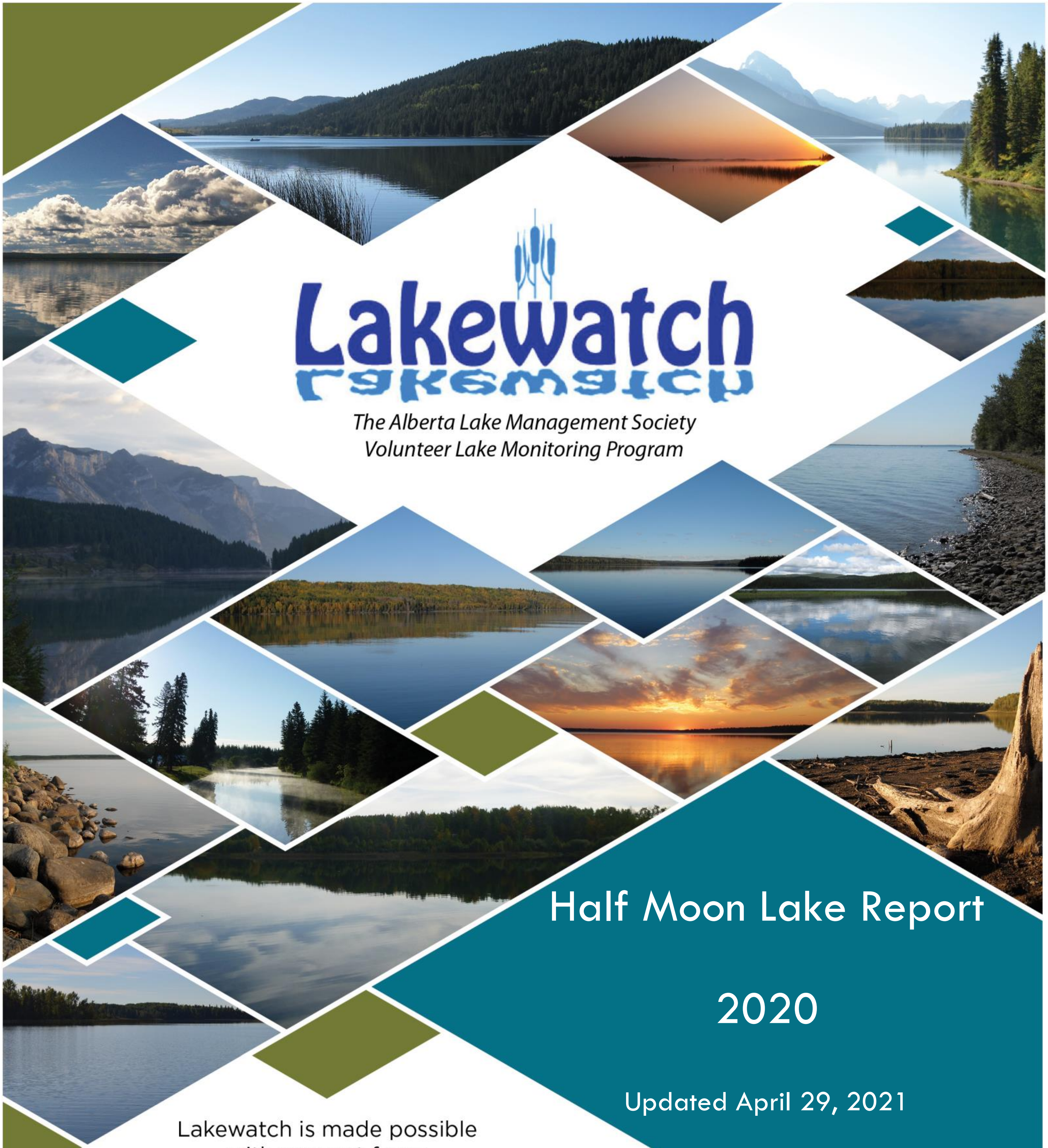


Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Half Moon Lake Report

2020

Updated April 29, 2021

Lakewatch is made possible with support from:

Alberta Environment and Parks
Pigeon Lake Watershed Association
Moose Lake Watershed Society
Lacombe County
LICA Environmental Stewards

ALBERTA LAKE MANAGEMENT SOCIETY'S LAKEWATCH PROGRAM

LakeWatch has several important objectives, one of which is to collect and interpret water quality data from Alberta's Lakes. Equally important is educating lake users about aquatic environments, encouraging public involvement in lake management, and facilitating cooperation and partnerships between government, industry, the scientific community and lake users. LakeWatch reports are designed to summarize basic lake data in understandable terms for the widest audience, and are not meant to be a complete synopsis of information about specific lakes. Additional information is available for many lakes that have been included in LakeWatch, and readers requiring more information are encouraged to seek those sources.

ALMS would like to thank all who express interest in Alberta's aquatic environments, and particularly those who have participated in the LakeWatch program. These leaders in stewardship give us hope that our water resources will not be the limiting factor in the health of our environment.

If you require data from this report, please contact ALMS for the raw data files.

ACKNOWLEDGEMENTS

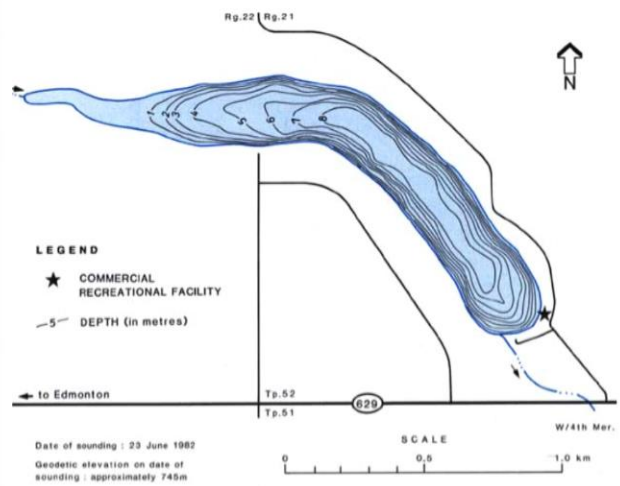
The LakeWatch program is made possible through the dedication of its volunteers. A special thanks to Richard Normandeau for his commitment to collecting data at Half Moon Lake – he was named 'LakeWatch Volunteer of the Year' for the 2020 season. We would also like to thank Kyra Ford and Ryan Turner, who were summer technicians in 2020. Executive Director Bradley Peter and Program Manager Caleb Sinn were instrumental in planning and organizing the field program. This report was prepared by Caleb Sinn and Bradley Peter.

HALF MOON LAKE

Half Moon Lake is a small lake east of the City of Edmonton in the County of Strathcona. Half Moon Lake lies in the North Saskatchewan River basin, within the Moist Mixedwood Subregion of the Boreal Mixedwood Ecoregion, thus the watershed is dominated by trembling aspen (Populus tremuloides) and balsam poplar (Populus balsamifera)[1].

Half Moon Lake, named for its shape, is small, with a surface area of only 0.41 km^2 and a maximum depth of 8.5 m. The drainage basin is also small, measuring only 2.43 km^2, resulting in a drainage basin to surface area ratio of 6:1. Only one intermittent stream flows into the lake from the north. Development in Half Moon Lake's watershed includes residential units on the East and West shores, and one resort, the Half Moon Lake Resort, on the South shore.

Despite the lakes popularity as a recreational destination, sport fishing is absent. Half Moon Lake has been the subject of several in-lake treatments for the control of nuisance algal/cyanobacterial blooms including herbicides and the addition of lime[2]. In 1989, 58 tonnes of calcium carbonate and 49 tonnes of calcium hydroxide were added to the lake in effort to reduce the amounts of phosphorus and algae/cyanobacteria biomass[3]. In 1989, after positive results from the first additions, an extra 139 tonnes of calcium hydroxide was added to the lake. Results of treating the lake with calcium hydroxide have been mixed and this treatment is likely not a viable way to treat Half Moon Lake. The Residents of Half Moon Lake are considering other treatment options for the lake, subject to better understanding of current and future conditions.



Bathymetry and shoreline features of Half Moon Lake. Source: Babin 1984.

Freshwater invertebrates (bryozoans) found at the bottom of Half Moon Lake—photo by Laura Redmond 2017

[1] Strong, W.L. and K.R. Leggat. (1981). Ecoregions of Alberta. Alta. En. Nat. Resour., Resour. Eval. Plan. Div., Edmonton.
[2] Mitchell, P and E. Prepas. (1990). Atlas of Alberta Lakes, University of Alberta Press. Available at: http://sunsite.ualberta.ca/Projects/Alberta-Lakes/
[3] Prepas, J. and Babin, J. (1990). Final Report on the 1989 Lime Treatment of Halfmoon Lake. Retrieved from: http://environment.gov.ab.ca/info/library/8316.pdf

METHODS

Profiles: Profile data is measured at the deepest spot in the main basin of the lake. At the profile site, temperature, dissolved oxygen, pH, conductivity and redox potential are measured at 0.5 – 1.0 m intervals. Additionally, Secchi depth is measured at the profile site and used to calculate the euphotic zone. For select lakes, metals are collected at the profile site by hand grab from the surface on one visit over the season.

Composite samples: At 10-sites across the lake, water is collected from the euphotic zone and combined across sites into one composite sample. This water is collected for analysis of water chemistry, chlorophyll-a, nutrients and microcystin. Quality control (QC) data for total phosphorus was taken as a duplicate true split on one sampling date. ALMS uses the following accredited labs for analysis: Routine water chemistry and nutrients are analyzed by Bureau Veritas, chlorophyll-*a* and metals are analyzed by Innotech Alberta, and microcystin is analyzed by the Alberta Centre for Toxicology (ACTF).

Invasive Species: : Invasive mussel monitoring involved sampling with a 63 µm plankton net at three sample sites twice through the summer season to determine the presence of juvenile dreissenid mussel veligers, and spiny water flea. Technicians also harvested potential Eurasian watermilfoil (*Myriophyllum spicatum)* samples and submitted them for further analysis at the Alberta Plant Health Lab to genetically differentiate whether the sample was the invasive Eurasian watermilfoil or a native watermilfoil. In addition, select lakes were subject to a bioblitz, where a concerted effort to sample the lake's aquatic plant diversity took place.

Data Storage and Analysis: Data is stored in the Water Data System (WDS), a module of the Environmental Management System (EMS) run by Alberta Environment and Parks (AEP). Data goes through a complete validation process by ALMS and AEP. Users should use caution when comparing historical data, as sampling and laboratory techniques have changed over time (e.g. detection limits). For more information on data storage, see AEP Surface Water Quality Data Reports at aep.alberta.ca/water.

Data analysis is done using the program R.[1] Data is reconfigured using packages tidyr [2] and dplyr [3] and figures are produced using the package ggplot2 [4]. Trophic status for each lake is classified based on lake water characteristics using values from Nurnberg (1996)[5]. The Canadian Council for Ministers of the Environment (CCME) guidelines for the Protection of Aquatic Life are used to compare heavy metals and dissolved oxygen measurements. Pearson's Correlation tests are used to examine relationships between TP, chlorophyll-*a,* TKN and Secchi depth, providing a correlation coefficient (r) to show the strength (0-1) and a p-value to assess significance of the relationship.

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[1] R Core Team (2016). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

[2] Wickman, H. and Henry, L. (2017). tidyr: Easily Tidy Data with 'spread ( )' and 'gather ( )' Functions. R package version 0.7.2. https://CRAN.R-project.org/package=tidyr.

[3] Wickman, H., Francois, R., Henry, L. and Muller, K. (2017). dplyr: A Grammar of Data Manipulation. R package version 0.7.4. http://CRAN.R-project.org/package=dplyr.

[4] Wickham, H. (2009). ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag New York.

[5] Nurnberg, G.K. (1996). Trophic state of clear and colored, soft- and hardwater lakes with special consideration of nutrients, anoxia, phytoplankton and fish. Lake and Reservoir Management 12: 432-447.

BEFORE READING THIS REPORT, CHECK OUT A BRIEF INTRODUCTION TO LIMNOLOGY AT ALMS.CA/REPORTS

WATER CHEMISTRY

ALMS measures a suite of water chemistry parameters. Phosphorus, nitrogen, and chlorophyll-a are important because they are indicators of eutrophication, or excess nutrients, which can lead to harmful algal/cyanobacteria blooms. One direct measure of harmful cyanobacteria blooms are Microcystins, a common group of toxins produced by cyanobacteria. See Table 2 for a complete list of parameters.

The average total phosphorus (TP) concentration for Half Moon Lake was 76 µg/L (Table 2), falling into the category of eutrophic, or productive trophic classification. This value is slightly lower than the range of observed historical averages. TP was lowest when sampled on July 6^{th} at 40 µg/L, and peaked at 110 µg/L during the September 3^{rd} sampling event (Figure 1).

Average chlorophyll-*a* concentration in 2020 was 27.3 µg/L (Table 2), falling into the hypereutrophic, or very highly productive trophic classification. Chlorophyll-*a* was lowest during the July 6^{th} sampling event, with a minimum concentration of 13.7 µg/L, and a maximum of 58.6 µg/L during the September 3^{rd} sampling event, corresponding to the peak TP value as well.

The average TKN concentration was 2.1 mg/L (Table 2) with concentrations remaining fairly steady throughout the sampling season. Visually (Figure 1), chlorophyll-*a* levels track similarly to levels of TP and TKN throughout the season. TP was not significantly correlated with chlorophyll-*a* (r = 0.95, p = 0.051), but TKN was significantly correlated with chlorophyll-*a* (r = 0.96, p = 0.039), assessing at significance of $p < 0.05$.

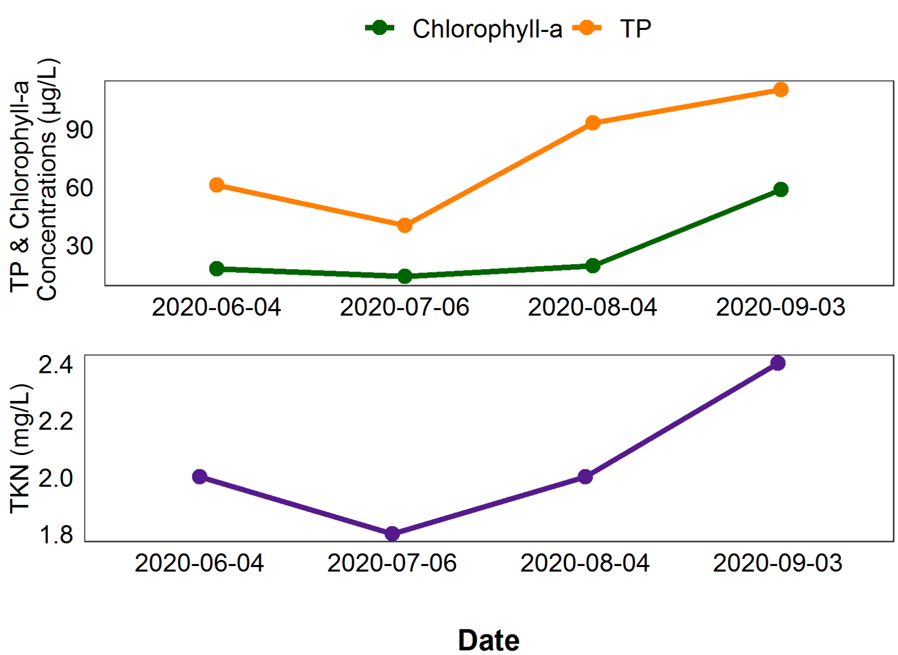

Figure 1. Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentrations measured four times over the course of the summer at Half Moon Lake, 2020.

Average pH was measured as 8.38 in 2020, buffered by moderate alkalinity (183 mg/L $CaCO_3$) and bicarbonate (215 mg/L HCO_3). Aside from bicarbonate, the dominant ions were sodium, calcium and chloride, contributing to a low conductivity of 443 µS/cm (Figure 2, top; Table 2). Half Moon Lake was in the average range of ion levels compared to other LakeWatch lakes sampled in 2020, with the exception of relatively low levels of sulphate (Figure 2, bottom).

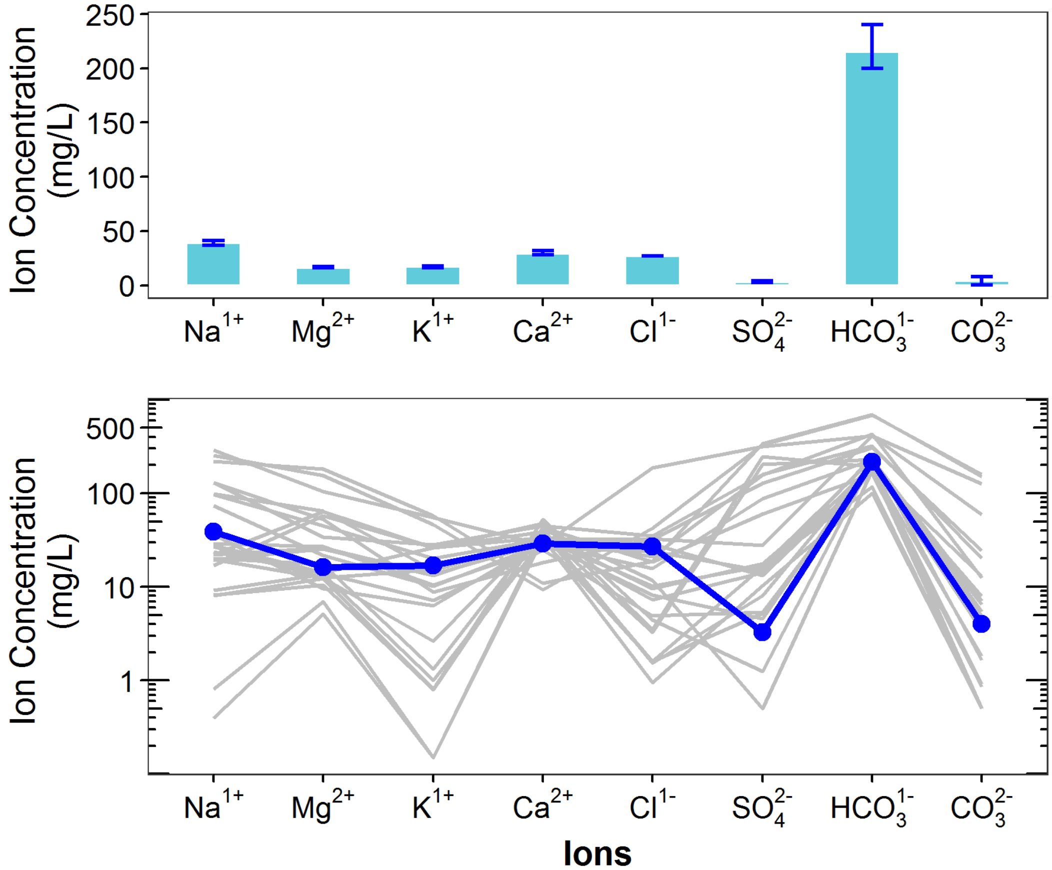

Figure 2. Average levels of cations (sodium = Na^{1+}, magnesium = Mg^{2+}, potassium = K^{1+}, calcium = Ca^{2+}) and anions (chloride = Cl^{1-}, sulphate = SO_4^{2-}, bicarbonate = HCO_3^{1-}, carbonate = CO_3^{2-}) from four measurements over the course of the summer at Half Moon Lake. Top) bars indicate range of values measured, and bottom) Schoeller diagram of average ion levels at Half Moon Lake (blue line) compared to 25 lake basins (gray lines) sampled through the LakeWatch program in 2020 (note $\log_{10}$ scale on y-axis of bottom figure).

METALS

Samples were analyzed for metals once throughout the summer (Table 3). In total, 27 metals were sampled for. It should be noted that many metals are naturally present in aquatic environments due to the weathering of rocks and may only become toxic at higher levels.

Metals were not measured at Half Moon Lake in 2020. Table 3 presents historical values from previously sampled years.

WATER CLARITY AND EUPHOTIC DEPTH

Water clarity is influenced by suspended materials, both living and dead, as well as dissolved colored compounds in the water column. During the melting of snow and ice in spring, lake water can become turbid (cloudy) from silt transported into the lake. Lake water usually clears in late spring but then becomes more turbid with increased algal growth as the summer progresses. The easiest and most widely used measure of lake water clarity is the Secchi depth. Two times the Secchi depth equals the euphotic depth – the depth to which there is enough light for photosynthesis.

The average euphotic depth of Half Moon Lake in 2020 was 2.54 m, corresponding to an average Secchi depth of 1.27 m (Table 2). Euphotic depth varied throughout the season, with the shallowest depth being 1.80 m on June 4th, compared to 3.94 m on July 6th (Figure 3), the sampling date also with the lowest chlorophyll-a, TP and TKN values (Figure 1).

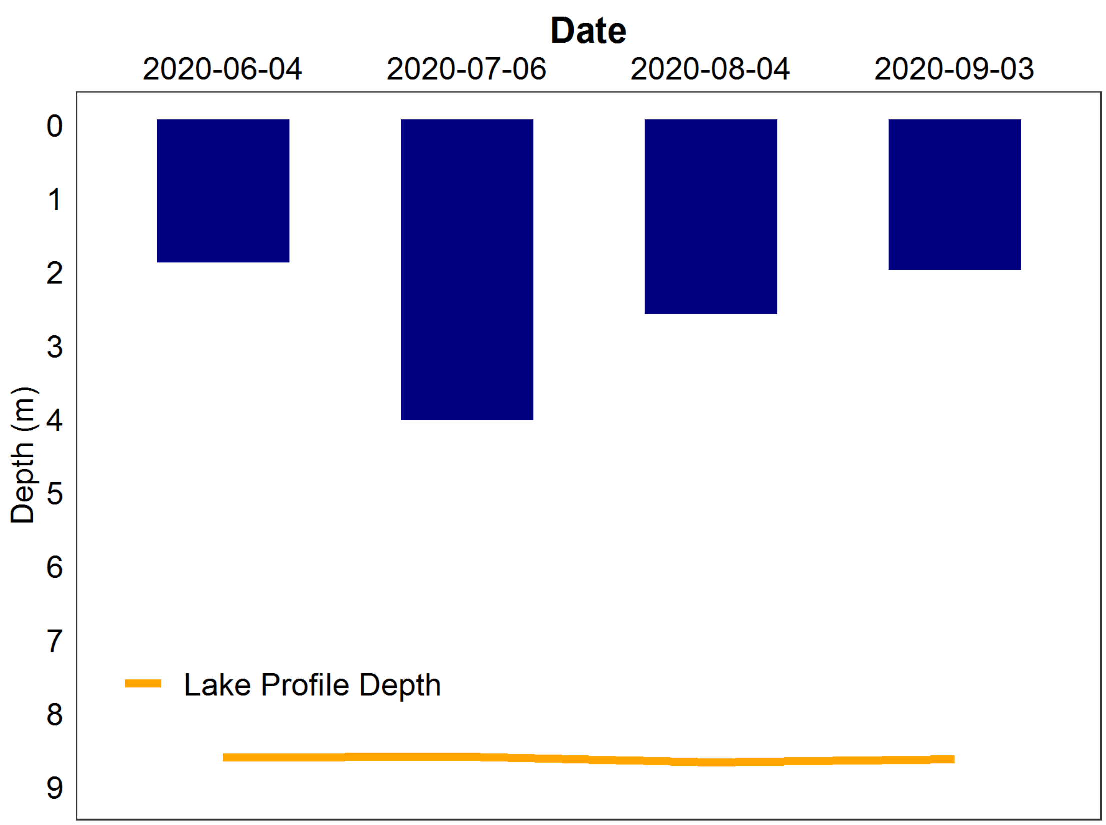

Figure 3. Secchi depth values measured four times over the course of the summer at Half Moon Lake in 2020.

WATER TEMPERATURE AND DISSOLVED OXYGEN

Water temperature and dissolved oxygen (DO) profiles in the water column can provide information on water quality and fish habitat. The depth of the thermocline is important in determining the depth to which dissolved oxygen from the surface can be mixed. Please refer to the end of this report for descriptions of technical terms.

Temperatures of Half Moon Lake varied throughout the summer, with a minimum temperature of 13.6°C at 8.5 m on June 4th, and a maximum temperature of 22.4°C measured at 1.5m on August 8th (Figure 4a). Half Moon Lake displayed mild stratification during July and August, with steep temperature gradients between the top and bottom layers of the water column. This is typical of deep temperate lakes and indicates that the top and bottom layers of the water column mix little during the middle of the season. The small size of Half Moon Lake likely restricts the wind's ability to mix the lake thoroughly. Early and late in the open water season, temperatures are lower and more consistent from top to bottom, indicating mixing occurring throughout the water column.

The upper layer of the water column remained well oxygenated from June to September, measuring above the CCME guidelines of 6.5 mg/L dissolved oxygen (Figure 4b). The oxygen level fell below this guideline below 4 m in July and August, but levels in June were above 6.5 mg/L to 7 m, and all depths in September were above the guideline.

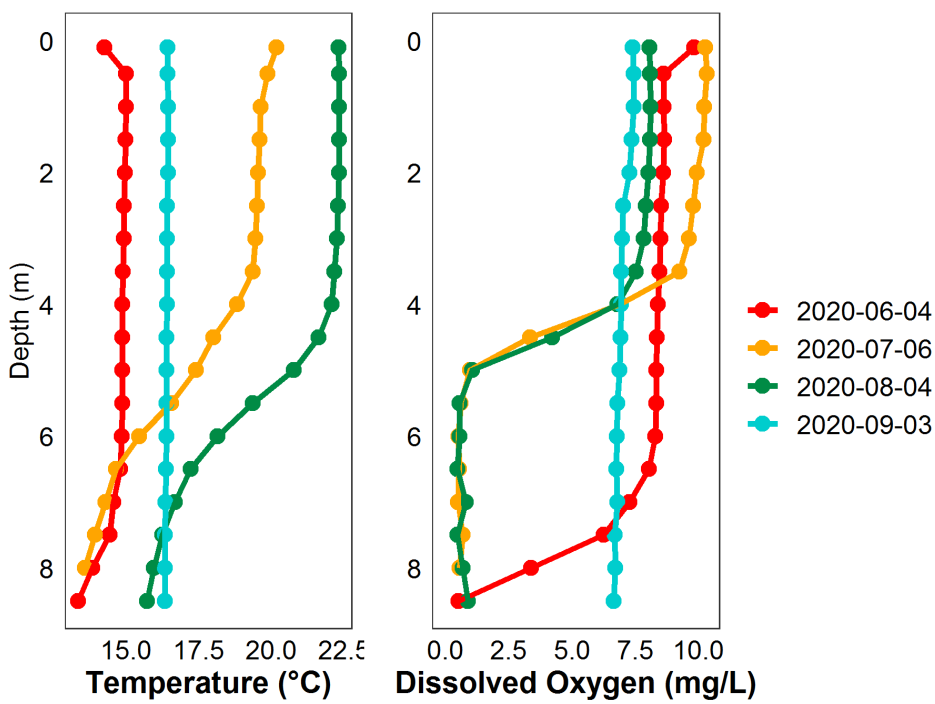

Figure 4. a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Half Moon Lake measured four times over the course of the summer of 2020.

MICROCYSTIN

Microcystins are toxins produced by cyanobacteria (blue-green algae) which, when ingested, can cause severe liver damage. Microcystins are produced by many species of cyanobacteria which are common to Alberta's Lakes, and are thought to be the one of the most common cyanobacteria toxins. In Alberta, recreational guidelines for microcystin are set at 20 µg/L. Blue-green algae advisories are managed by Alberta Health Services. Recreating in algal blooms, even if microcystin concentrations are not above guidelines, is not recommended.

Microcystin levels in Half Moon Lake fell below the recreational guideline of 20 µg/L during each sampling event in 2020 (Table 1). Further, the microcystin average for 2020 was an order of magnitude lower than the historical average levels (Table 2).

Table 1. Microcystin concentrations measured four times at Half Moon Lake in 2020.

Date	Microcystin Concentration (µg/L)
4-Jun-20	<0.1
6-Jul-20	0.22
4-Aug-20	0.27
3-Sep-20	0.57
Average	*0.28

* Half of the detection limit value is used to calculate an average value.

INVASIVE SPECIES MONITORING

Dreissenid mussels pose a significant concern for Alberta because they impair the function of water conveyance infrastructure and adversely impact the aquatic environment. These invasive mussels can change lake conditions which can then lead to toxic cyanobacteria blooms, decrease the amount of nutrients needed for fish and other native species, and cause millions of dollars in annual costs for repair and maintenance of water-operated infrastructure and facilities. Spiny water flea pose a concern for Alberta because they alter the abundance and diversity of native zooplankton as they are aggressive zooplankton predators. Through over-predation, they will impact higher trophic levels such as fish. They also disrupt fishing equipment by attaching in large numbers to fishing lines.

Monitoring involved sampling with a 63 µm plankton net at three sample sites to look for juvenile mussel veligers and spiny water flea in each lake sampled. In 2020, no mussels or spiny water flea were detected at Half Moon Lake.

Eurasian watermilfoil is non-native aquatic plant that poses a threat to aquatic habitats in Alberta because it grows in dense mats preventing light penetration through the water column, reduces oxygen levels when the dense mats decompose, and outcompetes native aquatic plants. Eurasian watermilfoil can look similar to the native Northern watermilfoil, thus genetic analysis is ideal for suspect watermilfoil species identification.

No suspect watermilfoil was observed or collected from Half Moon Lake in 2020.

WATER LEVELS

There are many factors influencing water quantity. Some of these factors include the size of the lake's drainage basin, precipitation, evaporation, water consumption, ground water influences, and the efficiency of the outlet channel structure at removing water from the lake. Requests for water quantity monitoring should go through Alberta Environment and Parks Monitoring and Science division.

Water levels of Half Moon Lake were monitored between 1991 and 2020, and fluctuated by less than 1 m throughout this monitoring extent (Figure 5). There was an absence of monitoring between 2004 and 2018, but AEP has since began to monitor lakes levels again, starting in 2019. Therefore, the region of the figure between 2004 and 2018 should be interpreted with caution. However, the recently measured levels in 2019 and 2020 indicate the water levels have increased to a range last seen in the early-1990s, compared to the low of 2003.

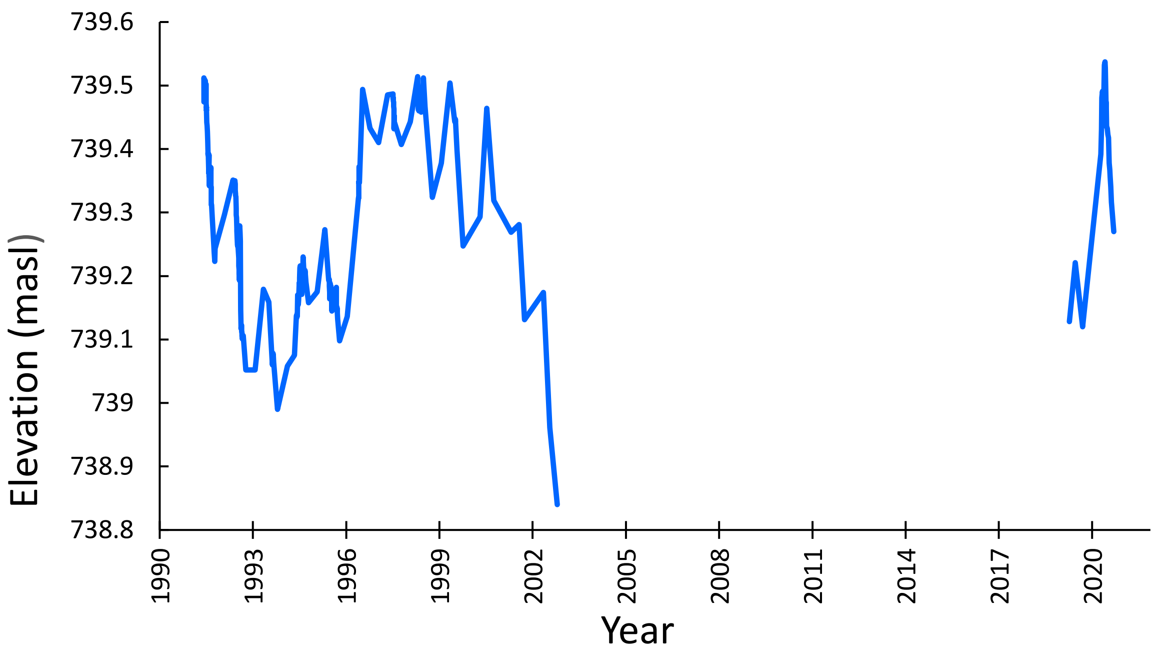

Figure 5. Water level measured in meters above sea level (masl) from 1991-2020. Data retrieved from Alberta Environment and Parks.

Table 2. Average Secchi depth and water chemistry values for Half Moon Lake. Historical values are given for reference.

Parameter	1982[a]	1987[b]	1988[b]	1989[b]	1990[b]	2011	2017	2018	2019	2020
TP (µg/L)	124	99	135	87	75	111	75	96	80	76
TDP (µg/L)	/	27	47	37	26	29	11	9	17	25
Chlorophyll-*a* (µg/L)	50.2	63.8	/	44.4	39.5	41.4	51.6	86.3	41.5	27.3
Secchi depth (m)	1.30	0.80	/	1.48	1.4	1.33	0.66	0.38	1.56	1.27
TKN (mg/L)	3.1	2.2	2.6	2.0	2.0	2.8	2.7	3.0	2.4	2.1
NO_2-N and NO_3-N (µg/L)	44	9	15	76	55	4	2	4	25	5
NH_3-N (µg/L)	/	/	127	212	65	41	38	81	173	107
DOC (mg/L)	/	/	20	19	18	22	22	24	21	19
Ca (mg/L)	/	19	20	17	19	22	24	23	24	29
Mg (mg/L)	/	11	14	11	12	17	19	18	17	16
Na (mg/L)	/	18	19	20	20	35	43	41	40	39
K (mg/L)	/	13	13	12	12	15	20	19	18	17
SO_4^{2-} (mg/L)	/	<5	<5	4	4	3	3	3	1	3
Cl^- (mg/L)	/	8	8	9	10	20	26	27	27	27
CO_3 (mg/L)	/	18	7	17	12	9	11	11	4	4
HCO_3 (mg/L)	/	133	167	134	156	196	205	208	218	215
pH	/	9.05	8.20	8.98	8.67	8.74	8.81	8.71	8.49	8.38
Conductivity (µS/cm)	/	287	304	291	294	697	430	430	435	443
Hardness (mg/L)	/	91	105	90	96	124	135	128	128	143
TDS (mg/L)	/	156	165	155	159	224	245	240	238	243
Microcystin (µg/L)	/	/	/	/	/	2.07	9.80	6.60	4.84	0.28
Total Alkalinity (mg/L $CaCO_3$)	/	139	143	136	138	175	188	185	185	183

[a] Data from: Mitchell, P and E. Prepas. (1990). Atlas of Alberta Lakes, University of Alberta Press. Available at: http://sunsite.ualberta.ca/Projects/Alberta-Lakes/

[b]Data from: Alberta Environment and Parks, Government of Alberta (2020). Available at: http://environment.alberta.ca/apps/EdwReportViewer/LakeWaterQuality.aspx

[/]A forward slash (/) indicates an absence of data.

Table 3. Concentrations of metals were last measured in Half Moon Lake on September 6, 2017. Concentrations were measured at the surface and at 1 m above bottom. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	**2017 Top**	**2017 Bottom**	**Guidelines**
Aluminum μg/L	9.6	12	100[a]
Antimony μg/L	0.07	0.07	/
Arsenic μg/L	1.36	1.38	5
Barium μg/L	49.5	53.5	/
Beryllium μg/L	0.0015	0.0015	100[c,d]
Bismuth μg/L	0.0015	0.0015	/
Boron μg/L	75.8	76.6	1500
Cadmium μg/L	0.005	0.005	0.26[b]
Chromium μg/L	0.3	5.3	/
Cobalt μg/L	0.084	0.119	1000[d]
Copper μg/L	0.23	0.45	4[b]
Iron μg/L	27.8	82.9	300
Lead μg/L	0.032	0.114	7[b]
Lithium μg/L	27.7	26.7	2500[e]
Manganese μg/L	42.4	104	200[e]
Mercury (dissolved) ng/L	0.23	0.16	/
Mercury (total) ng/L	0.36	10.3	26
Molybdenum μg/L	0.219	0.287	73[c]
Nickel μg/L	0.77	2.41	150[b]
Selenium μg/L	0.3	0.2	1
Silver μg/L	5.00E-04	5.00E-04	0.25
Strontium μg/L	118	115	/
Thallium μg/L	0.001	0.001	0.8
Thorium μg/L	0.011	0.008	/
Tin μg/L	0.03	0.03	/
Titanium μg/L	0.45	0.66	/
Uranium μg/L	0.545	0.536	15
Vanadium μg/L	0.297	0.337	100[d,e]
Zinc μg/L	0.7	1.4	30

Values represent means of total recoverable metal concentrations.
[a] Based on pH ≥ 6.5
[b] Based on water hardness > 180mg/L (as $CaCO_3$)
[c] CCME interim value.
[d] Based on CCME Guidelines for Agricultural use (Livestock Watering).
[e] Based on CCME Guidelines for Agricultural Use (Irrigation).
A forward slash (/) indicates an absence of data or guidelines.