Coastal Dune Lake 2020 Water Chemistry Report

A. Challen Hyman, M.S.

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Overview

Northwest Florida coastal dune lakes are located within a few kilometers of the coastline with intermittent hydrologic connection to the Gulf of Mexico. These hydrologic connections are known as outlets, or outfalls. When lake level reach flood stage, waters breach through the sand dunes and flows into the Gulf of Mexico. Typically, lake levels and subsequent outlet openings are dependent on precipitation, runoff, and groundwater conditions. However, strong winds, tides or storms can cause the outlet to open and saltwater inflow or overwash from the Gulf of Mexico to occur.

Coastal dune lakes of Northwest Florida reside within the geomorphological province of the Gulf Coastal Lowlands, where undifferentiated siliciclastic sediments occur in significant thickness (less than 6.1 meters). Walton County southern coastline is made up of Holocene sediments consisting of quartz sand, carbonate sands and muds, and organics. This area of Florida resides in the Coastal Strip division of the Apalachicola Delta District, built by sediments deposited by the Apalachicola River. Sediments are composed of medium fine sand, silty sand, silt, and clay representing estuarine facies of the Biloxi Formation. Geologic characteristics may influence the shape of the waterbody basin and, also, contribute to chemical characteristics and trophic state composition of the waterbody (Canfield and Hoyer 1988).

Differences in chemical composition of lakes in Florida are furthered explained by lake regions designations specific for the State of Florida. Lake regions of Florida include physical, chemical, and ecological components outlining regions with homogeneity among lake characteristics. Northwest Florida's coastal dune lakes occur in the Gulf Coast Lowlands Lake Region within the East Gulf Coastal Plain Ecoregion. Majority of lakes within these regions are acidic, soft water lakes containing high concentrations of dissolved organic carbons and low to moderate nutrients, comparatively. Coastal dune lakes have higher sulfate, sodium, and chloride levels than inland lakes, and can quickly decrease or increase in salt content depending on shifts in rainfall, saltwater input, or salt spray (Griffith et al. 1997).

Many of Northwest Florida's coastal dune lake watersheds include water flow through forested and wetland areas, increasing the contribution of dissolved organic carbons and tannic acids to the lake water. Dissolved organic carbons and tannic acids derive from slowly decomposing organic matter, which results in more colored, darker water with an acidic, pH condition. Total phosphorus (TP) and total nitrogen (TN) zones were developed to broadly highlight differences in lake nutrient concentrations associated with natural influences like geology. Northwest Florida's coastal dune lakes fall within TP Zone 3 and TN Zone 3. Geometric mean total phosphorus concentration for lakes with TP Zone 3 is 19 g/L with the 95% range of values being 4 to 39 g/L. Geometric mean total nitrogen concentration for lakes with TN Zone 3 is 611 g/L with the 95% range of values being 200 to 1030 g/L (Bachmann et al. 2012). For more information on lake water chemistry, see Hyman and Stephens (2020).

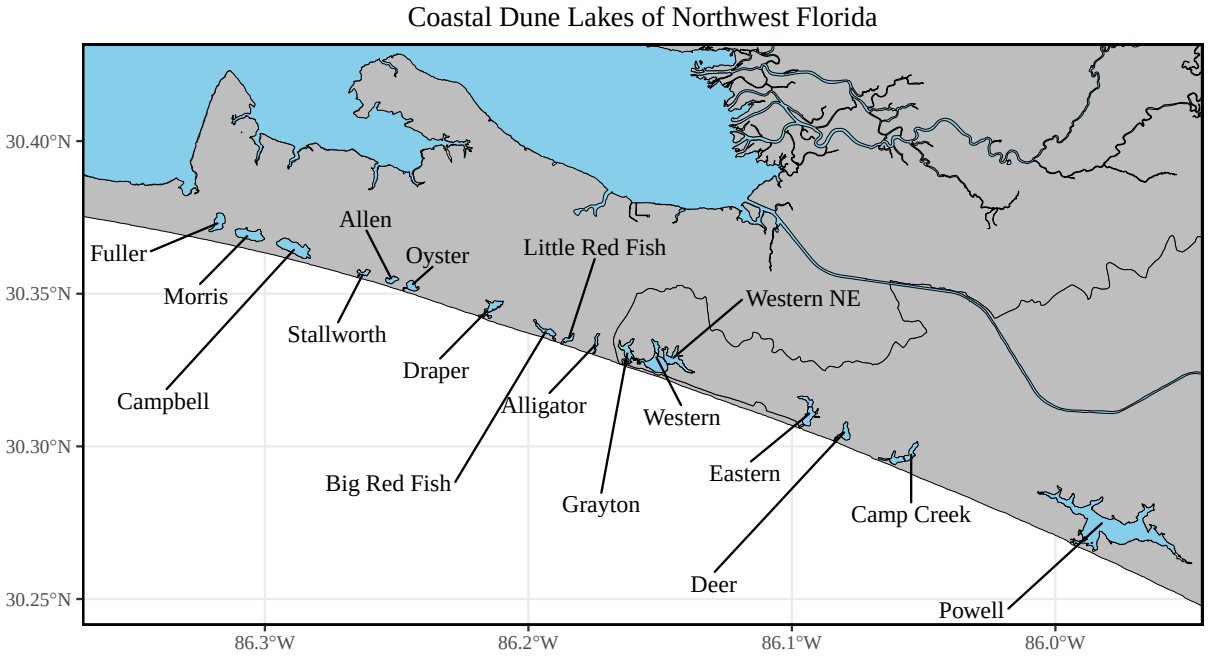

Figure 1: Geographic locations of the Northwest Florida Coastal Dune Lakes

Methods

A combination of physical and chemical variables were collected at each water quality monitoring station. Open water surface samples were collected in the field by Choctawhatchee Basin Alliance (CBA) citizen scientists. Water samples were analyzed for total phosphorus and total nitrogen, total chlorophyll, true color, and conductivity at Florida LAKEWATCH National Environmental Laboratory Accredited Certified (NELAC) laboratory located at University of Florida's Institute of Food and Agricultural Sciences. Sample collection, storage, transportation, and water chemistry analyses followed Florida LAKEWATCH Standard Operating Procedures (Hoyer and Brown 2017) in Gainesville, Florida.

In the field, at monitoring sites water samples were collected, citizen scientists also estimated water transparency data by use of a Secchi disk. Multi-variable data sonde was used to collect surface and bottom temperature, dissolved oxygen, pH, salinity, and turbidity.

Water Samples

- One, 250-mL, acid-cleaned, triple-rinsed Nalgene bottle was used to collect a water sample analyzed for total phosphorus (µg/L), total nitrogen (µg/L) and true color (Pt-Co Units) and conductivity (µS/cm).

- One, 1000-mL, Nalgene bottle was used to collect a water sample for total chlorophyll analysis. Secchi Disk — Measures the attenuation of light within the water column, or transparency, in meters.

Nutrient Parameters

- **Total Phosphorous (µg/L)** — Sum of all phosphorus compounds in the water column, organic and inorganic, at the time of collection. Phosphorous is an essential nutrient for alga and plant growth.
- **Total Nitrogen (µg/L)** — Sum of the all nitrogen compounds in the water column, organic and inorganic, at the time of collection. Nitrogen is an essential nutrient for alga and plant growth.

Algal Concentration Estimation

- **Total Chlorophyll (µg/L)**— Sum of all chlorophyll (common pigment found in alga frequently used as a proxy for aquatic flora abundance) in the water column at the time of sampling. CBA chlorophyll data were uncorrected for pheophytins until 2013. As a result, only chlorophyll data post-correction (i.e., 2013-present) are reported here.

Multi-probe Data Sonde

Hydrolab Quanta multi-probe data sondes measured physical and chemical variables temperature (C), specific conductivity (µS/cm), dissolved oxygen (mg/L), pH, salinity (PPS), and turbidity (NTU).

- **Temperature (˚ C)** — Temperature of the waterbody in degrees Celsius.
- **Dissolved oxygen (mg/L)** — Concentration of dissolved oxygen in water.
- **pH** — Measurement of hydrogen ions within the water indicating the level of acidic or basic condition of the waterbody.
- **Salinity (ppt)** — Measurement of dissolved sodium chloride content in the water. Measurements recorded in Practical Salinity Scale.

Morphometry

Summary of catchment area, surface area, average depth, max depth and volume for each coastal dune lake as determined by Choctawhatchee Basin Alliance, Mattie M. Kelly Environmental Institute and Florida LAKEWATCH.

- **Catchment Area (hectare)** — Area in which all surface water runoff drains to single point.
- **Surface Area (hectare)** — Sum of waterbody face area.
- **Average Depth (meter)** — Mean depth of water column.
- **Max Depth (meter)** — Maximum depth of waterbody.
- **Volume (cubic meter)** —Measurement of the amount of space occupied by waterbody.

Table 1: Morphometry of Coastal Dune Lakes

	Catchment Area (ha)	Surface Area (ha)	Average Depth (m)	Max Depth (m)	Volume (m^3)
Allen	71	8	1.28	1.85	71000
Alligator	38	5	0.94	1.82	42000
Big Red Fish	119	11	1.12	1.81	110000
Camp Creek	213	26	1.39	1.91	310000
Campbell	NA	45	3.54	4.93	1600000
Deer	127	17	2.83	1.99	480000
Draper	193	16	1.79	3.01	280000
Fuller	43	21	1.74	2.84	330000
Eastern	154	26	1.77	2.88	430000
Grayton	275	22	1.42	4.45	230000
Little Red Fish	NA	5	0.88	1.82	43000
Morris	87	35	2.80	4.68	900000
Oyster	56	11	1.38	2.35	140000
Powell	730	287	2.54	4.97	6600000
Stallworth	86	6	1.44	2.92	81000
Western	275	46	2.15	5.29	820000
Western Northeast	275	41	1.94	4.93	570000

Analyses

Trophic State Index

- The trophic state index is a classification system that is used to estimate the biological productivity of a waterbody based on concentrations of **chlorophyll**, **phosphorous**, and **secchi disk**. It is defined as the total weight of living biological material (biomass) in a waterbody at a specific location and time. Algal biomass is the most common basis for trophic state classification
  - *Equation* 1 (*chlorophyll*) : $TSI_{CHL} = 9.81 \bullet ln(CHL) + 30.6$
  - *Equation* 2 (*phosphorous*) : $TSI_{TP} = 14.42 \bullet ln(TP) + 4.15$
  - *Equation* 1 (*secchi disk*) : $TSI_{SD} = 60–14.41 \bullet ln(SD)$
- Note that the *best* trophic state indicator is **chlorophyll**, so we use **Equation 1** as our metric for TSI. This is because chlorophyll is directly related to algal biomass. Neither transparency (secchi disk depth) nor phosphorus are independent estimators of trophic state, so they are only used if we do not have reliable chlorophyll measurements.
- Trophic state classification
  - **TSI <40: Oligotrophic** - Clear, oxygen-rich water within minimal algal biomass
  - **TSI 40-50: Mesotrophic** - Water moderately clear; increasing probability of anoxia (lack of oxygen) during summer at deeper depths; moderate algal biomass
  - **TSI 50-70: Eutrophic** - Cloudy water characterized by high levels of algal biomass and anoxia at depth; possibly idicative of nutrient problems
  - **TSI 80+: Hyper-Eutrophic** - Water characterized by dense mats of algal scum floating on top of the water; water very murky and almost perpetually anoxic at depth; lake is likely impaired

Trend analysis

- While trophic state indices are useful for evaluating the current health of a lake, often managers are interested in whether lake health is improving or deteriorating over time. Trend analyses are commonly used to evaluate trends in water quality parameters over time to assess long-term lake health. CBA uses Kendall Rank Correlation Test to assess trends over time.

$$T = \frac{C–D}{C + D}$$

Where T represents the trend and is a function of C the concordant pairs minus D the number of discordant pairs, divided by the sum of C and D. Essentially, it measures how often an increase in one variable corresponds to an increase in another variable. T values approaching one indicate a **strong positive trend**, while T values approching negative one indicate a ***strong negative trend**, and T values near zero indicate **no trend**. For this report, we use the last 10 years of data for each lake to inform our analysis ($n \approx 120$).

Water Chemistry Tables

Summary statistics for both 2020 and for long-term timespans (2003 - 2020) are included in this report.

For 2020 summary statistics, mean, maximum (Max), minimum (Min), median, and standard error (Std Error) are reported for temperature (Celcius, top and bottom), dissolved oxygen (top and bottom), pH (top and bottom), salinity (top and bottom), total phosphorous (TP), total nitrogen (TN), and total chlorophyll (CHL) measurements.

For long-term (2003 - 2020) summary statistics, mean, maximum (Max), minimum (Min), median, and standard error (Std Error) are reported for on an annual basis using monthly data for dissolved oxygen,

pH, salinity, total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), and secchi disk depth measurements. 10-year trends determined using Kendall's Rank Order Correlation Test (Kendall's Tau) are also reported. Significant trends are indicated as increasing trend in a variable over time (**Increasing**) or decreasing trend in variable over time (**Decreasing**). Trends that are not statistically significant ($\alpha = 0.5$) are identified as ".". Results are summerized both in the **Long-Term Trends** table for all lakes, as well as in the **Long-Term Water Chemistry** tables for each lake individually.

Results

Long-Term Trends

Long term trends in total phosphorus (TP), total nitrogen (TN), total chlorophyll, and water transparency of Northwest Florida coastal dune lakes among all years of data collection. 10-year trends were determined using Kendall's rank order correlation analysis (Kendall's Tau). Significant trends are indicated with increasing trend in variable over time ("Increase") or decreasing trend in variable over time ("Decrease"). Trends that are not statistically significant ($\alpha = 0.5$) are identified as "." in table below.

Table 2: Ten Year Trends of Coastal Dune Lake Water Chemistry Variables

	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Phosphorous (µg/L)	Nitrogen (µg/L)	Chlorophyll (µg/L)
Allen	.	Increasing	Decreasing	Increasing	Decreasing	.
Alligator	Decreasing	Increasing	Increasing	.	Decreasing	.
Big Red Fish	.	Increasing	Increasing	Increasing	Decreasing	.
Camp Creek	Decreasing	.	.	.	.	.
Campbell	.	.	Decreasing	Increasing	Decreasing	.
Deer	Decreasing	.	Increasing	.	Decreasing	.
Draper	Decreasing	.	Increasing	Increasing	.	.
Eastern	.	Increasing	Increasing	.	.	.
Fuller	.	.	.	.	Decreasing	Increasing
Grayton	.	Increasing	Increasing	Increasing	.	.
Little Red Fish	.	.	.	.	.	.
Morris	.	.	Decreasing	Increasing	Decreasing	Increasing
Oyster	Decreasing	Increasing	Increasing	Decreasing	Increasing	Increasing
Powell	Decreasing	.	Decreasing	.	.	.
Stallworth	Decreasing	Increasing	Increasing	Increasing	.	.
Western	Decreasing	.	Increasing	Increasing	Increasing	Increasing

Allen Lake

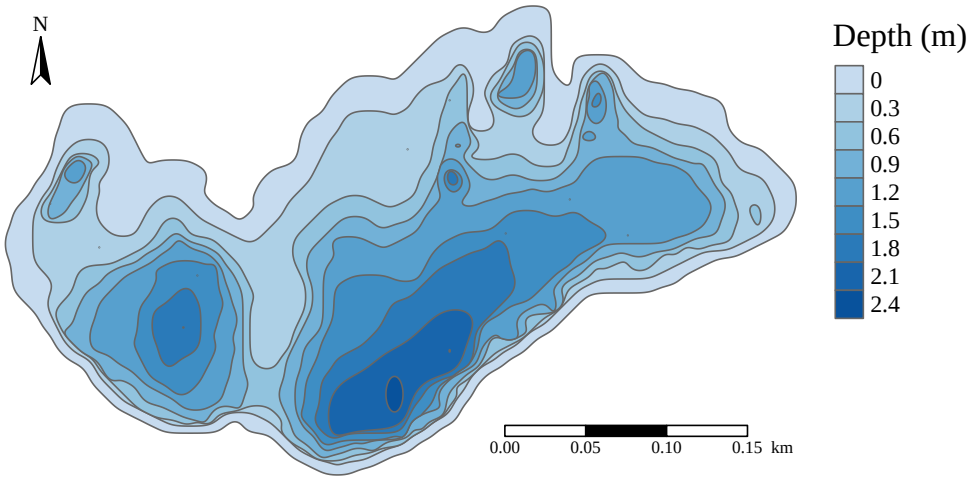

Figure 2: Bathymetry of Allen Lake.

Description

Allen Lake is an isolated, primarily fresh (0.07 ppt) system laying approximately 200m from the Gulf of Mexico. Among the population of coastal dune lakes, the system is relatively small; with a surface area of 8 hectares (80,000 m^2) and average volume of approximately 71,000 m^3. Currently, Allen Lake is one of several systems which do not possess a direct connection with the Gulf of Mexico. Although at one time Allen Lake was able to connect to the gulf via an outfall, this characteristic was lost as a direct result of the paving of Highway 30A, which created a barrier between the lake and the gulf. The system is thought to have retained a small measure of connectivity through a culvert connecting to Oyster Lake (Hoyer & Canfield, 2008). However, long-term salinity results suggest that this connection likely does not play a significant role in lake water chemistry.

Table 3: Allen Lake Water Chemistry

	Min	Mean	Max	Std Error
Temperature(C) surface	16.85	24.89	31.65	1.44
Temperature(C) bottom	16.63	24.51	31.67	1.46
DO (mg/L) surface	4.80	6.90	9.05	0.54
DO (mg/L) bottom	2.08	6.43	10.04	0.77
pH surface	5.36	6.17	6.62	0.13
pH bottom	5.05	5.86	6.23	0.14
Salinity (ppt) surface	0.05	0.06	0.06	0.00
Salinity (ppt) bottom	0.03	0.29	2.20	0.24
Phosphorous (µg/L)	11.35	16.36	25.23	1.78
Nitrogen (µg/L)	508.60	569.88	628.06	14.53
Chlorophyll (µg/L)	2.29	5.94	11.29	1.21
Secchi depth (m)	0.38	0.87	1.70	0.18

Trophic State Index

For summer, 2020, total chlorophyll in Allen Lake averaged 5.94, yielding a TSI classification of 48.08 and indicating that the system is currently mesotrophic. Chlorophyll in this system has been stable over the last decade, indicating water quality has not changed.

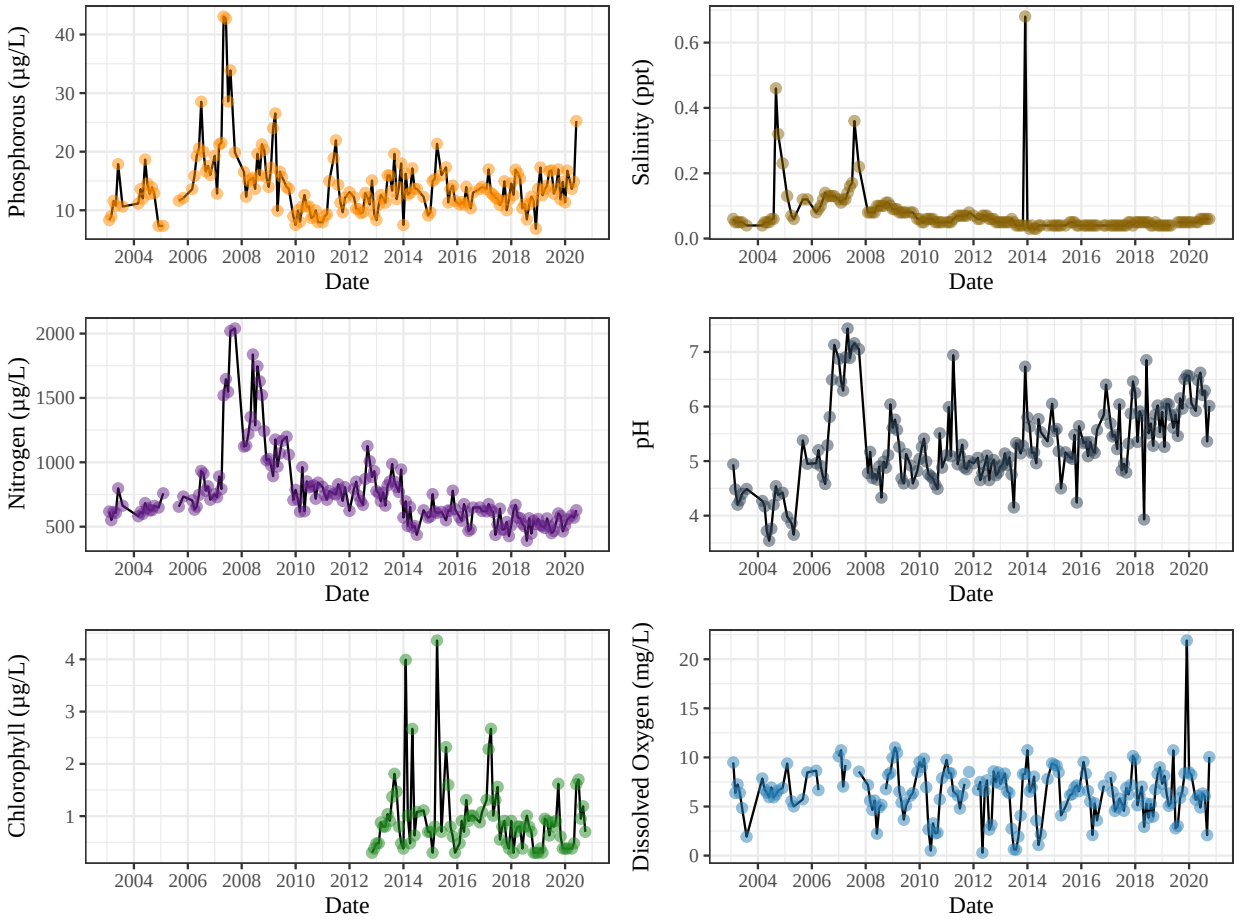

Figure 3: Timeseries of water chemistry variables in Allen Lake. CBA chlorophyll data were uncorrected for pheophytins until 2013. As a result, only chlorophyll data post-correction (i.e., 2013-present) are reported here.

Table 4: Allen Long-Term Water Chemistry Table

	Min	Mean	Max	Std Error	10-Year Trend
Dissolved Oxygen (mg/L)	0.29	6.48	21.91	0.18	.
pH	3.54	5.31	7.43	0.05	Increasing
Salinity (ppt)	0.03	0.07	0.68	0	Decreasing
Phosphorous (µg/L)	6.84	14.24	43.08	0.36	Increasing
Nitrogen (µg/L)	390.58	764.74	2039.67	20.31	Decreasing
Chlorophyll (µg/L)	0.3	0.96	4.36	0.05	.

Alligator Lake

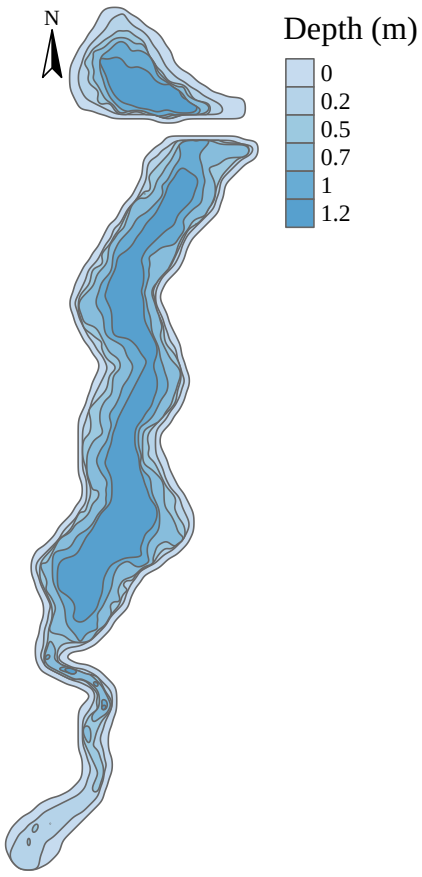

Figure 4: Bathymetry of Alligator Lake.

Description

Alligator Lake is a long, narrow system of relatively intermediate salinity (4.18 ppt) located approximately 260 meters from the Gulf of Mexico. Alligator Lake is among the smallest systems in the population of coastal dune lakes, with a surface area of 5.5 hectares (50,000 m^2) and an average volume of 42,000 m^3. The system is divided by Highway 30A into northern and southern sections. Connection between the two sections is facilitated via a culvert extending under the highway. Alligator Lake possesses an outfall which intermittently connects to the Gulf, enabling substantial fluctuations in water chemistry values.

Table 5: Alligator Lake Water Chemistry

	Min	Mean	Max	Std Error
Temperature(C) surface	16.82	25.83	33.84	1.73
Temperature(C) bottom	17.92	26.16	32.56	1.54
DO (mg/L) surface	3.21	4.43	5.81	0.31
DO (mg/L) bottom	0.79	2.73	4.38	0.44
pH surface	6.11	6.89	7.25	0.14
pH bottom	6.65	7.16	7.58	0.11
Salinity (ppt) surface	2.43	9.46	21.98	2.16
Salinity (ppt) bottom	9.17	18.73	26.80	2.03
Phosphorous (µg/L)	6.77	14.92	18.90	1.38
Nitrogen (µg/L)	325.06	467.54	698.50	39.50
Chlorophyll (µg/L)	1.19	4.00	8.32	0.68
Secchi depth (m)	0.30	0.72	1.24	0.10

Trophic State Index

For summer, 2020, total chlorophyll in Alligator Lake averaged 4, yielding a TSI classification of 44.2 and indicating that the system is currently mesotrophic. Chlorophyll in this system has been stable over the last decade, indicating water quality has not changed.

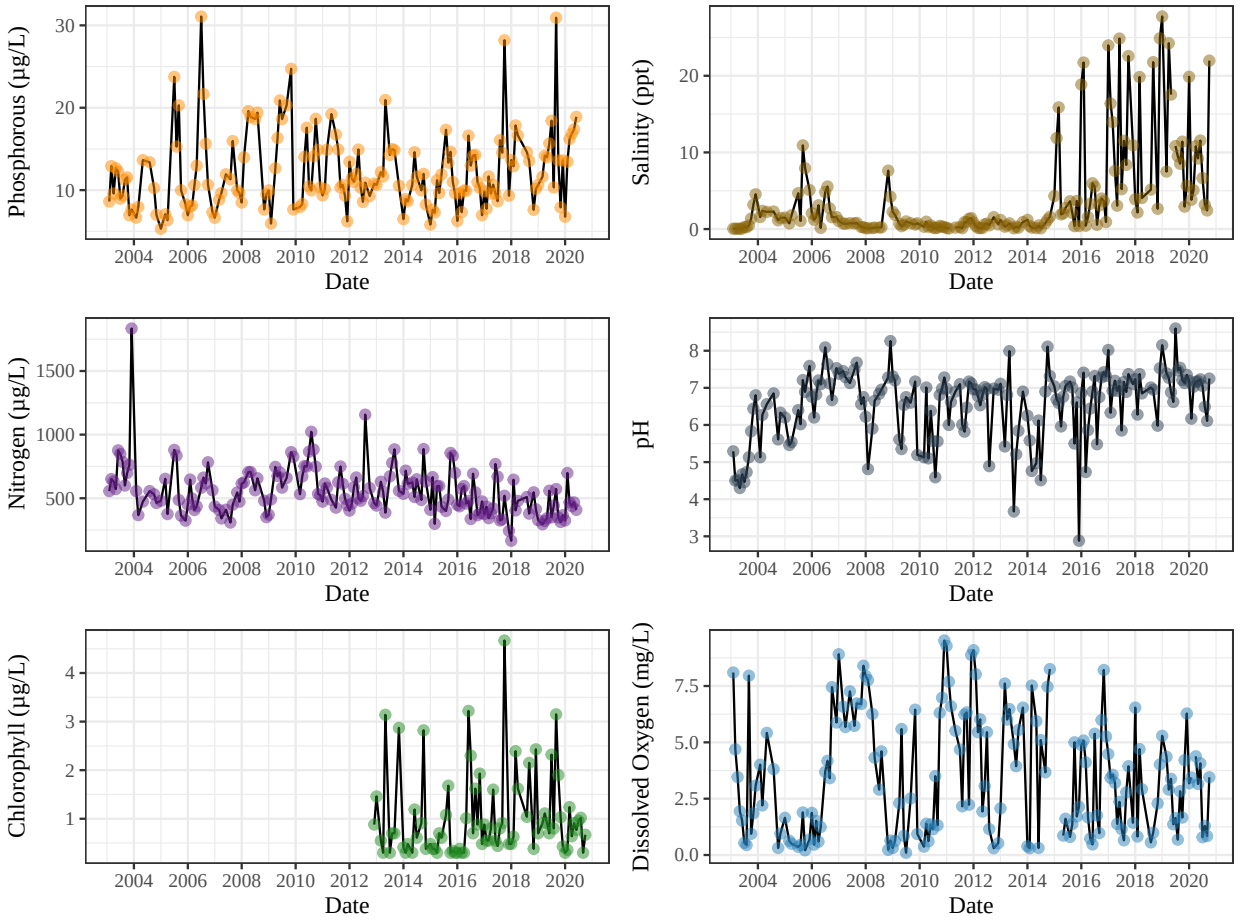

Figure 5: Timeseries of water chemistry variables in Alligator Lake. CBA chlorophyll data were uncorrected for pheophytins until 2013. As a result, only chlorophyll data post-correction (i.e., 2013-present) are reported here.

Table 6: Alligator Long-Term Water Chemistry Table

	Min	Mean	Max	Std Error	10-Year Trend
Dissolved Oxygen (mg/L)	0.1	3.53	9.52	0.18	Decreasing
pH	2.88	6.54	8.6	0.06	Increasing
Salinity (ppt)	0.04	4.18	27.74	0.43	Increasing
Phosphorous (µg/L)	5.31	12.3	31.08	0.32	.
Nitrogen (µg/L)	165.83	556.78	1834.43	13.19	Decreasing
Chlorophyll (µg/L)	0.3	1.02	4.67	0.06	.

Big Red Fish Lake

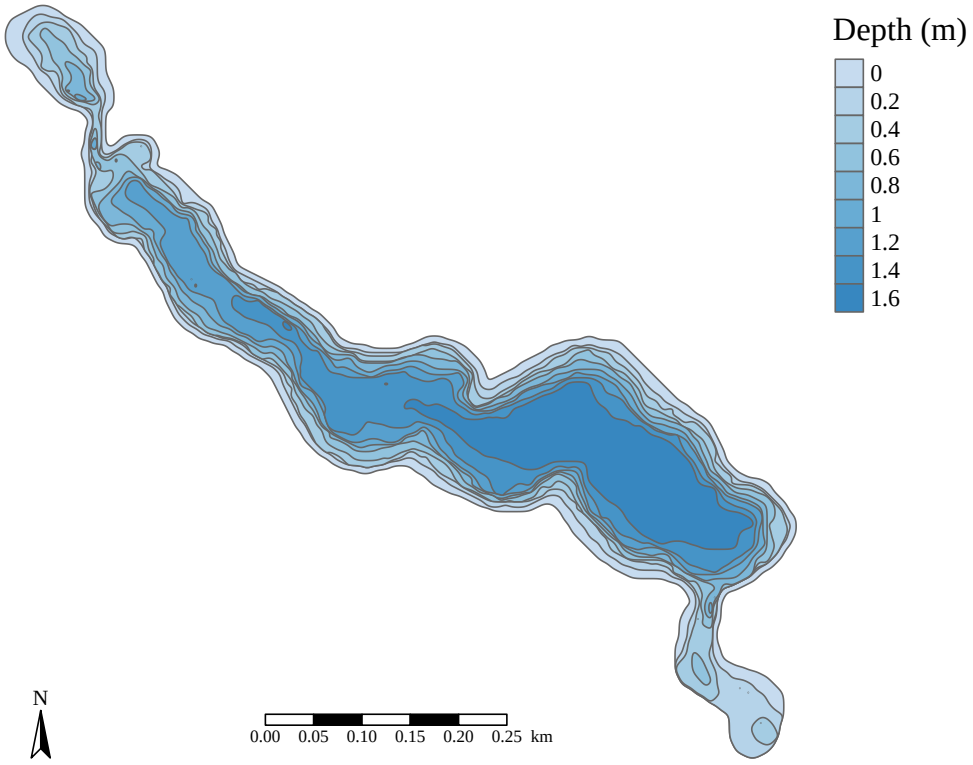

Figure 6: Bathymetry of Big Red Fish Lake.

Description

Big Red Fish Lake is elongated system approximately 200 meters from the Gulf of Mexico. The system is non-uniformly shaped; narrow at the northern end and widening into a larger, deeper southern section at the base. Big Red Fish Lake is an intermediate-sized coastal dune lake with a surface area of 12 hectares (120,000 m^2) and an approximate volume of 130,000 m^3. The system is divided by Highway 30A into a smaller northern section and a larger southern section. Connectivity between the two sections is maintained by a bridge. The system contains an outfall which regularly connects to the gulf. As a result, Big Red Fish Lake is brackish (9.66 ppt).

Table 7: Big Red Fish Lake Water Chemistry

	Min	Mean	Max	Std Error
Temperature(C) surface	17.64	25.75	32.05	1.61
Temperature(C) bottom	20.09	26.32	30.44	1.33
DO (mg/L) surface	3.99	5.52	7.99	0.47
DO (mg/L) bottom	0.82	2.78	5.15	0.54
pH surface	5.98	7.29	7.72	0.19
pH bottom	6.80	7.46	7.85	0.12
Salinity (ppt) surface	1.47	17.20	27.76	2.87
Salinity (ppt) bottom	15.50	22.25	30.80	1.97
Phosphorous (µg/L)	13.28	21.95	29.58	2.66
Nitrogen (µg/L)	273.17	384.45	480.42	23.67
Chlorophyll (µg/L)	1.00	8.48	13.45	1.39
Secchi depth (m)	0.30	1.50	2.94	0.33

Trophic State Index

For summer, 2020, total chlorophyll in Big Red Fish Lake averaged 8.48, yielding a TSI classification of 51.57 and indicating that the system is currently eutrophic, which is a cause for concern. Chlorophyll in this system has been stable over the last decade, indicating water quality has not changed.

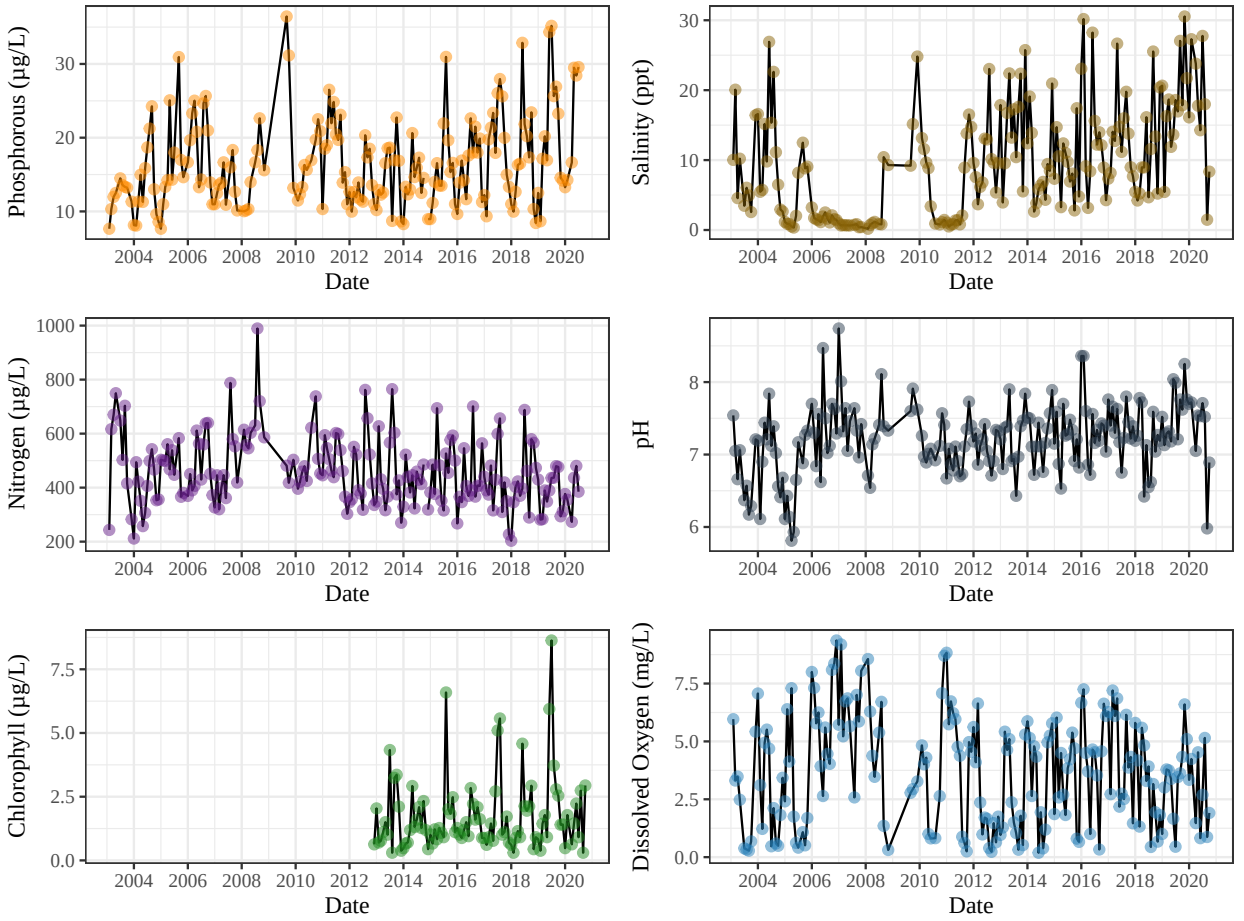

Figure 7: Timeseries of water chemistry variables in Big Red Fish Lake. CBA chlorophyll data were uncorrected for pheophytins until 2013. As a result, only chlorophyll data post-correction (i.e., 2013-present) are reported here.

Table 8: Big Red Fish Long-Term Water Chemistry Table

	Min	Mean	Max	Std Error	10-Year Trend
Dissolved Oxygen (mg/L)	0.19	3.69	9.36	0.16	.
pH	5.81	7.21	8.74	0.03	Increasing
Salinity (ppt)	0.18	9.66	30.54	0.52	Increasing
Phosphorous (µg/L)	7.65	16.51	36.44	0.41	Increasing
Nitrogen (µg/L)	203.28	459.15	989.35	8.62	Decreasing
Chlorophyll (µg/L)	0.3	1.74	8.63	0.1	.

Camp Creek Lake

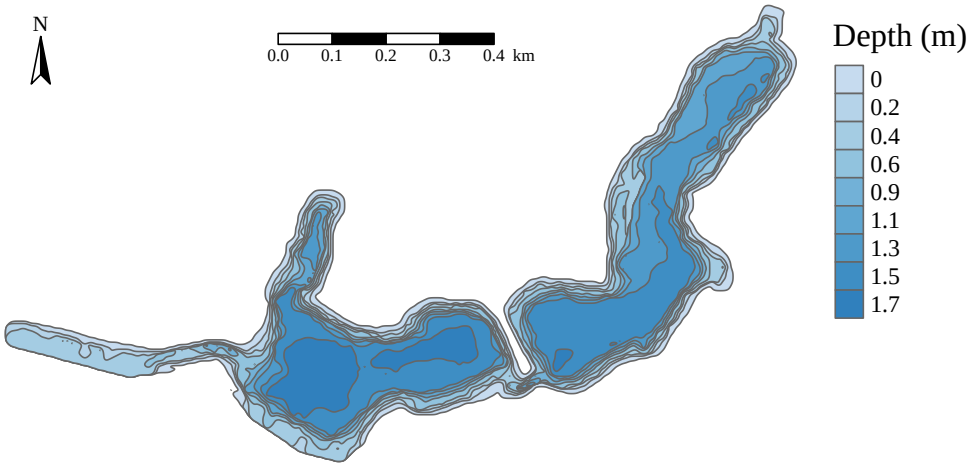

Figure 8: Bathymetry of Camp Creek Lake.

Description

Camp Creek Lake is an elongated system approximately 130 meters from the Gulf of Mexico. The system is divided into a northern and a southern section by Highway 30A. Connectivity between the two sections is preserved via a bridge. Camp Creek Lake is among the larger coastal dune lakes with a surface area of 26 hectares (260,000 m^2) and an approximate volume of 310,000 m^3. Camp Creek Lake contains an outfall which intermittently connects to the Gulf. The system's average water chemistry stays relatively low salinity (3.91 ppt).

Table 9: Camp Creek Lake Water Chemistry

	Min	Mean	Max	Std Error
Temperature(C) surface	13.72	23.05	31.51	3.03
Temperature(C) bottom	19.70	24.56	32.00	2.28
DO (mg/L) surface	3.30	6.38	8.38	0.89
DO (mg/L) bottom	0.28	3.87	12.30	2.14
pH surface	6.88	7.18	7.69	0.14
pH bottom	6.66	7.21	7.69	0.18
Salinity (ppt) surface	2.35	5.71	15.49	2.47
Salinity (ppt) bottom	9.86	17.18	23.93	2.41
Phosphorous (µg/L)	2.52	5.30	8.08	1.76
Nitrogen (µg/L)	218.98	261.08	303.18	26.63
Chlorophyll (µg/L)	1.00	4.36	9.02	1.45
Secchi depth (m)	0.30	0.98	2.30	0.37

Trophic State Index

For summer, 2020, total chlorophyll in Camp Creek Lake averaged 4.36, yielding a TSI classification of 45.04 and indicating that the system is currently mesotrophic. Chlorophyll in this system has been stable over the last decade, indicating water quality has not changed.

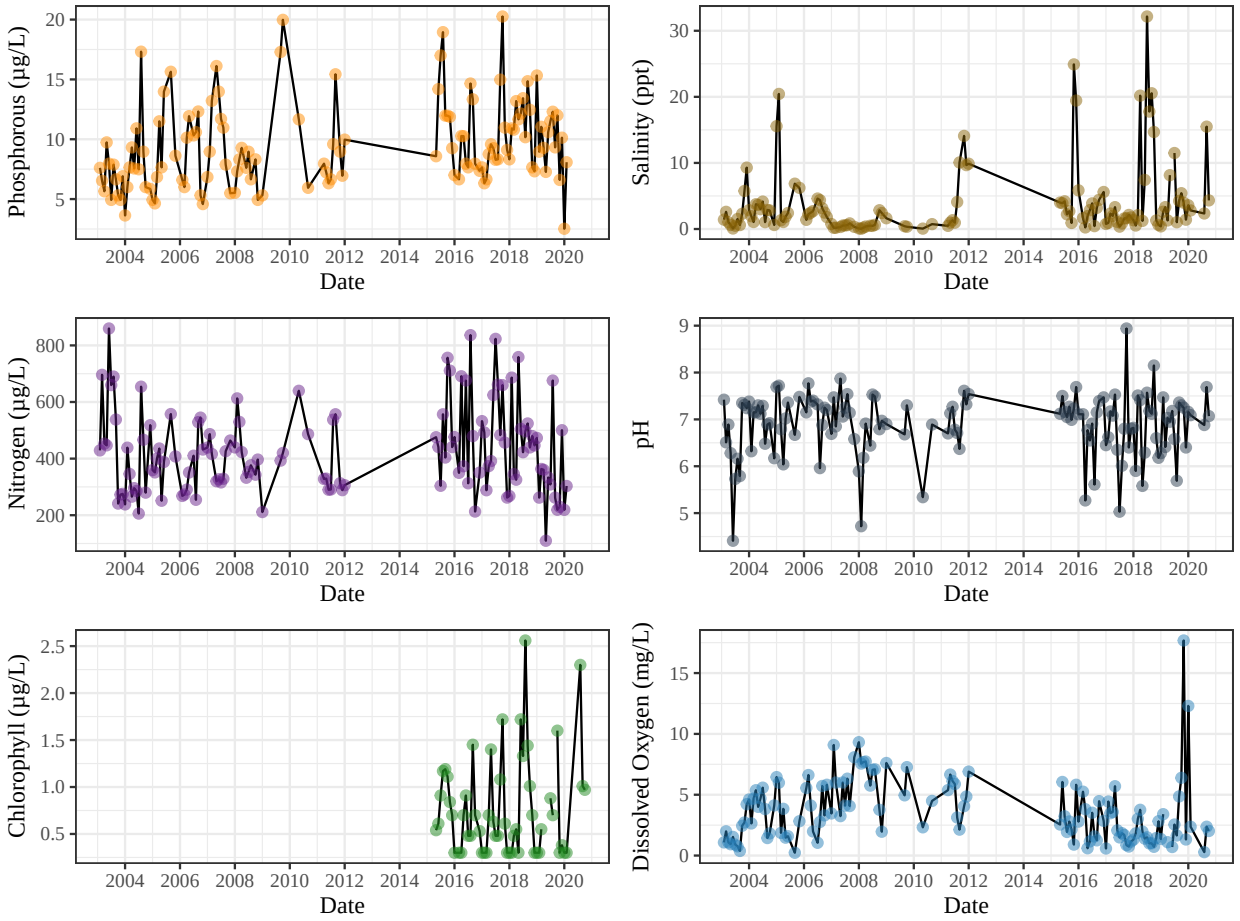

Figure 9: Timeseries of water chemistry variables in Camp Creek Lake. CBA chlorophyll data were uncorrected for pheophytins until 2013. As a result, only chlorophyll data post-correction (i.e., 2013-present) are reported here.

Table 10: Camp Creek Long-Term Water Chemistry Table

	Min	Mean	Max	Std Error	10-Year Trend
Dissolved Oxygen (mg/L)	0.23	3.63	17.68	0.18	Decreasing
pH	4.41	6.88	8.94	0.05	.
Salinity (ppt)	0.04	3.91	32.16	0.37	.
Phosphorous (µg/L)	2.52	9.47	20.26	0.24	.
Nitrogen (µg/L)	109.7	425.13	859.84	10.27	.
Chlorophyll (µg/L)	0.3	0.77	2.56	0.04	.

Campbell Lake

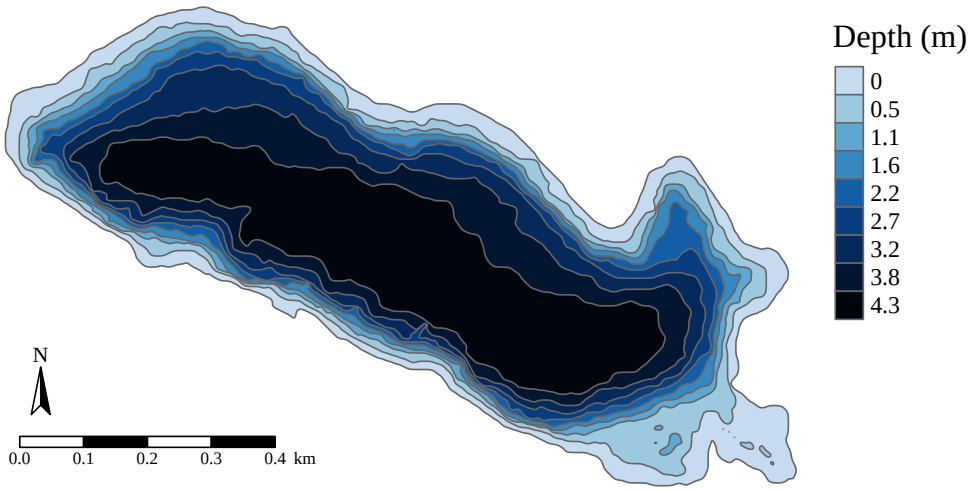

Figure 10: Bathymetry of Campbell Lake.

Description

Campbell Lake is an irregularly-ellipse shaped system approximately 200 meters from the Gulf of Mexico. The system is among the larger coastal dune lakes, with a surface area of 45 hectares (450,000 m^2) and an approximate volume of 1,300,000 m^3. The system is one of two lakes laying within Topsail State Park, which offers a degree of protection form the adverse effects of coastal development. While the system does contain an outfall, Campbell Lake seldom connects to the gulf. As a result, the system is primarily fresh (0.06 ppt).

Table 11: Campbell Lake Water Chemistry

	Min	Mean	Max	Std Error
Temperature(C) surface	13.19	25.42	31.98	2.20
Temperature(C) bottom	13.00	25.13	31.94	2.20
DO (mg/L) surface	5.92	7.64	9.82	0.47
DO (mg/L) bottom	5.76	7.41	9.56	0.46
pH surface	4.02	4.99	5.83	0.16
pH bottom	4.47	4.95	5.58	0.10
Salinity (ppt) surface	0.04	0.05	0.05	0.00
Salinity (ppt) bottom	0.04	0.05	0.05	0.00
Phosphorous (µg/L)	5.24	7.78	11.60	0.95
Nitrogen (µg/L)	199.83	239.36	273.24	9.77
Chlorophyll (µg/L)	2.00	3.79	8.32	0.65
Secchi depth (m)	0.30	0.44	0.80	0.05

Trophic State Index

For summer, 2020, total chlorophyll in Campbell Lake averaged 3.79, yielding a TSI classification of 43.67 and indicating that the system is currently mesotrophic. Chlorophyll in this system has been stable over the last decade, indicating water quality has not changed.

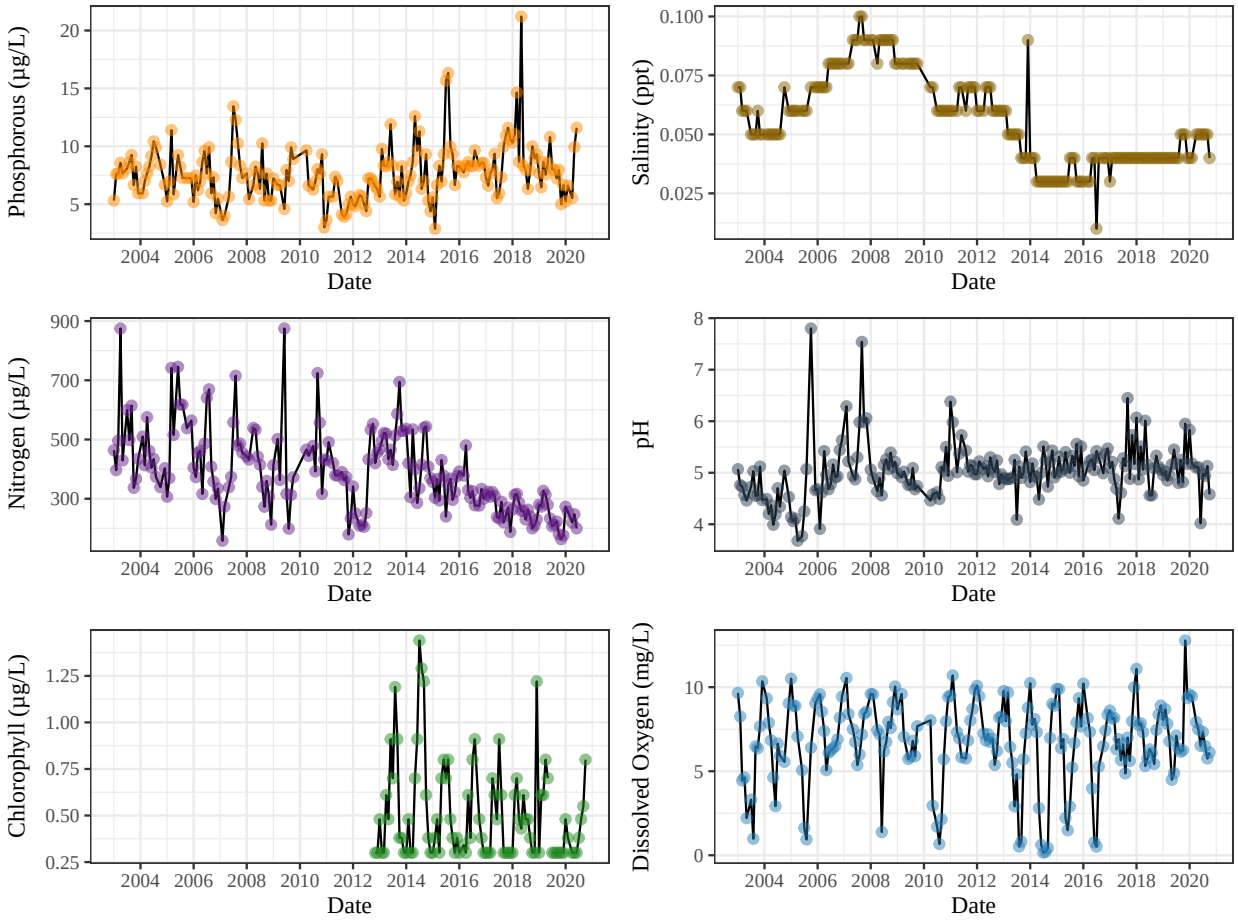

Figure 11: Timeseries of water chemistry variables in Campbell Lake. CBA chlorophyll data were uncorrected for pheophytins until 2013. As a result, only chlorophyll data post-correction (i.e., 2013-present) are reported here.

Table 12: Campbell Long-Term Water Chemistry Table

	Min	Mean	Max	Std Error	10-Year Trend
Dissolved Oxygen (mg/L)	0.15	6.76	12.78	0.17	.
pH	3.68	5.04	7.8	0.04	.
Salinity (ppt)	0.01	0.06	0.1	0	Decreasing
Phosphorous (µg/L)	2.88	7.72	21.21	0.16	Increasing
Nitrogen (µg/L)	158.1	386.94	874.95	9.28	Decreasing
Chlorophyll (µg/L)	0.3	0.51	1.44	0.02	.

Deer Lake

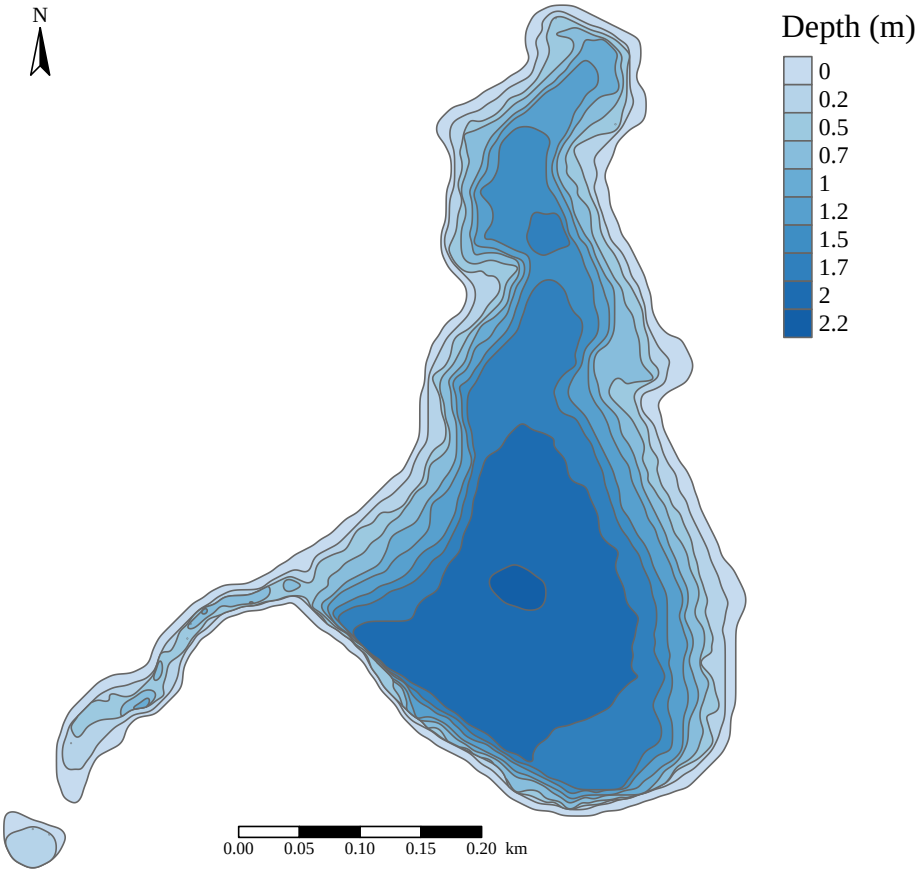

Figure 12: Bathymetry of Deer Lake.

Description

Deer Lake is a teardrop-shaped system approximately 250 meters away from the Gulf of Mexico. Deer Lake is an intermediate-sized coastal dune lake with a surface area of 17 hectares (170,000 m^2) and an approximate volume of 250,000 m^3. The system lays within Deer Lake State Park, which offers a degree of protection form the adverse effects of coastal development. The system contains an outfall which intermittently connects to the gulf, resulting in a relatively intermediate salinity system with a mean salinity of 6.12 ppt.

Table 13: Deer Lake Water Chemistry

	Min	Mean	Max	Std Error
Temperature(C) surface	16.03	25.37	34.16	2.34
Temperature(C) bottom	16.14	25.61	33.44	2.14
DO (mg/L) surface	5.15	6.40	8.30	0.37
DO (mg/L) bottom	0.47	4.37	9.17	1.14
pH surface	7.12	7.71	8.18	0.12
pH bottom	6.90	7.67	8.22	0.15
Salinity (ppt) surface	10.47	20.33	30.19	2.36
Salinity (ppt) bottom	16.90	25.52	32.55	2.20
Phosphorous (µg/L)	6.07	13.58	22.19	2.14
Nitrogen (µg/L)	192.94	343.81	499.54	46.05
Chlorophyll (µg/L)	1.00	4.95	9.25	1.04
Secchi depth (m)	0.30	0.79	1.40	0.16

Trophic State Index

For summer, 2020, total chlorophyll in Deer Lake averaged 4.95, yielding a TSI classification of 46.29 and indicating that the system is currently mesotrophic. Chlorophyll in this system has been stable over the last decade, indicating water quality has not changed.

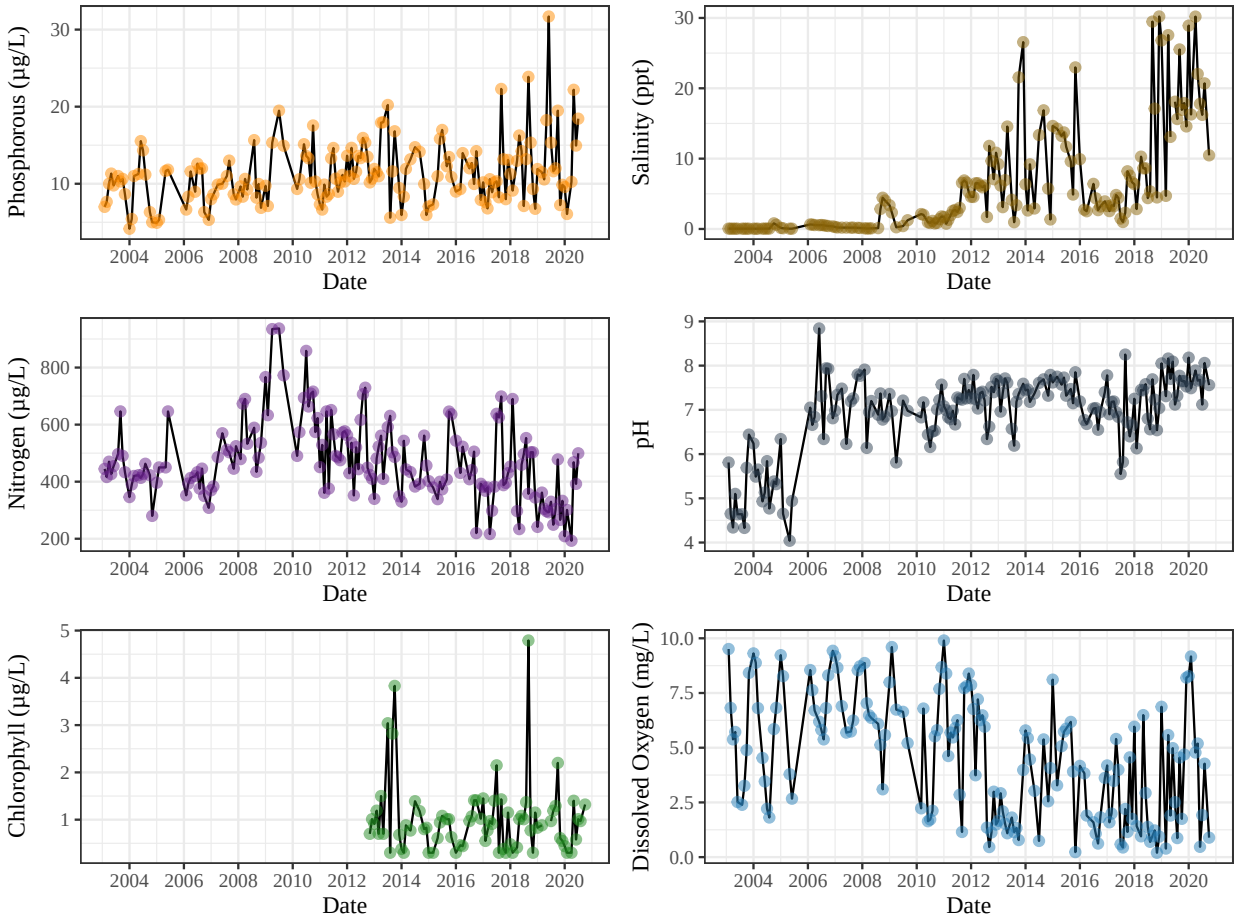

Figure 13: Timeseries of water chemistry variables in Deer Lake. CBA chlorophyll data were uncorrected for pheophytins until 2013. As a result, only chlorophyll data post-correction (i.e., 2013-present) are reported here.

Table 14: Deer Long-Term Water Chemistry Table

	Min	Mean	Max	Std Error	10-Year Trend
Dissolved Oxygen (mg/L)	0.2	4.59	9.9	0.18	Decreasing
pH	4.04	6.93	8.84	0.06	.
Salinity (ppt)	0.03	6.12	30.21	0.51	Increasing
Phosphorous (µg/L)	4.16	11.35	31.7	0.27	.
Nitrogen (µg/L)	192.94	471.03	936.95	9.3	Decreasing
Chlorophyll (µg/L)	0.3	1.02	4.79	0.05	.

Draper Lake

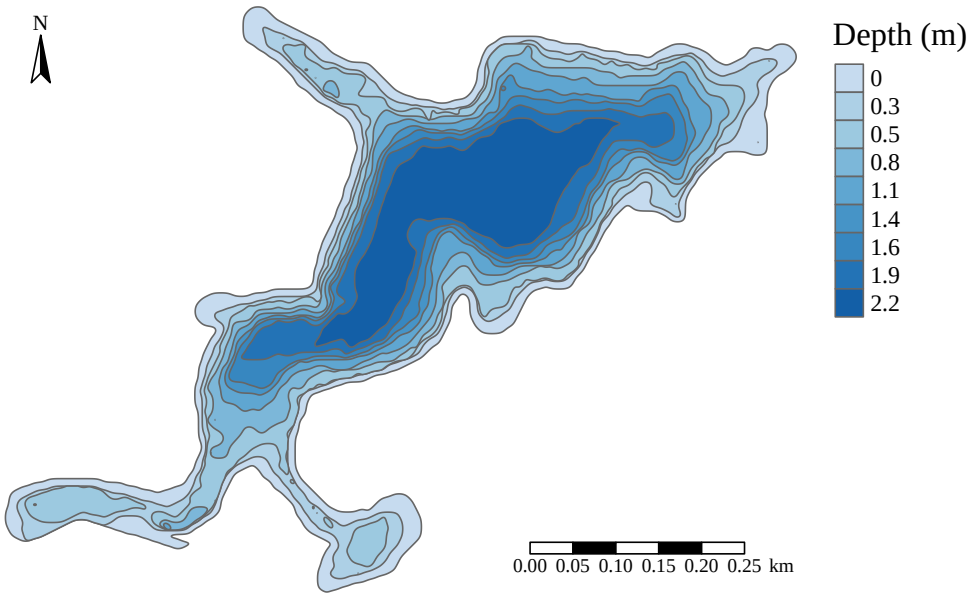

Figure 14: Bathymetry of Draper Lake.

Description

Draper Lake is an irregularly- shaped system approximately 200 meters from the Gulf of Mexico. The system is an intermediate-sized coastal dune lake, with a surface area of 16 hectares (160,000 m^2) and an approximate volume of 280,000 m^3. The system contains an outfall which regularly connects with the gulf. As a result, Draper Lake is a brackish system (8.17 ppt).

Table 15: Draper Lake Water Chemistry

	Min	Mean	Max	Std Error
Temperature(C) surface	17.24	26.27	32.85	2.26
Temperature(C) bottom	19.46	26.95	31.20	1.80
DO (mg/L) surface	2.66	5.47	7.64	0.70
DO (mg/L) bottom	1.29	2.53	3.60	0.34
pH surface	5.74	6.98	7.65	0.30
pH bottom	5.63	6.87	7.65	0.30
Salinity (ppt) surface	2.93	7.33	11.53	1.38
Salinity (ppt) bottom	6.44	11.75	21.79	2.19
Phosphorous (µg/L)	9.65	10.54	11.27	0.31
Nitrogen (µg/L)	129.58	198.21	280.34	25.48
Chlorophyll (µg/L)	1.59	2.46	4.58	0.44
Secchi depth (m)	0.30	0.40	0.78	0.08

Trophic State Index

For summer, 2020, total chlorophyll in Draper Lake averaged 2.46, yielding a TSI classification of 39.43 and indicating that the system is currently oligotrophic. Chlorophyll in this system has been stable over the last decade, indicating water quality has not changed.

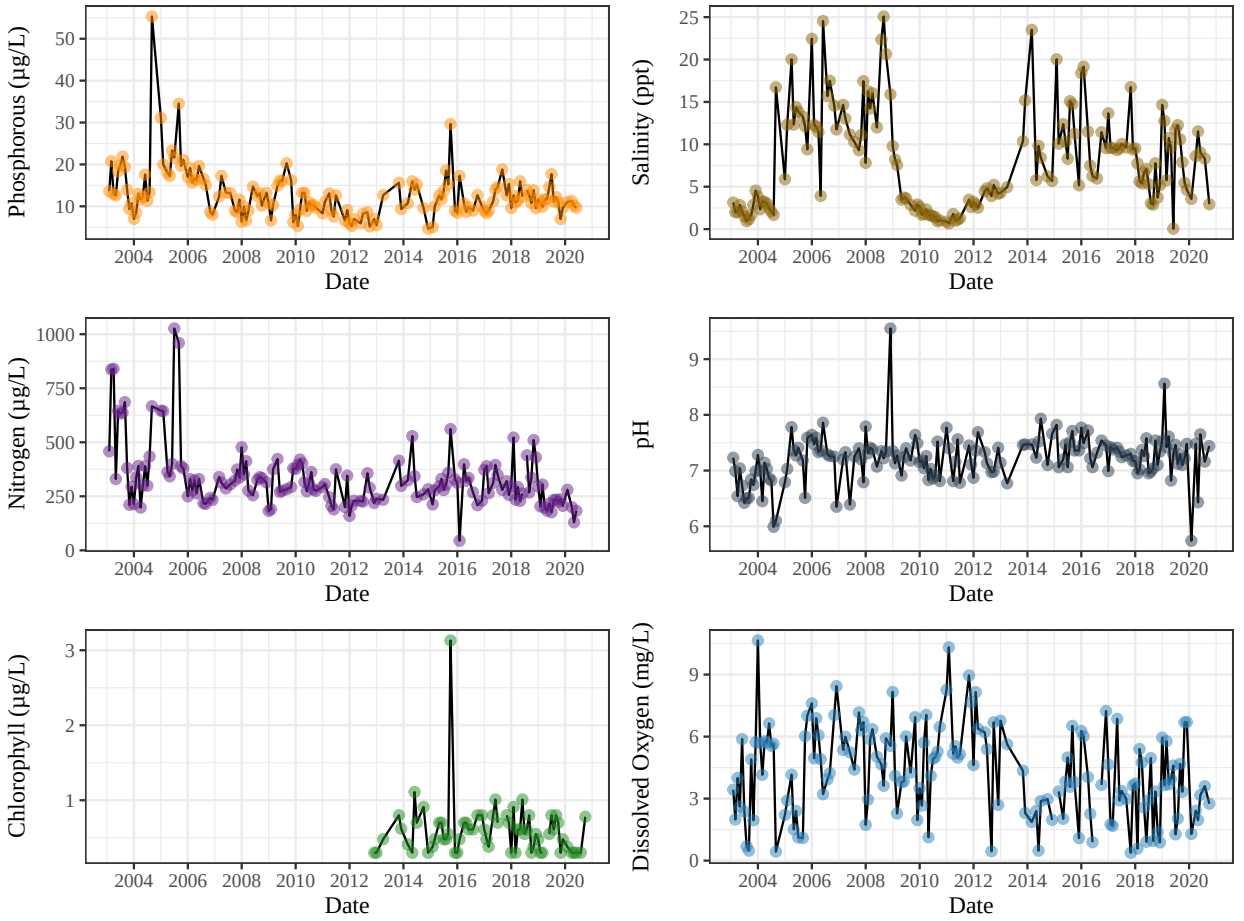

Figure 15: Timeseries of water chemistry variables in Draper Lake. CBA chlorophyll data were uncorrected for pheophytins until 2013. As a result, only chlorophyll data post-correction (i.e., 2013-present) are reported here.

Table 16: Draper Long-Term Water Chemistry Table

	Min	Mean	Max	Std Error	10-Year Trend
Dissolved Oxygen (mg/L)	0.38	4.26	10.65	0.15	Decreasing
pH	5.74	7.22	9.55	0.03	.
Salinity (ppt)	0.04	8.17	25.08	0.4	Increasing
Phosphorous (µg/L)	4.64	12.82	55.32	0.41	Increasing
Nitrogen (µg/L)	44.4	333.62	1026.53	9.89	.
Chlorophyll (µg/L)	0.3	0.6	3.13	0.03	.

Eastern Lake

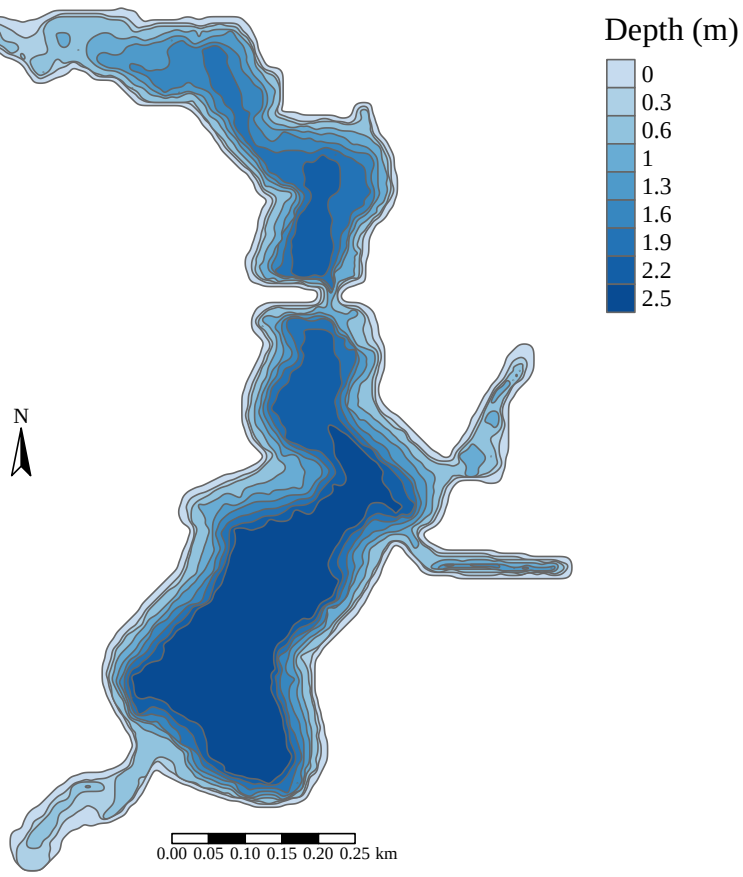

Figure 16: Bathymetry of Eastern Lake.

Description

Eastern Lake is a large, elongated system approximately 200 meters from the Gul of Mexico. The system is among the larger coastal dune lakes, with a total surface area of 30 hectares (300,000 m^2) and an approximate volume of 530,000 m^3. The system is divided by Highway 30A into a northern and a southern lobe. Connectivity between the two lobes is maintained by a bridge. The system contains an outfall which frequently connects to the gulf. As a result, Eastern Lake is among the most saline coastal dune lake systems (11.36 ppt).

Table 17: Eastern Lake Water Chemistry

	Min	Mean	Max	Std Error
Temperature(C) surface	14.13	24.98	31.98	2.60
Temperature(C) bottom	18.09	25.72	31.20	1.84
DO (mg/L) surface	4.98	6.19	7.48	0.33
DO (mg/L) bottom	0.07	2.90	4.12	0.63
pH surface	7.34	7.65	7.88	0.10
pH bottom	7.44	7.64	7.86	0.06
Salinity (ppt) surface	8.57	15.79	19.04	1.54
Salinity (ppt) bottom	17.47	22.64	28.26	1.63
Phosphorous (µg/L)	12.43	17.06	20.80	1.58
Nitrogen (µg/L)	293.30	352.35	439.46	27.04
Chlorophyll (µg/L)	2.00	3.98	6.65	0.70
Secchi depth (m)	0.30	0.66	1.08	0.14

Trophic State Index

For summer, 2020, total chlorophyll in Eastern Lake averaged 3.98, yielding a TSI classification of 44.15 and indicating that the system is currently mesotrophic. Chlorophyll in this system has been stable over the last decade, indicating water quality has not changed.

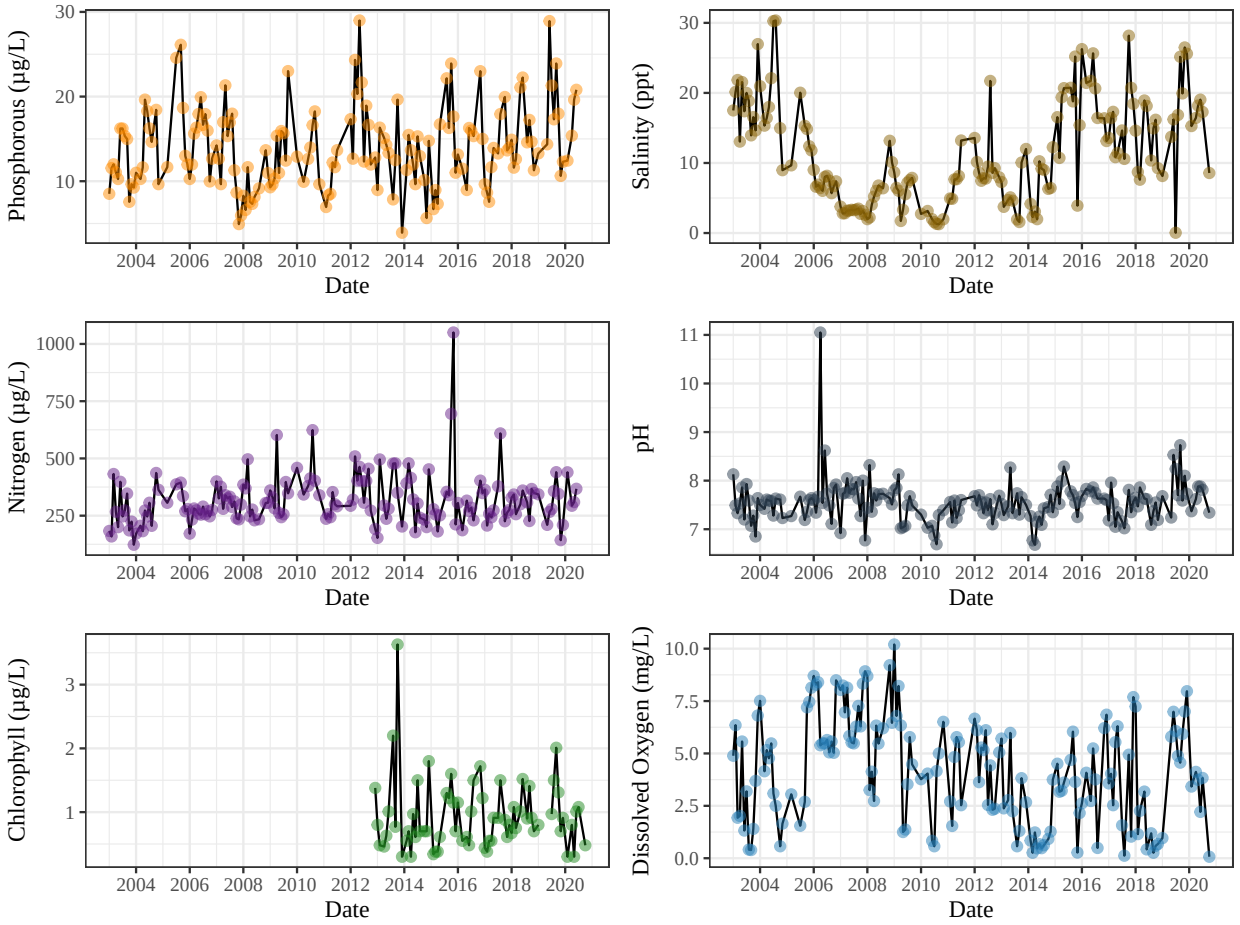

Figure 17: Timeseries of water chemistry variables in Eastern Lake. CBA chlorophyll data were uncorrected for pheophytins until 2013. As a result, only chlorophyll data post-correction (i.e., 2013-present) are reported here.

Table 18: Eastern Long-Term Water Chemistry Table

	Min	Mean	Max	Std Error	10-Year Trend
Dissolved Oxygen (mg/L)	0.07	4.2	10.2	0.17	.
pH	6.68	7.56	11.05	0.03	Increasing
Salinity (ppt)	0.04	11.36	30.34	0.49	Increasing
Phosphorous (µg/L)	3.91	14	28.99	0.32	.
Nitrogen (µg/L)	122.96	316.39	1050.11	7.64	.
Chlorophyll (µg/L)	0.3	0.94	3.63	0.04	.

Fuller Lake

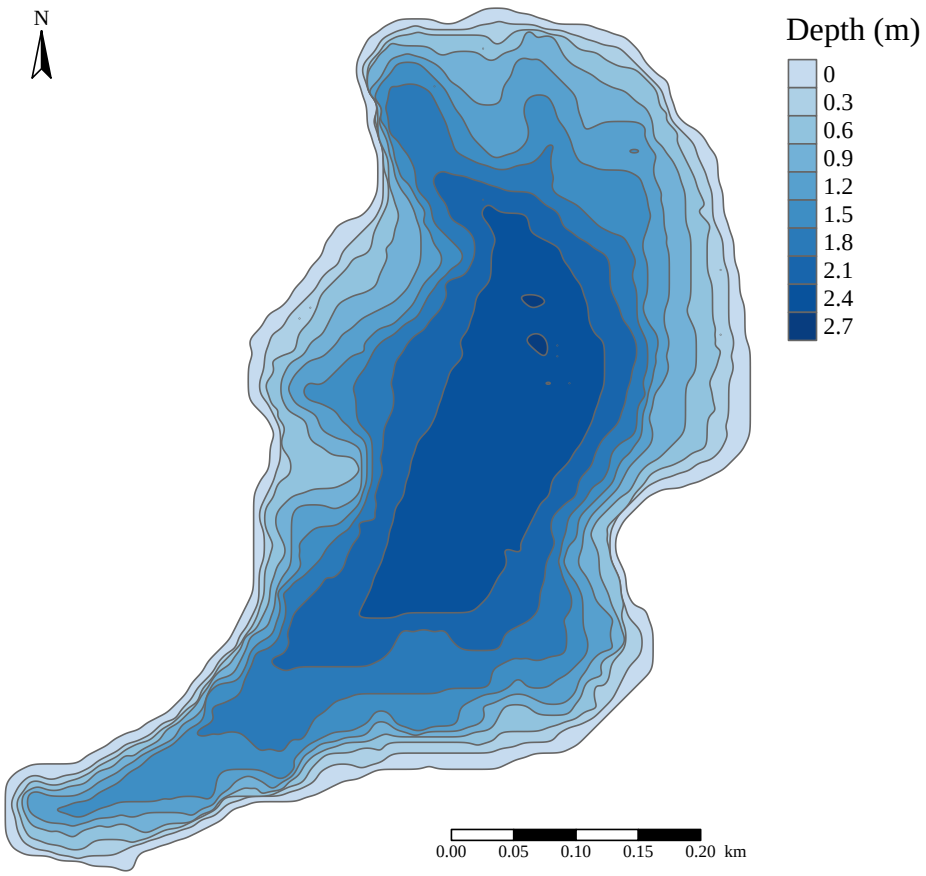

Figure 18: Bathymetry of Fuller Lake.

Description

Fuller Lake is a primarily isolated, freshwater (0.06 ppt) system laying approximately 400m from the Gulf of Mexico. The system is an intermediate-sized coastal dune lake; with a surface area of 21 hectares (210,000 m^2) and average volume of approximately 300,000 m^3. Fuller Lake is one of several systems which do not possess a direct connection with the Gulf of Mexico. The system retains indirect connectivity through a connection to Morris Lake (Hoyer & Canfield, 2008). However, long-term salinity results suggest that this connection likely does not play a significant role in lake water chemistry.

Table 19: Fuller Lake Water Chemistry

	Min	Mean	Max	Std Error
Temperature(C) surface	22.65	27.03	29.72	1.15
Temperature(C) bottom	22.52	25.94	29.54	1.13
DO (mg/L) surface	4.84	6.40	7.95	0.41
DO (mg/L) bottom	4.64	5.43	7.15	0.35
pH surface	4.59	5.10	5.39	0.13
pH bottom	4.56	5.07	5.50	0.13
Salinity (ppt) surface	0.05	0.06	0.06	0.00
Salinity (ppt) bottom	0.05	0.06	0.06	0.00
Phosphorous (µg/L)	9.32	10.41	11.27	0.38
Nitrogen (µg/L)	536.40	560.89	599.62	12.82
Chlorophyll (µg/L)	2.00	3.35	4.64	0.44
Secchi depth (m)	0.30	0.58	0.91	0.08

Trophic State Index

For summer, 2020, total chlorophyll in Fuller Lake averaged 3.35, yielding a TSI classification of 42.46 and indicating that the system is currently mesotrophic. Chlorophyll in this system has been increasing over the last decade, indicating water quality may be deteriorating.

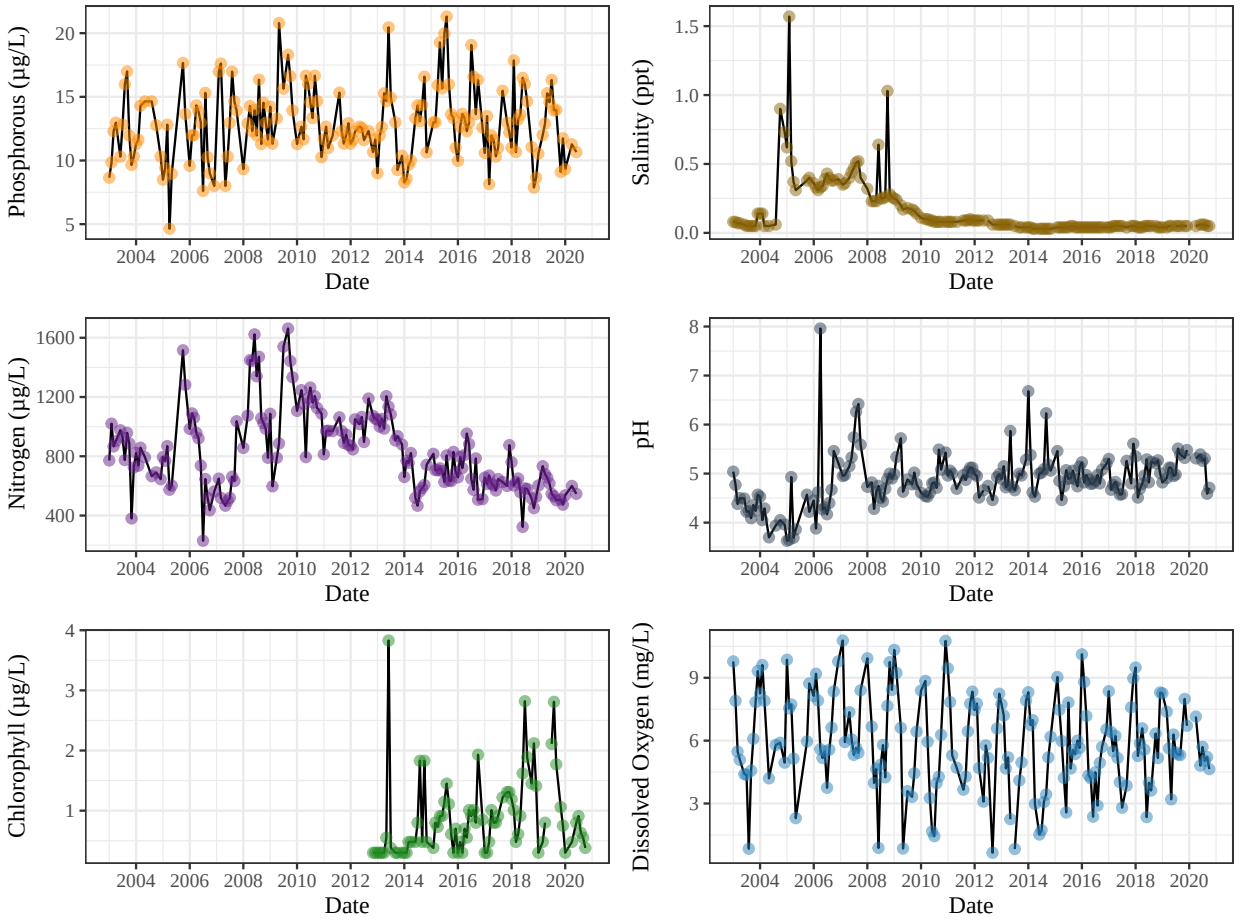

Figure 19: Timeseries of water chemistry variables in Fuller Lake. CBA chlorophyll data were uncorrected for pheophytins until 2013. As a result, only chlorophyll data post-correction (i.e., 2013-present) are reported here.

Table 20: Fuller Long-Term Water Chemistry Table

	Min	Mean	Max	Std Error	10-Year Trend
Dissolved Oxygen (mg/L)	0.65	5.89	10.78	0.15	.
pH	3.63	4.88	7.96	0.04	.
Salinity (ppt)	0.03	0.15	1.57	0.01	.
Phosphorous (µg/L)	4.64	12.88	21.31	0.19	.
Nitrogen (µg/L)	229.85	825.66	1662.6	18.42	Decreasing
Chlorophyll (µg/L)	0.3	0.89	3.83	0.05	Increasing

Little Red Fish Lake

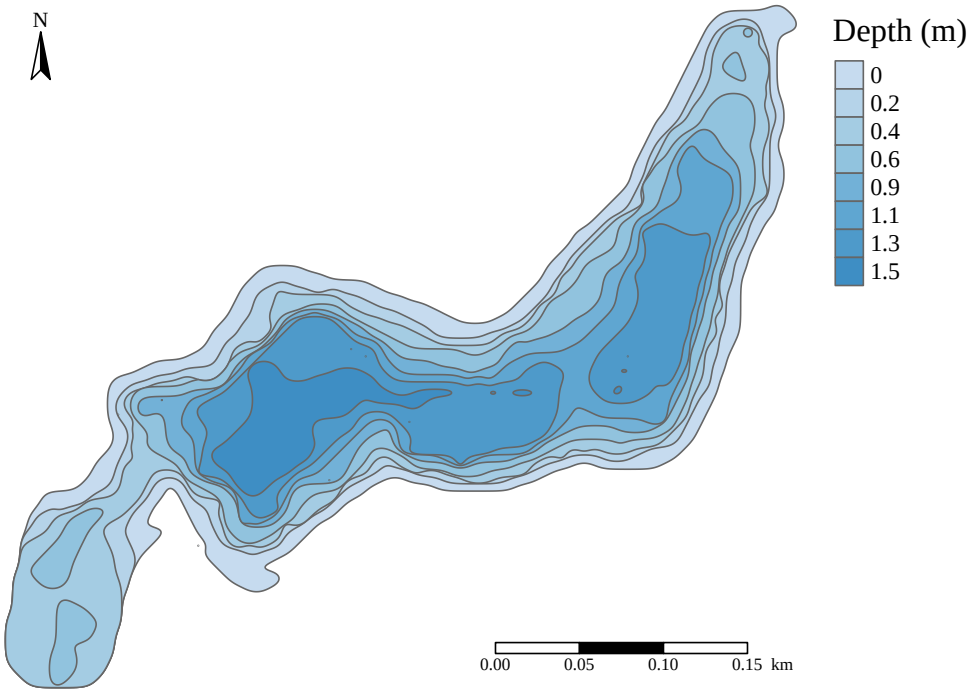

Figure 20: Bathymetry of Little Red Fish Lake.

Description

Little Red Fish lake is a narrow, elongated system approximately 100 meters from the Gulf of Mexico. Little Red Fish Lake is the smallest coastal dune lake, with a surface area of 5 hectares (50,000 m^2) and an approximate volume of 48,000 m^3. The system contains an outfall and frequently connects to the gulf. This, coupled with its small size, results in a brackish salinity (9.91 ppt) with large fluctuations (10.22 - 22.26ppt) depending on rainfall and seawater connections.

Table 21: Little Red Fish Lake Water Chemistry

	Min	Mean	Max	Std Error
Temperature(C) surface	-2.75	24.41	32.72	4.03
Temperature(C) bottom	26.00	28.76	31.37	0.82
DO (mg/L) surface	0.94	4.83	7.62	0.67
DO (mg/L) bottom	0.34	2.15	4.62	0.61
pH surface	6.12	7.13	7.84	0.17
pH bottom	4.73	6.70	7.68	0.36
Salinity (ppt) surface	10.22	15.28	22.26	1.50
Salinity (ppt) bottom	12.80	18.96	24.76	1.42
Phosphorous (µg/L)	7.73	16.61	23.99	2.16
Nitrogen (µg/L)	267.66	414.66	588.95	43.24
Chlorophyll (µg/L)	3.30	8.47	18.03	1.60
Secchi depth (m)	0.61	1.72	2.93	0.29

Trophic State Index

For summer, 2020, total chlorophyll in Little Red Fish Lake averaged 8.47, yielding a TSI classification of 51.56 and indicating that the system is currently eutrophic, which is a cause for concern. Chlorophyll in this system has been stable over the last decade, indicating water quality has not changed.

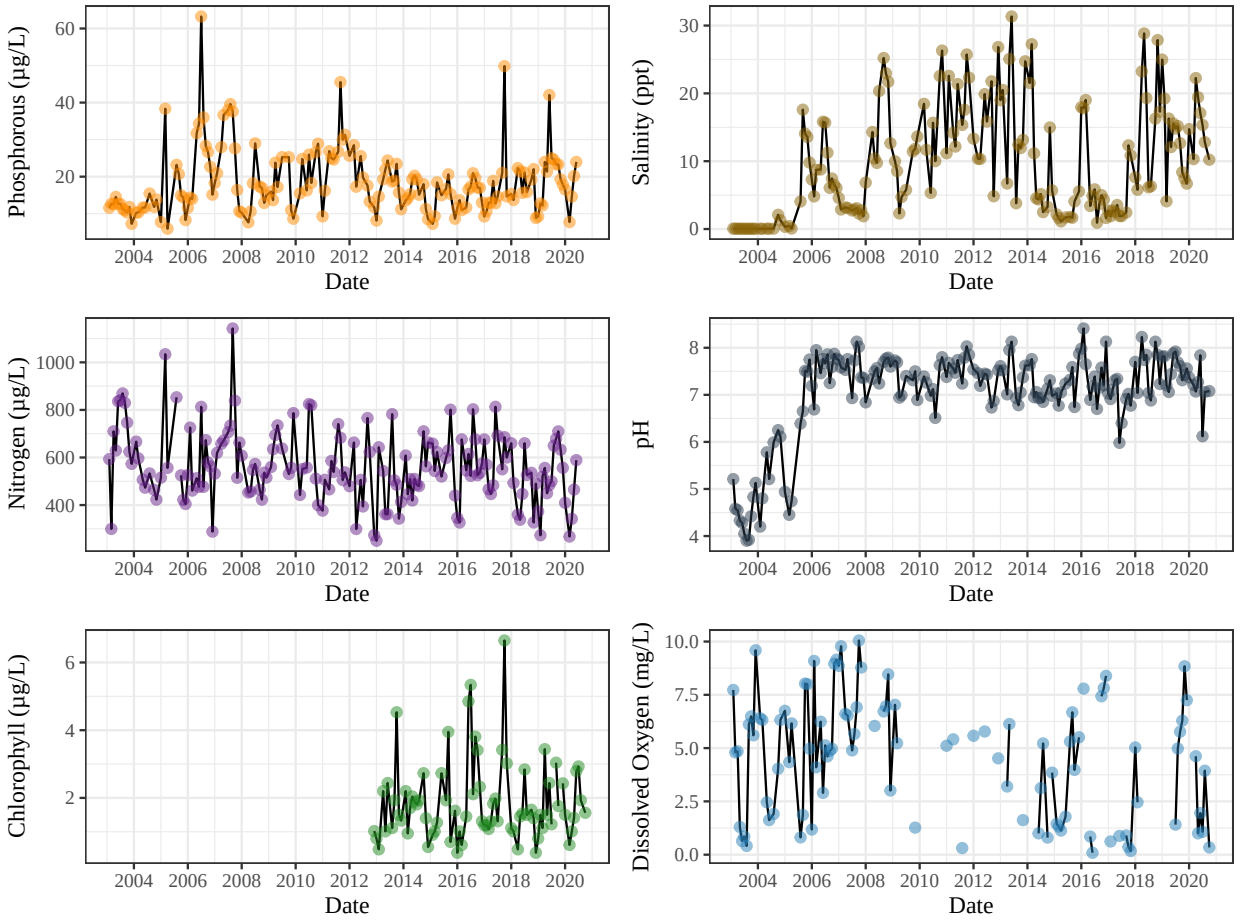

Figure 21: Timeseries of water chemistry variables in Little Red Fish Lake. CBA chlorophyll data were uncorrected for pheophytins until 2013. As a result, only chlorophyll data post-correction (i.e., 2013-present) are reported here.

Table 22: Little Red Fish Long-Term Water Chemistry Table

	Min	Mean	Max	Std Error	10-Year Trend
Dissolved Oxygen (mg/L)	0.09	4.57	10.05	0.19	.
pH	3.9	7.05	8.41	0.07	.
Salinity (ppt)	0.04	9.91	31.34	0.55	.
Phosphorous (µg/L)	5.94	18.61	63.25	0.6	.
Nitrogen (µg/L)	250	563.06	1142.35	10.19	.
Chlorophyll (µg/L)	0.38	1.87	6.65	0.08	.

Morris Lake

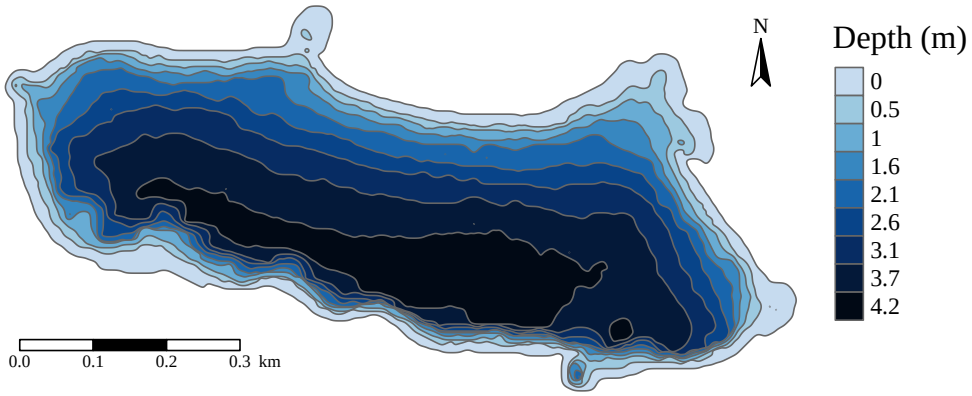

Figure 22: Bathymetry of Morris Lake.

Description

Morris Lake is an irregularly-ellipse shaped system approximately 400 meters from the Gulf of Mexico. The system is among the larger coastal dune lakes, with a surface area of 35 hectares (350,000 m^2) and an approximate volume of 900,000 m^3. The system is one of two lakes laying within Topsail State Park, which offers a degree of protection form the adverse effects of coastal development. While the system does contain an outfall, Morris Lake seldom connects to the gulf. As a result, the system is primarily fresh (0.67 ppt).

Table 23: Morris Lake Water Chemistry

	Min	Mean	Max	Std Error
Temperature(C) surface	14.52	25.77	32.24	2.09
Temperature(C) bottom	14.33	25.12	31.92	2.07
DO (mg/L) surface	5.50	7.83	9.69	0.47
DO (mg/L) bottom	4.57	6.99	9.66	0.55
pH surface	5.06	5.81	6.36	0.13
pH bottom	4.98	5.67	6.08	0.11
Salinity (ppt) surface	0.06	0.07	0.08	0.00
Salinity (ppt) bottom	0.06	0.07	0.07	0.00
Phosphorous (µg/L)	10.00	12.89	16.58	0.87
Nitrogen (µg/L)	355.09	413.45	443.31	11.86
Chlorophyll (µg/L)	2.29	4.71	7.00	0.57
Secchi depth (m)	0.30	0.66	1.01	0.09

Trophic State Index

For summer, 2020, total chlorophyll in Morris Lake averaged 4.71, yielding a TSI classification of 45.8 and indicating that the system is currently mesotrophic. Chlorophyll in this system has been increasing over the last decade, indicating water quality may be deteriorating.

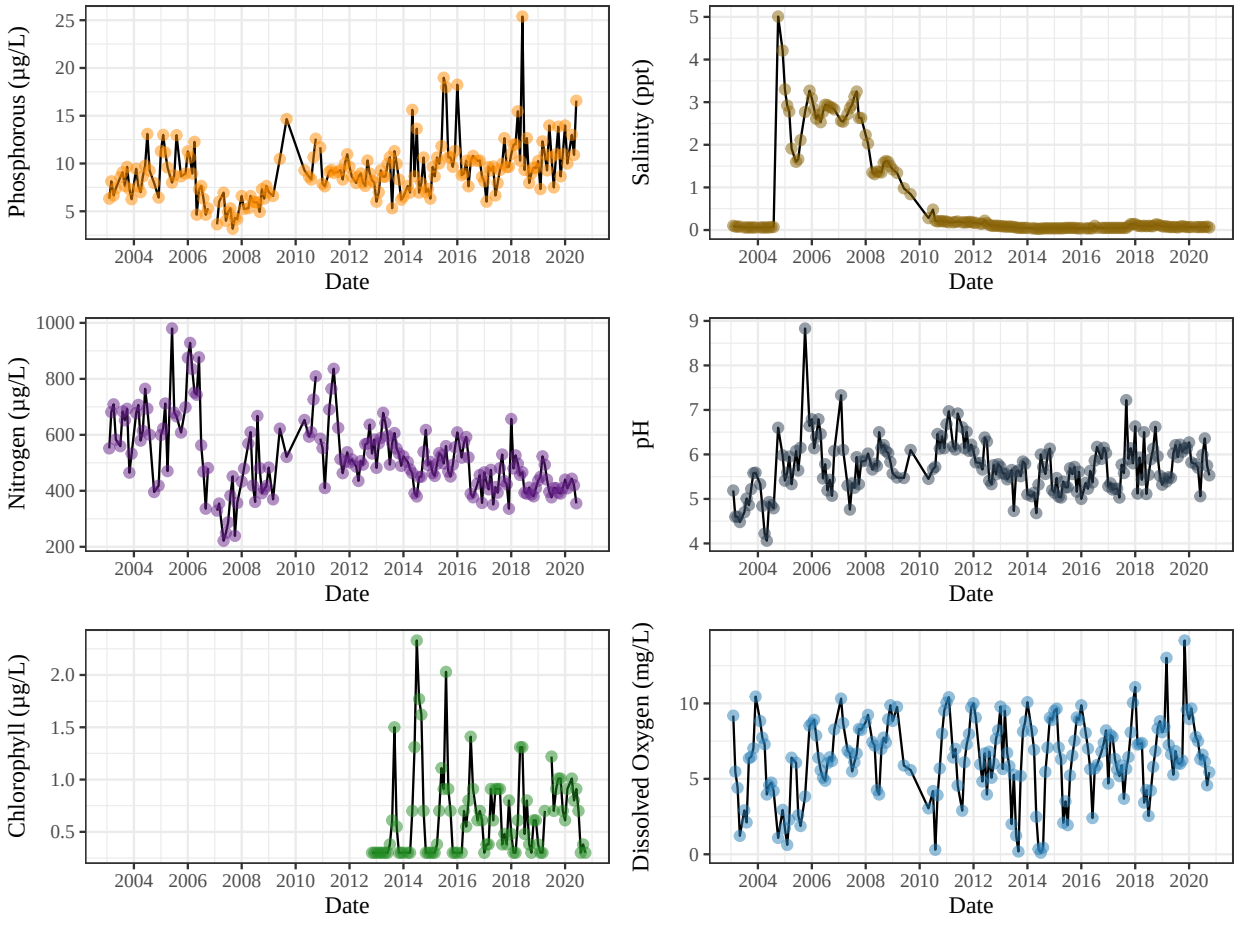

Table 24: Morris Long-Term Water Chemistry Table

	Min	Mean	Max	Std Error	10-Year Trend
Dissolved Oxygen (mg/L)	0.1	6.39	14.17	0.18	.
pH	4.06	5.71	8.83	0.04	.
Salinity (ppt)	0.03	0.67	5.01	0.07	Decreasing
Phosphorous (µg/L)	3.17	9.19	25.39	0.2	Increasing
Nitrogen (µg/L)	221.5	519.7	980	8.96	Decreasing
Chlorophyll (µg/L)	0.3	0.66	2.33	0.03	Increasing

Oyster Lake

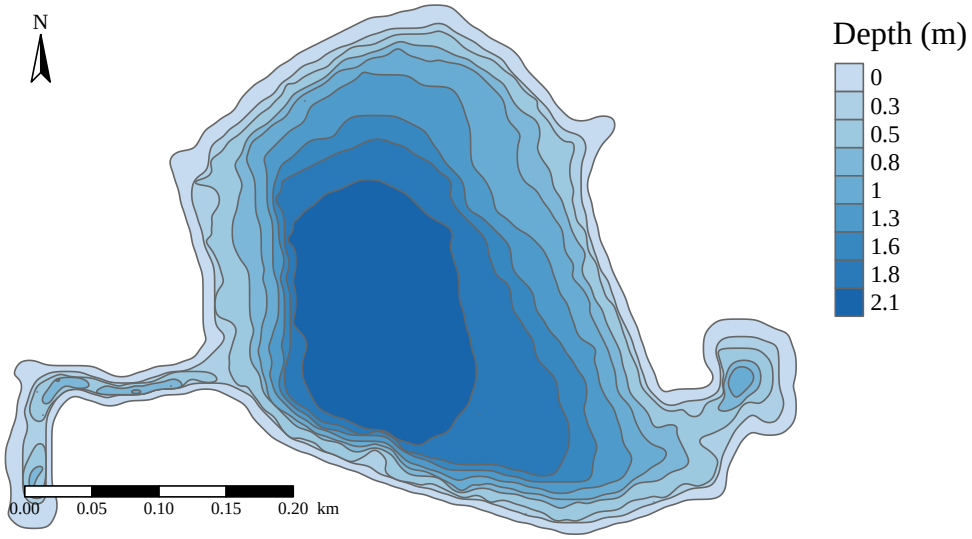

Figure 23: Bathymetry of Oyster Lake.

Description

Oyster Lake is a teardrop-shaped system approximately 200 meters away from the Gulf of Mexico. Oyster Lake is relatively intermediate-sized coastal dune lake with a surface area of 11 hectares (110,000 m^2) and an approximate volume of 140,000 m^3. Despite being separated from the gulf by Highway 30A similar to Allen Lake, Oyster Lake retains connectivity to the gulf through a man-made culvert; allowing the system to intermittently connect and resulting in a mean salinity of (4.43 ppt), or relatively intermediate salinity. Trend analysis of water chemistry variables in Oyster Lake indicate significantly increasing salinity, although this trend began after the connectivity was reestablished between the system and the gulf, and likely reflects the restored hydrology.

Table 25: Oyster Lake Water Chemistry

	Min	Mean	Max	Std Error
Temperature(C) surface	19.18	24.80	32.50	1.61
Temperature(C) bottom	22.60	26.34	31.07	1.11
DO (mg/L) surface	3.79	6.70	8.19	0.51
DO (mg/L) bottom	0.62	3.16	5.44	0.73
pH surface	7.22	7.83	8.67	0.15
pH bottom	6.85	7.45	7.91	0.16
Salinity (ppt) surface	7.66	14.29	16.50	1.10
Salinity (ppt) bottom	15.75	16.95	18.54	0.37
Phosphorous (µg/L)	57.83	76.25	95.35	4.79
Nitrogen (µg/L)	770.38	1066.21	1456.51	87.80
Chlorophyll (µg/L)	7.21	23.98	52.23	4.71
Secchi depth (m)	1.40	4.48	10.00	0.91

Trophic State Index

For summer, 2020, total chlorophyll in Oyster Lake averaged 23.98, yielding a TSI classification of 61.77 and indicating that the system is currently eutrophic, which is a cause for concern. An additional cause for concern is that chlorophyll in this system appears to be increasing over the last decade, indicating water quality is deteriorating. Action in the form of management is recommended.

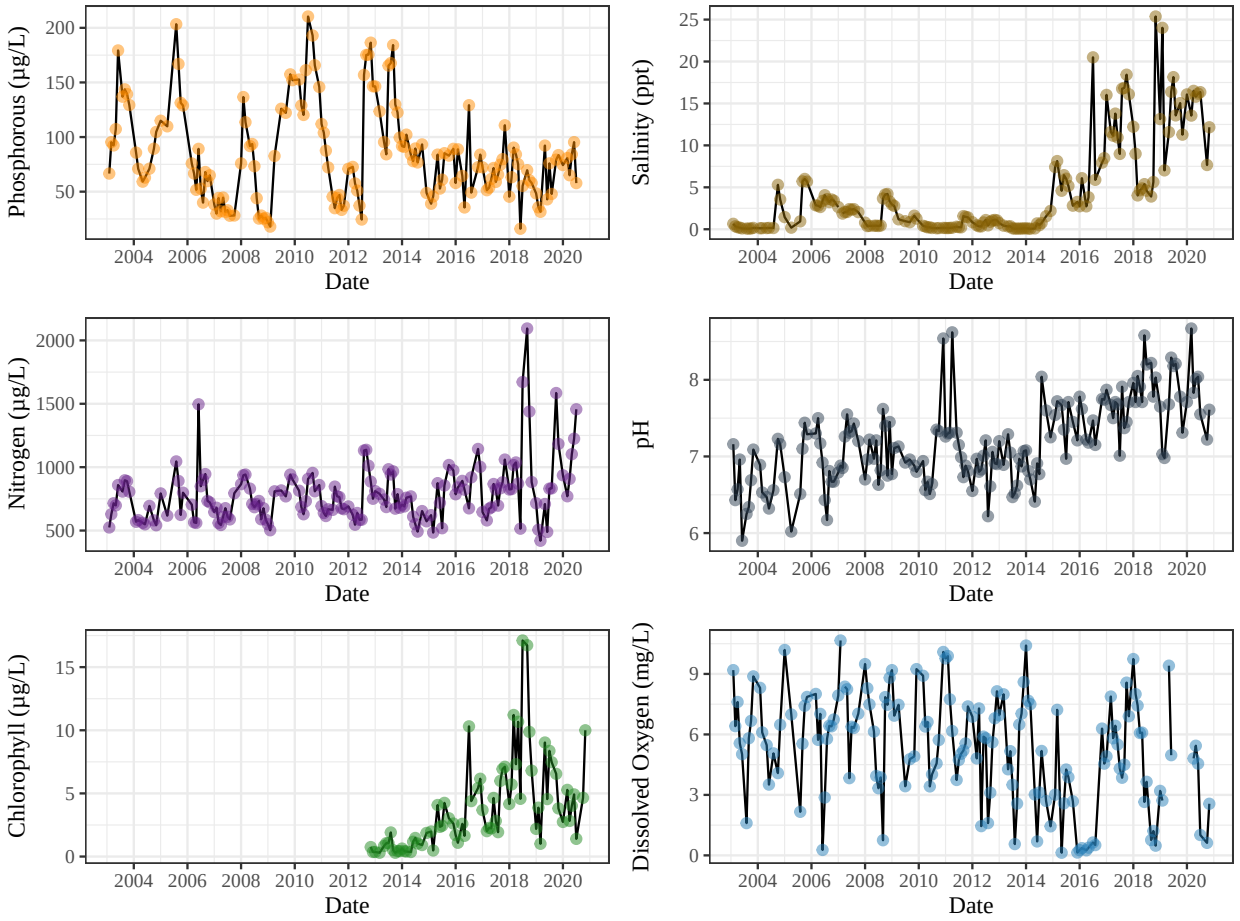

Figure 24: Timeseries of water chemistry variables in Oyster Lake. CBA chlorophyll data were uncorrected for pheophytins until 2013. As a result, only chlorophyll data post-correction (i.e., 2013-present) are reported here.

Table 26: Oyster Long-Term Water Chemistry Table

	Min	Mean	Max	Std Error	10-Year Trend
Dissolved Oxygen (mg/L)	0.13	5.34	10.66	0.18	Decreasing
pH	5.9	7.19	8.67	0.04	Increasing
Salinity (ppt)	0.06	4.43	25.37	0.39	Increasing
Phosphorous (µg/L)	16.04	84.95	210.39	2.98	Decreasing
Nitrogen (µg/L)	419.48	789.64	2093.98	16.03	Increasing
Chlorophyll (µg/L)	0.3	3.89	17.11	0.25	Increasing

Powell Lake

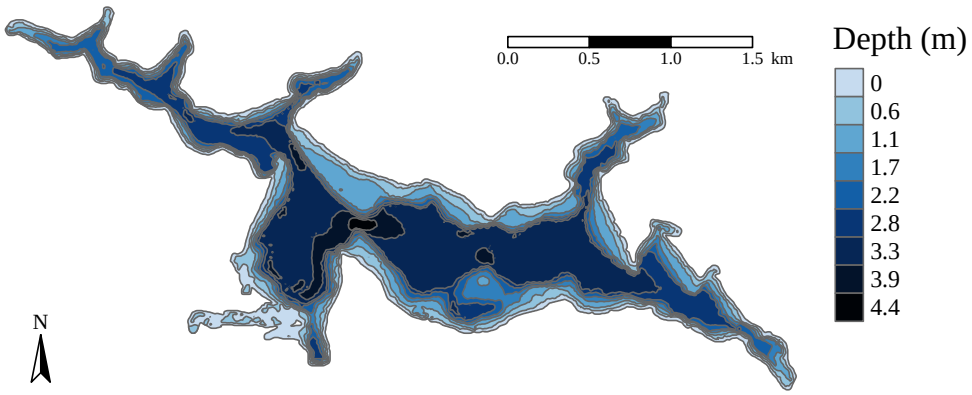

Figure 25: Bathymetry of Powell Lake.

Description

Powell Lake is an irregularly-shaped system approximately 300 meters away from the Gulf of Mexico. Powell Lake is the largest coastal dune lake system, with a surface area of 290 hectares (2,900,000 m^2) and an approximate volume of 6,600,000 m^3. Powell Lake is located along the border of Walton and Bay Counties. As a result, the system is sampled by both CBA in Walton County as well as St. Andrew's Bay Resource Management Association (RMA) in Bay County. Due to the efforts of both CBA and RMA, Powell Lake is consistently sampled at 9 sampling stations, providing a more accurate representation of water chemistry for the system. Powell Lake has an outfall which frequently connects to the gulf. As a result, Powell Lake generally has the highest inter-annual salinity of all the coastal dune lake systems (13.85 ppt).

Table 27: Powell Lake Water Chemistry

	Min	Mean	Max	Std Error
Temperature(C) surface	18.06	23.63	28.37	1.65
Temperature(C) bottom	17.72	22.52	28.52	1.85
DO (mg/L) surface	5.36	6.26	7.52	0.38
DO (mg/L) bottom	1.01	4.38	6.65	0.93
pH surface	6.58	7.02	7.54	0.18
pH bottom	6.73	7.02	7.54	0.14
Salinity (ppt) surface	4.69	7.33	9.45	0.85
Salinity (ppt) bottom	7.57	9.86	12.83	1.19
Phosphorous (µg/L)	8.28	11.35	14.98	1.20
Nitrogen (µg/L)	186.05	334.56	411.91	39.41
Chlorophyll (µg/L)	2.29	3.27	4.16	0.35
Secchi depth (m)	0.38	0.59	0.80	0.07

Trophic State Index

For summer, 2020, total chlorophyll in Powell Lake averaged 3.27, yielding a TSI classification of 42.22 and indicating that the system is currently mesotrophic. Chlorophyll in this system has been stable over the last decade, indicating water quality has not changed.

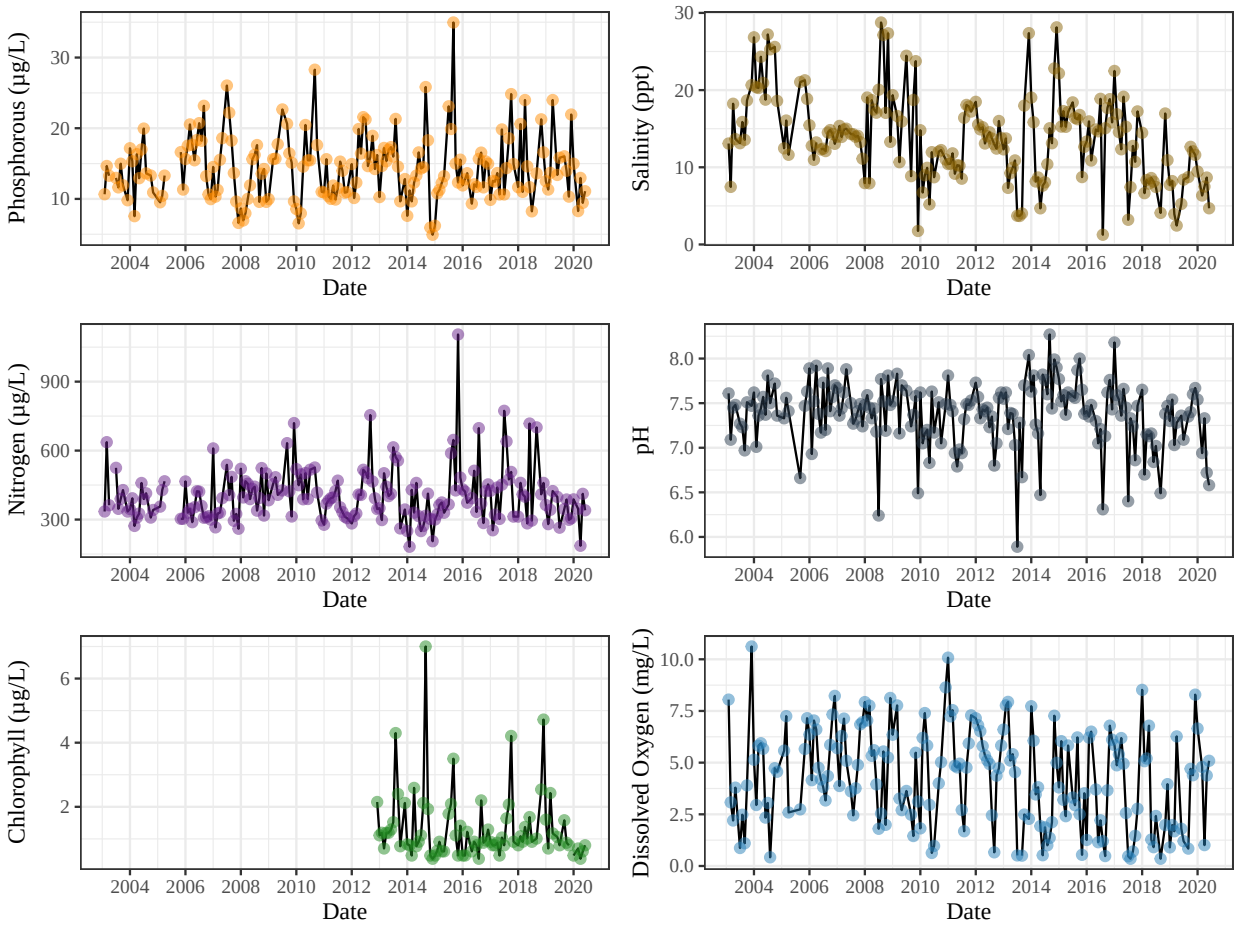

Figure 26: Timeseries of water chemistry variables in Powell Lake. CBA chlorophyll data were uncorrected for pheophytins until 2013. As a result, only chlorophyll data post-correction (i.e., 2013-present) are reported here.

Table 28: Powell Long-Term Water Chemistry Table

	Min	Mean	Max	Std Error	10-Year Trend
Dissolved Oxygen (mg/L)	0.35	4.31	10.62	0.16	Decreasing
pH	5.89	7.37	8.27	0.02	.
Salinity (ppt)	1.26	13.85	28.76	0.38	Decreasing
Phosphorous (µg/L)	4.93	14.35	34.96	0.31	.
Nitrogen (µg/L)	181.71	404.86	1105.06	8.16	.
Chlorophyll (µg/L)	0.38	1.33	7	0.07	.

Stallworth Lake

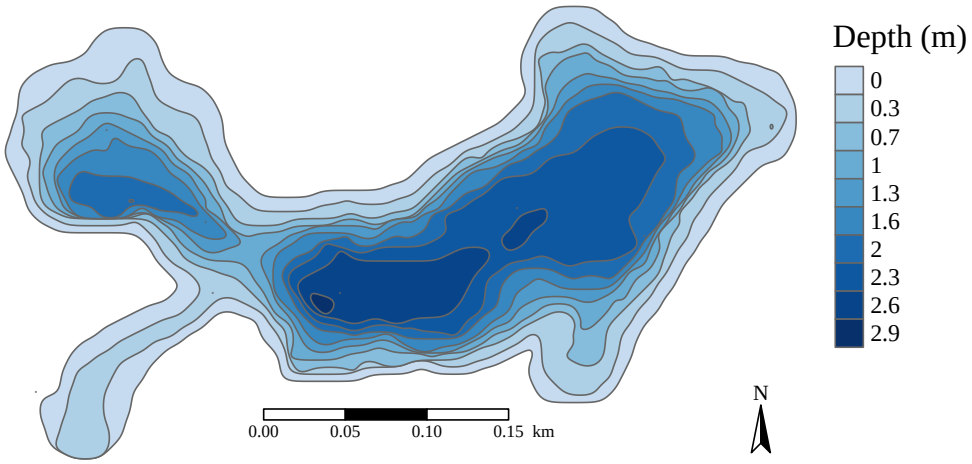

Figure 27: Bathymetry of Stallworth Lake.

Description

Stallworth Lake is an irregularly-shaped system approximately 150 meters from the Gulf of Mexico. Stallworth is among the smallest coastal dune lakes, with a surface area of 5.2 hectares (52,000 m^2) and approximate volume of 81,000 m^3. Stallworth Lake has an outfall which infrequently connects to the gulf. As a result the system is relatively low salinity (2.15 ppt).

Table 29: Stallworth Lake Water Chemistry

	Min	Mean	Max	Std Error
Temperature(C) surface	17.04	25.96	31.44	2.11
Temperature(C) bottom	15.97	25.47	31.02	2.18
DO (mg/L) surface	5.42	6.93	8.97	0.52
DO (mg/L) bottom	2.89	5.28	7.79	0.79
pH surface	5.37	6.04	6.58	0.19
pH bottom	5.23	5.95	6.62	0.22
Salinity (ppt) surface	1.37	2.60	3.62	0.41
Salinity (ppt) bottom	1.36	2.94	5.36	0.61
Phosphorous (µg/L)	13.94	16.97	19.06	0.97
Nitrogen (µg/L)	277.56	381.17	544.01	46.56
Chlorophyll (µg/L)	3.00	4.94	10.38	1.12
Secchi depth (m)	0.43	0.83	1.97	0.24

Trophic State Index

For summer, 2020, total chlorophyll in Stallworth Lake averaged 4.94, yielding a TSI classification of 46.27 and indicating that the system is currently mesotrophic. Chlorophyll in this system has been stable over the last decade, indicating water quality has not changed.

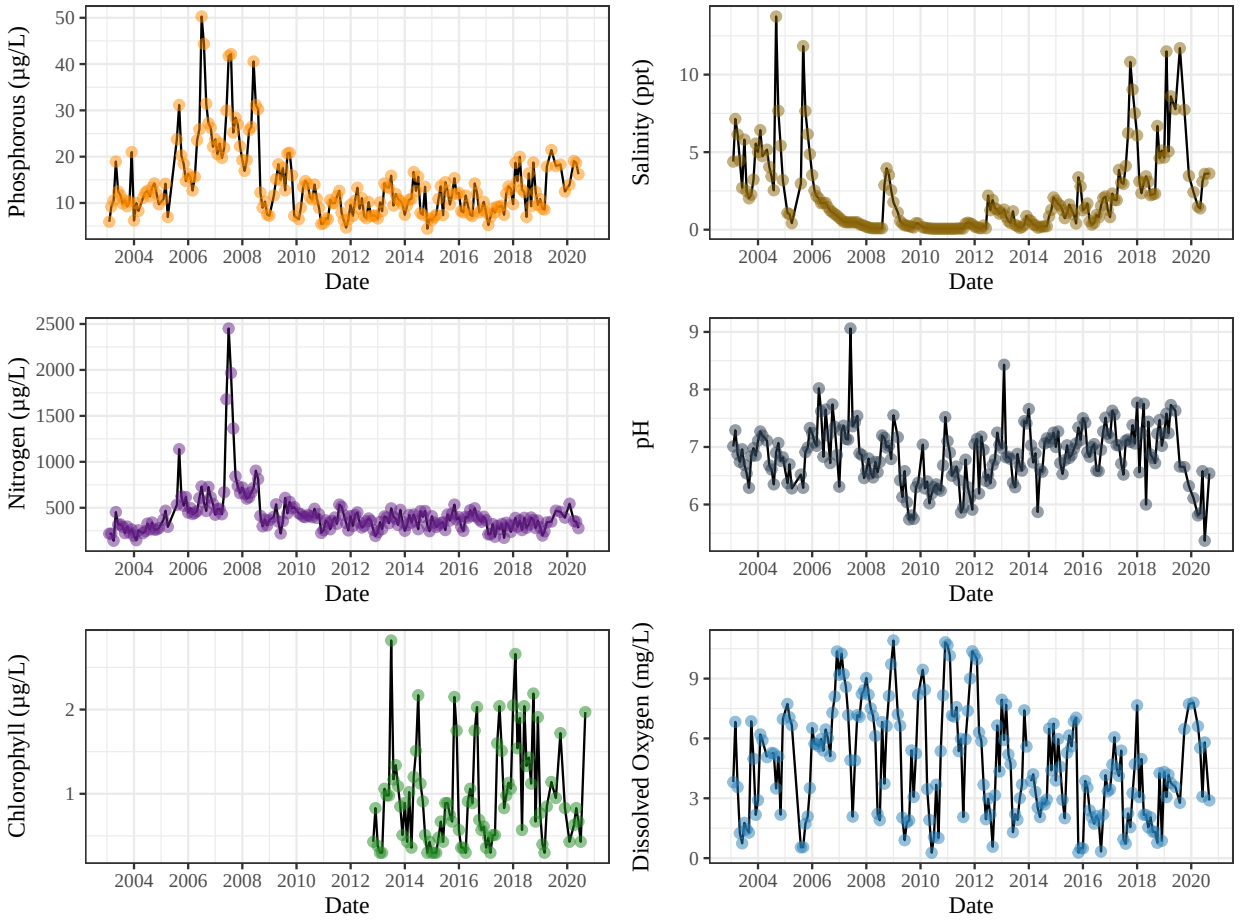

Figure 28: Timeseries of water chemistry variables in Stallworth Lake. CBA chlorophyll data were uncorrected for pheophytins until 2013. As a result, only chlorophyll data post-correction (i.e., 2013-present) are reported here.

Table 30: Stallworth Long-Term Water Chemistry Table

	Min	Mean	Max	Std Error	10-Year Trend
Dissolved Oxygen (mg/L)	0.27	4.73	10.91	0.18	Decreasing
pH	5.37	6.86	9.06	0.03	Increasing
Salinity (ppt)	0.06	2.15	13.75	0.18	Increasing
Phosphorous (µg/L)	4.43	13.89	50.28	0.52	Increasing
Nitrogen (µg/L)	141.03	423.61	2451.11	17.7	.
Chlorophyll (µg/L)	0.3	0.98	2.82	0.04	.

Western Lake

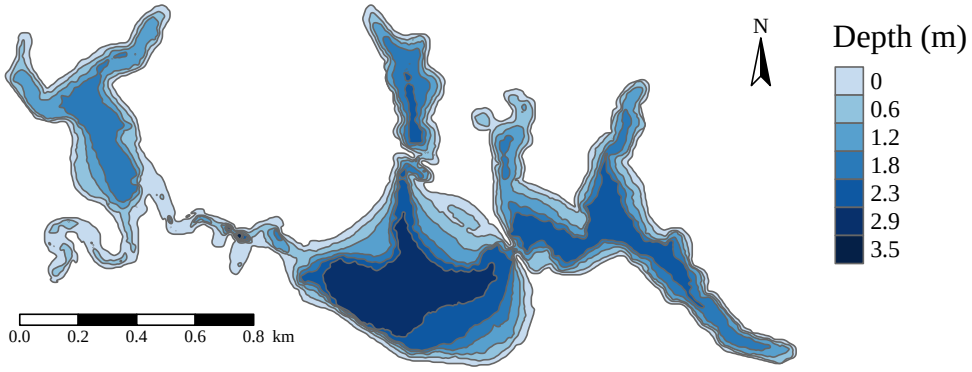

Figure 29: Bathymetry of Western Lake.

Description

The Western Lake system is an irregularly-shaped lake system approximately 300 meters from the Gul of Mexico. The system is the second largest coastal dune lake system, with a total surface area of 98 hectares (980,000 m^2) and an approximate volume of 1,590,000 m^3. The system is divided first by a shallow, narrow channel into western and eastern lobes, and then again by Highway 30A into an eastern and northeastern lobe. Connectivity between the three lobes is maintained by two bridges.

Grayton Lobe

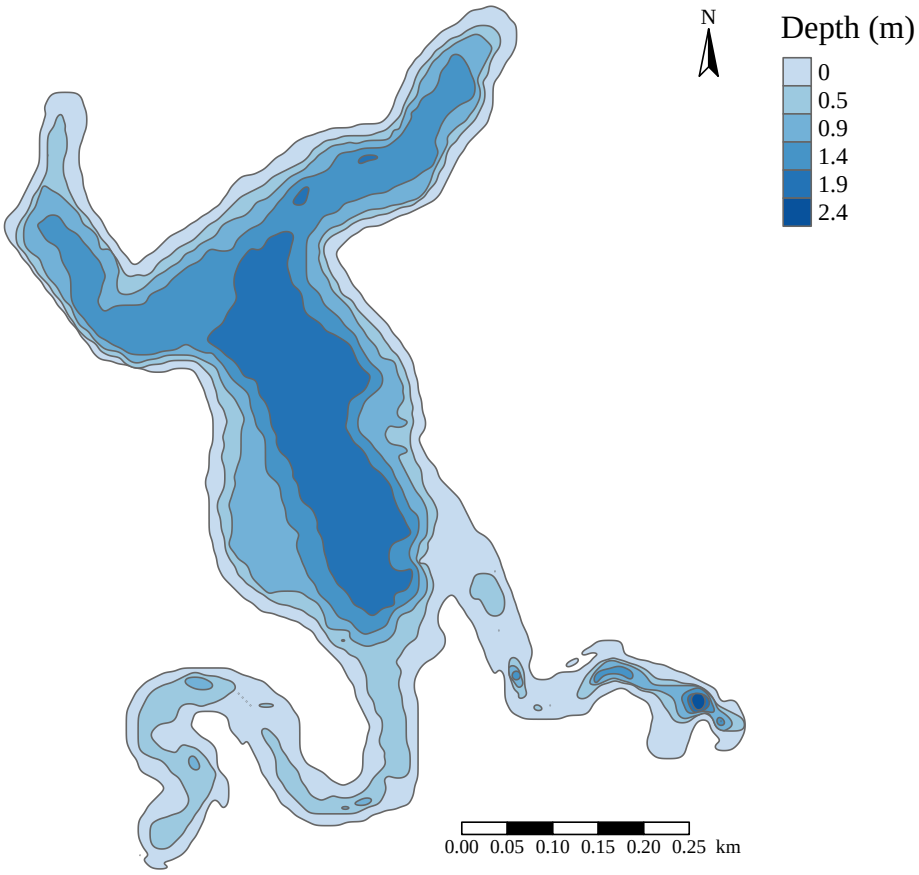

Figure 30: Bathymetry of Grayton Lobe within Western Lake.

Description Grayton Lobe refers to the western lobe of Western Lake. It is an intermediate-sized system with a surface area of 23 hectares (230,000 m^2) and an approximate volume of 330,000 m^3. Grayton Lobe contains an outfall which frequently connects to the gulf. As a result Grayton Lobe is among the most saline coastal dune lake systems (13.15 ppt). However, the long, narrow channel separating Grayton Lobe from the other two lobes in the system acts as a bottleneck for seawater inflows, and as a result Western Bowl lobe and Western Northeast Lobes have markedly different salinity regimes (5.41 and 4.75 ppt, respectively).

Table 31: Grayton Lake Water Chemistry

	Min	Mean	Max	Std Error
Temperature(C) surface	14.10	24.94	30.55	1.64
Temperature(C) bottom	19.05	25.21	30.22	1.26
DO (mg/L) surface	4.68	6.34	8.84	0.43
DO (mg/L) bottom	1.44	3.93	6.86	0.54
pH surface	7.24	7.47	7.81	0.06
pH bottom	6.32	7.41	8.01	0.16
Salinity (ppt) surface	6.53	15.18	29.08	2.68
Salinity (ppt) bottom	12.01	23.87	33.92	2.65
Phosphorous (µg/L)	7.96	11.34	14.30	0.73
Nitrogen (µg/L)	247.71	325.71	366.73	13.48
Chlorophyll (µg/L)	2.29	3.59	7.32	0.55
Secchi depth (m)	0.30	0.60	1.27	0.11

Trophic State Index For summer, 2020, total chlorophyll in Grayton Lobe averaged 3.59, yielding a TSI classification of 43.14 and indicating that the system is currently mesotrophic. Chlorophyll in this system has been stable over the last decade, indicating water quality has not changed.

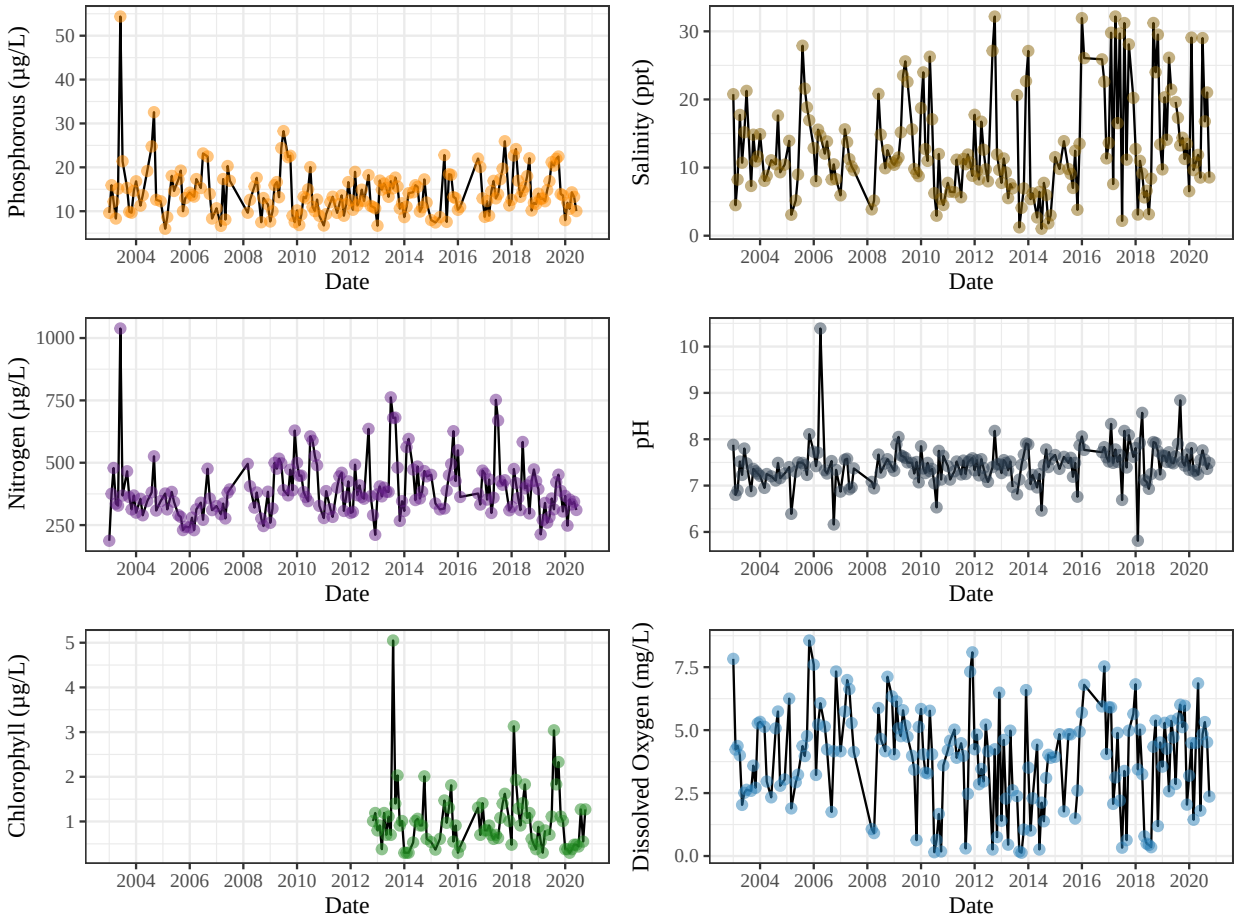

Figure 31: Timeseries of water chemistry variables in Grayton Lobe. CBA chlorophyll data were uncorrected for pheophytins until 2013. As a result, only chlorophyll data post-correction (i.e., 2013-present) are reported here.

Table 32: Grayton Long-Term Water Chemistry Table

	Min	Mean	Max	Std Error	10-Year Trend
Dissolved Oxygen (mg/L)	0.13	3.87	8.56	0.13	.
pH	5.81	7.45	10.39	0.03	Increasing
Salinity (ppt)	1.02	13.15	32.18	0.51	Increasing
Phosphorous (µg/L)	6	14.36	54.38	0.38	Increasing
Nitrogen (µg/L)	187.15	393.17	1038.36	7.88	.
Chlorophyll (µg/L)	0.3	1.02	5.05	0.05	.

Western Bowl Lobe

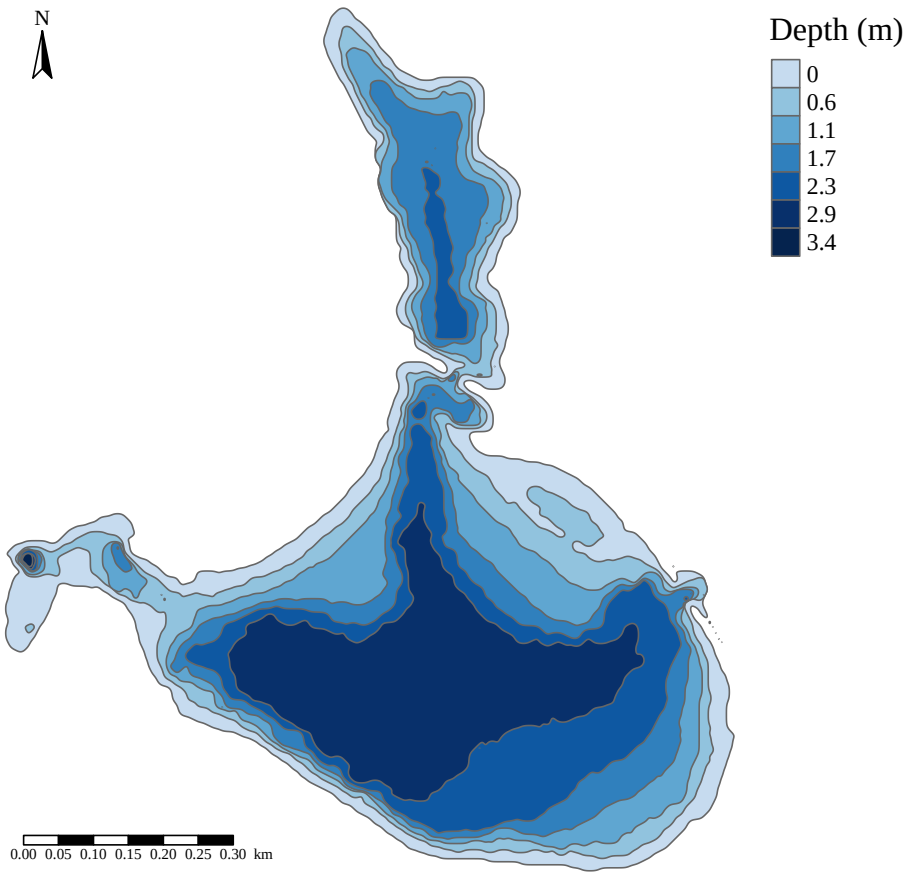

Figure 32: Bathymetry of Western Bowl Lobe within Western Lake.

Description Western Bowl Lobe refers to the central lobe of Western Lake. It is a large system with a surface area of 45 hectares (450,000 m^2) and an approximate volume of 730,000 m^3. Western Bowl Lobe does not have a direct connection to the gulf, but rather has indirect interactions with the gulf through its connection to Grayton Lobe. However, the long, narrow channel separating Grayton and Western Bowl Lobes acts as a bottleneck for seawater inflows, and as a result Western Bowl lobe and Western Northeast Lobes have markedly different salinity regimes from Grayton Lobe (5.41, 4.75, and 13.15 ppt respectively).

Table 33: Western Bowl Lake Water Chemistry

	Min	Mean	Max	Std Error
Temperature(C) surface	10.96	25.05	33.04	2.32
Temperature(C) bottom	18.31	24.83	32.39	1.89
DO (mg/L) surface	2.33	6.55	9.25	0.69
DO (mg/L) bottom	0.33	1.90	3.95	0.42
pH surface	6.98	7.40	7.70	0.10
pH bottom	6.56	7.15	7.50	0.10
Salinity (ppt) surface	4.65	8.11	11.40	0.76
Salinity (ppt) bottom	12.34	17.53	23.72	1.48
Phosphorous (µg/L)	4.93	8.40	11.29	0.94
Nitrogen (µg/L)	131.04	320.99	429.10	37.99
Chlorophyll (µg/L)	2.00	2.92	3.63	0.19
Secchi depth (m)	0.30	0.49	0.91	0.06

Trophic State Index For summer, 2020, total chlorophyll in Western Bowl Lobe averaged 2.92, yielding a TSI classification of 41.11 and indicating that the system is currently mesotrophic. Chlorophyll in this system has been increasing over the last decade, indicating water quality may be deteriorating.

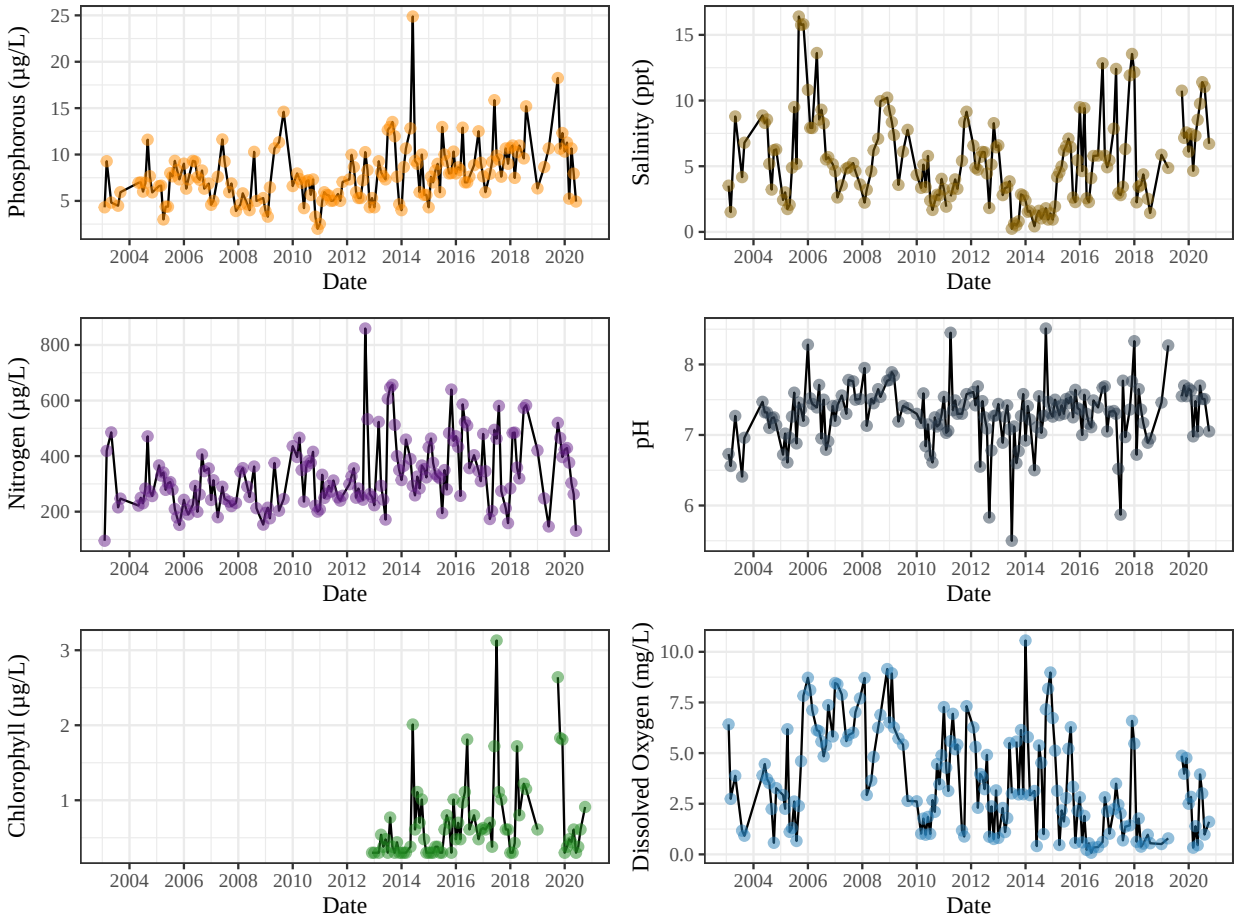

Figure 33: Timeseries of water chemistry variables in Western Bowl Lobe. CBA chlorophyll data were uncorrected for pheophytins until 2013. As a result, only chlorophyll data post-correction (i.e., 2013-present) are reported here.

Table 34: Western Bowl Long-Term Water Chemistry Table

	Min	Mean	Max	Std Error	10-Year Trend
Dissolved Oxygen (mg/L)	0.08	3.68	10.56	0.17	Decreasing
pH	5.5	7.29	8.51	0.03	.
Salinity (ppt)	0.24	5.41	16.4	0.23	Increasing
Phosphorous (µg/L)	2	7.9	24.88	0.21	Increasing
Nitrogen (µg/L)	95.24	332.32	859.49	8.39	Increasing
Chlorophyll (µg/L)	0.3	0.72	3.13	0.04	Increasing

Western Northeast Lobe

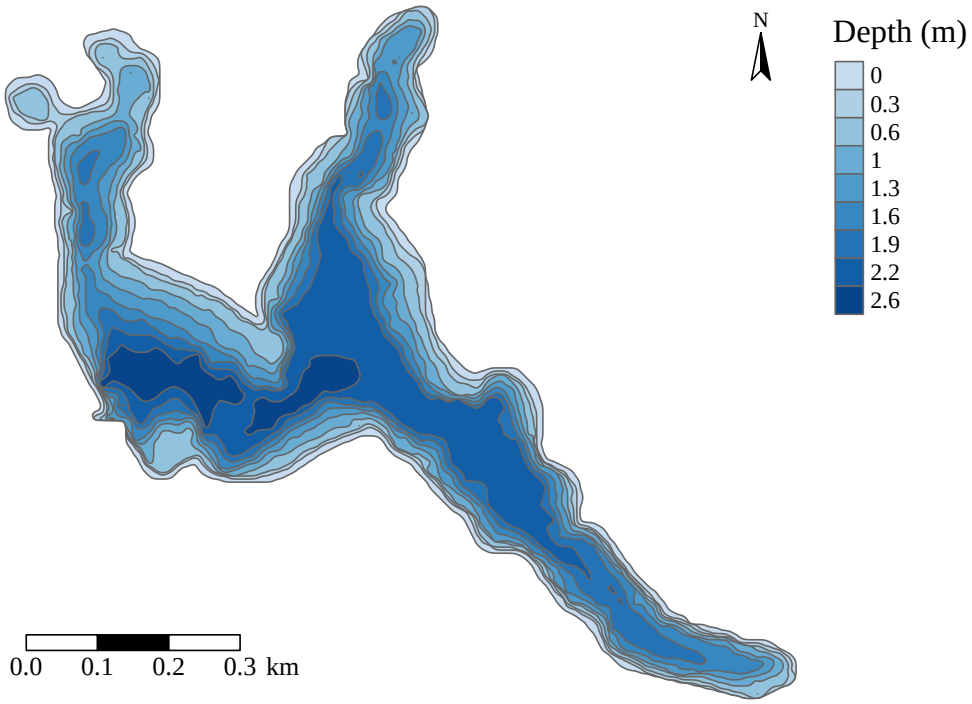

Figure 34: Bathymetry of Western Northeast Lobe within Western Lake.

Description Western Northeast Lobe refers to the northeastern lobe of Western Lake. It is a large system with a surface area of 30 hectares (300,000 m^2) and an approximate volume of 500,000 m^3. Western Northeast Lobe does not have a direct connection to the gulf, but rather has indirect interactions with the gulf through its connection to Grayton Lobe through Western Bowl Lobe. However, the long, narrow channel separating Grayton and Western Bowl Lobes acts as a bottleneck for seawater inflows, and as a result Western Bowl lobe and Western Northeast Lobes have markedly different salinity regimes from Grayton Lobe (4.75, 5.41, and 13.15 ppt respectively).

Table 35: Western Northeast Lake Water Chemistry

	Min	Mean	Max	Std Error
Temperature(C) surface	21.69	27.69	32.09	2.01
Temperature(C) bottom	22.37	27.52	32.22	1.74
DO (mg/L) surface	4.13	5.34	5.88	0.32
DO (mg/L) bottom	1.32	3.09	5.42	0.78
pH surface	6.86	7.26	7.96	0.20
pH bottom	6.76	7.12	7.76	0.18
Salinity (ppt) surface	4.59	7.81	12.07	1.24
Salinity (ppt) bottom	8.69	14.55	20.94	2.07
Phosphorous (µg/L)	7.37	11.65	16.94	2.18
Nitrogen (µg/L)	175.18	243.27	303.30	28.82
Chlorophyll (µg/L)	2.00	3.01	3.63	0.28
Secchi depth (m)	0.38	0.56	1.01	0.12

Trophic State Index For summer, 2020, total chlorophyll in Western Northeast Lobe averaged 3.01, yielding a TSI classification of 41.41 and indicating that the system is currently mesotrophic. Chlorophyll in this system has been increasing over the last decade, indicating water quality may be deteriorating.

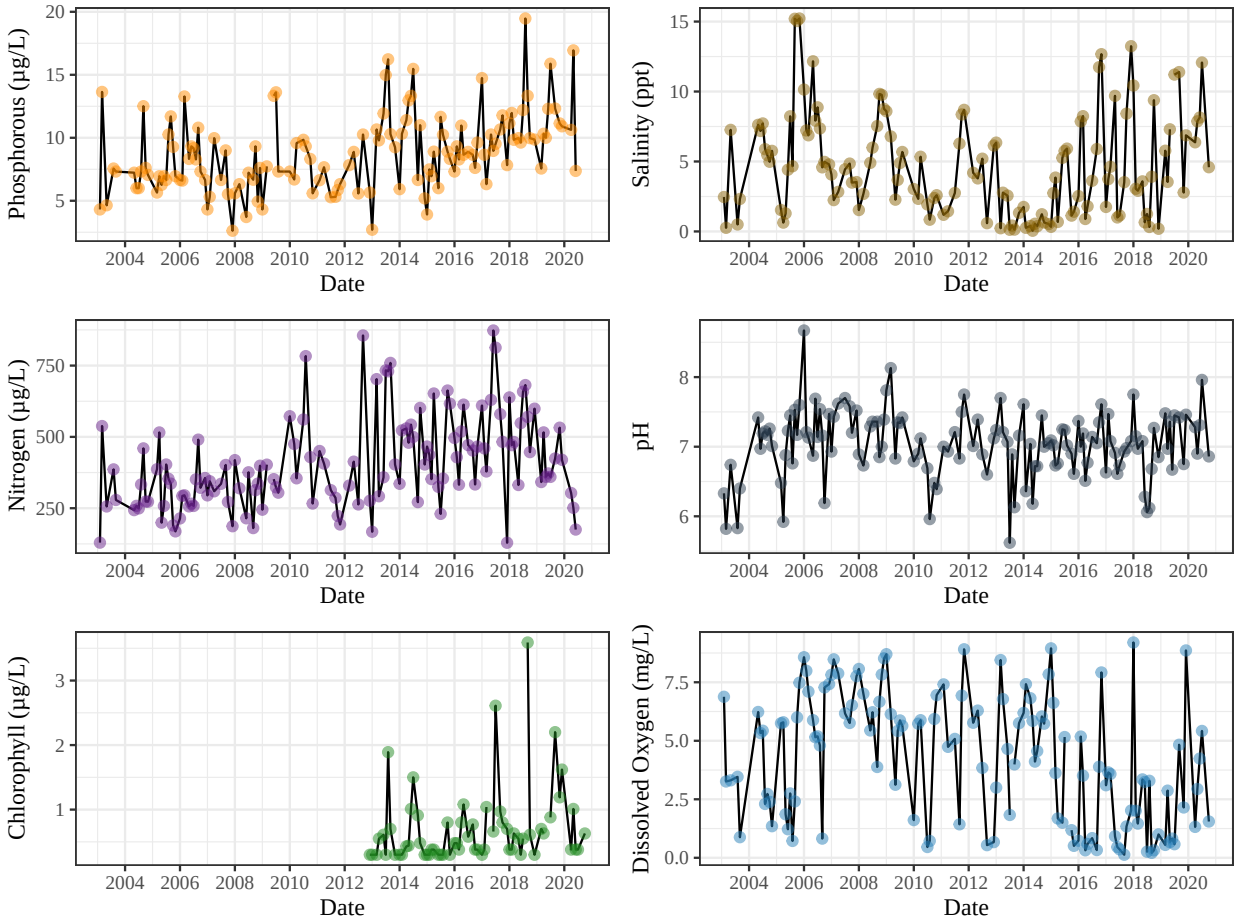

Figure 35: Timeseries of water chemistry variables in Western Northeast Lobe. CBA chlorophyll data were uncorrected for pheophytins until 2013. As a result, only chlorophyll data post-correction (i.e., 2013-present) are reported here.

Table 36: Western Northeast Long-Term Water Chemistry Table

	Min	Mean	Max	Std Error	10-Year Trend
Dissolved Oxygen (mg/L)	0.13	4.25	9.2	0.18	Decreasing
pH	5.62	7.04	8.67	0.03	.
Salinity (ppt)	0.05	4.75	15.22	0.25	Increasing
Phosphorous (µg/L)	2.62	8.82	19.47	0.21	Increasing
Nitrogen (µg/L)	128.91	405.6	873.06	10.79	.
Chlorophyll (µg/L)	0.3	0.69	3.59	0.04	Increasing

Citations

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