City of Sanibel NPDES Water Quality Monitoring

Trends and Status Update

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Background, Goals and Objectives

The City of Sanibel has been monitoring water quality at 12 stations monthly for over a decade as required in the National Pollutant Discharge Elimination System (NPDES) permit for their stormwater system. These stations are located in several waterbodies associated with Sanibel (Figure 1). One station is located in the Gulf of Mexico, two in Blind Pass, two in Dinkins Bayou, one in Clam Bayou, and three each in the east and west basins of Sanibel Slough. The goal of this document is to provide a concise summary of significant trends and current status of water quality parameters monitored for the NPDES project.

In 2004, the Florida Department of Environmental Protection classified the Sanibel Slough as impaired due to elevated concentrations of nitrogen and phosphorus which produce high values of chlorophyll *a*. In August 2017, total maximum daily loading (TMDL) criteria were established for the west and east basin of Sanibel Slough. The TMDL goal is to reduce the annual geometric mean chlorophyll *a* concentration in the west basin to 11ug/l and to 21ug/l in the east basin. This summary provides the following data:

1. Plots of geometric means for total nitrogen (TN), total phosphorus (TP), and chlorophyll *a* for each waterbody over the past 5 years compared to existing water quality criteria.
2. Statistical comparison of wet season verses dry season values for each monitored water quality parameter in each waterbody.
3. Statistical comparison of 12 year median nutrient values to numeric nutrient criteria values.
4. Statistical analyses of trends in water quality data over latest 12 years and 5 years of data collection in each waterbody and for each station.

Methods

Data from 2006 to October 2018 was manipulated to fit a standard format in an excel spreadsheet. Data previous to 2006 was not included in these analyses due to different laboratory techniques and methods used before that date. Data after October 2018 was not available at the time of this analysis.

Minitab18® was used for all statistical analyses. The non-parametric Kendall trend analysis was performed on each water quality parameter and summarized in a table by waterbody and station. The Kruskal-Wallis nonparametric comparison test was performed to determine differences between wet and dry season values for each parameter in each waterbody. The one sample Wilcoxon nonparametric test was used to determine if the 12 year median of sample values exceeded established water quality criteria. An alpha level of 0.05 was used to determine significance for all analyses.

Results and Conclusions

In this section, results are summarized by waterbody from data presented in Table 1 (Summary of Trends), Table 2 (Summary of Comparisons), and associated figures.

General Conclusions

Important indicators of water quality generally improved from east to west across Sanibel with the east basin of Sanibel Slough having poorest overall water quality and the Gulf of Mexico at Blind Pass having best the water quality. A general upward trend in TN concentration was noted across all waterbodies for both 12 and 5 year analyses (Table 1). In a downward trend was seen in inorganic nitrogen (IN) across all waterbodies. A similar decrease in total organic carbon (TOC) was noted across waterbodies over the analysis periods. Most inorganic nitrogen may have been converted to organic nitrogen and transferred to the TN component over this analysis period. However a corresponding general increase in chlorophyll a (Chla) was not readily apparent. All waterbodies and all stations had geometric mean TN values above state criteria for estuaries. An effort to tease out natural TN levels for these waterbodies from human influenced inputs is important. The increase in human development in all Florida watersheds leads to increased stormwater runoff. The stormwater runoff carries with it increasing TN loads from natural sources which would not "naturally" be transported downstream.

Turbidity, chlorophyll *a* and total organic carbon (TOC) was generally greater in the wet season for all waterbodies monitored (Table2). Increased surface water runoff, warmer water temperatures and increased radiation during wet season produce these differences. Salinity was also greater for most waterbodies in the dry season as would be expected. Inorganic nitrogen was significantly greater in all interior waterbodies in the dry season (Table 2). This finding may be associated with increased landscape fertilization during dry season associated with the Sanibel Fertilizer Ordinance.

Gulf of Mexico Blind Pass

One station (BP2_out) was located in this waterbody at the mouth of Blind Pass. Water quality at this site was best among all stations monitored for the NPDES permit. Dilution by gulf waters quickly decrease nutrient concentrations and buffers large swings in salinity and other water quality parameters. A significant decrease in pH over the past 12 years was noted, with ocean acidification processes associated with climate change a possible factor (Table 1). The upward trend in TN noted at all stations was significant over the past 12 and 5 years. An upward trend in OP was also found over the past 5 years. A significant downward trend in salinity at this station would support an opinion of influence from Caloosahatchee freshwater releases. However the Blind Pass, and Dinkins and Clam Bayou stations exhibited upward trends. In August 2009, Blind Pass was open to the Gulf re-creating a connection with Pine Island Sound which had been absent for years. The downward salinity trend at the Blind Pass station coupled with upward trends at the formerly isolated bayous are likely a result of new tidal influence – delivering additional freshwater to the mouth of Bland Pass while exchanging higher salinity Gulf waters further up in the Bayous.

Additionally plots of annual geometric means (Figure 2) over the most current 5 year period show TN at this station to be consistently greater than numeric nutrient criteria for Pine Island Sound while TP and chlorophyll *a* each exceeded the annual geometric mean criteria once in that period. The trend analysis showed that TN will increasingly be a concern for this area. Total phosphorus, total nitrogen and chlorophyll *a* concentrations were not found to be significantly greater than water quality criteria when analyzed over the 12 year period of this analysis.

Blind Pass

Two stations (BP1_in and BP_2in) are located within this waterbody northeast (inside) of the mouth of Blind Pass. Water quality for this waterbody shows some positive signs with an overall downward trend in OP and IN, the two nutrient forms most available to fuel algae blooms (Table 1). Chlorophyll *a* also showed a downward trend over 12 years strengthening the case that improvement in water quality has been significant in this area. The reconnection of Blind Pass to tidal waters of the Gulf of Mexico in 2009 is likely a major factor in these improving trends. Dilution by gulf waters decrease concentrations of terrestrial nutrient runoff and buffers large swings in salinity and other water quality parameters. Upward trends in salinity at the two stations reflect the increased influence of higher salinity Gulf Waters after the pass was opened. A significant downward trend in pH may be associated with the downward trend in chlorophyll *a*. Greater photosynthetic activity during the day associated with greater chlorophyll *a* levels can produce increased pH in a water body. With decreased chlorophyll *a*, photosynthetically elevated pH during the daytime (sampling time) may subside. The upward trend in TN noted at all stations was significant over the past 12 and 5 years

A plot of annual geometric means (Figure 3) over the most current 5 year period shows TN at this station to be consistently greater than numeric nutrient criteria for Pine Island Sound while TP exceeded the annual geometric mean criteria once in that period. Chlorophyll *a* was consistently below the numeric criteria for Pine Island Sound. Trend analysis suggests both TN and TP are increasing in this area.

TN was significantly greater during wet season, showing the possible influence of stormwater runoff (Table2). Chlorophyll *a* was found to be significantly greater in the wet season as was pH. The greater wet season phytoplankton stock would lead to greater daytime photosynthesis activity resulting in daytime increases in pH (Table 2).

Dinkins Bayou

Two stations (DB1 and WQ1) are located within this waterbody east (upstream) of Blind Pass (Figure 1). Water quality data for this waterbody showed positive signs with downward trends in IN (5yr) and chlorophyll *a* (12yr) (Table 1). The upward trends seen in salinity with the 12 and 5 year analyses suggest the influence of re-establishing tidal exchange with the Gulf of Mexico was a major driver in water quality trends (dilution). The 12 year trends showed an upward trend in turbidity, likely reflecting extra turbulence and resuspension associated with re-opening Blind Pass. However, analyzing turbidity data for the past 5 years shows this trend has now reversed and turbidity has decreased lately – a prediction originally proposed during the reconnection of this area to tidal flushing (turbidity would initially increase and then gradually the resuspended sediments would be flushed out and resettle). The upward trend in TN noted at all stations was significant over the past 12 and 5 years. A significant increase in water temperature was noted over the 5 and 12 year analysis periods. Hypotheses include the influence of global warming. This trend is seen at a few other stations and was close to being significant at additional stations.

TN was significantly greater during wet season, showing the possible influence of stormwater runoff (Table2). Chlorophyll *a* was found to be significantly greater in the wet season as was pH. The greater wet season phytoplankton stock would lead to greater daytime photosynthesis activity resulting in daytime increases in pH (Table 2).

A plot of annual geometric means (Figure 4) over the most current 5 year period shows the concentration of TN at this station to be consistently greater than the numeric nutrient criteria for Pine Island Sound while TP exceeded the annual geometric mean criteria twice and Chlorophyll *a* once in that period. The median TN and TP values taken over the past 12 years were found to be significantly greater than numeric nutrient criteria set by DEP for Pine Island Sound. Trend analysis suggests TN is increasing in this area.

Clam Bayou

One station (WQ2) is located within this waterbody east (upstream) of Dinkins Bayou (Figure 1). This waterbody is located at the upstream end of a dead end bayou system and as a result, receives less tidal flushing as Dinkins Bayou and Blind Pass downstream. Positive water quality trends for this station included significant downward trends in IN (5yr) and chlorophyll *a* (12yr.) (Table 1). A downward trend in turbidity over the last 5 years also suggest that the initial resuspension of sediments after reconnecting Blind Pass to the Gulf is subsiding (due to redistribution of sediments and a gradual decrease in current velocity due to partial filling of the Blind Pass channel). A significant downward trend in pH may be associated with the downward trend in chlorophyll *a*. Greater photosynthetic activity (associated with greater chlorophyll) during the day increases pH in a water body. With decreased chlorophyll, daytime photosynthetic activity is reduced and elevated daytime pH will also subside.

A significant upward trend in TN was found for this waterbody over 12 and 5 year analysis periods (Table 1). Additionally an increasing trend in TP was found over the latest 5 years. Median values of TP, TN and chlorophyll *a* were all found to be significantly greater than the numeric water quality criteria over the 12 year period of analysis (Table 2). A plot of annual geometric means (Figure 5) over the most current 5 year period shows concentrations of TN and chlorophyll *a* at this station to be consistently greater than numeric nutrient criteria for Pine Island Sound while TP exceeded the annual geometric mean criteria twice in that period.

A wastewater holding pond system was formerly located within this watershed and high TP concentrations have been found in groundwater in that area. Additionally The Sanctuary Golf Course located just downstream in Dinkins Bayou uses large quantities of phosphorus-rich reclaimed wastewater for irrigation.

TN was significantly greater during wet season, showing the possible influence of stormwater runoff (Table2). Chlorophyll *a* was found to be significantly greater in the wet season as was pH. The greater wet season phytoplankton stock would lead to greater daytime photosynthesis activity resulting in daytime increases in pH (Table 2).

Western Basin Sanibel Slough

Three stations (WQ3, WQ4 and WQ5) are located within this west central Sanibel waterbody (Figure 1). This waterbody is the western section of a central island wetland system which has been modified through dredging and channelization to more resemble a linear reservoir. There are two water control structures in the west basin. The first is located at a canal which empties northward in to Tarpon Bay. The second structure is at the east terminus (Tarpon Bay Road) of the west basin and separates the western basin form the east basin of the Sanibel Slough. The slough serves as the main stormwater conveyance system for Sanibel. Releases from the Sanibel Slough enter near shore estuary waters and can have significant water quality impacts in the surrounding sensitive estuaries.

A significant downward trend in IN (12yr and 5yr) was found indicating a possible positive influence from the fertilizer ordinance, or an increasingly rapid uptake of IN by phytoplankton or decomposers. Significant upward trends in chlorophyll *a*, TP, TN and OP over 5 and 12 year analyses periods indicate this waterbody will require further interventions to bring water quality improvements. A plot of geometric means shows the western basin exceeds established numeric nutrient criteria for TN and TP and the TMDL chlorophyll *a* goal for each of the last 5 years (Figure 6). Statistical comparison found the median value for all three of these parameters over last 12 years to be significantly greater than the established criteria (Table 2).

Although the amount of area irrigated with reclaimed water is small within this basin compared to the east basin, the increases in OP and TP suggest its influence through intermittent connections with the eastern basin, groundwater flow or other conveyance. Both TP and OP were found to be significantly greater during wet season than dry season. Both stormwater runoff input and groundwater input to this waterbody increase during rain events.

A decreasing trend in pH over the 12 year analyses period could be an indication of release of organic acids by decomposers. As organic matter in the form of dying phytoplankton (chlorophyll *a*) and detritus accumulates within the sediments of this waterbody, decomposers will release increasing amounts of hydrogen ions into the water column gradually lowering pH. At some point a lowered pH and lack of oxygen may slow further decomposition and sediment removal may produce a favorable improvement in water quality.

Eastern Basin Sanibel Slough

Three stations (WQ6, WQ7 and WQ8) are located within this east central Sanibel waterbody (Figure 1). This waterbody is the eastern section of a central island wetland system which has been modified through dredging and channelization to resemble a linear reservoir. There are two water control structures in the east basin. The eastern structure discharges to the Sanibel canal system which empties in to San Carlos Bay. A western structure allows waters from the eastern and western basin to mix at Tarpon Bay Road. The slough serves as the main stormwater conveyance system for Sanibel. Releases from the Sanibel Slough enter near shore estuary waters and can have significant water quality impacts in the surrounding sensitive estuaries.

A significant downward trend in IN (12yr and 5yr) was found, indicating a possible positive influence from the fertilizer ordinance, or an increasingly rapid uptake of IN by phytoplankton or decomposers. Significant upward trends in TP, TN and OP over 5 and 12 year analyses periods indicate this waterbody will require further interventions to bring water quality improvements. A plot of geometric means shows the eastern basin exceeds established numeric nutrient criteria for TN and TP and the TMDL chlorophyll *a* goal for each of the last 5 years (Figure 7). Statistical comparison found the median value over last 12 years for all three of these parameters to be significantly greater than the established criteria (Table 2).

This basin has the greatest volume of reclaimed wastewater applied annually for irrigation. The continued increase in TP and OP over the analysis period is likely partially a result of continued heavy use of this irrigation source with no decrease in its volume used or nutrient concentrations. No difference was found between wet and dry season nitrogen of phosphorus concentrations in the east basin. Concentrations in the eastern Sanibel Slough are nearly as high as groundwater or surface water runoff sources so variation in inflow will not affect concentration.

A decreasing trend in pH over the 12 year analyses period could be an indication of release of organic acids by decomposers. As organic matter in the form of dying phytoplankton (chlorophyll *a*) and detritus accumulates within the sediments of this waterbody, decomposers will release increasing amounts of hydrogen ions into the water column gradually lowering pH.

At some point a lowered pH and lack of oxygen may slow further decomposition and sediment removal may produce a favorable improvement in water quality.

Table 1. Summary of 5 and 12 year trends for each waterbody, station and parameter. Trends generally associated with decreasing water quality are shown with red background while improving trends are shown with green background.

Sites/Parameter		Gulf	Blind Pass			Dinkins Bayou		
		BP_2out	All	BP1_In	BP2_In	All	DB1	WQ1
TP	12 Yr Trend	None, p = 0.29	None, p = 0.11	None, p = 0.24	None, p = 0.41	None, p = 0.40	None, p = 0.19	None, p = 0.16
	5 Yr Trend	None, p = 0.12	**Upward, p = 0.016**	None, p = 0.09	None, p = 0.08	None, p = 0.17	None, p = 0.32	None, p = 0.23
TN	12 Yr Trend	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p < 0.001**
	5 Yr Trend	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p < 0.001**
OP	12 Yr Trend	None, p = 0.47	**Downward, p = 0.015**	**Downward, p = 0.05**	None p = 0.09	None p = 0.43	None p = 0.46	None p = 0.37
	5 Yr Trend	**Upward, p = 0.02**	None, p = 0.21	None, p = 0.41	**Upward, p = 0.03**	None p = 0.46	None p = 0.13	None p = 0.22
IN	12 Yr Trend	None, p = 0.46	**Downward, p = 0.025**	None, p = 0.15	**Downward, p = 0.05**	None, p = 0.34	None, p = 0.38	None, p = 0.35
	5 Yr Trend	None, p = 0.35	**Downward, p = 0.007**	**Downward, p = 0.004**	None, p = 0.27	**Downward, p = 0.001**	**Downward, p = 0.03**	**Downward, p = 0.007**
Chla	12 Yr Trend	None, p = 0.19	**Downward, p < 0.001**	**Downward, p = 0.005**	**Downward, p = 0.001**	**Downward, p = 0.001**	**Downward, p = 0.008**	**Downward, p < 0.001**
	5 Yr Trend	None, p = 0.47	None, p = 0.40	None, p = 0.32	None, p = 0.41	None, p = 0.32	None, p = 0.38	None, p = 0.22
Salinity	12 Yr Trend	**Downward, p = 0.04**	None, p = 0.09	**Upward, p = 0.03**	None, p = 0.40	**Upward, p = 0.01**	None, p = 0.10	**Upward, p = 0.02**
	5 Yr Trend	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p < 0.001**
Temperature	12 Yr Trend	None, p = 0.06	None, p = 0.11	None, p = 0.39	None, p = 0.07	**Upward, p = 0.02**	**Upward, p = 0.01**	None, p = 0.20
	5 Yr Trend	None, p = 0.12	**Upward, p = 0.03**	None, p = 0.07	None, p = 0.14	**Upward, p = 0.01**	None, p = 0.06	**Upward, p = 0.05**
pH	12 Yr Trend	**Downward, p < 0.001**	**Downward, p < 0.001**	**Downward, p = 0.001**	**Downward, p = 0.05**	None, p = 0.23	None, p = 0.32	None, p = 0.18
	5 Yr Trend	None, p = 0.23	None, p = 0.40	None, p = 0.19	None, p = 0.25	None, p = 0.11	None, p = 0.10	None, p = 0.35
TOC	12 Yr Trend	None, p = 0.32	**Downward, p < 0.001**	**Downward, p < 0.001**	**Downward, p < 0.001**	**Downward, p < 0.001**	**Downward, p < 0.001**	**Downward, p < 0.001**
	5 Yr Trend	None, p = 0.22	None, p = 0.50	None, p = 0.19	None, p = 0.18	None, p = 0.48	None, p = 0.23	None, p = 0.18
Turbidity	12 Yr Trend	None, p = 0.22	None, p = 0.21	None, p = 0.27	None, p = 0.37	**Upward, p = 0.001**	None, p = 0.06	**Upward, p = 0.001**
	5 Yr Trend	None, p = 0.17	**Downward, p = 0.004**	**Downward, p = 0.002**	None, p = 0.12	**Downward, p < 0.001**	**Downward, p < 0.001**	**Downward, p = 0.05**

Table 1 cont. Summary of 5 and 12 year trends for each waterbody, station and parameter. Trends generally associated with decreasing water quality are shown with red background while improving trends are shown with green background.

Sites/Parameter		Clam Bayou	West Slough				East Slough			
		WQ2	All	WQ3	WQ4	WQ5	All	WQ6	WQ7	WQ8
TP	12 Yr Trend	None, p = 0.11	**Upward, p < 0.001**	None, p = 0.07	**Upward, p = 0.05**	**Upward, p < 0.001**	None, p = 0.13	None, p = 0.12	None, p = 0.41	**Upward, p = 0.004**
	5 Yr Trend	**Upward, p = 0.004**	**Upward, p < 0.001**	**Upward, p = 0.005**	**Upward, p = 0.007**	**Upward, p = 0.007**	**Upward, p = 0.01**	None, p = 0.47	**Upward, p = 0.05**	**Upward, p = 0.02**
TN	12 Yr Trend	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p = 0.007**	None, p = 0.19	None, p = 0.45	**Upward, p < 0.001**
	5 Yr Trend	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p < 0.001**	None, p = 0.12	**Upward, p < 0.001**	**Upward, p = 0.01**	None, p = 0.12	None, p = 0.09	None, p = 0.09
OP	12 Yr Trend	None p = 0.36	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p = 0.009**	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p < 0.001**
	5 Yr Trend	None p = 0.33	None, p = 0.08	None, p = 0.42	None p = 0.23	None, p = 0.11	None, p = 0.29	None, p = 0.10	None, p = 0.17	None, p = 0.30
IN	12 Yr Trend	None, p = 0.26	**Downward, p = 0.001**	**Downward, p < 0.001**	**Downward, p = 0.008**	**Downward, p < 0.001**	**Downward, p < 0.001**	**Downward, p < 0.001**	**Downward, p < 0.001**	**Downward, p < 0.001**
	5 Yr Trend	**Downward, p = 0.05**	**Downward, p = 0.02**	None p = 0.13	None p = 0.15	None p = 0.09	**Downward, p = 0.05**	None p = 0.13	None p = 0.32	**Downward, p = 0.05**
Chla	12 Yr Trend	**Downward, p < 0.002**	**Upward, p = 0.02**	**Upward, p = 0.01**	None, p = 0.45	**Upward, p = 0.05**	**Downward, p < 0.001**	**Downward, p = 0.003**	**Downward, p < 0.001**	None, p = 0.47
	5 Yr Trend	None, p = 0.43	**Upward, p < 0.001**	**Upward, p < 0.001**	**Upward, p = 0.004**	None, p = 0.08	None, p = 0.39	None, p = 0.19	None, p = 0.39	None, p = 0.23
Salinity	12 Yr Trend	None, p = 0.13	**Upward, p = 0.01**	**Upward, p = 0.008**	**Upward, p = 0.002**	None, p = 0.18	None, p = 0.22	None, p = 0.12	**Downward, p = 0.02**	None, p = 0.13
	5 Yr Trend	**Upward, p < 0.002**	None, p = 0.07	None, p = 0.34	None, p = 0.09	**Upward, p = 0.01**	None, p = 0.25	None, p = 0.12	None, p = 0.16	None, p = 0.09
Temperature	12 Yr Trend	None, p = 0.17	None, p = 0.08	None, p = 0.17	None, p = 0.35	None, p = 0.17	None, p = 0.20	None, p = 0.14	None, p = 0.44	None, p = 0.46
	5 Yr Trend	None, p = 0.06	**Upward, p = 0.005**	None, p = 0.08	None, p = 0.09	None, p = 0.06	**Upward, p = 0.008**	None, p = 0.06	None, p = 0.14	**Upward, p = 0.05**
pH	12 Yr Trend	**Downward, p = 0.03**	**Downward, p = 0.02**	None, p = 0.09	**Downward, p = 0.001**	None, p = 0.18	**Downward, p < 0.001**	**Downward, p = 0.05**	**Downward, p = 0.003**	**Downward, p = 0.045**
	5 Yr Trend	None, p = 0.25	**Downward, p = 0.004**	**Downward, p = 0.008**	None, p = 0.08	None, p = 0.23	None, p = 0.07	None, p = 0.12	None, p = 0.44	None, p = 0.06
TOC	12 Yr Trend	**Downward, p < 0.001**	None, p = 0.20	None, p = 0.20	None, p = 0.32	None, p = 0.36	**Downward, p < 0.001**	**Downward, p < 0.001**	**Downward, p < 0.001**	**Downward, p = 0.048**
	5 Yr Trend	**Downward, p = 0.05**	**Downward, p < 0.001**	None, p = 0.12	**Downward, p < 0.001**	**Downward, p < 0.001**	**Downward, p < 0.001**	**Downward, p = 0.03**	**Downward, p = 0.04**	**Downward, p < 0.001**
Turbidity	12 Yr Trend	**Upward, p = 0.001**	**Upward, p < 0.001**	**Downward, p < 0.001**	**Upward, p = 0.04**	**Upward, p < 0.001**	None, p = 0.07	**Downward, p = 0.03**	**Downward, p < 0.001**	**Upward, p = 0.016**
	5 Yr Trend	**Downward, p = 0.03**	**Upward, p = 0.001**	**Upward, p = 0.005**	**Upward, p = 0.03**	None, p = 0.11	None, p = 0.38	**Downward, p = 0.05**	None, p = 0.31	None, p = 0.20

Table 2. Summary of wet vs. dry season comparisons and comparison of 12 year median values to established water quality criteria. Values found to be significantly greater than water quality criteria are shown with red background. Values with significantly different wet vs. dry season values are shown with blue background.

Sites/Parameter		Gulf BP_2out	Blind Pass All	Dinkins Bayou All	Clam Bayou WQ2	West Slough All	East Slough All
TP	Wet vs. Dry	No Diff $p = 0.35$	No Diff $p = 0.163$	No Diff $p = 0.437$	No Diff $p = 0.312$	GreaterWet $p < 0.001$	No Diff $p = 0.654$
	Actual vs. Criteria	Not Greater $p = 0.997$	Not Greater $p = 1.0$	Not Greater $p = 0.783$	AboveCriteria $p = 0.006$	AboveCriteria $p < 0.001$	AboveCriteria $p < 0.001$
TN	Wet vs. Dry	No Diff $p = 0.16$	GreaterWet $p < 0.001$	GreaterWet $p = 0.002$	GreaterWet $p < 0.001$	No Diff $p = 0.137$	No Diff $p = 0.325$
	Actual vs. Criteria	Not Greater $p = 1.0$	Not Greater $p = 1.0$	AboveCriteria $p = 0.001$	AboveCriteria $p < 0.001$	AboveCriteria $p < 0.001$	AboveCriteria $p < 0.001$
Chla	Wet vs. Dry	GreaterWet $p = 0.001$	GreaterWet $p = 0.001$	GreaterWet $p = 0.001$	GreaterWet $p < 0.001$	GreaterWet $p < 0.001$	No Diff $p = 0.555$
	Actual vs. Criteria	Not Greater $p = 1.0$	Not Greater $p = 0.62$	AboveCriteria $p = 0.008$	AboveCriteria $p < 0.001$	AboveCriteria $p < 0.001$	AboveCriteria $p < 0.001$
OP	Wet vs. Dry	GreaterWet $p = 0.045$	No Diff $p = 0.17$	No Diff $p = 0.99$	No Diff $p = 0.087$	GreaterWet $p = 0.002$	No Diff $p = 0.751$
IN	Wet vs. Dry	No Diff $p = 0.37$	No Diff $p = 0.09$	GreaterDry $p = 0.05$	GreaterDry $p = 0.034$	GreaterDry $p = 0.034$	GreaterDry $p = 0.025$
Salinity	Wet vs. Dry	No Diff $p = 0.54$	GreaterDry $p = 0.05$	GreaterDry $p = 0.02$	GreaterDry $p = 0.037$	No Diff $p = 0.119$	GreaterDry $p = 0.006$
pH	Wet vs. Dry	No $p = 0.09$	GreaterWet $p = 0.001$	GreaterWet $p < 0.001$	GreaterWet $p = 0.001$	GreaterDry $p < 0.001$	GreaterDry $p < 0.001$
TOC	Wet vs. Dry	GreaterWet $p < 0.001$	GreaterWet $p = 0.001$	GreaterWet $p < 0.001$	GreaterWet $p < 0.001$	No Diff $p = 0.06$	GreaterWet $p < 0.001$
Turbidity	Wet vs. Dry	GreaterDry $p = 0.002$	GreaterDry $p = 0.002$	GreaterDry $p = 0.004$	GreaterDry $p = 0.009$	GreaterWet $p < 0.001$	No Diff $p = 0.444$

Figure 1. Water quality monitoring stations. These stations are sampled monthly as required by Sanibel's NPDES permit.

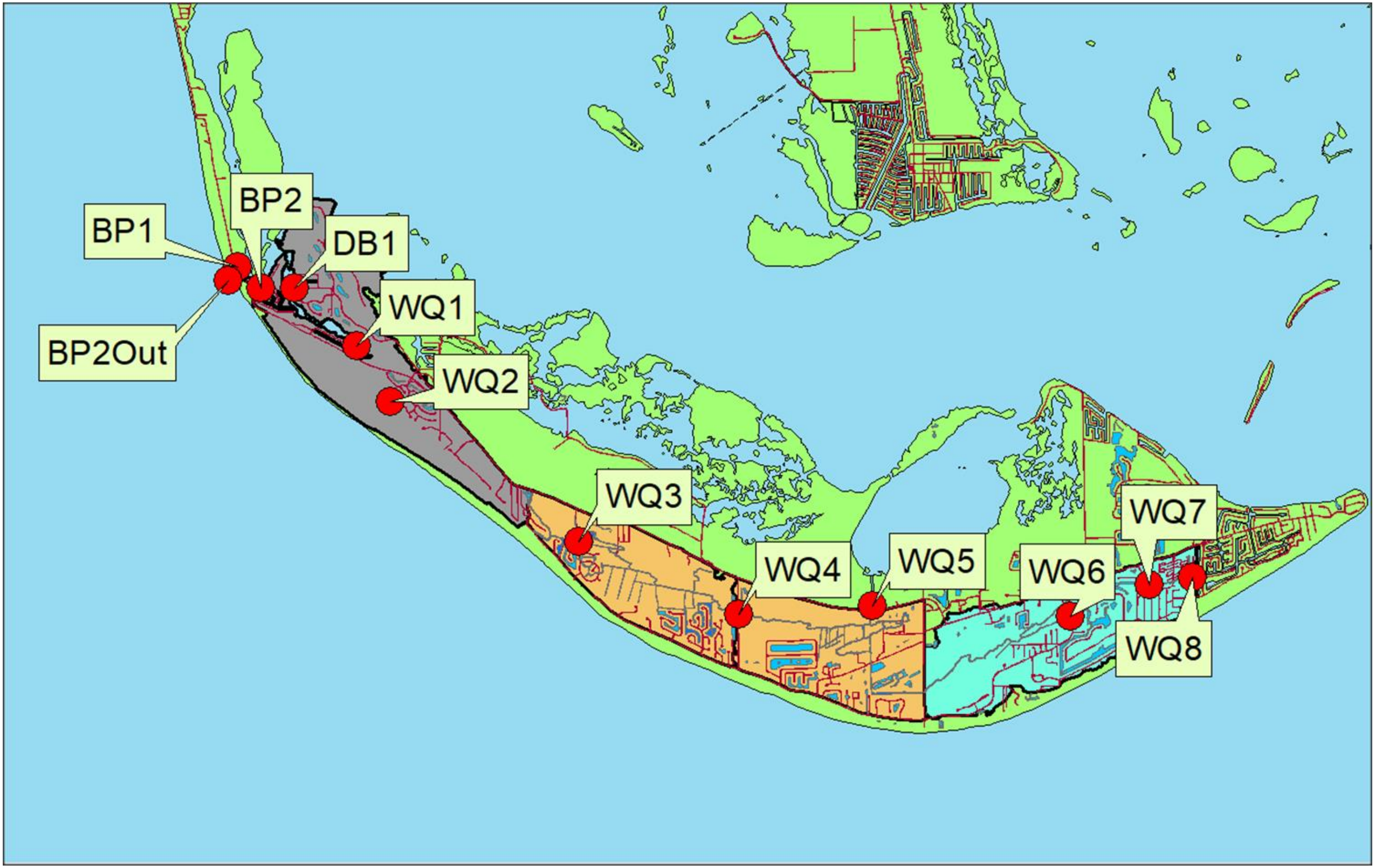


Figure 2. Annual geometric means of TN, TP and chlorophyll *a* over past 5 years for the Gulf of Mexico site at the mouth of Blind Pass. The numeric nutrient criterion for Pine Island Sound is indicated by the red line.

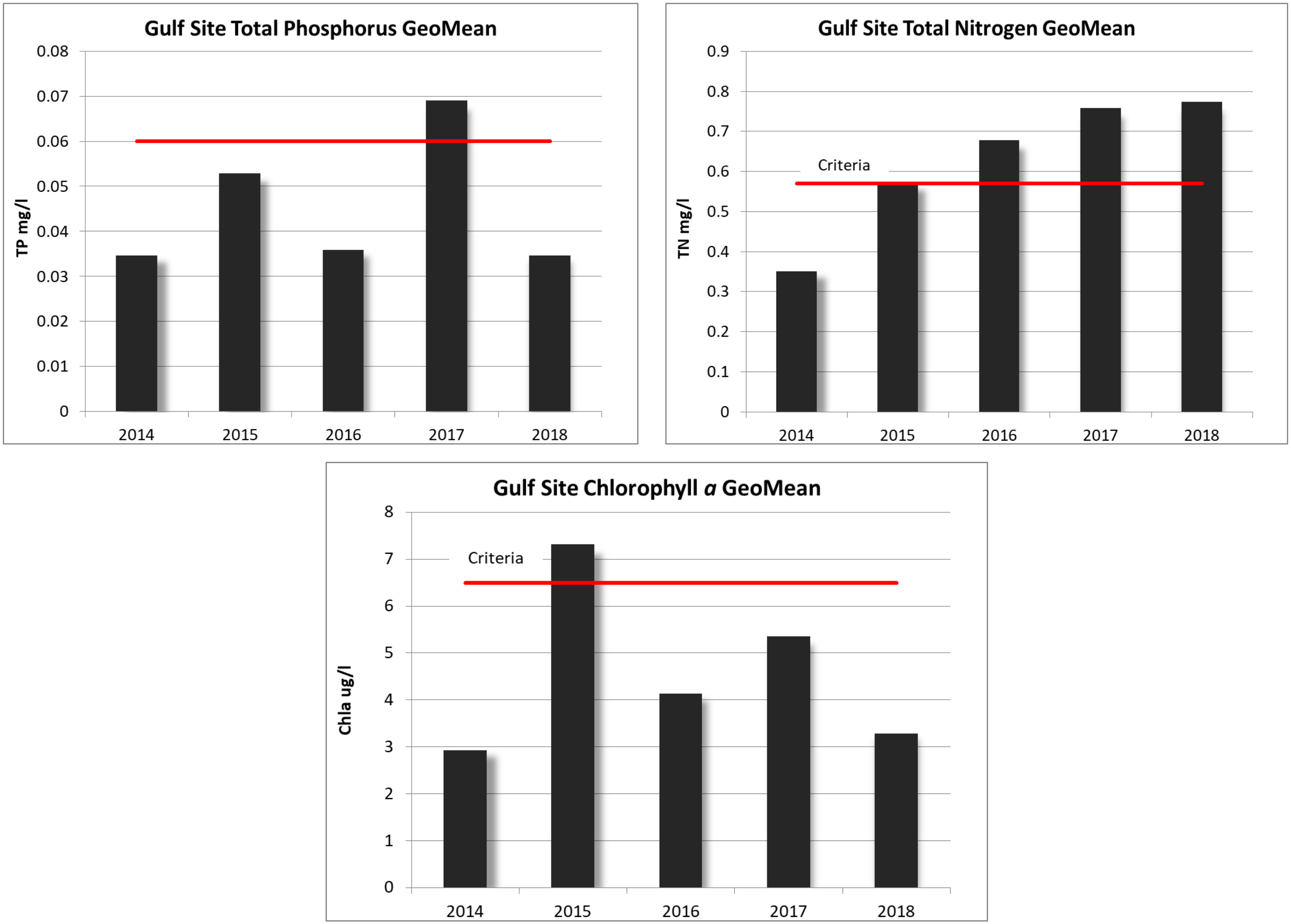


Figure 3. Annual geometric means of TN, TP and chlorophyll *a* over past 5 years for Blind Pass. The numeric nutrient criterion for Pine Island Sound is indicated by the red line.

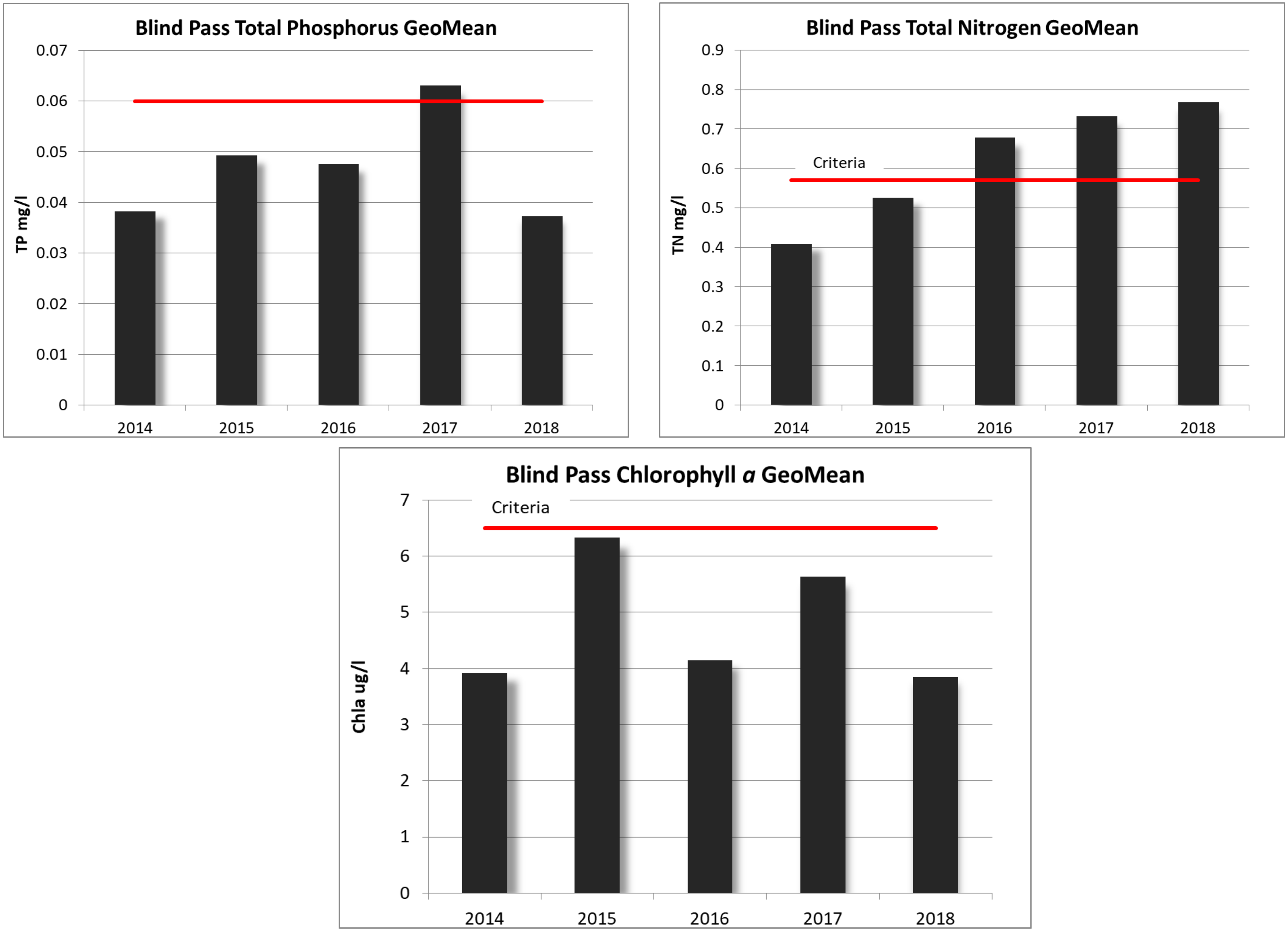
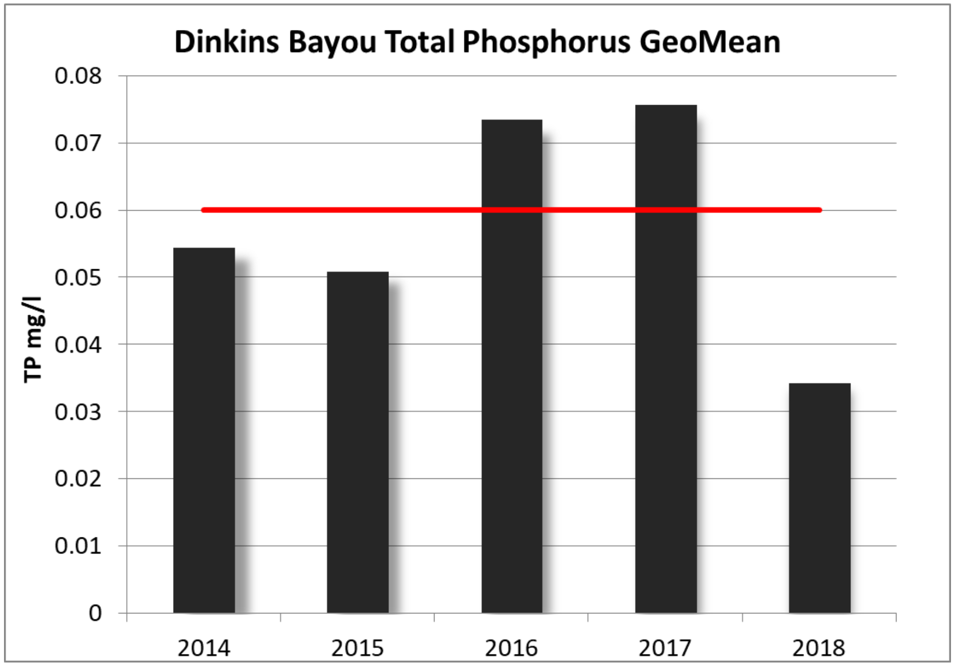
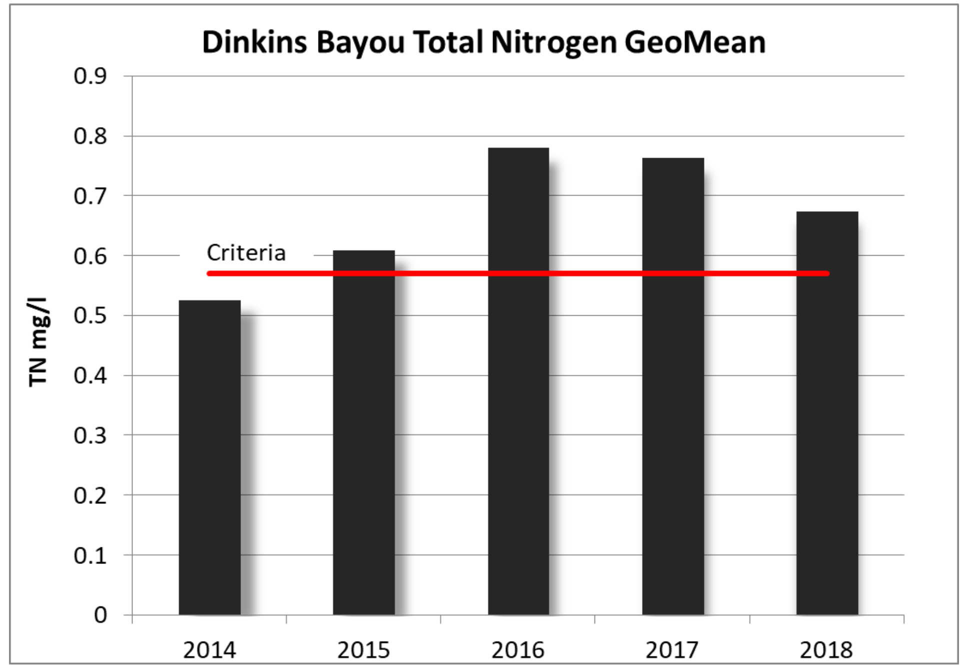


Figure 4. Annual geometric means of TN, TP and chlorophyll *a* over past 5 years for Dinkins Bayou. The numeric nutrient criterion for Pine Island Sound is indicated by the red line.





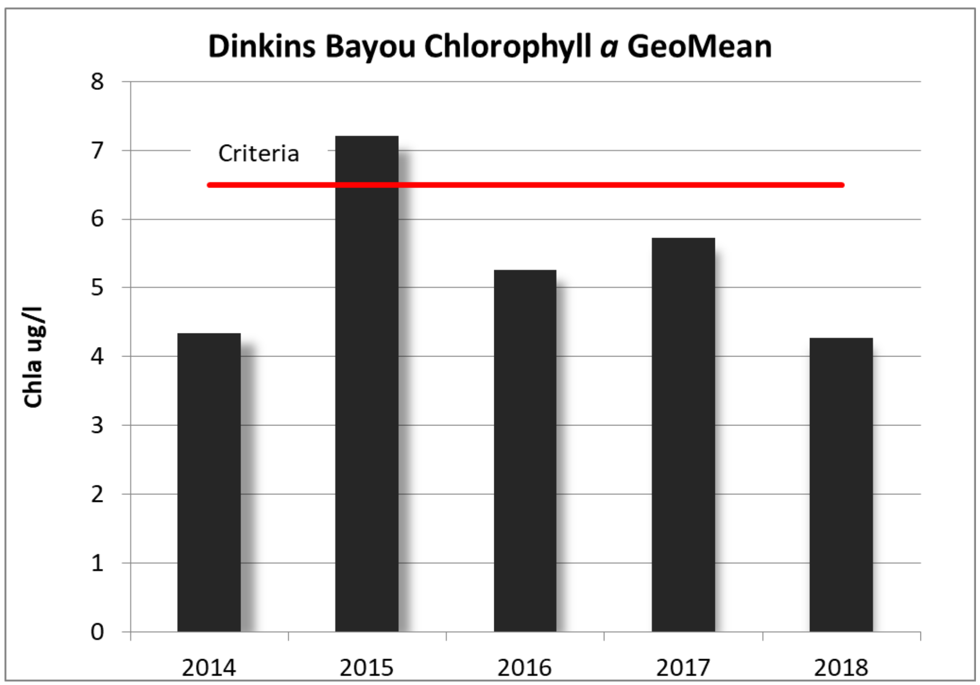
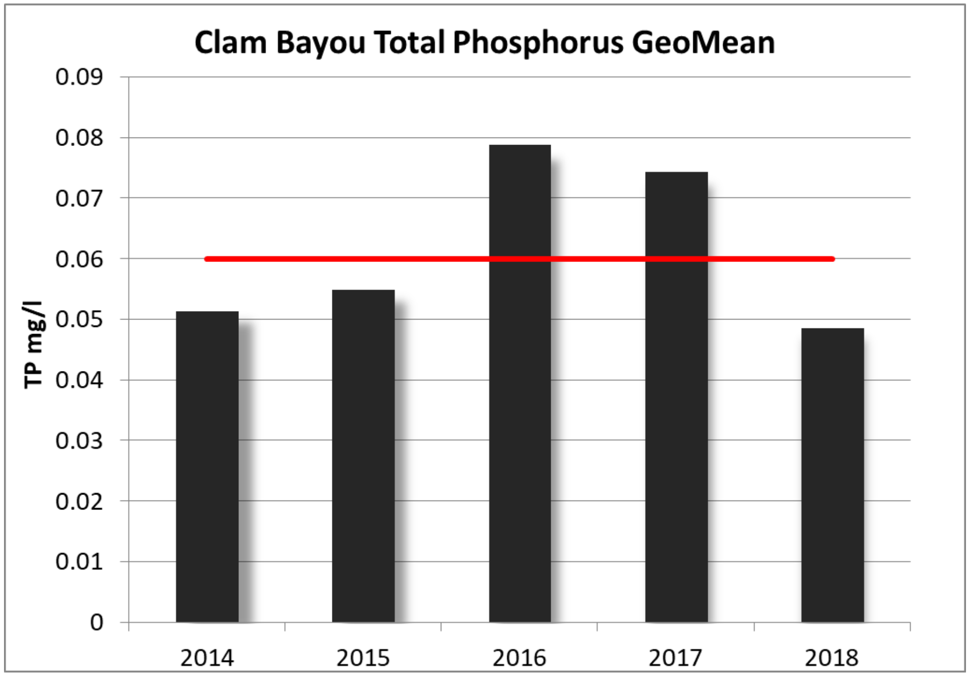
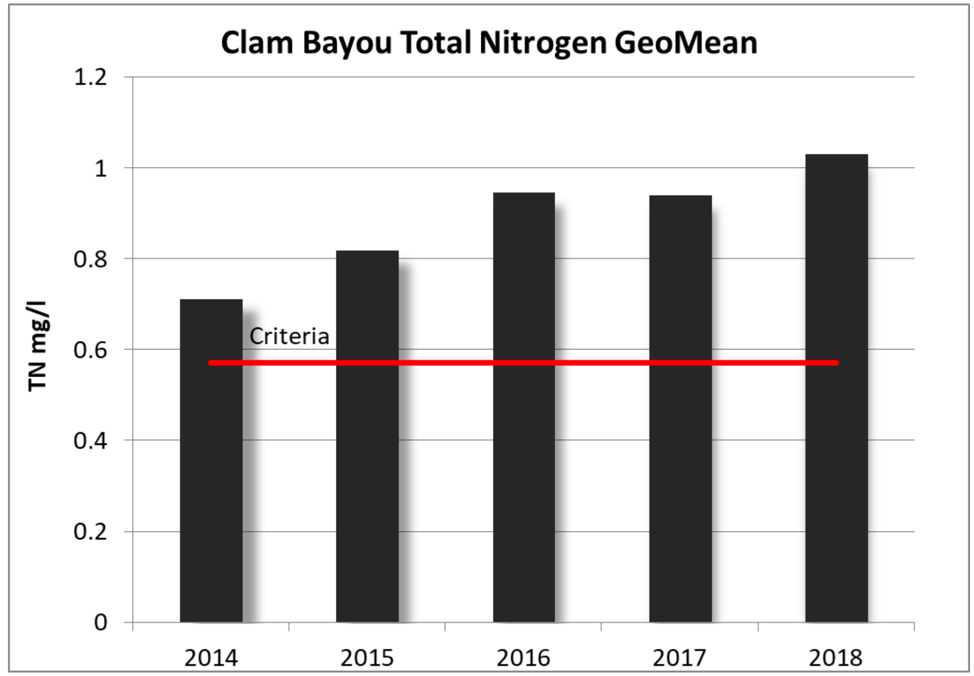


Figure 5. Annual geometric means of TN, TP and chlorophyll *a* over past 5 years for Clam Bayou. The numeric nutrient criterion for Pine Island Sound is indicated by the red line.





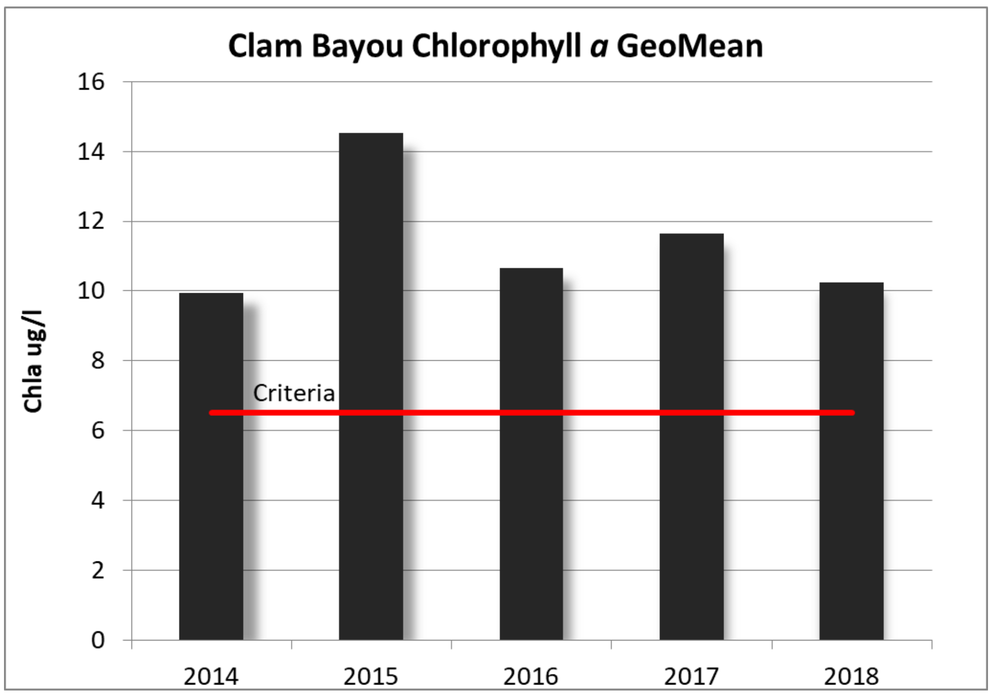


Figure 6. Annual geometric means of TN, TP and chlorophyll *a* over past 5 years for the western basin of the Sanibel Slough. The numeric nutrient criterion for Pine Island Sound is indicated by the red line. For Chlorophyll, the red line indicates the TMDL target.

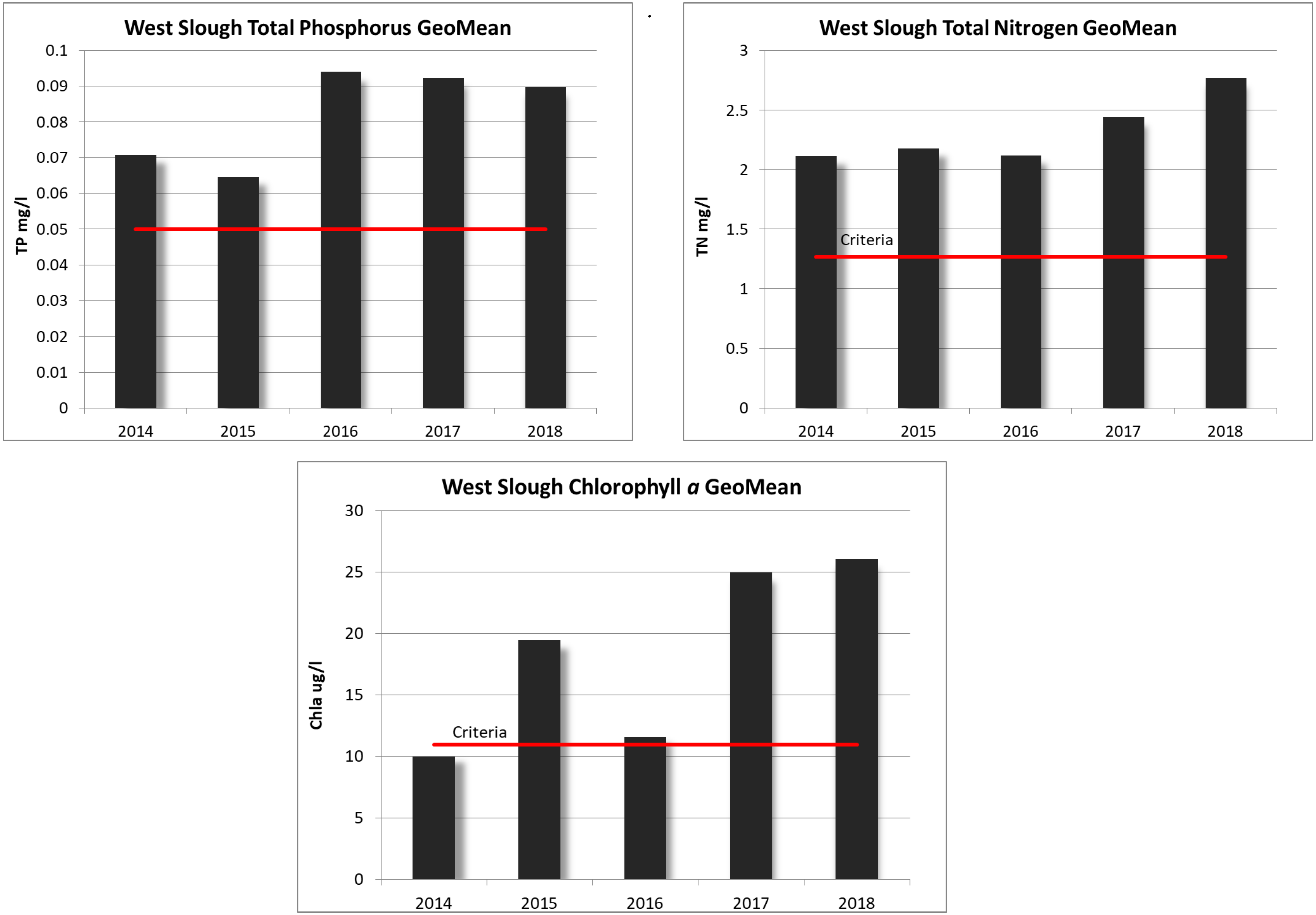


Figure 7. Annual geometric means of TN, TP and chlorophyll *a* over past 5 years for the eastern basin of the Sanibel Slough. The numeric nutrient criteria for Pine Island Sound is indicated by the red line. For Chlorophyll, the red line indicates the TMDL target.