WALTON COUNTY COASTAL DUNE LAKES WATER CHEMISTRY SUMMARY 2018

A. C. Hyman [1 2], B. Foley[2], & D. Stephens[1]

[1]Choctawhatchee Basin Alliance

[2]Mattie M. Kelly Environmental Institute

May 31, 2018

Contents

Overview Northwest Florida Coastal Dune Lakes

Lakes, located along coastlines across the globe, are frequently referred to as coastal dune lakes. Coastal dune lakes, however, are rare as they are found only in select areas of the globe, such as Australia, New Zealand, and the pacific northwest of the United States. Northwest Florida is home to numerous coastal dune lakes with the Walton County Dune Lake Advisory Board identifying 15 named coastal dune lakes in Walton County, Florida. Two lakes, Eastern and Western, are split into multiple lobes and sampled separately by CBA due to their complex morphologies. Due to the global scarcity, Northwest Florida's coastal dune lakes have been listed as imperiled by the Florida Natural Areas Inventory.

Northwest Florida coastal dune lakes are located within two miles 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, its waters breach through the sand dunes and flow 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 1986).

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, softwater 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).

Majority 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 µg/L with the 95% range of values being 4 to 39 µg/L. Geometric mean total nitrogen concentration for lakes with TN Zone 3 is 611 µg/L with the 95% range of values being 200 to 1030 µg/L (Bachmann et al. 2012).

Methods of Water Sample and Variable Collection

A combination of physical and chemical variables were collected at each water quality monitoring station. Open water surface samples were collected in the field and analyzed for nutrients, chlorophyll, color and conductivity at University of Florida's Institute of Food and Agricultural Sciences/SFRC Fisheries and Aquatic Sciences LAKEWATCH National Environmental Laboratory Accredited Certified (NELAC) laboratory. Secchi disk vanishing measurements were recorded and submitted to LAKEWATCH laboratory. In addition, multiparameter datasonde equipment collected surface and bottom water chemistry variables.

Water Samples

- One, 250-mL, acid-cleaned, triple-rinsed Nalgene bottle is used to collect a water sample that is analyzed for total phosphorus (µg/L), total nitrogen (µg/L) and analyze color (Pt-Co Units) and conductivity (µS/cm).
- One, 1000-mL, Nalgene bottle is used to collect a water sample for total chlorophyll analysis. Water is filtered through Gelman 47mm Type A-E glass fiber filter.
-

Secchi Disk — measures the attenuation of light within the water column, or transparency, in meters.

Nutrient Concentration Estimation

- **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.

Color

- **True Color—** Measurement of the color of the water after particles have been filtered out (Platinum-Cobalt Units). Based on the Alpha-Hazen color scale.

Conductivity

- **Specific Conductance (µS/cm) —** Measurement of the ability of water to conduct electricity. Values reported in micro-Siemens per centimeter at 25˚ Celsius.

Trophic State Index (TSI)

- The trophic state index is a classification system that is used to estimate the biological productivity of a waterbody based on concentrations of nutrients, chlorophyll and secchi disk.

Multiparameter Datasonde—Hydrolab Quanta multiparameter datasonde unit was used to measure physical and chemical variables including 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, which determine how acidic or basic a waterbody is based on a logarithmic scale.
- ***Salinity (PSS) —*** Measurement of dissolved sodium chloride content in the water. Measurements recorded in Practical Salinity Scale
- ***Turbidity (NTU) —*** Measurement of water clarity within the water column. Turbidity is an optical characteristic of water is measured by the amount of light scattered by material in the water. The higher intensity of scattered light, the higher the turbidity.

Walton County Coastal Dune Lakes Morphometry Table

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.

Morphometry

Catchment Area (hectare) — Area in which all surface water runoff drains to single point.

Surface Area (hectare) — Sum of waterbody face area.

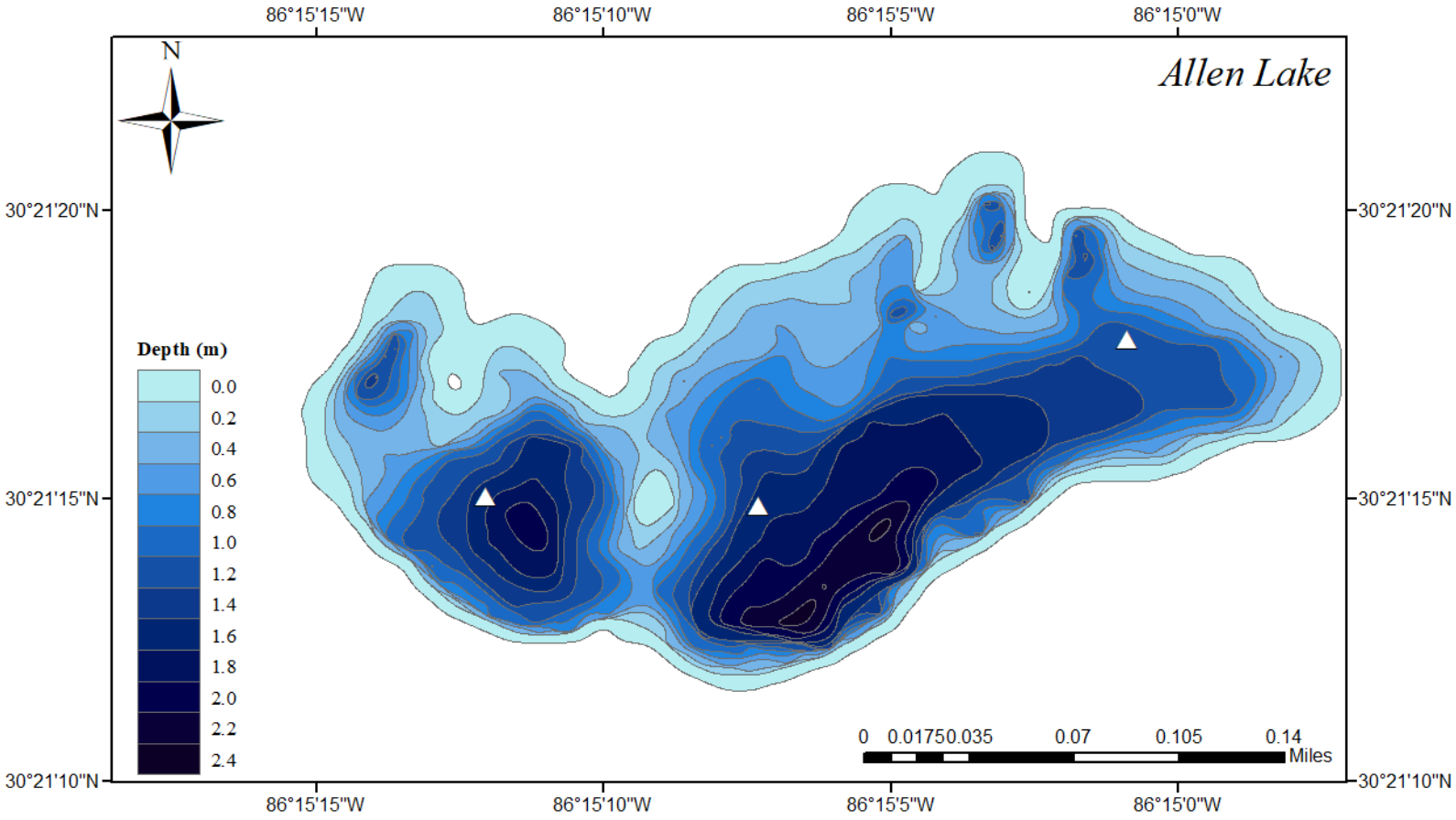
Average Depth (meter) — Mean depth of water column.

Max Depth (meter) — Maximum depth of waterbody.

Volume (cubic meter) —Measurement of the amount of space occupied by waterbody.

Lake	Catchment Area	Surface Area (ha)	Average depth (m)	Max depth (m)	Volume (m^3)	Perimeter (km)	Stations
Allen Lake	71	7.57	1.28	2.53	71000	1.8	3
Alligator Lake	38	5.45	0.94	2.33	42000	2.4	3
Big Red Fish Lake	119	12.40	1.12	1.81	130000	2.7	3
Camp Creek Lake	213	25.58	1.39	2.07	310000	5.1	3
Campbell Lake	NA	44.5	3.14	4.93	1300000	3.8	3
Deer Lake	127	16.9	1.49	2.43	180000	2.7	3
Draper Lake	193	16.32	1.79	3.01	280000	3.6	3
Eastern South Lobe (Eastern Lake)	43	20.56	1.77	2.88	360000	3.3	3
Eastern North Lobe (Eastern Lake)	154	8.50	1.77	2.88	150000	1.7	3
Fuller Lake	43	20.76	1.74	2.84	300000	2.2	3
Grayton Lobe (Western Lake)	275	22.93	1.42	4.45	33000	4.9	3
Little Red Fish Lake	NA	5.02	0.9	1.93	48000	1.4	3
Morris Lake	87	34.67	2.8	4.68	900000	3.1	3
Oyster Lake	56	10.56	1.38	2.16	140000	1.5	3
Powell Lake	730	287.13	2.54	4.98	6600000	21	9
Stalworth Lake	86	5.97	1.44	2.95	81000	1.6	4
Western Bowl Lobe (Western Lake)	275	45.91	1.58	4.78	73000	4.5	3
Western Northeast Lobe (Western Lake)	275	30.00	1.67	2.47	50000	4.4	3

Allen Lake, Walton County



Lake Description

Allen Lake is a primarily isolated, freshwater (0.08 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. Long-term water chemistry monitoring for Allen Lake occurs at three stations denoted as white triangles on the map above. 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.

Allen Lake Water Chemistry Data- 2018

Summary statistics include mean, maximum (Max), minimum (Min), median, and standard error (Std Error) calculated for both surface and bottom measurements for temperature, dissolved oxygen (DO), pH, and salinity, as well as surface measurements total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), secchi depth, as well as. These statistics represent 2018 water chemistry data.

2018 Summary Statistics

	min	mean	max	Std Error
Temperature surface	11.91	22.16	29.91	2.07
Temperature bottom	11.43	21.15	28.64	1.9
DO (mg/L) surface	6.18	7.55	9.92	0.36
DO (mg/L) bottom	2.93	6.24	9.79	0.61
pH surface	3.93	5.7	6.85	0.2
pH bottom	3.5	5.41	6.58	0.22
Salinity (ppt) surface	0.04	0.05	0.05	0
Salinity (ppt) bottom	0.04	0.05	0.05	0
TP (µg/L)	6.84	12.28	16.92	0.89
TN (µg/L)	390.58	536.11	669.36	21.4
CHL (µg/L)	2	3.03	4	0.2

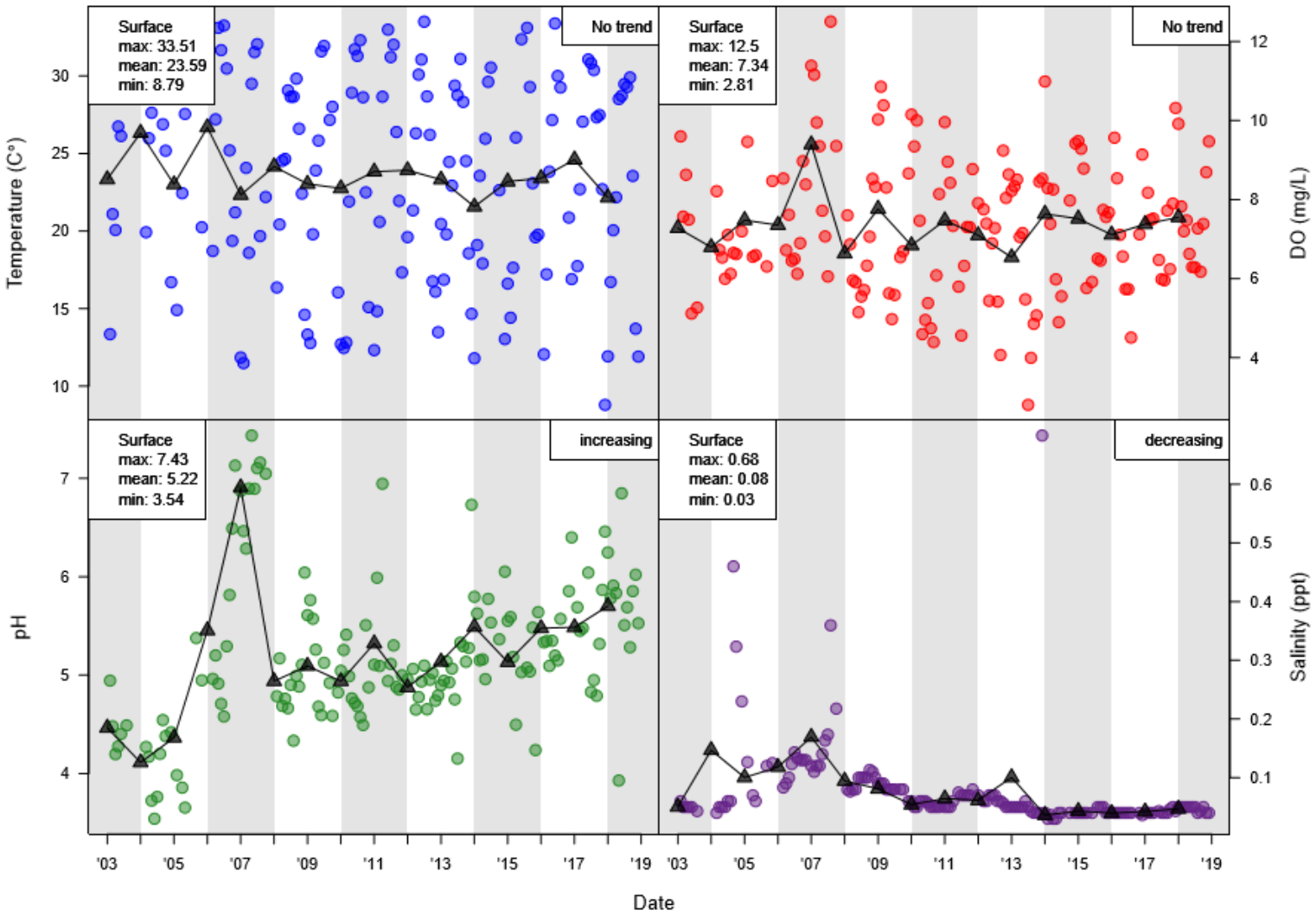
Allen Lake Water Chemistry Data- 2003 through 2018

Summary statistics include mean, maximum (max), and minimum (min) summary statistics calculated on an annual basis using monthly data for hydrolab data variables; temperature, dissolved oxygen (DO), pH, and salinity as well as nutrient data variables total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), and secchi depth,. Summary statistics and trends represent results from long-term analyses among annual means from 2003 through 2018.

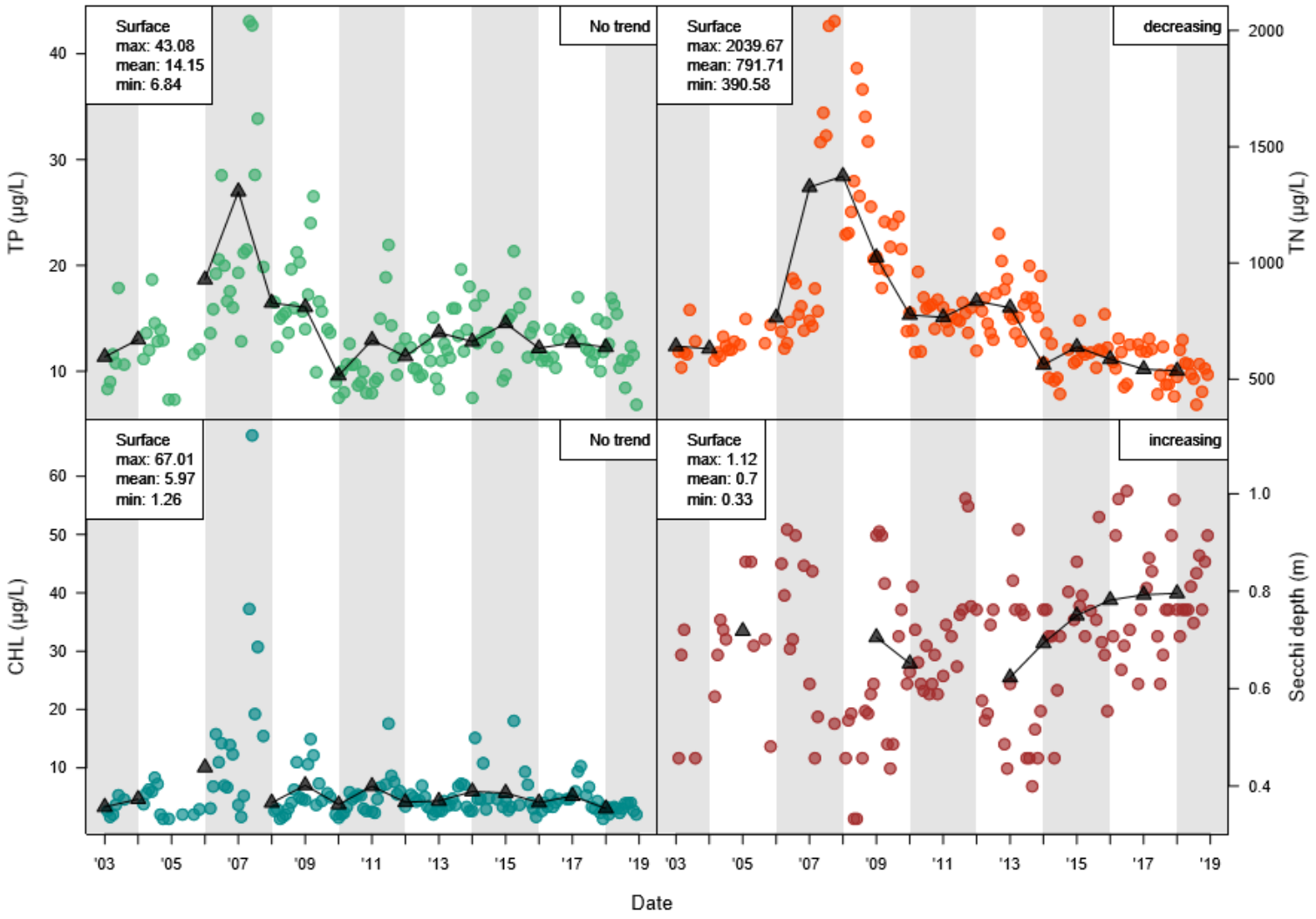
Times series plots display the inter-annual (monthly variability within the year - circles) and intra-annual variance (variability among years - triangles). Columns delineate three year time intervals.

Kendall-Tau trend analysis results are shown for each water chemistry variable on the surface-left of each plot. *No trend* indicates there was no significant trend found among the years examined (2003 through 2018). *Increasing* indicates a significant, positive trend was found over time. *Decreasing* indicates a significant, negative trend was found among the years examined. *Insufficient data* indicates insufficient annual data (year averages) were available for trend analysis.

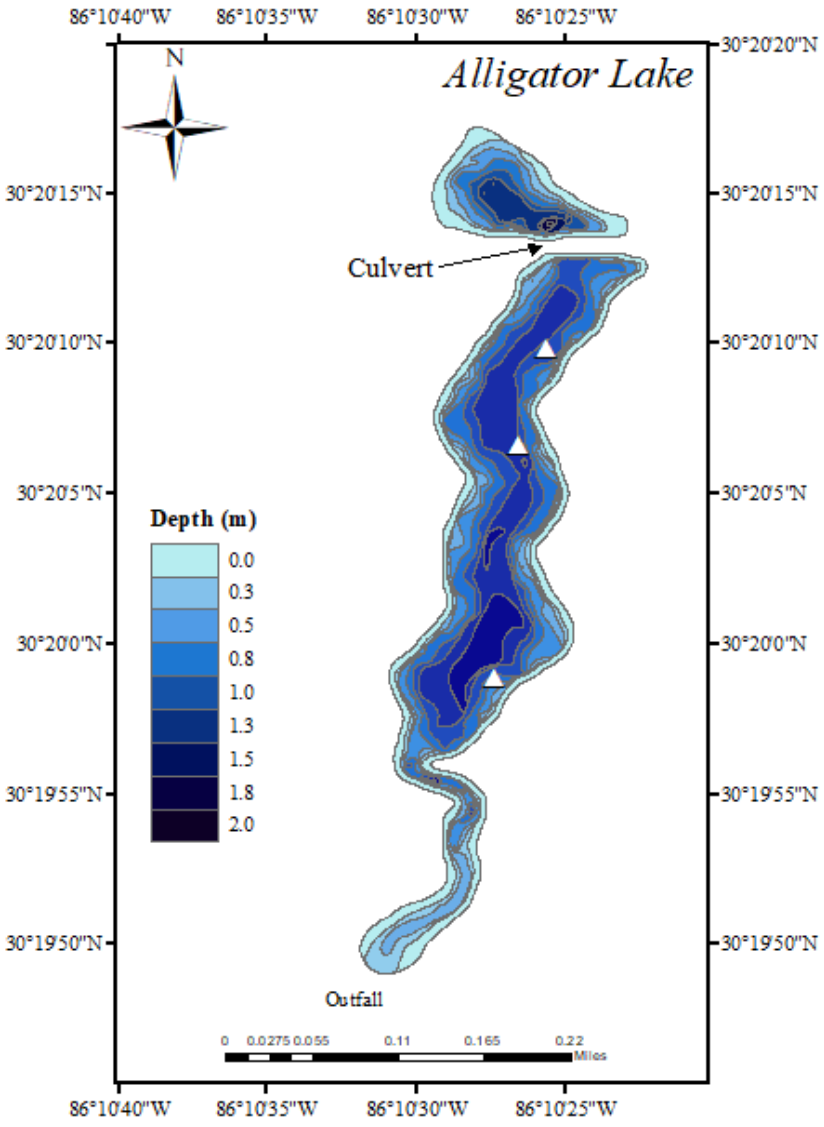
Hydrolab Trend Analyses



Nutrient Trend Analyses



Alligator Lake, Walton County



Lake Description

Alligator Lake is a long, narrow system of intermediate salinity (3.3 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. Long-term water chemistry monitoring for Alligator Lake occurs at three stations denoted as white triangles on the map above. Alligator Lake possesses an outfall which intermittently connects to the Gulf, enabling substantial fluctuations in water chemistry values. Although no significant trends in water chemistry were found within the 15 year timeframe analyzed, a potentially concerning trend of increasing salinity since 2014 is evident from hydrolab time series plots.

Alligator Lake Water Chemistry Data- 2018

Summary statistics include mean, maximum (Max), minimum (Min), median, and standard error (Std Error) calculated for both surface and bottom measurements for temperature, dissolved oxygen (DO), pH, and salinity, as well as surface measurements total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), secchi depth, as well as. These statistics represent 2018 water chemistry data.

2018 Summary Statistics

	min	mean	max	Std Error
Temperature surface	12.92	22.19	31.24	2.22
Temperature bottom	15.42	22.5	31.07	2
DO (mg/L) surface	2.41	5.85	9.55	0.75
DO (mg/L) bottom	0.65	2.99	6.54	0.71
pH surface	5.98	6.9	7.53	0.19
pH bottom	6.45	7.01	7.67	0.15
Salinity (ppt) surface	2.16	11.3	24.89	3.3
Salinity (ppt) bottom	14.86	20.89	28.43	1.41
TP (µg/L)	7.61	13.37	17.86	1.17
TN (µg/L)	165.83	442.94	645.6	50.16
CHL (µg/L)	1.26	5.64	9.59	1.2

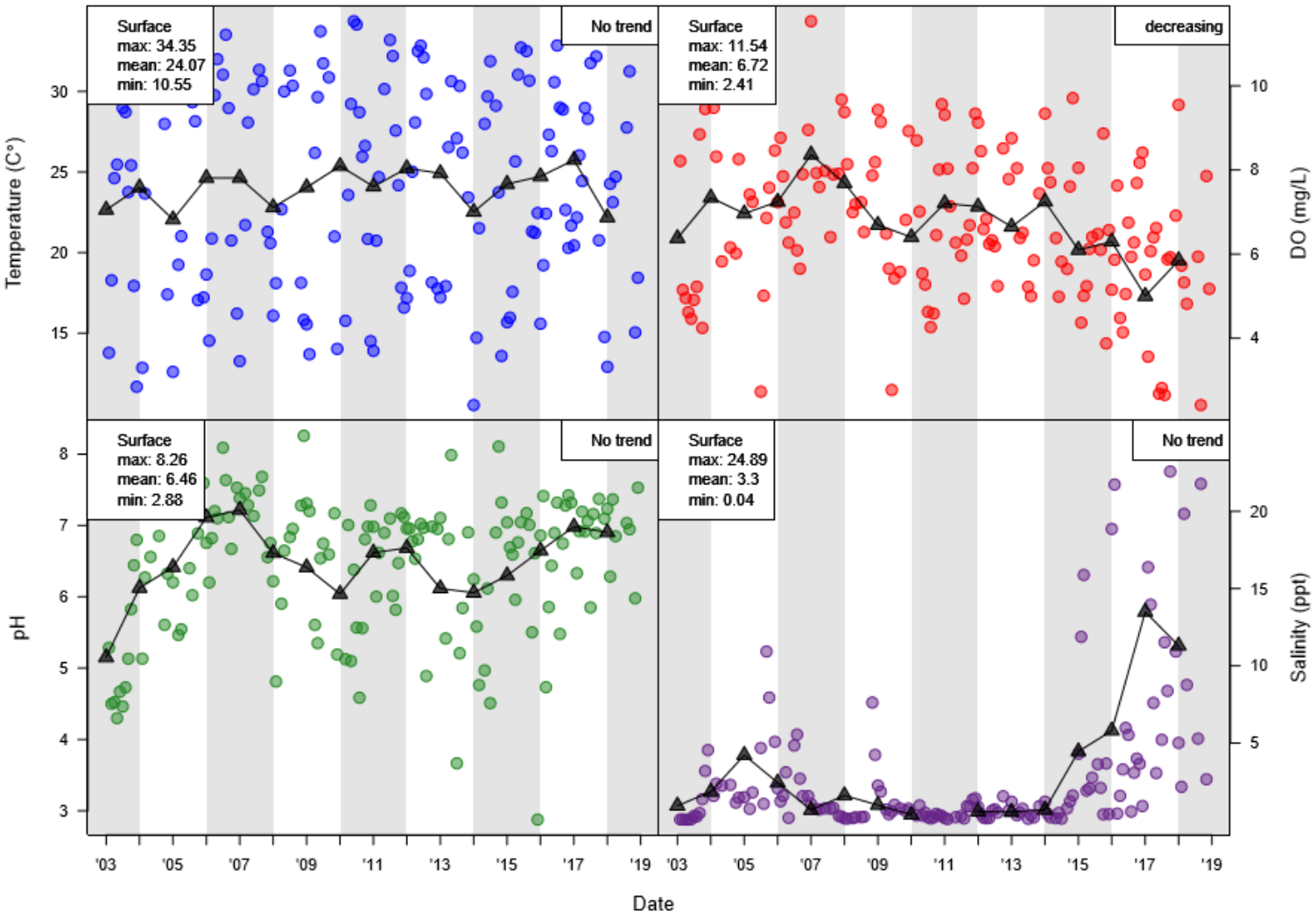
Alligator Lake Water Chemistry Data- 2003 through 2018

Summary statistics include mean, maximum (max), and minimum (min) summary statistics calculated on an annual basis using monthly data for hydrolab data variables; temperature, dissolved oxygen (DO), pH, and salinity as well as nutrient data variables total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), and secchi depth,. Summary statistics and trends represent results from long-term analyses among annual means from 2003 through 2018.

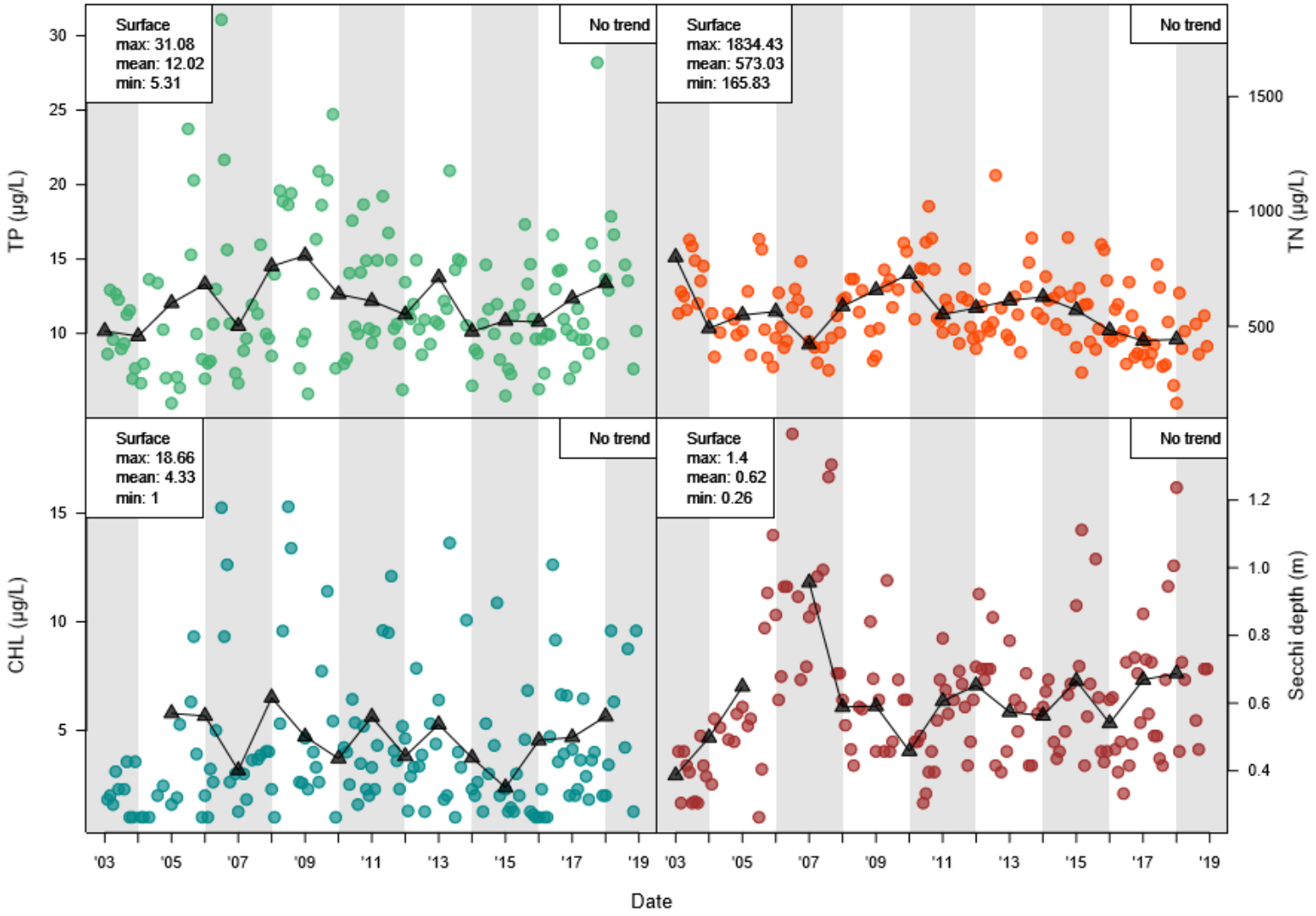
Times series plots display the inter-annual (monthly variability within the year - circles) and intra-annual variance (variability among years - triangles). Columns denote three year time intervals.

Kendall-Tau trend analysis results are shown for each water chemistry variable on the surface-left of each plot. *No trend* indicates there was no significant trend found among the years examined (2003 through 2018). *Increasing* indicates a significant, positive trend was found over time. *Decreasing* indicates a significant, negative trend was found among the years examined. *Insufficient data* indicates insufficient annual data (year averages) were available for trend analysis.

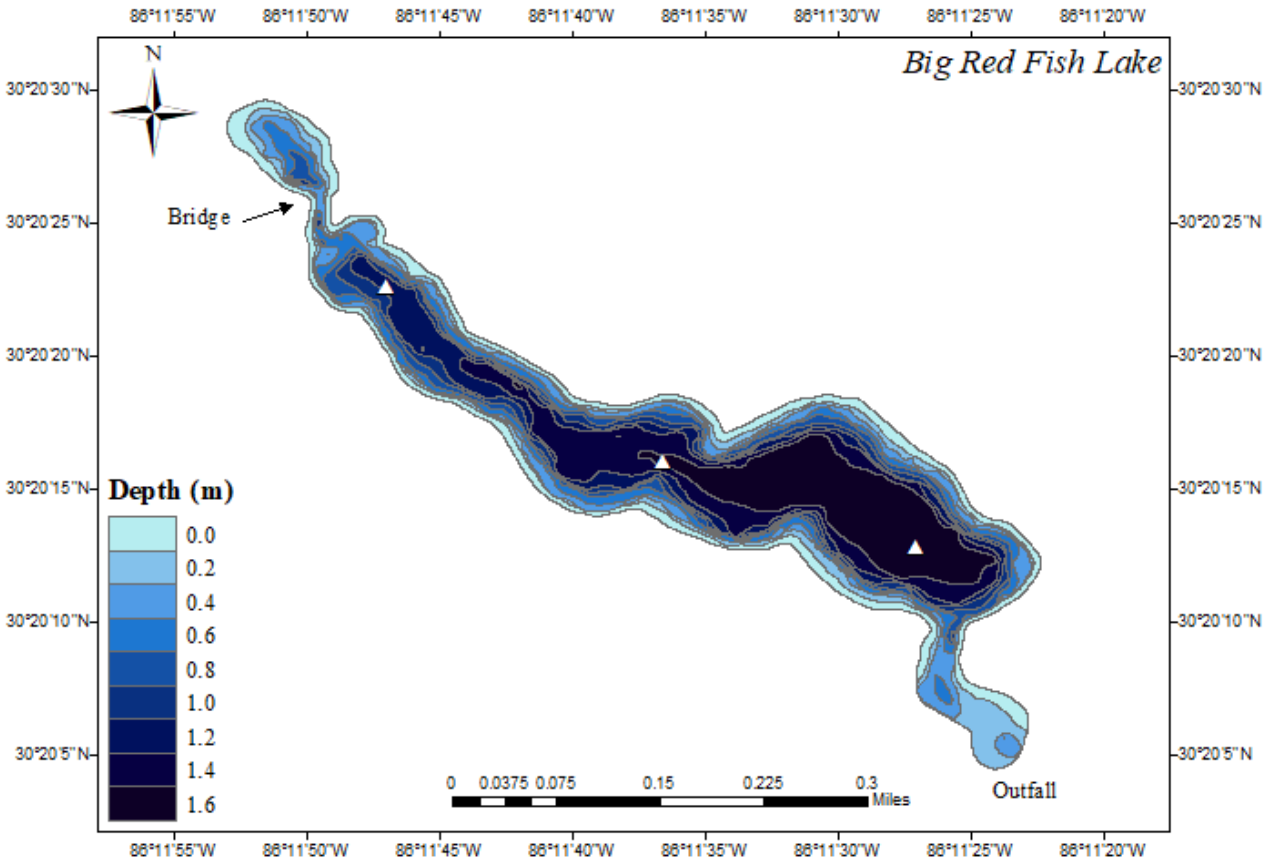
Hydrolab Trend Analyses



Nutrient Trend Analyses



Big Red Fish Lake, Walton County



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. Long-term water chemistry monitoring for Big Red Fish Lake occurs at three stations denoted as white triangles on the map above. The system contains an outfall which regularly connects to the gulf. As a result, Big Red Fish Lake is one of the more brackish systems (8.7 ppt).

Big Red Fish Lake Water Chemistry Data- 2018

Summary statistics include mean, maximum (Max), minimum (Min), median, and standard error (Std Error) calculated for both surface and bottom measurements for temperature, dissolved oxygen (DO), pH, and salinity, as well as surface measurements total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), secchi depth, as well as. These statistics represent 2018 water chemistry data.

2018 Summary Statistics

	min	mean	max	Std Error
Temperature surface	14.52	24.29	31.76	2.03
Temperature bottom	15.27	25.17	31.56	1.64
DO (mg/L) surface	3.51	6	9.25	0.56
DO (mg/L) bottom	0.44	3.08	5.8	0.53
pH surface	6.42	7.15	7.78	0.13
pH bottom	6.29	7.13	7.76	0.13
Salinity (ppt) surface	4.22	10.84	25.53	1.99
Salinity (ppt) bottom	5.53	18.01	33.49	2.4
TP (µg/L)	8.43	16.74	32.87	2.04
TN (µg/L)	203.28	433.22	687.71	38.32
CHL (µg/L)	1.82	6.57	16.96	1.36

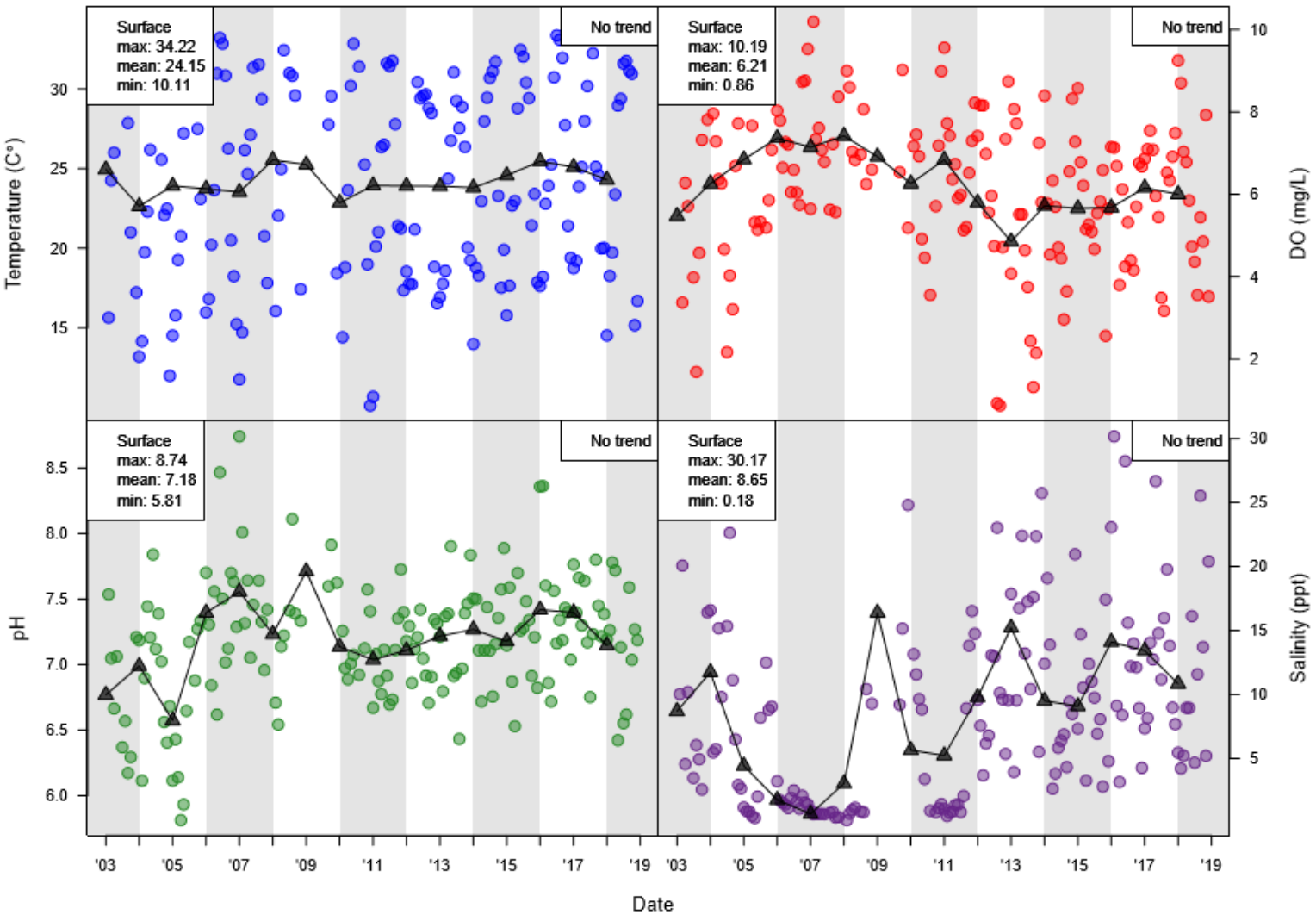
Big Red Fish Lake Water Chemistry Data- 2003 through 2018

Summary statistics include mean, maximum (max), and minimum (min) summary statistics calculated on an annual basis using monthly data for hydrolab data variables; temperature, dissolved oxygen (DO), pH, and salinity as well as nutrient data variables total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), and secchi depth,. Summary statistics and trends represent results from long-term analyses among annual means from 2003 through 2018.

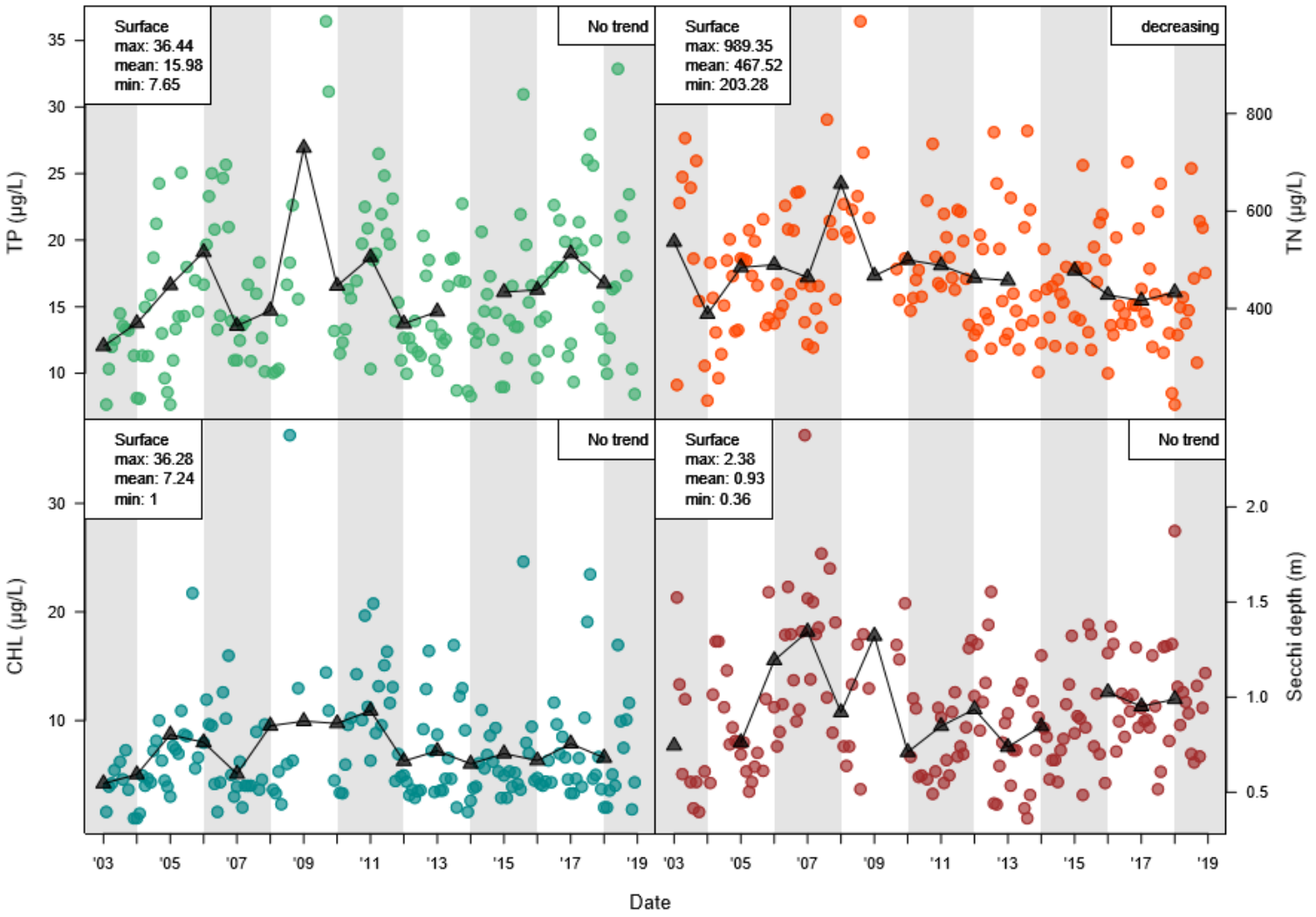
Times series plots display the inter-annual (monthly variability within the year - circles) and intra-annual variance (variability among years - triangles). Columns denote three year time intervals.

Kendall-Tau trend analysis results are shown for each water chemistry variable on the surface-left of each plot. *No trend* indicates there was no significant trend found among the years examined (2003 through 2018). *Increasing* indicates a significant, positive trend was found over time. *Decreasing* indicates a significant, negative trend was found among the years examined. *Insufficient data* indicates insufficient annual data (year averages) were available for trend analysis.

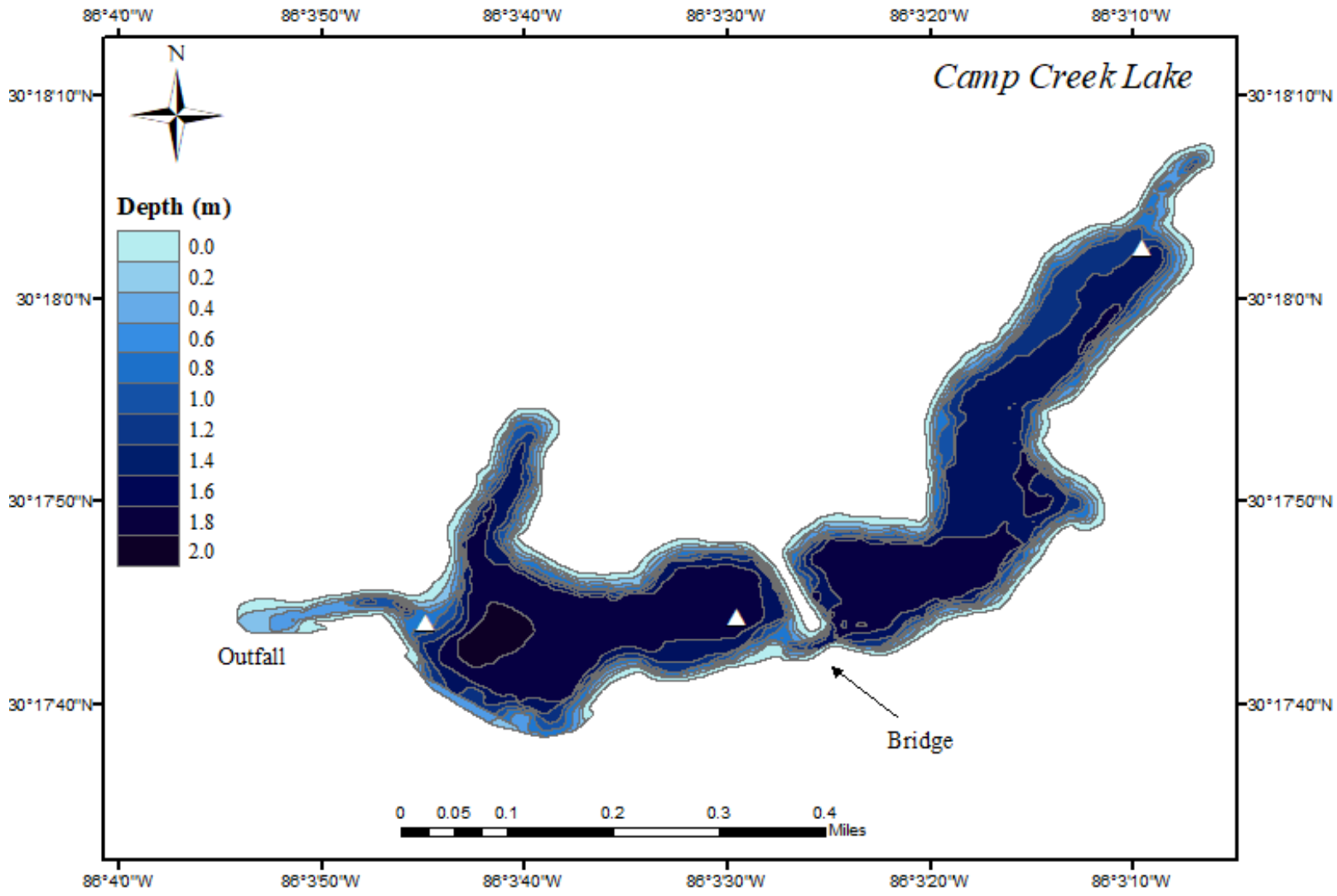
Hydrolab Trend Analyses



Nutrient Trend Analyses



Camp Creek Lake, Walton County



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. Long-term water chemistry monitoring for Camp Creek Lake occurs at three stations denoted as white triangles on the map above. Camp Creek Lake contains an outfall which intermittently connects to the Gulf. The system's average water chemistry stays relatively fresh (1.5 ppt).

Camp Creek Lake Water Chemistry Data- 2018

Summary statistics include mean, maximum (Max), minimum (Min), median, and standard error (Std Error) calculated for both surface and bottom measurements for temperature, dissolved oxygen (DO), pH, and salinity, as well as surface measurements total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), secchi depth, as well as. These statistics represent 2018 water chemistry data.

2018 Summary Statistics

	min	mean	max	Std Error
Temperature surface	11.2	23.32	32.51	2.31
Temperature bottom	14.95	24.59	30.04	1.51
DO (mg/L) surface	2.55	5.75	9.36	0.69
DO (mg/L) bottom	0.72	1.82	3.76	0.27
pH surface	5.58	6.86	8.15	0.22
pH bottom	6.33	7.34	8.27	0.16
Salinity (ppt) surface	0.53	9.99	32.16	3.09
Salinity (ppt) bottom	4.31	23.32	32.91	3.13
TP (µg/L)	7.32	11.08	14.85	0.69
TN (µg/L)	268.01	474.87	758.85	40.44
CHL (µg/L)	1	3.38	9.52	0.85

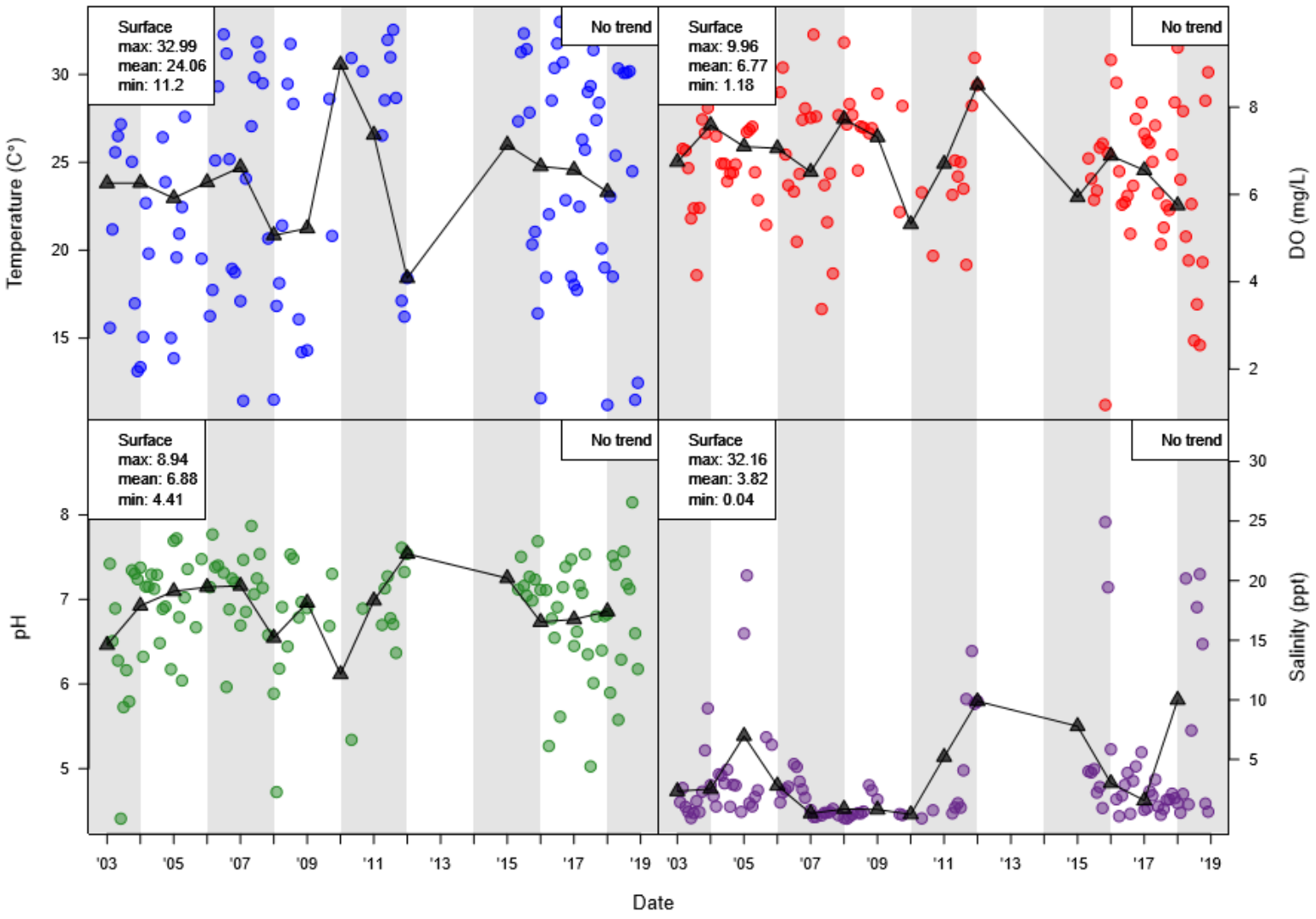
Camp Creek Lake Water Chemistry Data- 2003 through 2018

Summary statistics include mean, maximum (max), and minimum (min) summary statistics calculated on an annual basis using monthly data for hydrolab data variables; temperature, dissolved oxygen (DO), pH, and salinity as well as nutrient data variables total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), and secchi depth,. Summary statistics and trends represent results from long-term analyses among annual means from 2003 through 2018.

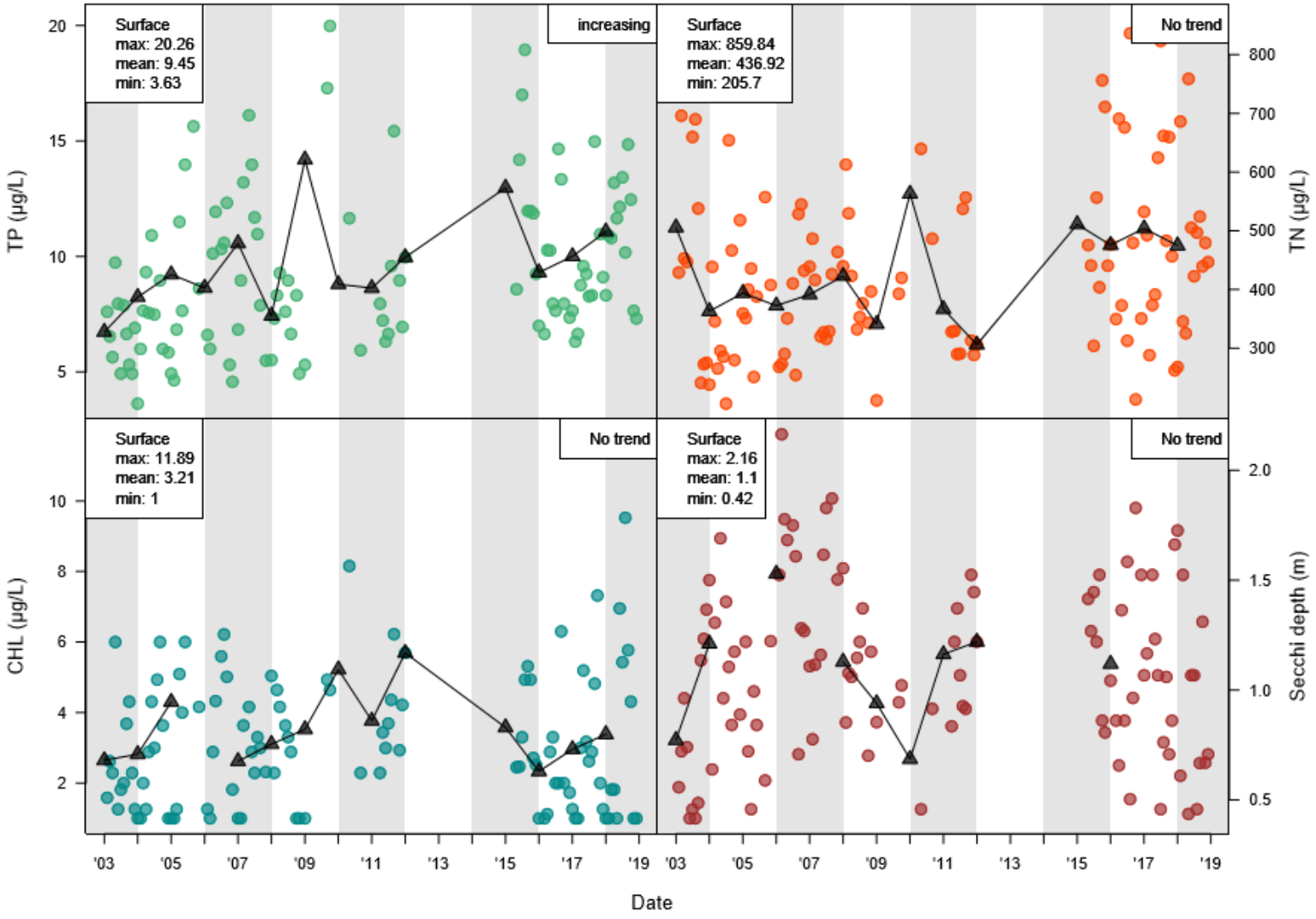
Times series plots display the inter-annual (monthly variability within the year - circles) and intra-annual variance (variability among years - triangles). Columns delineate three year time intervals.

Kendall-Tau trend analysis results are shown for each water chemistry variable on the surface-left of each plot. *No trend* indicates there was no significant trend found among the years examined (2003 through 2018). *Increasing* indicates a significant, positive trend was found over time. *Decreasing* indicates a significant, negative trend was found among the years examined. *Insufficient data* indicates insufficient annual data (year averages) were available for trend analysis.

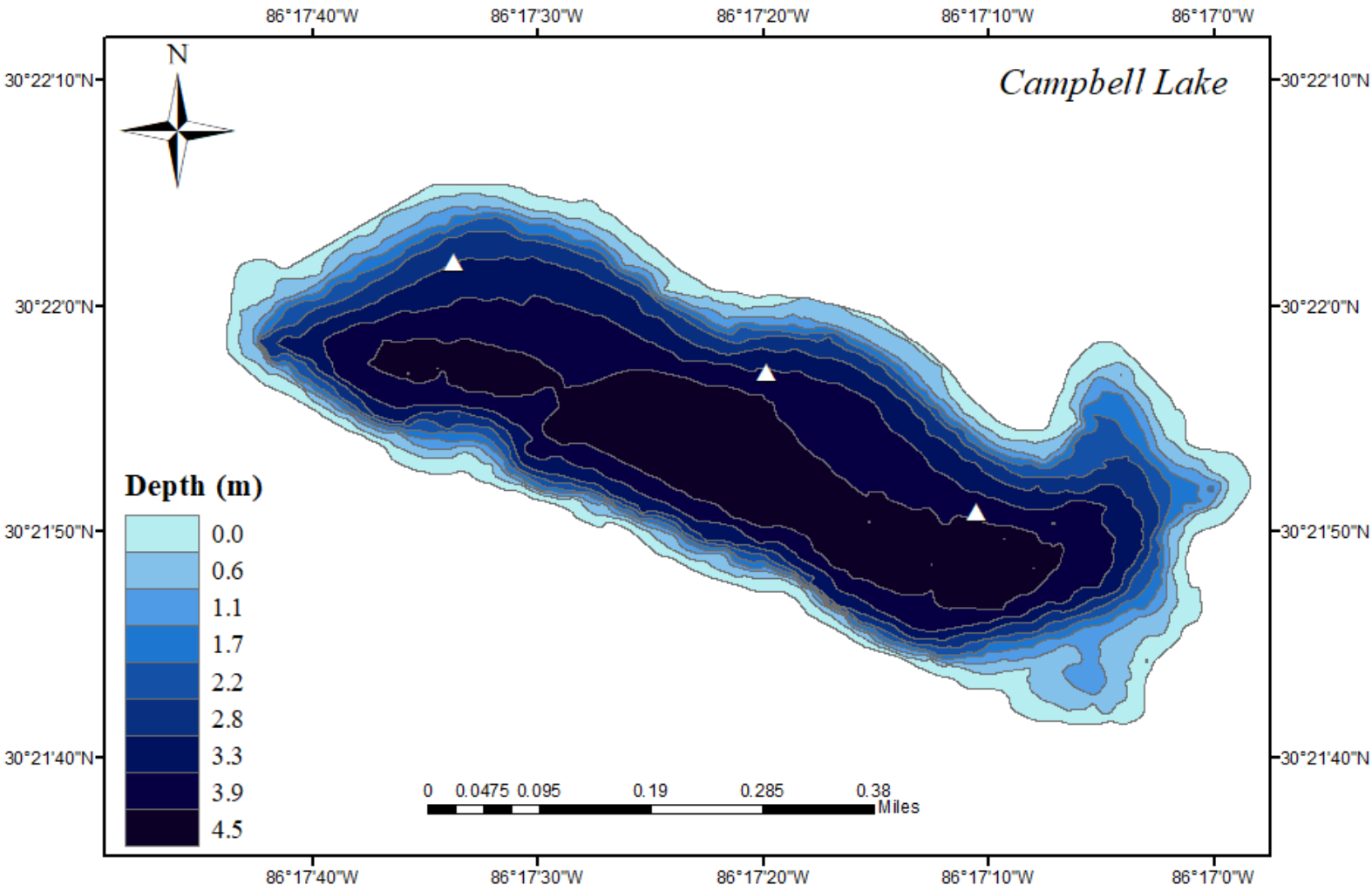
Hydrolab Trend Analyses



Nutrient Trend Analyses



Campbell Lake, Walton County



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. Long-term water chemistry monitoring for Campbell Lake occurs at three stations denoted as white triangles on the map above. While the system does contain an outfall, Campbell Lake seldom connects to the gulf. As a result the system is primarily freshwater (0.06 ppt).

Campbell Lake Water Chemistry Data- 2018

Summary statistics include mean, maximum (Max), minimum (Min), median, and standard error (Std Error) calculated for both surface and bottom measurements for temperature, dissolved oxygen (DO), pH, and salinity, as well as surface measurements total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), secchi depth, as well as. These statistics represent 2018 water chemistry data.

2018 Summary Statistics

	min	mean	max	Std Error
Temperature surface	9.59	24.21	32.31	1.99
Temperature bottom	9.2	23.06	31.61	2
DO (mg/L) surface	6.58	8	11.21	0.38
DO (mg/L) bottom	5.31	7.33	11.09	0.49
pH surface	4.56	5.2	6.07	0.14
pH bottom	4.34	5.15	6.26	0.15
Salinity (ppt) surface	0.04	0.04	0.04	0
Salinity (ppt) bottom	0.04	0.04	0.04	0
TP (µg/L)	6.32	10.39	21.21	1.15
TN (µg/L)	199.83	255.9	316.63	10.61
CHL (µg/L)	2	2.26	3	0.11

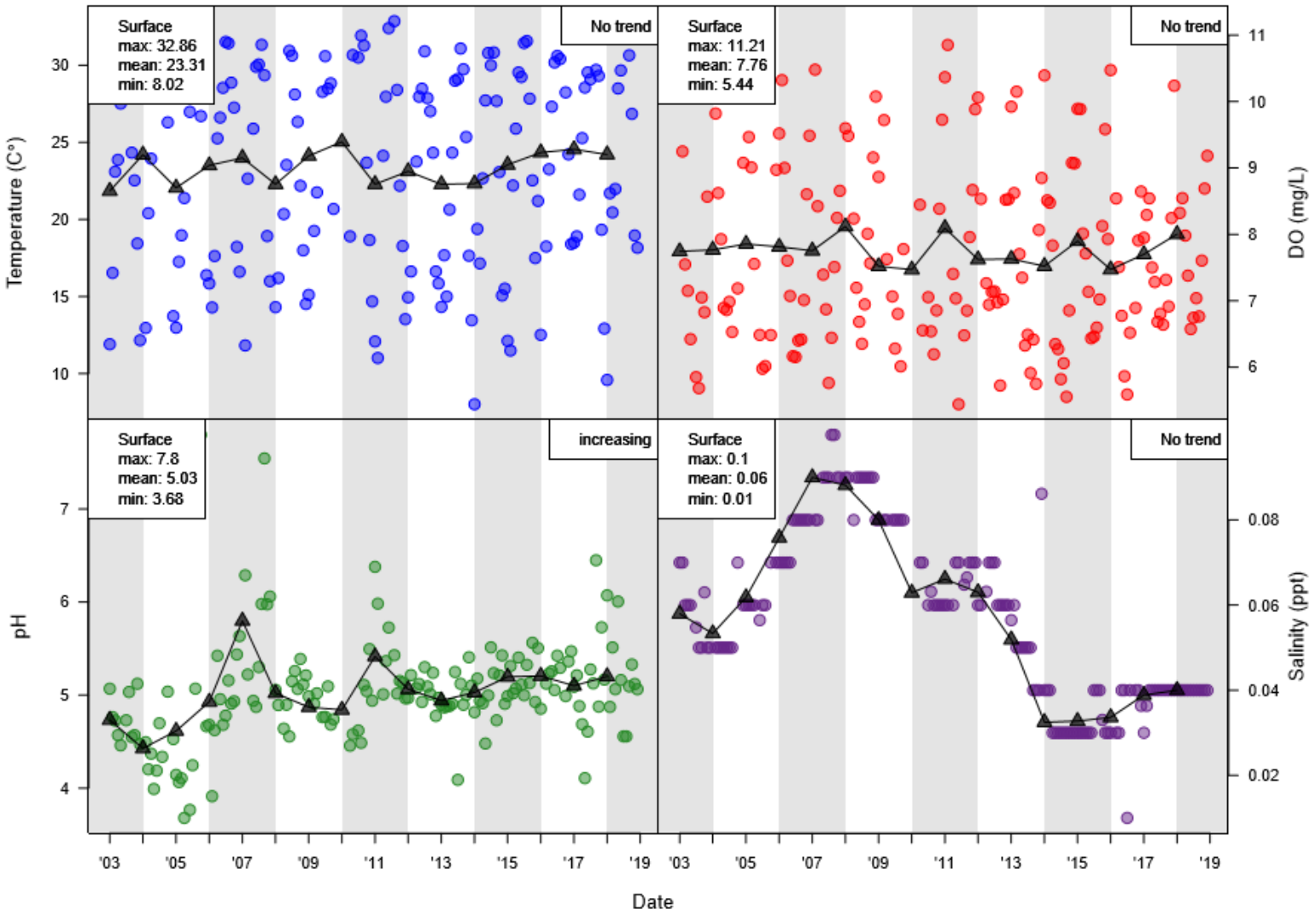
Campbell Lake Water Chemistry Data- 2003 through 2018

Summary statistics include mean, maximum (max), and minimum (min) summary statistics calculated on an annual basis using monthly data for hydrolab data variables; temperature, dissolved oxygen (DO), pH, and salinity as well as nutrient data variables total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), and secchi depth,. Summary statistics and trends represent results from long-term analyses among annual means from 2003 through 2018.

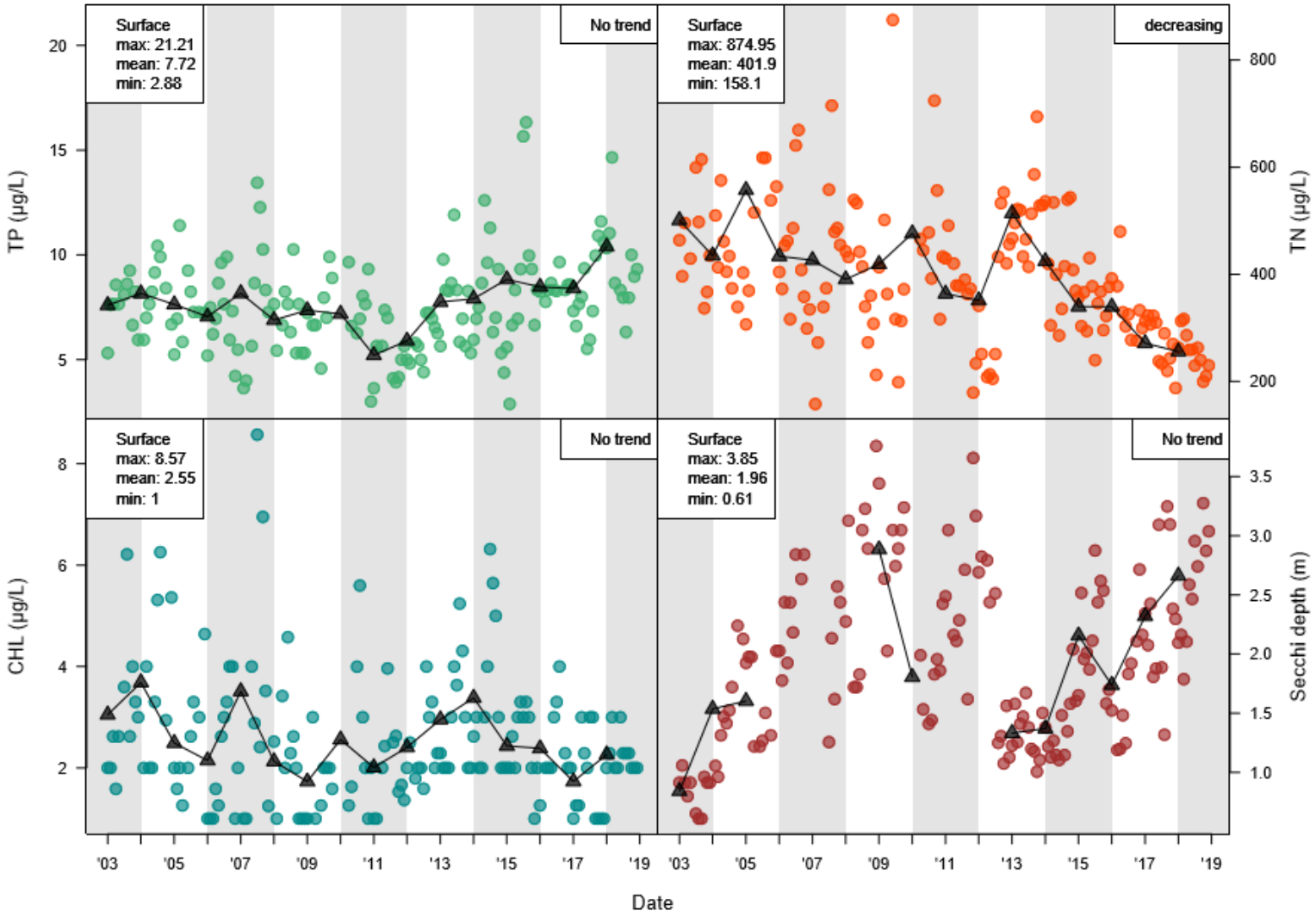
Times series plots display the inter-annual (monthly variability within the year - circles) and intra-annual variance (variability among years - triangles). Columns delineate three year time intervals.

Kendall-Tau trend analysis results are shown for each water chemistry variable on the surface-left of each plot. *No trend* indicates there was no significant trend found among the years examined (2003 through 2018). *Increasing* indicates a significant, positive trend was found over time. *Decreasing* indicates a significant, negative trend was found among the years examined. *Insufficient data* indicates insufficient annual data (year averages) were available for trend analysis.

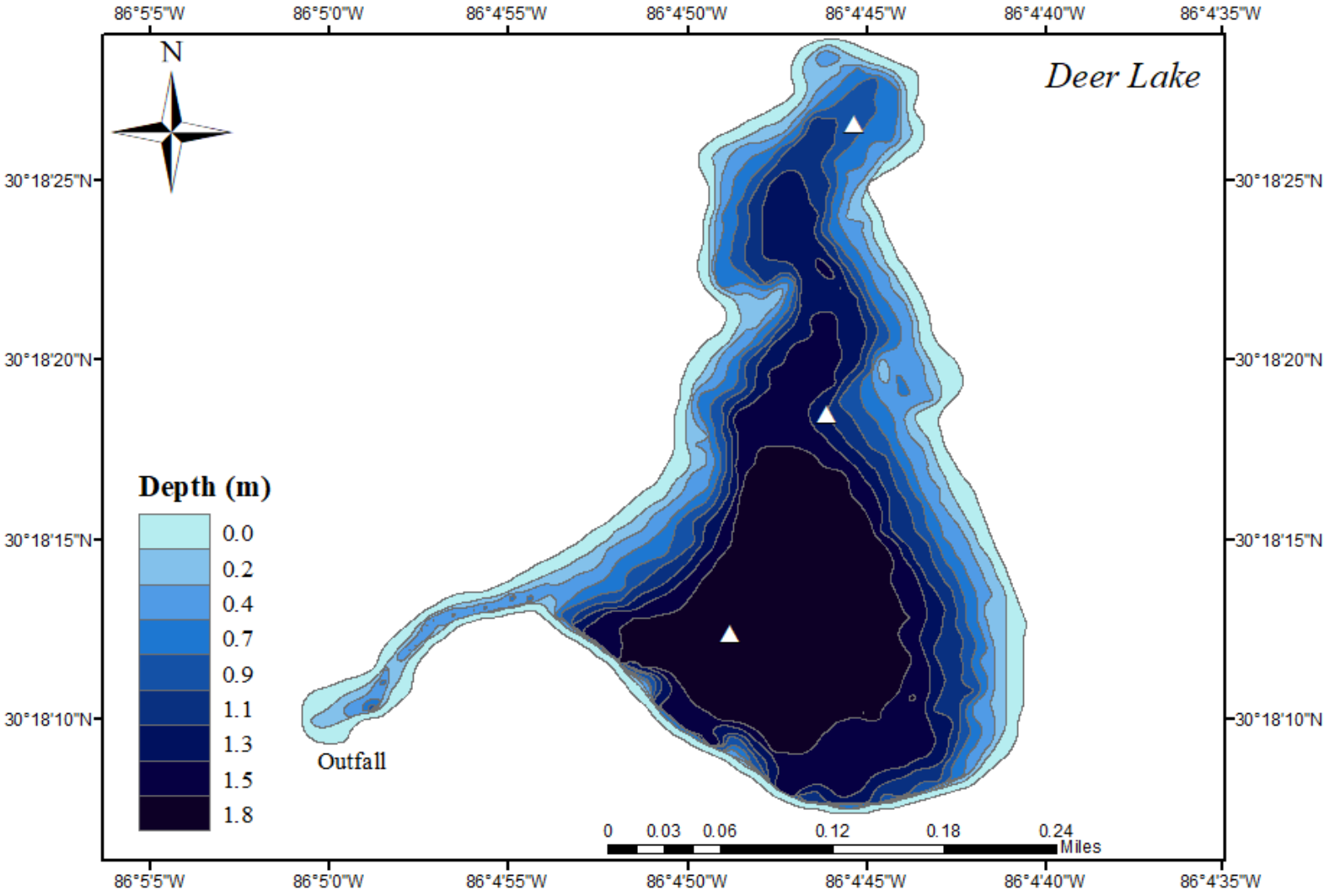
Hydrolab Trend Analyses



Nutrient Trend Analyses



Deer Lake, Walton County



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. Long-term water chemistry monitoring for Deer Lake occurs at three stations denoted as white triangles on the map above. The system contains an outfall which intermittently connects to the gulf. Trend analyses of water chemistry variables in Deer Lake indicate significantly increasing salinity and total phosphorous, as well as significantly decreasing dissolved oxygen concentration.

Deer Lake Water Chemistry Data- 2018

Summary statistics include mean, maximum (Max), minimum (Min), median, and standard error (Std Error) calculated for both surface and bottom measurements for temperature, dissolved oxygen (DO), pH, and salinity, as well as surface measurements total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), secchi depth, as well as. These statistics represent 2018 water chemistry data.

2018 Summary Statistics

	min	mean	max	Std Error
Temperature surface	11.02	24.65	32.97	2.15
Temperature bottom	11.16	24.12	30.25	1.95
DO (mg/L) surface	1.79	5.68	9.47	0.67
DO (mg/L) bottom	0.7	2.18	6.49	0.63
pH surface	6.13	7.06	7.69	0.15
pH bottom	6.93	7.3	7.9	0.08
Salinity (ppt) surface	2.83	11.61	30.21	2.96
Salinity (ppt) bottom	7.51	19.92	34.68	2.76
TP (µg/L)	6.75	12.68	23.87	1.48
TN (µg/L)	233.73	444.6	689.85	38.81
CHL (µg/L)	1.26	4.34	17.96	1.43

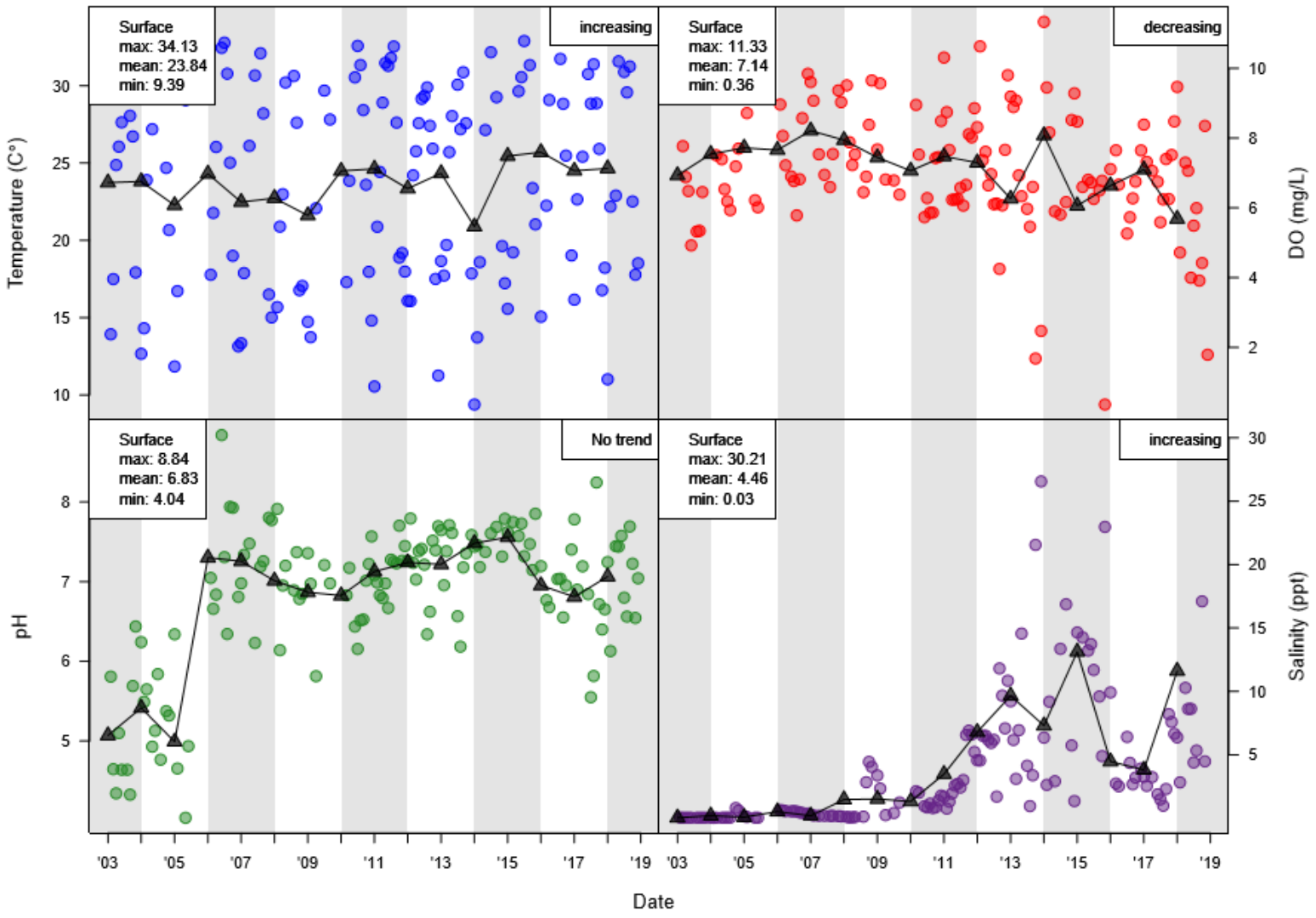
Deer Lake Water Chemistry Data- 2003 through 2018

Summary statistics include mean, maximum (max), and minimum (min) summary statistics calculated on an annual basis using monthly data for hydrolab data variables; temperature, dissolved oxygen (DO), pH, and salinity as well as nutrient data variables total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), and secchi depth,. Summary statistics and trends represent results from long-term analyses among annual means from 2003 through 2018.

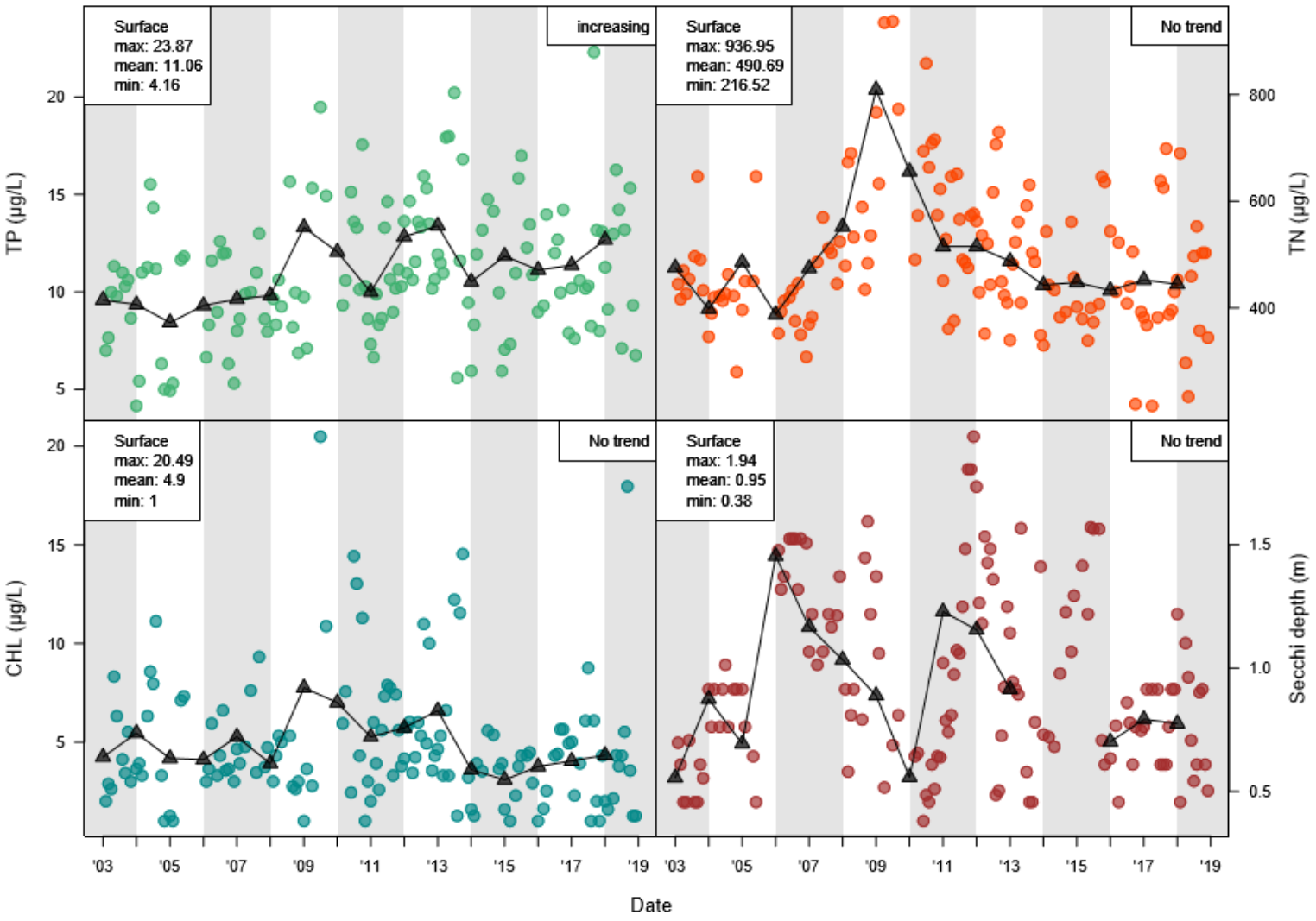
Times series plots display the inter-annual (monthly variability within the year - circles) and intra-annual variance (variability among years - triangles). Columns delineate three year time intervals.

Kendall-Tau trend analysis results are shown for each water chemistry variable on the surface-left of each plot. *No trend* indicates there was no significant trend found among the years examined (2003 through 2018). *Increasing* indicates a significant, positive trend was found over time. *Decreasing* indicates a significant, negative trend was found among the years examined. *Insufficient data* indicates insufficient annual data (year averages) were available for trend analysis

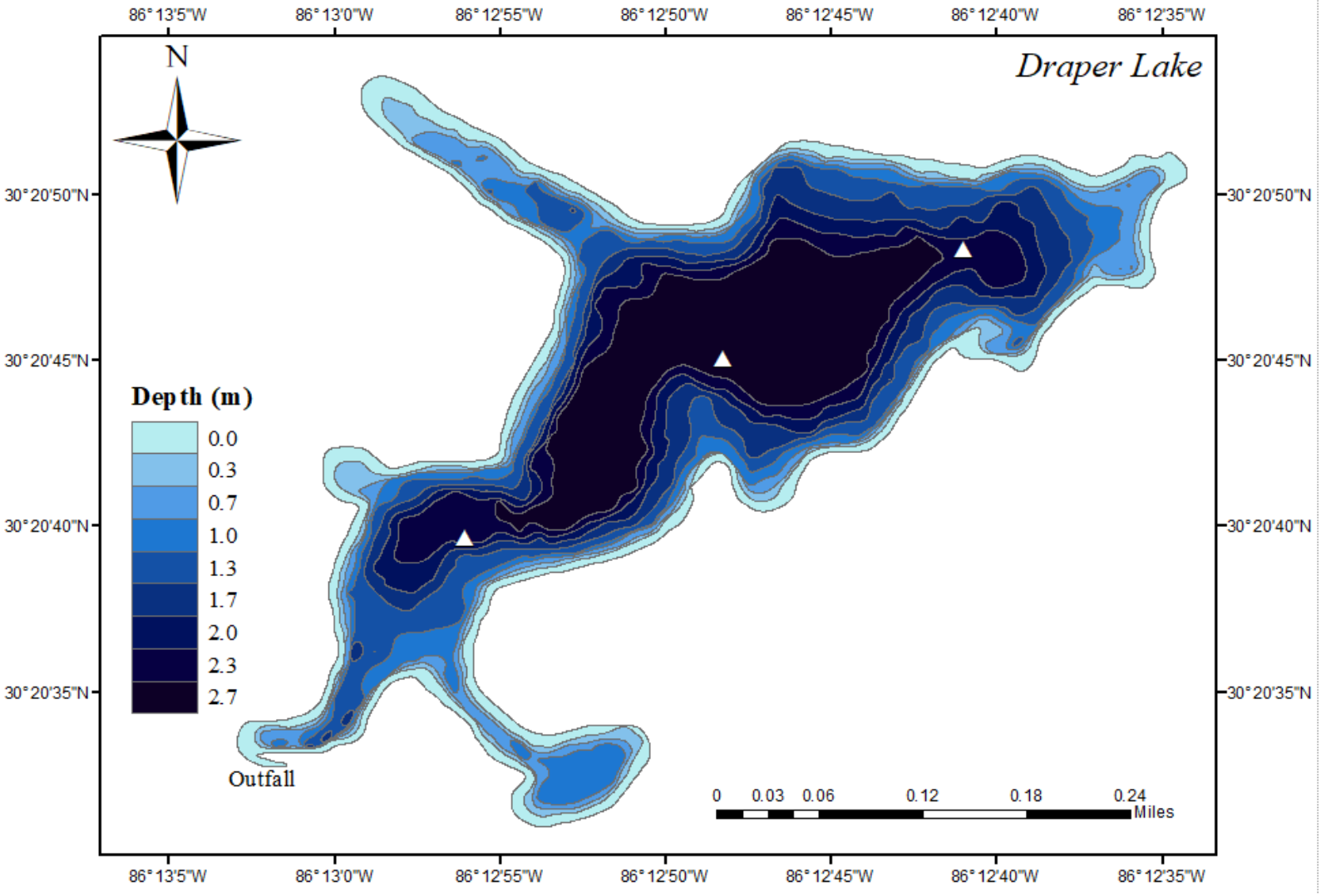
Hydrolab Trend Analyses



Nutrient Trend Analyses



Draper Lake, Walton County



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. Long-term water chemistry monitoring for Draper Lake occurs at three stations denoted as white triangles on the map above. The system contains an outfall which regularly connects with the gulf. As a result, Draper Lake is a brackish system (6.1 ppt).

Draper Lake Water Chemistry Data- 2018

Summary statistics include mean, maximum (Max), minimum (Min), median, and standard error (Std Error) calculated for both surface and bottom measurements for temperature, dissolved oxygen (DO), pH, and salinity, as well as surface measurements total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), secchi depth, as well as. These statistics represent 2018 water chemistry data.

2018 Summary Statistics

	min	mean	max	Std Error
Temperature surface	8.87	22.72	30.59	2.06
Temperature bottom	8.33	23.77	30.63	1.88
DO (mg/L) surface	5.25	6.7	8.72	0.37
DO (mg/L) bottom	0.27	2.67	5.4	0.52
pH surface	6.95	7.28	8.11	0.1
pH bottom	6.83	7.18	7.82	0.08
Salinity (ppt) surface	2.88	5.83	9.52	0.59
Salinity (ppt) bottom	3.02	15.36	27.87	2.44
TP (µg/L)	9.58	12.13	16	0.57
TN (µg/L)	228.52	347.4	521.83	31.43
CHL (µg/L)	1	2.52	4.31	0.31

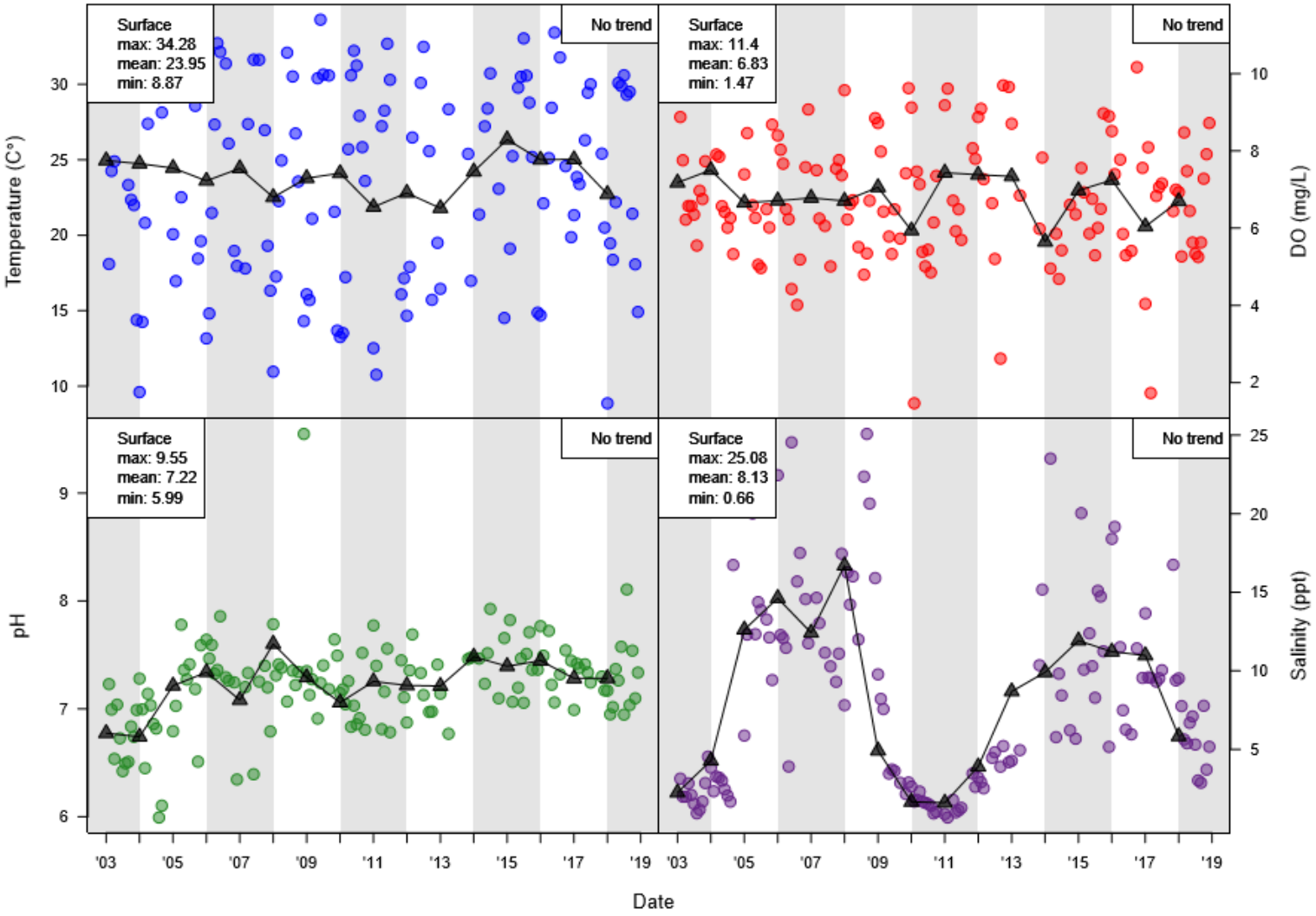
Draper Lake Water Chemistry Data- 2003 through 2018

Summary statistics include mean, maximum (max), and minimum (min) summary statistics calculated on an annual basis using monthly data for hydrolab data variables; temperature, dissolved oxygen (DO), pH, and salinity as well as nutrient data variables total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), and secchi depth,. Summary statistics and trends represent results from long-term analyses among annual means from 2003 through 2018.

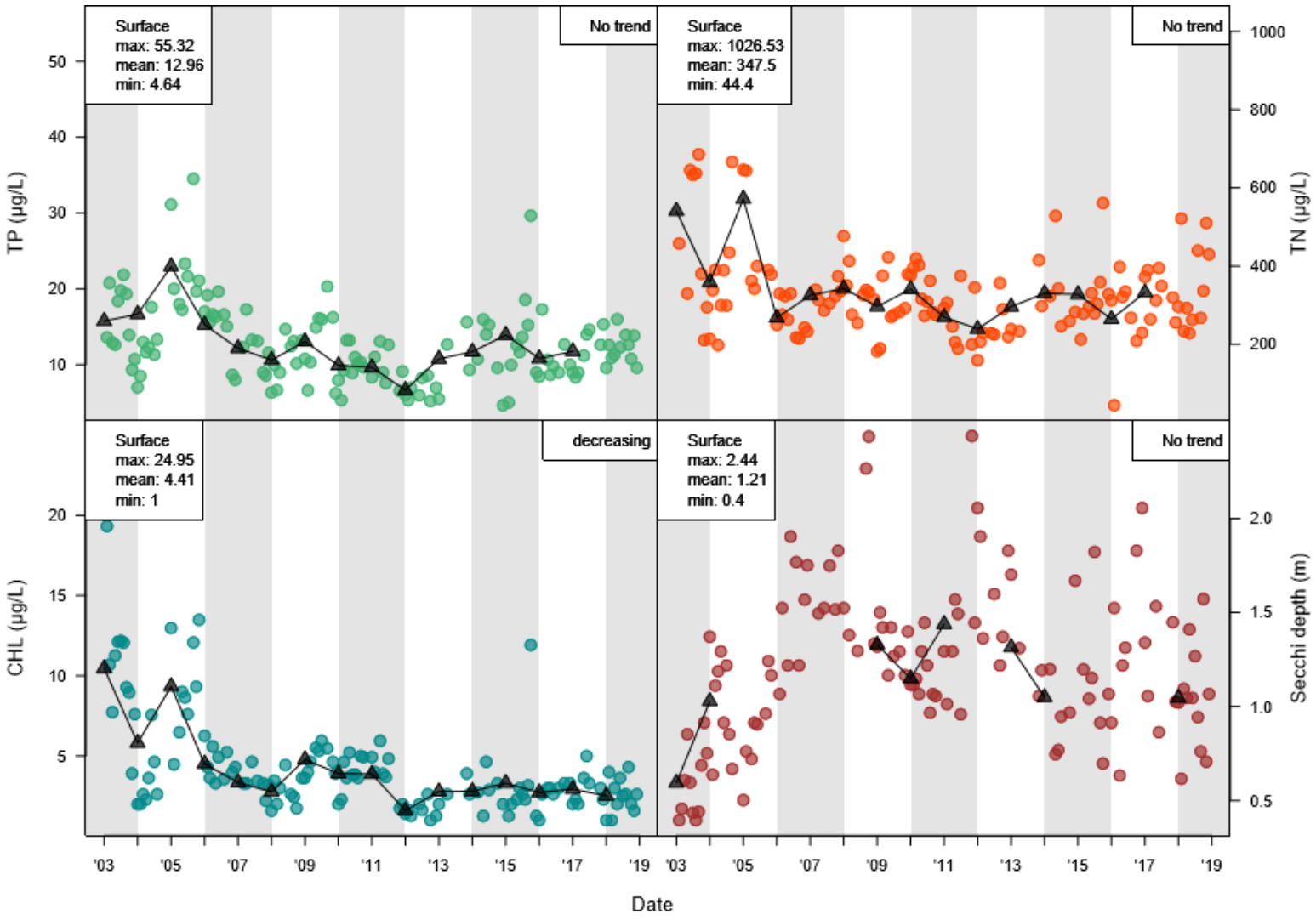
Times series plots display the inter-annual (monthly variability within the year - circles) and intra-annual variance (variability among years - triangles). Columns delineate three year time intervals.

Kendall-Tau trend analysis results are shown for each water chemistry variable on the surface-left of each plot. *No trend* indicates there was no significant trend found among the years examined (2003 through 2018). *Increasing* indicates a significant, positive trend was found over time. *Decreasing* indicates a significant, negative trend was found among the years examined. *Insufficient data* indicates insufficient annual data (year averages) were available for trend analysis.

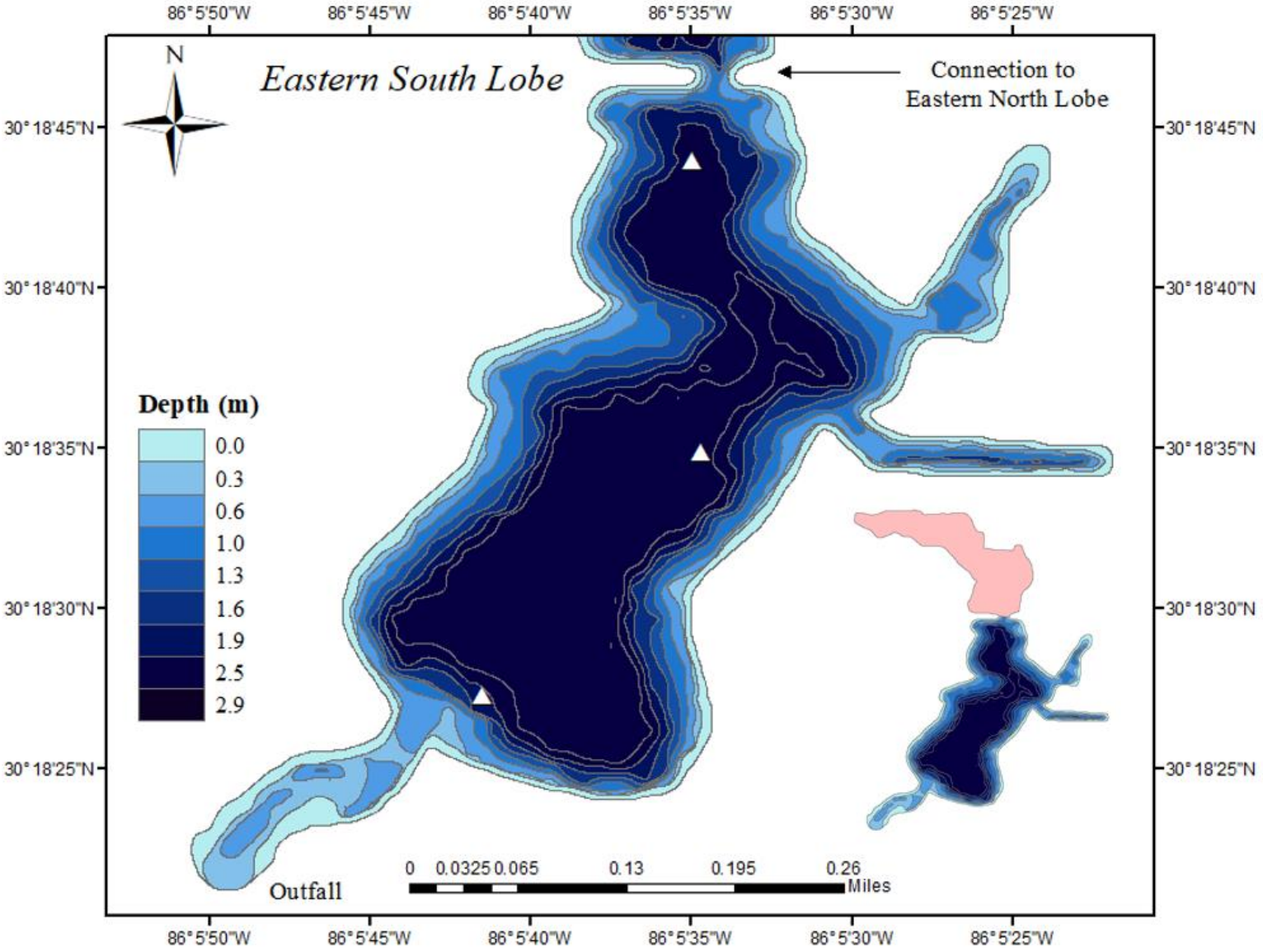
Hydrolab Trend Analyses



Nutrient Trend Analyses



Eastern South Lake Lobe, Walton County



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. Eastern South Lobe refers to the southern lobe of Eastern Lake. Long-term water chemistry monitoring for Eastern South Lobe occurs at three stations denoted as white triangles on the map above. The system contains an outfall which frequently connects to the gulf. As a result Eastern South Lobe and Eastern North Lobe are among the most saline coastal dune lake systems (11 ppt and 10 ppt respectively).

Eastern South Lake Lobe Water Chemistry Data- 2018

Summary statistics include mean, maximum (Max), minimum (Min), median, and standard error (Std Error) calculated for both surface and bottom measurements for temperature, dissolved oxygen (DO), pH, and salinity, as well as surface measurements total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), secchi depth, as well as. These statistics represent 2018 water chemistry data.

2018 Summary Statistics

	min	mean	max	Std Error
Temperature surface	12.8	23.48	31.47	2.17
Temperature bottom	12.84	23.97	30.81	2.03
DO (mg/L) surface	4.13	6.44	9.3	0.55
DO (mg/L) bottom	0.26	1.86	6.99	0.72
pH surface	7.19	7.52	7.86	0.07
pH bottom	7.13	7.49	8.04	0.09
Salinity (ppt) surface	7.61	13.54	18.91	1.38
Salinity (ppt) bottom	18.84	25.98	31.38	1.37
TP (µg/L)	11.29	15.58	22.25	1.31
TN (µg/L)	226.62	315.31	366.55	15.95
CHL (µg/L)	2.45	4.13	6.65	0.47

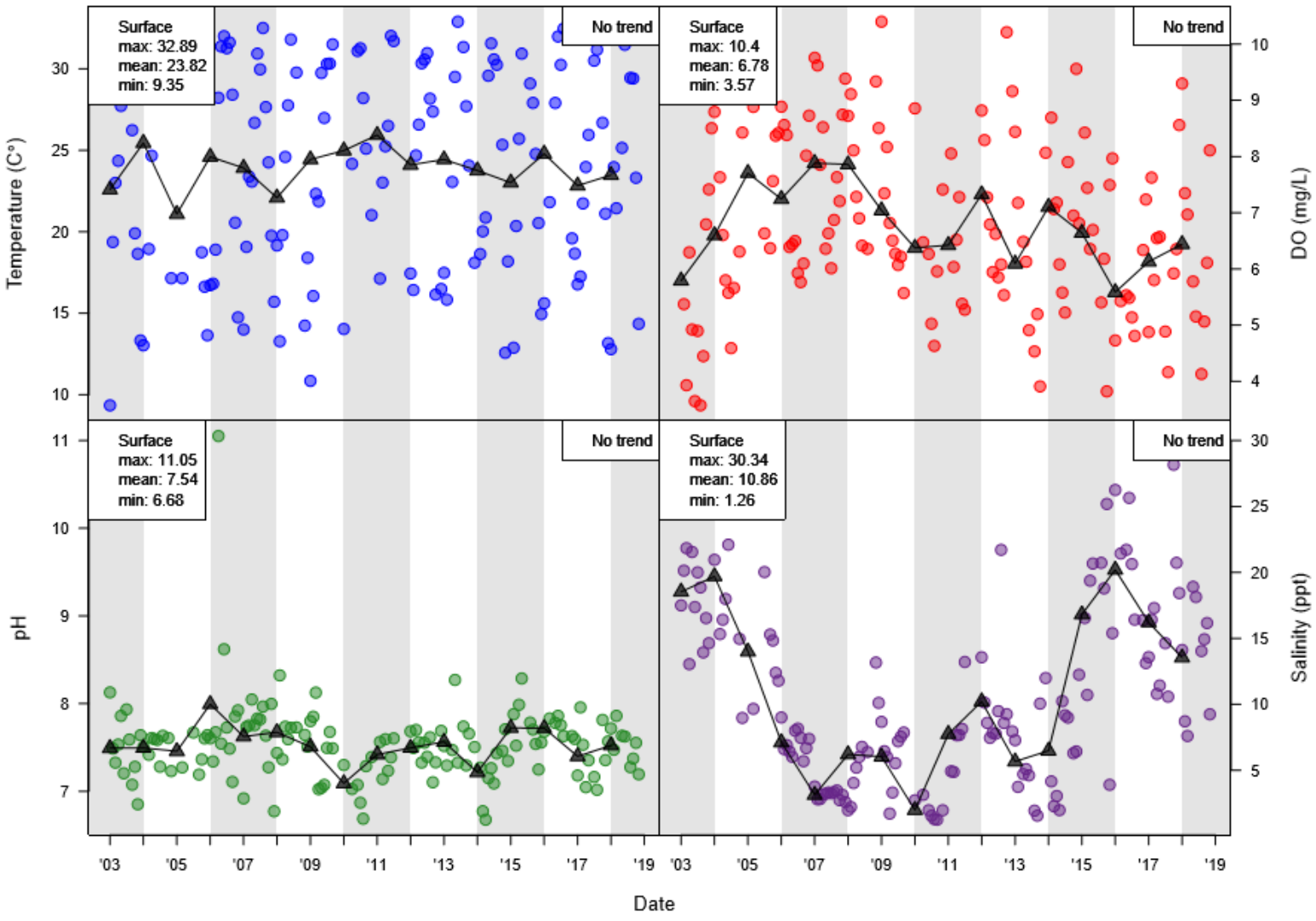
Eastern South Lake Lobe Water Chemistry Data- 2003 through 2018

Summary statistics include mean, maximum (max), and minimum (min) summary statistics calculated on an annual basis using monthly data for hydrolab data variables; temperature, dissolved oxygen (DO), pH, and salinity as well as nutrient data variables total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), and secchi depth,. Summary statistics and trends represent results from long-term analyses among annual means from 2003 through 2018.

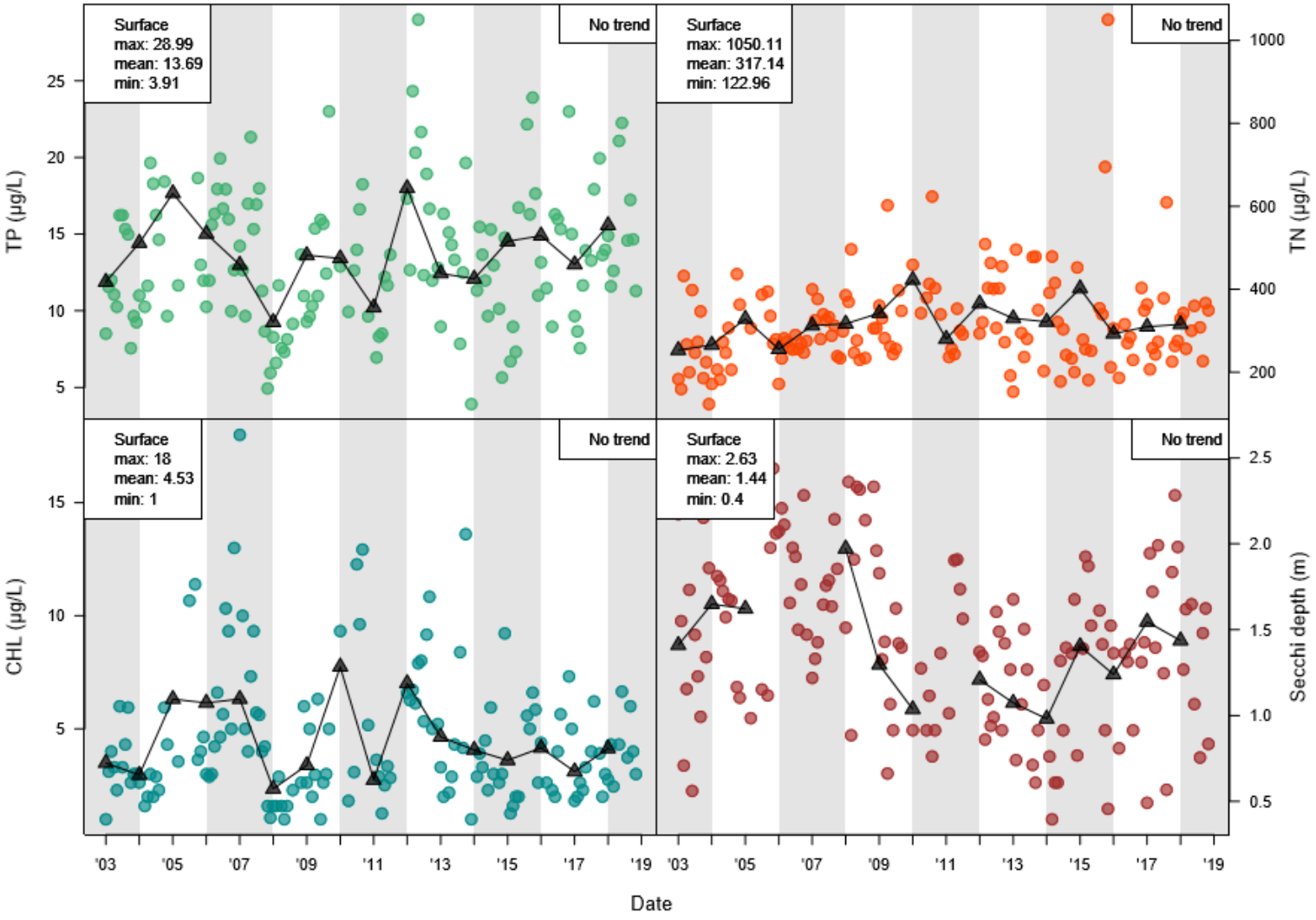
Times series plots display the inter-annual (monthly variability within the year - circles) and intra-annual variance (variability among years - triangles). Columns delineate three year time intervals.

Kendall-Tau trend analysis results are shown for each water chemistry variable on the surface-left of each plot. *No trend* indicates there was no significant trend found among the years examined (2003 through 2018). *Increasing* indicates a significant, positive trend was found over time. *Decreasing* indicates a significant, negative trend was found among the years examined. *Insufficient data* indicates insufficient annual data (year averages) were available for trend analysis.

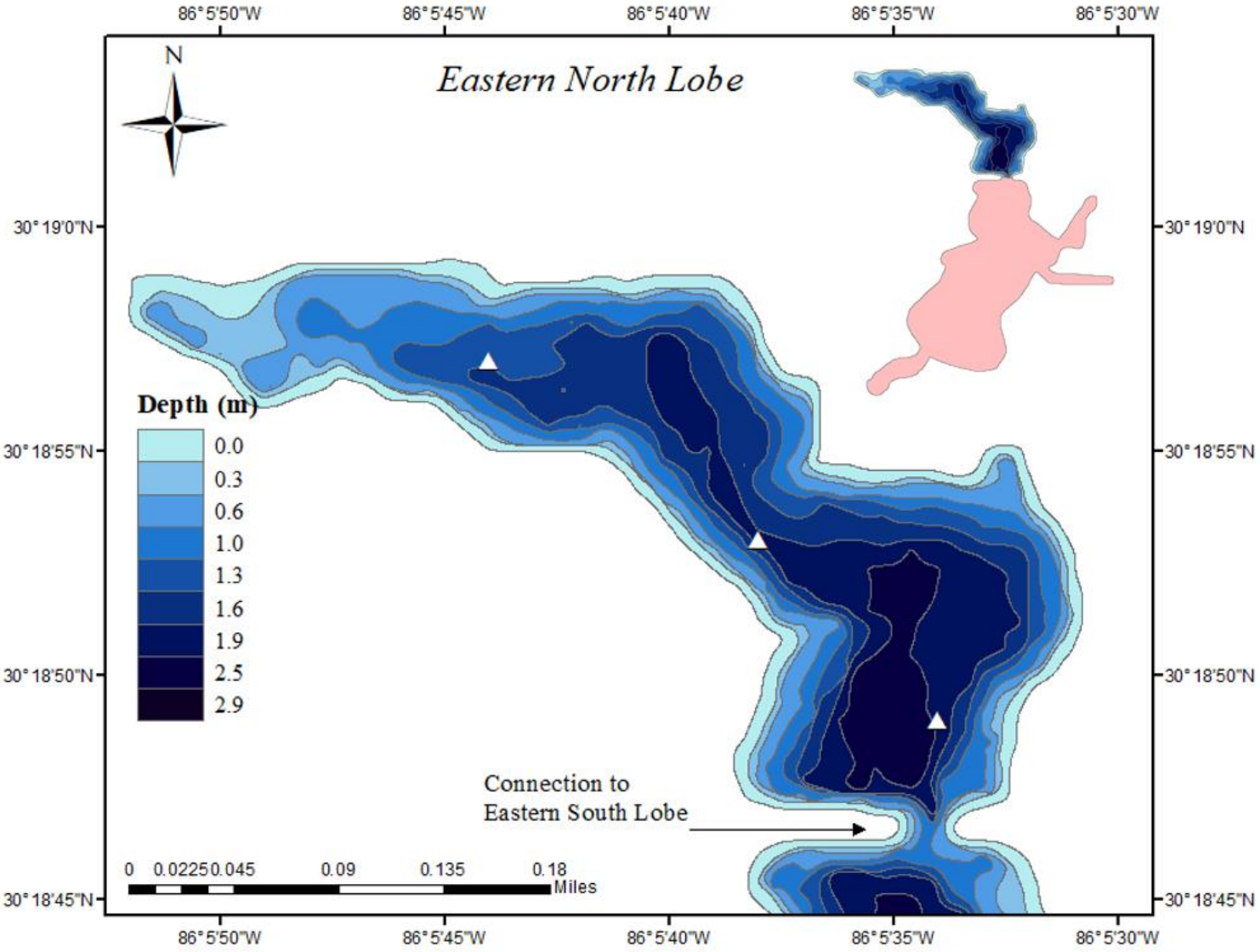
Hydrolab Data Analytics



Nutrient Trend Analyses



Eastern North Lake Lobe, Walton County



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. Eastern North Lobe refers to the Northern lobe of Eastern Lake. Long-term water chemistry monitoring for Eastern North Lobe occurs at three stations denoted as white triangles on the map above. Although Eastern North does not contain an outfall, it indirectly interacts with the gulf through its connection to Eastern South Lobe; which frequently connects to the gulf. As a result, Eastern South Lobe and Eastern North Lobe are among the most saline coastal dune lake systems (11 ppt and 10 ppt respectively).

Eastern North Lake Lobe Water Chemistry Data- 2018

Summary statistics include mean, maximum (Max), minimum (Min), median, and standard error (Std Error) calculated for both surface and bottom measurements for temperature, dissolved oxygen (DO), pH, and salinity, as well as surface measurements total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), secchi depth, as well as. These statistics represent 2018 water chemistry data.

2018 Summary Statistics

	min	mean	max	Std Error
Temperature surface	18.23	26.3	33.37	2.01
Temperature bottom	17.08	26.76	32.05	1.74
DO (mg/L) surface	2.35	5.28	7.62	0.53
DO (mg/L) bottom	0.54	2.76	6.2	0.62
pH surface	6.28	7.19	7.76	0.13
pH bottom	6.57	7.22	7.93	0.13
Salinity (ppt) surface	3.39	14.37	28.2	2.51
Salinity (ppt) bottom	10.86	20.38	29.62	2.19
TP (µg/L)	11.29	18.51	33.1	2.57
TN (µg/L)	254.06	375.7	608.69	33.44
CHL (µg/L)	1	5.62	23.61	2.06

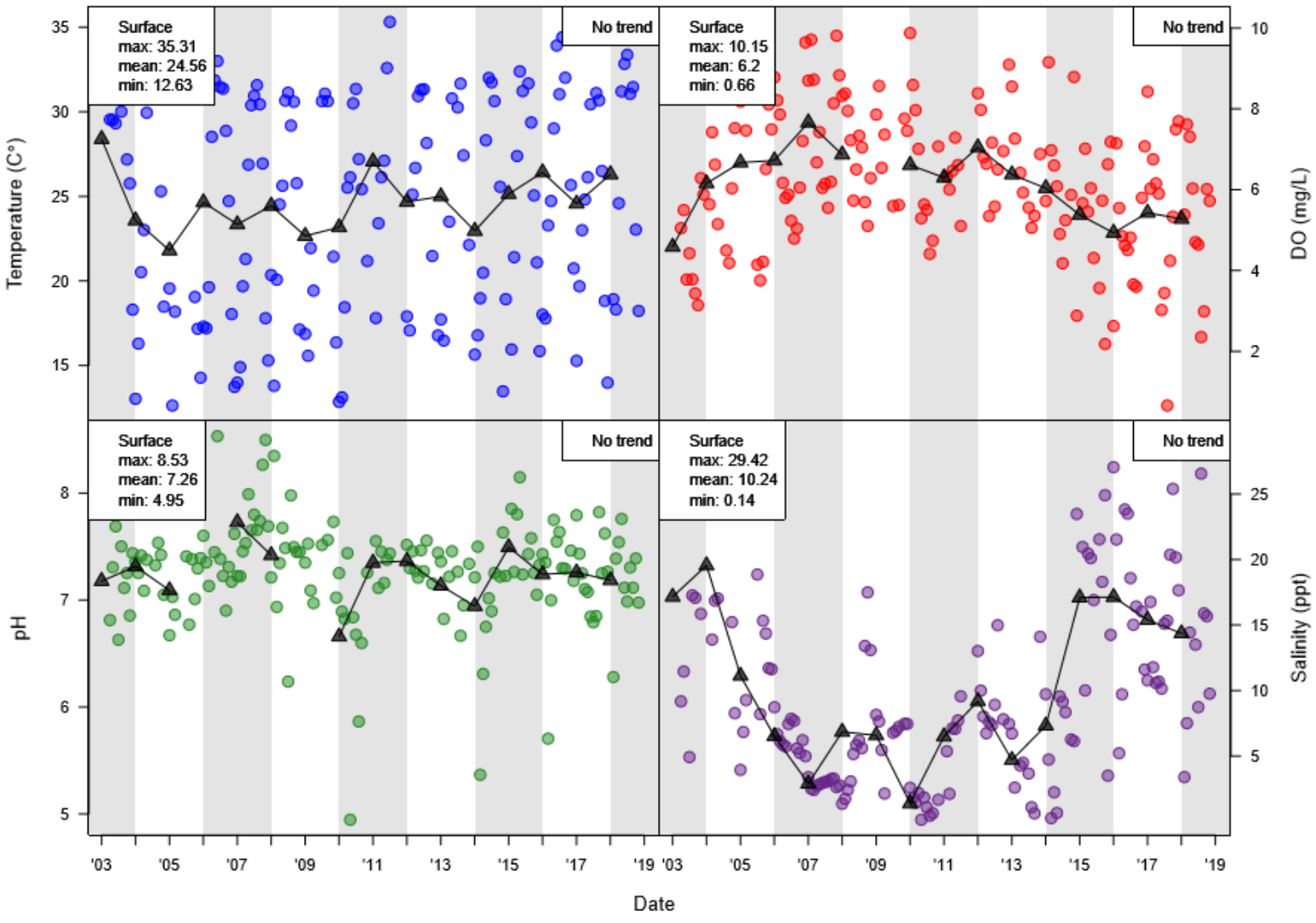
Eastern North Lake Lobe Water Chemistry Data- 2003 through 2018

Summary statistics include mean, maximum (max), and minimum (min) summary statistics calculated on an annual basis using monthly data for hydrolab data variables; temperature, dissolved oxygen (DO), pH, and salinity as well as nutrient data variables total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), and secchi depth,. Summary statistics and trends represent results from long-term analyses among annual means from 2003 through 2018.

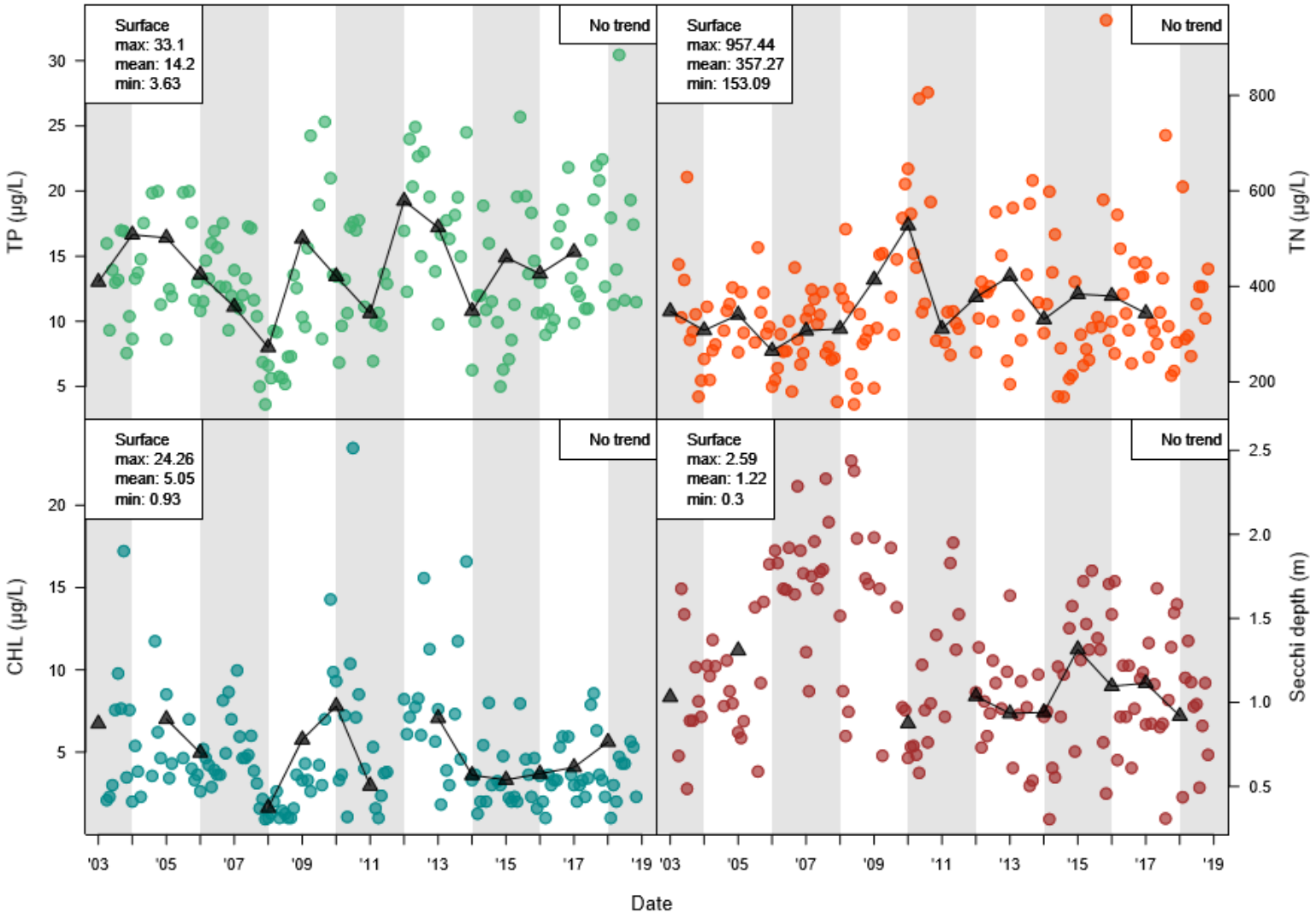
Times series plots display the inter-annual (monthly variability within the year - circles) and intra-annual variance (variability among years - triangles). Columns delineate three year time intervals.

Kendall-Tau trend analysis results are shown for each water chemistry variable on the surface-left of each plot. No trend indicates there was no significant trend found among the years examined (2003 through 2018). Increasing indicates a significant, positive trend was found over time. Decreasing indicates a significant, negative trend was found among the years examined. Insufficient data indicates insufficient annual data (year averages) were available for trend analysis.

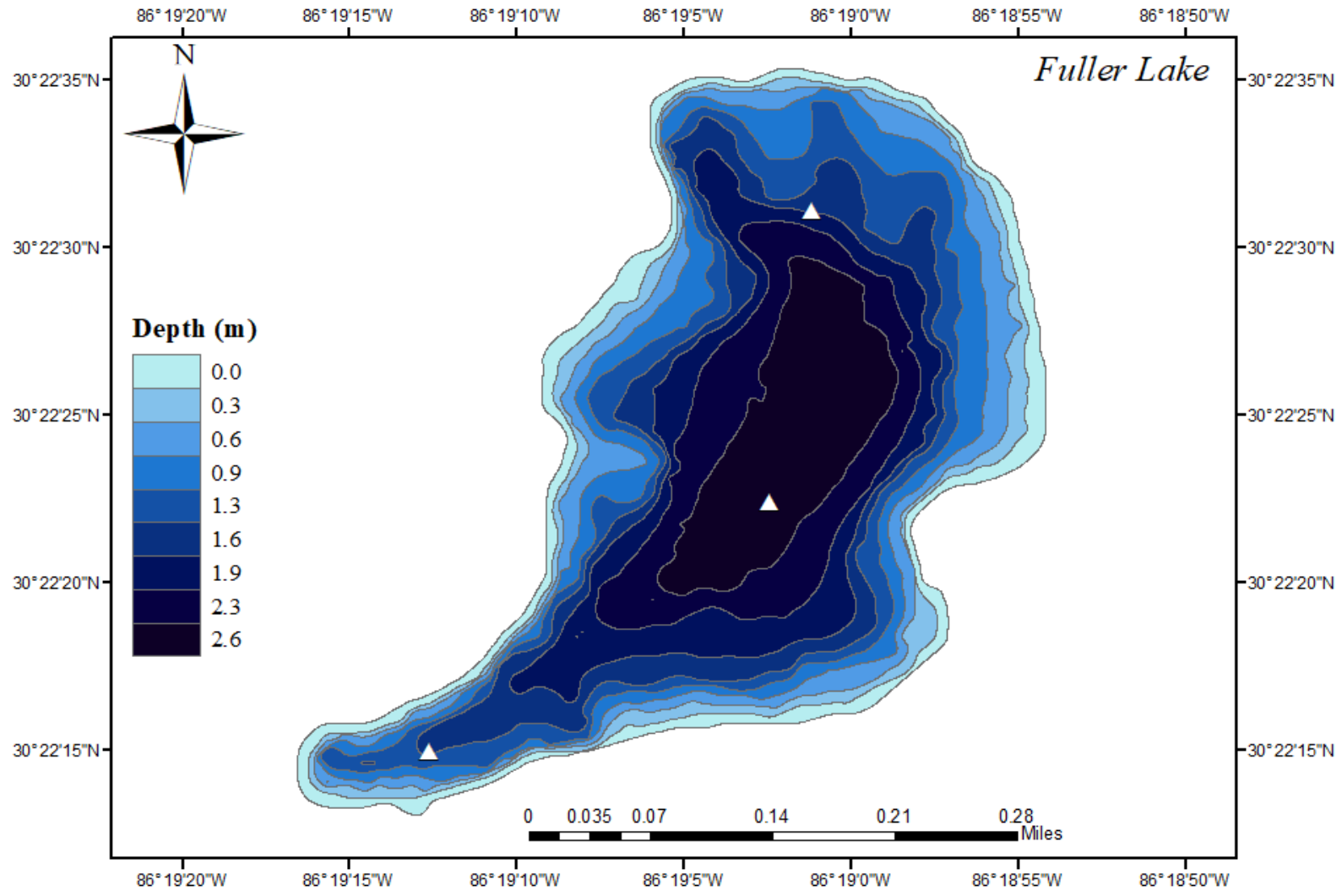
Hydrolab Trend Analyses



Nutrient Trend Analyses



Fuller Lake, Walton County



Lake Description

Fuller Lake is a primarily isolated, freshwater (0.11 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. Long-term water chemistry monitoring for Fuller Lake occurs at three stations denoted as white triangles on the map above. Fuller Lake is one of several systems which do not possess a direct connection with the Gulf of Mexico. The system is 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.

Fuller Lake Water Chemistry Data- 2018

Summary statistics include mean, maximum (Max), minimum (Min), median, and standard error (Std Error) calculated for both surface and bottom measurements for temperature, dissolved oxygen (DO), pH, and salinity, as well as surface measurements total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), secchi depth, as well as. These statistics represent 2018 water chemistry data.

2018 Summary Statistics

	min	mean	max	Std Error
Temperature surface	11.83	23.98	33.19	2.28
Temperature bottom	11.69	22.74	31.2	2.1
DO (mg/L) surface	5.65	7.19	10.57	0.48
DO (mg/L) bottom	2.35	5.69	9.49	0.61
pH surface	4.51	5.01	5.35	0.09
pH bottom	4.38	5.17	5.85	0.13
Salinity (ppt) surface	0.04	0.05	0.05	0
Salinity (ppt) bottom	0.04	0.05	0.05	0
TP (µg/L)	7.88	12.82	17.86	0.98
TN (µg/L)	323.3	561.25	759.96	33.93
CHL (µg/L)	2	5.13	11.33	0.85

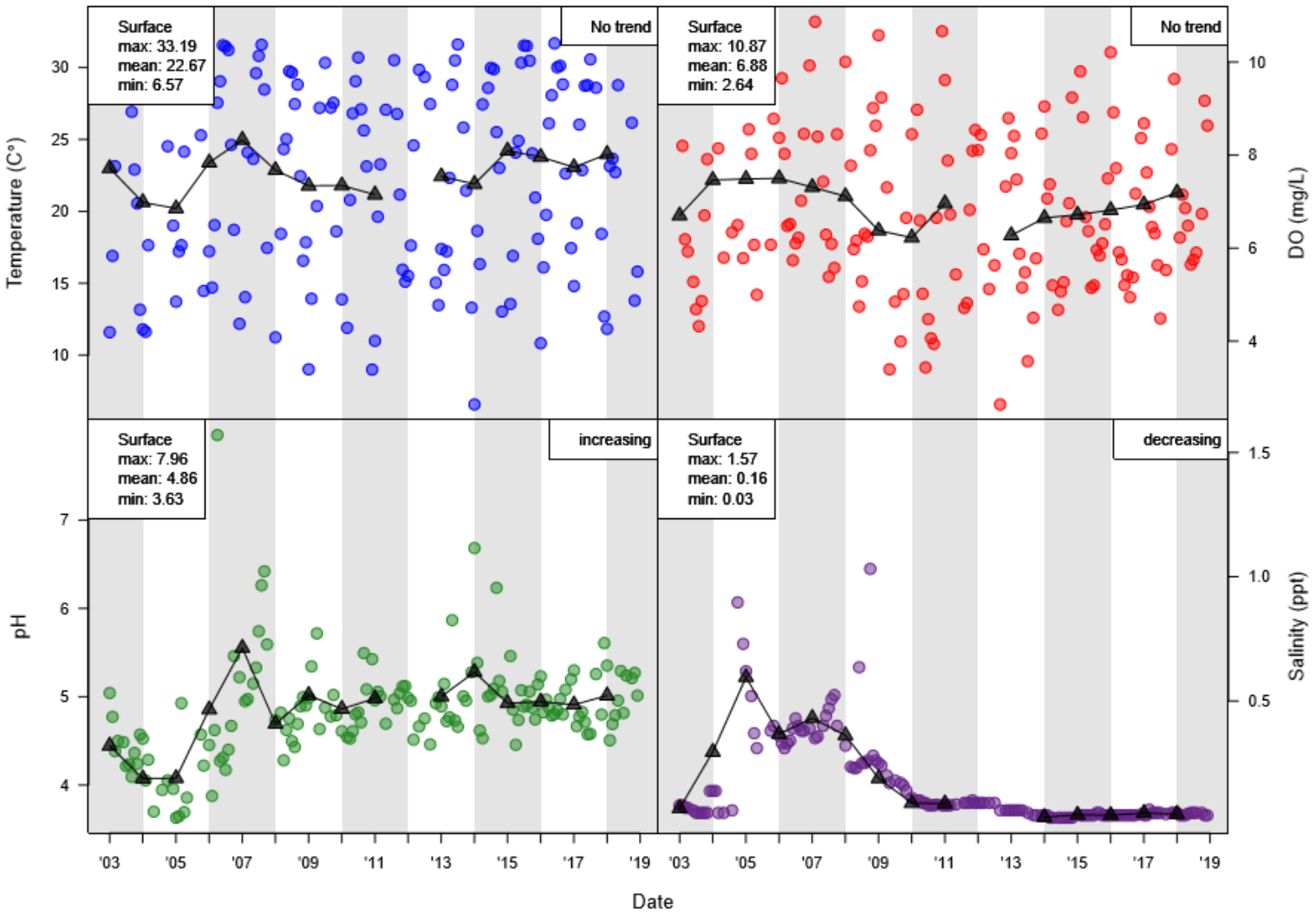
Fuller Lake Water Chemistry Data- 2003 through 2018

Summary statistics include mean, maximum (max), and minimum (min) summary statistics calculated on an annual basis using monthly data for hydrolab data variables; temperature, dissolved oxygen (DO), pH, and salinity as well as nutrient data variables total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), and secchi depth,. Summary statistics and trends represent results from long-term analyses among annual means from 2003 through 2018.

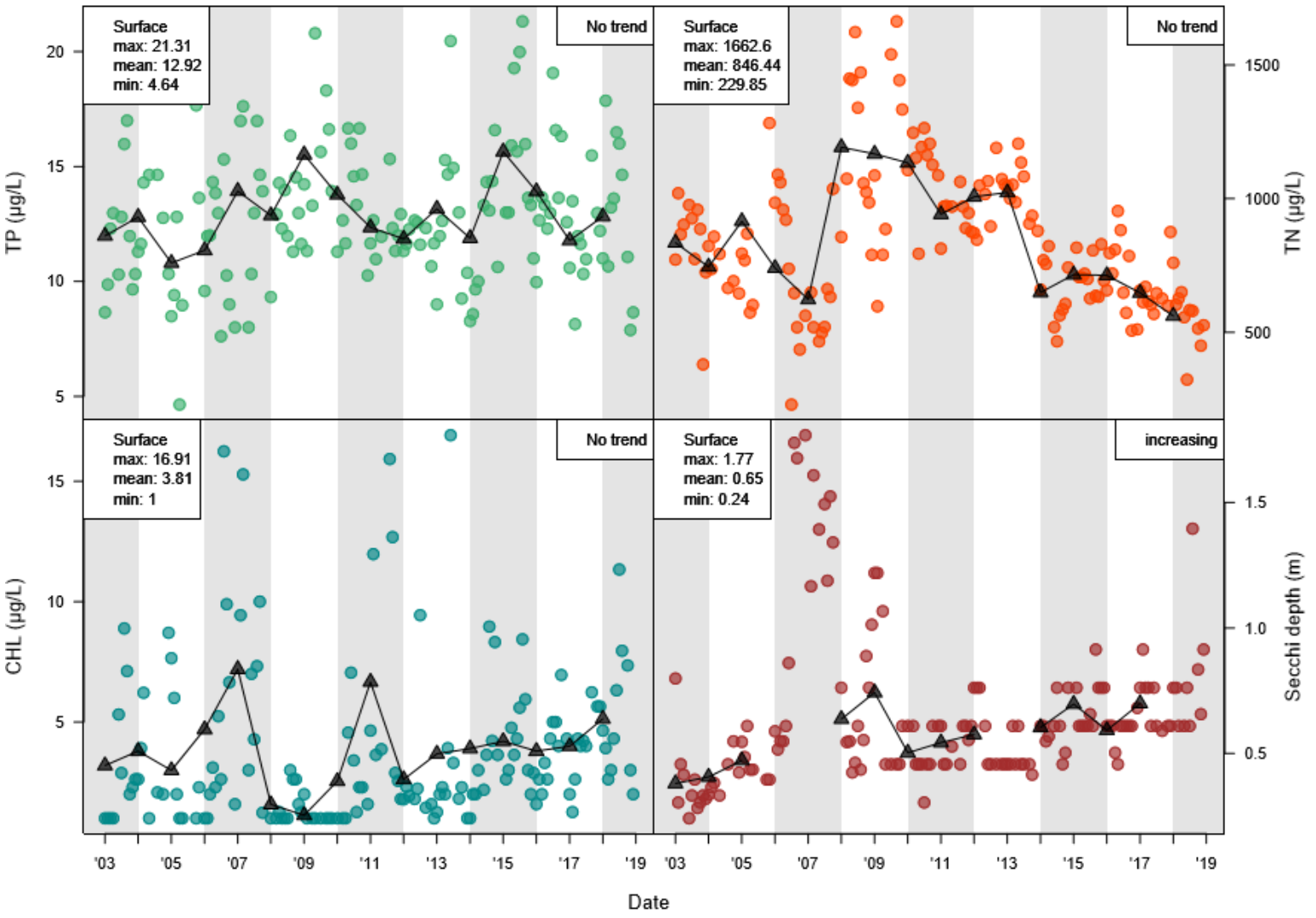
Times series plots display the inter-annual (monthly variability within the year - circles) and intra-annual variance (variability among years - triangles). Columns delineate three year time intervals.

Kendall-Tau trend analysis results are shown for each water chemistry variable on the surface-left of each plot. *No trend* indicates there was no significant trend found among the years examined (2003 through 2018). *Increasing* indicates a significant, positive trend was found over time. *Decreasing* indicates a significant, negative trend was found among the years examined. *Insufficient data* indicates insufficient annual data (year averages) were available for trend analysis.

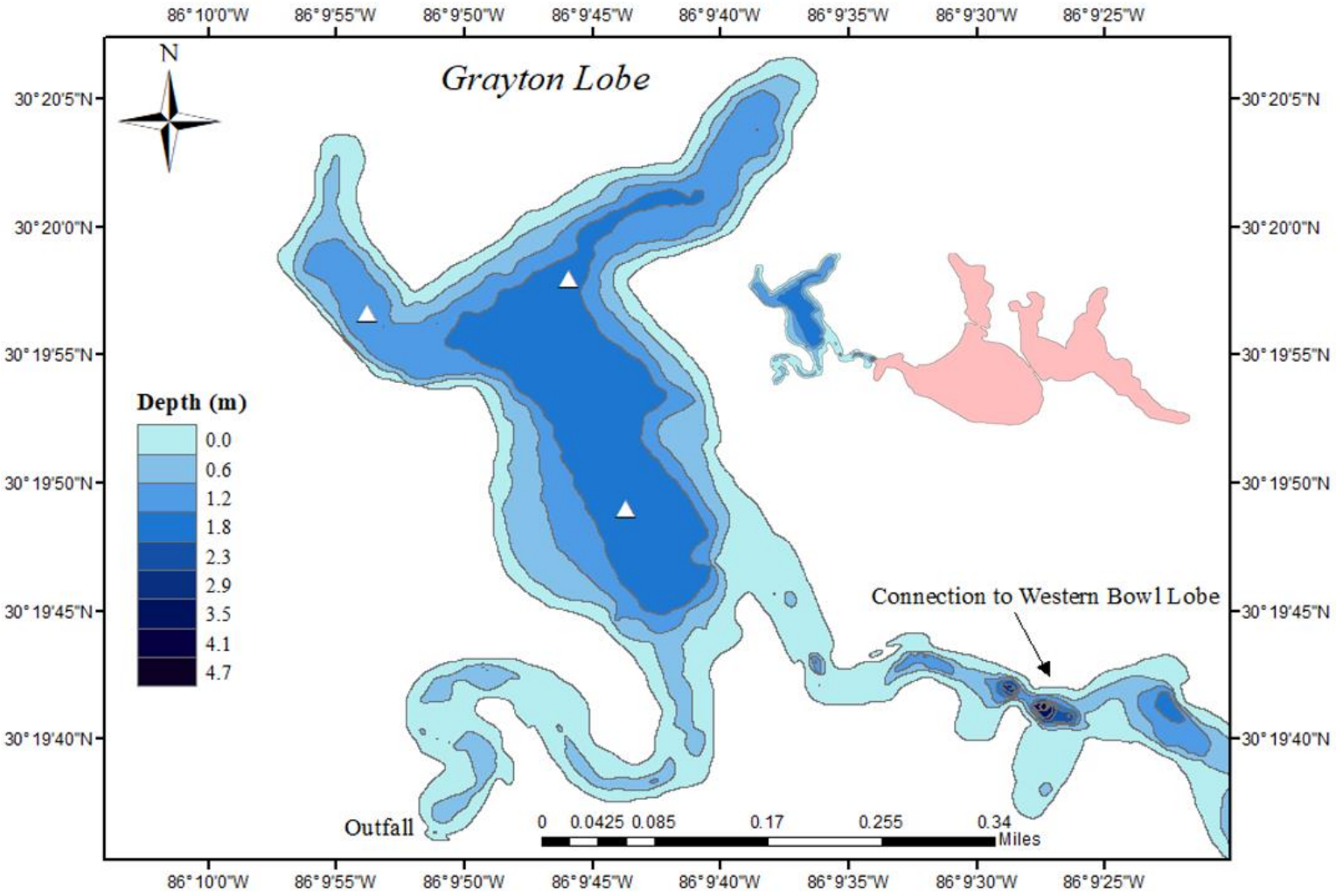
Hydrolab Trend Analyses



Nutrient Trend Analyses



Grayton Lake Lobe, Walton County



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 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. Long-term water chemistry monitoring for Grayton Lobe occurs at three stations denoted as white triangles on the map above. 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 (11 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 ppt each).

Grayton Lake Lobe Water Chemistry Data- 2018

Summary statistics include mean, maximum (Max), minimum (Min), median, and standard error (Std Error) calculated for both surface and bottom measurements for temperature, dissolved oxygen (DO), pH, and salinity, as well as surface measurements total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), secchi depth, as well as. These statistics represent 2018 water chemistry data.

2018 Summary Statistics

	min	mean	max	Std Error
Temperature surface	12.69	24.82	32.28	1.92
Temperature bottom	14.33	24.4	30.54	1.51
DO (mg/L) surface	2.3	6.05	9.56	0.54
DO (mg/L) bottom	0.35	3	6.82	0.66
pH surface	5.81	7.45	8.57	0.2
pH bottom	6.68	7.59	8.35	0.19
Salinity (ppt) surface	3.1	13.16	31.23	2.83
Salinity (ppt) bottom	13.52	25.03	33.95	2.4
TP (µg/L)	10.16	16.13	24.17	1.36
TN (µg/L)	296.4	408	583.31	23.38
CHL (µg/L)	1.82	5.24	11.63	0.85

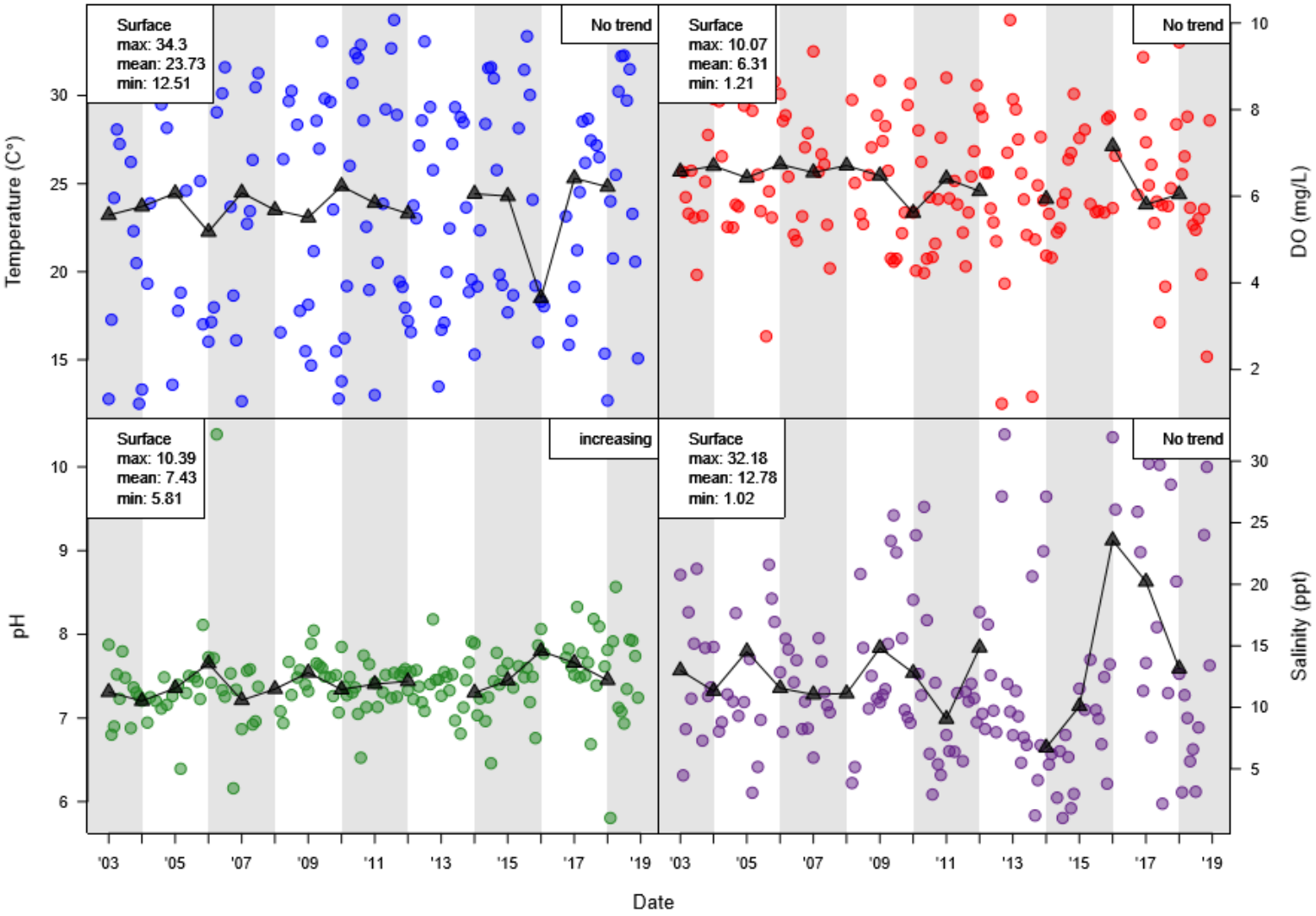
Grayton Lake Lobe Water Chemistry Data- 2003 through 2018

Summary statistics include mean, maximum (max), and minimum (min) summary statistics calculated on an annual basis using monthly data for hydrolab data variables; temperature, dissolved oxygen (DO), pH, and salinity as well as nutrient data variables total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), and secchi depth,. Summary statistics and trends represent results from long-term analyses among annual means from 2003 through 2018.

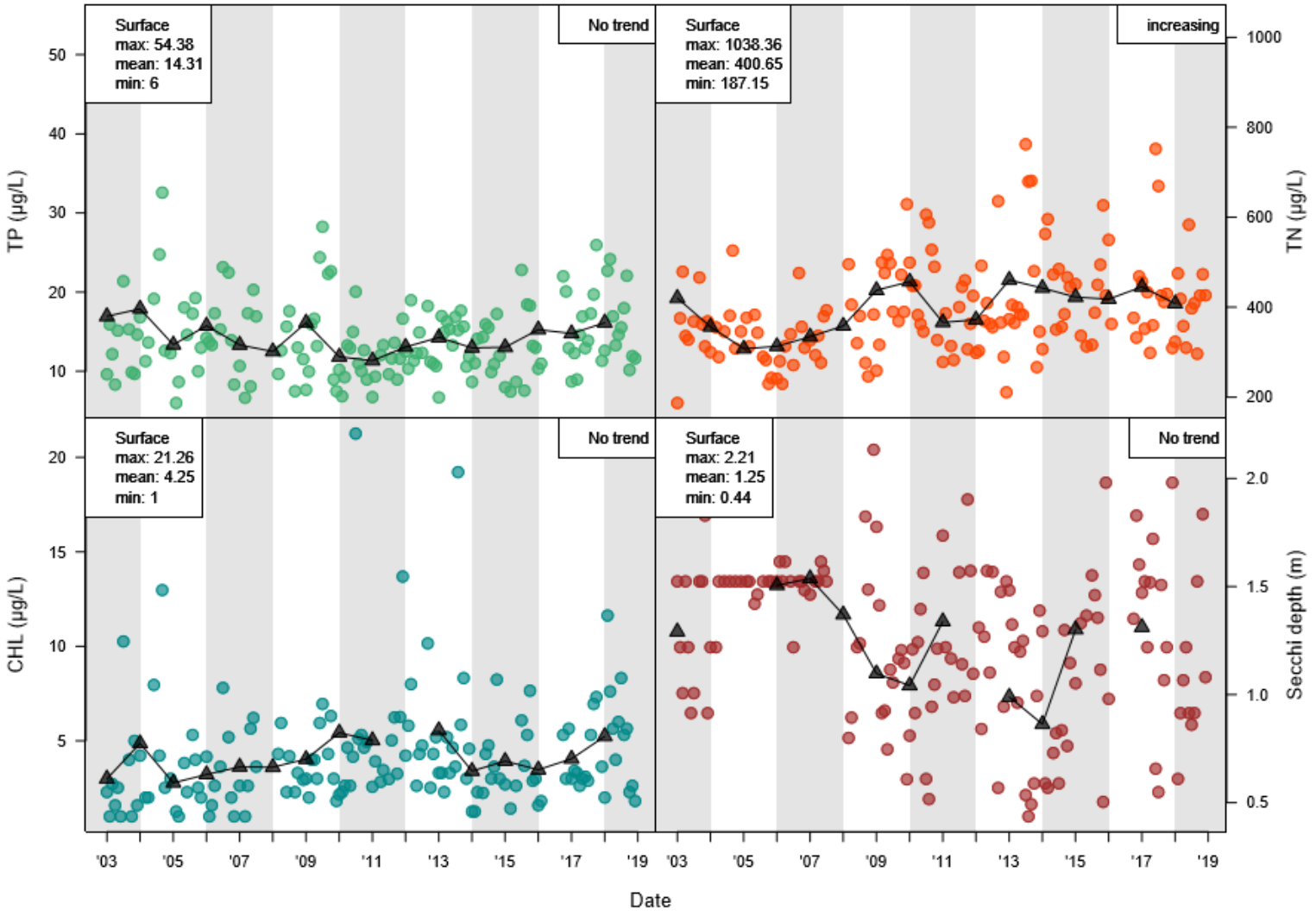
Times series plots display the inter-annual (monthly variability within the year - circles) and intra-annual variance (variability among years - triangles). Columns delineate three year time intervals.

Kendall-Tau trend analysis results are shown for each water chemistry variable on the surface-left of each plot. No trend indicates there was no significant trend found among the years examined (2003 through 2018). Increasing indicates a significant, positive trend was found over time. Decreasing indicates a significant, negative trend was found among the years examined. Insufficient data indicates insufficient annual data (year averages) were available for trend analysis.

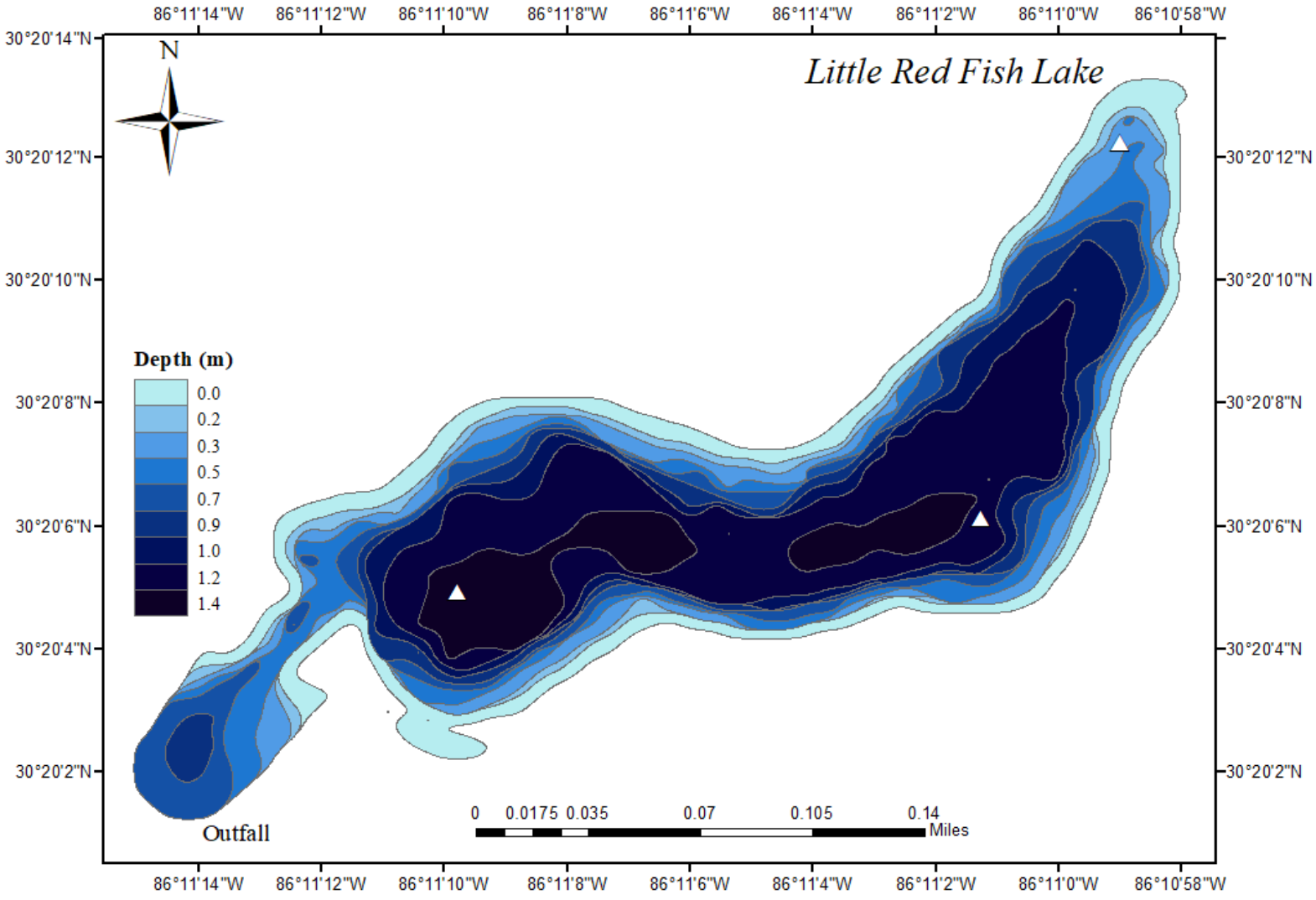
Hydrolab Trend Analyses



Nutrient Trend Analyses



Little Red Fish Lake, Walton County



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. Long-term water chemistry monitoring for Little Red Fish Lake occurs at three stations denoted as white triangles on the map above. The system contains an outfall and frequently connects to the gulf. This, coupled with its small size, results in an intermediate average salinity value (3.5 ppt) with large fluctuations in water chemistry depending on rainfall and seawater connections.

Little Red Fish Lake Water Chemistry Data- 2018

Summary statistics include mean, maximum (Max), minimum (Min), median, and standard error (Std Error) calculated for both surface and bottom measurements for temperature, dissolved oxygen (DO), pH, and salinity, as well as surface measurements total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), secchi depth, as well as. These statistics represent 2018 water chemistry data.

2018 Summary Statistics

	min	mean	max	Std Error
Temperature surface	14.9	24.36	32.67	2.12
Temperature bottom	10.43	11.92	13.41	0.67
DO (mg/L) surface	4.34	6.84	9.66	0.49
DO (mg/L) bottom	2.46	3.75	5.03	0.58
pH surface	6.88	7.57	8.23	0.15
pH bottom	6.73	7.06	7.38	0.15
Salinity (ppt) surface	6.15	15.96	28.84	2.83
Salinity (ppt) bottom	7.91	8.4	8.88	0.22
TP (µg/L)	8.85	17.55	22.32	1.4
TN (µg/L)	327	483.66	660	37.89
CHL (µg/L)	2	5.73	11.66	0.91

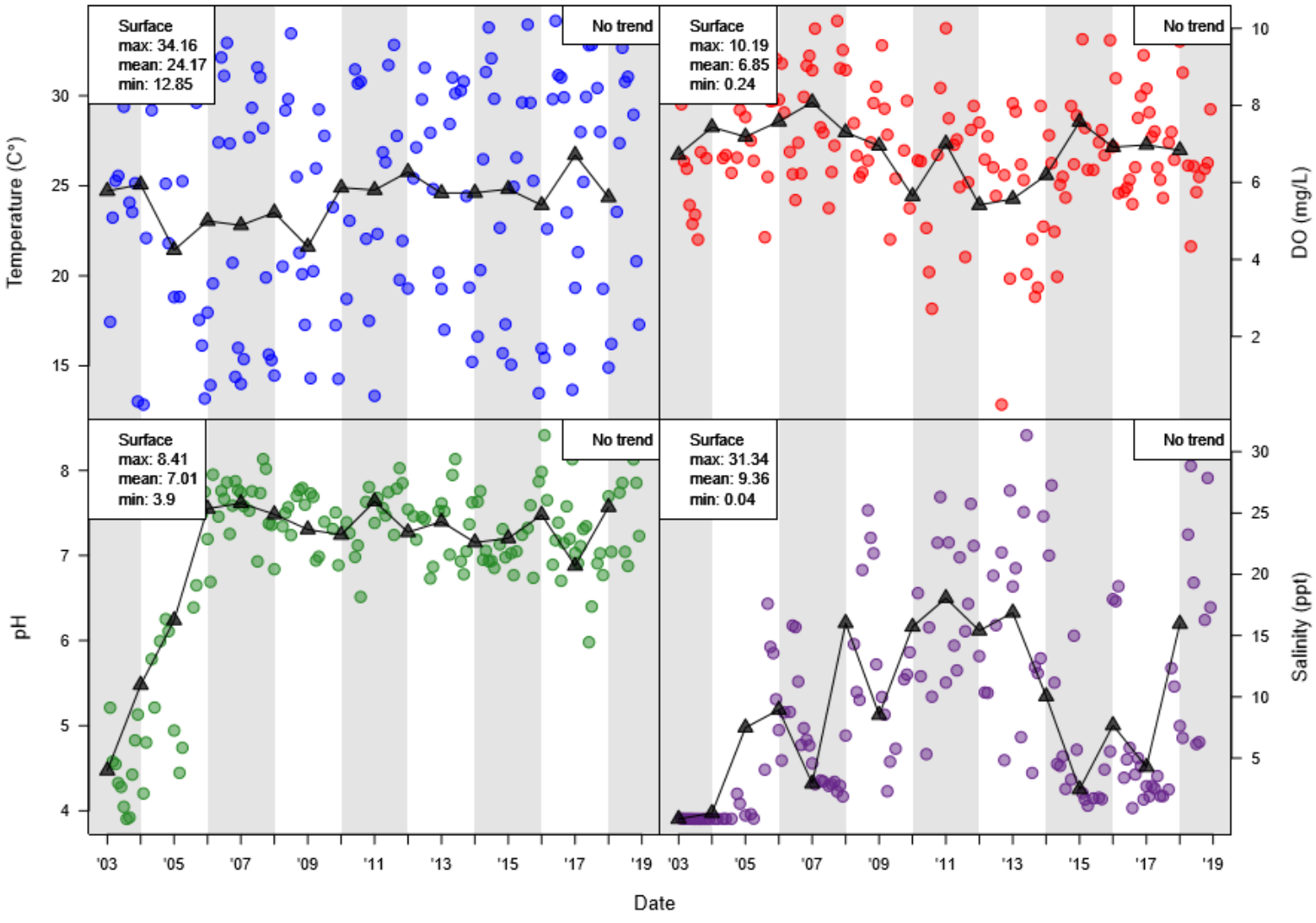
Little Red Fish Lake Water Chemistry Data- 2003 through 2018

Summary statistics include mean, maximum (max), and minimum (min) summary statistics calculated on an annual basis using monthly data for hydrolab data variables; temperature, dissolved oxygen (DO), pH, and salinity as well as nutrient data variables total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), and secchi depth,. Summary statistics and trends represent results from long-term analyses among annual means from 2003 through 2018.

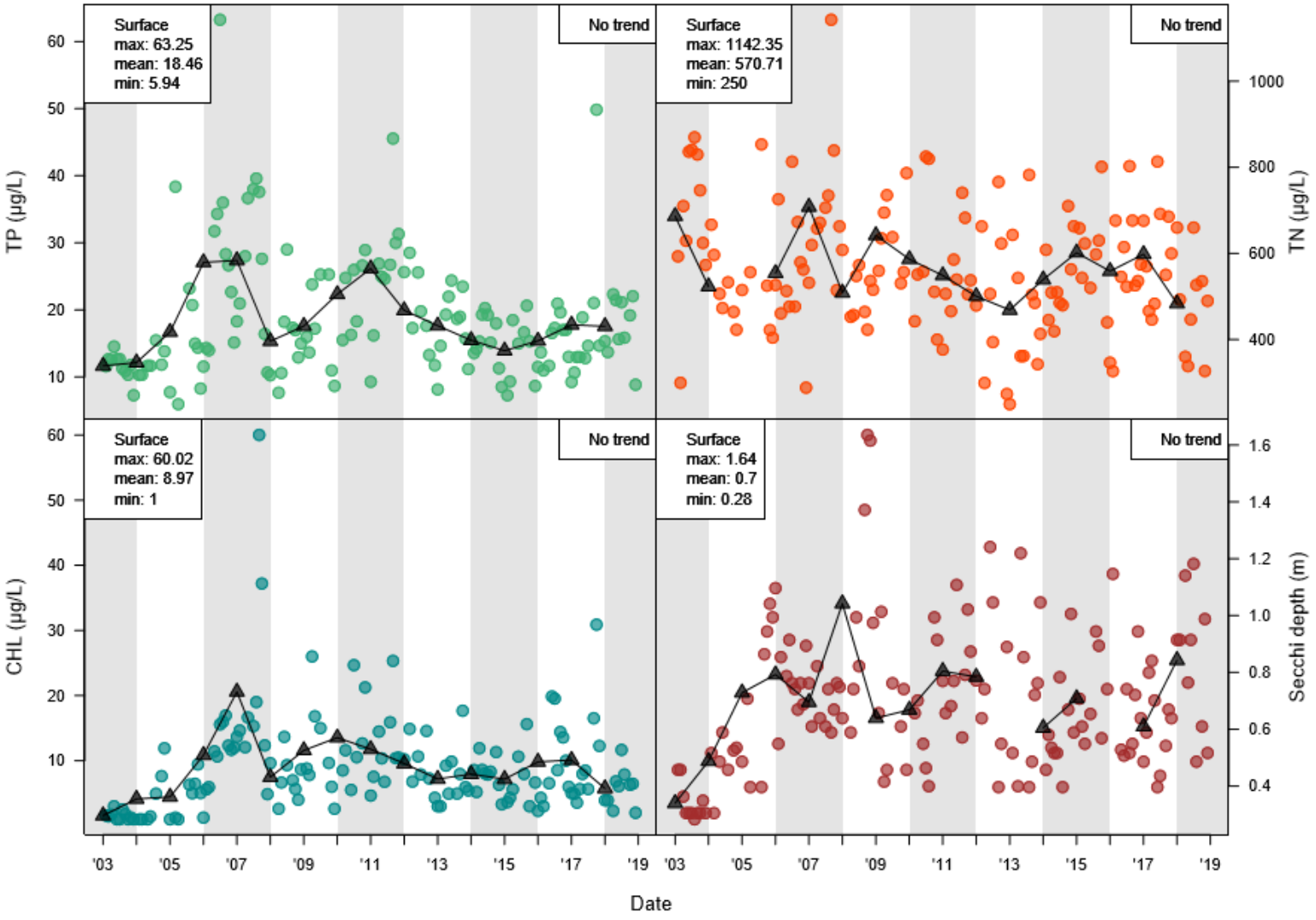
Times series plots display the inter-annual (monthly variability within the year - circles) and intra-annual variance (variability among years - triangles). Columns delineate three year time intervals.

Kendall-Tau trend analysis results are shown for each water chemistry variable on the surface-left of each plot. No trend indicates there was no significant trend found among the years examined (2003 through 2018). Increasing indicates a significant, positive trend was found over time. Decreasing indicates a significant, negative trend was found among the years examined. Insufficient data indicates insufficient annual data (year averages) were available for trend analysis.

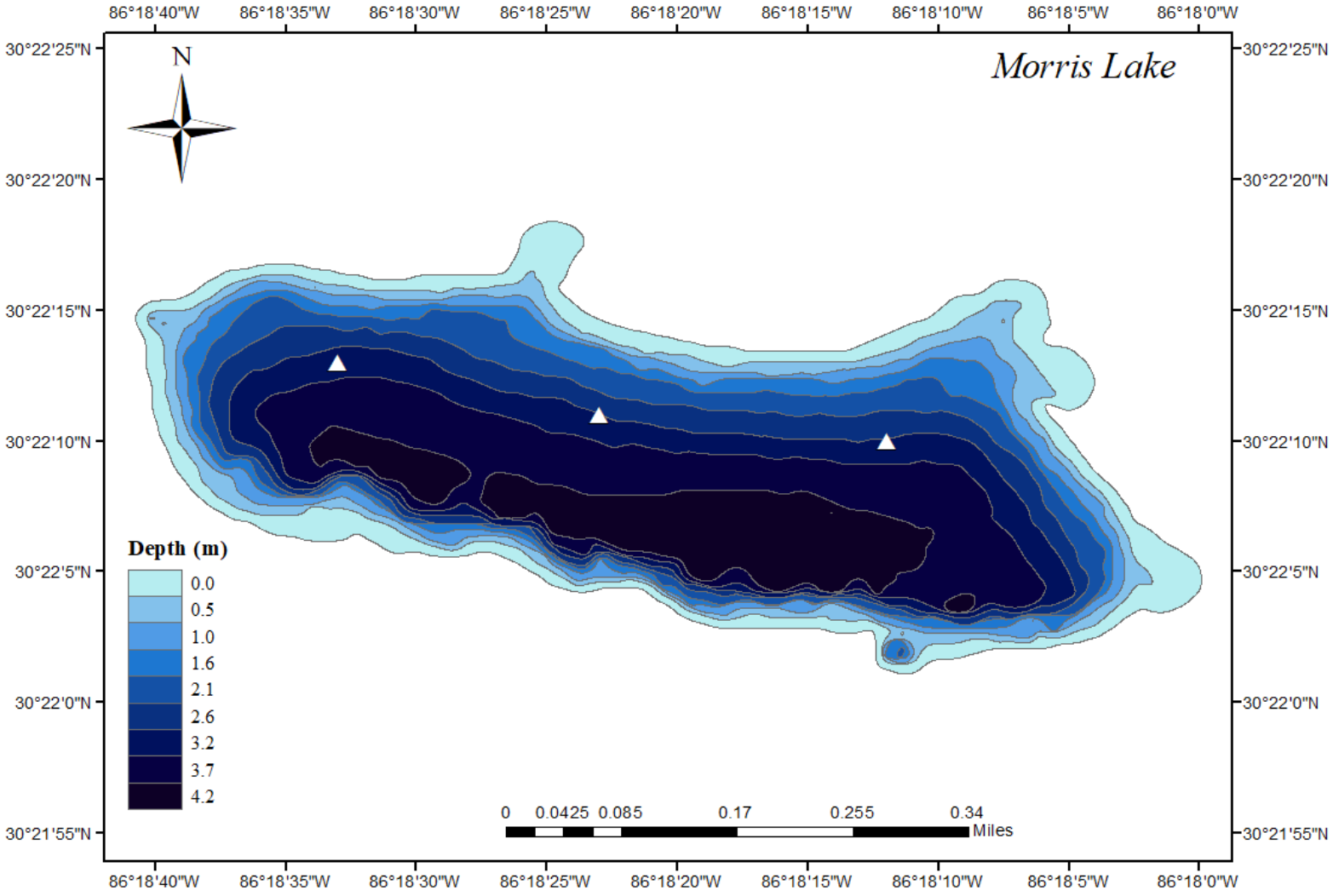
Hydrolab Trend Analyses



Nutrient Trend Analyses



Morris Lake, Walton County



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. Long-term water chemistry monitoring for Morris Lake occurs at three stations denoted as white triangles on the map above. While the system does contain an outfall, Morris Lake seldom connects to the gulf. As a result the system is primarily freshwater (0.25 ppt).

Morris Lake Water Chemistry Data- 2018

Summary statistics include mean, maximum (Max), minimum (Min), median, and standard error (Std Error) calculated for both surface and bottom measurements for temperature, dissolved oxygen (DO), pH, and salinity, as well as surface measurements total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), secchi depth, as well as. These statistics represent 2018 water chemistry data.

2018 Summary Statistics

	min	mean	max	Std Error
Temperature surface	9.52	24.13	31.93	1.98
Temperature bottom	9.28	21.84	29.15	1.75
DO (mg/L) surface	6.65	7.83	11.24	0.37
DO (mg/L) bottom	2.54	6.44	11.08	0.72
pH surface	5.11	5.86	6.63	0.16
pH bottom	5.03	5.79	7.17	0.2
Salinity (ppt) surface	0.09	0.11	0.14	0.01
Salinity (ppt) bottom	0.09	0.11	0.14	0.01
TP (µg/L)	7.96	12.01	25.39	1.35
TN (µg/L)	380	454.43	656.65	23.14
CHL (µg/L)	2	3.18	6	0.39

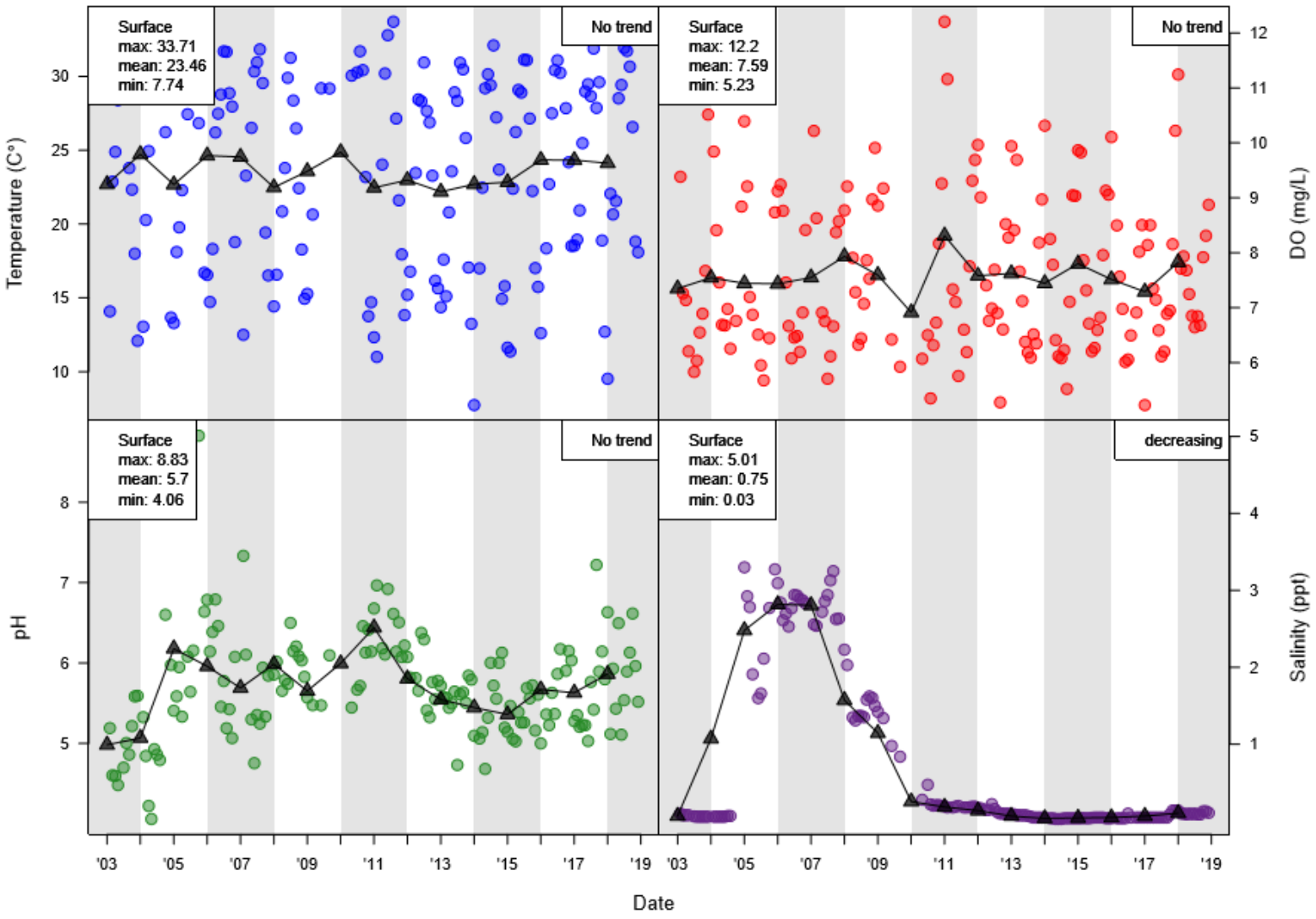
Morris Lake Water Chemistry Data- 2003 through 2018

Summary statistics include mean, maximum (max), and minimum (min) summary statistics calculated on an annual basis using monthly data for hydrolab data variables; temperature, dissolved oxygen (DO), pH, and salinity as well as nutrient data variables total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), and secchi depth,. Summary statistics and trends represent results from long-term analyses among annual means from 2003 through 2018.

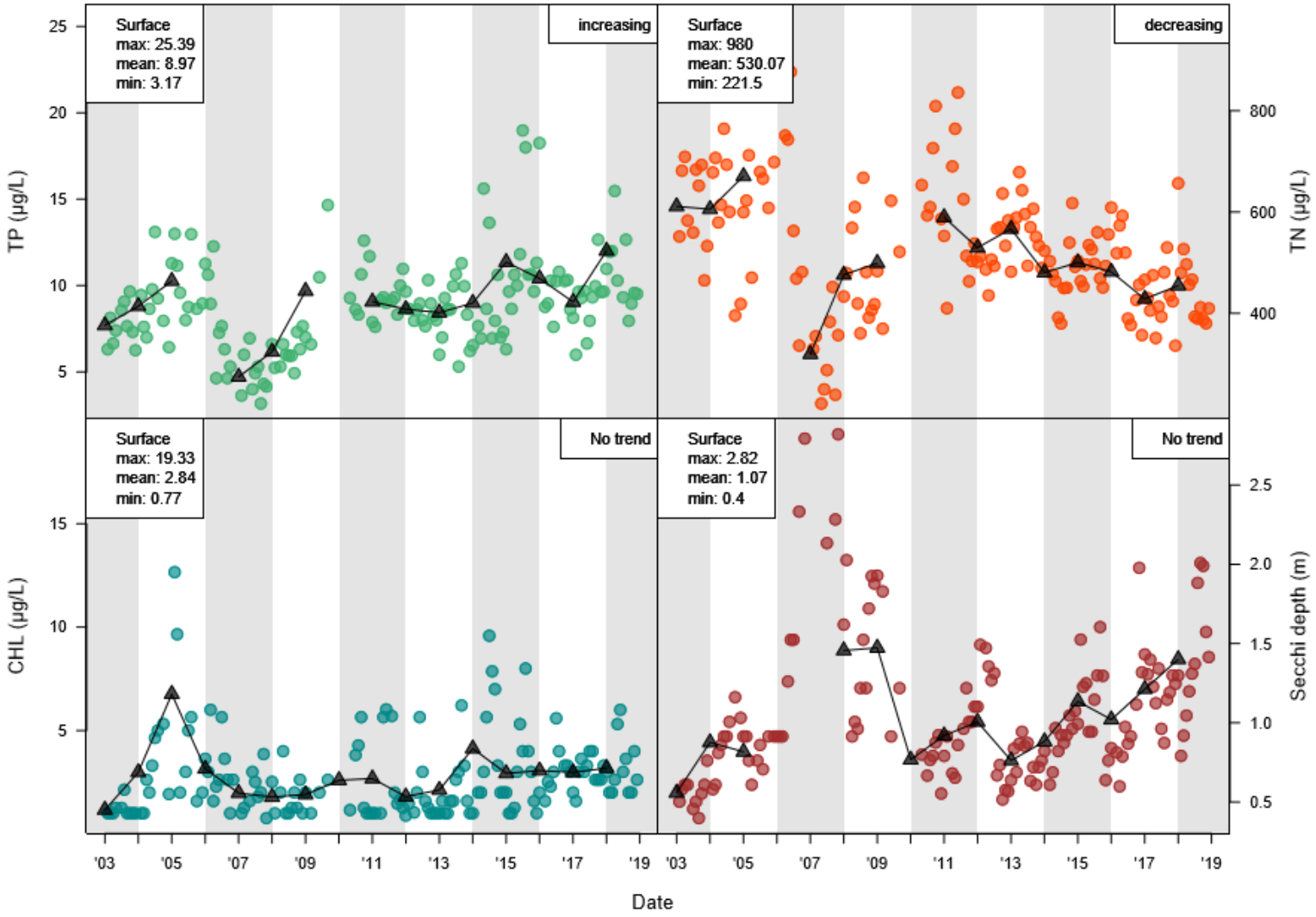
Times series plots display the inter-annual (monthly variability within the year - circles) and intra-annual variance (variability among years - triangles). Columns delineate three year time intervals.

Kendall-Tau trend analysis results are shown for each water chemistry variable on the surface-left of each plot. No trend indicates there was no significant trend found among the years examined (2003 through 2018). Increasing indicates a significant, positive trend was found over time. Decreasing indicates a significant, negative trend was found among the years examined. Insufficient data indicates insufficient annual data (year averages) were available for trend analysis.

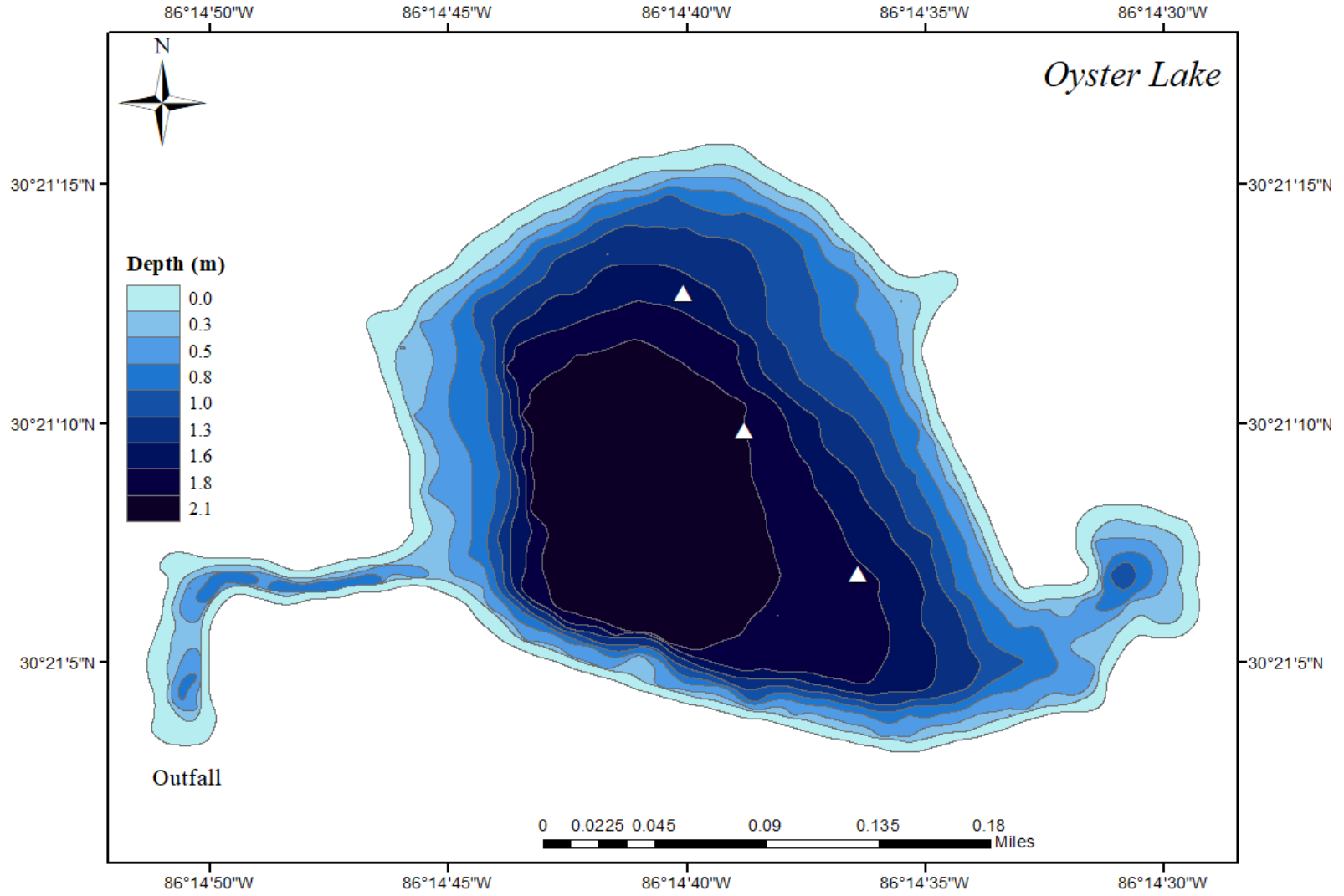
Hydrolab Trend Analyses



Nutrient Trend Analyses



Oyster Lake, Walton County



Lake Description

Oyster Lake is a teardrop-shaped system approximately 200 meters away from the Gulf of Mexico. Oyster Lake is a 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. Long-term water chemistry monitoring for Oyster Lake occurs at three stations denoted as white triangles on the map above. Trend analyses of water chemistry variables in Oyster Lake indicate significantly increasing salinity and pH, although this trend began after the connectivity was reestablished between the system and the gulf, and likely reflects the restored hydrology.

Oyster Lake Water Chemistry Data- 2018

Summary statistics include mean, maximum (Max), minimum (Min), median, and standard error (Std Error) calculated for both surface and bottom measurements for temperature, dissolved oxygen (DO), pH, and salinity, as well as surface measurements total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), secchi depth, as well as. These statistics represent 2018 water chemistry data.

2018 Summary Statistics

	min	mean	max	Std Error
Temperature surface	14.03	24.97	35.2	2.27
Temperature bottom	11.31	23	31.02	2.01
DO (mg/L) surface	5.17	8.1	10.66	0.47
DO (mg/L) bottom	0.48	4.61	9.74	1.05
pH surface	7.71	7.98	8.58	0.08
pH bottom	7.08	7.51	8.02	0.1
Salinity (ppt) surface	3.9	7.96	25.37	2.1
Salinity (ppt) bottom	4.88	11.33	27.9	2.09
TP (µg/L)	16.04	61.76	90.33	6.65
TN (µg/L)	514.59	1117.55	2093.98	150.23
CHL (µg/L)	15.66	35.4	63.57	5.4

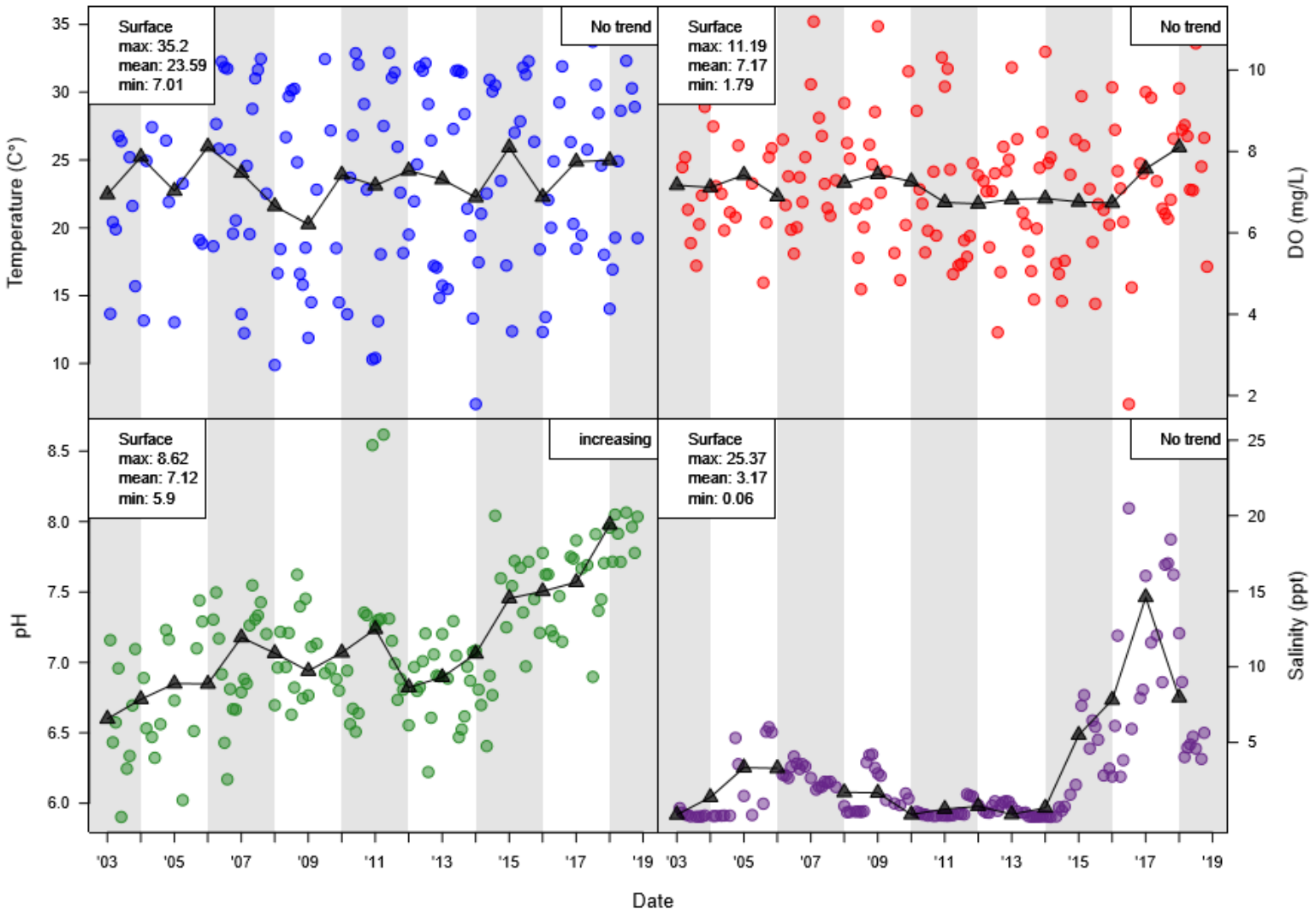
Oyster Lake Water Chemistry Data- 2003 through 2018

Summary statistics include mean, maximum (max), and minimum (min) summary statistics calculated on an annual basis using monthly data for hydrolab data variables; temperature, dissolved oxygen (DO), pH, and salinity as well as nutrient data variables total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), and secchi depth,. Summary statistics and trends represent results from long-term analyses among annual means from 2003 through 2018.

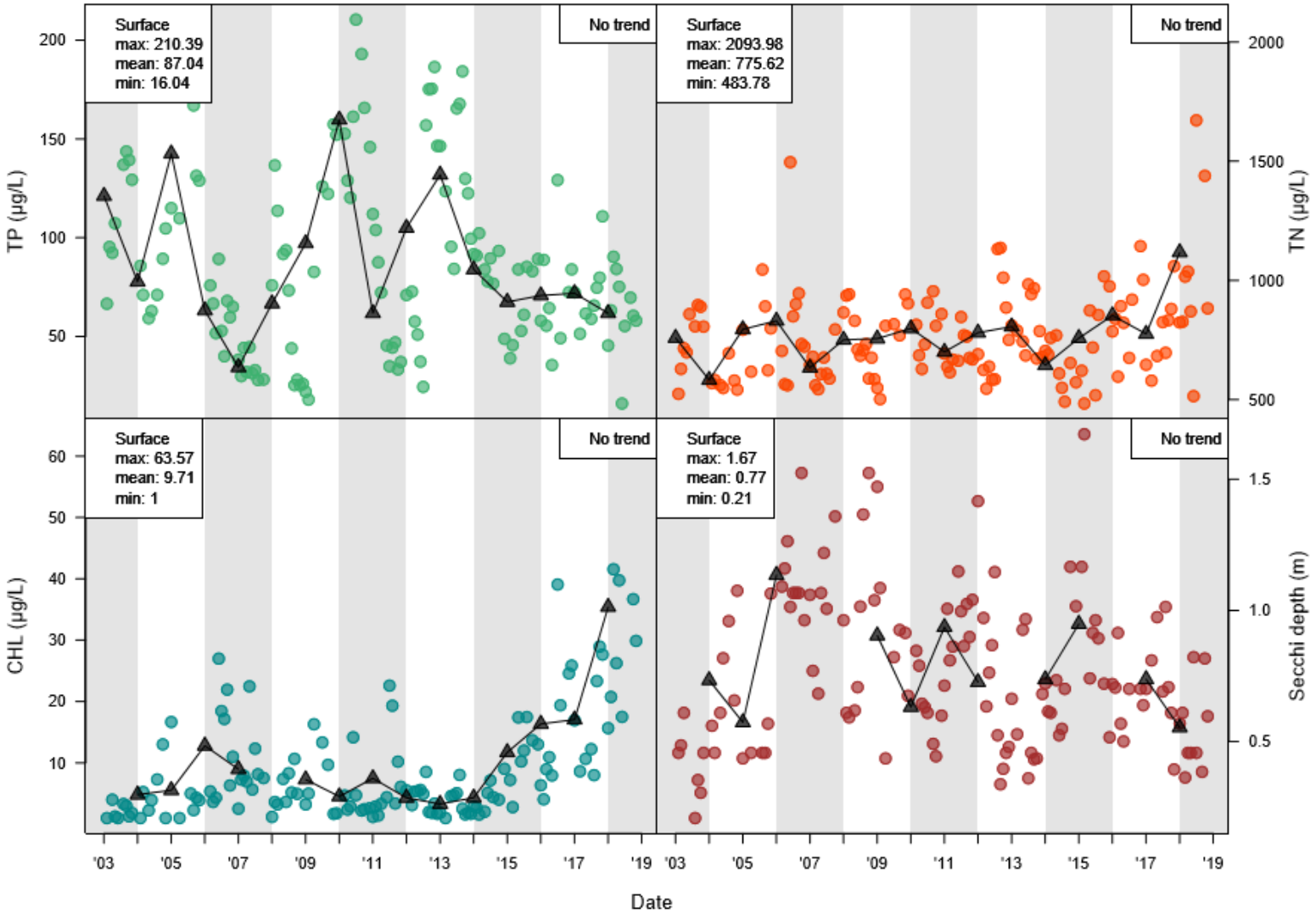
Times series plots display the inter-annual (monthly variability within the year - circles) and intra-annual variance (variability among years - triangles). Columns delineate three year time intervals.

Kendall-Tau trend analysis results are shown for each water chemistry variable on the surface-left of each plot. No trend indicates there was no significant trend found among the years examined (2003 through 2018). Increasing indicates a significant, positive trend was found over time. Decreasing indicates a significant, negative trend was found among the years examined. Insufficient data indicates insufficient annual data (year averages) were available for trend analysis.

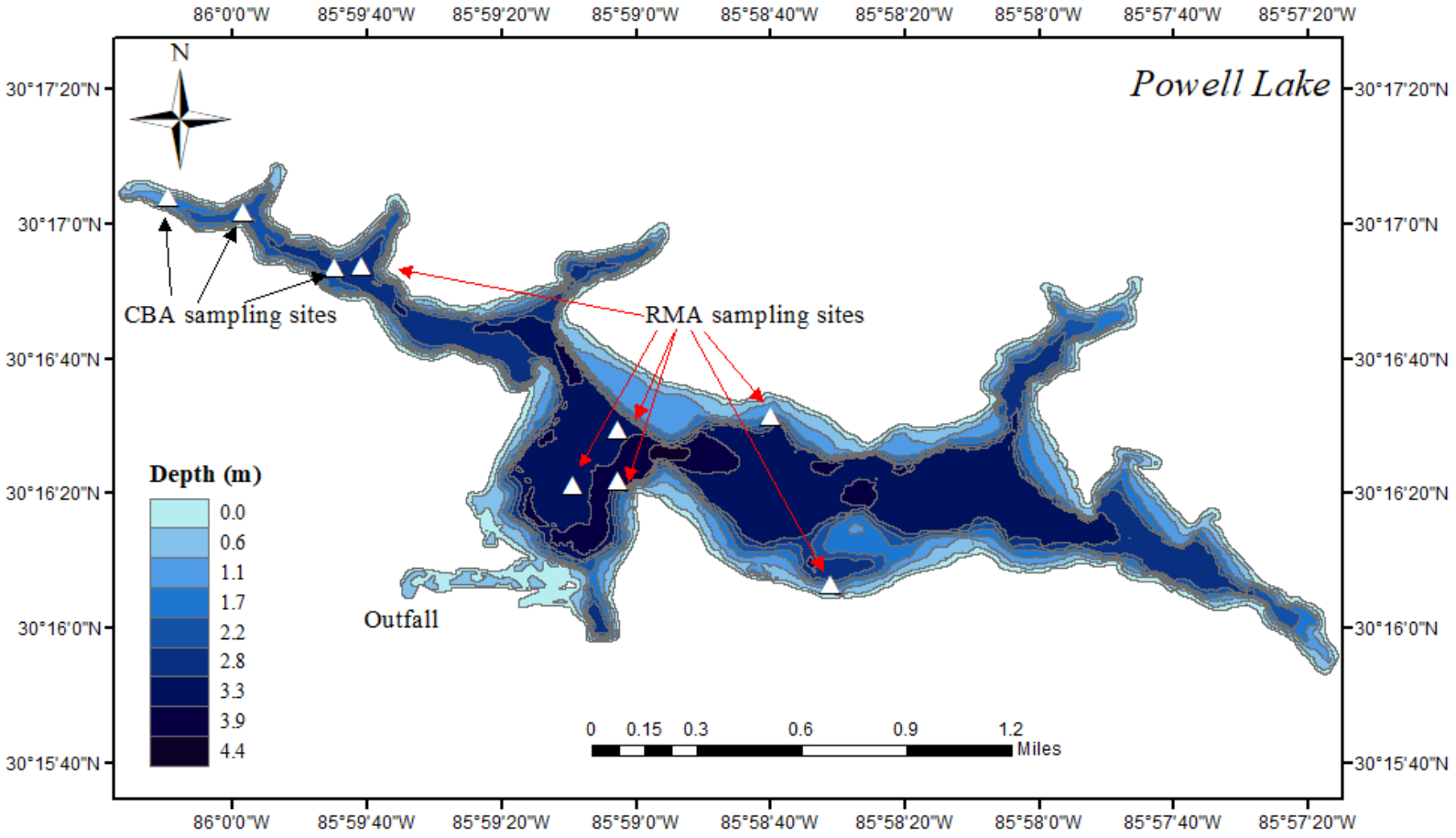
Hydrolab Trend analyses



Nutrient Trend Analyses



Powell Lake, Walton and Bay County



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. Because of this, 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. Sampling stations are depicted as white triangles in the map above. Powell Lake has an outfall which frequently connects to the gulf. As a result, Powell Lake has the highest inter-annual salinity of all the coastal dune lake systems (14 ppt).

Powell Lake Water Chemistry Data- 2018

Summary statistics include mean, maximum (Max), minimum (Min), median, and standard error (Std Error) calculated for both surface and bottom measurements for temperature, dissolved oxygen (DO), pH, and salinity, as well as surface measurements total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), secchi depth, as well as. These statistics represent 2018 water chemistry data.

2018 Summary Statistics

	min	mean	max	Std Error
Temperature surface	11.92	23.11	32.31	2.27
Temperature bottom	11.32	22.85	31.14	2.03
DO (mg/L) surface	3.56	6.06	8.54	0.49
DO (mg/L) bottom	0.35	3.78	8.52	0.83
pH surface	6.49	7.1	7.65	0.11
pH bottom	6.55	7.18	7.71	0.11
Salinity (ppt) surface	4.09	9.35	16.97	1.2
Salinity (ppt) bottom	8.01	13.16	20.2	1.39
TP (µg/L)	8.24	15.32	23.99	1.63
TN (µg/L)	283.29	444.85	717.72	48.41
CHL (µg/L)	2.62	5.13	9.32	0.64

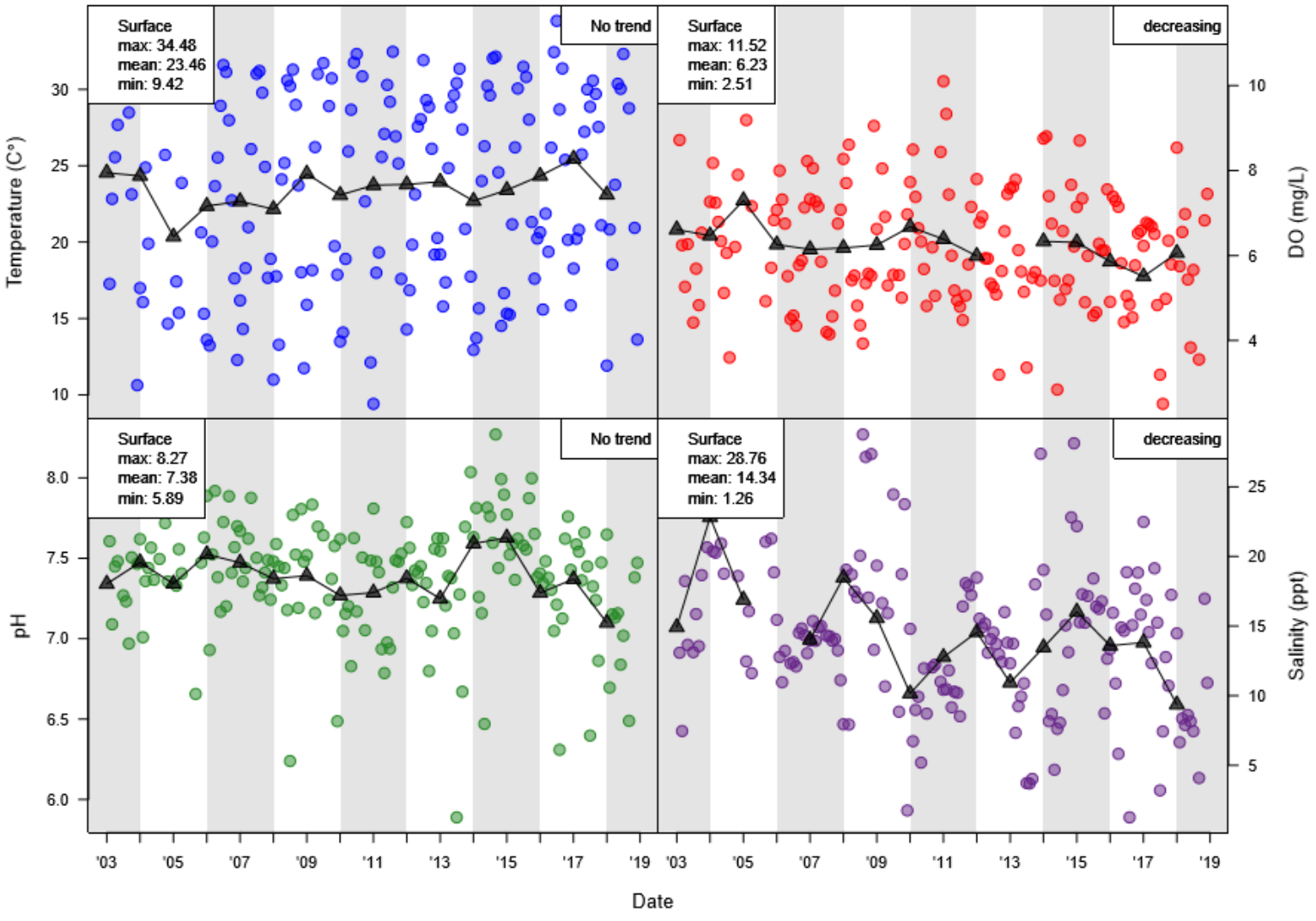
Powell Lake Water Chemistry Data- 2003 through 2018

Summary statistics include mean, maximum (max), and minimum (min) summary statistics calculated on an annual basis using monthly data for hydrolab data variables; temperature, dissolved oxygen (DO), pH, and salinity as well as nutrient data variables total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), and secchi depth,. Summary statistics and trends represent results from long-term analyses among annual means from 2003 through 2018.

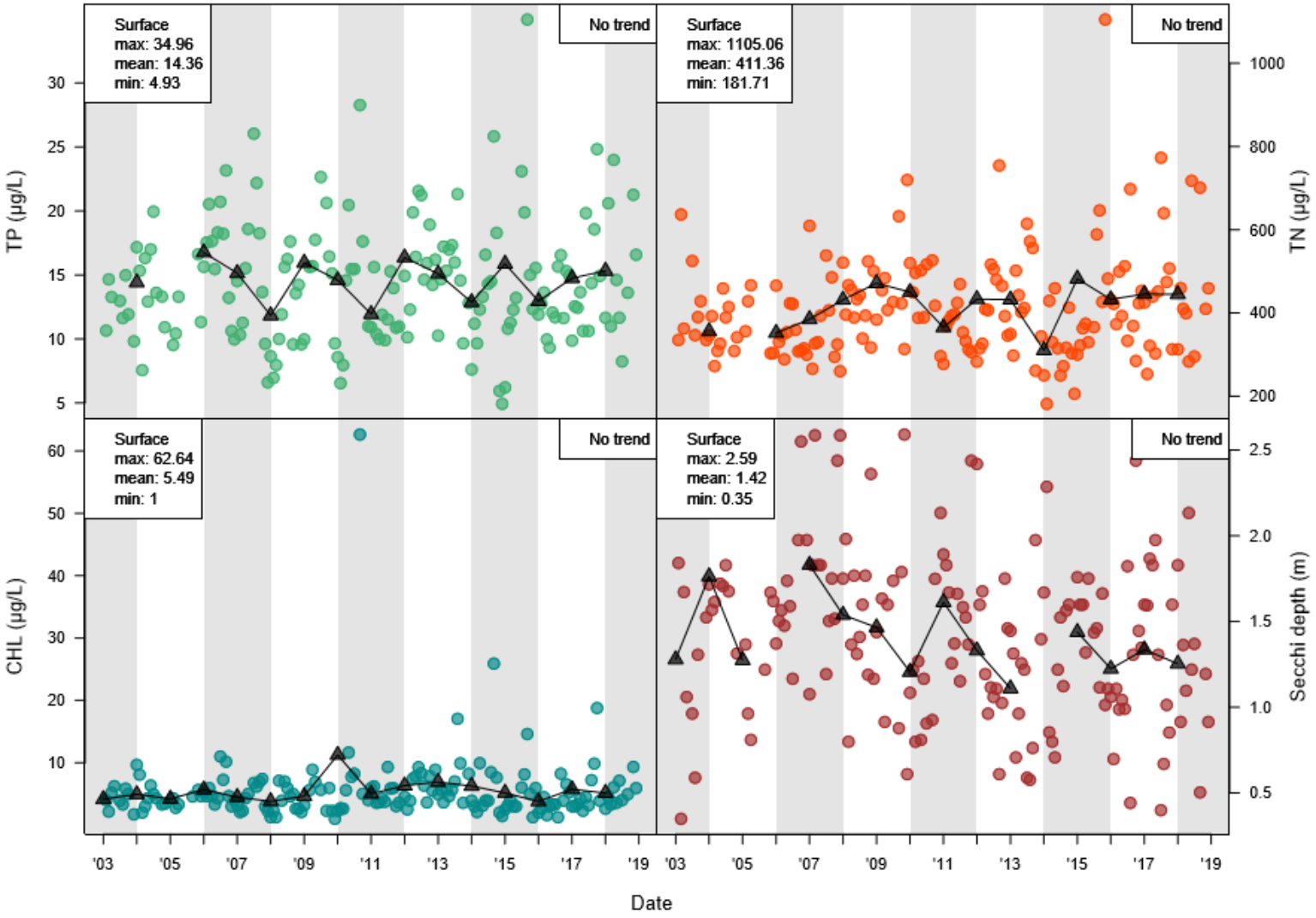
Times series plots display the inter-annual (monthly variability within the year - circles) and intra-annual variance (variability among years - triangles). Columns delineate three year time intervals.

Kendall-Tau trend analysis results are shown for each water chemistry variable on the surface-left of each plot. No trend indicates there was no significant trend found among the years examined (2003 through 2018). Increasing indicates a significant, positive trend was found over time. Decreasing indicates a significant, negative trend was found among the years examined. Insufficient data indicates insufficient annual data (year averages) were available for trend analysis.

Hydrolab Trend Analyses

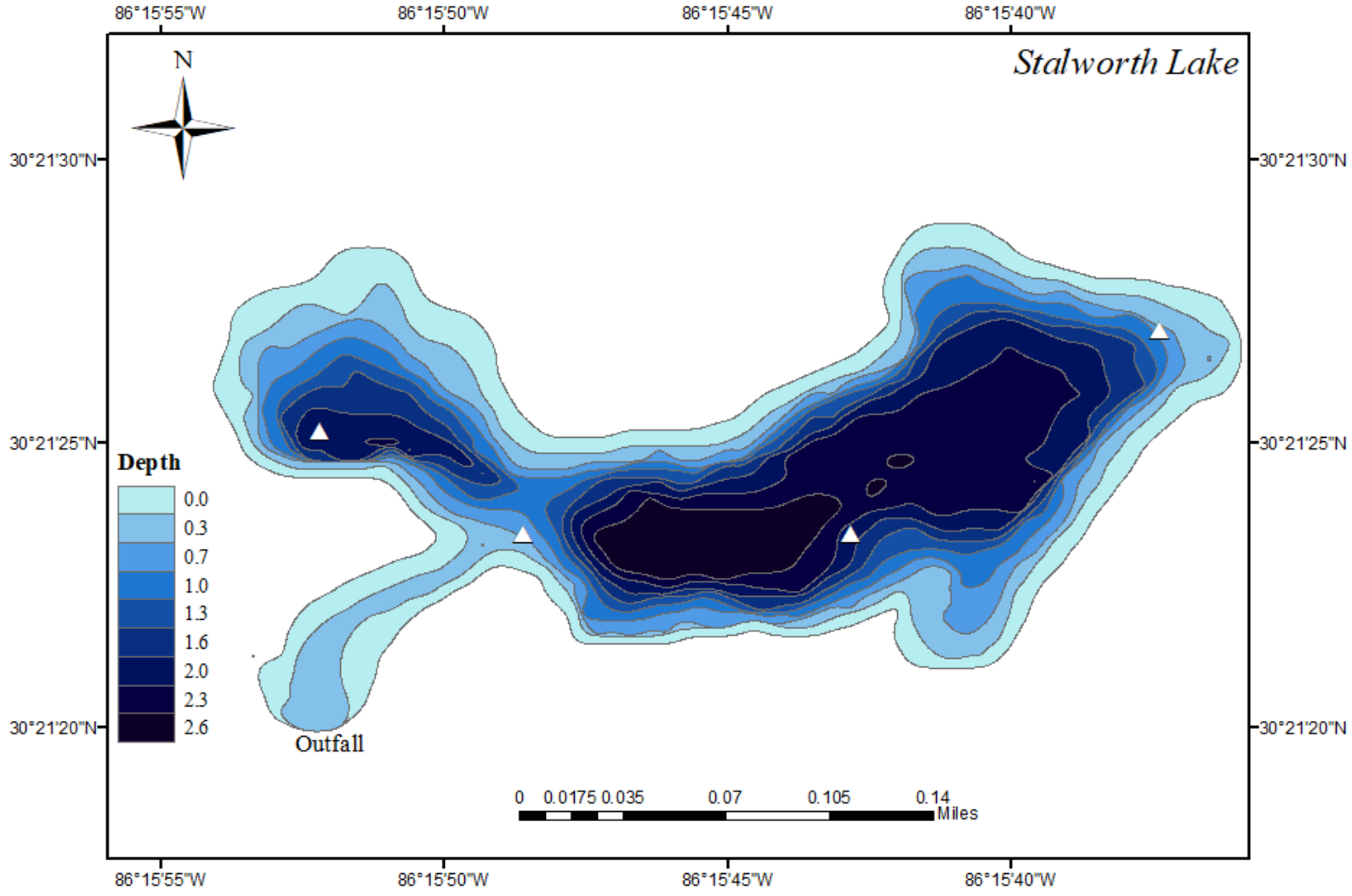


Nutrient Trend Analyses



.

Stallworth Lake, Walton County



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. Long-term water chemistry monitoring for Stalworth Lake occurs at four stations denoted as white triangles on the map above. Stallworth Lake has an outfall which infrequently connects to the gulf. As a result the system is primarily freshwater (0.77 ppt).

Stallworth Lake Water Chemistry Data- 2018

Summary statistics include mean, maximum (Max), minimum (Min), median, and standard error (Std Error) calculated for both surface and bottom measurements for temperature, dissolved oxygen (DO), pH, and salinity, as well as surface measurements total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), secchi depth, as well as. These statistics represent 2018 water chemistry data.

2018 Summary Statistics

	min	mean	max	Std Error
Temperature surface	15.4	23.68	33.17	2.19
Temperature bottom	13.99	23	31.31	1.8
DO (mg/L) surface	5.68	7.22	9.81	0.4
DO (mg/L) bottom	0.77	2.78	7.66	0.63
pH surface	6	7.04	7.77	0.16
pH bottom	5.74	6.93	7.6	0.17
Salinity (ppt) surface	2.22	3.75	6.69	0.49
Salinity (ppt) bottom	3.64	7.85	18.03	1.32
TP (µg/L)	6.98	13.58	19.96	1.34
TN (µg/L)	257.29	328.41	394.59	14.56
CHL (µg/L)	2.71	6.59	10.19	0.65

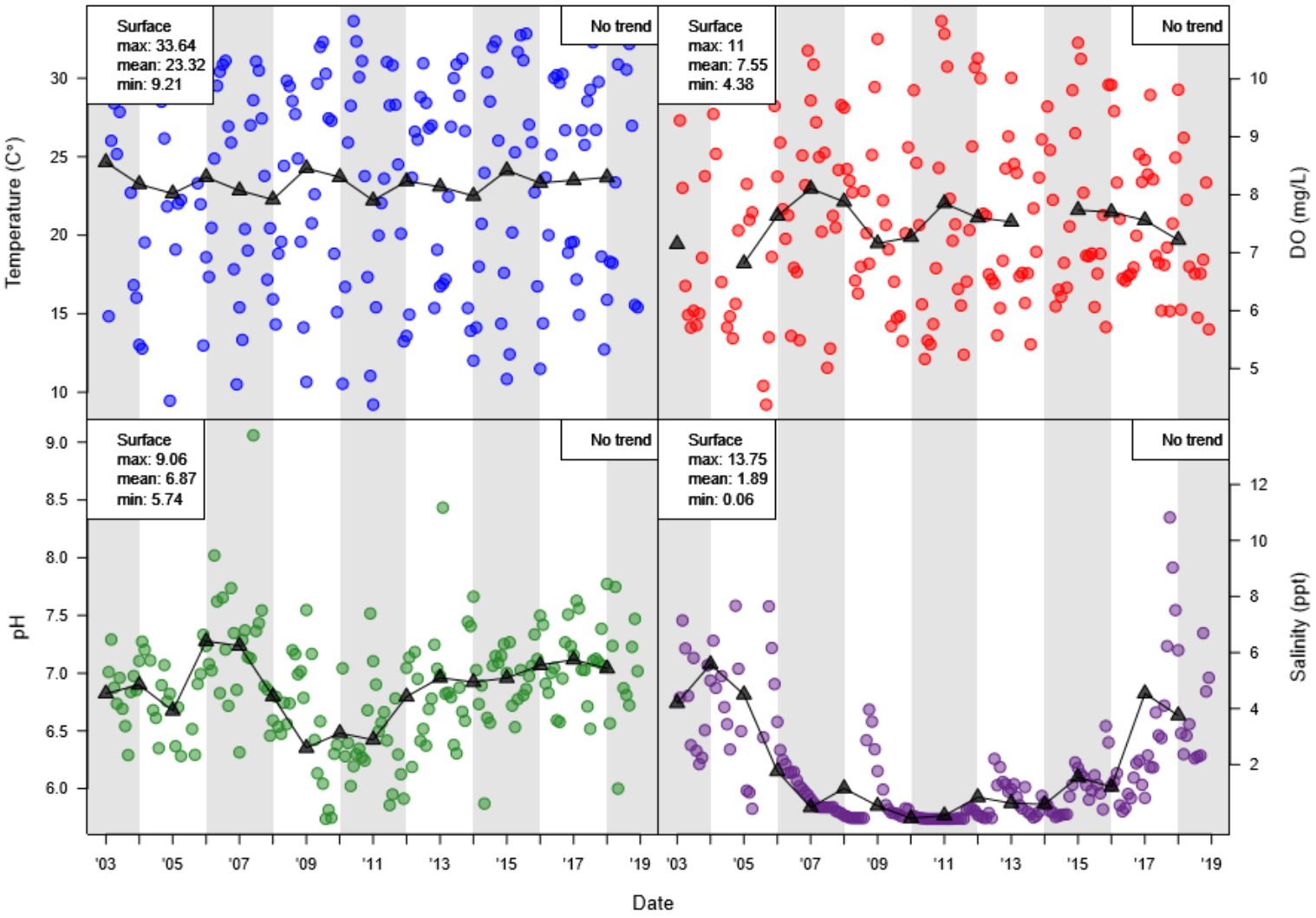
Stallworth Lake Water Chemistry Data- 2003 through 2018

Summary statistics include mean, maximum (max), and minimum (min) summary statistics calculated on an annual basis using monthly data for hydrolab data variables; temperature, dissolved oxygen (DO), pH, and salinity as well as nutrient data variables total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), and secchi depth,. Summary statistics and trends represent results from long-term analyses among annual means from 2003 through 2018.

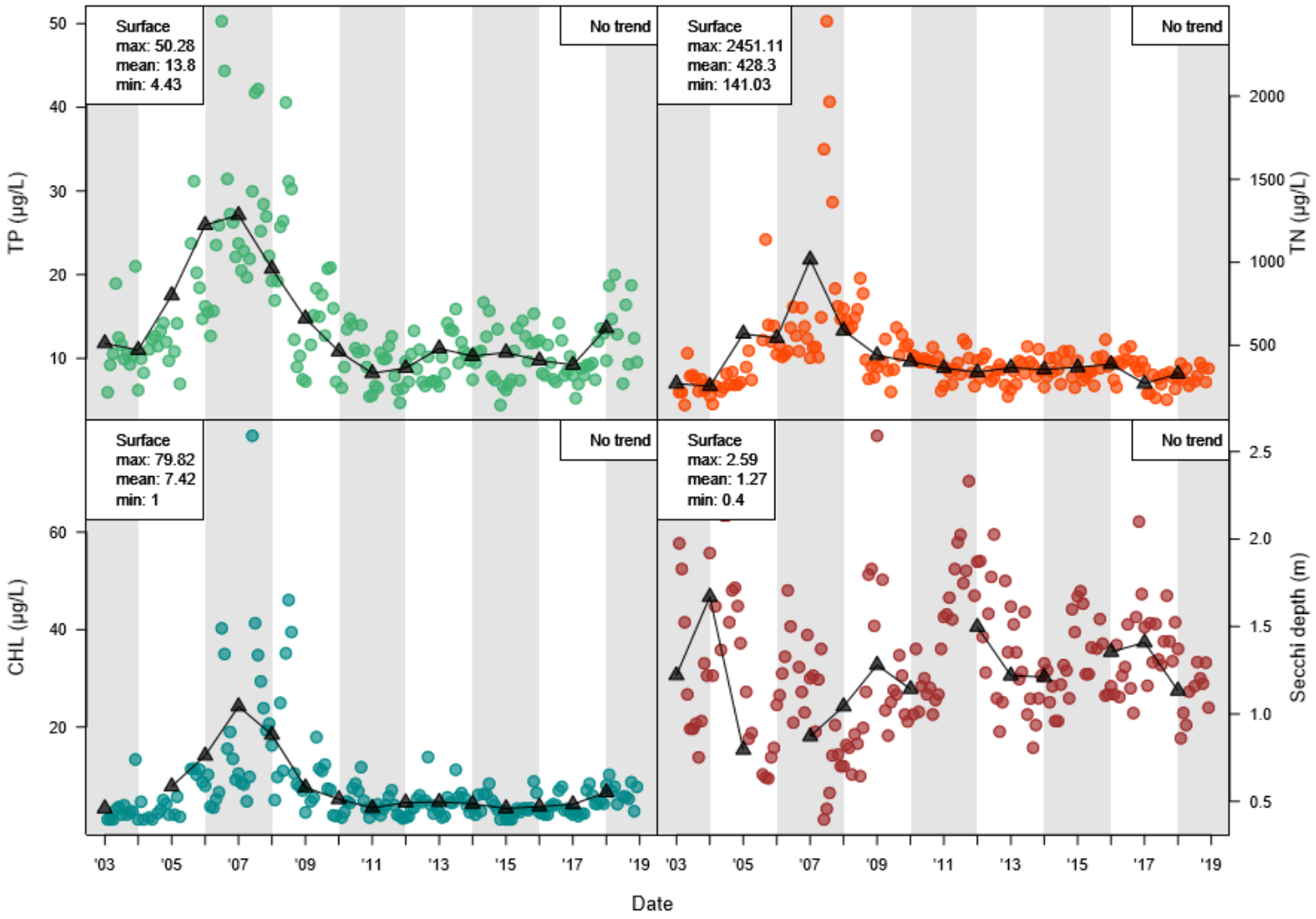
Times series plots display the inter-annual (monthly variability within the year - circles) and intra-annual variance (variability among years - triangles). Columns delineate three year time intervals.

Kendall-Tau trend analysis results are shown for each water chemistry variable on the surface-left of each plot. No trend indicates there was no significant trend found among the years examined (2003 through 2018). Increasing indicates a significant, positive trend was found over time. Decreasing indicates a significant, negative trend was found among the years examined. Insufficient data indicates insufficient annual data (year averages) were available for trend analysis.

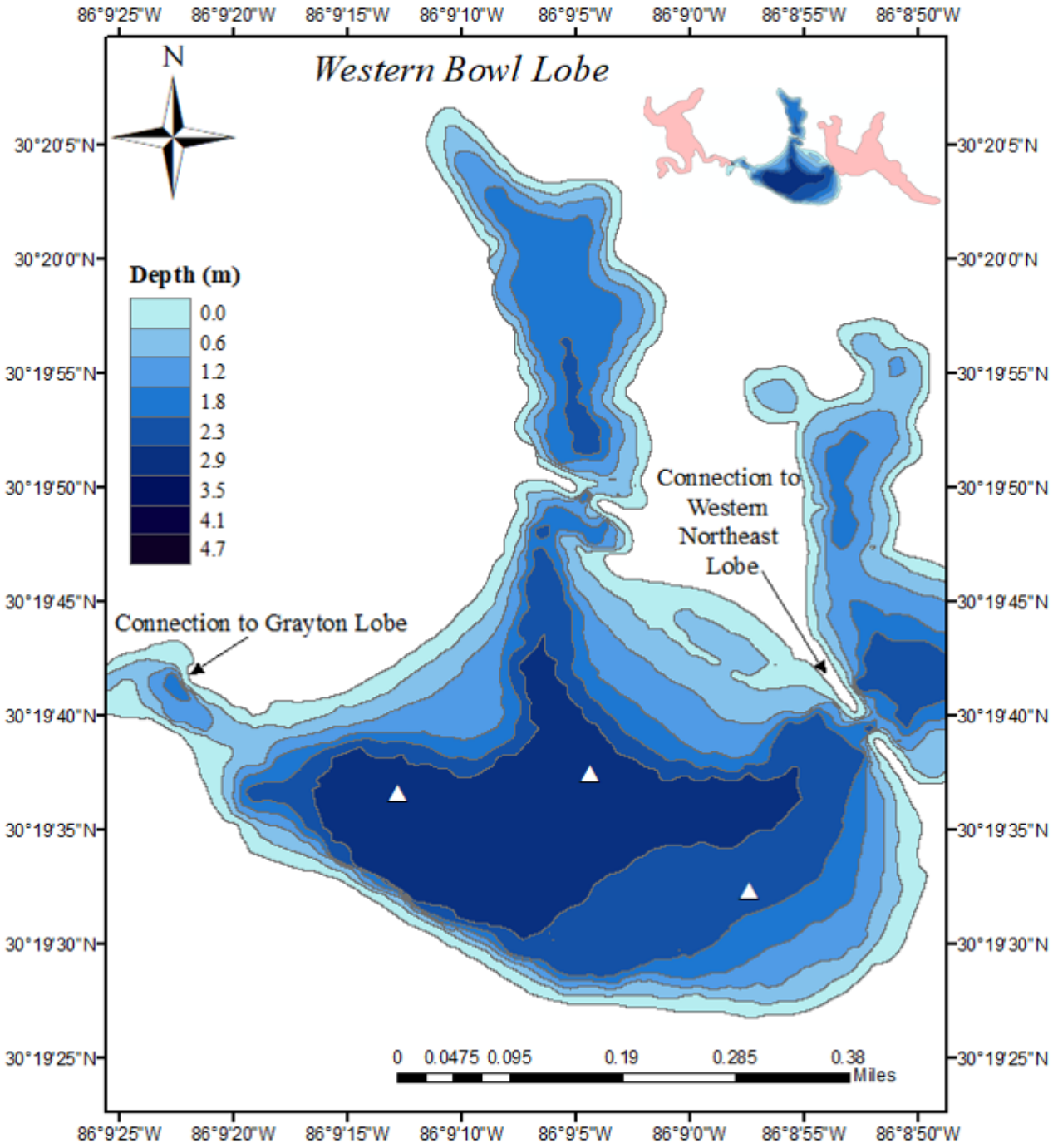
Hydrolab Trend analyses



Nutrient Trend Analyses



Western Bowl Lake Lobe, Walton County



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 a central and northeastern lobe. Connectivity between the three lobes is maintained by two

bridges. 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. Long-term water chemistry monitoring for Western Bowl Lobe occurs at three stations denoted as white triangles on the map above. 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 (5ppt, 5ppt and 11ppt respectively).

Western Bowl Lake Lobe Water Chemistry Data- 2018

Summary statistics include mean, maximum (Max), minimum (Min), median, and standard error (Std Error) calculated for both surface and bottom measurements for temperature, dissolved oxygen (DO), pH, and salinity, as well as surface measurements total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), secchi depth, as well as. These statistics represent 2018 water chemistry data.

2018 Summary Statistics

	min	mean	max	Std Error
Temperature surface	6.39	23.38	30.48	3.2
Temperature bottom	13.24	21.11	28.03	2.04
DO (mg/L) surface	5.88	7.52	11.34	0.69
DO (mg/L) bottom	0.18	1.44	5.47	0.7
pH surface	6.72	7.3	8.33	0.21
pH bottom	6.54	7.04	7.79	0.17
Salinity (ppt) surface	1.44	4.25	12.16	1.37
Salinity (ppt) bottom	6.19	12.42	20.21	2.16
TP (µg/L)	7.48	10.74	15.2	0.87
TN (µg/L)	283.63	440.9	583.08	45.67
CHL (µg/L)	1	3.42	6.32	0.84

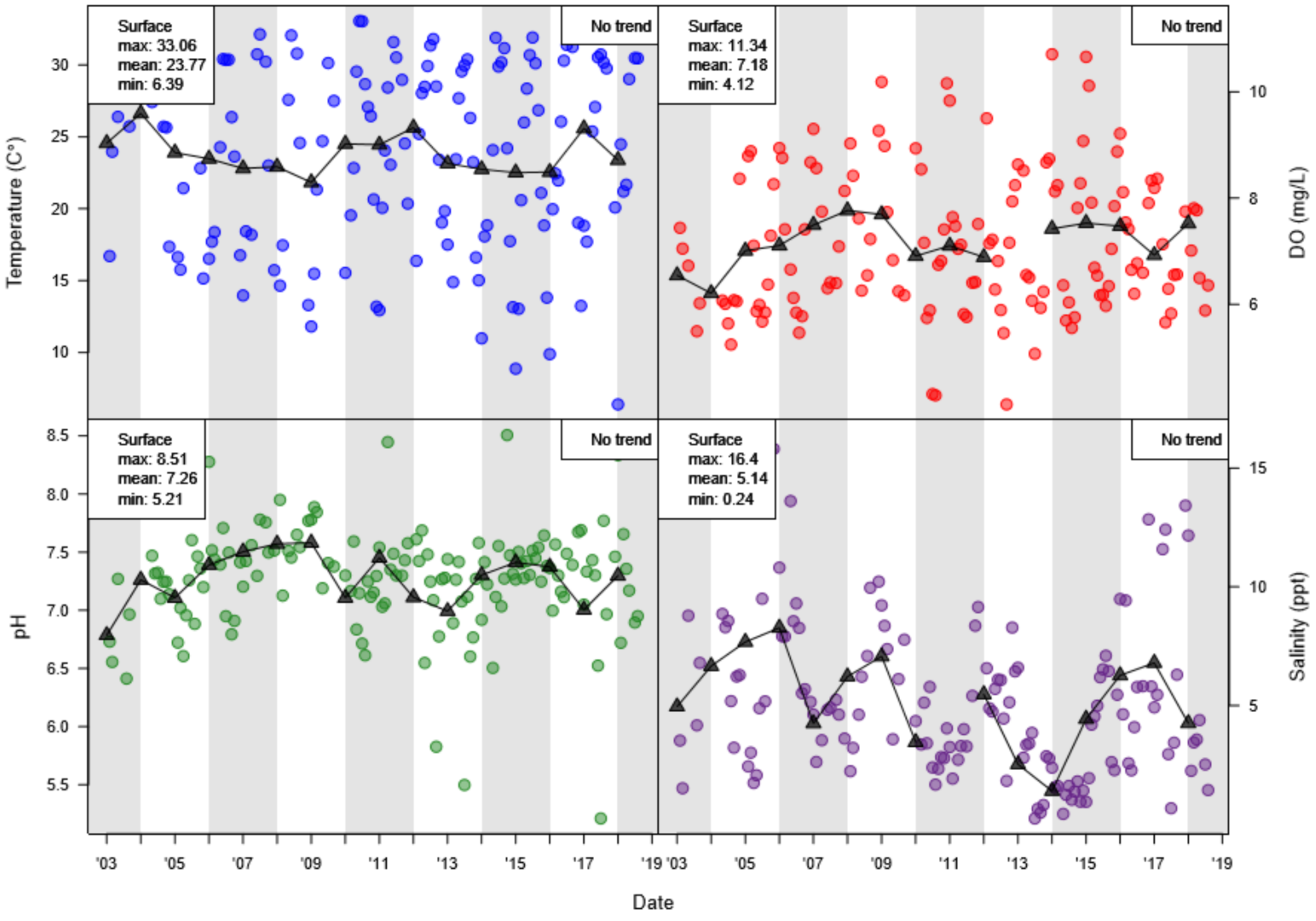
Western Bowl Lake Lobe Water Chemistry Data- 2003 through 2018

Summary statistics include mean, maximum (max), and minimum (min) summary statistics calculated on an annual basis using monthly data for hydrolab data variables; temperature, dissolved oxygen (DO), pH, and salinity as well as nutrient data variables total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), and secchi depth,. Summary statistics and trends represent results from long-term analyses among annual means from 2003 through 2018.

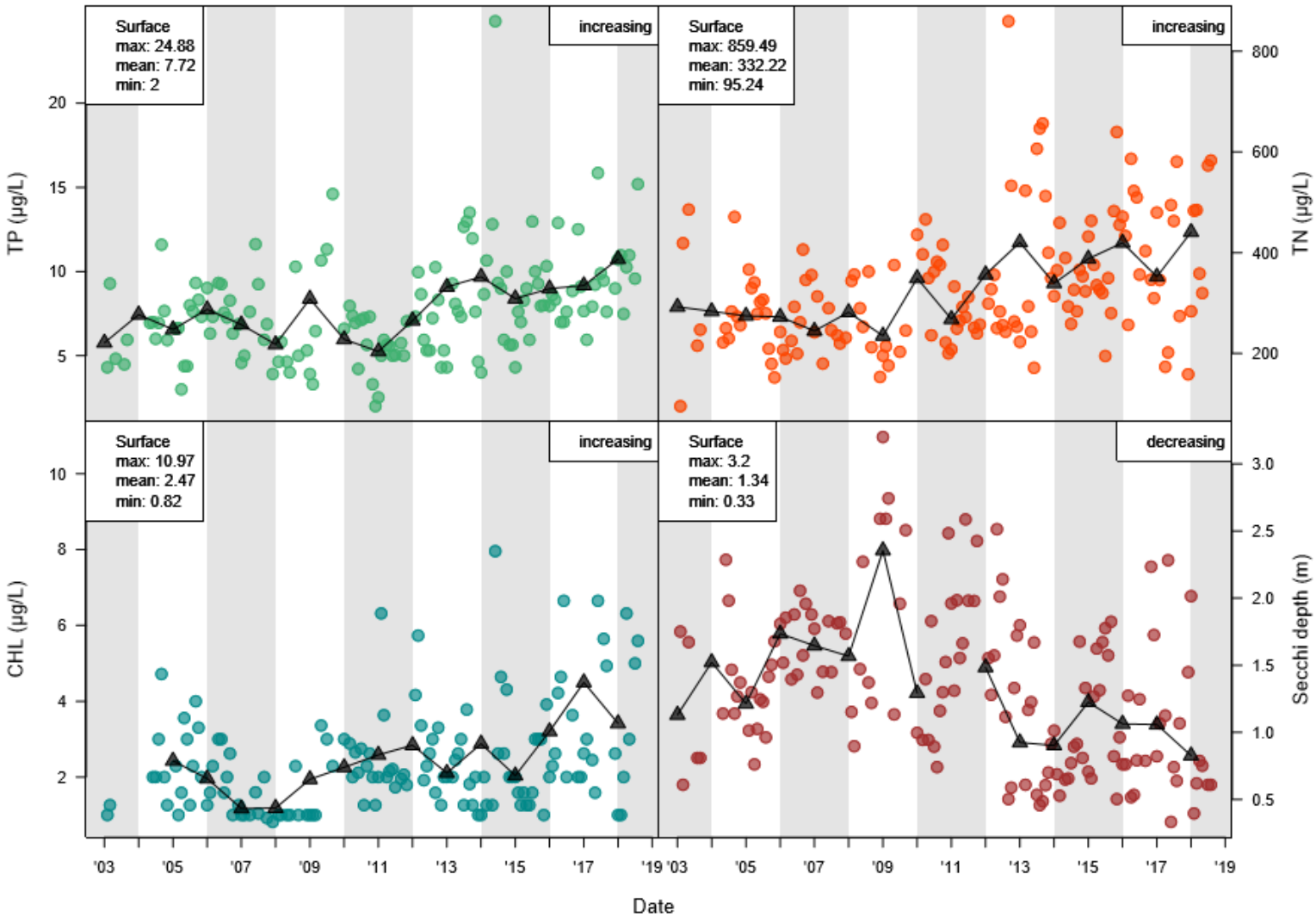
Times series plots display the inter-annual (monthly variability within the year - circles) and intra-annual variance (variability among years - triangles). Columns delineate three year time intervals.

Kendall-Tau trend analysis results are shown for each water chemistry variable on the surface-left of each plot. *No trend* indicates there was no significant trend found among the years examined (2003 through 2018). *Increasing* indicates a significant, positive trend was found over time. *Decreasing* indicates a significant, negative trend was found among the years examined. *Insufficient data* indicates insufficient annual data (year averages) were available for trend analysis.

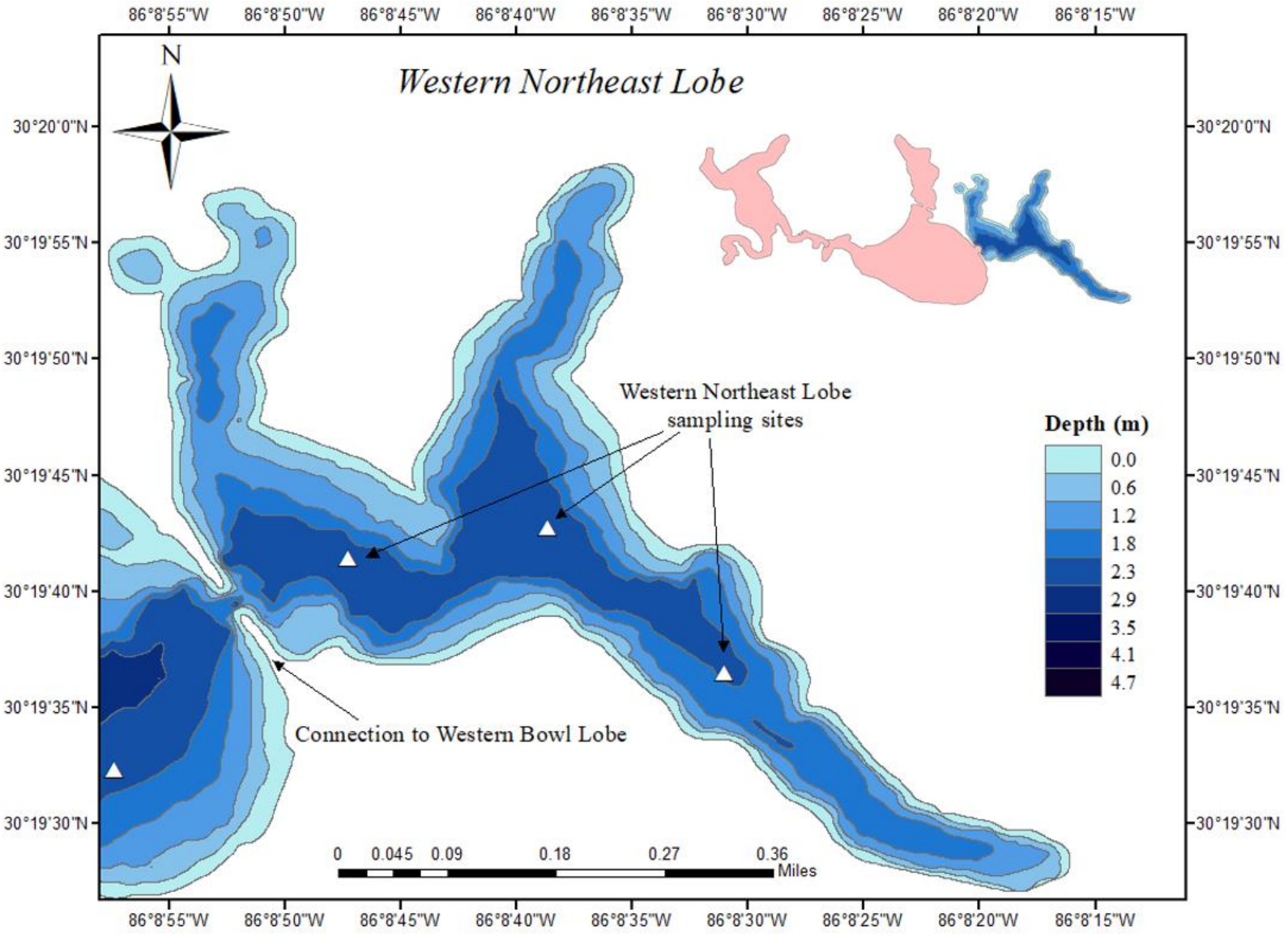
Hydrolab Trend Analyses



Nutrient Trend Analyses



Western Northeast Lake Lobe, Walton County



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 a central and northeastern lobe. Connectivity between the three lobes is maintained by two bridges. 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. Long-term water chemistry monitoring for Western Northeast Lobe occurs at three stations denoted as white triangles on the map above. 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 both Western Bowl lobe and Western Northeast Lobes have markedly different salinity regimes from Grayton Lobe (5ppt, 5ppt and 11ppt respectively).

Western Northeast Lake Lobe Water Chemistry Data- 2018

Summary statistics include mean, maximum (Max), minimum (Min), median, and standard error (Std Error) calculated for both surface and bottom measurements for temperature, dissolved oxygen (DO), pH, and salinity, as well as surface measurements total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), secchi depth, as well as. These statistics represent 2018 water chemistry data.

2018 Summary Statistics

	min	mean	max	Std Error
Temperature surface	12.36	24.34	31.43	1.97
Temperature bottom	11.66	23.5	29.29	1.76
DO (mg/L) surface	4.07	6.04	9.27	0.47
DO (mg/L) bottom	0.26	2.38	9.2	0.86
pH surface	5.27	6.68	7.75	0.23
pH bottom	5.92	6.77	7.75	0.17
Salinity (ppt) surface	0.19	3.49	10.43	1.14
Salinity (ppt) bottom	0.6	8.05	19.77	2.2
TP (µg/L)	9.62	11.74	19.47	0.95
TN (µg/L)	331.31	542.74	681.7	34.74
CHL (µg/L)	1	3.05	13.22	1.15

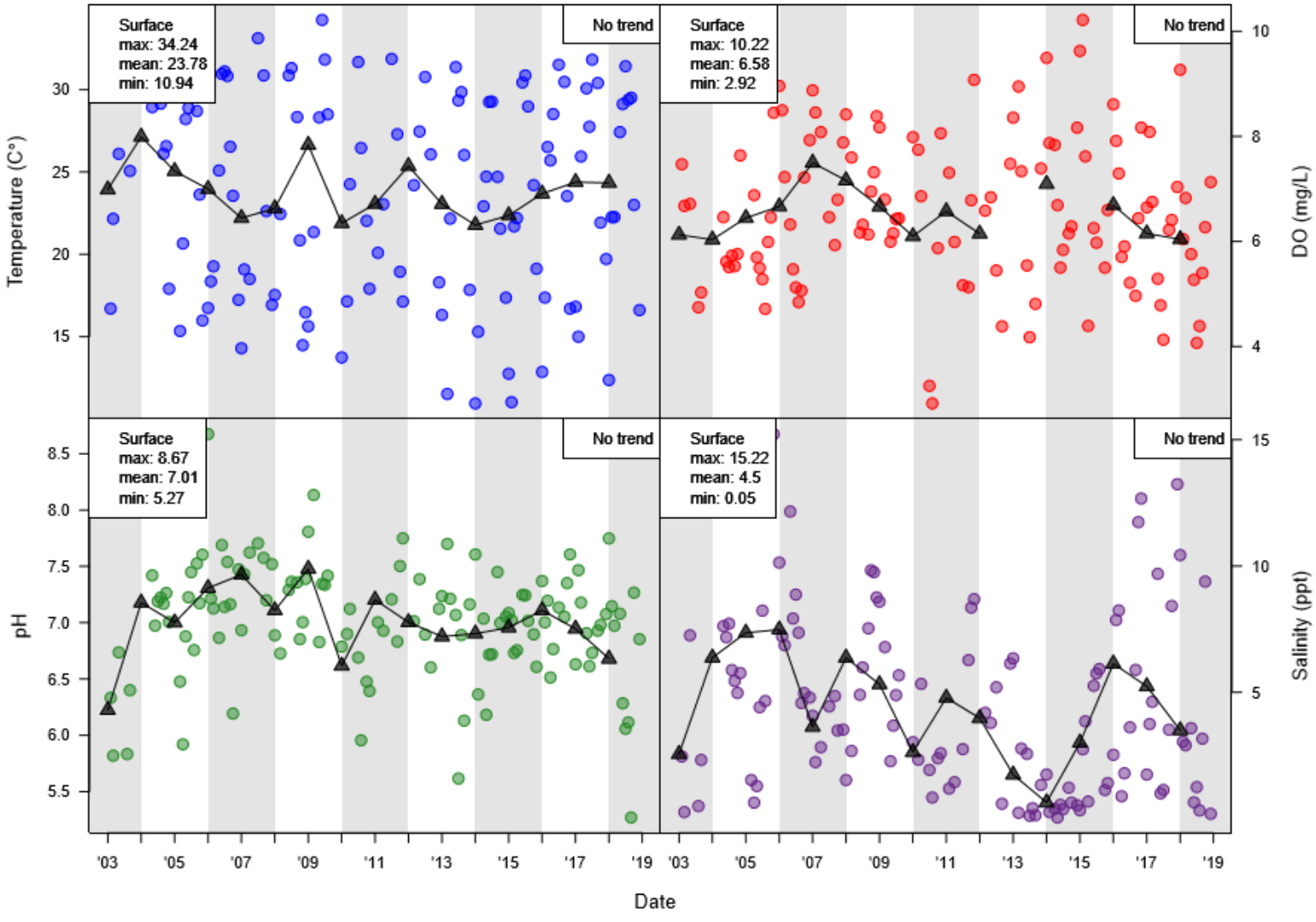
Western Northeast Lake Lobe Water Chemistry Data- 2003 through 2018

Summary statistics include mean, maximum (max), and minimum (min) summary statistics calculated on an annual basis using monthly data for hydrolab data variables; temperature, dissolved oxygen (DO), pH, and salinity as well as nutrient data variables total phosphorous (TP), total nitrogen (TN), total chlorophyll (CHL), and secchi depth,. Summary statistics and trends represent results from long-term analyses among annual means from 2003 through 2018.

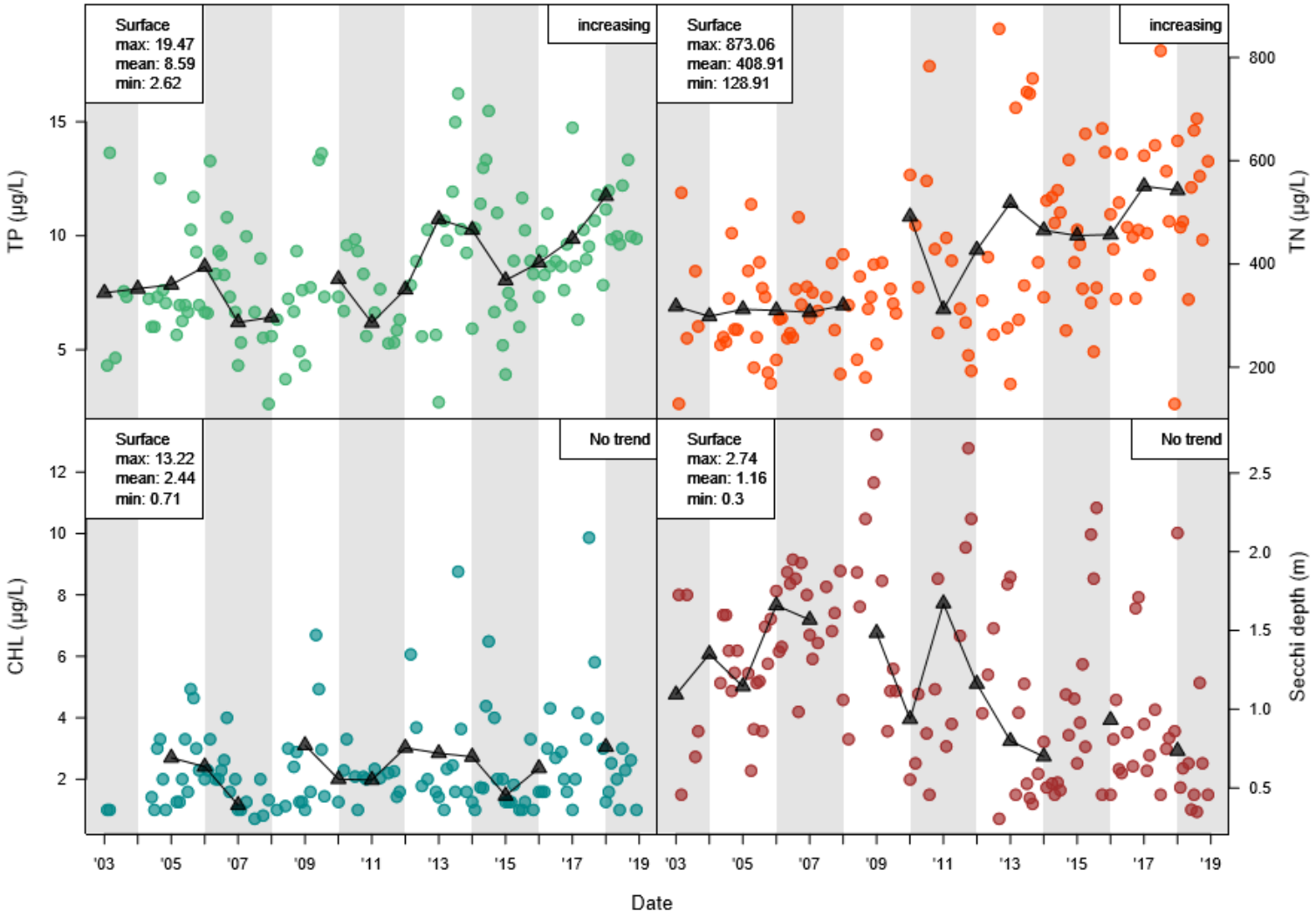
Times series plots display the inter-annual (monthly variability within the year - circles) and intra-annual variance (variability among years - triangles). Columns delineate three year time intervals.

Kendall-Tau trend analysis results are shown for each water chemistry variable on the surface-left of each plot. *No trend* indicates there was no significant trend found among the years examined (2003 through 2018). *Increasing* indicates a significant, positive trend was found over time. *Decreasing* indicates a significant, negative trend was found among the years examined. *Insufficient data* indicates insufficient annual data (year averages) were available for trend analysis.

Hydrolab Trend Analyses



Nutrient Trend Analyses



References:

Bachmann, R.W., D.L. Bigham, M.V. Hoyer, and D.E. Canfield, Jr. 2012. Factors determining the distributions of total phosphorus, total nitrogen, and chlorophyll a in Florida lakes. Lake and Reservoir Management 28:10-26 [doi:10.1080/07438141.2011.646458].

Canfield, Jr., D. E., and M. V. Hoyer. 1988. Regional geology and the chemical and trophic state characteristics of Florida lakes. Lake and Reservoir Management 4:21-31 [doi:10.1080/07438148809354375].

Griffith, G.E., D.E. Canfield, Jr., C.A. Horsburg, and J.M. Omernik. 1997. Lake regions of Florida. EPA (U.S. Environmental Protection Agency), report R-97/127 Corvallis, Oregon.