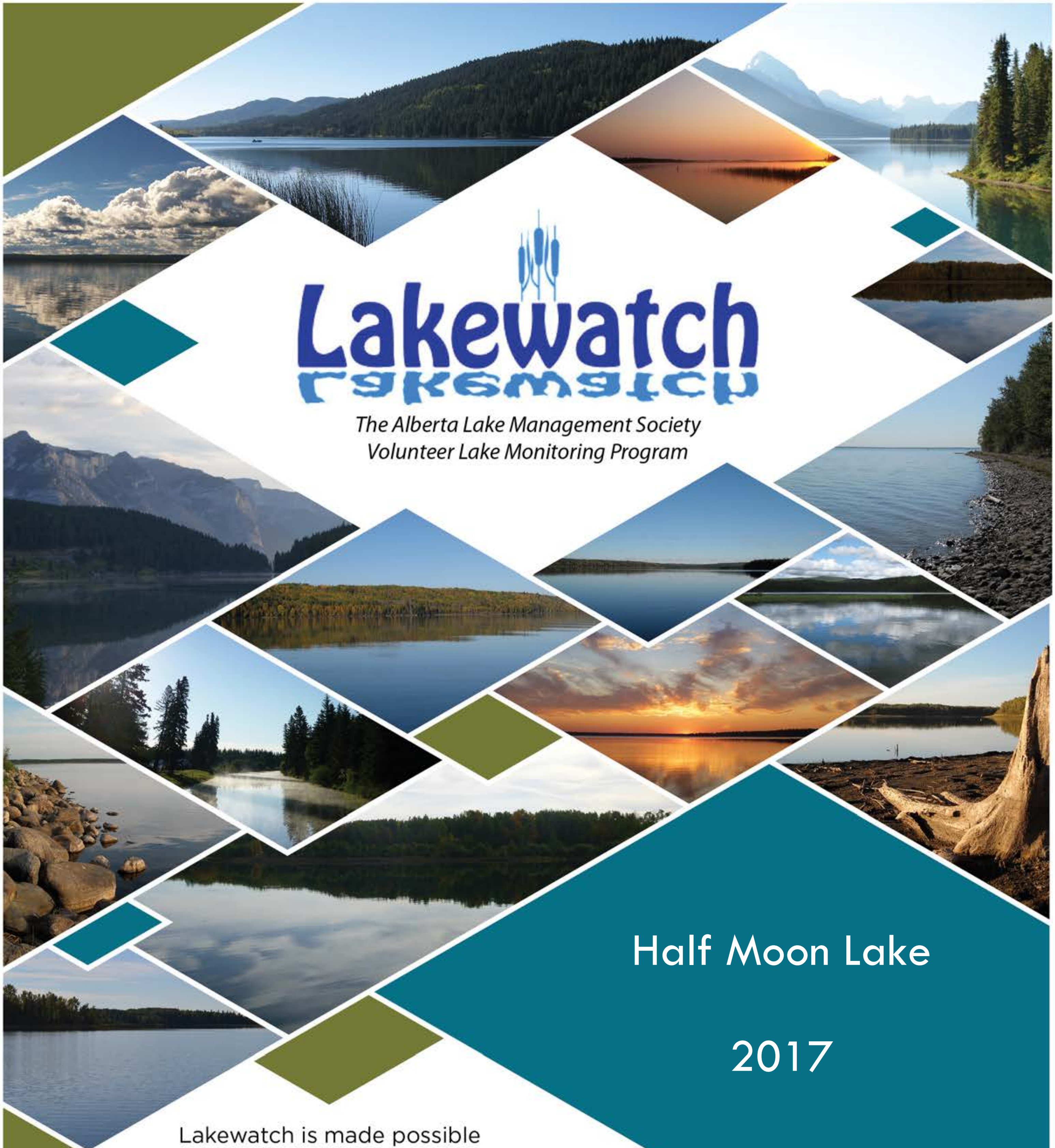

Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Half Moon Lake

2017

Lakewatch is made possible with support from:

Cargill — Helping the world thrive
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Pigeon Lake Watershed Association
LICA Lakeland Industry & Community Association
Red Deer River Watershed Alliance
Beaver River Watershed Alliance
Alberta Environment and Parks

ALBERTA LAKE MANAGEMENT SOCIETY'S LAKEWATCH PROGRAM

LakeWatch has several important objectives, one of which is to collect and interpret water quality data on Alberta Lakes. Equally important is educating lake users about their aquatic environment, 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 a lay 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 people prove that ecological apathy can be overcome and give us hope that our water resources will not be the limiting factor in the health of our environment.

ALMS is happy to discuss the results of this report with our stakeholders. If you would like information or a public presentation, contact us at info@alms.ca.

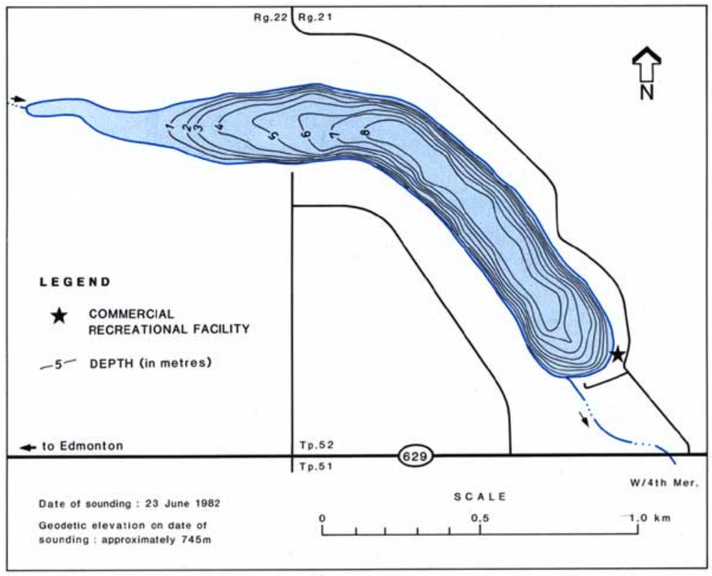
ACKNOWLEDGEMENTS

The LakeWatch program is made possible through the dedication of its volunteers. We would like to extend a special thanks to Richard Normandeau for the time and energy put into sampling Half Moon Lake in 2017. We would also like to thank Elashia Young and Melissa Risto who were summer technicians in 2017. Executive Director Bradley Peter and LakeWatch Coordinator Laura Redmond was instrumental in planning and organizing the field program. This report was prepared by Laura Redmond and Bradley Peter. The Beaver River Watershed, the Lakeland Industry and Community Association, Environment Canada, and Alberta Environment and Parks are major sponsors of the LakeWatch program.

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.



Bathymetric map of Half Moon Lake- picture from Mitchell and Prepas 1990

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.

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

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[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. On one visit per season, metals are collected at the profile site by hand grab from the surface and at some lakes, 1 m off bottom using a Kemmerer.

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 Maxxam Analytics, chlorophyll-*a* and metals are analyzed by Alberta Innovates Technology Futures (AITF), and microcystin is analyzed by the Alberta Centre for Toxicology (ACTF). In lakes where mercury samples are taken, they are analyzed by the Biogeochemical Analytical Service Laboratory (BASL).

Invasive Species: Monitoring for invasive quagga and zebra mussels involved two components: monitoring for juvenile mussel veligers using a 63 µm plankton net at three sample sites and monitoring for attached adult mussels using substrates installed at each lake.

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 75 µg/L (Table 2), falling into the eutrophic, or productive, trophic classification. This value is historically low. TP remained relatively constant over the sampling season, but was highest on June 7 (Figure 1).

Average chlorophyll-*a* concentration in 2017 was 51.6 µg/L (Table 2), putting Half Moon Lake into the hypereutrophic, or very productive classification. Chlorophyll-*a* concentrations increased over the five sampling visits, peaking in September. An average concentration of 51.6 µg/L fits well within the historical variability measured at Half Moon Lake.

Finally, the average TKN concentration was 2.7 mg/L (Table 2), and the maximum concentration was measured on July 5.

Average pH was measured as 8.81 in 2017, buffered by moderate alkalinity (187.5mg/L $CaCO_3$) and bicarbonate (205 mg/L HCO_3). Sodium and potassium were the dominant ions contributing to a low conductivity of 430 µS/cm (Table 2).

METALS

Samples were analyzed for metals once (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 as well as total and dissolved mercury were measured once on September 6 on Half Moon Lake at the surface and 1m off the bottom. In 2017, all metals were measured below their respective guidelines (Table 3).

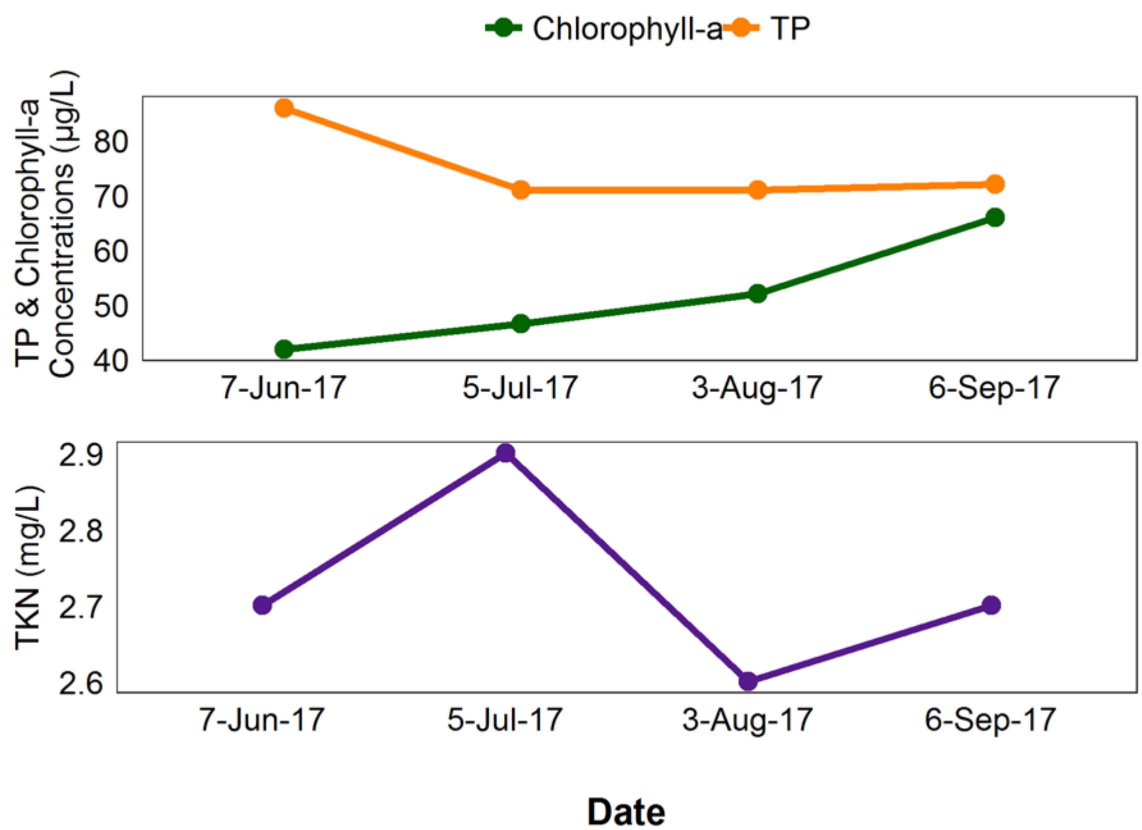

Figure 1- Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentrations measured four times over the course of the summer at Half Moon Lake.

WATER CLARITY AND SECCHI 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 Secchi depth of Half Moon Lake was 0.66 m in 2017 (Table 2). Secchi depth was relatively constant over the four sampling visits. Shallow Secchi depth may be attributed to high algal biomass given the high productivity status of the lake.

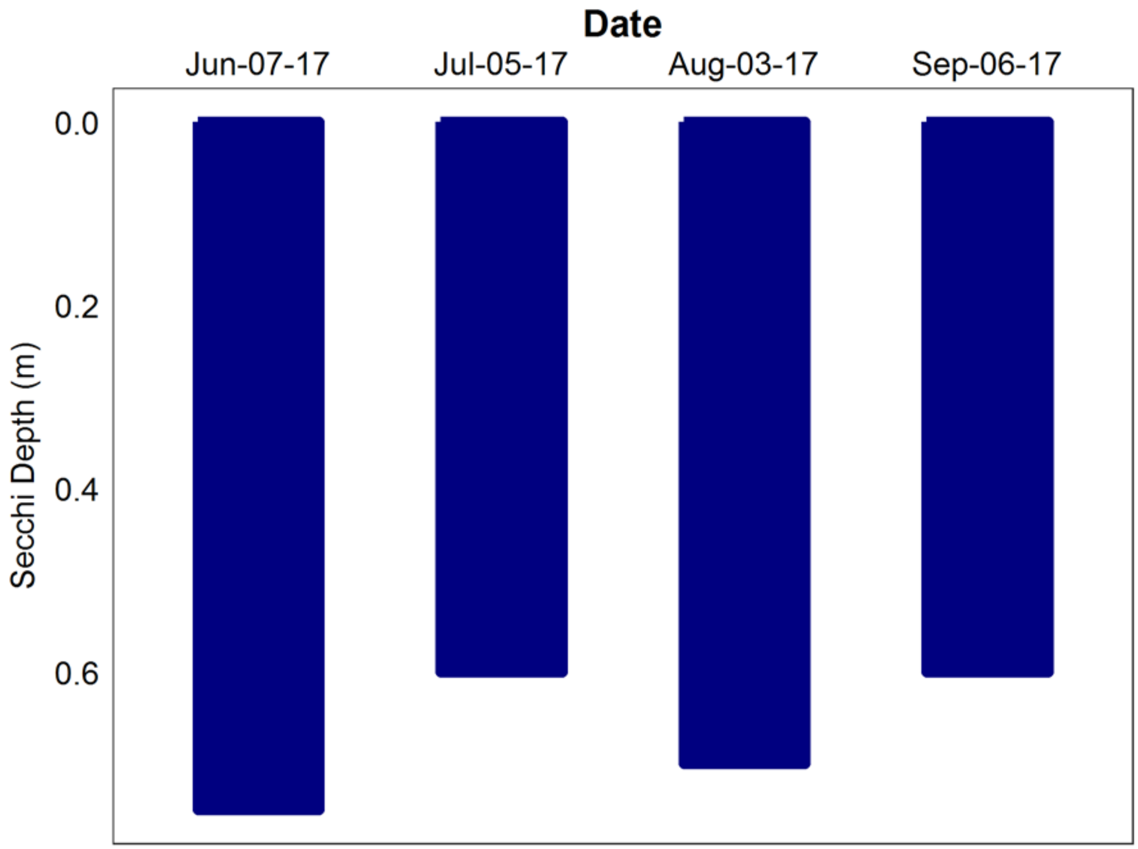

Figure 2 – Secchi depth values measured four times over the course of the summer at Half Moon Lake in 2017.

WATER TEMPERATURE AND DISSOLVED OXYGEN

Water temperature and dissolved oxygen 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 over the course of the summer, with a maximum temperature of 21.5°C measured at the surface on July 5 (Figure 3a). The lake was weakly thermally stratified from June until August, and broke down by early September.

Half Moon Lake remained well oxygenated at the surface throughout the summer, measuring above the CCME guidelines of 6.5 mg/L for the Protection of Aquatic Life (Figure 3b). Thermal stratification separated surface oxygen from the bottom from June-August, so Half Moon Lake reached anoxia at around 4 m depth. On September 6, the lake reached anoxia at the bottom as well, likely due to increased decomposition consuming oxygen at the sediments.

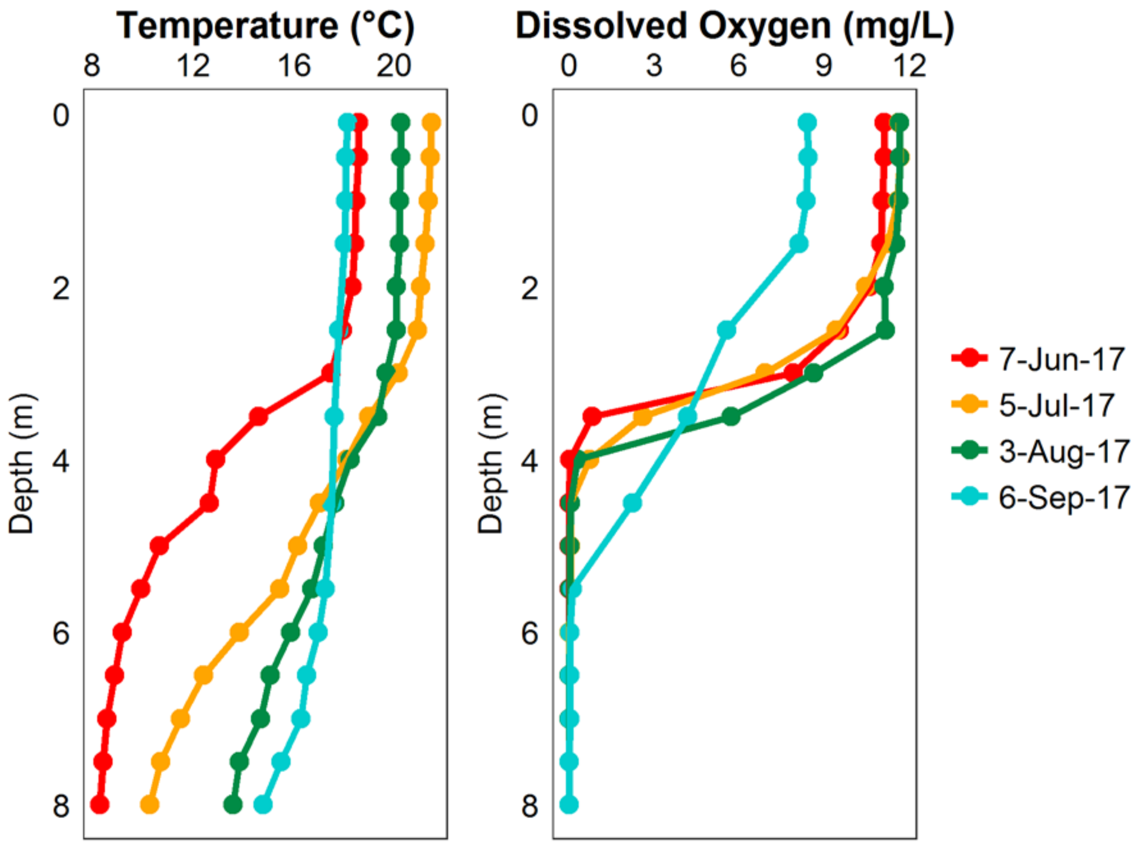

Figure 3 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Half Moon Lake measured four times over the course of the summer of 2017.

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 were high but composite averages fell below the recreational guideline for the entire sampling period of 2017 (Table 1). Individual locations on Half Moon Lake may have exceeded recreational guidelines.

Table 1 – Microcystin concentrations measured four times at Half Moon Lake in 2017.

Date	Microcystin Concentration (μg/L)
Jun-07-17	4.65
Jul-05-17	15.71
Aug-03-17	10.71
Sep-06-17	8.11
Average	9.80

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 have been linked to creating toxic algae blooms, decreasing the amount of nutrients needed for fish and other native species, and causing millions of dollars in annual costs for repair and maintenance of water-operated infrastructure and facilities.

Monitoring involved two components: monitoring for juvenile mussel veligers using a plankton net and monitoring for attached adult mussels using substrates installed in each lake. No mussels have been detected in Half Moon Lake.

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 in Half Moon Lake were monitored between 1991 and 2003, and fluctuated by less than 1 m throughout this monitoring extent (Figure 4). In 2003, water levels were at their lowest, however recent water level data is not available through Alberta Environment and Parks.

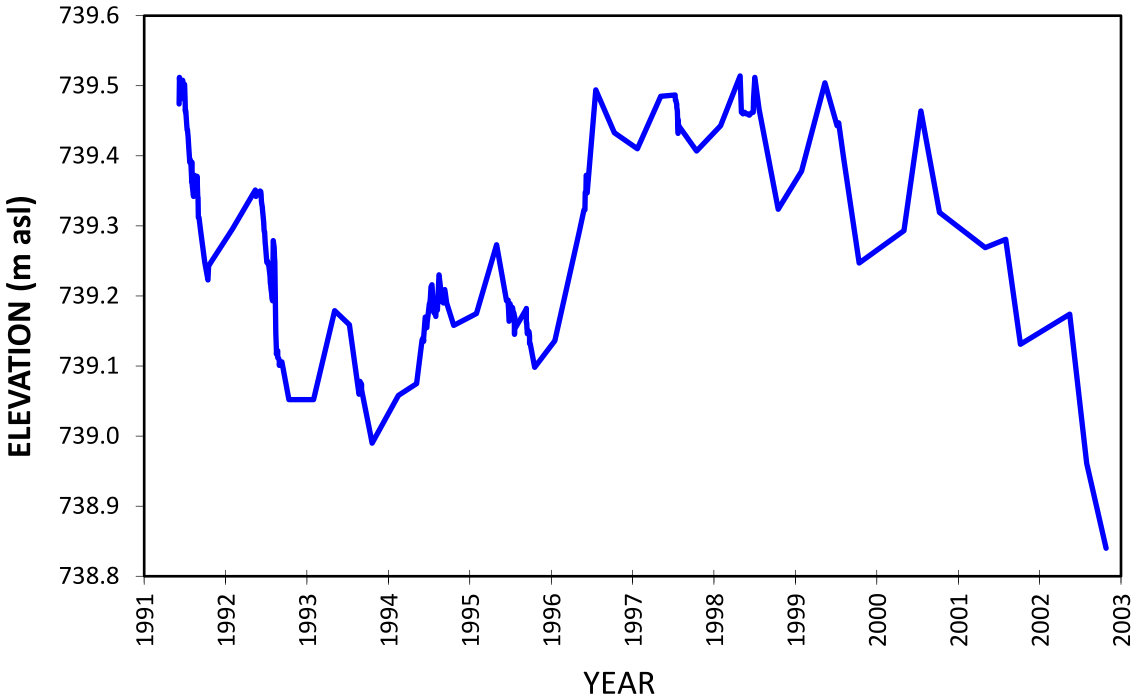

Figure 4- Water level measured in meters above sea level (m asl) from 1991-2003. Data retrieved from Alberta Environment and Parks.

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

Parameter	1982[a]	1987[a]	2011	2017
TP (µg/L)	124	99	111	75
TDP (µg/L)	/	27	29.3	11.3
Chlorophyll-*a* (µg/L)	50.2	63.8	41.4	51.6
Secchi depth (m)	1.3	0.8	1.33	0.66
TKN (mg/L)	3.111	2.180	2.793	2.725
NO_2-N and NO_3-N (µg/L)	44	9	4.13	2.35
NH_3-N (µg/L)	/	/	40.5	37.75
DOC (mg/L)	/	/	21.8	21.75
Ca (mg/L)	/	19	21.8	23.5
Mg (mg/L)	/	10	17	18.5
Na (mg/L)	/	18	35	43.25
K (mg/L)	/	12	15.1	19.75
SO_4^{2-} (mg/L)	/	<5	2.67	3.45
Cl^- (mg/L)	/	8	19.87	25.5
CO_3 (mg/L)	/	18	8.75	10.825
HCO_3 (mg/L)	/	133	195.75	205
pH	/	8.8-9.4	8.74	8.81
Conductivity (µS/cm)	/	287	697	430
Hardness (mg/L)	/	90	124	135
TDS (mg/L)	/	156	224	245
Microcystin (µg/L)	/	/	2.07	9.80
Total Alkalinity (mg/L $CaCO_3$)	/	139	175	187.5

Table 3: Concentrations of metals measured in Half Moon Lake on September 6. 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 CaCO3)

[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.