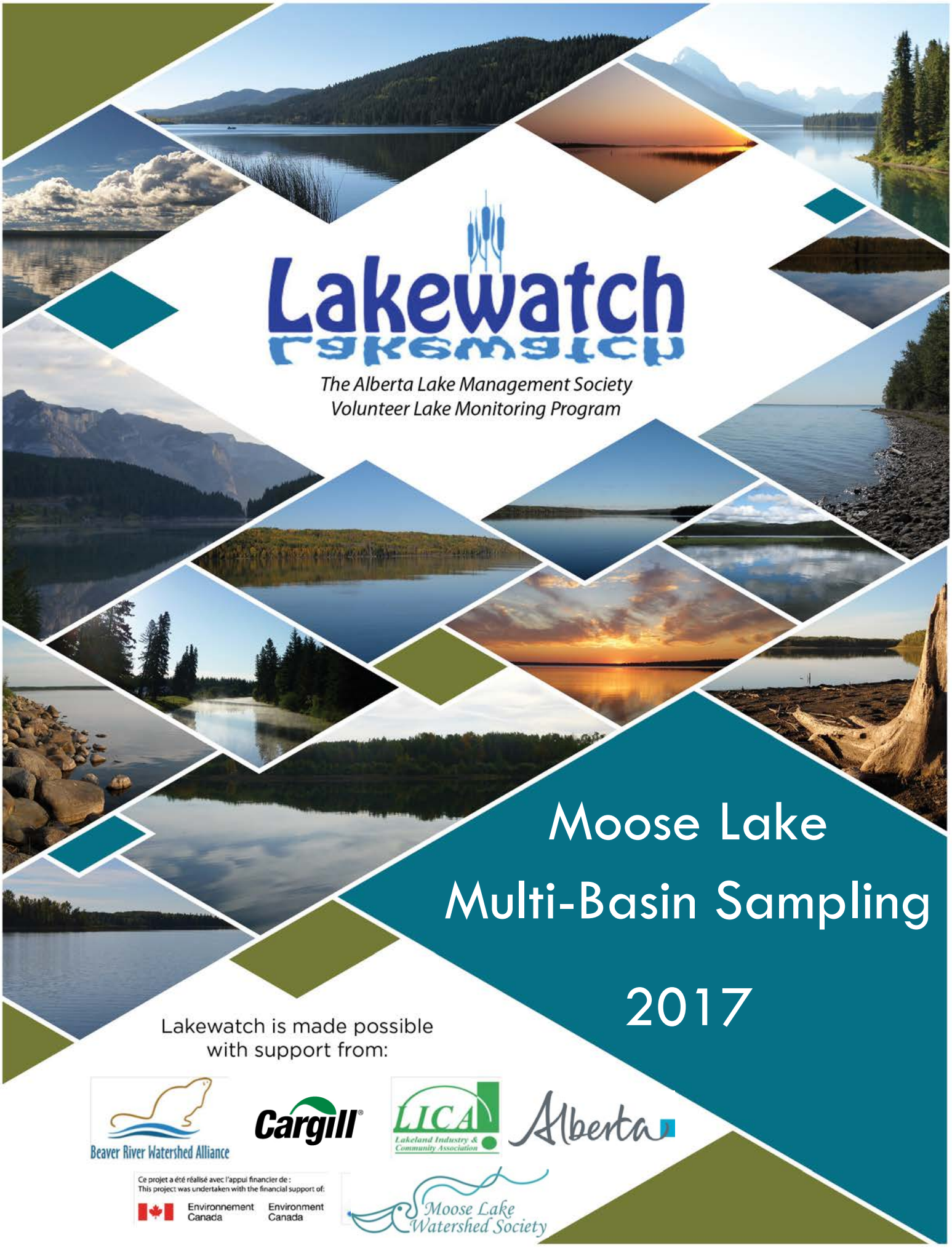

Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Moose Lake
Multi-Basin Sampling
2017

Lakewatch is made possible with support from:

Beaver River Watershed Alliance

Cargill

LICA Lakeland Industry & Community Association

Alberta

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Environnement Canada Environment Canada

Moose Lake Watershed Society

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.

This report has been prepared with un-validated data.

ACKNOWLEDGEMENTS

The LakeWatch program is made possible through the dedication of its volunteers. We would like to extend a special thanks to Grant Ferbey and Colin Hanusz for the time and energy put into sampling Moose Lake in 2017. We would also like to thank Kellie Nichiporik of the Moose Lake Watershed Stewardship Society for assistance in the field and for funding the project. We would also like to thank Elashia Young and Melissa Risto who were summer technicians in 2017. Executive Director Bradley Peter 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.

EXECUTIVE SUMMARY

In 2017, the Alberta Lake Management Society, with support from the Moose Lake Watershed Stewardship Society and local volunteers, monitored Moose Lake as four individual basins as well as a whole lake composite.

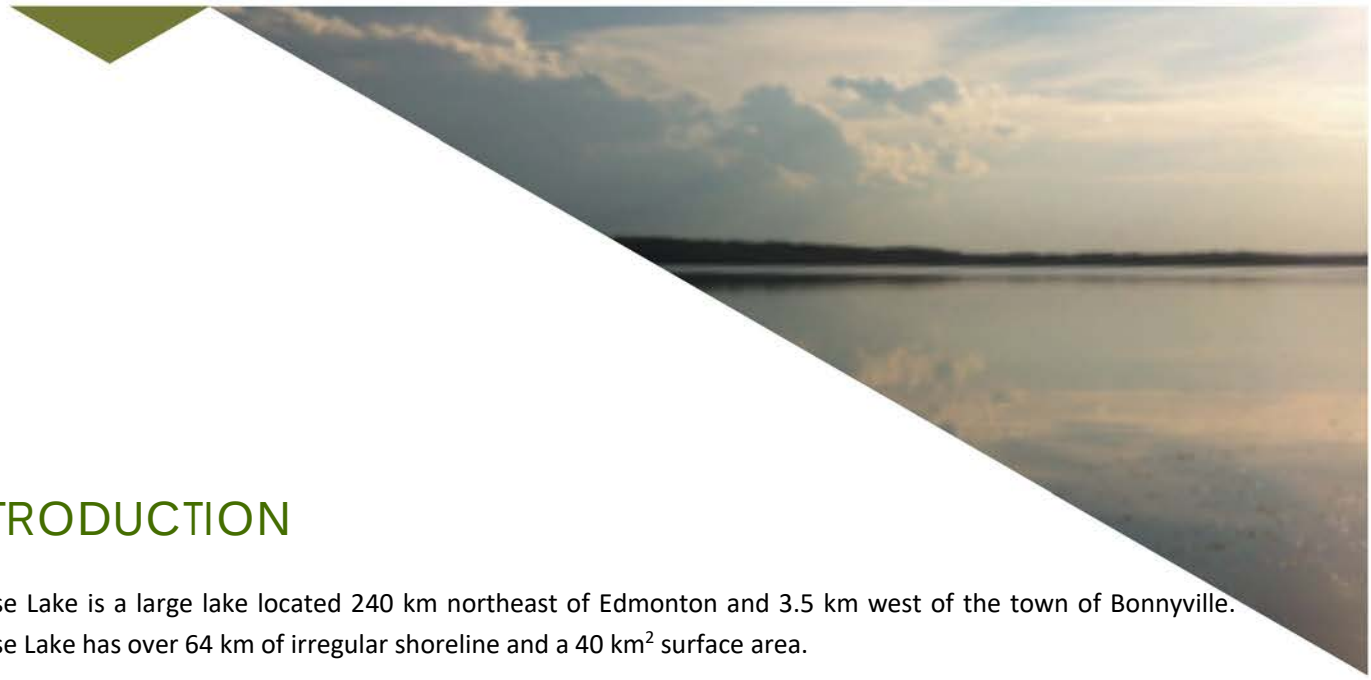
Average total phosphorus (TP) and total dissolved phosphorus (TDP) concentrations were highest in Franchere Bay and lowest in Vezeau Bay. Similarly, chlorophyll-*a* concentrations were highest in Franchere Bay and lowest in Main Basin.

Microcystin concentrations were low throughout much of the summer with the exception of June 29th when microcystin values were high but did not exceed the recreational guidelines in Franchere Bay.

Thermal stratification was observed in each of the basins at least once throughout the summer. Vezeau Bay was the most strongly stratified basin and showed no sign of mixing throughout the summer. Oxygen concentrations responded strongly to stratification, often proceeding toward anoxia in the hypolimnion. Top and bottom grabs of TP during stratification events revealed large differences above and below the thermocline. Concentrations of TP and TDP were, in some cases, two orders of magnitude higher in the hypolimnion than the epilimnion, however this was less pronounced in shallower basins.

Due to large amounts of spring runoff, nutrient concentrations were higher and water clarity was lower in 2017 than in 2016.

The multi-basin sampling has been useful in identifying the heterogeneity that exists across Moose Lake and helps to explain the results seen when the lake is sampled as a whole.



INTRODUCTION

Moose Lake is a large lake located 240 km northeast of Edmonton and 3.5 km west of the town of Bonnyville. Moose Lake has over 64 km of irregular shoreline and a 40 km^2 surface area.

While sampling of Moose Lake has occurred for many years, this method composited samples from across the lake into a 'Whole Lake' sample, with the lake's profile sampling (temperature and dissolved oxygen) occurring in the Main Basin (Page 4). However, because of Moose Lake's irregular shoreline, the lake can be divided into a number of basins: Franchere Bay in the West, Main Basin in the Southeast, Pelican Narrows in the North, and Vezeau Bay in the Northeast (Page 4). In 2017, our technicians also ventured into Island Bay, which is usually not accessible by boat. However, high water levels allowed for two visits (June 29th and August 9th) where water chemistry was taken.

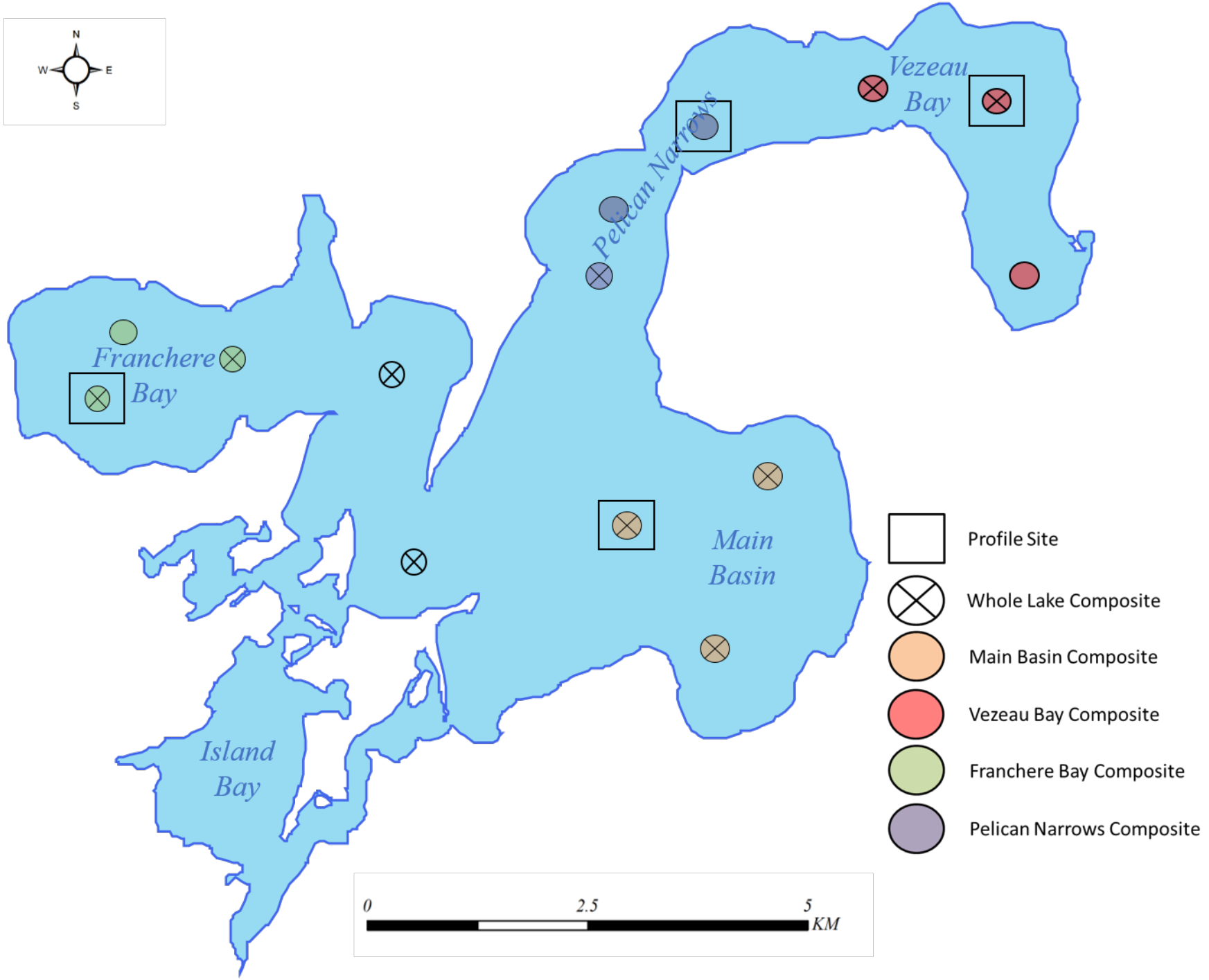
In 2017, the Alberta Lake Management Society (ALMS) with the support of the Moose Lake Watershed Society (MLWS) and local volunteers conducted sampling to identify variation among Moose Lake's major basins. Sampling was conducted on June 29th, August 9th, and September 20th. Composite samples for water chemistry were collected from each basin, and a single Profile Site was selected in each basin for the collection of Secchi disk depth, temperature, dissolved oxygen, and discrete nutrient grabs.

This report will compare and contrast the variability among Moose Lake's major basins with regards to key parameters including phosphorus, chlorophyll-*a*, microcystin, Secchi disk depth, temperature, and dissolved oxygen.

For a complete description of the Moose Lake's whole lake sampling and for historical reports, visit www.alms.ca.

Island Bay, Moose Lake- photo by Elashia Young 2017

2017 SAMPLE SITES



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.

Microcystin concentrations were low (<1 µg/L), on each sampling event in Vezeau Bay, Main Basin, and Pelican Narrows (Page 13). In contrast, a large spike in microcystin concentration was observed on June 29th in Franchere Bay, measuring 9.52 µg/L. A microcystin value of this concentration does not exceed the recreational guidelines of 20 µg/L. This microcystin spike also coincided with the season's highest chlorophyll-*a* concentration measured in Franchere Bay, suggesting there was a large cyanobacteria bloom event. This spike in microcystin observed in Franchere Bay on June 29th was reflected in the whole-lake sampling, as the whole-lake microcystin concentration on June 29th measured 1.96 µg/L.

It is recommended that individuals avoid recreating in cyanobacteria blooms. Even if microcystin concentrations are low, cyanobacteria may still produce other toxins and cause skin irritation which can be a health concern.

Double-crested cormorants taking off at Moose Lake. Photo by Breda Muldoon.

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 disk depth. Two times the Secchi disk depth equals the euphotic depth – the depth to which there is enough light for photosynthesis.

Secchi disk depth was measured three times over the course of the summer at the profile site within each basin of Moose Lake (Page 8). The lowest observed Secchi disk depth measurement occurred in Franchere Bay on August 9th, measuring 0.50 m, while the highest observed Secchi disk depth measurement occurred in Pelican Narrows, on September 20th, measuring 1.60 m.

Average water clarity values behaved similarly: when looking at average measurements from across the summer of 2017, the basin with the lowest average water clarity was Franchere Bay, measuring 0.83 m, while the basin with the highest average water clarity was Pelican Narrows, measuring 1.33 m. Average water clarity measurements were shallower in 2017 than in 2016, reflecting the increases in average chlorophyll-*a* concentrations (Table 2).

Secchi disk depth values generally decreased throughout the summer as chlorophyll-*a* concentrations increased, suggesting phytoplankton is the primary factor impeding water clarity in Moose Lake during warmer summer months. Other factors which may contribute to differences in water clarity include dissolved organic compounds (which make the water brown) or suspended sediments, particularly in shallow areas.

Technician Alicia Kennedy and volunteer Grant Ferbey sampling Moose Lake in 2016.

TOTAL PHOSPHORUS AND CHLOROPHYLL-A

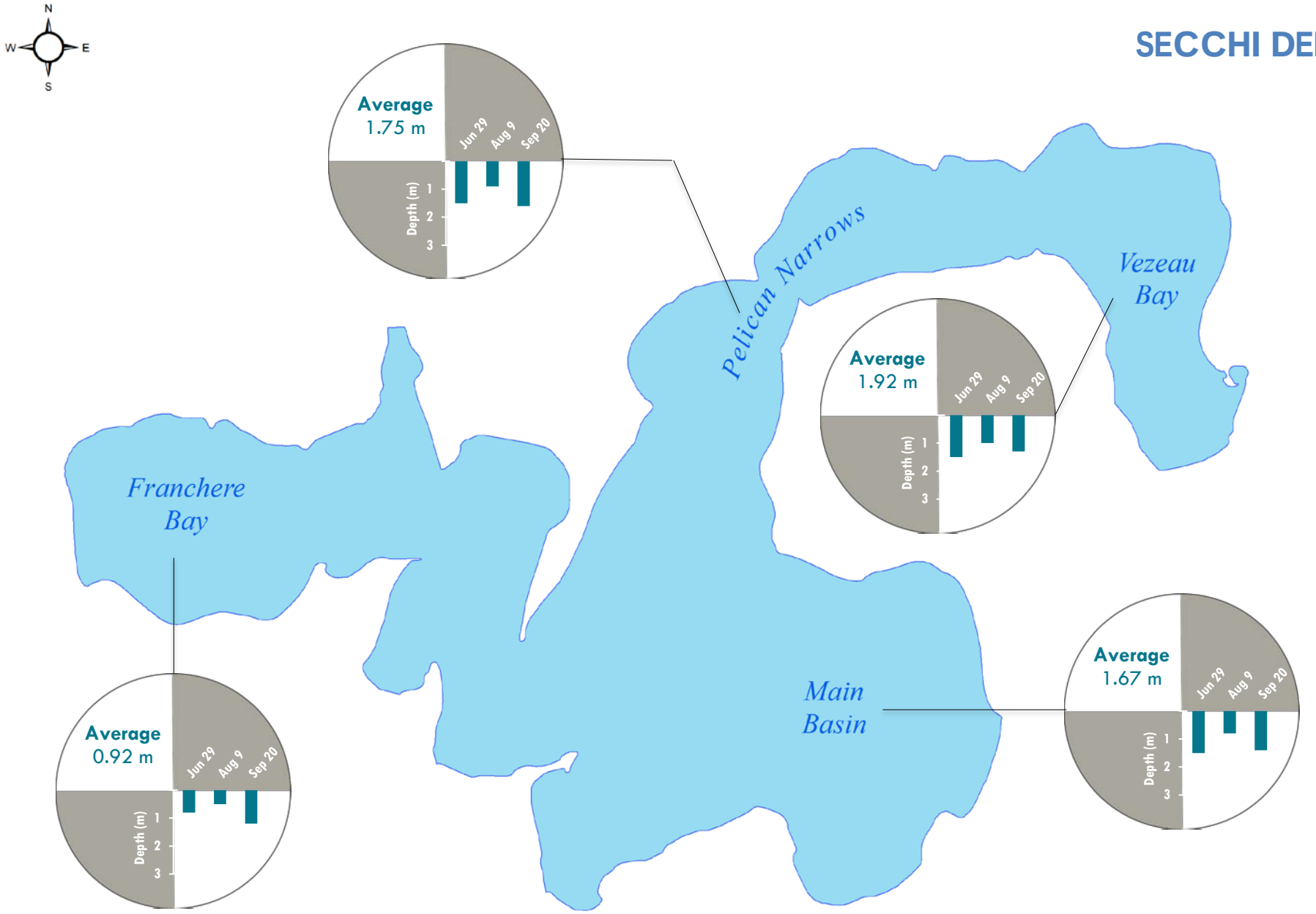
ALMS measures a suite of water chemistry parameters. Phosphorus acts as one of the nutrients driving algae blooms in Alberta, while chlorophyll-a acts as an indicator of phytoplankton biomass, or how much algae is in the lake. These parameters together can help to identify the process of eutrophication, or excess nutrients, which can lead to harmful algae/cyanobacteria blooms. Taking these parameters together, lakes can be classified into oligotrophic (low nutrients), mesotrophic (moderately productive), eutrophic (productive) or hypereutrophic (highly productive).

Total phosphorus (TP) and total dissolved phosphorus (TDP) were measured in two different ways at Moose Lake. First, phosphorus was collected as part of the individual basin and whole lake composite sampling – this technique provides an estimate of the average phosphorus concentrations for their respective areas. Average phosphorus was highest in Franchere Bay, measuring 109 µg/L, and lowest in Vezeau Bay, measuring 56 µg/L (Page 10). The whole lake sampling produced an average phosphorus concentration of 70 µg/L, which falls well within the range seen across each individual basin. Moreover, the whole-lake concentration of 70 µg/L falls into the eutrophic classification – similar to individual basins (Pelican Narrows, Main Basin, and Vezeau Bay). Franchere Bay falls into the hypereutrophic classification and is the most productive basin. In general, phosphorus concentrations increased throughout the summer – this is due to an accumulation of both external and internal sources of nutrients (Page 9). All average concentrations of TP and TDP across basins were higher than as measured in 2016 (Table 2). Above all, Franchere Bay TP concentrations doubled in 2017 compared to 2016. This could be attributed to increased inflow from the Thinlake River entering Franchere Bay from the west given the high water levels throughout the summer.

Secondly, TP and TDP were collected as discrete grabs at 1.0 m below the surface and 1.0 m above the sediment at the profile sites of stratified basins. These phosphorus concentrations highlight a contrast between surface and bottom water nutrient concentrations which can become exaggerated under stratified conditions. In each instance, bottom water TP and TDP concentrations exceeded the concentrations found in the overlying surface waters (Table 1). This suggests that internal processes such as phosphorus loading from the sediments and decomposition play an important role in Moose Lake's nutrient dynamics. One exception is Franchere Bay on June 29th, however this could be because this basin is shallow and well mixed earlier in the summer so there was no stratification to separate the internal and external loadings.

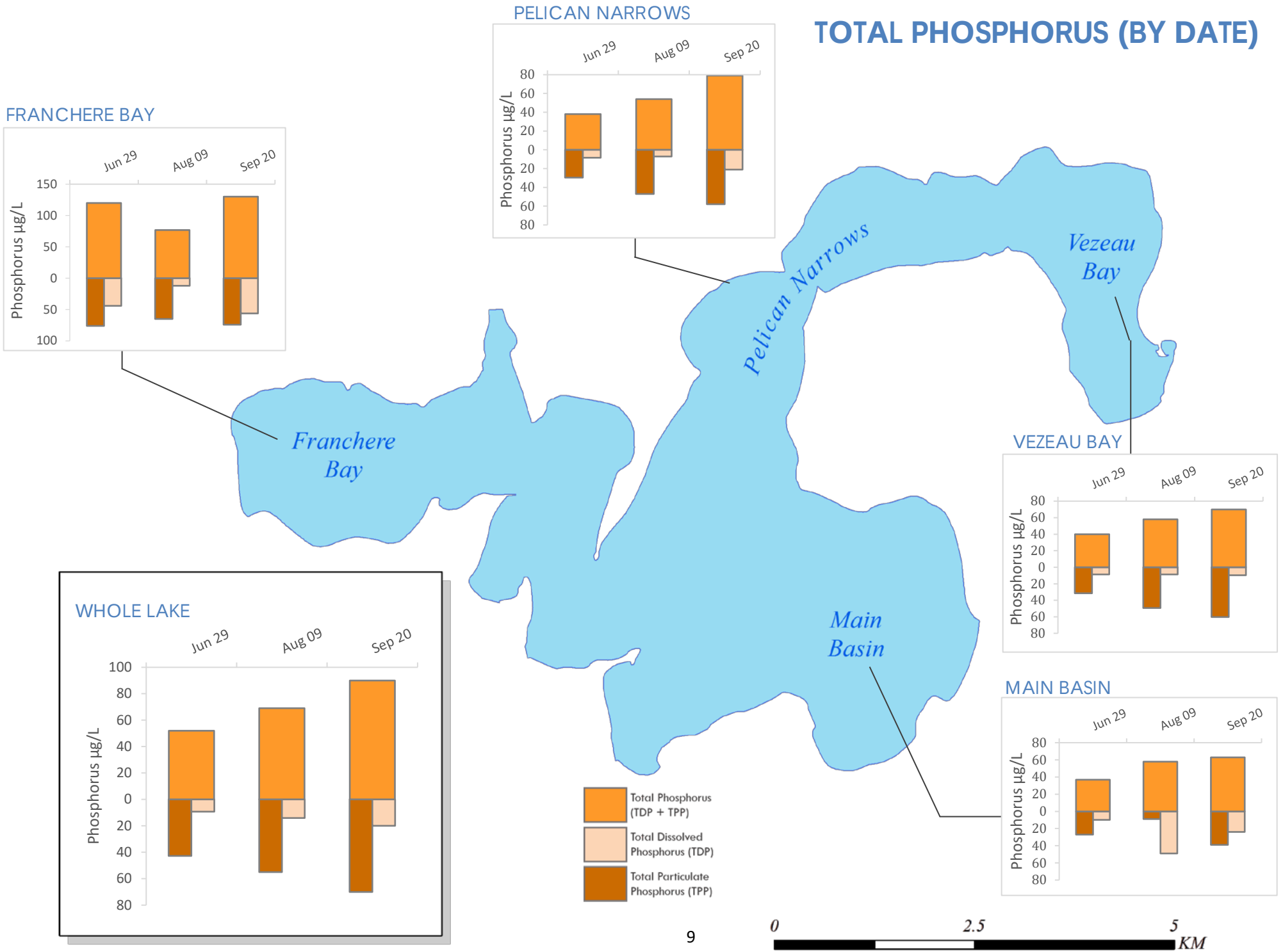
Similar to TP, average chlorophyll-*a* concentration was highest in Franchere Bay, measuring 55 µg/L, and lowest in Main Basin, measuring 28 µg/L (Page 12). Average chlorophyll-*a* concentration determined from the whole lake sampling measured 36 µg/L, which falls into the hypereutrophic classification and lies well within the range seen across each individual basin. As is typical of many Alberta lakes, chlorophyll-*a* concentrations generally increased throughout the course of the summer (Page 11). Chlorophyll-*a* levels were also higher in 2017 than 2016 (Table 2).

SECCHI DEPTH

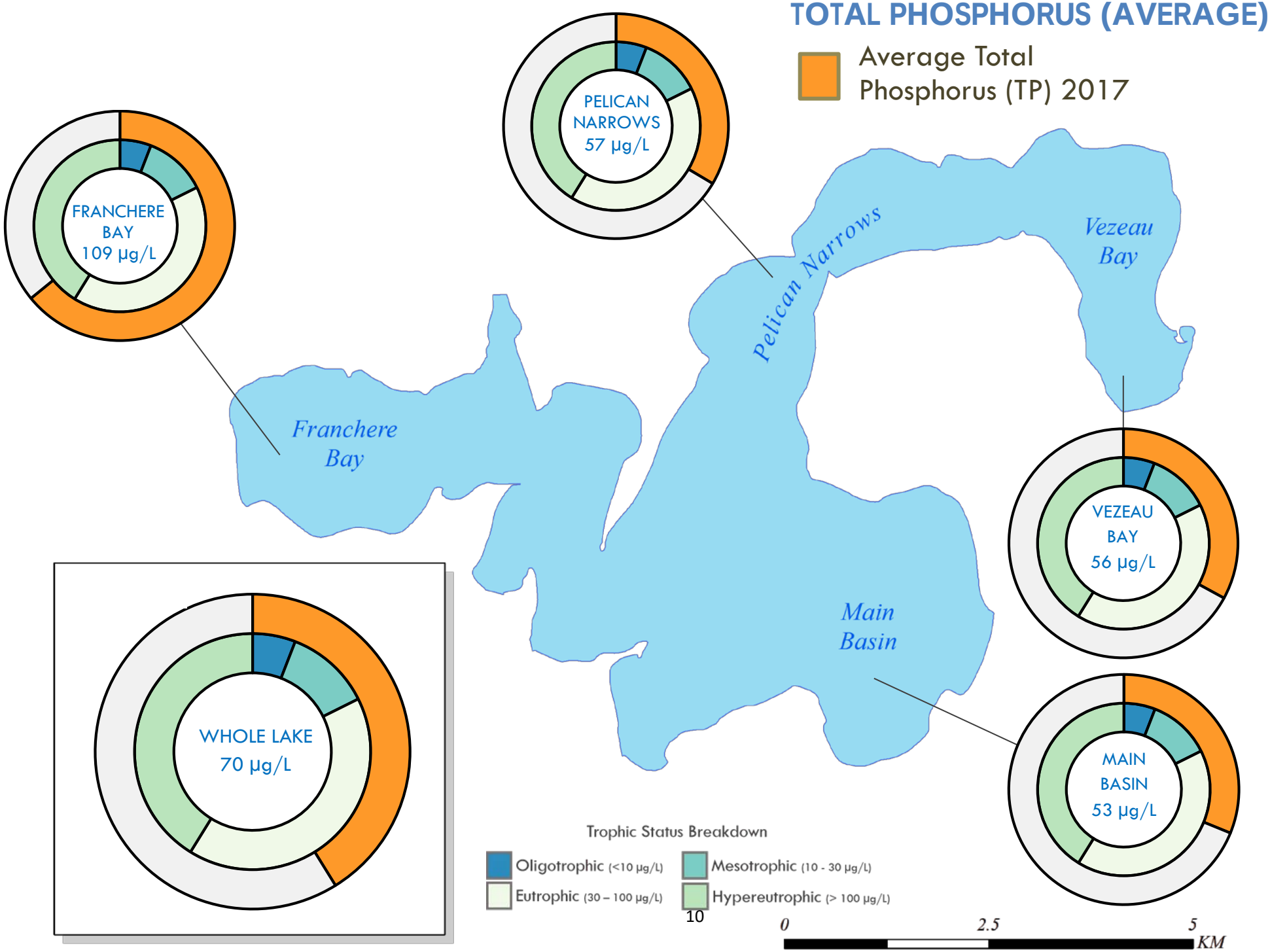


Secchi depths of each basin of Moose Lake taken on three different trips (Jun, Aug, Sep) in Summer 2017

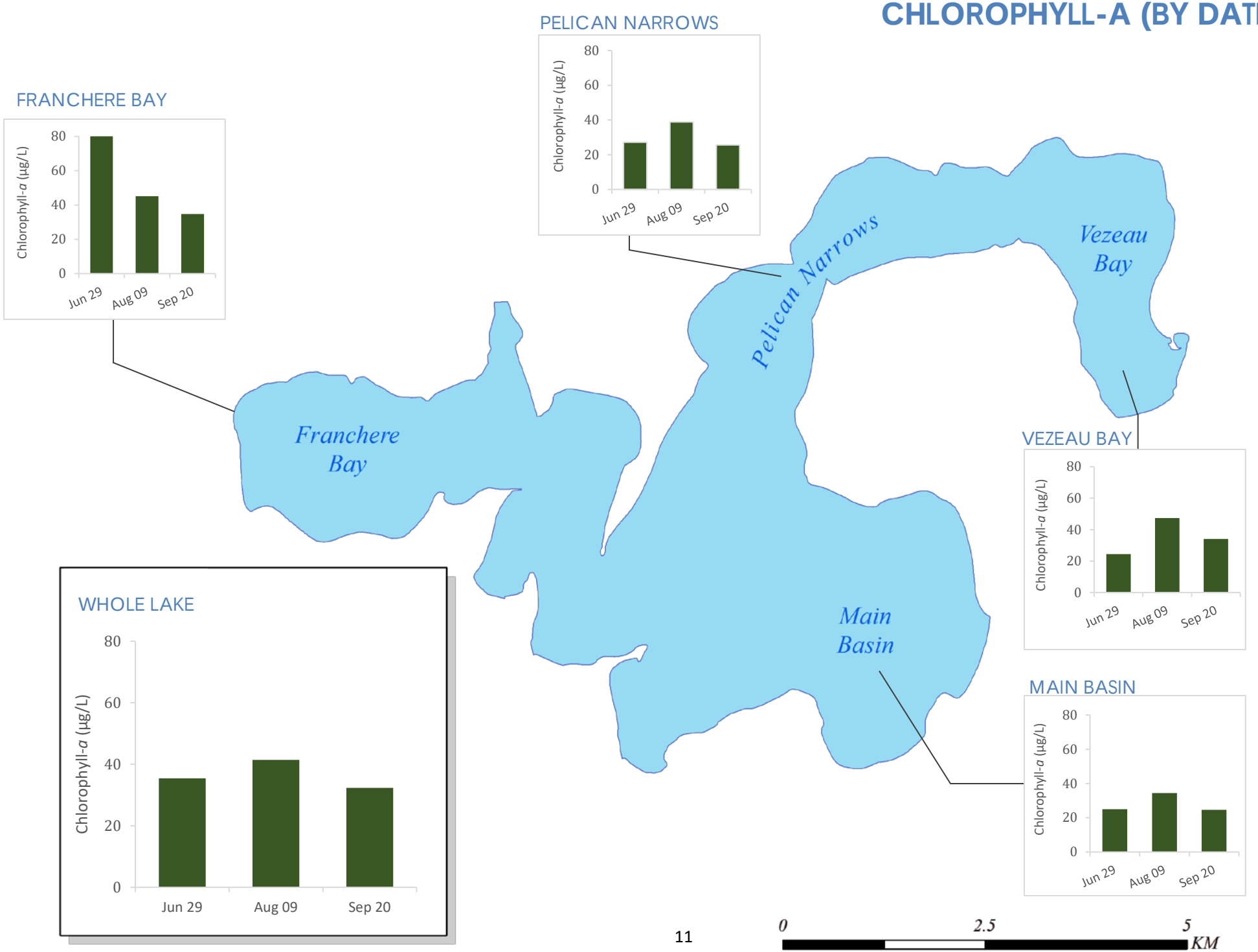
TOTAL PHOSPHORUS (BY DATE)



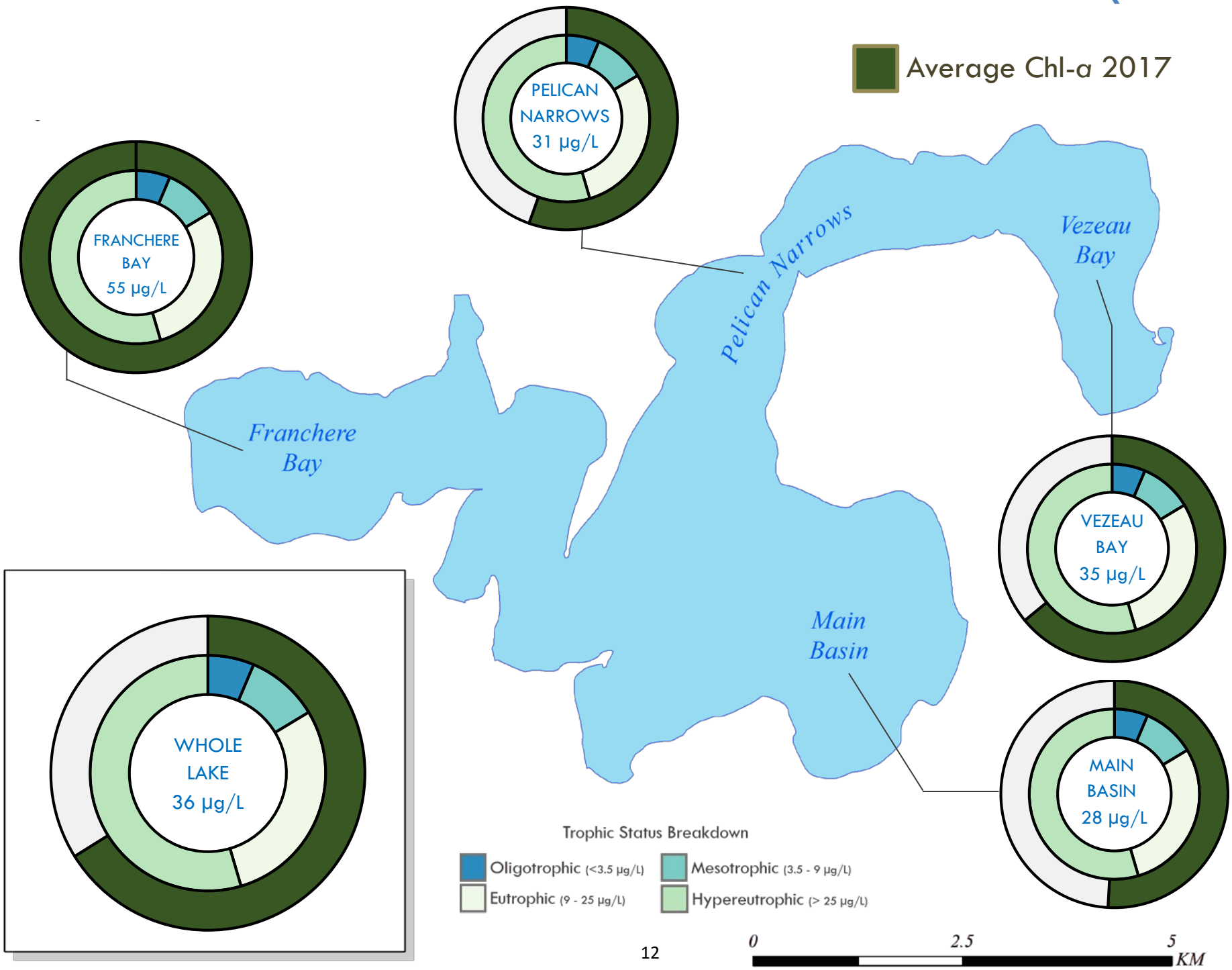
TOTAL PHOSPHORUS (AVERAGE)



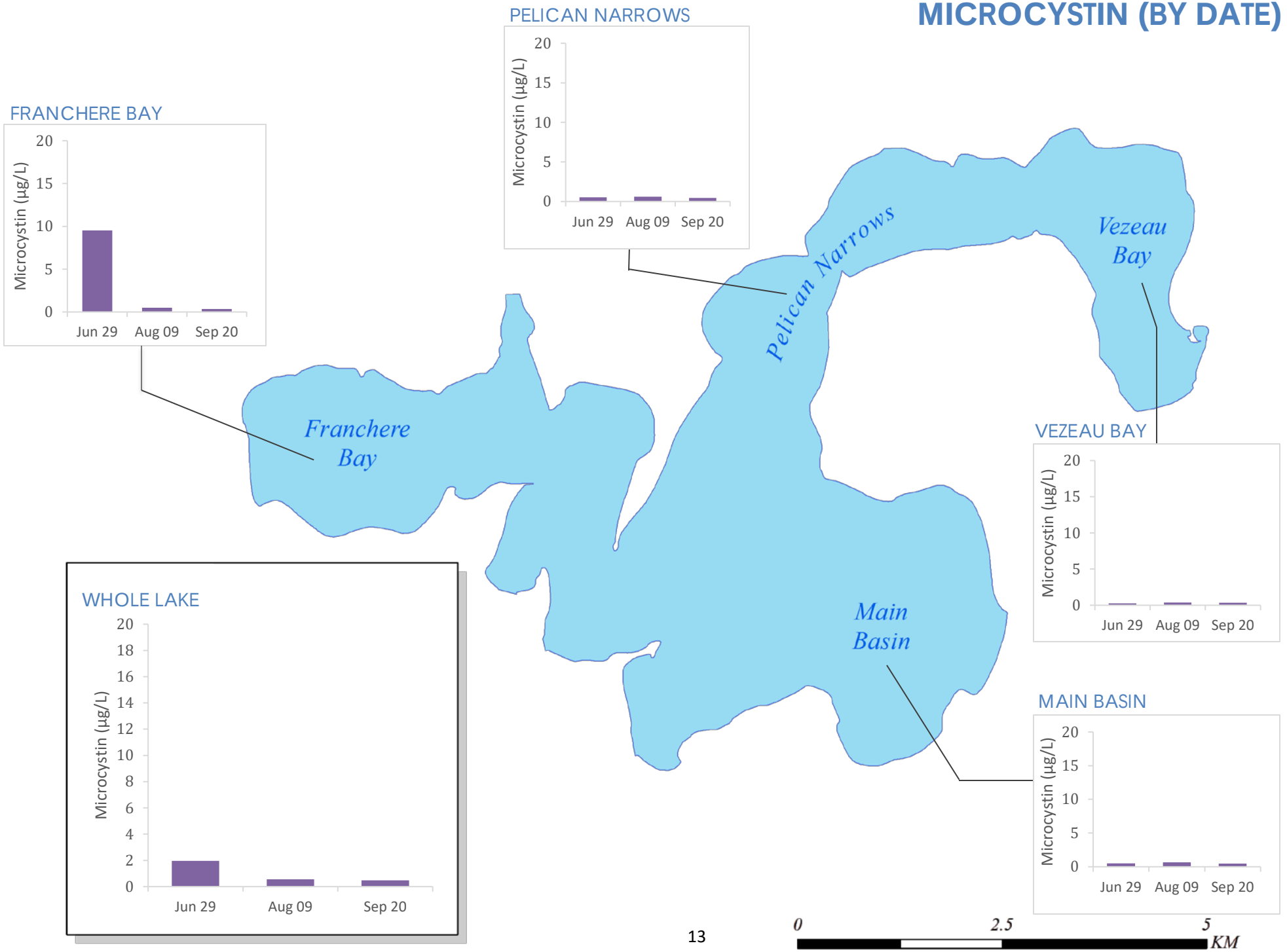
CHLOROPHYLL-A (BY DATE)



CHLOROPHYLL - *A* (AVERAGE)



MICROCYSTIN (BY DATE)



TEMPERATURE AND DISSOLVED OXYGEN PROFILES

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.

Temperature profiles revealed thermal stratification events in each of the basins of Moose Lake. These stratification events have important implications for dissolved oxygen concentrations. A probe malfunction on June 29th meant no profiles were taken in Franchere Bay or Pelican Narrows on that date.

In the Main Basin, weak stratification was observed only on August 9th (Figure 1). As this is the largest basin of Moose Lake, wind energy is more likely to mix the water column, preventing strong stratification throughout the summer. As a result, in the absence of stratification, the water column was well oxygenated in the main basin on September 20th. On June 29th, oxygen proceeded toward anoxia around 12.0 m and on August 9th around 8.0 m. (Figure 1)

In Franchere Bay, thermal stratification was observed on August 9th (Figure 2). During stratification, dissolved oxygen concentrations proceeded toward anoxia around 6.0 m.

Similarly, Pelican Narrows experienced thermal stratification on August 9th (Figure 3). As a result, anoxic dissolved oxygen concentrations were observed around 8.0 m.

Finally, as the deepest basin of Moose Lake, Vezeau Bay demonstrated strong thermal stratification on each of the three sampling trips (Figure 4). This stratification resulted in anoxic conditions as early as 7.0 m on August 9th.

While each basin showed oxygen concentrations which proceeded toward anoxia below the thermocline, the water column above the thermocline in each of the basins remained well oxygenated. Surface water temperatures were high in mid-summer, with a maximum observed temperature of 22.8 °C occurring at the surface of Vezeau Bay on August 9th.

PROFILE - MAIN BASIN

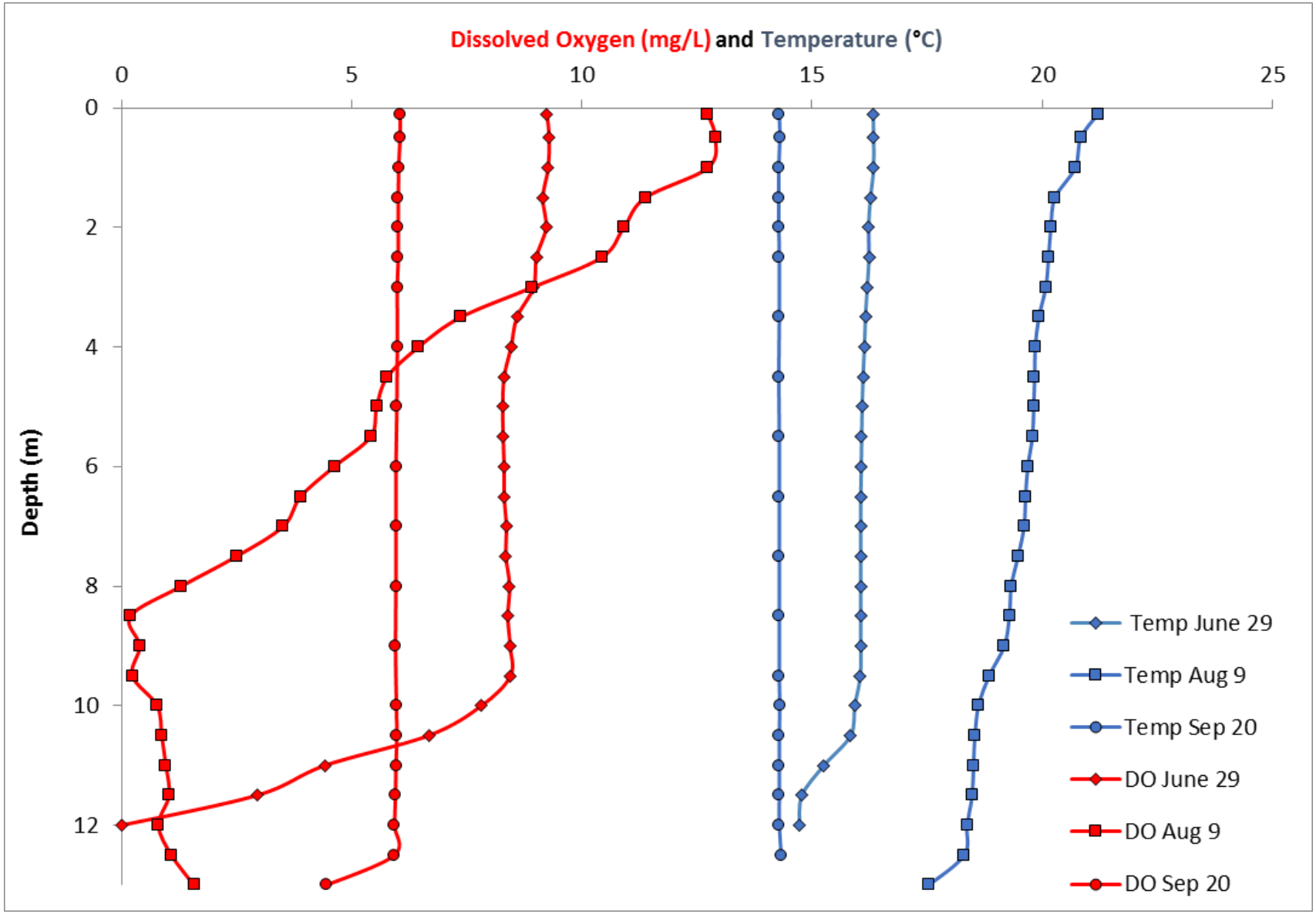


Figure 1: Dissolved oxygen and temperature profiles from Main Basin over three sampling dates during the summer of 2017

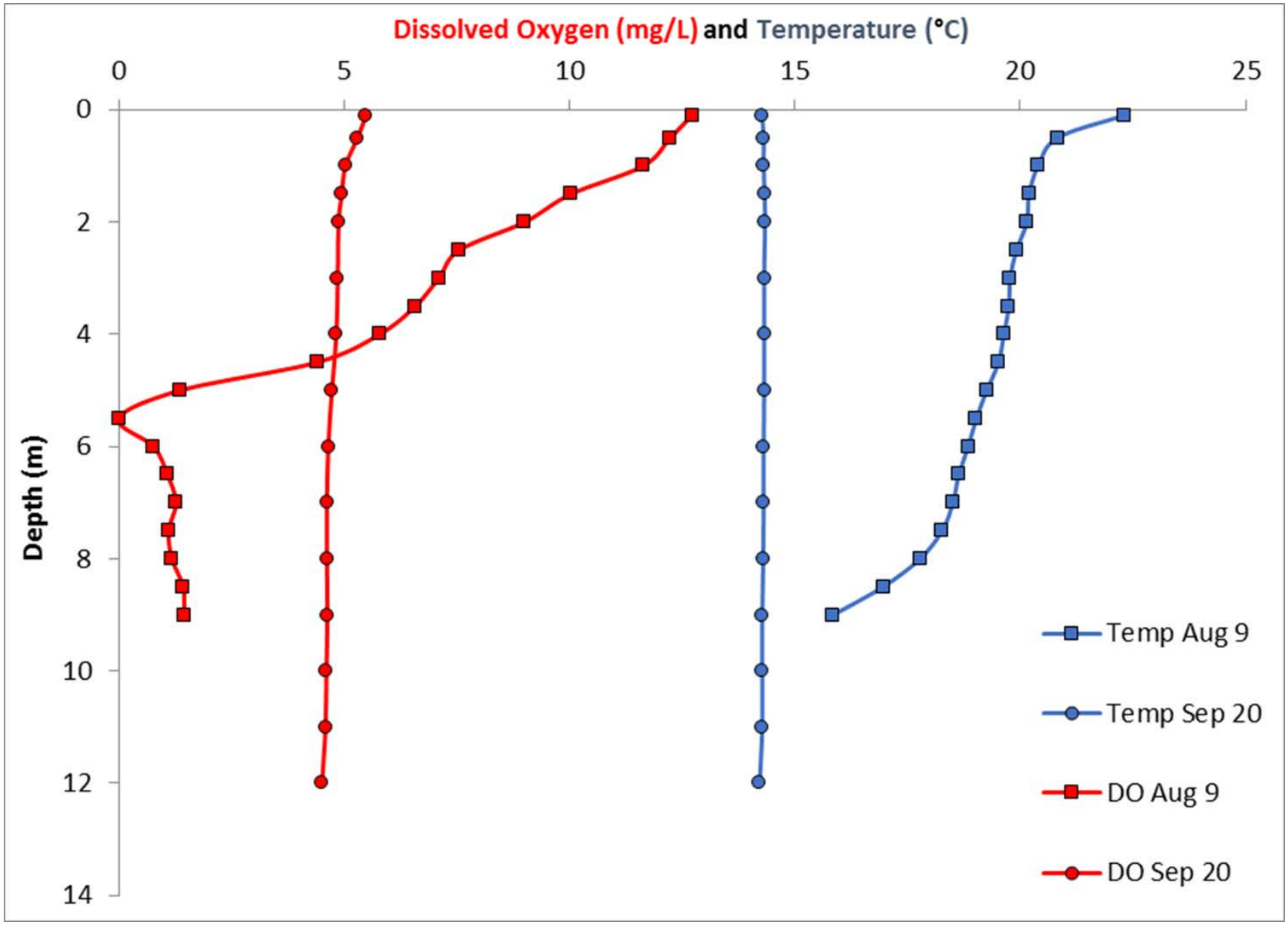


Figure 2: Dissolved oxygen and temperature profiles from Franchere Bay over two sampling dates during the summer of 2017

PROFILE - PELICAN NARROWS

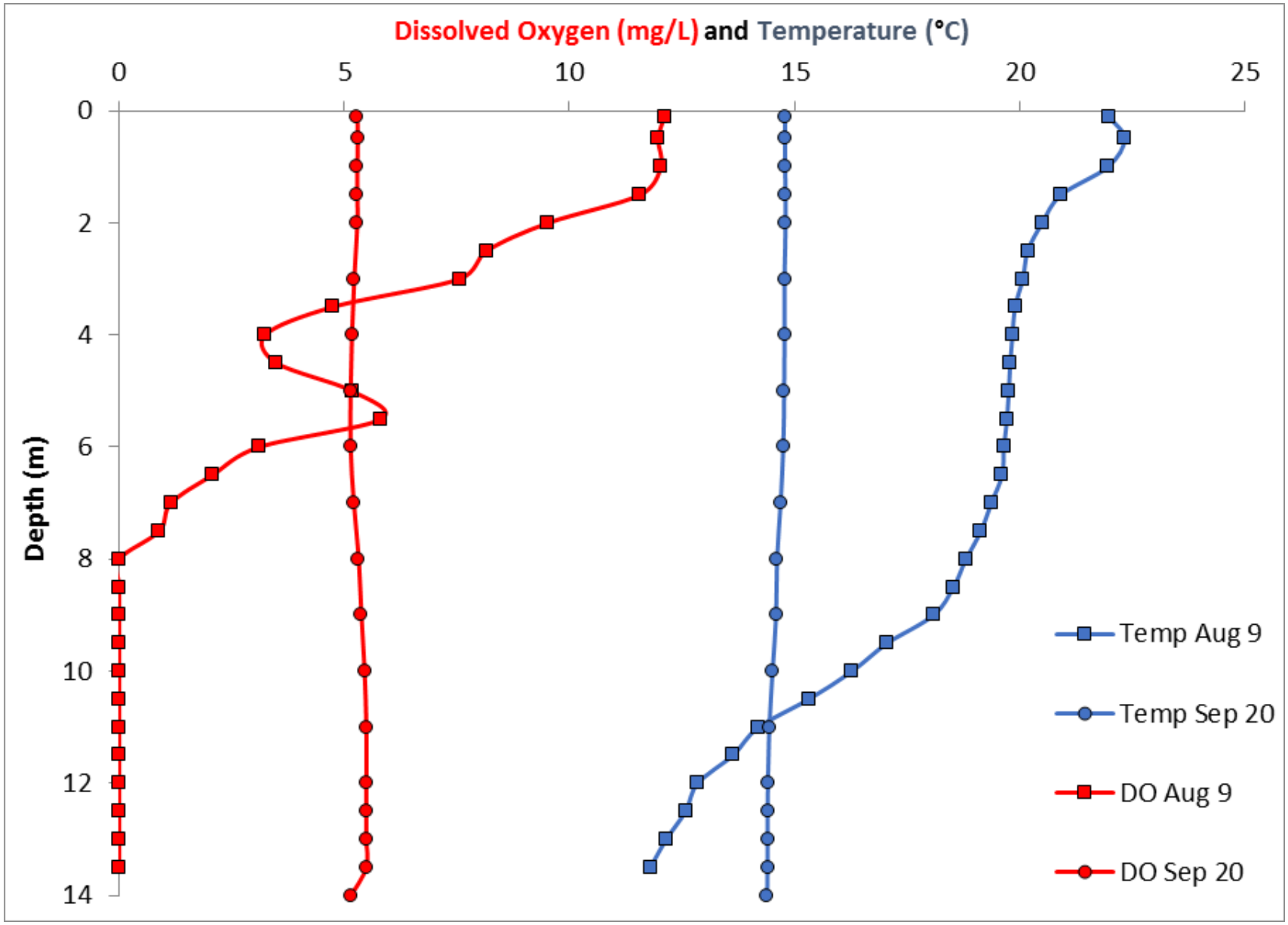


Figure 3: Dissolved oxygen and temperature profiles from Pelican Narrows over two sampling dates during the summer of 2017

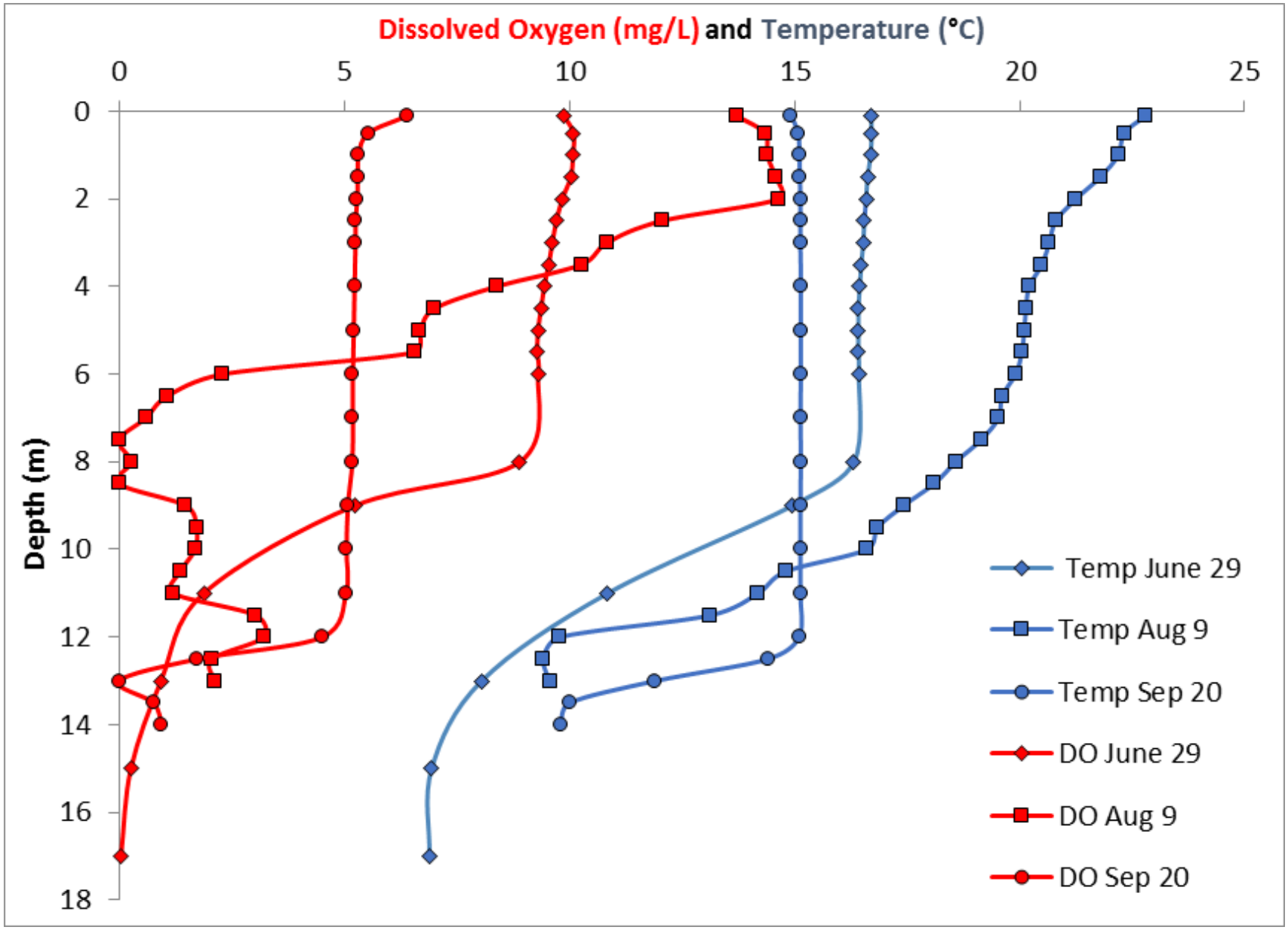


Figure 4: Dissolved oxygen and temperature profiles from Vezeau Bay over three sampling dates during the summer of 2017

Table 1: Discrete grab samples from the top and bottom of the water profile collected from each of the four basins during the summer of 2017

Basin	Date	Stratified (Y/N)	Top TP (µg/L)	Bottom TP (µg/L)	Top TDP (µg/L)	Bottom TDP (µg/L)
Main Basin	29-Jun	N	-	-	-	-
	9-Aug	Y	73	85	9.3	65
	20-Sep	N	-	-	-	-
Franchere Bay	29-Jun	*	130	120	12	85
	9-Aug	Y	100	110	9.5	87
	20-Sep	N	-	-	-	-
Pelican Narrows	29-Jun	Y	38	42	7.9	13
	9-Aug	Y	69	88	9	61
	20-Sep	N	-	-	-	-
Vezeau Bay	29-Jun	Y	39	93	7	64
	9-Aug	Y	49	110	8.7	87
	20-Sep	Y	66	68	12	8.8

TP: Total Phosphorus
TDP: Total Dissolved Phosphorus
*Franchere Bay profile was not taken on 29-Jun so may not have been stratified

Table 2: Water clarity and water chemistry values measured at each of the four basins and for the whole lake during the summer of 2017

Basin	Sample Date	TP (µg/L)	TDP (µg/L)	TPP (µg/L)	TKN (mg/L)	Chl-*a* (µg/L)	Secchi Depth (m)	Microcystin (µg/L)
Main Basin	29-Jun	37	10	27	1.7	25	1.50	0.51
	9-Aug	58	49	9	2.1	34.4	0.80	0.67
	20-Sep	63	24	39	1.9	24.6	1.40	0.47
	2017 Average	**53**	**28**	**25**	**1.9**	**28**	**1.20**	**0.55**
	2016 Average	**29**	**8**	**21**	**1.5**	**19.3**	**1.67**	**0.47**
Franchere Bay	29-Jun	120	44	76	2.1	85.2	0.80	9.52
	9-Aug	77	12	65	2.1	45.1	0.50	0.50
	20-Sep	130	56	74	2.3	34.7	1.20	0.36
	2017 Average	**109**	**37**	**72**	**2.2**	**55**	**0.80**	**3.46**
	2016 Average	**55**	**14**	**40**	**2.0**	**51.5**	**0.92**	**7.09**
Pelican Narrows	29-Jun	38	8.4	29.6	1.9	27.1	1.50	0.52
	9-Aug	54	7	47	2	38.8	0.90	0.62
	20-Sep	79	21	58	2.2	25.6	1.60	0.46
	2017 Average	**57**	**12**	**45**	**2**	**31**	**1.30**	**0.53**
	2016 Average	**27**	**8**	**19**	**1.5**	**16.9**	**1.75**	**0.34**
Vezeau Bay	29-Jun	40	8.6	31.4	1.9	24.4	1.50	0.27
	9-Aug	58	8.7	49.3	2	47.3	1.00	0.38
	20-Sep	70	9.8	60.2	2	34	1.30	0.34
	2017 Average	**56**	**9**	**47**	**2**	**35**	**1.30**	**0.33**
	2016 Average	**25**	**8**	**16**	**1.5**	**15.1**	**1.92**	**0.20**
Whole Lake	29-Jun	52	9.3	42.7	2	35.4	1.50	1.96
	9-Aug	69	14	55	2.1	41.4	0.80	0.55
	20-Sep	90	20	70	2.4	32.3	1.40	0.48
	2017 Average	**70**	**14**	**56**	**2.2**	**36**	**1.20**	**1.00**
	2016 Average	**41**	**11**	**30**	**1.6**	**26.9**	**1.67**	**1.97**

TP: Total Phosphorus
TDP: Total Dissolved Phosphorus
TPP: Total Particulate Phosphorus
TKN: Total Kjeldahl Nitrogen
Chl-*a*: Chlorophyll-*a*

ISLAND BAY

Island Bay was sampled on two dates in 2017 (June 29th and August 9th). Island Bay was sampled as an individual basin, but was not included in the whole lake composite. This basin lies between the Main basin and Franchere Bay, but historically it is not accessible by boat. Given the high water levels and increased precipitation of 2017, our technicians were able to access it to collect water clarity and chemistry data. A summary of the data collected can be found in Table 3. Although the location of the deepest spot was not exact, a depth of between 4 and 5 meters was found on both trips. Although profiles were not taken, the shallow depth means the basin is likely well mixed and not stratified.

Total phosphorus concentrations in Island Bay were lower than any other basin in 2017. Chlorophyll-*a* concentrations were also significantly lower in Island Bay than each individual basin as well as the lake as a whole. Water clarity was also highest in Island Bay, with a maximum Secchi depth of 2.5 m on June 29th. This likely contributes to the large macrophyte population within the basin.

Microcystin concentrations remained well below the guideline for recreation on both sampling dates.

Table 3: Water clarity and water chemistry values measured at Island Bay during the summer of 2017

Parameter	29-June	9-Aug
Depth (m)	4.8	4.2
TP (µg/L)	33	34
TDP (µg/L)	12	11
TPP (µg/L)	21	23
TKN (mg/L)	1.9	2.0
Chl-a (µg/L)	11.9	14.4
Secchi Depth (m)	2.5	1.2
Microcystin (µg/L)	0.28	0.61

TP: Total Phosphorus
TDP: Total Dissolved Phosphorus
TPP: Total Particulate Phosphorus
TKN: Total Kjeldahl Nitrogen
Chl-*a*: Chlorophyll-*a*