Water Quality Status and Trends in Bays of the Texas Coastal Bend

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Prepared by:

Amie O. West, Ph.D.
Michael Wetz, Ph.D.
Harte Research Institute for Gulf of Mexico Studies
Texas A&M University - Corpus Christi
6300 Ocean Drive, Unit 5869
Corpus Christi, TX 78412
Phone: 361-825-2000
E-mail: michael.wetz@tamucc.edu, amie.west@tamucc.edu

Submitted to:

Coastal Bend Bays & Estuaries Program

615 N. Upper Broadway, Suite 1200

Corpus Christi, TX 78401

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EXECUTIVE SUMMARY

Estuaries of the Coastal Bend region of Texas contain highly productive aquatic habitats for birds, fish, and shellfish that support local economies and ways of life. The Coastal Bend is also among the fastest growing regions of Texas due to a thriving industrial base and a major port. Changing land use, increasing populations and development, and greater demands for coastal resources can impact the health of the estuaries and regular evaluations of the status of the ecosystems and trends in water quality are important for supporting management and decision making for the Coastal Bend region.

This report provides an updated analysis of water quality in Coastal Bend bays using data obtained from the Texas Commission on Environmental Quality through 2019. Summary statistics for the period 2010 through 2019 and trend analysis over the period of record suggested that some bays are experiencing effects of eutrophication, changing freshwater inflows, and watershed derived pollutants.

Observations determined that:

- Several Coastal Bend bays are experiencing signs of eutrophication such as high and/or increasing chlorophyll *a* concentrations. The most consistent trends were observed in Port Bay, Oso Bay, Baffin Bay and segments of the Laguna Madre.
- Fecal bacteria concentrations periodically exceeded the single sample limit in several bays.
- Metal concentrations were below criteria except for copper, which exceeded criteria at all four stations where it is measured.

We acknowledge where data limitations contributed to uncertainty in results. We also include recommendations for additional monitoring to improve understanding of the patterns and drivers of water quality change.

INTRODUCTION

Estuaries of the Coastal Bend region of the Texas coast contain highly productive aquatic habitats that support birds, fish, and shellfish, while also supporting local economies. The Coastal Bend is also among the fastest growing regions of Texas due to a thriving industrial base and a major port. In other coastal ecosystems, high rates of population growth and accompanying land use change, along with climate change, have been shown to have a detrimental impact on water quality in the absence of best management practices. Regular assessments of water quality in estuaries can help to identify areas of concern in terms of water quality change, help to understand reasons for the change(s), and guide management interventions. Past assessments for the Coastal Bend region have identified locations where nutrients and dissolved metals have exceeded criteria developed by the Texas Commission on Environmental Quality (TCEQ) and evaluated "hot spots" where effects of land use change and climate change may be influencing water quality (see e.g., Ward and Armstrong 1997; Montagna and Palmer 2012; Bugica *et al.* 2020). This report provides an updated analysis of water quality in the Coastal Bend region using available TCEQ data through 2019. While in-depth evaluation of causative factors and correlation among variables was outside the scope of this project, we discuss relevant results in the context of possible drivers and impacts, and include an assessment of locations that may need additional monitoring to identify drivers of unwanted changes.

METHODS

DATA HANDLING

Texas Commission on Environmental Quality data were downloaded from the TCEQ Surface Water Quality monitoring program for 11 Assessment Units (AUs) of the Texas Coastal Bend (Figure 1; Table 1). Stations within each AU that were monitored through 2019 were included for analysis. A complete list of all stations and sampling periods, including those that were omitted from this analysis, can be found in Appendix A (Table A1). Stations were omitted when data was not current through 2019. All data manipulation and statistical analyses were performed in R (R Core Team 2020).

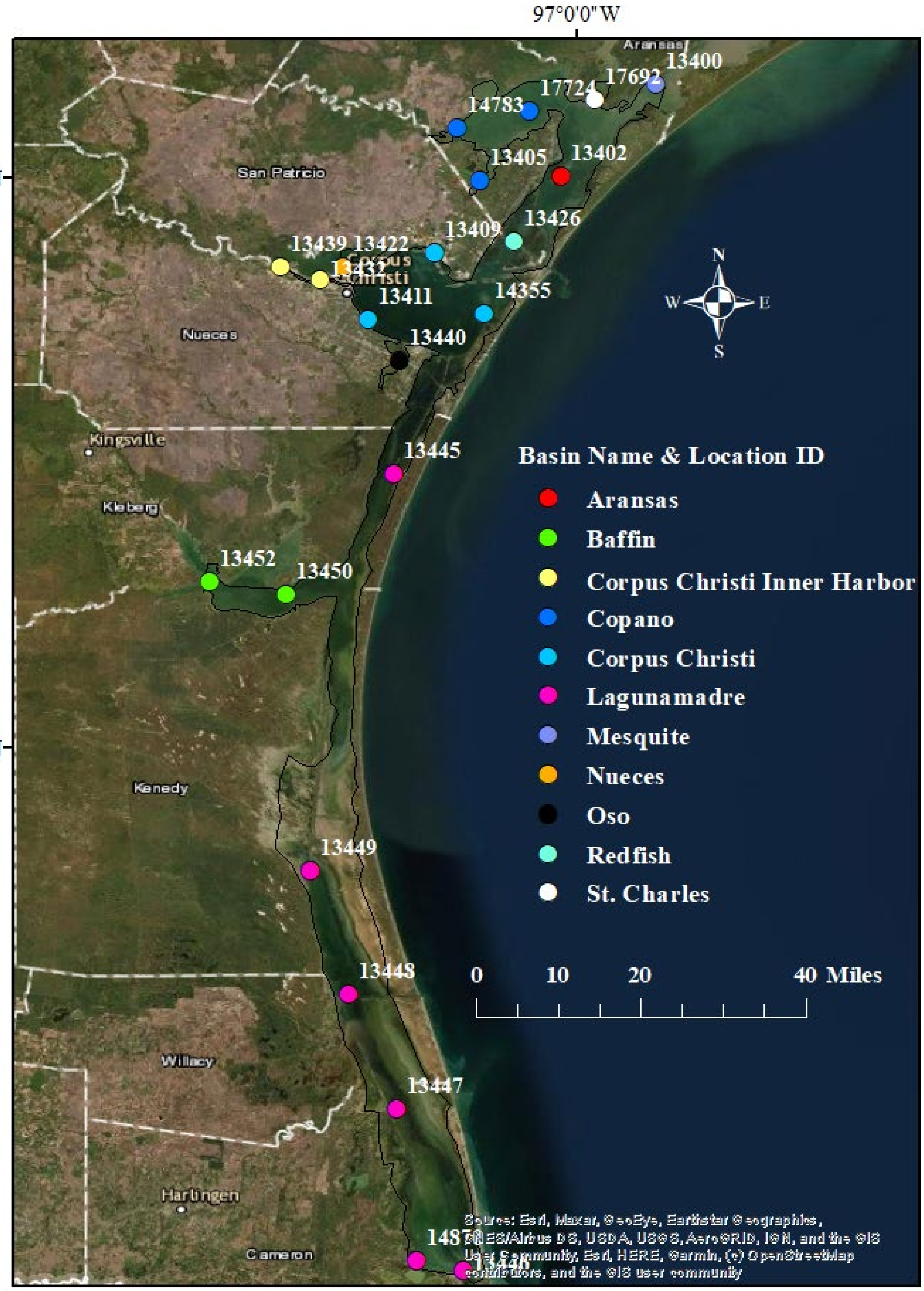

FIGURE 1: MAP OF MONITORING STATIONS

Monitoring stations for the Coastal Bend bays included in this study; data accessed 1 Feb 2021 at https://www80.tceq.texas.gov/SwqmisPublic/index.htm

TABLE 1: ASSESSMENT UNITS AND STATION ID

Assessment units (AU) and stations included in this study; data accessed 1 Feb 2021 at https://www80.tceq.texas.gov/SwqmisPublic/index.htm

Waterbody Name	**AU**	**Station ID**
St. Charles Bay	2473	17692
Mesquite Bay	2463	13400
Copano Bay	2472	13405
Copano Bay	2472	14783
Copano Bay	2472	17724
Aransas Bay	2471	13402
Redfish Bay	2483	13426
Nueces Bay	2482	13422
Oso Bay	2485	13440
Corpus Christi Inner Harbor	2484	13432
Corpus Christi Inner Harbor	2484	13439
Corpus Christi Bay	2481	13409
Corpus Christi Bay	2481	13411
Corpus Christi Bay	2481	14355
Baffin Bay	2492	13450
Baffin Bay	2492	13452
Laguna Madre	2491	13445
Laguna Madre	2491	13446
Laguna Madre	2491	13447
Laguna Madre	2491	13448
Laguna Madre	2491	13449
Laguna Madre	2491	14870

Twenty-three water quality variables were assessed in this study (Table 2). For all variables, observations at depths greater than 0.4 meters were removed, as the focus was on water quality based on surface-depth sampling (most common). Routine monitoring was, for the most part, performed on a quarterly schedule. Observations were categorized by year and season, where Winter = D(year+1) JF, Spring = MAM, Summer = JJA, and Fall = SON. In cases where there were multiple sampling events in a single season, the average value and date for the season were calculated.

TABLE 2: WATER QUALITY VARIABLES

Water quality variables included in this study and TCEQ screening levels/chronic criteria (TCEQ 2020a).

Parameter Name	Units	Parameter Code	Screening Level	Chronic Criterion
Aluminum, Dissolved	µg/L	01106	-	-
Arsenic, Dissolved	µg/L	01000	-	78 µg/L
Cadmium, Dissolved	µg/L	01025	-	8.75 µg/L
Chlorophyll *a*, Fluorometric	µg/L	70953	11.6 µg/L	-
Chromium, Dissolved	µg/L	01030	-	49.6 µg/L
Copper, Dissolved	µg/L	01040	-	3.6 µg/L
Enterococci, Enterolert	MPN/100 mL	31701	130 col/100mL	-
Fluoride, Total	mg/L	00951	-	-
Lead, Dissolved	µg/L	01049	-	5.3 µg/L
Mercury, Dissolved	µg/L	71960	-	1.1 µg/L
Nickel, Dissolved	µg/L	01065	-	13.1 µg/L
Nitrate + Nitrite	mg/L	00630	0.17 mg/L	-
Nitrogen, Ammonia	mg/L	00610	0.10 mg/L	-
Nitrogen, Total Kjeldahl	mg/L	00625	-	-
Oxygen, Surface Dissolved	mg/L	00300	-	-
pH	standard	00400	-	-
Phosphorus, Total	mg/L	00665	0.21 mg/L	-
Salinity	PPT	00480	-	-
Selenium, Dissolved	µg/L	01147	-	136 µg/L
Silver, Dissolved	µg/L	01075	-	-
Temperature, Water	Degrees C	00010	-	-
Transparency, Secchi Depth	m	00078	-	-
Zinc, Dissolved	µg/L	01090	-	84.2 µg/L

SUMMARY STATISTICS

Summary statistics, including both arithmetic and geometric means, were calculated for data collected in 2010 through 2019 (10 years). Based on the general practice of the TCEQ, censored observations (flagged by GTLT "<") were halved prior to calculation of means. Water quality screening levels and criteria were obtained from the TCEQ Guidance for Assessing and Reporting Surface Water Quality in Texas (TCEQ 2020a).

SPATIAL ANALYSIS

All maps were created in ArcGIS ArcMap version 10.8. Two types of spatial interpolation techniques, Spline and Spline with Barriers, were used for creating the maps with inputs of 10-year average values for each variable at each sample location. Both techniques interpolate a raster surface using polynomial functions. Spline interpolates a raster surface directly from input variables and was used for generating maps for surface dissolved oxygen and temperature. Spline with barriers uses polygon or polyline barriers from input variables to create smooth surfaces and was used for bacteria, chlorophyll *a*, bottom dissolved oxygen, fluoride, Ammonia-nitrogen, nitrate + nitrite, pH, salinity, Secchi depth, total Kjeldahl nitrogen, and total phosphorus.

TEMPORAL TREND ANALYSIS

A dataset with least 10 years of data, up to and including 2019, was required for trend analysis. Temporal trends for each variable (averaged for the year and season for the entire period of record, as described above) were computed using Kendall's tau regression analysis (Kendall 1955) with the NADA Package in R (Lee 2020). Kendall's tau is a nonparametric method that computes a correlation coefficient based on ranked values, where censored unedited values (i.e., not halved) are treated as ties. Trendlines were estimated using the Akritas-Theil-Sen nonparametric line (Akritas *et al.* 2021) and the Turnbull estimate for intercept (Turnbull 1976) with a critical alpha = 0.05.

RESULTS AND DISCUSSION

SUMMARY STATISTICS

Boxplots summarizing data for each parameter and site are shown in Figures 2.1 through 2.4[1]. The Draft 2020 Guidance for Assessing and Reporting Surface Water Quality in Texas from TCEQ defines screening levels for nutrients and chlorophyll *a* and criteria for bacteria to support designated uses, including primary contact recreation, as well as criteria for dissolved metals to protect aquatic life (TCEQ 2020a). Quarterly monitoring at the majority of sites in our analysis captured fecal bacteria concentrations above the single sample limit for contact recreation (Figure 2.2F). Excessive nutrients are determined when screening levels for concentrations of nitrite + nitrate (NO_2+NO_3), ammonia (NH_3-N), total phosphorus (TP), and chlorophyll *a* are exceeded in greater than 20% of samples for a given sample size (TCEQ 2020a). Based on the TCEQ screening levels, the 10-year dataset suggested that sites in Corpus Christi Inner Harbor, Laguna Madre, Oso Bay, and Baffin Bay experienced excessive nutrients and algal growth

[1]In Appendix B (Table B1), we report both the arithmetic mean and the geometric mean with their respective standard deviations. The geometric mean is often a more useful descriptor of the central tendency than the arithmetic mean for right skewed data (often when bounded on the left by zero) and this distribution tendency is common in water quality variables (Hirsch *et al.*).

(Table 3). Screening levels for ammonia NH_3-N and NO_3+NO_3 were exceeded in greater than 20% of samples for the period 2010-2019 in both stations in Corpus Christi Inner Harbor. The chlorophyll *a* screening level also exceeded in 25% of samples in the more inland site of the Corpus Christi Inner Harbor. Screening levels for NH_3-N, NO_3+NO_3, TP, and chlorophyll *a* were exceeded in greater than 20% of samples at the Laguna Madre monitoring site nearest the outlet of Arroyo Colorado. Screening levels for TP and chlorophyll *a* were exceeded in Oso Bay in 28% and 61% of samples, respectively (Table 3). Screening levels for chlorophyll *a*, but not nutrient concentrations, were exceeded in greater than 20% of samples in six other sites along the Coastal Bend: Copano Bay, Nueces Bay, Baffin Bay (2), and Laguna Madre (2) during the 10-year period (Table 3).

Dissolved metals were measured approximately twice per year at a single site in each of four assessment units of the Texas Coastal Bend region: Corpus Christi Bay, Corpus Christi Inner Harbor, Laguna Madre, and Baffin Bay. Copper was the only metal for which concentrations commonly exceeded criteria (Figures 2.3 & 2.4). Fourteen of 15 samples in Corpus Christi Inner Harbor, 10 of 11 samples in Corpus Christi Bay, 13 of 19 samples in Nueces Bay, and all samples in Baffin Bay exceeded the 3.6 µg/L saltwater chronic criterion (Figure 2.3E). The saltwater acute criterion for copper (13.5 µg/L) was exceeded in Nueces Bay in 2011, 2012, 2013, 2014, and 2018, in Corpus Christi Inner Harbor in 2019, and in Corpus Christi Bay in 2014 and 2019. Corpus Christi Inner Harbor and Nueces Bay are currently listed for copper in water on the 303(d) list of impaired water bodies (TCEQ 2020b). Copper contamination can occur from pipe corrosion, industrial wastes, anti-fouling paints, and stormwater runoff and is bioaccumulated in oysters (Rodney *et al.* 2011). Copper concentrations have historically been elevated in areas with significant boat traffic, such as Corpus Christi Inner Harbor and Galveston Bay, and can be attributed to anti-fouling paints used on boat hulls (Ward and Armstrong 1992; Barrera *et al.* 1995). While we did not observe other water-phase metals to have exceeded criteria, increased spatial and temporal monitoring for metals in the Coastal Bend region may increase understanding of sources, transport, and potential ecosystem effects of a variety of pollutants that carry metals to the bays.

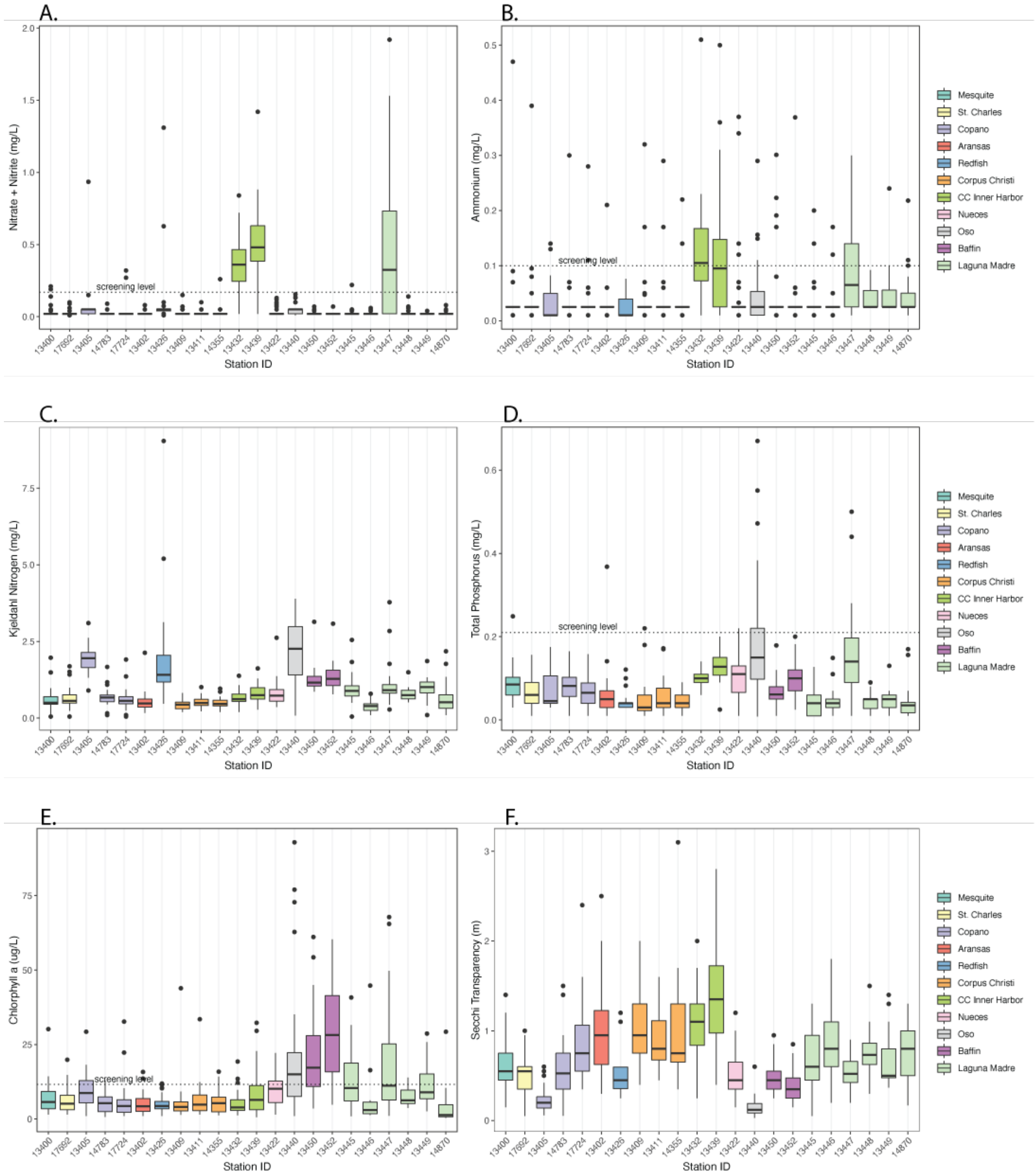

FIGURE 2.1: WATER QUALITY SUMMARY BOXPLOTS

Boxplots of values for water quality variables related to trophic conditions from 2010-2019 and screening levels (values shown in Table 2). Stations are arranged in approximate geographic order, from north to south. Screening levels were obtained from TCEQ 2020a.

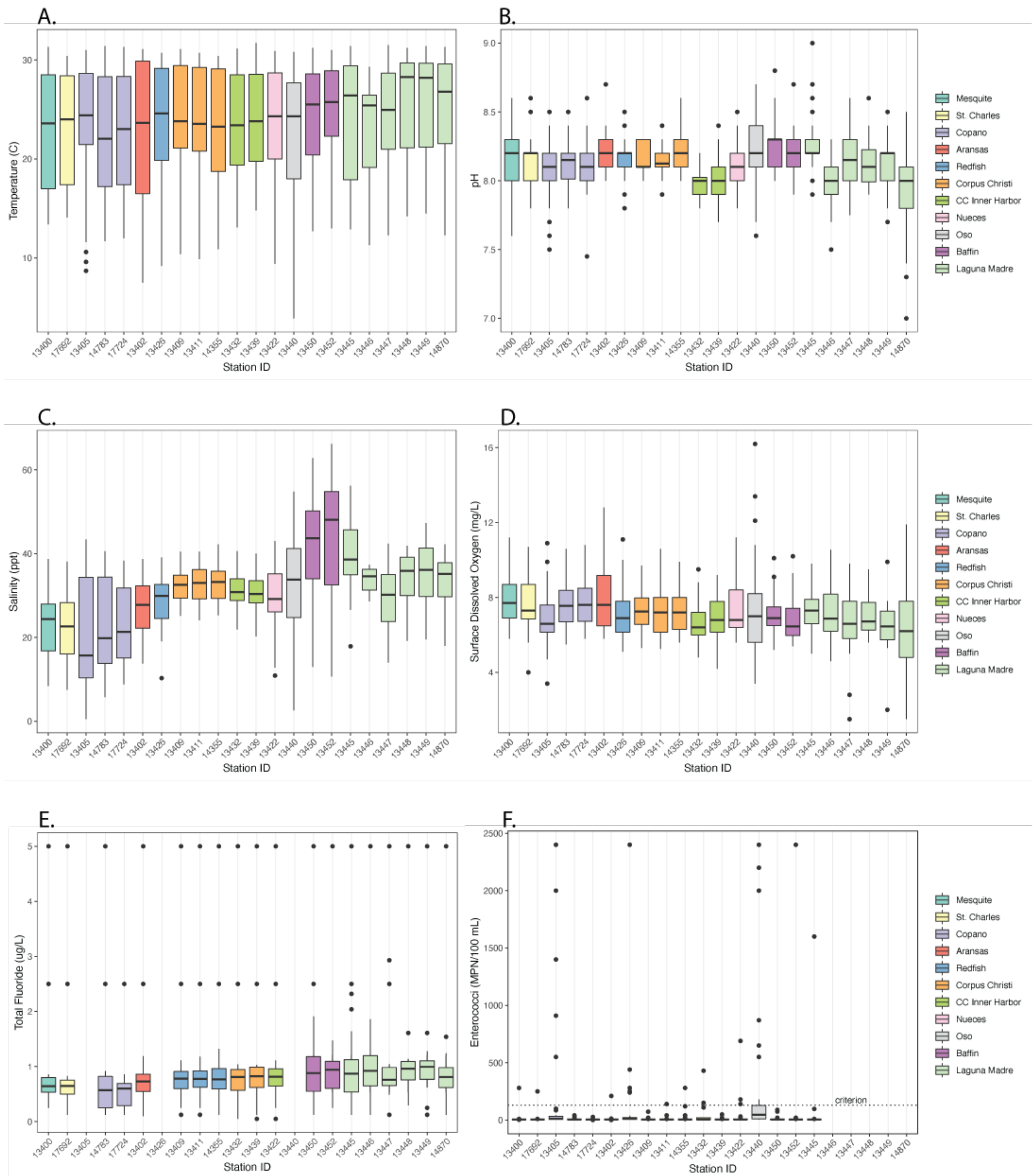

FIGURE 2.2: WATER QUALITY SUMMARY BOXPLOTS (CONT.)

Boxplots of values for water quality variables (cont.) measured from 2010-2019. Stations are arranged in approximate geographic order, from north to south. Criterion for enterococci (130 colonies/100 mL) is based on the single sample limit for primary contact recreation (TCEQ 2020a).

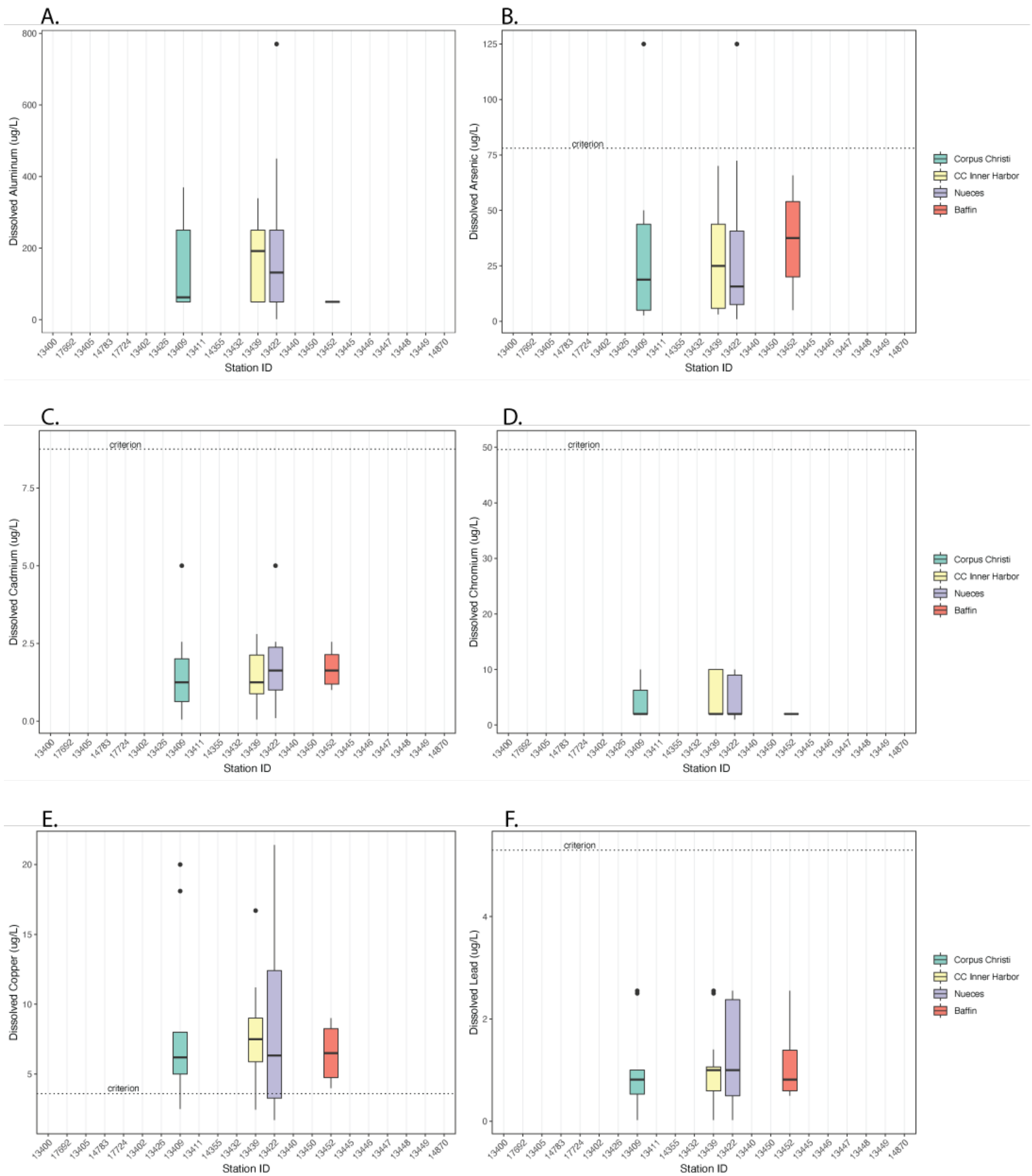

FIGURE 2.3: WATER-PHASE METALS SUMMARY BOXPLOTS

Boxplots of concentrations of metals measured from 2010-2019. Stations are arranged in approximate geographic order, from north to south. Limits shown are chronic criteria (Table 2; TCEQ 2020a).

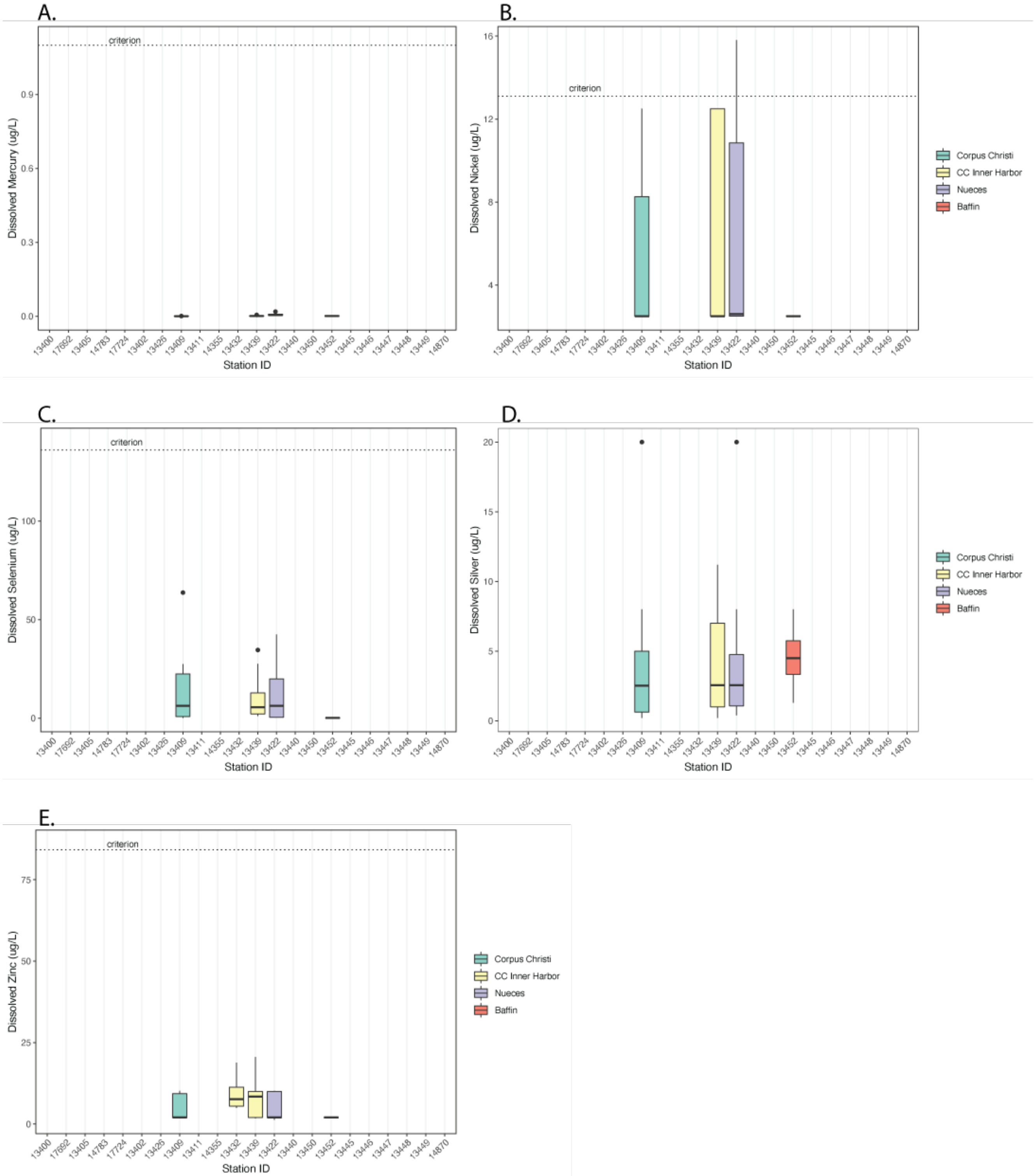

FIGURE 2.4: WATER-PHASE METALS SUMMARY BOXPLOTS (CONT.)

Boxplots of concentrations of metals (cont.) measured from 2010-2019. Stations are arranged in approximate geographic order, from north to south. Limits shown are chronic criteria (Table 2; TCEQ 2020a).

TABLE 3: SAMPLES EXCEEDING CRITERIA

Percent of samples from 2010-2019 that exceeded the screening level for ammonia (0.10 mg/L), total nitrite + nitrate (0.17 mg/L), total phosphorus (0.21 mg/L), and chlorophyll *a* (11.6 µg/L). Bold text indicates where the 10-year dataset suggested potential excessive concentrations because of screening level exceedance in at least 20% of samples. For enterococci, the value is the percent of samples that exceeded the single sample limit for primary contact recreation (130 colonies/100mL), n.d. indicates where there were no available data.

Waterbody Name	Station ID	NH_3-N	NO_2+NO_3	TP	Chl *a*	Enterococci
St. Charles Bay	17692	3.8	0.0	0.0	15.4	3.8
Mesquite Bay	13400	3.6	6.9	3.7	11.1	3.7
Copano Bay	13405	5.1	2.9	0.0	**28.9**	15.6
Copano Bay	14783	3.4	0.0	0.0	7.1	0.0
Copano Bay	17724	6.9	6.7	0.0	7.1	0.0
Aransas Bay	13402	3.2	0.0	3.4	6.1	3.8
Redfish Bay	13426	0.0	5.9	0.0	2.6	15.6
Nueces Bay	13422	11.1	0.0	5.9	**32.4**	9.4
Oso Bay	13440	10.3	0.0	**28.2**	**61.5**	25.0
CC Inner Harbor	13432	**50.0**	**88.2**	0.0	9.4	6.9
CC Inner Harbor	13439	**44.1**	**94.1**	0.0	**25.0**	0.0
Corpus Christi Bay	13409	6.1	0.0	3.2	3.0	0.0
Corpus Christi Bay	13411	6.1	0.0	0.0	6.1	3.3
Corpus Christi Bay	14355	5.9	2.9	0.0	5.9	3.2
Baffin Bay	13450	11.8	0.0	0.0	**75.0**	0.0
Baffin Bay	13452	4.2	0.0	0.0	**82.6**	5.6
Laguna Madre	13445	5.6	2.8	0.0	**43.2**	3.3
Laguna Madre	13449	4.5	0.0	0.0	**36.8**	n.d.
Laguna Madre	13448	0.0	0.0	0.0	20.0	n.d.
Laguna Madre	13447	**34.4**	**52.9**	**22.6**	**48.5**	n.d.
Laguna Madre	14870	10.3	0.0	0.0	3.7	n.d.
Laguna Madre	13870	10.3	0.0	0.0	3.7	n.d.

Plots of all data including statistically significant trendlines are presented in Appendix C. Negative trends for chlorophyll *a* concentrations (an important indicator of trophic status) were not commonly observed, except at two Corpus Christi Inner Harbor sites (Table 4.1). At both sites in Baffin Bay, we observed increasing trends for chlorophyll *a* concentrations (Table 4.1). Increasing trends for chlorophyll *a* concentrations were also determined for Copano and Oso Bays and Laguna Madre, while trends for both NH_3-N and NO_2-NO_3 suggested decreasing concentrations (see discussion of limitations concerning NH_3-N and NO_2-NO_3 data). Five of the six sites that exceeded screening levels for chlorophyll *a* but not nutrients for the period from 2010-2019 also demonstrated significant increasing trends in chlorophyll *a* concentrations over the period of record.

TABLE 4.1: DIRECTIONS OF TRENDS

Direction of trends for ammonia (NH3-N, mg/L), total Kjeldahl nitrogen (TKN, mg/L), nitrite + nitrate (mg/L), total phosphorus (TP, mg/L), Chlorophyll *a* (Chl *a*, µg/L), and Secchi depth at surface depth (SDO, mg/L); - indicates trend of decreasing concentration, + indicates trend of increasing concentration, ns indicates trend was not significantly different than zero. †Note that the direction of trend for Secchi depth is positive for relative decline in trophic status and negative for relative improvement, as opposed to those for the other parameters.

Waterbody Name	Station ID	NH_3-N	TKN	NO_2+NO_3	TP	Chl *a*	Secchi†
St. Charles Bay	17692	ns	ns	ns	ns	+	ns
Mesquite Bay	13400	-	ns	-	-	ns	+
Copano Bay	13405	-	+	-	ns	+	-
Copano Bay	14783	ns	-	ns	-	ns	ns
Copano Bay	17724	ns	-	ns	-	ns	ns
Aransas Bay	13402	-	ns	-	ns	ns	ns
Redfish Bay	13426	-	+	-	ns	ns	-
Nueces Bay	13422	-	ns	-	ns	ns	ns
Oso Bay	13440	-	+	-	ns	+	-
CC Inner Harbor	13432	-	ns	ns	ns	-	ns
CC Inner Harbor	13439	-	ns	+	+	-	ns
Corpus Christi Bay	13409	ns	-	-	ns	ns	ns
Corpus Christi Bay	13411	-	ns	-	ns	ns	ns
Corpus Christi Bay	14355	ns	-	ns	ns	ns	ns
Baffin Bay	13450	-	-	-	ns	+	+
Baffin Bay	13452	-	-	-	+	+	ns
Laguna Madre	13445	-	-	-	ns	+	ns
Laguna Madre	13449	-	ns	-	ns	+	ns
Laguna Madre	13448	-	ns	-	ns	ns	ns
Laguna Madre	13447	-	ns	ns	ns	ns	ns
Laguna Madre	14870	+	ns	ns	ns	ns	ns
Laguna Madre	13446	-	+	-	ns	ns	-

Trends of increasing temperature occurred in two sites, Laguna Madre and Baffin Bay. Previous trend analysis for the period from 2009-2016 also identified increasing temperature in the Laguna Madre site but not the Baffin Bay site (Bugica *et al.* 2020). Of note, the Baffin Bay site had a substantial monitoring gap from Fall 2015 through Summer 2019, which increases uncertainty about how well the statistical trend can be used to understand more recent change. Statistically significant trends of decreasing pH (evidence of acidification) occurred at sites in Corpus Christi Inner Harbor and Laguna Madre, whereas trends of increasing pH were observed in St. Charles, Copano, and Corpus Christi Bays. This was accompanied by a significant increasing trend for salinity at the Copano Bay site, where salinity appeared to be decreasing over time in St. Charles Bay (Table 4.2). Increasing salinity was also observed at two sites in Laguna Madre. Decreasing trends for dissolved oxygen concentrations were observed in Mesquite, Copano, Redfish, Nueces, and Baffin Bays. All but one site from Corpus Christi Inner Harbor southward showed trends of decreasing fluoride concentrations (Table 4.2).

TABLE 4.2: DIRECTIONS OF TRENDS (CONT.)

Direction of trends for temperature (Temp, °C), pH, salinity (PPT), dissolved oxygen at depth < 0.4 m (SDO, mg/L), fluoride (µg/L), and Enterococci bacteria (MPN/100 mL); - indicates trend of decreasing values, + indicates trend of increasing values, ns indicates trend was not significantly different than zero.

Waterbody Name	Station ID	Temp	pH	Salinity	SDO	Fluoride	Enterococci
St. Charles Bay	17692	ns	+	-	ns	ns	-
Mesquite Bay	13400	ns	ns	ns	-	ns	ns
Copano Bay	13405	ns	ns	ns	-	ns	ns
Copano Bay	14783	ns	+	+	ns	ns	ns
Copano Bay	17724	ns	ns	ns	ns	ns	ns
Aransas Bay	13402	ns	ns	ns	ns	ns	ns
Redfish Bay	13426	ns	ns	ns	-	ns	ns
Nueces Bay	13422	ns	ns	ns	-	ns	ns
Oso Bay	13440	ns	ns	ns	ns	ns	ns
CC Inner Harbor	13432	ns	-	ns	ns	-	ns
CC Inner Harbor	13439	ns	-	ns	ns	-	ns
Corpus Christi Bay	13409	ns	ns	ns	ns	-	ns
Corpus Christi Bay	13411	ns	ns	ns	ns	-	ns
Corpus Christi Bay	14355	ns	+	ns	ns	-	ns
Baffin Bay	13450	ns	ns	ns	-	-	ns
Baffin Bay	13452	+	ns	ns	ns	-	ns
Laguna Madre	13445	ns	ns	+	ns	-	ns
Laguna Madre	13449	+	ns	ns	ns	ns	ns
Laguna Madre	13448	ns	ns	ns	+	-	ns

Laguna Madre	13447	ns	ns	+	ns	-	ns
Laguna Madre	14870	ns	-	ns	ns	-	ns
Laguna Madre	13446	ns	-	ns	ns	-	ns

Infrequent sampling (biannual or less) and concentrations below laboratory detection limits did not allow for the interpretation of temporal patterns for water-phase metals. While no statistically significant trends were determined, it would not be appropriate to interpret this as a lack of trends in metals concentrations.

LOCATIONS OF CONCERN

Additional in-depth analyses that explore specific relationships among variables and potential drivers are needed to better understand change in Texas's Coastal Bend bays. The following section discusses results of our analysis for specific locations of concern, possible drivers of observed trends, and needs for increased understanding.

COPANO BAY

Water quality in Copano Bay can be greatly influenced by episodic precipitation events, where lasting increases in productivity occur after large runoff events (Mooney and McClelland 2012). Copano Bay also receives urban stormflow runoff during rain events. However, Aransas River also receives substantial outfalls from 10 wastewater treatment plants (WWTP), which contribute to a more consistent nitrogen supply to Copano Bay during dry periods (Bruesewitz *et al.* 2017). Copano Bay has been identified as a water body of concern for use attainment related to chlorophyll *a* concentrations (TCEQ 2020b). Our analysis determined an increasing trend for chlorophyll *a* concentrations and (related) decreasing trends in Secchi transparency and dissolved oxygen concentrations at the monitoring site with the longest period of record (1973-2019, site 13405 in Port Bay). Based on the 10-year data set (2010-2019), this same location exceeded the screening level for chlorophyll *a* in nearly 30% of samples. We observed a trend of increasing TKN concentrations at the Port Bay monitoring site (13405). However, the same site experienced trends of decreasing concentrations of NO_2+NO_3 and NH_3-N, thus suggesting an increase in sources of organic N. We highlight that caution should be taken in this interpretation as substantial proportions of both NO_2+NO_3 and NH_3-N values were censored, particularly after 2000 when detection limits appeared have increased* (Figure D2). Even so, one potential explanation for increasing organic nitrogen may include increasing urban stormflow runoff from the developing areas of Aransas Pass, Rockport, and Ingleside. Organic nitrogen concentrations in samples may also simply be a product of greater algal concentrations. Further study is required to determine whether organic nutrient loads are increasing to this segment of Copano Bay. In contrast, site 14783, which is near the Aransas River outlet, and an open water site within Copano Bay (17724) demonstrated trends of decreasing TKN and TP. Increasing salinity at the site nearest the Aransas River outlet suggests a decrease in freshwater input, thus potentially

* We emphasize that there is an apparent change in laboratory methods around 2000 that raised the detection limits of both NO_2+NO_3 and NH_3-N values and therefore these datasets may be limited in their use for interpretation of trends.

leading to reduced nutrient loads entering from the watershed. Continued research to describe nutrient dynamics as water supply is affected by increasing urbanization and changing precipitation patterns will be important to anticipate potential habitat effects, such as for seagrasses.

Copano Bay is presently impaired for bacteria for both oyster waters and primary contact recreation (TCEQ 2020b). Sources of bacterial contamination have been attributed to animal agriculture in the watershed, human wastes from septic and wastewater treatment plants, and other animal wastes (e.g., birds, household pets). Total Maximum Daily Loads (TMDLs) were determined and approved in 2016 for bacteria in the Mission and Aransas Rivers that flow into Copano Bay. Quarterly monitoring at the Port Bay site (13405) captured periodic (4% of samples) enterococcus bacteria concentrations greater than the TCEQ single sample limit for primary contact recreation (Figure 2.2F). Given the potential stressors of changing land use in the watershed and plans for oyster aquaculture in Copano Bay (https://coastalscience.noaa.gov/project/development-of-a-siting-tool-for-sustainable-oyster-aquaculture-in-texas/), we suggest targeted monitoring, of Port Bay in particular, that is designed to increase understanding of bacteria sources.

NUECES-CORPUS CHRISTI COMPLEX

NUECES BAY

Nueces Bay has been identified as a water body of concern for use attainment related to elevated chlorophyll *a* concentrations (TCEQ 2020b). Quarterly monitoring in 2010-2019 recorded 32% of chlorophyll *a* concentrations greater than the TCEQ screening level (Table 3). and Kendall's tau analysis determined a significant trend of decreasing DO (Table 4.2; Figure D8) as well as trends of decreasing NO_2+NO_3 and NH_3-N concentrations, though a majority of values after 2000 were censored[*]. Urban runoff in the Nueces River watershed is a substantial source of inorganic nitrogen to the estuary and concentrations are greater with greater freshwater inflow (Rebich *et al.* 2011), thus the possible decline in inorganic N may be related to reduced freshwater input

CORPUS CHRISTI INNER HARBOR

Corpus Christi Inner Harbor was the only waterbody in the Coastal Bend region for which a significant trend of decreasing pH was observed (Table 4.2) (the two southernmost Lower Laguna Madre sites also exhibited decreasing pH). Corpus Christi Inner Harbor receives discharges from numerous industrial facilities. Since nearby waterbodies did not appear to be experiencing similar changes in pH over time, we suggest further investigation into what may be contributing to the isolated acidification.

[*] We emphasize that there is an apparent change in laboratory methods around 2000 that raised the detection limits of both NO_2+NO_3 and NH_3-N values and therefore these datasets may be limited in their use for interpretation of trends.

Despite statistically significant trends of decreasing chlorophyll *a* concentrations, 25% of samples during the period of 2010-2019 were above the TCEQ screening level of 11.9 μg/L at the upper monitoring site (13439). We also observed trends of increasing NO_2+NO_3 and TP concentrations at the same location. Both sampling sites in our analysis showed excessive NO_2+NO_3 and NH_3-N concentrations, based on TCEQ screening levels (Table 3).

OSO BAY

Oso Bay has been identified as a water body of concern for use attainment related to elevated chlorophyll *a* and total phosphorus concentrations and is listed as impaired for low dissolved oxygen concentrations (TCEQ 2020b). Previous assessments of Oso Bay water quality have identified evidence of localized eutrophication, partially attributed to effluent from three WWTPs (Wetz *et al.* 2016; Wang *et al.* 2018) and a long-term trend of increasing chlorophyll *a* concentrations (Bugica *et al.* 2020). Our analysis determined that 28% of TP and 61% of chlorophyll *a* samples from Oso Bay for the period of 2010-2019 exceeded the TCEQ screening levels (Table 3). We also identified trends of increasing TKN and chlorophyll *a* concentrations and decreasing Secchi depth. However, we determined trends of decreasing inorganic nitrogen concentrations. As previously discussed for Copano Bay, trends suggested increasing organic N that may be explained by increasing organic input from stormflow runoff or by increasing algal concentrations[*]. Eutrophication in Oso Bay raises concerns about the health of local habitats, particularly aquatic nursery and bird habitats (Barrera *et al.* 1995), and the potential for eutrophic conditions to extend into Corpus Christi Bay. Local assessment of nitrogen sources and cycling could help identify potential pathways for remediation of chronic eutrophic conditions and habitat effects in Oso Bay.

A TMDL is currently in development to address fecal bacteria impairment for oyster waters of Oso Bay (TCEQ 2020b). Quarterly monitoring in Oso Bay captured periodic enterococcus bacteria concentrations greater than the TCEQ single sample limit for primary contact recreation in 25% of samples (Figure 2.2F).

CORPUS CHRISTI BAY

A TMDL is currently in development to address a fecal bacteria impairment for primary contact recreation in Corpus Christi Bay (TCEQ 2020b). Quarterly monitoring in Corpus Christi Bay captured periodic enterococcus bacteria concentrations greater than the TCEQ single sample limit for primary contact recreation in 3% of samples (Figure 2.2F). Bacteria sourcing has detected human contributions to the fecal bacteria at recreational beaches of Corpus Christi Bay as part of the Texas Beach Watch program (Mott *et al.* 2010), suggesting sewage overflow may contribute to increased concentrations.

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[*] We emphasize that there is an apparent change in laboratory methods around 2000 that raised the detection limits of both NO_2+NO_3 and NH_3-N values and therefore these datasets may be limited in their use for interpretation of trends.

BAFFIN BAY

Baffin Bay has been identified as a water body of concern for use attainment related to elevated chlorophyll *a* concentrations (TCEQ 2020b). Previous assessment of Baffin Bay observed multiple symptoms of eutrophication, including elevated nitrogen concentrations, primarily organic N (Wetz *et al.* 2017) and long-term trends of increasing chlorophyll *a* concentrations (Bugica *et al.* 2020). Our analysis determined decreasing trends for NH_3-N, NO_2+NO_3, and TKN at both Baffin Bay sampling sites, but increasing chlorophyll *a* concentrations (Table 4.1). Decreasing nitrogen concentration may indicate reduced input from the watershed. However, laboratory methods for quarterly monitoring for both NH_3-N and NO_2+NO_3 appeared have changed detection limits and values were recorded as below detection (but at a greater detection limit) after 2000*. The relatively long residence time in Baffin Bay may explain increasing productivity as internal nitrogen cycling can dominate and sustain algal growth (Wetz *et al.* 2017; Montagna *et al.* 2018). We also determined a significant increasing trend for temperature at the more inland sampling location, which may also enable greater algal growth and the potential for eutrophic conditions to extend into the more open-water area of Baffin Bay. These features will become increasingly influential in Baffin Bay and receiving waters as climate change proceeds. We suggest increased capacity to understand potential changes in the environment that may compound eutrophication risks. Targeted monitoring that can help describe nitrogen loads/cycling and drivers of increasing chlorophyll will also be important.

LAGUNA MADRE

Laguna Madre has been identified as a water body of concern for use attainment related to elevated NH_3-N, NO_2+NO_3, and chlorophyll *a* concentrations and is listed as impaired for depressed DO concentrations (TCEQ 2020b). Agricultural runoff from the watershed dominates in the Upper Laguna Madre, while the Lower Laguna Madre is more influenced by urban sources (Rebich *et al.* 2011). The two northern monitoring sites of the Upper Laguna Madre experienced greater than 20% of chlorophyll *a* concentrations exceeding the TCEQ screening level (Table 3) with significant increasing trends (Table 4.1). Concentrations of NH_3-N, NO_2+NO_3, TP, and chlorophyll *a* at the site nearest the Arroyo Colorado outlet (13447) over the 10-year dataset indicated excessive nutrients and potential eutrophic conditions. Our analysis also determined a significant increase in salinity at this location, potentially indicating reduced freshwater input from the Arroyo Colorado. Trends of decreasing NH_3-N concentration were determined for all except one site and decreasing NO_2+NO_3 in four of the six sites (Table 4.1)*. As in other estuaries of the Texas coast, internal N cycling is an important driver of trophic conditions (Gardner *et al.* 2006). We determined significant trends of decreasing pH at the two lower Laguna Madre monitoring sites, suggesting a need to monitor acidification in the region and anticipate the effects. Because the Laguna Madre system includes vast seagrass beds and unique habitats and species with relatively limited freshwater input, continuing research to understand nutrient cycling and sources and climate change effects.

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* We emphasize that there is an apparent change in laboratory methods around 2000 that raised the detection limits of both NO_2+NO_3 and NH_3-N values and therefore these datasets may be limited in their use for interpretation of trends.

Laguna Madre is presently impaired for bacteria for both oyster waters and primary contact recreation (TCEQ 2020b). Sources of bacterial contamination have been attributed to animal agriculture in the watershed, human wastes from septic and wastewater treatment plants, and other animal wastes (e.g., birds, household pets).

LIMITATIONS ON INTERPRETATION OF RESULTS

The statistical validity of analysis is dependent upon the dataset. Shorter time periods, infrequent monitoring, and laboratory detection limits should be considered when evaluating results. For example, where variables were commonly measured at or below laboratory method detection limits, summary statistics may be an inaccurate representation of central tendency and distribution. This occurred frequently for concentrations of NH_3-N and NO_2+NO_3 (Figure 2.1A) and for all of the metals (Figures 2.3 & 2.4). For example, 9 of 13 samples analyzed for Arsenic and 96 of 100 samples analyzed for NO_2+NO_3 in Corpus Christi Bay were flagged as below detection limits.

Changes in laboratory methods and detection limits may be particularly limiting for detecting change over time. As an example, where a significant decreasing trend was determined for NH_3-N in Aransas Bay, 60% of the values were recorded as below detection limits. Further, the recorded value for those observations (assumed to be the detection limit) appeared to have increased during the period of record, thus influencing ranking statistics. This was prevalent throughout the NO_2+NO_3 and NH_3-N datasets and should be considered carefully when interpreting the statistical results.

Seasonal analysis was beyond the scope of this project, but may be useful for identifying trends in areas where annual variability can interfere with statistical tests (e.g., summer temperature). In addition, quarterly monitoring may not be sufficient to capture the dynamics of some water quality variables. Precipitation events or extended dry periods alter freshwater flow, nutrient input, and productivity response. For example, rainstorms in the upper watershed during the early growing season may increase nutrient loads to the bay and contribute to increases in algal growth that may have been completely missed because the entire event occurred in between quarterly sampling. Alternatively, in dynamic systems fluctuating broadly with seasonal, tidal, and watershed influences, there is uncertainty in trend results because other variables (besides time) can dominate variability.

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APPENDICES

APPENDIX A. WATERBODIES AND STATIONS USED AND OMITTED FROM ANALYSIS

Table A1. Waterbodies, assessment units (AU), and stations evaluated for this study, accessed 1 Feb 2021 at https://www80.tceq.texas.gov/SwqmisPublic/index.htm.

Waterbody Name	AU	Station ID	Start Year	End Year	In Analysis?
Aransas Bay	2471	13402	1969	2020	yes
Aransas Bay	2471	16492	1998	2015	no
Baffin Bay	2492	13450	1973	2019	yes
Baffin Bay	2492	13452	1973	2020	yes
Corpus Christi Bay	2481	13407	1969	2015	no
Corpus Christi Bay	2481	13409	1973	2020	yes
Corpus Christi Bay	2481	13410	1973	2015	no
Corpus Christi Bay	2481	13411	1973	2020	yes
Corpus Christi Bay	2481	14355	1998	2020	yes
Corpus Christi Bay	2481	17791	2004	2015	no
Corpus Christi Inner Harbor	2484	13430	1973	2015	no
Corpus Christi Inner Harbor	2484	13432	1969	2020	yes
Corpus Christi Inner Harbor	2484	13439	1973	2020	yes
Copano Bay	2472	12945	1969	2017	no
Copano Bay	2472	13404	1969	2017	no
Copano Bay	2472	13405	1973	2019	yes
Copano Bay	2472	13660	2000	2011	no
Copano Bay	2472	14783	1998	2020	yes
Copano Bay	2472	17724	2004	2020	yes
Laguna Madre	2491	13443	1975	2015	no
Laguna Madre	2491	13444	1973	2015	no
Laguna Madre	2491	13445	1973	2019	yes
Laguna Madre	2491	13446	1969	2019	yes
Laguna Madre	2491	13447	1969	2020	yes
Laguna Madre	2491	13448	1969	2019	yes
Laguna Madre	2491	13449	1973	2019	yes
Laguna Madre	2491	14870	2003	2019	yes
Mesquite Bay	2463	13400	1973	2020	yes
Nueces Bay	2482	13420	1969	2014	no
Nueces Bay	2482	13421	1969	2015	no
Nueces Bay	2482	13422	1973	2019	yes
Nueces Bay	2482	13423	1973	2014	no
Nueces Bay	2482	13425	1991	2015	no

Nueces Bay	2482	14832	2008	2014	no
Nueces Bay	2482	14833	2008	2014	no
Nueces Bay	2482	18365	2008	2014	no
Nueces Bay	2482	18866	2008	2014	no
Oso Bay	2485	13440	1981	2019	yes
Oso Bay	2485	13442	1973	1995	no
Redfish Bay	2483	13426	1973	2019	yes
St. Charles Bay	2473	17692	2010	2020	yes
St. Charles Bay	2473	18222	2011	2011	no

APPENDIX B. MAPS OF SITE-SPECIFIC 10-YEAR MEAN VALUES AND TREND

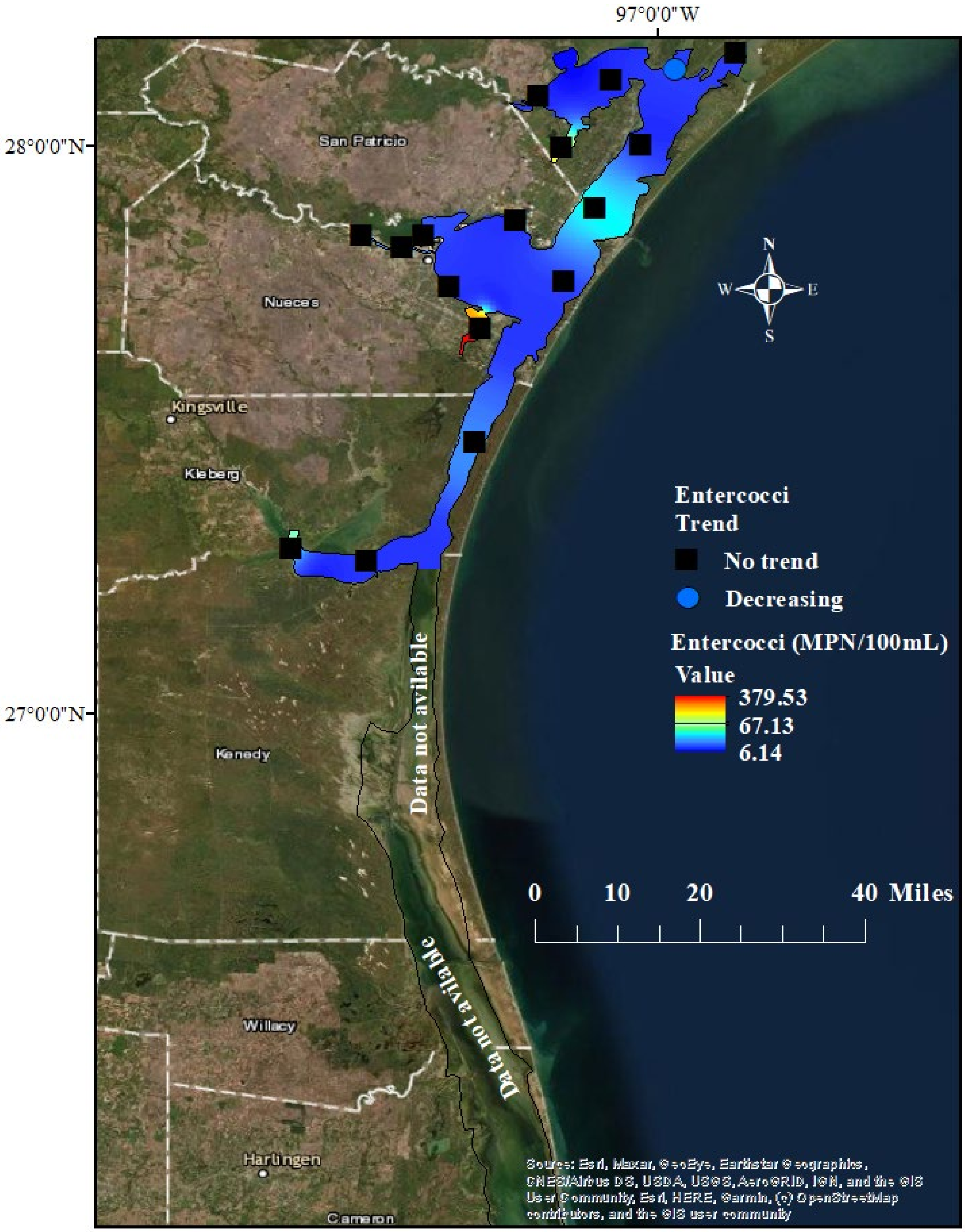


FIGURE B1: ENTEROCOCCI BACTERIA

Arithmetic mean values at each monitoring station for the period from 2010-2019 and direction of trends calculated for the period of record.

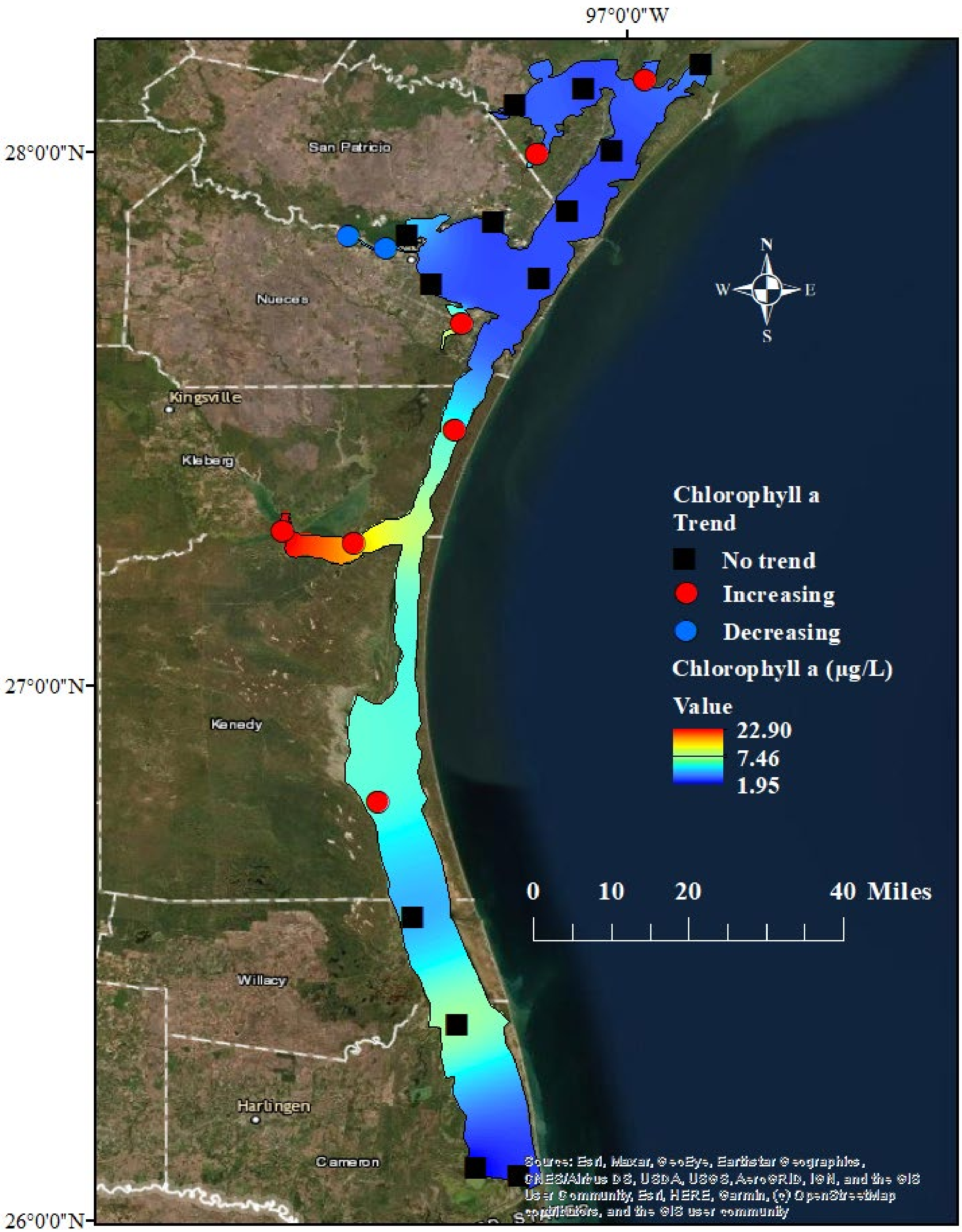


FIGURE B2: CHLOROPHYLL *A*

Geometric mean values for chlorophyll *a* concentrations at each monitoring station for the period from 2010-2019 and direction of trends calculated for the period of record.

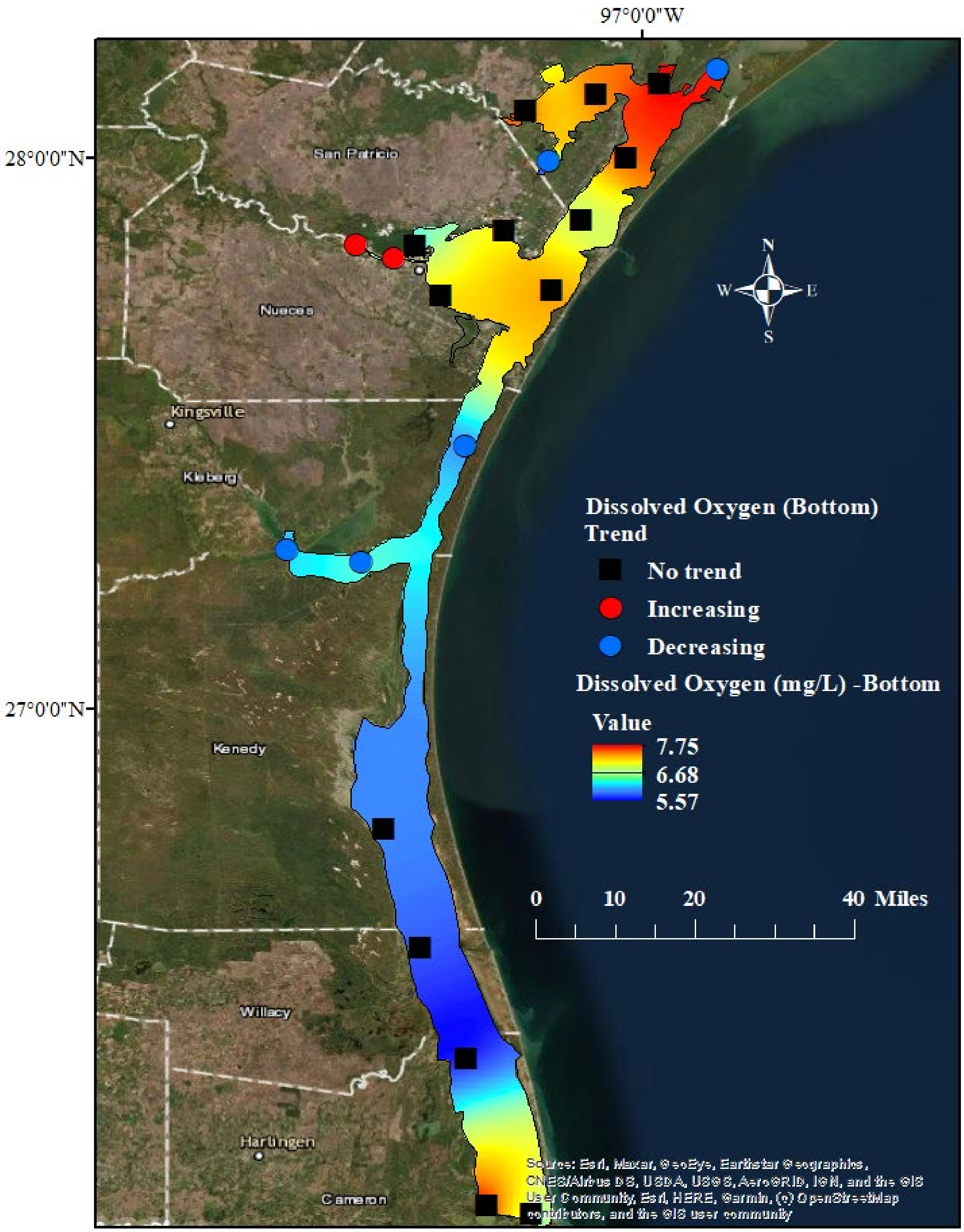


FIGURE B3: BOTTOM DISSOLVED OXYGEN

Geometric mean values for bottom dissolved oxygen concentrations at each monitoring station for the period from 2010-2019 and direction of trends calculated for the period of record.

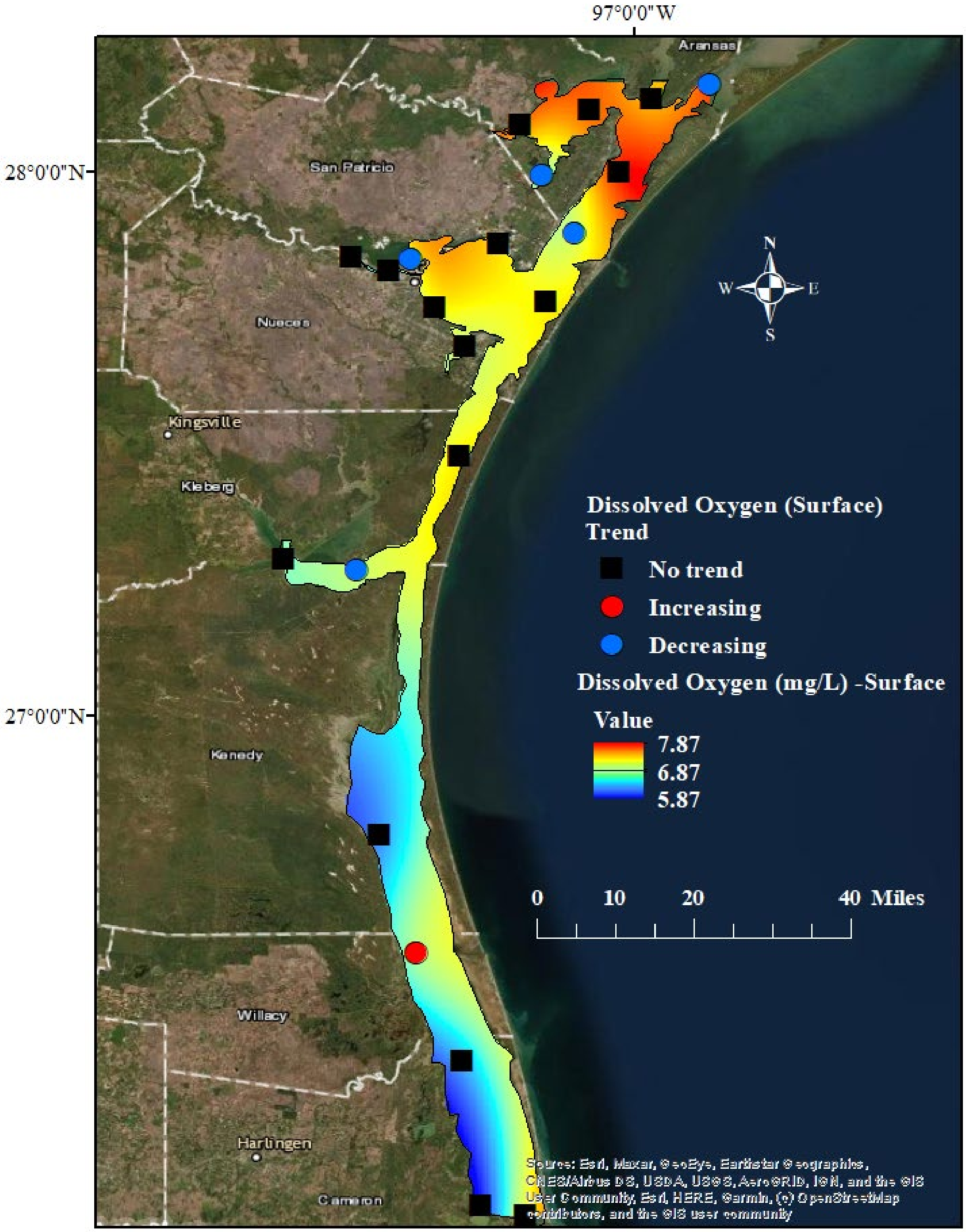


FIGURE B4: SURFACE DISSOLVED OXYGEN

Geometric mean values for surface dissolved oxygen concentrations at each monitoring station for the period from 2010-2019 and direction of trends calculated for the period of record.

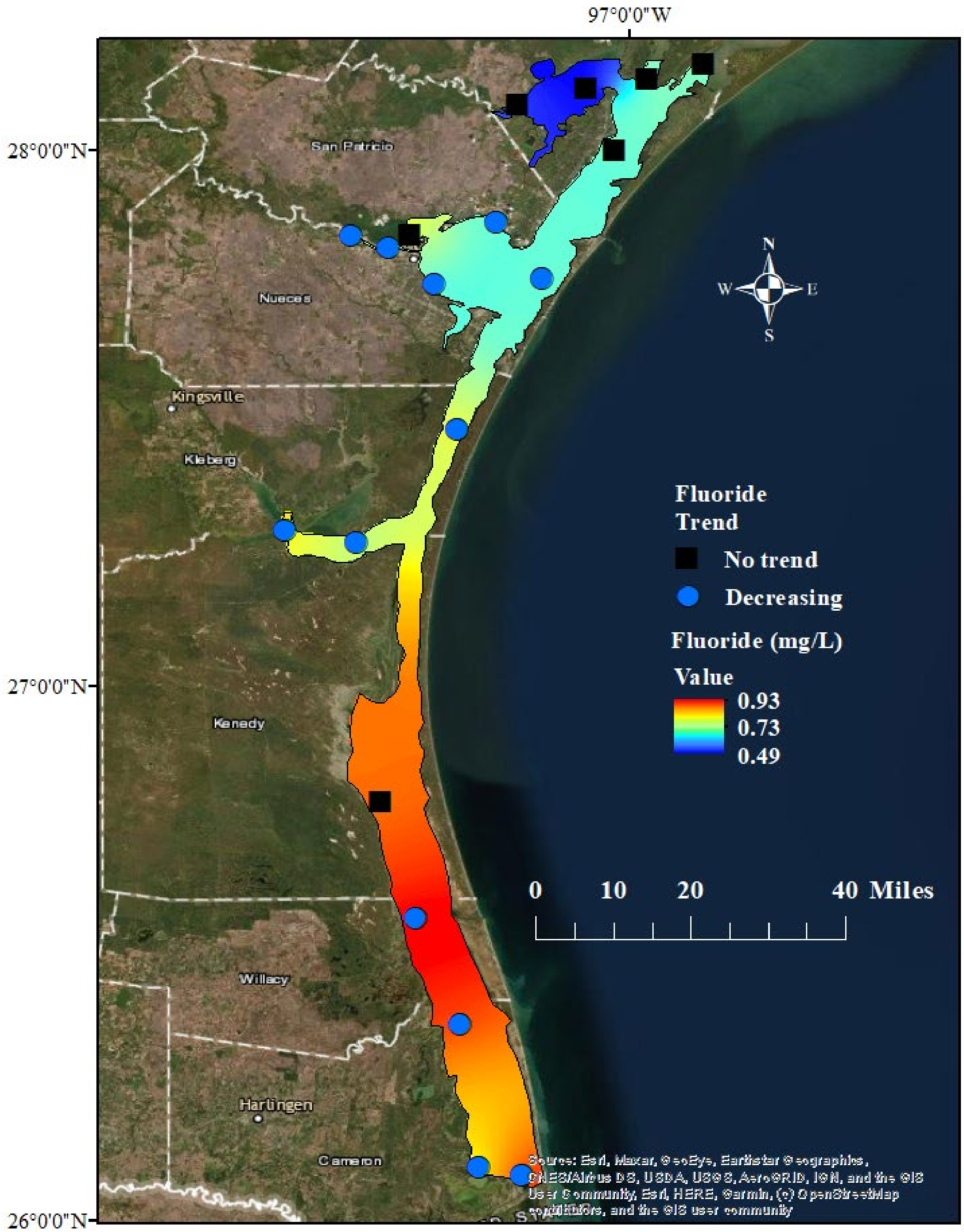


FIGURE B5: FLUORIDE

Geometric mean values for fluoride concentrations at each monitoring station for the period from 2010-2019 and direction of trends calculated for the period of record.

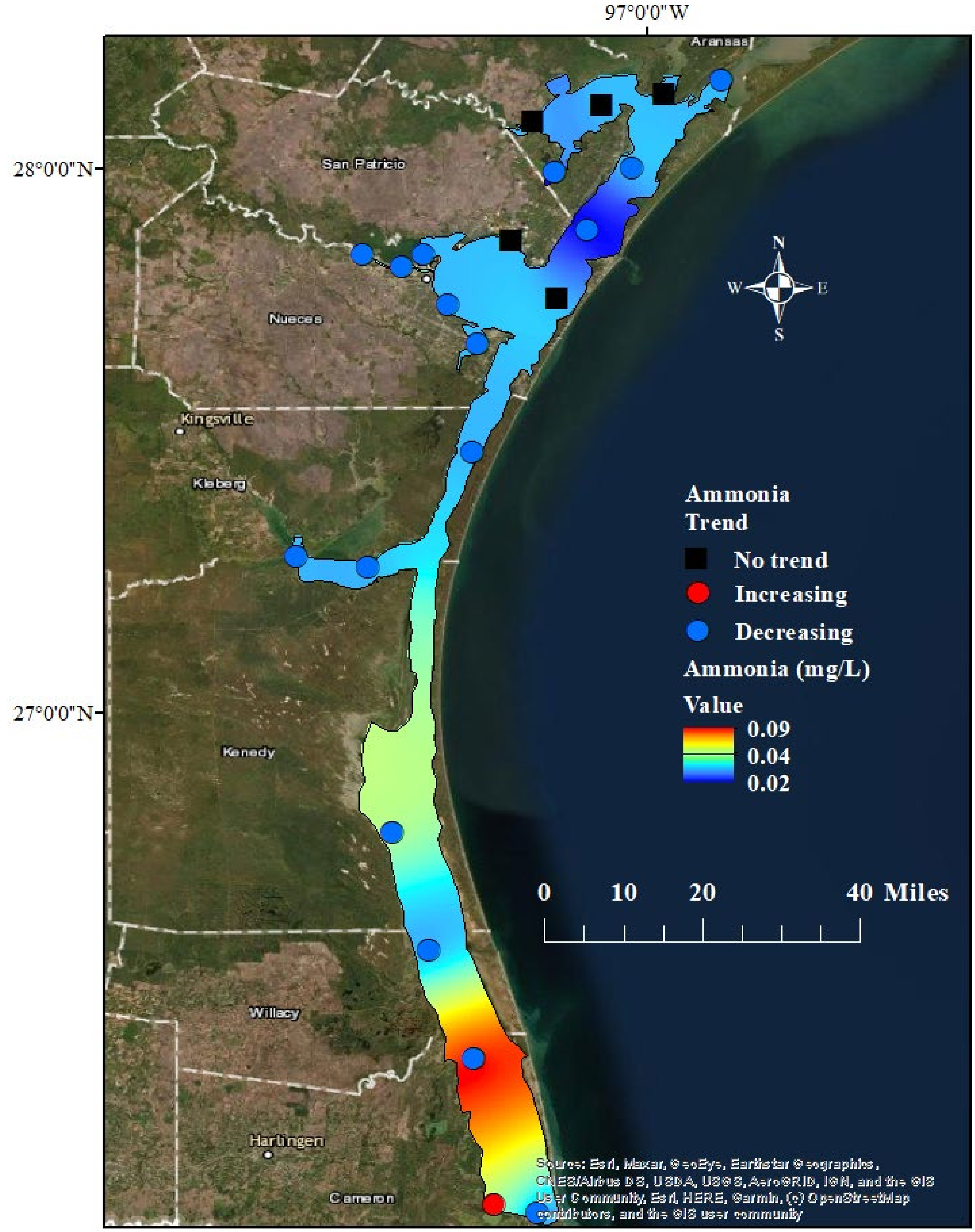


FIGURE B6: AMMONIA-N

Geometric mean values for Ammonia-N concentrations at each monitoring station for the period from 2010-2019 and direction of trends calculated for the period of record.

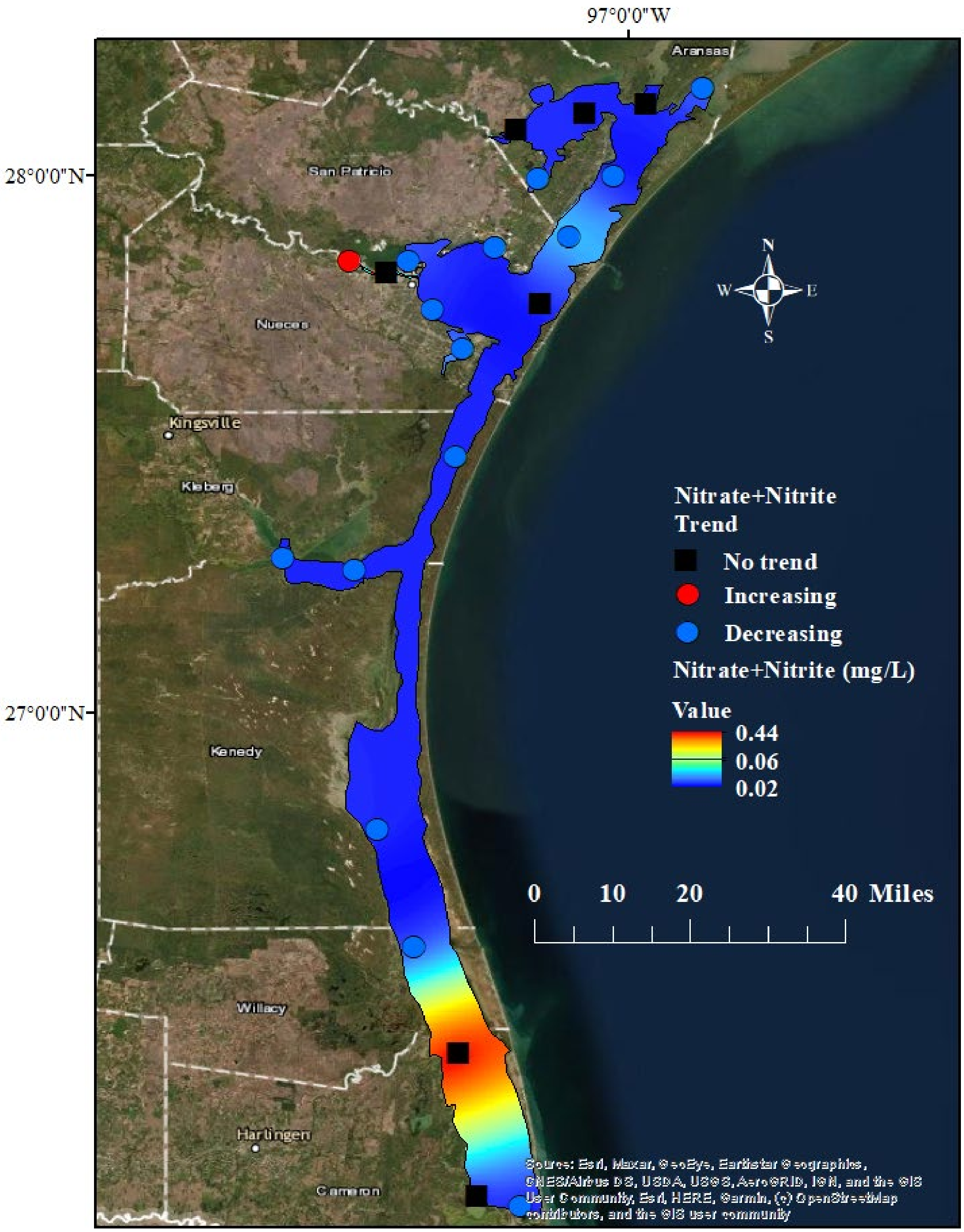


FIGURE B7: NITRATE + NIRITE

Geometric mean values for nitrate + nitrite concentrations at each monitoring station for the period from 2010-2019 and direction of trends calculated for the period of record.

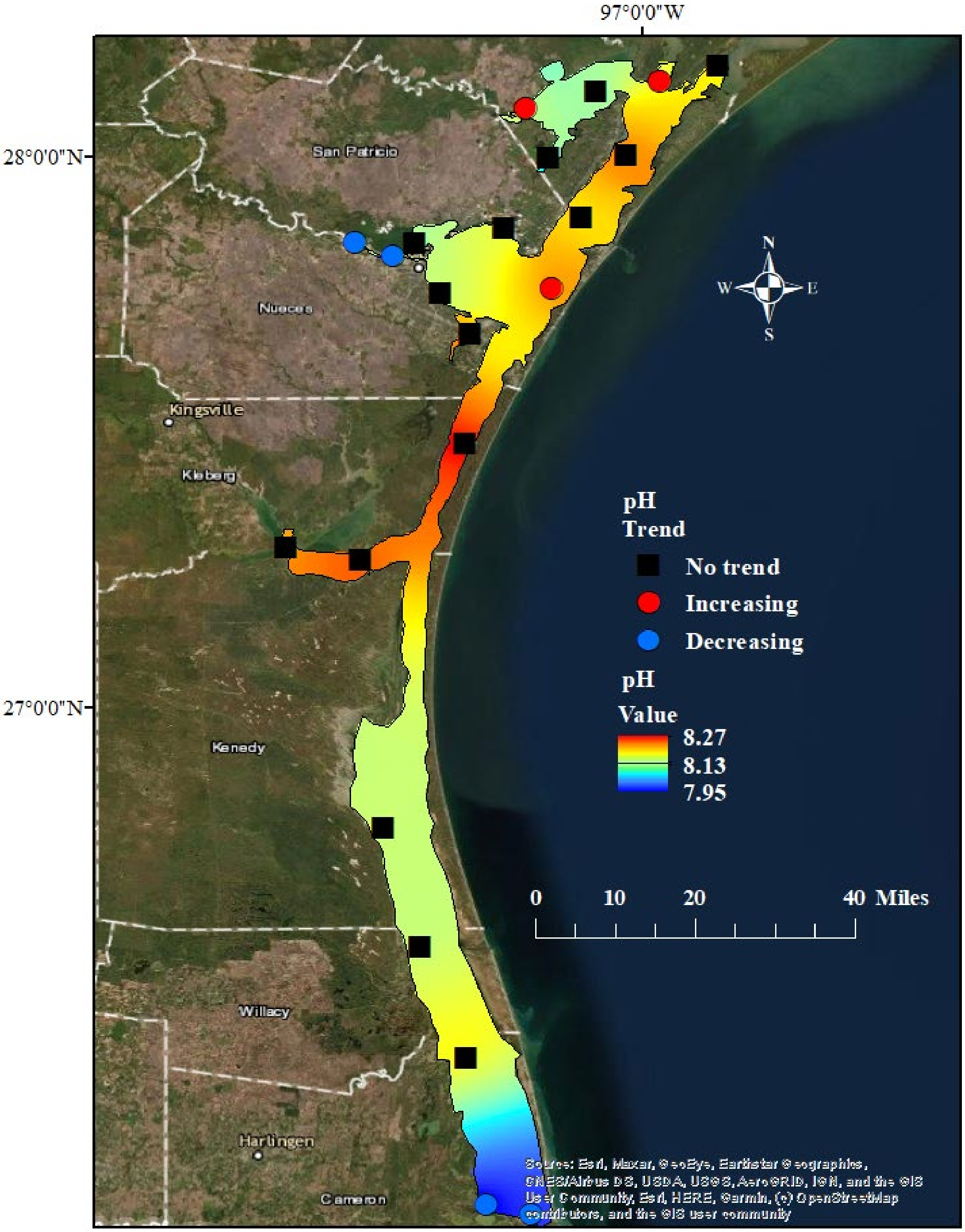


FIGURE B8: PH

Arithmetic mean values for pH at each monitoring station for the period from 2010-2019 and direction of trends calculated for the period of record.

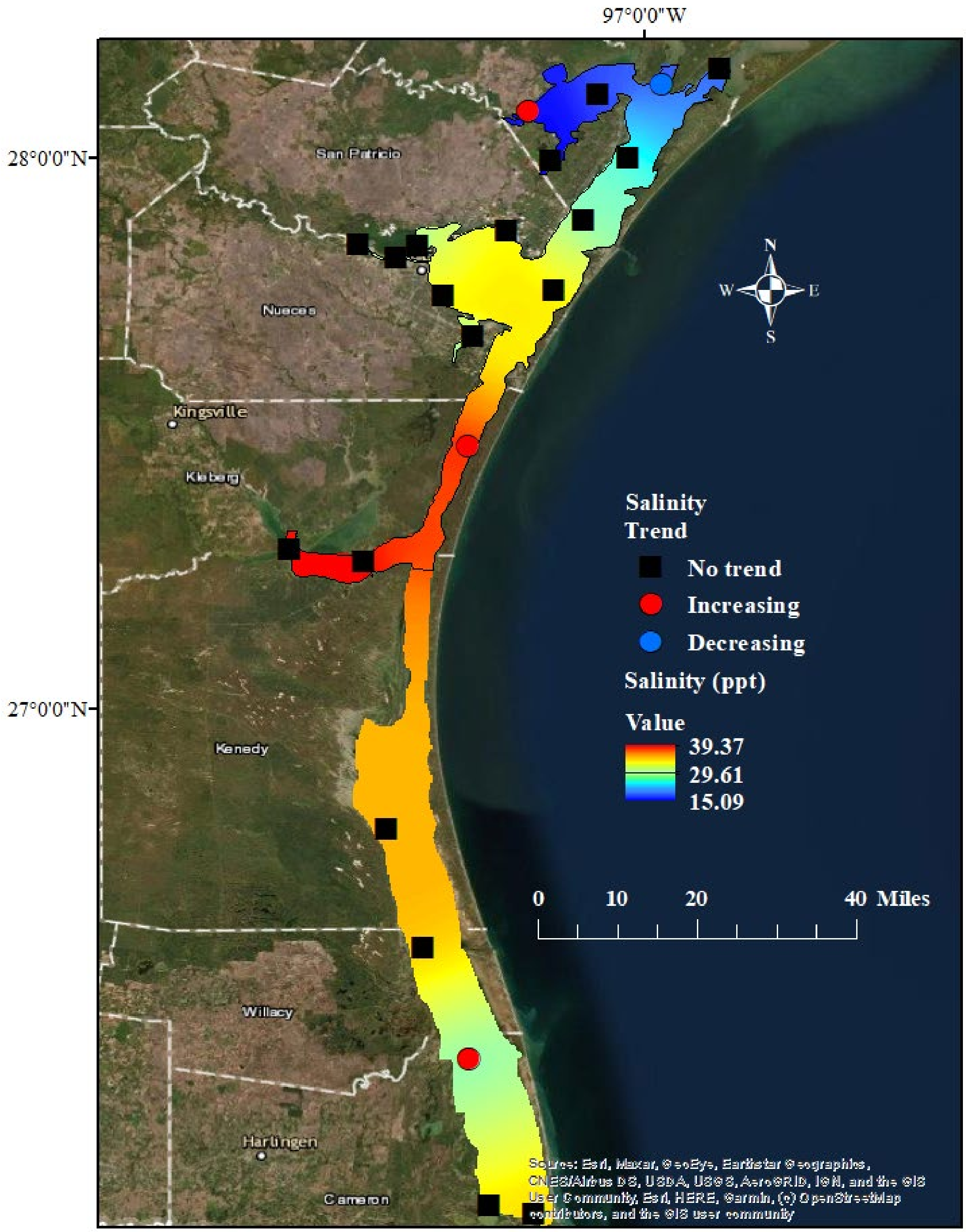


FIGURE B9: SALINITY

Geometric mean values for salinity concentrations at each monitoring station for the period from 2010-2019 and direction of trends calculated for the period of record.

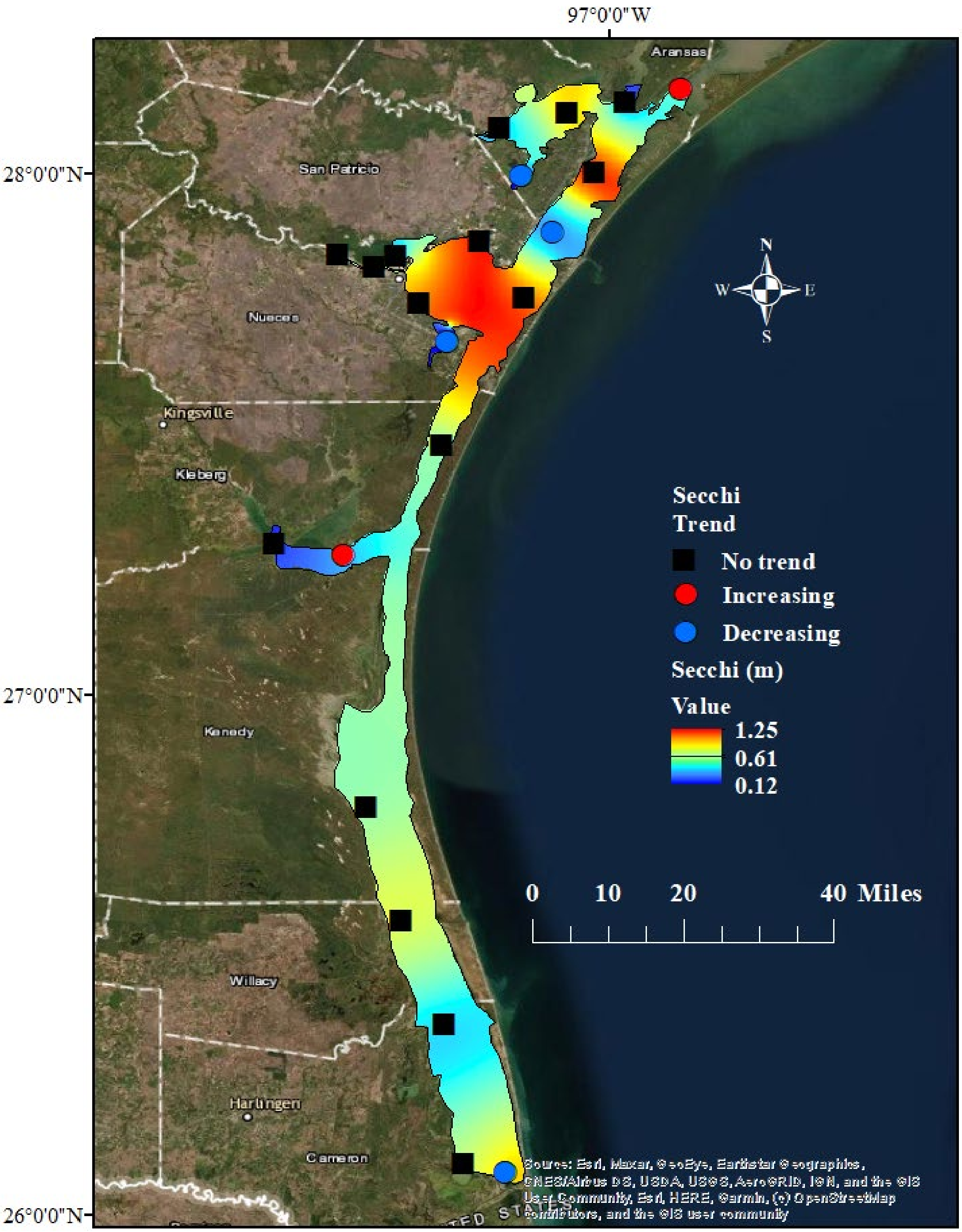


FIGURE B10: SECCHI DEPTH

Geometric mean values for Secchi depth at each monitoring station for the period from 2010-2019 and direction of trends calculated for the period of record.

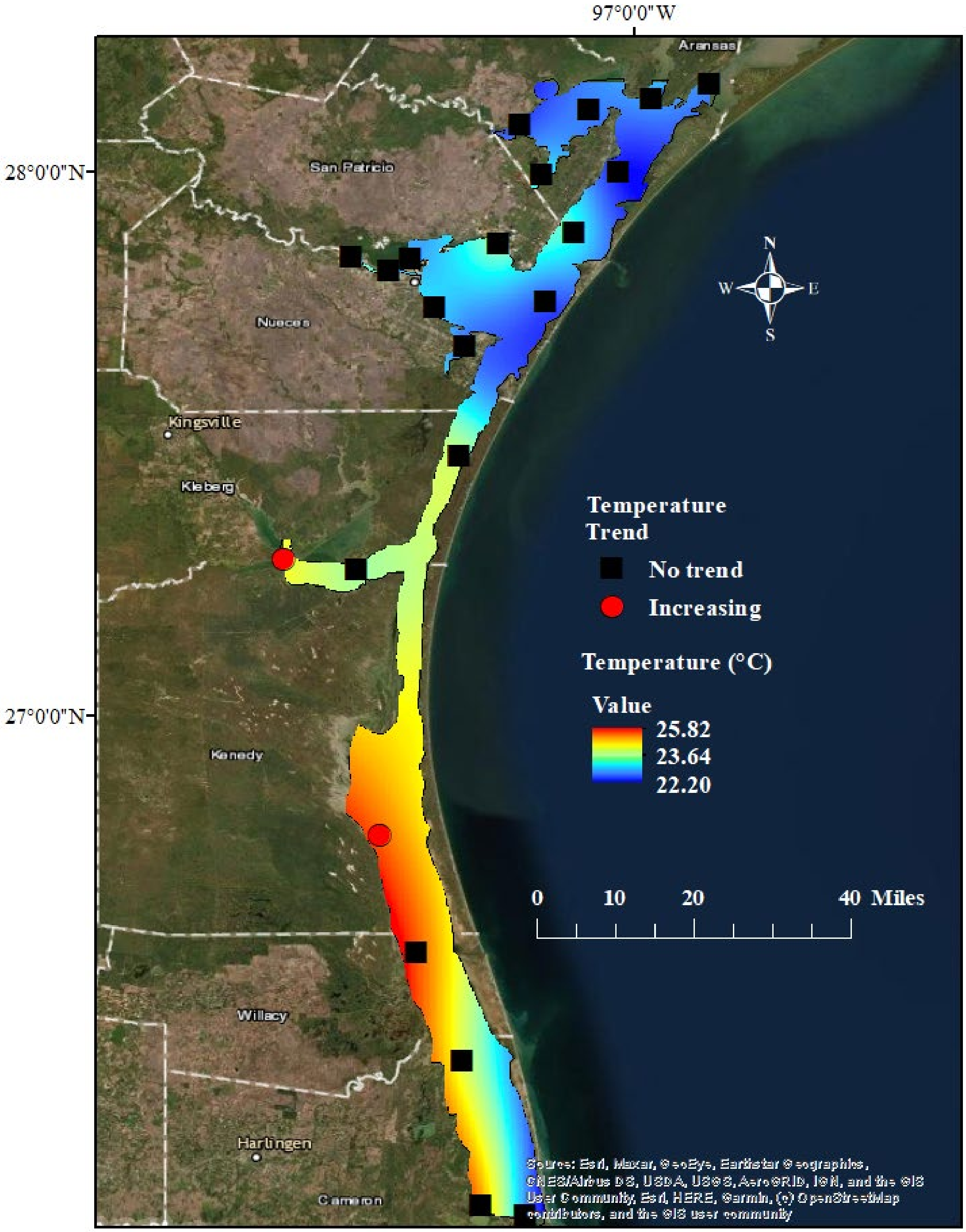


FIGURE B11: TEMPERATURE

Arithmetic mean values for temperature at each monitoring station for the period from 2010-2019 and direction of trends calculated for the period of record.

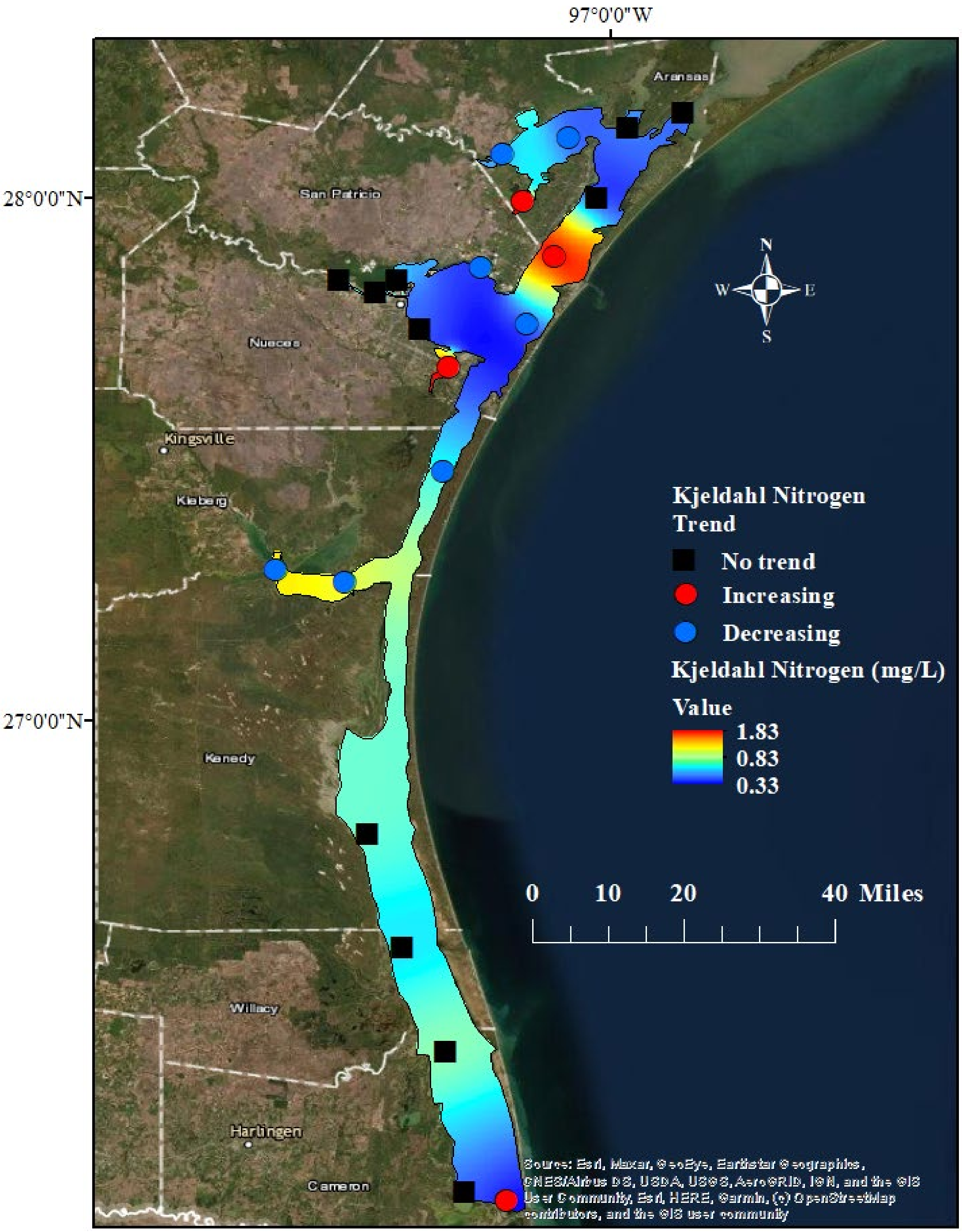


FIGURE B12: TOTAL KJELDAHL NITROGEN

Geometric mean values for total Kjeldahl nitrogen concentrations at each monitoring station for the period from 2010-2019 and direction of trends calculated for the period of record.

APPENDIX C: ARITHMETIC AND GEOMETRIC MEANS AND STANDARD DEVIATIONS BY BAY

Table C1. Arithmetic and geometric means and standard deviations and number of observations (n) for the period from 2010-2019 for each variable by waterbody and station.

Aransas Bay 13402

Basin	Station ID	Parameter	Arithmetic Mean	+/-	Standard Deviation	Geometric Mean	×/÷	Geometric Standard Deviation	n
Aransas	13402	Bottom Dissolved Oxygen (mg/L)	7.70		1.92	7.47		1.28	63
Aransas	13402	Chlorophyll *a*, fluoro (ug/L)	5.05		3.38	4.12		1.95	33
Aransas	13402	Enterococci (MPN/mL)	13.21		40.19	5.63		2.46	26
Aransas	13402	Fluoride (ug/L)	0.91		0.91	0.66		2.25	32
Aransas	13402	Nitrate + Nitrite (mg/L)	0.02		0.01	0.02		1.33	33
Aransas	13402	Nitrogen, Ammonium (mg/L)	0.03		0.03	0.03		1.56	31
Aransas	13402	pH	8.22		0.15	8.22		1.02	34
Aransas	13402	Salinity (ppt)	27.19		6.87	26.28		1.31	34
Aransas	13402	Secchi Depth(m)	1.06		0.55	0.93		1.72	32
Aransas	13402	Surface Dissolved Oxygen (mg/L)	8.05		1.82	7.87		1.24	34
Aransas	13402	Temperature (C)	22.20		7.28	20.84		1.46	34
Aransas	13402	Total Kjeldahl Nitrogen (mg/L)	0.53		0.34	0.47		1.63	33
Aransas	13402	Total Phosphorus (mg/L)	0.06		0.07	0.04		2.26	29

Baffin Bay 13450

Basin	Station ID	Parameter	Arithmetic Mean	+/-	Standard Deviation	Geometric Mean	×/÷	Geometric Standard Deviation	n
Baffin	13450	Bottom Dissolved Oxygen (mg/L)	6.47		1.31	6.33		1.23	49
Baffin	13450	Chlorophyll *a*, fluoro (ug/L)	21.28		14.29	16.90		2.05	36

Baffin	13450	Enterococci (MPN/mL)	11.43		19.41	7.08		2.11	30
Baffin	13450	Fluoride (ug/L)	1.08		1.11	0.72		2.56	35
Baffin	13450	Nitrate + Nitrite (mg/L)	0.02		0.01	0.02		1.32	36
Baffin	13450	Nitrogen, Ammonium (mg/L)	0.05		0.07	0.03		2.12	34
Baffin	13450	pH	8.24		0.17	8.24		1.02	37
Baffin	13450	Salinity (ppt)	41.48		12.04	39.37		1.42	37
Baffin	13450	Secchi Depth(m)	0.50		0.18	0.48		1.40	37
Baffin	13450	Surface Dissolved Oxygen (mg/L)	7.03		1.07	6.96		1.16	37
Baffin	13450	Temperature (C)	24.04		6.02	23.17		1.33	37
Baffin	13450	Total Kjeldahl Nitrogen (mg/L)	1.26		0.41	1.21		1.28	31
Baffin	13450	Total Phosphorus (mg/L)	0.07		0.03	0.06		1.72	30

Baffin Bay 13452

Basin	Station ID	Parameter	Arithmetic Mean	+/-	Standard Deviation	Geometric Mean	×/÷	Geometric Standard Deviation	n
Baffin	13452	Aluminum (ug/L)	50.00		0.00	50.00		1.00	4
Baffin	13452	Arsenic (ug/L)	36.45		26.79	25.44		3.15	4
Baffin	13452	Bottom Dissolved Oxygen (mg/L)	6.20		1.27	6.09		1.20	21
Baffin	13452	Cadmium (ug/L)	1.70		0.71	1.59		1.53	4
Baffin	13452	Chlorophyll *a*, fluoro (ug/L)	28.68		16.99	22.90		2.13	23
Baffin	13452	Chromium (ug/L)	2.00		0.00	2.00		1.00	4
Baffin	13452	Copper (ug/L)	6.50		2.38	6.16		1.47	4
Baffin	13452	Enterococci (MPN/mL)	147.35		580.51	8.46		4.51	17
Baffin	13452	Fluoride (ug/L)	1.01		0.94	0.79		1.99	23
Baffin	13452	Lead (ug/L)	1.17		0.95	0.94		2.06	4
Baffin	13452	Mercury (ug/L)	0.00		0.00	0.00		1.94	4
Baffin	13452	Nickel (ug/L)	2.50		0.00	2.50		1.00	4
Baffin	13452	Nitrate + Nitrite (mg/L)	0.02		0.01	0.02		1.30	23
Baffin	13452	Nitrogen, Ammonium (mg/L)	0.04		0.07	0.03		1.86	24

Baffin	13452	pH	8.21		0.18	8.21		1.02	24
Baffin	13452	Salinity (ppt)	43.44		16.67	39.25		1.66	24
Baffin	13452	Secchi Depth(m)	0.39		0.18	0.36		1.54	24
Baffin	13452	Selenium (ug/L)	0.13		0.00	0.13		1.00	4
Baffin	13452	Silver (ug/L)	4.58		2.77	3.80		2.16	4
Baffin	13452	Surface Dissolved Oxygen (mg/L)	6.83		1.21	6.74		1.18	24
Baffin	13452	Temperature (C)	24.68		5.64	23.94		1.30	24
Baffin	13452	Total Kjeldahl Nitrogen (mg/L)	1.39		0.50	1.32		1.38	21
Baffin	13452	Total Phosphorus (mg/L)	0.10		0.05	0.09		1.78	17
Baffin	13452	Zinc (ug/L)	2.00		0.00	2.00		1.00	4

Corpus Christi Inner Harbor 13432

Basin	Station ID	Parameter	Arithmetic Mean	+/-	Standard Deviation	Geometric Mean	×/÷	Geometric Standard Deviation	n
CC Inner Harbor	13432	Bottom Dissolved Oxygen (mg/L)	6.45		1.53	6.27		1.27	138
CC Inner Harbor	13432	Chlorophyll *a*, fluoro (ug/L)	5.31		3.93	4.29		1.91	32
CC Inner Harbor	13432	Enterococci (MPN/mL)	31.38		83.17	9.95		3.22	29
CC Inner Harbor	13432	Fluoride (ug/L)	0.99		1.10	0.69		2.43	34
CC Inner Harbor	13432	Nitrate + Nitrite (mg/L)	0.38		0.18	0.32		2.08	34
CC Inner Harbor	13432	Nitrogen, Ammonium (mg/L)	0.12		0.10	0.09		2.44	34
CC Inner Harbor	13432	pH	7.99		0.10	7.99		1.01	35
CC Inner Harbor	13432	Salinity (ppt)	31.60		4.56	31.27		1.16	35
CC Inner Harbor	13432	Secchi Depth(m)	1.10		0.37	1.03		1.48	35
CC Inner Harbor	13432	Surface Dissolved Oxygen (mg/L)	6.64		1.09	6.55		1.17	35
CC Inner Harbor	13432	Temperature (C)	23.37		5.46	22.70		1.28	35
CC Inner Harbor	13432	Total Kjeldahl Nitrogen (mg/L)	0.68		0.24	0.64		1.45	32
CC Inner Harbor	13432	Total Phosphorus (mg/L)	0.10		0.02	0.10		1.23	27
CC Inner Harbor	13432	Zinc (ug/L)	8.99		4.46	8.14		1.58	10

		Corpus Christi Inner Harbor			13439				
Basin	Station ID	Parameter	Arithmetic Mean	+/-	Standard Deviation	Geometric Mean	×/÷	Geometric Standard Deviation	n
CC Inner Harbor	13439	Aluminum (ug/L)	165.94		102.76	129.22		2.20	16
CC Inner Harbor	13439	Arsenic (ug/L)	26.62		23.05	16.51		2.99	15
CC Inner Harbor	13439	Bottom Dissolved Oxygen (mg/L)	6.34		1.59	6.08		1.38	132
CC Inner Harbor	13439	Cadmium (ug/L)	1.39		0.92	0.88		3.63	16
CC Inner Harbor	13439	Chlorophyll *a*, fluoro (ug/L)	8.99		8.26	6.02		2.61	32
CC Inner Harbor	13439	Chromium (ug/L)	5.00		4.00	3.66		2.24	16
CC Inner Harbor	13439	Copper (ug/L)	7.86		3.40	7.20		1.56	15
CC Inner Harbor	13439	Enterococci (MPN/mL)	8.00		8.68	6.45		1.71	28
CC Inner Harbor	13439	Fluoride (ug/L)	1.07		1.12	0.74		2.44	34
CC Inner Harbor	13439	Lead (ug/L)	0.96		0.74	0.57		4.06	16
CC Inner Harbor	13439	Mercury (ug/L)	0.00		0.00	0.00		2.17	16
CC Inner Harbor	13439	Nickel (ug/L)	6.25		5.00	4.57		2.24	16
CC Inner Harbor	13439	Nitrate + Nitrite (mg/L)	0.53		0.26	0.44		2.10	34
CC Inner Harbor	13439	Nitrogen, Ammonium (mg/L)	0.12		0.11	0.08		2.64	34
CC Inner Harbor	13439	pH	8.01		0.16	8.01		1.02	35
CC Inner Harbor	13439	Salinity (ppt)	31.23		4.52	30.90		1.16	35
CC Inner Harbor	13439	Secchi Depth(m)	1.39		0.62	1.25		1.62	35
CC Inner Harbor	13439	Selenium (ug/L)	8.94		9.87	5.35		2.84	16
CC Inner Harbor	13439	Silver (ug/L)	4.15		3.76	2.23		3.83	15
CC Inner Harbor	13439	Surface Dissolved Oxygen (mg/L)	6.95		1.23	6.84		1.20	35
CC Inner Harbor	13439	Temperature (C)	23.85		5.21	23.26		1.26	35
CC Inner Harbor	13439	Total Kjeldahl Nitrogen (mg/L)	0.81		0.28	0.76		1.44	32
CC Inner Harbor	13439	Total Phosphorus (mg/L)	0.13		0.04	0.12		1.47	28
CC Inner Harbor	13439	Zinc (ug/L)	7.39		4.92	5.59		2.29	25

		Copano Bay	13405						
Basin	Station ID	Parameter	Arithmetic Mean	+/-	Standard Deviation	Geometric Mean	×/÷	Geometric Standard Deviation	n
Copano	13405	Bottom Dissolved Oxygen (mg/L)	6.42		2.17	5.88		1.65	30
Copano	13405	Chlorophyll *a*, fluoro (ug/L)	9.59		5.81	7.91		1.96	38
Copano	13405	Enterococci (MPN/mL)	241.19		595.99	21.43		7.28	32
Copano	13405	Nitrate + Nitrite (mg/L)	0.06		0.16	0.03		2.48	34
Copano	13405	Nitrogen, Ammonium (mg/L)	0.03		0.03	0.02		2.36	39
Copano	13405	pH	8.07		0.23	8.06		1.03	39
Copano	13405	Salinity (ppt)	20.49		13.16	15.09		2.63	39
Copano	13405	Secchi Depth(m)	0.23		0.13	0.20		1.71	39
Copano	13405	Surface Dissolved Oxygen (mg/L)	6.95		1.55	6.79		1.25	39
Copano	13405	Temperature (C)	23.38		6.18	22.34		1.39	39
Copano	13405	Total Kjeldahl Nitrogen (mg/L)	1.91		0.56	1.83		1.37	13
Copano	13405	Total Phosphorus (mg/L)	0.07		0.05	0.06		1.83	39

		Copano Bay	14783						
Basin	Station ID	Parameter	Arithmetic Mean	+/-	Standard Deviation	Geometric Mean	×/÷	Geometric Standard Deviation	n
Copano	14783	Bottom Dissolved Oxygen (mg/L)	7.58		1.36	7.47		1.19	45
Copano	14783	Chlorophyll *a*, fluoro (ug/L)	5.57		3.33	4.47		2.09	28
Copano	14783	Enterococci (MPN/mL)	9.44		9.22	6.51		2.51	26
Copano	14783	Fluoride (ug/L)	0.79		0.99	0.52		2.35	29
Copano	14783	Nitrate + Nitrite (mg/L)	0.02		0.01	0.02		1.37	30
Copano	14783	Nitrogen, Ammonium (mg/L)	0.04		0.05	0.03		1.76	29

Copano	14783	pH	8.13		0.18	8.13		1.02	30
Copano	14783	Salinity (ppt)	22.57		11.61	19.21		1.85	30
Copano	14783	Secchi Depth(m)	0.60		0.36	0.49		1.99	30
Copano	14783	Surface Dissolved Oxygen (mg/L)	7.76		1.37	7.65		1.19	30
Copano	14783	Temperature (C)	22.47		6.17	21.60		1.34	30
Copano	14783	Total Kjeldahl Nitrogen (mg/L)	0.69		0.30	0.62		1.71	28
Copano	14783	Total Phosphorus (mg/L)	0.08		0.04	0.06		2.35	28

Copano Bay 17724

Basin	Station ID	Parameter	Arithmetic Mean	+/-	Standard Deviation	Geometric Mean	×/÷	Geometric Standard Deviation	n
Copano	17724	Bottom Dissolved Oxygen (mg/L)	7.51		1.44	7.38		1.20	55
Copano	17724	Chlorophyll *a*, fluoro (ug/L)	6.05		6.65	4.28		2.21	28
Copano	17724	Enterococci (MPN/mL)	6.14		4.84	4.97		2.04	25
Copano	17724	Fluoride (ug/L)	0.65		0.57	0.49		2.17	28
Copano	17724	Nitrate + Nitrite (mg/L)	0.04		0.07	0.02		1.98	30
Copano	17724	Nitrogen, Ammonium (mg/L)	0.04		0.05	0.03		1.79	29
Copano	17724	pH	8.11		0.20	8.11		1.03	30
Copano	17724	Salinity (ppt)	22.89		9.63	20.74		1.60	30
Copano	17724	Secchi Depth(m)	0.85		0.45	0.76		1.60	30
Copano	17724	Surface Dissolved Oxygen (mg/L)	7.80		1.34	7.69		1.18	30
Copano	17724	Temperature (C)	22.79		6.18	21.92		1.34	30
Copano	17724	Total Kjeldahl Nitrogen (mg/L)	0.62		0.35	0.52		1.97	29
Copano	17724	Total Phosphorus (mg/L)	0.07		0.04	0.06		1.96	28

Corpus Christi Bay 13409

Basin	Station ID	Parameter	Arithmetic Mean	+/-	Standard Deviation	Geometric Mean	×/÷	Geometric Standard Deviation	n
Corpus Christi	13409	Aluminum (ug/L)	142.03		111.15	104.35		2.27	15
Corpus Christi	13409	Arsenic (ug/L)	29.34		33.96	15.70		3.39	13
Corpus Christi	13409	Bottom Dissolved Oxygen (mg/L)	7.02		1.16	6.93		1.18	54
Corpus Christi	13409	Cadmium (ug/L)	1.51		1.28	0.98		3.17	14
Corpus Christi	13409	Chlorophyll *a*, fluoro (ug/L)	5.45		7.21	4.01		1.99	33
Corpus Christi	13409	Chromium (ug/L)	4.17		3.64	3.12		2.07	15
Corpus Christi	13409	Copper (ug/L)	8.19		5.60	6.90		1.81	11
Corpus Christi	13409	Enterococci (MPN/mL)	8.00		12.41	5.96		1.74	31
Corpus Christi	13409	Fluoride (ug/L)	0.87		0.85	0.66		2.13	33
Corpus Christi	13409	Lead (ug/L)	1.04		0.86	0.66		3.43	14
Corpus Christi	13409	Mercury (ug/L)	0.00		0.00	0.00		1.19	16
Corpus Christi	13409	Nickel (ug/L)	5.25		4.42	3.98		2.07	13
Corpus Christi	13409	Nitrate + Nitrite (mg/L)	0.03		0.02	0.02		1.54	33
Corpus Christi	13409	Nitrogen, Ammonium (mg/L)	0.04		0.06	0.03		1.89	33
Corpus Christi	13409	pH	8.15		0.11	8.15		1.01	33
Corpus Christi	13409	Salinity (ppt)	32.47		4.32	32.19		1.14	34
Corpus Christi	13409	Secchi Depth(m)	1.02		0.41	0.94		1.50	34
Corpus Christi	13409	Selenium (ug/L)	13.20		17.76	3.51		8.78	14
Corpus Christi	13409	Silver (ug/L)	4.25		5.30	1.96		4.14	14
Corpus Christi	13409	Surface Dissolved Oxygen (mg/L)	7.39		1.14	7.31		1.17	34
Corpus Christi	13409	Temperature (C)	23.84		6.11	22.89		1.36	34
Corpus Christi	13409	Total Kjeldahl Nitrogen (mg/L)	0.42		0.14	0.40		1.43	28
Corpus Christi	13409	Total Phosphorus (mg/L)	0.05		0.05	0.03		2.12	31
Corpus Christi	13409	Zinc (ug/L)	4.86		3.75	3.65		2.16	15

Corpus Christi Bay 13411

Basin	Station ID	Parameter	Arithmetic Mean	+/-	Standard Deviation	Geometric Mean	×/÷	Geometric Standard Deviation	n
Corpus Christi	13411	Bottom Dissolved Oxygen (mg/L)	7.14		1.18	7.05		1.18	35
Corpus Christi	13411	Chlorophyll *a*, fluoro (ug/L)	6.19		5.67	4.86		1.96	33
Corpus Christi	13411	Enterococci (MPN/mL)	11.53		25.17	6.73		2.07	30
Corpus Christi	13411	Fluoride (ug/L)	0.87		0.84	0.66		2.21	34
Corpus Christi	13411	Nitrate + Nitrite (mg/L)	0.02		0.01	0.02		1.37	33
Corpus Christi	13411	Nitrogen, Ammonium (mg/L)	0.04		0.05	0.03		1.92	33
Corpus Christi	13411	pH	8.13		0.12	8.13		1.01	34
Corpus Christi	13411	Salinity (ppt)	32.84		4.69	32.50		1.16	34
Corpus Christi	13411	Secchi Depth(m)	0.91		0.33	0.85		1.42	31
Corpus Christi	13411	Surface Dissolved Oxygen (mg/L)	7.30		1.31	7.19		1.19	34
Corpus Christi	13411	Temperature (C)	23.27		6.21	22.29		1.37	34
Corpus Christi	13411	Total Kjeldahl Nitrogen (mg/L)	0.51		0.18	0.48		1.42	29
Corpus Christi	13411	Total Phosphorus (mg/L)	0.06		0.04	0.04		2.13	33

Corpus Christi Bay 14355

Basin	Station ID	Parameter	Arithmetic Mean	+/-	Standard Deviation	Geometric Mean	×/÷	Geometric Standard Deviation	n
Corpus Christi	14355	Bottom Dissolved Oxygen (mg/L)	7.41		1.46	7.26		1.23	48
Corpus Christi	14355	Chlorophyll *a*, fluoro (ug/L)	5.55		3.73	4.39		2.07	34
Corpus Christi	14355	Enterococci (MPN/mL)	19.71		52.83	7.55		2.67	31
Corpus Christi	14355	Fluoride (ug/L)	0.87		0.85	0.66		2.15	34
Corpus Christi	14355	Nitrate + Nitrite (mg/L)	0.03		0.04	0.02		1.62	34
Corpus Christi	14355	Nitrogen, Ammonium (mg/L)	0.03		0.04	0.03		1.78	34

Corpus Christi	14355	pH	8.21	0.13	8.20	1.02	34
Corpus Christi	14355	Salinity (ppt)	32.99	4.88	32.64	1.16	34
Corpus Christi	14355	Secchi Depth(m)	1.02	0.64	0.88	1.66	33
Corpus Christi	14355	Surface Dissolved Oxygen (mg/L)	7.32	1.23	7.23	1.18	34
Corpus Christi	14355	Temperature (C)	22.53	6.29	21.56	1.37	34
Corpus Christi	14355	Total Kjeldahl Nitrogen (mg/L)	0.49	0.16	0.47	1.37	31
Corpus Christi	14355	Total Phosphorus (mg/L)	0.04	0.02	0.04	1.96	32

Laguna Madre 13445

Basin	Station ID	Parameter	Arithmetic Mean	+/- Standard Deviation	Geometric Mean	×/÷ Geometric Standard Deviation	n
Laguna Madre	13445	Bottom Dissolved Oxygen (mg/L)	6.05	1.33	5.95	1.23	4
Laguna Madre	13445	Chlorophyll *a*, fluoro (ug/L)	13.06	9.34	9.75	2.32	37
Laguna Madre	13445	Enterococci (MPN/mL)	61.57	291.05	7.01	3.22	30
Laguna Madre	13445	Fluoride (ug/L)	1.04	0.94	0.75	2.39	35
Laguna Madre	13445	Nitrate + Nitrite (mg/L)	0.03	0.03	0.02	1.58	36
Laguna Madre	13445	Nitrogen, Ammonium (mg/L)	0.03	0.04	0.03	1.77	36
Laguna Madre	13445	pH	8.27	0.21	8.27	1.03	37
Laguna Madre	13445	Salinity (ppt)	39.56	8.28	38.63	1.26	37
Laguna Madre	13445	Secchi Depth(m)	0.70	0.32	0.61	1.82	37
Laguna Madre	13445	Surface Dissolved Oxygen (mg/L)	7.33	1.20	7.24	1.18	37
Laguna Madre	13445	Temperature (C)	24.22	6.25	23.29	1.35	37
Laguna Madre	13445	Total Kjeldahl Nitrogen (mg/L)	0.95	0.45	0.83	1.88	32
Laguna Madre	13445	Total Phosphorus (mg/L)	0.04	0.03	0.03	2.25	33

Laguna Madre 13446

Basin	Station ID	Parameter	Arithmetic Mean	+/-	Standard Deviation	Geometric Mean	×/÷	Geometric Standard Deviation	n
Laguna Madre	13446	Bottom Dissolved Oxygen (mg/L)	6.75		1.11	6.67		1.18	80
Laguna Madre	13446	Chlorophyll *a*, fluoro (ug/L)	5.57		8.58	3.57		2.26	26
Laguna Madre	13446	Fluoride (ug/L)	1.19		1.15	0.90		2.07	27
Laguna Madre	13446	Nitrate + Nitrite (mg/L)	0.02		0.01	0.02		1.39	28
Laguna Madre	13446	Nitrogen, Ammonium (mg/L)	0.03		0.03	0.03		1.70	26
Laguna Madre	13446	pH	7.98		0.17	7.97		1.02	25
Laguna Madre	13446	Salinity (ppt)	33.72		2.85	33.61		1.09	25
Laguna Madre	13446	Secchi Depth(m)	0.86		0.38	0.77		1.68	25
Laguna Madre	13446	Surface Dissolved Oxygen (mg/L)	7.27		1.60	7.11		1.24	26
Laguna Madre	13446	Temperature (C)	22.91		4.91	22.31		1.28	26
Laguna Madre	13446	Total Kjeldahl Nitrogen (mg/L)	0.39		0.20	0.33		1.85	28
Laguna Madre	13446	Total Phosphorus (mg/L)	0.05		0.03	0.04		1.81	24

Laguna Madre 13447

Basin	Station ID	Parameter	Arithmetic Mean	+/-	Standard Deviation	Geometric Mean	×/÷	Geometric Standard Deviation	n
Laguna Madre	13447	Bottom Dissolved Oxygen (mg/L)	6.11		1.87	5.57		1.77	49
Laguna Madre	13447	Chlorophyll *a*, fluoro (ug/L)	18.50		17.15	11.63		2.96	33
Laguna Madre	13447	Fluoride (ug/L)	1.19		1.18	0.90		2.04	31
Laguna Madre	13447	Nitrate + Nitrite (mg/L)	0.48		0.54	0.16		6.15	34
Laguna Madre	13447	Nitrogen, Ammonium (mg/L)	0.10		0.08	0.06		2.54	32
Laguna Madre	13447	pH	8.16		0.21	8.15		1.03	32
Laguna Madre	13447	Salinity (ppt)	29.43		7.63	28.33		1.34	26
Laguna Madre	13447	Secchi Depth(m)	0.54		0.17	0.51		1.42	32
Laguna Madre	13447	Surface Dissolved Oxygen (mg/L)	6.64		1.75	6.32		1.43	31
Laguna Madre	13447	Temperature (C)	24.53		4.77	24.03		1.24	32

Laguna Madre	13447	Total Kjeldahl Nitrogen (mg/L)	1.08		0.68	0.95		1.61	30
Laguna Madre	13447	Total Phosphorus (mg/L)	0.16		0.11	0.12		2.63	31

Laguna Madre 13448

Basin	Station ID	Parameter	Arithmetic Mean	+/-	Standard Deviation	Geometric Mean	×/÷	Geometric Standard Deviation	n
Laguna Madre	13448	Bottom Dissolved Oxygen (mg/L)	6.02		1.71	5.73		1.41	35
Laguna Madre	13448	Chlorophyll *a*, fluoro (ug/L)	7.62		3.21	7.04		1.49	20
Laguna Madre	13448	Fluoride (ug/L)	1.11		0.96	0.93		1.70	20
Laguna Madre	13448	Nitrate + Nitrite (mg/L)	0.03		0.03	0.03		1.74	20
Laguna Madre	13448	Nitrogen, Ammonium (mg/L)	0.04		0.02	0.03		1.68	23
Laguna Madre	13448	pH	8.13		0.19	8.12		1.02	20
Laguna Madre	13448	Salinity (ppt)	34.49		5.90	33.94		1.21	19
Laguna Madre	13448	Secchi Depth(m)	0.74		0.28	0.69		1.49	20
Laguna Madre	13448	Surface Dissolved Oxygen (mg/L)	6.94		1.03	6.87		1.15	20
Laguna Madre	13448	Temperature (C)	25.82		5.06	25.27		1.25	20
Laguna Madre	13448	Total Kjeldahl Nitrogen (mg/L)	0.79		0.24	0.76		1.31	18
Laguna Madre	13448	Total Phosphorus (mg/L)	0.04		0.02	0.04		1.96	19

Laguna Madre 13449

Basin	Station ID	Parameter	Arithmetic Mean	+/-	Standard Deviation	Geometric Mean	×/÷	Geometric Standard Deviation	n
Laguna Madre	13449	Bottom Dissolved Oxygen (mg/L)	6.02		1.28	5.88		1.25	42
Laguna Madre	13449	Chlorophyll *a*, fluoro (ug/L)	11.83		7.65	9.82		1.88	19
Laguna Madre	13449	Fluoride (ug/L)	1.11		0.98	0.88		2.03	20
Laguna Madre	13449	Nitrate + Nitrite (mg/L)	0.02		0.00	0.02		1.18	18
Laguna Madre	13449	Nitrogen, Ammonium (mg/L)	0.05		0.05	0.04		1.94	22

Laguna Madre	13449	pH	8.13		0.20	8.13		1.03	20
Laguna Madre	13449	Salinity (ppt)	35.53		7.15	34.78		1.24	19
Laguna Madre	13449	Secchi Depth(m)	0.66		0.31	0.61		1.50	20
Laguna Madre	13449	Surface Dissolved Oxygen (mg/L)	6.45		1.51	6.22		1.36	20
Laguna Madre	13449	Temperature (C)	25.71		5.09	25.16		1.25	20
Laguna Madre	13449	Total Kjeldahl Nitrogen (mg/L)	0.98		0.37	0.88		1.84	19
Laguna Madre	13449	Total Phosphorus (mg/L)	0.05		0.03	0.04		2.07	18

Laguna Madre 14870

Basin	Station ID	Parameter	Arithmetic Mean	+/-	Standard Deviation	Geometric Mean	×/÷	Geometric Standard Deviation	n
Laguna Madre	14870	Bottom Dissolved Oxygen (mg/L)	7.90		1.76	7.75		1.26	4
Laguna Madre	14870	Chlorophyll *a*, fluoro (ug/L)	3.81		5.79	1.95		3.11	27
Laguna Madre	14870	Fluoride (ug/L)	1.06		1.13	0.78		2.18	29
Laguna Madre	14870	Nitrate + Nitrite (mg/L)	0.02		0.01	0.02		1.42	30
Laguna Madre	14870	Nitrogen, Ammonium (mg/L)	0.05		0.04	0.04		1.94	29
Laguna Madre	14870	pH	7.95		0.34	7.94		1.04	25
Laguna Madre	14870	Salinity (ppt)	33.71		5.68	33.17		1.21	23
Laguna Madre	14870	Secchi Depth(m)	0.74		0.33	0.65		1.73	29
Laguna Madre	14870	Surface Dissolved Oxygen (mg/L)	6.32		2.27	5.87		1.53	25
Laguna Madre	14870	Temperature (C)	25.39		5.37	24.74		1.27	26
Laguna Madre	14870	Total Kjeldahl Nitrogen (mg/L)	0.62		0.47	0.49		2.04	29
Laguna Madre	14870	Total Phosphorus (mg/L)	0.04		0.04	0.03		2.28	28

Mesquite Bay 13400

Basin	Station ID	Parameter	Arithmetic Mean	+/-	Standard Deviation	Geometric Mean	×/÷	Geometric Standard Deviation	n

Mesquite	13400	Bottom Dissolved Oxygen (mg/L)	7.70		0.62	7.68		1.09	4
Mesquite	13400	Chlorophyll *a*, fluoro (ug/L)	7.22		5.78	5.73		1.97	27
Mesquite	13400	Enterococci (MPN/mL)	15.84		52.83	6.29		2.25	27
Mesquite	13400	Fluoride (ug/L)	0.88		0.97	0.67		1.95	28
Mesquite	13400	Nitrate + Nitrite (mg/L)	0.04		0.05	0.03		2.05	29
Mesquite	13400	Nitrogen, Ammonium (mg/L)	0.04		0.08	0.03		1.92	28
Mesquite	13400	pH	8.17		0.22	8.17		1.03	29
Mesquite	13400	Salinity (ppt)	23.48		8.67	21.79		1.51	29
Mesquite	13400	Secchi Depth(m)	0.63		0.31	0.56		1.67	29
Mesquite	13400	Surface Dissolved Oxygen (mg/L)	7.90		1.47	7.77		1.20	29
Mesquite	13400	Temperature (C)	22.83		6.00	22.03		1.32	29
Mesquite	13400	Total Kjeldahl Nitrogen (mg/L)	0.62		0.39	0.51		2.04	26
Mesquite	13400	Total Phosphorus (mg/L)	0.09		0.05	0.08		1.61	27

Nueces Bay 13422

Basin	Station ID	Parameter	Arithmetic Mean	+/-	Standard Deviation	Geometric Mean	×/÷	Geometric Standard Deviation	n
Nueces	13422	Aluminum (ug/L)	184.53		192.23	92.18		4.63	18
Nueces	13422	Arsenic (ug/L)	27.80		30.85	15.86		3.21	19
Nueces	13422	Bottom Dissolved Oxygen (mg/L)	6.35		1.07	6.26		1.19	11
Nueces	13422	Cadmium (ug/L)	1.69		1.14	1.29		2.41	18
Nueces	13422	Chlorophyll *a*, fluoro (ug/L)	9.81		5.20	8.20		1.96	34
Nueces	13422	Chromium (ug/L)	4.26		3.81	2.96		2.34	19
Nueces	13422	Copper (ug/L)	8.52		6.47	6.44		2.19	19
Nueces	13422	Enterococci (MPN/mL)	38.16		124.94	8.92		3.34	32
Nueces	13422	Fluoride (ug/L)	0.96		0.84	0.76		2.04	36
Nueces	13422	Lead (ug/L)	1.24		0.93	0.77		3.64	18
Nueces	13422	Mercury (ug/L)	0.01		0.00	0.01		1.93	18

Nueces	13422	Nickel (ug/L)	5.87		4.80	4.43		2.09	18
Nueces	13422	Nitrate + Nitrite (mg/L)	0.03		0.03	0.03		1.84	37
Nueces	13422	Nitrogen, Ammonium (mg/L)	0.05		0.08	0.03		2.16	36
Nueces	13422	pH	8.11		0.15	8.11		1.02	37
Nueces	13422	Salinity (ppt)	30.19		7.28	29.13		1.34	37
Nueces	13422	Secchi Depth(m)	0.51		0.26	0.46		1.67	37
Nueces	13422	Selenium (ug/L)	10.82		12.32	3.88		6.03	17
Nueces	13422	Silver (ug/L)	4.18		4.71	2.49		2.98	18
Nueces	13422	Surface Dissolved Oxygen (mg/L)	7.34		1.36	7.23		1.19	37
Nueces	13422	Temperature (C)	23.02		6.16	22.05		1.37	37
Nueces	13422	Total Kjeldahl Nitrogen (mg/L)	0.80		0.40	0.73		1.49	33
Nueces	13422	Total Phosphorus (mg/L)	0.36		1.47	0.10		2.68	34
Nueces	13422	Zinc (ug/L)	5.33		3.93	3.95		2.26	19

Oso Bay 13440

Basin	Station ID	Parameter	Arithmetic Mean	+/-	Standard Deviation	Geometric Mean	×/÷	Geometric Standard Deviation	n
Oso	13440	Chlorophyll *a*, fluoro (ug/L)	20.65		21.33	12.73		2.95	39
Oso	13440	Enterococci (MPN/mL)	379.53		747.62	57.13		7.52	32
Oso	13440	Nitrate + Nitrite (mg/L)	0.05		0.03	0.04		2.05	34
Oso	13440	Nitrogen, Ammonium (mg/L)	0.05		0.05	0.03		2.54	39
Oso	13440	pH	8.22		0.24	8.21		1.03	39
Oso	13440	Salinity (ppt)	32.21		12.10	28.82		1.77	39
Oso	13440	Secchi Depth(m)	0.15		0.10	0.12		1.78	39
Oso	13440	Surface Dissolved Oxygen (mg/L)	7.37		2.68	6.96		1.39	39
Oso	13440	Temperature (C)	22.71		6.63	21.35		1.50	39
Oso	13440	Total Kjeldahl Nitrogen (mg/L)	2.24		1.08	1.80		2.32	32
Oso	13440	Total Phosphorus (mg/L)	0.18		0.14	0.13		2.39	39

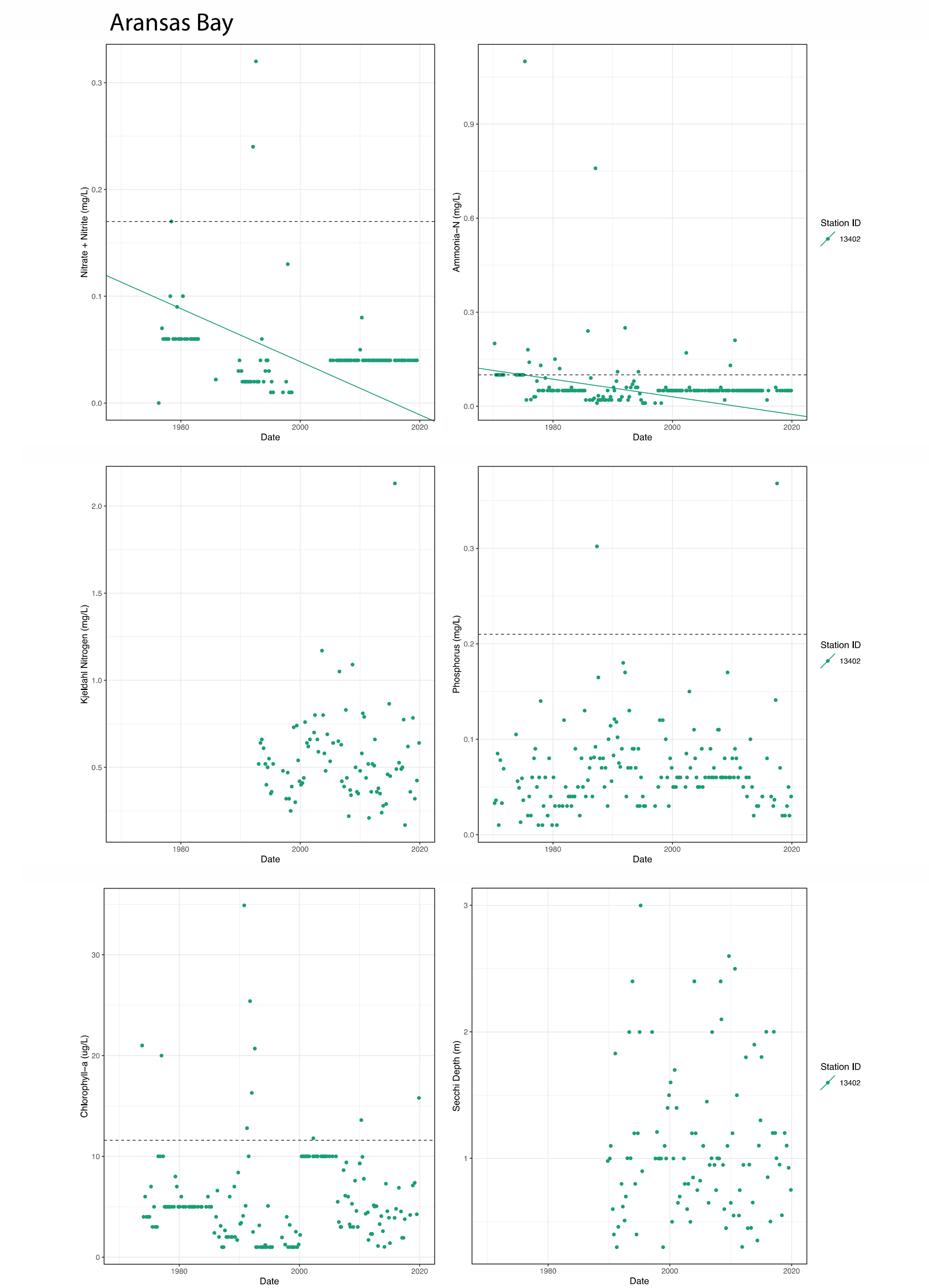
		Redfish Bay	13426						
Basin	**Station ID**	**Parameter**	**Arithmetic Mean**	**+/-**	**Standard Deviation**	**Geometric Mean**	**×/÷**	**Geometric Standard Deviation**	**n**
Redfish	13426	Bottom Dissolved Oxygen (mg/L)	6.85		1.28	6.74		1.20	90
Redfish	13426	Chlorophyll *a*, fluoro (ug/L)	4.97		2.71	4.31		1.75	38
Redfish	13426	Enterococci (MPN/mL)	123.34		427.73	17.95		4.83	32
Redfish	13426	Nitrate + Nitrite (mg/L)	0.10		0.24	0.05		2.34	34
Redfish	13426	Nitrogen, Ammonium (mg/L)	0.02		0.02	0.02		2.12	39
Redfish	13426	pH	8.18		0.15	8.18		1.02	39
Redfish	13426	Salinity (ppt)	28.89		6.28	28.10		1.29	39
Redfish	13426	Secchi Depth(m)	0.48		0.20	0.45		1.43	39
Redfish	13426	Surface Dissolved Oxygen (mg/L)	7.14		1.35	7.02		1.20	39
Redfish	13426	Temperature (C)	23.51		6.45	22.41		1.40	39
Redfish	13426	Total Kjeldahl Nitrogen (mg/L)	2.38		2.34	1.76		2.15	13
Redfish	13426	Total Phosphorus (mg/L)	0.04		0.02	0.04		1.36	39

		St. Charles Bay	17692						
Basin	**Station ID**	**Parameter**	**Arithmetic Mean**	**+/-**	**Standard Deviation**	**Geometric Mean**	**×/÷**	**Geometric Standard Deviation**	**n**
St. Charles	17692	Bottom Dissolved Oxygen (mg/L)	7.75		0.07	7.75		1.01	2
St. Charles	17692	Chlorophyll *a*, fluoro (ug/L)	6.61		4.76	5.16		2.09	26
St. Charles	17692	Enterococci (MPN/mL)	15.38		47.89	6.64		2.20	26

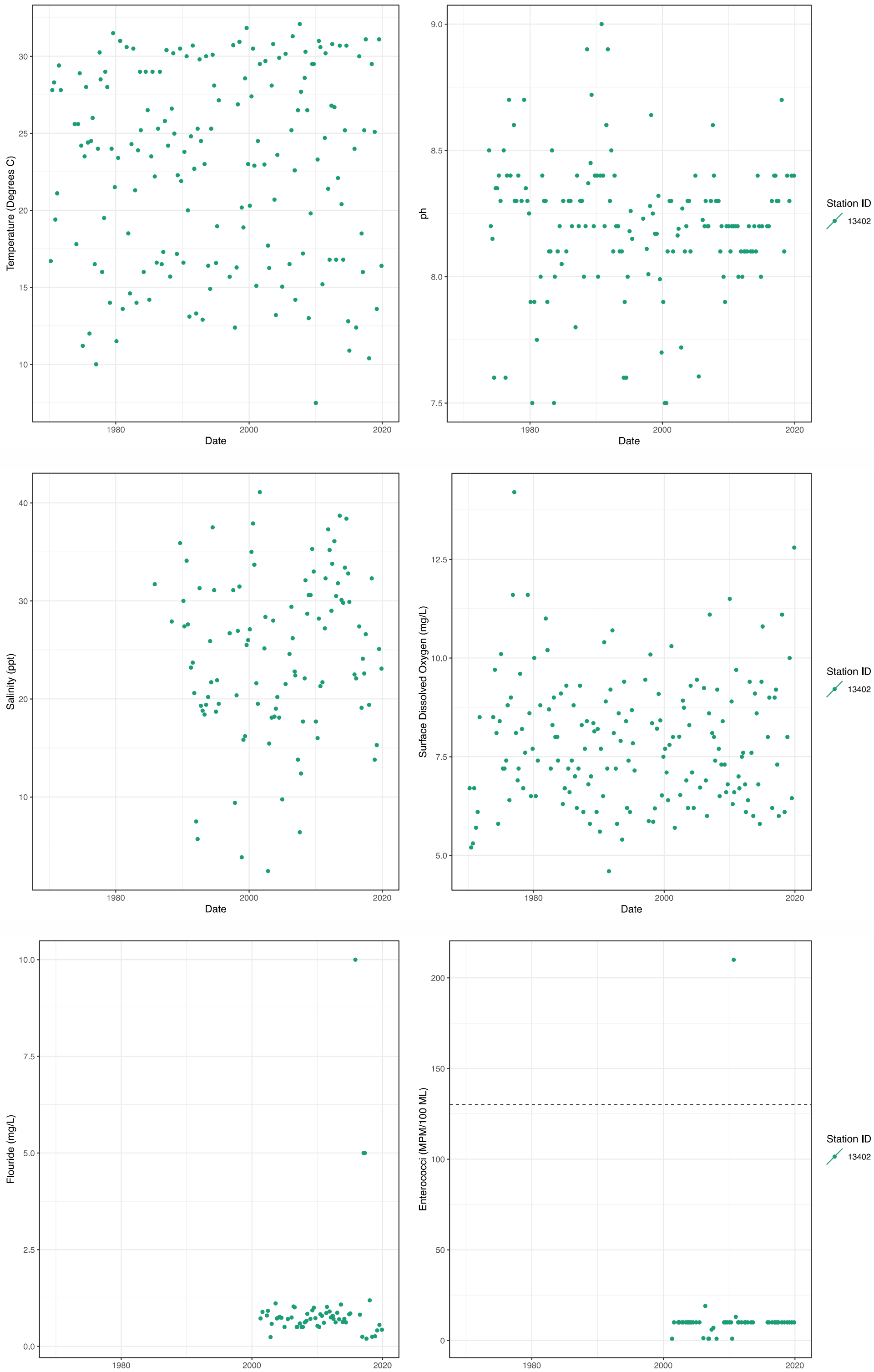
St. Charles	17692	Fluoride (ug/L)	0.97	1.07	0.67	2.24	25
St. Charles	17692	Nitrate + Nitrite (mg/L)	0.03	0.02	0.02	1.61	29
St. Charles	17692	Nitrogen, Ammonium (mg/L)	0.04	0.07	0.03	2.01	26
St. Charles	17692	pH	8.16	0.19	8.16	1.02	29
St. Charles	17692	Salinity (ppt)	23.25	8.53	21.60	1.50	29
St. Charles	17692	Secchi Depth(m)	0.51	0.25	0.43	1.95	29
St. Charles	17692	Surface Dissolved Oxygen (mg/L)	7.57	1.48	7.43	1.23	29
St. Charles	17692	Temperature (C)	22.96	5.80	22.21	1.30	29
St. Charles	17692	Total Kjeldahl Nitrogen (mg/L)	0.66	0.38	0.56	1.96	27
St. Charles	17692	Total Phosphorus (mg/L)	0.07	0.04	0.06	1.81	26

APPENDIX D: TREND PLOTS

Estimated trends for each bay and monitoring site included in this study. Data points are the quarterly or seasonally averaged value for each parameter. Lines indicate estimated slope over the period of record and are only included where analysis resulted in significant trends ($p < 0.05$). Dashed horizontal line indicates the TCEQ screening level/criterion for the parameter.

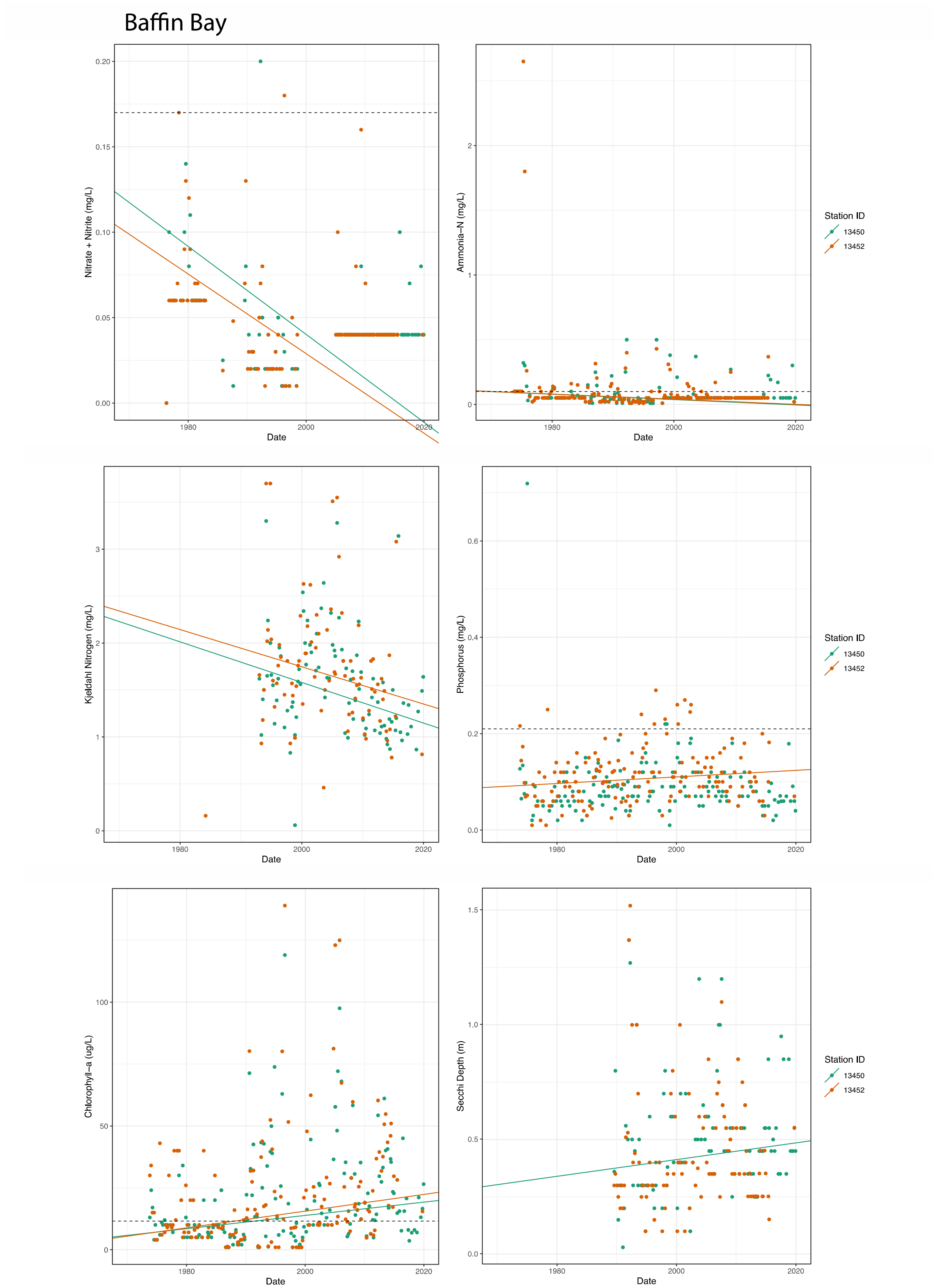

Aransas Bay
Nitrate + Nitrite (mg/L)
Ammonia−N (mg/L)
Kjeldahl Nitrogen (mg/L)
Phosphorus (mg/L)
Chlorophyll−a (ug/L)
Secchi Depth (m)
Date
1980
2000
2020
Station ID
13402

Aransas Bay



Temperature (Degrees C)
Date
ph
Date
Station ID
13402
Salinity (ppt)
Date
Surface Dissolved Oxygen (mg/L)
Date
Station ID
13402
Flouride (mg/L)
Date
Enterococci (MPM/100 ML)
Date
Station ID
13402

FIGURE D2: BAFFIN BAY



Baffin Bay

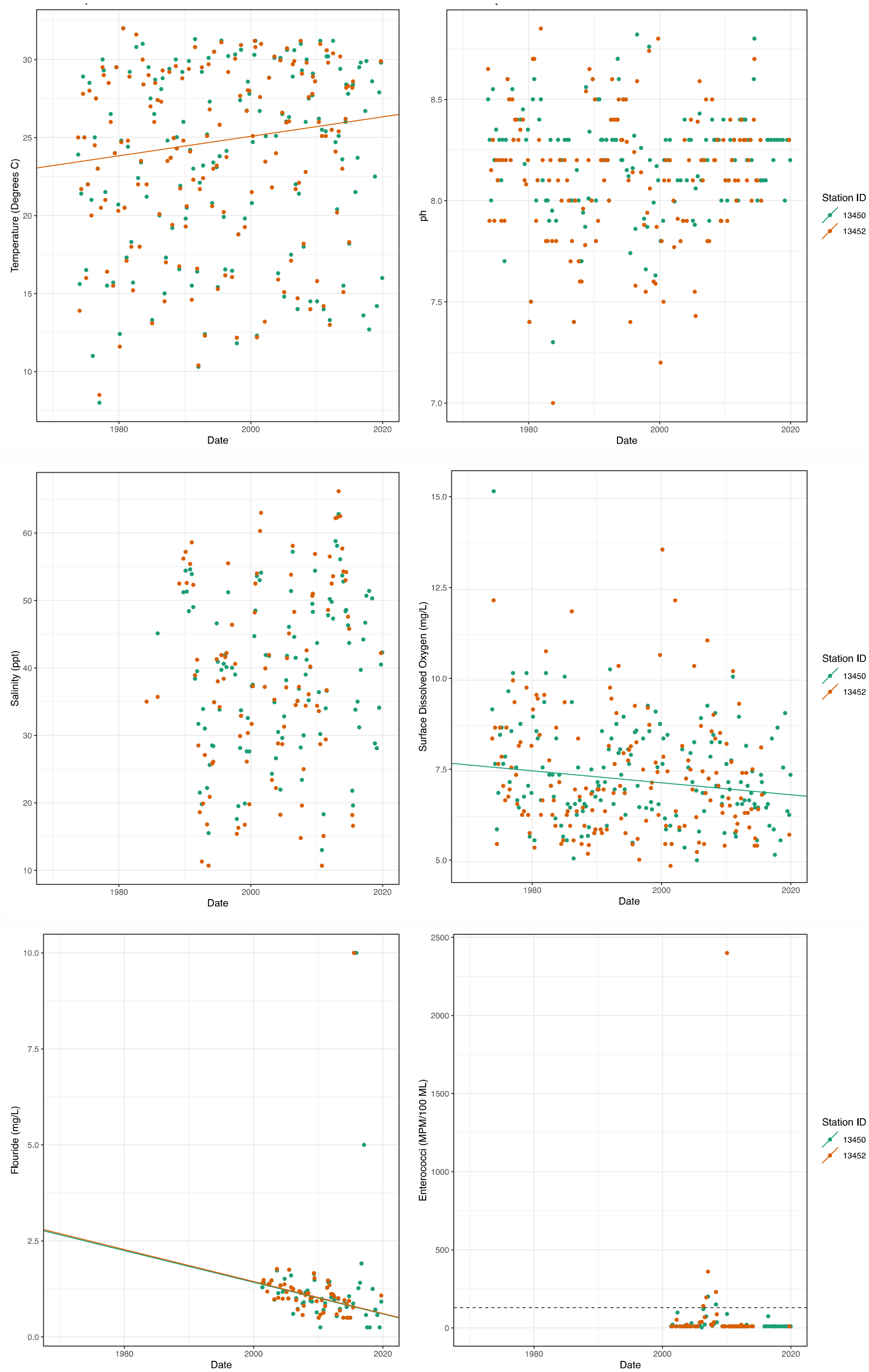
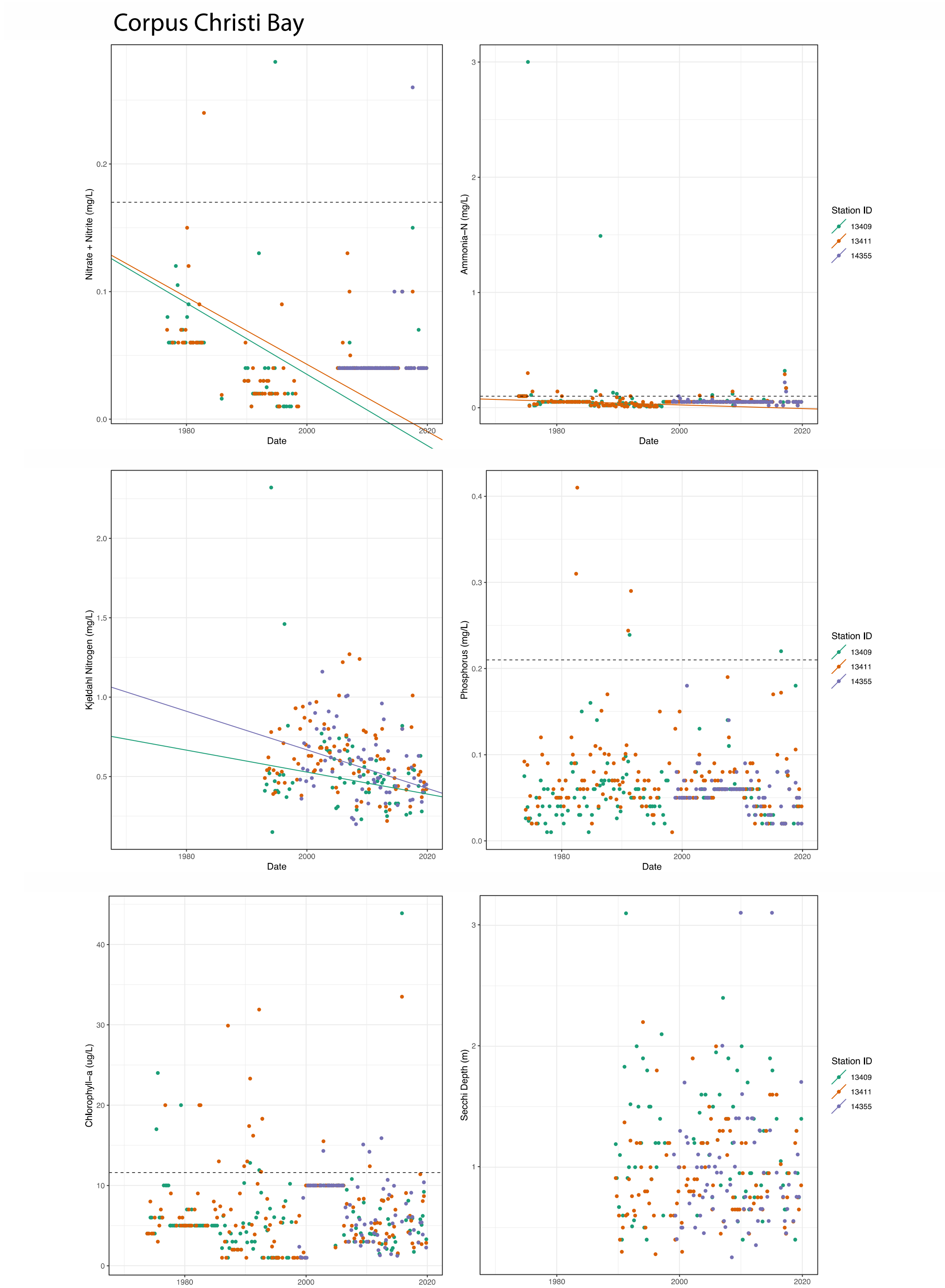

Temperature (Degrees C)
Date
ph
Date
Station ID
13450
13452
Salinity (ppt)
Date
Surface Dissolved Oxygen (mg/L)
Date
Station ID
13450
13452
Flouride (mg/L)
Date
Enterococci (MPM/100 ML)
Date
Station ID
13450
13452

FIGURE D3: CORPUS CHRISTI BAY



Corpus Christi Bay

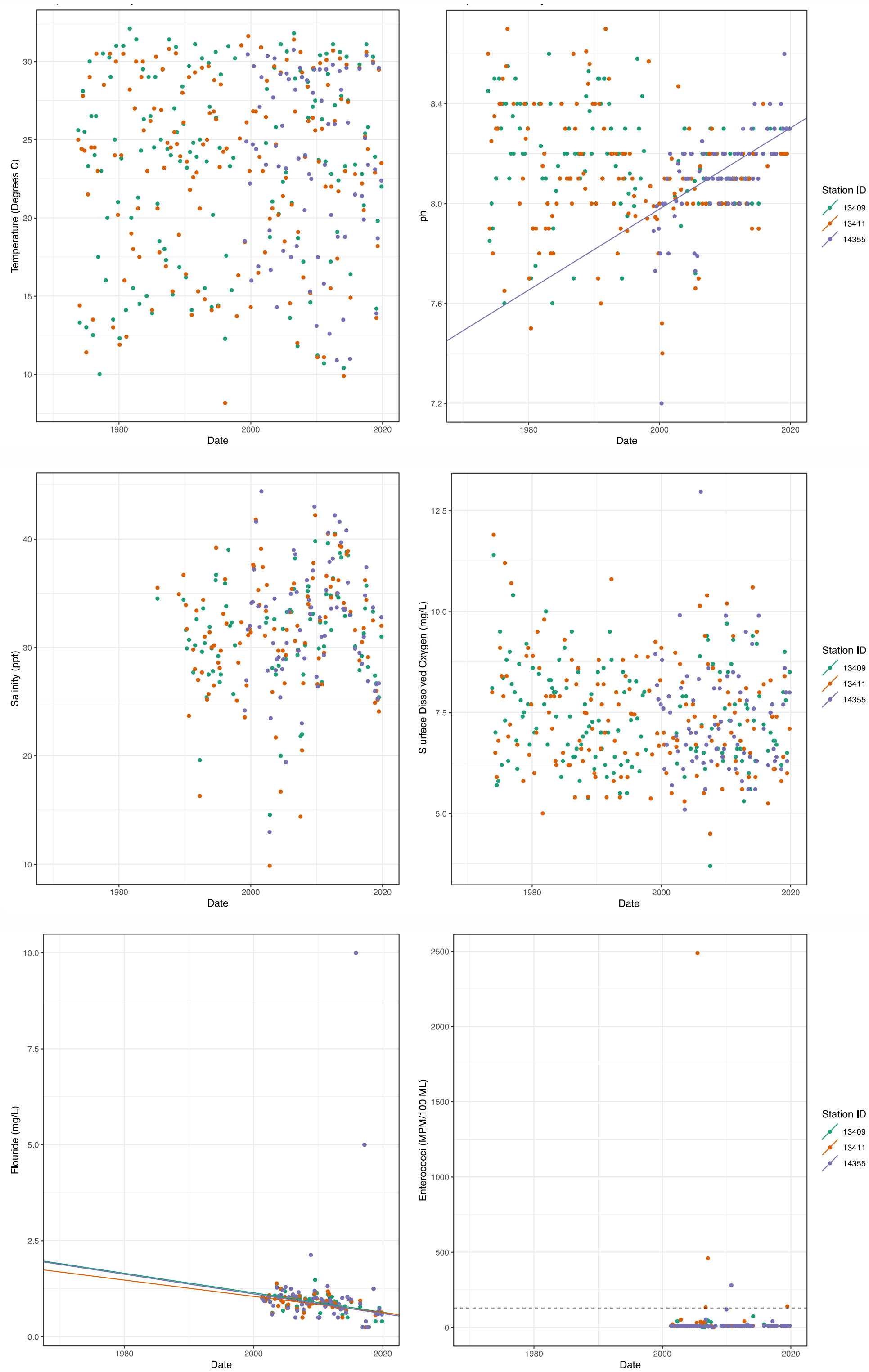
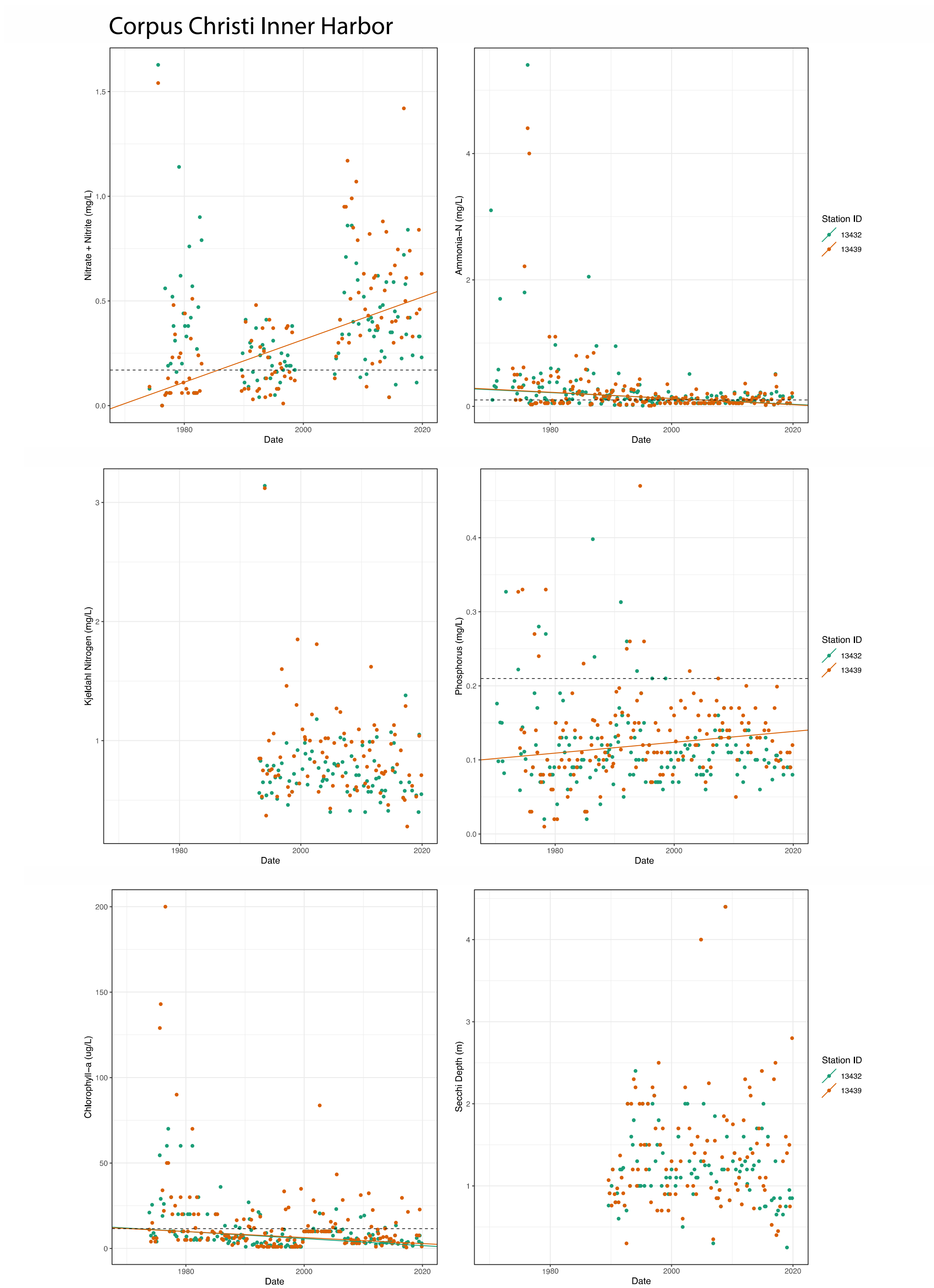
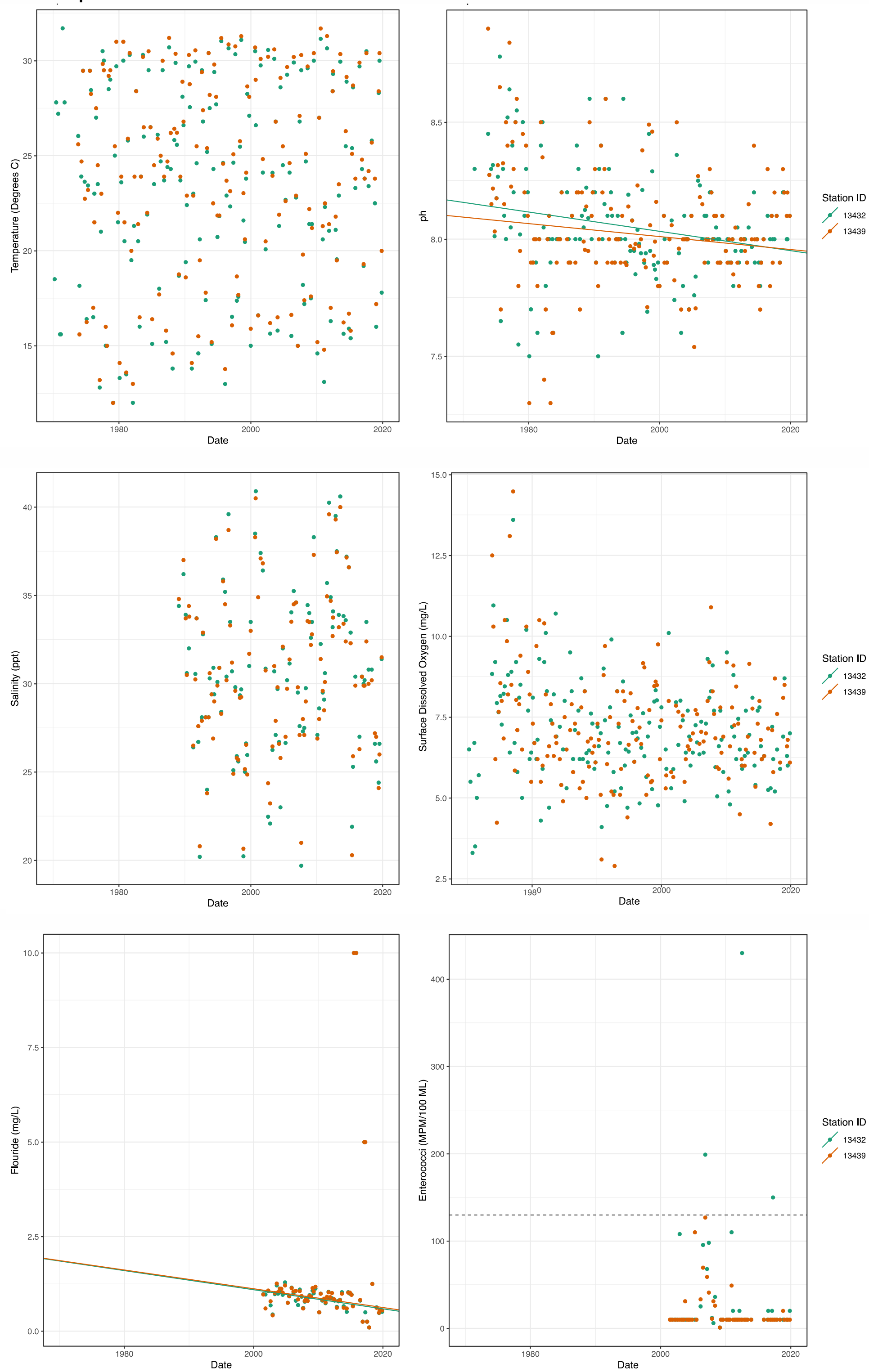
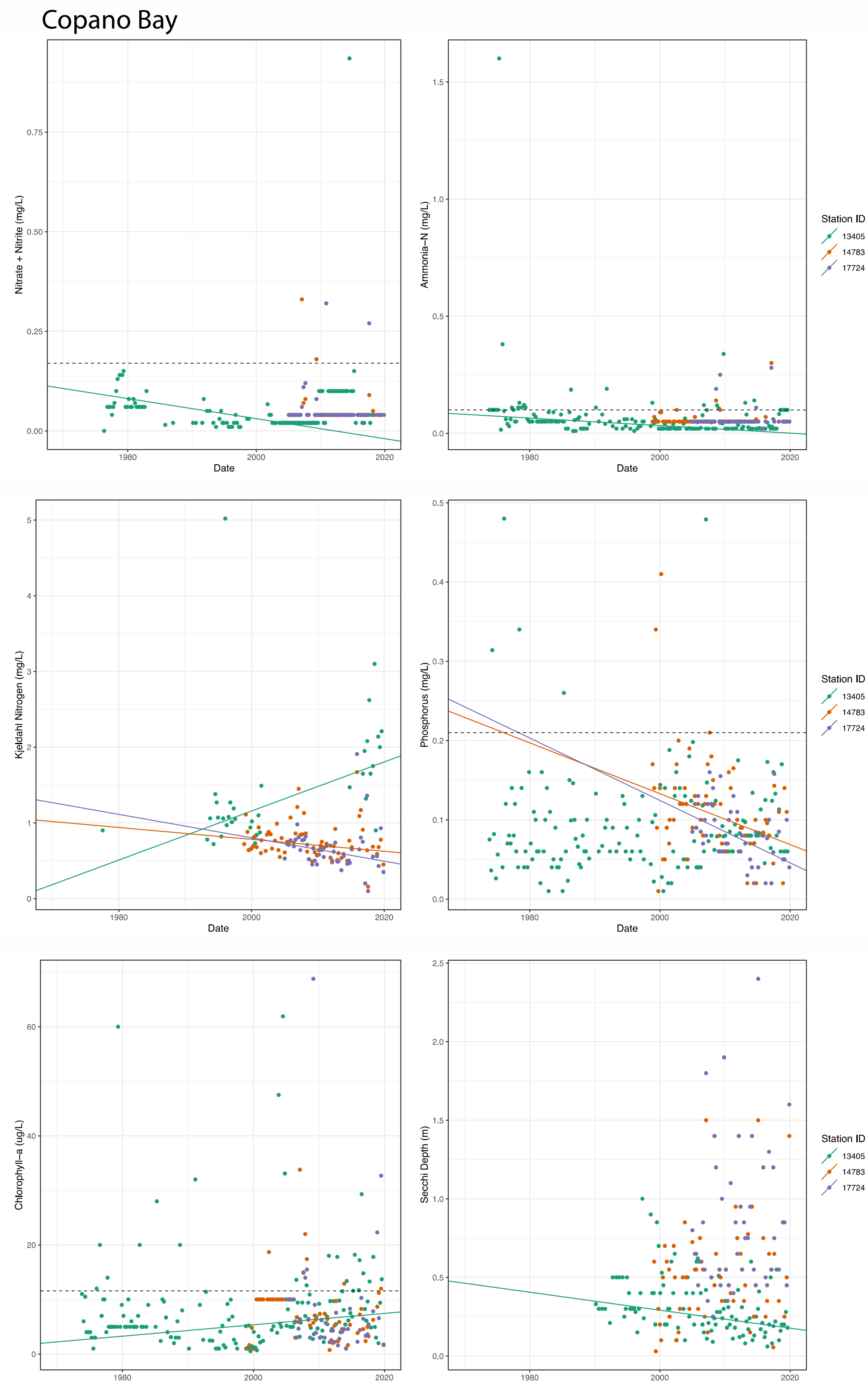


FIGURE D4: CORPUS CHRISTI INNER HARBOR

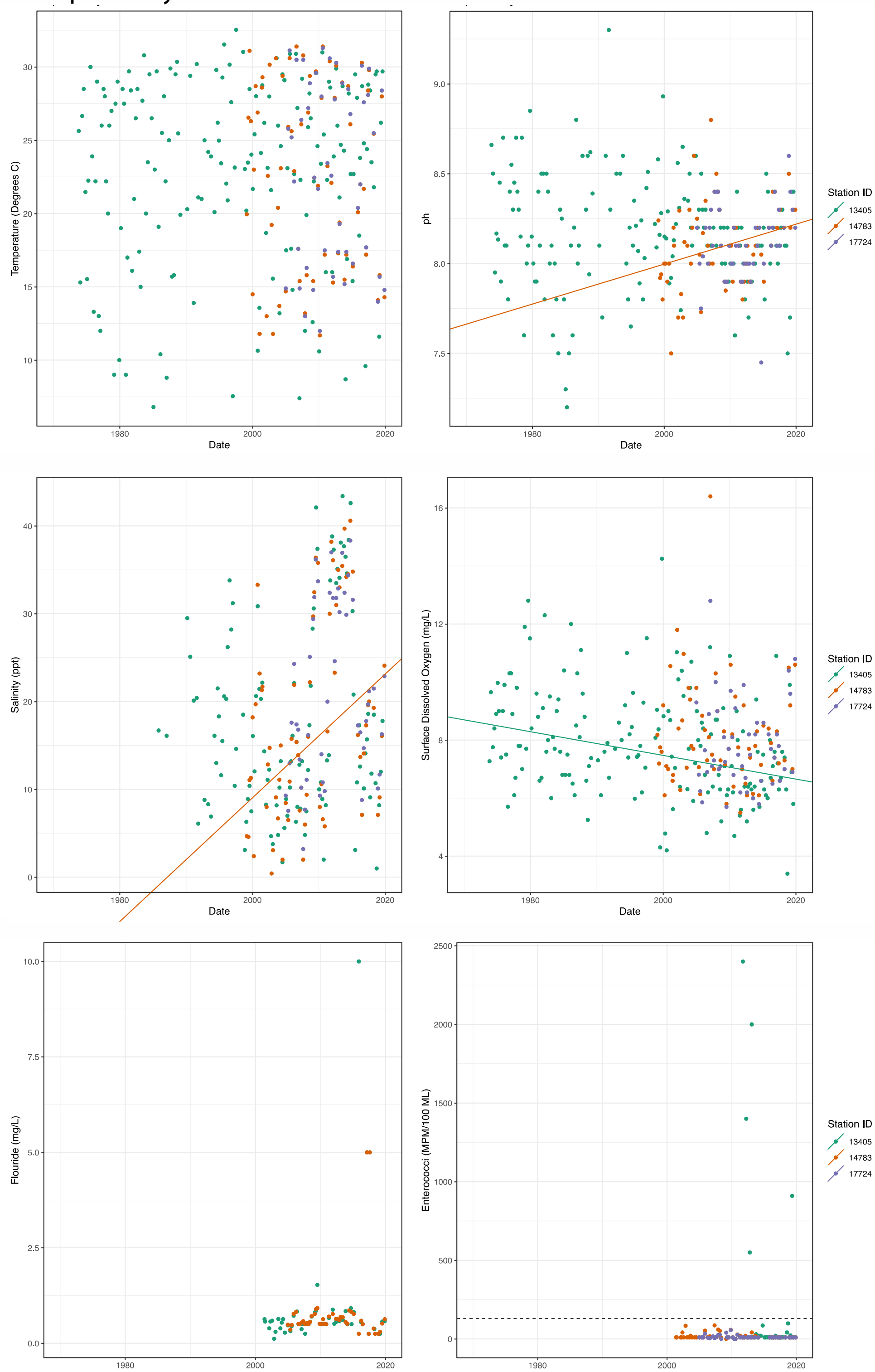


Corpus Christi Inner Harbor

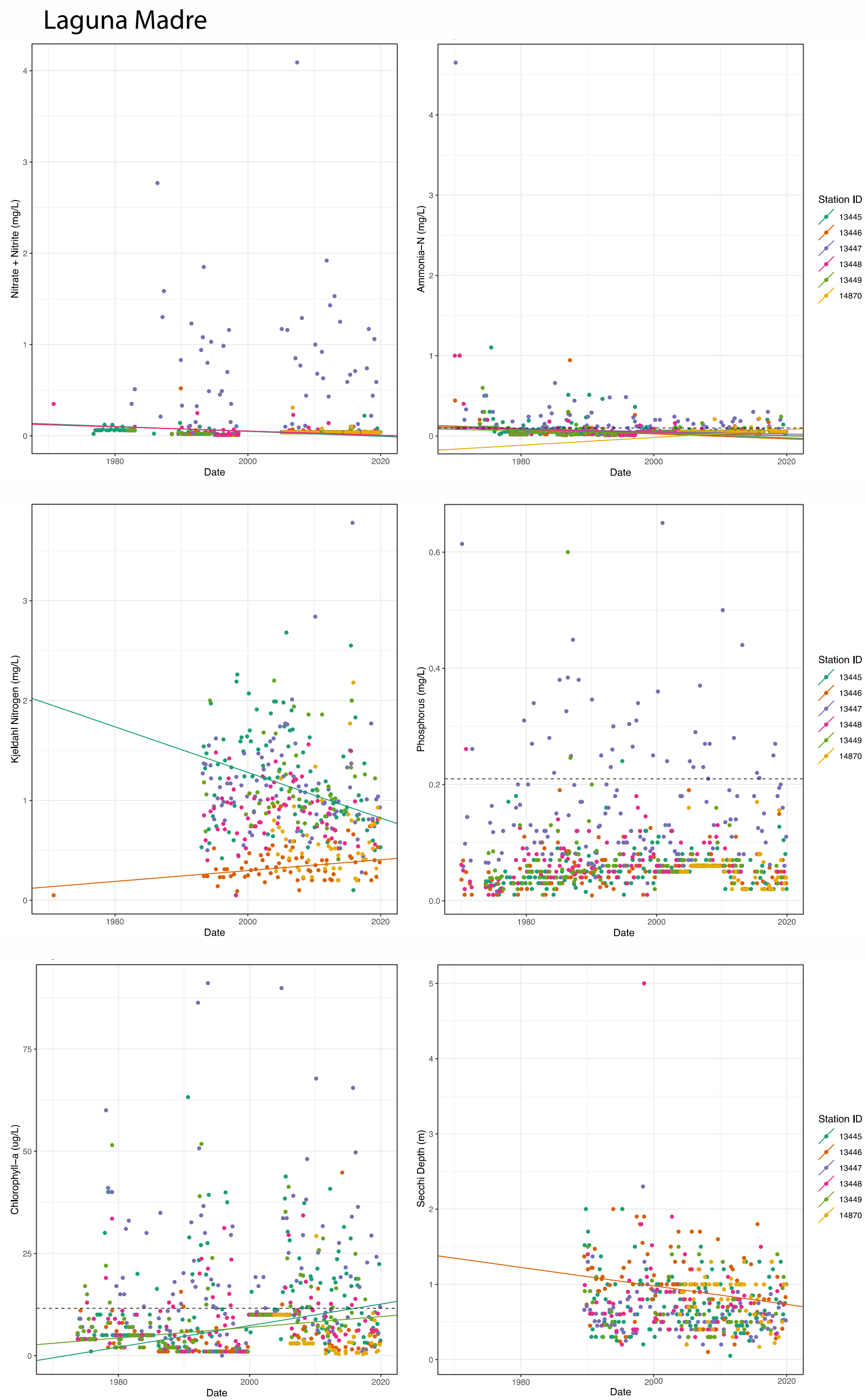



Copano Bay
Nitrate + Nitrite (mg/L)
Ammonia-N (mg/L)
Kjeldahl Nitrogen (mg/L)
Phosphorus (mg/L)
Chlorophyll-a (ug/L)
Secchi Depth (m)
Date
1980
2000
2020
Station ID
13405
14783
17724

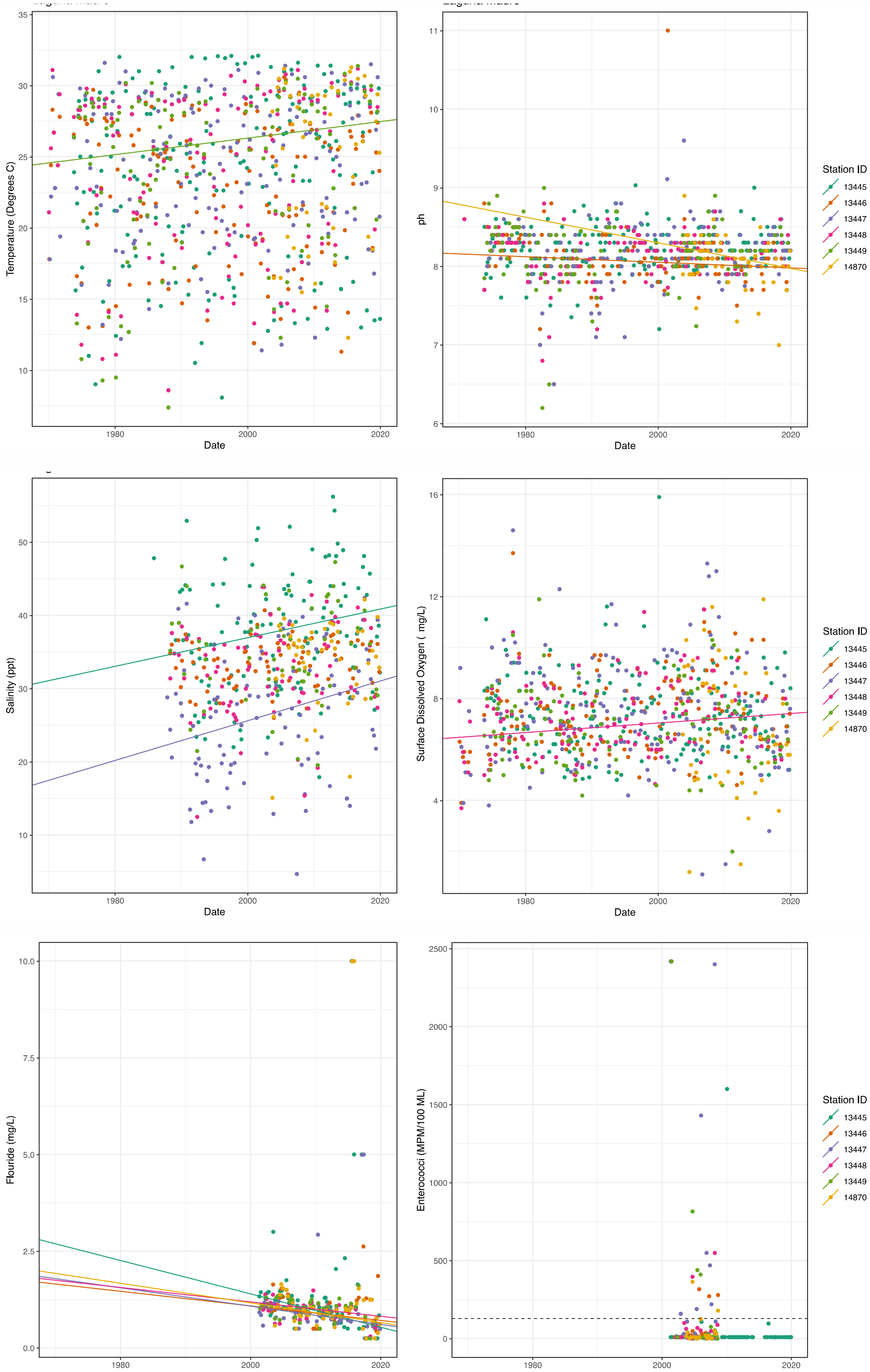
Copano Bay

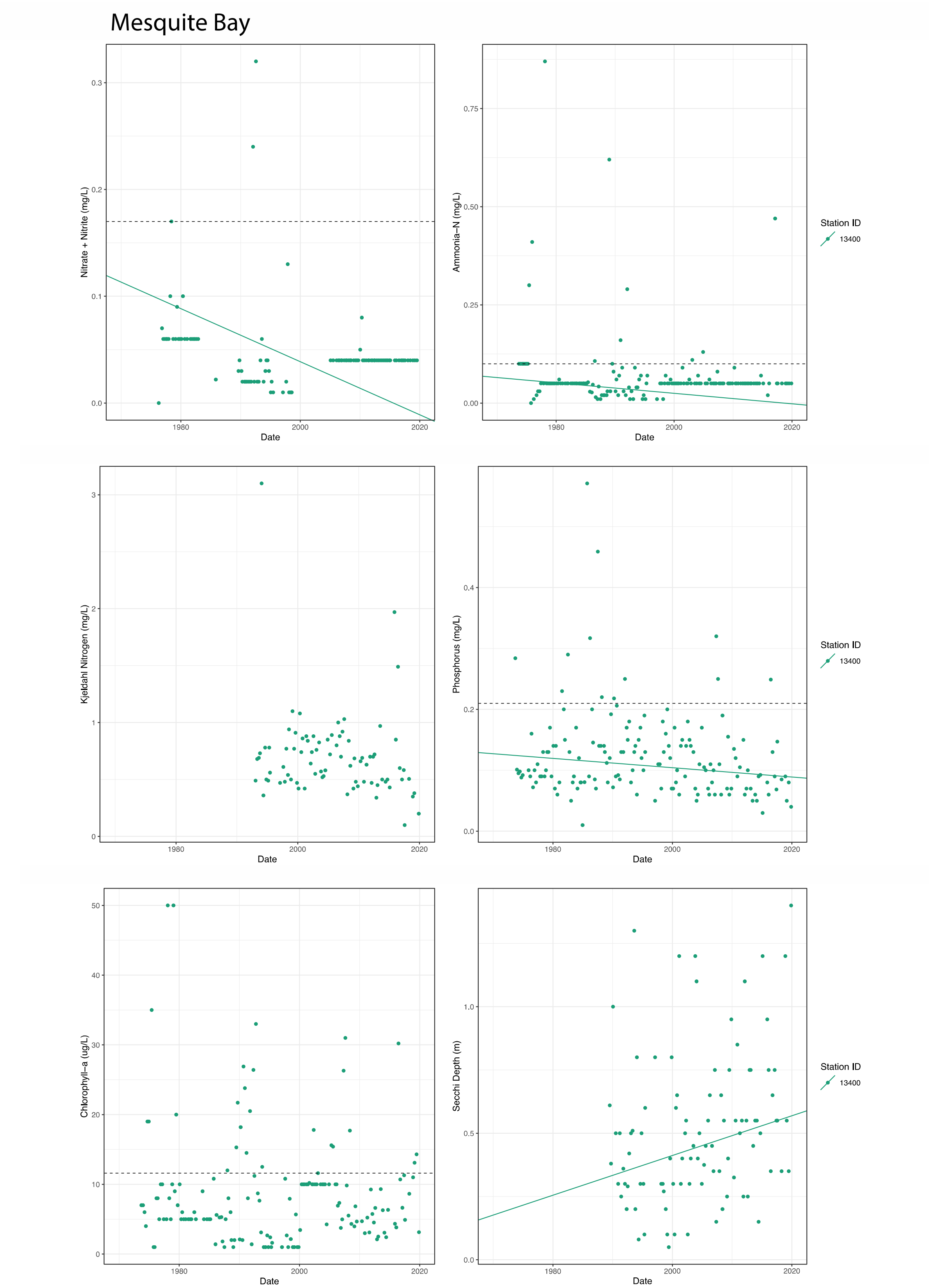


Temperature (Degrees C)
Date
ph
Salinity (ppt)
Surface Dissolved Oxygen (mg/L)
Flouride (mg/L)
Enterococci (MPM/100 ML)
Station ID
13405
14783
17724

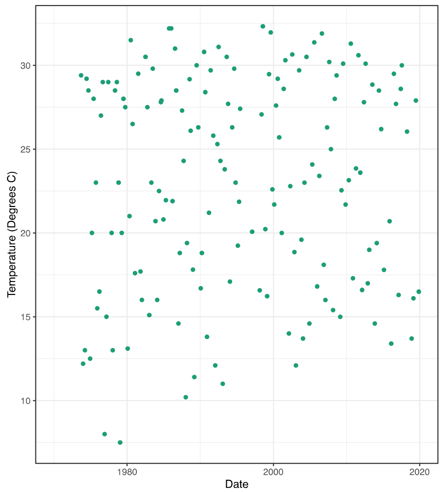

Laguna Madre
Nitrate + Nitrite (mg/L)
Ammonia−N (mg/L)
Kjeldahl Nitrogen (mg/L)
Phosphorus (mg/L)
Chlorophyll−a (ug/L)
Secchi Depth (m)
Date
1980
2000
2020
Station ID
13445
13446
13447
13448
13449
14870

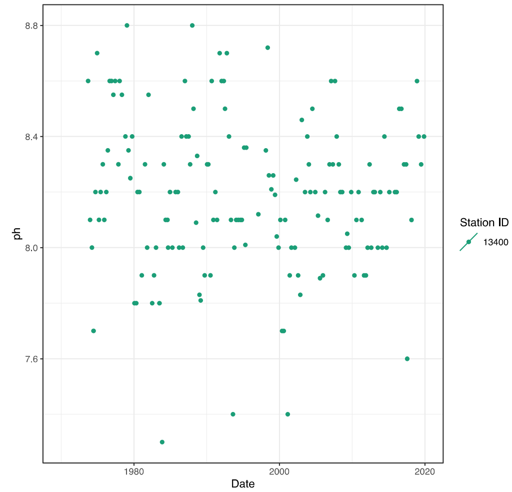
Laguna Madre

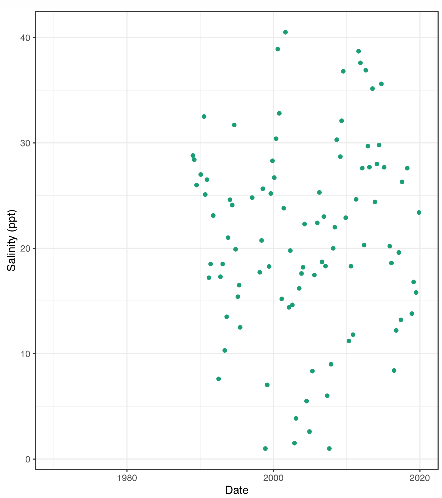


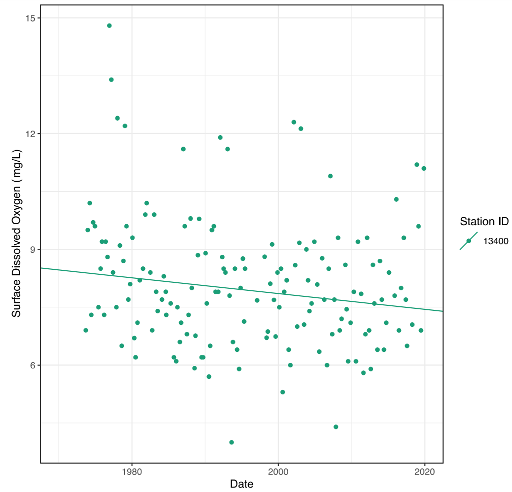

Mesquite Bay
Nitrate + Nitrite (mg/L)
Ammonia−N (mg/L)
Kjeldahl Nitrogen (mg/L)
Phosphorus (mg/L)
Chlorophyll−a (ug/L)
Secchi Depth (m)
Date
1980
2000
2020
Station ID
13400

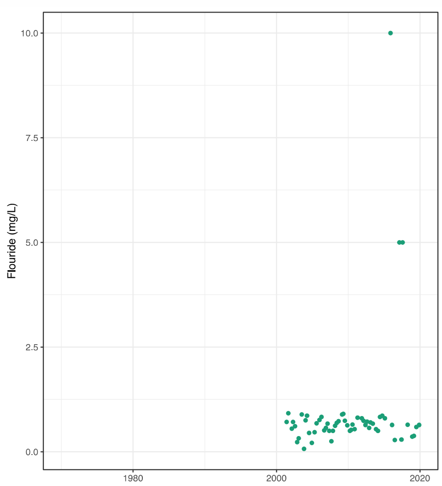
Mesquite Bay

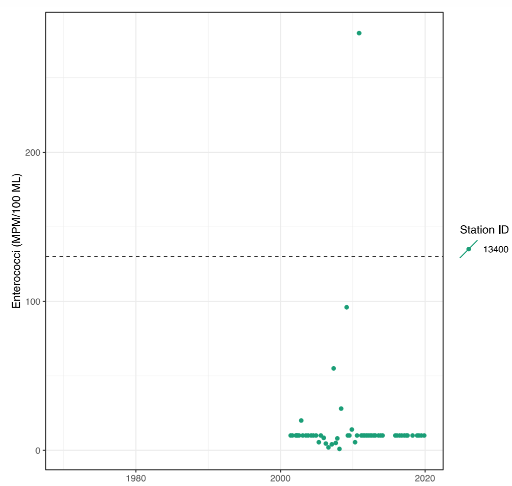


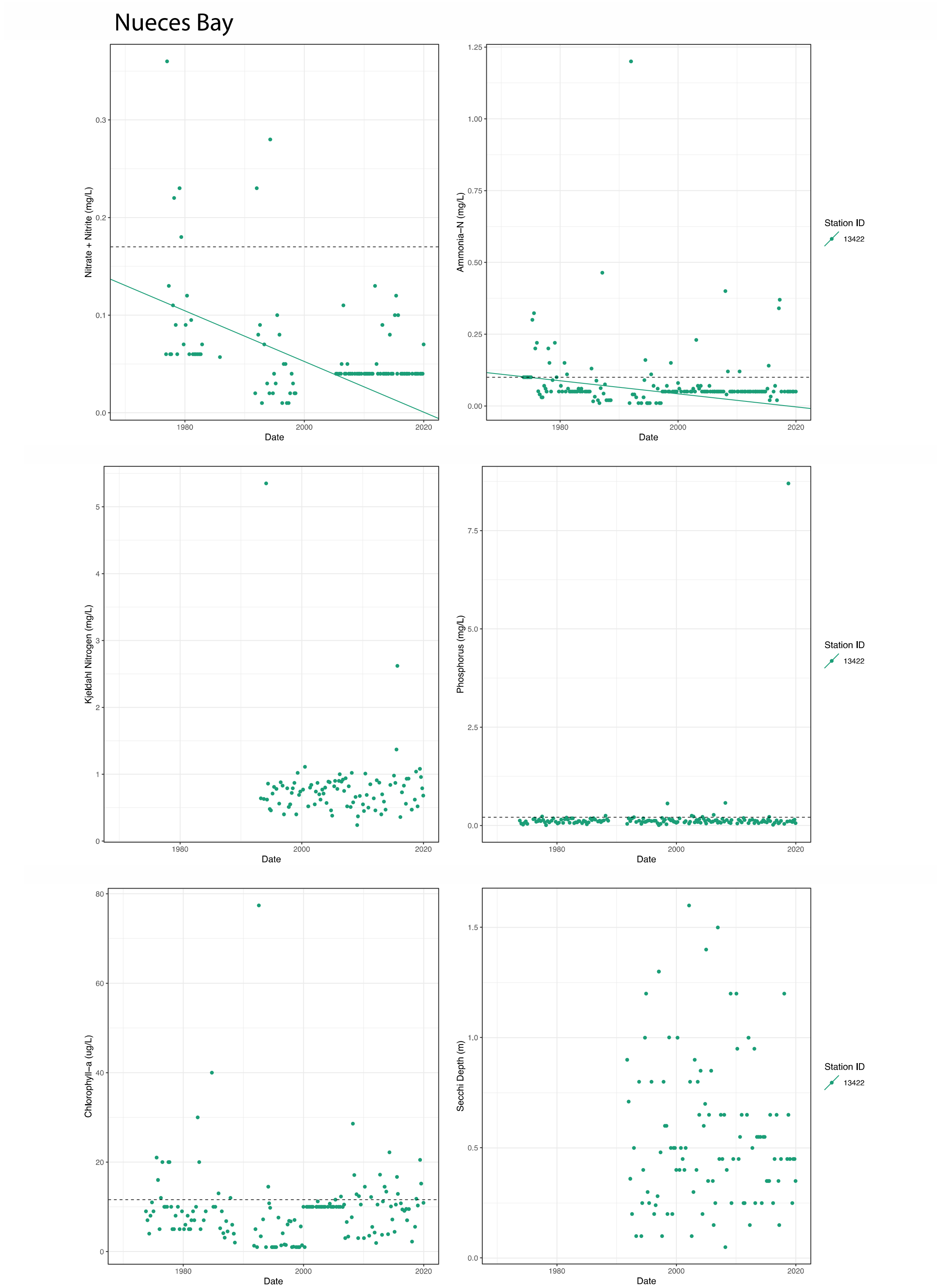




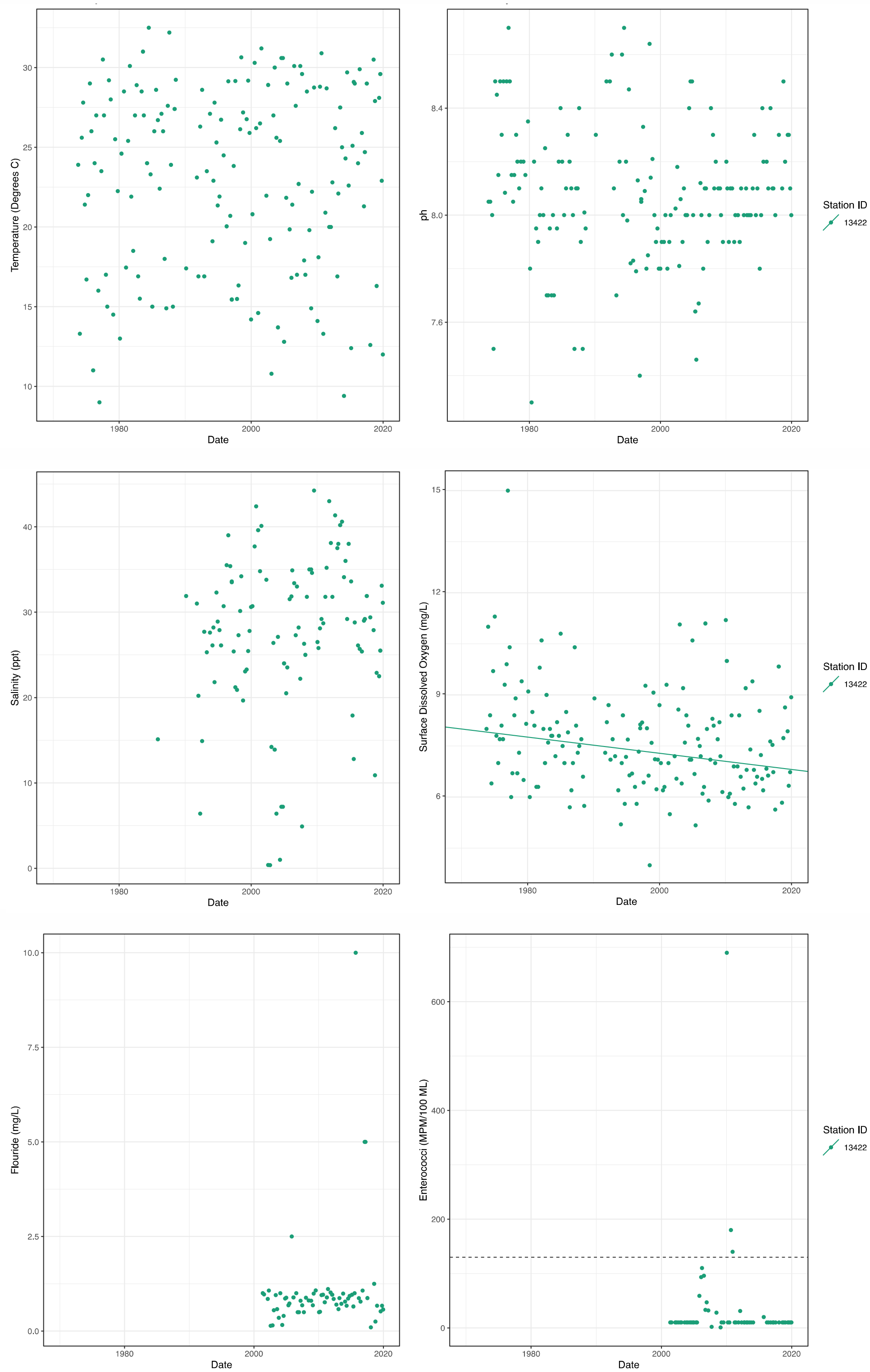


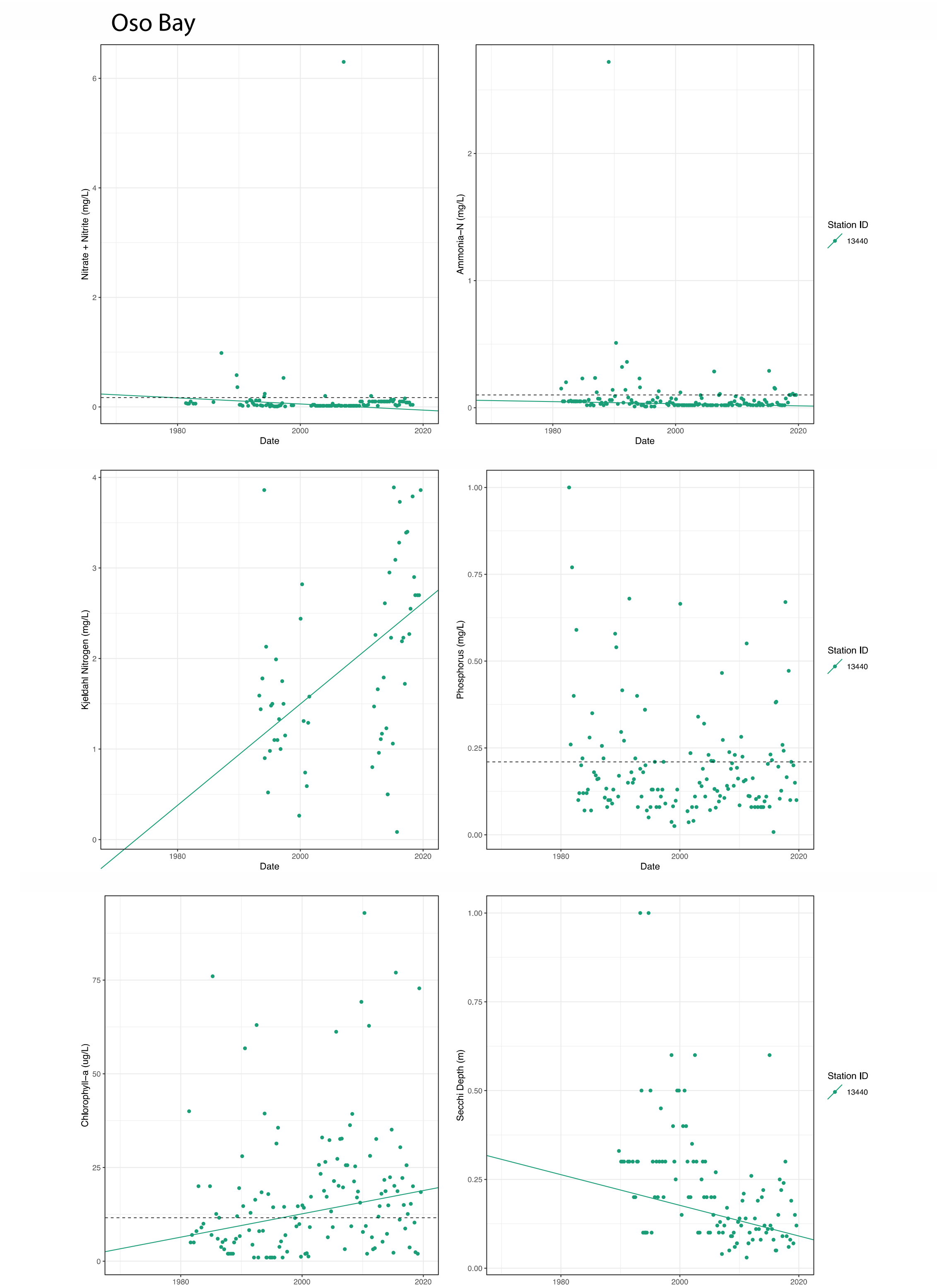




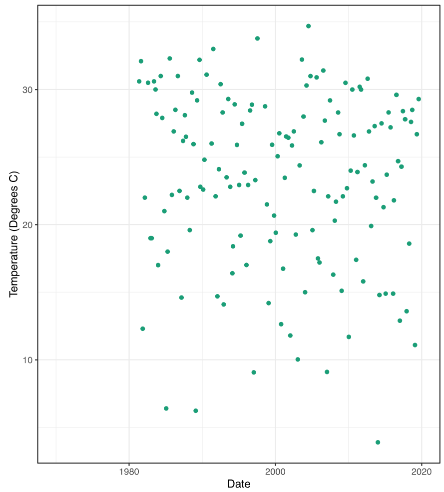

Nueces Bay
Nitrate + Nitrite (mg/L)
Ammonia−N (mg/L)
Kjeldahl Nitrogen (mg/L)
Phosphorus (mg/L)
Chlorophyll−a (ug/L)
Secchi Depth (m)
Date
Station ID
13422

Nueces Bay

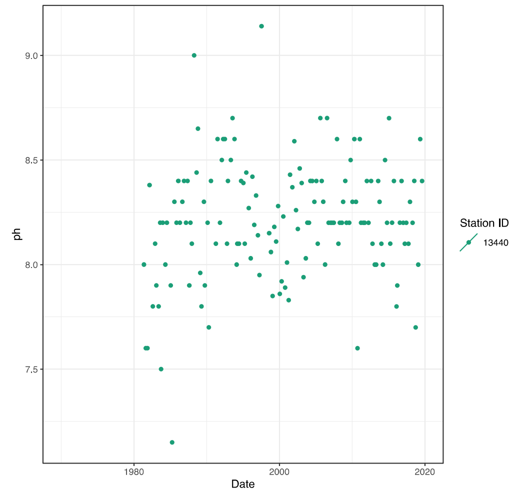

Temperature (Degrees C)
ph
Salinity (ppt)
Surface Dissolved Oxygen (mg/L)
Flouride (mg/L)
Enterococci (MPM/100 ML)
Date
Station ID
13422


Oso Bay
Nitrate + Nitrite (mg/L)
0
2
4
6
1980
2000
2020
Date
Ammonia−N (mg/L)
0
1
2
1980
2000
2020
Date
Station ID
13440
Kjeldahl Nitrogen (mg/L)
0
1
2
3
4
1980
2000
2020
Date
Phosphorus (mg/L)
0.00
0.25
0.50
0.75
1.00
1980
2000
2020
Date
Station ID
13440
Chlorophyll−a (ug/L)
0
25
50
75
1980
2000
2020
Date
Secchi Depth (m)
0.00
0.25
0.50
0.75
1.00
1980
2000
2020
Date
Station ID
13440

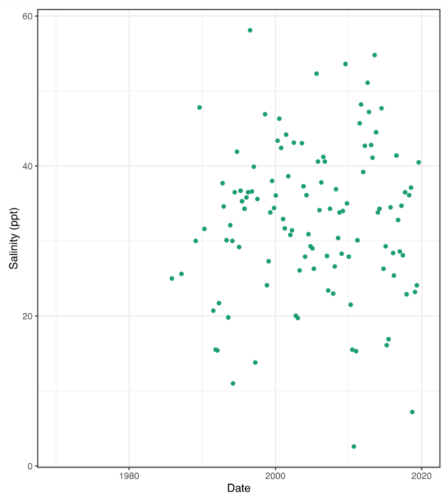
Oso Bay



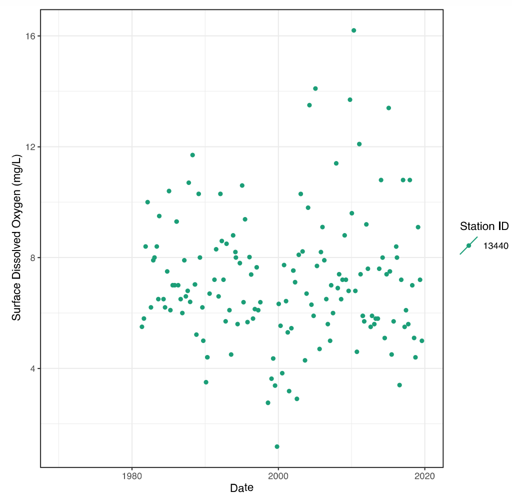
Temperature (Degrees C)
30
20
10
1980
2000
2020
Date



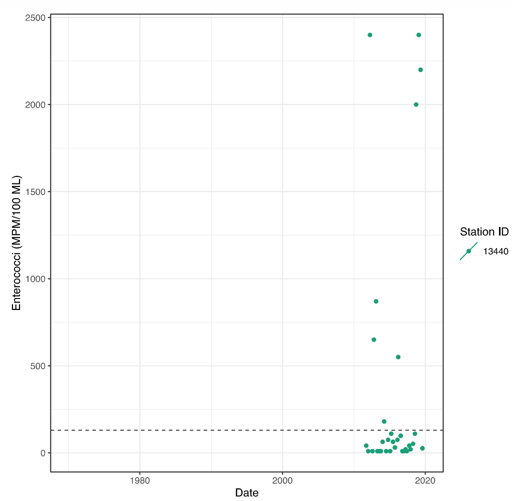
ph
9.0
8.5
8.0
7.5
1980
2000
2020
Date
Station ID
13440



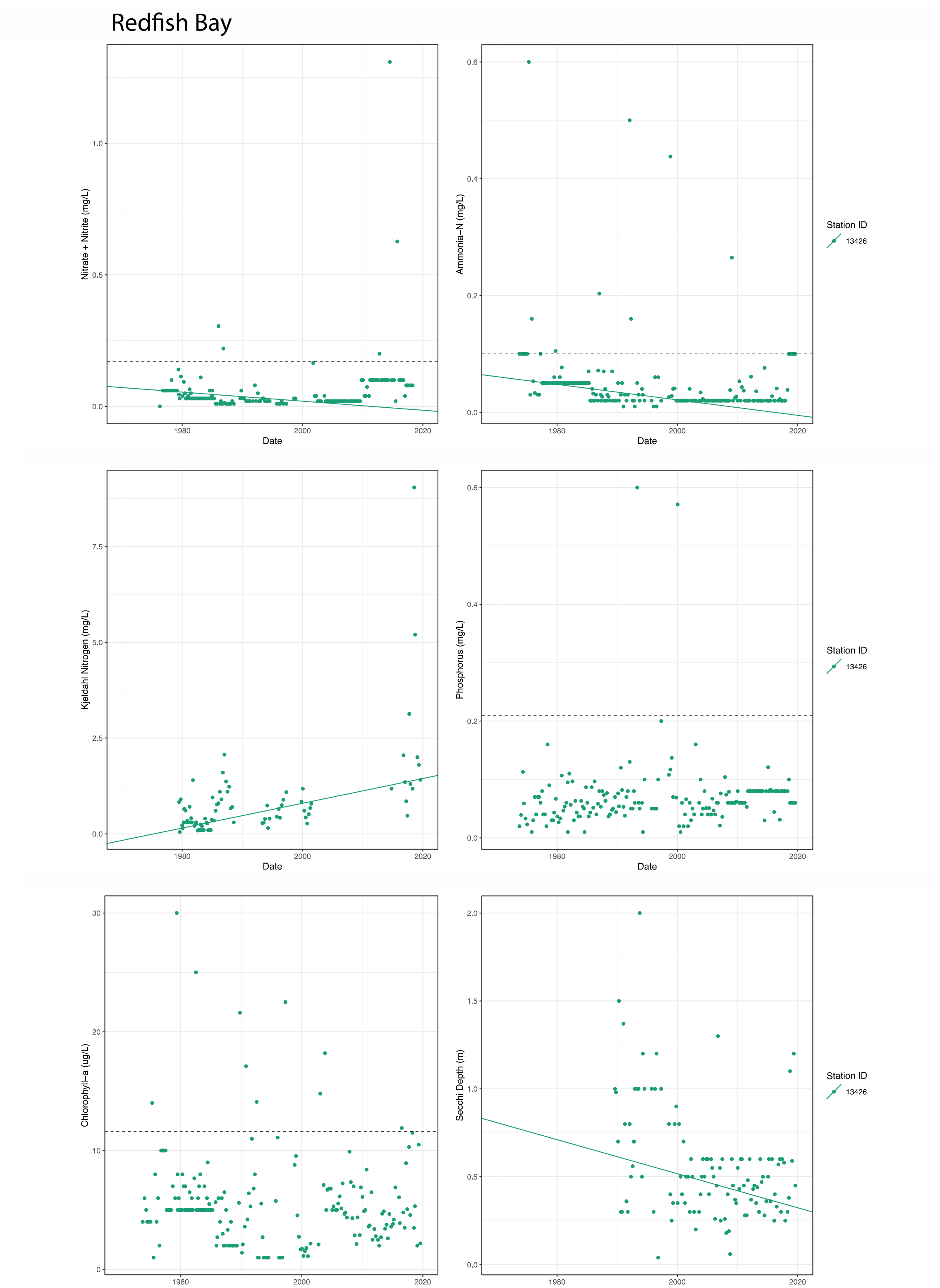
Salinity (ppt)
60
40
20
0
1980
2000
2020
Date



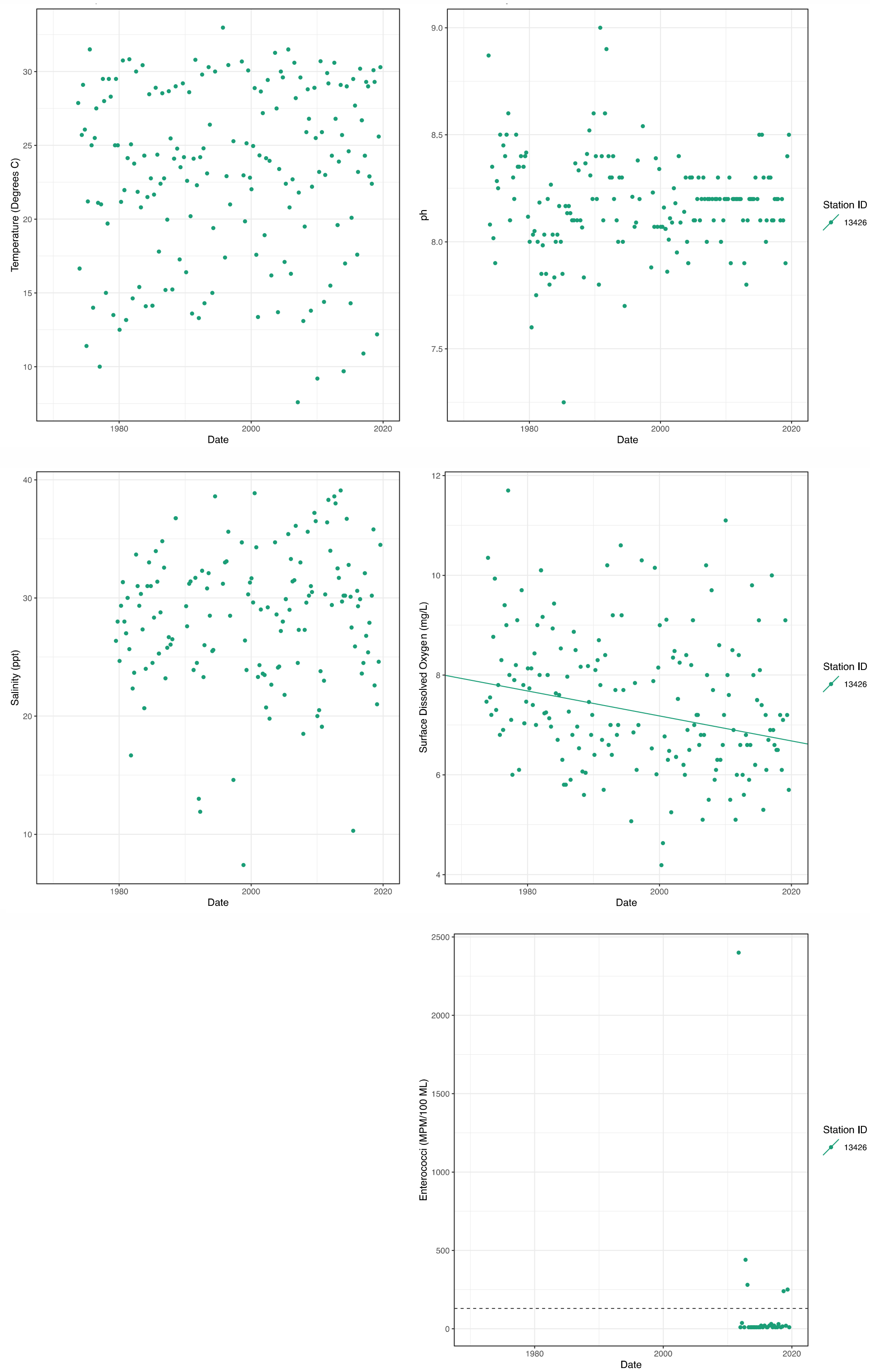
Surface Dissolved Oxygen (mg/L)
16
12
8
4
1980
2000
2020
Date
Station ID
13440



Enterococci (MPM/100 ML)
2500
2000
1500
1000
500
0
1980
2000
2020
Date
Station ID
13440

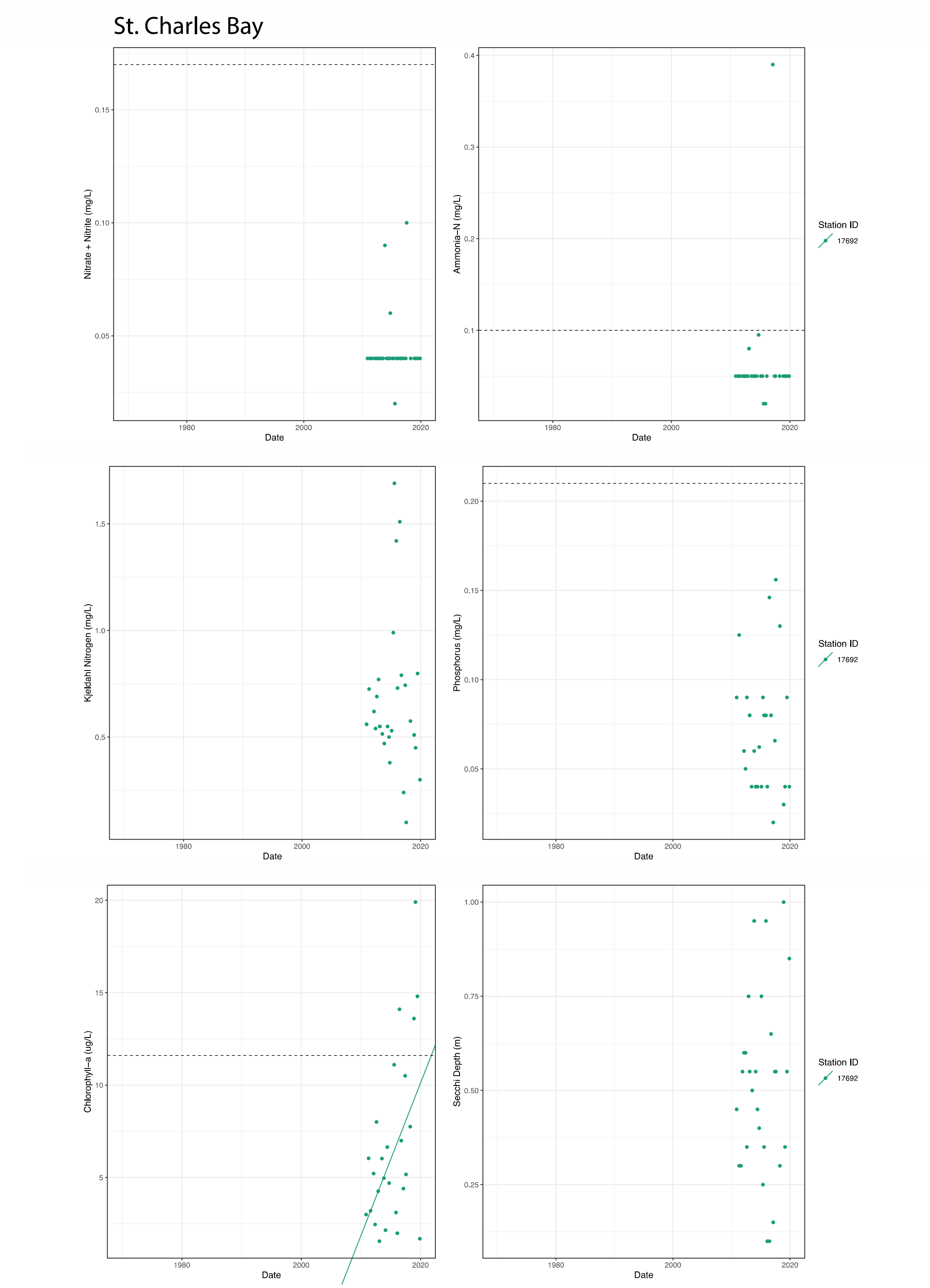

Redfish Bay
Nitrate + Nitrite (mg/L)
Ammonia-N (mg/L)
Kjeldahl Nitrogen (mg/L)
Phosphorus (mg/L)
Chlorophyll-a (ug/L)
Secchi Depth (m)
Date
Station ID
13426

Redfish Bay



Temperature (Degrees C)
Date
ph
Date
Station ID
13426
Salinity (ppt)
Date
Surface Dissolved Oxygen (mg/L)
Date
Station ID
13426
Enterococci (MPM/100 ML)
Date
Station ID
13426

FIGURE D11: ST. CHARLES BAY



St. Charles Bay