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Technical Memorandum

date	March 24, 2021
to	Tim Hall Turrell, Hall and Associates, Inc.
cc	
from	Emily Keenan, M.S. Bob Woithe, PhD.
subject	Annual Report (2020) on Clam Bay Numeric Nutrient Concentration (NNC) Criteria

Executive Summary

Water quality data collected from Clam Bay between January 2020 and December 2020 were analyzed to determine the degree to which the waters of Upper, Inner and Outer Clam Bay are in compliance with relevant criteria. For nutrients, it was found that levels of phosphorous were out of compliance with existing site-specific criteria for Clam Bay both in the current year (2020) as well as previous years. Levels of nitrogen were not out of compliance. Due to elevated phosphorus concentrations in consecutive years, an analysis of the potential impact on water clarity within the system was performed to identify potential management actions.

The results from these past 12 months were then compared against water quality data going back to March 2015. In general, phosphorus concentrations have increased over recent years in a pattern that suggests that the impacts from Hurricane Irma may have had longer-term consequences than was originally anticipated. A timeline of impacts, activities and water quality suggests that the rainy season of 2018 might have brought more phosphorus into the Clam Bay system than even the hurricane- impacted prior year. This may have been associated with activities that were conducted in 2018 to reestablish tidal channels in the mangrove forests adjacent to Clam Bay. These channels were reestablished in large part due to damage to the forests that occurred in response to the passage of Hurricane Irma in September 2017. In the most recent monitoring period (January 2020 to December 2020), a notable reduction in phosphorus exceedances was observed throughout the Clam Bay system further supporting the likelihood that the previous period of wide-spread elevated phosphorus concentrations was due to extreme weather events.

Based on data from throughout the Clam Bay system, there is a positive correlation between phosphorous concentrations and the amount of algae in the water column, and an inverse correlation between phosphorous and levels of dissolved oxygen (DO). These results suggest that phosphorous concentrations are at potentially problematic levels in Clam Bay, and they should be carefully monitored, to ensure that conditions do not deteriorate, and that the recent impairments do not become a long-term condition. Should phosphorous continue to exceed established criteria; the County might wish to consider developing a site-specific phosphorus loading model, to develop appropriate management responses.

Similar trends were found for nitrogen, but phosphorus tended to explain more of the variability in levels of chlorophyll-a and DO than was found for nitrogen. These data suggest that both nitrogen and phosphorus are important for the management of water quality in Clam Bay, but phosphorus might have more of an influence on ecosystem health than nitrogen.

Unfortunately, the trend over the past six years has been of an increase in both nitrogen and phosphorus, at least in Outer Clam Bay. Upper and Inner Clam Bay do not show the same trend of increased nitrogen and phosphorus that was seen in Outer Clam Bay. However, despite the trends of increased nutrient concentrations, the majority of stations did not exhibit a concurrent increase in the amount of algae in the water column, as quantified by concentrations of chlorophyll-a.

The waters of Clam Bay would be considered to be out of compliance with existing DO criteria used by the state of Florida. This conclusion is consistent with the results of the previous annual report which identified sufficient depressed DO concentrations to be considered out of compliance over the 12- month period. However, a formal determination of impairment for DO by FDEP would require the review of data over a 7.5-year period, rather than an individual year. Nonetheless, it would be helpful to better characterize the benthic habitats in Upper and Inner Clam Bay, as it is not that unusual for mangrove-lined creeks to have healthy ecology, even if they "fail" state-designated water quality criteria.

While the amount of copper in the various treatment ponds sampled along the eastern border of Clam Bay exceeded criteria for freshwater water bodies, the open waters of Clam Bay would not be considered to be impaired for copper. That finding seems to represent an improvement in water quality in the bay, most likely associated with reductions in the amount of copper-containing herbicides used in the Pelican Bay stormwater treatment system.

Background

In 2012, the United States Environmental Protection Agency formally adopted nutrient concentration criteria for Clam Bay (which had been produced for Collier County) that had also been reviewed and approved by FDEP. The Numeric Nutrient Concentration (NNC) criteria produced for Clam Bay are termed Site Specific Alternative Criteria (SSAC) and they are listed in Florida Administrative Code (FAC) 62-302.531. The SSAC for Clam Bay were based upon a relationship between salinity and nutrients that was initially established at one of FDEP's "reference sites" in Estero Bay. The need to take into account salinity was based upon the finding that nutrient concentrations in estuaries and tidal rivers vary as a function of rainfall and runoff, as well as tidal influence. Even FDEP's reference sites, which were chosen to represent waterbodies with little to no human impacts, have nutrient concentrations that are inversely correlated with salinity. This reflects land-based nutrient sources combining with lower nutrient concentrations in offshore waters. Therefore, a single nutrient concentration criterion does not make much sense, as water quality data from even pristine locations could potentially pass or fail proposed criteria simply as a function of location, tidal stage or antecedent rainfall.

The SSAC for Clam Bay incorporates nutrient concentrations, while also taking into account the salinity, such that a finding of elevated nutrients in combination with higher salinities is considered more problematic than elevated nutrients in combination with lower salinities. Additionally, the frequency with which values exceed NNC criteria is taken into account when determining the appropriate management response as is the amount of time over which an exceedance has occurred. For example, if nutrient concentrations were to exceed NNC criteria by a relatively small percentage, and if such an exceedance was to only last a short period of time, the appropriate management response would be different than if water quality was to exceed criteria by a greater margin, and if the condition of exceedance lasts for a greater period of time. In this manner, the management response associated with any impairment determination is proportional, and based upon both the magnitude and duration of any exceedances.

Based on prior work conducted in Clam Bay, it was found that the amount of floating microscopic algae (i.e., phytoplankton) in the bay was likely stimulated by both Total Nitrogen (TN) and Total Phosphorous (TP). Accordingly, the amount of both TN and TP in Clam Bay is used to determine the degree of nutrient enrichment of Clam Bay's waters. The language in FAC 62-302.531 states that the water quality status of waterbodies is to be determined on an annual basis, preferably within a calendar year.

As outlined in FAC 62-302.532, for each year, the value of each individual TN and TP sample collected within Clam Bay is compared to an "upper boundary" of the expected relationship between those two variables and salinity. This boundary was originally informed by the water quality data from an FDEP-designated reference water body. The formal name of the upper boundary condition is the "90th percentile prediction limit" which was originally derived for the relationship between nutrient concentrations and salinity in Clam Bay, and which is based on the determination by FDEP that Clam Bay's water (in 2012) was sufficient to protect its biological integrity. In other words, a TN or TP concentration higher than the 90th percentile prediction limit is a nutrient concentration higher than at least 90 percent of the values that would be expected, after taking into account the salinity value at the time that the water quality sample was collected.

The number of occasions when a nutrient concentration is higher than the 90th percentile prediction limit is quantified for each year, and an annual percent exceedance is then calculated. To attempt to be consistent with previous methods used by FDEP, if more than 13 percent of TN or TP concentrations exceed the 90th percentile prediction limit (for a given year) then the year as a whole is classified as one where water quality is out of compliance with the existing criteria. If fewer than 13 percent of the values exceed the 90th percentile prediction limit, then water quality is not considered to be out of compliance.

If more than 15 percent of TN or TP values exceed the 90th percentile prediction limit, then the degree of impairment is determined (as per FDEP guidance) to be more problematic than if only 13 percent of values exceeded the established criteria. The screening of water quality data against the adopted NNC criteria is performed as outlined in Figure 1, where different outcomes are given different scores, depending on the frequency of impairment, as well as the duration that the impairment has lasted. The possible outcomes displayed in Figure 1 are then compared for both TN and TP, and the combined outcomes are converted into designations of "green", "yellow" and "red" which correspond to an increasing need for concern (Figure 2).

As a final step, the appropriate management response to water quality within a given year is then identified based on the results from Figure 2. For example, if water quality data suggest that TN and TP concentrations are elevated, then it is important to determine if the ecological health of Clam Bay appears to be adversely impacted by those nutrient concentrations. As a test of the impact of potential nutrient enrichment, water quality data would then be tested to determine if phytoplankton levels are perhaps higher, or dissolved oxygen levels lower, based on nutrient concentrations (Figure 3).

In this manner, management responses are proportional to the frequency and duration of exceedance conditions, as well as the determination of whether or not nutrient supply appears to be causing adverse water quality conditions. With this information as background, the rest of this report will focus on the analysis of water quality data collected during the period of January 2020 to December 2020, at nine open water locations shown in Figure 4. In addition to the open water sample sites, a number of sampling locations were located in the stormwater treatment ponds and swales east of the mangrove fringe and stormwater berm on the east side of Outer, Inner and Upper Clam Bays (Figure 4).

Figure 1. Flow chart for determining water quality compliance in Clam Bay.

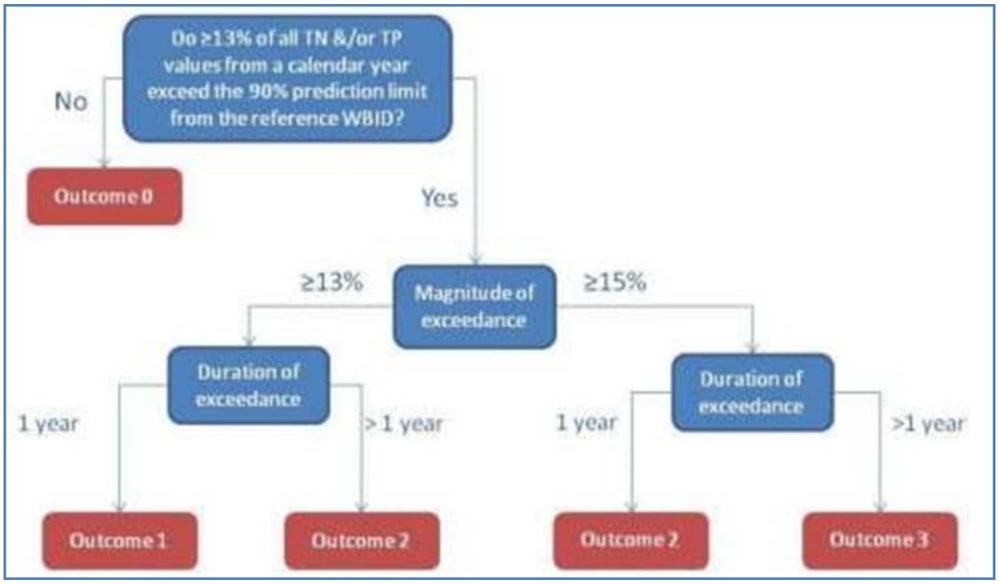
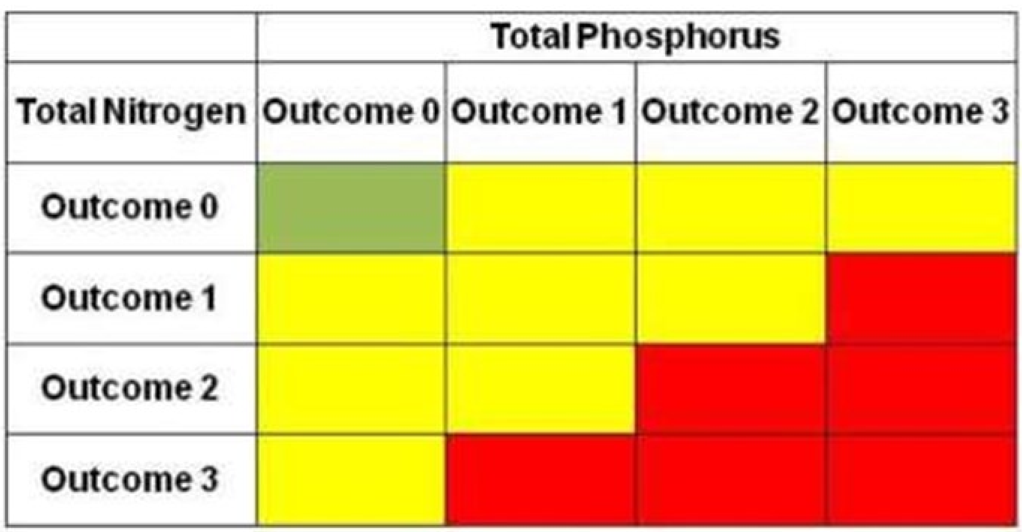


Figure 2. Management response matrix using outcomes for TN and TP.



	Total Phosphorus			
Total Nitrogen	Outcome 0	Outcome 1	Outcome 2	Outcome 3
Outcome 0				
Outcome 1				
Outcome 2				
Outcome 3				

Figure 3. Management response actions in response to various outcomes in Clam Bay.

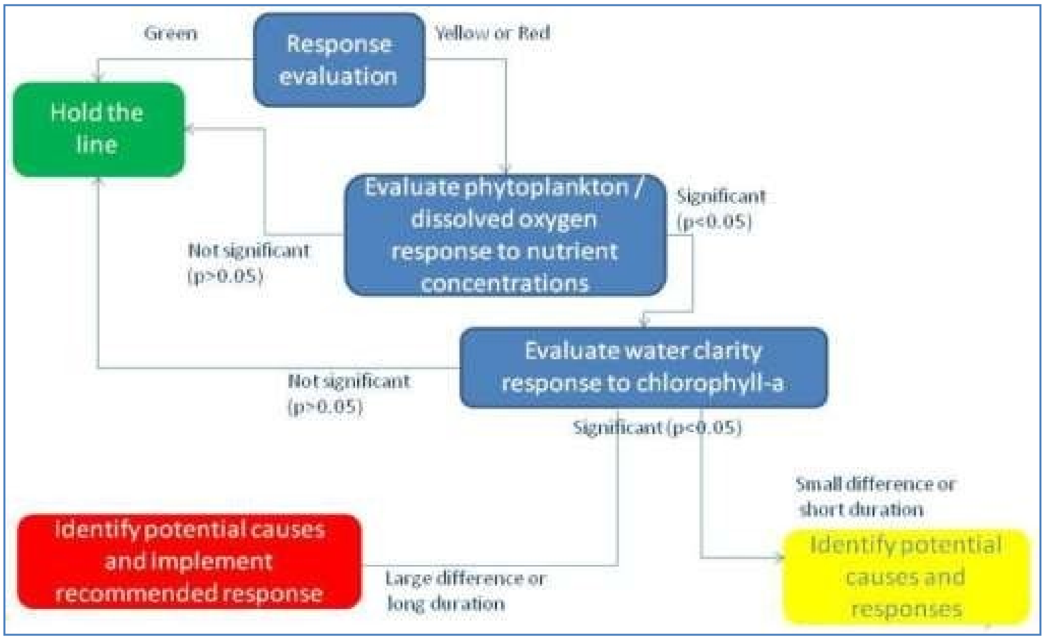
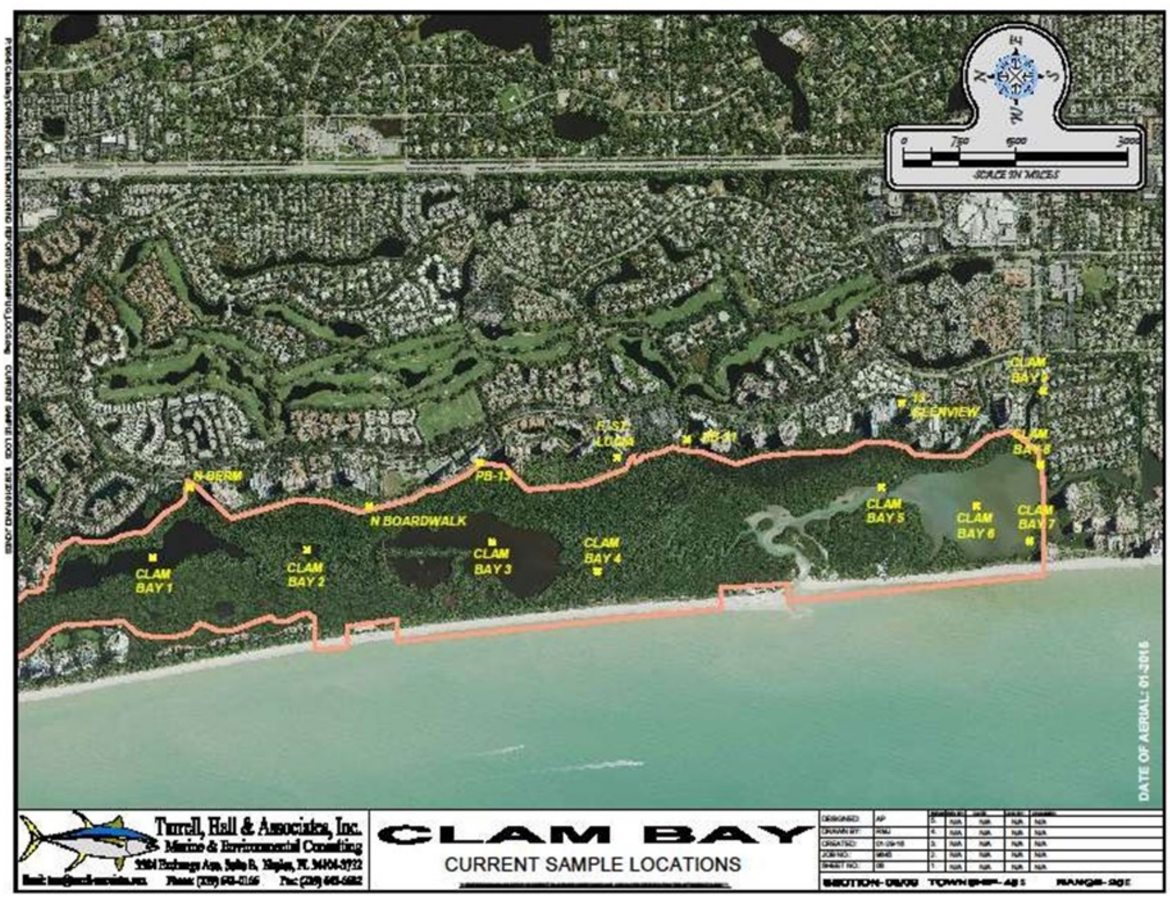


Figure 4. Locations of monthly monitoring stations sampled for Clam Bay and its directly adjacent watershed.



Data Analysis – Nutrient Status

The analysis conducted below was used to assess the water quality status of Clam Bay during the months of January 2020 to December 2020. Samples were collected monthly at each of the nine sampling stations; therefore, a total of 108 water quality samples were reported within Clam Bay for the analysis period. Water quality data from Clam Bay and its watershed were provided by Turrell, Hall and Associates, Inc.

For comparison with the FDEP adopted SSAC for Clam Bay, as listed within FAC. 62-302-532, the water quality data set provided by Turrell, Hall and Associates was analyzed based on the following criteria:

> *No more than 10 percent of the individual Total Phosphorus (TP) or Total Nitrogen (TN) measurements shall exceed the respective TP Upper Limit or TN Upper Limit*

The Upper Limits for TP and TN concentrations noted above are derived based on Equations 1 and 2, respectively:

$$\underline{Equation\ 1:}\ TP\ Upper\ Limit\ (mg/L) = e^{(-1.06256-0.0000328465*Conductivity(\mu s))}$$

$$\underline{Equation\ 2:}\ TN\ Upper\ Limit\ (mg/L) = 2.3601 - 0.0000268325*Conductivity(\mu S)$$

The nutrient dataset examined was supplemented with in situ water quality data (e.g., temperature, dissolved oxygen, pH, conductivity, and salinity) retrieved from the chain of surface water grab sample custody forms for each sampling event. TN and TP concentrations were compared to the derived upper limit thresholds to quantify the presence or absence of elevated concentrations of TP and/or TN, with results listed in (Appendix A).

Over the period analyzed (January 2020 to December 2020), no (0) ambient water quality values for TN exceeded the respective TN Upper Limit. In comparison, 26 of the 108 TP measurements (approximately 24 percent) exceeded their respective TP Upper Limit. Based on these results, the frequency of exceedance would be high enough for the waters of Clam Bay to be determined to be impaired for TP.

This report is intended to present results over the most recent annual reporting period. However, in order to more extensively investigate the nutrient exceedances observed in Clam Bay, all data collected as part of the existing ambient monitoring program implemented by Turrell Hall and Associates were evaluated to identify potential trends (March 2015 to December 2020). For this effort, TN and TP event exceedances were displayed in a manner intended to allow a quick visualization or results by month and by station (Tables 1 and 2). Sampling locations and months are color coded according to results. Green represents "passing" values while red represents time and month combinations where TN or TP values exceeded NNC criteria. Additionally, red cells denoted with an "x" represent date and location combinations where criteria were exceeded, but where the TN or TP concentrations were within 5 percent of the relevant threshold concentration. On those occasions, the TN or TP concentrations are close enough to "non-impaired" levels that impairment could be related to issues such as rounding errors or laboratory precision.

Table 1. Representation of frequency of impairment for TP for different site and date combinations. Green represents samples in compliance with criteria. Red cells indicate exceedance of criteria. Red cells with an "X" represent values that are within 5% of criteria concentrations, suggesting lack of compliance should be interpreted with caution, due to analytical precision. Clear cells represent a lack of data.

Sampling Event	Station								
	1	2	3	4	5	6	7	8	9
15-Mar			X						
15-Mar									
15-Apr									
15-May		X							
15-Jun									
15-Jul									
15-Aug									
15-Sep									
15-Oct									
15-Nov		X							
15-Dec									
16-Jan									
16-Feb		X							
16-Mar									
16-Apr									
16-May									
16-Jun									
16-Jul									
16-Aug									
16-Sep				X					
16-Oct									
16-Nov									
16-Dec									
17-Jan									
17-Feb									
17-Mar			X						
17-Apr									
17-May									X
17-Jun									
17-Jul									
17-Aug									
17-Oct									
17-Nov									
17-Dec									

Table 1. Continued.

Sampling Event	Station								
	1	2	3	4	5	6	7	8	9
18-Jan									
18-Feb									
18-Mar					X	X			
18-Apr									X
18-May							X		
18-Jun									
18-Jul									
18-Aug									
18-Sep									
18-Oct									
18-Nov									
18-Dec									
19-Jan									
19-Feb									
Mar-19			X		X				
19-Apr									
19-May									
19-Jun									
19-Jul							X		
19-Aug									
19-Sep		X							
19-Oct									
19-Nov									
19-Dec									
20-Jan						X			
20-Feb									
20-Mar									
20-Apr									
20-May									
20-Jun								X	X
20-Jul								X	X
20-Aug		X							
20-Sep									
20-Oct									X
20-Nov									
20-Dec									

Table 2. Representation of frequency of impairment for TN for different site and date combinations. Green represents samples in compliance with criteria. Red cells indicate exceedance of criteria. Red cells with an "X" represent values that are within 5% of criteria concentrations, suggesting lack of compliance should be interpreted with caution, due to analytical precision. Clear cells represent a lack of data.

Sampling Event	Station								
	1	2	3	4	5	6	7	8	9
15-Mar									
15-Mar									
15-Apr									
15-May									
15-Jun									
15-Jul									
15-Aug									
15-Sep									
15-Oct									
15-Nov									
15-Dec									
16-Jan									
16-Feb									
16-Mar									
16-Apr									
16-May									
16-Jun									
16-Jul									
16-Aug									
16-Sep									
16-Oct									
16-Nov									
16-Dec									
17-Jan									
17-Feb									
17-Mar									
17-Apr									
17-May									
17-Jun									
17-Jul									
17-Aug									
17-Oct									
17-Nov									
17-Dec									

Table 2. Continued.

Sampling Event	Station								
	1	2	3	4	5	6	7	8	9
18-Jan									
18-Feb									
18-Mar									
18-Apr									
18-May									
18-Jun									
18-Jul			X						
18-Aug									
18-Sep									
18-Oct									
18-Nov			X						
18-Dec									X
19-Jan									
19-Feb									
Mar-19									
19-Apr									
19-May								X	
19-Jun									
19-Jul									
19-Aug									
19-Sep									
19-Oct									
19-Nov									
19-Dec									
20-Jan									
20-Feb									
20-Mar									
20-Apr									
20-May									
20-Jun									
20-Jul									
20-Aug									
20-Sep									
20-Oct									
20-Nov									
20-Dec									

Since TP exceedances have occurred in all reporting periods, the process shown in the Figure 1 flowchart yields a score of "3" for TP compared to a score of "0" for TN (Figure 2). Using three years' worth of data, the combination of outcome "3" for TP and outcome "0" for TN would result in a "yellow" management response as illustrated in Figure 3. Since the TP exceedance rate was greater than 15 percent, has persisted for more than one year, and coincides with a TN exceedance rate less than 13 percent, the "yellow" management response would be the outcome for the 2020 annual data collection effort. This is an improvement compared to previous annual evaluations (2018 and 2019) when the management response was "red". Consequently, the following additional data investigations were conducted:

- Determining the relationship, if any, between nutrients and chlorophyll-a
- Determining the relationship, if any, between nutrients and dissolved oxygen
- Determining the relationship, if any, between chlorophyll-a and water clarity

Depending upon the findings of the analyses listed above, management implications would be developed, which could include the need to determine the basis for a potential adverse impact on water quality.

A review of the monitoring program's complete record of 51 months of data of data (October 2016 to December 2020) indicated a direct relationship between nutrients and chlorophyll-concentrations (Figures 5 and 6). However, chlorophyll concentrations appear to more strongly influenced by TP than TN based upon the respective R^2 for each regression (TP r^2=0.4157; TN r^2=0.1269)). Additionally, an inverse relationship between nutrients and DO was observed (Figure 7 and 8). The collection of Secchi depth readings as a surrogate for water clarity began in November 2017. Therefore, the analysis relating algal production to water clarity was restricted to the period of November 2017 to December 2020. A significant inverse relationship between Chl-a and water clarity was observed. This suggests that increased algal production was responsible for reduction in water clarity (p=0.0011, r^2=0.0318); however, the strength of the interaction was weak suggesting that other factors such as color and suspended solids also impact water clarity.

Figure 5. Relationship between total nitrogen and chlorophyll-a over the period of October 2016 to December 2020 in Clam Bay (p<0.0001, r2=0.1269).

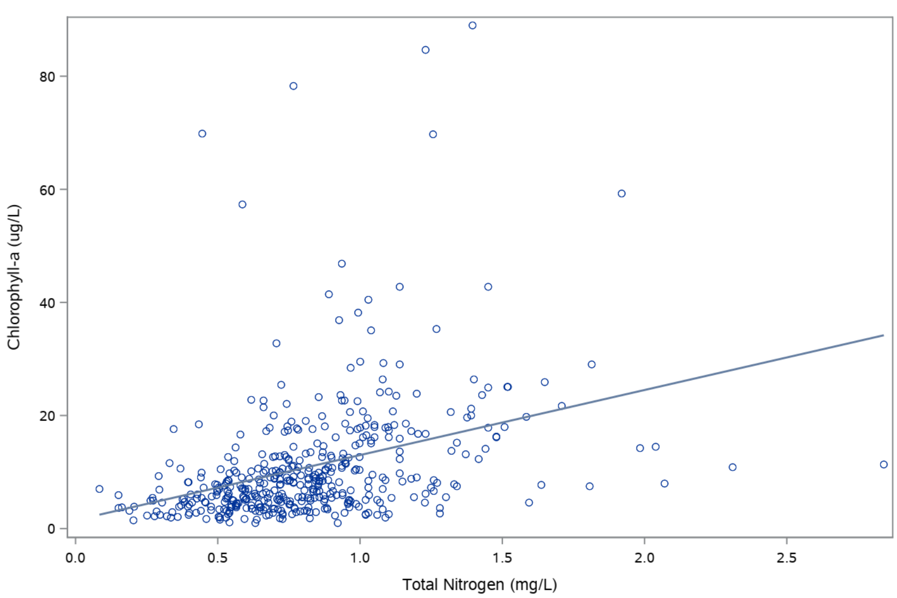


Figure 6. Relationship between total phosphorus and chlorophyll-a over the period of October 2016 to December 2020 in Clam Bay (p<0.0001, r2=0.4157).

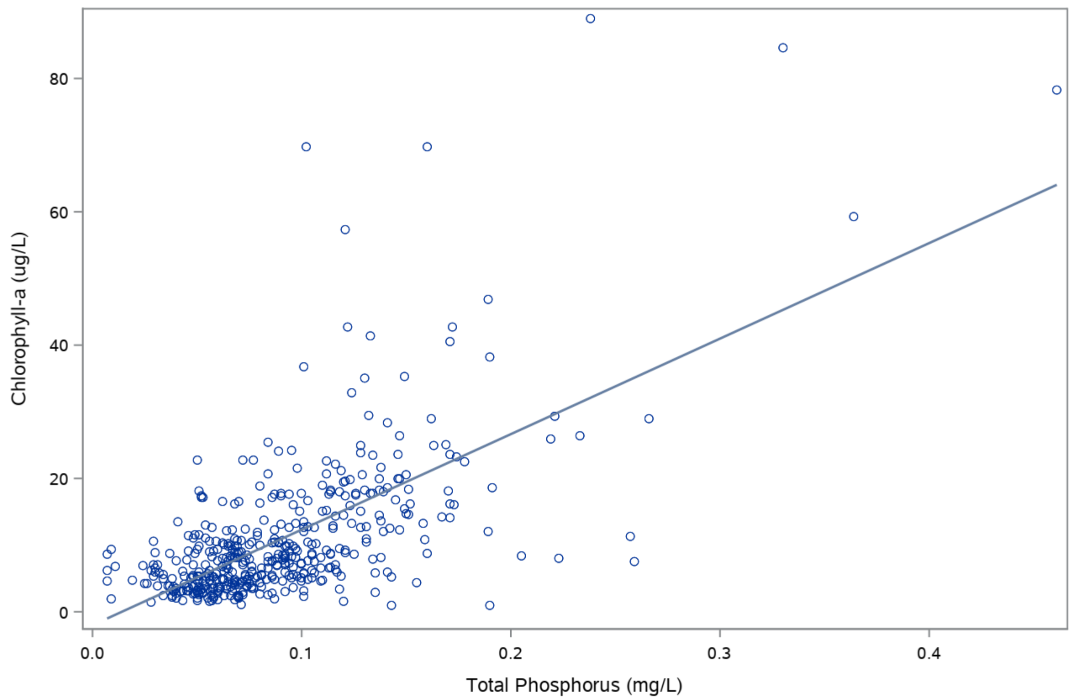


Figure 7. Relationship between total nitrogen and dissolved oxygen over the period of October 2016 to December 2020 in Clam Bay (p<0.001, r2=0.1456).

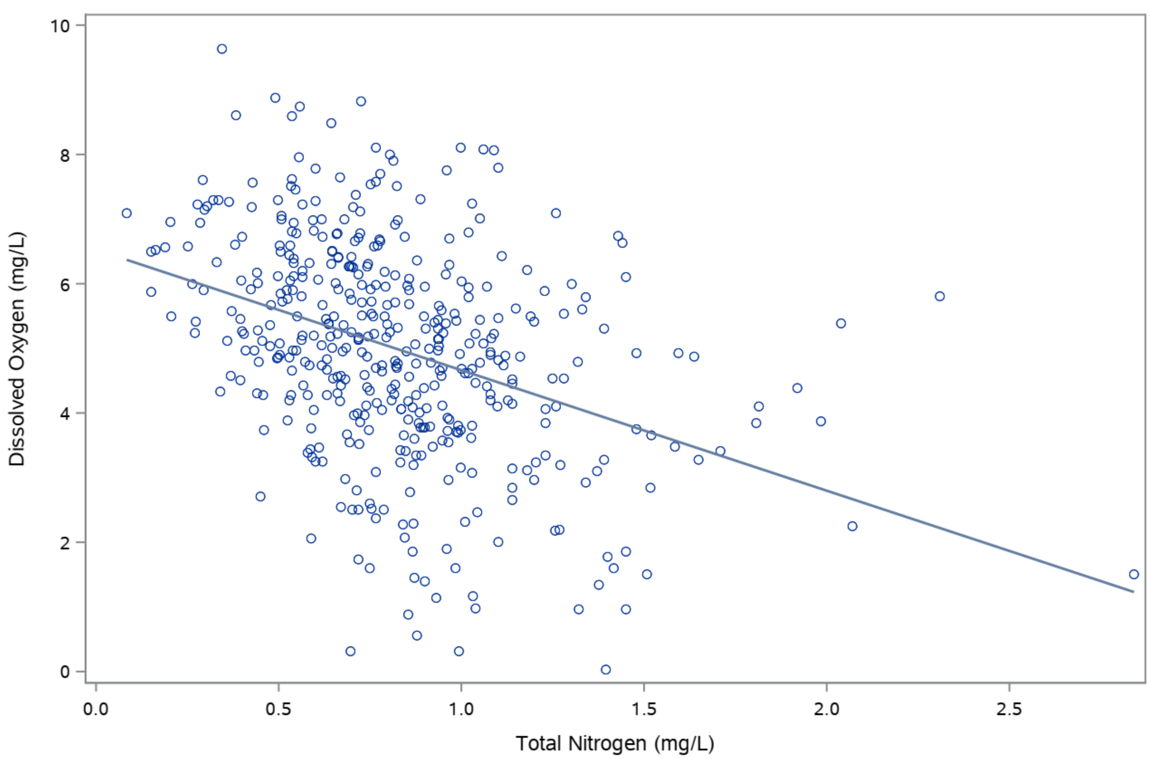
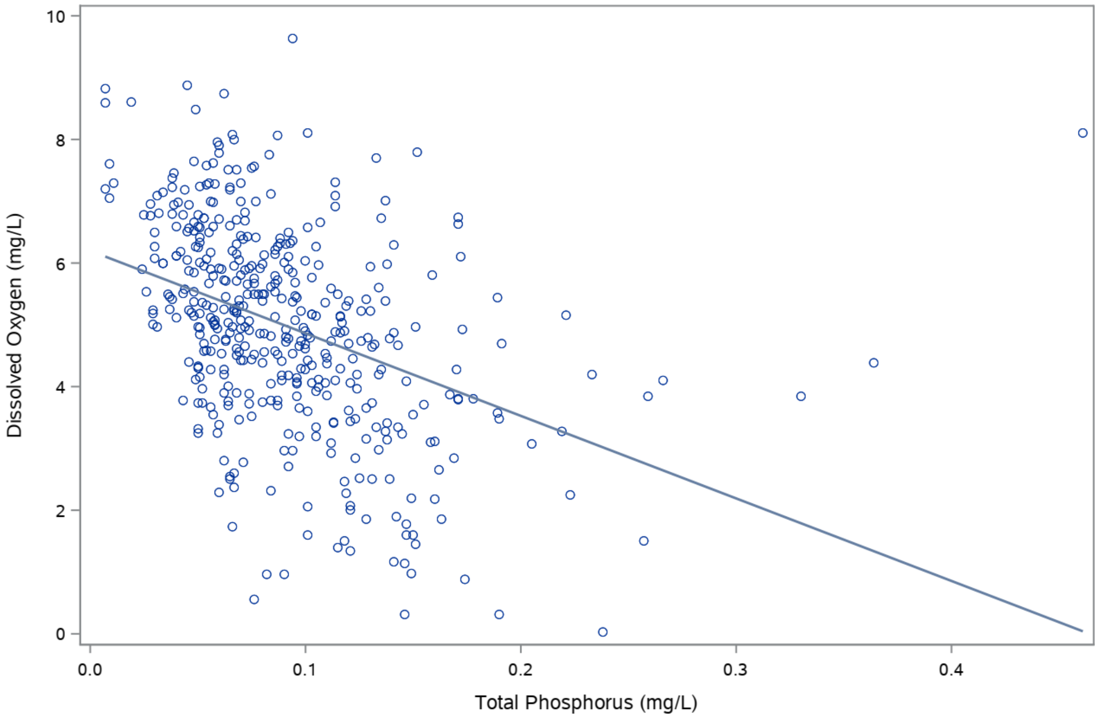


Figure 8. Relationship between total phosphorus and dissolved oxygen over the period of October 2016 to December 2020 in Clam Bay ($p<0.001$, $r^2=0.1592$).



In addition to the data assessments described above, data from Clam Bay outfall monitoring stations were compared to the proposed Downstream Protective Values (DPV) derived for Clam Bay (PBS&J 2011). Due to concerns and restrictions related to the Coronavirus pandemic, no samples were collected in April 2020 at the outfall monitoring stations. Outfall TN and TP concentrations were compared to the median and 90th percentile DPV values to determine if elevated concentrations were found at those locations (Appendices B and C).

The median DPV quantity represents a value that would be expected to be exceeded approximately 50 percent of the time, while the 90th percentile value represents a concentration sufficiently high that only 10 percent of values would be expected to be higher. Using this approach, the amount of TN or TP in the water column at stations sampled in the Clam Bay watershed can be compared to criteria that are meant to be protective of the open waters of Clam Bay proper. The TN and TP concentrations in DPV estimates are expected to be higher than concentrations in the open waters of Clam Bay. The influence of the more saline and lower nutrient content waters of the Gulf of Mexico would not yet have diluted the higher nutrient concentrations found in freshwater inflows from the watershed. The median and 90th percentile DPVs for TN were 1.31 and 1.8 mg/L respectively. The median and 90th percentile DPVs for TP were 0.10 and .25 mg/L respectively

For data collected at the outfall monitoring sites, 63 percent and 27 percent of the TN concentrations exceeded the median and 90th percentile DPV values for TN respectively (Table 3). For those same outfall monitoring sites, 64 percent and 22 percent of the TP concentrations exceeded the median and 90th percentile DPV values respectively (Table 3). It should be noted that DPV values would be expected to be exceeded approximately 50 percent and 10 percent of the time for "median" and "90th percentile" thresholds. The results in Table 3 suggest that the concentrations of TN and TP were elevated above levels that would be expected in stormwater runoff during both typical (i.e., median) and non-typical (i.e., 90th percentile) conditions, compared to the data set used to develop NNC criteria for Clam Bay.

Table 3. Percentage of TN or TP concentrations from outfall stations which exceeded the median or 90th percentile DPV values.

	Total Nitrogen		***Total Phosphorus***	
	Median	**90th Percentile**	**Median**	**90th Percentile**
Exceedance rate (%)	63	27	64	22

Daily cumulative rainfall data reported by the South Florida Water Management District meteorological station located at the Cocohatchee Canal at Palm River Road (COCO1_R) were retrieved over the period of January 1, 1997 - December 31, 2020. The long-term average annual rainfall was calculated as 48.6 inches over the twenty four-year period (Figure 9). In the most recent eight-year period (since 2013), seven of the eight years exceeded the long-term average with four of the years (2013, 2015, 2017 and 2019) reporting at least 10 inches more rain per year than the long-term average. Overall, it appears that this region has experienced greater than average rainfall than during the previous 16 years. A review of the cumulative departure of Cocohatchee River monthly rainfall from the long-term geometric mean monthly rainfall (1997-2020) shows an apparent transition in rainfall starting in 2008 (Figure 10). Rainfall prior to 2008 presents drier months compared to the long-term geometric mean combined with limited heavy monthly rainfall events. In contrast, the period after 2008 depicts an increased frequency of months with both much higher and much lower than average rainfall. It appears that the region is experiencing more frequent very high and very low rainfall months in both the "wet" and the "dry" seasons. It is possible that this deviation from the previously observed rainfall pattern has contributed to the observed change in water quality within the Clam Bay system. However, it is unlikely that stormwater impacts alone are responsible for the prolonged TP exceedances observed in Clam Bay starting in 2017.

Figure 9. Annual Cumulative Rainfall at long-term SFWMD meteorological monitoring station (COCO1_R) over period of 1997-2020. Red dashed line indicates long-term average annual rainfall (48.6 inches).

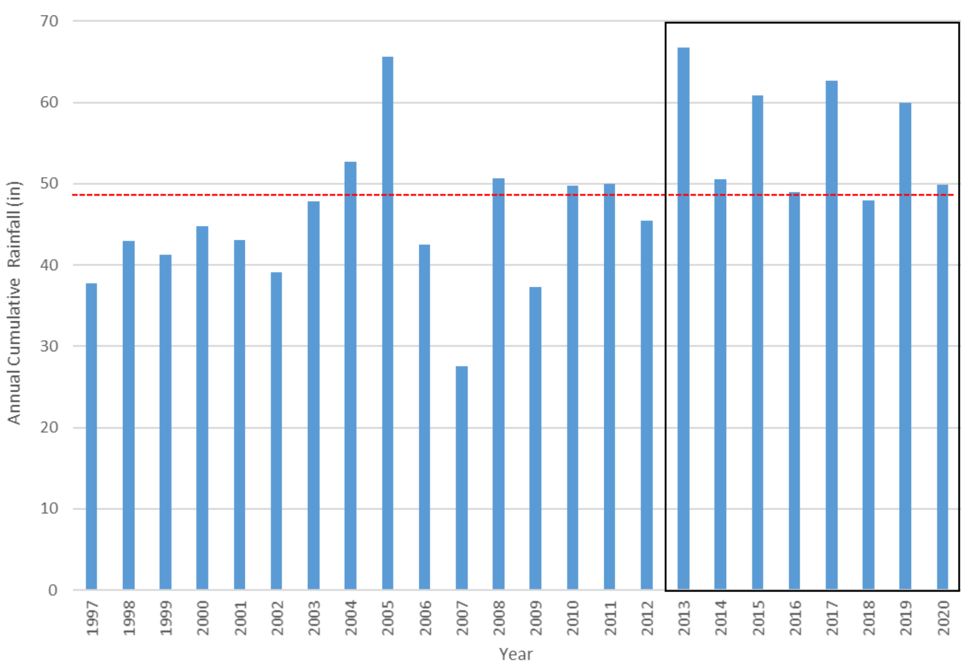
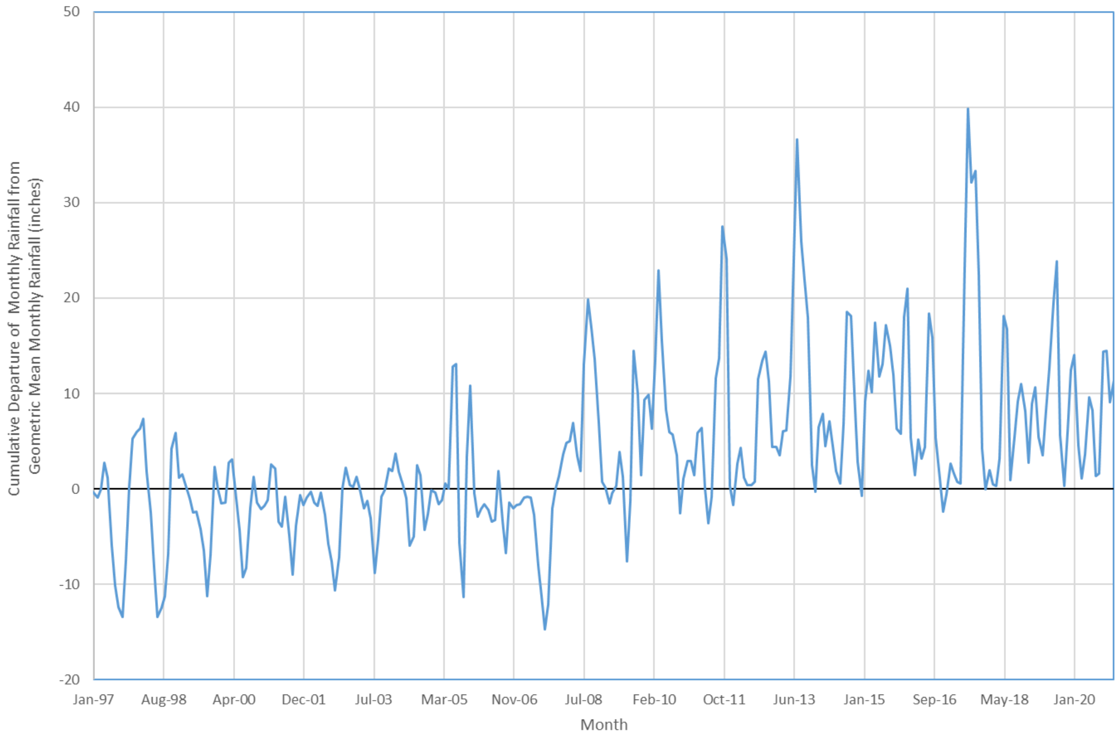


Figure 10. Cumulative Departure of long-term SFWMD meteorological monitoring station (COCO1_R) Monthly Rainfall from Geometric Mean Monthly Rainfall (1997-2020).



Results – Nutrient Status

Table 1 shows that exceedances of TP criteria have decreased in the most recent annual monitoring period. From March 2015 to April 2016, there were never more than 4 stations (out of the 9 sampled) that had TP concentrations higher than guidance criteria. From May 2016 to February 2017, there was only one month with more stations exceeding criteria than stations with TP concentrations below criteria. From March 2017 to June 2018, six of the fifteen months had results where the majority of stations exceeded criteria. From July 2018 to December of 2019, twelve of the eighteen months had every station exceeded the NNC criteria for TP. System-wide exceedances were reporting in January and April of 2020 followed by several exceedances limited to the southern portions of Clam Bay. Overall in 2020, there has been a substantial reduction in TP concentrations compared to previous year.

For most months, up until July 2018, stations 1, 2 and 3 were much more likely to have exceeded NNC criteria for TP than stations 4 to 9. Stations 1, 2 and 3 represent locations in Upper Clam Bay, the channel between Upper and Inner Clam Bay, and Inner Clam Bay, respectively. A trend test was performed for each station using the Mann's one-sided, upper-tail test for trend consistent with approach used by FDEP for planning list consideration (FAC 62-303.351) to evaluate for notable changes in concentrations over time that may indicate a change within the system. The annual geometric mean for TN, TP and chlorophyll-a were evaluated over the period of 2015 to 2020 (Table 4).

Table 4. Results of trend analysis for Total Nitrogen (TN), Total Phosphorus (TP) and Chlorophyll-a for the period of 2015 to 2020. Statistical significance is set at $p < 0.05$. However, "potential significance" is indicated for relationships where the p value was between 0.10 and 0.05.

Location	TN	TP	Chl-a	Location
CB 1	No	No	No	Upper Clam Bay
CB 2	No	No	Potential decrease (p<0.10)	Channel Between Inner & Upper Clam Bay
CB 3	No	No	Potential decrease (p<0.10)	Inner Clam Bay
CB 4	Potential increase (p<0.10)	No	No	Channel Between Inner and Outer Clam
CB 5	Potential increase (p<0.10)	Potential increase (p<0.10)	No	Outer Clam Bay
CB 6	Potential increase (p<0.10)	Potential increase (p<0.10)	No	Outer Clam Bay
CB 7	Increase (p<0.05)	Potential increase (p<0.10)	No	Outer Clam Bay
CB 8	Increase (p<0.05)	Potential increase (p<0.10)	No	Outer Clam Bay
CB 9	No	No	No	Canal to Outer Clam Bay

The results of the trend analysis show evidence of a fairly widespread increase in the abundance of both nitrogen and phosphorus at those stations outside of Upper and Inner Clam Bay. These results suggest that Upper and Inner Clam Bay may not be degrading, in terms of nutrient supply, but nutrients do seem to be increasing in most of the stations located throughout Outer Clam Bay (CB4 to CB8).

While nutrients are increasing in most of the stations in Outer Clam Bay, there does not yet appear to be evidence of a similar system-wide increase in algal populations, at least for those species of algae (i.e., phytoplankton) suspended in the water column. It is important to note that an increase in chlorophyll-a concentrations were not identified within Clam Bay. However, a potential reduction in the abundance of phytoplankton was observed in Inner Clam Bay and interconnecting channels (Clam Bay 2 and 3). Continued evaluation of the linkage between nutrients (TN and TP) on phytoplankton production and ultimately, water clarity is necessary to determine potential water quality impacts in Clam Bay due to nutrient loading.

As shown in Table 2, TN values only rarely exceeded NNC guidance criteria prior to May 2018. The first month where more stations failed TN criteria than passed was in May 2018. The majority of stations failed NNC criteria for TN only in the months of May and October of 2018. In contrast to TP, prior to 2020 stations in Upper and Inner Clam Bay do not appear to exceed criteria for TN any more often than stations in the better flushed waters of Outer Clam Bay. In the most recent monitoring year (2020), there were disproportionately more TP exceedances in Outer Clam Bay compared to the other areas of the system.

Based on these results, the following sequence of events is expanded upon from those provided in the 2019 reporting effort to assist in documenting the pattern of TN and TP impairments illustrated in Tables 1 and 2:

- In the spring of 2017, heavy rainfall may have resulted in some of the impairments noted for TP
- The passage of Hurricane Irma in September 2017 (no samples were taken that month) likely adversely impacted water quality through rainfall and runoff
  - Hurricane Irma also defoliated many of the mangroves along the shoreline, and resulted in clogging of tidal channels with debris from limbs and trees being blown over
- During the spring of 2018, the reestablishment of tidal channels in the mangrove forests adjacent to Upper, Inner and Outer Clam Bay may have resulted in discharges of water that were enriched with nutrients from mangrove leaves and Irma-induced damage
  - May 2018, which coincided with channel reestablishment, was the only month (out of 43) where the majority of stations exceeded TN criteria
- After the start of the wet season of 2018, runoff from nutrient-enriched mangrove forests (with newly established tidal channels and much mangrove debris) resulted in the sustained impairments for TN noted from July to October 2018
- However, elevated levels of TP have extended until April 2020, which suggests an impact not directly related to nutrient inflow from either Hurricane Irma or the initial efforts to reestablish tidal drainage patterns in the mangrove fringe
- A reduction in TP exceedances have been observed in the Clam Bay system starting in May 2020, with observed exceedances occurring predominantly in the Outer Clam Bay portion of the system.

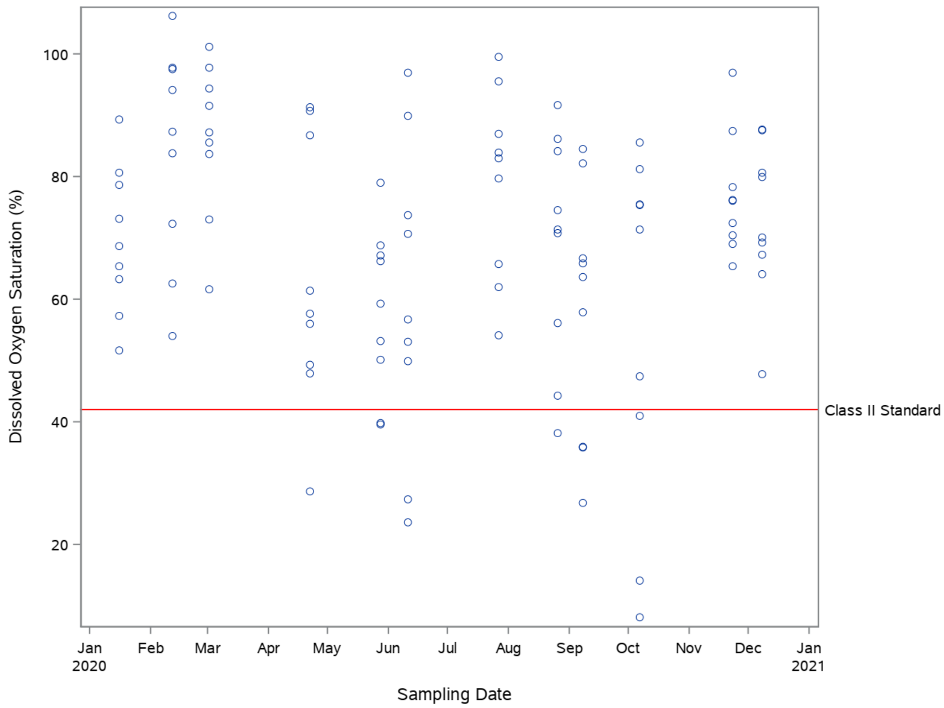
Although the time series of impairments for TP suggests an initial impact from Hurricane Irma, those initial impacts were either sustained for more than 2 years after the landfall of the hurricane (up to April 2020) or the Clam Bay system has fundamentally changed over time, in terms of nutrient supply. Possible scenarios for sustained effects from Hurricane Irma include a combination of: 1.) ongoing nutrient inflow from hurricane derived mangrove forest detritus; 2.) continuing sediment erosion or reworking from tidal channel reestablishment; and/or resuspension or recycling of nutrients initially introduced by Hurricane Irma that have not yet left the Clam Bay system.

Results – Dissolved Oxygen

For levels of DO the applicable regulatory criterion, as outlined in FAC 62-302.533, is that minimum DO levels (for Class II waters like Clam Bay) shall not be lower than 42 percent saturation more than 10 percent of the time (for average daily values) or that 7-day average values shall not be below 51 percent saturation more than once in any 12-week period, or that the 30-day average DO percent saturation shall not be below 56 percent more than once per year.

The less-restrictive 7-day and 30-day criteria require DO measurements to be made over a 24-hour period, which is not applicable for comparison with water quality data collected at a single time of day, once a month. As such, the more restrictive criterion was used for Clam Bay, and DO values (in units of percent saturation) were compared against the 42 percent saturation value. Results are shown in Figure 11.

Figure 11. Dissolved oxygen values (percent of 100 percent saturation) for nine stations in Clam Bay, over the period of January 2020 to December 2020.



DO values were collected at nine stations over twelve months (n = 108). As such, it would take eleven values below 42 percent saturation for Clam Bay to be considered to be out of compliance with the DO criteria listed in FAC 62-302.533. Twelve values show DO at lower than 42 percent saturation, the majority of which occurred at Clam Bay stations 1 and 2 (five sampling events each). All but two of the depressed values were from either Upper Clam Bay (Clam Bay 1) or the narrow channel between Upper Clam Bay and Inner Clam Bay (Clam Bay 2). The remaining depressed values were identified in Inner Clam Bay (Clam Bay 3) and northern portion of the channel between Inner Clam Bay and Outer Clam Bay (Clam Bay 4), as shown in Table 5. Based on these results, the waters of Clam Bay would be considered to be out of compliance with existing DO criteria. This conclusion is consistent with the results of the previous annual report which identified sufficient depressed concentrations to be considered out of compliance over the 12-month period. An impairment designation as presented by FDEP would encompass the review of data over a 7.5-year period, as such, a more comprehensive review of the data would be necessary to incorporate the annual fluctuations in dissolved oxygen concentrations.

Table 5. Dissolved Oxygen Saturation values at sites Clam Bay 1 to 9, in units of %. Values highlighted in yellow are below the criteria for Class II waters (42%). Grey cells indicate no data collected.

Station	1	2	3	4	5	6	7	8	9
1/16/2020	68.7	51.6	63.3	65.4	78.6	89.3	80.6	73.1	57.3
2/12/2020	97.7	62.5	54.0	72.3	87.3	94.1	97.5	106.2	83.8
3/2/2020	73.0	61.6	83.7	85.6	87.2	97.7	101.1	91.5	94.3
4/22/2020	47.9	28.7	49.3	56.0	57.6	86.7	90.7	91.3	61.4
5/28/2020	39.8	39.6	53.2	50.1	67.1	79.0	66.2	68.8	59.3
6/11/2020	27.4	23.6	49.9	53.1	73.7	89.9	96.9	70.7	56.7
7/27/2020	62.0	54.1	65.7	79.7	83.9	86.9	83.0	95.5	99.5
8/26/2020	38.2	44.2	56.1	74.5	86.1	91.6	84.1	70.8	71.4
9/8/2020	35.9	26.8	35.8	57.9	65.8	82.2	84.5	66.7	63.6
10/7/2020	14.1	8.1	47.4	41.0	75.5	81.2	75.3	71.3	85.5
11/23/2020	69.0	65.4	72.4	70.4	78.3	96.9	87.4	76.2	76.0

Results - Copper

For levels of copper, there are different criteria used for marine waters versus freshwater systems such as stormwater ponds. For marine waters, the standard, as listed in FAC 62-302.530, is that concentrations are not to exceed 3.7 µg / liter. However, the State of Florida's Impaired Waters Rule (FAC 62-303) allows for a certain amount of "exceedances" to occur, before water quality is considered to be out of compliance. Table 6 summarizes the data collected from all stations, from January of 2020 to December of 2020, for Stations Clam Bay 1 to Clam Bay 9, all of which are located in the open waters of Upper, Inner or Outer Clam Bay.

Of the 108 samples collected for copper, only eight of them exceeded the established criteria of 3.7 µg / liter. Based on guidance in Table 3 of FAC 62-303, Clam Bay is not out of compliance for copper for the sampling period evaluated. The determination of copper exceedances in freshwater sampling sites in the watershed requires the simultaneous collection of data on "hardness". Over this analysis period, all samples from freshwater locations included results on hardness, and those data are analyzed below.

The copper standard for freshwater is more complicated than the marine standard as it requires the concurrent recording of a value for "hardness" in units of mg $CaCO_3$ / liter. The toxicity of copper is mostly restricted to the abundance of the copper ion, and the greater the abundance of other dissolved compounds, the lower the probability that free copper ions will be available to bind with cell membranes, etc. and cause direct and indirect biological impacts. Briefly stated, the higher the hardness level of a water sample, the lower the probability that a given level of copper will be toxic.

Table 6. Copper values at sites Clam Bay 1 to 9, in units of µg / liter. Values highlighted in yellow exceed copper criteria for Class II waters (3.7 µg Cu / liter).

Station	1	2	3	4	5	6	7	8	9
1/16/2020	5.1	2.7	2.0	1.7	1.6	1.6	1.6	1.6	1.6
2/12/2020	2.4	3.6	4.3	2.2	1.6	1.6	2.7	1.6	1.6
3/2/2020	3.2	4.3	2.1	1.6	1.6	1.6	2.9	1.6	0.2
4/22/2020	3.0	2.1	1.7	2.0	1.2	1.2	1.5	1.2	1.2
5/28/2020	2.5	1.9	1.4	1.6	1.2	1.2	1.2	1.2	1.2
6/11/2020	2.6	2.6	2.1	2.4	1.1	1.1	1.1	1.1	1.1
7/27/2020	3.2	2.3	1.4	1.2	1.2	1.2	1.2	1.2	1.2
8/26/2020	1.4	1.8	1.2	1.2	1.2	1.2	1.3	1.2	1.2
9/8/2020	2.0	2.1	1.9	1.6	1.2	2.0	1.3	1.2	1.5
10/7/2020	2.1	1.7	1.2	1.3	1.1	1.1	1.1	1.1	1.1
11/23/2020	1.5	1.5	1.5	1.2	1.2	1.1	1.1	1.1	1.2
12/8/2020	3.7	5.8	6.3	4.9	3.1	4.0	4.4	2.9	3.6
mean	2.7	2.7	2.3	1.9	1.4	1.6	1.8	1.4	1.4
median	2.6	2.2	1.8	1.6	1.2	1.2	1.3	1.2	1.2
N	12	12	12	12	12	12	12	12	12
#> 3.7	1	1	2	1	0	1	1	0	0
% > 3.7	8	8	17	8	0	8	8	0	0

Once the level of hardness is determined, the copper criterion for a sample collected from freshwater is derived as:

$$\text{Copper standard (mg / liter)} = e^{(0.8545[\ln H]-1.702)}$$

Where:

e = the base of the natural logarithm (ca. 2.718281), and

lnH = natural log of hardness (in units of mg CaCO3 / liter)

Thus, the determination of whether a sample meets or exceeds the water quality standards for copper only requires determination of the concentration of copper for marine samples; a concurrent value for hardness is required to determine compliance with freshwater criteria. In the data set examined it appears that there were 68 date and location combinations where freshwater stations were sampled (Table 7).

Table 7. Copper values at Stormwater Pond Sites, in units of µg / liter. Values highlighted in yellow exceed copper criteria for Class IIIF waters. Grey cells indicate no data available.

Date	Glenview	PB-11	St Lucia	PB-13	N-Berm	N-Boardwalk
1/16/2020	22.5	22.3			38.7	5.8
2/12/2020	23.6	19.4	19.9	23.4	23.8	13.3
3/9/2020	18.3				35.4	21.3
4/x/2020	No Samples Collected due to Coronavirus Concerns					
5/26/2020	16.3	36.6	40.9	20.6	16.7	9.7
6/11/2020	13.4	23.3	12.2	19.8	15.5	
7/27/2020	16.1	15.5	11.2	10.4	13.5	5.7
8/24/2020	26.2	54.8	84.5	13.1	8.6	5.7
9/15/2020	25.6	18.0	8.6	15.0	9.9	11.6
10/13/2020	24.5	11.6	27.7	11.2	21.9	13.5
11/3/2020	6.0	17.6	11.9	8.0	19.5	12.4
12/1/2020	13.7	12.7	16.4		25.1	29.4

Copper concentrations at all sites exceeded the hardness-normalized copper criteria for Class III freshwater systems during at least one monitoring period. The levels of copper were often many times higher than impairment thresholds. The N-Boardwalk locations had lower exceedance rates than the other sampled locations. The pond monitoring stations are located within the series of open water features on the west side of the Pelican Bay development, just east of the mangrove fringe that separates Clam Bay from its developed watershed.

Recommendations

For the waters of Upper, Inner and Outer Clam Bay, water quality monitoring should continue at the same nine stations locations sampled in the reviewed data set. For determining compliance with nutrient criteria, chlorophyll-a data should be collected (and be corrected for phaeophytin) along with both Total Nitrogen and Total Phosphorous data. To ensure results can be compared to NNC criteria established specifically for Clam Bay, specific conductance data also need to continue to be collected in association with the chlorophyll-a, Total Nitrogen, and Total Phosphorous samples.

The finding of increased concentrations of nitrogen and phosphorus in Outer Clam Bay should be considered to be indicative of a problem that cannot be dismissed as being solely related to hurricanes, changes in rainfall, and/or local efforts to increase tidal exchange in the mangrove forests that bound the Clam Bay system. In addition to the potential effect of the recreation of tidal channels in the adjacent mangrove fringe, the use of reclaimed water for irrigation should be investigated. Reclaimed water might not by itself add more nutrients to landscapes than the landscapes can effectively assimilate. However, if homeowners or property managers are adding fertilizers on top of the nutrients supplied by reclaimed water, the combination of reclaimed water irrigation with fertilizer application could be a potential mechanism though which excessive nitrogen and phosphorus loads are brought into the Clam Bay system.

As of now, the increased nutrient supply does not seem to have brought about a subsequent decline in ecosystem health, as concentrations of chlorophyll-a (an indicator of algal abundance in the water column) are not similarly increasing in most stations. While levels of dissolved oxygen do not meet state criteria for the Clam Bay system as a whole, most of the locations where values are out of compliance are in Upper and Inner Clam Bay, areas where reduced tidal flushing and an extensive mangrove fringe likely would produce non-compliant values even in the absence of human activities.

For copper, values recorded in 2020 show that while the stormwater treatment system often fails copper standards for freshwater water bodies, there were substantial fewer exceedances (N=8) observed in the open waters of Upper, Inner and Outer Clam Bay. While there was an observed increased compared to 2019, when only one exceedance was reported, these results suggest that reductions in the use of copper-containing herbicides have had a positive impact on the abundance of copper in the bay itself.

APPENDIX C. COLOR CODE EXCEEDANCE TABLES FOR CLAM BAY OUTFALLS.

Table A1. Representation of frequency of impairment for *median TP DPV* (0.10 mg/L) for different outfall site and date combinations. Green represents samples in below with median DPV value. Red cells indicate exceedance of median DPV value. Gray cells represent a lack of data.

Month/Year	Outfall Stations						
	Glenview	N-41 Pipe	N-Berm	N-Boardwalk	P-11	PB-13	St. Lucia
March-15							
April-15							
May-15							
June-15							
July-15							
August-15							
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December-15							
January-16							
February-16							
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March-17							
April-17							
May-17							
June-17							
July-17							
August-17							
September-17							
October-17							

Month/Year	Outfall Stations						
	Glenview	N-41 Pipe	N-Berm	N-Boardwalk	P-11	PB-13	St. Lucia
November-17							
December-17							
January-18							
February-18							
March-18							
April-18							
May-18							
June-18							
July-18							
August-18							
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May-20							
June-20							
July-20							
August-20							
September-20							
October-20							
November-20							
December-20							

Note: In an event that multiple outfall samples were taken within a given month at a specify location, cell color indicates worse findings.

Table A2. Representation of frequency of impairment for *<u>90th TP DPV</u>* (0.25 mg/L) for different outfall site and date combinations. Green represents samples in below with 90th DPV value. Red cells indicate exceedance of 90th DPV value. Gray cells represent a lack of data.

Month/Year	Outfall Stations						
	Glenview	N-41 Pipe	N-Berm	N-Boardwalk	P-11	PB-13	St. Lucia
March-15							
April-15							
May-15							
June-15							
July-15							
August-15							
September-15							
October-15							
November-15							
December-15							
January-16							
February-16							
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July-17							
August-17							
September-17							
October-17							
November-17							
December-17							
January-18							
February-18							

Month/Year	Outfall Stations						
	Glenview	N-41 Pipe	N-Berm	N-Boardwalk	P-11	PB-13	St. Lucia
March-18							
April-18							
May-18							
June-18							
July-18							
August-18							
September-18							
October-18							
November-18							
December-18							
January-19							
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March-20							
April-20							
May-20							
June-20							
July-20							
August-20							
September-20							
October-20							
November-20							
December-20							

Note: In an event that multiple outfall samples were taken within a given month at a specify location, cell color indicates worse findings.

Table A3. Representation of frequency of impairment for *median TN DPV* (1.31 mg/L) for different outfall site and date combinations. Green represents samples in below with median DPV value. Red cells indicate exceedance of median DPV value. Gray cells represent a lack of data.

Month/Year	Outfall Stations						
	Glenview	N-41 Pipe	N-Berm	N-Boardwalk	P-11	PB-13	St. Lucia
March-15	Green	Gray	Red	Red	Red	Green	Gray
April-15	Red	Gray	Red	Red	Red	Gray	Gray
May-15	Gray	Gray	Gray	Gray	Gray	Gray	Gray
June-15	Green	Gray	Red	Green	Green	Gray	Gray
July-15	Green	Gray	Red	Red	Red	Red	Red
August-15	Green	Gray	Red	Red	Red	Red	Green
September-15	Red	Gray	Red	Green	Red	Red	Red
October-15	Red	Gray	Red	Red	Red	Gray	Gray
November-15	Green	Gray	Red	Red	Red	Gray	Gray
December-15	Green	Gray	Red	Green	Green	Red	Green
January-16	Green	Gray	Red	Green	Red	Red	Green
February-16	Red	Gray	Red	Green	Red	Red	Red
March-16	Green	Gray	Red	Green	Green	Gray	Green
April-16	Green	Gray	Green	Red	Red	Red	Red
May-16	Green	Gray	Red	Green	Red	Red	Gray
June-16	Green	Gray	Green	Green	Red	Red	Red
July-16	Green	Red	Red	Green	Red	Red	Red
August-16	Green	Gray	Red	Red	Green	Red	Red
September-16	Green	Gray	Red	Red	Green	Red	Red
October-16	Green	Green	Red	Green	Green	Red	Green
November-16	Green	Gray	Green	Red	Green	Gray	Red
December-16	Red	Gray	Red	Green	Red	Gray	Gray
January-17	Green	Gray	Red	Green	Red	Gray	Gray
February-17	Green	Gray	Green	Green	Green	Gray	Gray
March-17	Green	Gray	Red	Red	Gray	Gray	Gray
April-17	Gray	Gray	Red	Red	Gray	Gray	Gray
May-17	Green	Gray	Red	Green	Red	Gray	Green
June-17	Green	Green	Red	Red	Red	Red	Red
July-17	Green	Green	Red	Green	Green	Red	Green
August-17	Red	Gray	Red	Red	Red	Red	Green
September-17	Gray	Gray	Gray	Gray	Gray	Gray	Gray
October-17	Green	Gray	Red	Green	Red	Red	Green
November-17	Green	Gray	Red	Green	Green	Red	Red
December-17	Green	Gray	Red	Red	Green	Red	Green
January-18	Green	Gray	Red	Red	Green	Gray	Green

Month/Year	Outfall Stations						
	Glenview	N-41 Pipe	N-Berm	N-Boardwalk	P-11	PB-13	St. Lucia
February-18							
March-18							
April-18							
May-18							
June-18							
July-18							
August-18							
September-18							
October-18							
November-18							
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May-20							
June-20							
July-20							
August-20							
September-20							
October-20							
November-20							
December-20							

Note: In an event that multiple outfall samples were taken within a given month at a specify location, cell color indicates worse findings.

Table A4. Representation of frequency of impairment for *90th TN DPV* (1.8 mg/L) for different outfall site and date combinations. Green represents samples in below with 90th DPV value. Red cells indicate exceedance of 90th DPV value. Gray cells represent a lack of data.

Month/Year	Outfall Stations						
	Glenview	N-41 Pipe	N-Berm	N-Boardwalk	P-11	PB-13	St. Lucia
March-15							
April-15							
May-15							
June-15							
July-15							
August-15							
September-15							
October-15							
November-15							
December-15							
January-16							
February-16							
March-16							
April-16							
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July-16							
August-16							
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July-17							
August-17							
September-17							
October-17							
November-17							
December-17							
January-18							
February-18							

Month/Year	Outfall Stations						
	Glenview	N-41 Pipe	N-Berm	N-Boardwalk	P-11	PB-13	St. Lucia
March-18							
April-18							
May-18							
June-18							
July-18							
August-18							
September-18							
October-18							
November-18							
December-18							
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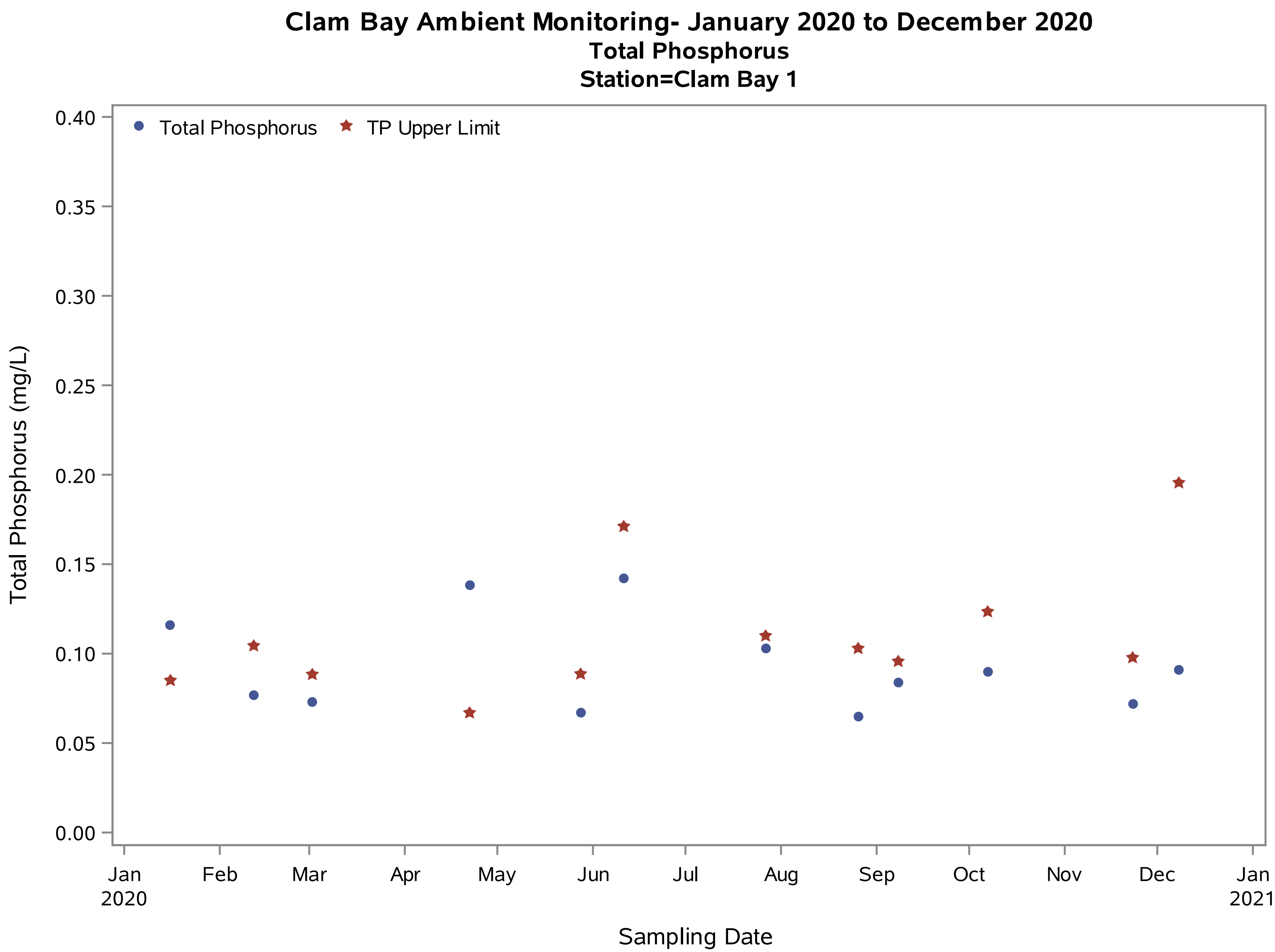
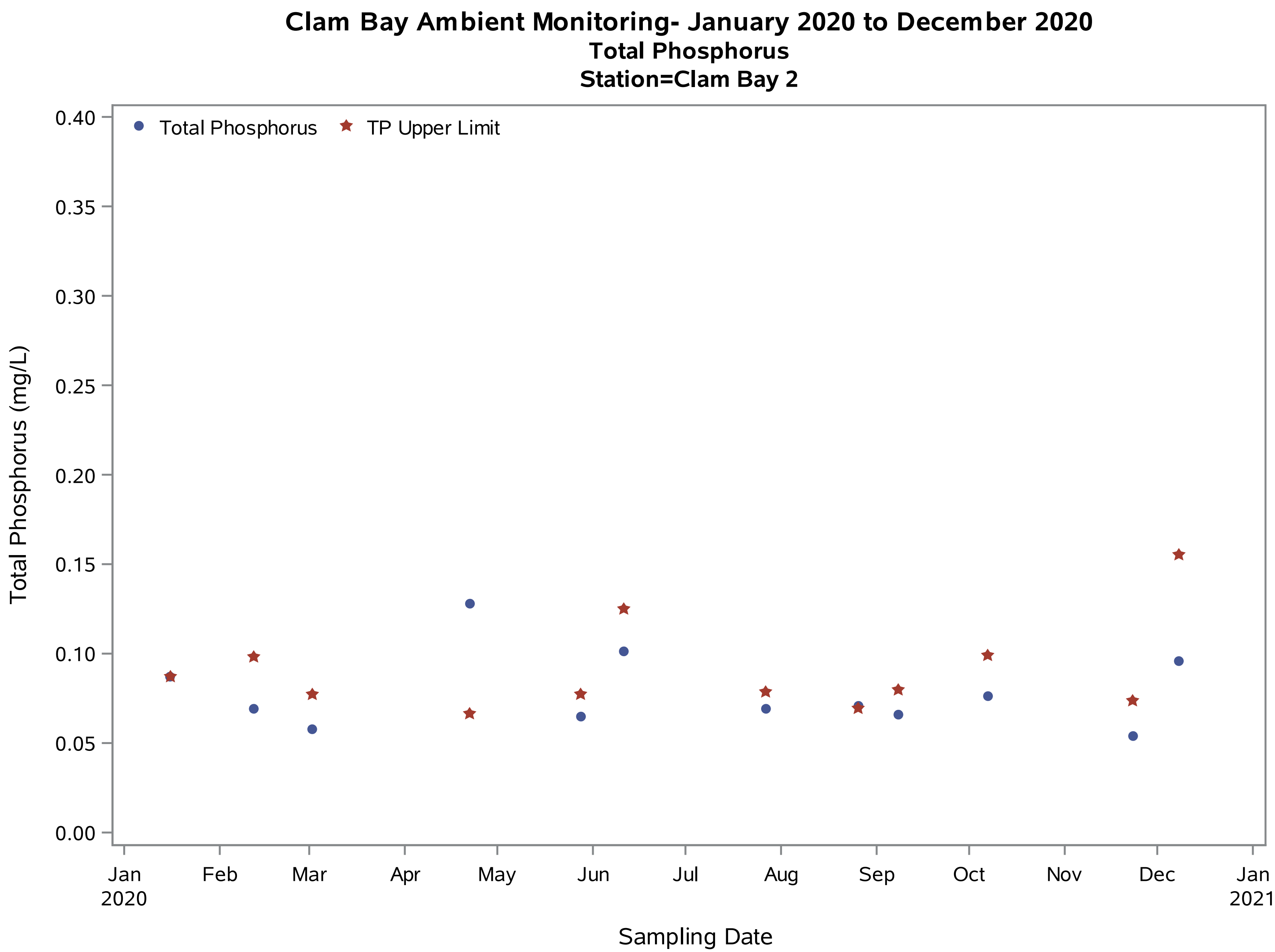
April-20							
May-20							
June-20							
July-20							
August-20							
September-20							
October-20							
November-20							
December-20							

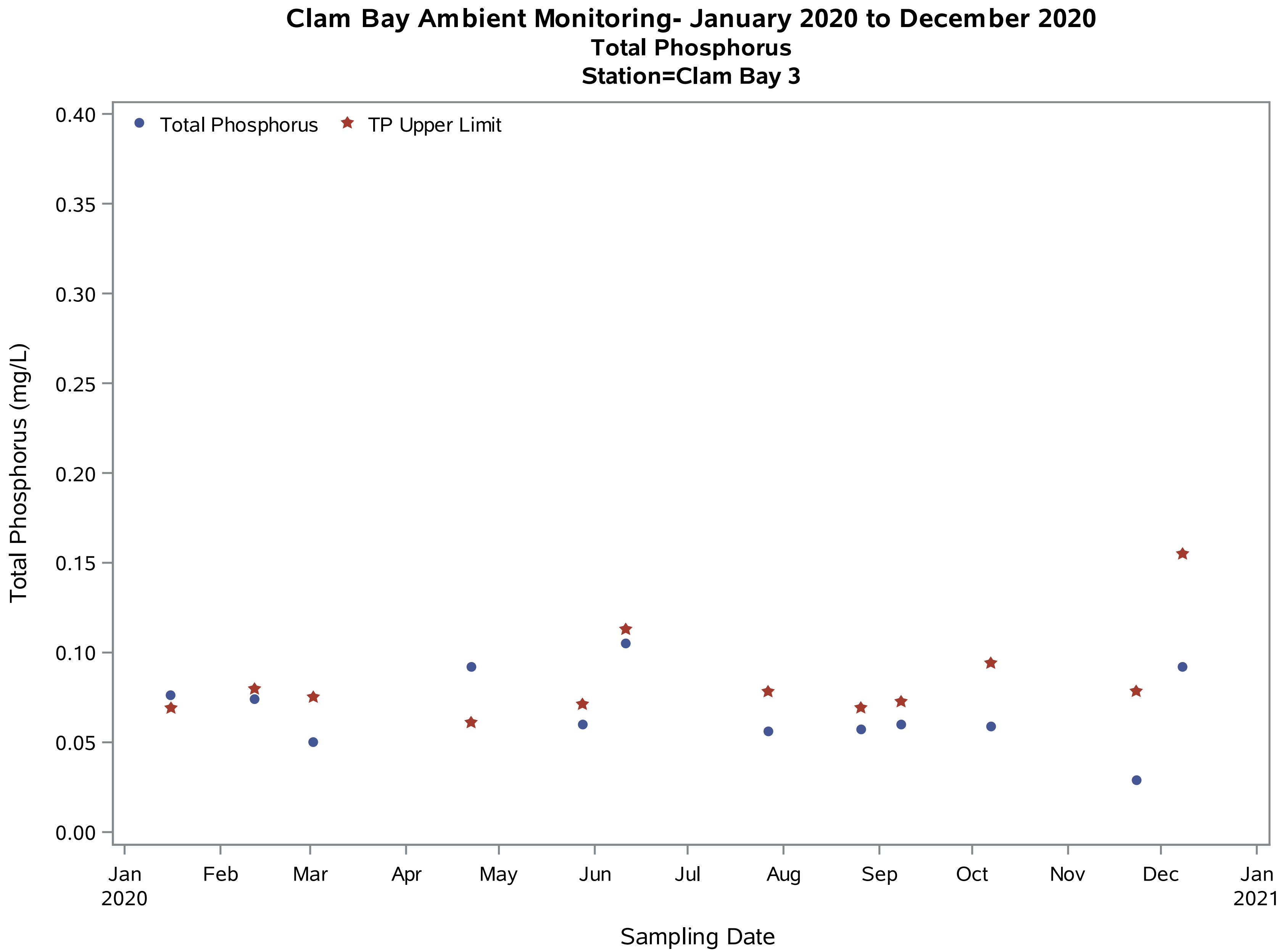
Note: In an event that multiple outfall samples were taken within a given month at a specify location, cell color indicates worse findings.

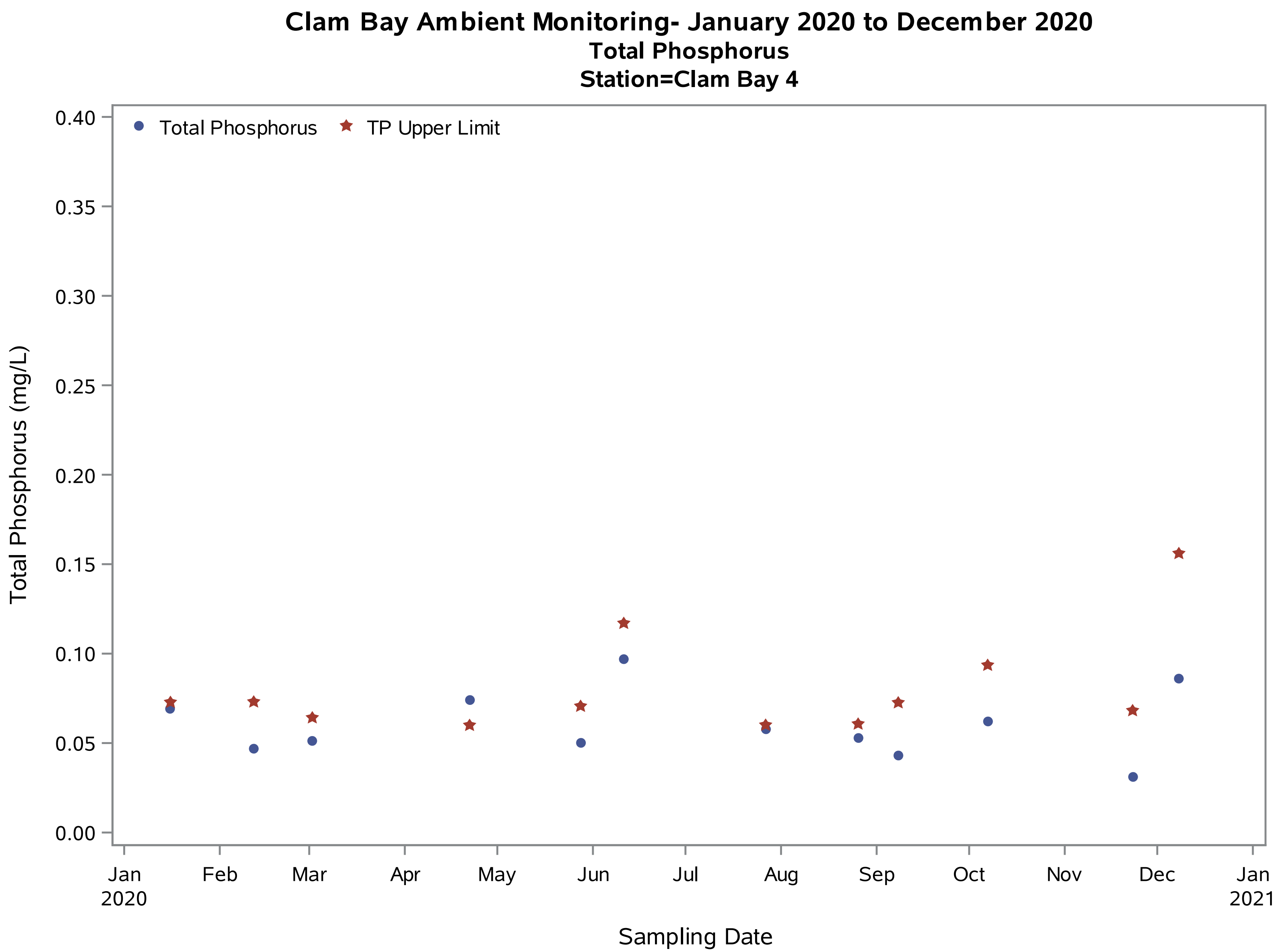


Clam Bay Ambient Monitoring- January 2020 to December 2020
Total Phosphorus
Station=Clam Bay 1
Total Phosphorus
TP Upper Limit
Total Phosphorus (mg/L)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
Jan 2020
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan 2021
Sampling Date

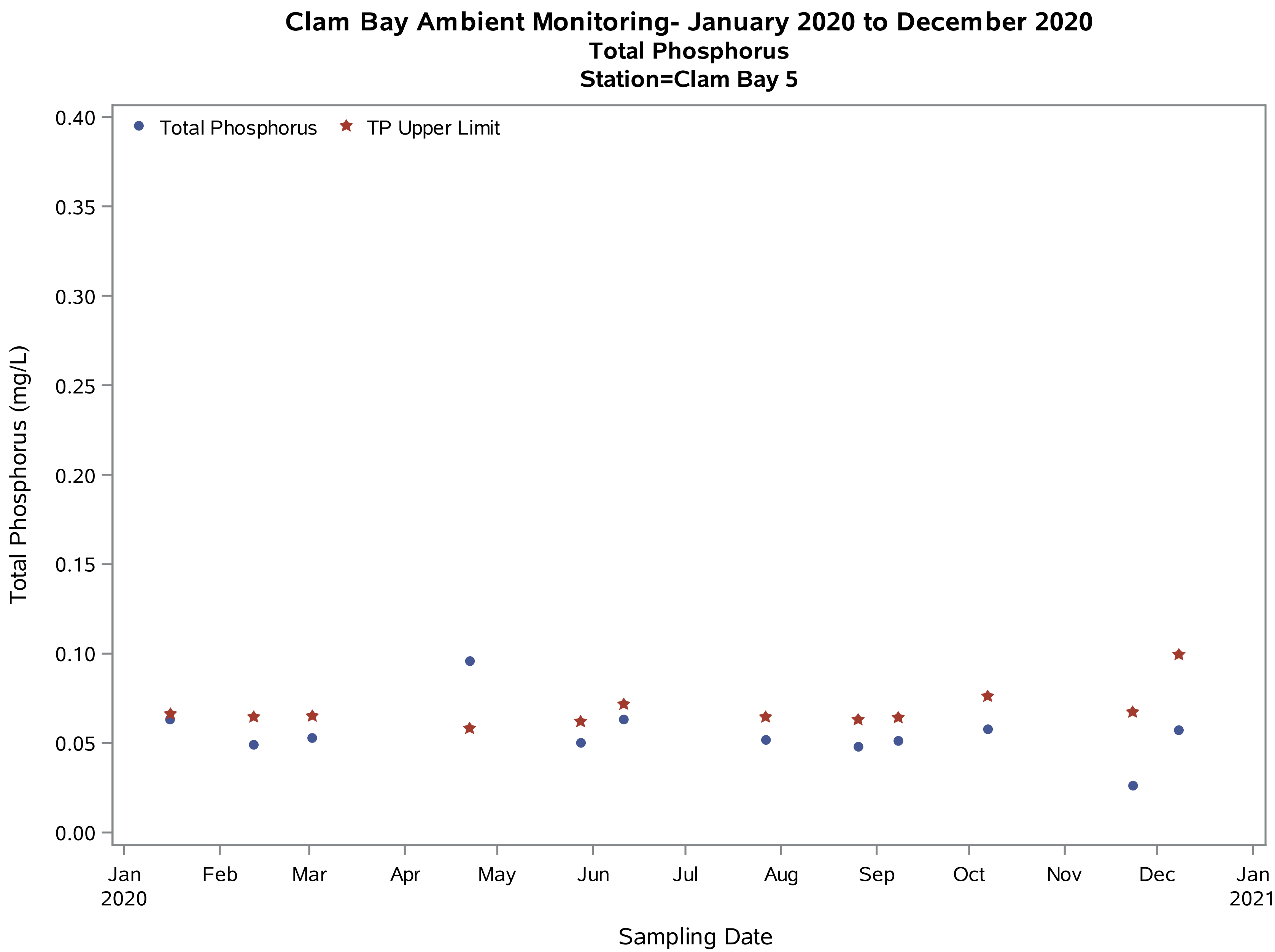


Clam Bay Ambient Monitoring- January 2020 to December 2020
Total Phosphorus
Station=Clam Bay 2
Total Phosphorus
TP Upper Limit
Total Phosphorus (mg/L)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan 2020
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan 2021
Sampling Date

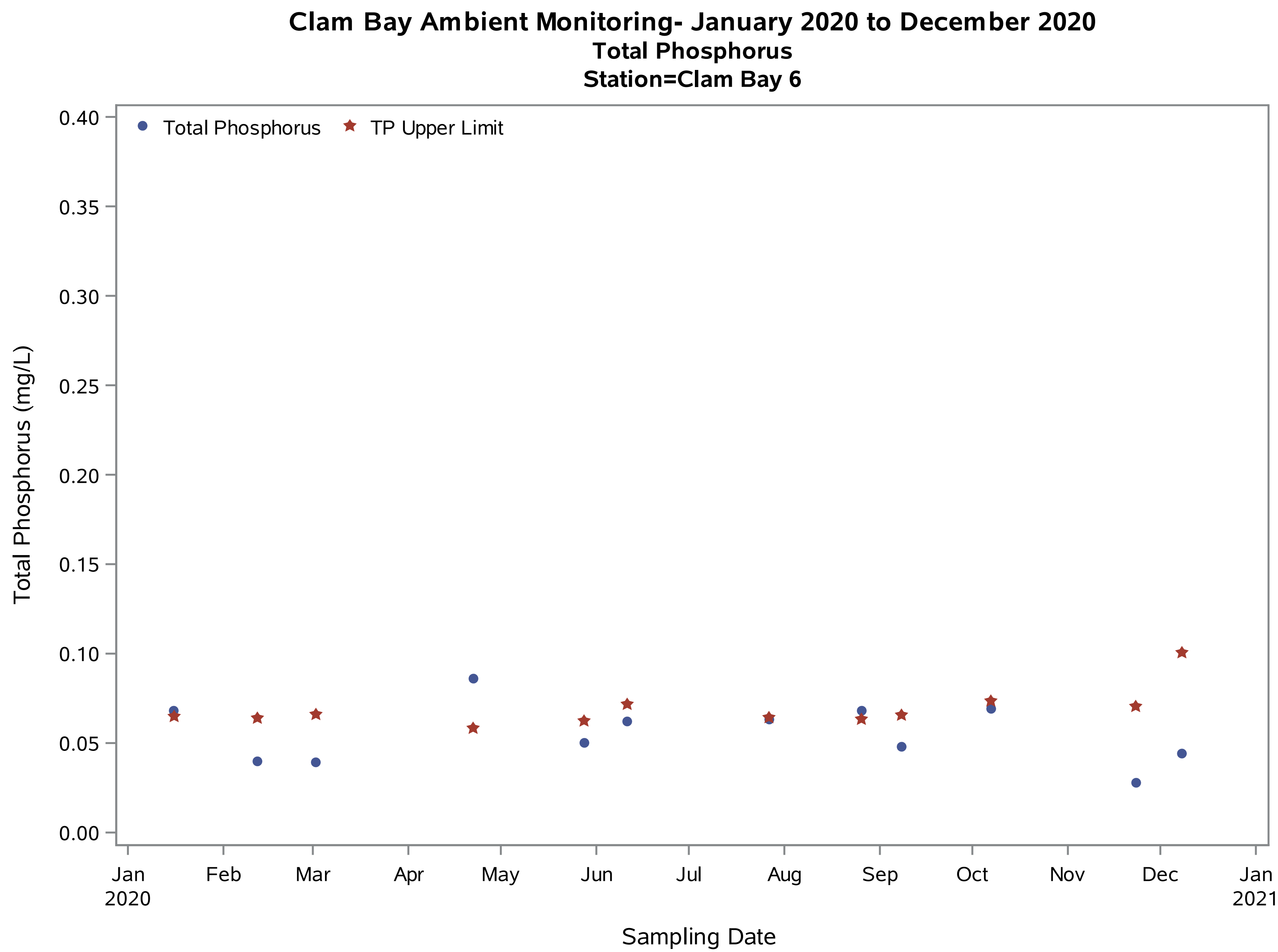

Clam Bay Ambient Monitoring- January 2020 to December 2020
Total Phosphorus
Station=Clam Bay 3
Total Phosphorus
TP Upper Limit
Total Phosphorus (mg/L)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan 2020
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan 2021
Sampling Date



Clam Bay Ambient Monitoring- January 2020 to December 2020
Total Phosphorus
Station=Clam Bay 4
Total Phosphorus
TP Upper Limit
Total Phosphorus (mg/L)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan 2020
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan 2021
Sampling Date

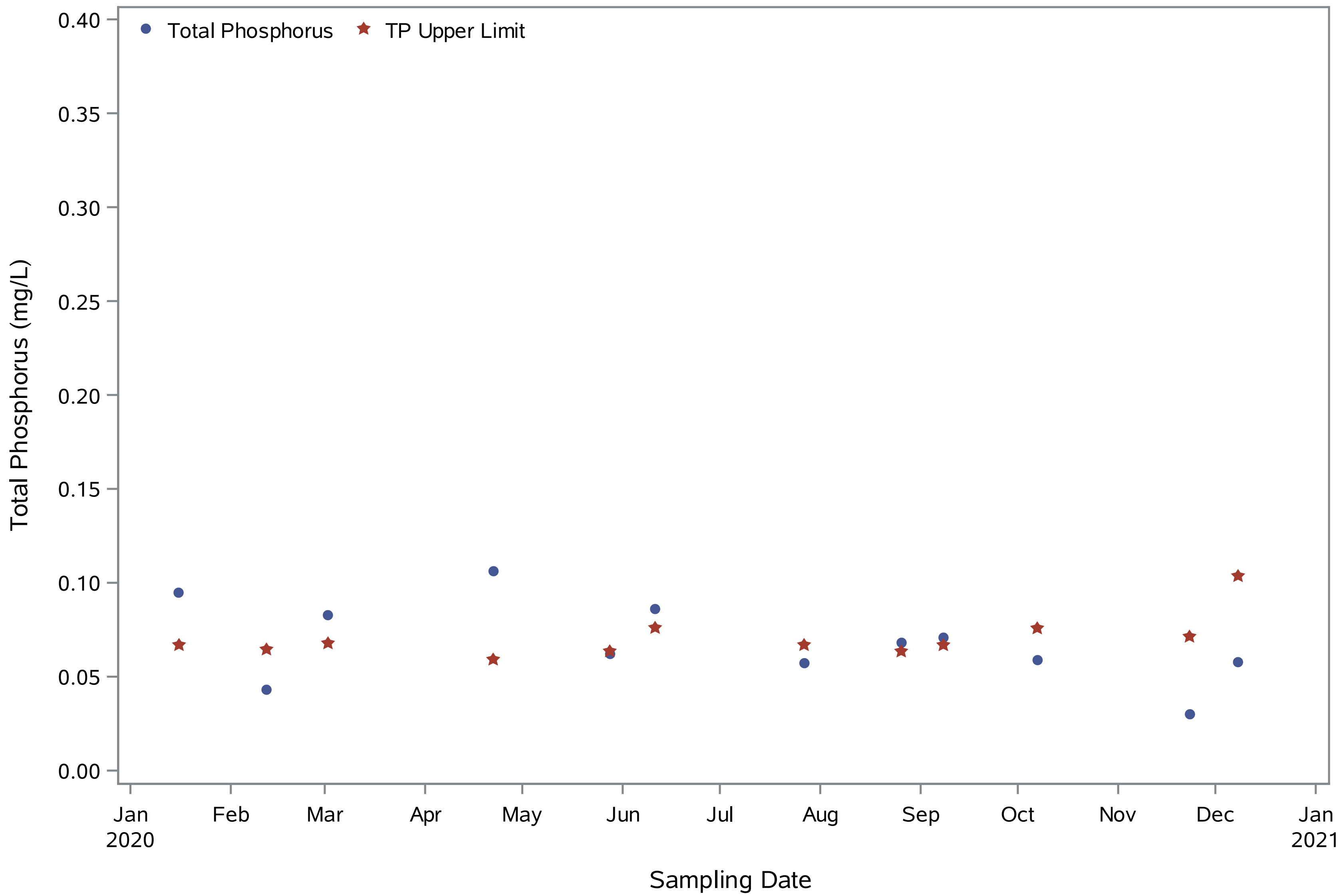


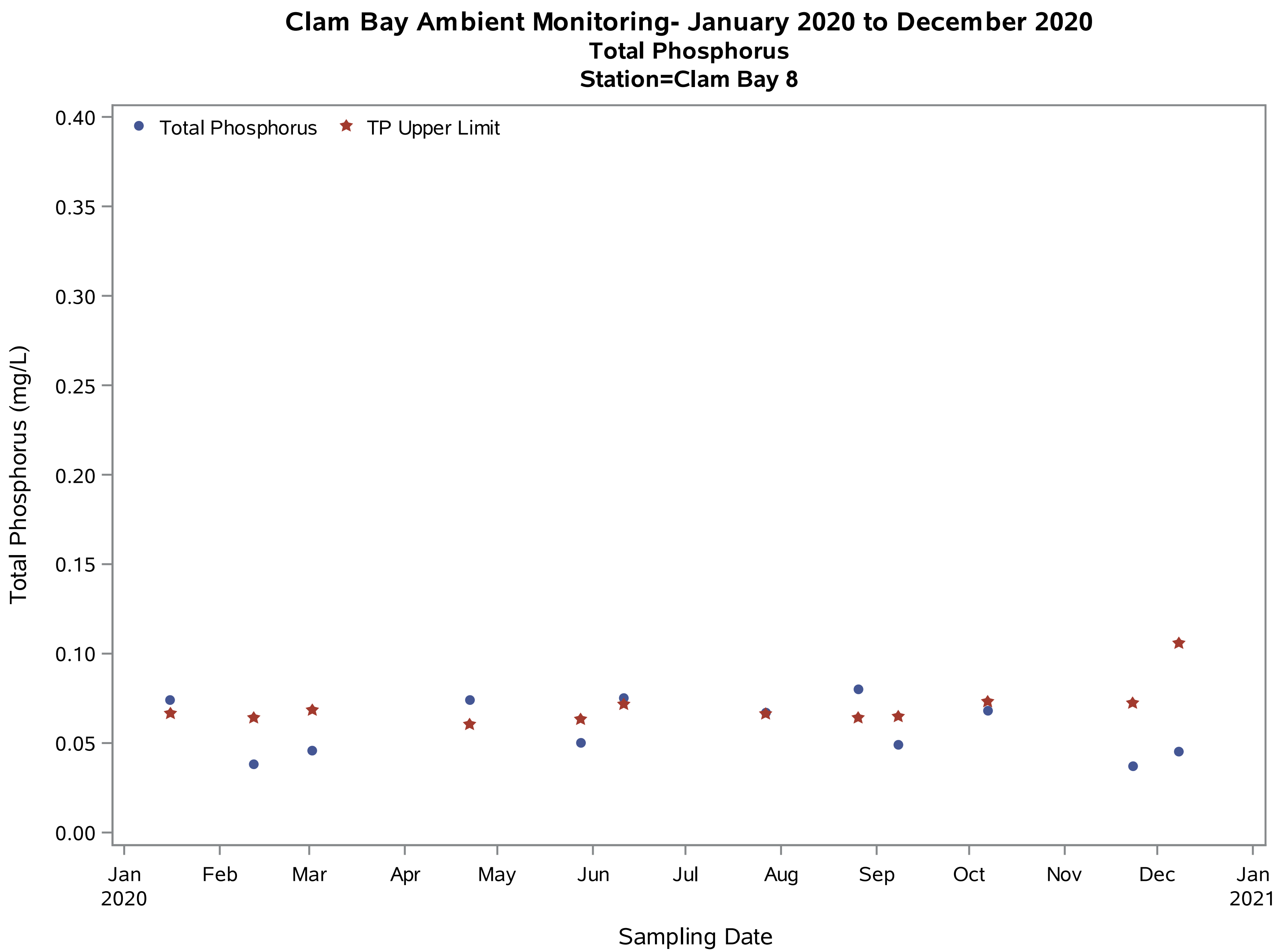
Clam Bay Ambient Monitoring- January 2020 to December 2020
Total Phosphorus
Station=Clam Bay 5
Total Phosphorus
TP Upper Limit
Total Phosphorus (mg/L)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan 2020
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan 2021
Sampling Date

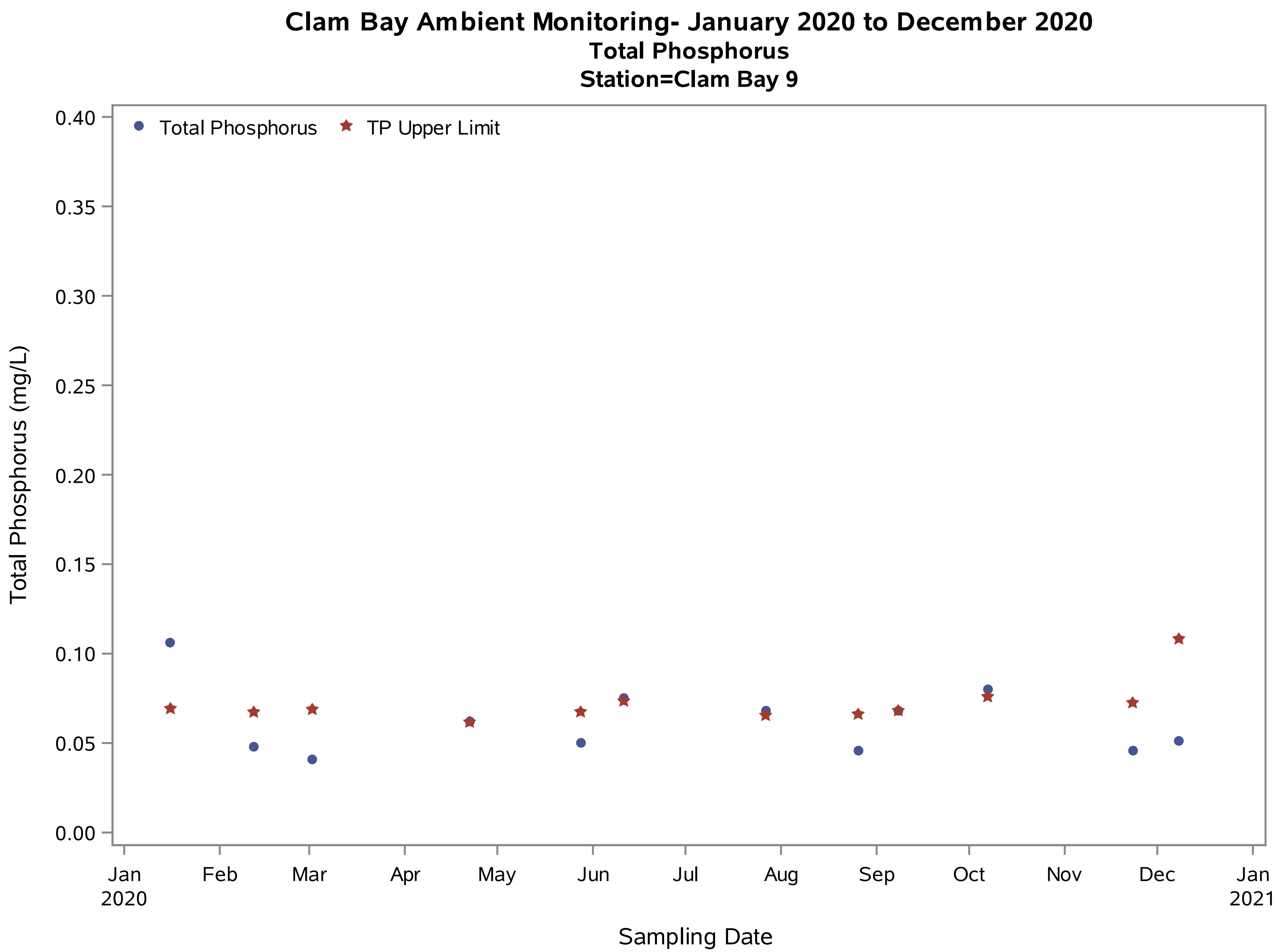


Clam Bay Ambient Monitoring- January 2020 to December 2020
Total Phosphorus
Station=Clam Bay 6
Total Phosphorus
TP Upper Limit
Total Phosphorus (mg/L)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan 2020
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan 2021
Sampling Date

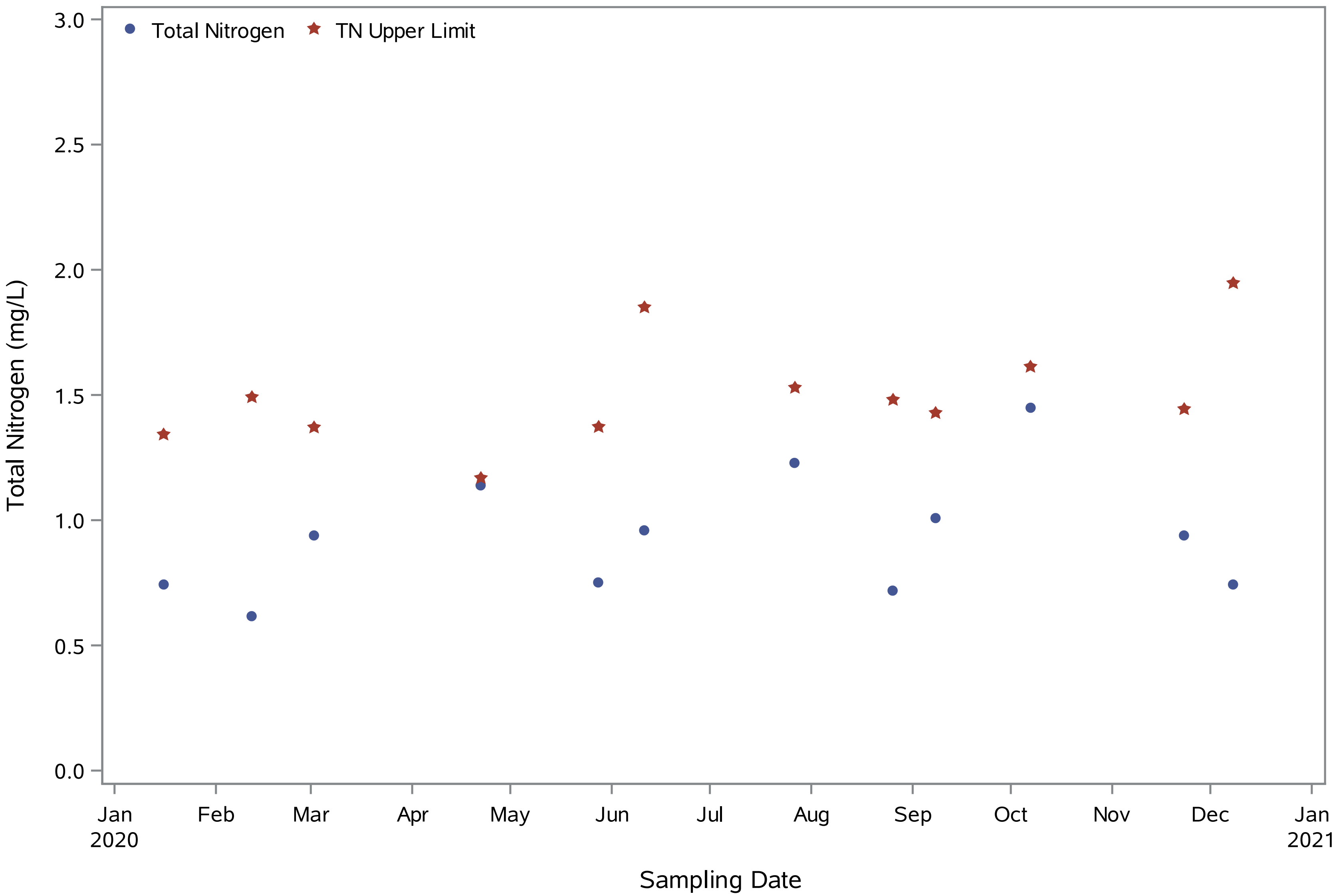
Clam Bay Ambient Monitoring- January 2020 to December 2020
Total Phosphorus
Station=Clam Bay 7

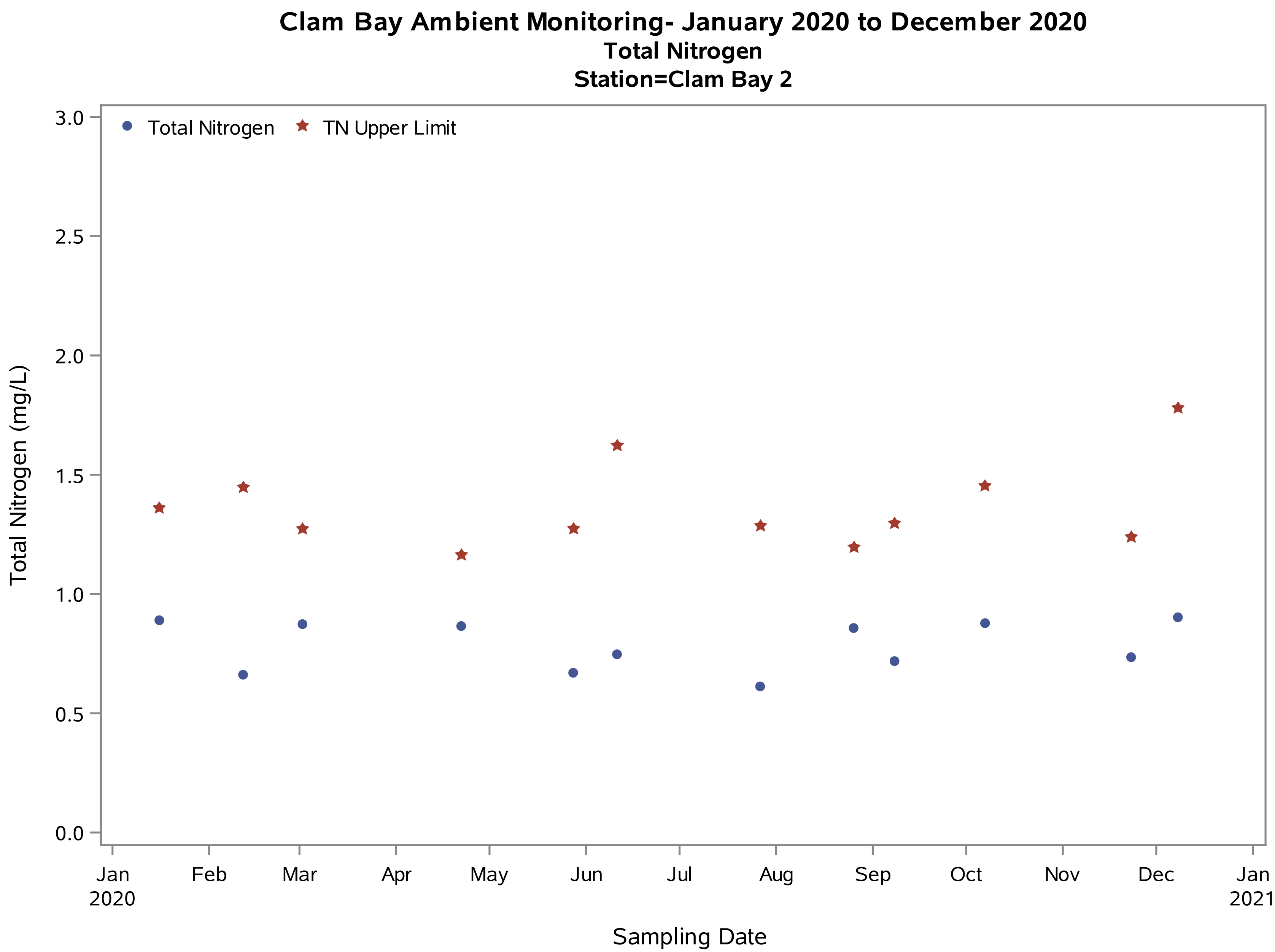



Clam Bay Ambient Monitoring- January 2020 to December 2020
Total Phosphorus
Station=Clam Bay 8
Total Phosphorus
TP Upper Limit
Total Phosphorus (mg/L)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan 2020
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan 2021
Sampling Date


Clam Bay Ambient Monitoring- January 2020 to December 2020
Total Phosphorus
Station=Clam Bay 9
Total Phosphorus
TP Upper Limit
Total Phosphorus (mg/L)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan 2020
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan 2021
Sampling Date

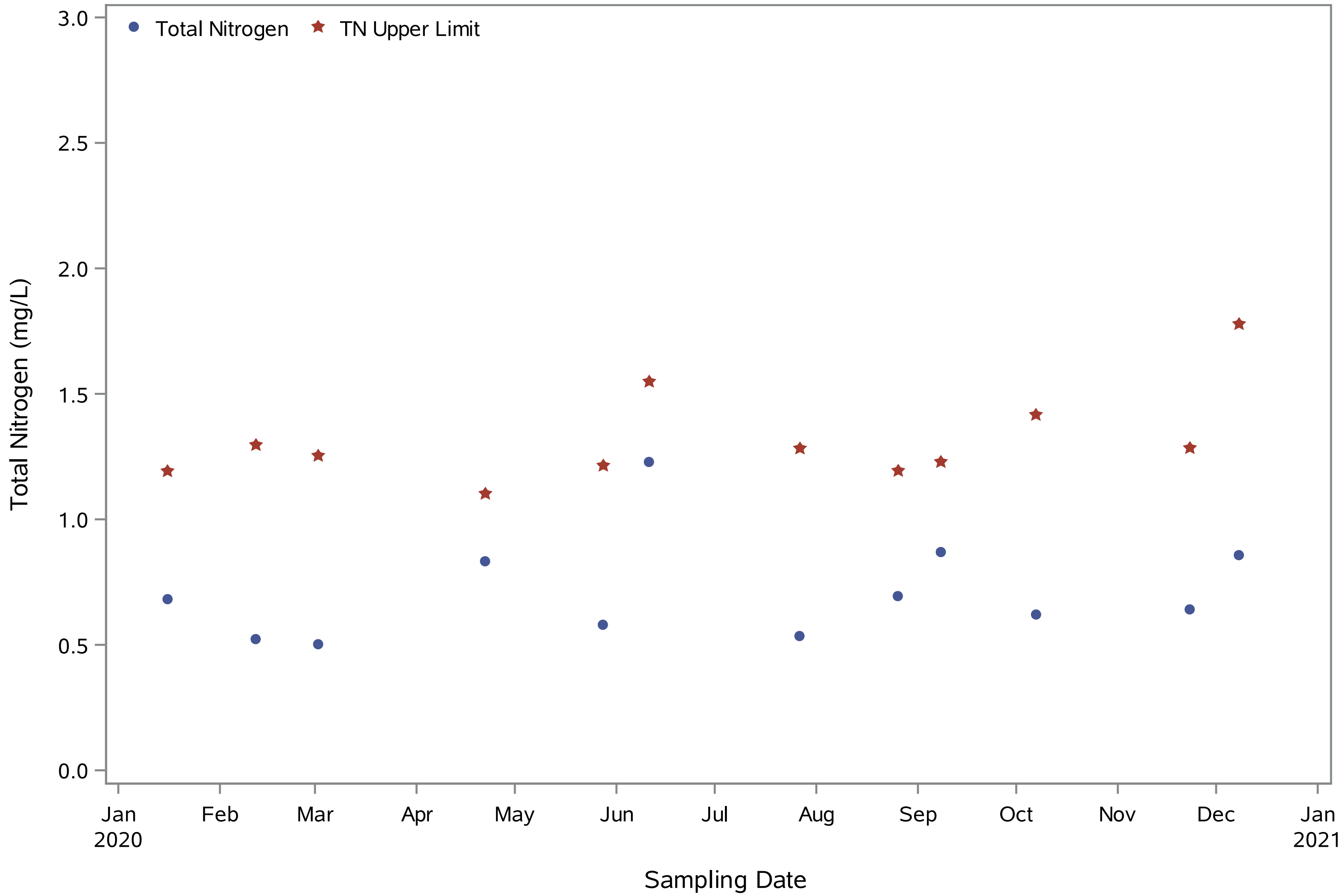
Clam Bay Ambient Monitoring- January 2020 to December 2020
Total Nitrogen
Station=Clam Bay 1



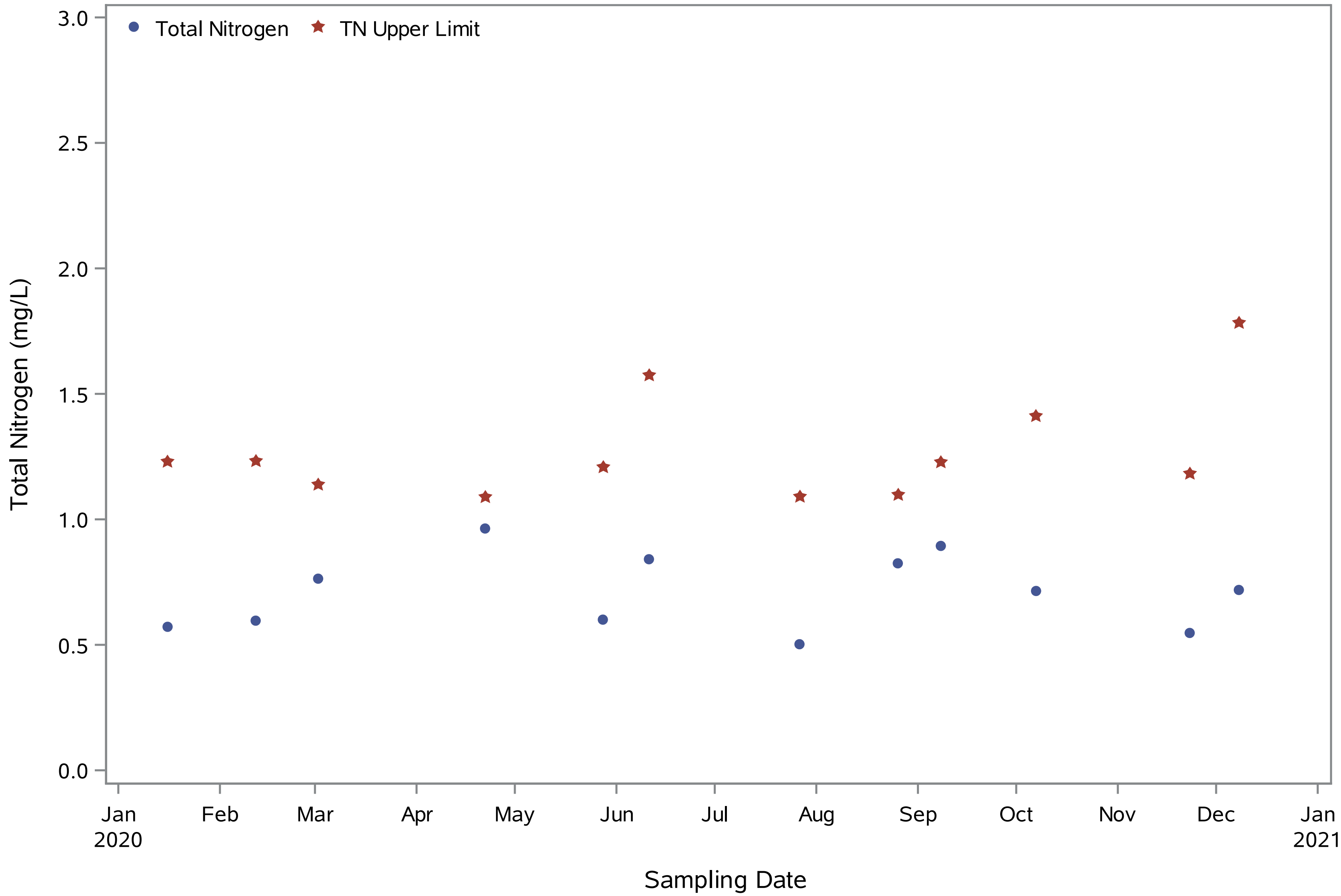


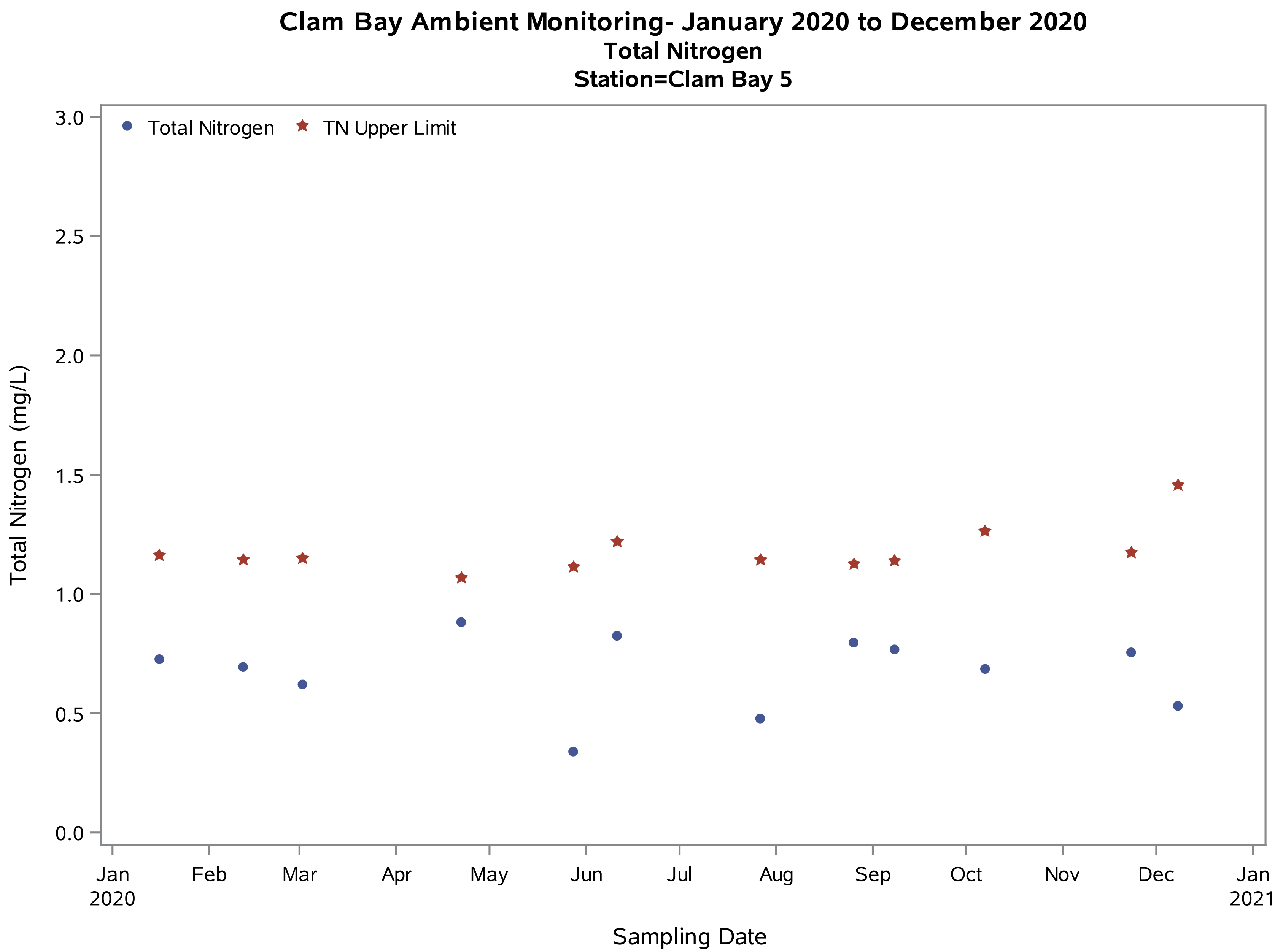
Clam Bay Ambient Monitoring- January 2020 to December 2020
Total Nitrogen
Station=Clam Bay 2
Total Nitrogen
TN Upper Limit
Total Nitrogen (mg/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan 2020
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan 2021
Sampling Date

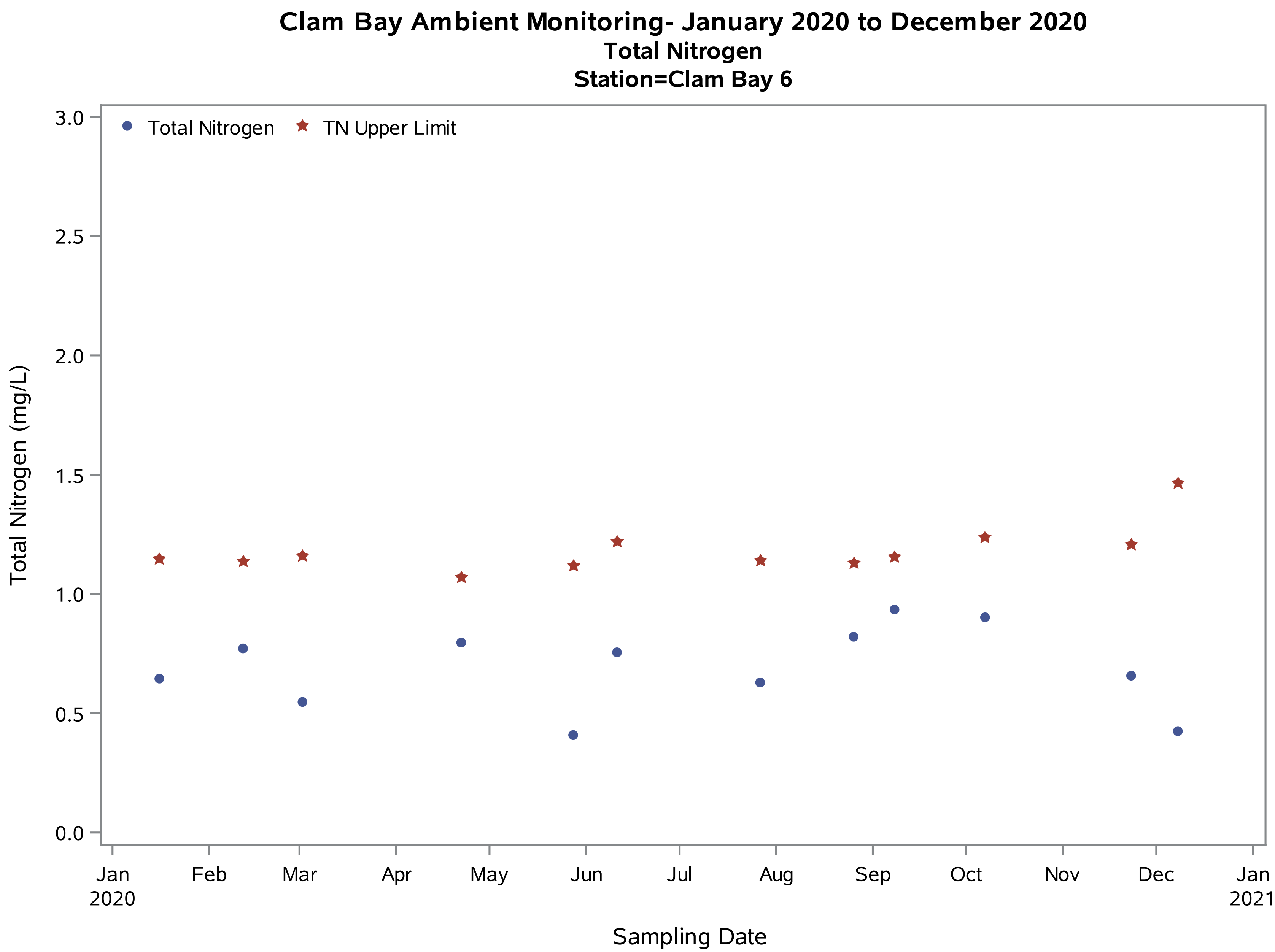
Clam Bay Ambient Monitoring- January 2020 to December 2020
Total Nitrogen
Station=Clam Bay 3



Clam Bay Ambient Monitoring- January 2020 to December 2020
Total Nitrogen
Station=Clam Bay 4

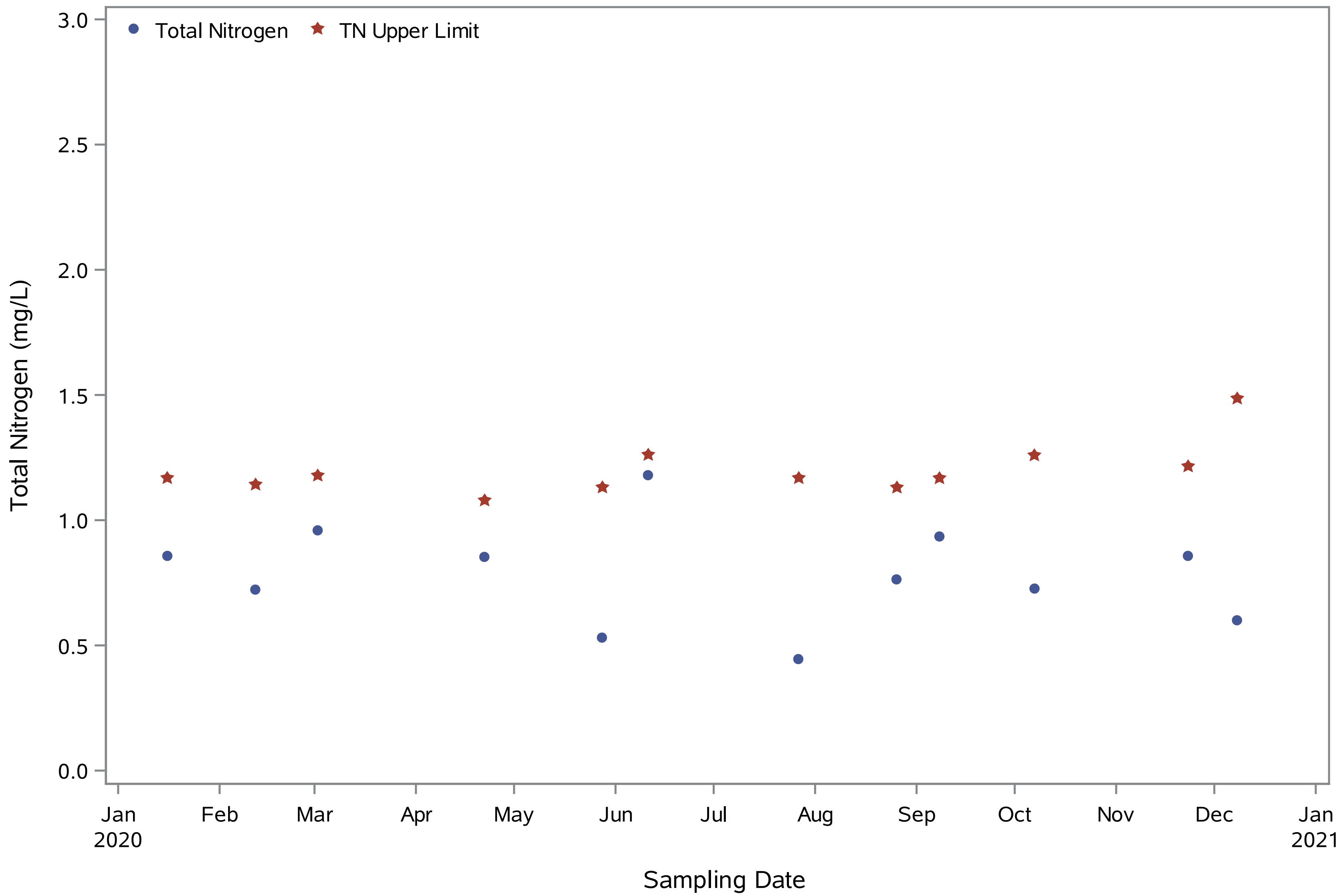


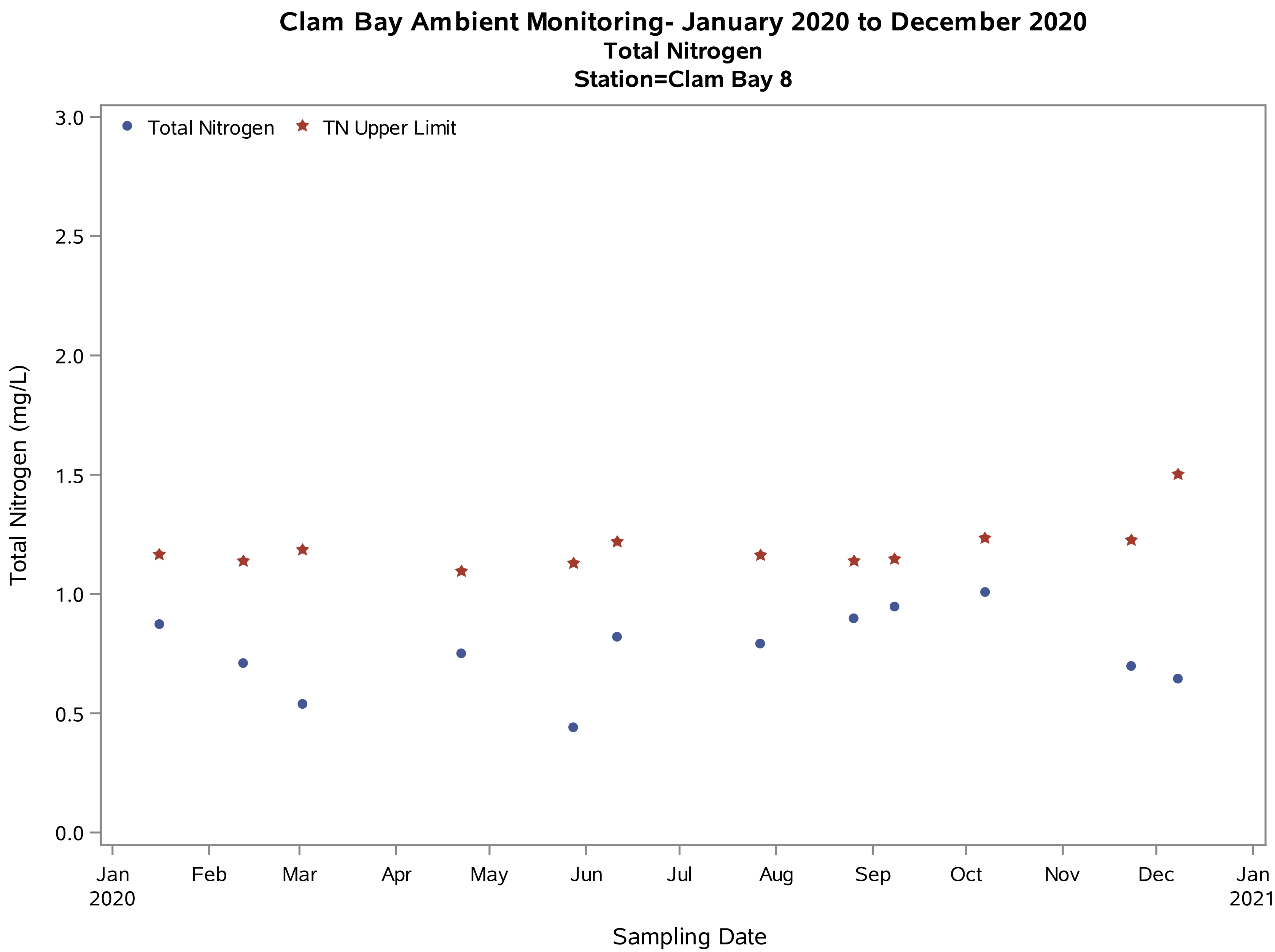

Clam Bay Ambient Monitoring- January 2020 to December 2020
Total Nitrogen
Station=Clam Bay 5
Total Nitrogen
TN Upper Limit
Total Nitrogen (mg/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan 2020
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan 2021
Sampling Date



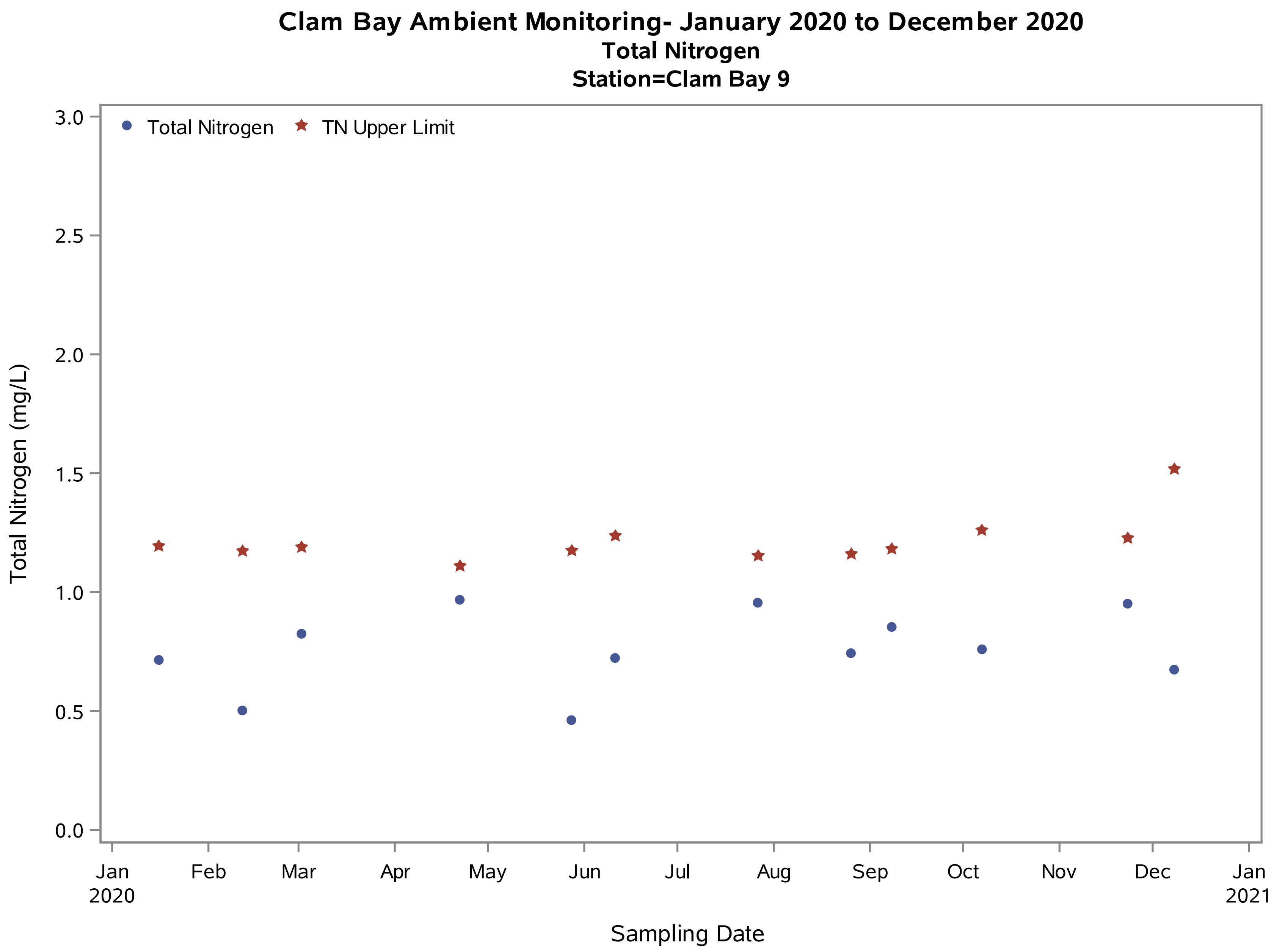
Clam Bay Ambient Monitoring- January 2020 to December 2020
Total Nitrogen
Station=Clam Bay 6
Total Nitrogen
TN Upper Limit
Total Nitrogen (mg/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan 2020
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan 2021
Sampling Date

Clam Bay Ambient Monitoring- January 2020 to December 2020
Total Nitrogen
Station=Clam Bay 7



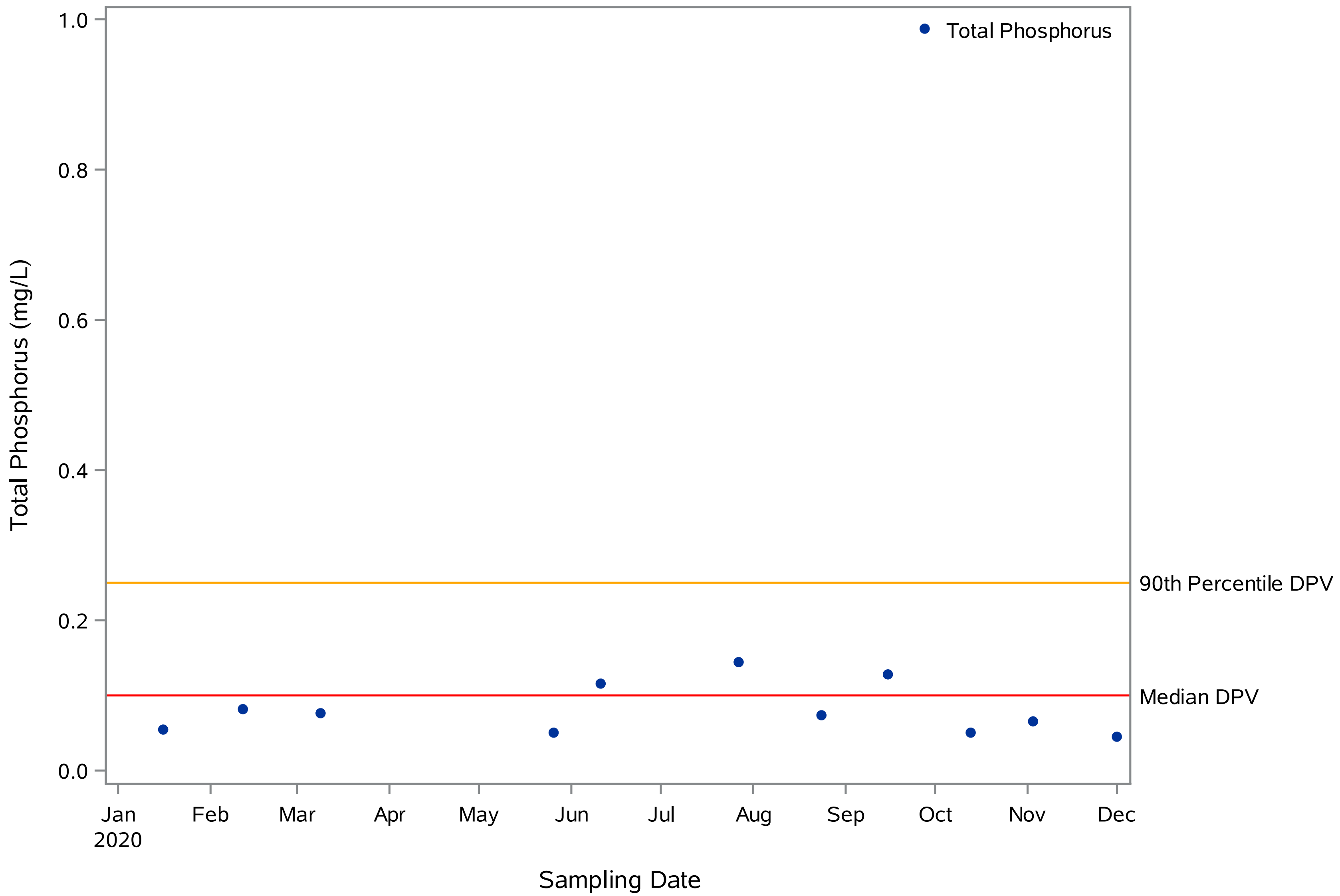


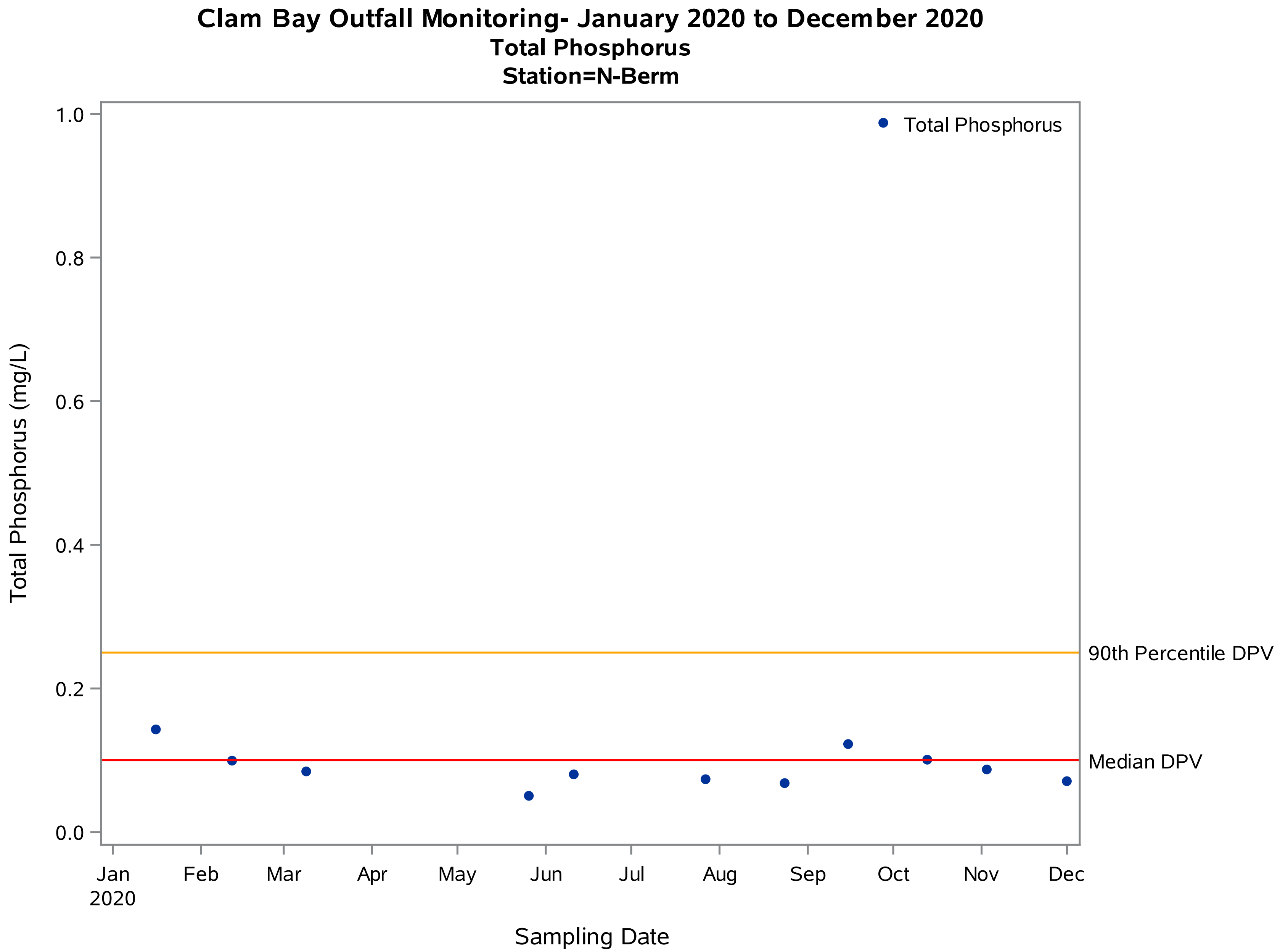
Clam Bay Ambient Monitoring- January 2020 to December 2020
Total Nitrogen
Station=Clam Bay 8
Total Nitrogen
TN Upper Limit
Total Nitrogen (mg/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan 2020
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan 2021
Sampling Date

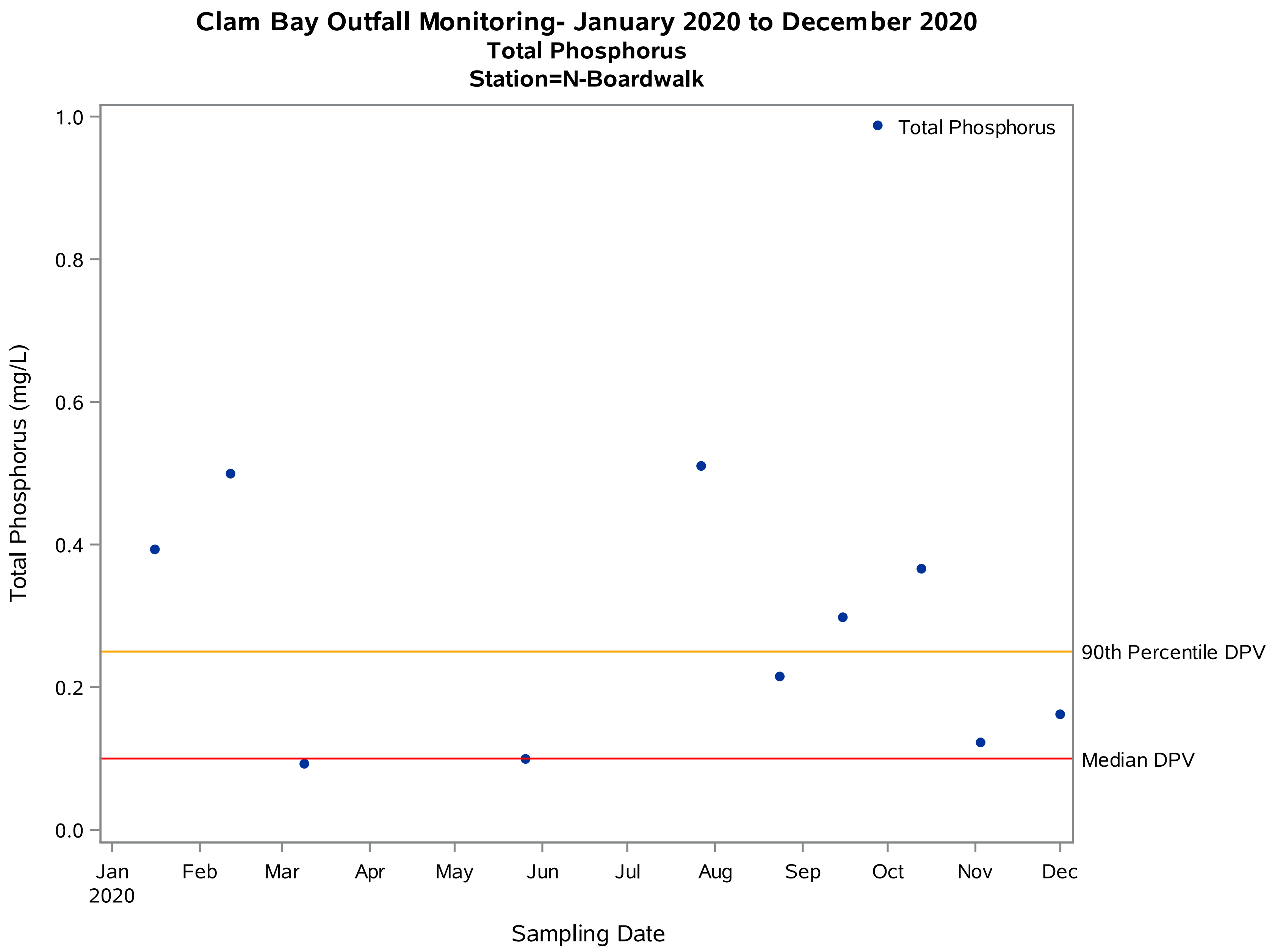


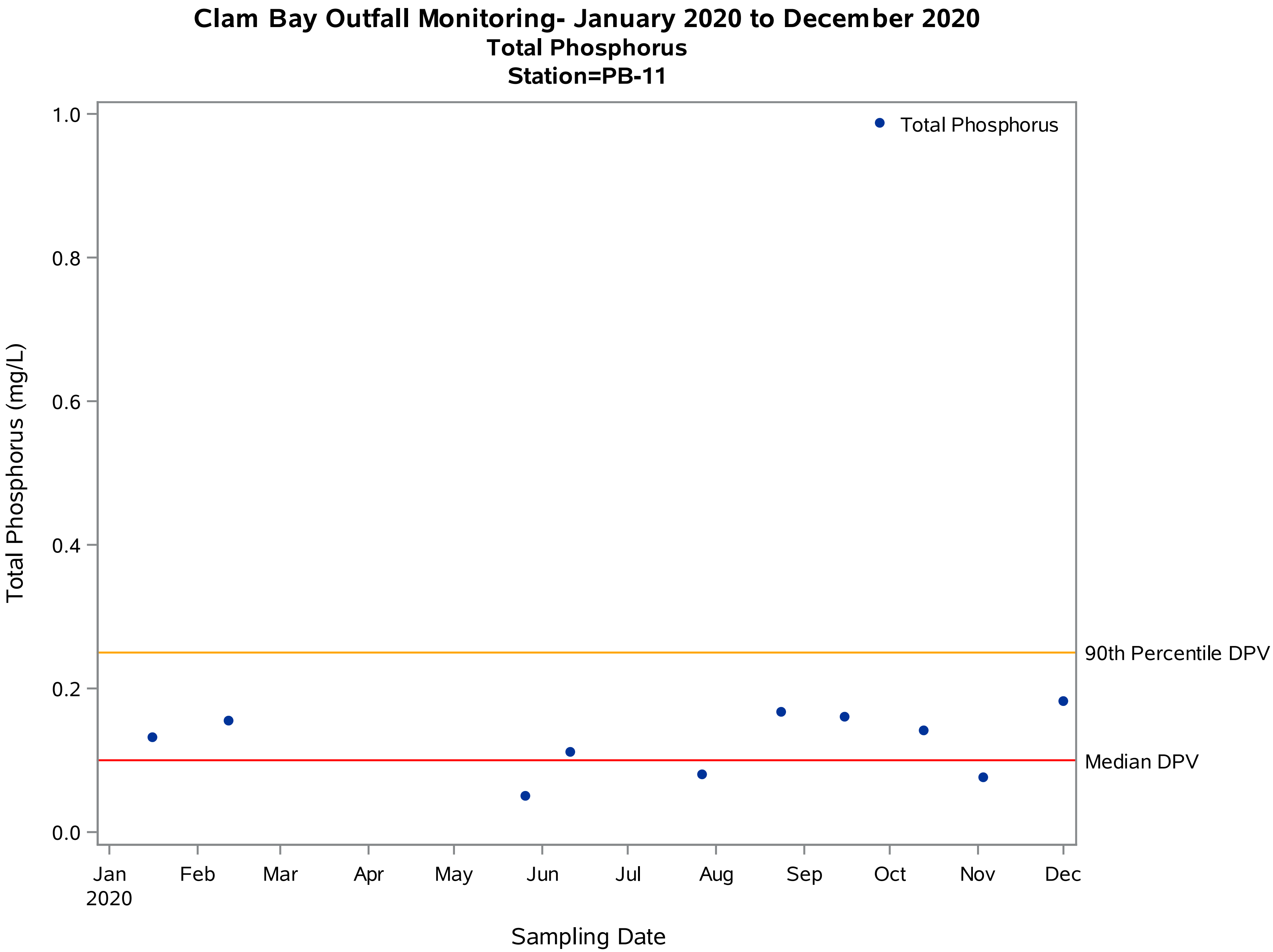
Clam Bay Ambient Monitoring- January 2020 to December 2020
Total Nitrogen
Station=Clam Bay 9
Total Nitrogen
TN Upper Limit
Total Nitrogen (mg/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan 2020
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan 2021
Sampling Date

Clam Bay Outfall Monitoring- January 2020 to December 2020
Total Phosphorus
Station=Glenview

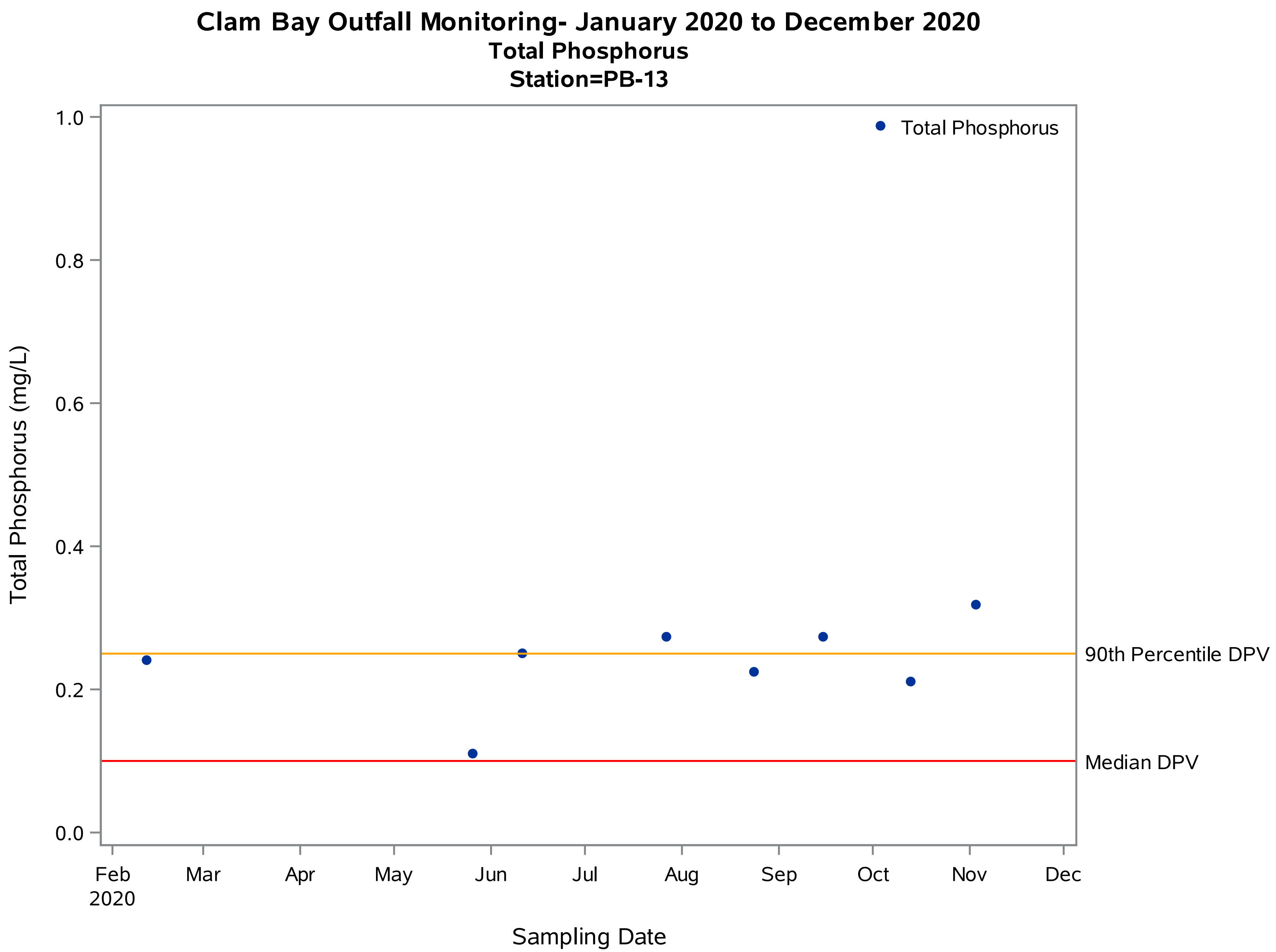


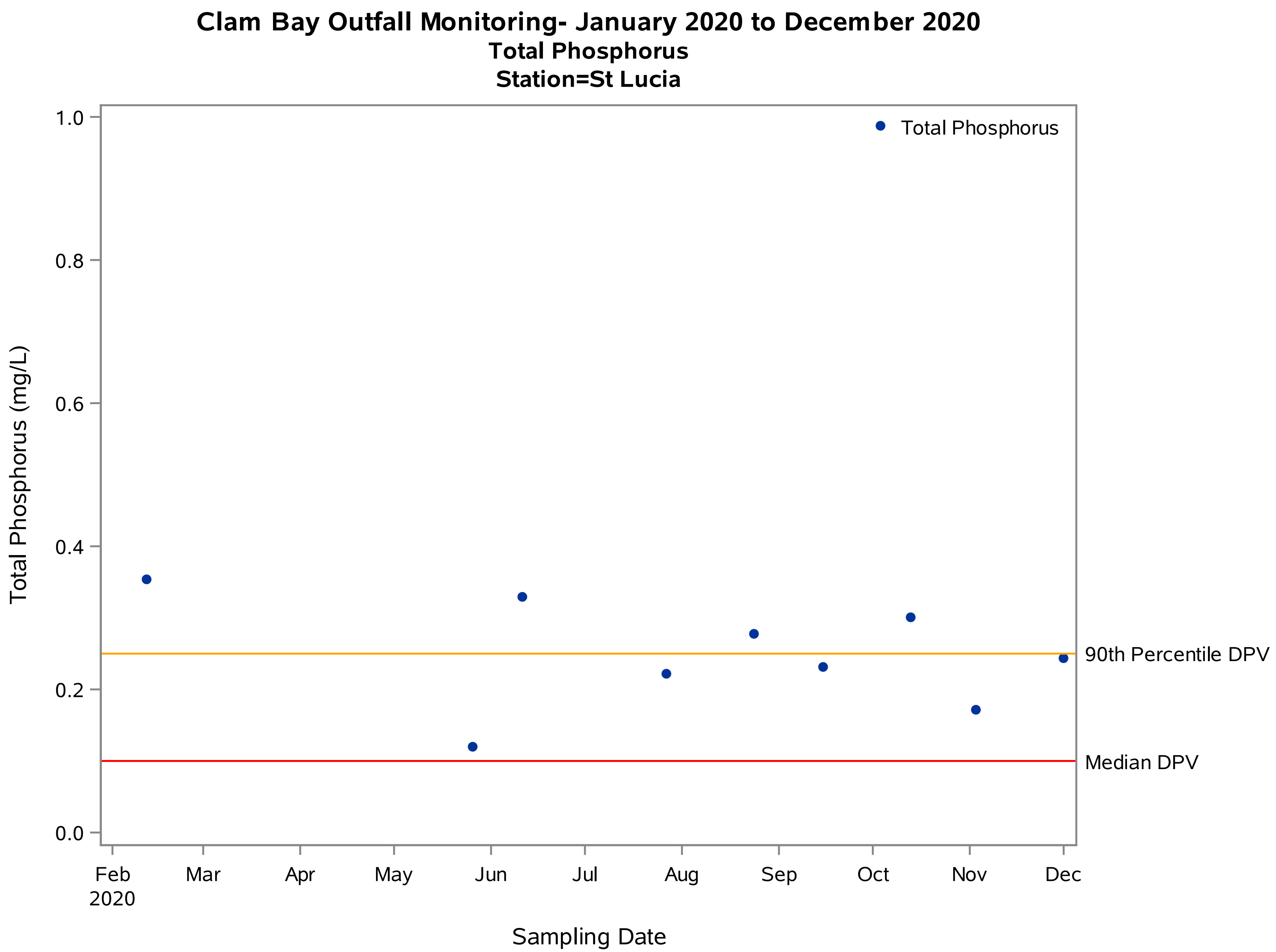

Clam Bay Outfall Monitoring- January 2020 to December 2020
Total Phosphorus
Station=N-Berm
Total Phosphorus
1.0
0.8
0.6
0.4
0.2
0.0
Total Phosphorus (mg/L)
90th Percentile DPV
Median DPV
Jan
2020
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Sampling Date


Clam Bay Outfall Monitoring- January 2020 to December 2020
Total Phosphorus
Station=N-Boardwalk
Total Phosphorus
90th Percentile DPV
Median DPV
Total Phosphorus (mg/L)
0.0
0.2
0.4
0.6
0.8
1.0
Jan
2020
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Sampling Date

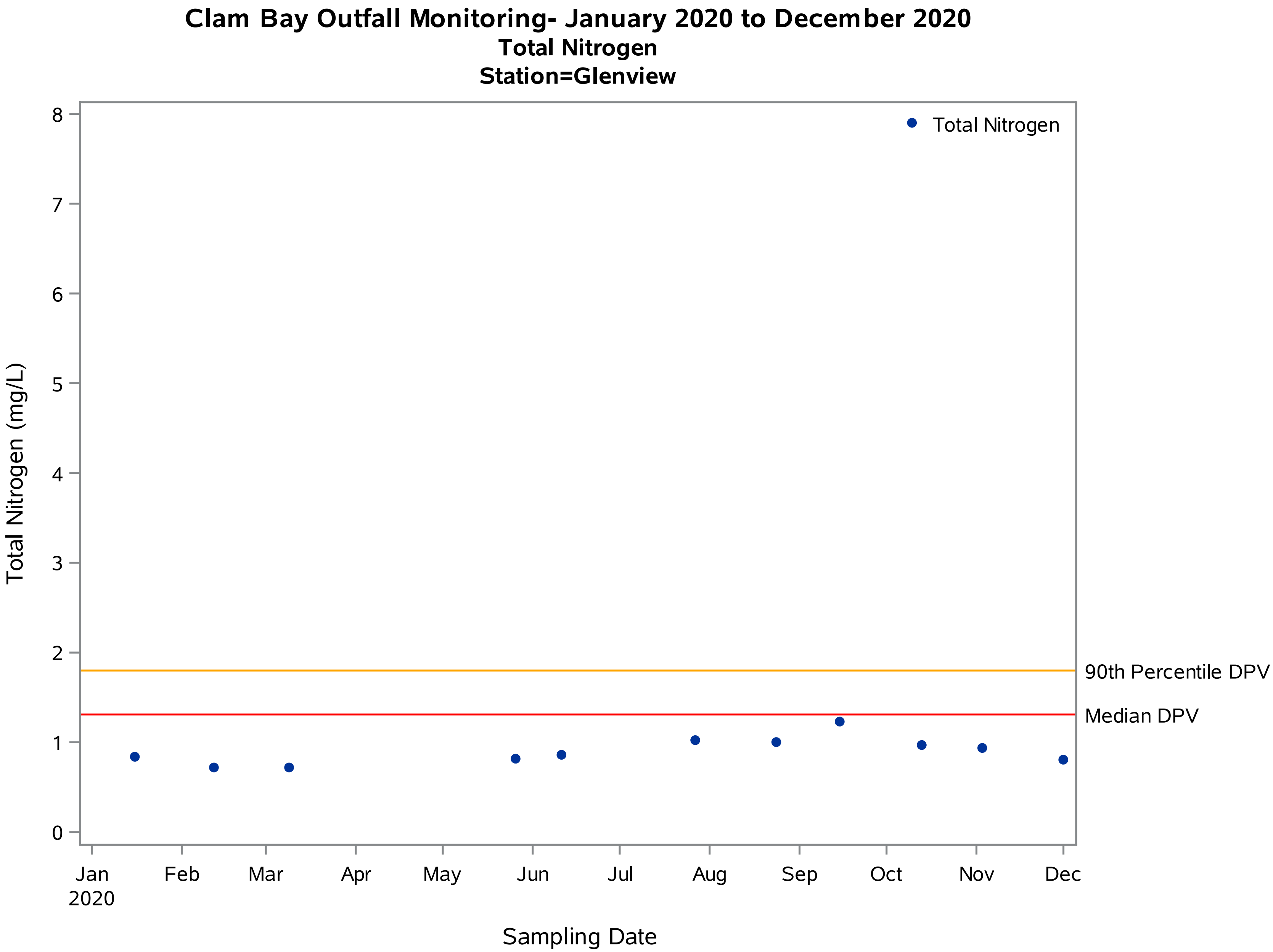


Clam Bay Outfall Monitoring- January 2020 to December 2020
Total Phosphorus
Station=PB-11
Total Phosphorus
90th Percentile DPV
Median DPV
Total Phosphorus (mg/L)
0.0
0.2
0.4
0.6
0.8
1.0
Jan
2020
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Sampling Date

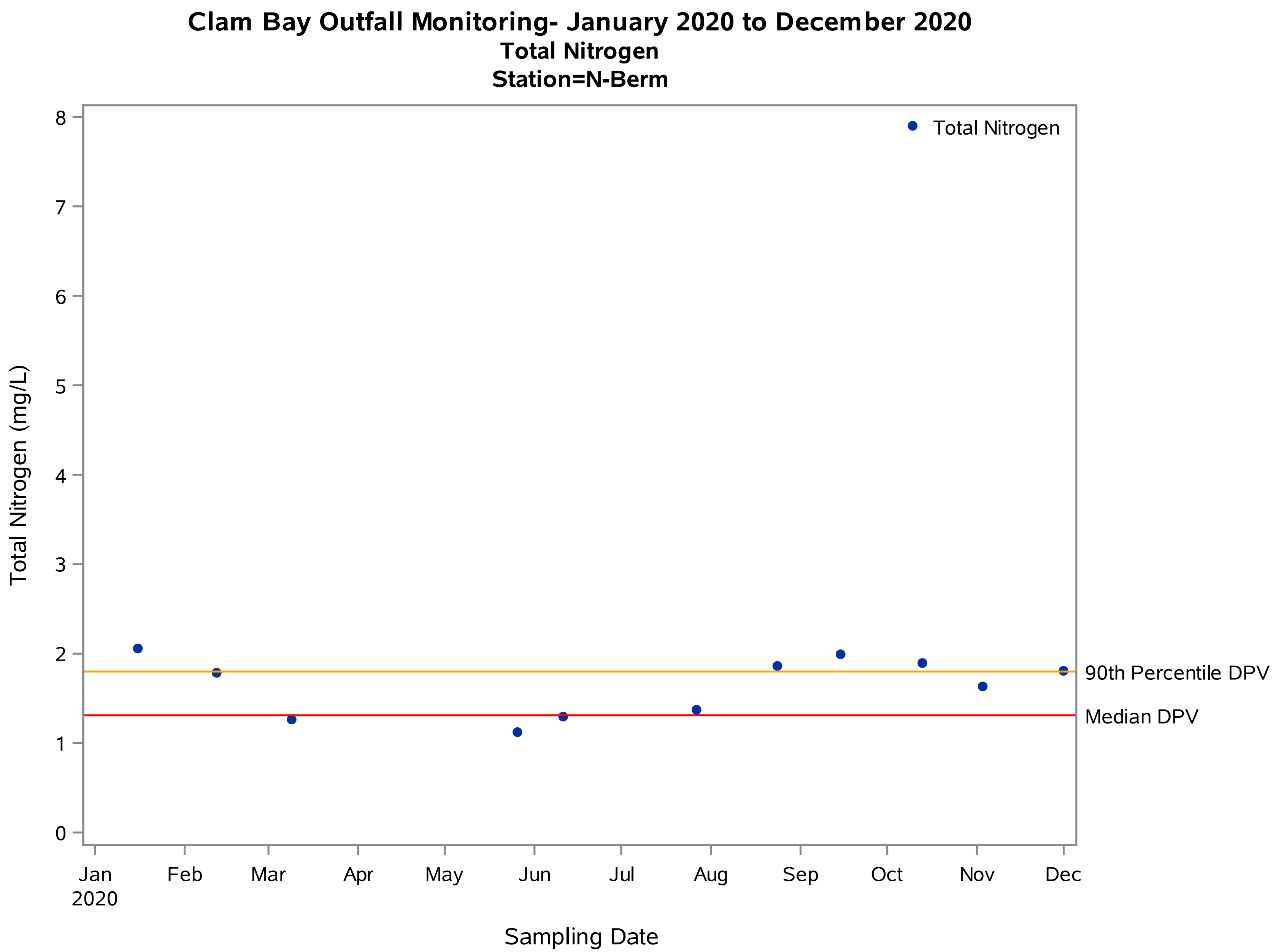

Clam Bay Outfall Monitoring- January 2020 to December 2020
Total Phosphorus
Station=PB-13
Total Phosphorus
1.0
0.8
0.6
0.4
0.2
0.0
Total Phosphorus (mg/L)
90th Percentile DPV
Median DPV
Feb
2020
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Sampling Date

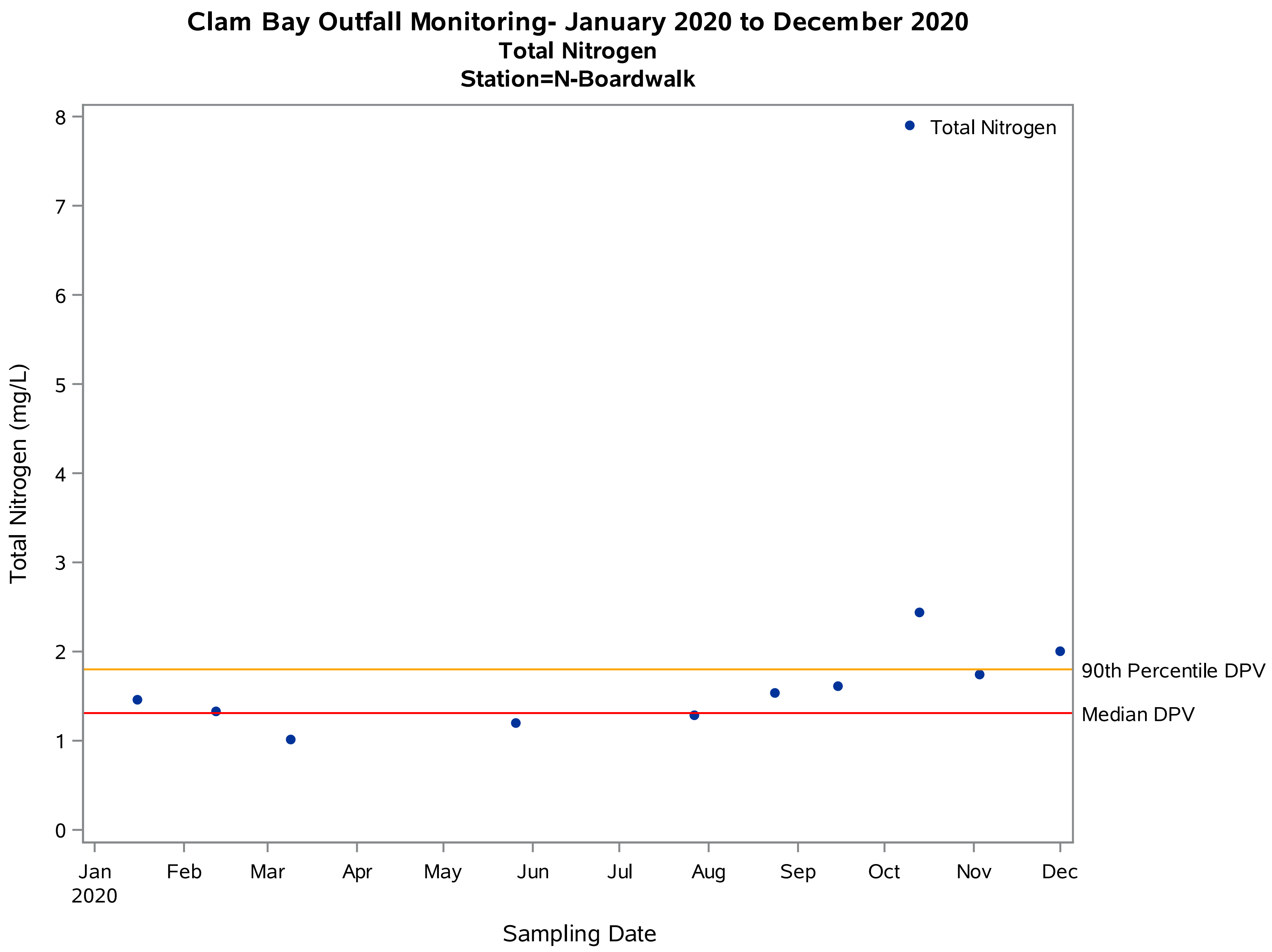


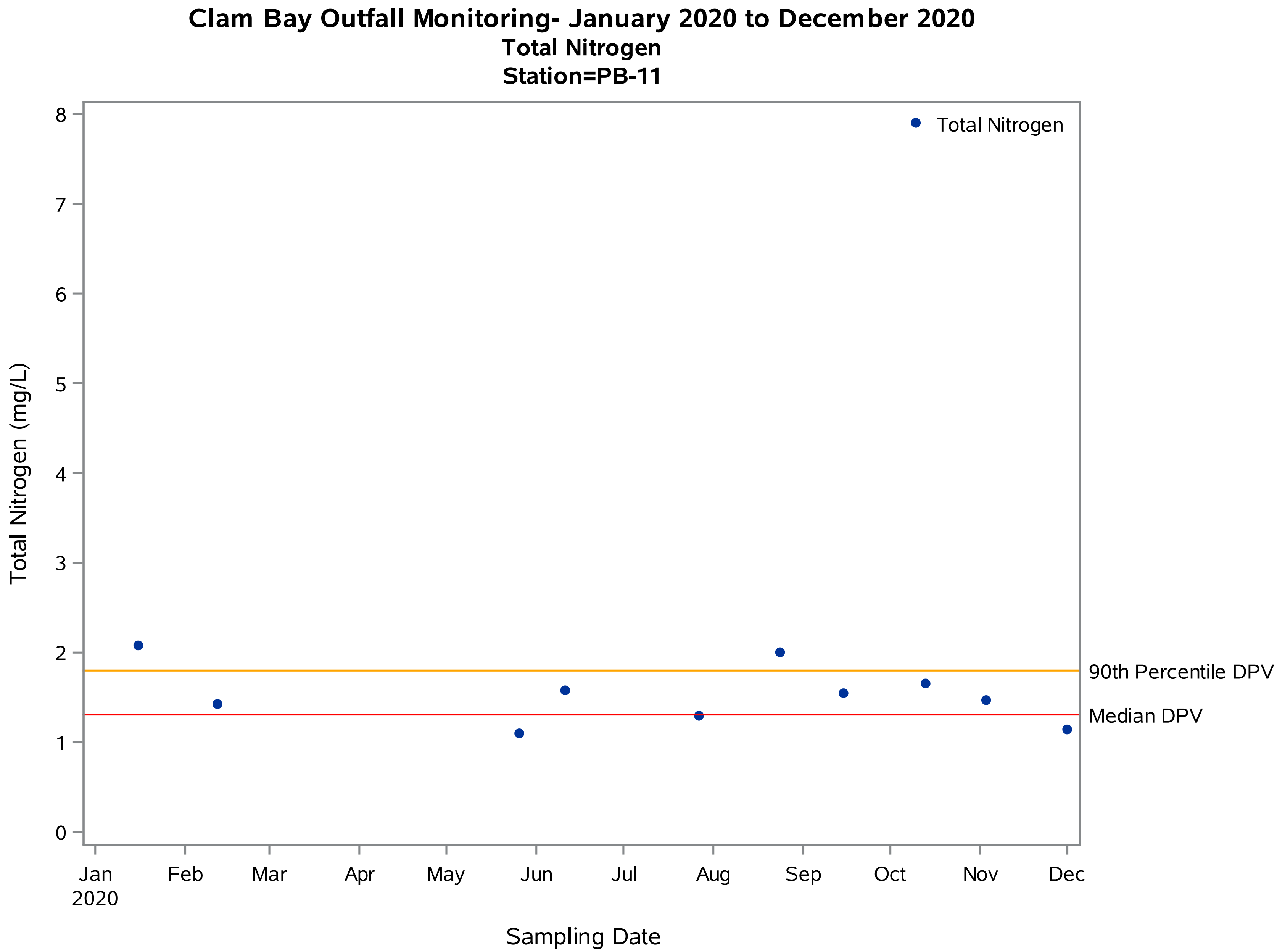
Clam Bay Outfall Monitoring- January 2020 to December 2020
Total Phosphorus
Station=St Lucia
Total Phosphorus
90th Percentile DPV
Median DPV
Total Phosphorus (mg/L)
1.0
0.8
0.6
0.4
0.2
0.0
Feb 2020
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Sampling Date

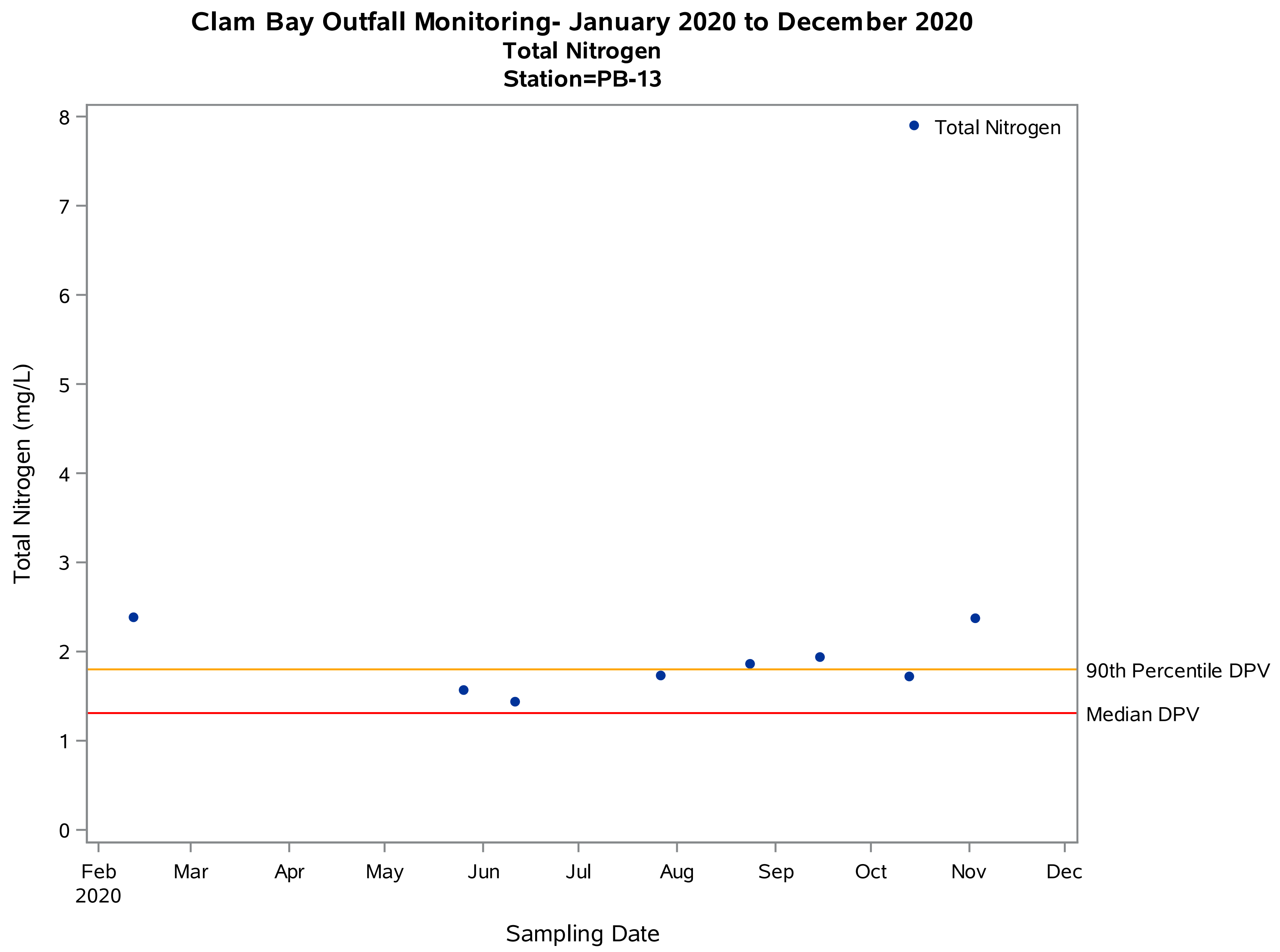


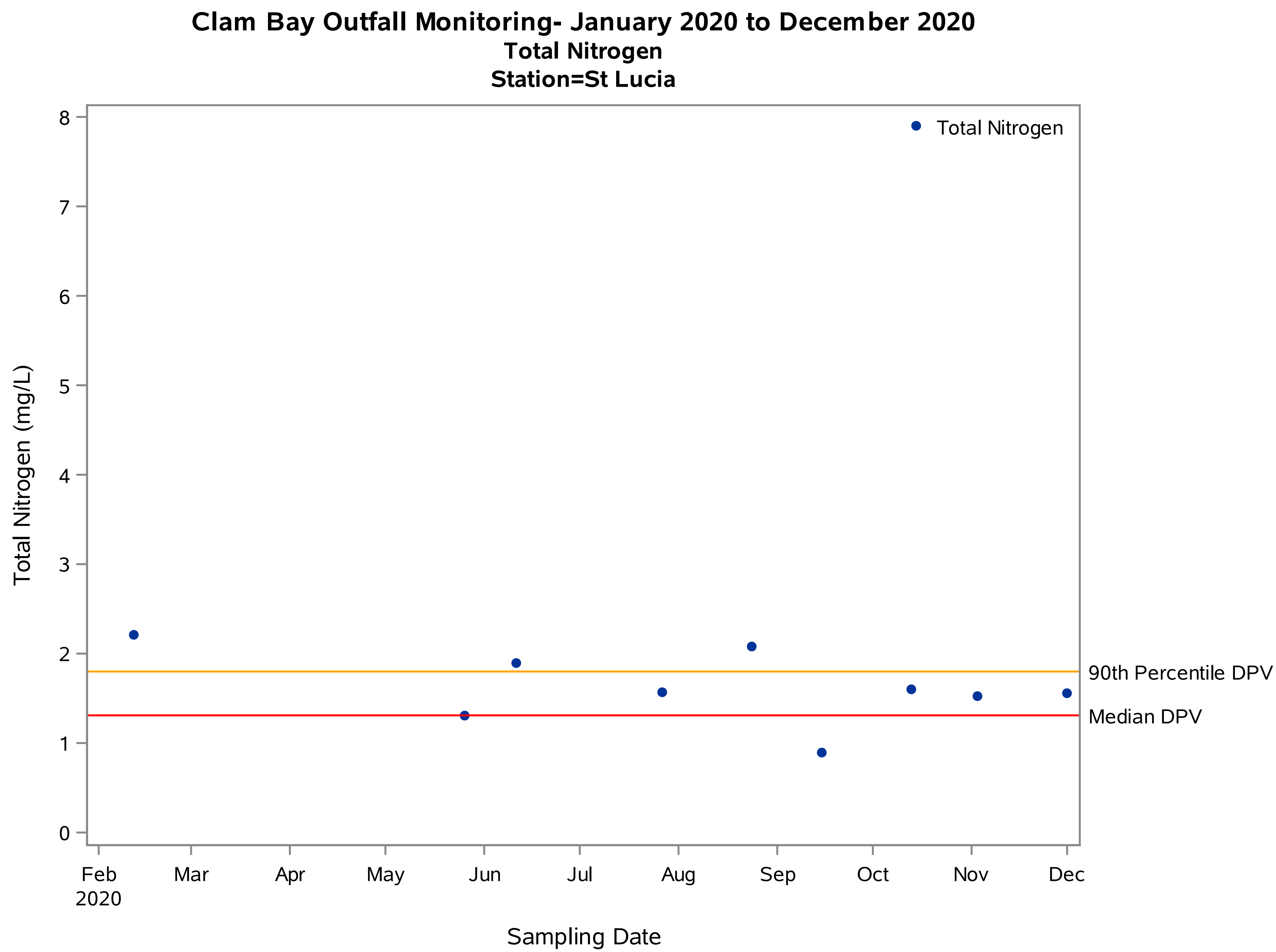
Clam Bay Outfall Monitoring- January 2020 to December 2020
Total Nitrogen
Station=Glenview
Total Nitrogen
Total Nitrogen (mg/L)
0
1
2
3
4
5
6
7
8
90th Percentile DPV
Median DPV
Jan
2020
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Sampling Date


Clam Bay Outfall Monitoring- January 2020 to December 2020
Total Nitrogen
Station=N-Berm
Total Nitrogen
Total Nitrogen (mg/L)
0
1
2
3
4
5
6
7
8
Jan
2020
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Sampling Date
90th Percentile DPV
Median DPV


Clam Bay Outfall Monitoring- January 2020 to December 2020
Total Nitrogen
Station=N-Boardwalk
Total Nitrogen
90th Percentile DPV
Median DPV
Total Nitrogen (mg/L)
0
1
2
3
4
5
6
7
8
Jan 2020
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Sampling Date


Clam Bay Outfall Monitoring- January 2020 to December 2020
Total Nitrogen
Station=PB-11
Total Nitrogen
90th Percentile DPV
Median DPV
Total Nitrogen (mg/L)
0
1
2
3
4
5
6
7
8
Jan
2020
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Sampling Date


Clam Bay Outfall Monitoring- January 2020 to December 2020
Total Nitrogen
Station=PB-13
Total Nitrogen
Total Nitrogen (mg/L)
0
1
2
3
4
5
6
7
8
90th Percentile DPV
Median DPV
Feb 2020
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Sampling Date


Clam Bay Outfall Monitoring- January 2020 to December 2020
Total Nitrogen
Station=St Lucia
Total Nitrogen
Total Nitrogen (mg/L)
0
1
2
3
4
5
6
7
8
90th Percentile DPV
Median DPV
Feb
2020
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Sampling Date