459	24.0	3.0	4.8	21.0
	GN-01	24-Jul-21	14	523913	6213682	21.8	5.8	7.6	20.0
	GN-02	24-Jul-21	14	523332	6217420	22.6	1.8	4.3	20.0
	GN-05	24-Jul-21	14	525866	6217041	25.1	3.7	3.4	20.0
	GN-08	25-Jul-21	14	518405	6210004	22.2	5.9	4.6	20.0
	GN-09	25-Jul-21	14	521615	6213734	23.4	3.0	3.1	20.0
	GN-10	27-Jul-21	14	517111	6213458	23.0	5.8	6.3	20.0
	GN-11	26-Jul-21	14	523295	6217434	23.9	8.8	11.4	20.0
	GN-12	26-Jul-21	14	517121	6213414	23.6	5.1	4.6	20.0
	GN-13	27-Jul-21	14	523986	6213798	22.7	4.1	7.3	20.0

Table A5-1-1. continued.

Waterbody	Site	Set Date	UTM Coordinates			Duration (dec. hrs)	Water Depth (m)		Set Water Temperature (°C)
			Zone	Easting	Northing		Start	End	
LEFT	SN-05	24-Jul-21	14	525405	6216123	25.1	1.4	3.7	20.0
	SN-08	25-Jul-21	14	519703	6209065	22.2	4.6	4.4	20.0
	SN-12	26-Jul-21	14	517979	6213168	23.6	2.5	5.1	20.0

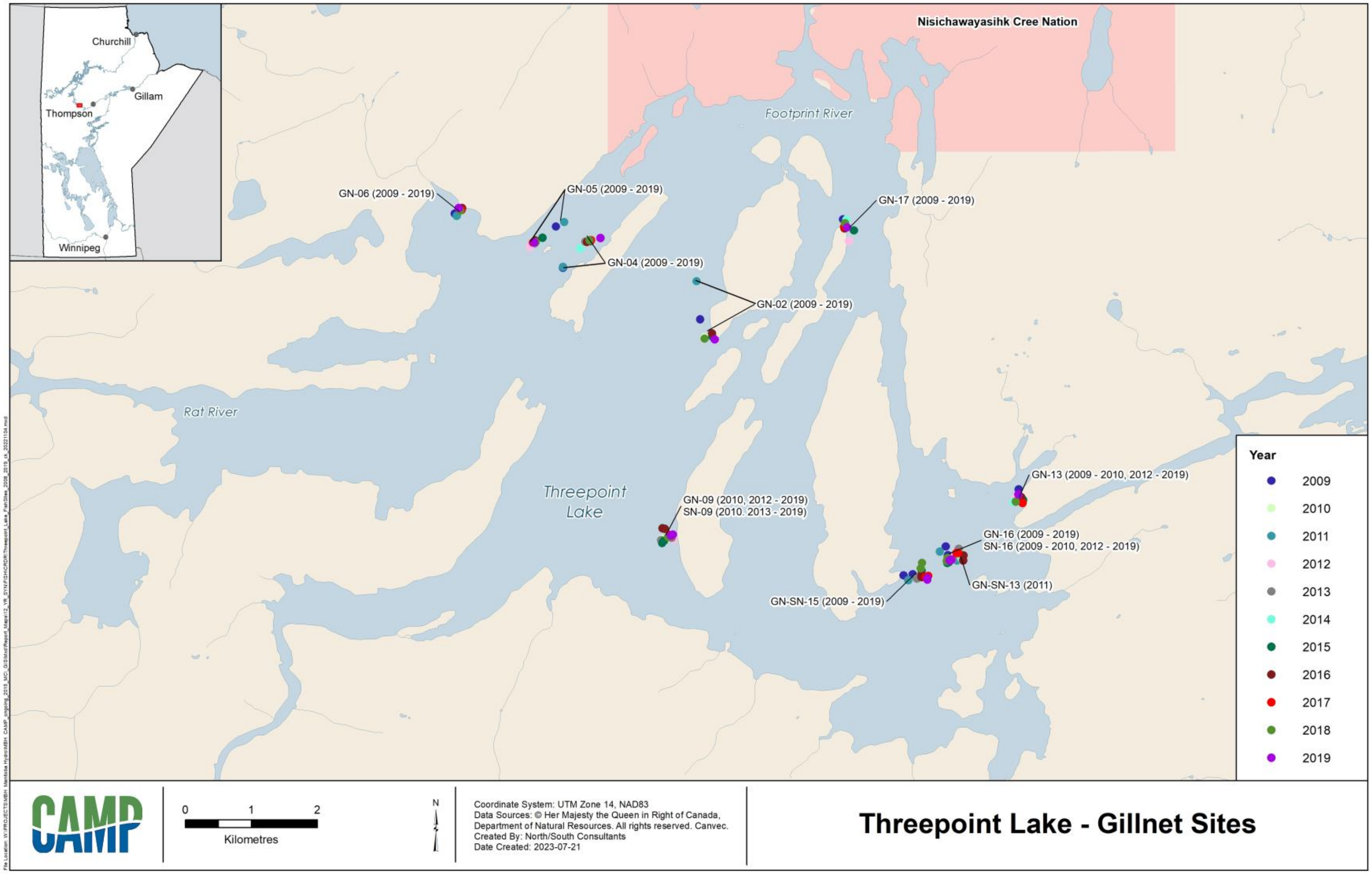


Figure A5-1-1. 2008-2019 Gillnetting sites in Threepoint Lake.

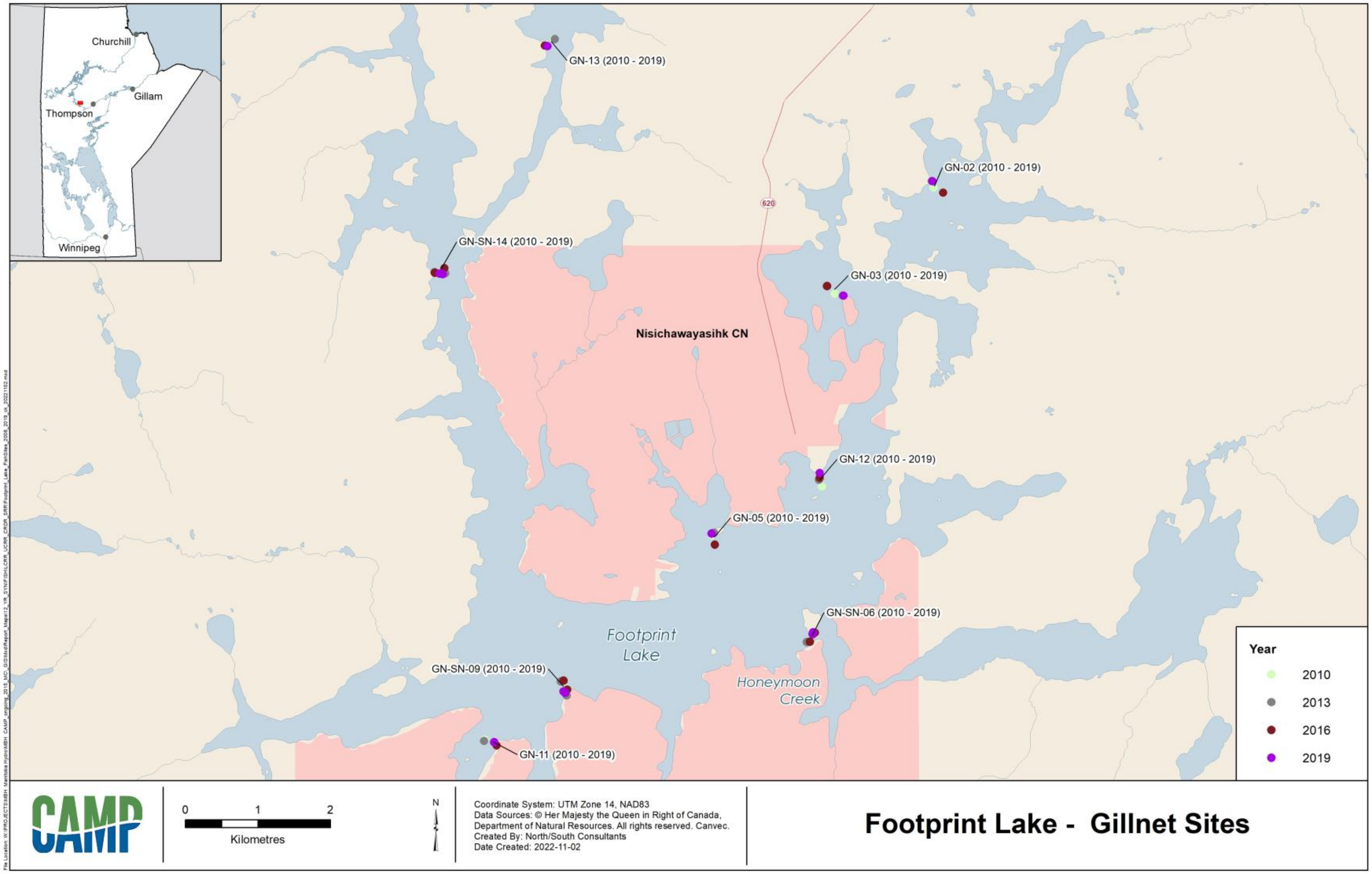


Figure A5-1-2. 2008-2019 Gillnetting sites in Footprint Lake.

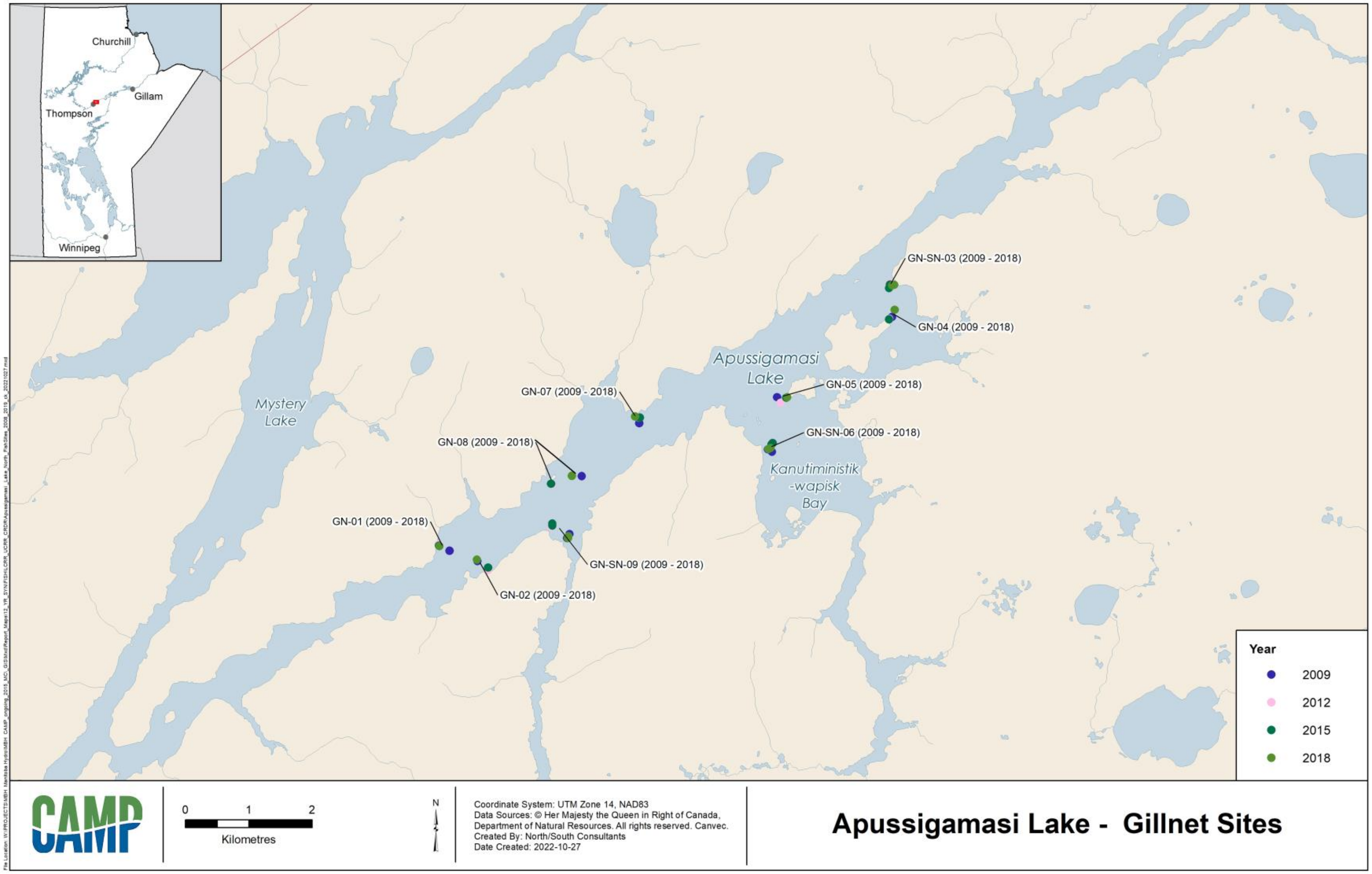


Figure A5-1-3. 2008-2019 Gillnetting sites in Apussigamasi Lake.

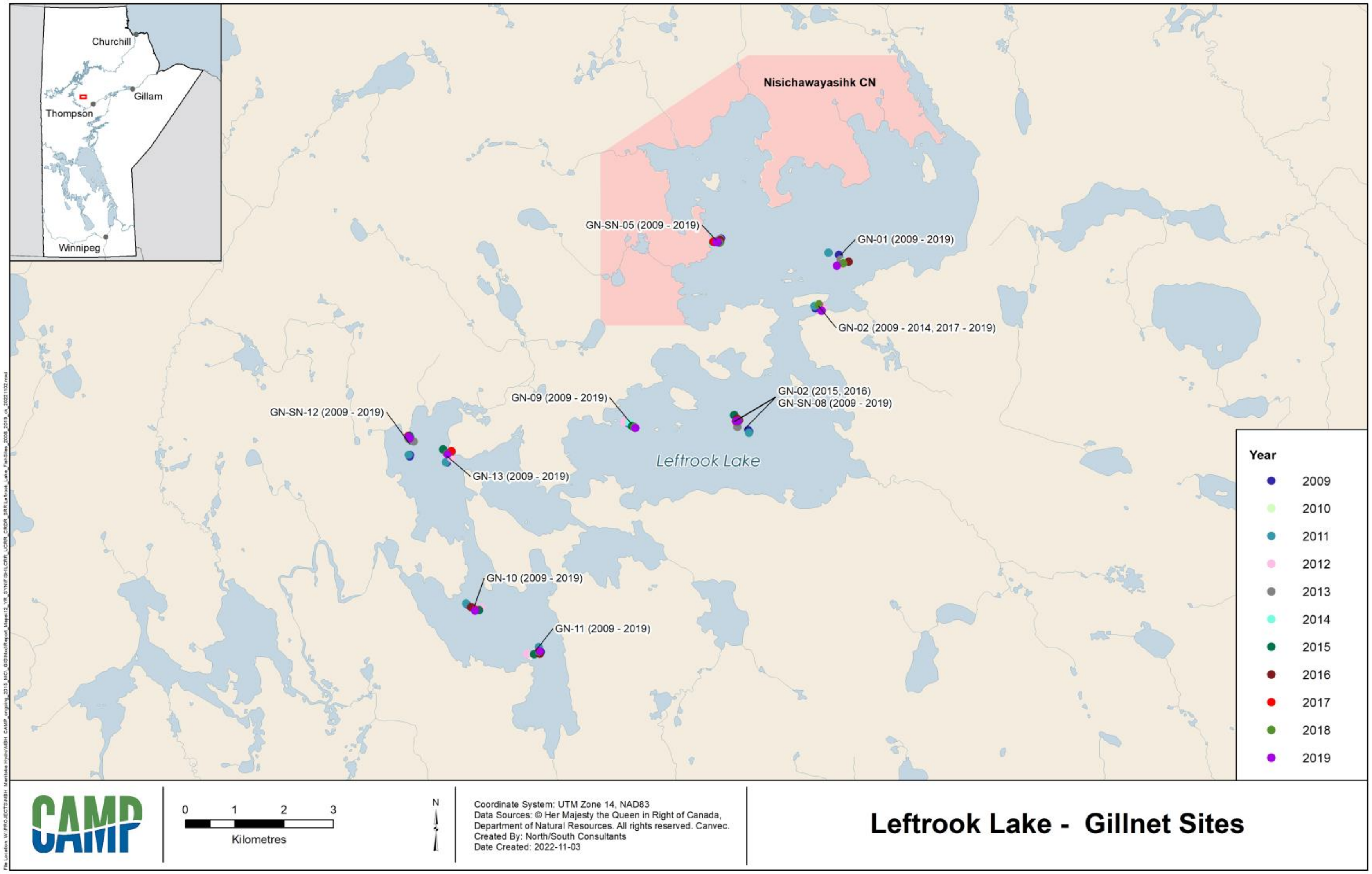


Figure A5-1-4. 2008-2019 Gillnetting sites in Leftrook Lake.

6.0 MERCURY IN FISH

6.1 INTRODUCTION

The following presents the results of fish mercury monitoring conducted from 2008-2019 in the Churchill River Diversion Region. Fish mercury sampling was conducted annually beginning in 2010 at one on-system waterbody, Threepoint Lake, and one off-system waterbody, Leftrook Lake (Table 6-1.1; Figure 6.1-1). Threepoint and Leftrook lakes are monitored annually to ensure short-term changes in mercury concentrations that may be indicative of regional (i.e., northern Manitoba) effects on the rates of mercury methylation and biomagnification are not being missed by rotational sampling. Leftrook Lake is the only reference water body sampled under CAMP with a strong historic record and Threepoint Lake is one of the waterbodies that has experienced the longest recovery time since construction of the CRD.

Mercury concentrations are measured in muscle tissue of commercially important fish species – Northern Pike, Walleye, and Lake Whitefish. Monitoring of mercury in 1-year-old Yellow Perch (*Perca flavescens*) is also conducted as a potential early indicator of changes in mercury in the food web. Samples of fish muscle are collected during the conduct of fish community monitoring. Mercury is analysed in the trunk muscle of Northern Pike, Lake Whitefish, and Walleye selected over a range of fork lengths. Yearling Yellow Perch are analyzed for mercury as carcass with the head, pelvic and pectoral girdles, caudal fin, and digestive tract removed.

There were no departures from the planned field sampling schedule during the 12-year period.

Two metrics were selected for detailed reporting: arithmetic mean mercury concentrations; and length-standardized mean mercury concentrations (also referred to as "standard mean(s)"; Table 6.1-2). Standard lengths varied by species as follows: Lake Whitefish (350 mm); Northern Pike (550 mm); and Walleye (400 mm). As CAMP targets a specific age class of Yellow Perch, fish captured for this component are inherently of a limited size range; therefore, length-standardization for this species was not undertaken.

A detailed description of the program design and sampling methods is provided in Technical Document 1, Section 2.6.

Table 6.1-1. 2008-2019 Inventory of fish mercury sampling.

Waterbody/Area	Sampling Year											
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
3PT			●	●	●	●	●	●	●	●	●	●
LEFT			●	●	●	●	●	●	●	●	●	●

Table 6.1-2. Mercury in fish indicators and metrics.

Indicator	Metric	Units
Mercury in Fish	• Arithmetic mean mercury concentration	Parts per million (ppm)
	• Length-standardized mean mercury concentration of large-bodied species	ppm

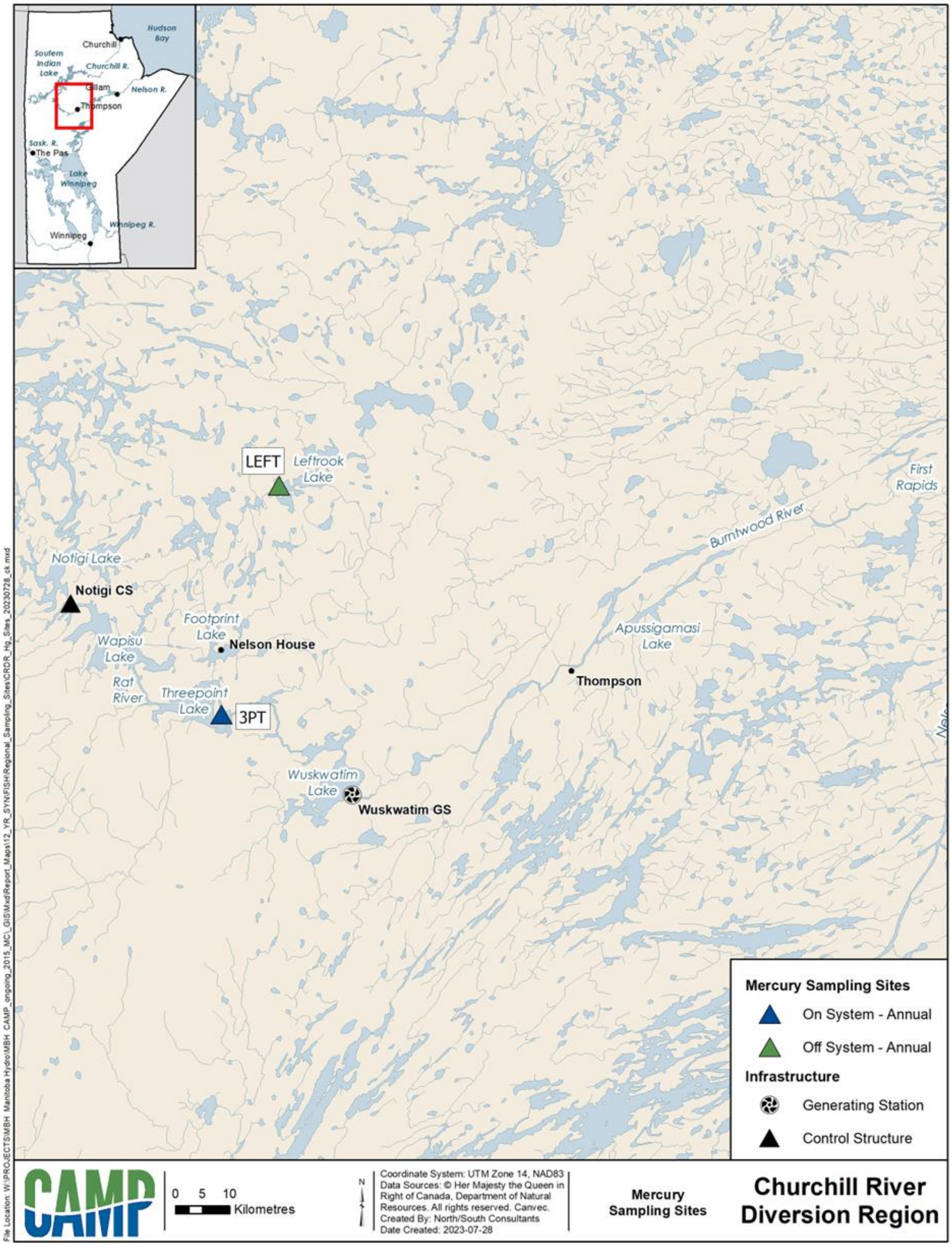


Figure 6.1-1. 2008-2019 Fish mercury sampling sites.

6.2 MERCURY IN FISH

6.2.1 ARITHMETIC MEAN MERCURY CONCENTRATION

6.2.1.1 ON-SYSTEM SITES

ANNUAL SITES

Threepoint Lake

Lake Whitefish

The arithmetic mean mercury concentration of Lake Whitefish over the 10 years of monitoring ranged from a low of 0.053 ppm in 2014 to a high of 0.148 ppm in 2017 (Table 6.2-1). The mercury concentration typically increased with fork length, although there was variation in the mercury concentration of Lake Whitefish of the same length (Figure 6.2-1).

Northern Pike

The arithmetic mean mercury concentration of Northern Pike over the 10 years of monitoring ranged from a low of 0.323 ppm in 2011 and 2015 to a high of 0.507 ppm in 2018 (Table 6.2-1). The mercury concentration typically increased with fork length, although there was variation in the mercury concentration of Northern Pike of the same length (Figure 6.2-2).

Walleye

The arithmetic mean mercury concentration of Walleye over the 10 years of monitoring ranged from a low of 0.361 ppm in 2012 to a high of 0.541 ppm in 2019 (Table 6.2-1). The mercury concentration typically increased with fork length, although there was variation in the mercury concentration of Walleye of the same length (Figure 6.2-3).

Yellow Perch

Over 10 years of monitoring, 1-year-old Yellow Perch were only submitted for mercury analysis in 2018 (Table 6.2-2). In this year the arithmetic mean mercury concentration was 0.033 ppm (Figure 6.2-4).

ROTATIONAL SITES

There are no on-system waterbodies in the Churchill River Diversion Region that are monitored for fish mercury on a rotational basis.

6.2.1.2 OFF-SYSTEM SITES

ANNUAL SITES

Leftrook Lake

Lake Whitefish

The arithmetic mean mercury concentration of Lake Whitefish over the 10 years of monitoring ranged from a low of 0.029 ppm in 2014 to a high of 0.064 ppm in 2017 (Table 6.2-1). The mercury concentration typically increased with fork length, although there was variation in the mercury concentration of Lake Whitefish of the same length (Figure 6.2-1).

Northern Pike

The arithmetic mean mercury concentration of Northern Pike over the 10 years of monitoring ranged from a low of 0.140 ppm in 2014 to a high of 0.247 ppm in 2010 (Table 6.2-1). The mercury concentration typically increased with fork length, although there was variation in the mercury concentration of Northern Pike of the same length (Figure 6.2-2).

Walleye

The arithmetic mean mercury concentration of Walleye over the 10 years of monitoring ranged from a low of 0.184 ppm in 2011 to a high of 0.243 ppm in 2015 (Table 6.2-1). The mercury concentration typically increased with fork length, although there was variation in the mercury concentration of Walleye of the same length (Figure 6.2-3).

Yellow Perch

The arithmetic mean mercury concentration of 1-year-old Yellow Perch over the 10 years of monitoring ranged from a low of <0.010 ppm in 2014 and 2016 to a high of 0.038 ppm in 2015 (Figure 6.2-4). No Yellow Perch were submitted for mercury analysis in 2011, 2012, 2013, or 2019.

ROTATIONAL SITES

There are no off-system waterbodies in the Churchill River Diversion Region that are monitored for fish mercury on a rotational basis.

Table 6.2-1. 2010-2019 Fork length, age, and mercury concentrations of Lake Whitefish, Northern Pike, and Walleye.

Species	Waterbody	Year	Fork Length (mm)					Age (years)					Mercury (ppm)						
			n[1]	Mean	Min[2]	Max[2]	SE[2]	n	Mean	Min	Max	SE	n	Mean	Min	Max	SE	Standard Mean[3]	95% CL[4]
LKWH	3PT	2010	2	389	335	442	54	2	8	5	11	3	2	0.082	0.042	0.121	0.040	-	
		2011	18	402	265	481	13	18	10	3	26	1	18	0.087	0.036	0.169	0.011	0.055	0.043-0.070
		2012	7	399	277	480	25	6	12	5	28	4	7	0.107	0.041	0.251	0.029	0.062	0.034-0.111
		2013	15	392	273	483	14	15	10	4	24	1	15	0.092	0.030	0.238	0.014	0.055	0.045-0.066
		2014	10	359	196	442	23	10	6	2	10	1	10	0.053	0.027	0.087	0.007	0.049	0.040-0.059
		2015	13	423	333	493	13	13	9	4	19	1	13	0.095	0.039	0.190	0.015	0.035	0.025-0.050
		2016	6	332	147	455	54	6	9	1	20	3	6	0.067	0.020	0.135	0.022	not significant	
		2017	15	429	200	548	20	15	14	4	24	2	15	0.148	0.0331	0.269	0.020	0.081	0.059-0.112
		2018	7	360	191	461	33	7	7	3	13	1	7	0.074	0.023	0.131	0.015	0.065	0.049-0.085
		2019	11	365	181	454	28	11	8	2	16	1	11	0.077	0.032	0.123	0.011	0.069	0.057-0.083
	LEFT	2010	36	418	282	520	10	30	14	5	28	1	36	0.044	0.017	0.093	0.004	0.026	0.022-0.031
		2011	36	397	270	485	10	36	10	4	24	1	36	0.042	0.017	0.113	0.004	0.026	0.023-0.029
		2012	36	424	320	530	9	36	12	4	27	1	36	0.049	0.013	0.137	0.005	0.021	0.017-0.025
		2013	36	408	354	485	5	36	9	4	26	1	36	0.048	0.025	0.176	0.004	0.027	0.021-0.034
		2014	36	402	297	491	7	34	8	4	22	1	36	0.029	<0.010	0.116	0.003	0.014	0.012-0.016
		2015	35	429	320	495	6	35	9	4	24	1	35	0.039	0.016	0.093	0.003	0.019	0.015-0.025
		2016	36	414	213	492	8	36	10	2	28	1	36	0.049	0.019	0.090	0.003	0.032	0.027-0.039
		2017	36	435	357	501	6	36	12	4	26	1	36	0.064	0.025	0.135	0.004	0.029	0.023-0.037
		2018	35	440	367	535	6	35	10	4	23	1	35	0.057	0.027	0.086	0.003	0.029	0.022-0.039
		2019	36	432	233	486	7	36	13	3	26	1	36	0.059	0.016	0.153	0.004	0.033	0.028-0.041
NRPK	3PT	2010	32	484	325	760	22	32	5	2	10	0	32	0.502	0.129	0.917	0.039	0.591	0.527-0.663
		2011	31	423	303	742	19	30	5	3	10	0	31	0.323	0.096	1.07	0.036	0.485	0.396-0.592
		2012	20	444	236	871	31	20	5	2	11	0	20	0.344	0.083	1.00	0.045	0.460	0.373-0.568
		2013	26	413	190	790	28	25	4	1	10	0	26	0.370	0.093	1.28	0.065	0.516	0.407-0.653
		2014	33	431	228	720	23	33	4	1	8	0	33	0.338	0.057	1.25	0.048	0.485	0.416-0.565
		2015	32	445	275	875	26	32	5	2	11	0	32	0.323	0.110	0.793	0.034	0.422	0.373-0.478
		2016	29	440	224	646	22	29	4	1	6	0	29	0.350	0.069	0.683	0.031	0.484	0.419-0.559
		2017	26	496	305	728	26	26	5	2	9	0	26	0.407	0.100	0.879	0.048	0.456	0.402-0.518
		2018	21	513	296	640	20	21	5	2	7	0	21	0.507	0.138	1.02	0.056	0.545	0.469-0.633
		2019	13	467	290	594	25	12	4	2	8	1	13	0.434	0.134	0.955	0.079	0.579	0.410-0.817
	LEFT	2010	36	470	345	548	7	36	5	3	7	0	36	0.247	0.082	0.432	0.017	0.392	0.317-0.484
		2011	36	494	355	871	17	35	6	2	15	0	36	0.205	0.057	0.778	0.023	0.241	0.213-0.272
		2012	36	449	275	675	13	36	5	2	8	0	36	0.171	0.039	0.453	0.017	0.245	0.195-0.308
		2013	35	445	236	687	15	33	4	1	8	0	35	0.166	0.039	0.492	0.018	0.230	0.193-0.274
		2014	36	457	284	700	17	36	4	2	10	0	36	0.140	0.042	0.327	0.015	0.187	0.156-0.223
		2015	35	481	320	636	12	35	6	3	12	0	35	0.220	0.074	0.454	0.017	0.283	0.246-0.325
		2016	36	494	335	672	12	36	5	2	7	0	36	0.221	0.074	0.417	0.014	0.247	0.212-0.288
		2017	36	457	283	603	11	36	4	2	7	0	36	0.186	0.066	0.467	0.016	0.283	0.242-0.330
		2018	32	463	290	653	14	31	5	2	12	0	32	0.171	0.0603	0.365	0.016	0.237	0.204-0.275

Table 6.2-1. continued.

Species	Waterbody	Year	Fork Length (mm)					Age (years)					Mercury (ppm)						
			n[1]	Mean	Min[2]	Max[2]	SE[3]	n	Mean	Min	Max	SE	n	Mean	Min	Max	SE	Standard Mean[4]	95% CL[5]
NRPK	LEFT	2019	38	478	337	780	13	38	4	2	9	0	38	0.193	0.042	0.760	0.021	0.251	0.216-0.291
WALL	3PT	2010	36	358	228	444	9	36	11	4	20	1	36	0.510	0.170	0.984	0.036	0.577	0.495-0.673
		2011	36	361	237	455	10	35	11	5	22	1	36	0.386	0.134	0.698	0.028	0.431	0.370-0.502
		2012	36	287	127	444	17	35	7	1	17	1	36	0.361	0.057	0.910	0.038	0.567	0.471-0.682
		2013	35	360	150	486	13	35	10	1	19	1	35	0.468	0.068	1.24	0.045	0.520	0.455-0.595
		2014	34	371	230	485	10	33	10	3	18	1	34	0.477	0.220	0.950	0.034	0.502	0.437-0.576
		2015	36	352	205	465	12	36	9	3	22	1	36	0.466	0.142	1.10	0.043	0.558	0.492-0.632
		2016	36	331	163	488	15	36	8	1	18	1	36	0.378	0.059	1.03	0.046	0.476	0.394-0.576
		2017	35	354	189	541	13	33	9	3	19	1	35	0.404	0.118	1.11	0.044	0.456	0.393-0.530
		2018	35	332	132	482	16	35	9	1	17	1	35	0.410	0.051	0.971	0.043	0.530	0.454-0.620
		2019	32	355	169	501	14	32	10	2	24	1	32	0.541	0.092	1.10	0.049	0.618	0.539-0.708
	LEFT	2010	36	353	210	393	6	36	11	4	21	1	36	0.220	0.087	0.498	0.015	0.255	0.216-0.301
		2011	36	338	212	422	11	36	9	3	17	1	36	0.184	0.061	0.445	0.016	0.244	0.215-0.276
		2012	38	342	211	455	11	38	10	3	21	1	38	0.226	0.082	0.515	0.021	0.288	0.252-0.329
		2013	36	352	220	480	12	36	9	2	18	1	36	0.201	0.064	0.547	0.017	0.235	0.207-0.266
		2014	35	340	211	477	13	35	9	2	16	1	35	0.231	0.043	0.522	0.022	0.293	0.250-0.344
		2015	36	389	225	487	10	36	10	3	19	1	36	0.243	0.115	0.511	0.018	0.239	0.214-0.266
		2016	35	345	125	475	13	34	9	2	17	1	35	0.225	0.032	0.550	0.023	0.277	0.248-0.309
		2017	35	337	213	490	12	35	7	3	17	1	35	0.220	0.085	0.539	0.016	0.278	0.257-0.301
		2018	35	355	160	523	16	35	9	1	20	1	35	0.210	0.045	0.652	0.024	0.237	0.214-0.263
		2019	30	353	170	581	19	30	8	2	21	1	30	0.205	0.048	0.555	0.026	0.223	0.195-0.255

Notes:

1. n = Sample size.
2. Min = minimum; Max = maximum.
3. SE = standard error.
4. For standard lengths of 350 mm for Lake Whitefish (LKWH), 550 mm for Northern Pike (NRPK), and 400 mm for Walleye (WALL.).
5. CL = confidence limits.

Table 6.2-2. 2010-2019 Fork length and mercury concentrations of 1-year-old Yellow Perch.

Species	Waterbody	Year	n[1]	Fork Length (mm)				Mercury (ppm)			
				Mean	Min[2]	Max[2]	SE[3]	Mean	Min	Max	SE
YLPR	3PT	2010	0	-	-	-	-	-	-	-	-
		2011	0	-	-	-	-	-	-	-	-
		2012	0	-	-	-	-	-	-	-	-
		2013	0	-	-	-	-	-	-	-	-
		2014	0	-	-	-	-	-	-	-	-
		2015	0	-	-	-	-	-	-	-	-
		2016	0	-	-	-	-	-	-	-	-
		2017	0	-	-	-	-	-	-	-	-
		2018	3	80	73	93	5	0.033	0.0294	0.040	0.003
		2019	0	-	-	-	-	-	-	-	-
	LEFT	2010	3	78	70	85	4	0.028	0.017	0.044	0.007
		2011	0	-	-	-	-	-	-	-	-
		2012	0	-	-	-	-	-	-	-	-
		2013	0	-	-	-	-	-	-	-	-
		2014	10	79	73	86	1	<0.010	<0.010	0.015	-
		2015	2	72	70	74	1	0.038	0.032	0.043	0.004
		2016	1	77	-	-	-	<0.010	-	-	-
		2017	16	69	62	76	1	0.018	0.012	0.028	0.001
		2018	12	82	67	96	3	0.010	0.007	0.013	0.001
		2019	0	-	-	-	-	-	-	-	-

Notes:

1. n = sample size.
2. Min = minimum; Max = maximum.
3. SE = standard error.

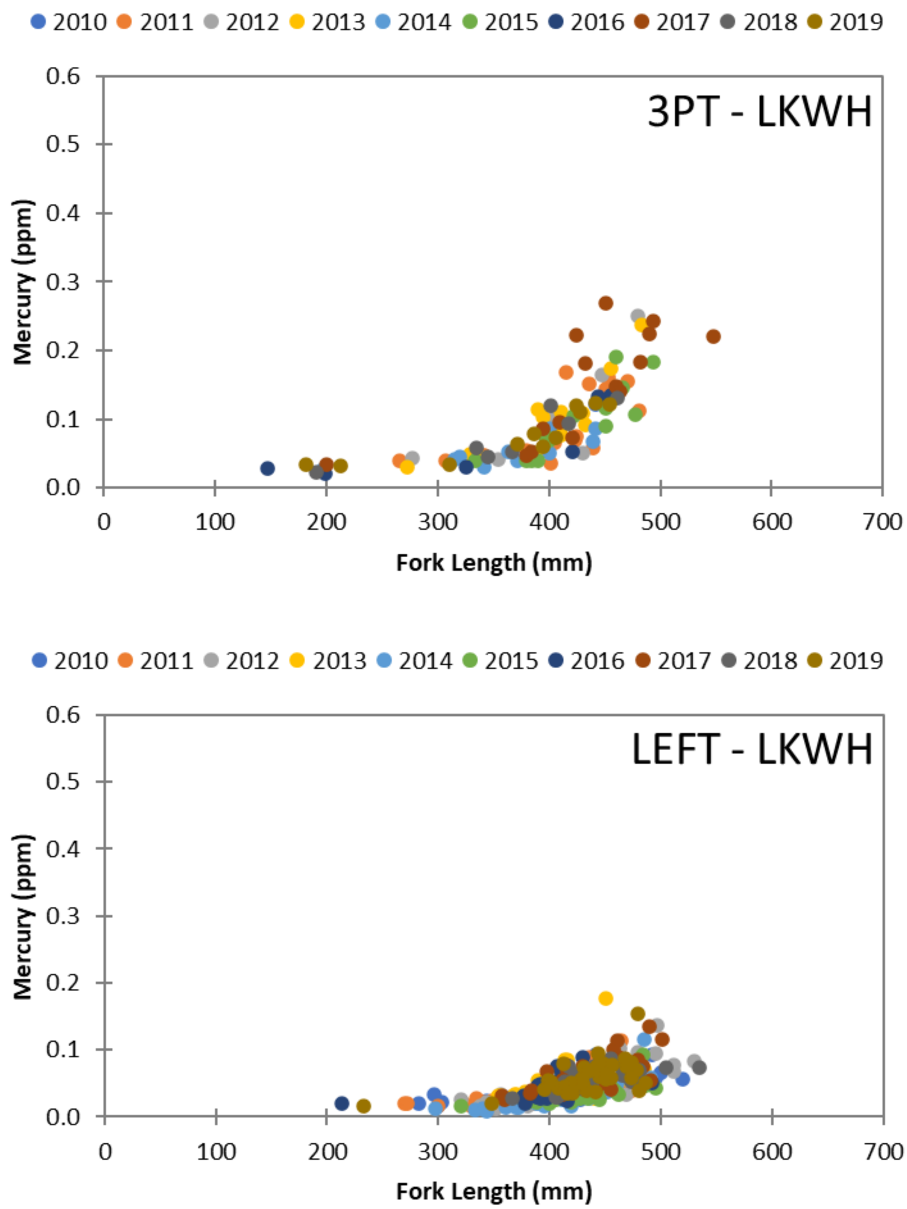


Figure 6.2-1. 2010-2019 Mercury concentration versus fork length of Lake Whitefish.

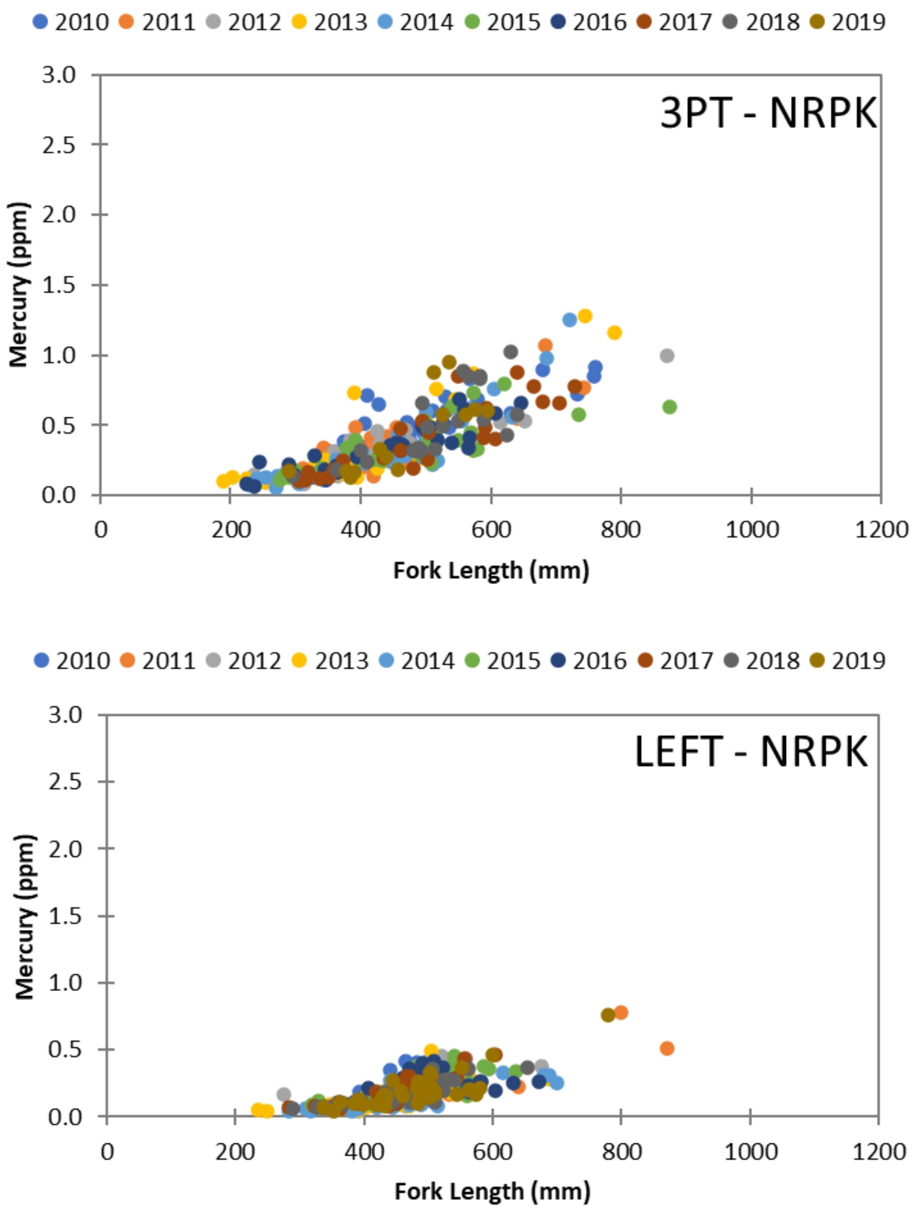
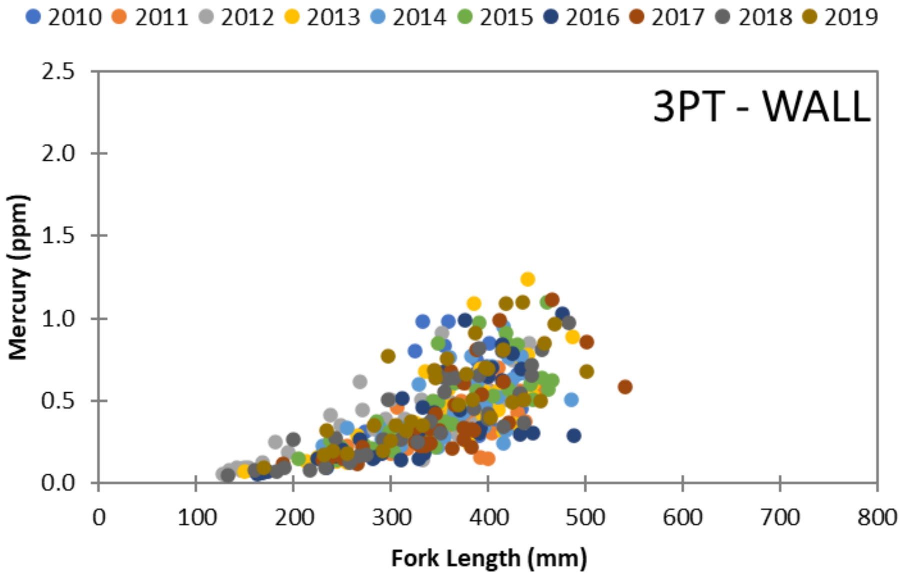


Figure 6.2-2. 2010-2019 Mercury concentration versus fork length of Northern Pike.



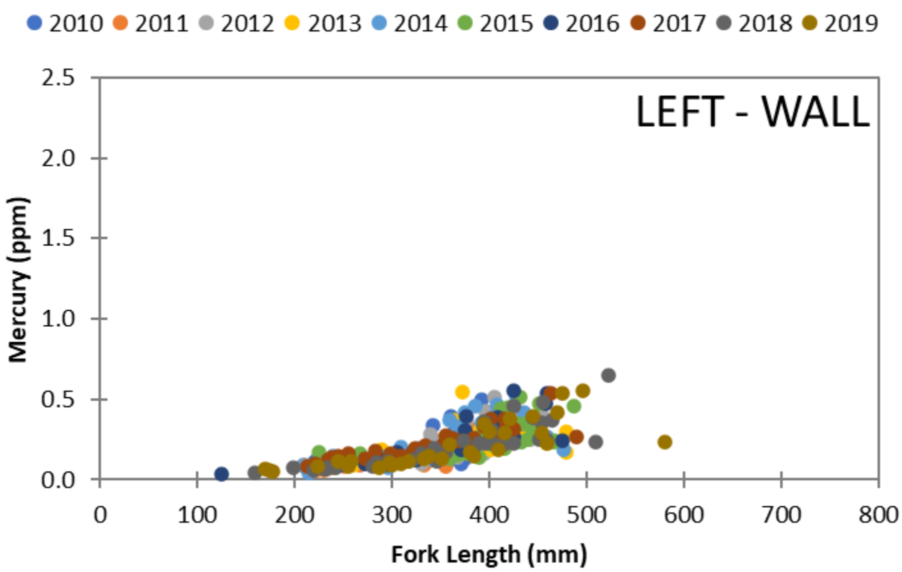


Figure 6.2-3. 2010-2019 Mercury concentration versus fork length of Walleye.

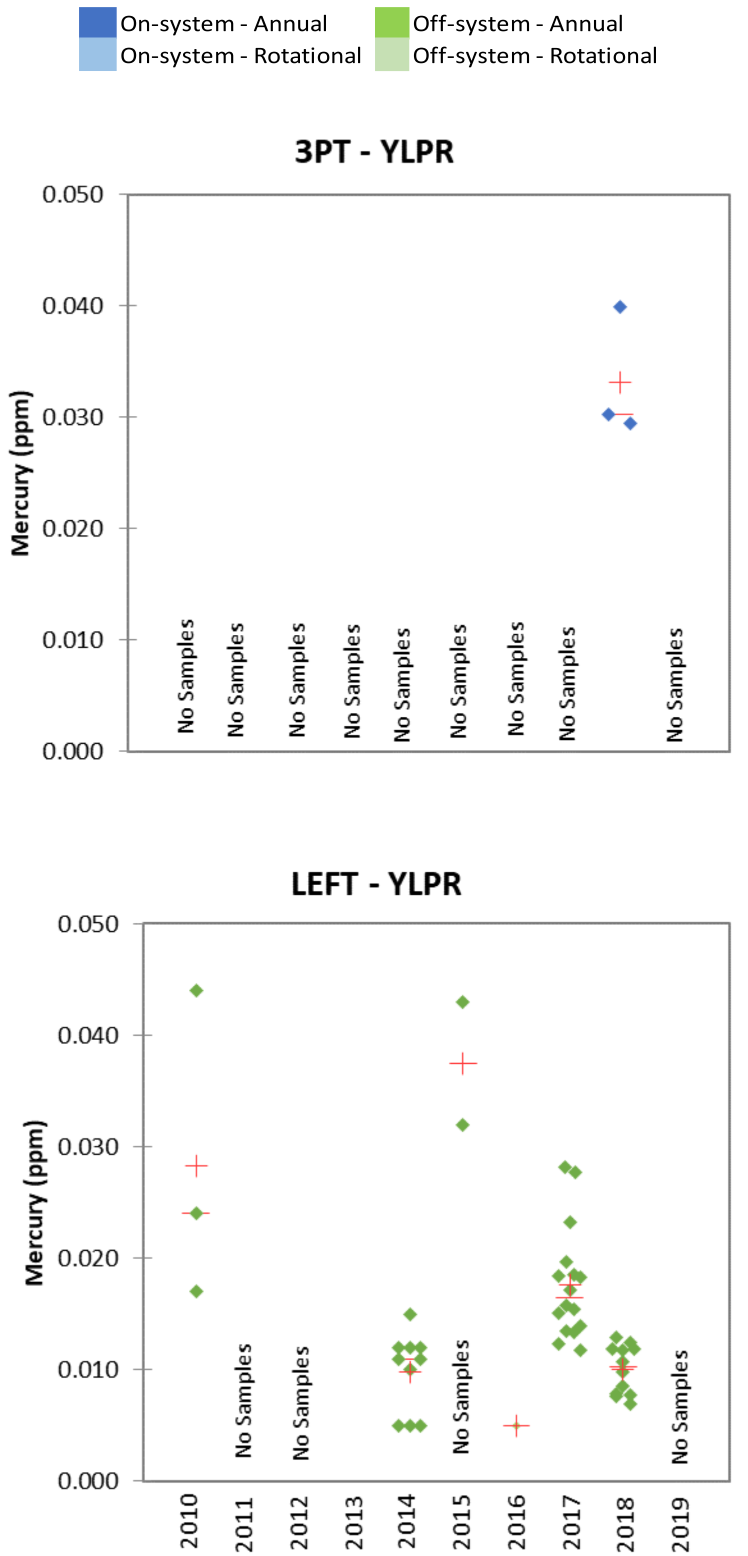


Figure 6.2-4. 2010-2019 Mercury concentrations of 1-year-old Yellow Perch.

6.2.2 LENGTH-STANDARDIZED MEAN CONCENTRATION

6.2.2.1 ON-SYSTEM SITES

ANNUAL SITES

Threepoint Lake

Lake Whitefish

The length-standardized mean mercury concentration of a 350 mm Lake Whitefish over the 10 years of monitoring ranged from 0.035 in 2015 to a high of 0.081 ppm in 2017 (Table 6.2-1). A standard mean could not be calculated for 2010 because only two fish were submitted for mercury analysis or in 2016 because there was not a significant relationship between mercury concentration and fork length.

The overall mean concentration was 0.059 ppm, the median concentration was 0.058 ppm, and the IQR was 0.053–0.066 ppm (Figure 6.2-5). The annual mean mercury concentration fell within the IQR except in 2014 and 2015 when it was below the IQR and in 2017 and 2019 when it was above the IQR.

Northern Pike

The length-standardized mean mercury concentration of a 550 mm Northern Pike over the 10 years of monitoring ranged from a low of 0.422 ppm in 2015 to a high of 0.591 ppm in 2010 (Table 6.2-1).

The overall mean concentration was 0.502 ppm, the median concentration was 0.485 ppm, and the IQR was 0.466–0.538 ppm (Figure 6.2-6). The annual mean mercury concentration fell within the IQR except in 2012, 2015, and 2017 when it was below the IQR and in 2010, 2018, and 2019 when it was above the IQR.

Walleye

The length-standardized mean mercury concentration of a 400 mm Walleye over the 10 years of monitoring ranged from a low of 0.431 ppm in 2011 to a high of 0.618 ppm in 2019 (Table 6.2-1).

The overall mean concentration was 0.524 ppm, the median concentration was 0.525 ppm, and the IQR was 0.483–0.565 ppm (Figure 6.2-7). The annual mean mercury concentration fell within the IQR except in 2011, 2016, and 2017 when it was below the IQR and in 2010, 2012, and 2019 when it was above the IQR.

ROTATIONAL SITES

There are no on-system waterbodies in the Churchill River Diversion Region that are monitored for fish mercury on a rotational basis.

6.2.2.2 OFF-SYSTEM SITES

ANNUAL SITES

Leftrook Lake

Lake 2333

The length-standardized mean mercury concentration of a 350 mm Lake Whitefish over the 10 years of monitoring ranged from a low of 0.014 ppm in 2014 to a high of 0.033 ppm in 2019 (Table 6.2-1).

The overall mean concentration was 0.026 ppm, the median concentration was 0.027 ppm, and the IQR was 0.022–0.029 ppm (Figure 6.2-5). The annual mean mercury concentration fell within the IQR except in 2012, 2014, and 2015 when it was below the IQR and in 2016 and 2019 when it was above the IQR.

Northern Pike

The length-standardized mean mercury concentration of a 550 mm Northern Pike over the 10 years of monitoring ranged from a low of 0.187 ppm in 2014 to a high of 0.392 ppm in 2010 (Table 6.2-1).

The overall mean concentration was 0.260 ppm, the median concentration was 0.246 ppm, and the IQR was 0.238–0.275 ppm (Figure 6.2-6). The annual mean mercury concentration fell within the IQR except in 2013, 2014, 2018 when it was below the IQR and in 2010, 2015, and 2017 when it was above the IQR.

Walleye

The length-standardized mean mercury concentration of a 400 mm Walleye over the 10 years of monitoring ranged from a low of 0.223 ppm in 2019 to a high of 0.293 ppm in 2014 (Table 6.2-1).

The overall mean concentration was 0.257 ppm, the median concentration was 0.249 ppm, and the IQR was 0.238–0.278 ppm (Figure 6.2-7). The annual mean mercury concentration fell within the IQR except in 2013, 2018, and 2019 when it was below the IQR and in 2012 and 2014 when it was above the IQR.

ROTATIONAL SITES

There are no off-system waterbodies in the Churchill River Diversion Region that are monitored for fish mercury on a rotational basis.

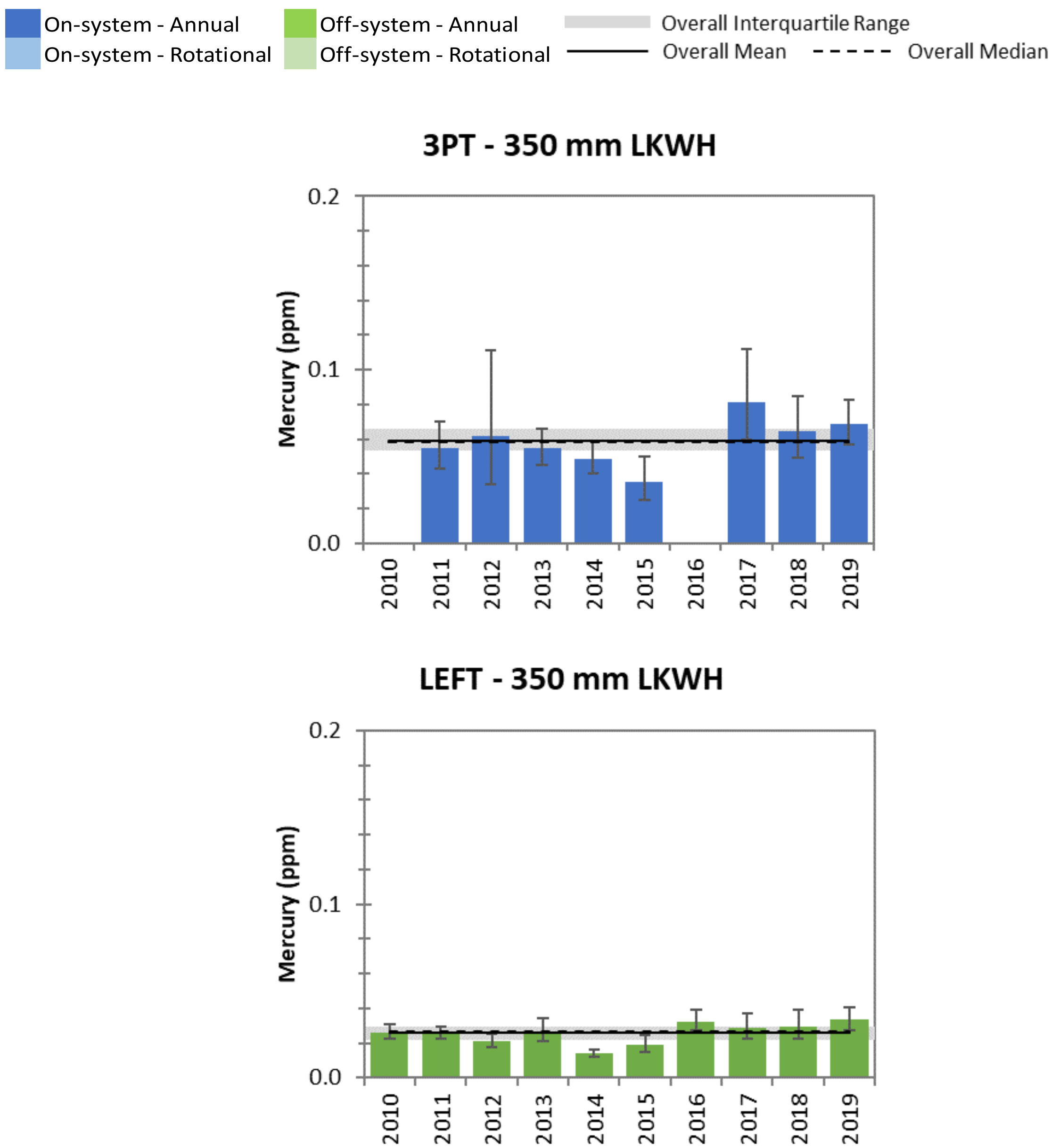


Figure 6.2-5. 2010-2019 Length-standardized mean mercury concentrations (±95% confidence intervals) of Lake Whitefish.

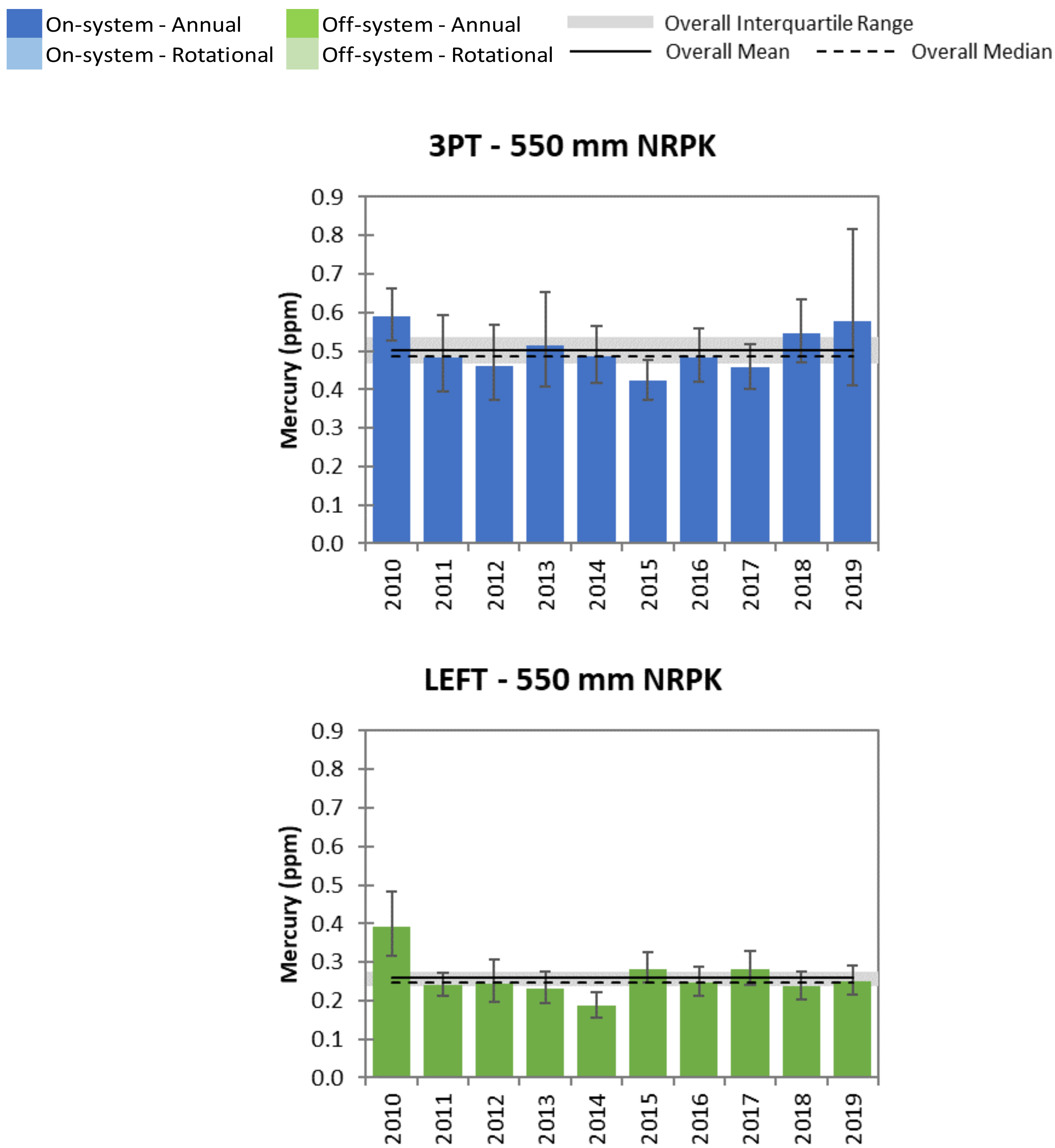


Figure 6.2-6. 2010-2019 Length-standardized mean mercury concentrations (±95% confidence intervals) of Northern Pike.

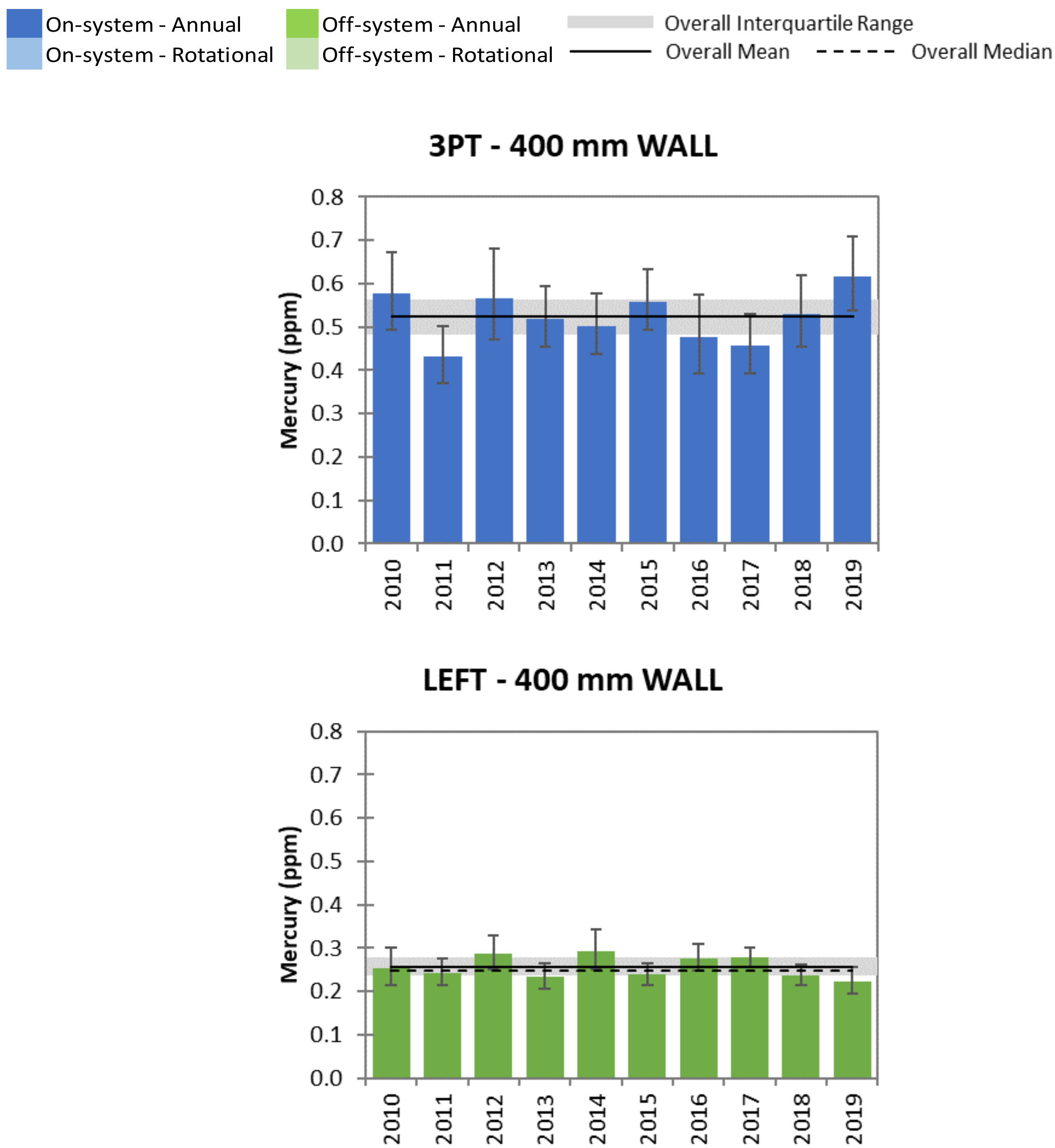


Figure 6.2-7. 2010-2019 Length-standardized mean mercury concentrations (±95% confidence intervals) of Walleye.

7.0 LITERATURE CITED

Canadian Council of Ministers of the Environment (CCME). 1999. Canadian environmental quality guidelines. Canadian Council of Ministers of the Environment, Winnipeg, MB. Updated to 2024.

Coordinated Aquatic Monitoring Program (CAMP). 2024. CAMP Indicator Report. Prepared for Manitoba/Manitoba Hydro Steering Committee by Manitoba Hydro, Winnipeg, MB.

Manitoba Hydro and the Province of Manitoba. 2015. Regional cumulative effects assessment for hydroelectric developments on the Churchill, Burntwood and Nelson river systems: Phase II Report. Winnipeg, MB.

Manitoba Water Stewardship (MWS). 2011. Manitoba Water Quality Standards, Objectives, and Guidelines. Water Science and Management Branch, MWS. MWS Report 2011-01, November 28, 2011. 67 pp.

Muñoz Sabater, J. 2019. ERA5-Land monthly averaged data from 1950 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). DOI: 10.24381/cds.68d2bb30

Nürnberg, G.K. 1996. Trophic state in clear and colored, soft- and hardwater lakes with special consideration of nutrients, anoxia, phytoplankton and fish. Lake Reservoir Management. 12: 432-447.

Organization for Economic Cooperation and Development (OECD). 1982. Eutrophication of waters: monitoring, assessment and control. Final Report. OECD cooperative programme on monitoring of inland waters (eutrophication control). Environment Directorate, OECD, Paris, France. 154 pp.

Stewart, K.W. and D.A. Watkinson. 2004. The freshwater fishes of Manitoba. University of Manitoba Press, Winnipeg, MB. 276 p.