# DEVELOPMENT OF NUMERIC NUTRIENT CRITERIA FOR THE ESTUARINE WATERS OF THE CHARLOTTE HARBOR NATIONAL ESTUARY PROGRAM

## Task 7: Numeric Nutrient Criteria Development

## Interim Report 6

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# FOREWORD

This report was prepared by Janicki Environmental, Inc. for the Charlotte Harbor National Estuary Program in fulfillment of Task 7 of the Water Quality Target Refinement Project.

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# EXECUTIVE SUMMARY

The Charlotte Harbor estuarine system is located in southwest Florida. The system includes 224,000 acres of estuarine waters downstream from a 3,008,000 acre watershed. The Charlotte Harbor National Estuary Program (CHNEP) is a partnership of citizens, elected officials, resource managers and commercial and recreational resource users working to improve and maintain the water quality and ecological integrity of the greater Charlotte Harbor Watershed.

Over-enrichment of water bodies by nitrogen and phosphorus typically stimulates plant and microbial growth, and can result in biological and physical responses that adversely affect water quality and aquatic life. The U.S. Environmental Protection Agency (USEPA) is developing numeric nutrient water quality standards for Florida waters, including lakes and flowing waters, and estuarine and coastal waters. The goal of defining numeric nutrient water quality criteria levels for nutrients (i.e., nitrogen and phosphorus) is to protect the designated uses of water bodies as prescribed by the Clean Water Act. The USEPA nutrient criteria guidance recommends development of criteria for both total nitrogen (TN) and total phosphorus (TP) while not precluding the use of alternative causal or response constituents (USEPA, 2009).

In this document, candidate numeric nutrient criteria for the estuarine waters of the CHNEP have been developed and presented, including the estuarine segments in the Charlotte Harbor National Estuary Program's jurisdiction. The methods that were employed to derive candidate criteria have been previously identified in a data analysis plan (Janicki Environmental, 2010b) and are discussed in the following sections of this report. These methods were developed based on peer-reviewed literature, the many local scientists and natural resource managers studying southwest Florida estuaries, previous USEPA documents (USEPA, 2009), and reviews by its Science Advisory Board (SAB, 2010) on methods for establishing numeric nutrient criteria.

A number of data sources were used to develop the data base used to determine candidate numeric nutrient criteria for the estuarine waters of the CHNEP. These included ambient water quality data from numerous ambient water quality sampling programs, hydrologic and nutrient loading estimates, seagrass coverage, and bathymetry.

Before attempting to identify appropriate stressor-response relationships to be used in developing numeric nutrient criteria, response variable (chlorophyll) target and threshold concentrations were needed. Several methods were investigated to determine the appropriate chlorophyll concentrations. The CHNEP Technical Advisory Committee (TAC) selected the reference period approach to define segment-specific chlorophyll target and threshold concentrations. The segment-specific chlorophyll *a* targets, i.e., a desired chlorophyll *a* concentration that results in water clarity conditions that are protective of seagrasses were estimated. In turn, segment-specific chlorophyll a thresholds, i.e., the chlorophyll *a* concentrations above which water quality is likely to degrade were estimated. In estimating the thresholds it was noted that natural variability can result in years in which the targets are exceeded without causing significant reductions in seagrass cover. Therefore, there is some allowable amount of variation that should not elicit a significant degradation in water quality and therefore seagrass coverage.

Given the experience of the neighboring estuary programs, the CHNEP TAC decided to use a similar approach, but with different thresholds depending on whether or not a segment was classified as "restoration" or "protection" for seagrass. If a segment is classified as "protection", it logically follows that water clarity and chlorophyll concentrations are protective of seagrasses. Therefore, the chlorophyll *a* threshold for segments that are classified as "protection" is calculated by summing the mean plus one standard deviation. This is the same strategy that was employed by the SBEP in criteria development for the SBEP segments. However, if the segment is under "restoration", the chlorophyll target is calculated by summing the mean plus one-half standard deviation. This provides a threshold that is more stringent than for segments that are classified as "protection" because the "restoration" segments have not achieved the desired levels of seagrass coverage. The reference period used to establish the chlorophyll *a* targets was 2003-2007. This corresponds to the time period used in establishing the water clarity targets for CHNEP (Janicki Environmental, 2010a). The mean chlorophyll *a* concentrations for the reference period (targets), along with the standard deviation (for the period of record) and the thresholds were estimated.

After the chlorophyll *a* thresholds were estimated, the relationships between chlorophyll *a* concentrations and nutrient loads or concentrations were investigated. The methods included a series of techniques that can be used to estimate statistically defensible relationships between chlorophyll *a* concentrations and nutrient concentrations and/or loadings. These techniques included regression models and changepoint analysis.

As is discussed in Section 5.0, though statistically significant relationships were previously identified for most segments of the CHNEP area, these previously identified relationships left a considerable amount of variability unexplained. Therefore, the Policy Committee agreed to develop candidate numeric nutrient criteria for TN concentrations based on the reference period approach. Additionally, for segments that have been identified as impaired for nutrients and have had a TMDL developed, the TMDL would be used as the nutrient criteria. As is discussed above, if a segment is classified as a seagrass "protection" segment, the TN concentration criterion is calculated by summing the annual mean from the reference period (2003-2007) plus one standard deviation (for the period of record). However, if a segment is classified as a seagrass "restoration" segment, the TN concentration criterion is calculated by summing the annual mean from the reference period (2003-2007) plus ½ standard deviation (for the period of record). The candidate criteria for the CHNEP jurisdiction are presented in the table below for all segments.

Tidal Caloosahatchee has been identified as impaired and a TMDL has been drafted. However, due to concerns raised with the draft TMDL for the Tidal Caloosahatchee, the

TMDL is currently being revised. Therefore, it was decided to list the nutrient criteria for Tidal Caloosahatchee as "to be determined" (TBD) until the revision to the draft TMDL is completed.

It should be noted that these criteria are being proposed as interim nutrient criteria and should be evaluated at some future date, perhaps in five years. This should be done to insure that the proposed interim criteria are consistent with the reaction of the response variable. For example, if we are seeing exceedences of the TN criterion in a segment that has increasing seagrass populations and chlorophyll concentrations that are below the threshold, the TN criterion is likely too stringent. Alternatively, if the TN criterion is not being exceeded but the seagrasses are declining and the segment is not meeting chlorophyll concentration thresholds, the TN criterion is not stringent enough.

**Candidate numeric nutrient criteria for TN based on the Reference Period Method.**

| **Segment** | **Reference Period Method** |
|---|---|
| Dona and Roberts Bays | 0.42 mg/l |
| Upper Lemon Bay | 0.56 mg/l |
| Lower Lemon Bay | 0.62 mg/l |
| Tidal Myakka | 1.02 mg/l |
| Tidal Peace | 1.08 mg/l |
| Charlotte Harbor Proper | 0.67 mg/l |
| Matlacha Pass | 0.58 mg/l |
| Pine Island Sound | 0.57 mg/l |
| Tidal Caloosahatchee | TBD |
| San Carlos Bay | 0.56 mg/l |
| Estero Bay | 0.63 mg/l |

# 1.0 INTRODUCTION

The U.S. Environmental Protection Agency (USEPA) is developing numeric nutrient water quality standards for Florida waters, including lakes and flowing waters, and estuarine and coastal waters. The schedule for estuarine and coastal water criteria has been recently modified and requires USEPA to propose estuarine and coastal waters nutrient criteria and downstream protective values in Florida by November 14, 2011. This will allow adequate time for public comment and peer review by the Science Advisory Board (SAB), followed by USEPA revision of the proposed numeric nutrient criteria.

In this document, candidate numeric nutrient criteria for the estuarine waters of the Charlotte Harbor National Estuary Program (CHNEP) are presented, including the estuarine segments in the Charlotte Harbor National Estuary Program's jurisdiction (Figure 1-1). The methods employed in deriving these candidate criteria have been previously identified in a data analysis plan (Janicki Environmental, 2010b). These methods have been developed based on peer reviewed literature, the many local scientists and natural resource managers studying southwest Florida estuaries, previous USEPA documents (USEPA, 2009) and reviews by its Science Advisory Board (SAB, 2010) on methods for establishing numeric nutrient criteria.

Numeric nutrient water quality criteria define levels of nutrients (i.e., nitrogen and phosphorus) that are protective of the designated uses of water bodies as prescribed by the Clean Water Act. Over-enrichment of water bodies by nitrogen and phosphorus typically stimulates plant and microbial growth, and can result in biological and physical responses that adversely affect water quality and aquatic life. The USEPA nutrient criteria guidance recommends development of criteria for both total nitrogen (TN) and total phosphorus (TP), the primary causal constituents, through a stressor response relationship involving the response variables, chlorophyll *a*, water clarity, and dissolved oxygen, while not precluding the use of alternative causal or response constituents (USEPA, 2009).


**Figure 1-1. CHNEP Segments and Water Management District Boundaries.**

# 2.0 OBJECTIVES

The primary objectives of this project are:

- To develop a data base of nutrient loads for each of the major segments for which seagrass targets exist for the period 1989-2008;

- To define the chlorophyll thresholds to meet the light attenuation and seagrass targets in each segment;

- To determine if quantitative relationships between nutrient concentrations or loading and chlorophyll concentrations in each segment can be obtained; and

- To estimate the numeric nutrient criteria, i.e., the nutrient concentration or loading consistent with the chlorophyll thresholds, for each segment.

# 3.0 CHNEP GOALS AND TARGETS

The Charlotte Harbor estuarine system is located in southwest Florida (Figure 1-1) and includes 224,000 acres (350 square miles) of estuarine waters downstream from a 3,008,000 acre (4,700 square mile) watershed. The CHNEP is a partnership of citizens, elected officials, resource managers and commercial and recreational resource users working to improve the water quality and ecological integrity of the greater Charlotte Harbor Watershed. A cooperative decision-making process is used within the program to address diverse resource management concerns in the jurisdiction of the CHNEP.

This study addresses some of the priority problems that have been identified by the CHNEP's Comprehensive Conservation and Management Plan (CCMP) (CHNEP, 2008) and that could impede the health of the watersheds and estuaries including water quality degradation and hydrologic alterations. The area economy is driven by tourism and recreational and commercial fishing. Good water quality is a principal feature that attracts users to the Charlotte Harbor region. Coastal areas have been urbanized in the last 50 years while much of the upland watersheds remain agricultural with some mining activities, predominantly in the Peace River watershed.

This study focuses on the relationships between nutrient loads from the watershed, nutrient concentrations in the estuarine waters, and water quality responses such as phytoplankton biomass (as measured by chlorophyll *a* concentrations) and water clarity. These responses are critical determinants of management programs that seek to protect and restore seagrasses. The goal is to set numeric nutrient criteria for total nitrogen (TN) and total phosphorus (TP) in the CHNEP segments.

The CHNEP area is comprised of 14 segments (Figure 1-1) which have been divided into eight regions for the purpose of this report. These segments, along with their watersheds, are delineated based on hydrologic, ecologic, and management characteristics. The 14 segments (from north to south) are:

- Dona and Roberts Bays,
- Lemon Bay
    - Upper Lemon Bay,
    - Lower Lemon Bay,
- Tidal Myakka River,
- Tidal Peace River,
- Charlotte Harbor Proper
    - Cape Haze,
    - Bokeelia,
    - West Wall of Charlotte Harbor,
    - East Wall of Charlotte Harbor,
- Pine Island Sound/Matlacha Pass,
- Tidal Caloosahatchee River/San Carlos Bay, and
- Estero Bay.

The segmentation scheme in the CHNEP was designed to take into account the various ecosystem factors that are important to the CHNEP region and its inhabitants. This segmentation scheme is the result of an effort to subdivide the CHNEP area into separate reporting units which represent relatively homogeneous conditions with respect to variations in water quality and to resultant seagrass protection and restoration within the estuary (Corbett, 2004; Janicki Environmental, 2009).

### 3.1 Seagrass Targets

Seagrass targets were developed and approved as a CHNEP management tool in August 2009 in order to track changes in an important ecological indicator over time (Janicki Environmental, 2009). Baseline seagrass coverage was determined through photo-interpretation of aerial photos of the study area from circa 1950 obtained from the National Archives in Washington, DC. The CHNEP contracted Photo Science, experts in photo-interpretation services, which provided electronic data coverage of the area of interest for the CHNEP using ArcGIS9. This coverage served as a historic baseline from which to compare recent surveys conducted by the South and Southwest Florida Water Management Districts (Janicki Environmental, 2009). Historic (1950) and recent (1988 to present) surveyed seagrass acreages were compared to establish seagrass targets. These seagrass targets were designed to maintain and/or restore seagrass acreage to its historical extent. While the extent of seagrass in the CHNEP area may be governed by a variety of processes including erosion, salinity changes, biological perturbations, prop scarring and sedimentation, water clarity is thought to be the principal controlling factor in the long-term health of seagrasses in the study area. Therefore, management-level water clarity targets that are related to the light requirements of seagrass were developed to allow managers to correlate changes in water clarity conditions and seagrass conditions over time.

The CHNEP seagrass target for each harbor segment is the greater of either the adjusted baseline acreage or the mean of all recent seagrass surveys (Janicki Environmental, 2009). Application of this definition provided the targets identified for each harbor segment in Table 3-1.

In addition to defining these targets, an appropriate definition of a target range, i.e., the range of acceptable seagrass area, was also desired. The target range for each segment is also presented in Table 3-1.

### 3.2 Water Clarity Targets

The CHNEP identified the need to develop water quality targets that preserve and restore seagrass health throughout the estuarine system. The resource-based water quality targets address the *Priority Problems* (Hydrologic Alterations and Water Quality Degradation) identified in the CHNEP CCMP.

| Table 3-1. CHNEP Seagrass targets (from Janicki Environmental, Inc., 2009). | | | | | | |
|---|---|---|---|---|---|---|
| **Harbor Segment** | **Adjusted Baseline** | **Mean Annual Extent (all years)** | **Protection Target** | **Restoration Target** | **Total Target** | **Target Range** |
| Dona and Roberts Bay* | 112 | 91 | 91 | 21 | 112 | 70-124 |
| Upper Lemon Bay | 880 | 1,009 | 1,009 | | 1,009 | 949-1,175 |
| Lower Lemon Bay | 2,882 | 2,502 | 2,502 | 380 | 2,882 | 2,396-2,597 |
| Tidal Myakka River* | 344 | 456 | 456 | | 456 | 331-539 |
| Tidal Peace River* | 975 | 384 | 384 | 591 | 975 | 295-573 |
| West Wall | 2,106 | 1,907 | 1,907 | 199 | 2,106 | 1,676-2,121 |
| East Wall | 3,898 | 3,465 | 3,465 | 433 | 3,898 | 3,275-3,591 |
| Cape Haze | 5,670 | 6,998 | 6,998 | | 6,998 | 6,709-7,464 |
| Bokeelia | 2,964 | 3,342 | 3,342 | | 3,342 | 3,101-3,520 |
| Pine Island Sound | 23,757 | 26,837 | 26,837 | | 26,837 | 25,941-29,204 |
| Matlacha Pass | 9,315 | 7,582 | 7,582 | 1,733 | 9,315 | 6,055-7,619 |
| Tidal Caloosahatchee River* | 93 | 87 | 87 | 6 | 93 | 2-103 |
| San Carlos Bay | 3,118 | 4,372 | 4,372 | | 4,372 | 3,709-5,376 |
| Estero Bay | 3,662 | 3,071 | 3,071 | 591 | 3,662 | 2,393-3,409 |

* These riverine segments may have underreported seagrass acreages, due to difficulty in delineating seagrass in highly colored waters. These numbers are presented for completeness only and should not be used for reporting of seagrass loss or gain over time.

Optical models have recently been applied to establish water quality targets to protect estuarine seagrass coverage (Gallegos and Kenworthy, 1996; Gallegos, 2001; Dixon *et al.*, 2010). In Charlotte Harbor, initial resource-based water quality targets were developed based on measured deep edge of seagrasses and the light requirements necessary to maintain seagrass at that deep edge (CHNEP, 2006). An optical model developed by McPherson and Miller (1994) served as the basis for partitioning the light attenuating properties of three water quality variables; color (PtCo units), turbidity (NTU), and chlorophyll *a* concentrations ($\mu$g/l). A comparison of ambient light attenuation data and modeled estimates indicated that a large degree of variability was observed between model predictions and these data (Wessel and Corbett, 2009).

Based on this evaluation, interim water clarity targets were proposed for Charlotte Harbor based on conditions when seagrasses in Charlotte Harbor were stable (2003-2007) and the distribution of water clarity is being used as a benchmark from which to compare future years (Janicki Environmental, 2010a). To develop these targets, the empirical distribution of $K_d$ in each segment for a **reference period** when seagrasses were stable or improving was defined as an internal reference. This reference period is 2003-2007.

Two points along each segment-specific $K_d$ distribution (i.e., the 30$^{th}$ and 70$^{th}$ percentiles) were used to establish benchmark points for comparison to empirical data collected in future years (Table 3-2). These benchmark points were chosen based on previous work to estimate the light attenuation requirements of seagrass in Charlotte Harbor (CHNEP, 2006). Based on these benchmark points, a management tool was developed to determine if each year's $K_d$ distribution was improved, similar, or degraded relative to the reference period. The binomial test was established as the evaluation tool such that statistical uncertainty could be incorporated into the evaluation metric, providing confidence that observed differences were not due to chance alone. For example, if more than 30% of the $K_d$ measurements in a given future year are below the benchmark value with statistical significance ($\alpha$=0.05), then the water clarity was considered to be improving and assigned a scoring value of +1. If less than 30% of the values are below the benchmark value with statistical significance ($\alpha$=0.05), then the water clarity is considered to be degrading and is assigned a value of negative 1. Otherwise, the value is 0. The evaluation is performed on the 30$^{th}$ and 70$^{th}$ percentile values and the scores are summed to provide an evaluation measure for each year of data collection.

**Table 3-2. Segment-specific empirically-derived light attenuation $K_d$ ($m^{-1}$) values for the 30$^{th}$ percentile and 70$^{th}$ percentile based on data collected from 2003-2007.**

| Harbor Segment | 30$^{th}$ Percentile | 70$^{th}$ Percentile |
|---|---|---|
| Dona and Roberts Bay | 0.64 | 1.04 |
| Lemon Bay | | |
| Upper Lemon Bay | 0.73 | 1.18 |
| Lower Lemon Bay | 0.73 | 1.12 |
| Charlotte Harbor Proper | | |
| West Wall | 0.73 | 1.36 |
| East Wall | 0.64 | 1.16 |
| Bokeelia | 0.58 | 1.16 |
| Cape Haze | 0.63 | 1.15 |
| Tidal Myakka River | 1.3 | 2.27 |
| Tidal Peace River | 1.06 | 2.4 |
| Pine Island Sound | 0.64 | 1.1 |
| Matlacha Pass | 0.73 | 1.63 |
| Tidal Caloosahatchee River | 1.58 | 2.93 |
| San Carlos Bay | 0.73 | 1.16 |
| Estero Bay | 0.91 | 1.58 |

Recent spectral light attenuation modeling efforts in Charlotte Harbor have suggested that non-linearity in attenuation as a function of sample depth may result in biased estimates of the specific light requirements of seagrasses and that previously specified seagrass light requirements may need to be revisited in future years (Dixon *et al.*, 2010). Based on these efforts, the CHNEP is using the interim targets developed by Janicki Environmental (2010a) in an adaptive management strategy until 2012 when water clarity targets will be revisited.

### 3.3 Chlorophyll *a* Targets and Thresholds

Establishment of defensible, protective environmental endpoints largely depends upon the definition of a defensible baseline. Three potential candidate methods for defining chlorophyll *a* thresholds are discussed below. These potential methods are:

- Regulatory-based Method,
- Optical Model Method, and
- Reference Period Method.

#### 3.3.1 Regulatory Method

The Florida Department of Environmental Protection developed the Impaired Waters Rule (IWR) in 2002. The IWR was to be used to identify those waterbodies that are impaired, i.e., those that do not meet water quality standards. Given the existing criteria for nutrients (i.e., N and P) were narrative, there was a need to identify an acceptable numeric criterion for those nutrients or an appropriate surrogate to allow identification of waterbodies that are nutrient impaired. In the case of marine waters, a chlorophyll *a* threshold was established as the numeric criterion surrogate and this value was a mean annual chlorophyll *a* concentration of 11.0 µg/l.

#### 3.3.2 Optical Model Method

The results from Corbett and Hale (2006) and CHNEP (2006) discussed above can be used to estimate chlorophyll *a* targets for the estuarine waters of Charlotte Harbor. The general model is:

$$K_d = \alpha + \beta_1 C_1 + \beta_2 C_2 + \beta_3 C_3$$

where: $C_1$ = coefficient related to water color
$C_2$ = coefficient related to turbidity
$C_3$ = coefficient related to chlorophyll *a* concentrations.

The partial attenuation coefficients were derived by stepwise multiple regression analysis. Using the equation, a value for any of the three light attenuation properties can be calculated given values for the other two properties. Therefore, given a critical $K_d$ and some assumed values for color and turbidity, the chlorophyll *a* concentration needed to meet the critical $K_d$ can be calculated.

Given a critical $K_d$, the simplest application of the optical model would assume that two of the three light attenuation properties are fixed values and estimate the third. The maximum concentration of each partial light attenuation component that meets the critical $K_d$ was calculated by assuming two properties are zero and solving for the third (CHNEP, 2006). The results from these calculations are presented in Table 3-3.

DEP developed a TMDL for the tidal Caloosahatchee River and used the Corbett and Hale method to define the chlorophyll *a* target (FDEP, 2009).

For this study, two methods were attempted to apply the thresholds from CHNEP (2006). In the first method, it was assumed that color and turbidity were equal to zero and the resulting chlorophyll *a* concentrations were estimated. However, as noted by CHNEP (2006):

> "These intercepts are the maximum potential concentration of the analytes and are acceptable for meeting the percent-light-at-depth goal only when the concentrations for both the other 2 analytes are zero, an unlikely situation except when color is sufficiently high to limit phytoplankton production."

Examining the database of water quality used for the analyses, there were no samples that had zeros for two of the three constituents.

**Table 3-3. Estimated maximum concentration of each partial attenuation property assuming the other two properties are zero. (from CHNEP, 2006). Critical Kd data not available for Dona and Roberts Bays.**

| Segment | Critical $K_d$ | Color (Pt-Co units) | Turbidity (NTU) | Chlorophyll *a* (µg/L) |
|---|---|---|---|---|
| Dona and Roberts Bays | n/a | n/a | n/a | n/a |
| Lemon Bay | | | | |
| Upper Lemon Bay | 0.7 | 28.6 | 6.5 | 8.2 |
| Lower Lemon Bay | 0.7 | 28.6 | 6.5 | 8.2 |
| Charlotte Harbor Proper | | | | |
| West Wall | 1.0 | 50.0 | 11.3 | 14.3 |
| East Wall | 1.0 | 50.0 | 11.3 | 14.3 |
| Bokeelia | 0.6 | 20.2 | 4.6 | 5.8 |
| Cape Haze | 0.7 | 31.2 | 7.0 | 8.9 |
| Tidal Myakka River | 1.6 | 89.7 | 20.3 | 25.6 |
| Tidal Peace River | 1.4 | 78.6 | 17.7 | 22.4 |
| Matlacha Pass | 0.7 | 28.6 | 6.5 | 8.2 |
| Pine Island Sound | 0.6 | 24.0 | 5.4 | 6.9 |
| Tidal Caloosahatchee River | 1.2 | 61.9 | 14.0 | 17.7 |
| San Carlos Bay | 0.6 | 24.0 | 5.4 | 6.9 |
| Estero Bay | 0.9 | 41.1 | 9.3 | 11.7 |

Secondly, the long-term mean values of color and turbidity for each calendar month were used to calculate chlorophyll *a* concentrations based on the critical $K_d$ values. The results from this application of the CHNEP optical model included negative chlorophyll *a* concentrations in each segment.

Therefore, the CHNEP optical model application where both color and turbidity are assumed to be zero was used to estimate the chlorophyll *a* thresholds for the Optical Model Method.

### 3.3.3 Reference Period Method

As was discussed above, seagrass and water clarity targets have been established for the segments of the CHNEP area. Given that the recent extents of seagrasses in some segments are meeting their established targets, it logically follows that recent water clarity and chlorophyll *a* concentrations are protective of the seagrasses in those segments that are meeting established targets. However, for the segments that are not meeting their targets, the same assumption is not valid.

The Tampa Bay Estuary Program (TBEP) (Janicki and Wade, 1996) and Sarasota Bay Estuary Program (SBEP) (Janicki Environmental, 2010c) used a similar reference period approach to define chlorophyll *a* targets. Both programs recognized that there may be years in which chlorophyll *a* targets may be exceeded without causing significant reductions in seagrass cover. Therefore, there is some allowable amount of variation that should not elicit a significant degradation in water quality and therefore seagrass coverage. The SBEP defined this level of variation as the standard deviation around the mean annual chlorophyll *a* concentrations in each segment for the entire period of record. The target was defined as the annual mean of the reference period, i.e., the period that was deemed to be protective on seagrass and water clarity. Therefore, a distinction is made between a **target, i.e., a desired chlorophyll *a* concentration** and **a threshold, i.e., a chlorophyll *a* concentration above which undesirable chlorophyll *a* concentrations exist**.

Given the experience of the neighboring estuary programs, the CHNEP Technical Advisory Committee (TAC) decided to use a similar approach, but with different thresholds depending on whether or not a segment was classified as "restoration" or "protection" for seagrass. If a segment is classified as "protection", it logically follows that water clarity and chlorophyll concentrations are protective of seagrasses. Therefore, the chlorophyll *a* threshold for segments that are classified as "protection" is calculated by summing the mean plus one standard deviation. This is the same strategy that was employed by the SBEP in criteria development for the SBEP segments. However, if the segment is under "restoration", the chlorophyll target is calculated by summing the mean plus one-half standard deviation. This provides a threshold that is more stringent than for segments that are classified as "protection" because the "restoration" segments have not achieved the desired levels of seagrass coverage. The reference period used to establish the chlorophyll *a* targets was 2003-2007. This corresponds to the time period used in establishing the water clarity targets for CHNEP (Janicki Environmental, 2010a). The mean chlorophyll *a* concentrations for the reference period (targets), along with the standard deviation (for the period of record) and the thresholds are presented for each segment in Table 3-4.

**Table 3-4. Recommended chlorophyll *a* targets and thresholds (µg/L) developed based on reference period (2003-2007).**

| Segment | Restoration/ Protection | Target Chlorophyll *a* (µg/L) | Standard Deviation of Annual Means (µg/L) | Threshold Chlorophyll *a* (µg/L) |
|---|---|---|---|---|
| Dona and Roberts Bays | Restoration | 4.3 | 1.2 | 4.9 |
| Upper Lemon Bay | Protection | 6.7 | 2.2 | 8.9 |
| Lower Lemon Bay | Restoration | 5.1 | 2.0 | 6.1 |
| Tidal Myakka | Protection | 8.9 | 2.8 | 11.7 |
| Tidal Peace | Restoration | 10.6 | 4.0 | 12.6 |
| Charlotte Harbor Proper (EW+WW+BK+CH) | Restoration/ Protection | 4.9 | 2.4 | 7.3/6.1 |
| Matlacha Pass | Restoration | 4.0 | 4.1 | 6.1 |
| Pine Island Sound | Protection | 5.1 | 1.4 | 6.5 |
| San Carlos Bay | Protection | 2.8 | 0.7 | 3.5 |
| Tidal Caloosahatchee | Restoration | 9.0 | n/a | 6.9 (TMDL) |
| Estero Bay | Restoration | 4.9 | 2.0 | 5.9 |

Since establishing seagrass targets for tidal rivers is questionable due to issues with color and visibility (Janicki Environmental, 2009), the chlorophyll thresholds for the Tidal Myakka, Tidal Peace, and Tidal Caloosahatchee rivers were not used in criteria development. Instead, the chlorophyll targets for the downstream areas, Charlotte Harbor Proper for the Tidal Peace and Tidal Myakka and San Carlos Bay for Tidal Caloosahatchee, were used. Please note that a proposed Total Maximum Daily Load (TMDL) has been developed for the Tidal Caloosahatchee River as a result of the system being identified as impaired. In the proposed TMDL, a target chlorophyll a concentration of 6.9 µg/L was identified for the Tidal Caloosahatchee.

# 4.0 APPROACH AND RATIONALE

This chapter includes a discussion of the following:

- Data sources
  - Water quality data
  - Loadings
  - Bathymetry and residence times

- Data analyses
  - Linear regression
  - Changepoint analysis

## 4.1 Data Sources

A number of data sources were used to develop the data base used to determine numeric nutrient criteria for the estuarine waters of the CHNEP. These included ambient water quality data, hydrologic and nutrient loading estimates, seagrass coverage, and bathymetry. These data sources are described in the following subsections.

### 4.1.1 Water Quality

Ambient water quality data were obtained from the following agencies and programs:

- Southwest Florida Water Management District,
- South Florida Water Management District,
- Sarasota County,
- Lee County,
- Peace River Manasota Regional Water Supply Authority,
- Coastal Charlotte Harbor Monitoring Network,
- Charlotte Harbor Volunteer Monitoring Network,
- Charlotte Harbor Aquatic Preserves,
- City of Cape Coral, and
- Florida International University.

### 4.1.2 Loadings

Estimates of hydrologic, TN, and TP loadings have recently been developed for Charlotte Harbor (Janicki Environmental, 2010d). The loading sources include:

- atmospheric deposition directly to the surface of the estuary,
- nonpoint sources,

- septic tanks (on-site sewage treatment and disposal systems), and
- domestic and industrial point sources (wastewater treatment facilities and industrial facility discharges).

Monthly loading estimates for each CHNEP segment are reported.

### 4.1.3 Bathymetry and Residence Time

The bathymetry data used in this study were obtained from NOAA (2005) and National Geophysical Data Center (2009). A box model was developed to estimate the hydraulic residence times within the CHNEP segments. The box model was based on observed salinity distributions within the system and estimated freshwater inflows to the system. Methods were similar to those described by Hagy *et al.* (2000), with the exception that the CHNEP system was assumed to be well-mixed vertically, so that all transport was horizontal. Hydraulic residence time is also called pulse residence time (PRT), as residence times are dependent upon introducing a pulse of tracer into a selected segment at the beginning of the box model simulation and tracking the time necessary for the concentration of this tracer to decrease to a certain level. The specific method used to estimate the pulse residence times for each segment is given in Appendix 2. The box model iterations resulted in segment- and monthly-specific estimates of PRT. For each segment, the median PRT for each year was calculated, and then the median PRT of the annual values for each segment were calculated. These segment-specific PRTs represent the median hydraulic residence time within each segment given the observed conditions of 1995-2007.

## 4.2 Limiting Nutrients and Data Analysis Approaches

This section presents a discussion of limiting nutrients and the data analysis approaches used in estimating the numeric nutrient criteria for the CHNEP estuarine waters.

### 4.2.1 Limiting Nutrients

Setting numeric nutrient criteria depends upon knowledge of the nutrient most likely limiting in the waterbodies of concern. In many estuarine ecosystems, nitrogen is the most limiting nutrient (the nutrient whose concentration in the environment of an organism determines the growth and productivity of that organism) (Boynton *et al.*, 1982; Howarth *et al.*, 1988a, 1988b; Chapra, 1997; National Research Council, 2000; Smith, 1984). As such, nitrogen has been identified as the primary nutrient of concern in estuarine ecosystems nationwide (see review in National Research Council, 1993). Aquatic ecosystems are commonly characterized by their N:P ratios. Receiving waters with ratios less than 10:1 (molar) are considered nitrogen limited, ratios of greater than 30:1 (molar) indicate phosphorus limitation, and ratios of 10-30:1 (molar) indicate co-limitation (FDEP, 2002). The average N:P ratios for the segments of the

CHNEP, both by weight and molar, are presented in Table 4-1 for the period 1996 to 2009. Most of the northern segments have molar N:P ratios near or less than 10:1 and would therefore be considered nitrogen limited. Ratios are higher in the southern segments, indicating potential co-limitation. The exception to this is the Tidal Caloosahatchee, which receives discharge from Lake Okeechobee and thus has a higher TP concentration, and lower TN:TP ratio, than do the other adjacent segments. Several segments have molar N:P ratios of nine or less, including Dona and Roberts Bays, Upper Lemon Bay, Tidal Peace, Tidal Myakka, East Wall, and West Wall, indicating nitrogen limitation of phytoplankton growth in these segments. While nitrogen limitation seems to be indicated in several of the segments of CHNEP, the nutrient that is most limiting can vary seasonally (Malone *et al.*, 1996; Conley *et al.*, 2009). So areas that are generally nitrogen limited may be phosphorus limited at times. In addition to nutrient limitation, phytoplankton growth may also be light-limited during certain parts of the year (Pennock and Sharp, 1994).

**Table 4-1. Average TN and TP concentrations and TN:TP by CHNEP segments (1996-2009).**

| Segment | TN (mg/l) | TP (mg/l) | TN : TP (Weight) | TN : TP (Molar) |
|---|---|---|---|---|
| Dona and Roberts Bays | 0.39 | 0.15 | 2.59 | 5.75 |
| Lemon Bay | | | | |
| Upper Lemon Bay | 0.62 | 0.22 | 2.87 | 6.23 |
| Lower Lemon Bay | 0.69 | 0.11 | 6.45 | 13.87 |
| Charlotte Harbor Proper | | | | |
| West Wall | 0.76 | 0.21 | 3.67 | 8.00 |
| East Wall | 0.67 | 0.17 | 4.06 | 8.72 |
| Bokeelia | 0.50 | 0.09 | 5.73 | 12.29 |
| Cape Haze | 0.68 | 0.12 | 5.47 | 12.53 |
| Tidal Myakka | 0.97 | 0.27 | 3.62 | 7.94 |
| Tidal Peace | 1.07 | 0.42 | 2.58 | 5.63 |
| Pine Island Sound | 0.50 | 0.05 | 9.61 | 22.11 |
| Matlacha Pass | 0.61 | 0.08 | 7.83 | 16.86 |
| Tidal Caloosahatchee | 0.91 | 0.11 | 8.23 | 8.27 |
| San Carlos Bay | 0.52 | 0.06 | 8.38 | 19.17 |
| Estero Bay | 0.53 | 0.06 | 8.25 | 19.53 |

### 4.2.2 Data Analysis Approaches

A data analysis plan was developed previously by Janicki Environmental (2010b). This plan identifies a series of techniques that could be used to estimate statistically defensible relationships between chlorophyll *a* concentrations and nutrient concentrations and/or loadings. These techniques included linear regression, logistic regression, and change point analysis (CPA). These techniques are described in detail in the plan and are summarized below.

### 4.2.2.1 Linear Regression

Linear regression is a parametric statistical technique that is used to explore the relationship between two or more variables. In ordinary least-squares regression, the relationship between the dependent variable (y-axis) and independent variable (x-axis) is developed. This is done by fitting a straight line through the set of points such that the sum of squared residuals of the model is as small as possible. That is to say, the vertical distances between the individual points and the fitted line are minimized.

In linear regression, it is assumed that the data are independent samples from the population that is being sampled. Thus, the data should come from samples that are representative of the spatial and temporal variability of the system. Another important assumption of linear regression is that the error term of the model is normally distributed, with constant variance. Often times, one or more of the variables exhibits a non-linear relationship with the other variables. While there are non-linear regression techniques that can be employed, one should attempt to transform the data before resorting to nonlinear methods. Often, linear relationships can be developed using transformed data and these models will satisfy the assumptions of linear regression.

The independent variables used in the model building process included nutrient loadings, nutrient concentrations, and estimates of residence time. The loadings data included monthly hydrologic, TN and TP loads as well as cumulative total loads from the previous two to six months (e.g., 2-month cumulative TN load = TN load current month + TN load one- month prior). The water quality constituents included TN and TP concentrations along with numerous other water quality constituents.

### 4.2.2.2 Change Point Analysis

In those segments where no distinct linear relationship between chlorophyll *a* and nutrient concentrations or loadings could be identified, a changepoint analysis method was applied. Changepoint analyses were also used to provide an alternative approach to linear regression to identify potential weight-of-evidence conclusions.

The changepoint method employed uses a decision tree approach which has been employed successfully in a previous effort to develop numeric nutrient criteria (Soranno *et al.*, 2008). Decision tree analysis is founded on well-established techniques designed to identify a threshold value corresponding to a non-linear change in a response variable as a function of some independent (predictor) variable. The Conditional Inference tree was implemented using the statistical software package R (R Core Development Team, 2009) to determine threshold values in the chlorophyll *a* – TN relationship. The analysis was performed to identify a potential threshold TN value that was associated with a non-linear increase in chlorophyll *a* concentrations.

Decision tree analysis performs an iterative search through the data sorted in increasing order of TN values to identify a “changepoint” in the relationship that maximizes the difference in chlorophyll *a* concentrations between two groups of data. In this way a threshold value for TN is identified. No *a priori* threshold is specified. The decision tree approach defines the changepoint as that which maximizes the difference by minimizing the p value (Hothorn *et al.*, 2006). The point in the covariate (TN concentration) at which the p value is minimized, after adjustment for multiple comparisons using the Bonferroni correction (Dunn, 1961), is assigned as the changepoint defining the split of the chlorophyll data into 2 groups. These statistical stopping rules eliminate over-fitting that is common in some other types of recursive partitioning algorithms. The approach can be implemented using a continuous response variable (Regression Tree) or nominal variable (Classification Tree). The classification tree approach is similar in construct to the Logistic regression approach though the p values are based on permutation tests and are non-parametric. Once the first split is made the process continues to test for subsequent splits that are conditional on the first split. This is called “conditional inference” or “conditional probability analysis” which has been popularized recently by the EPA as a potential approach for establishing numeric nutrient criteria. Bootstrap methods have not been employed for this analysis to date. If it is decided that results of changepoint analysis are to be used as the final numeric nutrient criteria, it is recommended that bootstrap methods be investigated to insure that the changepoint is robust to the influence of outliers.

# 5.0 DEVELOPMENT OF NUTRIENT CRITERIA

The USEPA is developing numeric nutrient water quality standards for Florida waters, including lakes and flowing waters, and estuarine and coastal waters. The goal of defining numeric nutrient water quality criteria levels for nutrients (i.e., nitrogen and phosphorus) is to protect the designated uses of water bodies as prescribed by the Clean Water Act. The USEPA nutrient criteria guidance recommends development of criteria for both total nitrogen (TN) and total phosphorus (TP) while not precluding the use of alternative causal or response constituents (USEPA, 2009). To this end, the CHNEP has taken steps to develop numeric nutrient criteria for the segments of the CHNEP area.

A flowchart of the overall process used to develop numeric nutrient criteria for the segments of the CHNEP area is presented in Figure 5-1.

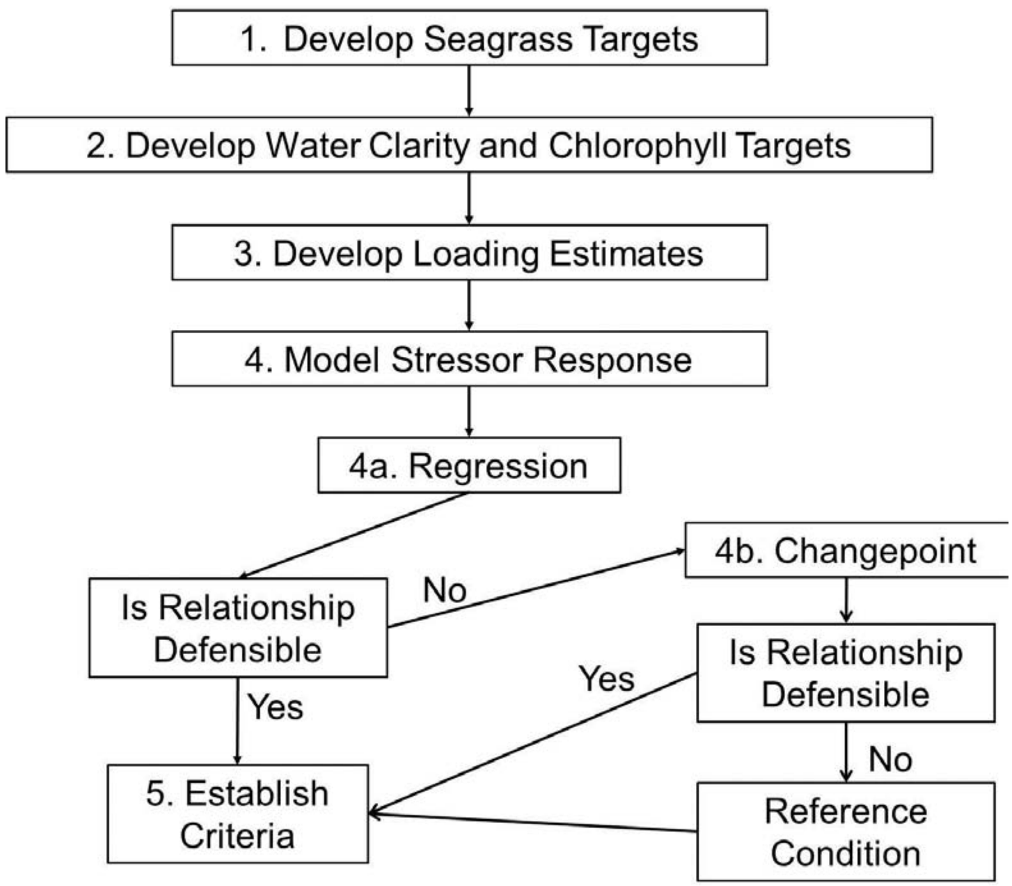



**Figure 5-1. Flowchart of Process Used to Develop Numeric Nutrient Criteria.**

Before stressor-response relationships could be developed between the response (chlorophyll *a*) and stressors (nutrient concentrations, nutrient loads, residence time, etc.), estimates of nutrient loadings were necessary. Therefore, estimates of hydrologic and nutrient loads were developed as part of a previous task (Janicki Environmental, 2010d).

After all estimates of potential stressors and the response (chlorophyll *a* thresholds) were available, the relationships between chlorophyll *a* concentrations and nutrient loads or concentrations were investigated (as per Step 4 in Figure 5-1).

In each subsection of section 5.0, the development of nutrient criteria is described for the individual regions of CHNEP. These "regions" consist of one or more of the segments that have previously been defined for CHNEP. Each subsection contains the following for each region:

- a description of the hydrology,
- a summary of the water quality and loadings,
- a synthesis of available seagrass data,
- a summary of the stressor-response relationships investigated, and
- the candidate numeric nutrient criteria.

## 5.1 Dona and Roberts Bays

The Dona and Roberts Bays segment is comprised of the open water estuary, primarily Dona and Roberts Bay proper (Figure 5-2). The surface area of this segment is approximately 617 acres. The watershed is approximately 61,673 acres, or 96.4 square miles. The watershed to segment water surface ratio is 100 which is high relative to other CHNEP segments.

Dona Bay has three main tributaries, Fox Creek, the Cow Pen Slough Canal, and Salt Creek, which converge in Shakett Creek at the upstream end of Dona Bay. Roberts Bay has two main tributaries, Blackburn Canal/Curry Creek and Hatchett Creek. The Blackburn Canal drains to Curry Creek, which is connected to the eastern end of Roberts Bay. The Blackburn Canal was constructed in the 1950s to provide relief from periodic flooding of the Blackburn property east of the Myakka River. The Blackburn Canal connects Roberts Bay to the Myakka River. Hatchett Creek flows into the Gulf Intracoastal Waterway at the southern end of Roberts Bay (SWFWMD, 2009).

The main tributary to Dona and Roberts Bay is Cow Pen Slough, which drains into Dona Bay. Cow Pen Slough did not always flow into Dona Bay. Analysis of historical surveys shows that Cow Pen Slough once flowed east to the Myakka River (SWFMWD, 2009). However, efforts to curb the flooding that impacted local pastures and rangelands were pursued through a series of hydrologic modifications, which included rerouting Cow Pen Slough from the Myakka River system south and west into Dona Bay (SWFWMD, 2009).


**Figure 5-2.** **Dona and Roberts Bays water segment.**

The alterations to the hydrologic connections have resulted in Dona Bay's watershed area increasing nearly five-fold. The corresponding increase in the amount of freshwater entering the Dona and Roberts Bays system has had significant effects on conditions in the estuary, including increased flushing and circulation above historical conditions (SWFWMD, 2009). Construction of the Cow Pen Slough and Blackburn Canals has led to an increase in the volume of freshwater entering Dona and Roberts Bays and has also altered the timing of freshwater inflows. Construction of the Gulf Intracoastal Waterway and the Venice Inlet has influenced horizontal (longitudinal) and vertical (water column) salinity gradients in the system and exchange with the Gulf of Mexico. The construction of bridges over Dona Bay and Roberts Bay has also altered salinity patterns by restricting longitudinal exchange of water within the estuary (SWFWMD, 2009).

About one-third of the Dona and Roberts Bays watershed is developed and one-fifth of the watershed used for agricultural activities. Approximately 40% of the watershed remains relatively undeveloped, with wetlands and uplands each comprising about one-fifth of the watershed (SWFWMD, 2009).

A measure of residence time in the system is provided by the pulse residence time (PRT), which is estimated as a function of tidal mixing and freshwater inflows, as described previously (Appendix 2). The median PRT for each year was calculated based on monthly data, and then the median PRT of the annual values was calculated, as representative of the median hydraulic residence time given the observed conditions of 1995-2007. The median hydraulic residence time for Dona and Roberts Bays was 17 days, indicating relatively rapid flushing of the system.

### 5.1.1 Dona and Roberts Bays Water Quality and Nutrient Loadings

Time series plots of monthly average chlorophyll *a*, TN, and TP concentrations are presented in Figure 5-3. As can be seen in the plots, there is marked seasonality in nutrient concentrations with highest concentrations observed during the wet season. The monthly average chlorophyll *a* concentrations varied from 0.5 to 33.1 µg/l, and the interquartile range (the difference between the $25^{th}$ and $75^{th}$ percentiles) was 1.8 to 5.8 µg/l. The mean and median chlorophyll *a* concentrations were 4.5 and 3.4 µg/l, respectively. This difference between the mean and median indicates that the mean is influenced by a few high concentration values. Monthly average TN concentrations in Dona and Roberts Bays varied from 0.17 to 1.24 mg/l. The interquartile range was 0.27 to 0.44 mg/l. The mean TN concentration was 0.39 mg/l, while the median was 0.35 mg/l. The monthly average TP concentrations varied from 0.06 to 0.42 mg/l, and the interquartile range was 0.12 to 0.18 mg/l. The mean and median TP concentrations were 0.15 and 0.14 mg/l, respectively. Unlike chlorophyll *a*, the differences between the mean and median for TN and TP were much less as TN and TP do not exhibit the peaks that are sometimes observed in chlorophyll *a* concentrations.

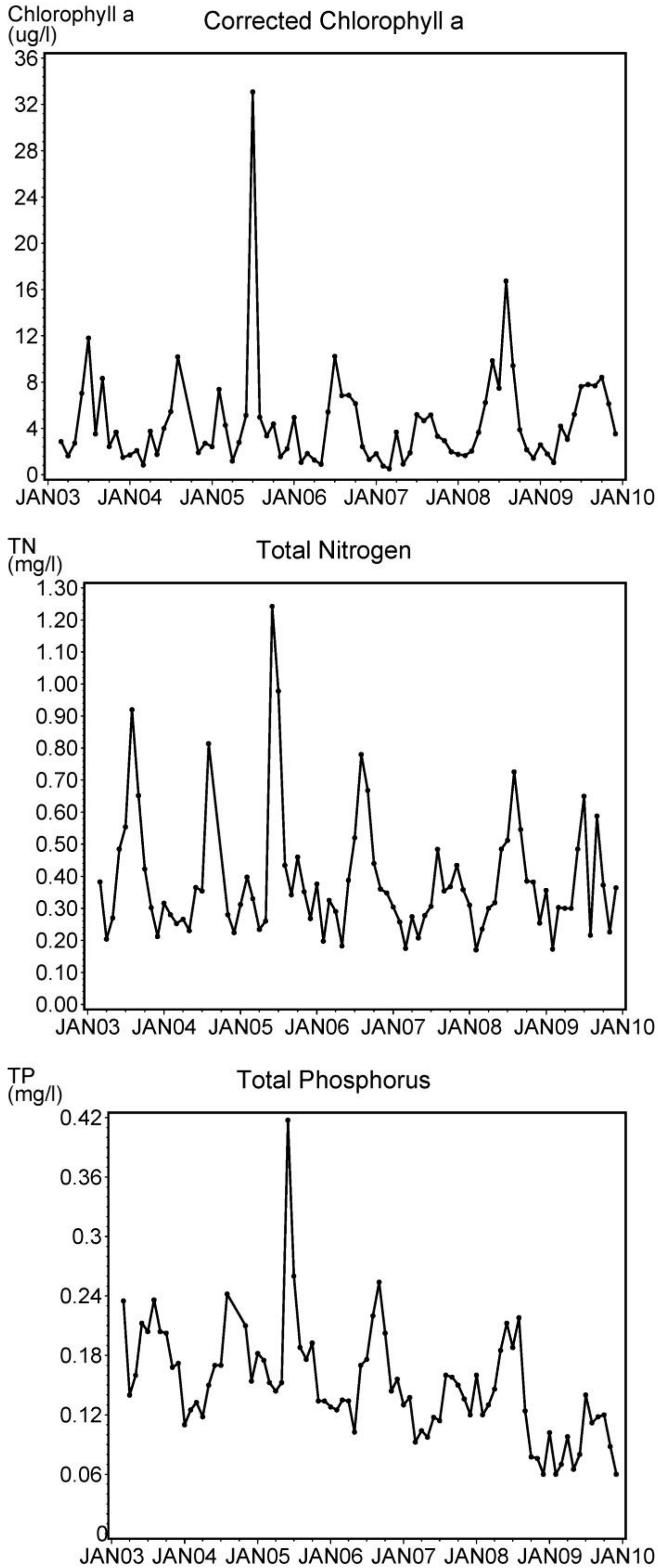



**Figure 5-3. Time series of chlorophyll *a* (top plot), TN (middle plot), and TP (bottom plot) for Dona and Roberts Bays.**

There were no statistically significant trends in chlorophyll *a* or TN concentrations in Dona and Roberts Bays during this period (complete trend test results are presented in Appendix 3). A significant decreasing trend ($p<0.01$) was detected in TP during the period analyzed (1998-2008).

Figure 5-4 presents the time series of monthly TN, TP, and hydrologic loads to Dona and Roberts Bays. The monthly TN loads varied from 0.6 to 104.6 tons/month, and the interquartile range was 2.9 to 20.8 tons/month. The mean and median TN loads were 15.9 and 6.2 tons/month, respectively. Monthly TP loads varied from 0.1 to 20.5 tons/month. The interquartile range was 0.5 to 4.0 tons/month. The mean TP load was 3.0 tons/month, while the median was 1.1 tons/month. The monthly hydrologic loads varied from 0.1 to 64.7 million $m^3$/month, and the interquartile range was 11.2 million $m^3$/month (1.6 to 12.8 million $m^3$/month). The mean and median hydrologic loads were 9.7 and 3.6 million $m^3$/month, respectively. This difference between the mean and median indicates that the mean is highly influenced by a series of high loadings values that are typically seen in the wet season when both hydrologic loads and nutrient loads are elevated. Though increased runoff associated with increased rainfall in the wet season is expected, it is at times magnified in the Dona and Roberts Bays system because there is a structure which is used to control flows into the system from the Cow Pen Slough watershed. Also, as noted in SWFWMD (2009), the historical Dona and Roberts Bays watershed has been significantly altered resulting in more freshwater entering the system currently than had entered the system historically.

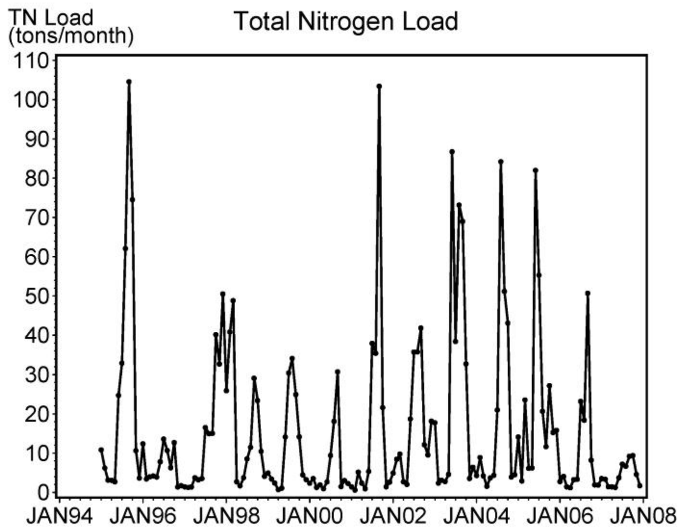
### 5.1.2 Seagrass Target and Chlorophyll Target and Threshold

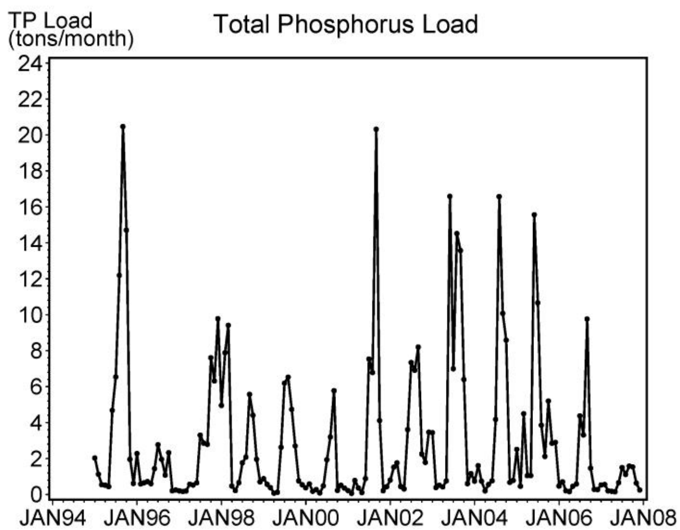
- Seagrass Target

  - The seagrass target for this segment is 112 acres (Janicki Environmental, 2009).
  - Seagrass acreages from 1988-2008 are provided in Figure 5-5.
  - Dona and Roberts Bay is classified as a seagrass “restoration” segment.

- Chlorophyll *a* Target and Threshold

  - Approved method is the Reference Period Method
  - Reference Period = 2003-2007
  - Chlorophyll Target = 4.3 µg/l
  - Standard Deviation of Annual Chlorophyll = 1.2 µg/l
  - Chlorophyll Threshold (mean + ½ SD) = 4.9 µg/l



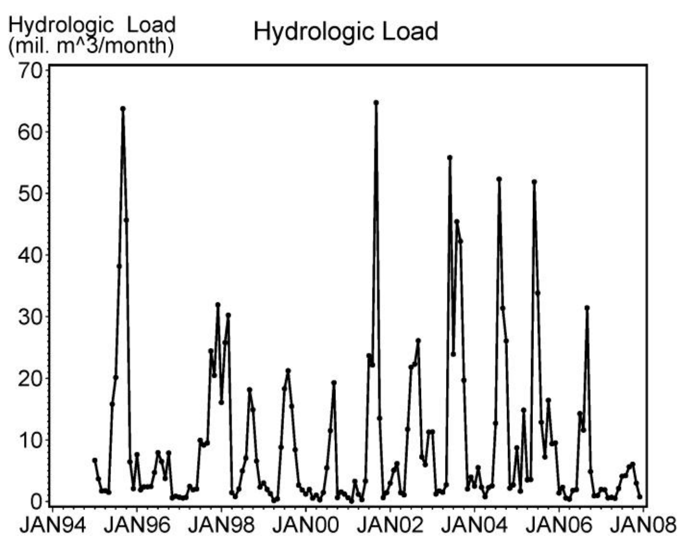




**Figure 5-4. Time series of TN loads (top plot), TP loads (middle plot), and hydrologic loads (bottom plot) for Dona and Roberts Bays.**

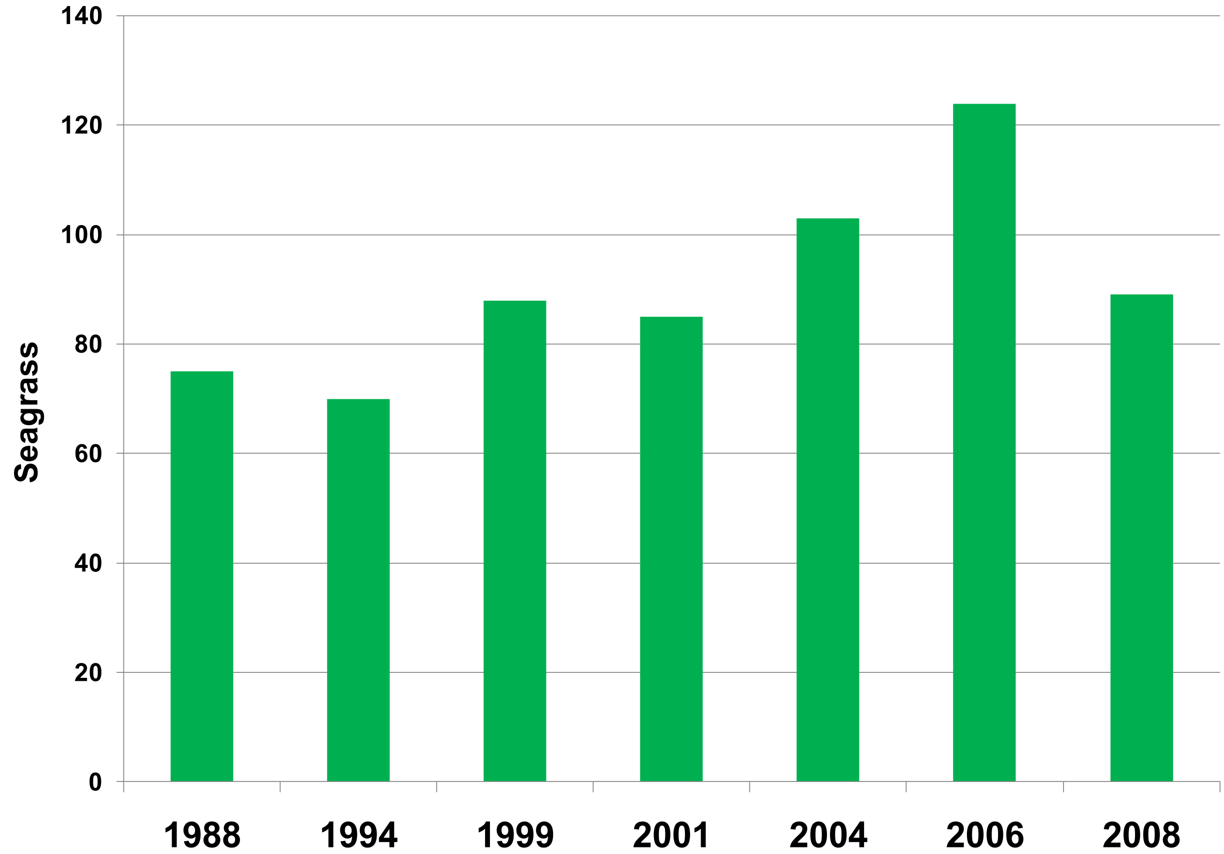



**Figure 5-5.** **Seagrass acreage in Dona and Roberts Bays.**

### 5.1.3 Relationships Between Chlorophyll *a* and Concentrations and Loads

In addition to the time series plots, a series of bivariate plots were examined to investigate relationships between chlorophyll *a* and nutrient loads and concentrations. These plots and a description of the potential relationship developed are included in Appendix 5.1. While a statistically significant relationship was identified between chlorophyll a and TN concentration for Dona and Roberts Bays, a considerable amount of variability was left unexplained by this relationship (Appendix 5.1).

### 5.1.4 Candidate Criterion - Dona and Roberts Bays

Based on discussions with the CHNEP Technical Advisory Committee, there is not sufficient confidence in the use of this regression to develop defensible numeric nutrient criterion due to the amount of variability left unexplained by the regression. Therefore, as described in Figure 5-1, the reference period approach was recommended for developing a TN concentration criterion for Dona and Roberts Bays. As Dona and Roberts Bays is classified as a seagrass “restoration” segment, the TN concentration criterion is calculated by summing the annual mean from the reference period (2003-2007) plus ½ standard deviation (for the period of record). This results in the following TN concentration criterion for Dona and Roberts Bays:

TN criterion = 0.40 mg/l (mean) + ½ * 0.04 (SD) = 0.42 mg/l

A comparison of the candidate numeric TN concentration criterion based on the Reference Period method is presented in Figure 5-6.

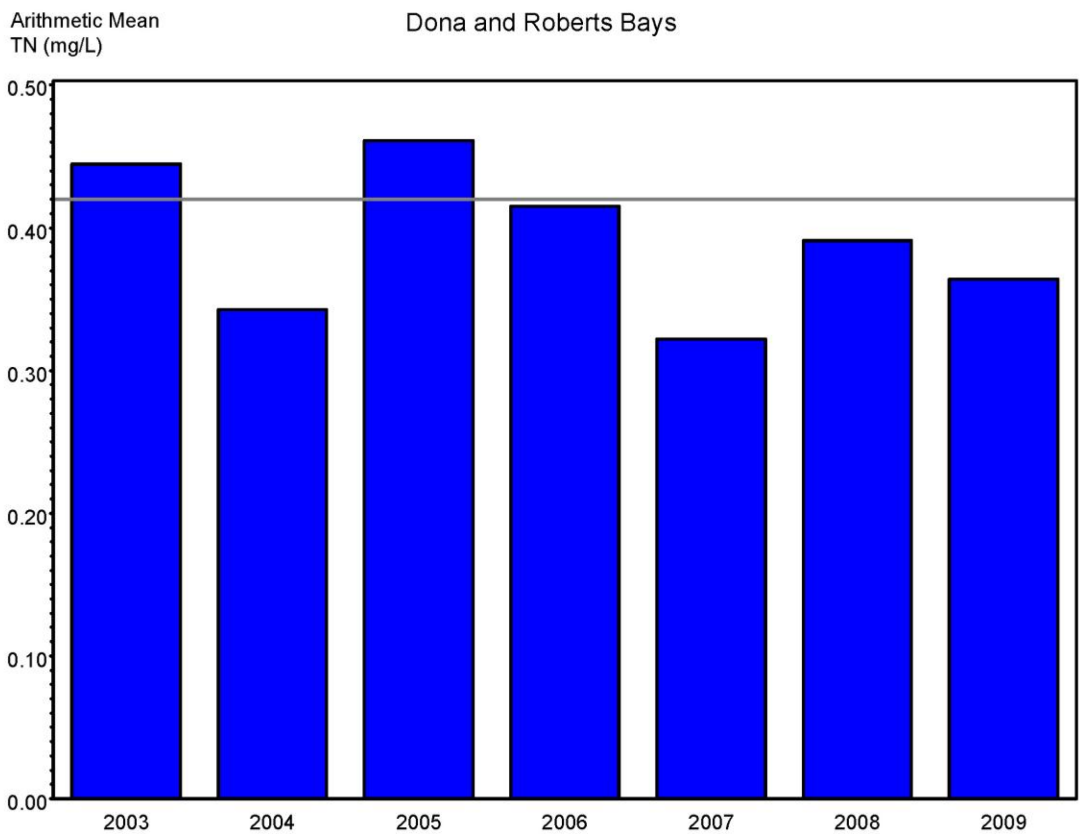



**Figure 5-6. Comparison of the candidate TN criterion to observed TN concentrations (expressed as arithmetic means) in Dona and Roberts Bays.**

## 5.2 Lemon Bay

Lemon Bay has been divided into the Upper and Lower Lemon Bay segments for previous work performed by the CHNEP (Janicki Environmental, 2009). However, CHNEP (2006) and Corbett and Hale (2006) treated Lemon Bay as a single entity for development of light and chlorophyll *a* targets. Because the reference period divided Lemon Bay into Upper and Lower Lemon Bay segments and light and seagrass targets were developed individually for Upper and Lower Lemon Bay, an attempt was made to develop numeric nutrient criteria that are specific to the Upper and Lower Lemon Bay segments.

The Upper Lemon Bay segment is the northernmost portion of Lemon Bay and consists of approximately 2,357 acres of open water (Figure 5-7). The Upper Lemon Bay watershed has approximately 17,676 acres or 27.6 $mi^2$. This results in a watershed to water ratio of 7.5, which is intermediate with respect to other segments. The Upper Lemon Bay segment is hydraulically connected to the north, via the Intracoastal Waterway, to Dona and Roberts Bays (Janicki Environmental, 2010d; Jones Edmunds, 2010). The watershed is primarily urban, with urbanization along the coast and open land and wetlands inland (Janicki Environmental, 2010d).

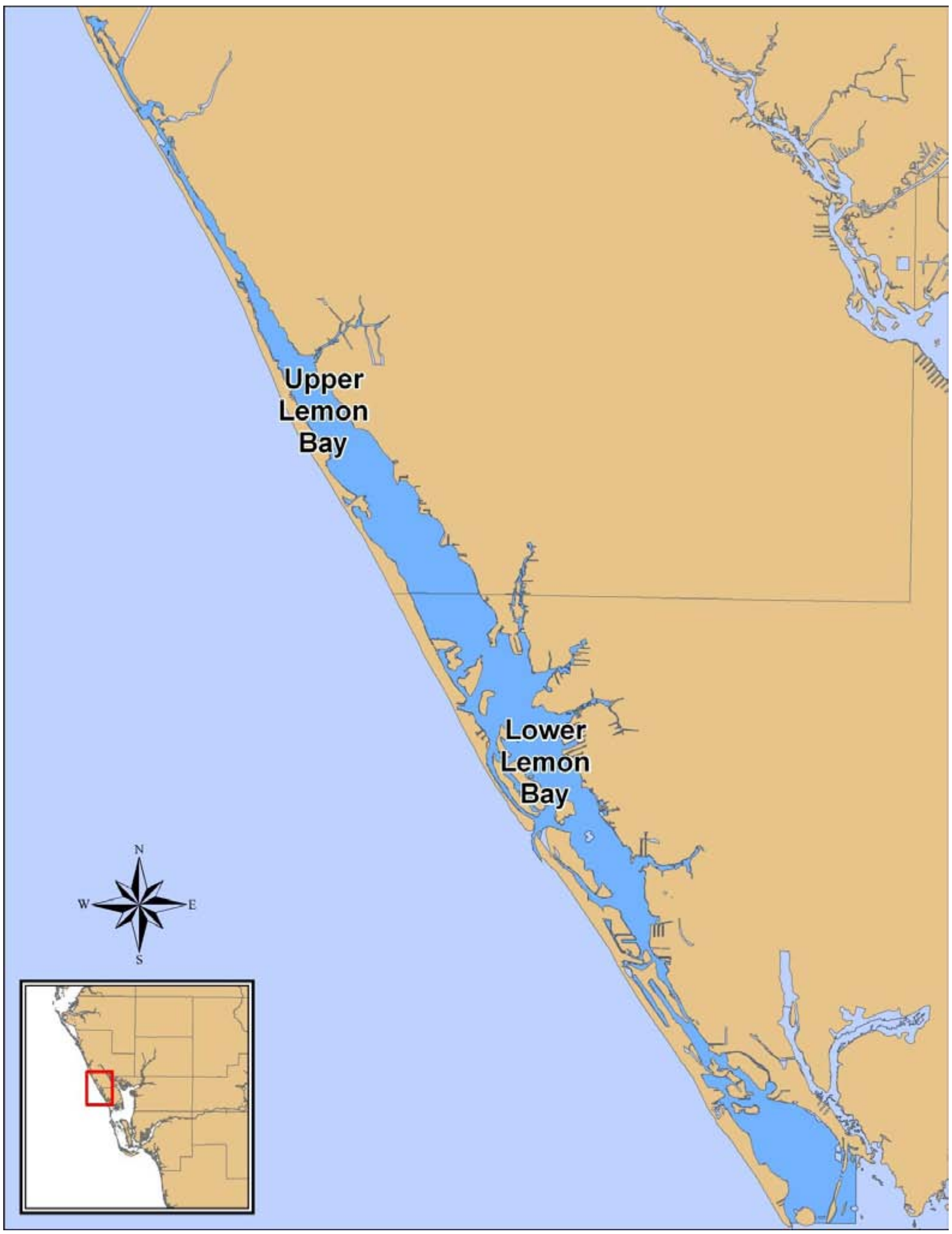



**Figure 5-7. Upper and Lower Lemon Bay water segments.**

A few small tidal creeks drain into Upper Lemon Bay, including Alligator, Woodmere, and Forked Creeks; however, these creeks are not major freshwater inputs. Coastal wetlands supplement the freshwater inflows to Lemon Bay after they have been inundated and yield freshwater flows, as sheetflow, into the estuary.

Lemon Bay is considered a coastal lagoon ecosystem, running parallel to the coastal barrier islands on the west and the Florida mainland shoreline on the east. Lemon Bay has limited connectivity with the Gulf of Mexico to the west, only through a series of passes in between the coastal barrier islands.

Because of the small watershed area with only a few freshwater inflows it can be anticipated that Upper Lemon Bay has a relatively small freshwater inflow. Also, one would expect very limited estuarine circulation to dilute and process pollutant loads because of the limited tidal connectivity.

Lower Lemon Bay is the southernmost portion of Lemon Bay and consists of approximately 4,713 acres of open water (Figure 5-7). The Lower Lemon Bay segment is connected to the south, via the Intracoastal Waterway, with Gasparilla Sound, a primary feature in the Cape Haze segment. Several creeks drain into Lower Lemon Bay, including Ainger, Oyster, and Buck Creeks.

The Lower Lemon Bay watershed's surface area is approximately 34,941 acres, or 54.6 $mi^2$. This results in a watershed to water ratio of 7.4, about the same as Upper Lemon Bay. The northern and eastern portions of the watershed are primary open lands and wetlands, with the urbanized areas along the coast. Although large areas of the upper watershed are in a relatively natural state, significant dredging and channelization has occurred in coastal areas, especially to the south. This would be expected to contribute to higher peak wet season flows, as discussed above.

A significant hydrologic feature in the Lower Lemon Bay watershed is the Rotonda, a closed series of dredged canals within the community of Rotonda West. The canal network of the Rotonda resembles an incomplete circle. The Rotonda is bounded by wetlands to its south. Buck Creek historically drained a portion of the Rotonda but a control structure at the west boundary of the Rotonda now restricts freshwater flow to the west. The capture of freshwater in the hydraulically isolated Rotunda canals has reduced the volume of freshwater entering the estuary from pre-development conditions, which reduces flushing and circulation.

Circulation in Lower Lemon Bay does benefit from Stump Pass, which facilitates tidal flows between the bay and the Gulf of Mexico. Stump Pass is very dynamic inlet. Several flood-tidal deltas in Lemon Bay near the inlet have been stabilized over the years and are covered with extensive seagrasses. Some of the deltaic deposits have become intertidal and are vegetated with mangroves. There is significant southerly longshore drift at Stump Pass that was closing off the inlet and prompted recent dredging.

A measure of residence time in the system is provided by the pulse residence time (PRT), which is estimated as a function of tidal mixing and freshwater inflows, as described previously (see Appendix 2). The median PRT for each year was calculated based on monthly data, and then the median PRT of the annual values was calculated, as representative of the median hydraulic residence time given the observed conditions of 1995-2007. The median hydraulic residence time for Lemon Bay was 248 days, indicating a very low flushing rate for the system.

### 5.2.1 Lemon Bay Water Quality and Nutrient Loadings

Time series plots of monthly average chlorophyll *a*, TN, and TP concentrations in Upper Lemon Bay are presented in Figure 5-8. The monthly average concentration data for Upper Lemon Bay were analyzed for the period 1998 through 2009. The chlorophyll *a* concentrations varied from 0.9 µg/l to 35.3 µg/l, and the interquartile range (the difference between the $25^{th}$ and $75^{th}$ percentiles) was 3.7 to 10.3 µg/l. The mean and median chlorophyll *a* concentrations were 8.5 µg/l and 6.4 µg/l, respectively. This difference between the mean and median indicates that the mean is influenced by a few high concentration values. Monthly average TN concentrations in Upper Lemon Bay varied from 0.11 to 1.23 mg/l. The interquartile range was 0.42 to 0.60 mg/l. The mean TN concentration was 0.53 mg/l, while the median was 0.51 mg/l. The monthly average TP concentrations in Upper Lemon Bay varied from 0.11 to 0.57 mg/l, and the interquartile range was 0.19 to 0.26 mg/l. The mean and median TP concentrations were 0.23 and 0.21 mg/l, respectively. Unlike chlorophyll *a*, the differences between the mean and median for TN and TP were much less as TN and TP do not exhibit the peaks that are sometimes observed in chlorophyll *a* concentrations.

There were no statistically significant trends in TN in Upper Lemon Bay during this period ($p>0.05$) (Appendix 3 presents the complete trend test results). A significant decreasing trend was detected in TP for the period analyzed ($p<0.0001$, slope=-0.005), as well as for chlorophyll *a* ($p<0.0001$, slope=-0.39).

Time series plots of monthly average chlorophyll *a*, TN, and TP concentrations are presented for Lower Lemon Bay in Figure 5-8 as well. The monthly average chlorophyll *a* concentrations varied from 1.3 to 20.0 µg/l, and the interquartile range was 3.5 to 7.7 µg/l. The mean and median chlorophyll *a* concentrations were 6.0 and 5.3 µg/l, respectively. This difference between the mean and median indicates that the mean is influenced by several high concentration values. Monthly average TN concentrations in Lower Lemon Bay varied from 0.03 to 1.59 mg/l. The interquartile range was 0.36 to 0.78 mg/l. The mean TN concentration was 0.58 mg/l, while the median was 0.55 mg/l. The monthly average TP concentrations varied from 0.01 to 1.03 mg/l, and the interquartile range was 0.05 to 0.12 mg/l. The mean and median TP concentrations were 0.11 and 0.07 mg/l, respectively. Unlike chlorophyll *a*, the differences between the mean and median for TN were much less as TN does not exhibit the bloom characteristics often found in chlorophyll *a* concentrations. TP exhibited a large difference between the mean and median due to several high TP concentrations.

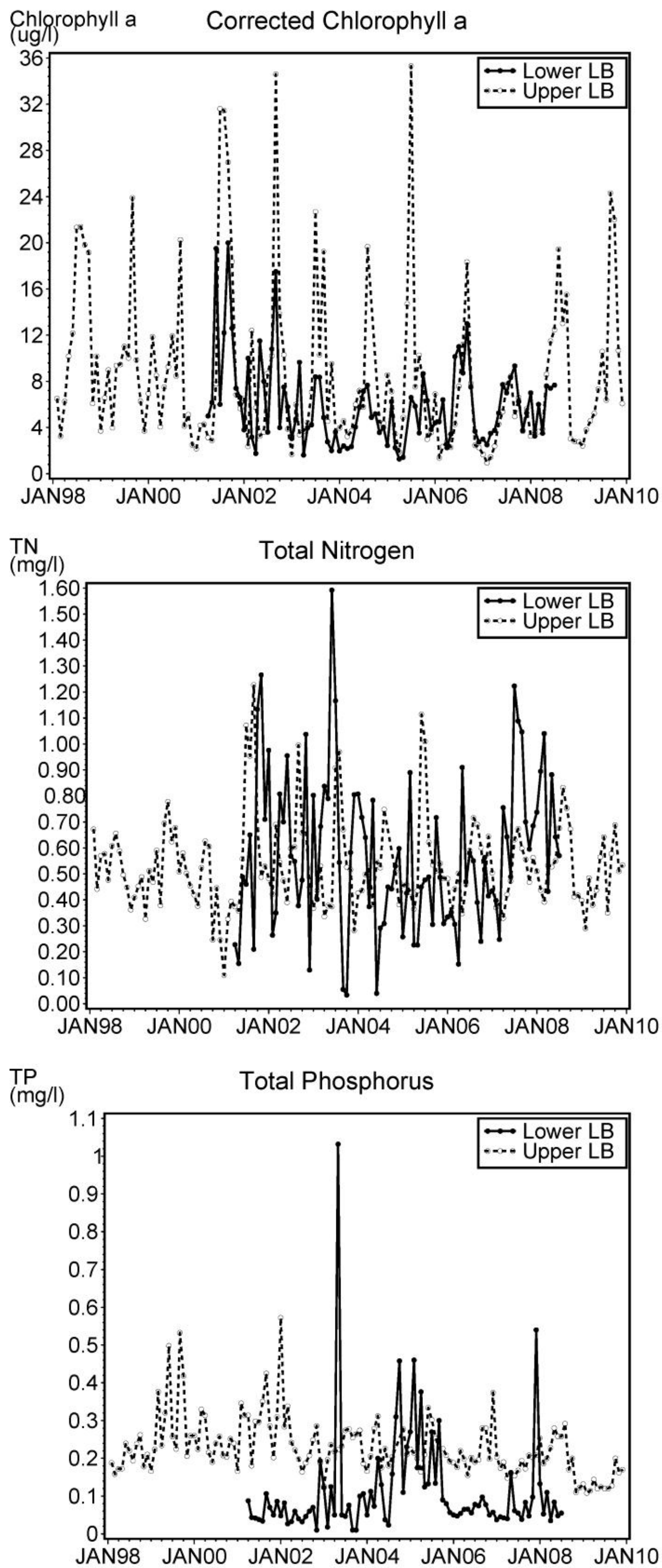



**Figure 5-8.** **Time series of chlorophyll *a* (top plot), TN (middle plot), and TP (bottom plot) for Lemon Bay.**

There were no statistically significant trends in chlorophyll *a*, TN or TP in Lower Lemon Bay during this period ($p>0.05$) (Appendix 3 presents the complete trend test results).

Previous efforts have linked Lemon Bay water quality to loadings to the system and estimated the effects on seagrass extent (Tomasko *et al.*, 2001), Loadings to Upper Lemon Bay were analyzed for the period 1995 through 2007. Figure 5-9 presents the time series of monthly TN, TP, and hydrologic loads to Upper Lemon Bay. The monthly TN loads varied from 0.2 to 36.4 tons/month, and the interquartile range was 1.3 to 7.1 tons/month. The mean and median TN loads to Upper Lemon Bay were 5.6 and 2.8 tons/month, respectively. Monthly TP loads varied from 0.02 to 7.0 tons/month. The interquartile range was 0.2 to 1.3 tons/month. The mean TP load was 1.0 ton/month, while the median was 0.4 tons/month. The monthly hydrologic loads varied from 0.003 to 22.0 million $m^3$/month, and the interquartile range was 4.0 million $m^3$/month (0.9 to 4.9 million $m^3$/month). The mean and median hydrologic loads were 3.8 and 2.2 million $m^3$/month, respectively. This difference between the mean and median indicates that the mean is highly influenced by a series of high loadings values that are typically seen in the wet season when both hydrologic loads and nutrient loads are elevated.

Figure 5-9 also presents the time series of monthly TN, TP, and hydrologic loads to Lower Lemon Bay. The monthly TN loads varied from 0.3 to 48.0 tons/month, and the interquartile range was 1.6 to 10.5 tons/month. The mean and median TN loads to Lower Lemon Bay were 7.8 and 4.2 tons/month, respectively. Monthly TP loads to Lower Lemon Bay varied from 0.04 to 7.75 tons/month. The interquartile range was 0.2 to 1.6 tons/month. The mean TP load was 1.2 tons/month, while the median was 0.5 tons/month. The monthly hydrologic loads varied from 0.03 to 39.2 million $m^3$/month, and the interquartile range was 7.3 million $m^3$/month (1.2 to 8.5 million $m^3$/month). The mean and median hydrologic loads were 6.1 and 3.4 million $m^3$/month, respectively. This difference between the mean and median indicates that the mean is highly influenced by a series of high loadings values that are typically seen in the wet season when rainfall driven hydrologic loads and corresponding nutrient loads are substantially higher than during the dry season.

### 5.2.2 Seagrass Targets and Chlorophyll Targets and Thresholds

- Seagrass Targets
  - The seagrass targets are 1,009 acres for Upper Lemon Bay and 2,882 acres for Lower Lemon Bay (Janicki Environmental, 2009).
  - Seagrass acreages in Upper and Lower Lemon Bay over the 1988-2008 period are provided in Figure 5-10.
  - Upper Lemon Bay is classified as a seagrass “protection” segment, while Lower Lemon Bay is classified as a seagrass “restoration” segment.

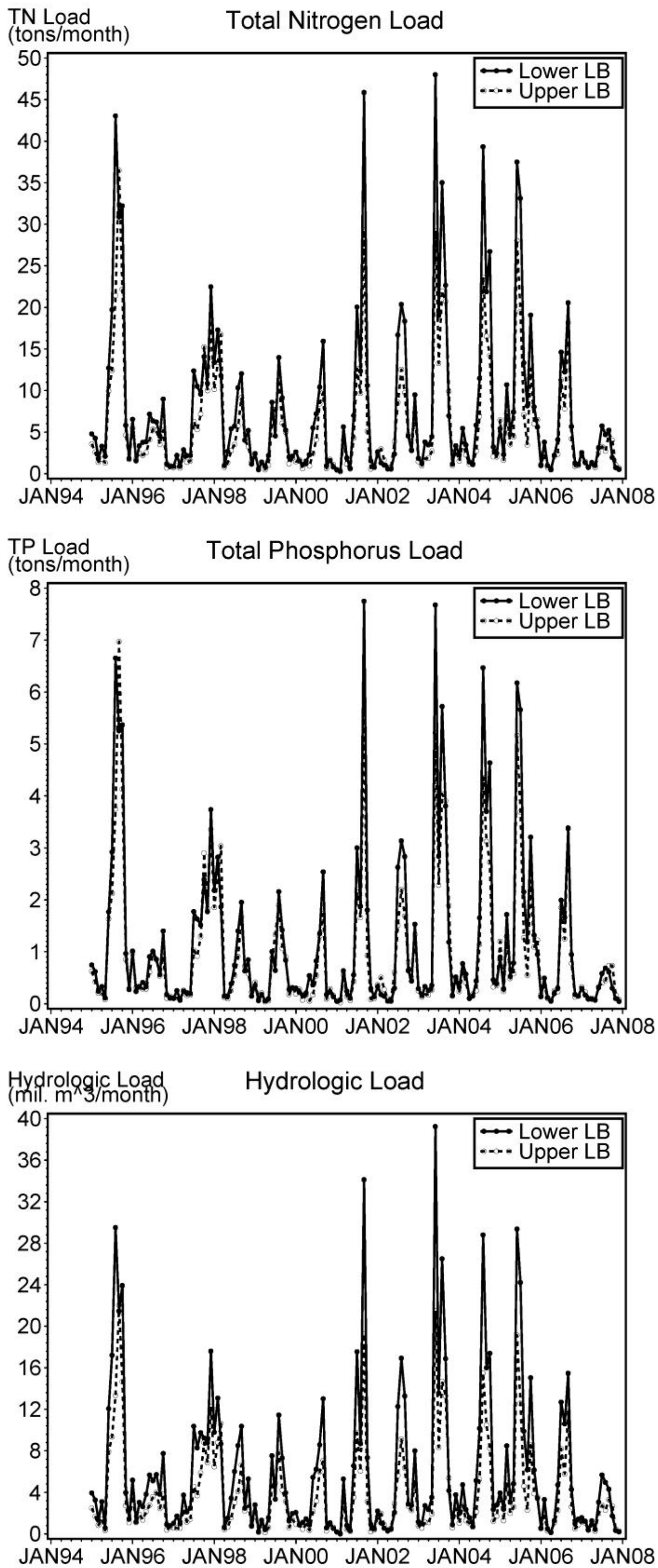



**Figure 5-9. Time series of TN loads (top plot), TP loads (middle plot), and hydrologic loads (bottom plot) for Lemon Bay.**

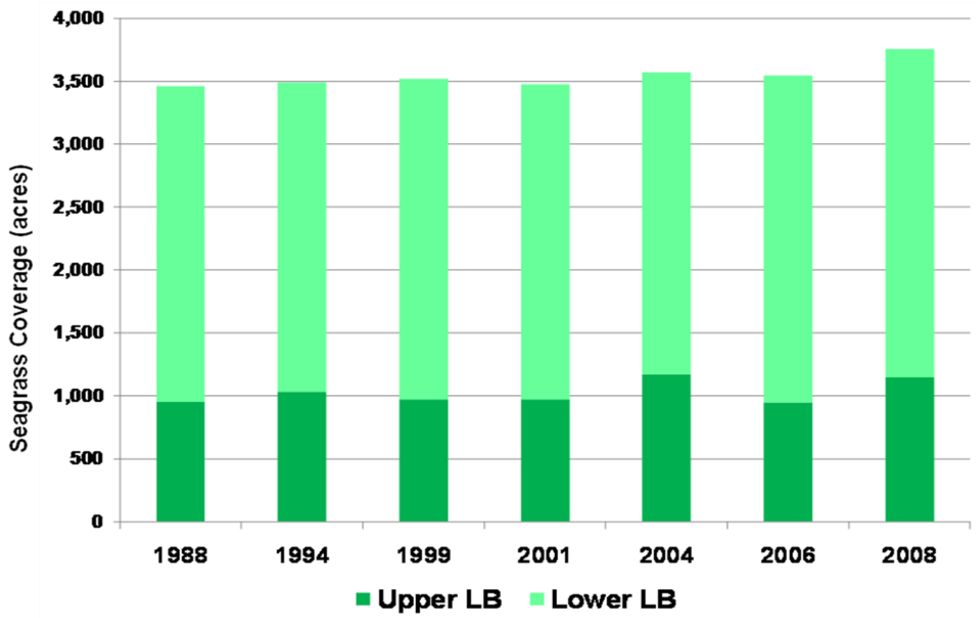



**Figure 5-10. Seagrass acreage in Upper and Lower Lemon Bay.**

- Chlorophyll *a* Target and Threshold Upper Lemon Bay
  - Approved method is the Reference Period Method
  - Reference Period = 2003-2007
  - Chlorophyll Target = 6.7 µg/l
  - Standard Deviation of Annual Chlorophyll = 2.2 µg/l
  - Chlorophyll Threshold (mean + SD) = 8.9 µg/l

- Chlorophyll *a* Target and Threshold Lower Lemon Bay
  - Approved method is the Reference Period Method
  - Reference Period = 2003-2007
  - Chlorophyll Target = 5.1 µg/l
  - Standard Deviation of Annual Chlorophyll = 2.0 µg/l
  - Chlorophyll Threshold (mean + ½ SD) = 6.1 µg/l

### 5.2.3 Relationship Between Chlorophyll *a* and Concentrations and Loads - Lemon Bay

In addition to the time series plots, a series of bivariate plots were examined to investigate relationships between chlorophyll *a* and nutrient loads and concentrations. These plots and a description of the potential relationship developed are included in Appendix 5.2. Although a statistically significant relationship was identified between chlorophyll a and TN concentration for Upper Lemon Bay, this relationship left a considerable amount of variability unexplained (Appendix 5.2). No statistically significant relationship was identified for Lower Lemon Bay.

### 5.2.4 Candidate Criteria – Lemon Bay

Based on discussions with the CHNEP Technical Advisory Committee, there is not sufficient confidence in the Upper Lemon Bay regression to develop defensible numeric nutrient criterion due to the amount of variability left unexplained by the regression. Therefore, as described in Figure 5-1, the reference period approach was recommended for developing TN concentration criteria for Upper and Lower Lemon bays. As Upper Lemon Bay is classified as “protection” for seagrass, the TN concentration criterion is calculated by summing the annual mean from the reference period (2003-2007) plus one standard deviation (for the period of record):

TN criterion = 0.52 mg/l (mean) + 0.04 (SD) = 0.56 mg/l

Lower Lemon Bay is classified as a seagrass “restoration” segment, therefore the TN concentration criterion is calculated by summing the annual mean from the reference period (2003-2007) plus ½ standard deviation (for the period of record):

TN criterion = 0.56 mg/l (mean) + ½ * 0.12 (SD) = 0.62 mg/l

A comparison of the candidate numeric TN concentration criteria for Upper and Lower Lemon bays based on the Reference Period method are presented in Figure 5-11 and Figure 5-12, respectively.

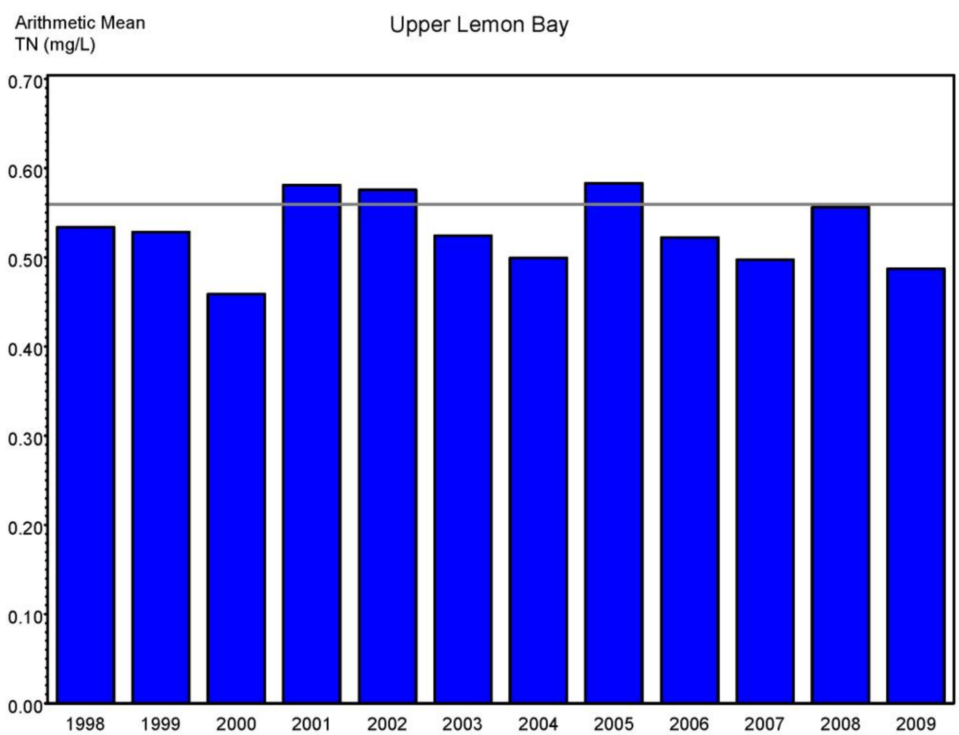



**Figure 5-11. Comparison of the candidate TN criterion to observed TN concentrations (expressed as arithmetic means) in Upper Lemon Bay.**

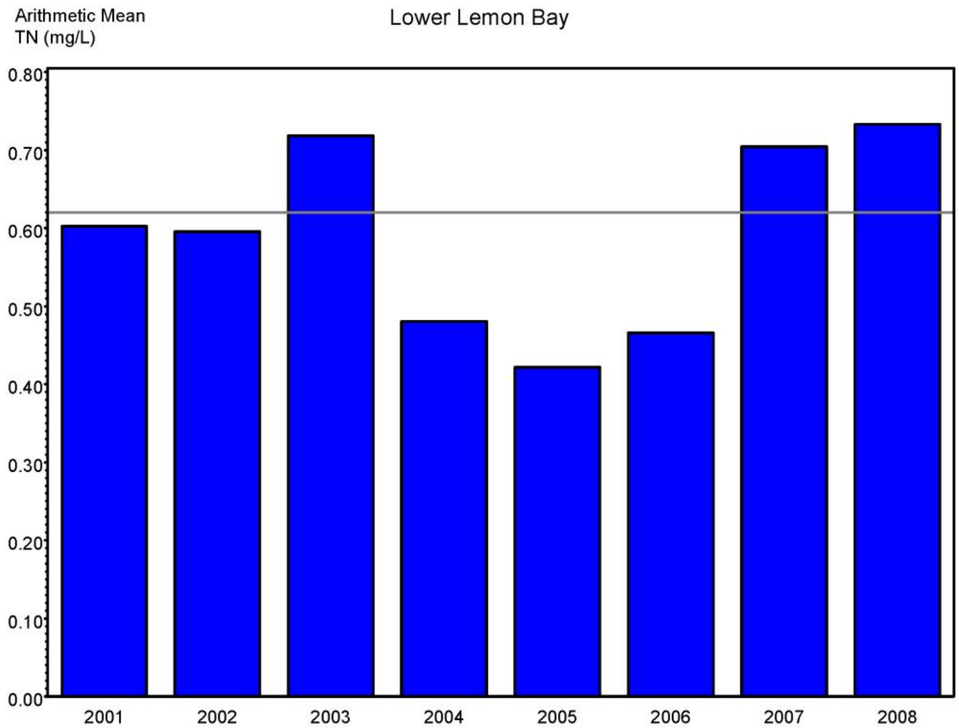



**Figure 5-12. Comparison of the candidate TN criterion to observed TN concentrations (expressed as arithmetic means) in Lower Lemon Bay.**

## 5.3 Charlotte Harbor Proper

The segments of Charlotte Harbor proper (Figure 5-13; West Wall, East Wall, Bokeelia, and Cape Haze) have been grouped, producing an average water quality condition for Charlotte Harbor Proper. With regard to loadings to Charlotte Harbor Proper, this area of the harbor is influenced by the loads from the Tidal Peace and Tidal Myakka rivers. Therefore, loadings for Charlotte Harbor Proper were calculated by adding together the estimated loadings to the Tidal Peace, Tidal Myakka, West Wall, East Wall, Bokeelia, and Cape Haze.

Charlotte Harbor proper consists of the four segments: Cape Haze, Bokeelia, West Wall, and East Wall. The Cape Haze segment includes the northwest open water portion of Charlotte Harbor proper and Gasparilla Sound, and is approximately 13,106 acres (Figure 5-14). It is bounded on the west by coastal barrier islands and Lower Lemon Bay. The surface area of the Cape Haze watershed is approximately 19,402 acres, or 30.3 $mi^2$. This results in a watershed to water ratio of 1.5, which is fairly low compared to other segments.

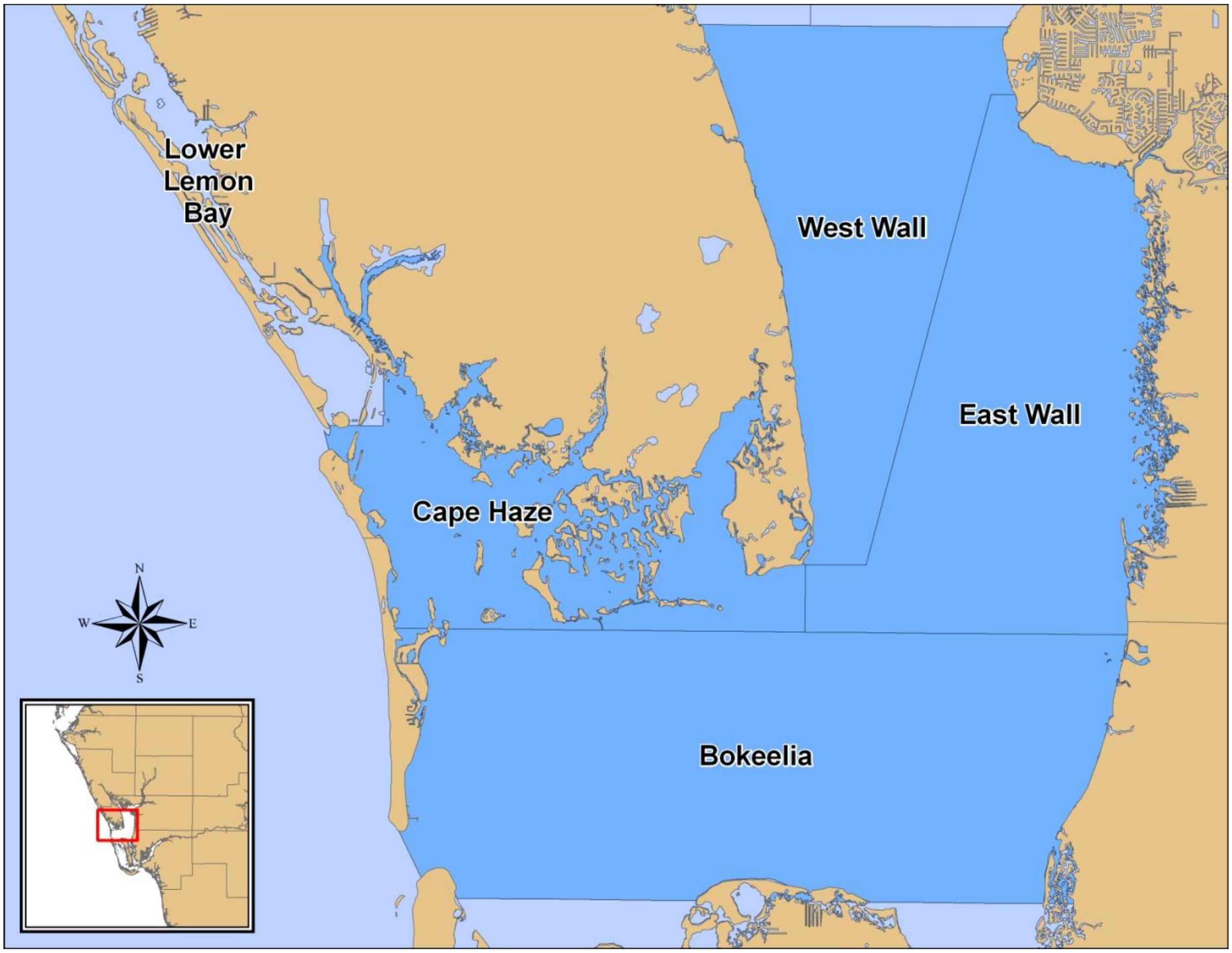


**Figure 5-13. Charlotte Harbor Proper water segments.**

The Cape Haze watershed does not have any major freshwater inputs to Charlotte Harbor or Gasparilla Sound. Coral Creek, in the northwest portion of the Cape Haze watershed, historically drained a portion of the Rotonda. However, a dam was constructed across the creek just south of the southern boundary of the development, greatly restricting freshwater flow into the estuary. The majority of the land cover within the watershed is classified as wetlands. The primary source for freshwater inputs to the Gasparilla Sound estuary is direct precipitation and sheet flow from the coastal wetlands. The watershed of Cape Haze is predominantly wetlands, with some open lands in the northern portions (Janicki Environmental, 2010d).

Water quality in Gasparilla Sound is profoundly influenced by tidal interaction with the Gulf of Mexico. The sound opens into Charlotte Harbor near its mouth at Boca Grande Pass, and strong currents flush the sound daily with water from the gulf and Charlotte Harbor. Therefore, controlling pollutant loadings to areas with larger contributing watersheds will have a great influence on water quality in the sound.


**Figure 5-14. Cape Haze water segment.**

The Bokeelia segment contains the lower portion of the Charlotte Harbor estuary (Figure 5-15). The open water portion of the segment (33,331 acres) is much larger than its direct watershed, which is approximately 16,172 acres, or 25.3 mi². This results in a watershed to water ratio of 0.5, making inflows from the watershed largely insignificant on a regional level.

Bokeelia is bounded on the west by coastal barrier islands between the estuarine portion of Charlotte Harbor and the Gulf of Mexico and to the south by a narrow strip of northern Pine Island. The Bokeelia watershed lacks major hydrologic features, and receives freshwater from a series of small tidal creeks and man-made canals along its eastern shore, as well as direct precipitation. Land use in the watershed is predominantly open lands and wetlands (Janicki Environmental, 2010d).

This portion of Charlotte Harbor is a major mixing zone, where freshwater from the upper bay watershed mixes with salt water from the Gulf of Mexico. Major sources of freshwater include the Peace River, and water from the Caloosahatchee River that has mixed with estuarine waters in Matlacha Pass.

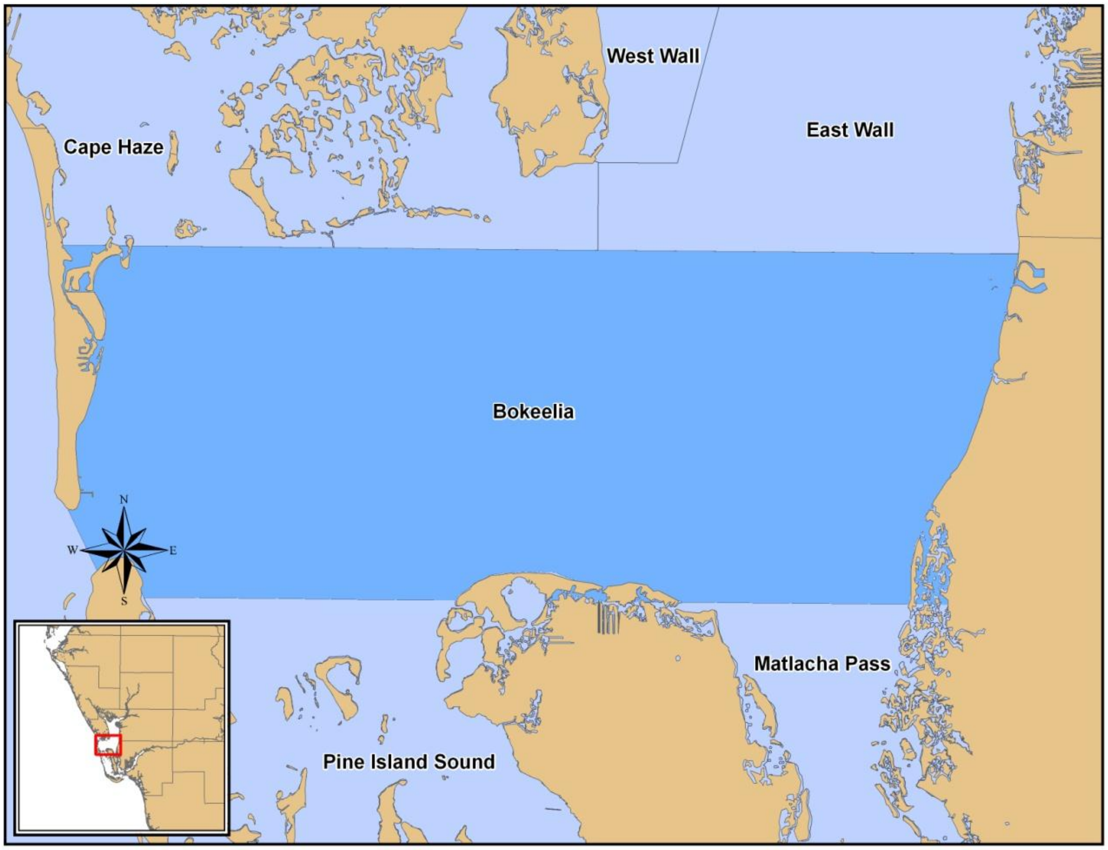



**Figure 5-15.** **Bokeelia water segment.**

The West Wall segment includes a significant portion of northern Charlotte Harbor (Figure 5-16). The Tidal Myakka River and Tidal Peace River segments flow into the West Wall segment from the north. The open water area of the segment is approximately 16,701 acres, while the watershed is approximately 4,579 acres, or 7.2 mi². This results in a watershed to water ratio of 0.3, making inflows from the watershed relatively insignificant on a regional basis.

The West Wall watershed is characterized by small tidal creeks on its western shore and the man-made canals of the Punta Gorda Isles community on its eastern shore. The western portion of the watershed is largely covered in coastal wetlands, resulting in freshwater inflow patterns that mirror those of its westerly neighbor, Cape Haze. A small amount of urbanized lands is on the eastern shore (Janicki Environmental, 2010d). This portion of Charlotte Harbor is also a major mixing zone, where freshwater from the northern Charlotte Harbor watershed (Tidal Peace and Tidal Myakka) mixes with salt water from the Gulf of Mexico.

Direct freshwater inflows to this segment from the tributary area are very small compared to inflows to the estuary from adjoining segments, especially the Tidal Peace and Myakka Rivers. Circulation and flushing are good in the estuary due to the high river inflows and connection to the open water harbor.

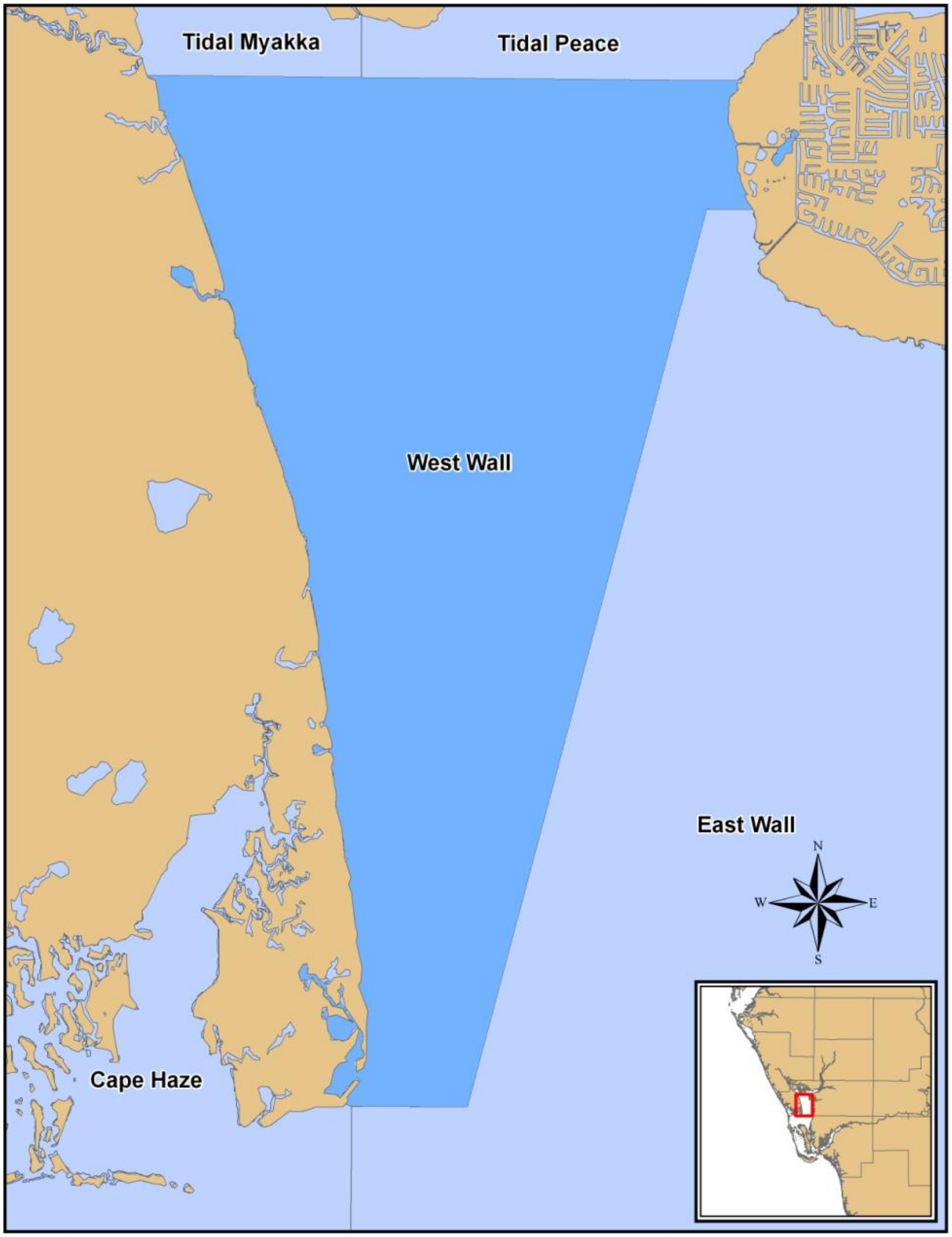



**Figure 5-16. West Wall water segment.**

The East Wall segment contains the eastern half of northern Charlotte Harbor (Figure 5-17). It is bordered on its west by the West Wall and to its south by Bokeelia. The East Wall segment proper is approximately 21,910 acres. Its watershed is approximately 61,349 acres (95.8 $mi^2$). This results in a watershed to open water area ratio of 2.8, relatively low compared to other segments in the CHNEP area.

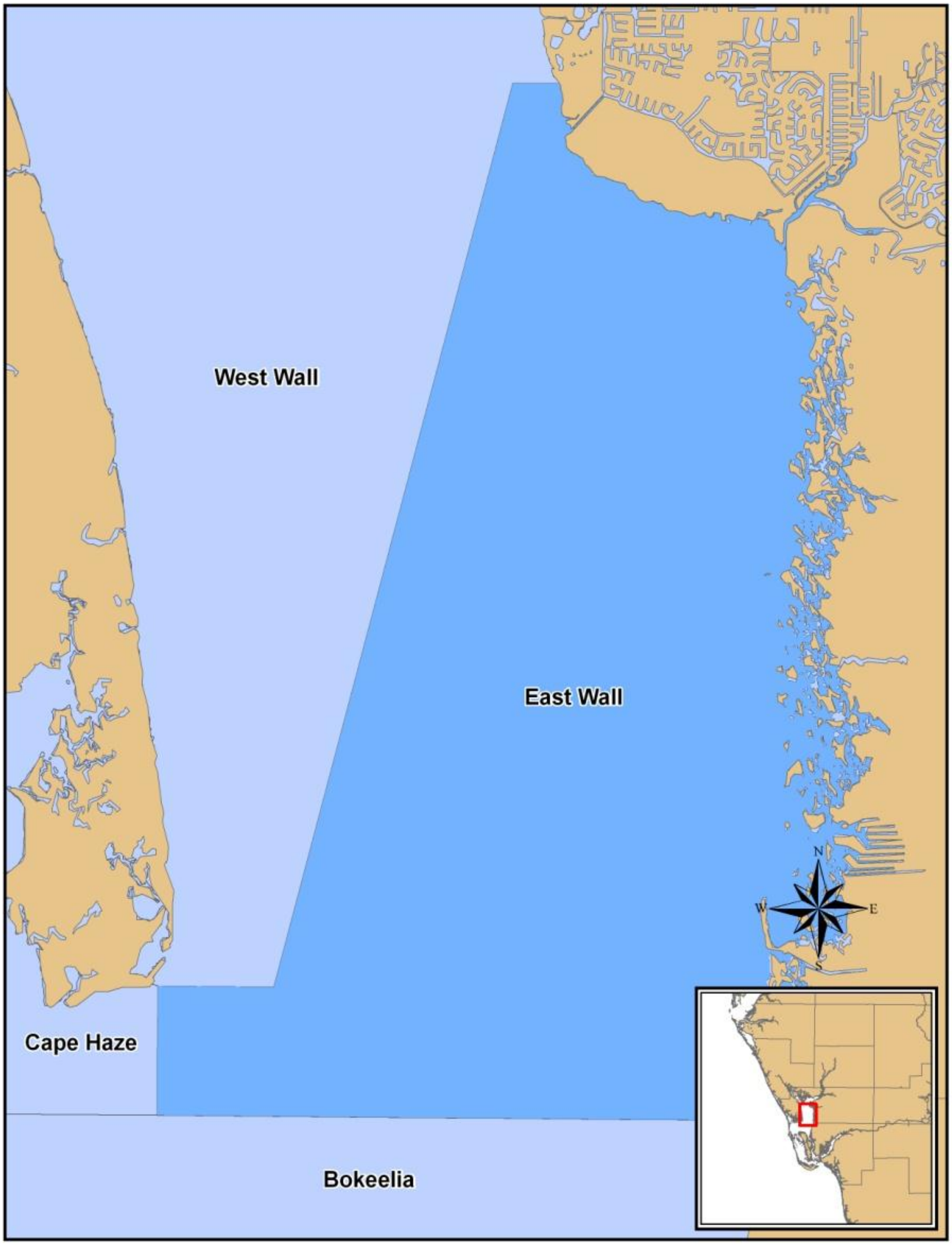



**Figure 5-17. East Wall water segment.**

In its northern portions, the East Wall watershed contains the City of Punta Gorda, which has an extensive network of canals serving its residential developments. Similarly, man-made canals of the Burnt Store community exist along the southern shore of East Wall, albeit on a smaller scale. In between these two communities are coastal wetlands, where water levels are augmented by natural tidal streams as well as some additional man-made canals flowing from the east.

Circulation in Charlotte Harbor Proper is driven by tidal exchange through Boca Grande Pass, at the western end of Bokeelia, and freshwater inflows from the Peace and Myakka rivers. Net transport in the northern portion of the Harbor is southward fresher water transport along the West Wall, and northward saltier water transport along the East Wall (Zheng and Weisberg, 2004). This can result in relatively large horizontal salinity gradients across the Harbor, with high variability.

A measure of residence time in the system is provided by the pulse residence time (PRT), which is estimated as a function of tidal mixing and freshwater inflows, as described previously (see Appendix 2). The median PRT for each year was calculated based on monthly data, and then the median PRT of the annual values was calculated, as representative of the median hydraulic residence time given the observed conditions of 1995-2007. The median hydraulic residence time for Upper Harbor (West Wall and East Wall) was 299 days, indicating a relatively low flushing rate for the upper portion of Charlotte Harbor Proper, but was 104 days for the Lower Harbor (Cape Haze and Bokeelia), indicative of the more rapid flushing given the proximity to the Gulf.

### 5.3.1 Charlotte Harbor Proper Water Quality and Nutrient Loadings

Time series plots of monthly average chlorophyll *a*, TN, and TP concentrations are presented in Figure 5-18. Monthly average concentration data for Charlotte Harbor Proper were analyzed for the period 2001 through 2008. The chlorophyll *a* concentrations varied from a low of 1.6 µg/l to a high of 30.4 µg/l. The 25$^{th}$ and 75$^{th}$ percentile chlorophyll *a* concentrations were 3.3 and 7.7 µg/l, resulting in an interquartile range of 4.4 µg/l. The mean chlorophyll *a* concentration was 6.4 µg/l and the median was 4.9 µg/l. The mean is influenced by several high concentration values. The monthly average TN concentrations varied from 0.15 to 1.58 mg/l. The interquartile range was 0.30 mg/l (0.45 to 0.75 mg/l). The mean TN concentration was 0.63 mg/l, while the median was 0.61 mg/l. The monthly average TP concentrations in Charlotte Harbor Proper varied from 0.05 to 0.47 mg/l, and the interquartile range was 0.13 mg/l (0.08 to 0.21 mg/l). The mean and median TP concentrations were 0.15 and 0.12 µg/l, respectively. As expected, the differences between the mean and median for TN and TP were much less as TN and TP do not show the inter-annual variability exhibited by chlorophyll *a* concentrations.

There were no statistically significant trends in chlorophyll *a*, TN or TP in Charlotte Harbor Proper during this period ($p>0.05$) (Appendix 3 presents the complete trend test results).

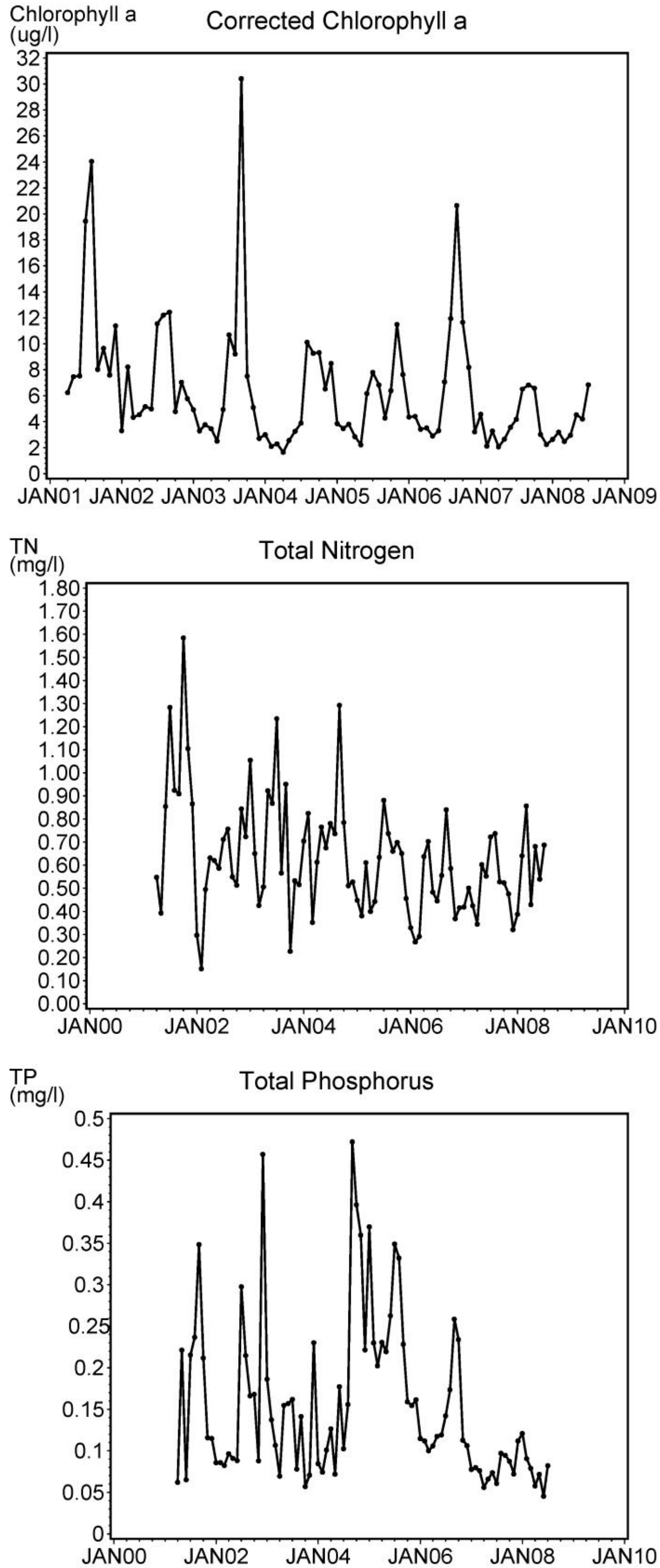



**Figure 5-18. Time series of chlorophyll *a* (top plot), TN (middle plot), and TP (bottom plot) for Charlotte Harbor Proper.**

Figures 5-19 presents the times series of monthly TN, TP, and hydrologic loads to Charlotte Harbor Proper. The monthly TN loads varied from 14.2 to 2212.4 tons/month, with an interquartile range of 374.2 tons/month (84.6 to 458.8 tons/month). The mean and median TN loads to Charlotte Harbor Proper were 375.9 and 183.1 tons/month, respectively. Monthly TP loads varied from 2.2 to 757.1 tons/month. The interquartile range for TP loads was 123.2 tons/month (23.3 to 146.5 tons/month). The mean TP load was 127.7 tons/month, while the median was 61.8 tons/month. The monthly hydrologic loads varied from a low of 6.7 million $m^3$/month to a high of 1441.5 million $m^3$/month. The interquartile range was 274.2 million $m^3$/month (58.5 to 332.7 million $m^3$/month). The mean and median hydrologic loads were 266.6 and 138.2 million $m^3$/month, respectively. These differences between the means and medians are a sign that the means are highly influenced by a series of high loadings values that are typically seen in the wet season when rainfall driven hydrologic loads and corresponding nutrient loads are substantially higher than during the dry season.

### 5.3.2 Seagrass Target and Chlorophyll Target and Threshold

- Seagrass Targets
  - The seagrass targets is 16,344 acres (West Wall=2,106 acres, East Wall=3,898 acres, Cape Haze=6,998, Bokeelia=3,342 acres) (Janicki Environmental, 2009).
  - Seagrass acreages in Charlotte Harbor over the 1988-2008 period are provided in Figure 5-20.
  - Cape Haze and Bokeelia are classified as seagrass “protection” segments, while West Wall and East Wall are classified as seagrass “restoration” segments. In order to be conservative, Charlotte Harbor Proper was classified as seagrass “restoration”.

- Chlorophyll *a* Target and Threshold
  - Approved method is the Reference Period Method
  - Reference Period = 2003-2007
  - Chlorophyll Target = 4.9 µg/l
  - Standard Deviation of Annual Chlorophyll = 2.4 µg/l
  - Chlorophyll Threshold (mean + ½ SD) = 6.1 µg/l

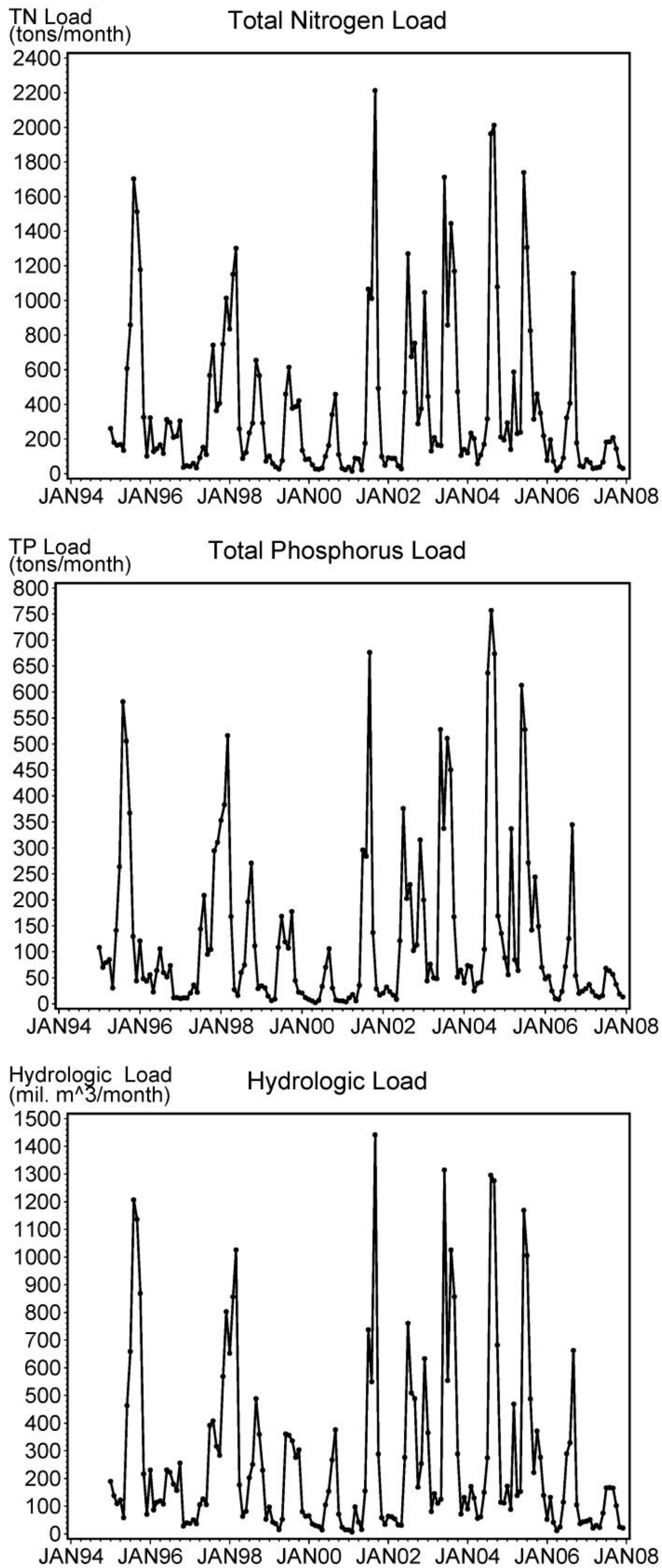



**Figure 5-19. Time series of TN loads (top plot), TP loads (middle plot), and hydrologic loads (bottom plot) for Charlotte Harbor Proper.**

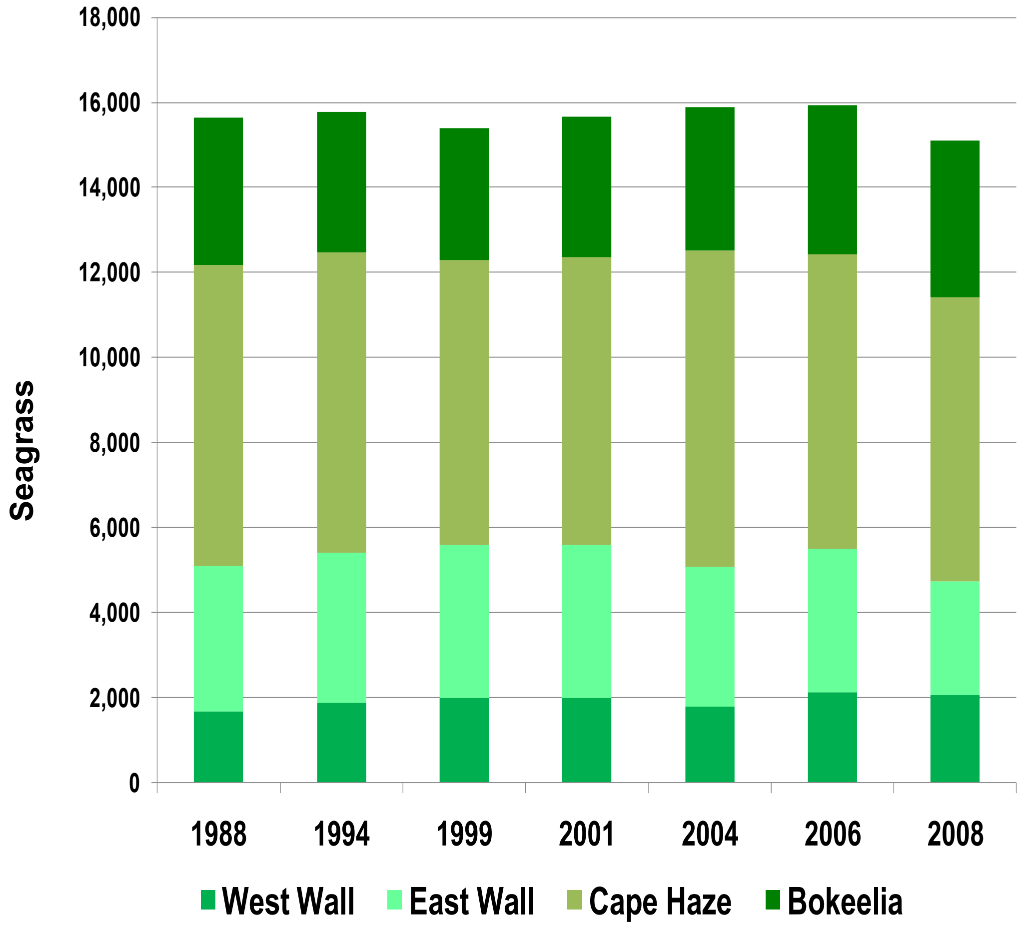



**Figure 5-20. Seagrass acreage in Charlotte Harbor Proper.**

### 5.3.3 Relationship Between Chlorophyll *a* and Concentrations and Loads – Charlotte Harbor Proper

In addition to the time series plots, a series of bivariate plots were examined to investigate relationships between chlorophyll *a* and nutrient loads and concentrations. These plots and a description of the relationship developed are included in Appendix 5.3. Although the regression analysis produced a significant relationship, the amount of variation explained by the regression was quite low. Therefore, changepoint analysis was also investigated (Appendix 5.3).

### 5.3.4 Candidate Criteria – Charlotte Harbor Proper

Based on discussions with the CHNEP Technical Advisory Committee, there is not sufficient confidence in the Charlotte Harbor Proper regression or changepoint analysis to develop a defensible numeric nutrient criterion. Therefore, as described in Figure 5-

1, the reference period approach was recommended for developing a TN concentration criterion for Charlotte Harbor Proper. As Charlotte Harbor Proper is classified as "restoration" for seagrass, the TN concentration criterion is calculated by summing the annual mean from the reference period (2003-2007) plus ½ standard deviation (for the period of record):

TN criterion = 0.60 mg/l (mean) + ½ * 0.14 (SD) = 0.67 mg/l

A comparison of the candidate numeric TN concentration criteria for Charlotte Harbor Proper based on the Reference Period method is presented in Figure 5-21.

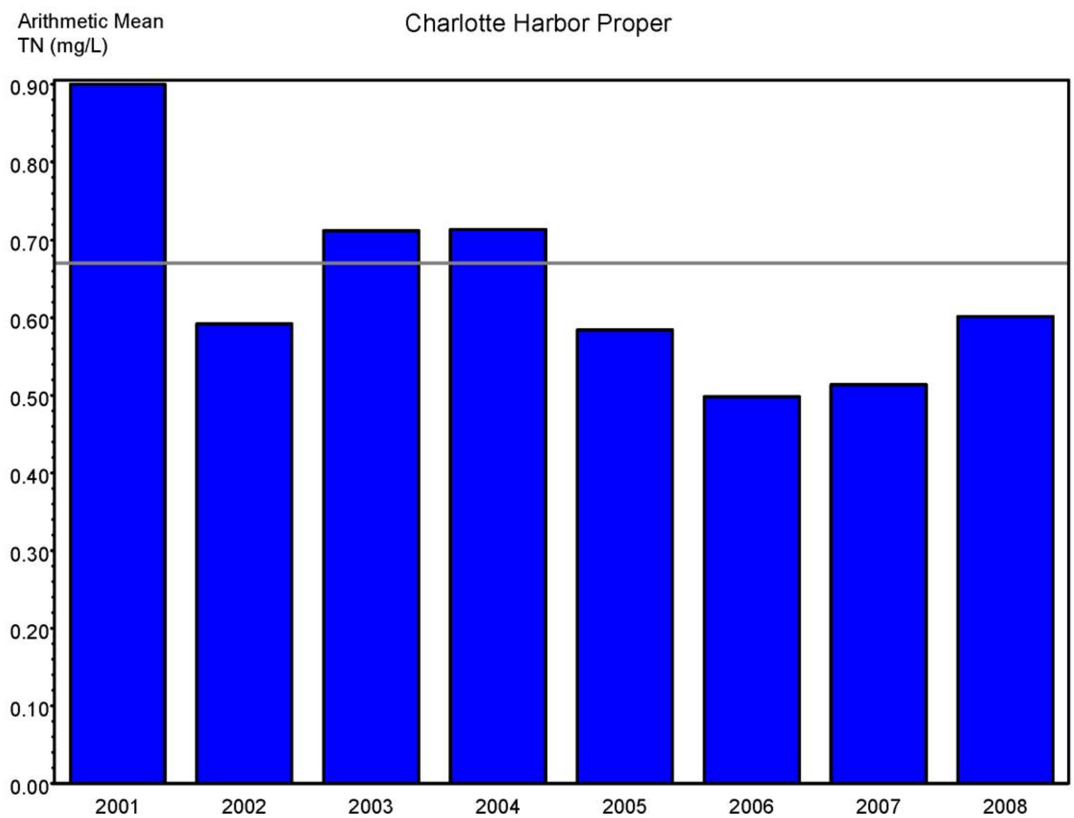



**Figure 5-21. Comparison of the candidate TN criterion to observed TN concentrations (expressed as arithmetic means) in Charlotte Harbor Proper.**

## 5.4 Tidal Myakka

The Tidal Myakka River segment includes the mouth of the Myakka River (Figure 5-22). The Myakka River proper drains into Charlotte Harbor at its northern end, with an approximate segment open water surface area of 7,055 acres. In relation to the segment proper, the Tidal Myakka River watershed is large, at approximately 385,866 acres, or 603 mi². This results in a watershed to open water area ratio of 55, high compared to most others in the CHNEP area and generating relatively high runoff per rainfall unit area.


**Figure 5-22. Tidal Myakka water segment.**

The dendritic Myakka River is a regionally large river that is a significant source of freshwater inflow to the Charlotte Harbor estuary. It flows southwest nearly 66 miles from its source at Myakka Head to Charlotte Harbor (SWFWMD, 2005). Major tributaries to the Myakka River include Big Slough and Deer Prairie Creek. The hydrology of Myakka River is influenced by the Flatford Swamp, which is located immediately upstream from the USGS flow gage on the Myakka River at Myakka City, as well as the extensive freshwater wetlands in the basin. A number of small creeks have their confluence with the Myakka River at Flatford Swamp, which functions to slow the movement of the water in the system, leading to higher evapotranspiration and groundwater influx rates. Although the Myakka River watershed is relatively large with respect to others in the CHNEP and has experienced some stream channelization, the numerous wetlands help to moderate peak flows to the receiving waters. Agricultural irrigation has been identified as contributing to river flows (SWFWMD, 2005). The vast majority of the Tidal Myakka River watershed is natural land, as open lands and wetlands can be observed throughout the drainage basin, particularly in its central reaches. Urbanization is most predominant in the southern portion of the watershed, where the City of North Port is located. Agriculture is a major land use in the northern portion of the watershed, with some mining also observed (Janicki Environmental, 2010d).

A measure of residence time in the system is provided by the pulse residence time (PRT), which is estimated as a function of tidal mixing and freshwater inflows, as described previously (see Appendix 2). The median PRT for each year was calculated based on monthly data, and then the median PRT of the annual values was calculated, as representative of the median hydraulic residence time given the observed conditions of 1995-2007. The median hydraulic residence time for Tidal Myakka was 232 days, indicating a relatively slow flushing rate for the system.

### 5.4.1 Tidal Myakka Water Quality and Nutrient Loadings

Time series plots of monthly average chlorophyll *a*, TN, and TP concentrations are presented in Figure 5-23. The chlorophyll *a* concentrations varied from a low of 1.1 µg/l to a high of 27.9 µg/l. The 25$^{th}$ and 75$^{th}$ percentile chlorophyll *a* concentrations were 5.4 and 9.7 µg/l, resulting in an interquartile range of 4.3 µg/l. The mean chlorophyll *a* concentration was 8.3 µg/l and the median was 7.2 µg/l. The mean is influenced by several high concentration values. The monthly average TN concentrations varied from 0.37 to 2.29 mg/l. The interquartile range was 0.40 mg/l (0.72 to 1.12 mg/l). The mean TN concentration was 0.95 mg/l, while the median was 0.90 mg/l. The monthly average TP concentrations in Tidal Myakka varied from 0.01 to 0.85 mg/l, and the interquartile range was 0.11 mg/l (0.20 to 0.21 mg/l). The mean and median TP concentrations were 0.27 and 0.25 mg/l, respectively. As expected, the differences between the mean and median for TN and TP were much less as TN and TP do not show the inter-annual variability exhibited by chlorophyll *a* concentrations.

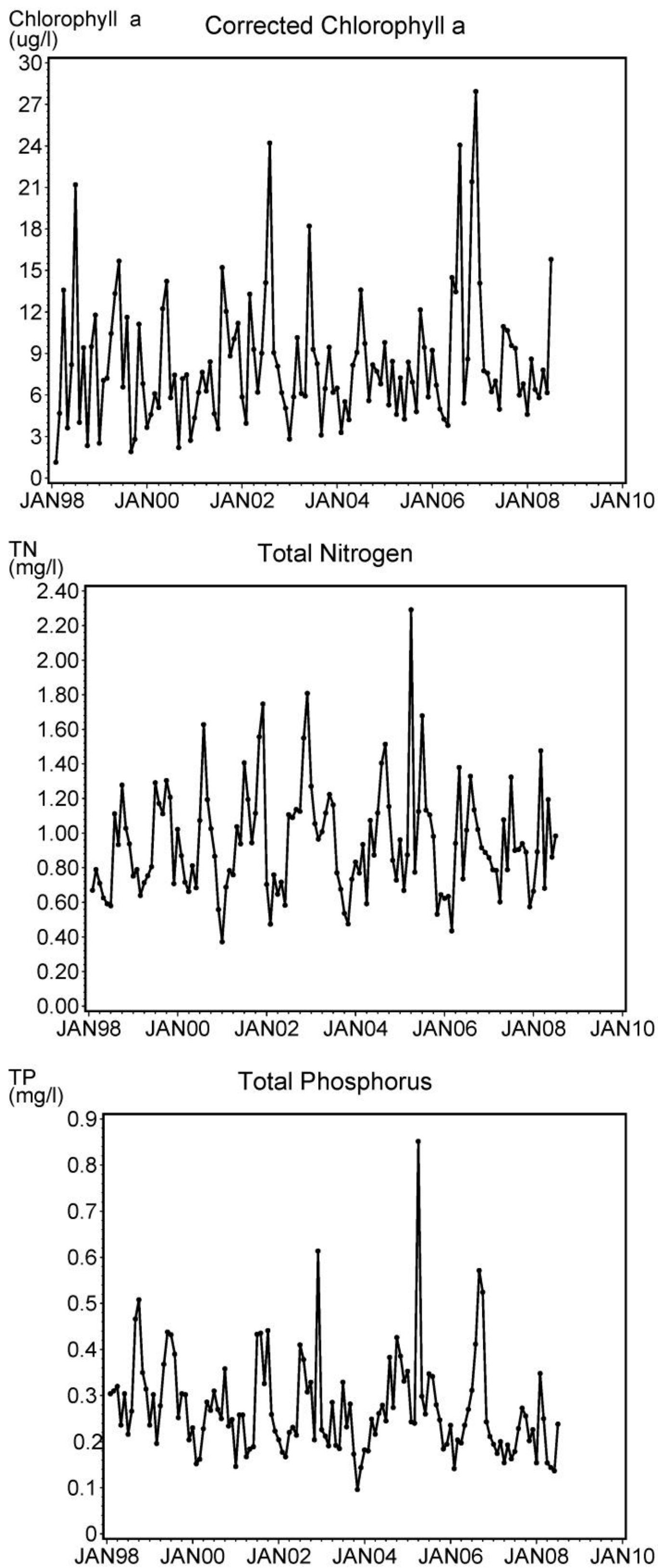



**Figure 5-23. Time series of chlorophyll *a* (top plot), TN (middle plot), and TP (bottom plot) for Tidal Myakka.**

There were no statistically significant trends in chlorophyll *a*, TN or TP in Tidal Myakka during this period ($p>0.05$) (Appendix 3 presents the complete trend test results).

Figure 5-24 presents the time series of monthly TN, TP, and hydrologic loads to Tidal Myakka. The monthly TN loads varied from 2.4 to 520.6 tons/month, with an interquartile range of 83.3 tons/month (12.5 to 95.8 tons/month). The mean and median TN loads to Tidal Myakka were 73.2 and 31.2 tons/month, respectively. Monthly TP loads varied from 0.2 to 146.5 tons/month. The interquartile range for TP loads was 20.3 tons/month (2.4 to 22.7 tons/month). The mean TP load was 18.5 tons/month, while the median was 7.1 tons/month. The monthly hydrologic loads varied from a low of 0.8 million $m^3$/month to a high of 384.8 million $m^3$/month. The interquartile range was 62.7 million $m^3$/month (9.5 to 72.2 million $m^3$/month). The mean and median hydrologic loads were 55.3 and 24.6 million $m^3$/month, respectively. These differences between the means and medians are a sign that the means are highly influenced by a series of high loadings values that are typically seen in the wet season when rainfall driven hydrologic loads and corresponding nutrient loads are substantially higher than during the dry season.

### 5.4.2 Seagrass Target and Chlorophyll Target and Threshold

- Seagrass Target
  - The seagrass target for this segment is 456 acres (Janicki Environmental, 2009).
  - Seagrass acreages from 1988-2008 are provided in Figure 5-25.
  - Tidal Myakka is classified as a seagrass “protection” segment.

- Chlorophyll *a* Target and Threshold
  - Approved method is the Reference Period Method
  - Reference Period = 2003-2007
  - Chlorophyll Target = 4.9 µg/l (target or Charlotte Harbor Proper)
  - Standard Deviation of Annual Chlorophyll = 2.4 µg/l
  - Chlorophyll Threshold (mean + SD) = 7.3 µg/l (threshold for Charlotte Harbor Proper under protection)

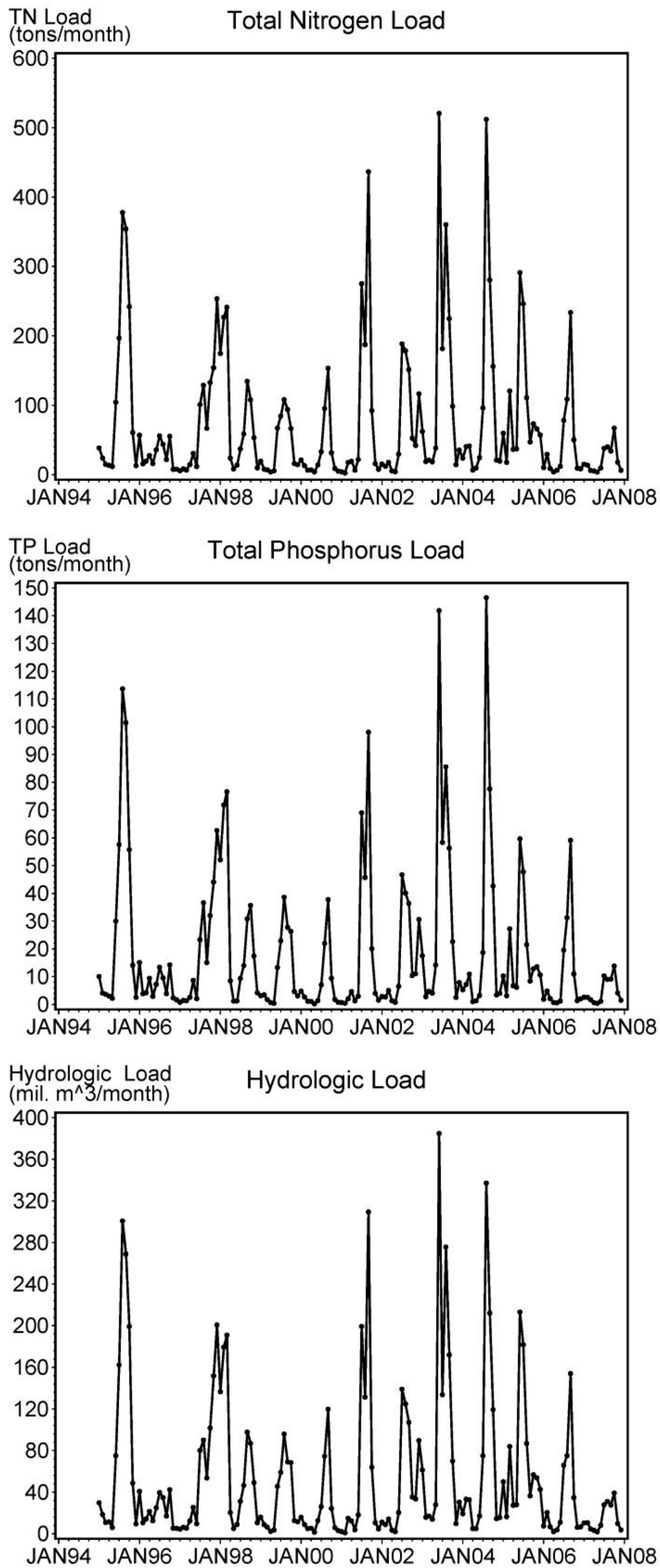



**Figure 5-24. Time series of TN loads (top plot), TP loads (middle plot), and hydrologic loads (bottom plot) for Tidal Myakka.**

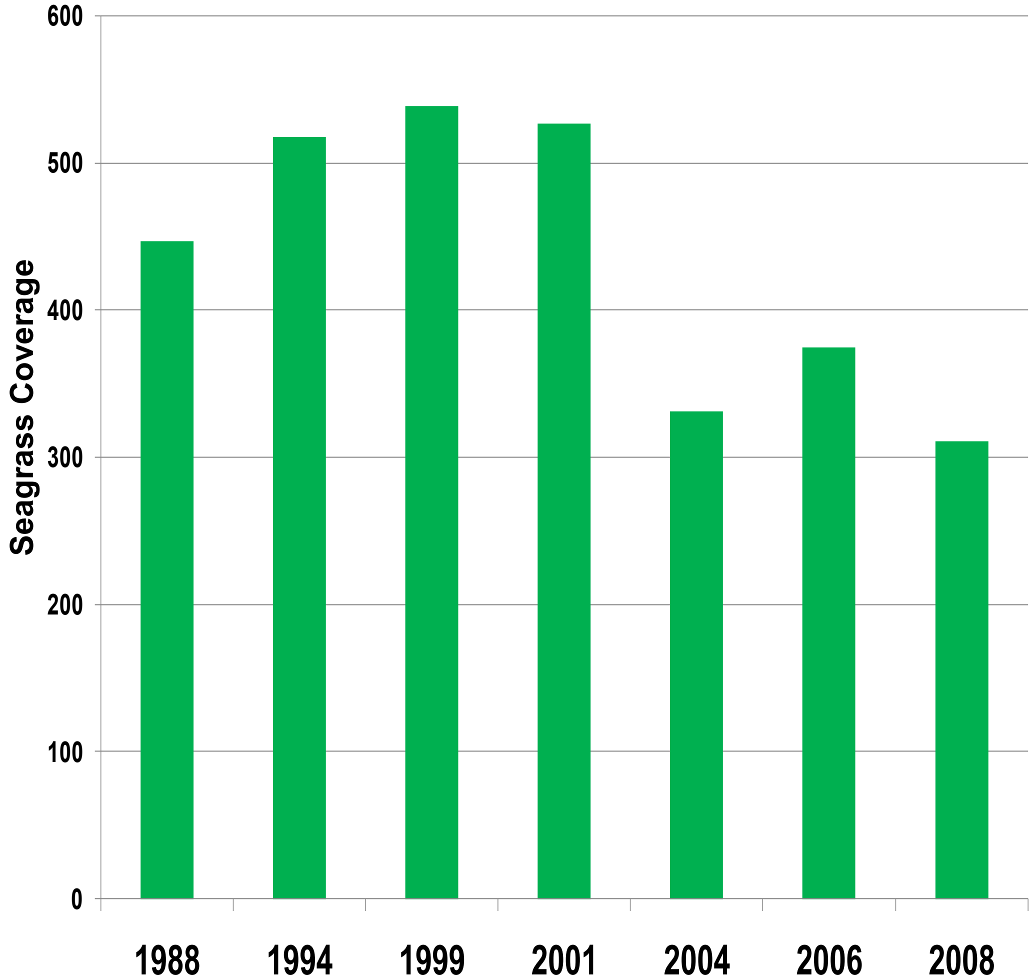



**Figure 5-25. Seagrass acreage in Tidal Myakka.**

### 5.4.3 Relationship Between Chlorophyll *a* and Concentrations and Loads - Tidal Myakka

In addition to the time series plots, a series of bivariate plots were examined to investigate relationships between chlorophyll *a* and nutrient loads and concentrations. No statistically defensible relationships were found for Tidal Myakka chlorophyll *a* concentrations and other water quality parameters or loadings in Tidal Myakka. Therefore, a downstream compliance area was investigated. This included using the average chlorophyll a concentration for Charlotte Harbor Proper and loading and concentrations from Tidal Myakka (Appendix 5.4). A statistically significant relationship was found between Charlotte Harbor chlorophyll concentrations and Tidal Myakka TN loads, however the relationship was weak. Lastly, changepoint analysis was also investigated (Appendix 5.4).

### 5.4.4 Candidate Criteria – Tidal Myakka

Based on discussions with the CHNEP Technical Advisory Committee, there is not sufficient confidence in the Tidal Myakka changepoint analysis to develop a defensible numeric nutrient criterion. Therefore, as described in Figure 5-1, the reference period approach was recommended for developing a TN concentration criterion for Tidal Myakka. As the segment is classified as "protection" for seagrass, the TN concentration criterion is calculated by summing the annual mean from the reference period (2003-2007) plus one standard deviation (for the period of record):

TN criterion = 0.95 mg/l (mean) + 0.07 (SD) = 1.02 mg/l

A comparison of the candidate numeric TN concentration criteria for Tidal Myakka based on the Reference Period method is presented in Figure 5-26.

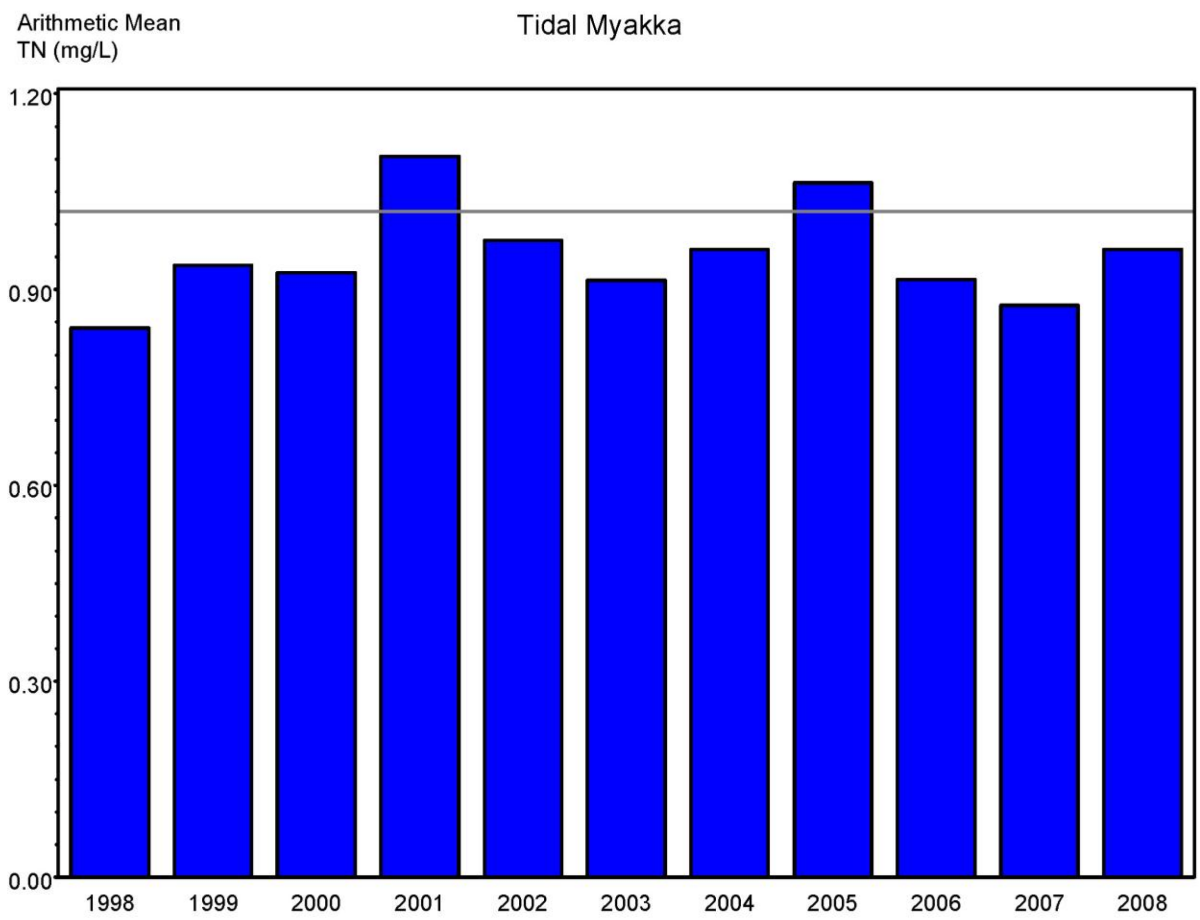



**Figure 5-26. Comparison of the candidate TN criterion to observed TN concentrations (expressed as arithmetic means) in Tidal Myakka.**

## 5.5 Tidal Peace

The Tidal Peace River segment defines the mouth of the Peace River, the largest tributary of the CHNEP watershed (Figure 5-27). The segment proper is comprised of the estuarine portion of the Peace River and Shell Creek. It has an open water surface area of approximately 12,894 acres and is connected to Charlotte Harbor at its southern boundary. Its watershed has a surface area of approximately 1,477,486 acres or 2,308 $mi^2$, which is the largest of all of the 14 segment watersheds in the study area. This results in a watershed to open water area ratio of 114, the highest ratio compared to others in the CHNEP area and generating high runoff per rainfall unit.

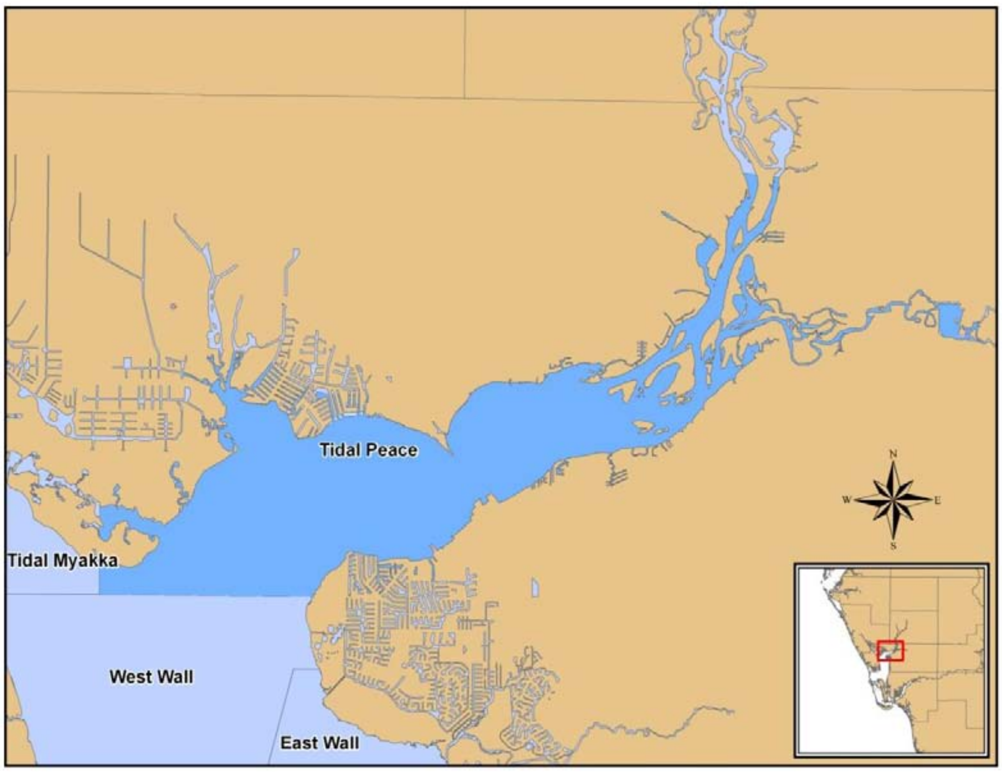



**Figure 5-27. Tidal Peace water segment.**

The Peace River meanders 120 miles from its source in the Green Swamp to its mouth at Port Charlotte. There are several large tributaries in the river's dendritic network, including Joshua Creek, Payne Creek, Charlie Creek, Horse Creek, and Shell Creek. It is the major source of freshwater inflow to Charlotte Harbor. The Peace River headwaters are in the Green Swamp, a vast series of inland wetlands comprising approximately 560,000 acres in parts of Polk, Lake, Sumter, Hernando and Pasco counties. Periods of extreme drought can occasionally cause the Green Swamp to become dry and reduce Peace River flows in its northern reaches to zero (SWFWMD, 2007). A multitude of lakes, where flow is dictated by control structures, are located adjacent to the Green Swamp in the northern extent of the watershed in central Polk County.

While open lands and wetlands have the highest proportions of land use in the Tidal Peace River watershed, significant amounts of developed land exist throughout. The northwestern portion of the watershed is dominated by active or closed phosphate mines and represents the vast majority of the mining land uses in the entire CHNEP watershed. There are urbanized areas of central Polk County to the north and Port Charlotte to the, and large-scale agricultural operations, particularly in the south (Janicki Environmental, 2010d).

A measure of residence time in the system is provided by the pulse residence time (PRT), which is estimated as a function of tidal mixing and freshwater inflows, as described previously (see Appendix 2). The median PRT for each year was calculated based on monthly data, and then the median PRT of the annual values was calculated, as representative of the median hydraulic residence time given the observed conditions of 1995-2007. The median hydraulic residence time for Tidal Peace was 152 days, indicating a mid-range flushing rate for the system.

### 5.5.1 Tidal Peace Water Quality and Nutrient Loadings

Time series plots of monthly average chlorophyll *a*, TN, and TP concentrations are presented in Figure 5-28. The monthly average chlorophyll *a* concentrations varied from 1.4 to 65.8 µg/l, and the interquartile range was 8.0 µg/l (7.9 to 15.9 µg/l). The mean and median chlorophyll *a* concentrations were 13.8 and 11.2 µg/l, respectively. Monthly average TN concentrations in Tidal Peace varied from 0.36 to 2.88 mg/l. The interquartile range was 0.52 mg/l (0.76 to 1.28 mg/l). The mean TN concentration was 1.06 mg/l, while the median was 0.96 mg/l. The monthly average TP concentrations varied from 0.12 to 1.20 mg/l, and the interquartile range was 0.21 mg/l (0.31 to 0.52 mg/l). The mean and median TP concentrations were 0.43 and 0.40 mg/l, respectively.

There were no statistically significant trends in chlorophyll *a*, TN or TP in Tidal Peace during this period ($p>0.05$) (Appendix 3 presents the complete trend test results).

Figure 5-29 presents the time series of monthly TN, TP, and hydrologic loads. The monthly TN loads varied from 7 to 1675 tons/month, and the interquartile range was 290 tons/month (50 to 340 tons/month). The mean and median TN loads were 269 and 133 tons/month, respectively. Monthly TP loads in Tidal Peace varied from 2 to 672 tons/month. The interquartile range was 113 tons/month (19 to 132 tons/month). The mean TP load was 107 tons/month, while the median was 49 tons/month. The monthly hydrologic loads varied from 3 to 976 million $m^3$/month, and the interquartile range was 171 million $m^3$/month (31 to 202 million $m^3$/month). The mean and median hydrologic loads were 164 and 77 million $m^3$/month, respectively. These differences between the means and medians are a sign that the means are highly influenced by a series of high loadings values that are typically seen in the wet season when rainfall driven hydrologic loads and corresponding nutrient loads are substantially higher than during the dry season.

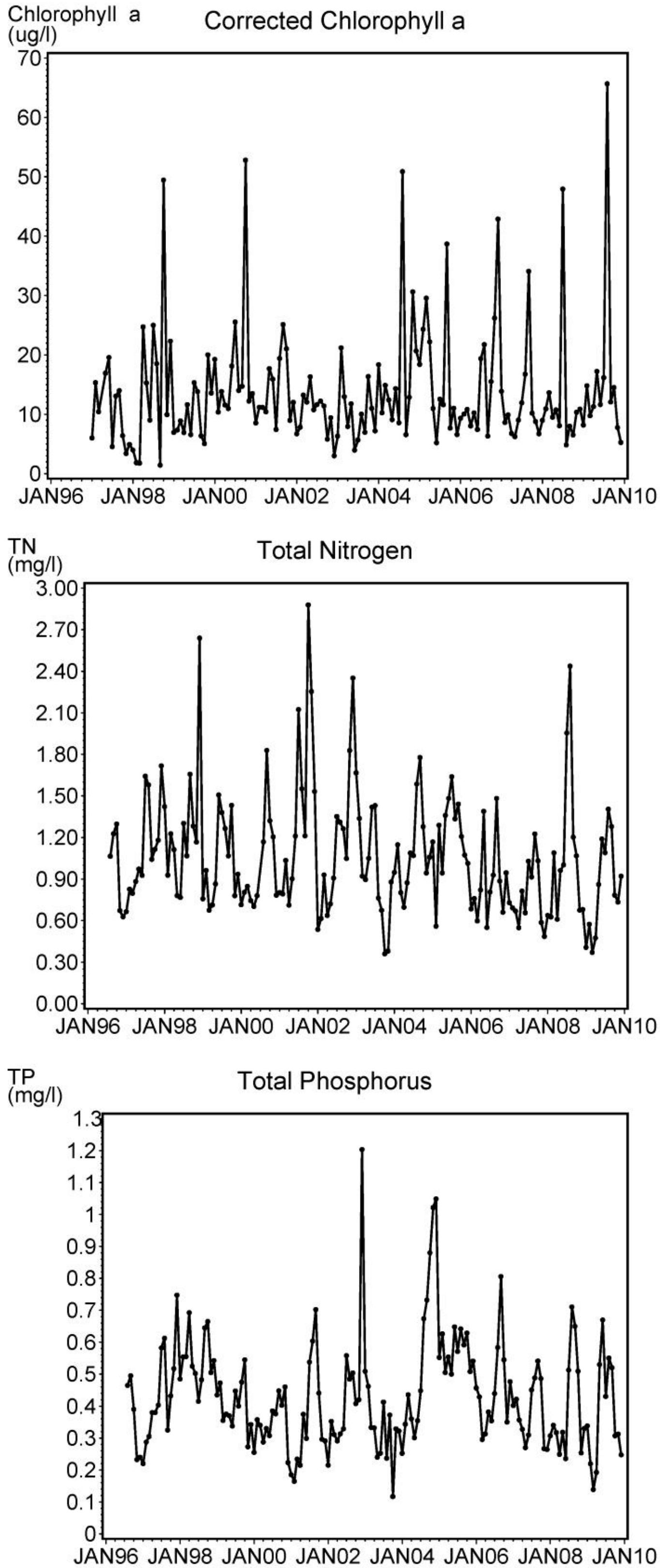



**Figure 5-28. Time series of chlorophyll *a* (top plot), TN (middle plot), and TP (bottom plot) for Tidal Peace.**

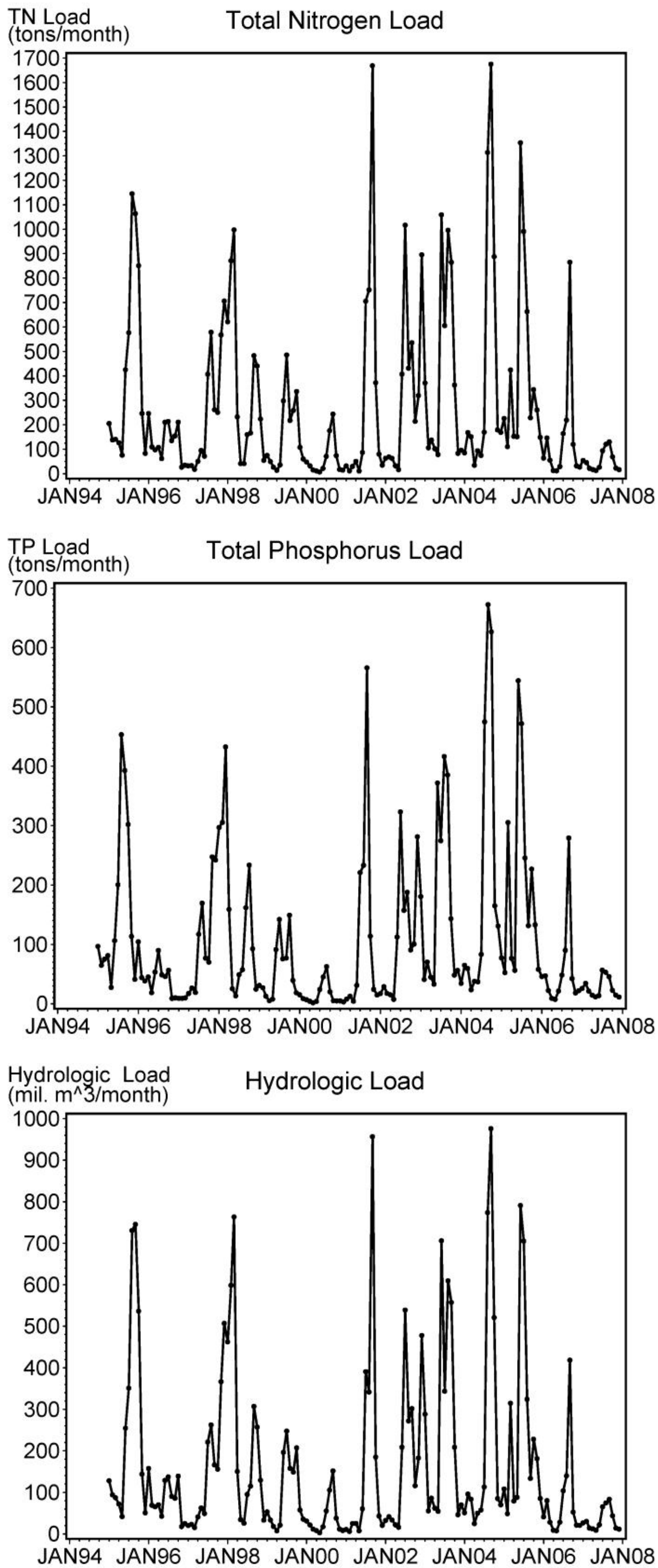



**Figure 5-29. Time series of TN loads (top plot), TP loads (middle plot), and hydrologic loads (bottom plot) for Tidal Peace.**

### 5.5.2 Seagrass Target and Chlorophyll Target and Threshold

- Seagrass Target
  - The seagrass target for this segment is 975 acres (Janicki Environmental, 2009).
  - Seagrass acreages from 1988-2008 are provided in Figure 5-30.
  - Tidal Peace is classified as a seagrass “restoration” segment.

- Chlorophyll *a* Target and Threshold
  - Approved method is the Reference Period Method
  - Reference Period = 2003-2007
  - Chlorophyll Target = 4.9 µg/l (target for Charlotte Harbor Proper)
  - Standard Deviation of Annual Chlorophyll = 2.4 µg/l
  - Chlorophyll Threshold (mean + ½ SD) = 6.1 µg/l (threshold for Charlotte Harbor Proper under restoration)

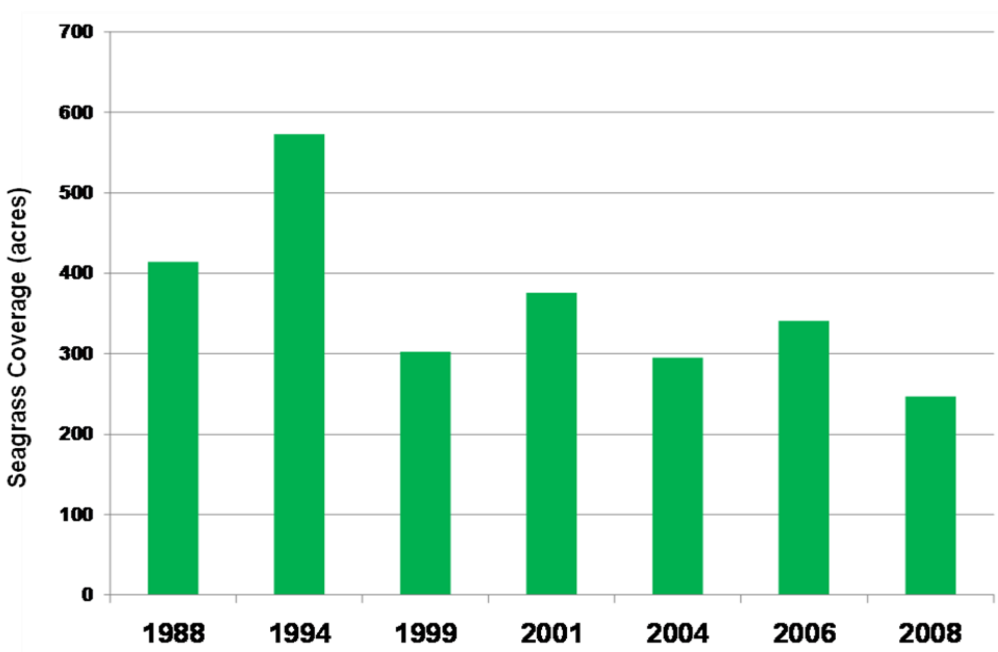



**Figure 5-30. Seagrass acreage in Tidal Peace.**

### 5.5.3 Relationship Between Chlorophyll *a* and Concentrations and Loads - Tidal Peace

In addition to the time series plots, a series of bivariate plots were examined to investigate relationships between chlorophyll *a* and nutrient loads and concentrations. No statistically defensible relationships were found for Tidal Peace chlorophyll *a* concentrations and other water quality parameters or loadings in Tidal Peace. Therefore, a downstream compliance area was investigated. This included using the average chlorophyll a concentration for Charlotte Harbor Proper and loadings and concentrations from Tidal Peace (Appendix 5.5). A statistically significant relationship was found between Charlotte Harbor chlorophyll concentrations and Tidal Peace loads, the relationship was weak. Lastly, changepoint analysis was also investigated (Appendix 5.5).

### 5.5.4 Candidate Criteria – Tidal Peace

Based on discussions with the CHNEP Technical Advisory Committee, there is not sufficient confidence in the Tidal Peace changepoint analysis to develop a defensible numeric nutrient criterion. Therefore, as described in Figure 5-1, the reference period approach was recommended for developing a TN concentration criterion for Tidal Peace. As the segment is classified as "restoration" for seagrass, the TN concentration criterion is calculated by summing the annual mean from the reference period (2003-2007) plus ½ standard deviation (for the period of record):

TN criterion = 0.99 mg/l (mean) + ½ * 0.18 (SD) = 1.08 mg/l

A comparison of the candidate numeric TN concentration criteria for Tidal Peace based on the Reference Period method is presented in Figure 5-31.

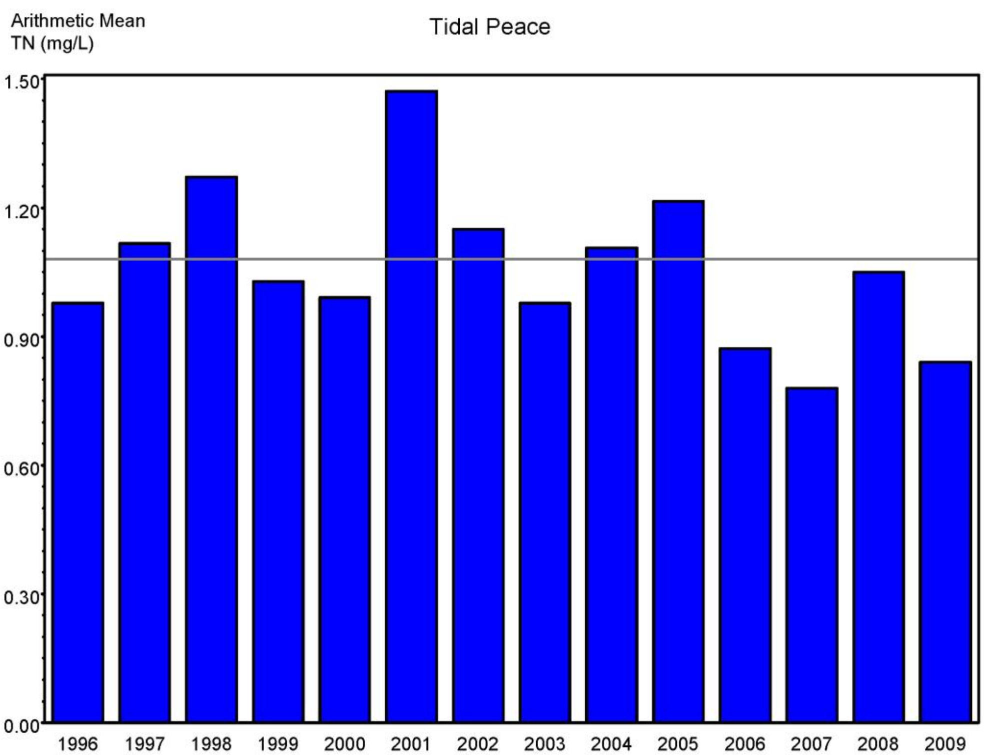



**Figure 5-31. Comparison of the candidate TN criterion to observed TN concentrations (expressed as arithmetic means) in Tidal Peace.**

### 5.6 Pine Island Sound and Matlacha Pass

For purposes of numeric nutrient criteria development, the Pine Island Sound and Matlacha Pass segments were combined, as each are midway between the northern freshwater inflows of the Peace and Myakka rivers, and the southern inflow from the Caloosahatchee River (Figures 5-32 and 5-33).


**Figure 5-32. Pine Island Sound water segment.**

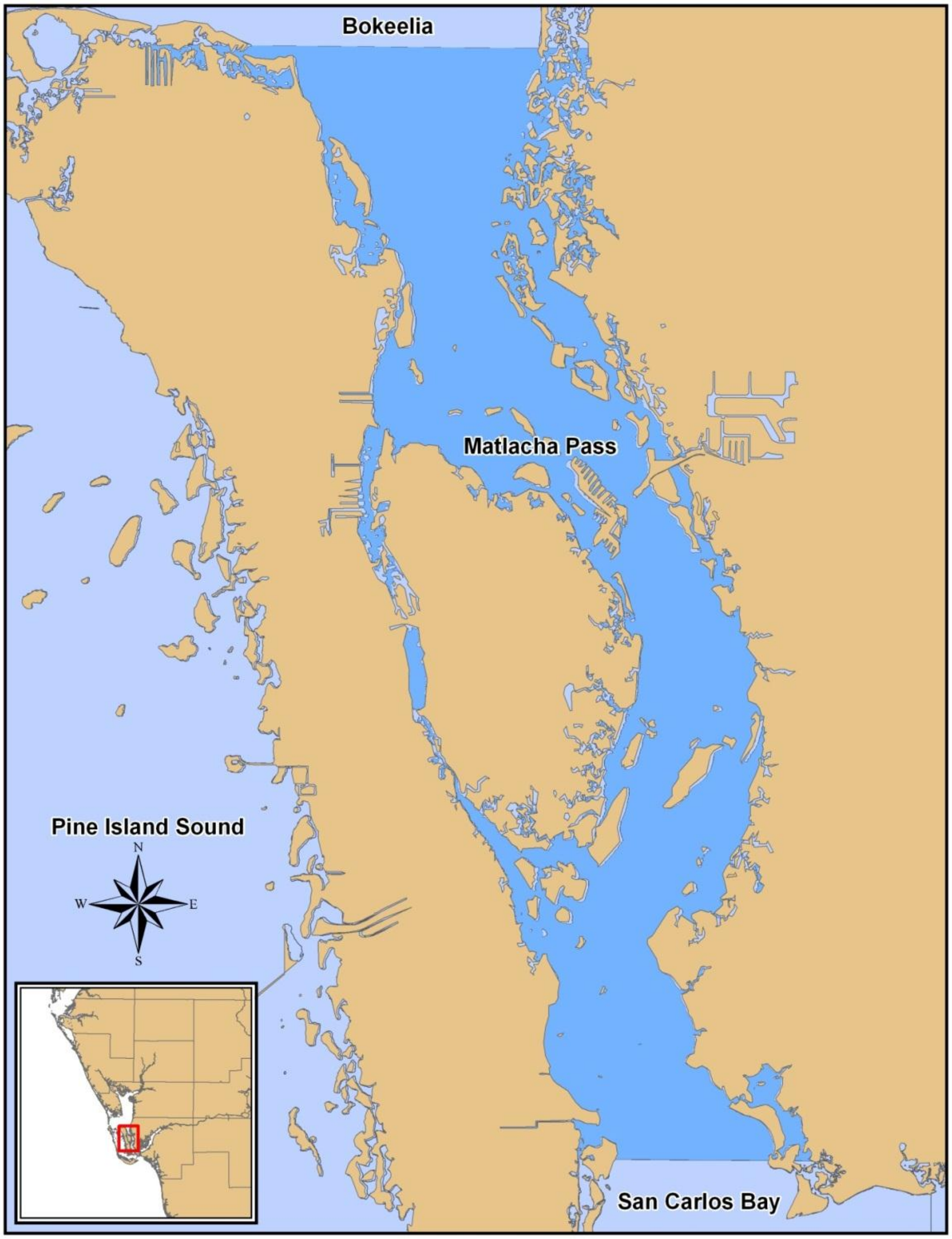



**Figure 5-33.** **Matlacha Pass water segment.**

The Pine Island Sound segment consists of the Pine Island Sound estuary and a fringing watershed. It is bounded on the north by the Bokeelia segment in Charlotte Harbor, to the east by Pine Island, to the west by various barrier islands and the Gulf of Mexico, and to the south by Sanibel Island and San Carlos Bay (Figure 5-32). The surface area of the open water segment is approximately 50,483 acres. The watershed contains wetlands and some urban lands along the coast, and open lands and agricultural lands in the central area of Pine Island (Janicki Environmental, 2010d). Its comparatively small watershed is approximately 19,259 acres, or 30.1 mi². This results in a watershed to open water area ratio of 0.4, one of the lowest ratios compared to others in the CHNEP area and generating low runoff per rainfall unit.

With the islands of Pine Island, Captiva, Sanibel, and numerous other smaller barrier islands comprising its surrounding watershed, there are minimal amounts of freshwater entering the segment from streams or overland flow. However, with coastal wetlands on either side of Pine Island Sound, freshwater inputs can be received from the watershed when the wetlands become inundated and flow into the open water as sheetflow.

Matlacha Pass connects Charlotte Harbor to San Carlos Bay at the mouth of the Caloosahatchee River (Figure 5-33). It is bounded on the west by Pine Island and on the east by the City of Cape Coral. Its watershed includes an extensive network of man-made waterways in Cape Coral, which drain into Matlacha Pass. The open water surface area of Matlacha Pass is approximately 13,190 acres, and its watershed is approximately 63,095 acres, or 98.6 mi². This results in a watershed to open water area ratio of 4.8, intermediate compared to others in the CHNEP area. The watershed is heavily urbanized, with the City of Cape Coral located on the eastern shore. The eastern watershed of Matlacha Pass has been heavily altered by human activities. The canal network in Cape Coral includes over 400 miles of navigable waterways, all of which drain either to Matlacha Pass or the Caloosahatchee River to the south (City of Cape Coral, 2009). Many of these canals, such as Gator Slough and Horseshoe, Hermosa, and Shadroe canals, are controlled by weirs that regulate the passage of water into the coastal wetlands buffering the canals from Matlacha Pass. These structures are particularly useful in times of high flows, where diversions are used to sustain agricultural operations and for wetlands maintenance.

The relatively large watershed and highly channelized conveyance system promote high peak runoff rates during rain events. A “spreader canal” was constructed along the shoreline to intercept runoff from the residential canal system, with the intent of treating and distributing the water to coastal mangroves in the pass via sheet flow over the west side of the canal. The west canal bank has developed a series of breaches that allow water to flow into the mangroves at a few concentrated locations, rather than be evenly distributed along the entire 7-mile canal length (Janicki Environmental and Florida Conflict Resolution Consortium Consensus Center, 2010).

A measure of residence time in the system is provided by the pulse residence time (PRT), which is estimated as a function of tidal mixing and freshwater inflows, as described previously (see Appendix 2). The median PRT for each year was calculated based on monthly data, and then the median PRT of the annual values was calculated, as representative of the median hydraulic residence time given the observed conditions of 1995-2007. The median hydraulic residence time for Pine Island Sound was 692 days, indicating a very slow flushing rate, and was 534 days for Matlacha Pass, indicative that both these segments typically experience very long residence times.

### 5.6.1 Pine Island Sound and Matlacha Pass Water Quality and Nutrient Loadings

Time series plots of monthly average chlorophyll *a*, TN, and TP concentrations in Pine Island Sound are presented in Figure 5-34. The monthly average chlorophyll *a* concentrations varied from 1.1 to 19.2 µg/l, and the interquartile range was 3.7 µg/l (2.3 to 6.0 µg/l). The mean and median chlorophyll *a* concentrations were 4.7 and 3.3 µg/l, respectively. This difference between the mean and median is a sign that the mean is influenced by several high concentration values. Monthly average TN concentrations in Pine Island Sound varied from 0.05 to 2.53 mg/l. The interquartile range was 0.21 mg/l (0.26 to 0.47 mg/l). The mean TN concentration was 0.40 mg/l, while the median was 0.34 mg/l. The monthly average TP concentrations varied from 0.02 to 0.35 mg/l, and the interquartile range was 0.02 mg/l (0.03 to 0.05 mg/l). The mean and median TP concentrations were 0.05 and 0.04 mg/l, respectively. Unlike chlorophyll *a*, the differences between the mean and median for TN and TP were much less as TN and TP do not exhibit the sharp increases that are often associated with chlorophyll blooms.

There were no statistically significant trend in chlorophyll *a* in Pine Island Sound during this period ($p>0.05$). However, significant decreasing trends were detected in TN ($p<0.0001$, slope=-0.08) and TP ($p<0.01$, slope=-0.005) (Appendix 3).

Figure 5-35 presents the time series of TN, TP, and hydrologic loads to Pine Island Sound. The monthly TN loads varied from 0.1 to 62.6 tons/month, and the interquartile range was 18.4 tons/month (3.1 to 21.5 tons/month). The mean and median TN loads were 13.5 and 9.9 tons/month, respectively. Monthly TP loads in Pine Island Sound varied from 0.01 to 2.5 tons/month. The interquartile range was 0.6 tons/month (0.1 to 0.7 tons/month). The mean TP load was 0.5 tons/month, while the median was 0.3 tons/month. The monthly hydrologic loads varied from 0.1 to 83.2 million $m^3$/month, and the interquartile range was 30.8 million $m^3$/month (6.4 to 37.2 million $m^3$/month). The mean and median hydrologic loads were 23.6 and 16.9 million $m^3$/month, respectively. This difference between the mean and median is indicative of the fact that the mean is influenced by a series of high loadings values that are typically seen in the wet season when rainfall driven hydrologic loads and corresponding nutrient loads are higher.

Time series plots of monthly average chlorophyll *a*, TN, and TP concentrations in Matlacha Pass are presented in Figure 5-36. The chlorophyll *a* concentrations varied from a low of 0.8 µg/l to a high of 52.3 µg/l. The $25^{th}$ and $75^{th}$ percentile chlorophyll *a* concentrations were 2.7 and 6.6 µg/l, resulting in an interquartile range of 3.9 µg/l. The mean chlorophyll *a* concentration was 6.0 µg/l and the median was 3.7 µg/l. The mean is influenced by several high concentration values. The monthly average TN concentrations varied from 0.01 to 1.43 mg/l. The interquartile range was 0.25 mg/l (0.35 to 0.60 mg/l). The mean TN concentration was 0.51 mg/l, while the median was 0.46 mg/l. The monthly average TP concentrations in Matlacha Pass varied from 0.01 to 0.26 mg/l, and the interquartile range was 0.03 mg/l (0.05 to 0.08 mg/l). The mean and median TP concentrations were 0.07 and 0.06 mg/l, respectively. As expected, the differences between the mean and median for TN and TP were much less as TN and TP do not show the inter-annual variability exhibit by chlorophyll *a* concentrations.

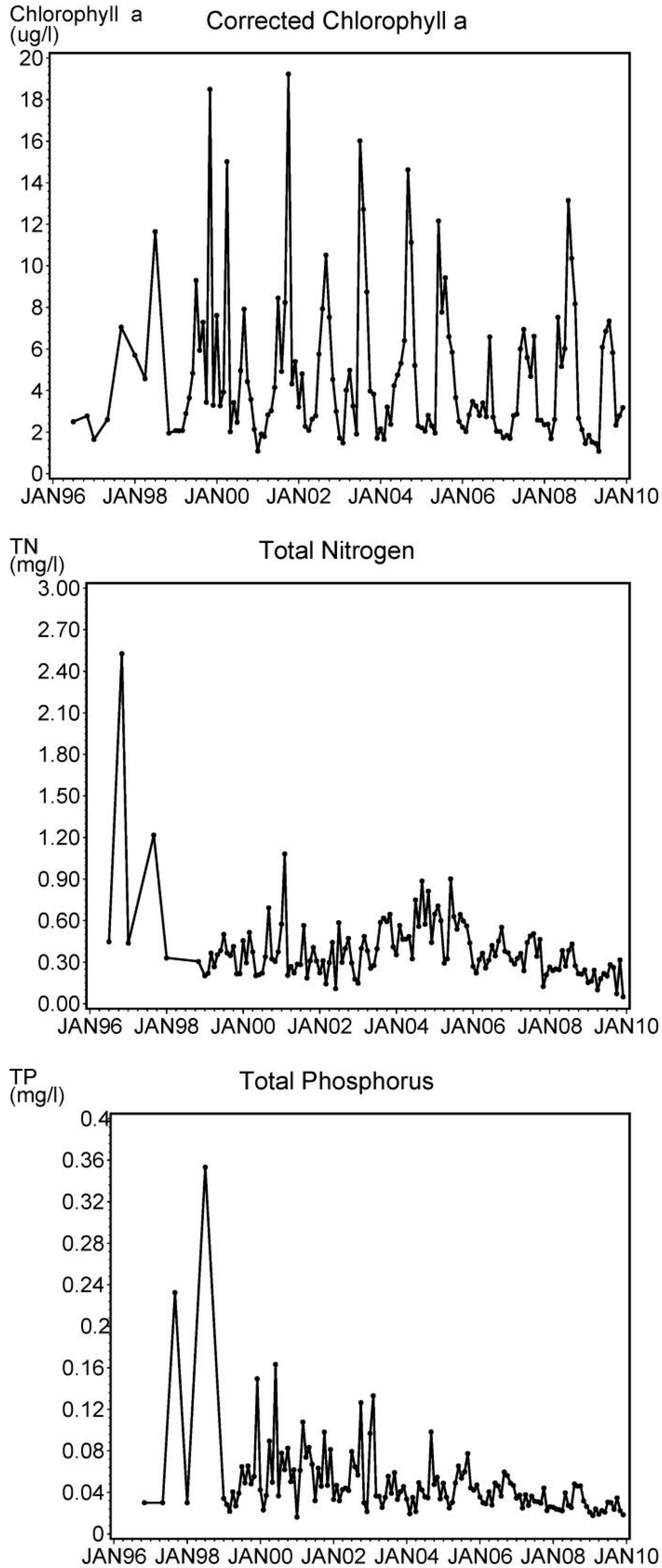



**Figure 5-34. Time series of chlorophyll *a* (top plot), TN (middle plot), and TP (bottom plot) for Pine Island Sound.**

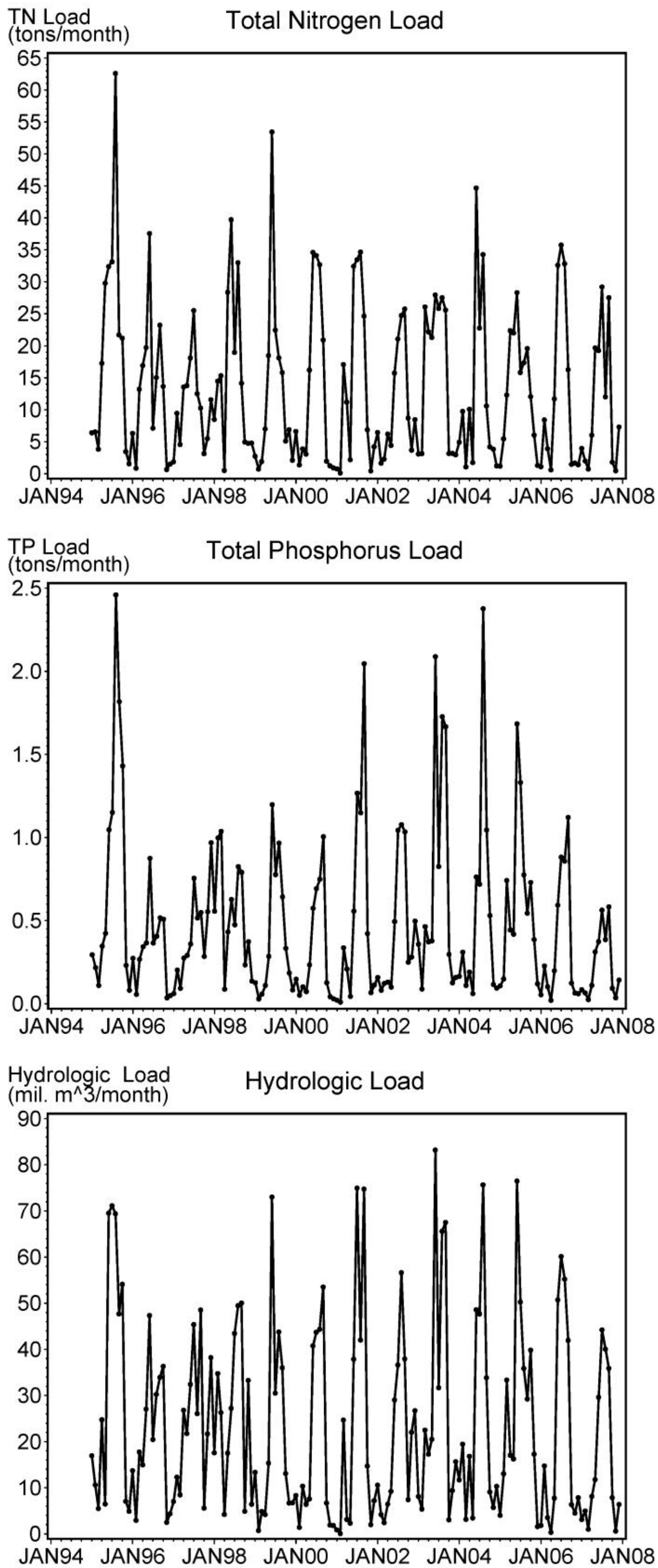



**Figure 5-35. Time series of TN loads (top plot), TP loads (middle plot), and hydrologic loads (bottom plot) for Pine Island Sound.**

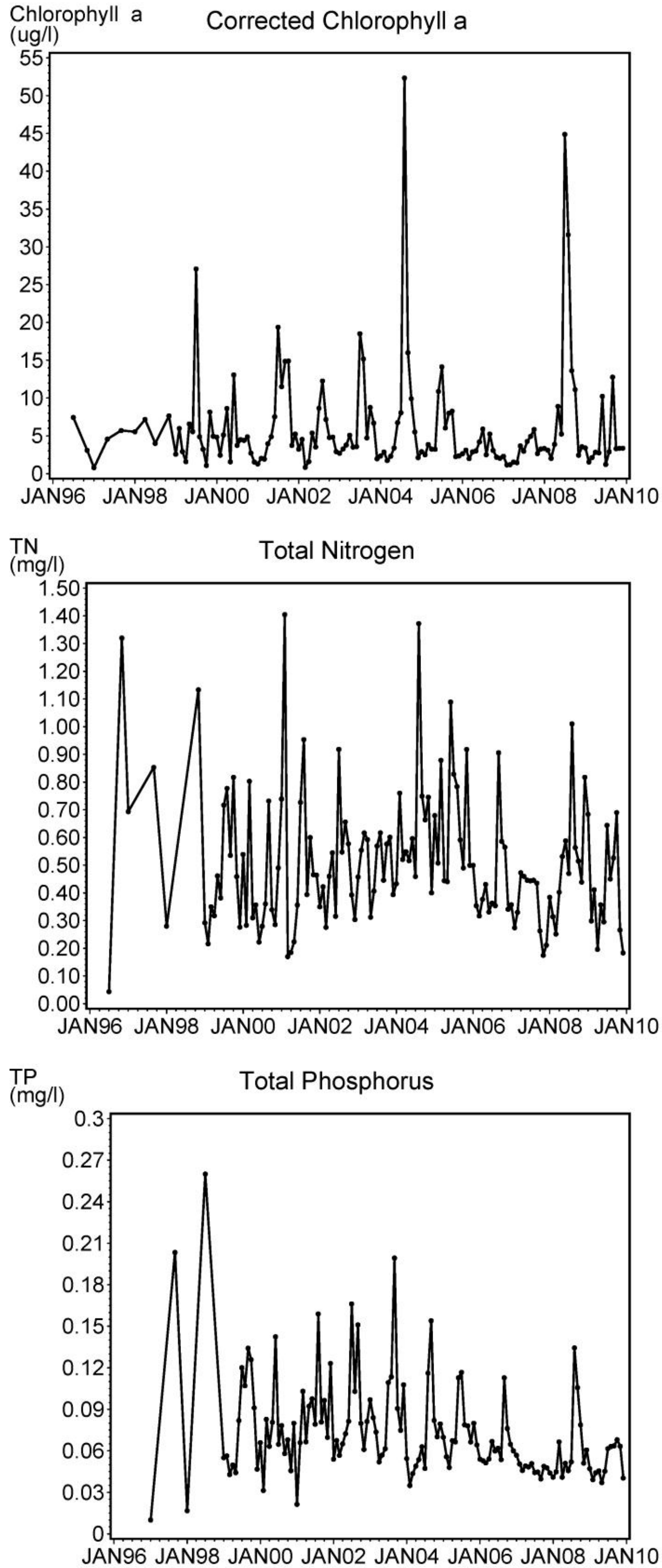



**Figure 5-36. Time series of chlorophyll *a* (top plot), TN (middle plot), and TP (bottom plot) for Matlacha Pass.**

There were no statistically significant trends in TN or chlorophyll *a* in Matlacha Pass during this period ($p>0.05$) (Appendix 3 presents the complete trend test results). A significant decreasing trend was detected in TP ($p<0.05$, slope=-0.003).

Figure 5-37 presents the time series of monthly TN, TP, and hydrologic loads to Matlacha pass. The monthly TN loads varied from 0.5 to 64.9 tons/month, with an interquartile range of 17.4 tons/month (2.6 to 20.0 tons/month). The mean and median TN loads to Matlacha Pass were 13.0 and 8.6 tons/month, respectively. Monthly TP loads varied from 0.05 to 10.7 tons/month. The interquartile range for TP loads was 1.4 tons/month (0.2 to 1.6 tons/month). The mean TP load was 1.5 tons/month, while the median was 0.6 tons/month. The monthly hydrologic loads varied from a low of 0.2 million $m^3$/month to a high of 80.8 million $m^3$/month. The interquartile range was 24.8 million $m^3$/month (3.4 to 28.2 million $m^3$/month). The mean and median hydrologic loads were 17.9 and 9.2 million $m^3$/month, respectively. These differences between the means and medians are a sign that the means are highly influenced by a series of high loadings values that are typically seen in the wet season when rainfall driven hydrologic loads and corresponding nutrient loads are substantially higher than during the dry season.

### 5.6.2 Seagrass Targets and Chlorophyll Targets and Thresholds

- Seagrass Targets
  - The seagrass targets are 26,837 acres for Pine Island Sound and 9,315 acres for Matlacha Pass (Janicki Environmental, 2009).
  - Seagrass acreages in Pine Island Sound and Matlacha Pass over the 1988-2008 period are provided in Figure 5-38.
  - Pine Island Sound is classified as a seagrass “protection” segment, while Matlacha Pass is classified as a seagrass “restoration” segment.

- Chlorophyll *a* Target and Threshold Pine Island Sound
  - Approved method is the Reference Period Method
  - Reference Period = 2003-2007
  - Chlorophyll Target = 5.1 µg/l
  - Standard Deviation of Annual Chlorophyll = 1.4 µg/l
  - Chlorophyll Threshold (mean + SD) = 6.5 µg/l

- Chlorophyll *a* Target and Threshold Matlacha Pass
  - Approved method is the Reference Period Method
  - Reference Period = 2003-2007
  - Chlorophyll Target = 4.0 µg/l
  - Standard Deviation of Annual Chlorophyll = 4.1 µg/l
  - Chlorophyll Threshold (mean + ½ SD) = 6.1 µg/l

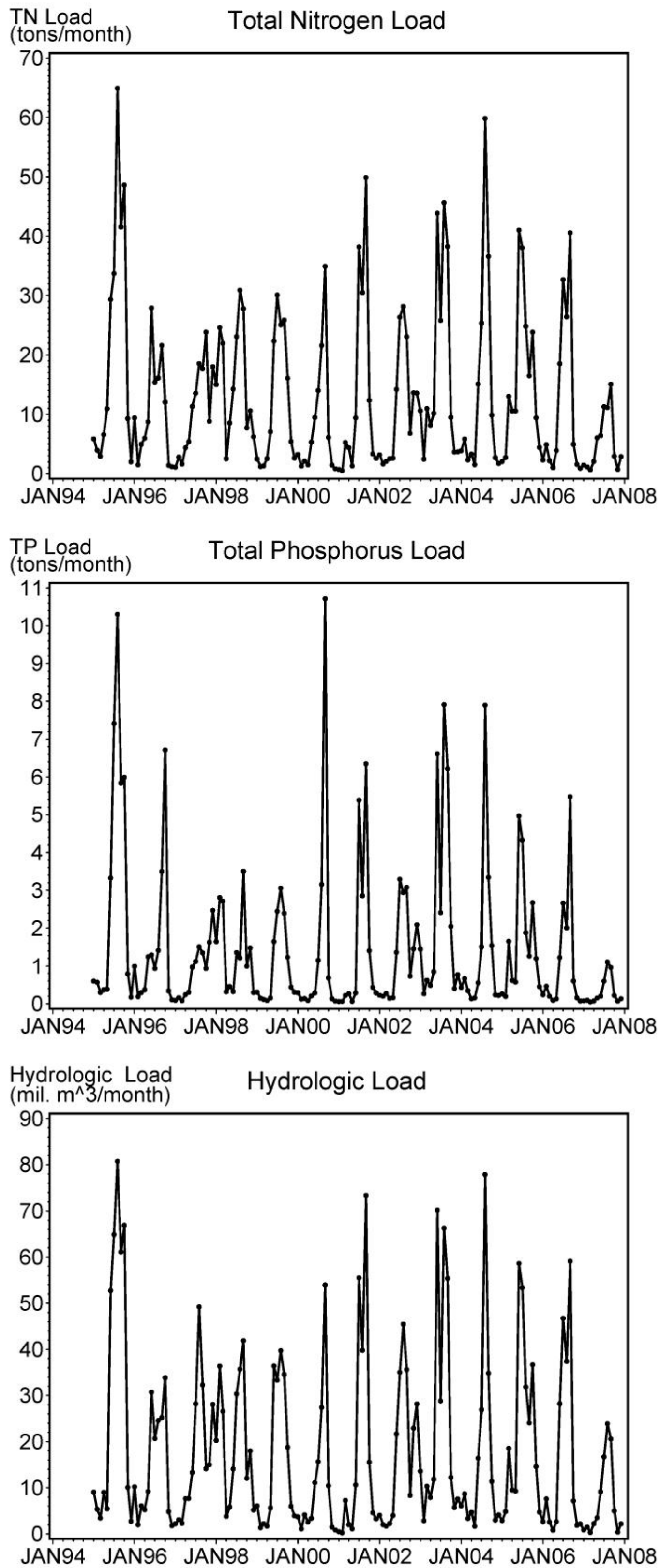



**Figure 5-37. Time series of TN loads (top plot), TP loads (middle plot), and hydrologic loads (bottom plot) for Matlacha Pass.**

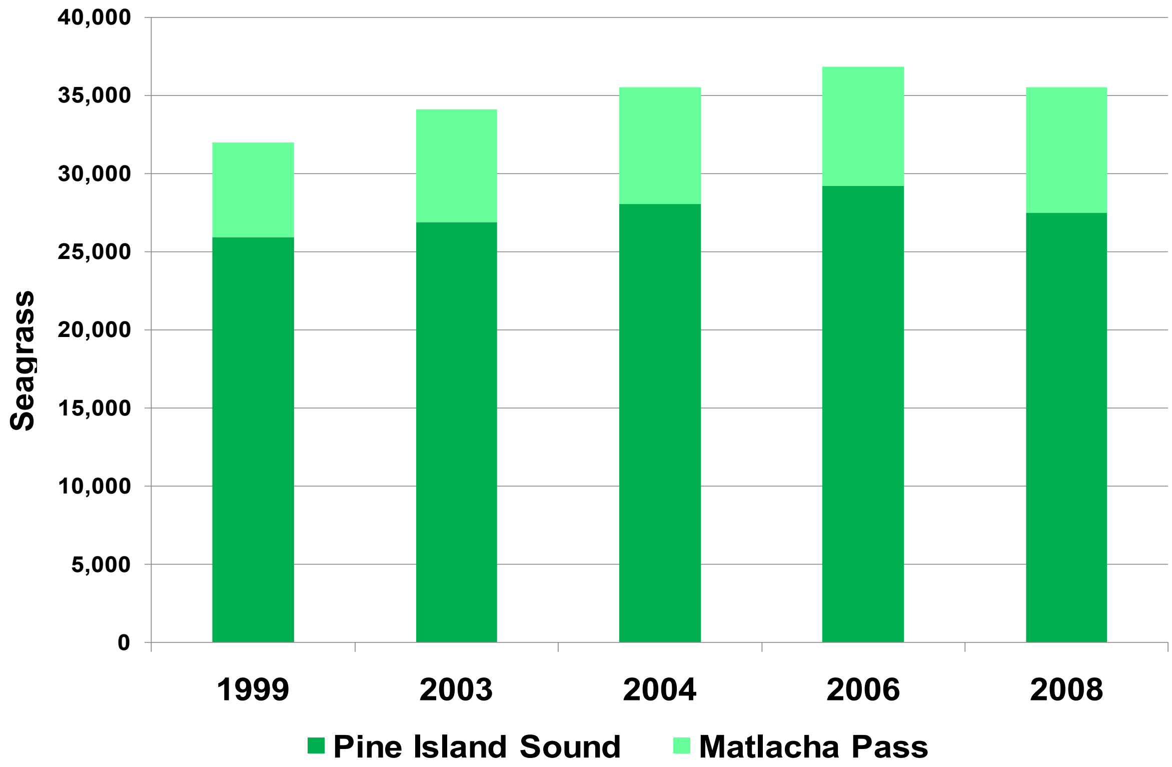



**Figure 5-38. Seagrass acreage in Pine Island Sound and Matlacha Pass.**

### 5.6.3 Relationship Between Chlorophyll *a* and Concentrations and Loads - Pine Island Sound and Matlacha Pass

In addition to the time series plots, a series of bivariate plots were examined to investigate relationships between chlorophyll *a* and nutrient loads and concentrations. These plots and a description of the relationships developed are included in Appendix 5.6. While statistically significant relationships were identified between chlorophyll a and TN concentration in Pine Island Sound and between chlorophyll a and TN load in Matlacha Pass, a considerable amount of variability was left unexplained by these relationships (Appendix 5.6).

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### 5.6.4 Candidate Criteria – Pine Island Sound and Matlacha Pass

Based on discussions with the CHNEP Technical Advisory Committee, there is not sufficient confidence in the Pine Island Sound and Matlacha Pass regressions to develop defensible numeric nutrient criteria due to the amount of variability left unexplained by the regressions. Therefore, as described in Figure 5-1, the reference period approach was recommended for developing TN concentration criteria for Pine Island Sound and Matlacha Pass. As Pine Island Sound is classified as a seagrass "protection" segment, the TN concentration criterion is calculated by summing the annual mean from the reference period (2003-2007) plus one standard deviation (for the period of record):

TN criterion = 0.46 mg/l (mean) + 0.11 (SD) = 0.57 mg/l

Matlacha Pass is classified as a seagrass “restoration” segment, therefore the TN concentration criterion is calculated by summing the annual mean from the reference period (2003-2007) plus ½ standard deviation (for the period of record):

TN criterion = 0.53 mg/l (mean) + ½ * 0.10 (SD) = 0.58 mg/l

A comparison of the candidate numeric TN concentration criteria for Pine Island Sound and Matlacha Pass based on the Reference Period method are presented in Figure 5-39 and Figure 5-40, respectively.

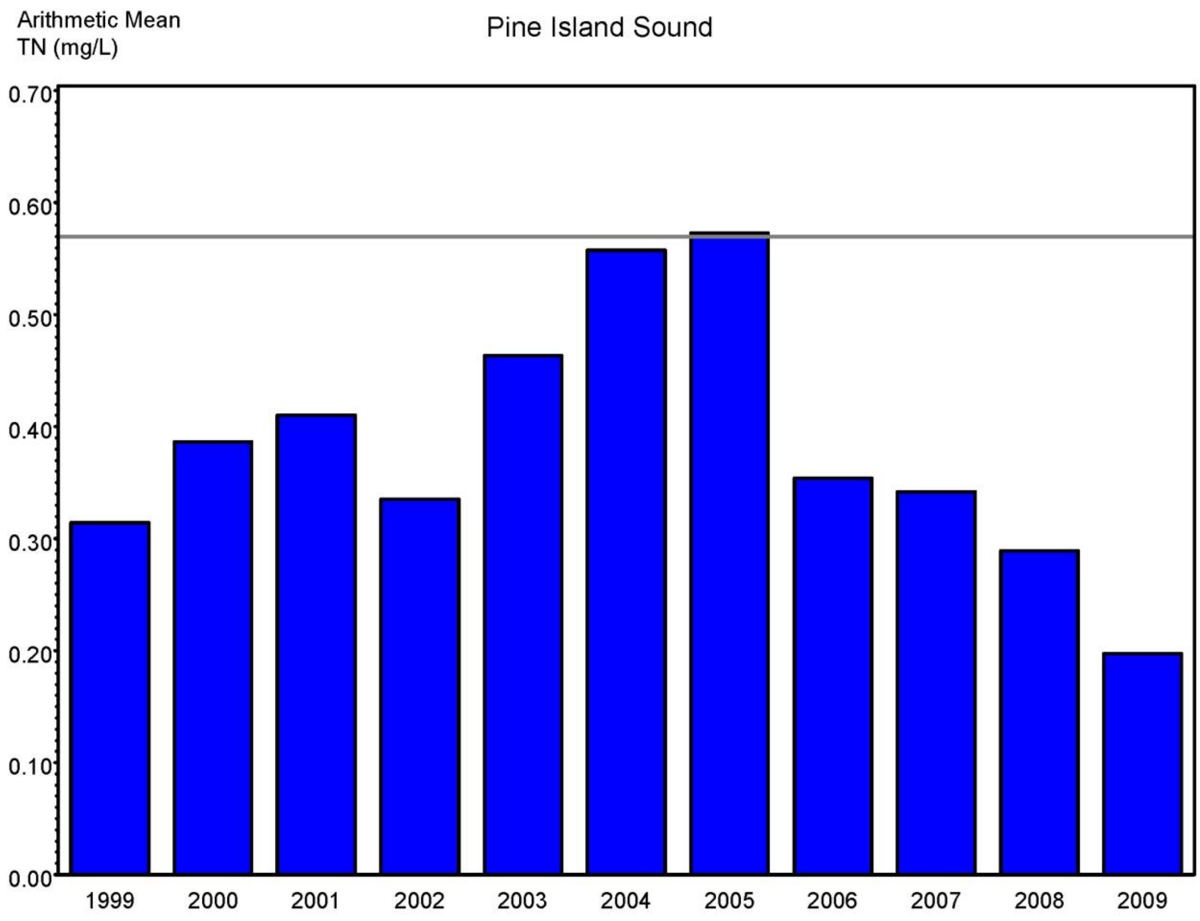


**Figure 5-39. Comparison of the candidate TN criterion to observed TN concentrations (expressed as arithmetic means) in Pine Island Sound.**

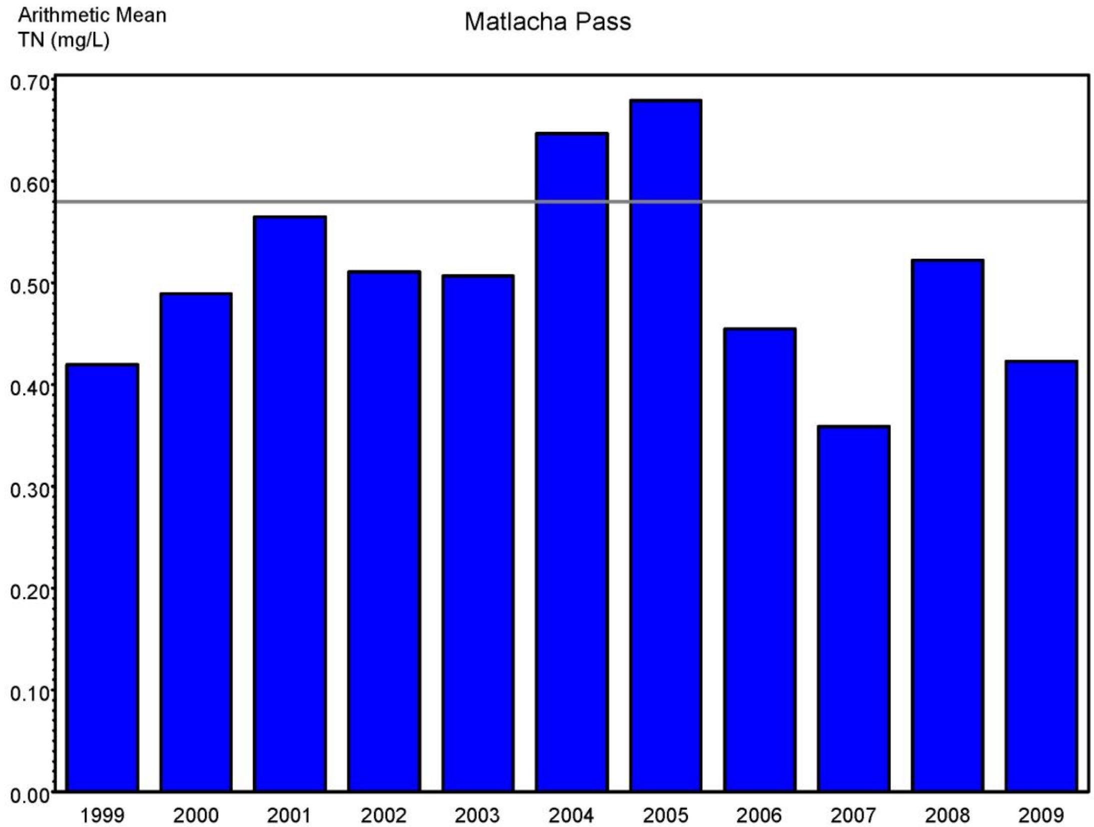


**Figure 5-40. Comparison of the candidate TN criterion to observed TN concentrations (expressed as arithmetic means) in Matlacha Pass.**

## 5.7 San Carlos Bay and Tidal Caloosahatchee

For purposes of numeric nutrient criteria development, the San Carlos Bay and Tidal Caloosahatchee segments were combined, as the Tidal Caloosahatchee River discharges directly to San Carlos Bay, which serves not only as the receiving water for freshwater from the river, but also as a conduit for more saline Gulf water to reach the tidal river.

The San Carlos Bay segment is an embayment located between Pine Island Sound to the west, Matlacha Pass to the north, the Caloosahatchee River to the east, and the Gulf of Mexico and Estero Bay to the south (Figure 5-41). Its watershed is comprised of areas of the mainland, Pine Island, and coastal barrier islands, with wetlands the primary land use other than open water, and some urban land uses at the southern tip of Pine Island, Sanibel Island, and the western tip of the mainland (Fort Myers and Fort Myers Beach). The segment has a surface area of approximately 19,921 acres, while the watershed is approximately 11,599 acres, or 18.1 mi². This results in a watershed to open water area ratio of 0.6, one of the lower ratios compared to all others in the CHNEP area and generating low runoff per rainfall unit.

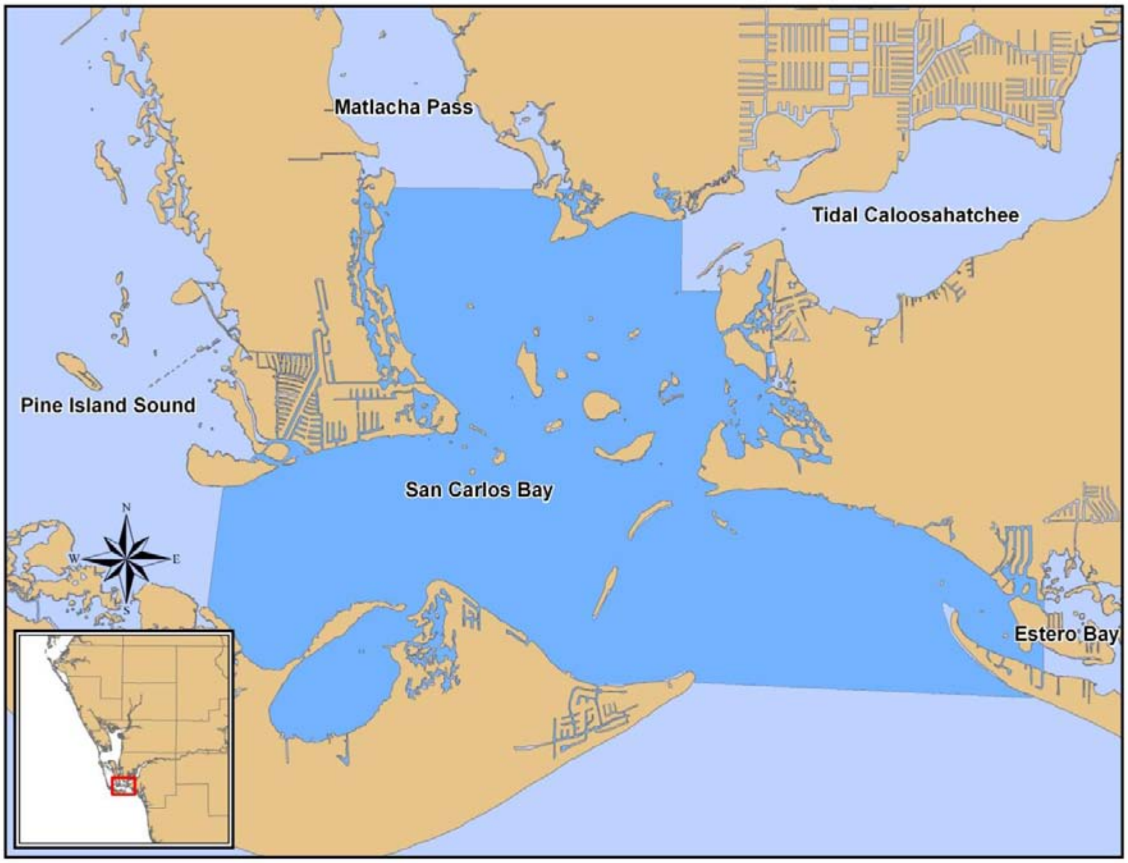


**Figure 5-41. San Carlos Bay water segment.**

The southern boundary of San Carlos Bay, on the Gulf of Mexico, is the largest pass along the outer CHNEP boundary between Estero Bay and Charlotte Harbor proper. This interface factors into the mixing and flushing of the southern open water portion of the CHNEP area. With the freshwater of the Caloosahatchee River and the advective forces coming in from the Gulf of Mexico converging with the waters of the neighboring passes (Pine Island Sound and Matlacha Pass), San Carlos Bay functions as a hydrological crossroads in this region of the CHNEP. Thus inflows from the watershed proper are not significant compared to the other segments' inputs.

The Tidal Caloosahatchee River segment's dominant feature is the estuarine portion of the Caloosahatchee River, which drains to the west into San Carlos Bay (Figure 5-42). The watershed contains primarily open lands, with urban lands making up about one-quarter of the watershed, and wetlands about one-sixth (Janicki Environmental, 2010d). The segment proper is approximately 16,760 acres, while the watershed is approximately 356,477 acres, or 557 mi². This results in a watershed to open water area ratio of 20, one of the higher ratios compared to others in the CHNEP area. However, this ratio is not valid for comparison with other segments because flows include discharges from Lake Okeechobee which is outside the historical watershed.

**Figure 5-42. Tidal Caloosahatchee water segment.**

The Caloosahatchee River is the major freshwater input into the estuarine waters of San Carlos Bay. The flows on the Caloosahatchee River are controlled by a structure known as S-79 at the far eastern boundary of the Tidal Caloosahatchee River watershed. A series of canals link Lake Okeechobee to the Caloosahatchee River. Flows at S-79 are regulated in order to help manage water levels on Lake Okeechobee, thus river flows are not directly proportional to local rainfall. The Orange River is a major tributary to the Caloosahatchee River, which also has several smaller streams and man-made canals draining into it on its northern bank. Telegraph Swamp is a large wetland located in the upstream portion of the watershed.

A measure of residence time in the system is provided by the pulse residence time (PRT), which is estimated as a function of tidal mixing and freshwater inflows, as described previously (see Appendix 2). The median PRT for each year was calculated based on monthly data, and then the median PRT of the annual values was calculated, as representative of the median hydraulic residence time given the observed conditions of 1995-2007. The median hydraulic residence time for the Tidal Caloosahatchee River was 340 days, indicating a very slow flushing rate, and was 78 days for San Carlos Bay, indicative of the strong influence of the Gulf on more rapid tidal mixing and flushing in San Carlos Bay.

### 5.7.1 San Carlos Bay and Tidal Caloosahatchee Water Quality and Nutrient Loadings

Time series plots of monthly average chlorophyll *a*, TN, and TP concentrations in San Carlos Bay are presented in Figure 5-43. The chlorophyll *a* concentrations varied from a low of 0.9 µg/l to a high of 16.0 µg/l. The 25$^{th}$ and 75$^{th}$ percentile chlorophyll *a* concentrations were 2.3 and 4.8 µg/l, resulting in an interquartile range of 2.5 µg/l. The mean chlorophyll *a* concentration was 4.1 µg/l and the median was 3.4 µg/l. The mean is influenced by several high concentration values. The monthly average TN concentrations varied from 0.10 to 2.30 mg/l. The interquartile range was 0.24 mg/l (0.30 to 0.54 mg/l). The mean TN concentration was 0.46 mg/l, while the median was 0.39 mg/l. The monthly average TP concentrations in San Carlos Bay varied from 0.01 to 0.35 mg/l, and the interquartile range was 0.03 mg/l (0.04 to 0.07 mg/l). The mean and median TP concentrations were 0.06 and 0.05 mg/l, respectively. As expected, the differences between the mean and median for TN and TP were much less as TN and TP do not show the inter-annual variability exhibited by chlorophyll *a* concentrations.

There was no statistically significant trend in chlorophyll *a* in San Carlos Bay during this period (p>0.05). Significant decreasing trends were detected in TN (p<0.0001, slope=-0,02) and TP (p<0.0001, slope=-0.003) (Appendix 3).

Figure 5-44 presents the time series of monthly TN, TP, and hydrologic loads to San Carlos Bay. The monthly TN loads varied from 0.3 to 33.2 tons/month, with an interquartile range of 8.9 tons/month (1.5 to 10.4 tons/month). The mean and median TN loads to San Carlos Bay were 6.5 and 4.6 tons/month, respectively. Monthly TP loads varied from 0.02 to 1.92 tons/month. The interquartile range for TP loads was 0.39 tons/month (0.08 to 0.47 tons/month). The mean TP load was 0.4 tons/month, while the median was 0.2 tons/month. The monthly hydrologic loads varied from a low of 0.2 million m$^3$/month to a high of 40.1 million m$^3$/month. The interquartile range was 14.4 million m$^3$/month (2.6 to 17.0 million m$^3$/month). The mean and median hydrologic loads were 10.6 and 6.3 million m$^3$/month, respectively. The difference between means and medians is a sign that the means are highly influenced by a series of high loadings values that are typically seen in the wet season when rainfall driven hydrologic loads and corresponding nutrient loads are substantially higher than during the dry season.

Time series plots of monthly average chlorophyll *a*, TN, and TP concentrations in the Tidal Caloosahatchee are presented in Figure 5-45. The monthly average chlorophyll *a* concentrations varied from 1.6 to 67.0 µg/l, and the interquartile range was 5.7 µg/l (4.2 to 9.9 µg/l). The mean and median chlorophyll *a* concentrations were 8.7 and 7.1 µg/l, respectively. Monthly average TN concentrations in Tidal Caloosahatchee varied from 0.16 to 1.94 mg/l. The interquartile range was 0.38 mg/l (0.68 to 1.06 mg/l). The mean TN concentration was 0.89 mg/l, while the median was 0.88 mg/l. The monthly average TP concentrations varied from 0.03 to 0.51 mg/l, and the interquartile range was 0.06 mg/l (0.07 to 0.13 µg/l). The mean and median TP concentrations were 0.11 and 0.10 µg/l, respectively.

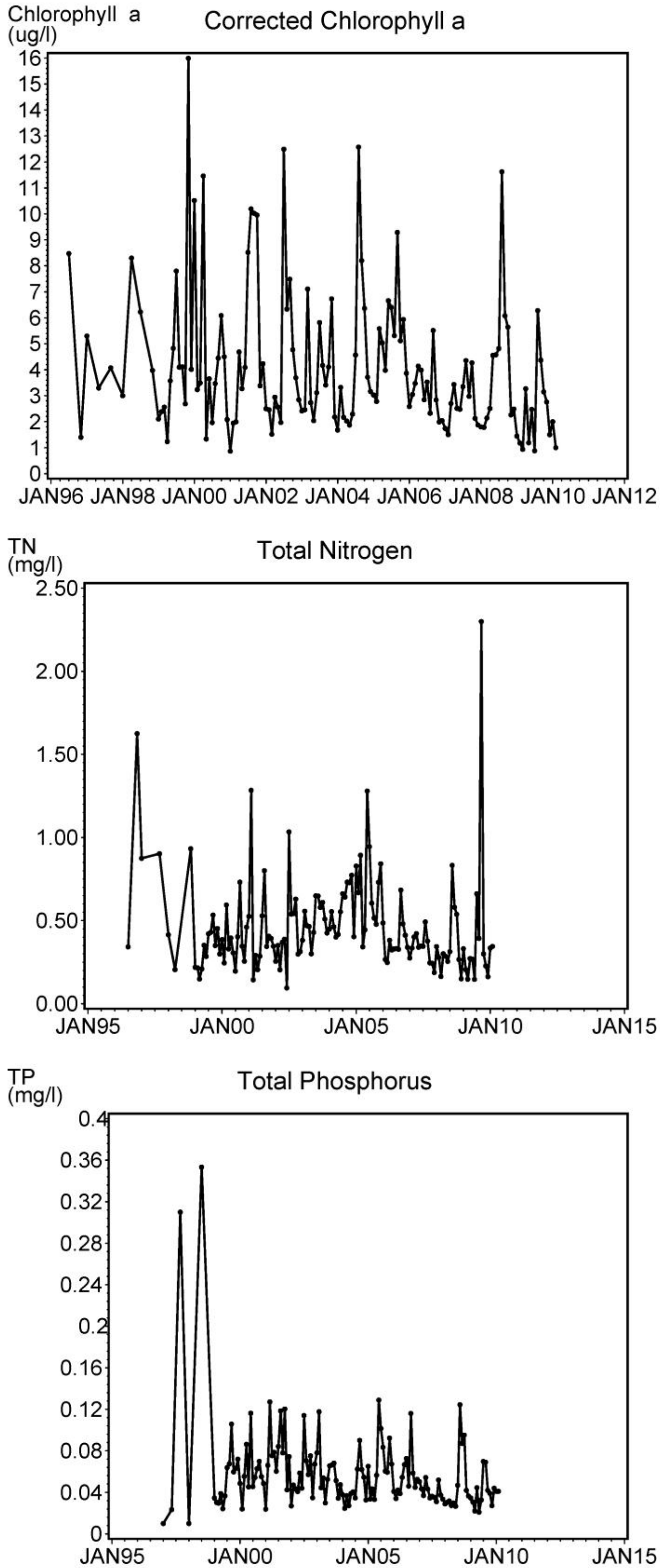


**Figure 5-43.** **Time series of chlorophyll *a* (top plot), TN (middle plot), and TP (bottom plot) for San Carlos Bay.**

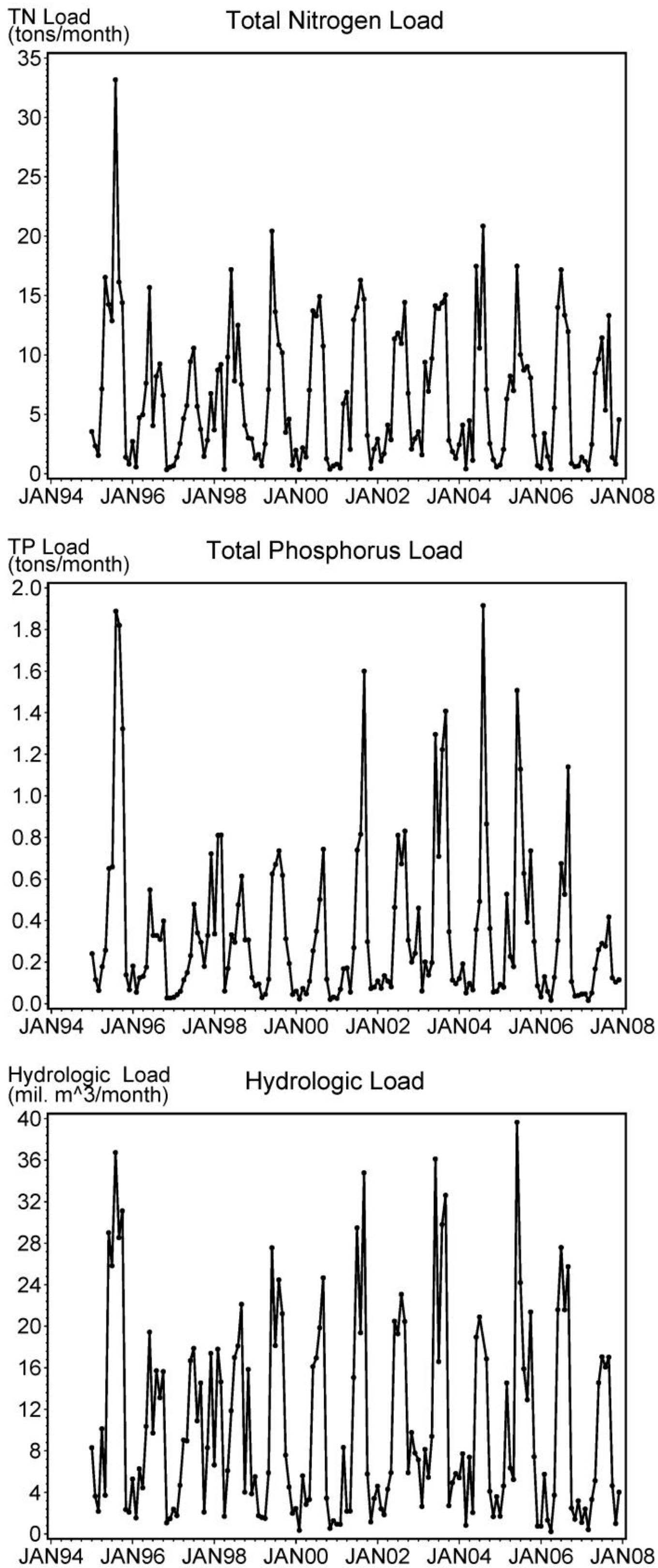


**Figure 5-44. Time series of TN loads (top plot), TP loads (middle plot), and hydrologic loads (bottom plot) for San Carlos Bay.**

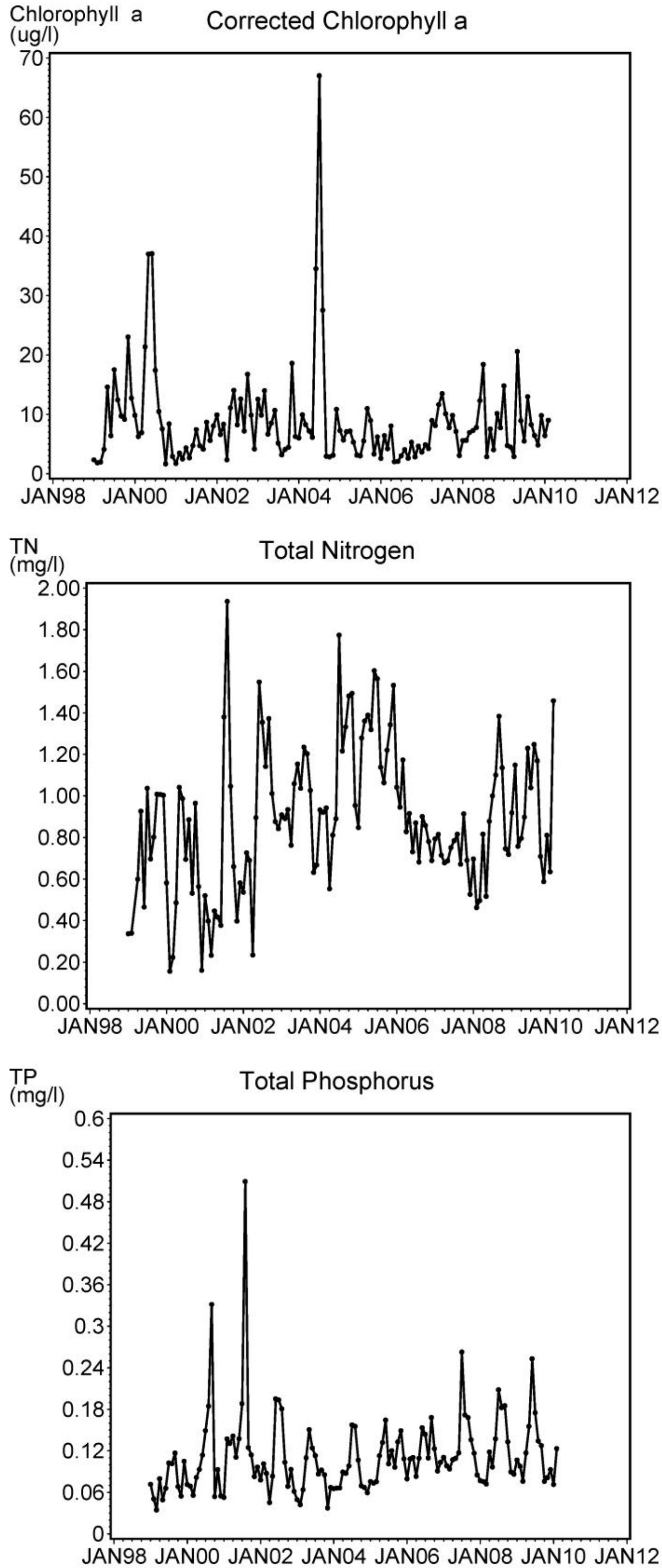


**Figure 5-45. Time series of chlorophyll *a* (top plot), TN (middle plot), and TP (bottom plot) for Tidal Caloosahatchee.**

There was a statistically significant increase in TP in Tidal Caloosahatchee during this period ($p<0.01$, slope=0.006) (Appendix 3 presents the complete trend test results). Lastly, a significant decreasing trend was detected in TN ($p<0.0001$, slope=-0.08).

Figure 5-46 presents the times series of monthly TN, TP, and hydrologic loads to Tidal Caloosahatchee. The monthly TN loads varied from 5 to 1875 tons/month, and the interquartile range was 456 tons/month (67 to 523 tons/month). The mean and median TN loads were 341 and 168 tons/month, respectively. Monthly TP loads in Tidal Peace varied from 1 to 223 tons/month. The interquartile range was 41 tons/month (7 to 48 tons/month). The mean TP load was 33 tons/month, while the median was 17 tons/month. The monthly hydrologic loads varied from 3 to 1150 million $m^3$/month, and the interquartile range was 296 million $m^3$/month (46 to 342 million $m^3$/month). The mean and median hydrologic loads were 225 and 46 million $m^3$/month, respectively. These differences between the means and medians are a sign that the means are highly influenced by a series of high loadings values that are typically seen in the wet season when rainfall driven hydrologic loads and corresponding nutrient loads are substantially higher than during the dry season.

### 5.7.2 Seagrass Targets and Chlorophyll Targets and Thresholds

- Seagrass Targets

  - The seagrass targets are 4,372 acres for San Carlos Bay and 93 acres for Tidal Caloosahatchee (Janicki Environmental, 2009).
  - Seagrass acreages in San Carlos Bay over the 1988-2008 period are provided in Figure 5-47.
  - San Carlos Bay is classified as a seagrass “protection” segment, while Tidal Caloosahatchee is classified as a seagrass “restoration” segment.

- Chlorophyll *a* Target San Carlos Bay

  - Approved method is the Reference Period Method
  - Reference Period = 2003-2007
  - Chlorophyll Target = 2.8 µg/l
  - Standard Deviation of Annual Chlorophyll = 0.7 µg/l
  - Chlorophyll Threshold (mean + ½ SD) = 3.5 µg/l

- Chlorophyll *a* Target Tidal Caloosahatchee

  - Tidal Caloosahatchee has been identified as impaired
  - Draft TMDL has a chlorophyll target of 6.9 µg/l

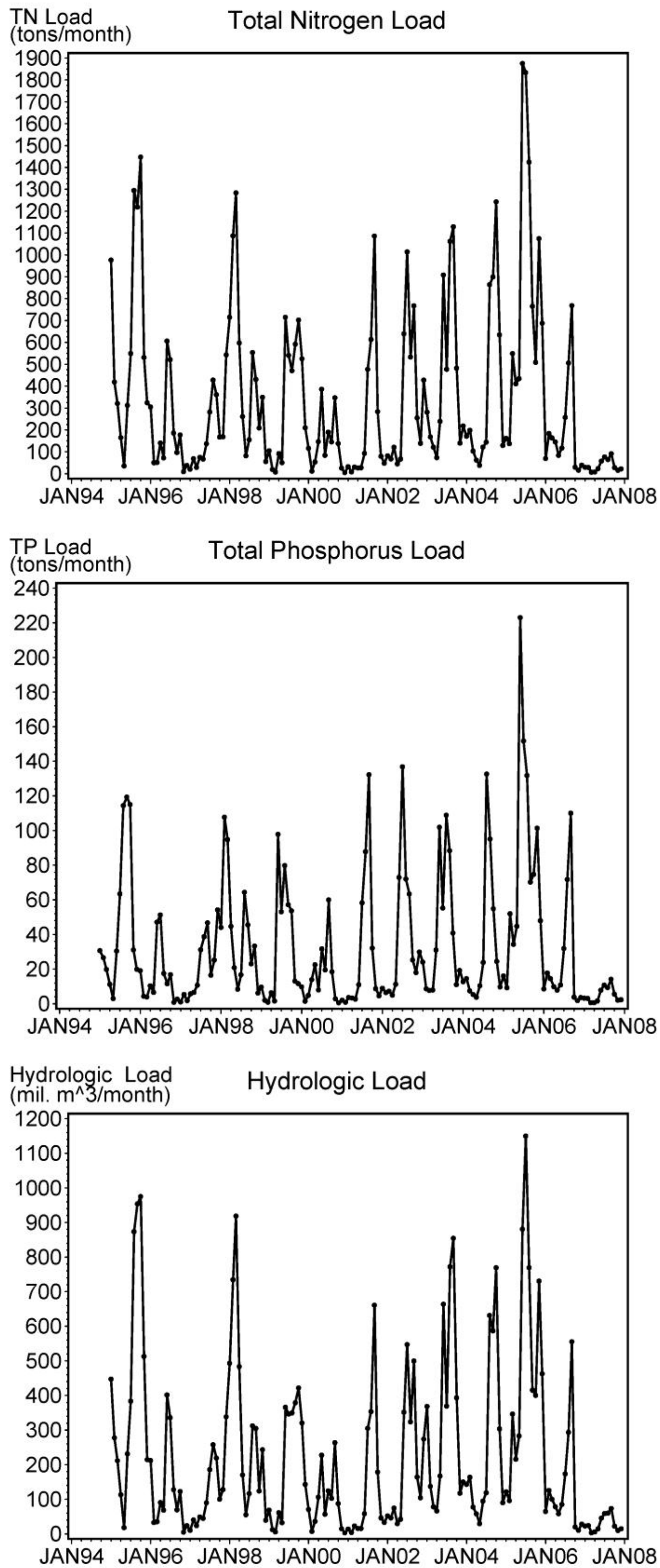


**Figure 5-46. Time series of TN loads (top plot), TP loads (middle plot), and hydrologic loads (bottom plot) for Tidal Caloosahatchee.**

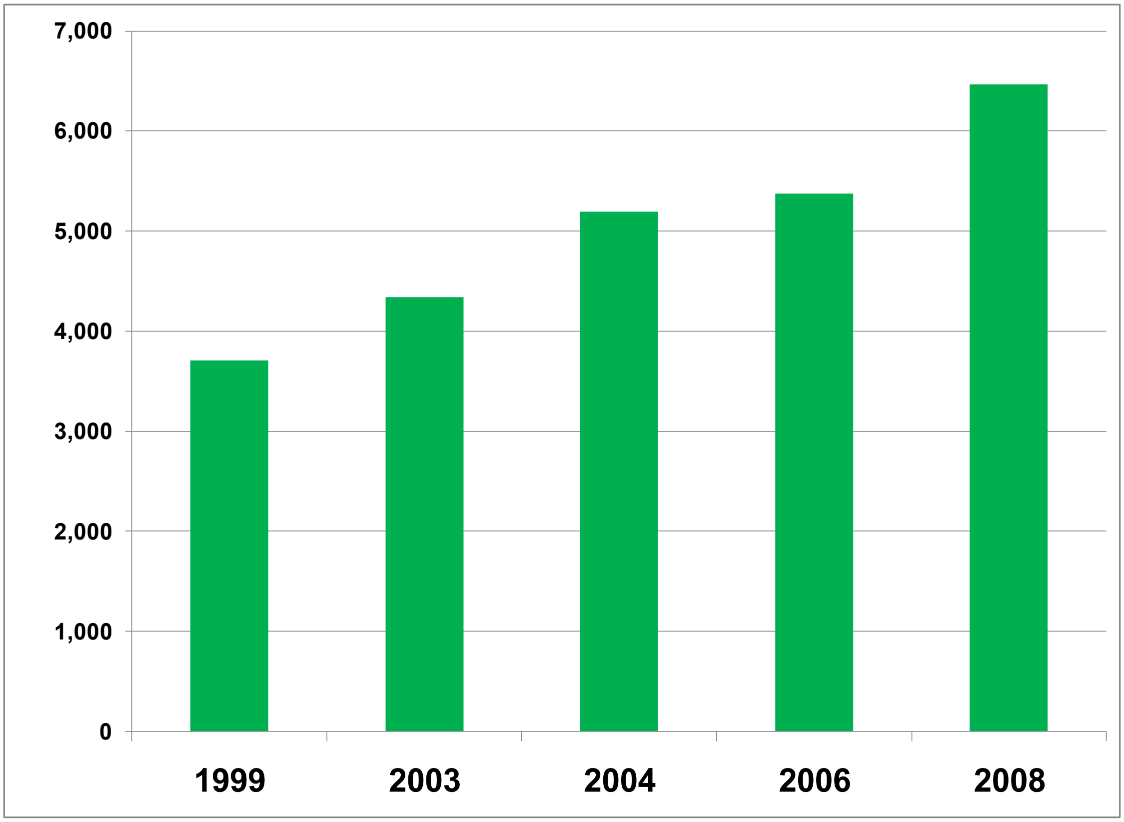


**Figure 5-47. Seagrass acreage in San Carlos Bay.**

### 5.7.3 Relationship Between Chlorophyll *a* and Concentrations and Loads - San Carlos Bay and Tidal Caloosahatchee

In addition to the time series plots, a series of bivariate plots were examined to investigate relationships between chlorophyll *a* and nutrient loads and concentrations. These plots and a description of the relationship developed are included in Appendix 5.7. No significant statistical relationship was identified for San Carlos Bay, therefore the reference period approach was used. While a statistically significant relationship was identified between chlorophyll a and TN load in Tidal Caloosahatchee, a considerable amount of variability was left unexplained by this relationship (Appendix 5.7).

### 5.7.4 Candidate Criteria – San Carlos Bay and Tidal Caloosahatchee

Based on discussions with the CHNEP Technical Advisory Committee, there is not sufficient confidence in the Tidal Caloosahatchee regression to develop a defensible numeric nutrient criterion due to the amount of variability left unexplained by the regression. Therefore, as described in Figure 5-1, the reference period approach was recommended for developing TN concentration criteria for Tidal Caloosahatchee. As San Carlos Bay is classified as “protection” for seagrass, the TN concentration criterion is calculated by summing the annual mean from the reference period (2003-2007) plus one standard deviation (for the period of record):

TN criterion = 0.46 mg/l (mean) + 0.10 (SD) = 0.56 mg/l

Tidal Caloosahatchee is classified as a seagrass "restoration" segment, therefore the TN concentration criterion is calculated by summing the annual mean from the reference period (2003-2007) plus ½ standard deviation (for the period of record):

TN criterion = 1.00 mg/l (mean) + ½ * 0.18 (SD) = 1.09 mg/l

A comparison of the candidate numeric TN concentration criteria for San Carlos Bay and Tidal Caloosahatchee based on the Reference Period method are presented in Figure 5-48 and Figure 5-49, respectively.

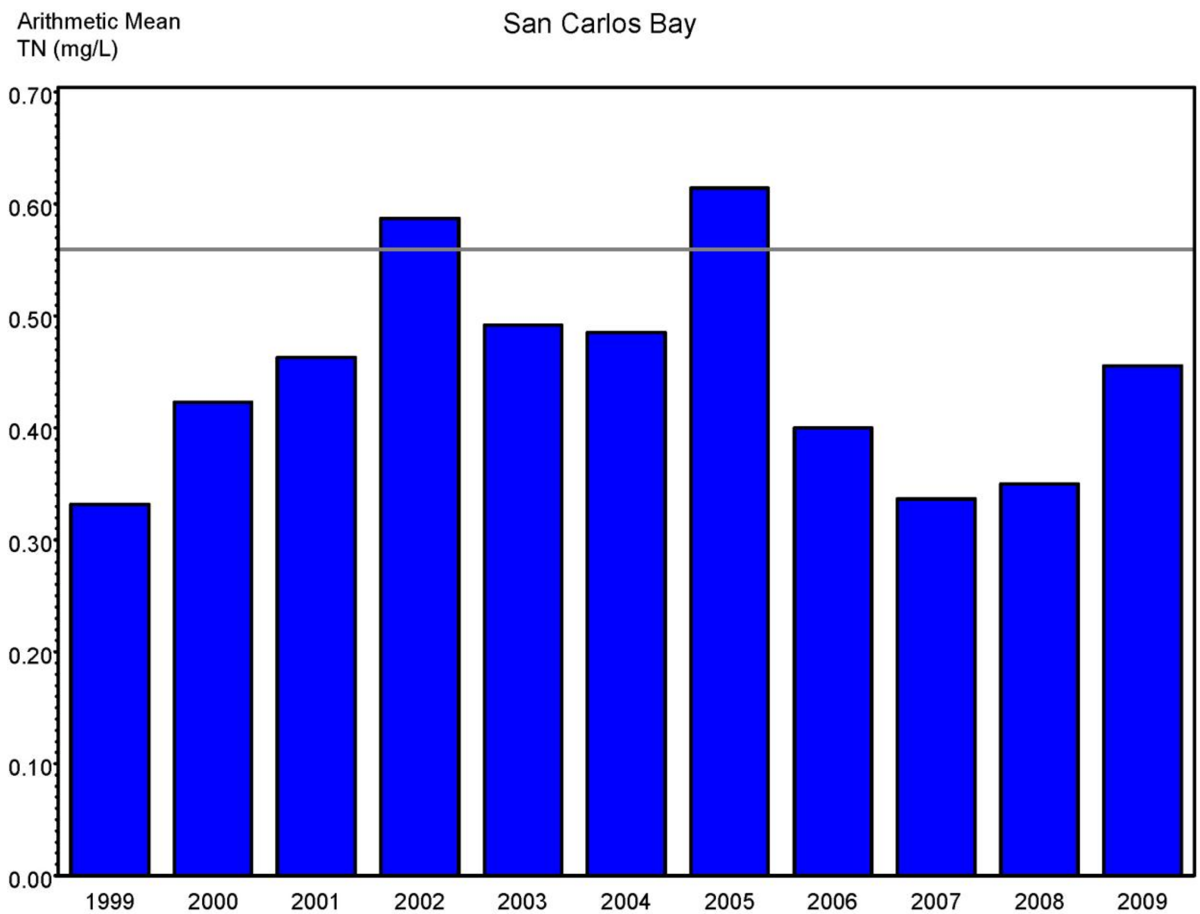


**Figure 5-48. Comparison of the candidate TN criterion to observed TN concentrations (expressed as arithmetic means) in San Carlos Bay.**

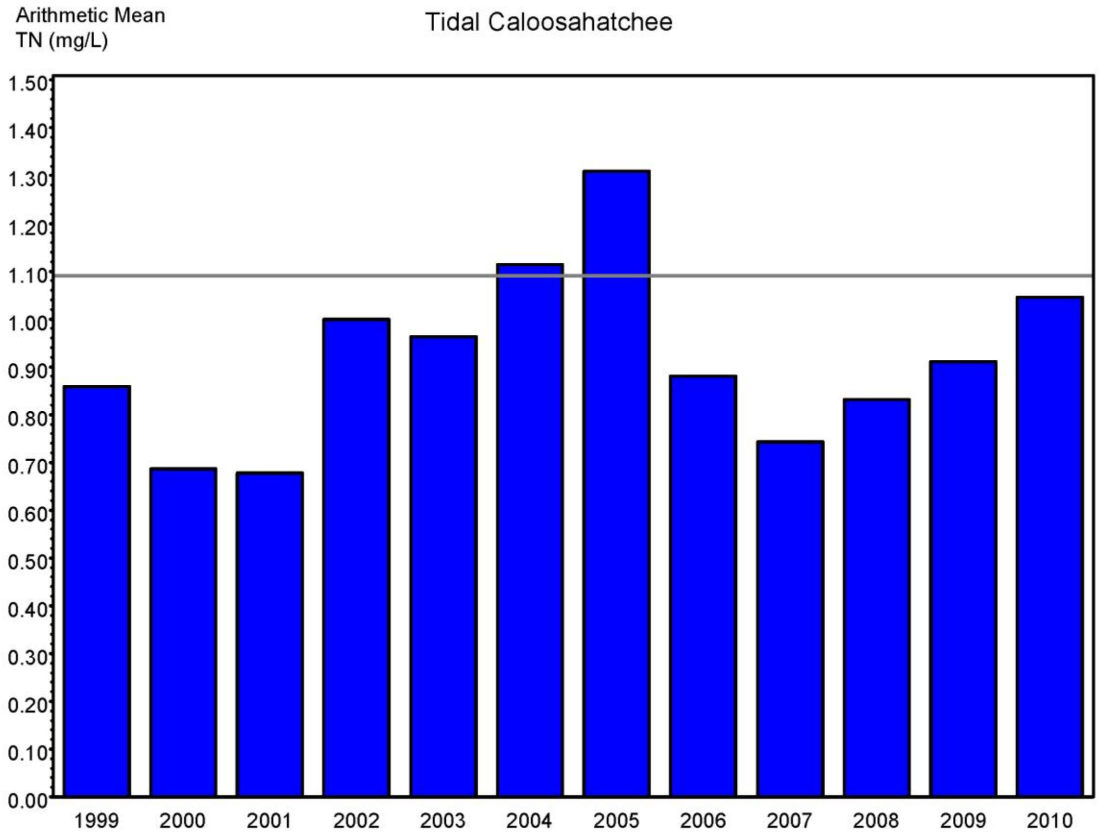


**Figure 5-49. Comparison of the candidate TN criterion to observed TN concentrations (expressed as arithmetic means) in Tidal Caloosahatchee.**

## 5.8 Estero Bay

The Estero Bay segment is bounded on the north by San Carlos Bay and is the southernmost of the segments in the CHNEP watershed (Figure 5-50). The Estero Bay segment surface area is approximately 10,813 acres, with its watershed covering approximately 229,671 acres, or 359 mi². This results in a watershed to open water area ratio of 21, relatively high compared to others in the CHNEP area and generating moderate runoff per rainfall unit.

Estero Bay, like Lemon Bay, is a coastal lagoon that has limited connectivity with the Gulf of Mexico on the west, and is relatively shallow. Four main rivers/streams provide freshwater inputs to Estero Bay: Estero River, Imperial River, Six Mile Cypress, and Ten Mile Canal. Coastal wetlands along the shores of Estero Bay augment hydrologic inputs to the system. The watershed is also characterized by a large network of man-made canals serving the communities throughout the Estero Bay drainage basin. Land used in the watershed is predominantly wetlands (40%), with about one-quarter of the watershed classified as open lands and one-fifth as urban (Janicki Environmental, 2010d). The urban lands in the western portion of the watershed are parts of Fort Myers and Estero.

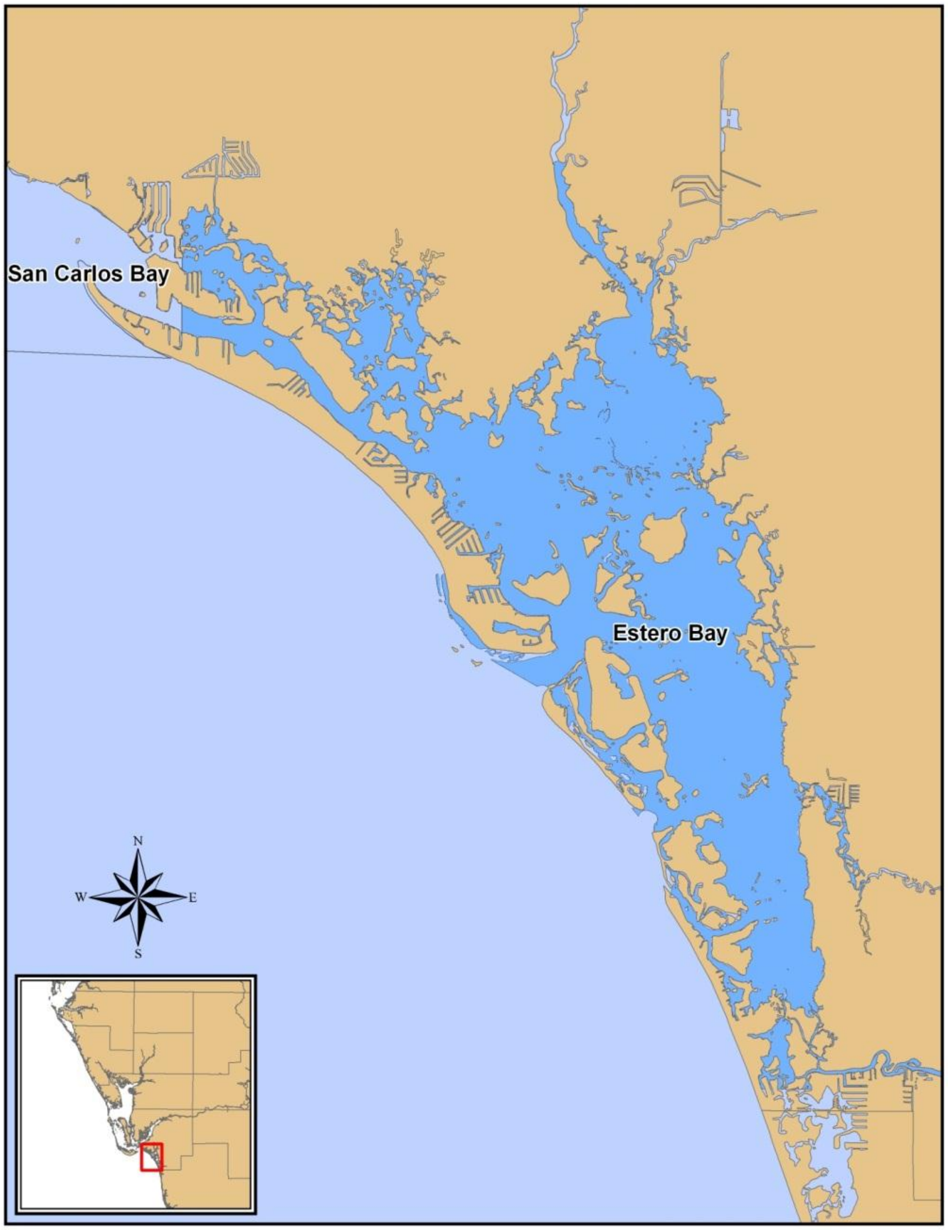


**Figure 5-50. Map of Estero Bay water segment.**

A measure of residence time in the system is provided by the pulse residence time (PRT), which is estimated as a function of tidal mixing and freshwater inflows, as described previously (see Appendix 2). The median PRT for each year was calculated based on monthly data, and then the median PRT of the annual values was calculated, as representative of the median hydraulic residence time given the observed conditions of 1995-2007. The median hydraulic residence time for Estero Bay was 150 days, indicating a relatively slow flushing rate, indicative of the relatively small freshwater influx to the system and the limited tidal exchange with the Gulf.

### 5.8.1 Estero Bay Water Quality and Nutrient Loadings

Time series plots of monthly average chlorophyll *a*, TN, and TP concentrations in Estero Bay are presented in Figure 5-51. The chlorophyll *a* concentrations varied from a low of 1.6 µg/l to a high of 17.7 µg/l. The 25$^{th}$ and 75$^{th}$ percentile chlorophyll *a* concentrations were 3.3 and 6.4 µg/l, resulting in an interquartile range of 3.1 µg/l. The mean chlorophyll *a* concentration was 5.1 µg/l and the median was 4.4 µg/l. The mean is influenced by several high concentration values. The monthly average TN concentrations varied from 0.01 to 1.67 mg/l. The interquartile range was 0.26 mg/l (0.30 to 0.56 mg/l). The mean TN concentration was 0.48 mg/l, while the median was 0.43 mg/l. The monthly average TP concentrations in Estero Bay varied from 0.01 to 0.75 mg/l, and the interquartile range was 0.03 mg/l (0.04 to 0.07 mg/l). The mean and median TP concentrations were 0.05 and 0.04 mg/l, respectively. As expected, the differences between the mean and median for TN and TP were much less as TN and TP do not show the inter-annual variability exhibited by chlorophyll *a* concentrations.

There was no statistically significant trend in TP in Estero Bay during this period ($p>0.05$) (Appendix 3 presents the complete trend test results). A significant decreasing trend was detected in TN ($p<0.01$, slope= -0.07) and a significant increasing trend was detected in chlorophyll *a* ($p<0.01$, slope=0.58).

Figure 5-52 presents the times series of monthly TN, TP, and hydrologic loads to Estero Bay. The monthly TN loads varied from 2 to 229 tons/month, with an interquartile range of 37 tons/month (7 to 44 tons/month). The mean and median TN loads to Estero Bay were 36 and 16 tons/month, respectively. Monthly TP loads varied from 0.2 to 39.1 tons/month. The interquartile range for TP loads was 4.9 tons/month (0.7 to 5.6 tons/month). The mean TP load was 4.5 tons/month, while the median was 1.7 tons/month. The monthly hydrologic loads varied from a low of 2 million $m^3$/month to a high of 241 million $m^3$/month. The interquartile range was 37 million $m^3$/month (6 to 43 million $m^3$/month). The mean and median hydrologic loads were 34 and 17 million $m^3$/month, respectively. These differences between the means and medians are a sign that the means are highly influenced by a series of high loadings values that are typically seen in the wet season when rainfall driven hydrologic loads and corresponding nutrient loads are substantially higher than during the dry season.

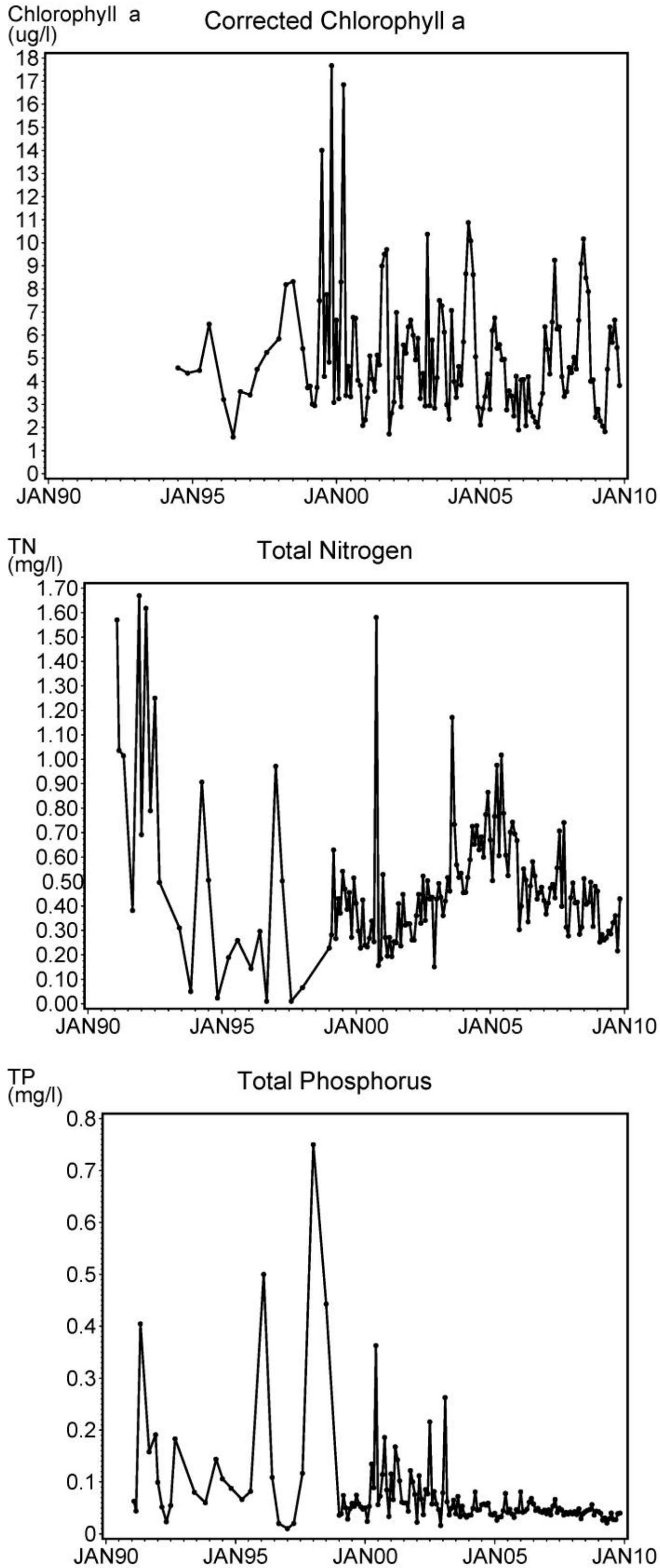


**Figure 5-51. Time series of chlorophyll *a* (top plot), TN (middle plot), and TP (bottom plot) for Estero Bay.**

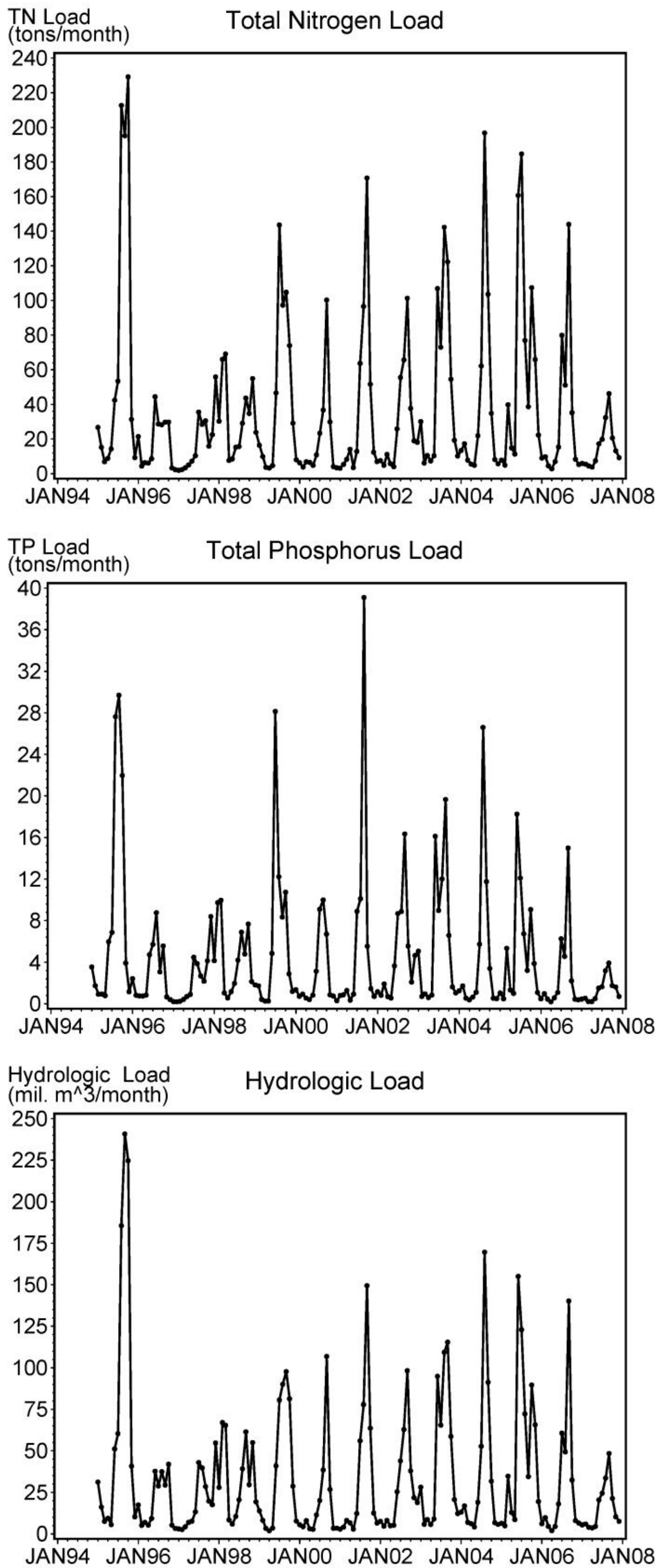


**Figure 5-52. Time series of TN loads (top plot), TP loads (middle plot), and hydrologic loads (bottom plot) for Estero Bay.**

### 5.8.2 Seagrass Target and Chlorophyll Target and Threshold

- Seagrass Target

  - The seagrass target for this segment is 3,662 acres (Janicki Environmental, 2009).
  - Seagrass acreages from 1988-2008 are provided in Figure 5-53.
  - Estero Bay is classified as a seagrass “restoration” segment.

- Chlorophyll *a* Target

  - Approved method is the Reference Period Method
  - Reference Period = 2003-2007
  - Chlorophyll Target = 4.9 µg/l
  - Standard Deviation of Annual Chlorophyll = 2.0 µg/l
  - Chlorophyll Threshold (mean + ½ SD) = 5.9 µg/l

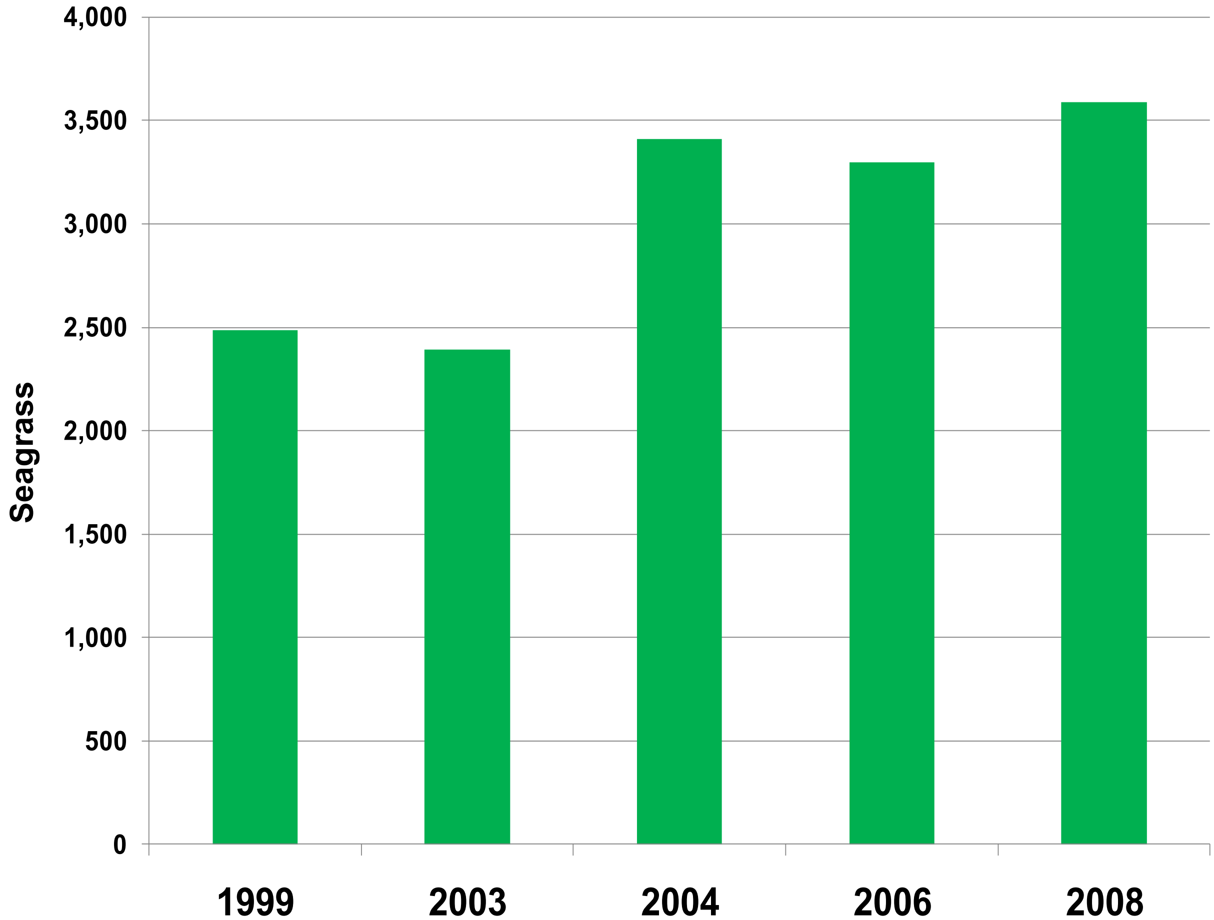


**Figure 5-53. Seagrass acreage in Estero Bay.**

### 5.8.3 Relationship Between Chlorophyll *a* and Concentrations and Loads - Estero Bay

In addition to the time series plots, a series of bivariate plots were examined to investigate relationships between chlorophyll *a* and nutrient loads and concentrations. These plots and a description of the relationship developed are included in Appendix 5.8. No statistically significant relationship was developed for Estero Bay. Therefore, changepoint analysis was also investigated (Appendix 5.8).

### 5.8.4 Candidate Criterion – Estero Bay

Based on discussions with the CHNEP Technical Advisory Committee, there is not sufficient confidence in the use of the changepoint analysis to develop a defensible numeric nutrient criterion. Therefore, as described in Figure 5-1, the reference period approach was recommended for developing a TN concentration criterion for Estero Bay. As Estero Bay is classified as “restoration” for seagrass, the TN concentration criterion is calculated by summing the annual mean from the reference period (2003-2007) plus ½ standard deviation (for the period of record). This results in the following TN concentration criterion for Estero Bay:

TN criterion = 0.57 mg/l (mean) + ½ * 0.12 (SD) = 0.63 mg/l

A comparison of the candidate numeric TN concentration criterion based on the Reference Period method is presented in Figure 5-54.

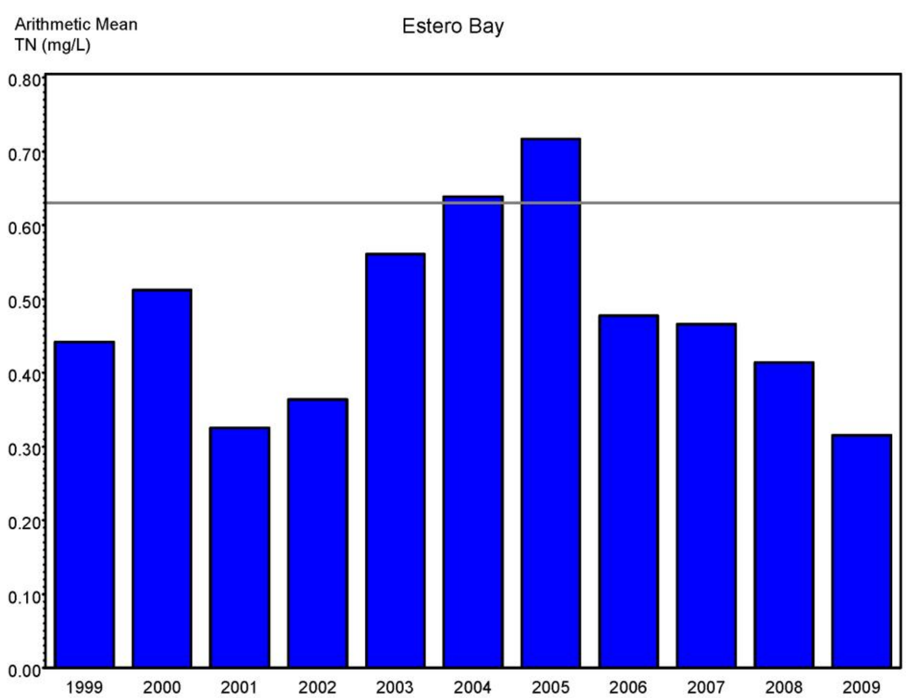


**Figure 5-54. Comparison of the candidate TN criterion to observed TN concentrations (expressed as arithmetic means) in Estero Bay.**

# 6.0 CONCLUSIONS AND RECOMMENDATIONS

In this document, candidate numeric nutrient criteria for the estuarine waters of the Charlotte Harbor National Estuary Program (CHNEP) have been developed and presented, including the estuarine segments in the Charlotte Harbor National Estuary Program's jurisdiction. The methods that were attempted to derive candidate criteria have been previously identified in a data analysis plan (Janicki Environmental, 2010b) and have been discussed in the previous sections of this report. These methods were developed based on peer-reviewed literature, the many local scientists and natural resource managers studying southwest Florida estuaries, previous USEPA documents (USEPA, 2009), and reviews by its Science Advisory Board (SAB, 2010) on methods for establishing numeric nutrient criteria. Several methods were evaluated to determine threshold values for the response variable (chlorophyll) in the segments.

As discussed in Section 5.0, though statistically significant relationships were previously identified for most segments of the CHNEP area, these previously identified relationships left a considerable amount of variability unexplained. Therefore, the Policy Committee agreed to develop candidate numeric nutrient criteria for TN concentrations based on the reference period approach. Additionally, for segments that have been identified as impaired for nutrients and have had a TMDL developed, the TMDL would be used as the nutrient criteria. As was discussed in Section 3.3.3, if a segment is classified as a seagrass "protection" segment, the TN concentration criterion is calculated by summing the annual mean from the reference period (2003-2007) plus one standard deviation (for the period of record). However, if a segment is classified as a seagrass "restoration" segment, the TN concentration criterion is calculated by summing the annual mean from the reference period (2003-2007) plus ½ standard deviation (for the period of record). The candidate criteria for the CHNEP jurisdiction are presented in Table 6-1.

Tidal Caloosahatchee has been identified as impaired and a TMDL has been drafted. However, due to concerns raised with the draft TMDL for the Tidal Caloosahatchee, the TMDL is currently being revised. Therefore, it was decided to list the nutrient criteria for Tidal Caloosahatchee as "to be determined" (TBD) until the revision to the draft TMDL is completed.

It should be noted that these criteria are being proposed as interim nutrient criteria and should be evaluated at some future date, perhaps in five years. This should be done to insure that the proposed interim criteria are consistent with the reaction of the response variable. For example, if we are seeing exceedences of the TN criterion in a segment that has increasing seagrass populations and chlorophyll concentrations that are below the threshold, the TN criterion is likely too stringent. Alternatively, if the TN criterion is not being exceeded but the seagrasses are declining and the segment is not meeting chlorophyll concentration thresholds, the TN criterion is not stringent enough. Issues pertaining to the implementation of the proposed nutrient criteria are discussed in a separate technical memo (Janicki Environmental, 2011).

| **Table 6-1.** | **Candidate numeric nutrient criteria based on the reference period approach for TN concentration.** |
|---|---|
| **Segment** | **Candidate Criterion** |
| Dona and Roberts Bays | 0.42 mg/l |
| Upper Lemon Bay | 0.56 mg/l |
| Lower Lemon Bay | 0.62 mg/l |
| Tidal Myakka | 1.02 mg/l |
| Tidal Peace | 1.08 mg/l |
| Charlotte Harbor Proper | 0.67 mg/l |
| Matlacha Pass | 0.58 mg/l |
| Pine Island Sound | 0.57 mg/l |
| Tidal Caloosahatchee | TBD |
| San Carlos Bay | 0.56 mg/l |
| Estero Bay | 0.63 mg/l |

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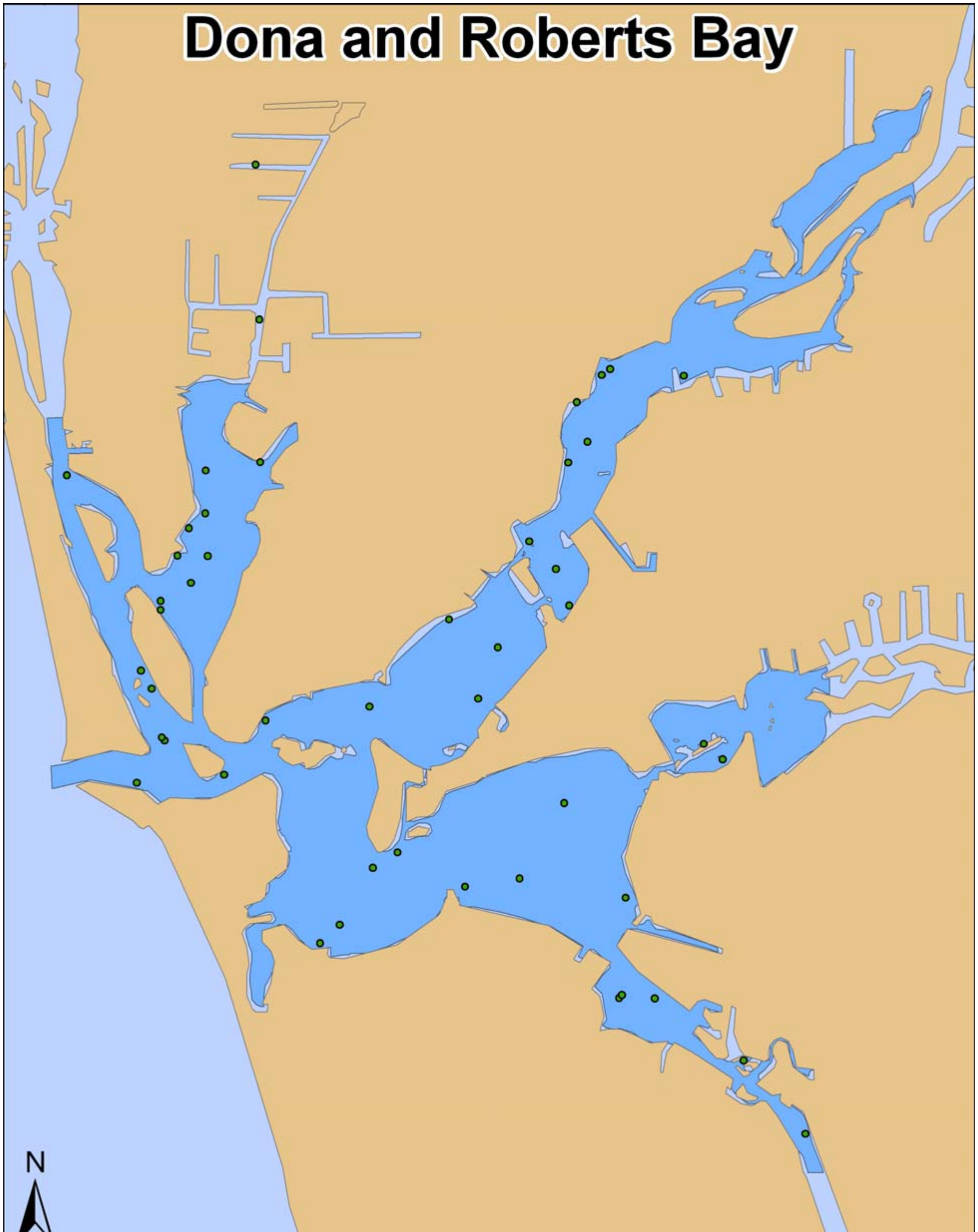
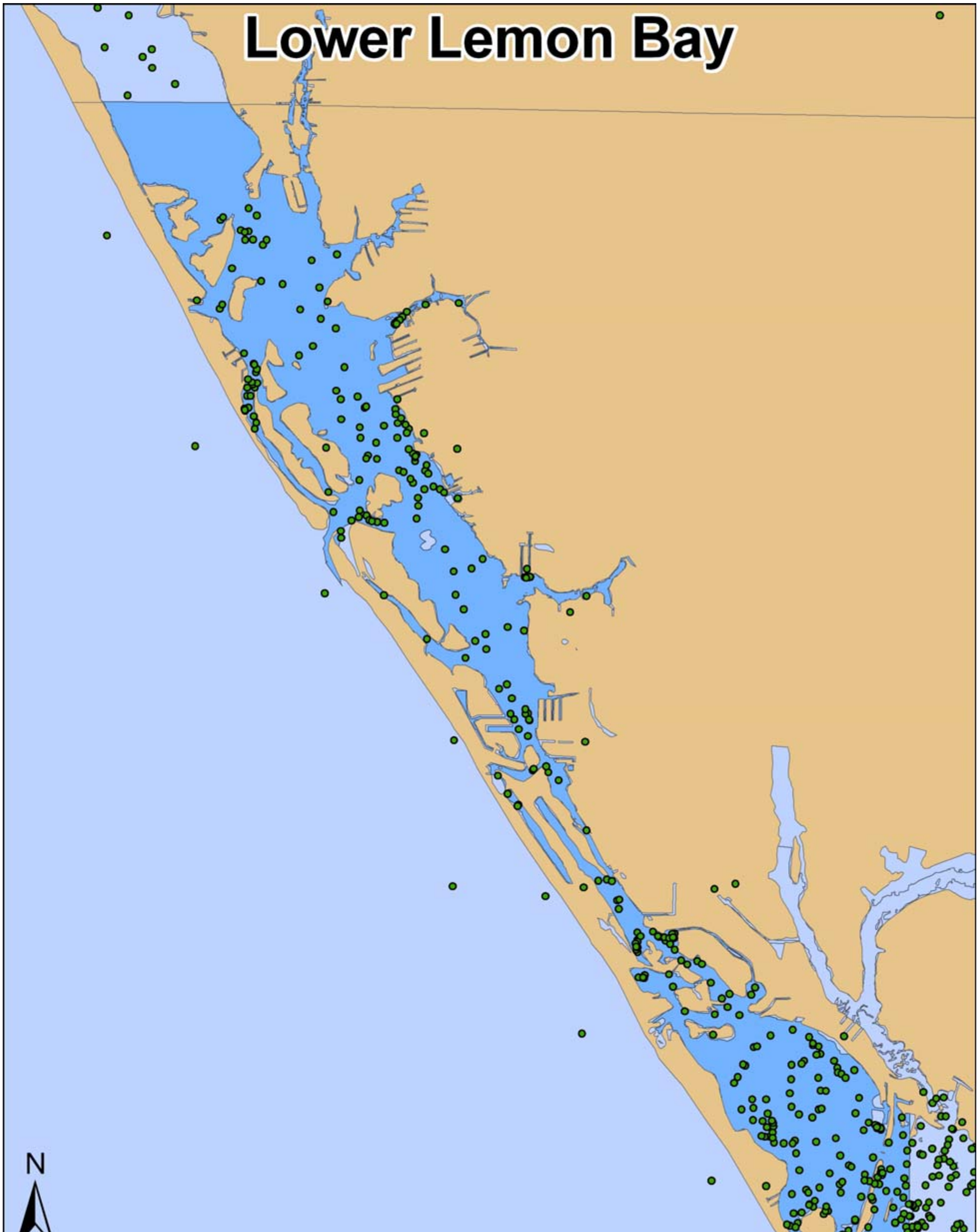
# Appendix 1 - Water Quality Sampling Stations


Dona and Roberts Bay
N


Upper Lemon Bay
N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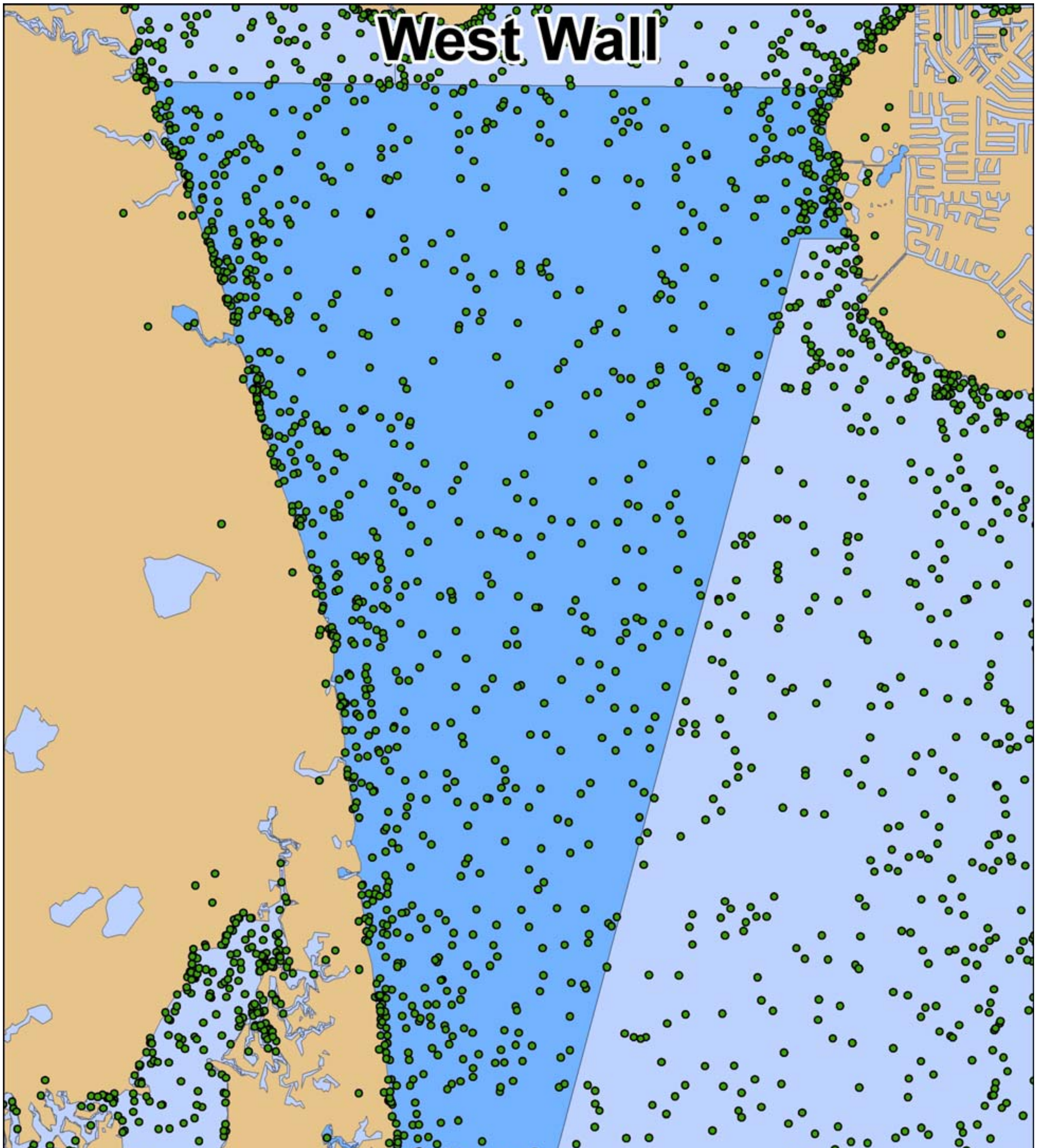
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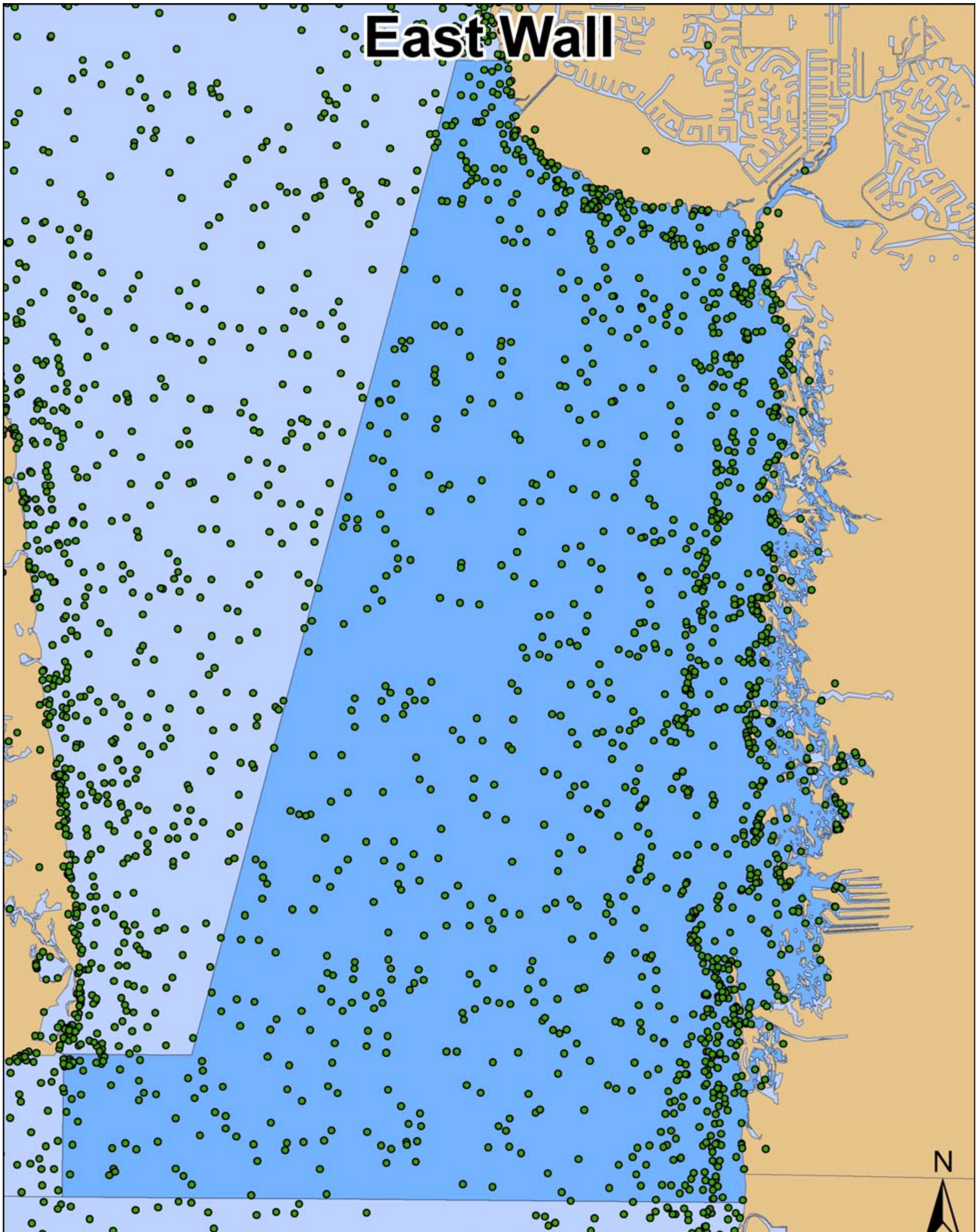
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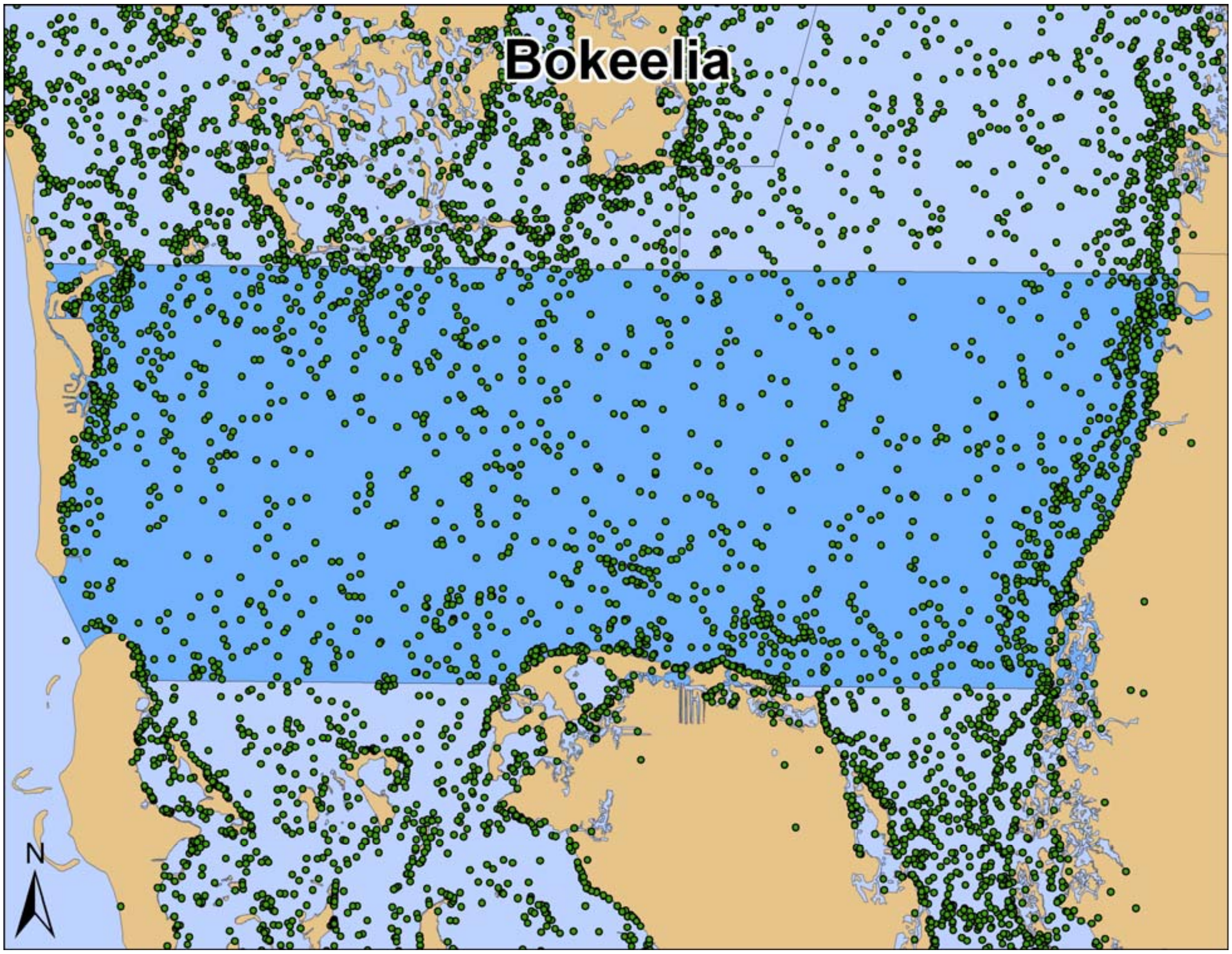
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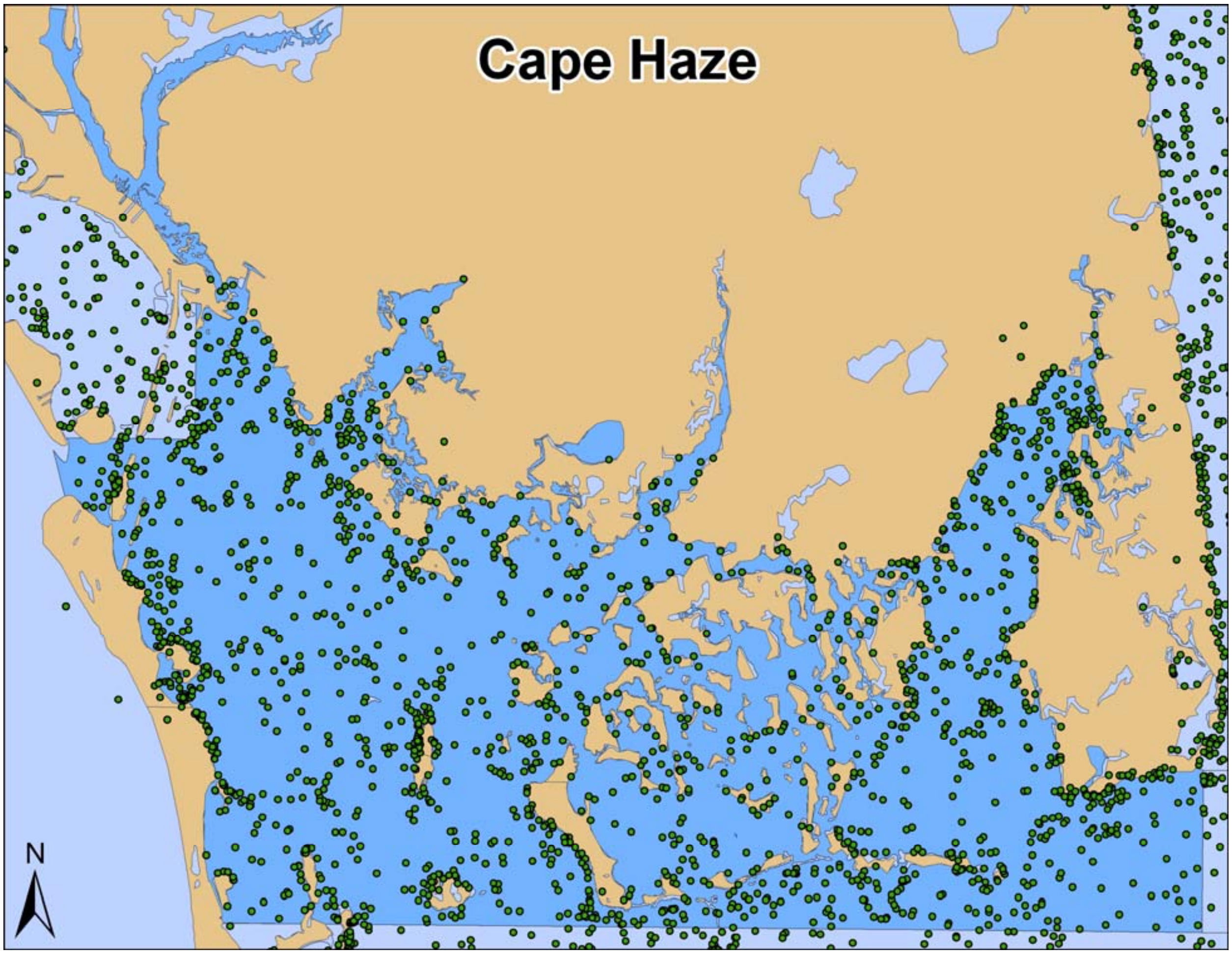
Cape Haze
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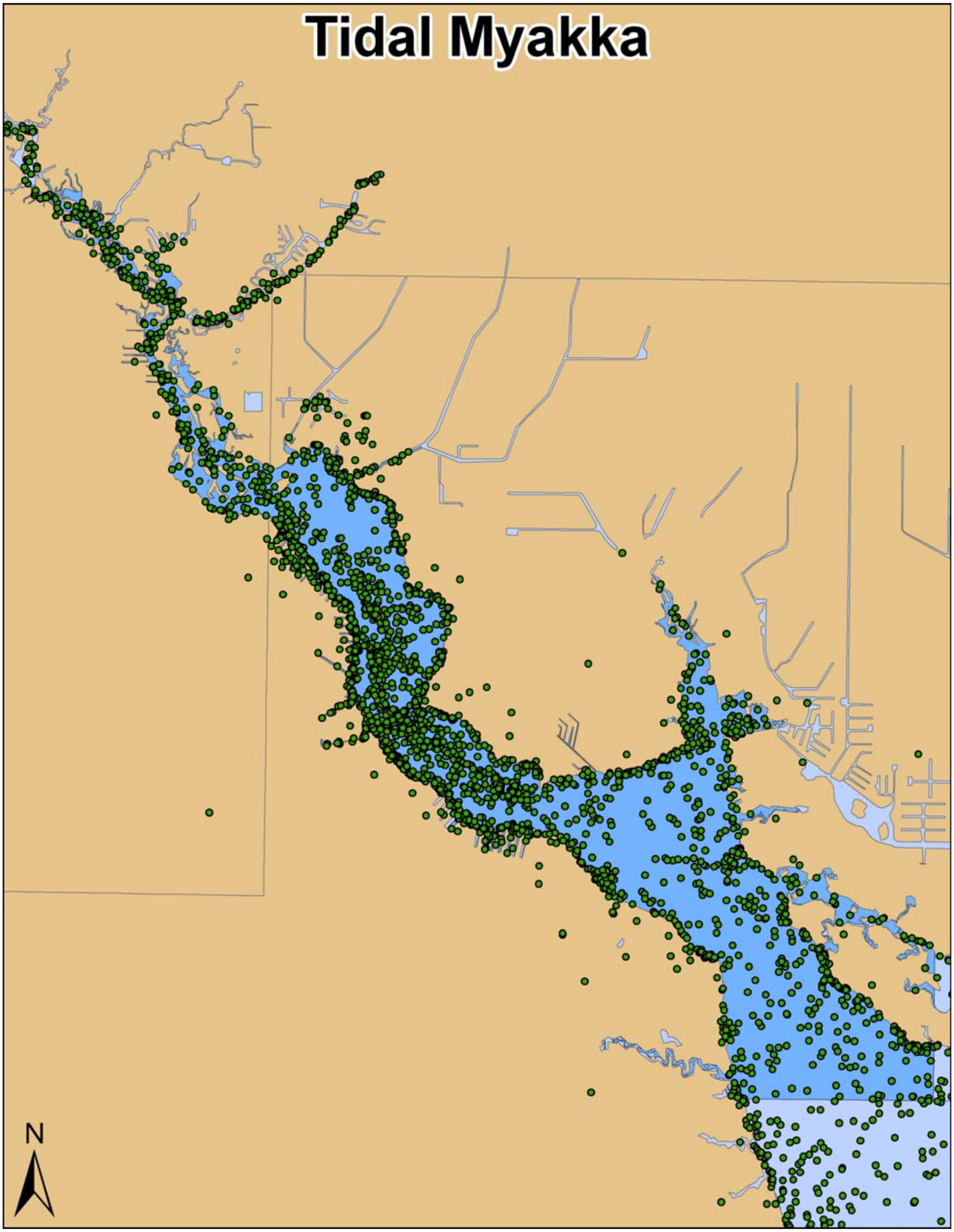
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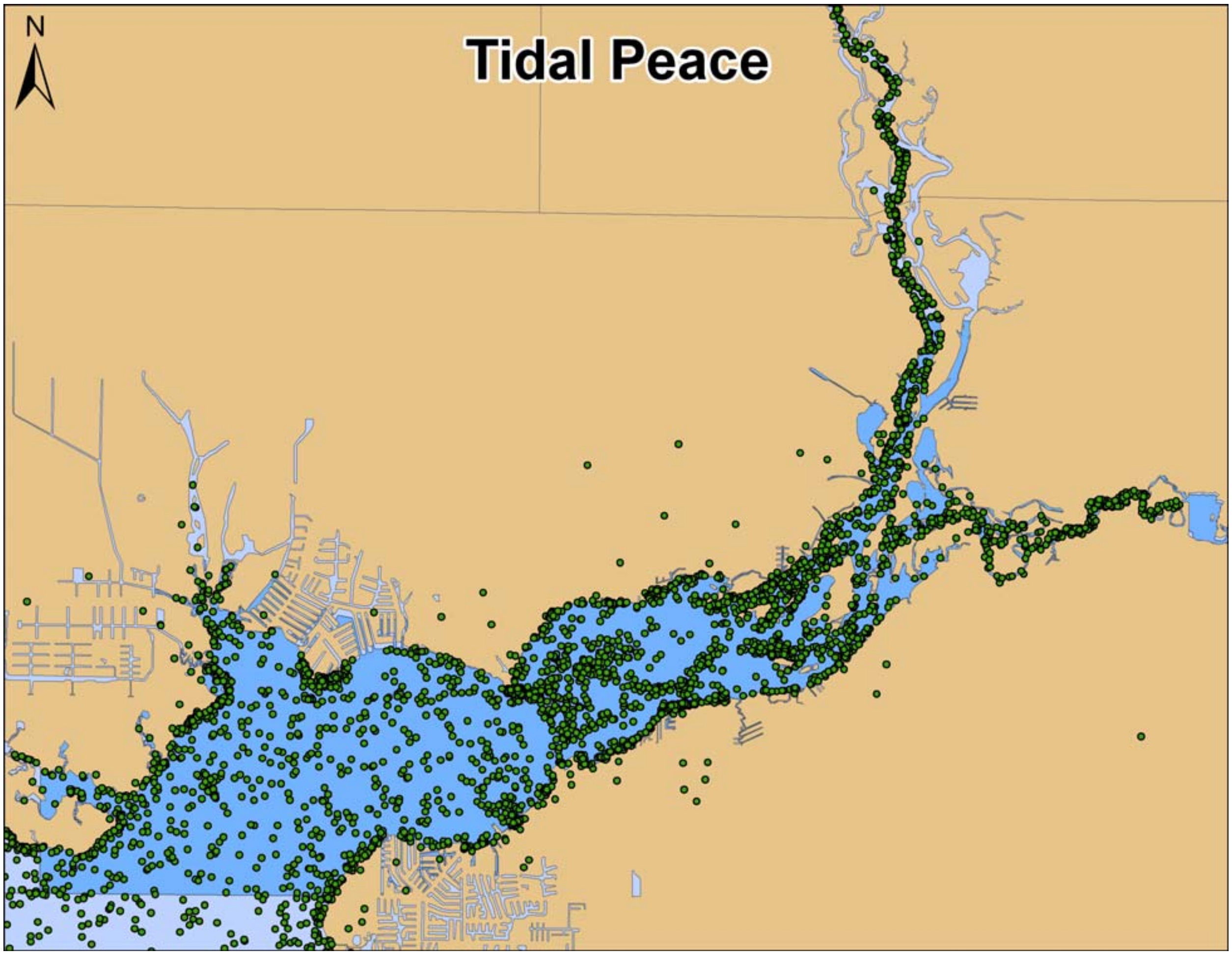
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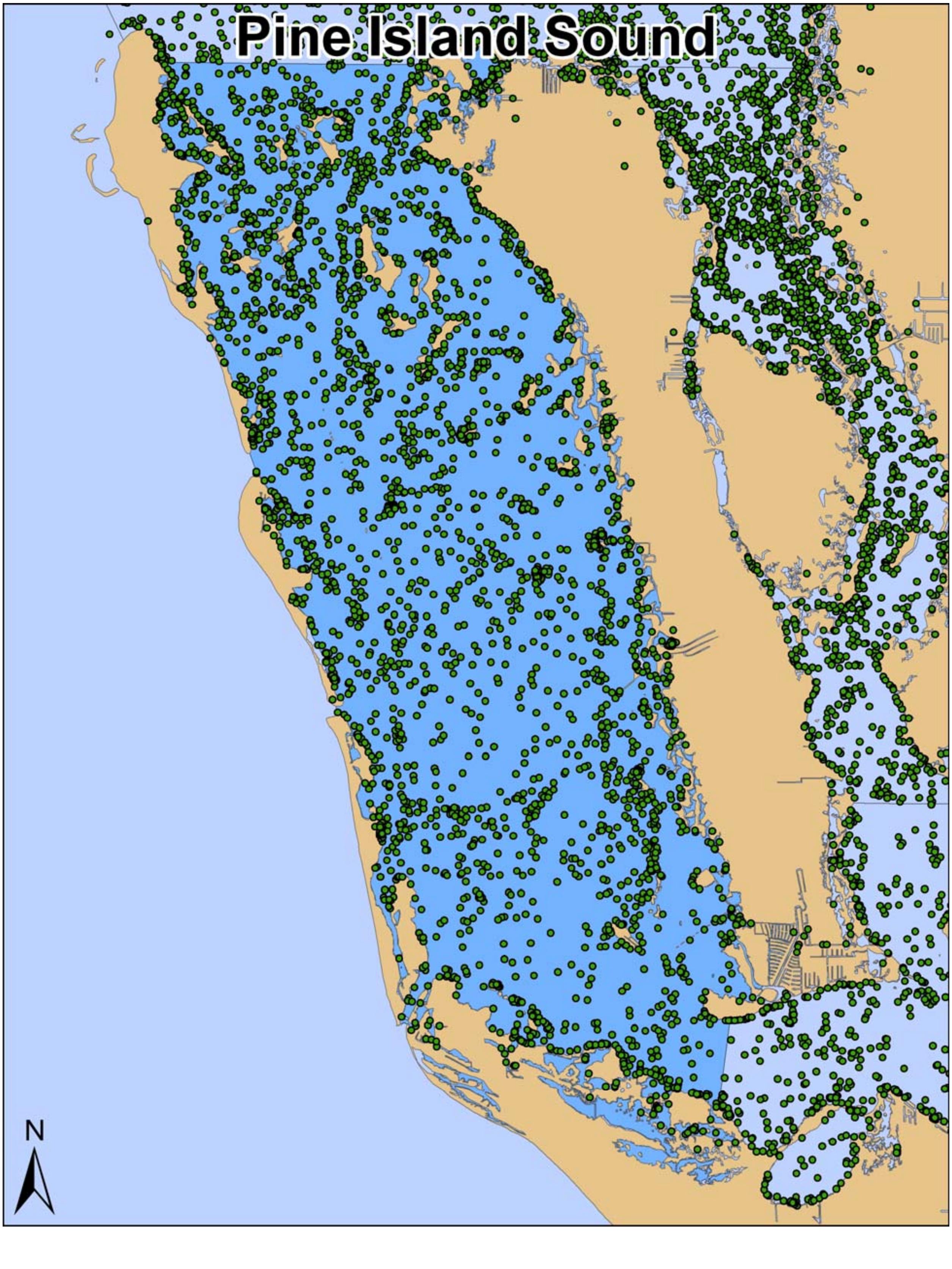
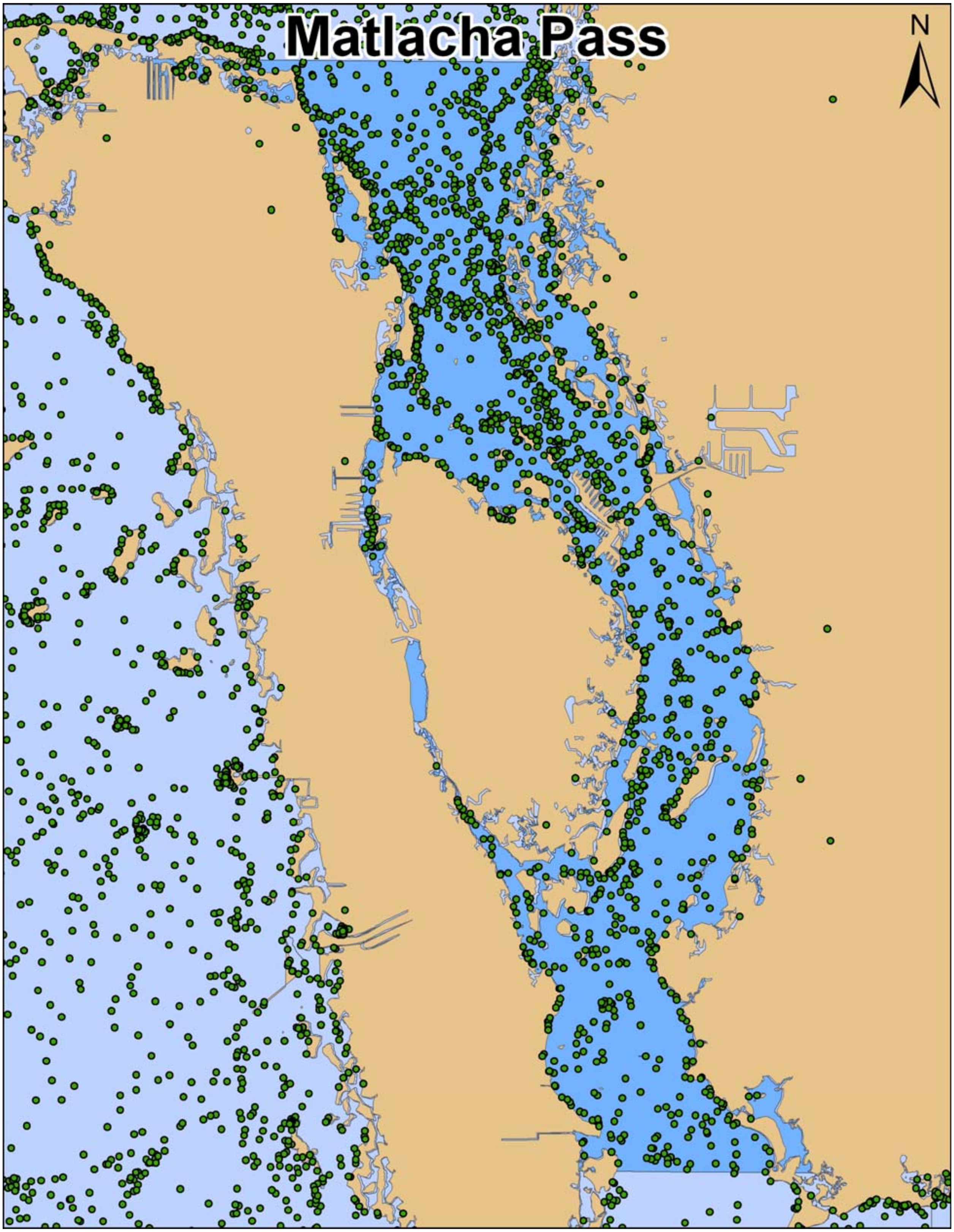
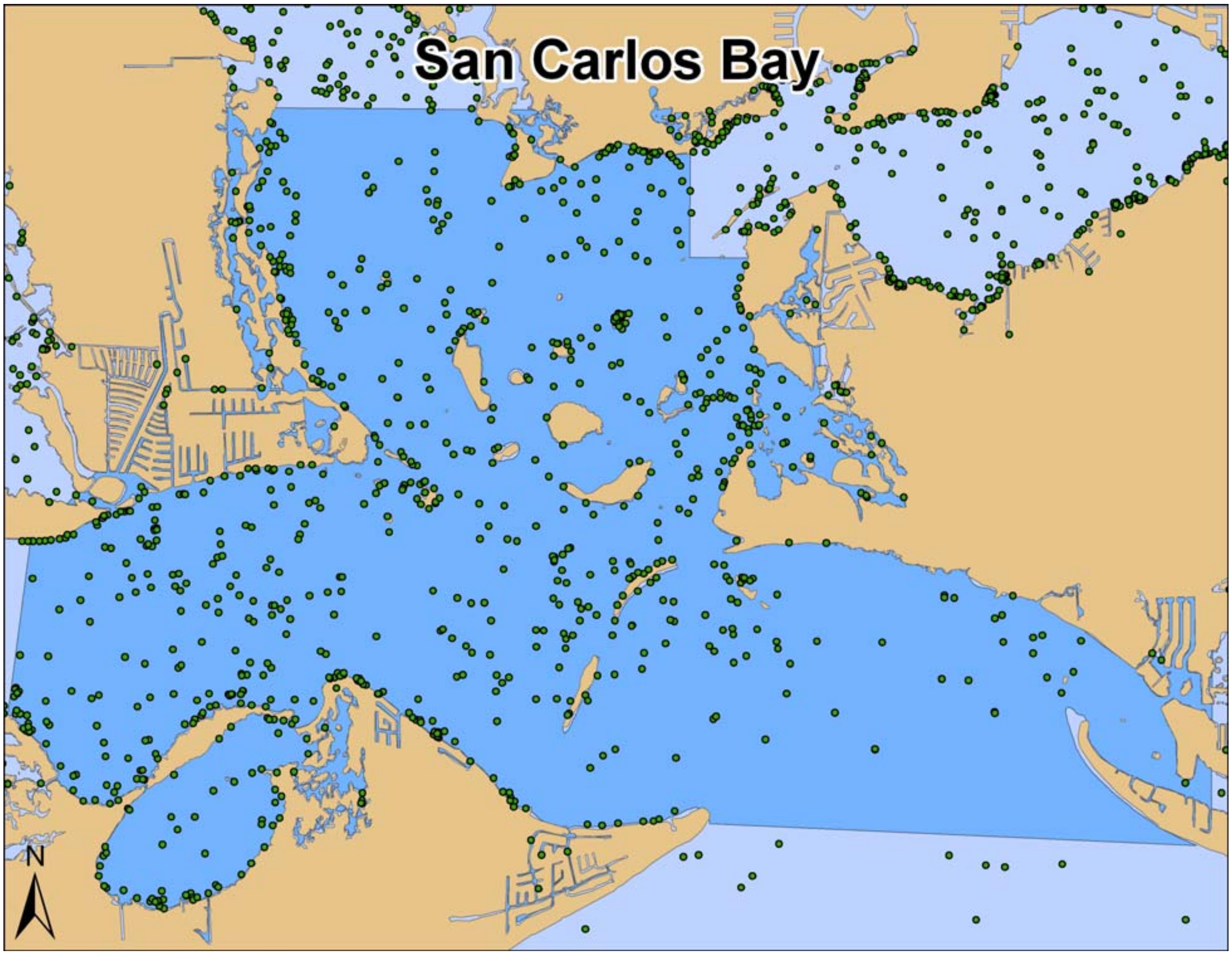
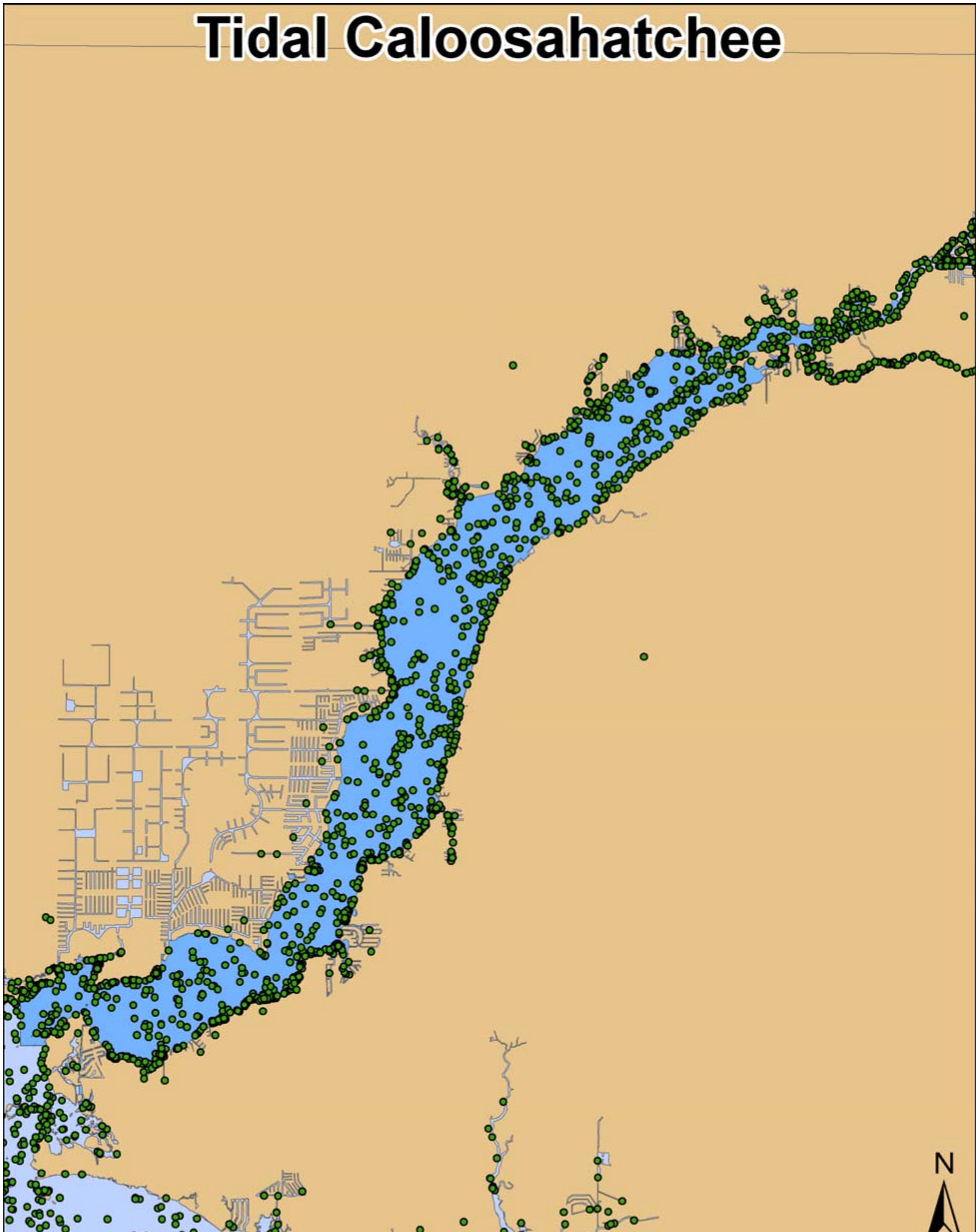
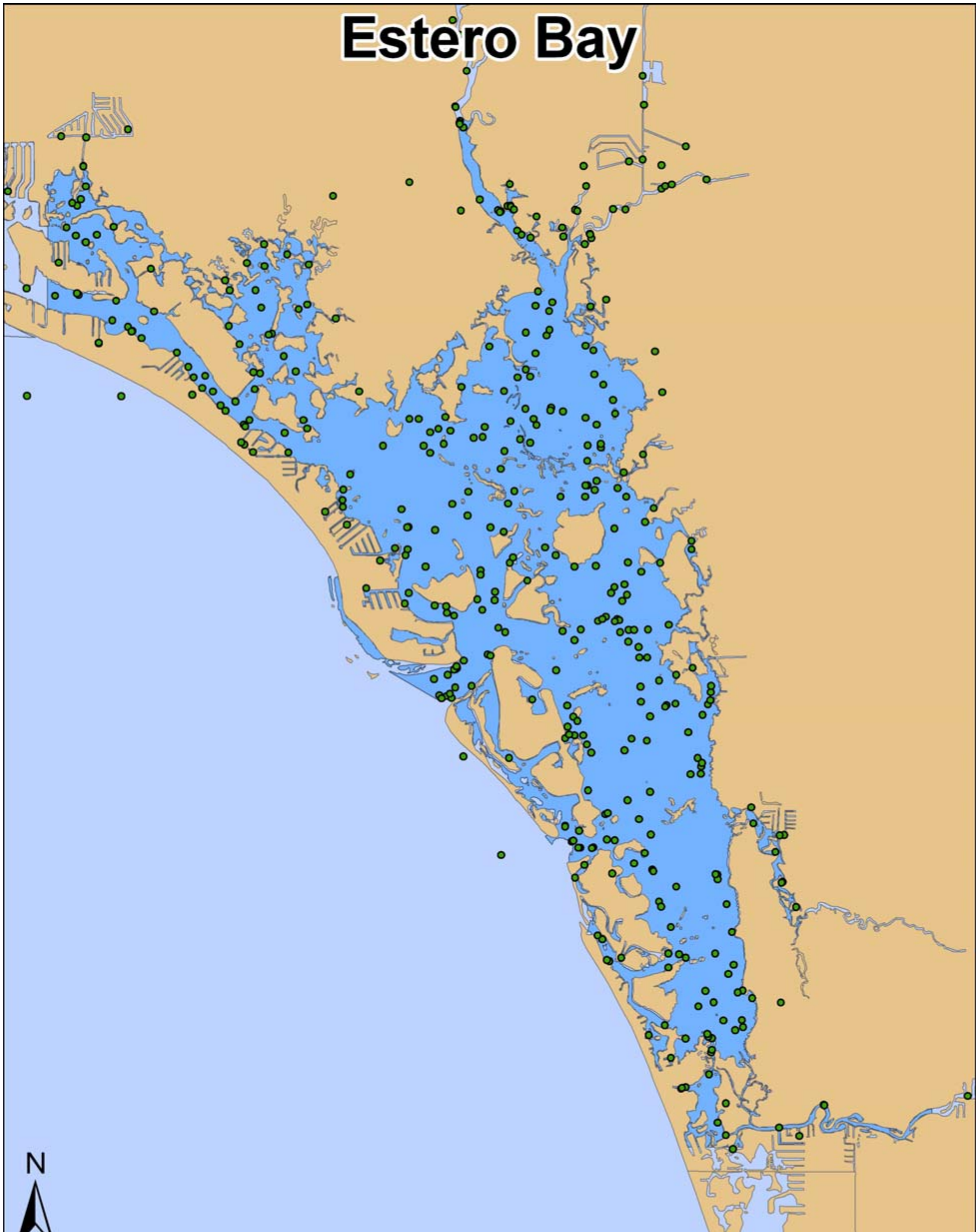
Tidal Peace


Pine Island Sound
N


Matlacha Pass
N


San Carlos Bay
N


Tidal Caloosahatchee
N


Estero Bay
N

# Appendix 2 – Pulse Residence Time

**Charlotte Harbor Residence Time**

A box model was developed to estimate the hydraulic residence times within the Charlotte Harbor National Estuary Program bay segments. The box model was based on observed salinity distributions within the system and estimated freshwater inflows to the system. Methods were similar to those described by Hagy et al. (2000), with the exception that the Sarasota Bay Estuary system was assumed to be well mixed vertically, so that all transport was horizontal. Hydraulic residence time is also named the pulse residence time (PRT), as residence times are dependent upon introducing a pulse of tracer into a selected segment at the beginning of the box model simulation and tracking the time necessary for the concentration of this tracer to decrease to a certain level.

The method used in this effort is predicated on a well-defined flow path for freshwater beginning at the head of an estuary. For a lagoonal system, it is necessary to define the flow path for freshwater entering the estuary at a given point. For the Charlotte Harbor National Estuary system, five segment groupings were used to represent separate freshwater flow paths, defined as follows for each grouping (Figure 1):

- Dona and Roberts Bays: Freshwater inflow to the segment flows downstream to the Gulf of Mexico.

- Lemon Bay: Freshwater inflow to the Upper and Lower Lemon Bay segments flows downstream to the Gulf of Mexico.

- Charlotte Harbor: Freshwater inflows from the Tidal Myakka and the Tidal Peace segments flow into the Upper Harbor (combined East Wall and West Wall segments). Freshwater inflows to the Upper Harbor flow into the Lower Harbor (Bokeelia and Cape Haze segments), and then to the Gulf of Mexico. Freshwater inflows from the northern half of the Matlacha Pass segment flow into the Lower Harbor, and then to the Gulf of Mexico.

- Pine Island Sound: Freshwater inflows to the Pine Island Sound segment flow to the Gulf of Mexico through the passes along the western boundary of the segment.

- San Carlos Bay: Freshwater inflows from the southern half of the Matlacha Pass segment flow into San Carlos Bay, as do freshwater inflows from the Tidal Caloosahatchee segment. Freshwater inflows to San Carlos Bay flow into the Gulf of Mexico.

- Estero Bay: Freshwater inflows to the Estero Bay segment flow to the Gulf of Mexico.

For each of the bay boxes (Figure 1) containing one or more segments in these groupings, non-advective transports were estimated based on observed salinity.

Exchange coefficients for non-advective transport were estimated using mean water column salinity data, obtained from the FDEP IWR database. The algorithm for exchange coefficients estimation was based on the salinity mass balance equations developed for each of the bay boxes the Charlotte Harbor National Estuary Program system. The salinity mass balance equations are provided below for each box, based on the assumption that for a given month, the mass of salinity coming into the segment is balanced by the mass of salinity leaving the segment. Here, as in Figure 1, Q is the freshwater inflow to the box from its watershed, C is the salinity in the box, and E is the non-advective exchange rate between two boxes.

Dona and Roberts Bays

$$0= -Q_{DARB}C_{DARB} + E_{GOM,DARB}(C_{GOM}-C_{DARB})$$

Lemon Bay

$$0= -Q_{LB}C_{LB} + E_{GOM,LB}(C_{GOM}-C_{LB})$$

Pine Island Sound

$$0= -Q_{PI}C_{PI} + E_{GOM,PI}(C_{GOM}-C_{PI})$$

Estero Bay

$$0= -Q_{EB}C_{EB} + E_{GOM,EB}(C_{GOM}-C_{EB})$$

Charlotte Harbor Group

Tidal Myakka:

$$0= -Q_{TM}C_{TM} + E_{UH,TM}(C_{UH}-C_{TM})$$

Tidal Peace:

$$0= -Q_{TP}C_{TP} + E_{UH,TP}(C_{UH}-C_{TP})$$

Upper Harbor:

$$0= -(Q_{TM}+Q_{TP}+Q_{UH})C_{UH} + Q_{TM}C_{TM} + Q_{TP}C_{TP} - E_{UH,TM}(C_{UH}-C_{TM}) - E_{UH,TP}(C_{UH}-C_{TP}) + E_{LH,UH}(C_{LH}-C_{UH})$$

Matlacha Pass:

$$0= -0.5Q_{MP}C_{MP} + E_{LH,MP}(C_{LH}-C_{MP})$$

Lower Harbor:

$$0= -(Q_{TM}+Q_{TP}+Q_{UH}+0.5Q_{MP}+Q_{LH})C_{LH} + (Q_{TM}+Q_{TP}+Q_{UH})C_{UH} + 0.5Q_{MP}C_{MP} - E_{LH,UH}(C_{LH}-C_{UH}) - E_{LH,MP}(C_{LH}-C_{MP}) + E_{GOM,LH}(C_{GOM}-C_{LH})$$

San Carlos Bay Group

Matlacha Pass:

$$0= -Q_{MP}C_{MP} + E_{SC,MP}(C_{SC}-C_{MP})$$

Tidal Caloosahatchee:

$$0= -Q_{TC}C_{TC} + E_{SC,TC}(C_{SC}-C_{TC})$$

San Carlos Bay:

$$0= -(0.5Q_{MP}+Q_{TC}+Q_{SC})C_{SC} + 0.5Q_{MP}C_{MP} + Q_{TC}C_{TC} - E_{SC,MP}(C_{SC}-C_{MP}) - E_{SC,TC}(C_{SC}-C_{TC}) + E_{GOM,SC}(C_{GOM}-C_{SC})$$

The equation sets for each grouping (Dona and Roberts Bays, Lemon Bay, Pine Island Sound, Charlotte Harbor Group, and San Carlos Bay Group) can be solved for the non-advective exchange rates (E-values) as follows:

Dona and Roberts Bays/Gulf of Mexico:

$$E_{GOM,DARB} = Q_{DARB}C_{DARB}/(C_{GOM}-C_{DARB})$$

Lemon Bay/Gulf of Mexico:

$$E_{GOM,LB} = Q_{LB}C_{LB}/(C_{GOM}-C_{LB})$$

Pine Island Sound/Gulf of Mexico:

$$E_{GOM,PI} = Q_{PI}C_{PI}/(C_{GOM}-C_{PI})$$

Estero Bay/Gulf of Mexico:

$$E_{GOM,EB} = Q_{EB}C_{EB}/(C_{GOM}-C_{EB})$$

Tidal Myakka/Upper Harbor:

$$E_{UH,TM} = Q_{TM}C_{TM}/(C_{UH}-C_{TM})$$

Tidal Peace/Upper Harbor:

$$E_{UH,TP} = Q_{TP}C_{TP}/(C_{UH}-C_{TP})$$

Upper Harbor/Lower Harbor:

$$E_{LH,UH} = (Q_{TM}+Q_{TP}+Q_{UH})C_{UH}/(C_{LH}-C_{UH})$$

Matlacha Pass/Lower Harbor:

$$E_{LH,MP} = 0.5Q_{MP}C_{MP}/(C_{LH}-C_{MP})$$

Lower Harbor/Gulf of Mexico:

$$E_{GOM,LH} = (Q_{TM}+Q_{TP}+Q_{UH}+0.5Q_{MP}+Q_{LH})C_{LH}/(C_{GOM}-C_{LH})$$

Matlacha Pass/San Carlos Bay:

$$E_{SC,MP} = 0.5Q_{MP}C_{MP}/(C_{SC}-C_{MP})$$

Tidal Caloosahatchee/San Carlos Bay:

$$E_{SC,TC} = Q_{TC}C_{TC}/(C_{SC}-C_{Tc})$$

San Carlos Bay/Gulf of Mexico:

$$E_{GOM,SC} = (0.5Q_{MP}+Q_{TC}+Q_{SC})C_{SC}/(C_{GOM}-C_{SC})$$

Monthly exchange coefficients were calculated using hydrologic loading data and salinity concentration data for 1995-2007. The median exchange coefficients over all months for a given boundary were determined, and used for calculation of the PRTs, described below.

Equations for dilution of a simulated conservative tracer were developed based on the methods of Hagy et al. (2000). The PRT was defined as the length of time required to reduce the mass of a tracer in a given segment to $e^{-1}$ (1/2.71828) times the initial mass. This calculation was performed using the monthly inflows for each month of the 1995-2007 period, so that a segment-specific PRT was calculated for each month's inflows.

The box model equations for mass balance provided above were used to estimate the change in mass ($\Delta M$) of tracer (C) present in each box (segment) of the model for relatively small time increments ($\Delta t$=1 hour). The equation for Dona and Roberts Bays is provided below:

Dona and Roberts Bays:

$$\Delta M_{DARB} = -Q_{DARB}C_{DARB}\Delta t + E_{GOM,DARB}(C_{GOM}-C_{DARB})\Delta t,$$

with $C_{DARB}$ updated after each time step until the mass of the tracer in Dona and Roberts Bays declines to $e^{-1}$ of its original value. Similar equations were used for each of the segments, modifying the mass balance equations provided above to provide tracking of conservative tracer masses in each segment. For the boundary conditions, the salinity values in the Gulf of Mexico and Dona and Roberts Bay were set to 36 ppt, and the tracer mass was set to 0.

The box model iterations resulted in segment- and monthly-specific estimates of PRT. For each segment, the median PRT for each year was calculated from the monthly PRTs, and then the median PRT of the annual values for each segment were calculated. These segment-specific PRTs are provided in Table 1, and represent the median hydraulic residence time within each segment given the observed conditions of 1995-2007.

**Table 1. Median annual Pulse Residence Time for Charlotte Harbor National Estuary Program segments, based on 1995-2007 conditions.**

| Segment | Pulse Residence Time (days) |
|---|---|
| Dona and Roberts Bays | 17.0 |
| Lemon Bay | 210.1 |
| Tidal Myakka | 232.3 |
| Tidal Peace | 151.6 |
| Upper Harbor | 299.3 |
| Lower Harbor | 103.9 |
| Pine Island Sound | 691.7 |
| Matlacha Pass | 534.3 |
| San Carlos Bay | 78.3 |
| Tidal Caloosahatchee | 339.9 |
| Estero Bay | 149.5 |

Time-series plots of the annual PRTs, derived from the median of the monthly PRTs, for each segment during the 1995-2007 period are provided in Figure 2. As in Table 1, the PRTs are in units of days, so that a shorter PRT indicates more rapid exchange between the segment and downstream waters, and a longer PRT indicates slower exchange. Not surprisingly, the smaller segments with large freshwater inflows relative to the segment size (Dona and Roberts Bays) and those with higher exchanges with the Gulf of Mexico (Lower Harbor, San Carlos Bay) have shorter residence times than do those with smaller inflows and relatively larger segment volumes (Pine Island Sound, Matlacha Pass). As can be seen from Figure 2, the interannual variability in PRT reflects the wet and dry years of the period, with PRT higher in the dry years (2000, 2001, 2006, 2007).

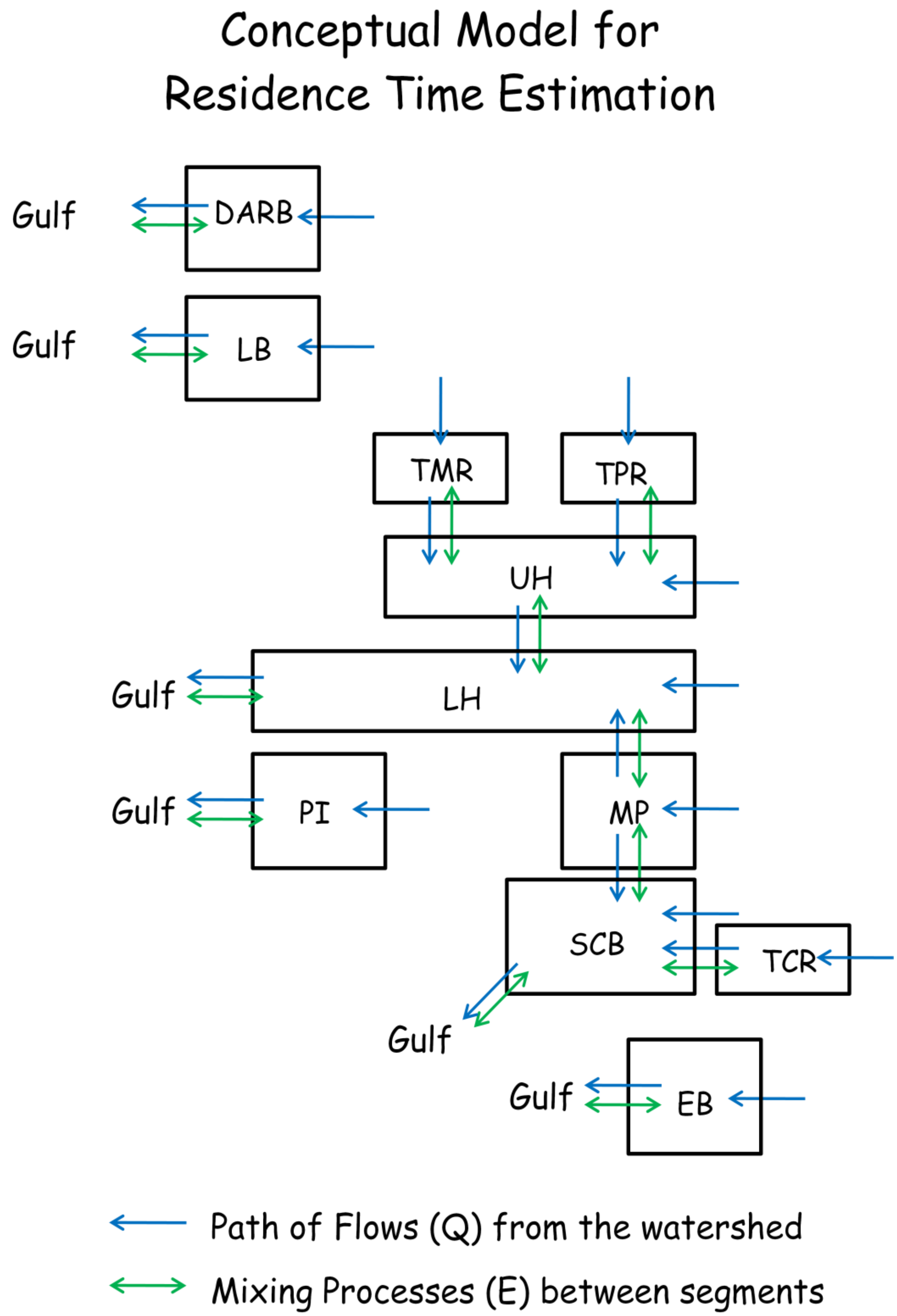
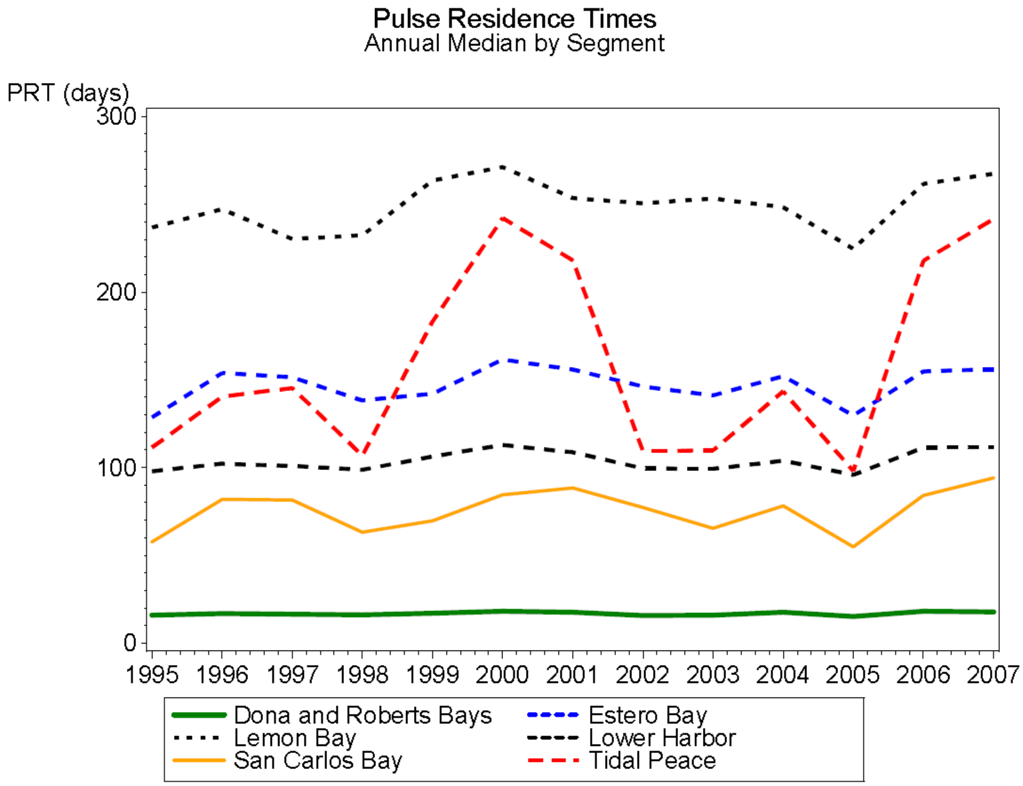



**Figure 1. Box model schematic for Charlotte Harbor National Estuary Program. DARB – Dona and Roberts Bays; LB - Lemon Bay; TMR – Tidal Myakka River; TPR – Tidal Peace River; UH – Upper Harbor (West Wall and East Wall); LH – Lower Harbor (Bokeelia and Cape Haze); PI – Pine Island Sound; MP – Matlacha Pass; SCB – San Carlos Bay; TCR – Tidal Caloosahatchee River; EB – Estero Bay.**



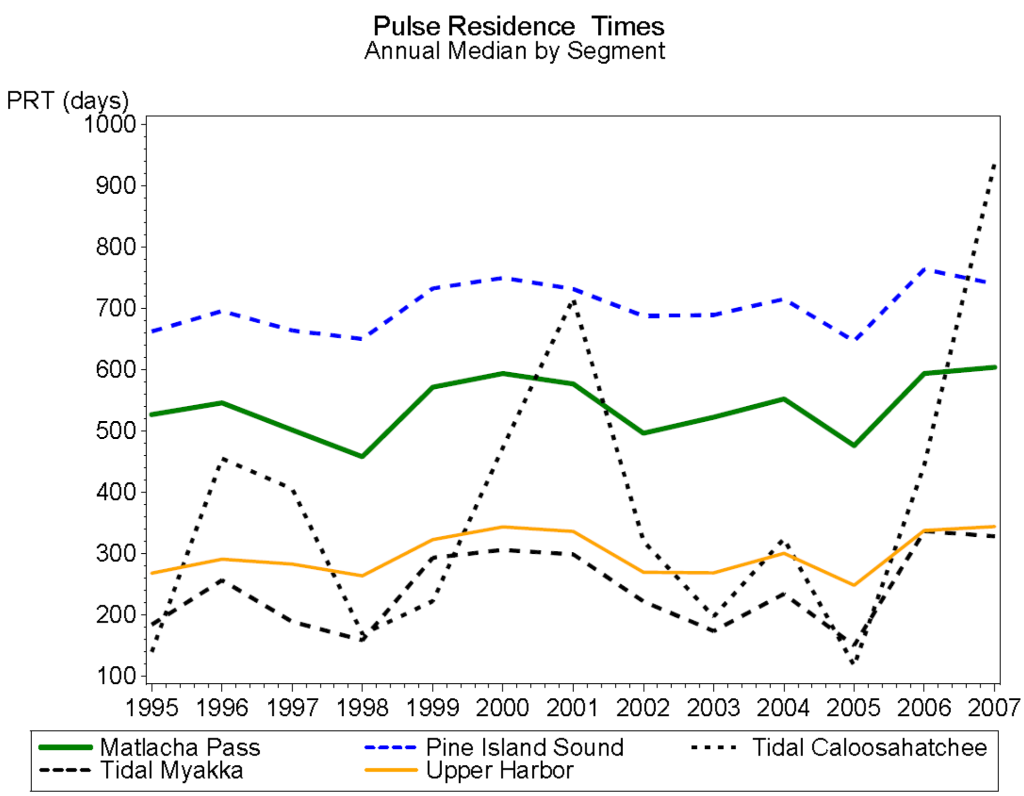



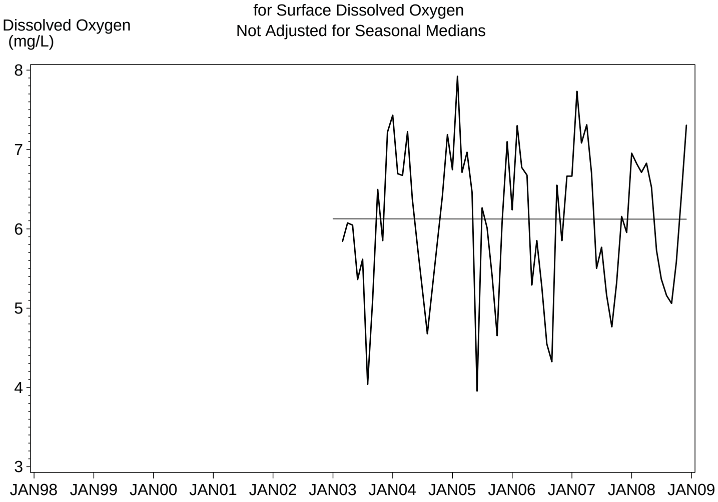

**Figure 2. Median annual PRTs (days) for each segment, based on monthly PRTs for each years.**

**Reference**

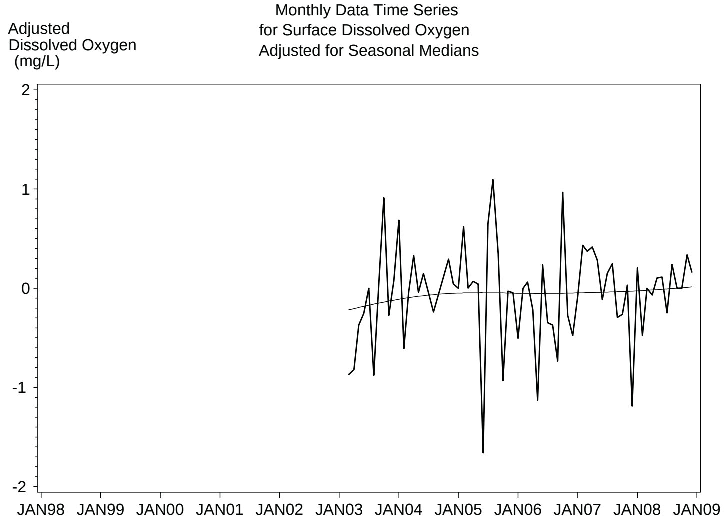
Hagy, J.D., L.P. Sanford, and W.R. Boynton. 2000. Estimation of net physical transport and hydraulic residence times for a coastal plain estuary using box models. Estuaries 23: 328-340.

# Appendix 3 – Trend Tests Results

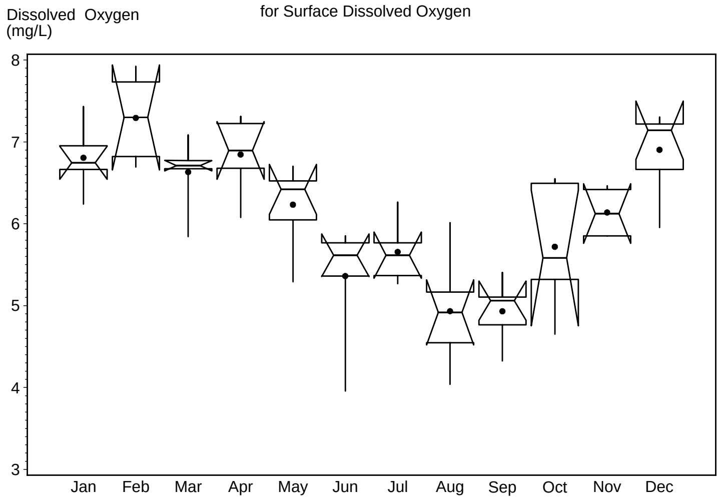
Dona And Roberts Bays Trends Appendix - Display 1
Monthly Data Time Series
for Surface Dissolved Oxygen
Not Adjusted for Seasonal Medians




Dona And Roberts Bays Trends Appendix - Display 2
Monthly Data Time Series
for Surface Dissolved Oxygen
Adjusted for Seasonal Medians




Dona And Roberts Bays Trends Appendix - Display 3
Seasonal Univariate Statistics
for Surface Dissolved Oxygen



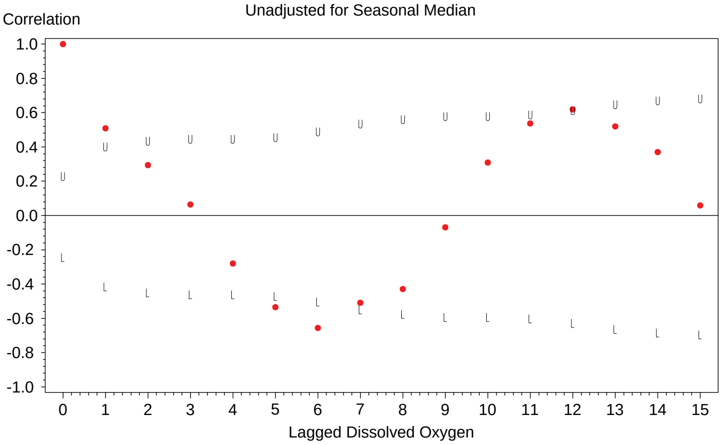

Dona And Roberts Bays Trends Appendix - Display 4
Autocorrelation Statistics for Surface Dissolved Oxygen

Unadjusted for Seasonal Medians

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.118 | 0.236 | -0.236 |
| 1 | 0.509 | 0.204 | 0.408 | -0.408 |
| 2 | 0.294 | 0.221 | 0.442 | -0.442 |
| 3 | 0.064 | 0.226 | 0.453 | -0.453 |
| 4 | -0.280 | 0.227 | 0.453 | -0.453 |
| 5 | -0.535 | 0.231 | 0.463 | -0.463 |
| 6 | -0.656 | 0.248 | 0.496 | -0.496 |
| 7 | -0.509 | 0.271 | 0.542 | -0.542 |
| 8 | -0.429 | 0.284 | 0.568 | -0.568 |
| 9 | -0.069 | 0.293 | 0.586 | -0.586 |
| 10 | 0.309 | 0.293 | 0.586 | -0.586 |
| 11 | 0.537 | 0.298 | 0.595 | -0.595 |
| 12 | 0.619 | 0.311 | 0.621 | -0.621 |
| 13 | 0.520 | 0.327 | 0.655 | -0.655 |
| 14 | 0.370 | 0.339 | 0.677 | -0.677 |
| 15 | 0.059 | 0.344 | 0.688 | -0.688 |

Dona And Roberts Bays Trends Appendix - Display 5
Correlogram for Surface Dissolved Oxygen

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Dona And Roberts Bays Trends Appendix - Display 6

Seasonal Kendall Tau Trend Test Statistics
for Surface Dissolved Oxygen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.135 | 0.233 | 0.313 | 0.036 |

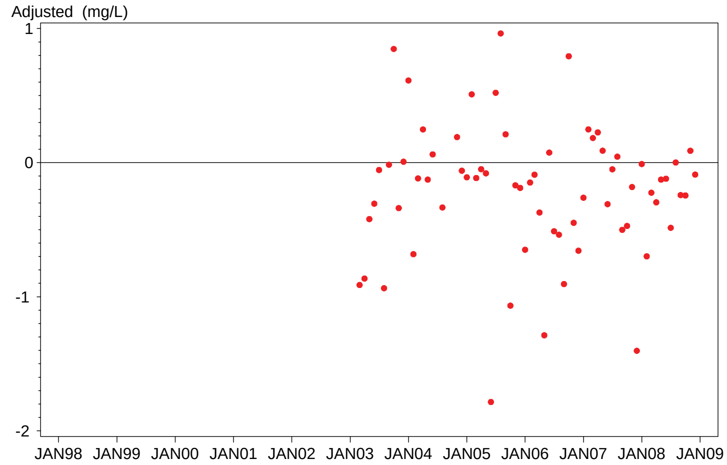
Dona And Roberts Bays Trends Appendix - Display 7

Seasonal Kendall Tau Trend Test Statistics
for Surface Dissolved Oxygen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.14194 | 0.21002 | 0.29089 | 0.03625 |

Dona And Roberts Bays Trends Appendix - Display 8
Time Series Plot of Surface Dissolved Oxygen Data Adjusted for Season and Detrended




Zero Reference Line Shown

Dona And Roberts Bays Trends Appendix - Display 9
Autocorrelation Statistics for Surface Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.118 | 0.236 | -0.236 |
| 1 | -0.039 | 0.204 | 0.408 | -0.408 |
| 2 | -0.159 | 0.204 | 0.408 | -0.408 |
| 3 | 0.123 | 0.206 | 0.412 | -0.412 |
| 4 | 0.122 | 0.207 | 0.414 | -0.414 |
| 5 | -0.097 | 0.208 | 0.416 | -0.416 |
| 6 | 0.035 | 0.209 | 0.417 | -0.417 |
| 7 | 0.066 | 0.209 | 0.417 | -0.417 |
| 8 | -0.150 | 0.209 | 0.418 | -0.418 |
| 9 | -0.220 | 0.210 | 0.421 | -0.421 |
| 10 | -0.032 | 0.214 | 0.427 | -0.427 |
| 11 | 0.058 | 0.214 | 0.427 | -0.427 |
| 12 | -0.297 | 0.214 | 0.428 | -0.428 |
| 13 | 0.080 | 0.220 | 0.439 | -0.439 |

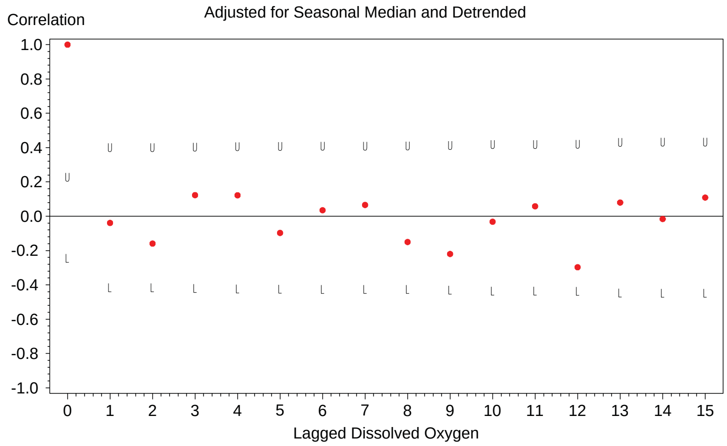
Dona And Roberts Bays Trends Appendix - Display 9
Autocorrelation Statistics for Surface Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | -0.016 | 0.220 | 0.440 | -0.440 |
| 15 | 0.109 | 0.220 | 0.440 | -0.440 |

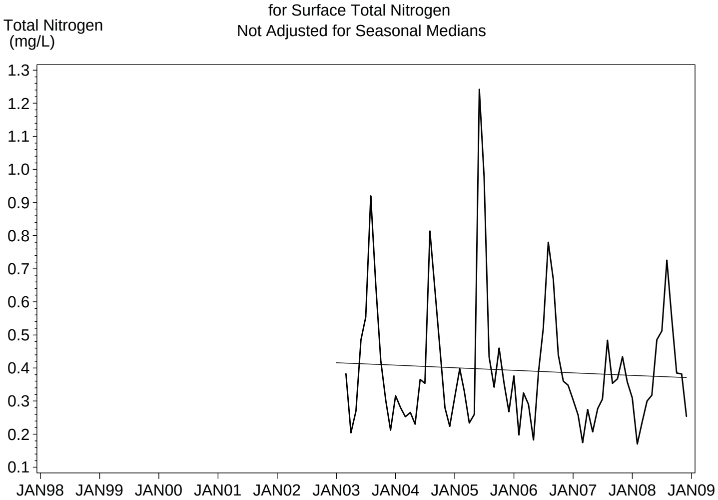
Dona And Roberts Bays Trends Appendix - Display 10
Correlogram for Surface Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

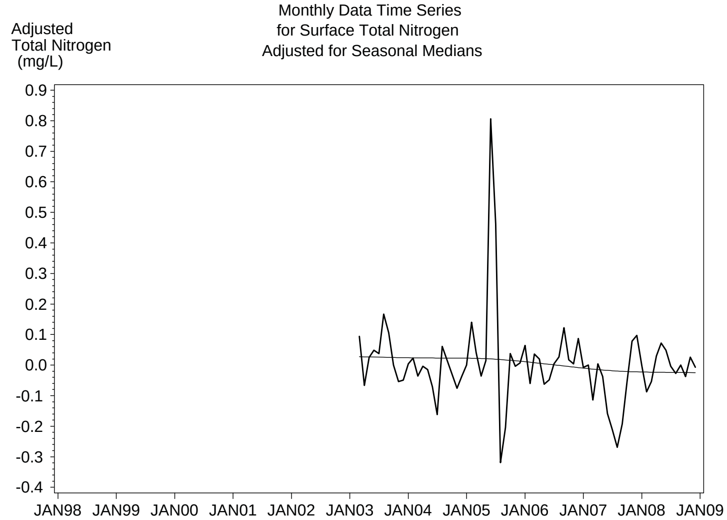



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

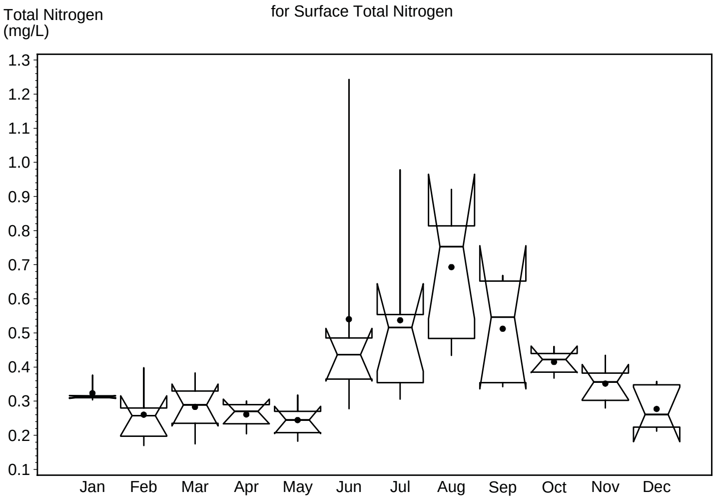
Dona And Roberts Bays Trends Appendix - Display 11
Monthly Data Time Series
for Surface Total Nitrogen
Not Adjusted for Seasonal Medians




Dona And Roberts Bays Trends Appendix - Display 12
Monthly Data Time Series
for Surface Total Nitrogen
Adjusted for Seasonal Medians




Dona And Roberts Bays Trends Appendix - Display 13
Seasonal Univariate Statistics
for Surface Total Nitrogen



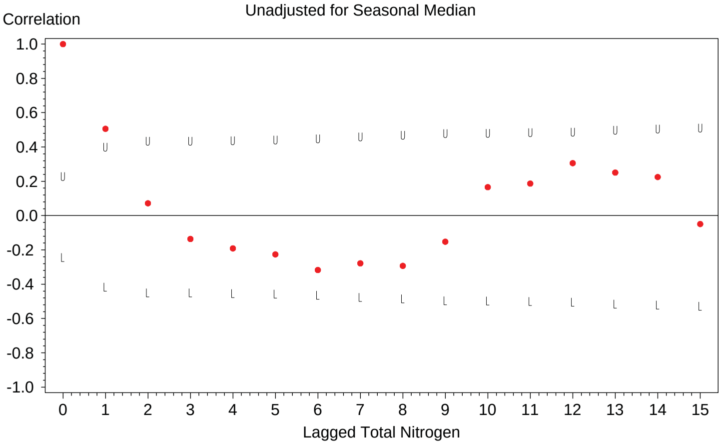

Dona And Roberts Bays Trends Appendix - Display 14
Autocorrelation Statistics for Surface Total Nitrogen

Unadjusted for Seasonal Medians

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.118 | 0.236 | -0.236 |
| 1 | 0.506 | 0.204 | 0.408 | -0.408 |
| 2 | 0.072 | 0.221 | 0.442 | -0.442 |
| 3 | -0.136 | 0.221 | 0.442 | -0.442 |
| 4 | -0.191 | 0.222 | 0.445 | -0.445 |
| 5 | -0.226 | 0.225 | 0.449 | -0.449 |
| 6 | -0.317 | 0.228 | 0.456 | -0.456 |
| 7 | -0.278 | 0.234 | 0.468 | -0.468 |
| 8 | -0.293 | 0.238 | 0.477 | -0.477 |
| 9 | -0.152 | 0.243 | 0.487 | -0.487 |
| 10 | 0.166 | 0.245 | 0.489 | -0.489 |
| 11 | 0.187 | 0.246 | 0.492 | -0.492 |
| 12 | 0.306 | 0.248 | 0.496 | -0.496 |
| 13 | 0.251 | 0.253 | 0.507 | -0.507 |
| 14 | 0.225 | 0.257 | 0.513 | -0.513 |
| 15 | -0.049 | 0.259 | 0.519 | -0.519 |

Dona And Roberts Bays Trends Appendix - Display 15
Correlogram for Surface Total Nitrogen

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Dona And Roberts Bays Trends Appendix - Display 16
Seasonal Kendall Tau Trend Test Statistics
for Surface Total Nitrogen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.044 | 0.726 | 0.737 | -.004 |

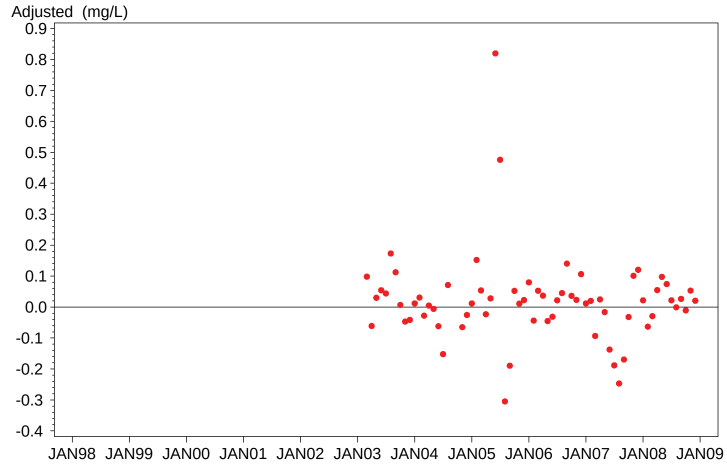
Dona And Roberts Bays Trends Appendix - Display 17

Seasonal Kendall Tau Trend Test Statistics
for Surface Total Nitrogen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.04375 | 0.72565 | 0.73718 | -.004 |

Dona And Roberts Bays Trends Appendix - Display 18
Time Series Plot of Surface Total Nitrogen Data Adjusted for Season and Detrended




Zero Reference Line Shown

Dona And Roberts Bays Trends Appendix - Display 19
Autocorrelation Statistics for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.118 | 0.236 | -0.236 |
| 1 | 0.347 | 0.204 | 0.408 | -0.408 |
| 2 | -0.244 | 0.212 | 0.424 | -0.424 |
| 3 | -0.119 | 0.216 | 0.432 | -0.432 |
| 4 | 0.090 | 0.217 | 0.434 | -0.434 |
| 5 | 0.058 | 0.217 | 0.435 | -0.435 |
| 6 | -0.002 | 0.218 | 0.435 | -0.435 |
| 7 | -0.086 | 0.218 | 0.435 | -0.435 |
| 8 | -0.097 | 0.218 | 0.436 | -0.436 |
| 9 | 0.008 | 0.219 | 0.437 | -0.437 |
| 10 | -0.037 | 0.219 | 0.437 | -0.437 |
| 11 | -0.198 | 0.219 | 0.438 | -0.438 |
| 12 | -0.186 | 0.221 | 0.443 | -0.443 |
| 13 | -0.014 | 0.223 | 0.447 | -0.447 |

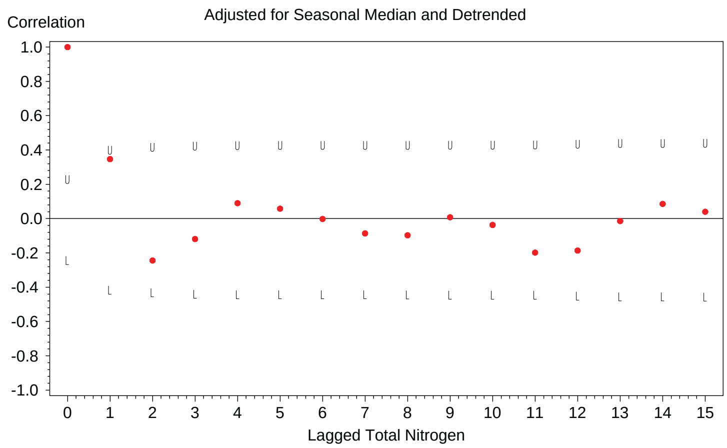
Dona And Roberts Bays Trends Appendix - Display 19
Autocorrelation Statistics for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | 0.086 | 0.223 | 0.447 | -0.447 |
| 15 | 0.040 | 0.224 | 0.448 | -0.448 |

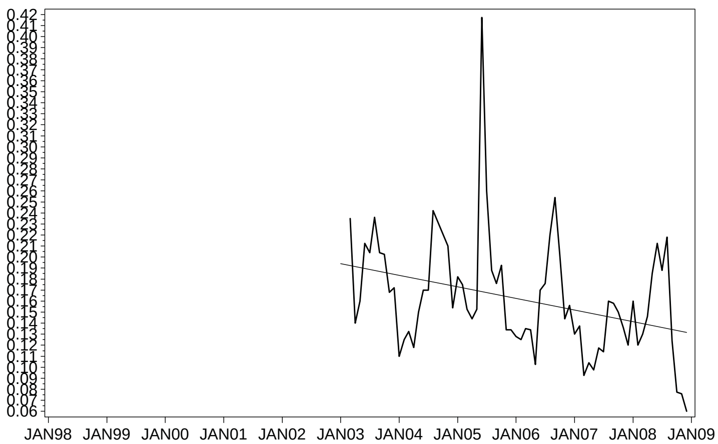
Dona And Roberts Bays Trends Appendix - Display 20
Correlogram for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

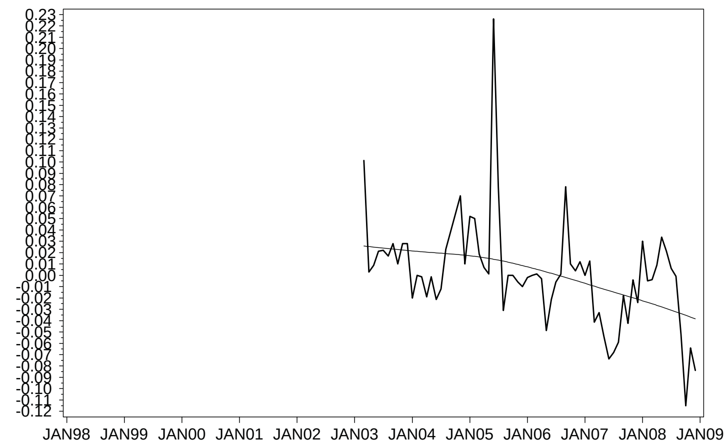



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

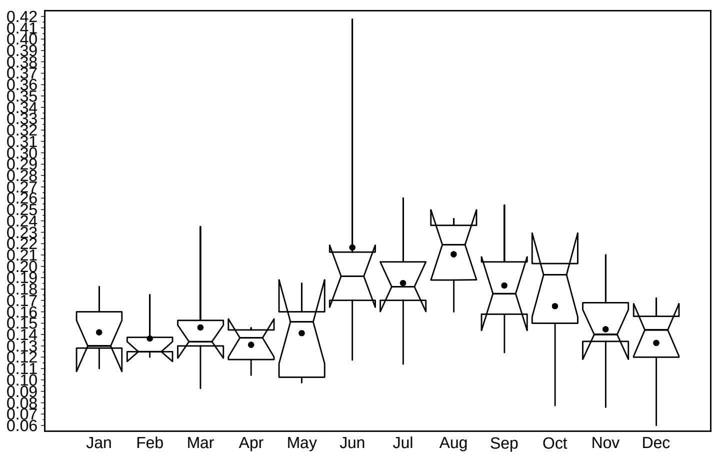
Dona And Roberts Bays Trends Appendix - Display 21
Monthly Data Time Series
for Surface Total Phosphorous
Not Adjusted for Seasonal Medians




Dona And Roberts Bays Trends Appendix - Display 22
Monthly Data Time Series
for Surface Total Phosphorous
Adjusted for Seasonal Medians




Dona And Roberts Bays Trends Appendix - Display 23
Seasonal Univariate Statistics
for Surface Total Phosphorous



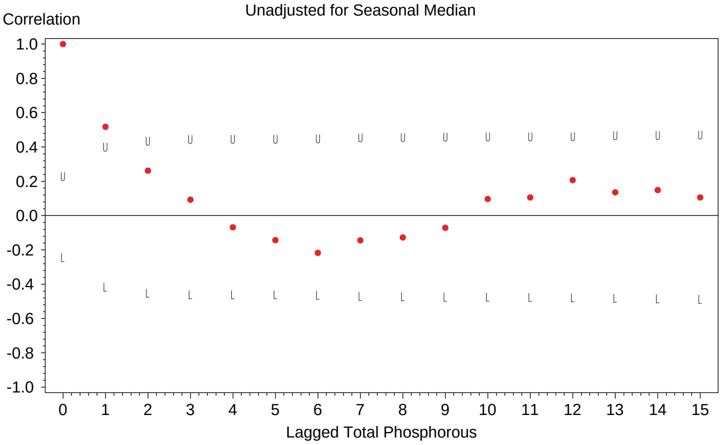

Dona And Roberts Bays Trends Appendix - Display 24
Autocorrelation Statistics for Surface Total Phosphorous

Unadjusted for Seasonal Medians

| Lagged Total Phosphorous | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.118 | 0.236 | -0.236 |
| 1 | 0.518 | 0.204 | 0.408 | -0.408 |
| 2 | 0.262 | 0.222 | 0.443 | -0.443 |
| 3 | 0.093 | 0.226 | 0.452 | -0.452 |
| 4 | -0.068 | 0.226 | 0.453 | -0.453 |
| 5 | -0.143 | 0.227 | 0.453 | -0.453 |
| 6 | -0.217 | 0.228 | 0.456 | -0.456 |
| 7 | -0.144 | 0.231 | 0.462 | -0.462 |
| 8 | -0.127 | 0.232 | 0.464 | -0.464 |
| 9 | -0.071 | 0.233 | 0.466 | -0.466 |
| 10 | 0.097 | 0.233 | 0.467 | -0.467 |
| 11 | 0.106 | 0.234 | 0.468 | -0.468 |
| 12 | 0.207 | 0.235 | 0.469 | -0.469 |
| 13 | 0.136 | 0.237 | 0.474 | -0.474 |
| 14 | 0.149 | 0.238 | 0.476 | -0.476 |
| 15 | 0.106 | 0.239 | 0.479 | -0.479 |

Dona And Roberts Bays Trends Appendix - Display 25
Correlogram for Surface Total Phosphorous

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Dona And Roberts Bays Trends Appendix - Display 26
Seasonal Kendall Tau Trend Test Statistics
for Surface Total Phosphorous

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.35 | .001 | 0.089 | -0.011 |

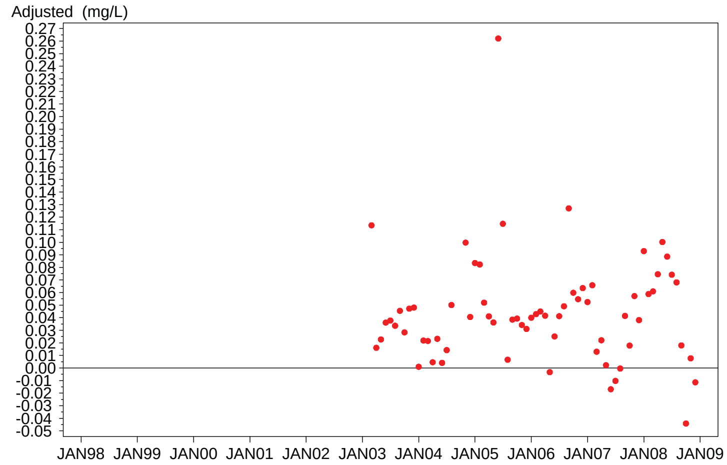
Dona And Roberts Bays Trends Appendix - Display 27

Seasonal Kendall Tau Trend Test Statistics
for Surface Total Phosphorous

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.35 | .00122315 | 0.089124 | -0.0105 |

Dona And Roberts Bays Trends Appendix - Display 28
Time Series Plot of Surface Total Phosphorous Data Adjusted for Season and Detrended




Zero Reference Line Shown

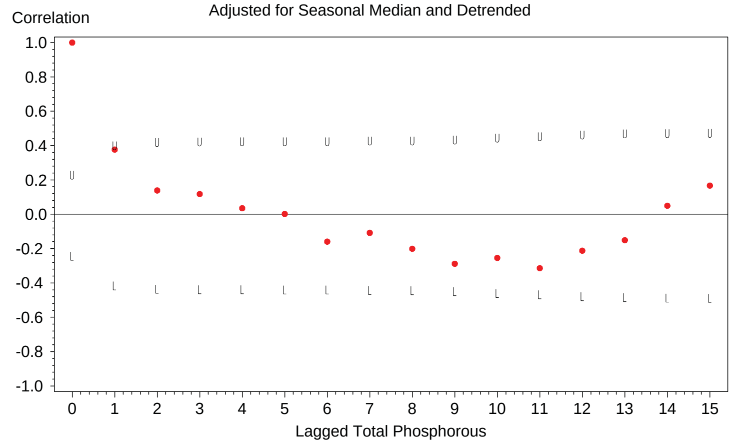
Dona And Roberts Bays Trends Appendix - Display 29
Autocorrelation Statistics for Surface Total Phosphorous

Adjusted for Seasonal Median and Detrended

| Lagged Total Phosphorous | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.118 | 0.236 | -0.236 |
| 1 | 0.377 | 0.204 | 0.408 | -0.408 |
| 2 | 0.139 | 0.214 | 0.427 | -0.427 |
| 3 | 0.118 | 0.215 | 0.430 | -0.430 |
| 4 | 0.035 | 0.216 | 0.431 | -0.431 |
| 5 | 0.002 | 0.216 | 0.432 | -0.432 |
| 6 | -0.159 | 0.216 | 0.432 | -0.432 |
| 7 | -0.108 | 0.217 | 0.435 | -0.435 |
| 8 | -0.201 | 0.218 | 0.436 | -0.436 |
| 9 | -0.288 | 0.221 | 0.441 | -0.441 |
| 10 | -0.254 | 0.226 | 0.452 | -0.452 |
| 11 | -0.314 | 0.230 | 0.460 | -0.460 |
| 12 | -0.212 | 0.236 | 0.471 | -0.471 |
| 13 | -0.151 | 0.238 | 0.477 | -0.477 |
| 14 | 0.050 | 0.240 | 0.479 | -0.479 |
| 15 | 0.167 | 0.240 | 0.480 | -0.480 |

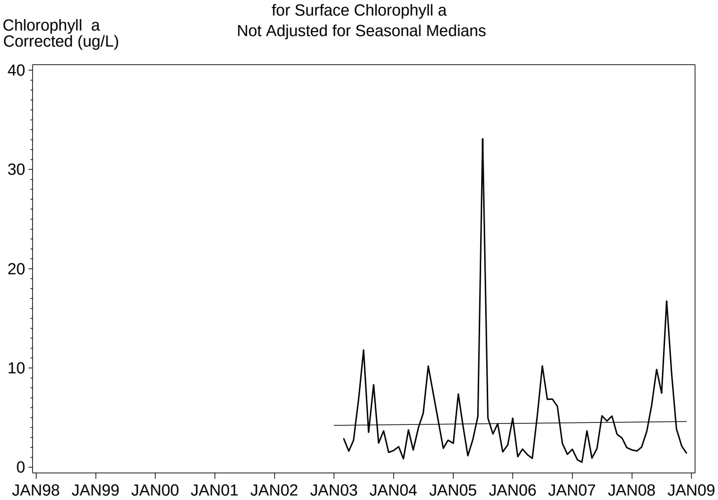
Dona And Roberts Bays Trends Appendix - Display 30
Correlogram for Surface Total Phosphorous

Adjusted for Seasonal Median and Detrended

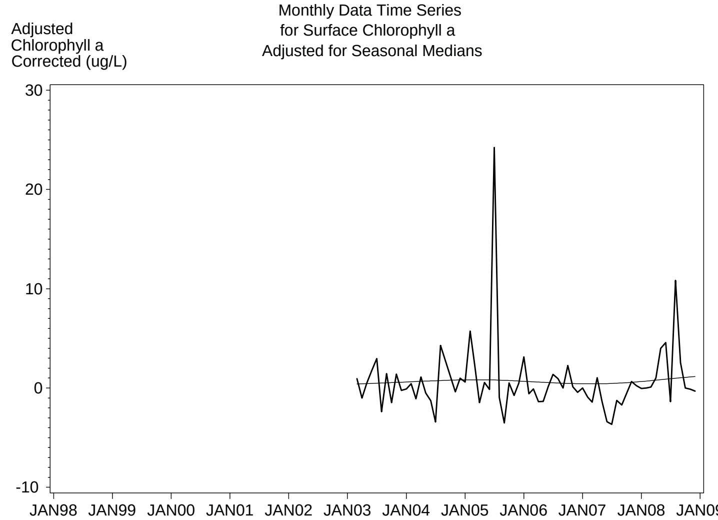



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

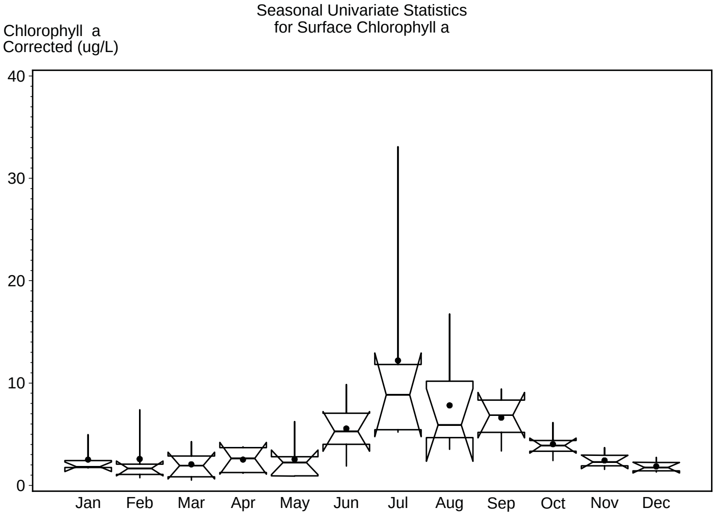
Dona And Roberts Bays Trends Appendix - Display 31
Monthly Data Time Series
for Surface Chlorophyll a
Not Adjusted for Seasonal Medians




Dona And Roberts Bays Trends Appendix - Display 32
Monthly Data Time Series
for Surface Chlorophyll a
Adjusted for Seasonal Medians




Dona And Roberts Bays Trends Appendix - Display 33
Seasonal Univariate Statistics
for Surface Chlorophyll a



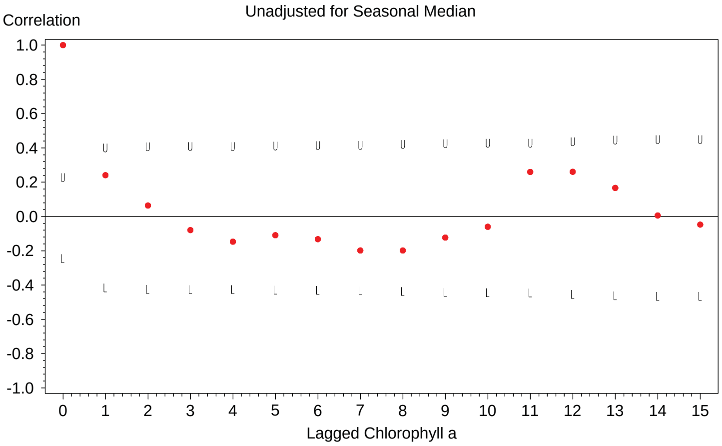

Dona And Roberts Bays Trends Appendix - Display 34
Autocorrelation Statistics for Surface Chlorophyll a

Unadjusted for Seasonal Medians

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.118 | 0.236 | -0.236 |
| 1 | 0.241 | 0.204 | 0.408 | -0.408 |
| 2 | 0.064 | 0.208 | 0.416 | -0.416 |
| 3 | -0.079 | 0.208 | 0.417 | -0.417 |
| 4 | -0.147 | 0.209 | 0.417 | -0.417 |
| 5 | -0.109 | 0.210 | 0.420 | -0.420 |
| 6 | -0.132 | 0.211 | 0.422 | -0.422 |
| 7 | -0.198 | 0.212 | 0.424 | -0.424 |
| 8 | -0.198 | 0.215 | 0.429 | -0.429 |
| 9 | -0.123 | 0.217 | 0.434 | -0.434 |
| 10 | -0.060 | 0.218 | 0.436 | -0.436 |
| 11 | 0.260 | 0.218 | 0.437 | -0.437 |
| 12 | 0.261 | 0.223 | 0.445 | -0.445 |
| 13 | 0.167 | 0.227 | 0.454 | -0.454 |
| 14 | 0.006 | 0.229 | 0.457 | -0.457 |
| 15 | -0.047 | 0.229 | 0.457 | -0.457 |

Dona And Roberts Bays Trends Appendix - Display 35
Correlogram for Surface Chlorophyll a

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Dona And Roberts Bays Trends Appendix - Display 36
Seasonal Kendall Tau Trend Test Statistics
for Surface Chlorophyll a

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.038 | 0.77 | 0.784 | -0.026 |

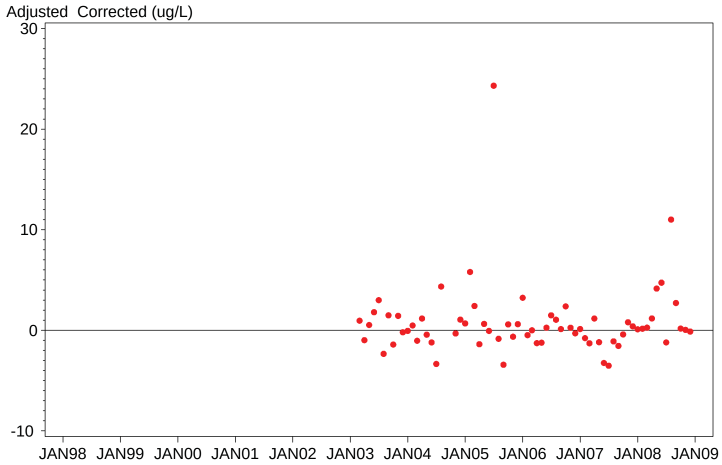
Dona And Roberts Bays Trends Appendix - Display 37

Seasonal Kendall Tau Trend Test Statistics
for Surface Chlorophyll a

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.0375 | 0.77034 | 0.78377 | -0.026083 |

Dona And Roberts Bays Trends Appendix - Display 38
Time Series Plot of Surface Chlorophyll a Data Adjusted for Season and Detrended




Zero Reference Line Shown

Dona And Roberts Bays Trends Appendix - Display 39
Autocorrelation Statistics for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.118 | 0.236 | -0.236 |
| 1 | -0.007 | 0.204 | 0.408 | -0.408 |
| 2 | -0.048 | 0.204 | 0.408 | -0.408 |
| 3 | -0.009 | 0.204 | 0.409 | -0.409 |
| 4 | 0.040 | 0.204 | 0.409 | -0.409 |
| 5 | 0.163 | 0.204 | 0.409 | -0.409 |
| 6 | 0.099 | 0.206 | 0.412 | -0.412 |
| 7 | -0.045 | 0.207 | 0.414 | -0.414 |
| 8 | -0.090 | 0.207 | 0.414 | -0.414 |
| 9 | -0.097 | 0.208 | 0.415 | -0.415 |
| 10 | -0.135 | 0.208 | 0.416 | -0.416 |
| 11 | 0.053 | 0.209 | 0.419 | -0.419 |
| 12 | -0.176 | 0.210 | 0.419 | -0.419 |
| 13 | -0.094 | 0.212 | 0.423 | -0.423 |

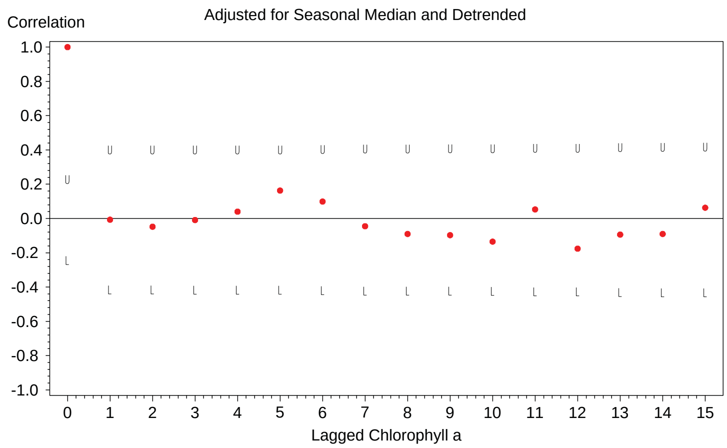
Dona And Roberts Bays Trends Appendix - Display 39
Autocorrelation Statistics for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | -0.090 | 0.212 | 0.424 | -0.424 |
| 15 | 0.063 | 0.213 | 0.425 | -0.425 |

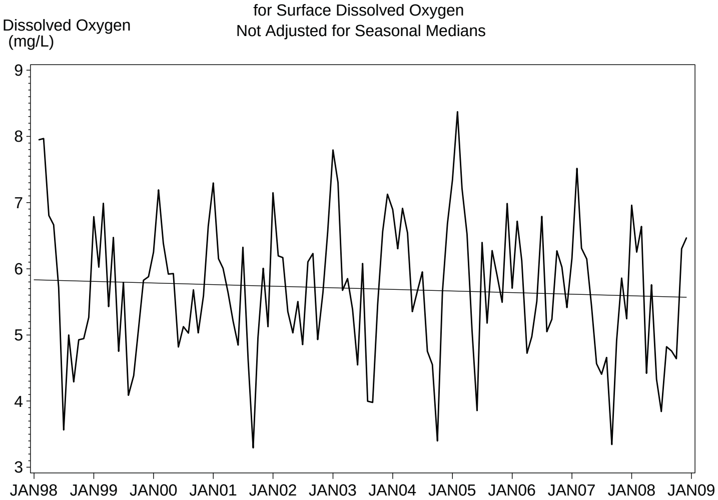
Dona And Roberts Bays Trends Appendix - Display 40
Correlogram for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended

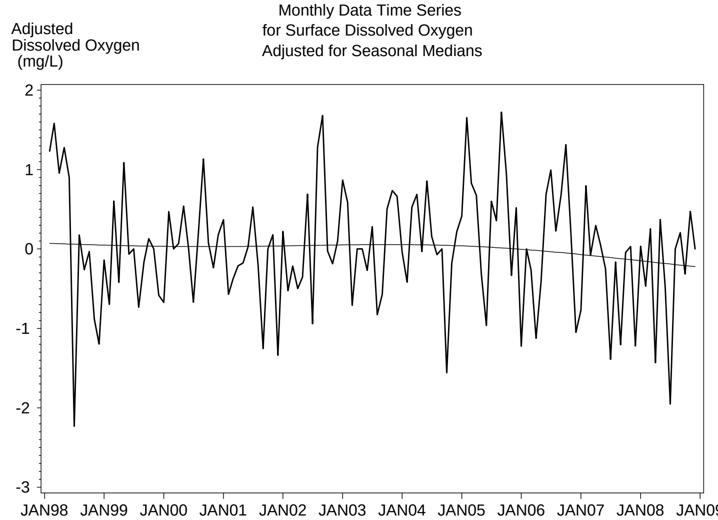



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

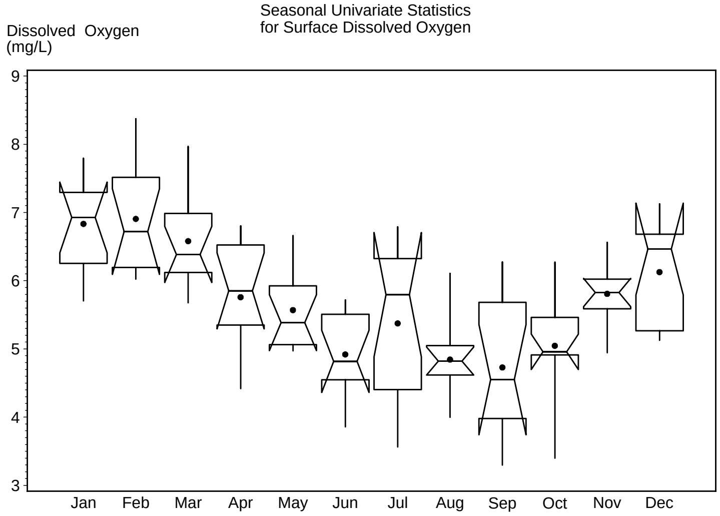
Upper Lemon Bay Trends Appendix - Display 1
Monthly Data Time Series
for Surface Dissolved Oxygen
Not Adjusted for Seasonal Medians




Upper Lemon Bay Trends Appendix - Display 2
Monthly Data Time Series
for Surface Dissolved Oxygen
Adjusted for Seasonal Medians




Upper Lemon Bay Trends Appendix - Display 3
Seasonal Univariate Statistics
for Surface Dissolved Oxygen



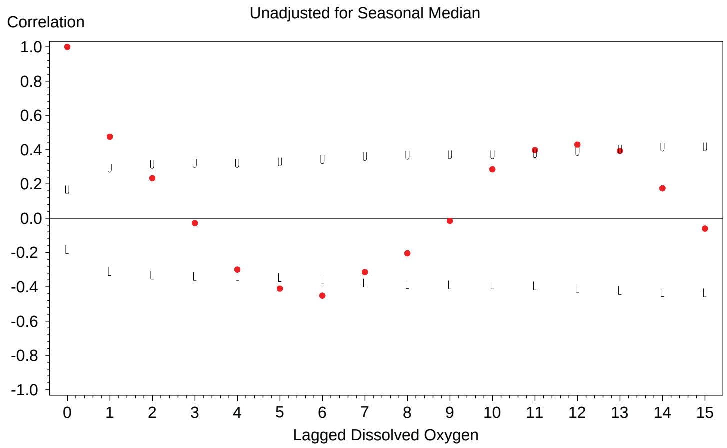

Upper Lemon Bay Trends Appendix - Display 4
Autocorrelation Statistics for Surface Dissolved Oxygen

Unadjusted for Seasonal Medians

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.476 | 0.151 | 0.302 | -0.302 |
| 2 | 0.234 | 0.162 | 0.323 | -0.323 |
| 3 | -0.028 | 0.164 | 0.329 | -0.329 |
| 4 | -0.299 | 0.164 | 0.329 | -0.329 |
| 5 | -0.410 | 0.168 | 0.337 | -0.337 |
| 6 | -0.451 | 0.176 | 0.351 | -0.351 |
| 7 | -0.314 | 0.184 | 0.369 | -0.369 |
| 8 | -0.204 | 0.188 | 0.377 | -0.377 |
| 9 | -0.015 | 0.190 | 0.380 | -0.380 |
| 10 | 0.286 | 0.190 | 0.380 | -0.380 |
| 11 | 0.398 | 0.193 | 0.386 | -0.386 |
| 12 | 0.430 | 0.199 | 0.399 | -0.399 |
| 13 | 0.393 | 0.206 | 0.412 | -0.412 |
| 14 | 0.175 | 0.212 | 0.424 | -0.424 |
| 15 | -0.060 | 0.213 | 0.426 | -0.426 |

Upper Lemon Bay Trends Appendix - Display 5
Correlogram for Surface Dissolved Oxygen

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Upper Lemon Bay Trends Appendix - Display 6
Seasonal Kendall Tau Trend Test Statistics
for Surface Dissolved Oxygen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.012 | 0.874 | 0.879 | -.007 |

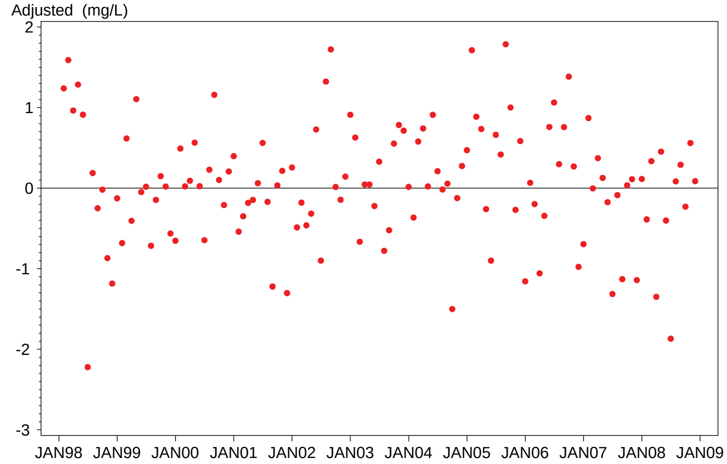
Upper Lemon Bay Trends  Appendix - Display 7

Seasonal Kendall Tau Trend Test Statistics
for Surface Dissolved Oxygen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.012308 | 0.87373 | 0.87882 | -.00733333 |

Upper Lemon Bay Trends Appendix - Display 8
Time Series Plot of Surface Dissolved  Oxygen Data Adjusted for Season and Detrended




Zero Reference Line Shown

Upper Lemon Bay Trends  Appendix - Display 9

Autocorrelation Statistics for Surface Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.165 | 0.151 | 0.302 | -0.302 |
| 2 | 0.037 | 0.152 | 0.304 | -0.304 |
| 3 | 0.049 | 0.152 | 0.304 | -0.304 |
| 4 | -0.096 | 0.152 | 0.305 | -0.305 |
| 5 | -0.022 | 0.153 | 0.306 | -0.306 |
| 6 | -0.121 | 0.153 | 0.306 | -0.306 |
| 7 | 0.107 | 0.154 | 0.307 | -0.307 |
| 8 | -0.006 | 0.154 | 0.308 | -0.308 |
| 9 | -0.061 | 0.154 | 0.308 | -0.308 |
| 10 | 0.024 | 0.154 | 0.309 | -0.309 |
| 11 | -0.049 | 0.154 | 0.309 | -0.309 |
| 12 | -0.132 | 0.154 | 0.309 | -0.309 |
| 13 | 0.063 | 0.155 | 0.311 | -0.311 |

Upper Lemon Bay Trends  Appendix - Display 9

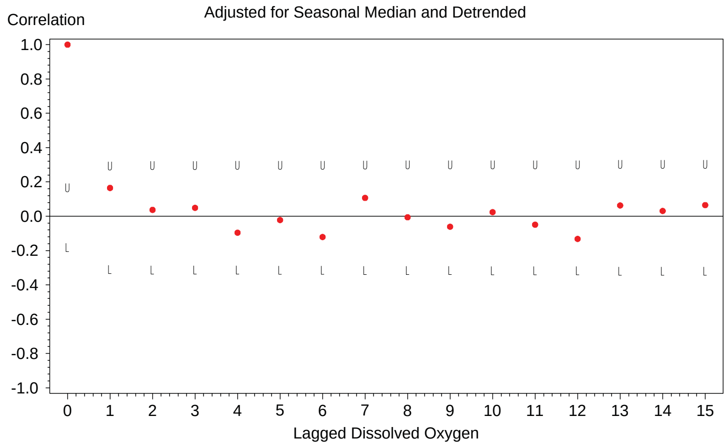
Autocorrelation Statistics for Surface Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | 0.031 | 0.155 | 0.311 | -0.311 |
| 15 | 0.065 | 0.156 | 0.311 | -0.311 |

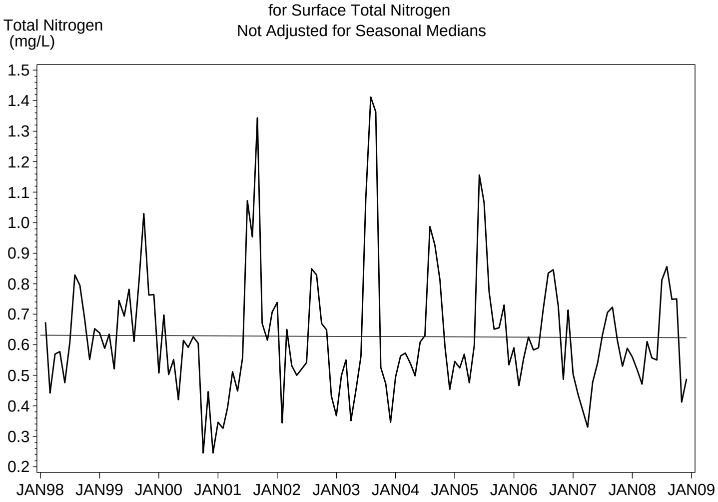
Upper Lemon Bay Trends Appendix - Display 10
Correlogram for Surface Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

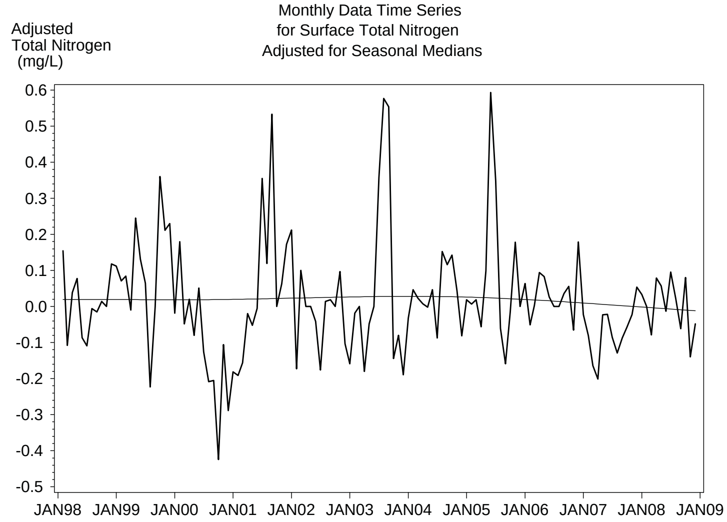



U=Upper 95% Confidence Limit   L=Lower 95% Confidence Limit
Zero Reference Line Shown

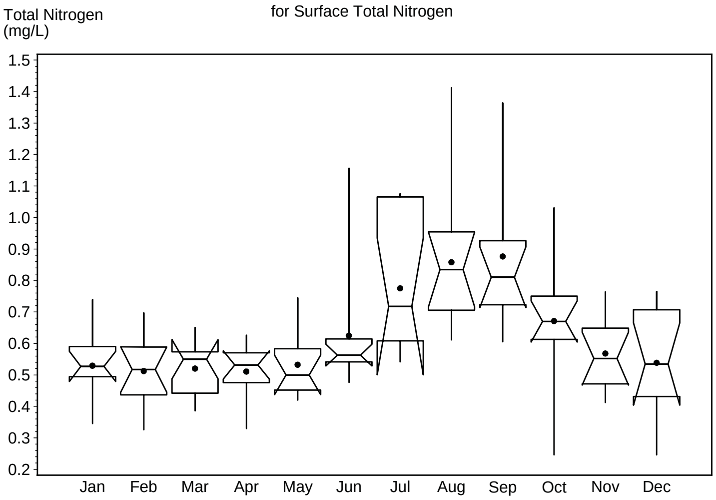
Upper Lemon Bay Trends Appendix - Display 11
Monthly Data Time Series
for Surface Total Nitrogen
Not Adjusted for Seasonal Medians




Upper Lemon Bay Trends Appendix - Display 12
Monthly Data Time Series
for Surface Total Nitrogen
Adjusted for Seasonal Medians




Upper Lemon Bay Trends Appendix - Display 13
Seasonal Univariate Statistics
for Surface Total Nitrogen



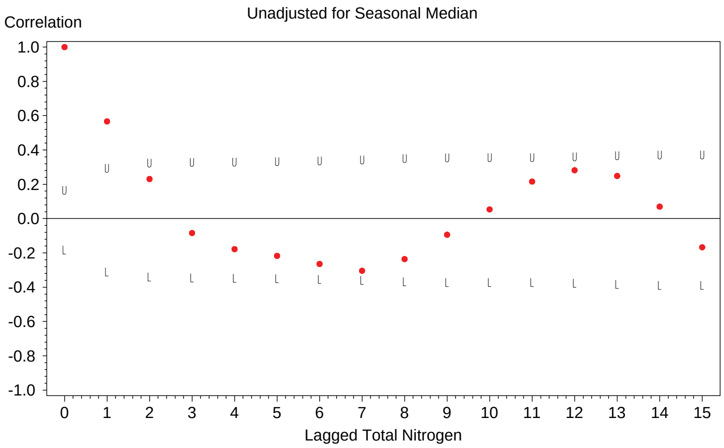

Upper Lemon Bay Trends Appendix - Display 14
Autocorrelation Statistics for Surface Total Nitrogen

Unadjusted for Seasonal Medians

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.567 | 0.151 | 0.302 | -0.302 |
| 2 | 0.231 | 0.166 | 0.332 | -0.332 |
| 3 | -0.084 | 0.169 | 0.337 | -0.337 |
| 4 | -0.178 | 0.169 | 0.338 | -0.338 |
| 5 | -0.217 | 0.170 | 0.341 | -0.341 |
| 6 | -0.264 | 0.172 | 0.345 | -0.345 |
| 7 | -0.304 | 0.175 | 0.351 | -0.351 |
| 8 | -0.236 | 0.179 | 0.359 | -0.359 |
| 9 | -0.094 | 0.182 | 0.363 | -0.363 |
| 10 | 0.054 | 0.182 | 0.364 | -0.364 |
| 11 | 0.216 | 0.182 | 0.364 | -0.364 |
| 12 | 0.282 | 0.184 | 0.368 | -0.368 |
| 13 | 0.249 | 0.187 | 0.375 | -0.375 |
| 14 | 0.070 | 0.190 | 0.380 | -0.380 |
| 15 | -0.167 | 0.190 | 0.380 | -0.380 |

Upper Lemon Bay Trends Appendix - Display 15
Correlogram for Surface Total Nitrogen

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Upper Lemon Bay Trends Appendix - Display 16
Seasonal Kendall Tau Trend Test Statistics
for Surface Total Nitrogen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.023 | 0.751 | 0.83 | -.002 |

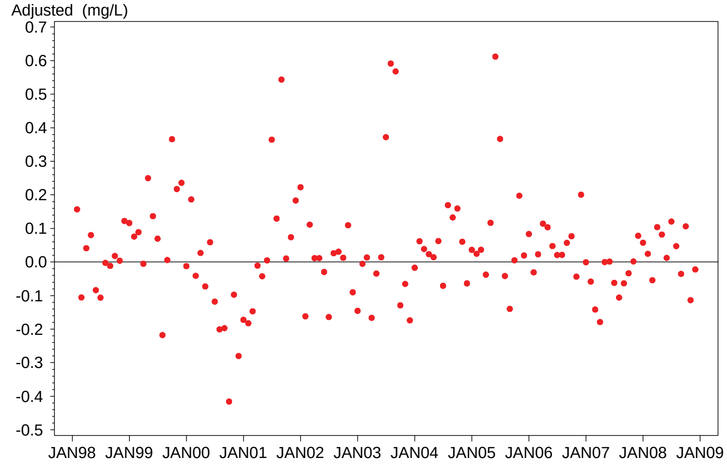
Upper Lemon Bay Trends  Appendix - Display 17

Seasonal Kendall Tau Trend Test Statistics
for Surface Total Nitrogen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.023077 | 0.75053 | 0.83018 | -.00221667 |

Upper Lemon Bay Trends Appendix - Display 18
Time Series Plot of Surface Total  Nitrogen Data Adjusted for Season and Detrended




Zero Reference Line Shown

Upper Lemon Bay Trends  Appendix - Display 19

Autocorrelation Statistics for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.418 | 0.151 | 0.302 | -0.302 |
| 2 | 0.186 | 0.159 | 0.319 | -0.319 |
| 3 | -0.021 | 0.161 | 0.322 | -0.322 |
| 4 | 0.035 | 0.161 | 0.322 | -0.322 |
| 5 | 0.067 | 0.161 | 0.322 | -0.322 |
| 6 | -0.004 | 0.161 | 0.322 | -0.322 |
| 7 | -0.098 | 0.161 | 0.322 | -0.322 |
| 8 | -0.094 | 0.162 | 0.323 | -0.323 |
| 9 | -0.081 | 0.162 | 0.324 | -0.324 |
| 10 | -0.140 | 0.162 | 0.325 | -0.325 |
| 11 | -0.166 | 0.163 | 0.327 | -0.327 |
| 12 | -0.174 | 0.165 | 0.329 | -0.329 |
| 13 | -0.087 | 0.166 | 0.332 | -0.332 |

Upper Lemon Bay Trends  Appendix - Display 19

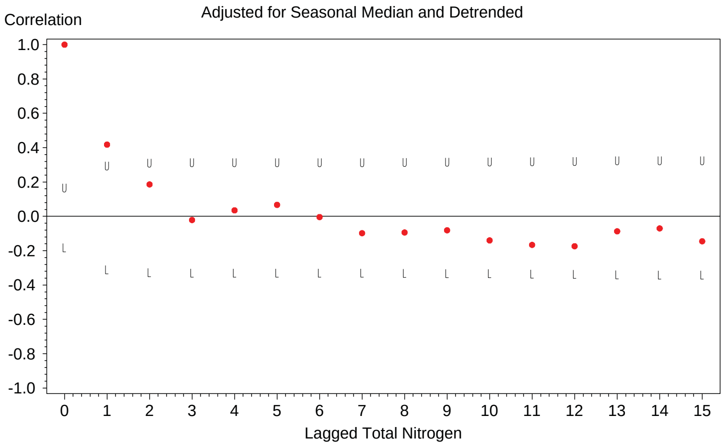
Autocorrelation Statistics for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | -0.070 | 0.166 | 0.333 | -0.333 |
| 15 | -0.145 | 0.167 | 0.333 | -0.333 |

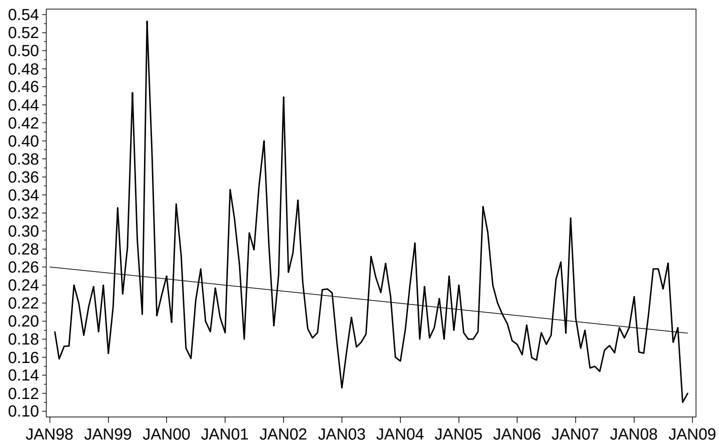
Upper Lemon Bay Trends Appendix - Display 20
Correlogram for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

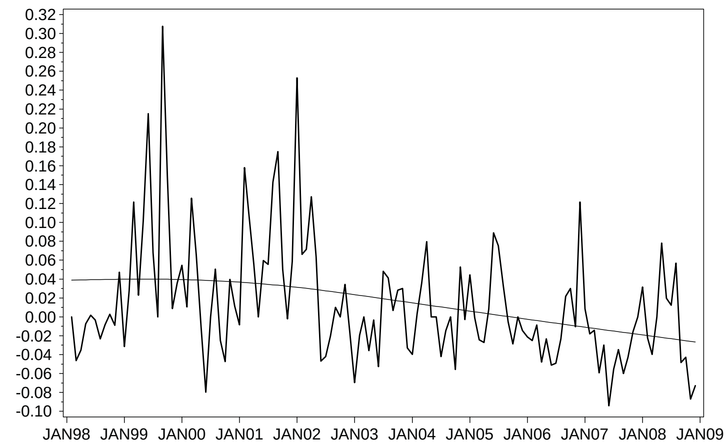



U=Upper  95% Confidence Limit   L=Lower 95% Confidence Limit
Zero Reference Line Shown

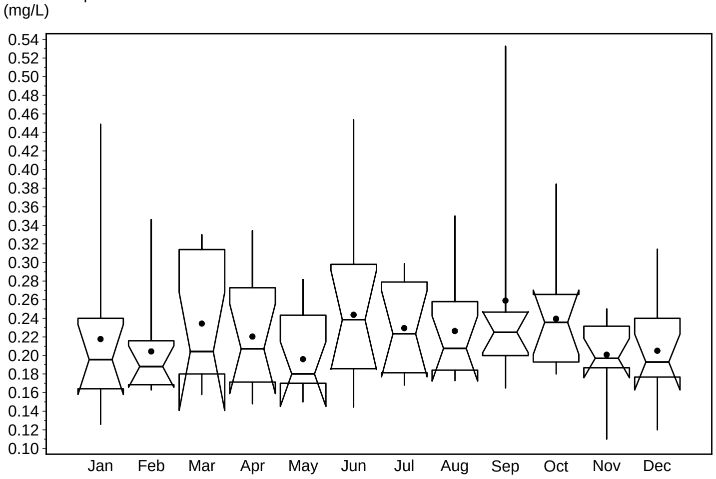
Upper Lemon Bay Trends Appendix - Display 21
Monthly Data Time Series
for Surface Total Phosphorous
Not Adjusted for Seasonal Medians




Upper Lemon Bay Trends Appendix - Display 22
Monthly Data Time Series
for Surface Total Phosphorous
Adjusted for Seasonal Medians




Upper Lemon Bay Trends Appendix - Display 23
Seasonal Univariate Statistics
for Surface Total Phosphorous



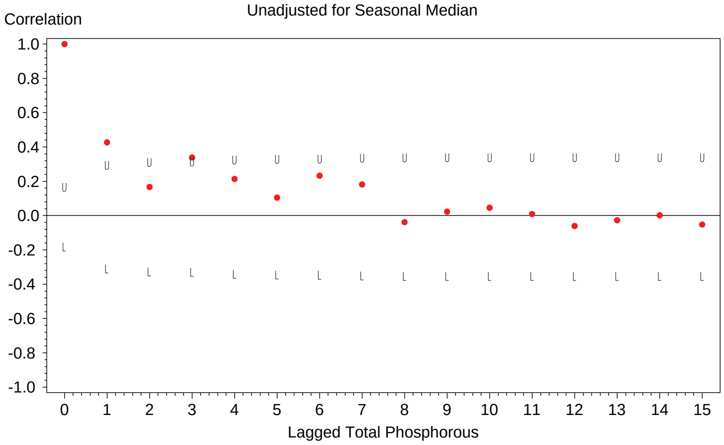

Upper Lemon Bay Trends Appendix - Display 24
Autocorrelation Statistics for Surface Total Phosphorous

Unadjusted for Seasonal Medians

| Lagged Total Phosphorous | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.427 | 0.151 | 0.302 | -0.302 |
| 2 | 0.167 | 0.160 | 0.319 | -0.319 |
| 3 | 0.339 | 0.161 | 0.322 | -0.322 |
| 4 | 0.214 | 0.166 | 0.333 | -0.333 |
| 5 | 0.105 | 0.168 | 0.337 | -0.337 |
| 6 | 0.233 | 0.169 | 0.338 | -0.338 |
| 7 | 0.182 | 0.171 | 0.343 | -0.343 |
| 8 | -0.038 | 0.173 | 0.345 | -0.345 |
| 9 | 0.023 | 0.173 | 0.346 | -0.346 |
| 10 | 0.046 | 0.173 | 0.346 | -0.346 |
| 11 | 0.009 | 0.173 | 0.346 | -0.346 |
| 12 | -0.060 | 0.173 | 0.346 | -0.346 |
| 13 | -0.027 | 0.173 | 0.346 | -0.346 |
| 14 | 0.002 | 0.173 | 0.346 | -0.346 |
| 15 | -0.052 | 0.173 | 0.346 | -0.346 |

Upper Lemon Bay Trends Appendix - Display 25
Correlogram for Surface Total Phosphorous

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Upper Lemon Bay Trends Appendix - Display 26
Seasonal Kendall Tau Trend Test Statistics
for Surface Total Phosphorous

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.255 | 0 | 0.046 | -.005 |

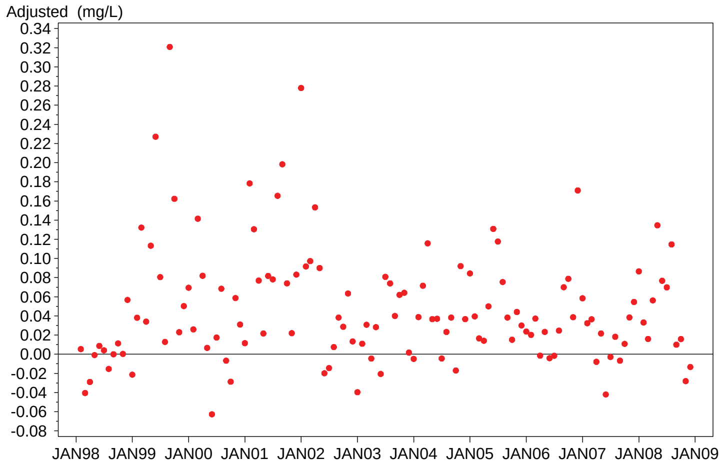
Upper Lemon Bay Trends Appendix - Display 27

Seasonal Kendall Tau Trend Test Statistics
for Surface Total Phosphorous

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.25539 | .000177092 | 0.046238 | -.005 |

Upper Lemon Bay Trends Appendix - Display 28
Time Series Plot of Surface Total Phosphorous Data Adjusted for Season and Detrended




Zero Reference Line Shown

Upper Lemon Bay Trends Appendix - Display 29

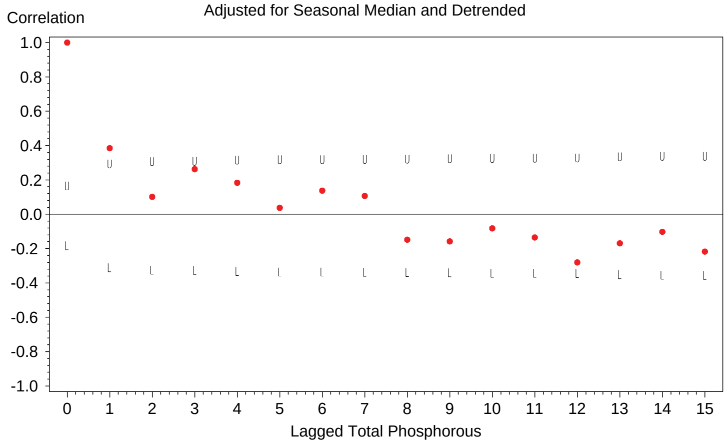
Autocorrelation Statistics for Surface Total Phosphorous

Adjusted for Seasonal Median and Detrended

| Lagged Total Phosphorous | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.385 | 0.151 | 0.302 | -0.302 |
| 2 | 0.102 | 0.158 | 0.316 | -0.316 |
| 3 | 0.263 | 0.159 | 0.317 | -0.317 |
| 4 | 0.184 | 0.162 | 0.324 | -0.324 |
| 5 | 0.038 | 0.163 | 0.327 | -0.327 |
| 6 | 0.138 | 0.163 | 0.327 | -0.327 |
| 7 | 0.107 | 0.164 | 0.329 | -0.329 |
| 8 | -0.148 | 0.165 | 0.330 | -0.330 |
| 9 | -0.158 | 0.166 | 0.332 | -0.332 |
| 10 | -0.082 | 0.167 | 0.334 | -0.334 |
| 11 | -0.135 | 0.167 | 0.335 | -0.335 |
| 12 | -0.280 | 0.168 | 0.336 | -0.336 |
| 13 | -0.169 | 0.172 | 0.343 | -0.343 |
| 14 | -0.102 | 0.173 | 0.346 | -0.346 |
| 15 | -0.217 | 0.173 | 0.347 | -0.347 |

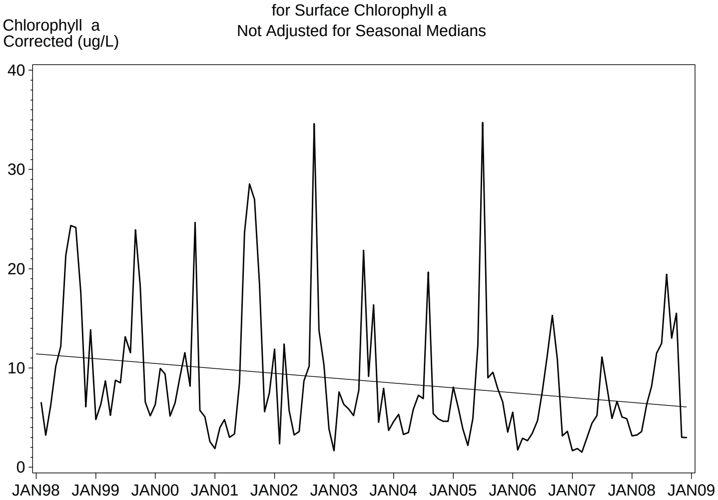
Upper Lemon Bay Trends Appendix - Display 30
Correlogram for Surface Total Phosphorous

Adjusted for Seasonal Median and Detrended

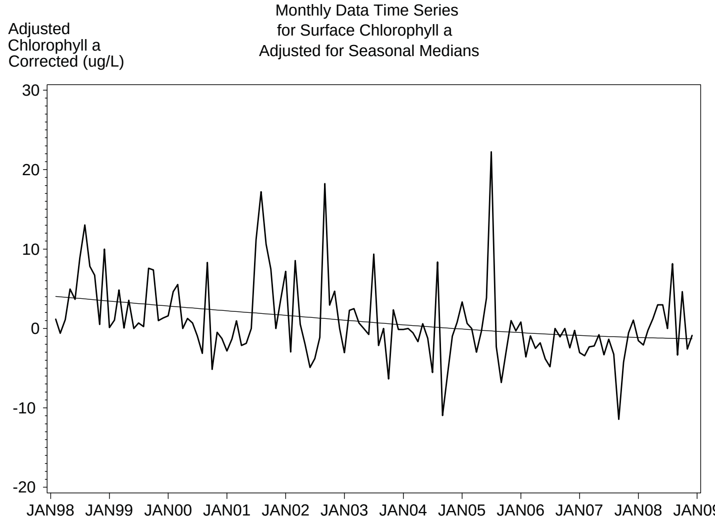



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

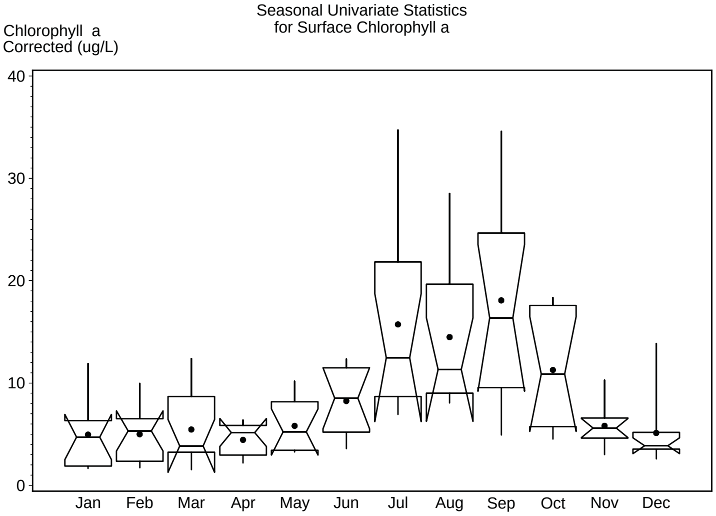
Upper Lemon Bay Trends Appendix - Display 31
Monthly Data Time Series
for Surface Chlorophyll a
Not Adjusted for Seasonal Medians




Upper Lemon Bay Trends Appendix - Display 32
Monthly Data Time Series
for Surface Chlorophyll a
Adjusted for Seasonal Medians




Upper Lemon Bay Trends Appendix - Display 33
Seasonal Univariate Statistics
for Surface Chlorophyll a



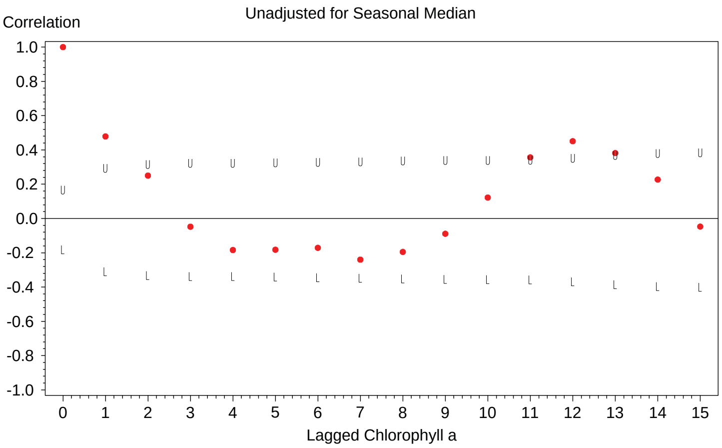

Upper Lemon Bay Trends Appendix - Display 34
Autocorrelation Statistics for Surface Chlorophyll a

Unadjusted for Seasonal Medians

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.479 | 0.151 | 0.302 | -0.302 |
| 2 | 0.250 | 0.162 | 0.324 | -0.324 |
| 3 | -0.048 | 0.165 | 0.330 | -0.330 |
| 4 | -0.184 | 0.165 | 0.330 | -0.330 |
| 5 | -0.182 | 0.166 | 0.333 | -0.333 |
| 6 | -0.171 | 0.168 | 0.336 | -0.336 |
| 7 | -0.240 | 0.169 | 0.339 | -0.339 |
| 8 | -0.195 | 0.172 | 0.344 | -0.344 |
| 9 | -0.089 | 0.173 | 0.347 | -0.347 |
| 10 | 0.122 | 0.174 | 0.348 | -0.348 |
| 11 | 0.357 | 0.174 | 0.349 | -0.349 |
| 12 | 0.451 | 0.180 | 0.360 | -0.360 |
| 13 | 0.382 | 0.188 | 0.377 | -0.377 |
| 14 | 0.227 | 0.194 | 0.388 | -0.388 |
| 15 | -0.047 | 0.196 | 0.392 | -0.392 |

Upper Lemon Bay Trends Appendix - Display 35
Correlogram for Surface Chlorophyll a

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Upper Lemon Bay Trends Appendix - Display 36
Seasonal Kendall Tau Trend Test Statistics
for Surface Chlorophyll a

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.295 | 0 | 0.014 | -0.392 |

Upper Lemon Bay Trends  Appendix - Display 37

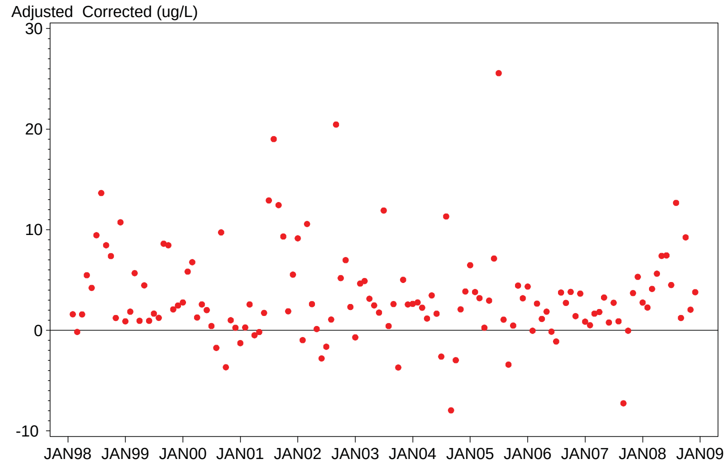
Seasonal Kendall Tau Trend Test Statistics
for Surface Chlorophyll a

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.29539 | .000014629 | 0.013744 | -0.39176 |

Upper Lemon Bay Trends Appendix - Display 38

Time Series Plot of Surface  Chlorophyll a Data Adjusted for Season and Detrended




Zero Reference Line Shown

Upper Lemon Bay Trends  Appendix - Display 39

Autocorrelation Statistics for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.185 | 0.151 | 0.302 | -0.302 |
| 2 | 0.090 | 0.152 | 0.305 | -0.305 |
| 3 | -0.067 | 0.153 | 0.306 | -0.306 |
| 4 | -0.021 | 0.153 | 0.306 | -0.306 |
| 5 | 0.080 | 0.153 | 0.306 | -0.306 |
| 6 | 0.080 | 0.153 | 0.307 | -0.307 |
| 7 | -0.054 | 0.154 | 0.308 | -0.308 |
| 8 | -0.074 | 0.154 | 0.308 | -0.308 |
| 9 | -0.170 | 0.154 | 0.308 | -0.308 |
| 10 | -0.170 | 0.156 | 0.311 | -0.311 |
| 11 | -0.021 | 0.157 | 0.314 | -0.314 |
| 12 | -0.079 | 0.157 | 0.314 | -0.314 |
| 13 | 0.034 | 0.157 | 0.315 | -0.315 |

Upper Lemon Bay Trends  Appendix - Display 39

Autocorrelation Statistics for Surface Chlorophyll a

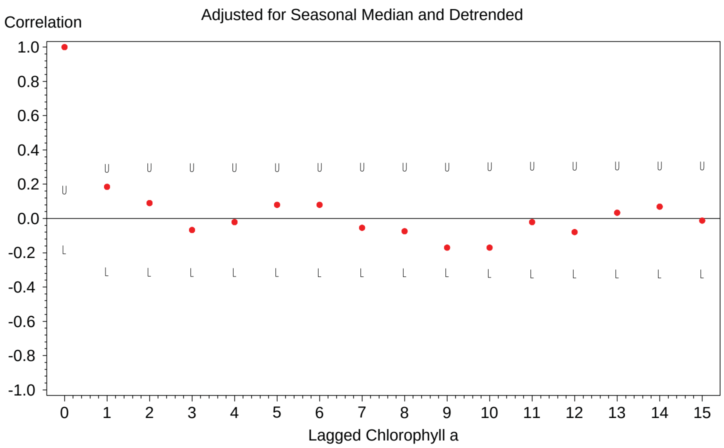
Adjusted for Seasonal Median and Detrended

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | 0.069 | 0.157 | 0.315 | -0.315 |
| 15 | -0.012 | 0.158 | 0.315 | -0.315 |

Upper Lemon Bay Trends Appendix - Display 40

Correlogram for Surface Chlorophyll a

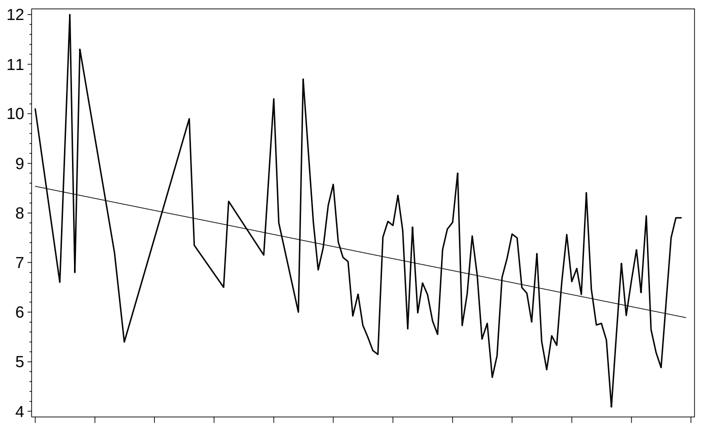
Adjusted for Seasonal Median and Detrended




U=Upper  95% Confidence Limit   L=Lower 95% Confidence Limit
Zero Reference Line Shown

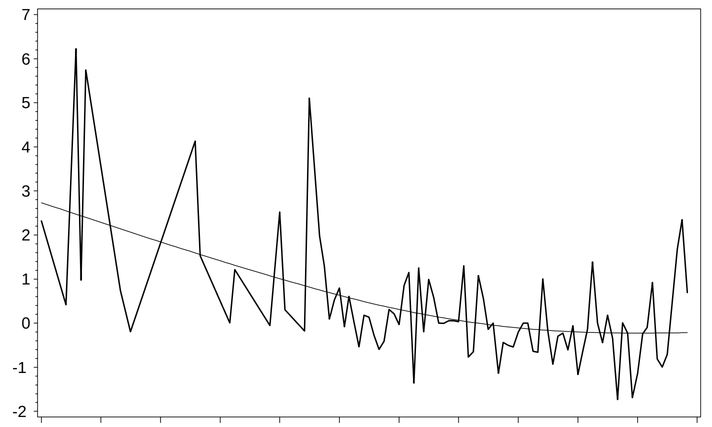
Lower Lemon Bay Trends Appendix - Display 1
Monthly Data Time Series
for Surface Dissolved Oxygen
Not Adjusted for Seasonal Medians

Dissolved Oxygen
(mg/L)



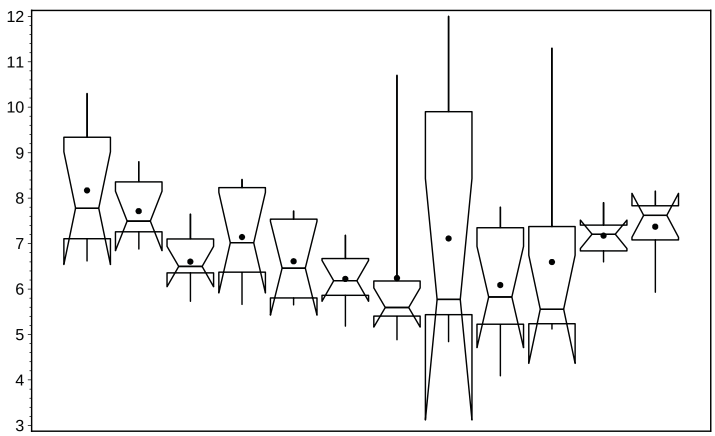

Lower Lemon Bay Trends Appendix - Display 2
Monthly Data Time Series
for Surface Dissolved Oxygen
Adjusted for Seasonal Medians

Adjusted
Dissolved Oxygen
(mg/L)




Lower Lemon Bay Trends Appendix - Display 3
Seasonal Univariate Statistics
for Surface Dissolved Oxygen

Dissolved Oxygen
(mg/L)




Lower Lemon Bay Trends Appendix - Display 4
Autocorrelation Statistics for Surface Dissolved Oxygen

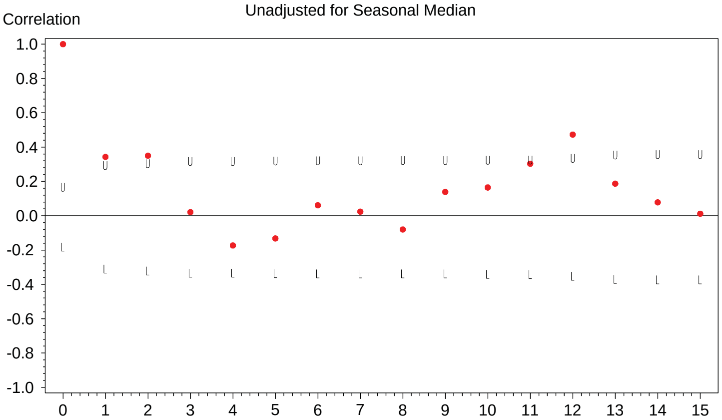
Unadjusted for Seasonal Medians

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.343 | 0.151 | 0.302 | -0.302 |
| 2 | 0.350 | 0.157 | 0.313 | -0.313 |
| 3 | 0.021 | 0.162 | 0.325 | -0.325 |
| 4 | -0.173 | 0.162 | 0.325 | -0.325 |
| 5 | -0.132 | 0.164 | 0.328 | -0.328 |
| 6 | 0.061 | 0.165 | 0.329 | -0.329 |
| 7 | 0.024 | 0.165 | 0.329 | -0.329 |
| 8 | -0.080 | 0.165 | 0.330 | -0.330 |
| 9 | 0.139 | 0.165 | 0.330 | -0.330 |
| 10 | 0.165 | 0.166 | 0.332 | -0.332 |
| 11 | 0.303 | 0.167 | 0.334 | -0.334 |
| 12 | 0.473 | 0.171 | 0.343 | -0.343 |
| 13 | 0.187 | 0.181 | 0.362 | -0.362 |
| 14 | 0.078 | 0.182 | 0.365 | -0.365 |
| 15 | 0.012 | 0.183 | 0.365 | -0.365 |

Lower Lemon Bay Trends Appendix - Display 5
Correlogram for Surface Dissolved Oxygen

Unadjusted for Seasonal Median

Correlation




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Lower Lemon Bay Trends Appendix - Display 6
Seasonal Kendall Tau Trend Test Statistics
for Surface Dissolved Oxygen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.338 | 0 | 0.011 | -0.166 |

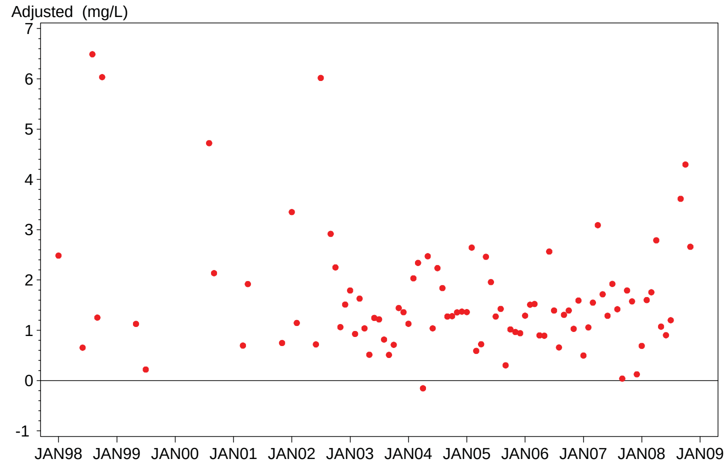
Lower Lemon Bay Trends Appendix - Display 7

Seasonal Kendall Tau Trend Test Statistics
for Surface Dissolved Oxygen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.33784 | .000129177 | 0.010652 | -0.16617 |

Lower Lemon Bay Trends Appendix - Display 8
Time Series Plot of Surface Dissolved Oxygen Data Adjusted for Season and Detrended




Zero Reference Line Shown

Lower Lemon Bay Trends Appendix - Display 9

Autocorrelation Statistics for Surface Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.069 | 0.151 | 0.302 | -0.302 |
| 2 | 0.260 | 0.151 | 0.302 | -0.302 |
| 3 | 0.084 | 0.154 | 0.309 | -0.309 |
| 4 | -0.142 | 0.155 | 0.309 | -0.309 |
| 5 | -0.057 | 0.156 | 0.311 | -0.311 |
| 6 | 0.275 | 0.156 | 0.312 | -0.312 |
| 7 | -0.032 | 0.159 | 0.319 | -0.319 |
| 8 | -0.044 | 0.160 | 0.319 | -0.319 |
| 9 | -0.099 | 0.160 | 0.319 | -0.319 |
| 10 | -0.227 | 0.160 | 0.320 | -0.320 |
| 11 | -0.083 | 0.162 | 0.325 | -0.325 |
| 12 | 0.004 | 0.163 | 0.326 | -0.326 |
| 13 | -0.197 | 0.163 | 0.326 | -0.326 |

Lower Lemon Bay Trends Appendix - Display 9

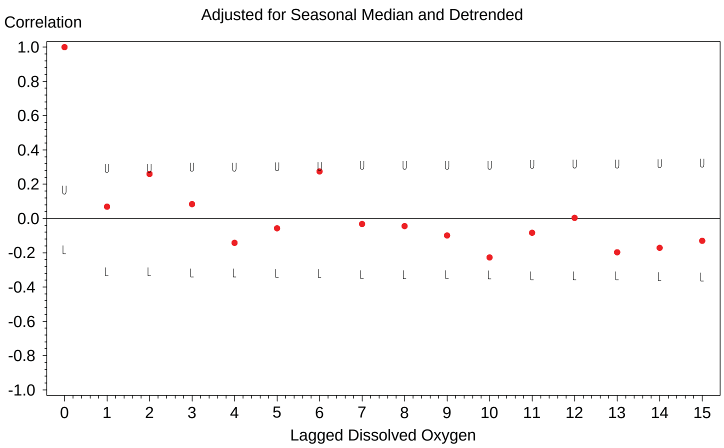
Autocorrelation Statistics for Surface Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | -0.171 | 0.165 | 0.329 | -0.329 |
| 15 | -0.130 | 0.166 | 0.332 | -0.332 |

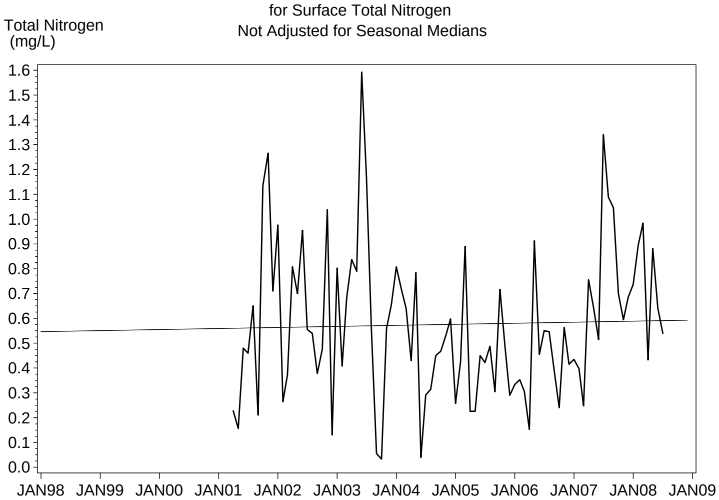
Lower Lemon Bay Trends Appendix - Display 10
Correlogram for Surface Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

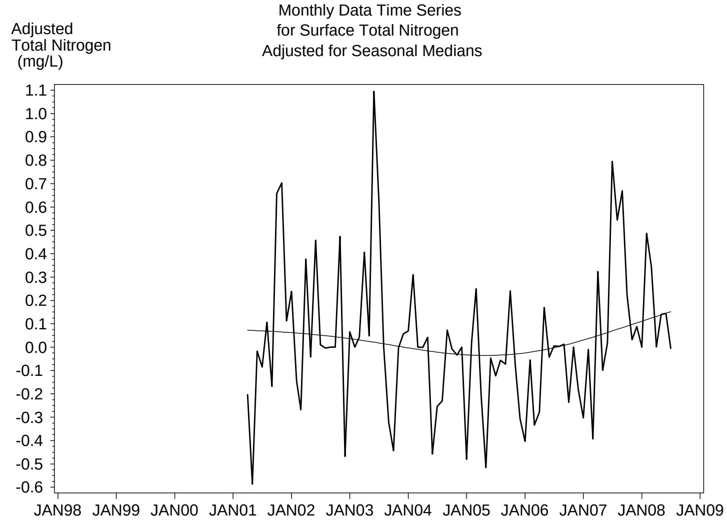



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

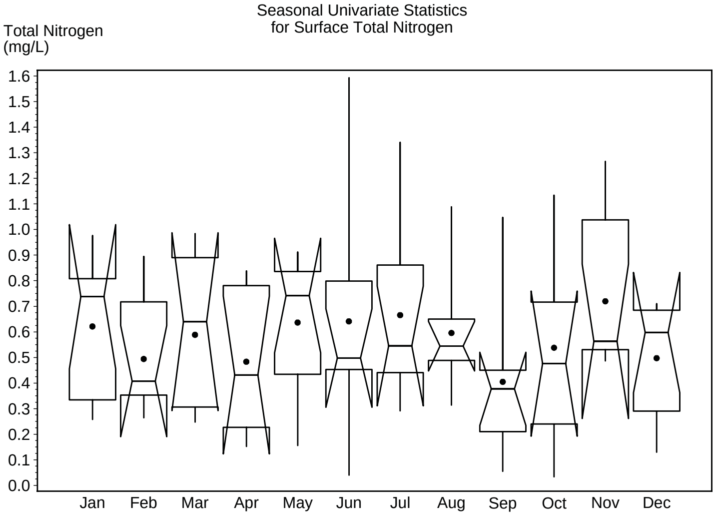
Lower Lemon Bay Trends Appendix - Display 11
Monthly Data Time Series
for Surface Total Nitrogen
Not Adjusted for Seasonal Medians




Lower Lemon Bay Trends Appendix - Display 12
Monthly Data Time Series
for Surface Total Nitrogen
Adjusted for Seasonal Medians




Lower Lemon Bay Trends Appendix - Display 13
Seasonal Univariate Statistics
for Surface Total Nitrogen



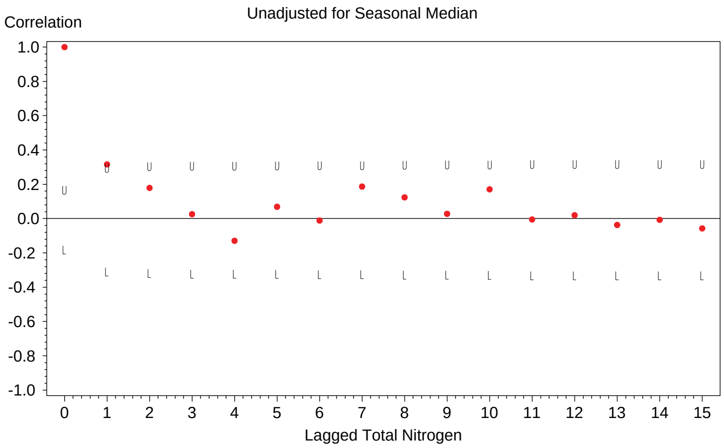

Lower Lemon Bay Trends Appendix - Display 14
Autocorrelation Statistics for Surface Total Nitrogen

Unadjusted for Seasonal Medians

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.316 | 0.151 | 0.302 | -0.302 |
| 2 | 0.179 | 0.156 | 0.311 | -0.311 |
| 3 | 0.026 | 0.157 | 0.315 | -0.315 |
| 4 | -0.129 | 0.157 | 0.315 | -0.315 |
| 5 | 0.069 | 0.158 | 0.316 | -0.316 |
| 6 | -0.011 | 0.158 | 0.317 | -0.317 |
| 7 | 0.187 | 0.158 | 0.317 | -0.317 |
| 8 | 0.124 | 0.160 | 0.320 | -0.320 |
| 9 | 0.028 | 0.161 | 0.321 | -0.321 |
| 10 | 0.171 | 0.161 | 0.322 | -0.322 |
| 11 | -0.005 | 0.162 | 0.324 | -0.324 |
| 12 | 0.020 | 0.162 | 0.324 | -0.324 |
| 13 | -0.037 | 0.162 | 0.324 | -0.324 |
| 14 | -0.007 | 0.162 | 0.324 | -0.324 |
| 15 | -0.057 | 0.162 | 0.324 | -0.324 |

Lower Lemon Bay Trends Appendix - Display 15
Correlogram for Surface Total Nitrogen

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Lower Lemon Bay Trends Appendix - Display 16
Seasonal Kendall Tau Trend Test Statistics
for Surface Total Nitrogen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.057 | 0.546 | 0.625 | .005 |

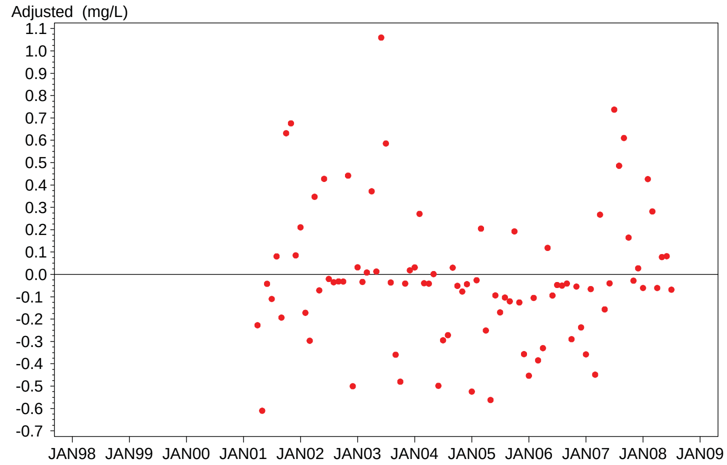
Lower Lemon Bay Trends Appendix - Display 17

Seasonal Kendall Tau Trend Test Statistics
for Surface Total Nitrogen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.057143 | 0.5456 | 0.62516 | .0055 |

Lower Lemon Bay Trends Appendix - Display 18
Time Series Plot of Surface Total Nitrogen Data Adjusted for Season and Detrended




Zero Reference Line Shown

Lower Lemon Bay Trends Appendix - Display 19
Autocorrelation Statistics for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.309 | 0.151 | 0.302 | -0.302 |
| 2 | 0.182 | 0.155 | 0.311 | -0.311 |
| 3 | 0.054 | 0.157 | 0.314 | -0.314 |
| 4 | -0.124 | 0.157 | 0.314 | -0.314 |
| 5 | 0.058 | 0.158 | 0.316 | -0.316 |
| 6 | -0.116 | 0.158 | 0.316 | -0.316 |
| 7 | 0.194 | 0.159 | 0.318 | -0.318 |
| 8 | 0.147 | 0.161 | 0.321 | -0.321 |
| 9 | 0.058 | 0.162 | 0.323 | -0.323 |
| 10 | 0.211 | 0.162 | 0.323 | -0.323 |
| 11 | -0.005 | 0.164 | 0.328 | -0.328 |
| 12 | 0.037 | 0.164 | 0.328 | -0.328 |
| 13 | -0.065 | 0.164 | 0.328 | -0.328 |

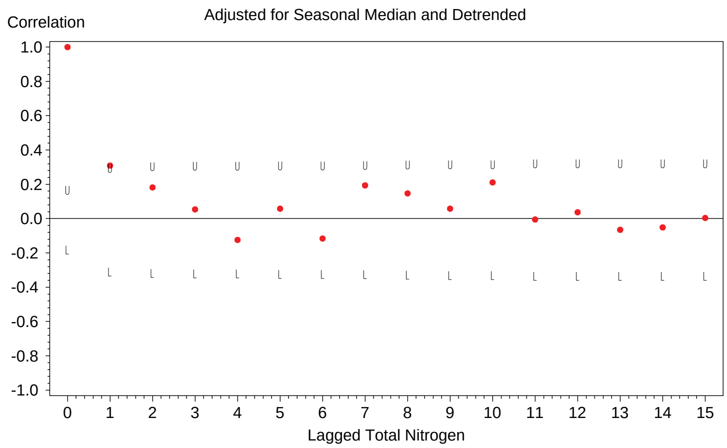
Lower Lemon Bay Trends Appendix - Display 19
Autocorrelation Statistics for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | -0.051 | 0.164 | 0.328 | -0.328 |
| 15 | 0.004 | 0.164 | 0.328 | -0.328 |

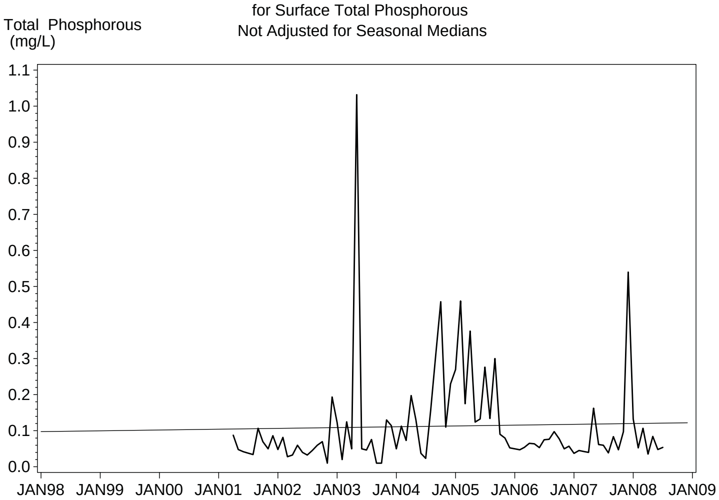
Lower Lemon Bay Trends Appendix - Display 20
Correlogram for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

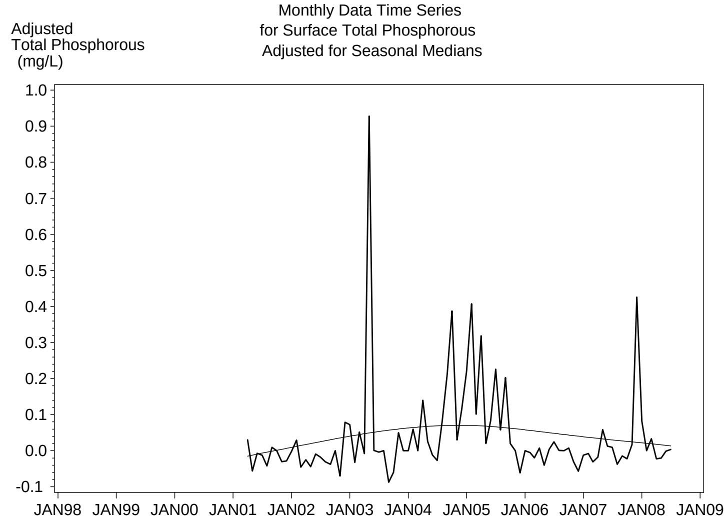



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

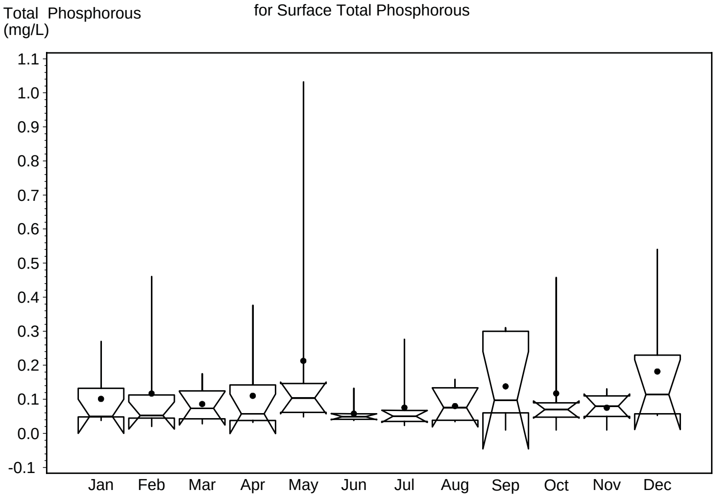
Lower Lemon Bay Trends Appendix - Display 21
Monthly Data Time Series
for Surface Total Phosphorous
Not Adjusted for Seasonal Medians




Lower Lemon Bay Trends Appendix - Display 22
Monthly Data Time Series
for Surface Total Phosphorous
Adjusted for Seasonal Medians




Lower Lemon Bay Trends Appendix - Display 23
Seasonal Univariate Statistics
for Surface Total Phosphorous



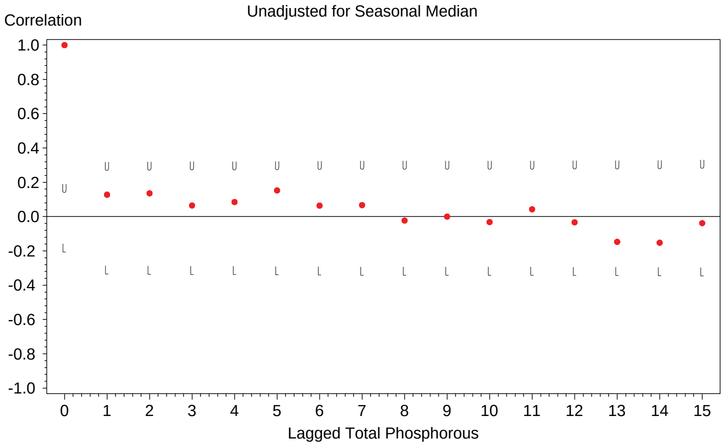

Lower Lemon Bay Trends Appendix - Display 24
Autocorrelation Statistics for Surface Total Phosphorous

Unadjusted for Seasonal Medians

| Lagged Total Phosphorous | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.128 | 0.151 | 0.302 | -0.302 |
| 2 | 0.136 | 0.152 | 0.303 | -0.303 |
| 3 | 0.065 | 0.152 | 0.305 | -0.305 |
| 4 | 0.085 | 0.153 | 0.305 | -0.305 |
| 5 | 0.153 | 0.153 | 0.306 | -0.306 |
| 6 | 0.064 | 0.154 | 0.308 | -0.308 |
| 7 | 0.067 | 0.154 | 0.309 | -0.309 |
| 8 | -0.023 | 0.155 | 0.309 | -0.309 |
| 9 | 0.000 | 0.155 | 0.309 | -0.309 |
| 10 | -0.032 | 0.155 | 0.309 | -0.309 |
| 11 | 0.043 | 0.155 | 0.309 | -0.309 |
| 12 | -0.033 | 0.155 | 0.310 | -0.310 |
| 13 | -0.147 | 0.155 | 0.310 | -0.310 |
| 14 | -0.152 | 0.156 | 0.312 | -0.312 |
| 15 | -0.038 | 0.157 | 0.314 | -0.314 |

Lower Lemon Bay Trends Appendix - Display 25
Correlogram for Surface Total Phosphorous

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Lower Lemon Bay Trends Appendix - Display 26
Seasonal Kendall Tau Trend Test Statistics
for Surface Total Phosphorous

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.104 | 0.258 | 0.512 | .002 |

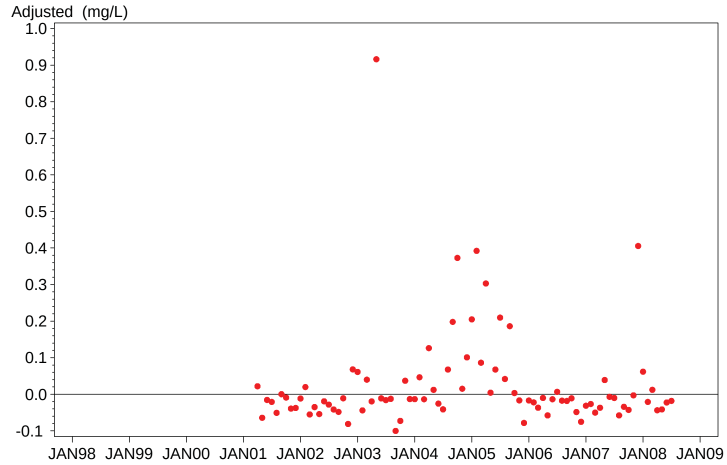
Lower Lemon Bay Trends  Appendix - Display 27

Seasonal Kendall Tau Trend Test Statistics
for Surface Total Phosphorous

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.10357 | 0.25809 | 0.51181 | .001875 |

Lower Lemon Bay Trends Appendix - Display 28
Time Series Plot of Surface Total  Phosphorous Data Adjusted for Season and Detrended




Zero Reference Line Shown

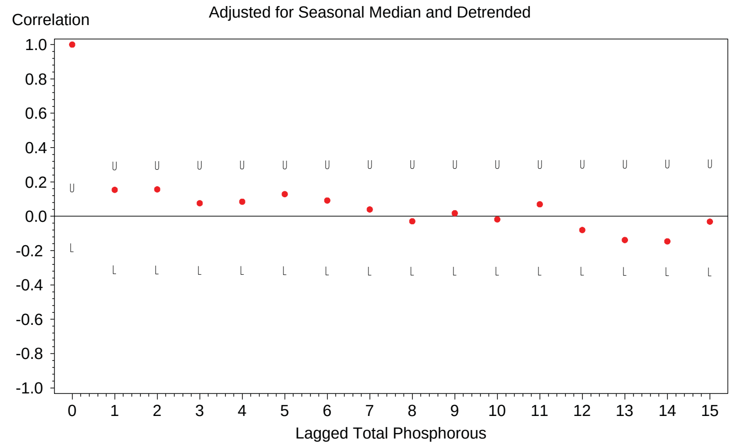
Lower Lemon Bay Trends  Appendix - Display 29
Autocorrelation Statistics for Surface Total Phosphorous

Adjusted for Seasonal Median and Detrended

| Lagged Total Phosphorous | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.154 | 0.151 | 0.302 | -0.302 |
| 2 | 0.157 | 0.152 | 0.304 | -0.304 |
| 3 | 0.076 | 0.153 | 0.306 | -0.306 |
| 4 | 0.085 | 0.153 | 0.307 | -0.307 |
| 5 | 0.129 | 0.154 | 0.308 | -0.308 |
| 6 | 0.092 | 0.155 | 0.309 | -0.309 |
| 7 | 0.040 | 0.155 | 0.310 | -0.310 |
| 8 | -0.029 | 0.155 | 0.310 | -0.310 |
| 9 | 0.018 | 0.155 | 0.310 | -0.310 |
| 10 | -0.018 | 0.155 | 0.310 | -0.310 |
| 11 | 0.070 | 0.155 | 0.310 | -0.310 |
| 12 | -0.080 | 0.155 | 0.311 | -0.311 |
| 13 | -0.138 | 0.156 | 0.312 | -0.312 |
| 14 | -0.146 | 0.157 | 0.313 | -0.313 |
| 15 | -0.031 | 0.158 | 0.315 | -0.315 |

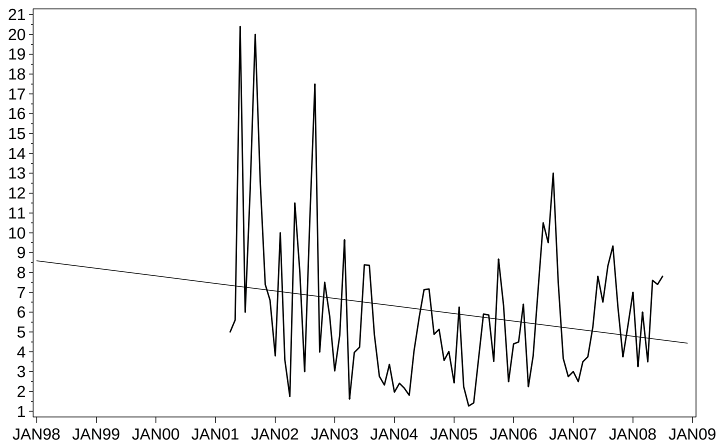
Lower Lemon Bay Trends Appendix - Display 30
Correlogram for Surface Total Phosphorous

Adjusted for Seasonal Median and Detrended

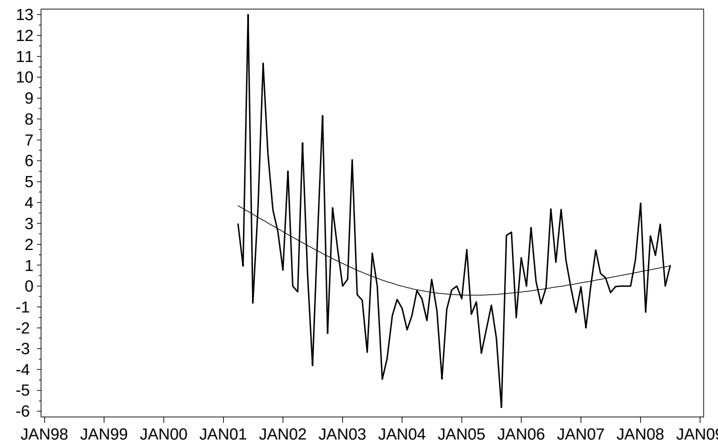



U=Upper 95% Confidence Limit   L=Lower 95% Confidence Limit
Zero Reference Line Shown

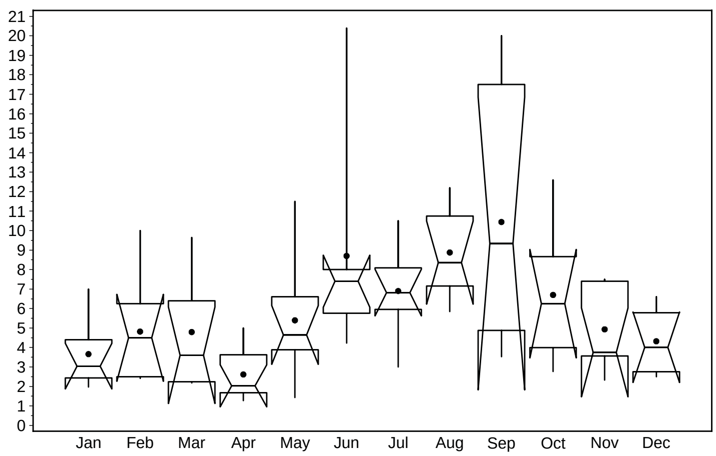
Lower Lemon Bay Trends Appendix - Display 31
Monthly Data Time Series
for Surface Chlorophyll a
Not Adjusted for Seasonal Medians




Lower Lemon Bay Trends Appendix - Display 32
Monthly Data Time Series
for Surface Chlorophyll a
Adjusted for Seasonal Medians




Lower Lemon Bay Trends Appendix - Display 33
Seasonal Univariate Statistics
for Surface Chlorophyll a



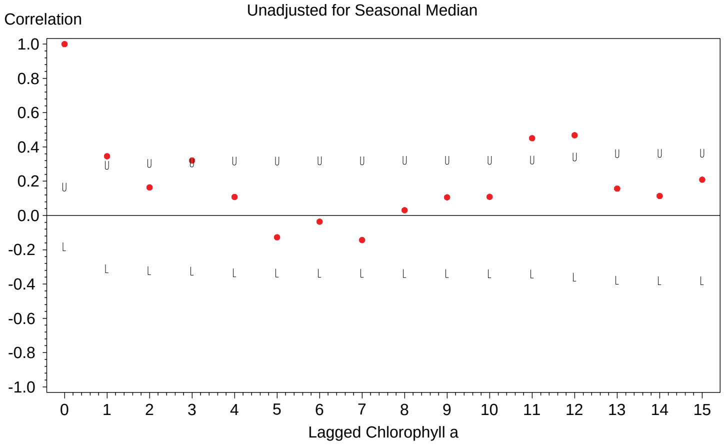

Lower Lemon Bay Trends Appendix - Display 34
Autocorrelation Statistics for Surface Chlorophyll a

Unadjusted for Seasonal Medians

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.346 | 0.151 | 0.302 | -0.302 |
| 2 | 0.164 | 0.157 | 0.313 | -0.313 |
| 3 | 0.321 | 0.158 | 0.316 | -0.316 |
| 4 | 0.108 | 0.163 | 0.326 | -0.326 |
| 5 | -0.127 | 0.163 | 0.327 | -0.327 |
| 6 | -0.036 | 0.164 | 0.328 | -0.328 |
| 7 | -0.143 | 0.164 | 0.328 | -0.328 |
| 8 | 0.031 | 0.165 | 0.330 | -0.330 |
| 9 | 0.106 | 0.165 | 0.330 | -0.330 |
| 10 | 0.109 | 0.166 | 0.331 | -0.331 |
| 11 | 0.451 | 0.166 | 0.332 | -0.332 |
| 12 | 0.468 | 0.175 | 0.350 | -0.350 |
| 13 | 0.157 | 0.184 | 0.369 | -0.369 |
| 14 | 0.114 | 0.185 | 0.371 | -0.371 |
| 15 | 0.209 | 0.186 | 0.372 | -0.372 |

Lower Lemon Bay Trends Appendix - Display 35
Correlogram for Surface Chlorophyll a

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Lower Lemon Bay Trends Appendix - Display 36
Seasonal Kendall Tau Trend Test Statistics
for Surface Chlorophyll a

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.092 | 0.325 | 0.598 | -0.137 |

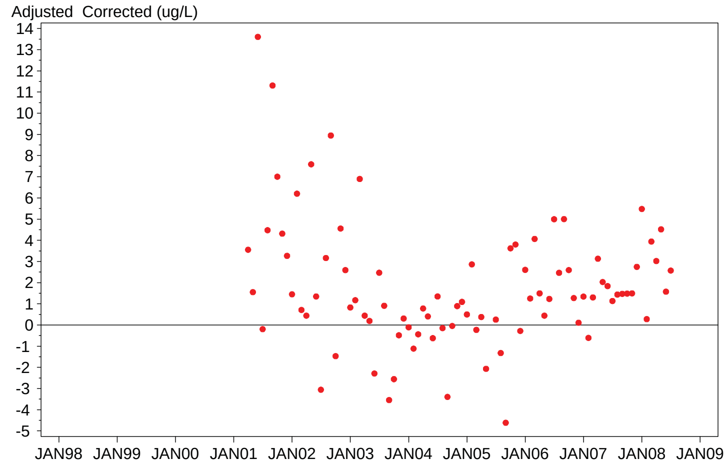
Lower Lemon Bay Trends Appendix - Display 37

Seasonal Kendall Tau Trend Test Statistics
for Surface Chlorophyll a

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.091575 | 0.32516 | 0.59787 | -0.138 |

Lower Lemon Bay Trends Appendix - Display 38
Time Series Plot of Surface Chlorophyll a Data Adjusted for Season and Detrended




Zero Reference Line Shown

Lower Lemon Bay Trends Appendix - Display 39
Autocorrelation Statistics for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.167 | 0.151 | 0.302 | -0.302 |
| 2 | 0.124 | 0.152 | 0.304 | -0.304 |
| 3 | 0.406 | 0.153 | 0.306 | -0.306 |
| 4 | 0.381 | 0.161 | 0.322 | -0.322 |
| 5 | 0.112 | 0.168 | 0.335 | -0.335 |
| 6 | 0.218 | 0.168 | 0.336 | -0.336 |
| 7 | 0.119 | 0.170 | 0.341 | -0.341 |
| 8 | 0.244 | 0.171 | 0.342 | -0.342 |
| 9 | 0.097 | 0.174 | 0.347 | -0.347 |
| 10 | 0.011 | 0.174 | 0.348 | -0.348 |
| 11 | 0.280 | 0.174 | 0.348 | -0.348 |
| 12 | 0.134 | 0.177 | 0.355 | -0.355 |
| 13 | -0.104 | 0.178 | 0.356 | -0.356 |

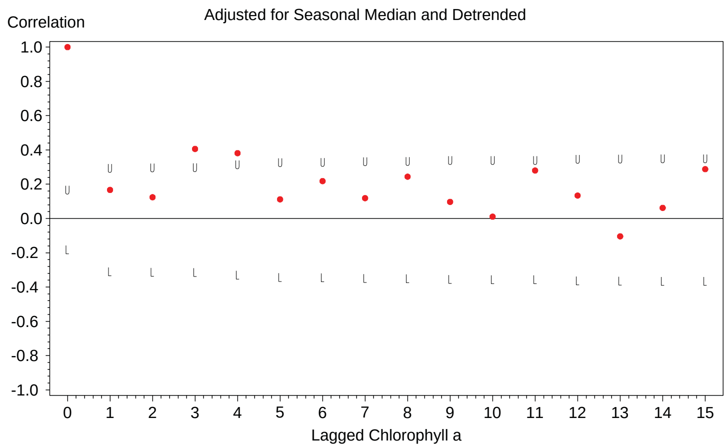
Lower Lemon Bay Trends Appendix - Display 39
Autocorrelation Statistics for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | 0.062 | 0.179 | 0.357 | -0.357 |
| 15 | 0.288 | 0.179 | 0.357 | -0.357 |

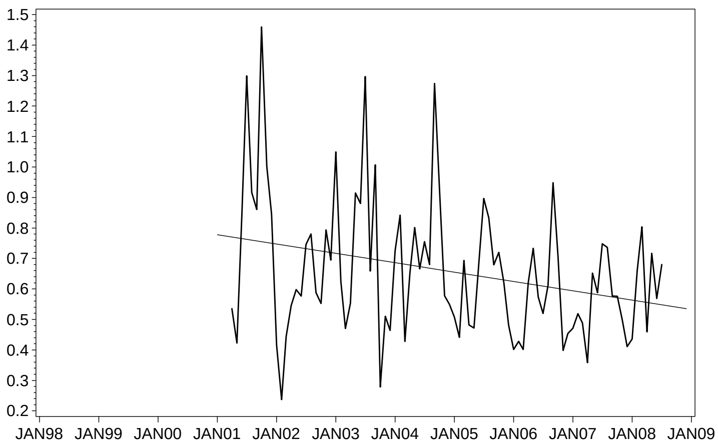
Lower Lemon Bay Trends Appendix - Display 40
Correlogram for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended

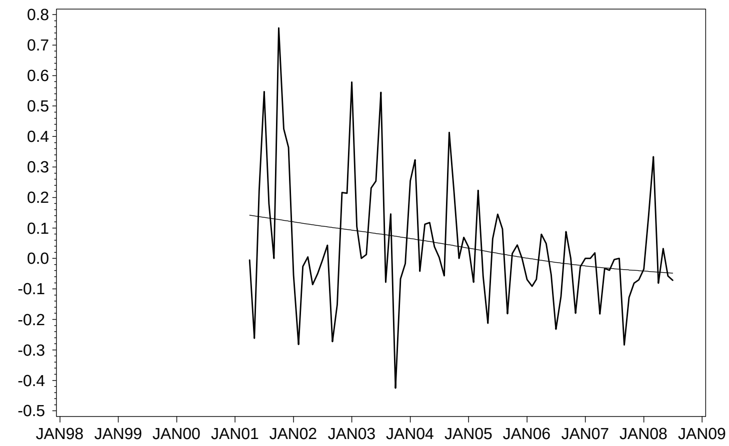



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

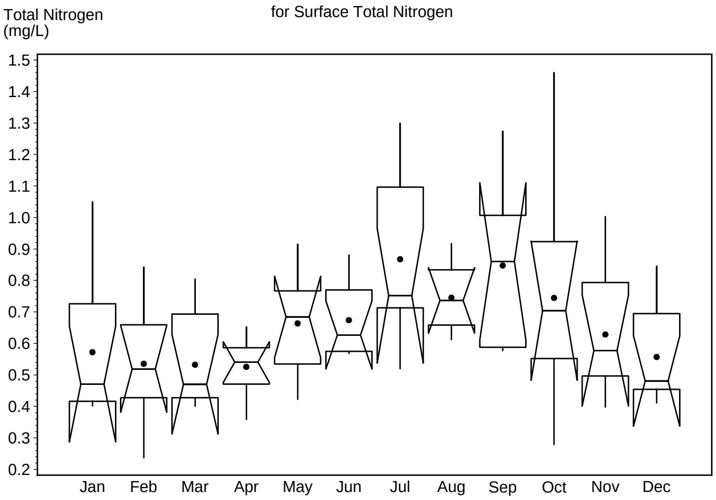
Charlotte Harbor Proper Trends Appendix - Display 1
Monthly Data Time Series
for Surface Total Nitrogen
Not Adjusted for Seasonal Medians




Charlotte Harbor Proper Trends Appendix - Display 2
Monthly Data Time Series
for Surface Total Nitrogen
Adjusted for Seasonal Medians




Charlotte Harbor Proper Trends Appendix - Display 3
Seasonal Univariate Statistics
for Surface Total Nitrogen



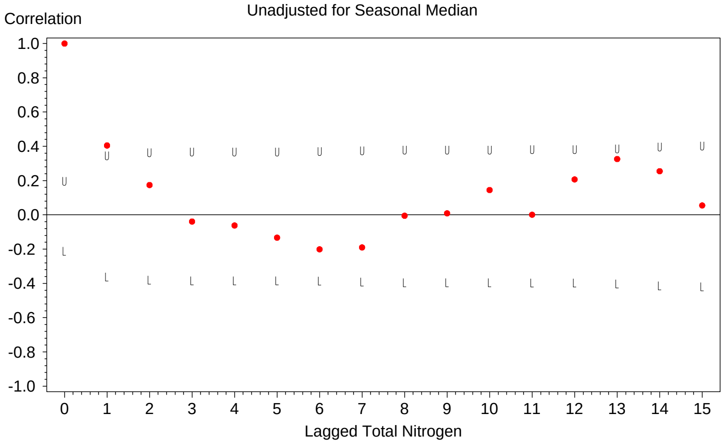

Charlotte Harbor Proper Trends Appendix - Display 4
Autocorrelation Statistics for Surface Total Nitrogen

Unadjusted for Seasonal Medians

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.102 | 0.204 | -0.204 |
| 1 | 0.405 | 0.177 | 0.354 | -0.354 |
| 2 | 0.174 | 0.186 | 0.372 | -0.372 |
| 3 | -0.039 | 0.188 | 0.376 | -0.376 |
| 4 | -0.062 | 0.188 | 0.376 | -0.376 |
| 5 | -0.133 | 0.188 | 0.376 | -0.376 |
| 6 | -0.201 | 0.189 | 0.378 | -0.378 |
| 7 | -0.190 | 0.191 | 0.383 | -0.383 |
| 8 | -0.005 | 0.193 | 0.387 | -0.387 |
| 9 | 0.009 | 0.193 | 0.387 | -0.387 |
| 10 | 0.145 | 0.193 | 0.387 | -0.387 |
| 11 | 0.001 | 0.194 | 0.389 | -0.389 |
| 12 | 0.207 | 0.194 | 0.389 | -0.389 |
| 13 | 0.326 | 0.197 | 0.394 | -0.394 |
| 14 | 0.255 | 0.202 | 0.405 | -0.405 |
| 15 | 0.055 | 0.206 | 0.411 | -0.411 |

Charlotte Harbor Proper Trends Appendix - Display 5
Correlogram for Surface Total Nitrogen

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Charlotte Harbor Proper Trends Appendix - Display 6
Seasonal Kendall Tau Trend Test Statistics
for Surface Total Nitrogen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.25 | .005 | 0.092 | -0.025 |

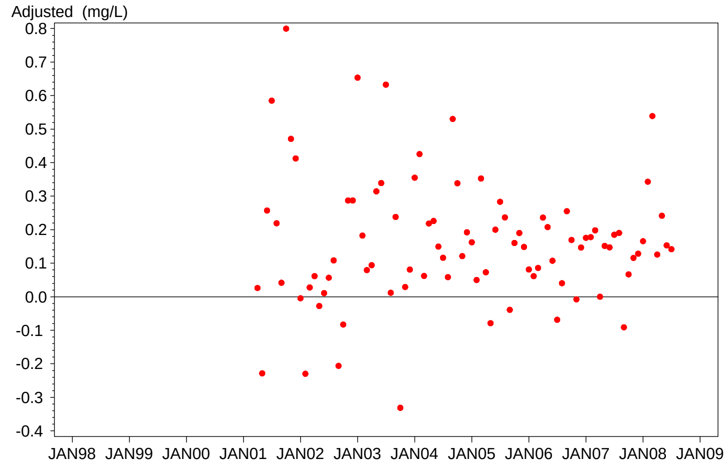
Charlotte Harbor Proper  Trends Appendix - Display 7

Seasonal Kendall Tau Trend Test Statistics
for Surface Total Nitrogen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.25 | .00543414 | 0.092034 | -0.025125 |

Charlotte Harbor Proper Trends Appendix - Display 8
Time Series Plot of Surface Total  Nitrogen Data Adjusted for Season and Detrended




Zero Reference Line Shown

Charlotte Harbor Proper  Trends Appendix - Display 9

Autocorrelation Statistics for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.102 | 0.204 | -0.204 |
| 1 | 0.244 | 0.177 | 0.354 | -0.354 |
| 2 | -0.052 | 0.180 | 0.360 | -0.360 |
| 3 | -0.156 | 0.180 | 0.361 | -0.361 |
| 4 | -0.054 | 0.182 | 0.364 | -0.364 |
| 5 | -0.006 | 0.182 | 0.364 | -0.364 |
| 6 | -0.067 | 0.182 | 0.364 | -0.364 |
| 7 | -0.115 | 0.182 | 0.364 | -0.364 |
| 8 | -0.031 | 0.183 | 0.366 | -0.366 |
| 9 | -0.141 | 0.183 | 0.366 | -0.366 |
| 10 | -0.161 | 0.184 | 0.368 | -0.368 |
| 11 | -0.368 | 0.186 | 0.371 | -0.371 |
| 12 | -0.136 | 0.193 | 0.386 | -0.386 |
| 13 | 0.234 | 0.194 | 0.388 | -0.388 |

Charlotte Harbor Proper  Trends Appendix - Display 9

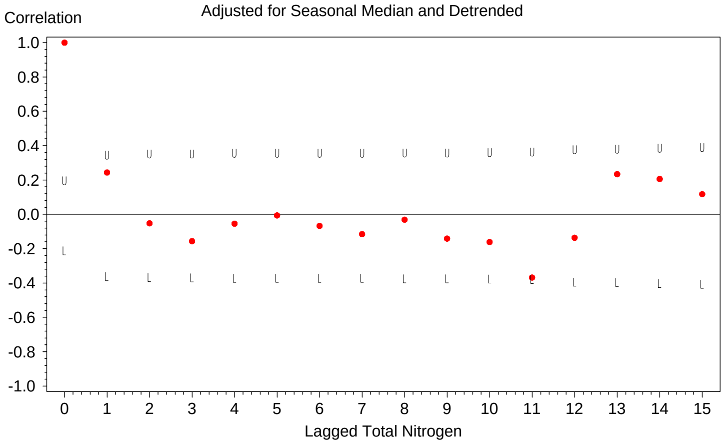
Autocorrelation Statistics for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | 0.206 | 0.197 | 0.394 | -0.394 |
| 15 | 0.118 | 0.199 | 0.398 | -0.398 |

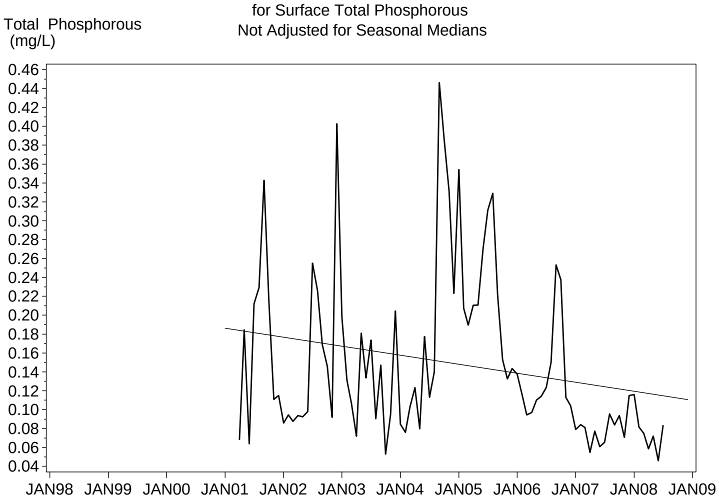
Charlotte Harbor Proper Trends Appendix - Display 10
Correlogram for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

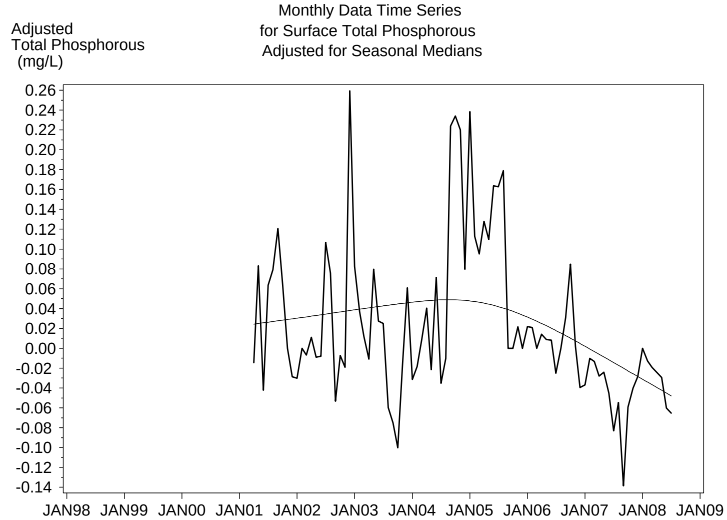



U=Upper 95% Confidence Limit   L=Lower 95% Confidence Limit
Zero Reference Line Shown

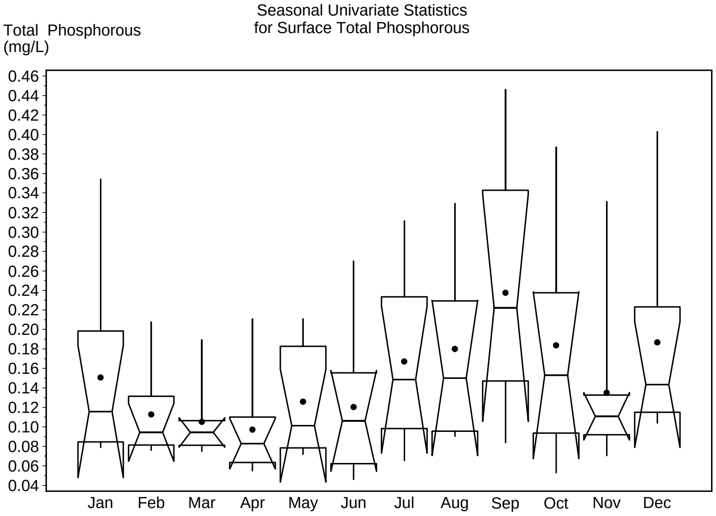
Charlotte Harbor Proper Trends Appendix - Display 11
Monthly Data Time Series
for Surface Total Phosphorous
Not Adjusted for Seasonal Medians




Charlotte Harbor Proper Trends Appendix - Display 12
Monthly Data Time Series
for Surface Total Phosphorous
Adjusted for Seasonal Medians




Charlotte Harbor Proper Trends Appendix - Display 13
Seasonal Univariate Statistics
for Surface Total Phosphorous



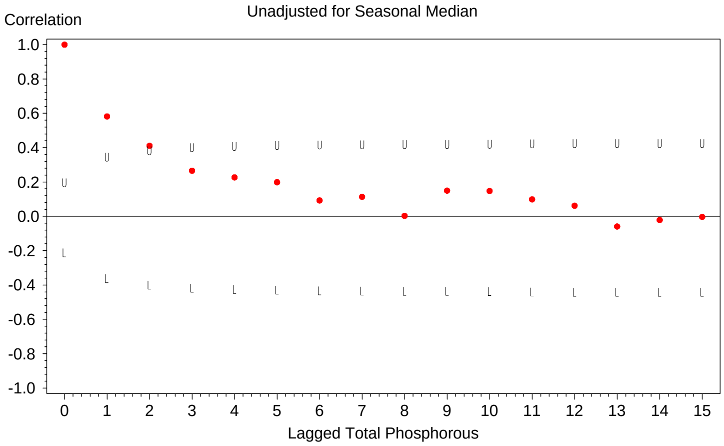

Charlotte Harbor Proper Trends Appendix - Display 14
Autocorrelation Statistics for Surface Total Phosphorous

Unadjusted for Seasonal Medians

| Lagged Total Phosphorous | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.102 | 0.204 | -0.204 |
| 1 | 0.582 | 0.177 | 0.354 | -0.354 |
| 2 | 0.411 | 0.196 | 0.391 | -0.391 |
| 3 | 0.266 | 0.204 | 0.409 | -0.409 |
| 4 | 0.227 | 0.208 | 0.416 | -0.416 |
| 5 | 0.199 | 0.211 | 0.421 | -0.421 |
| 6 | 0.093 | 0.213 | 0.425 | -0.425 |
| 7 | 0.114 | 0.213 | 0.426 | -0.426 |
| 8 | 0.003 | 0.214 | 0.427 | -0.427 |
| 9 | 0.150 | 0.214 | 0.427 | -0.427 |
| 10 | 0.148 | 0.215 | 0.429 | -0.429 |
| 11 | 0.099 | 0.216 | 0.432 | -0.432 |
| 12 | 0.062 | 0.216 | 0.433 | -0.433 |
| 13 | -0.059 | 0.216 | 0.433 | -0.433 |
| 14 | -0.021 | 0.217 | 0.433 | -0.433 |
| 15 | -0.003 | 0.217 | 0.433 | -0.433 |

Charlotte Harbor Proper Trends Appendix - Display 15
Correlogram for Surface Total Phosphorous

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Charlotte Harbor Proper Trends Appendix - Display 16
Seasonal Kendall Tau Trend Test Statistics
for Surface Total Phosphorous

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.254 | .005 | 0.211 | -.007 |

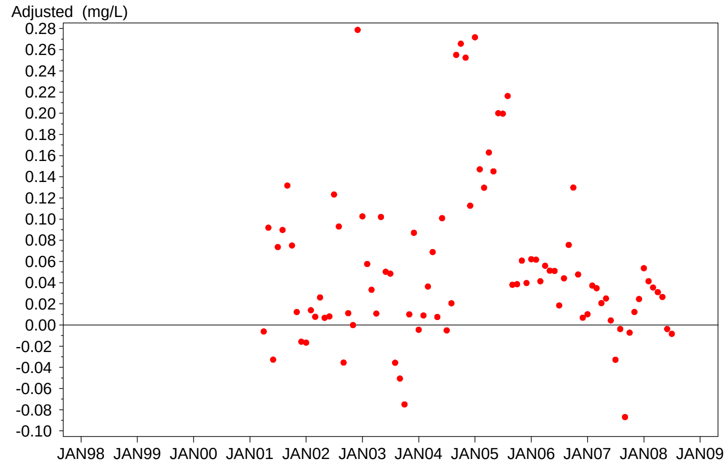
Charlotte Harbor Proper Trends Appendix - Display 17

Seasonal Kendall Tau Trend Test Statistics
for Surface Total Phosphorous

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.25357 | .00476227 | 0.21113 | -.00670833 |

Charlotte Harbor Proper Trends Appendix - Display 18
Time Series Plot of Surface Total Phosphorous Data Adjusted for Season and Detrended




Zero Reference Line Shown

Charlotte Harbor Proper Trends Appendix - Display 19

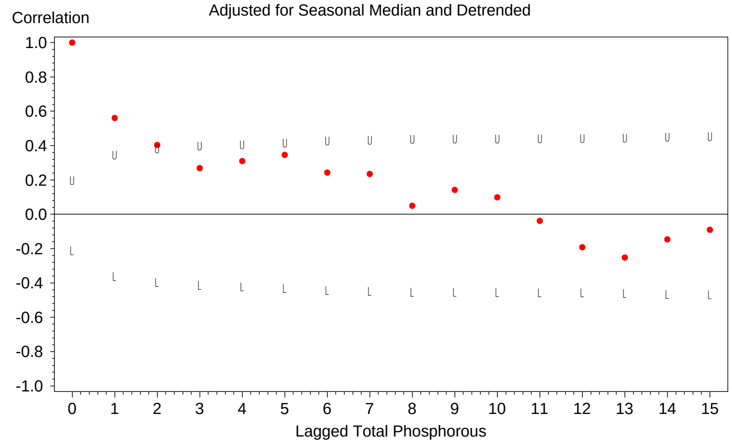
Autocorrelation Statistics for Surface Total Phosphorous

Adjusted for Seasonal Median and Detrended

| Lagged Total Phosphorous | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.102 | 0.204 | -0.204 |
| 1 | 0.561 | 0.177 | 0.354 | -0.354 |
| 2 | 0.404 | 0.194 | 0.389 | -0.389 |
| 3 | 0.269 | 0.203 | 0.406 | -0.406 |
| 4 | 0.310 | 0.207 | 0.413 | -0.413 |
| 5 | 0.346 | 0.211 | 0.423 | -0.423 |
| 6 | 0.243 | 0.217 | 0.435 | -0.435 |
| 7 | 0.235 | 0.220 | 0.440 | -0.440 |
| 8 | 0.050 | 0.223 | 0.445 | -0.445 |
| 9 | 0.142 | 0.223 | 0.446 | -0.446 |
| 10 | 0.099 | 0.224 | 0.447 | -0.447 |
| 11 | -0.038 | 0.224 | 0.448 | -0.448 |
| 12 | -0.192 | 0.224 | 0.449 | -0.449 |
| 13 | -0.252 | 0.226 | 0.452 | -0.452 |
| 14 | -0.146 | 0.229 | 0.458 | -0.458 |
| 15 | -0.090 | 0.230 | 0.460 | -0.460 |

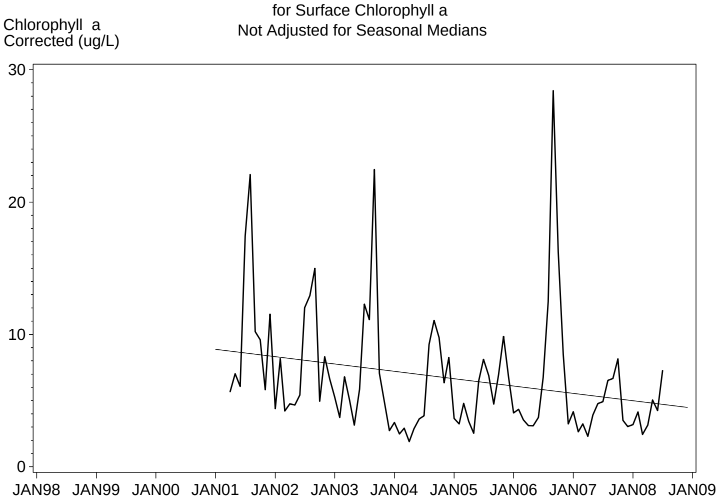
Charlotte Harbor Proper Trends Appendix - Display 20
Correlogram for Surface Total Phosphorous

Adjusted for Seasonal Median and Detrended

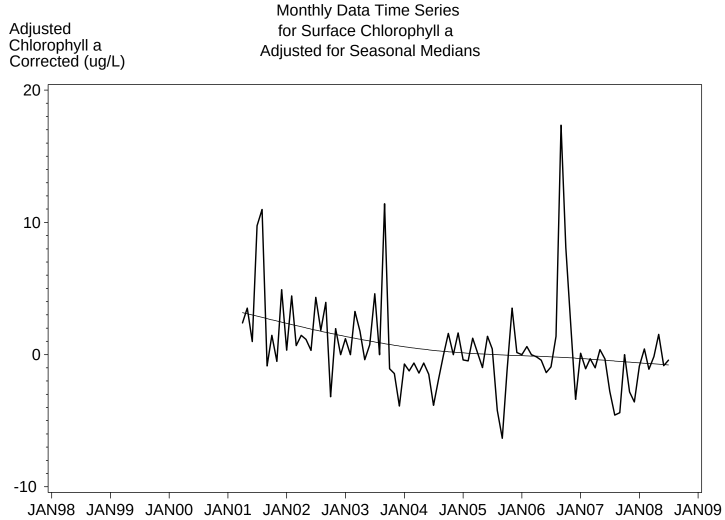



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

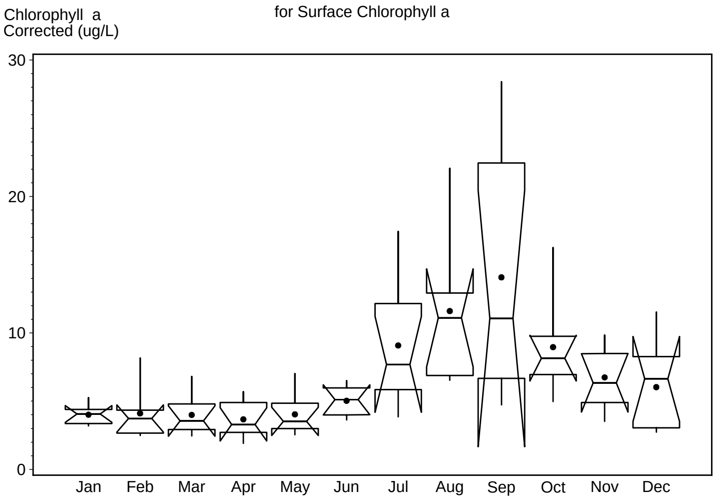
Charlotte Harbor Proper Trends Appendix - Display 21
Monthly Data Time Series
for Surface Chlorophyll a
Not Adjusted for Seasonal Medians




Charlotte Harbor Proper Trends Appendix - Display 22
Monthly Data Time Series
for Surface Chlorophyll a
Adjusted for Seasonal Medians




Charlotte Harbor Proper Trends Appendix - Display 23
Seasonal Univariate Statistics
for Surface Chlorophyll a



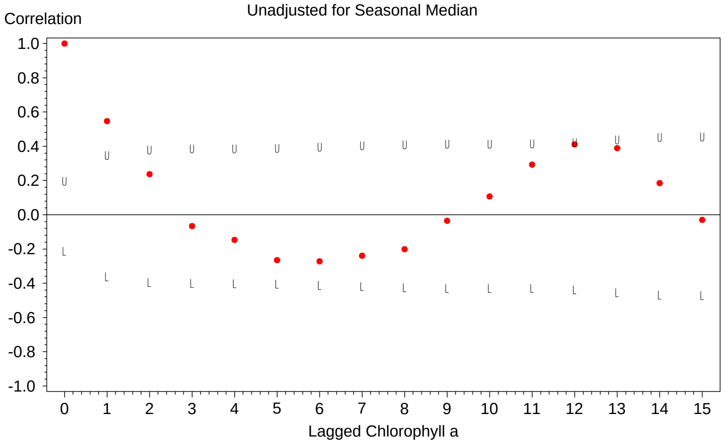

Charlotte Harbor Proper Trends Appendix - Display 24
Autocorrelation Statistics for Surface Chlorophyll a

Unadjusted for Seasonal Medians

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.102 | 0.204 | -0.204 |
| 1 | 0.547 | 0.177 | 0.354 | -0.354 |
| 2 | 0.237 | 0.194 | 0.387 | -0.387 |
| 3 | -0.066 | 0.197 | 0.393 | -0.393 |
| 4 | -0.147 | 0.197 | 0.394 | -0.394 |
| 5 | -0.265 | 0.198 | 0.396 | -0.396 |
| 6 | -0.272 | 0.202 | 0.403 | -0.403 |
| 7 | -0.239 | 0.205 | 0.411 | -0.411 |
| 8 | -0.201 | 0.208 | 0.417 | -0.417 |
| 9 | -0.035 | 0.210 | 0.421 | -0.421 |
| 10 | 0.107 | 0.210 | 0.421 | -0.421 |
| 11 | 0.293 | 0.211 | 0.422 | -0.422 |
| 12 | 0.411 | 0.215 | 0.430 | -0.430 |
| 13 | 0.389 | 0.223 | 0.446 | -0.446 |
| 14 | 0.185 | 0.230 | 0.460 | -0.460 |
| 15 | -0.030 | 0.232 | 0.463 | -0.463 |

Charlotte Harbor Proper Trends Appendix - Display 25
Correlogram for Surface Chlorophyll a

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Charlotte Harbor Proper Trends Appendix - Display 26

Seasonal Kendall Tau Trend Test Statistics
for Surface Chlorophyll a

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.286 | .001 | 0.061 | -0.356 |

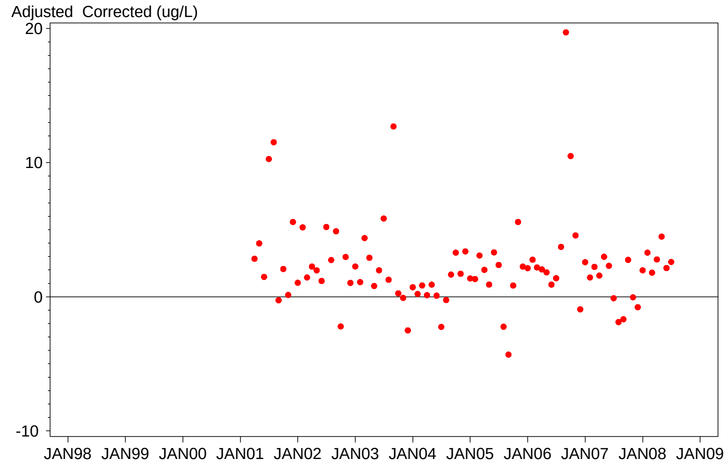
Charlotte Harbor Proper Trends Appendix - Display 27

Seasonal Kendall Tau Trend Test Statistics
for Surface Chlorophyll a

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.28571 | .00145754 | 0.061044 | -0.35536 |

Charlotte Harbor Proper Trends Appendix - Display 28
Time Series Plot of Surface Chlorophyll a Data Adjusted for Season and Detrended




Zero Reference Line Shown

Charlotte Harbor Proper Trends Appendix - Display 29
Autocorrelation Statistics for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.102 | 0.204 | -0.204 |
| 1 | 0.283 | 0.177 | 0.354 | -0.354 |
| 2 | 0.073 | 0.181 | 0.363 | -0.363 |
| 3 | -0.136 | 0.182 | 0.363 | -0.363 |
| 4 | 0.036 | 0.183 | 0.366 | -0.366 |
| 5 | -0.029 | 0.183 | 0.366 | -0.366 |
| 6 | 0.036 | 0.183 | 0.366 | -0.366 |
| 7 | 0.066 | 0.183 | 0.366 | -0.366 |
| 8 | 0.008 | 0.183 | 0.366 | -0.366 |
| 9 | -0.038 | 0.183 | 0.366 | -0.366 |
| 10 | -0.111 | 0.183 | 0.367 | -0.367 |
| 11 | -0.170 | 0.184 | 0.368 | -0.368 |
| 12 | -0.163 | 0.186 | 0.371 | -0.371 |
| 13 | -0.076 | 0.187 | 0.374 | -0.374 |

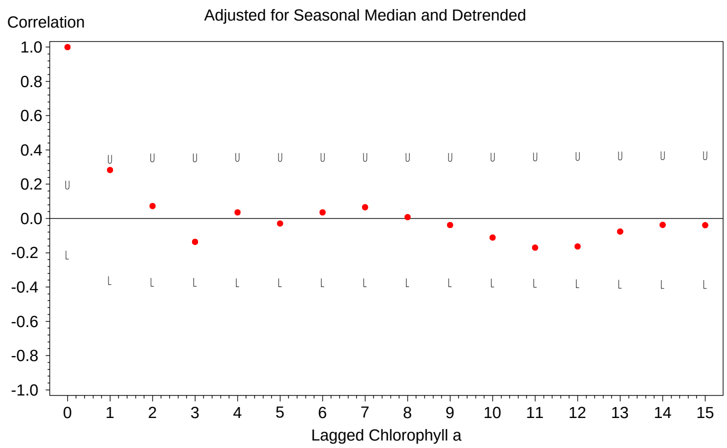
Charlotte Harbor Proper Trends Appendix - Display 29
Autocorrelation Statistics for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | -0.037 | 0.187 | 0.375 | -0.375 |
| 15 | -0.039 | 0.188 | 0.375 | -0.375 |

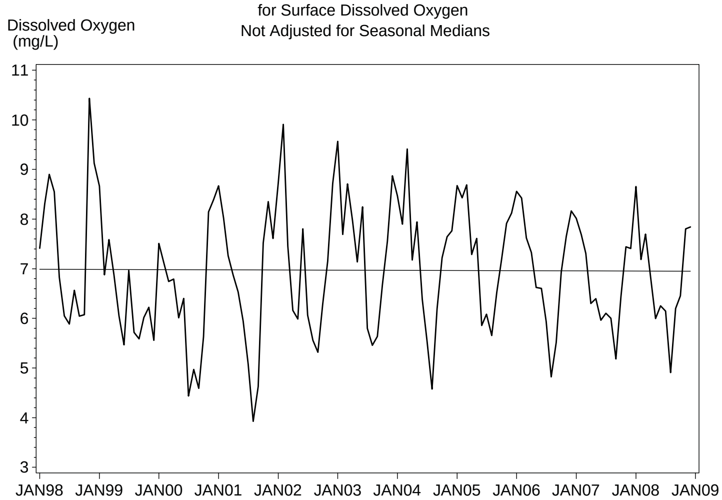
Charlotte Harbor Proper Trends Appendix - Display 30
Correlogram for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended

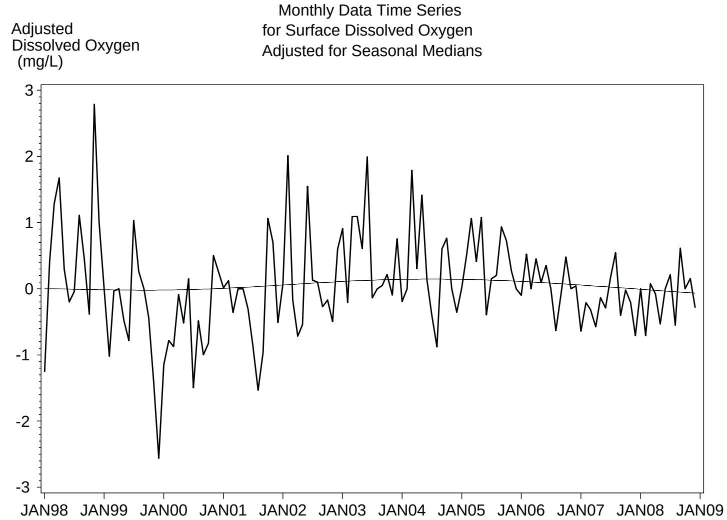



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

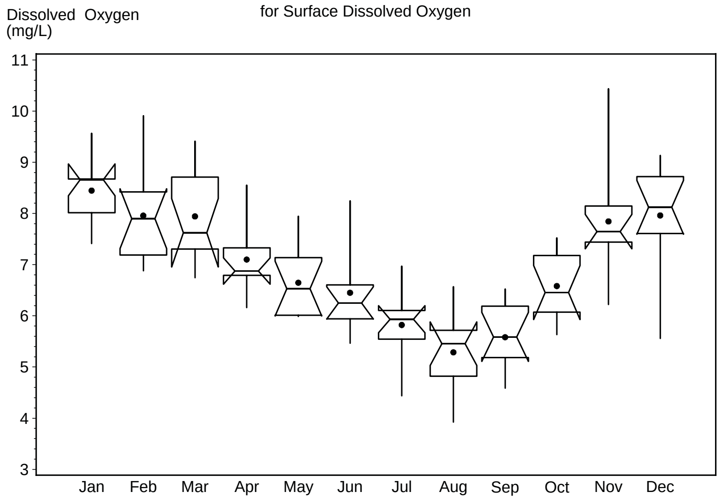
Tidal Myakka Trends Appendix - Display 1
Monthly Data Time Series
for Surface Dissolved Oxygen
Not Adjusted for Seasonal Medians




Tidal Myakka Trends Appendix - Display 2
Monthly Data Time Series
for Surface Dissolved Oxygen
Adjusted for Seasonal Medians




Tidal Myakka Trends Appendix - Display 3
Seasonal Univariate Statistics
for Surface Dissolved Oxygen



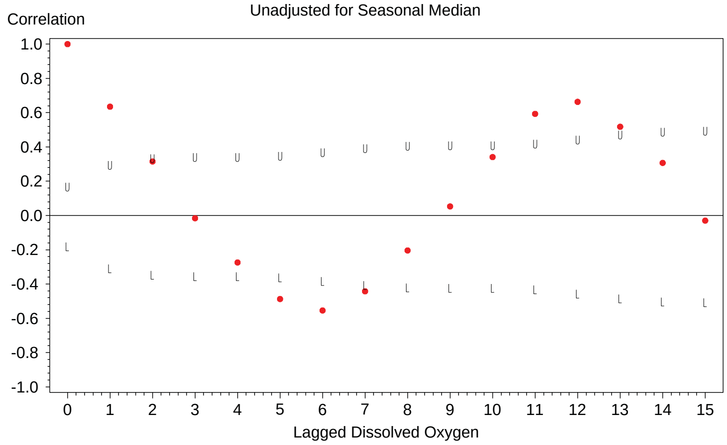

Tidal Myakka Trends Appendix - Display 4
Autocorrelation Statistics for Surface Dissolved Oxygen

Unadjusted for Seasonal Medians

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.635 | 0.151 | 0.302 | -0.302 |
| 2 | 0.315 | 0.170 | 0.340 | -0.340 |
| 3 | -0.016 | 0.174 | 0.348 | -0.348 |
| 4 | -0.274 | 0.174 | 0.348 | -0.348 |
| 5 | -0.487 | 0.177 | 0.355 | -0.355 |
| 6 | -0.554 | 0.187 | 0.375 | -0.375 |
| 7 | -0.442 | 0.199 | 0.399 | -0.399 |
| 8 | -0.204 | 0.207 | 0.413 | -0.413 |
| 9 | 0.053 | 0.208 | 0.416 | -0.416 |
| 10 | 0.341 | 0.208 | 0.416 | -0.416 |
| 11 | 0.593 | 0.212 | 0.425 | -0.425 |
| 12 | 0.663 | 0.225 | 0.449 | -0.449 |
| 13 | 0.518 | 0.239 | 0.478 | -0.478 |
| 14 | 0.307 | 0.247 | 0.495 | -0.495 |
| 15 | -0.030 | 0.250 | 0.500 | -0.500 |

Tidal Myakka Trends Appendix - Display 5
Correlogram for Surface Dissolved Oxygen

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Tidal Myakka Trends Appendix - Display 6

Seasonal Kendall Tau Trend Test Statistics
for Surface Dissolved Oxygen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.048 | 0.486 | 0.653 | 0.012 |

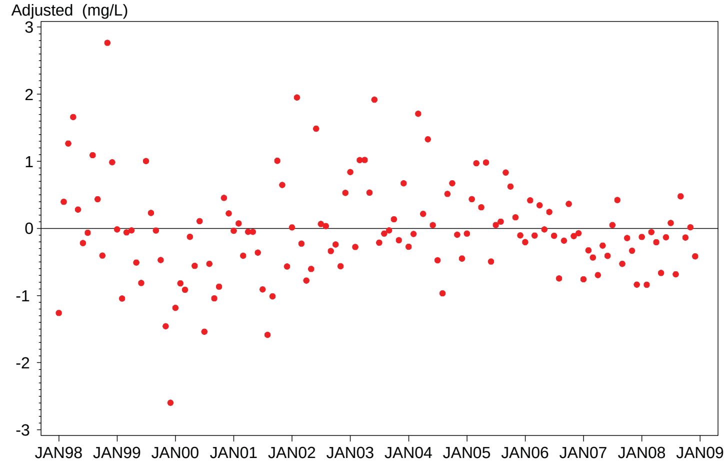
Tidal Myakka Trends  Appendix - Display 7

Seasonal Kendall Tau Trend Test Statistics
for Surface Dissolved Oxygen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.048485 | 0.48601 | 0.65302 | 0.011444 |

Tidal Myakka Trends Appendix - Display 8
Time Series Plot of Surface Dissolved Oxygen  Data Adjusted for Season and Detrended




Zero Reference Line Shown

Tidal Myakka Trends  Appendix - Display 9

Autocorrelation Statistics for Surface Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.304 | 0.151 | 0.302 | -0.302 |
| 2 | 0.088 | 0.155 | 0.311 | -0.311 |
| 3 | 0.071 | 0.156 | 0.311 | -0.311 |
| 4 | 0.151 | 0.156 | 0.312 | -0.312 |
| 5 | 0.080 | 0.157 | 0.314 | -0.314 |
| 6 | 0.073 | 0.157 | 0.315 | -0.315 |
| 7 | 0.137 | 0.158 | 0.315 | -0.315 |
| 8 | 0.225 | 0.159 | 0.317 | -0.317 |
| 9 | 0.173 | 0.161 | 0.322 | -0.322 |
| 10 | 0.083 | 0.162 | 0.325 | -0.325 |
| 11 | 0.140 | 0.163 | 0.325 | -0.325 |
| 12 | 0.027 | 0.164 | 0.327 | -0.327 |
| 13 | -0.054 | 0.164 | 0.327 | -0.327 |

Tidal Myakka Trends  Appendix - Display 9

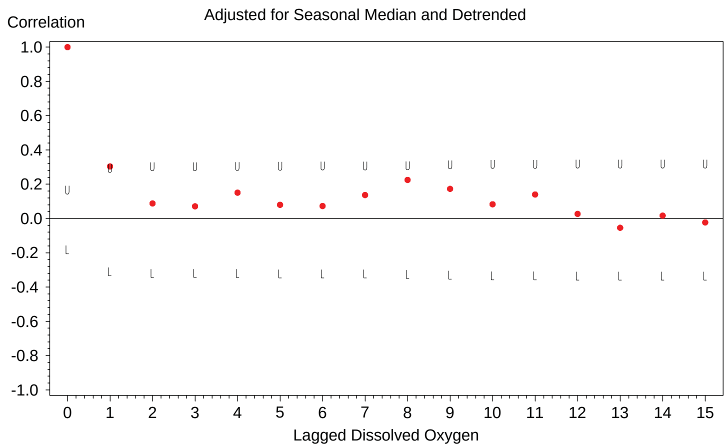
Autocorrelation Statistics for Surface Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | 0.017 | 0.164 | 0.327 | -0.327 |
| 15 | -0.023 | 0.164 | 0.327 | -0.327 |

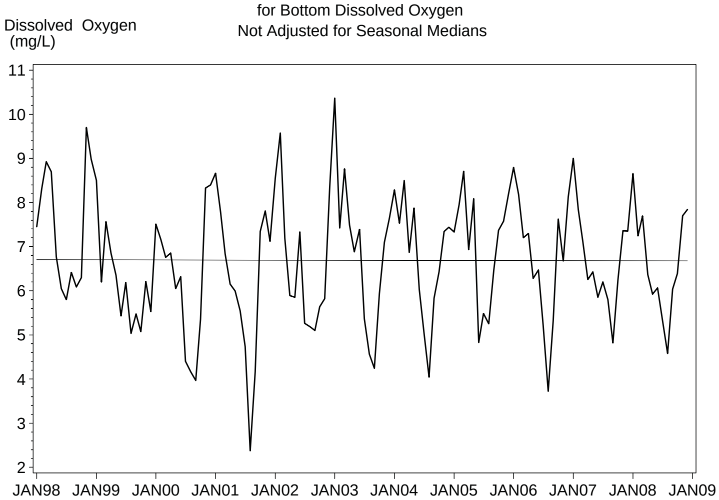
Tidal Myakka Trends Appendix - Display 10
Correlogram for Surface Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

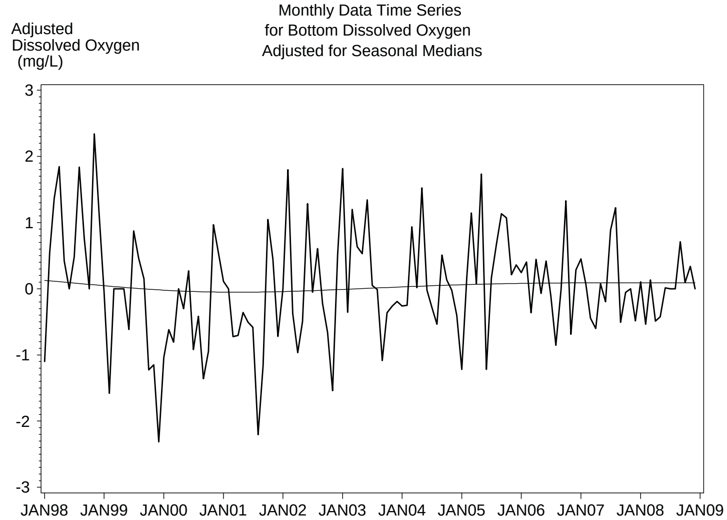



U=Upper 95% Confidence Limit   L=Lower 95% Confidence Limit
Zero Reference Line Shown

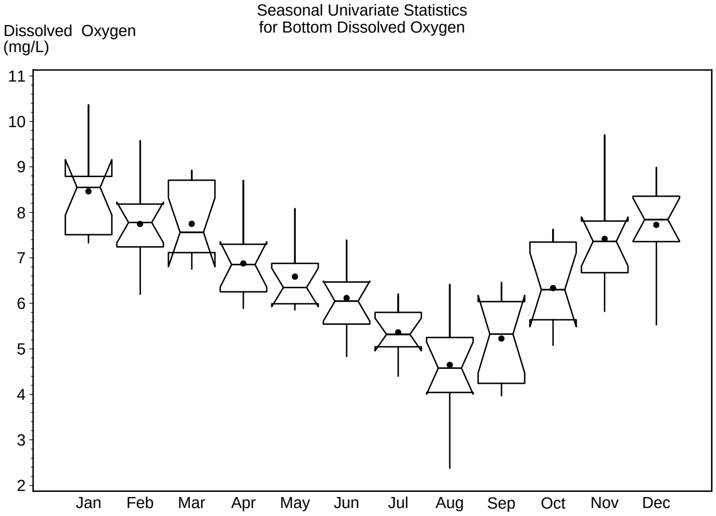
Tidal Myakka Trends Appendix - Display 11
Monthly Data Time Series
for Bottom Dissolved Oxygen
Not Adjusted for Seasonal Medians




Tidal Myakka Trends Appendix - Display 12
Monthly Data Time Series
for Bottom Dissolved Oxygen
Adjusted for Seasonal Medians




Tidal Myakka Trends Appendix - Display 13
Seasonal Univariate Statistics
for Bottom Dissolved Oxygen



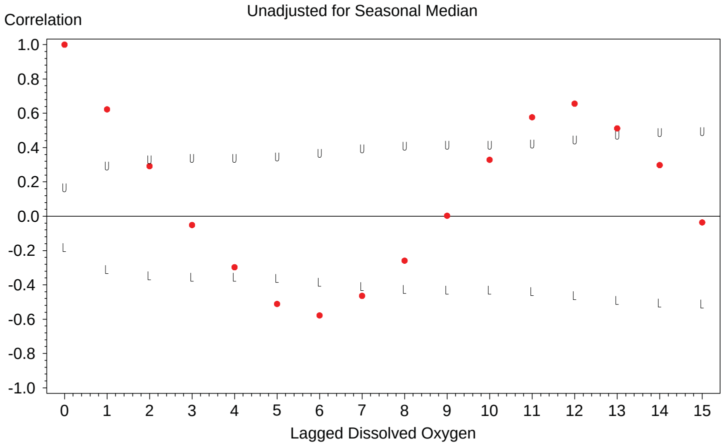

Tidal Myakka Trends Appendix - Display 14
Autocorrelation Statistics for Bottom Dissolved Oxygen

Unadjusted for Seasonal Medians

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.623 | 0.151 | 0.302 | -0.302 |
| 2 | 0.292 | 0.169 | 0.338 | -0.338 |
| 3 | -0.051 | 0.173 | 0.346 | -0.346 |
| 4 | -0.297 | 0.173 | 0.346 | -0.346 |
| 5 | -0.511 | 0.177 | 0.354 | -0.354 |
| 6 | -0.578 | 0.188 | 0.375 | -0.375 |
| 7 | -0.464 | 0.201 | 0.401 | -0.401 |
| 8 | -0.259 | 0.209 | 0.417 | -0.417 |
| 9 | 0.003 | 0.211 | 0.422 | -0.422 |
| 10 | 0.329 | 0.211 | 0.422 | -0.422 |
| 11 | 0.577 | 0.215 | 0.430 | -0.430 |
| 12 | 0.656 | 0.226 | 0.453 | -0.453 |
| 13 | 0.512 | 0.240 | 0.481 | -0.481 |
| 14 | 0.298 | 0.248 | 0.497 | -0.497 |
| 15 | -0.036 | 0.251 | 0.502 | -0.502 |

Tidal Myakka Trends Appendix - Display 15
Correlogram for Bottom Dissolved Oxygen

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Tidal Myakka Trends Appendix - Display 16

Seasonal Kendall Tau Trend Test Statistics
for Bottom Dissolved Oxygen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.061 | 0.381 | 0.561 | 0.017 |

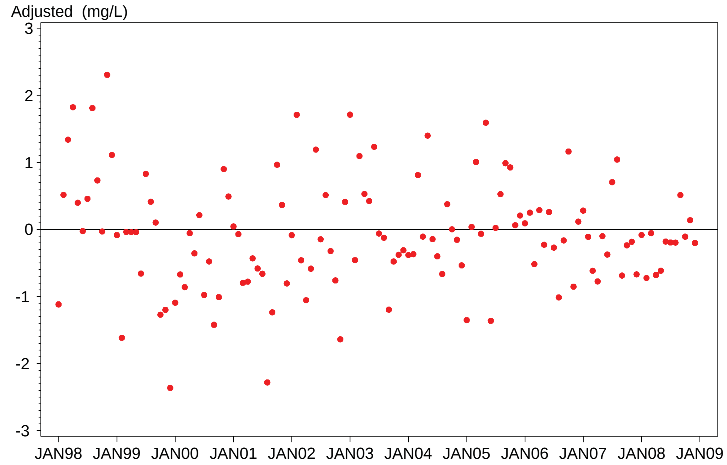
Tidal Myakka Trends Appendix - Display 17

Seasonal Kendall Tau Trend Test Statistics
for Bottom Dissolved Oxygen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.060606 | 0.38078 | 0.56081 | 0.016833 |

Tidal Myakka Trends Appendix - Display 18
Time Series Plot of Bottom Dissolved Oxygen Data Adjusted for Season and Detrended




Zero Reference Line Shown

Tidal Myakka Trends Appendix - Display 19
Autocorrelation Statistics for Bottom Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.265 | 0.151 | 0.302 | -0.302 |
| 2 | 0.037 | 0.154 | 0.308 | -0.308 |
| 3 | 0.008 | 0.154 | 0.309 | -0.309 |
| 4 | 0.112 | 0.154 | 0.309 | -0.309 |
| 5 | 0.044 | 0.155 | 0.310 | -0.310 |
| 6 | -0.032 | 0.155 | 0.310 | -0.310 |
| 7 | 0.078 | 0.155 | 0.310 | -0.310 |
| 8 | 0.059 | 0.155 | 0.311 | -0.311 |
| 9 | 0.034 | 0.156 | 0.311 | -0.311 |
| 10 | 0.051 | 0.156 | 0.311 | -0.311 |
| 11 | 0.073 | 0.156 | 0.311 | -0.311 |
| 12 | -0.042 | 0.156 | 0.312 | -0.312 |
| 13 | -0.074 | 0.156 | 0.312 | -0.312 |

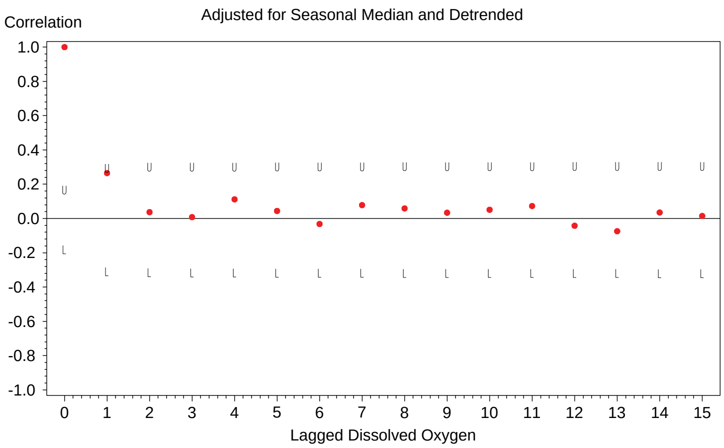
Tidal Myakka Trends Appendix - Display 19
Autocorrelation Statistics for Bottom Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | 0.035 | 0.156 | 0.313 | -0.313 |
| 15 | 0.015 | 0.156 | 0.313 | -0.313 |

Tidal Myakka Trends Appendix - Display 20
Correlogram for Bottom Dissolved Oxygen

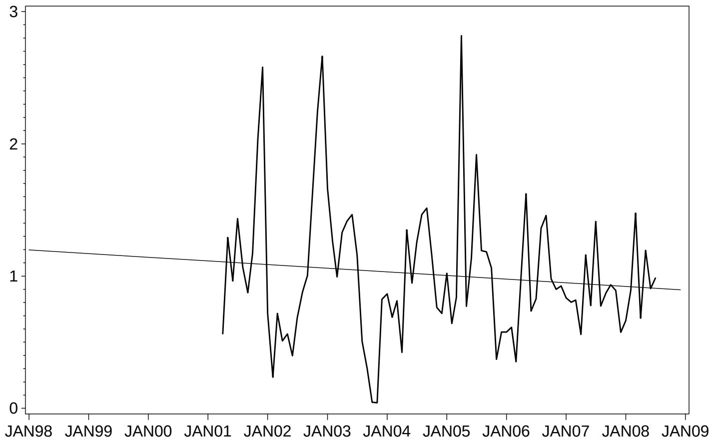
Adjusted for Seasonal Median and Detrended




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

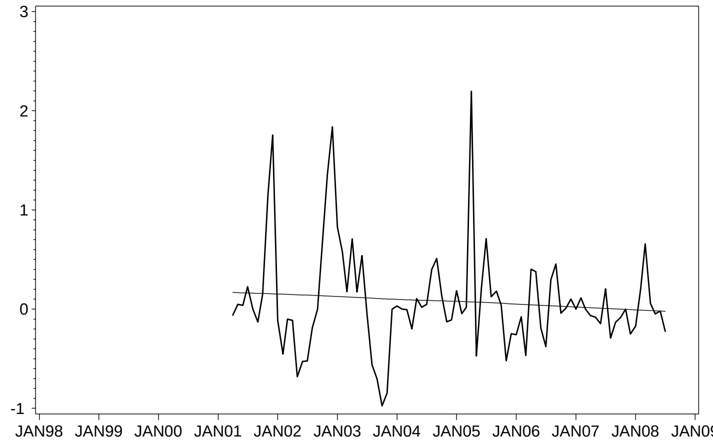
Tidal Myakka Trends Appendix - Display 21
Monthly Data Time Series
for Surface Total Nitrogen
Not Adjusted for Seasonal Medians

Total Nitrogen (mg/L)



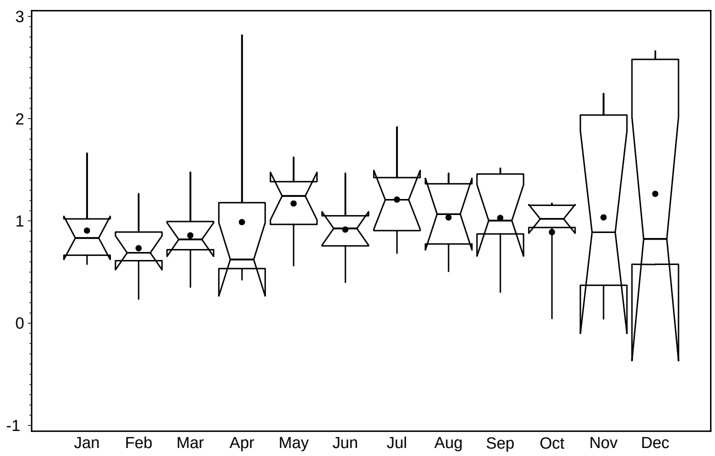

Tidal Myakka Trends Appendix - Display 22
Monthly Data Time Series
for Surface Total Nitrogen
Adjusted for Seasonal Medians

Adjusted Total Nitrogen (mg/L)




Tidal Myakka Trends Appendix - Display 23
Seasonal Univariate Statistics
for Surface Total Nitrogen

Total Nitrogen (mg/L)




Tidal Myakka Trends Appendix - Display 24
Autocorrelation Statistics for Surface Total Nitrogen

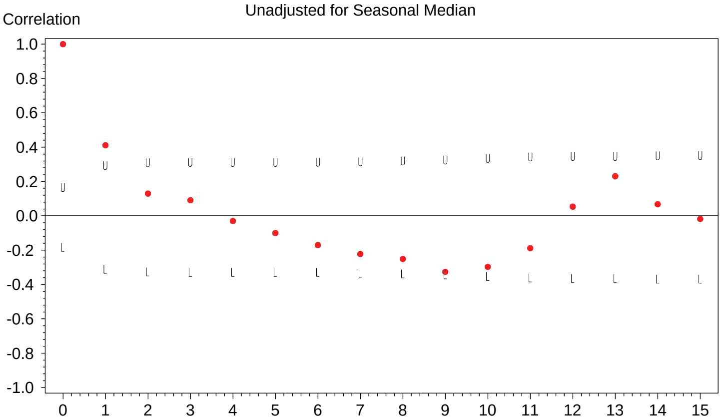
Unadjusted for Seasonal Medians

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.411 | 0.151 | 0.302 | -0.302 |
| 2 | 0.130 | 0.159 | 0.318 | -0.318 |
| 3 | 0.091 | 0.160 | 0.320 | -0.320 |
| 4 | -0.030 | 0.160 | 0.320 | -0.320 |
| 5 | -0.100 | 0.160 | 0.320 | -0.320 |
| 6 | -0.170 | 0.161 | 0.321 | -0.321 |
| 7 | -0.222 | 0.162 | 0.324 | -0.324 |
| 8 | -0.251 | 0.164 | 0.329 | -0.329 |
| 9 | -0.326 | 0.167 | 0.334 | -0.334 |
| 10 | -0.297 | 0.172 | 0.344 | -0.344 |
| 11 | -0.188 | 0.176 | 0.352 | -0.352 |
| 12 | 0.054 | 0.177 | 0.355 | -0.355 |
| 13 | 0.231 | 0.177 | 0.355 | -0.355 |
| 14 | 0.068 | 0.180 | 0.359 | -0.359 |
| 15 | -0.018 | 0.180 | 0.360 | -0.360 |

Tidal Myakka Trends Appendix - Display 25
Correlogram for Surface Total Nitrogen

Unadjusted for Seasonal Median

Correlation




Lagged Total Nitrogen

U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Tidal Myakka Trends Appendix - Display 26

Seasonal Kendall Tau Trend Test Statistics
for Surface Total Nitrogen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.058 | 0.54 | 0.593 | -0.01 |

Tidal Myakka Trends  Appendix - Display 27

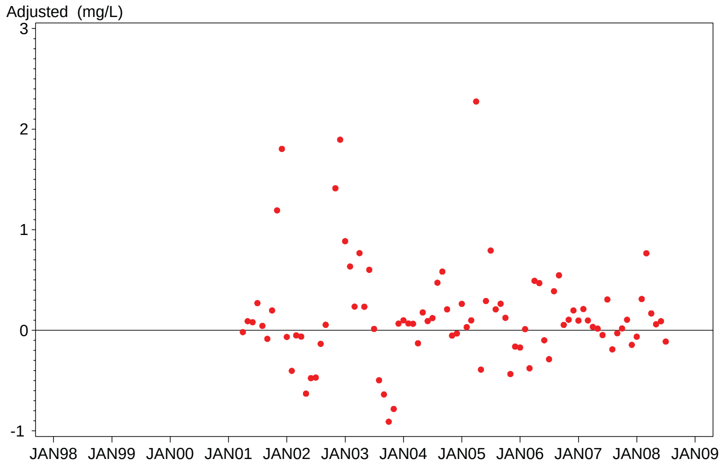
Seasonal Kendall Tau Trend Test Statistics for Surface Total Nitrogen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.058394 | 0.54029 | 0.59263 | -.00966667 |

Tidal Myakka Trends Appendix - Display 28

Time Series Plot of Surface Total Nitrogen  Data Adjusted for Season and Detrended




Zero Reference Line Shown

Tidal Myakka Trends  Appendix - Display 29

Autocorrelation Statistics for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.402 | 0.151 | 0.302 | -0.302 |
| 2 | 0.132 | 0.159 | 0.317 | -0.317 |
| 3 | 0.102 | 0.159 | 0.319 | -0.319 |
| 4 | -0.024 | 0.160 | 0.320 | -0.320 |
| 5 | -0.131 | 0.160 | 0.320 | -0.320 |
| 6 | -0.200 | 0.161 | 0.322 | -0.322 |
| 7 | -0.245 | 0.163 | 0.325 | -0.325 |
| 8 | -0.247 | 0.165 | 0.331 | -0.331 |
| 9 | -0.333 | 0.168 | 0.336 | -0.336 |
| 10 | -0.319 | 0.173 | 0.346 | -0.346 |
| 11 | -0.210 | 0.178 | 0.355 | -0.355 |
| 12 | 0.071 | 0.179 | 0.359 | -0.359 |
| 13 | 0.210 | 0.180 | 0.359 | -0.359 |


Tidal Myakka Trends  Appendix - Display 29

Autocorrelation Statistics for Surface Total Nitrogen

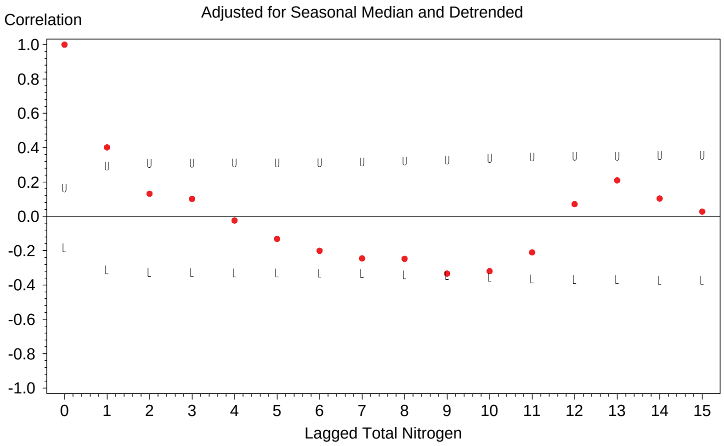
Adjusted for Seasonal Median and Detrended


| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | 0.104 | 0.181 | 0.363 | -0.363 |
| 15 | 0.028 | 0.182 | 0.364 | -0.364 |

Tidal Myakka Trends Appendix - Display 30

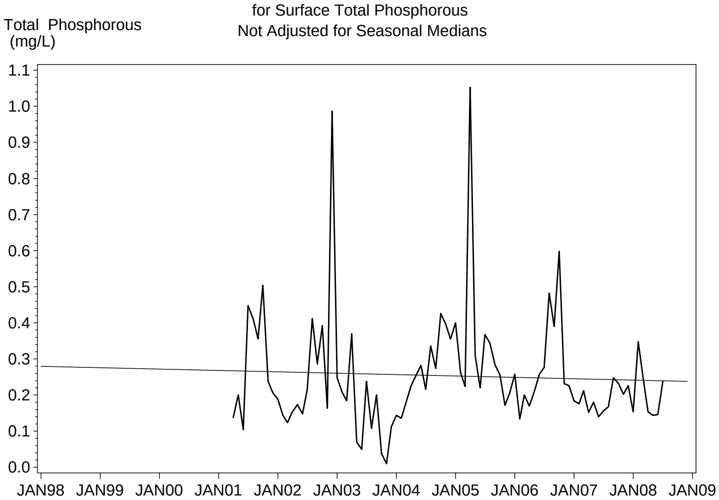
Correlogram for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

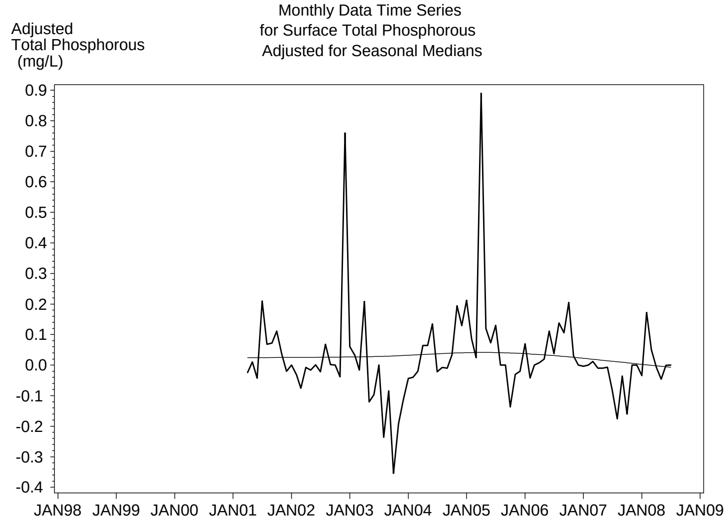



U=Upper  95% Confidence Limit   L=Lower 95% Confidence Limit
Zero Reference Line Shown

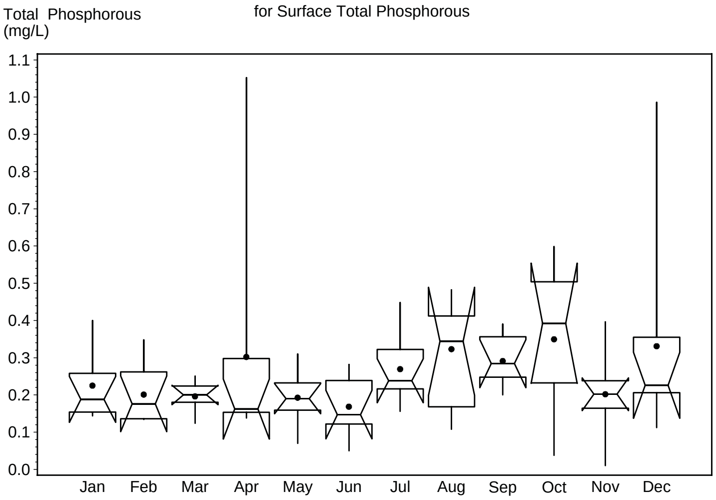
Tidal Myakka Trends Appendix - Display 31
Monthly Data Time Series
for Surface Total Phosphorous
Not Adjusted for Seasonal Medians




Tidal Myakka Trends Appendix - Display 32
Monthly Data Time Series
for Surface Total Phosphorous
Adjusted for Seasonal Medians




Tidal Myakka Trends Appendix - Display 33
Seasonal Univariate Statistics
for Surface Total Phosphorous



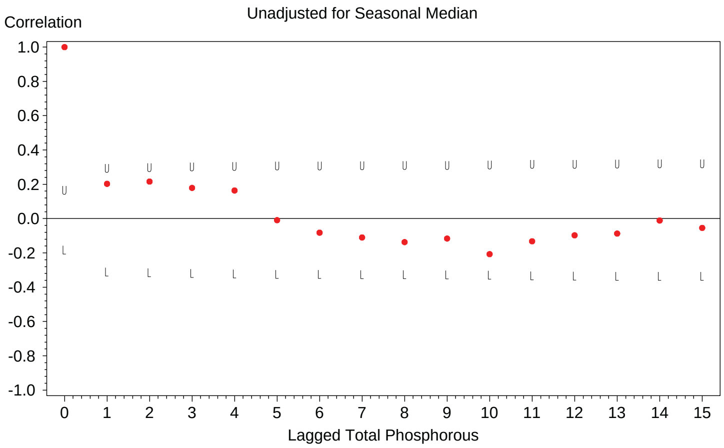

Tidal Myakka Trends Appendix - Display 34
Autocorrelation Statistics for Surface Total Phosphorous

Unadjusted for Seasonal Medians

| Lagged Total Phosphorous | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.203 | 0.151 | 0.302 | -0.302 |
| 2 | 0.216 | 0.153 | 0.306 | -0.306 |
| 3 | 0.179 | 0.155 | 0.310 | -0.310 |
| 4 | 0.164 | 0.157 | 0.313 | -0.313 |
| 5 | -0.009 | 0.158 | 0.316 | -0.316 |
| 6 | -0.082 | 0.158 | 0.316 | -0.316 |
| 7 | -0.110 | 0.158 | 0.317 | -0.317 |
| 8 | -0.137 | 0.159 | 0.318 | -0.318 |
| 9 | -0.116 | 0.160 | 0.319 | -0.319 |
| 10 | -0.207 | 0.160 | 0.321 | -0.321 |
| 11 | -0.132 | 0.162 | 0.325 | -0.325 |
| 12 | -0.097 | 0.163 | 0.326 | -0.326 |
| 13 | -0.087 | 0.164 | 0.327 | -0.327 |
| 14 | -0.011 | 0.164 | 0.328 | -0.328 |
| 15 | -0.054 | 0.164 | 0.328 | -0.328 |

Tidal Myakka Trends Appendix - Display 35
Correlogram for Surface Total Phosphorous

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Tidal Myakka Trends Appendix - Display 36
Seasonal Kendall Tau Trend Test Statistics
for Surface Total Phosphorous

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.029 | 0.777 | 0.859 | .002 |

Tidal Myakka Trends  Appendix - Display 37

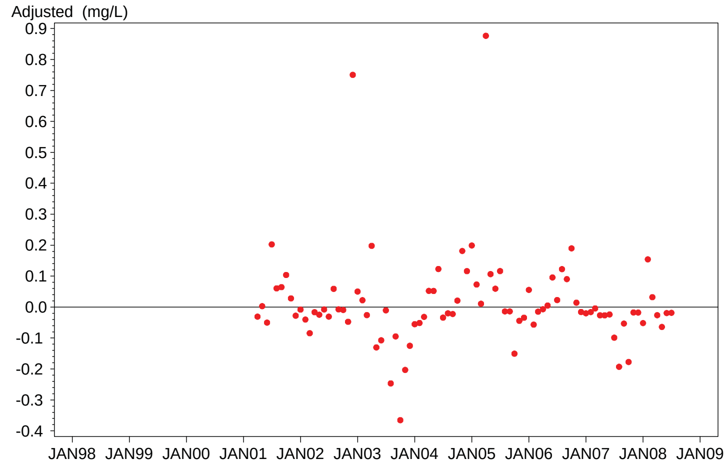
Seasonal Kendall Tau Trend Test Statistics
for Surface Total Phosphorous

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.028571 | 0.77685 | 0.85945 | .0016 |

Tidal Myakka Trends Appendix - Display 38

Time Series Plot of Surface Total  Phosphorous Data Adjusted for Season and Detrended




Zero Reference Line Shown

Tidal Myakka Trends  Appendix - Display 39

Autocorrelation Statistics for Surface Total Phosphorous

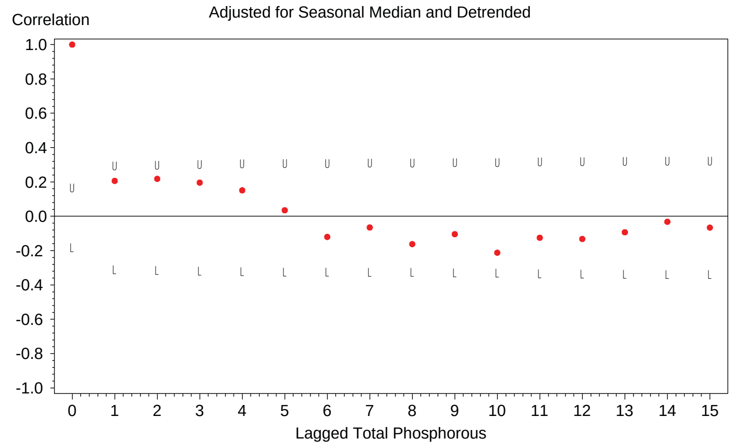
Adjusted for Seasonal Median and Detrended

| Lagged Total Phosphorous | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.206 | 0.151 | 0.302 | -0.302 |
| 2 | 0.218 | 0.153 | 0.306 | -0.306 |
| 3 | 0.196 | 0.155 | 0.310 | -0.310 |
| 4 | 0.151 | 0.157 | 0.314 | -0.314 |
| 5 | 0.035 | 0.158 | 0.316 | -0.316 |
| 6 | -0.120 | 0.158 | 0.316 | -0.316 |
| 7 | -0.065 | 0.159 | 0.318 | -0.318 |
| 8 | -0.162 | 0.159 | 0.318 | -0.318 |
| 9 | -0.104 | 0.160 | 0.321 | -0.321 |
| 10 | -0.212 | 0.161 | 0.322 | -0.322 |
| 11 | -0.125 | 0.163 | 0.326 | -0.326 |
| 12 | -0.132 | 0.164 | 0.327 | -0.327 |
| 13 | -0.093 | 0.165 | 0.329 | -0.329 |
| 14 | -0.032 | 0.165 | 0.330 | -0.330 |
| 15 | -0.066 | 0.165 | 0.330 | -0.330 |

Tidal Myakka Trends Appendix - Display 40

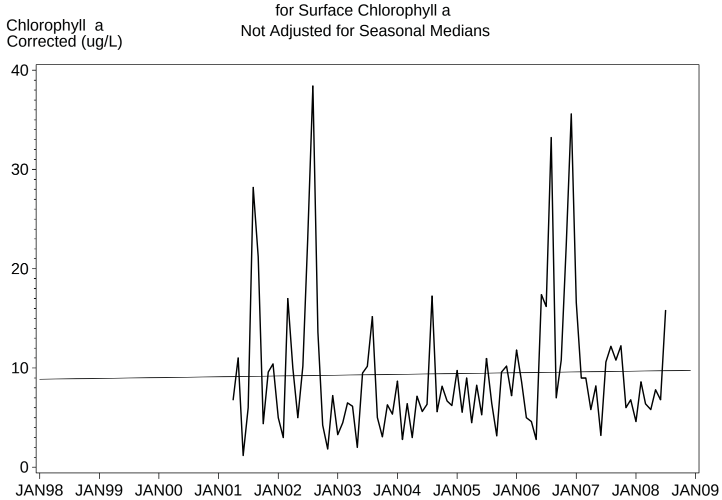
Correlogram for Surface Total Phosphorous

Adjusted for Seasonal Median and Detrended

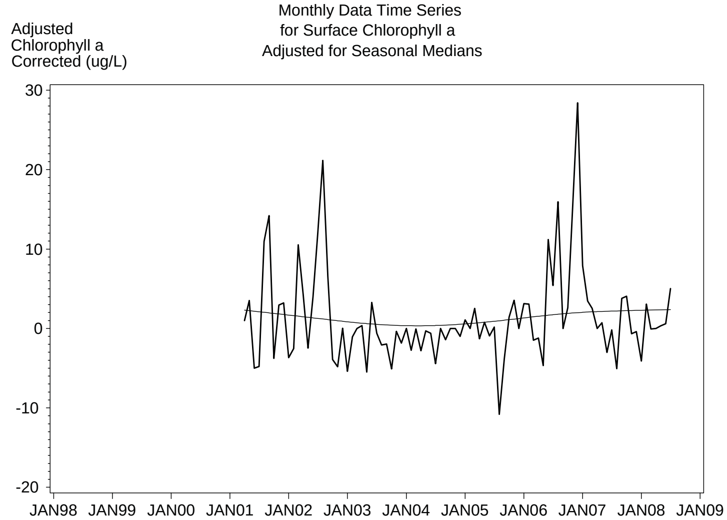



U=Upper  95% Confidence Limit   L=Lower 95% Confidence Limit
Zero Reference Line Shown

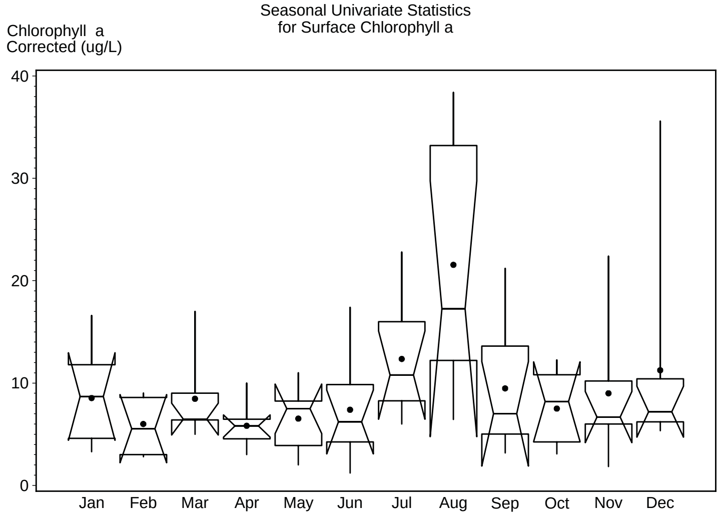
Tidal Myakka Trends Appendix - Display 41
Monthly Data Time Series
for Surface Chlorophyll a
Not Adjusted for Seasonal Medians




Tidal Myakka Trends Appendix - Display 42
Monthly Data Time Series
for Surface Chlorophyll a
Adjusted for Seasonal Medians




Tidal Myakka Trends Appendix - Display 43
Seasonal Univariate Statistics
for Surface Chlorophyll a



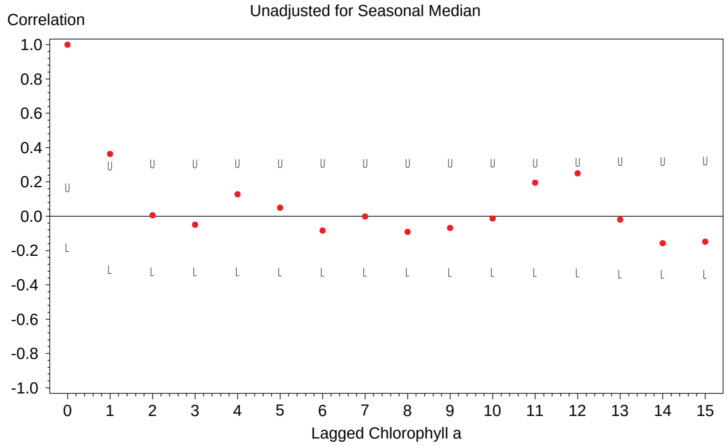

Tidal Myakka Trends Appendix - Display 44
Autocorrelation Statistics for Surface Chlorophyll a

Unadjusted for Seasonal Medians

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.363 | 0.151 | 0.302 | -0.302 |
| 2 | 0.006 | 0.157 | 0.314 | -0.314 |
| 3 | -0.049 | 0.157 | 0.314 | -0.314 |
| 4 | 0.128 | 0.157 | 0.315 | -0.315 |
| 5 | 0.050 | 0.158 | 0.316 | -0.316 |
| 6 | -0.083 | 0.158 | 0.317 | -0.317 |
| 7 | -0.001 | 0.159 | 0.317 | -0.317 |
| 8 | -0.091 | 0.159 | 0.317 | -0.317 |
| 9 | -0.068 | 0.159 | 0.318 | -0.318 |
| 10 | -0.013 | 0.159 | 0.318 | -0.318 |
| 11 | 0.196 | 0.159 | 0.318 | -0.318 |
| 12 | 0.250 | 0.161 | 0.322 | -0.322 |
| 13 | -0.019 | 0.164 | 0.328 | -0.328 |
| 14 | -0.157 | 0.164 | 0.328 | -0.328 |
| 15 | -0.148 | 0.165 | 0.330 | -0.330 |

Tidal Myakka Trends Appendix - Display 45
Correlogram for Surface Chlorophyll a

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Tidal Myakka Trends Appendix - Display 46

Seasonal Kendall Tau Trend Test Statistics
for Surface Chlorophyll a

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.086 | 0.353 | 0.499 | 0.339 |

Tidal Myakka Trends Appendix - Display 47

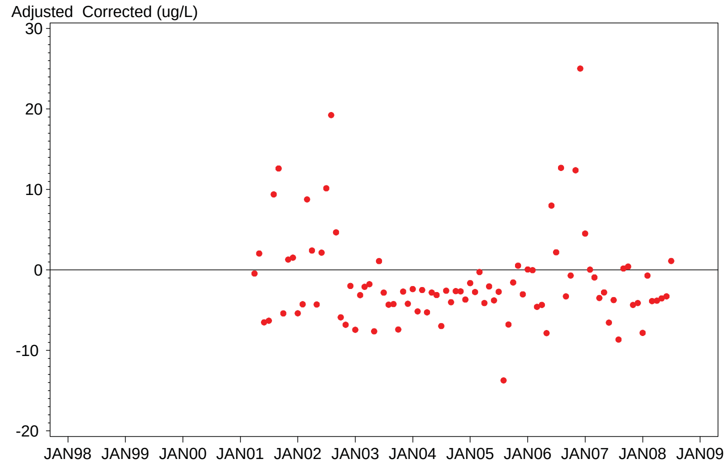
Seasonal Kendall Tau Trend Test Statistics for Surface Chlorophyll a

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.085714 | 0.35330 | 0.49874 | 0.33933 |

Tidal Myakka Trends Appendix - Display 48

Time Series Plot of Surface Chlorophyll a Data Adjusted for Season and Detrended




Zero Reference Line Shown

Tidal Myakka Trends Appendix - Display 49

Autocorrelation Statistics for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.393 | 0.151 | 0.302 | -0.302 |
| 2 | 0.065 | 0.158 | 0.317 | -0.317 |
| 3 | 0.048 | 0.159 | 0.317 | -0.317 |
| 4 | 0.222 | 0.159 | 0.317 | -0.317 |
| 5 | 0.084 | 0.161 | 0.322 | -0.322 |
| 6 | 0.044 | 0.161 | 0.323 | -0.323 |
| 7 | 0.004 | 0.161 | 0.323 | -0.323 |
| 8 | -0.094 | 0.161 | 0.323 | -0.323 |
| 9 | 0.003 | 0.162 | 0.324 | -0.324 |
| 10 | 0.035 | 0.162 | 0.324 | -0.324 |
| 11 | 0.117 | 0.162 | 0.324 | -0.324 |
| 12 | -0.051 | 0.162 | 0.325 | -0.325 |
| 13 | -0.109 | 0.163 | 0.325 | -0.325 |

Tidal Myakka Trends Appendix - Display 49

Autocorrelation Statistics for Surface Chlorophyll a

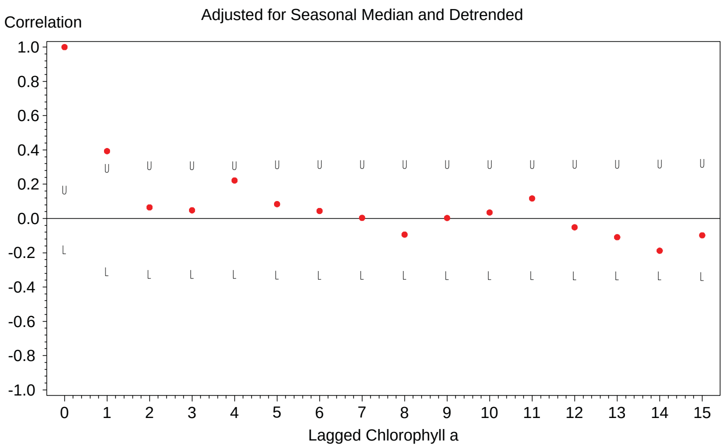
Adjusted for Seasonal Median and Detrended

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | -0.188 | 0.163 | 0.326 | -0.326 |
| 15 | -0.098 | 0.165 | 0.330 | -0.330 |

Tidal Myakka Trends Appendix - Display 50

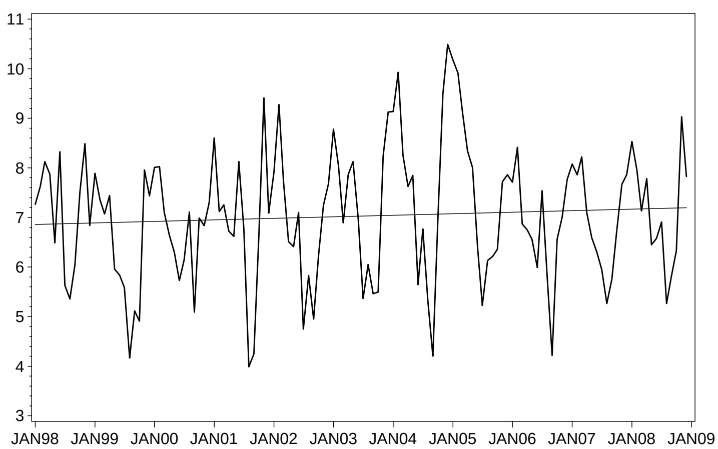
Correlogram for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended

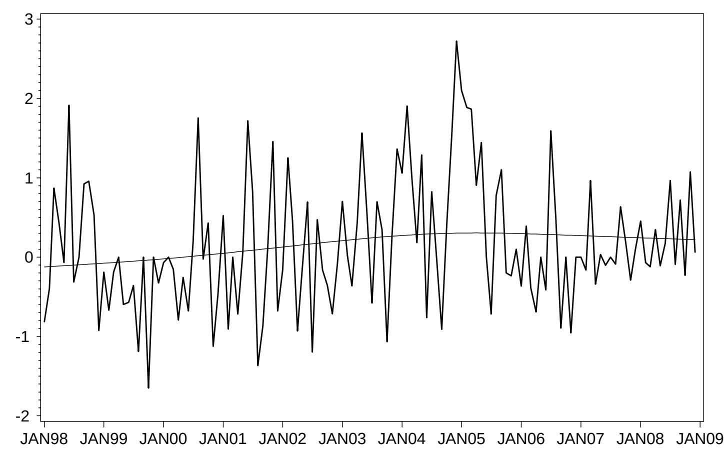



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

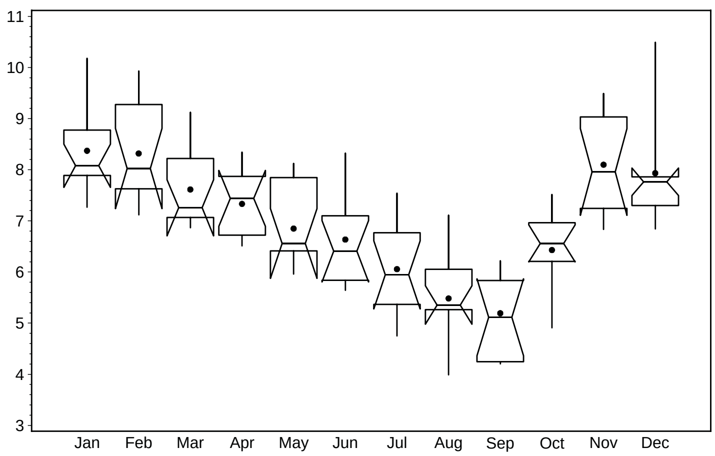
Tidal Peace Trends Appendix - Display 1
Monthly Data Time Series
for Surface Dissolved Oxygen
Not Adjusted for Seasonal Medians




Tidal Peace Trends Appendix - Display 2
Monthly Data Time Series
for Surface Dissolved Oxygen
Adjusted for Seasonal Medians




Tidal Peace Trends Appendix - Display 3
Seasonal Univariate Statistics
for Surface Dissolved Oxygen



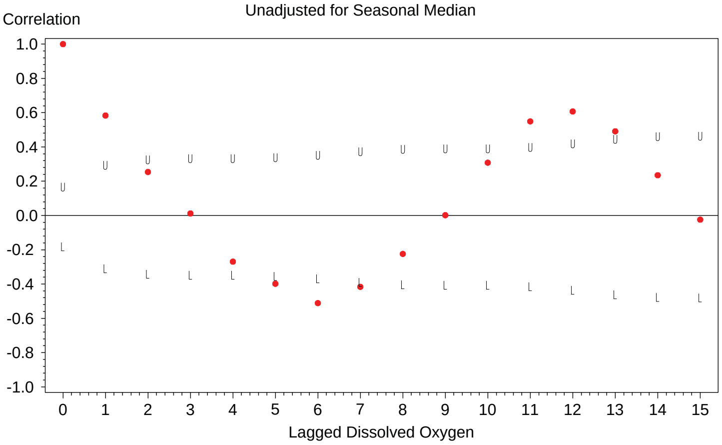

Tidal Peace Trends Appendix - Display 4
Autocorrelation Statistics for Surface Dissolved Oxygen

Unadjusted for Seasonal Medians

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.583 | 0.151 | 0.302 | -0.302 |
| 2 | 0.254 | 0.167 | 0.334 | -0.334 |
| 3 | 0.012 | 0.170 | 0.340 | -0.340 |
| 4 | -0.269 | 0.170 | 0.340 | -0.340 |
| 5 | -0.398 | 0.173 | 0.346 | -0.346 |
| 6 | -0.511 | 0.180 | 0.360 | -0.360 |
| 7 | -0.416 | 0.191 | 0.381 | -0.381 |
| 8 | -0.224 | 0.197 | 0.395 | -0.395 |
| 9 | 0.002 | 0.199 | 0.398 | -0.398 |
| 10 | 0.308 | 0.199 | 0.398 | -0.398 |
| 11 | 0.549 | 0.203 | 0.406 | -0.406 |
| 12 | 0.607 | 0.214 | 0.427 | -0.427 |
| 13 | 0.491 | 0.226 | 0.453 | -0.453 |
| 14 | 0.235 | 0.234 | 0.469 | -0.469 |
| 15 | -0.024 | 0.236 | 0.472 | -0.472 |

Tidal Peace Trends Appendix - Display 5
Correlogram for Surface Dissolved Oxygen

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Tidal Peace Trends Appendix - Display 6
Seasonal Kendall Tau Trend Test Statistics
for Surface Dissolved Oxygen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.115 | 0.092 | 0.271 | 0.038 |

Tidal Peace Trends Appendix - Display 7

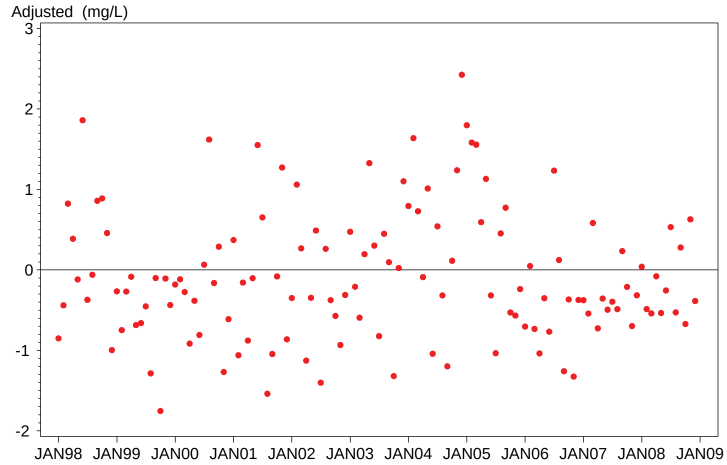
Seasonal Kendall Tau Trend Test Statistics for Surface Dissolved Oxygen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.11515 | 0.091892 | 0.27061 | 0.037567 |

Tidal Peace Trends Appendix - Display 8

Time Series Plot of Surface Dissolved Oxygen Data Adjusted for Season and Detrended




Zero Reference Line Shown

Tidal Peace Trends Appendix - Display 9

Autocorrelation Statistics for Surface Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.242 | 0.151 | 0.302 | -0.302 |
| 2 | 0.088 | 0.154 | 0.307 | -0.307 |
| 3 | 0.160 | 0.154 | 0.308 | -0.308 |
| 4 | 0.062 | 0.155 | 0.311 | -0.311 |
| 5 | 0.097 | 0.155 | 0.311 | -0.311 |
| 6 | -0.050 | 0.156 | 0.312 | -0.312 |
| 7 | 0.032 | 0.156 | 0.312 | -0.312 |
| 8 | 0.101 | 0.156 | 0.312 | -0.312 |
| 9 | 0.036 | 0.157 | 0.313 | -0.313 |
| 10 | 0.164 | 0.157 | 0.313 | -0.313 |
| 11 | 0.140 | 0.158 | 0.316 | -0.316 |
| 12 | -0.065 | 0.159 | 0.318 | -0.318 |
| 13 | -0.045 | 0.159 | 0.318 | -0.318 |

Tidal Peace Trends Appendix - Display 9

Autocorrelation Statistics for Surface Dissolved Oxygen

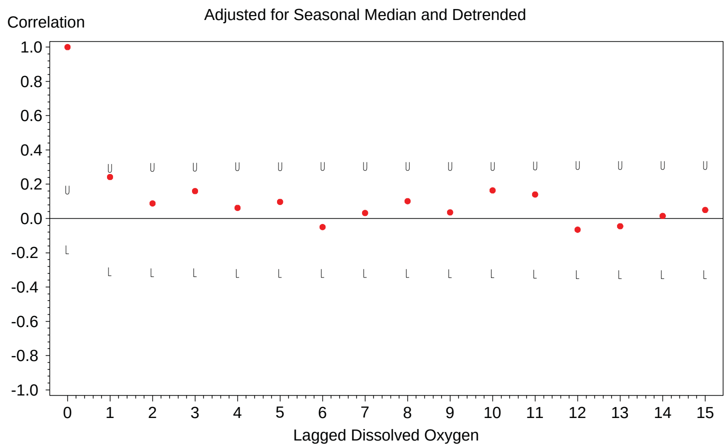
Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | 0.015 | 0.159 | 0.318 | -0.318 |
| 15 | 0.050 | 0.159 | 0.318 | -0.318 |

Tidal Peace Trends Appendix - Display 10

Correlogram for Surface Dissolved Oxygen

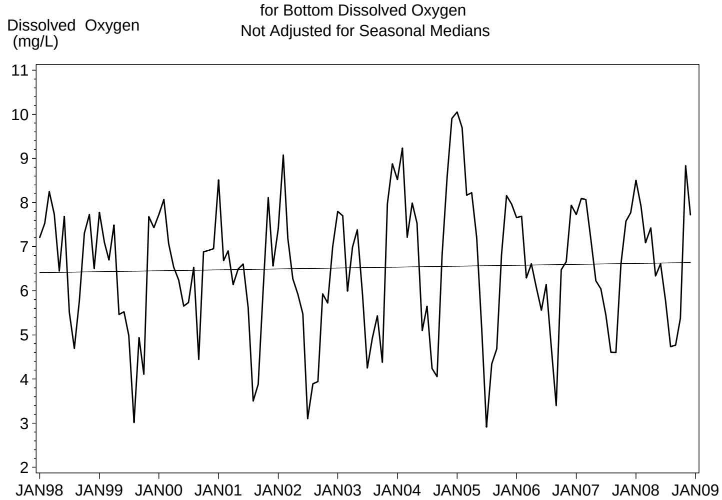
Adjusted for Seasonal Median and Detrended



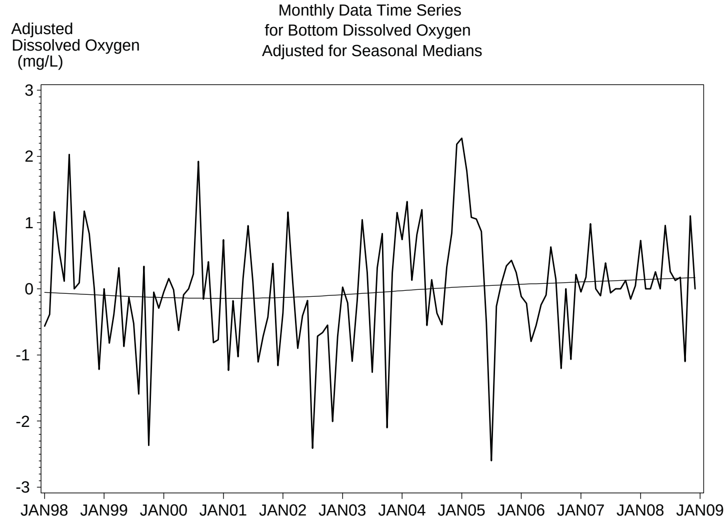

U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit

Zero Reference Line Shown

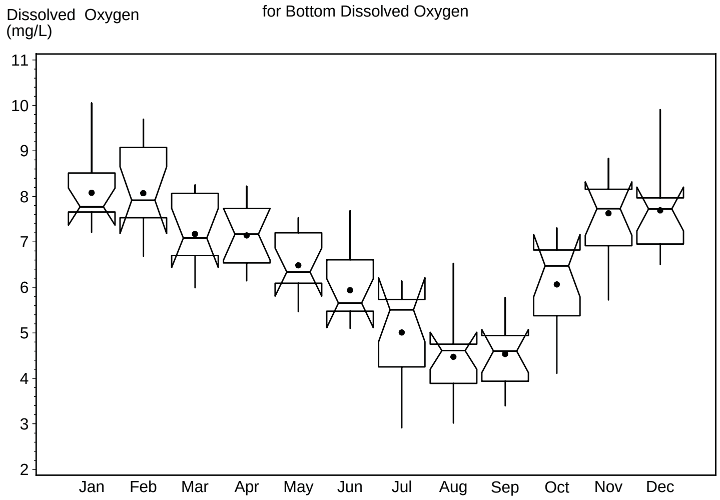
Tidal Peace Trends Appendix - Display 11
Monthly Data Time Series
for Bottom Dissolved Oxygen
Not Adjusted for Seasonal Medians




Tidal Peace Trends Appendix - Display 12
Monthly Data Time Series
for Bottom Dissolved Oxygen
Adjusted for Seasonal Medians




Tidal Peace Trends Appendix - Display 13
Seasonal Univariate Statistics
for Bottom Dissolved Oxygen



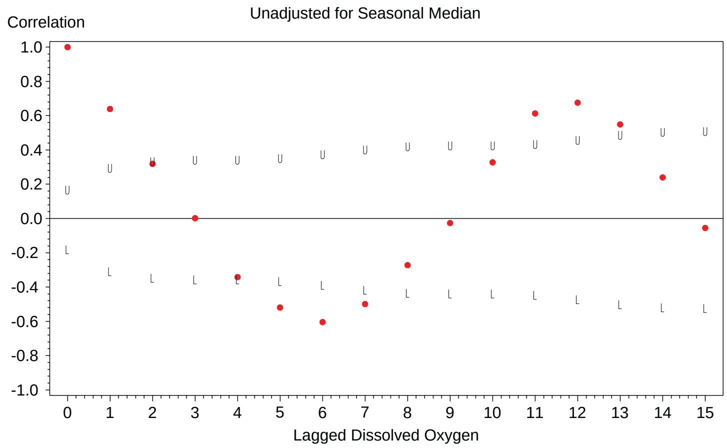

Tidal Peace Trends Appendix - Display 14
Autocorrelation Statistics for Bottom Dissolved Oxygen

Unadjusted for Seasonal Medians

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.639 | 0.151 | 0.302 | -0.302 |
| 2 | 0.319 | 0.170 | 0.340 | -0.340 |
| 3 | 0.002 | 0.175 | 0.349 | -0.349 |
| 4 | -0.342 | 0.175 | 0.349 | -0.349 |
| 5 | -0.519 | 0.180 | 0.359 | -0.359 |
| 6 | -0.604 | 0.191 | 0.381 | -0.381 |
| 7 | -0.499 | 0.205 | 0.409 | -0.409 |
| 8 | -0.272 | 0.214 | 0.427 | -0.427 |
| 9 | -0.026 | 0.216 | 0.432 | -0.432 |
| 10 | 0.328 | 0.216 | 0.432 | -0.432 |
| 11 | 0.613 | 0.220 | 0.440 | -0.440 |
| 12 | 0.676 | 0.233 | 0.465 | -0.465 |
| 13 | 0.549 | 0.247 | 0.494 | -0.494 |
| 14 | 0.240 | 0.256 | 0.512 | -0.512 |
| 15 | -0.055 | 0.258 | 0.516 | -0.516 |

Tidal Peace Trends Appendix - Display 15
Correlogram for Bottom Dissolved Oxygen

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Tidal Peace Trends Appendix - Display 16

Seasonal Kendall Tau Trend Test Statistics
for Bottom Dissolved Oxygen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.126 | 0.065 | 0.24 | 0.044 |

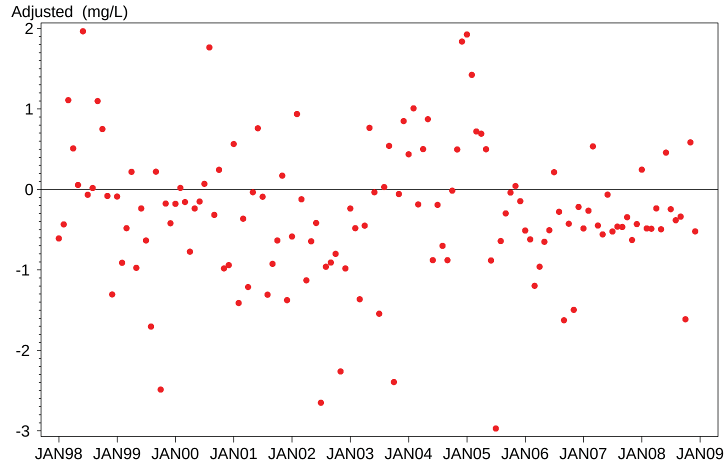
Tidal Peace Trends Appendix - Display 17

Seasonal Kendall Tau Trend Test Statistics
for Bottom Dissolved Oxygen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.12424 | 0.068708 | 0.24580 | 0.043625 |

Tidal Peace Trends Appendix - Display 18
Time Series Plot of Bottom Dissolved Oxygen Data Adjusted for Season and Detrended




Zero Reference Line Shown

Tidal Peace Trends Appendix - Display 19
Autocorrelation Statistics for Bottom Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.242 | 0.151 | 0.302 | -0.302 |
| 2 | 0.145 | 0.154 | 0.307 | -0.307 |
| 3 | 0.195 | 0.155 | 0.309 | -0.309 |
| 4 | 0.014 | 0.157 | 0.313 | -0.313 |
| 5 | 0.003 | 0.157 | 0.313 | -0.313 |
| 6 | -0.153 | 0.157 | 0.313 | -0.313 |
| 7 | 0.017 | 0.158 | 0.315 | -0.315 |
| 8 | 0.155 | 0.158 | 0.315 | -0.315 |
| 9 | -0.022 | 0.159 | 0.318 | -0.318 |
| 10 | 0.089 | 0.159 | 0.318 | -0.318 |
| 11 | 0.157 | 0.159 | 0.319 | -0.319 |
| 12 | -0.042 | 0.160 | 0.321 | -0.321 |
| 13 | -0.089 | 0.161 | 0.321 | -0.321 |

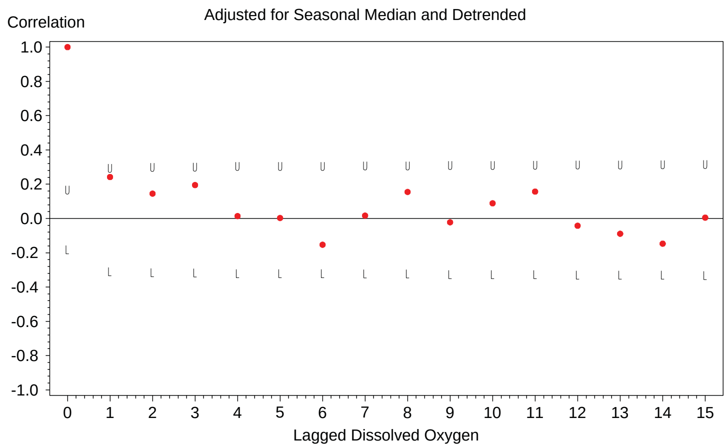
Tidal Peace Trends Appendix - Display 19
Autocorrelation Statistics for Bottom Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | -0.147 | 0.161 | 0.322 | -0.322 |
| 15 | 0.005 | 0.162 | 0.324 | -0.324 |

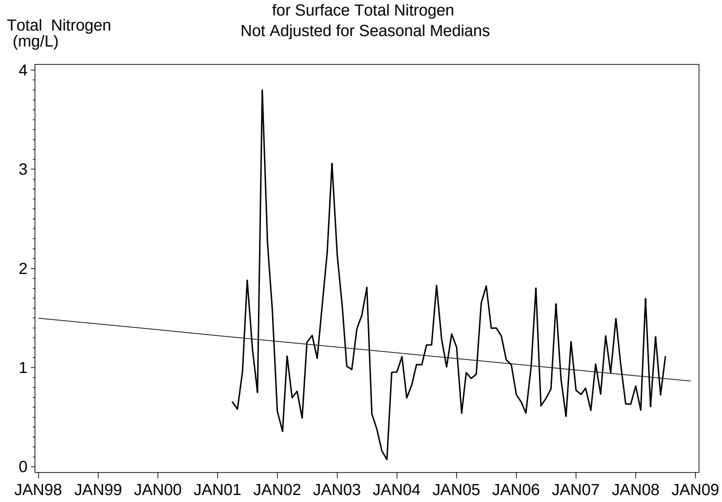
Tidal Peace Trends Appendix - Display 20
Correlogram for Bottom Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

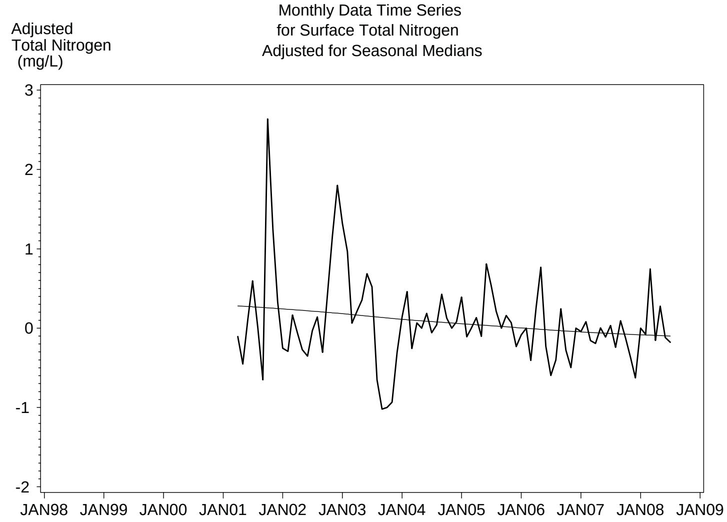



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

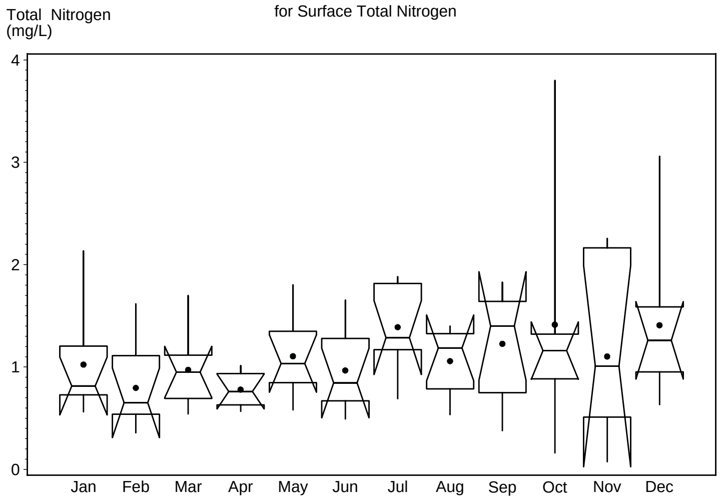
Tidal Peace Trends Appendix - Display 21
Monthly Data Time Series
for Surface Total Nitrogen
Not Adjusted for Seasonal Medians




Tidal Peace Trends Appendix - Display 22
Monthly Data Time Series
for Surface Total Nitrogen
Adjusted for Seasonal Medians




Tidal Peace Trends Appendix - Display 23
Seasonal Univariate Statistics
for Surface Total Nitrogen



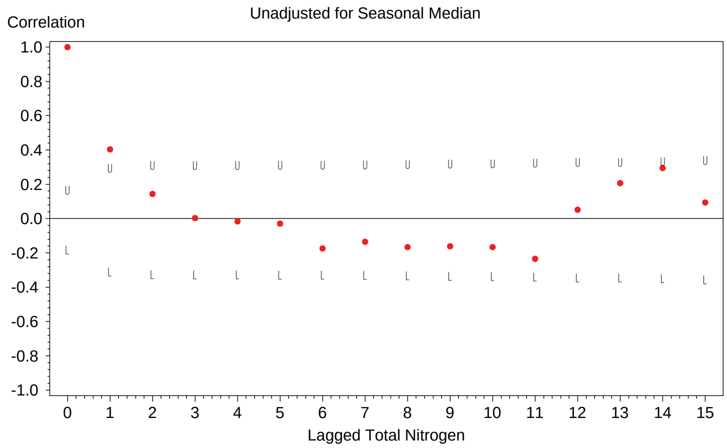

Tidal Peace Trends Appendix - Display 24
Autocorrelation Statistics for Surface Total Nitrogen

Unadjusted for Seasonal Medians

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.404 | 0.151 | 0.302 | -0.302 |
| 2 | 0.144 | 0.159 | 0.318 | -0.318 |
| 3 | 0.003 | 0.160 | 0.319 | -0.319 |
| 4 | -0.016 | 0.160 | 0.319 | -0.319 |
| 5 | -0.029 | 0.160 | 0.320 | -0.320 |
| 6 | -0.174 | 0.160 | 0.320 | -0.320 |
| 7 | -0.135 | 0.161 | 0.322 | -0.322 |
| 8 | -0.166 | 0.162 | 0.324 | -0.324 |
| 9 | -0.161 | 0.163 | 0.327 | -0.327 |
| 10 | -0.166 | 0.165 | 0.329 | -0.329 |
| 11 | -0.234 | 0.166 | 0.332 | -0.332 |
| 12 | 0.052 | 0.168 | 0.337 | -0.337 |
| 13 | 0.207 | 0.168 | 0.337 | -0.337 |
| 14 | 0.295 | 0.170 | 0.341 | -0.341 |
| 15 | 0.094 | 0.174 | 0.348 | -0.348 |

Tidal Peace Trends Appendix - Display 25
Correlogram for Surface Total Nitrogen

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Tidal Peace Trends Appendix - Display 26

Seasonal Kendall Tau Trend Test Statistics
for Surface Total Nitrogen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.073 | 0.438 | 0.424 | -0.031 |

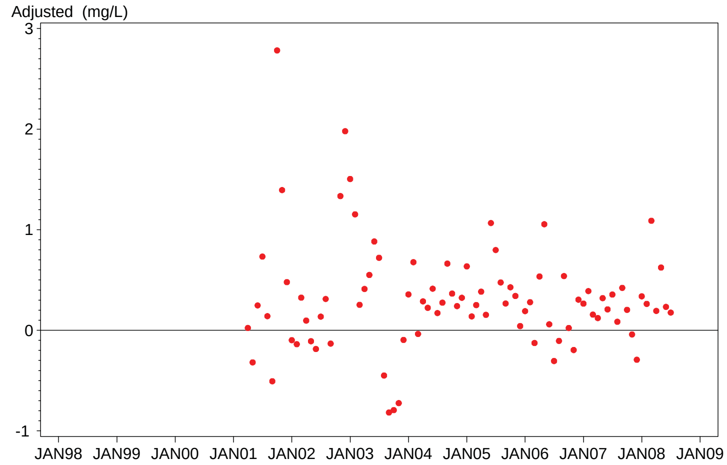
Tidal Peace Trends  Appendix - Display 27

Seasonal Kendall Tau Trend Test Statistics
for Surface Total Nitrogen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.072993 | 0.43794 | 0.42396 | -0.03075 |

Tidal Peace Trends Appendix - Display 28
Time Series Plot of Surface Total Nitrogen  Data Adjusted for Season and Detrended




Zero Reference Line Shown

Tidal Peace Trends  Appendix - Display 29

Autocorrelation Statistics for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.425 | 0.151 | 0.302 | -0.302 |
| 2 | 0.066 | 0.160 | 0.319 | -0.319 |
| 3 | -0.025 | 0.160 | 0.320 | -0.320 |
| 4 | 0.005 | 0.160 | 0.320 | -0.320 |
| 5 | -0.070 | 0.160 | 0.320 | -0.320 |
| 6 | -0.155 | 0.160 | 0.320 | -0.320 |
| 7 | -0.162 | 0.161 | 0.322 | -0.322 |
| 8 | -0.223 | 0.162 | 0.325 | -0.325 |
| 9 | -0.284 | 0.165 | 0.329 | -0.329 |
| 10 | -0.304 | 0.168 | 0.337 | -0.337 |
| 11 | -0.300 | 0.172 | 0.345 | -0.345 |
| 12 | -0.063 | 0.176 | 0.353 | -0.353 |
| 13 | 0.221 | 0.177 | 0.353 | -0.353 |

Tidal Peace Trends  Appendix - Display 29

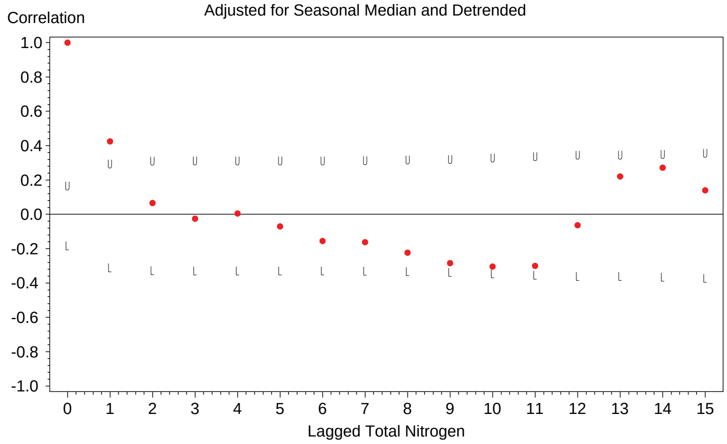
Autocorrelation Statistics for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | 0.272 | 0.179 | 0.357 | -0.357 |
| 15 | 0.140 | 0.182 | 0.364 | -0.364 |

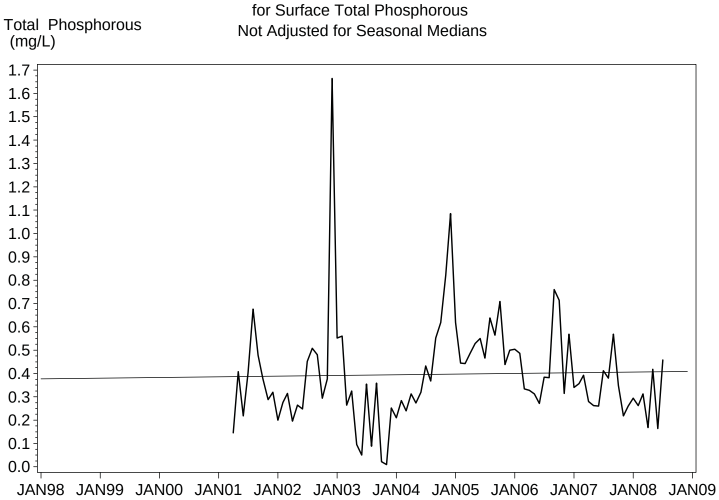
Tidal Peace Trends Appendix - Display 30
Correlogram for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

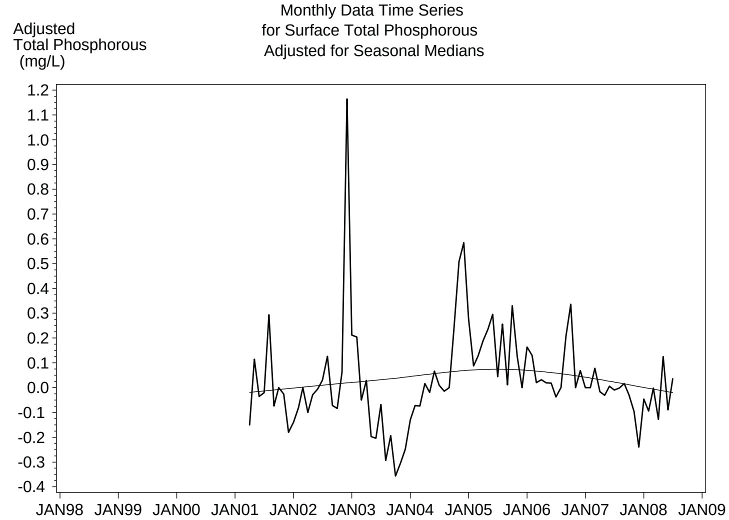



U=Upper  95% Confidence Limit   L=Lower 95% Confidence Limit
Zero Reference Line Shown

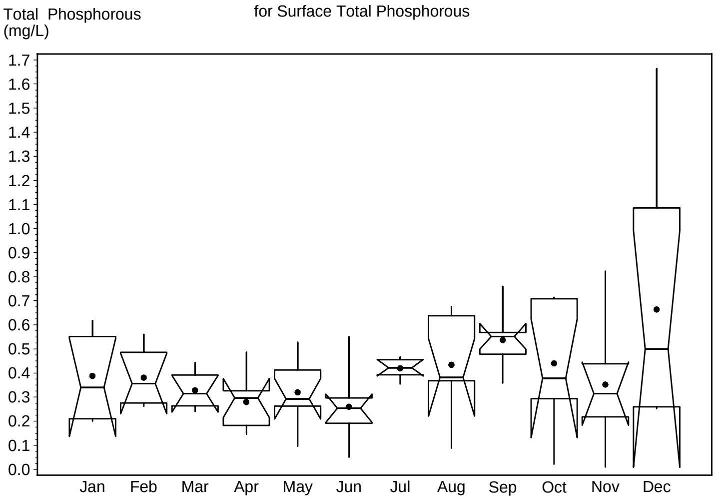
Tidal Peace Trends Appendix - Display 31
Monthly Data Time Series
for Surface Total Phosphorous
Not Adjusted for Seasonal Medians




Tidal Peace Trends Appendix - Display 32
Monthly Data Time Series
for Surface Total Phosphorous
Adjusted for Seasonal Medians




Tidal Peace Trends Appendix - Display 33
Seasonal Univariate Statistics
for Surface Total Phosphorous



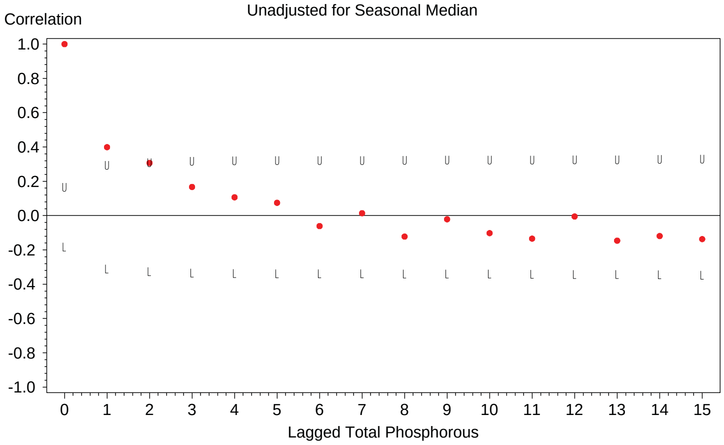

Tidal Peace Trends Appendix - Display 34
Autocorrelation Statistics for Surface Total Phosphorous

Unadjusted for Seasonal Medians

| Lagged Total Phosphorous | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.399 | 0.151 | 0.302 | -0.302 |
| 2 | 0.307 | 0.159 | 0.317 | -0.317 |
| 3 | 0.167 | 0.163 | 0.326 | -0.326 |
| 4 | 0.107 | 0.164 | 0.329 | -0.329 |
| 5 | 0.075 | 0.165 | 0.330 | -0.330 |
| 6 | -0.061 | 0.165 | 0.330 | -0.330 |
| 7 | 0.014 | 0.165 | 0.330 | -0.330 |
| 8 | -0.122 | 0.165 | 0.331 | -0.331 |
| 9 | -0.021 | 0.166 | 0.332 | -0.332 |
| 10 | -0.102 | 0.166 | 0.332 | -0.332 |
| 11 | -0.134 | 0.166 | 0.333 | -0.333 |
| 12 | -0.005 | 0.167 | 0.334 | -0.334 |
| 13 | -0.146 | 0.167 | 0.334 | -0.334 |
| 14 | -0.119 | 0.168 | 0.336 | -0.336 |
| 15 | -0.137 | 0.169 | 0.338 | -0.338 |

Tidal Peace Trends Appendix - Display 35
Correlogram for Surface Total Phosphorous

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Tidal Peace Trends Appendix - Display 36
Seasonal Kendall Tau Trend Test Statistics
for Surface Total Phosphorous

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.107 | 0.243 | 0.545 | .005 |

Tidal Peace Trends Appendix - Display 37

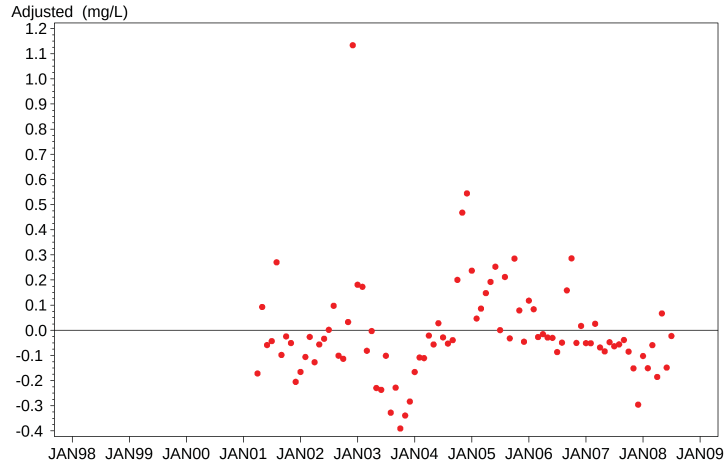
Seasonal Kendall Tau Trend Test Statistics
for Surface Total Phosphorous

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.10714 | 0.24263 | 0.54515 | .0051 |

Tidal Peace Trends Appendix - Display 38

Time Series Plot of Surface Total Phosphorous Data Adjusted for Season and Detrended




Zero Reference Line Shown

Tidal Peace Trends Appendix - Display 39

Autocorrelation Statistics for Surface Total Phosphorous

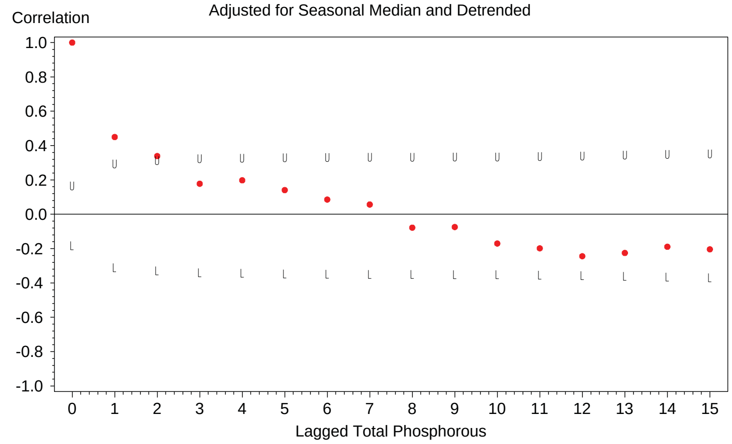
Adjusted for Seasonal Median and Detrended

| Lagged Total Phosphorous | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.450 | 0.151 | 0.302 | -0.302 |
| 2 | 0.339 | 0.161 | 0.321 | -0.321 |
| 3 | 0.178 | 0.166 | 0.332 | -0.332 |
| 4 | 0.198 | 0.167 | 0.335 | -0.335 |
| 5 | 0.141 | 0.169 | 0.338 | -0.338 |
| 6 | 0.086 | 0.170 | 0.340 | -0.340 |
| 7 | 0.057 | 0.170 | 0.341 | -0.341 |
| 8 | -0.078 | 0.171 | 0.341 | -0.341 |
| 9 | -0.074 | 0.171 | 0.342 | -0.342 |
| 10 | -0.170 | 0.171 | 0.342 | -0.342 |
| 11 | -0.198 | 0.172 | 0.345 | -0.345 |
| 12 | -0.244 | 0.174 | 0.348 | -0.348 |
| 13 | -0.225 | 0.177 | 0.353 | -0.353 |
| 14 | -0.189 | 0.179 | 0.357 | -0.357 |
| 15 | -0.204 | 0.180 | 0.361 | -0.361 |

Tidal Peace Trends Appendix - Display 40

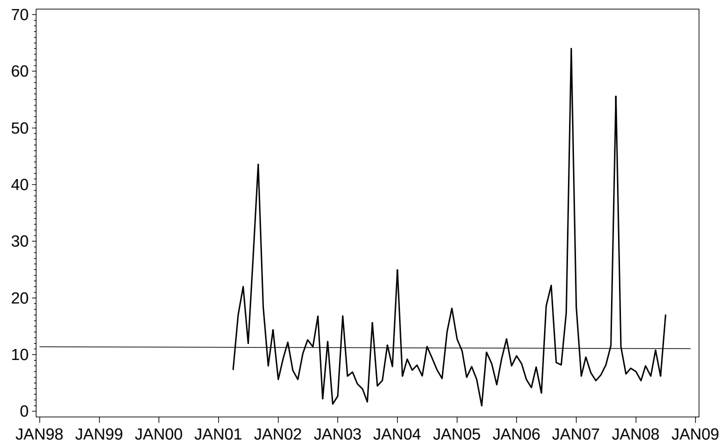
Correlogram for Surface Total Phosphorous

Adjusted for Seasonal Median and Detrended

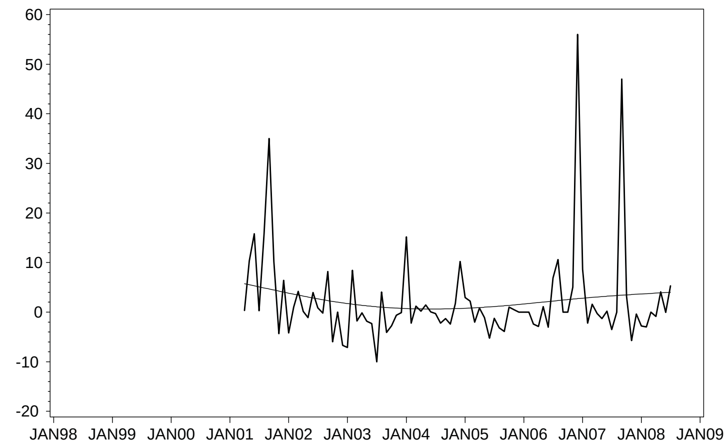



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

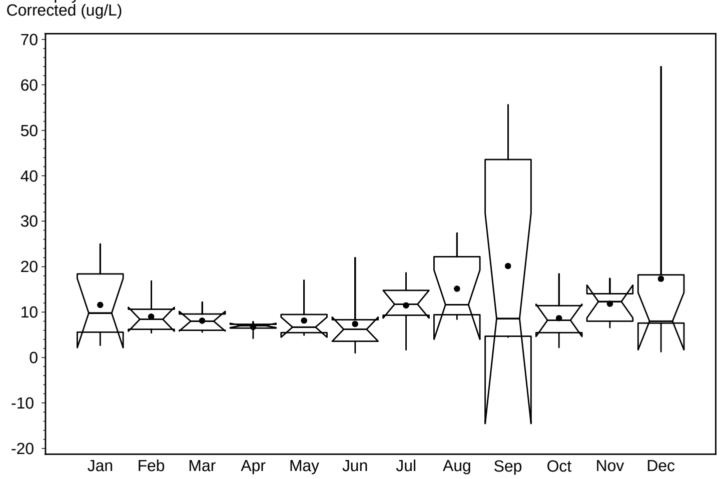
Tidal Peace Trends Appendix - Display 41
Monthly Data Time Series
for Surface Chlorophyll a
Not Adjusted for Seasonal Medians




Tidal Peace Trends Appendix - Display 42
Monthly Data Time Series
for Surface Chlorophyll a
Adjusted for Seasonal Medians




Tidal Peace Trends Appendix - Display 43
Seasonal Univariate Statistics
for Surface Chlorophyll a



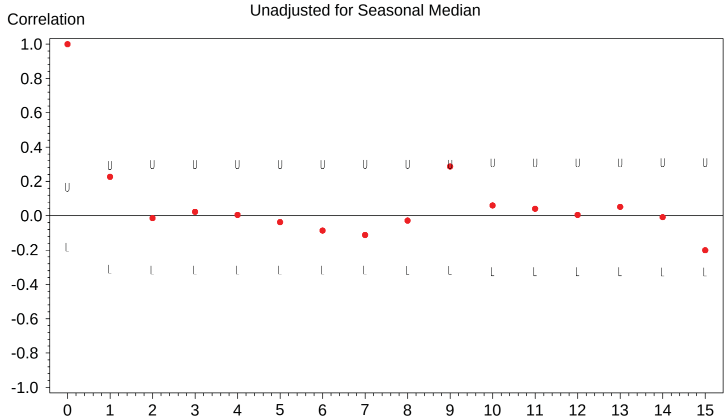

Tidal Peace Trends Appendix - Display 44
Autocorrelation Statistics for Surface Chlorophyll a

Unadjusted for Seasonal Medians

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.227 | 0.151 | 0.302 | -0.302 |
| 2 | -0.014 | 0.153 | 0.307 | -0.307 |
| 3 | 0.023 | 0.153 | 0.307 | -0.307 |
| 4 | 0.005 | 0.153 | 0.307 | -0.307 |
| 5 | -0.037 | 0.153 | 0.307 | -0.307 |
| 6 | -0.086 | 0.153 | 0.307 | -0.307 |
| 7 | -0.112 | 0.154 | 0.308 | -0.308 |
| 8 | -0.028 | 0.154 | 0.309 | -0.309 |
| 9 | 0.287 | 0.154 | 0.309 | -0.309 |
| 10 | 0.060 | 0.158 | 0.317 | -0.317 |
| 11 | 0.041 | 0.159 | 0.317 | -0.317 |
| 12 | 0.005 | 0.159 | 0.317 | -0.317 |
| 13 | 0.052 | 0.159 | 0.317 | -0.317 |
| 14 | -0.008 | 0.159 | 0.318 | -0.318 |
| 15 | -0.201 | 0.159 | 0.318 | -0.318 |

Tidal Peace Trends Appendix - Display 45
Correlogram for Surface Chlorophyll a

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Tidal Peace Trends Appendix - Display 46
Seasonal Kendall Tau Trend Test Statistics
for Surface Chlorophyll a

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.079 | 0.397 | 0.492 | -0.164 |

Tidal Peace Trends Appendix - Display 47

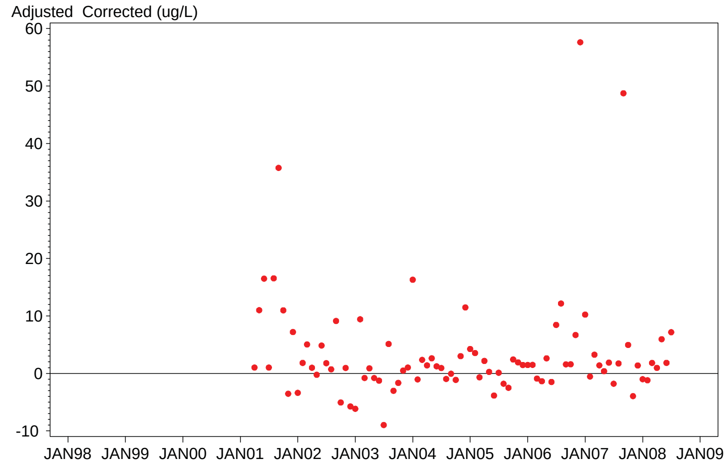
Seasonal Kendall Tau Trend Test Statistics
for Surface Chlorophyll a

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.078571 | 0.39749 | 0.49215 | -0.16367 |

Tidal Peace Trends Appendix - Display 48

Time Series Plot of Surface Chlorophyll a Data Adjusted for Season and Detrended




Zero Reference Line Shown

Tidal Peace Trends Appendix - Display 49

Autocorrelation Statistics for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.171 | 0.151 | 0.302 | -0.302 |
| 2 | -0.061 | 0.152 | 0.304 | -0.304 |
| 3 | 0.071 | 0.152 | 0.305 | -0.305 |
| 4 | 0.032 | 0.153 | 0.305 | -0.305 |
| 5 | -0.009 | 0.153 | 0.305 | -0.305 |
| 6 | -0.031 | 0.153 | 0.305 | -0.305 |
| 7 | -0.074 | 0.153 | 0.306 | -0.306 |
| 8 | 0.002 | 0.153 | 0.306 | -0.306 |
| 9 | 0.354 | 0.153 | 0.306 | -0.306 |
| 10 | 0.037 | 0.159 | 0.318 | -0.318 |
| 11 | -0.013 | 0.159 | 0.318 | -0.318 |
| 12 | -0.032 | 0.159 | 0.318 | -0.318 |
| 13 | -0.008 | 0.159 | 0.318 | -0.318 |

Tidal Peace Trends Appendix - Display 49

Autocorrelation Statistics for Surface Chlorophyll a

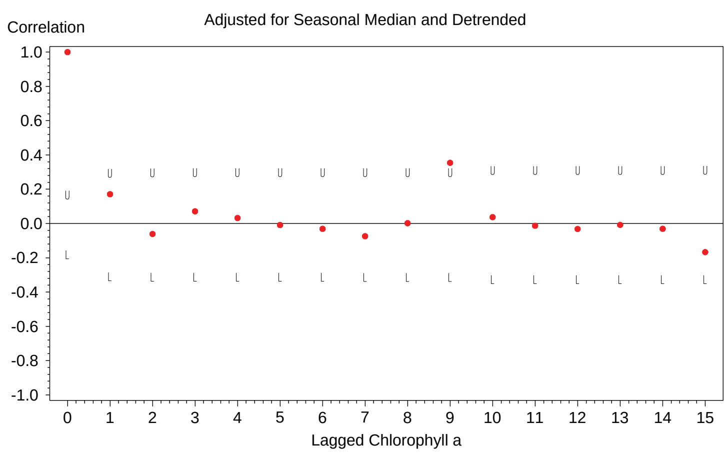
Adjusted for Seasonal Median and Detrended

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | -0.031 | 0.159 | 0.318 | -0.318 |
| 15 | -0.167 | 0.159 | 0.319 | -0.319 |

Tidal Peace Trends Appendix - Display 50

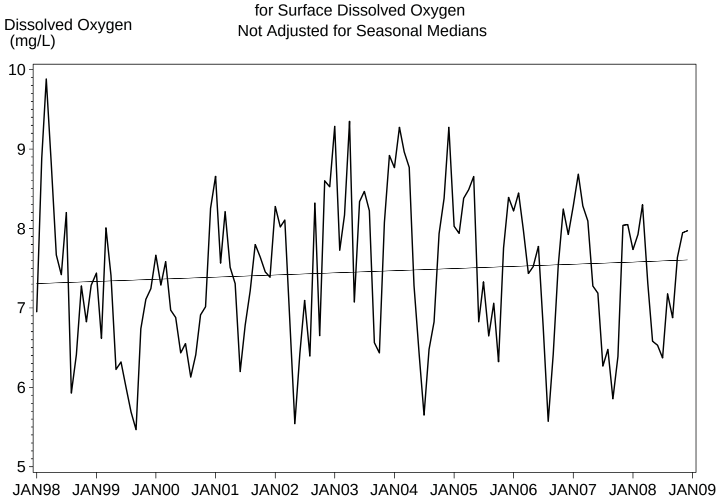
Correlogram for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended

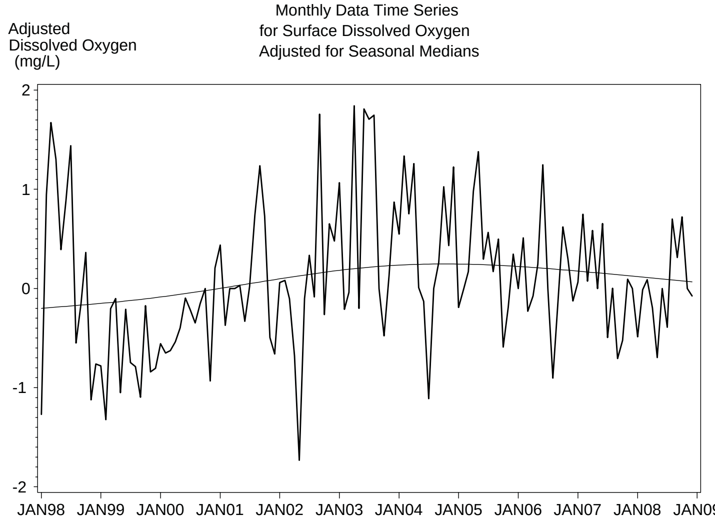



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

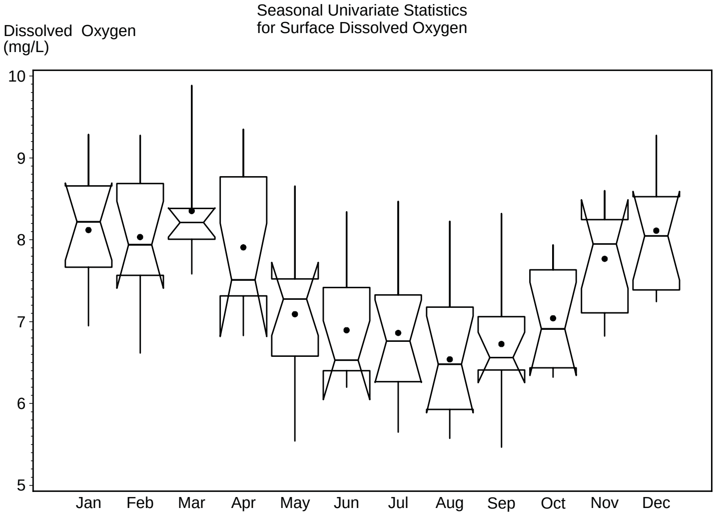
Pine Island Sound Trends Appendix - Display 1
Monthly Data Time Series
for Surface Dissolved Oxygen
Not Adjusted for Seasonal Medians




Pine Island Sound Trends Appendix - Display 2
Monthly Data Time Series
for Surface Dissolved Oxygen
Adjusted for Seasonal Medians




Pine Island Sound Trends Appendix - Display 3
Seasonal Univariate Statistics
for Surface Dissolved Oxygen



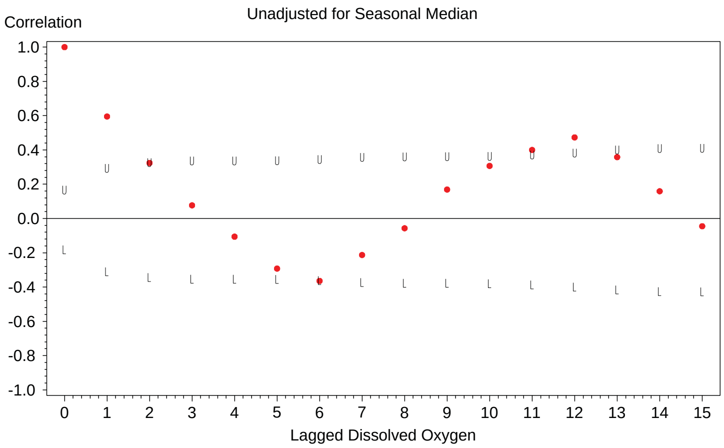

Pine Island Sound Trends Appendix - Display 4
Autocorrelation Statistics for Surface Dissolved Oxygen

Unadjusted for Seasonal Medians

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.595 | 0.151 | 0.302 | -0.302 |
| 2 | 0.324 | 0.168 | 0.335 | -0.335 |
| 3 | 0.077 | 0.172 | 0.345 | -0.345 |
| 4 | -0.106 | 0.173 | 0.345 | -0.345 |
| 5 | -0.292 | 0.173 | 0.346 | -0.346 |
| 6 | -0.364 | 0.177 | 0.353 | -0.353 |
| 7 | -0.213 | 0.182 | 0.365 | -0.365 |
| 8 | -0.057 | 0.184 | 0.368 | -0.368 |
| 9 | 0.169 | 0.184 | 0.369 | -0.369 |
| 10 | 0.307 | 0.185 | 0.371 | -0.371 |
| 11 | 0.400 | 0.189 | 0.379 | -0.379 |
| 12 | 0.473 | 0.196 | 0.391 | -0.391 |
| 13 | 0.358 | 0.204 | 0.408 | -0.408 |
| 14 | 0.159 | 0.209 | 0.417 | -0.417 |
| 15 | -0.045 | 0.210 | 0.419 | -0.419 |

Pine Island Sound Trends Appendix - Display 5
Correlogram for Surface Dissolved Oxygen

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Pine Island Sound Trends Appendix - Display 6

Seasonal Kendall Tau Trend Test Statistics
for Surface Dissolved Oxygen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.144 | 0.035 | 0.225 | 0.049 |

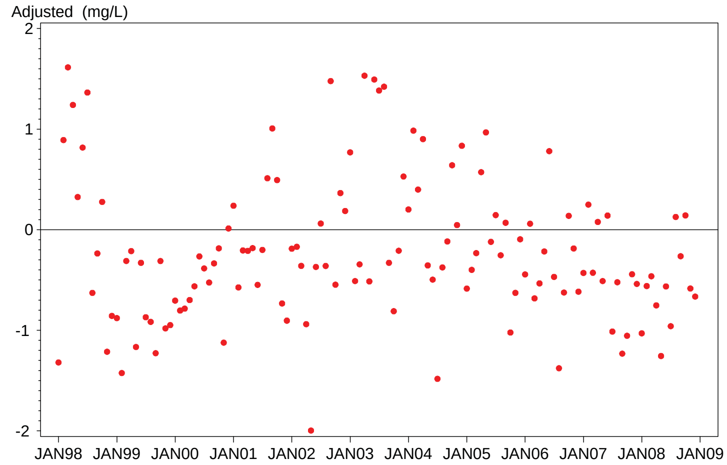
Pine Island Sound Trends Appendix - Display 7

Seasonal Kendall Tau Trend Test Statistics
for Surface Dissolved Oxygen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.14394 | 0.034599 | 0.22543 | 0.049366 |

Pine Island Sound Trends Appendix - Display 8
Time Series Plot of Surface Dissolved Oxygen Data Adjusted for Season and Detrended




Zero Reference Line Shown

Pine Island Sound Trends Appendix - Display 9

Autocorrelation Statistics for Surface Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.371 | 0.151 | 0.302 | -0.302 |
| 2 | 0.244 | 0.158 | 0.315 | -0.315 |
| 3 | 0.149 | 0.160 | 0.321 | -0.321 |
| 4 | 0.171 | 0.161 | 0.323 | -0.323 |
| 5 | 0.100 | 0.163 | 0.326 | -0.326 |
| 6 | 0.106 | 0.163 | 0.326 | -0.326 |
| 7 | 0.182 | 0.164 | 0.328 | -0.328 |
| 8 | 0.110 | 0.165 | 0.331 | -0.331 |
| 9 | 0.133 | 0.166 | 0.332 | -0.332 |
| 10 | 0.084 | 0.167 | 0.333 | -0.333 |
| 11 | -0.051 | 0.167 | 0.334 | -0.334 |
| 12 | 0.038 | 0.167 | 0.334 | -0.334 |
| 13 | -0.041 | 0.167 | 0.334 | -0.334 |

Pine Island Sound Trends Appendix - Display 9

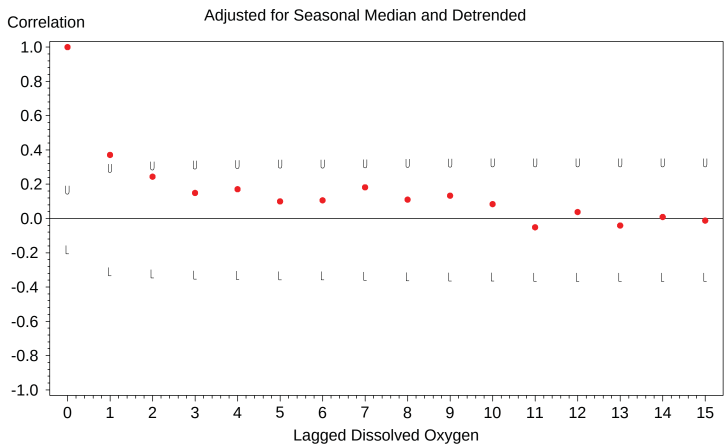
Autocorrelation Statistics for Surface Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | 0.009 | 0.167 | 0.334 | -0.334 |
| 15 | -0.012 | 0.167 | 0.334 | -0.334 |

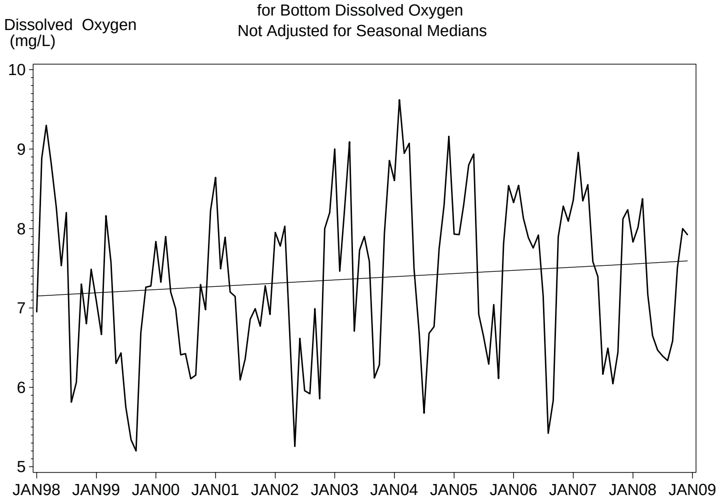
Pine Island Sound Trends Appendix - Display 10
Correlogram for Surface Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

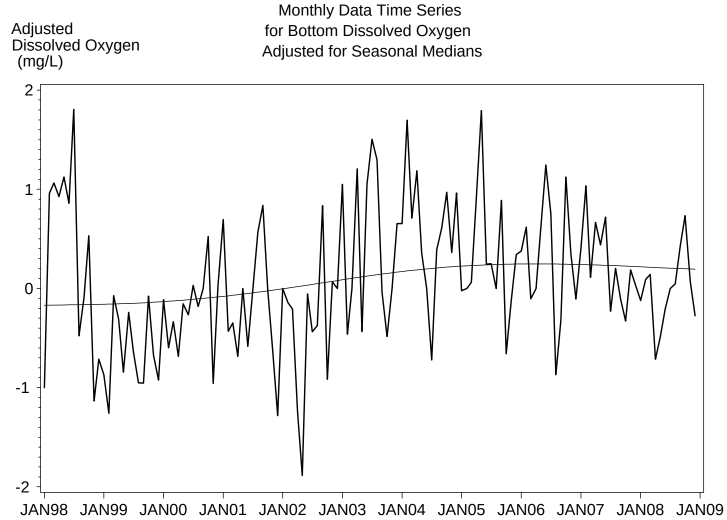



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

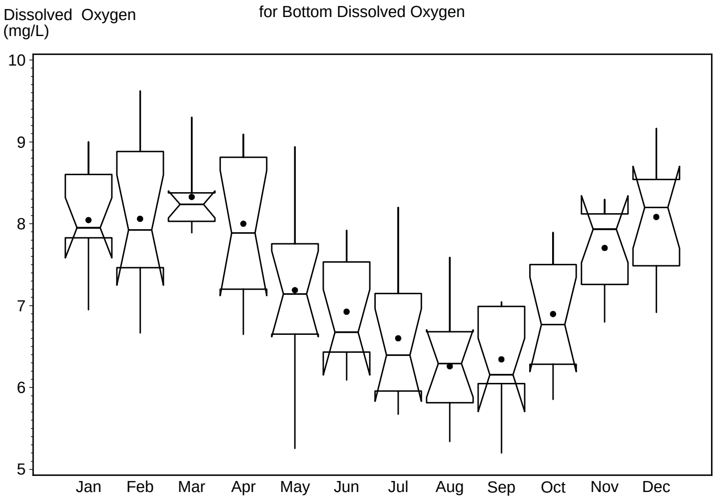
Pine Island Sound Trends Appendix - Display 11
Monthly Data Time Series
for Bottom Dissolved Oxygen
Not Adjusted for Seasonal Medians




Pine Island Sound Trends Appendix - Display 12
Monthly Data Time Series
for Bottom Dissolved Oxygen
Adjusted for Seasonal Medians




Pine Island Sound Trends Appendix - Display 13
Seasonal Univariate Statistics
for Bottom Dissolved Oxygen



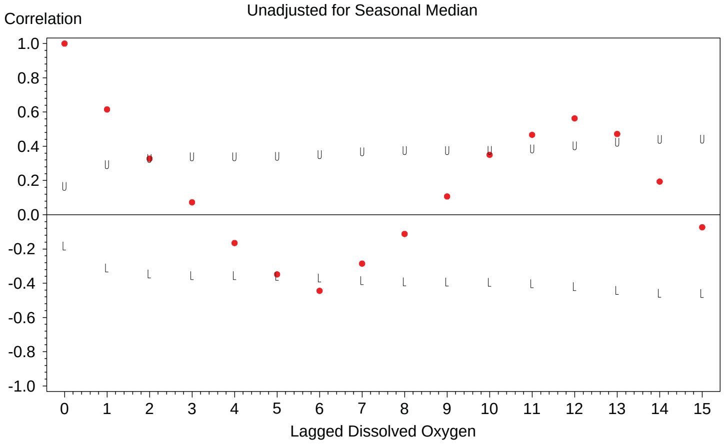

Pine Island Sound Trends Appendix - Display 14
Autocorrelation Statistics for Bottom Dissolved Oxygen

Unadjusted for Seasonal Medians

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.615 | 0.151 | 0.302 | -0.302 |
| 2 | 0.328 | 0.169 | 0.337 | -0.337 |
| 3 | 0.073 | 0.173 | 0.347 | -0.347 |
| 4 | -0.165 | 0.174 | 0.347 | -0.347 |
| 5 | -0.348 | 0.175 | 0.350 | -0.350 |
| 6 | -0.444 | 0.180 | 0.360 | -0.360 |
| 7 | -0.285 | 0.188 | 0.376 | -0.376 |
| 8 | -0.112 | 0.191 | 0.383 | -0.383 |
| 9 | 0.107 | 0.192 | 0.384 | -0.384 |
| 10 | 0.350 | 0.192 | 0.385 | -0.385 |
| 11 | 0.467 | 0.197 | 0.394 | -0.394 |
| 12 | 0.563 | 0.205 | 0.411 | -0.411 |
| 13 | 0.472 | 0.217 | 0.433 | -0.433 |
| 14 | 0.194 | 0.224 | 0.449 | -0.449 |
| 15 | -0.073 | 0.226 | 0.451 | -0.451 |

Pine Island Sound Trends Appendix - Display 15
Correlogram for Bottom Dissolved Oxygen

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Pine Island Sound Trends Appendix - Display 16

Seasonal Kendall Tau Trend Test Statistics
for Bottom Dissolved Oxygen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.185 | .007 | 0.13 | 0.056 |

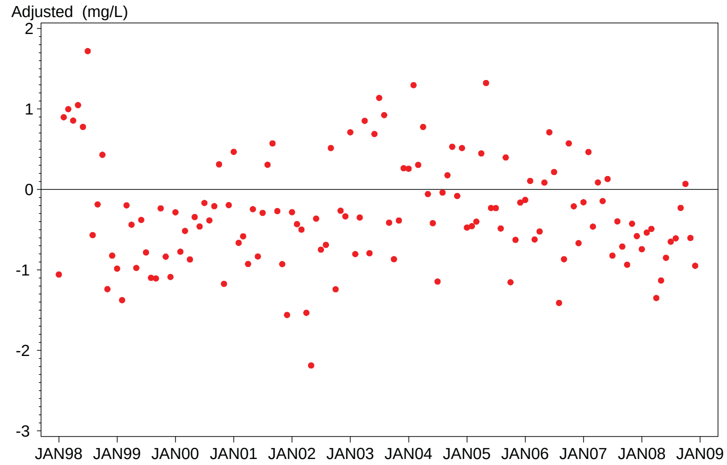
Pine Island Sound Trends  Appendix - Display 17

Seasonal Kendall Tau Trend Test Statistics
for Bottom Dissolved Oxygen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.18485 | .00651515 | 0.12963 | 0.0564 |

Pine Island Sound Trends Appendix - Display 18
Time Series Plot of Bottom Dissolved  Oxygen Data Adjusted for Season and Detrended




Zero Reference Line Shown

Pine Island Sound Trends  Appendix - Display 19
Autocorrelation Statistics for Bottom Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.344 | 0.151 | 0.302 | -0.302 |
| 2 | 0.173 | 0.157 | 0.313 | -0.313 |
| 3 | 0.176 | 0.158 | 0.316 | -0.316 |
| 4 | 0.153 | 0.160 | 0.319 | -0.319 |
| 5 | 0.130 | 0.161 | 0.321 | -0.321 |
| 6 | 0.048 | 0.161 | 0.323 | -0.323 |
| 7 | 0.187 | 0.162 | 0.323 | -0.323 |
| 8 | 0.091 | 0.163 | 0.326 | -0.326 |
| 9 | 0.012 | 0.164 | 0.327 | -0.327 |
| 10 | 0.042 | 0.164 | 0.327 | -0.327 |
| 11 | -0.095 | 0.164 | 0.327 | -0.327 |
| 12 | -0.001 | 0.164 | 0.328 | -0.328 |
| 13 | 0.046 | 0.164 | 0.328 | -0.328 |

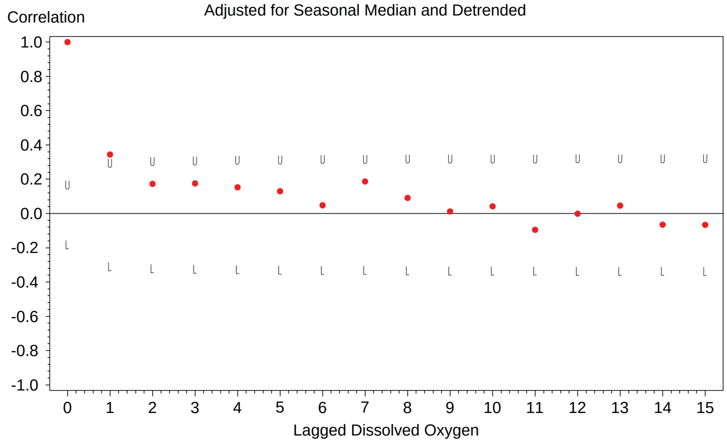
Pine Island Sound Trends  Appendix - Display 19
Autocorrelation Statistics for Bottom Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | -0.065 | 0.164 | 0.328 | -0.328 |
| 15 | -0.066 | 0.164 | 0.329 | -0.329 |

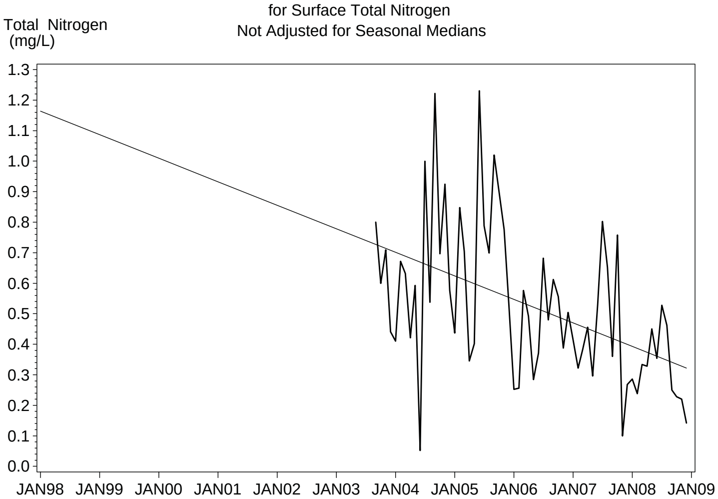
Pine Island Sound Trends Appendix - Display 20
Correlogram for Bottom Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

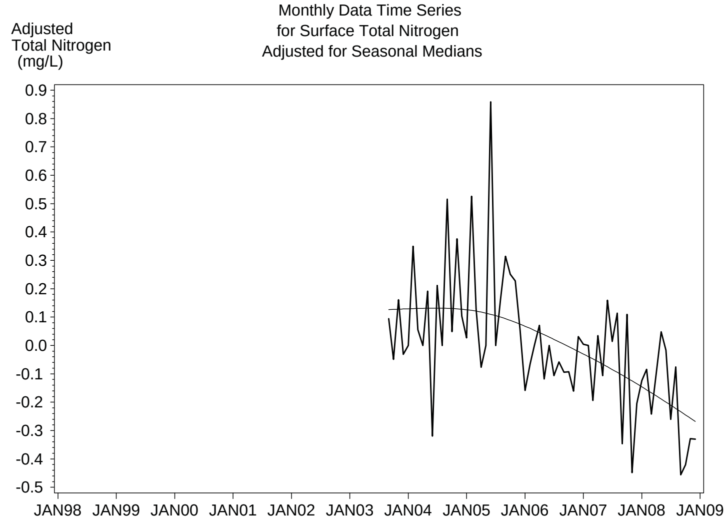



U=Upper  95% Confidence Limit   L=Lower 95% Confidence Limit
Zero Reference Line Shown

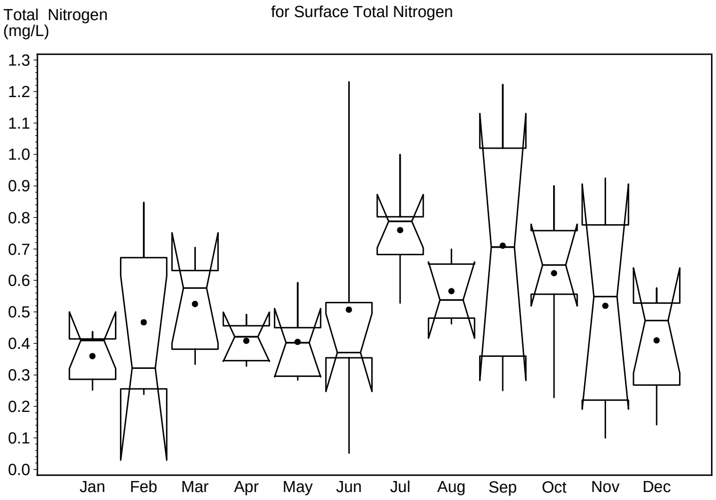
Pine Island Sound Trends Appendix - Display 21
Monthly Data Time Series
for Surface Total Nitrogen
Not Adjusted for Seasonal Medians




Pine Island Sound Trends Appendix - Display 22
Monthly Data Time Series
for Surface Total Nitrogen
Adjusted for Seasonal Medians




Pine Island Sound Trends Appendix - Display 23
Seasonal Univariate Statistics
for Surface Total Nitrogen



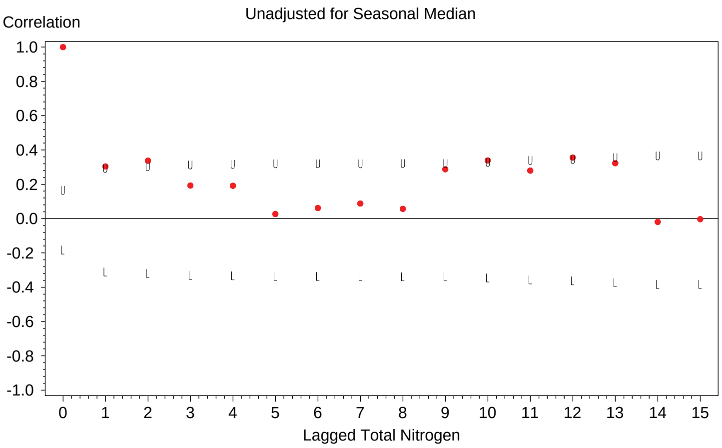

Pine Island Sound Trends Appendix - Display 24
Autocorrelation Statistics for Surface Total Nitrogen

Unadjusted for Seasonal Medians

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.304 | 0.151 | 0.302 | -0.302 |
| 2 | 0.338 | 0.155 | 0.311 | -0.311 |
| 3 | 0.193 | 0.161 | 0.322 | -0.322 |
| 4 | 0.192 | 0.163 | 0.325 | -0.325 |
| 5 | 0.027 | 0.164 | 0.329 | -0.329 |
| 6 | 0.062 | 0.164 | 0.329 | -0.329 |
| 7 | 0.088 | 0.164 | 0.329 | -0.329 |
| 8 | 0.057 | 0.165 | 0.330 | -0.330 |
| 9 | 0.288 | 0.165 | 0.330 | -0.330 |
| 10 | 0.339 | 0.169 | 0.337 | -0.337 |
| 11 | 0.280 | 0.174 | 0.348 | -0.348 |
| 12 | 0.356 | 0.177 | 0.354 | -0.354 |
| 13 | 0.323 | 0.183 | 0.365 | -0.365 |
| 14 | -0.019 | 0.187 | 0.374 | -0.374 |
| 15 | -0.003 | 0.187 | 0.374 | -0.374 |

Pine Island Sound Trends Appendix - Display 25
Correlogram for Surface Total Nitrogen

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Pine Island Sound Trends Appendix - Display 26
Seasonal Kendall Tau Trend Test Statistics
for Surface Total Nitrogen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.443 | 0 | 0.096 | -0.079 |

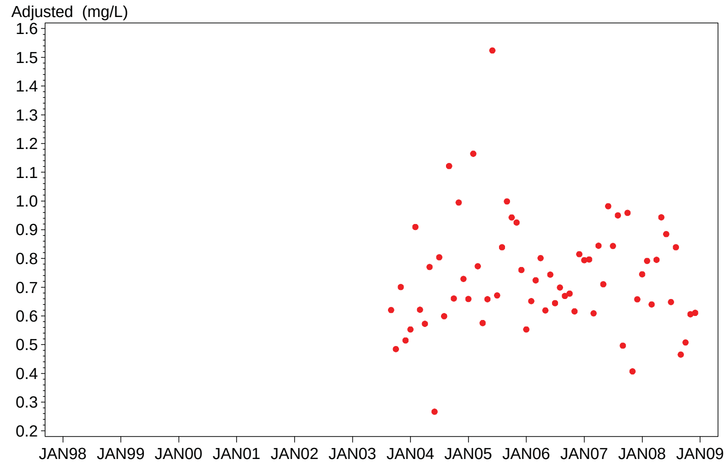
Pine Island Sound Trends  Appendix - Display 27

Seasonal Kendall Tau Trend Test Statistics
for Surface Total Nitrogen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.44286 | .000103023 | 0.095635 | -0.079 |

Pine Island Sound Trends Appendix - Display 28
Time Series Plot of Surface Total Nitrogen  Data Adjusted for Season and Detrended




Zero Reference Line Shown

Pine Island Sound Trends  Appendix - Display 29

Autocorrelation Statistics for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | -0.059 | 0.151 | 0.302 | -0.302 |
| 2 | 0.170 | 0.151 | 0.302 | -0.302 |
| 3 | 0.045 | 0.152 | 0.305 | -0.305 |
| 4 | 0.174 | 0.152 | 0.305 | -0.305 |
| 5 | -0.119 | 0.154 | 0.308 | -0.308 |
| 6 | 0.046 | 0.155 | 0.309 | -0.309 |
| 7 | 0.026 | 0.155 | 0.310 | -0.310 |
| 8 | -0.103 | 0.155 | 0.310 | -0.310 |
| 9 | 0.141 | 0.155 | 0.311 | -0.311 |
| 10 | 0.083 | 0.156 | 0.313 | -0.313 |
| 11 | -0.180 | 0.157 | 0.313 | -0.313 |
| 12 | -0.053 | 0.158 | 0.316 | -0.316 |
| 13 | -0.045 | 0.158 | 0.317 | -0.317 |

Pine Island Sound Trends  Appendix - Display 29

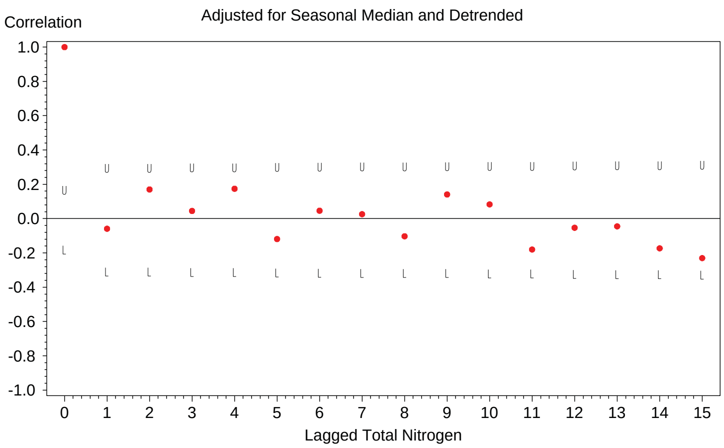
Autocorrelation Statistics for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | -0.173 | 0.158 | 0.317 | -0.317 |
| 15 | -0.230 | 0.160 | 0.320 | -0.320 |

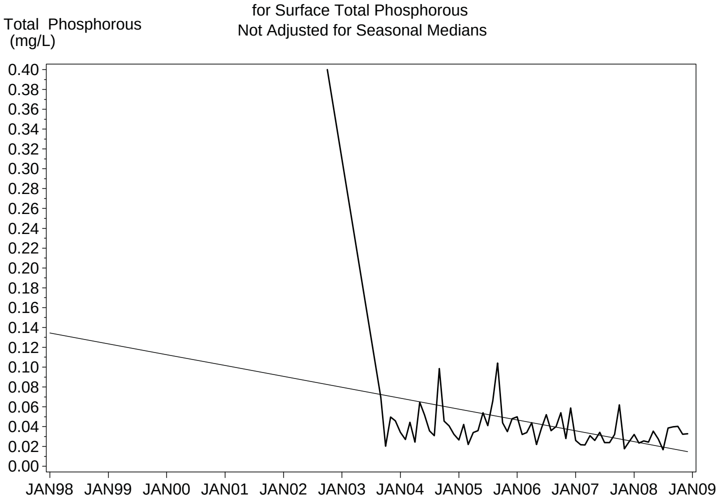
Pine Island Sound Trends Appendix - Display 30
Correlogram for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

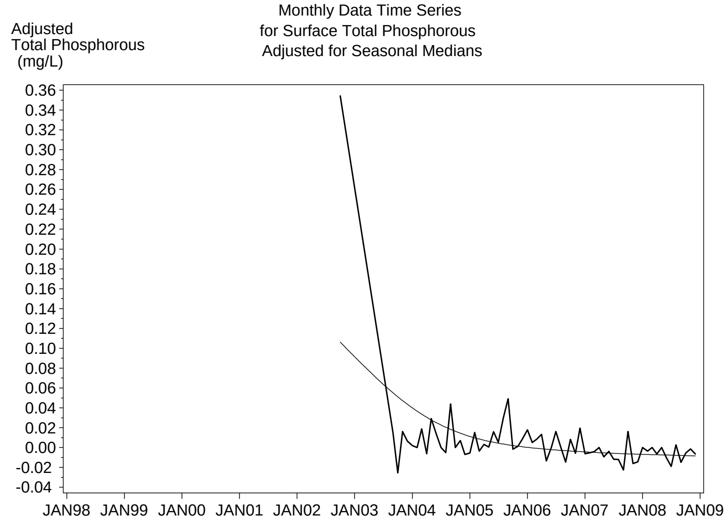



U=Upper  95% Confidence Limit   L=Lower 95% Confidence Limit
Zero Reference Line Shown

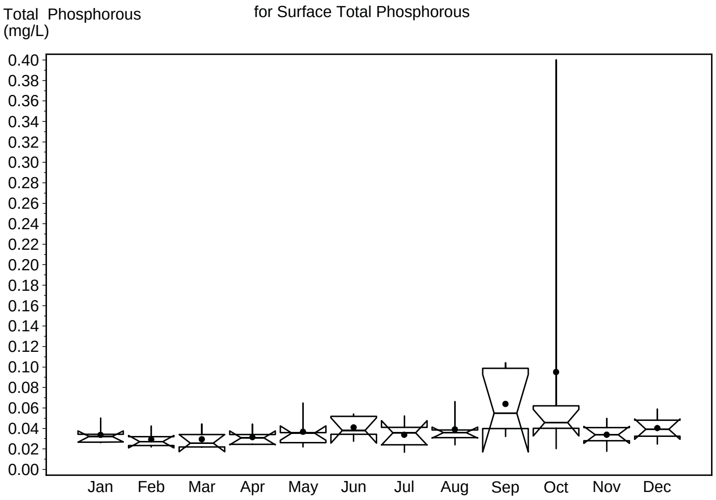
Pine Island Sound Trends Appendix - Display 31
Monthly Data Time Series
for Surface Total Phosphorous
Not Adjusted for Seasonal Medians




Pine Island Sound Trends Appendix - Display 32
Monthly Data Time Series
for Surface Total Phosphorous
Adjusted for Seasonal Medians




Pine Island Sound Trends Appendix - Display 33
Seasonal Univariate Statistics
for Surface Total Phosphorous



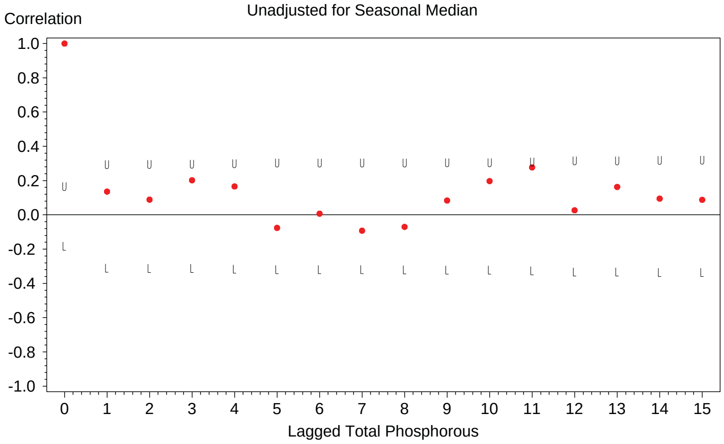

Pine Island Sound Trends Appendix - Display 34
Autocorrelation Statistics for Surface Total Phosphorous

Unadjusted for Seasonal Medians

| Lagged Total Phosphorous | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.136 | 0.151 | 0.302 | -0.302 |
| 2 | 0.089 | 0.152 | 0.303 | -0.303 |
| 3 | 0.202 | 0.152 | 0.304 | -0.304 |
| 4 | 0.166 | 0.154 | 0.308 | -0.308 |
| 5 | -0.076 | 0.155 | 0.311 | -0.311 |
| 6 | 0.007 | 0.156 | 0.311 | -0.311 |
| 7 | -0.092 | 0.156 | 0.311 | -0.311 |
| 8 | -0.070 | 0.156 | 0.312 | -0.312 |
| 9 | 0.084 | 0.156 | 0.313 | -0.313 |
| 10 | 0.197 | 0.157 | 0.313 | -0.313 |
| 11 | 0.277 | 0.159 | 0.317 | -0.317 |
| 12 | 0.027 | 0.162 | 0.324 | -0.324 |
| 13 | 0.163 | 0.162 | 0.324 | -0.324 |
| 14 | 0.095 | 0.163 | 0.327 | -0.327 |
| 15 | 0.088 | 0.164 | 0.328 | -0.328 |

Pine Island Sound Trends Appendix - Display 35
Correlogram for Surface Total Phosphorous

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Pine Island Sound Trends Appendix - Display 36
Seasonal Kendall Tau Trend Test Statistics
for Surface Total Phosphorous

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.315 | .005 | 0.125 | -.005 |

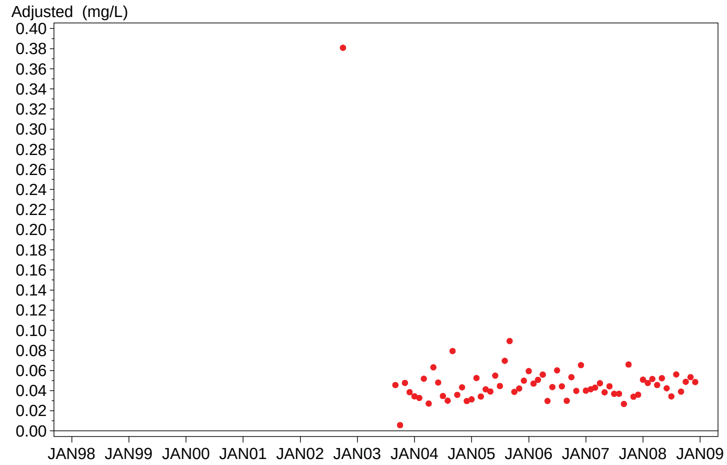
Pine Island Sound Trends Appendix - Display 37

Seasonal Kendall Tau Trend Test Statistics
for Surface Total Phosphorous

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.30822 | .00612328 | 0.12463 | -.004625 |

Pine Island Sound Trends Appendix - Display 38
Time Series Plot of Surface Total Phosphorous Data Adjusted for Season and Detrended




Zero Reference Line Shown

Pine Island Sound Trends Appendix - Display 39

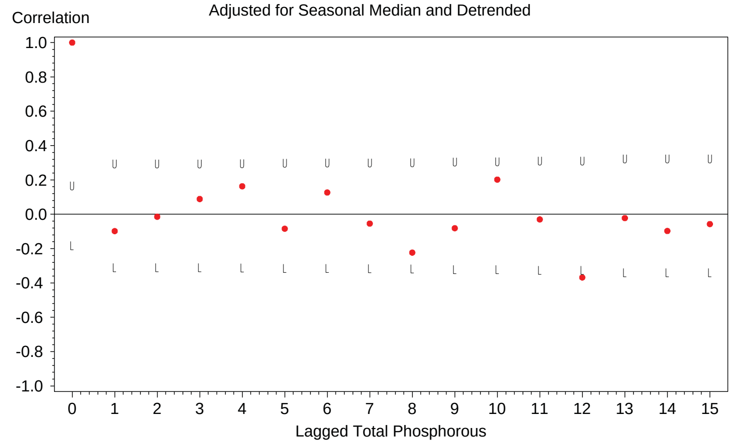
Autocorrelation Statistics for Surface Total Phosphorous

Adjusted for Seasonal Median and Detrended

| Lagged Total Phosphorous | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | -0.098 | 0.151 | 0.302 | -0.302 |
| 2 | -0.014 | 0.151 | 0.302 | -0.302 |
| 3 | 0.089 | 0.151 | 0.302 | -0.302 |
| 4 | 0.163 | 0.152 | 0.303 | -0.303 |
| 5 | -0.084 | 0.153 | 0.306 | -0.306 |
| 6 | 0.127 | 0.153 | 0.307 | -0.307 |
| 7 | -0.054 | 0.154 | 0.308 | -0.308 |
| 8 | -0.223 | 0.154 | 0.309 | -0.309 |
| 9 | -0.081 | 0.157 | 0.313 | -0.313 |
| 10 | 0.202 | 0.157 | 0.314 | -0.314 |
| 11 | -0.030 | 0.159 | 0.318 | -0.318 |
| 12 | -0.368 | 0.159 | 0.318 | -0.318 |
| 13 | -0.022 | 0.165 | 0.331 | -0.331 |
| 14 | -0.097 | 0.165 | 0.331 | -0.331 |
| 15 | -0.057 | 0.166 | 0.331 | -0.331 |

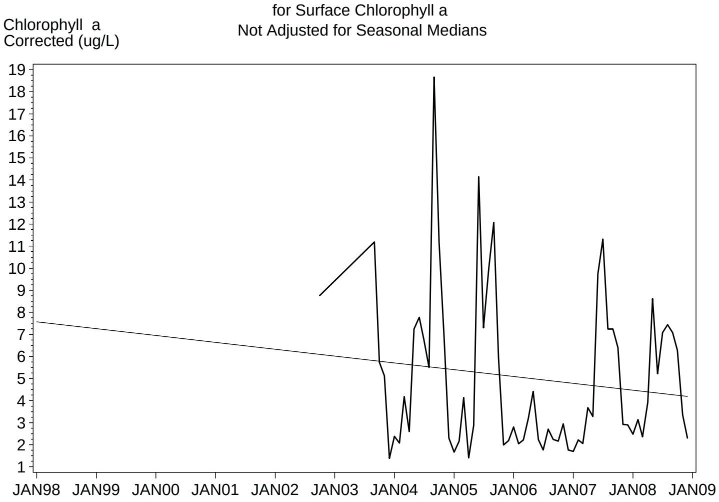
Pine Island Sound Trends Appendix - Display 40
Correlogram for Surface Total Phosphorous

Adjusted for Seasonal Median and Detrended

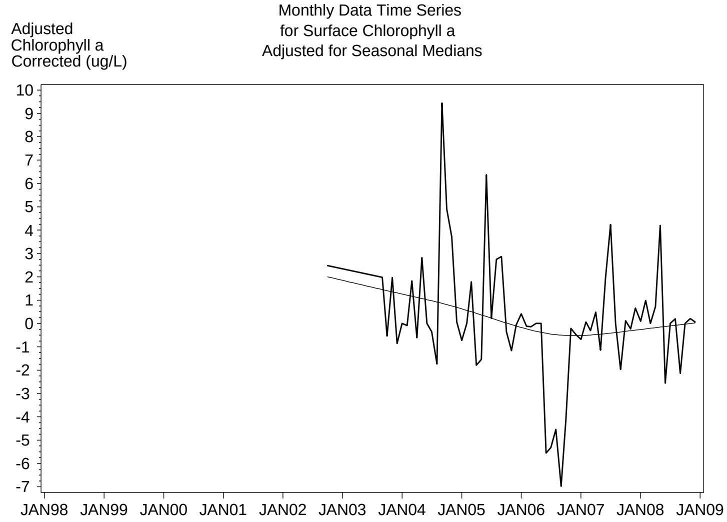



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

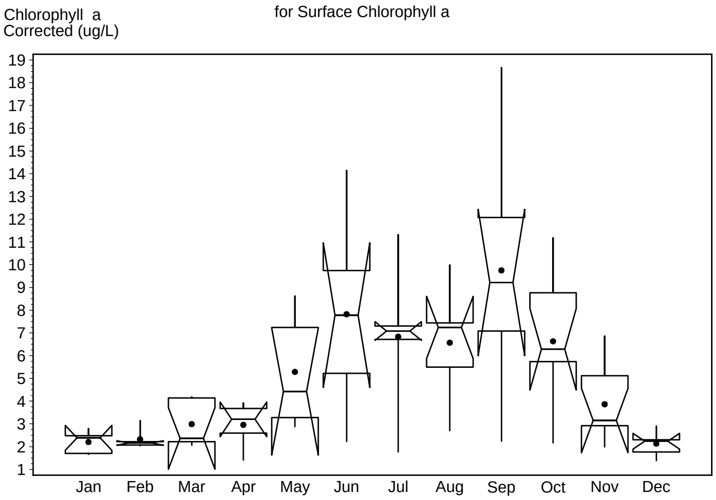
Pine Island Sound Trends Appendix - Display 41
Monthly Data Time Series
for Surface Chlorophyll a
Not Adjusted for Seasonal Medians




Pine Island Sound Trends Appendix - Display 42
Monthly Data Time Series
for Surface Chlorophyll a
Adjusted for Seasonal Medians




Pine Island Sound Trends Appendix - Display 43
Seasonal Univariate Statistics
for Surface Chlorophyll a



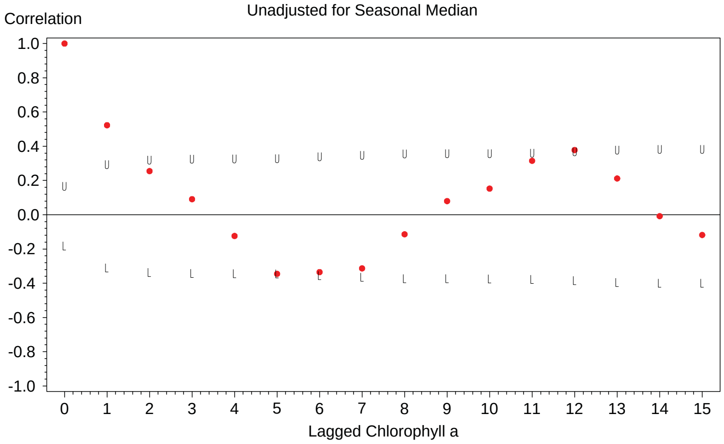

Pine Island Sound Trends Appendix - Display 44
Autocorrelation Statistics for Surface Chlorophyll a

Unadjusted for Seasonal Medians

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.523 | 0.151 | 0.302 | -0.302 |
| 2 | 0.255 | 0.164 | 0.328 | -0.328 |
| 3 | 0.091 | 0.167 | 0.334 | -0.334 |
| 4 | -0.124 | 0.167 | 0.335 | -0.335 |
| 5 | -0.345 | 0.168 | 0.336 | -0.336 |
| 6 | -0.335 | 0.173 | 0.347 | -0.347 |
| 7 | -0.313 | 0.178 | 0.356 | -0.356 |
| 8 | -0.114 | 0.182 | 0.364 | -0.364 |
| 9 | 0.080 | 0.183 | 0.365 | -0.365 |
| 10 | 0.153 | 0.183 | 0.366 | -0.366 |
| 11 | 0.315 | 0.184 | 0.368 | -0.368 |
| 12 | 0.378 | 0.188 | 0.376 | -0.376 |
| 13 | 0.212 | 0.194 | 0.387 | -0.387 |
| 14 | -0.008 | 0.195 | 0.391 | -0.391 |
| 15 | -0.118 | 0.195 | 0.391 | -0.391 |

Pine Island Sound Trends Appendix - Display 45
Correlogram for Surface Chlorophyll a

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Pine Island Sound Trends Appendix - Display 46

Seasonal Kendall Tau Trend Test Statistics
for Surface Chlorophyll a

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.048 | 0.711 | 0.798 | 0.035 |

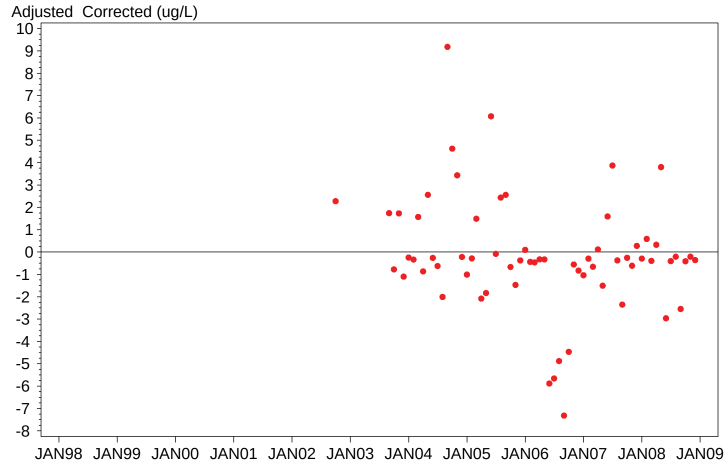
Pine Island Sound Trends  Appendix - Display 47

Seasonal Kendall Tau Trend Test Statistics
for Surface Chlorophyll a

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.047945 | 0.71070 | 0.79813 | 0.035 |

Pine Island Sound Trends Appendix - Display 48
Time Series Plot of Surface  Chlorophyll a Data Adjusted for Season and Detrended




Zero Reference Line Shown

Pine Island Sound Trends  Appendix - Display 49

Autocorrelation Statistics for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.368 | 0.151 | 0.302 | -0.302 |
| 2 | 0.239 | 0.157 | 0.315 | -0.315 |
| 3 | 0.193 | 0.160 | 0.320 | -0.320 |
| 4 | 0.107 | 0.162 | 0.324 | -0.324 |
| 5 | 0.000 | 0.162 | 0.325 | -0.325 |
| 6 | 0.117 | 0.162 | 0.325 | -0.325 |
| 7 | 0.035 | 0.163 | 0.326 | -0.326 |
| 8 | 0.066 | 0.163 | 0.326 | -0.326 |
| 9 | 0.087 | 0.163 | 0.327 | -0.327 |
| 10 | 0.010 | 0.164 | 0.327 | -0.327 |
| 11 | -0.015 | 0.164 | 0.327 | -0.327 |
| 12 | -0.132 | 0.164 | 0.327 | -0.327 |
| 13 | -0.139 | 0.165 | 0.329 | -0.329 |

Pine Island Sound Trends  Appendix - Display 49

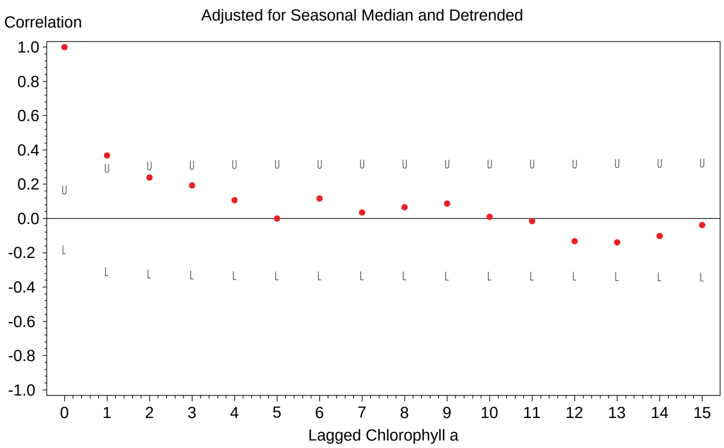
Autocorrelation Statistics for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | -0.102 | 0.165 | 0.331 | -0.331 |
| 15 | -0.038 | 0.166 | 0.332 | -0.332 |

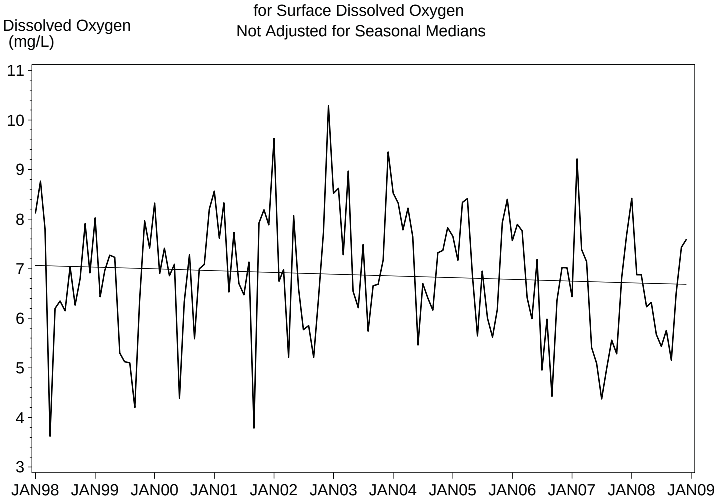
Pine Island Sound Trends Appendix - Display 50
Correlogram for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended

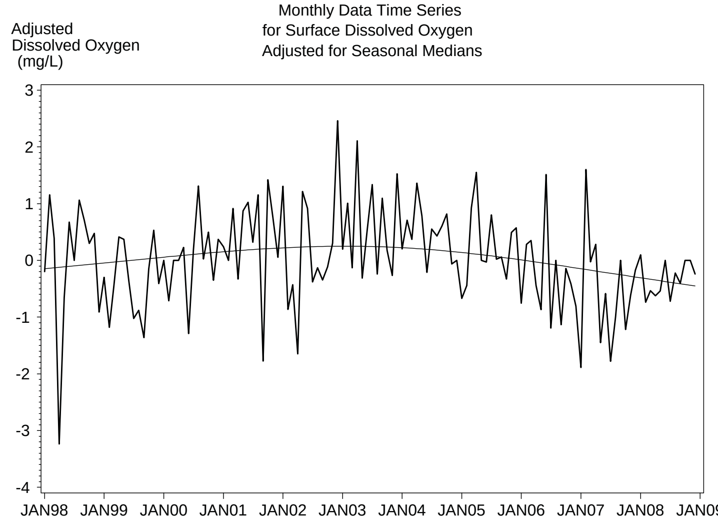



U=Upper 95%  Confidence Limit   L=Lower 95% Confidence Limit
Zero Reference Line Shown

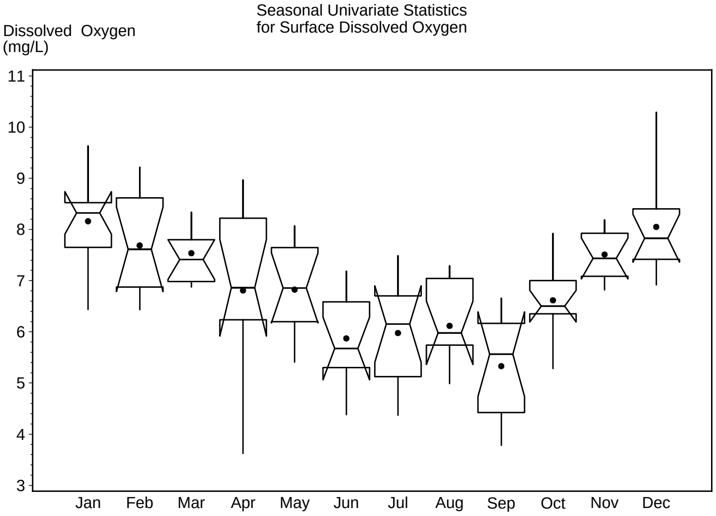
Matlacha Pass Trends Appendix - Display 1
Monthly Data Time Series
for Surface Dissolved Oxygen
Not Adjusted for Seasonal Medians




Matlacha Pass Trends Appendix - Display 2
Monthly Data Time Series
for Surface Dissolved Oxygen
Adjusted for Seasonal Medians




Matlacha Pass Trends Appendix - Display 3
Seasonal Univariate Statistics
for Surface Dissolved Oxygen



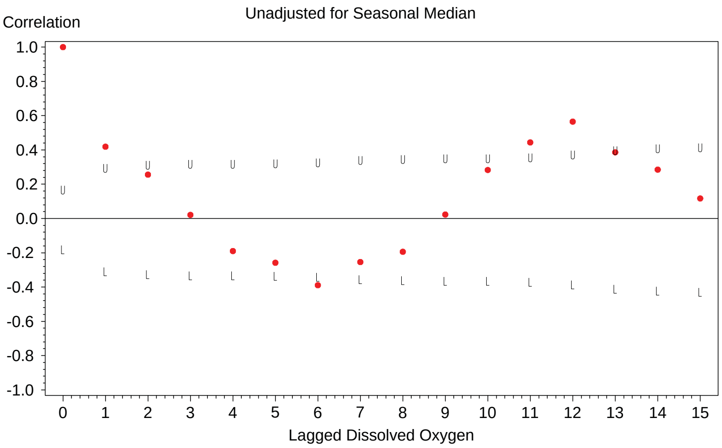

Matlacha Pass Trends Appendix - Display 4
Autocorrelation Statistics for Surface Dissolved Oxygen

Unadjusted for Seasonal Medians

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.419 | 0.151 | 0.302 | -0.302 |
| 2 | 0.256 | 0.159 | 0.319 | -0.319 |
| 3 | 0.021 | 0.162 | 0.325 | -0.325 |
| 4 | -0.190 | 0.162 | 0.325 | -0.325 |
| 5 | -0.258 | 0.164 | 0.328 | -0.328 |
| 6 | -0.389 | 0.167 | 0.334 | -0.334 |
| 7 | -0.254 | 0.174 | 0.348 | -0.348 |
| 8 | -0.194 | 0.177 | 0.353 | -0.353 |
| 9 | 0.023 | 0.178 | 0.357 | -0.357 |
| 10 | 0.283 | 0.178 | 0.357 | -0.357 |
| 11 | 0.444 | 0.182 | 0.363 | -0.363 |
| 12 | 0.565 | 0.190 | 0.379 | -0.379 |
| 13 | 0.386 | 0.202 | 0.404 | -0.404 |
| 14 | 0.285 | 0.208 | 0.415 | -0.415 |
| 15 | 0.117 | 0.211 | 0.421 | -0.421 |

Matlacha Pass Trends Appendix - Display 5
Correlogram for Surface Dissolved Oxygen

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Matlacha Pass Trends Appendix - Display 6
Seasonal Kendall Tau Trend Test Statistics
for Surface Dissolved Oxygen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.133 | 0.051 | 0.257 | -0.047 |

Matlacha Pass Trends  Appendix - Display 7

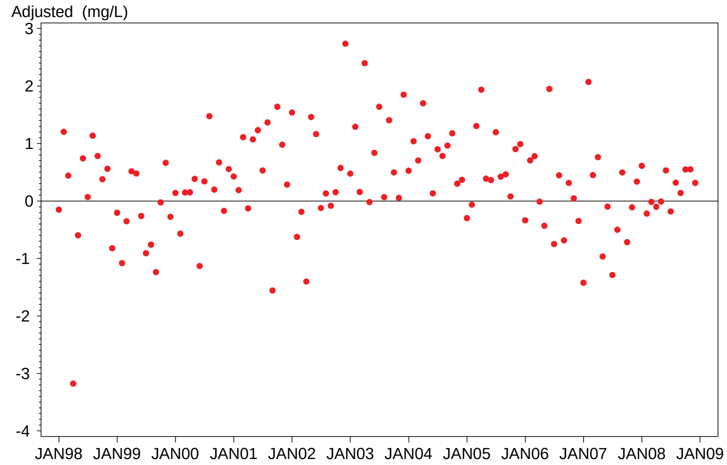
Seasonal Kendall Tau Trend Test Statistics
for Surface Dissolved Oxygen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.13333 | 0.050562 | 0.25677 | -0.0467 |

Matlacha Pass Trends Appendix - Display 8

Time Series Plot of Surface Dissolved Oxygen  Data Adjusted for Season and Detrended




Zero Reference Line Shown

Matlacha Pass Trends  Appendix - Display 9

Autocorrelation Statistics for Surface Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.056 | 0.151 | 0.302 | -0.302 |
| 2 | 0.119 | 0.151 | 0.302 | -0.302 |
| 3 | 0.075 | 0.152 | 0.303 | -0.303 |
| 4 | 0.081 | 0.152 | 0.304 | -0.304 |
| 5 | 0.175 | 0.152 | 0.304 | -0.304 |
| 6 | 0.127 | 0.154 | 0.308 | -0.308 |
| 7 | 0.265 | 0.155 | 0.309 | -0.309 |
| 8 | 0.145 | 0.158 | 0.316 | -0.316 |
| 9 | 0.087 | 0.159 | 0.318 | -0.318 |
| 10 | 0.188 | 0.159 | 0.319 | -0.319 |
| 11 | 0.093 | 0.161 | 0.322 | -0.322 |
| 12 | 0.093 | 0.161 | 0.323 | -0.323 |
| 13 | -0.023 | 0.162 | 0.324 | -0.324 |

Matlacha Pass Trends  Appendix - Display 9

Autocorrelation Statistics for Surface Dissolved Oxygen

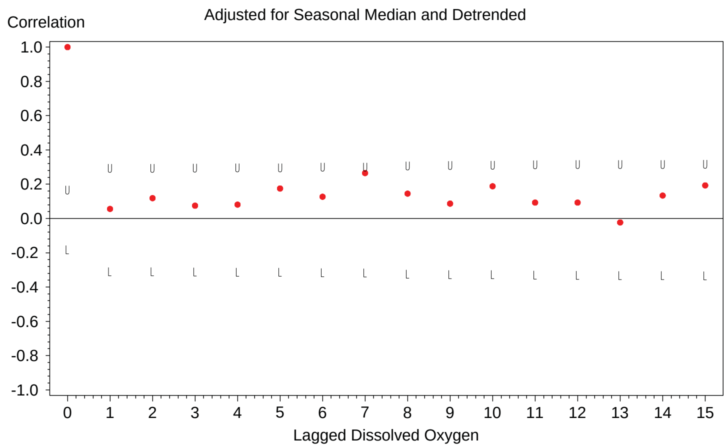
Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | 0.134 | 0.162 | 0.324 | -0.324 |
| 15 | 0.193 | 0.163 | 0.325 | -0.325 |

Matlacha Pass Trends Appendix - Display 10

Correlogram for Surface Dissolved Oxygen

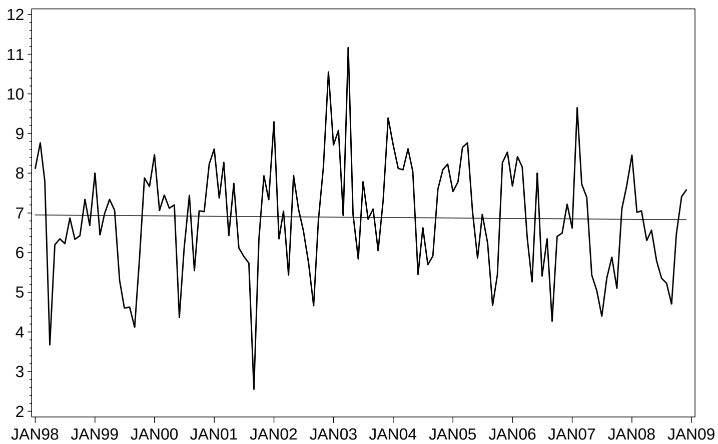
Adjusted for Seasonal Median and Detrended



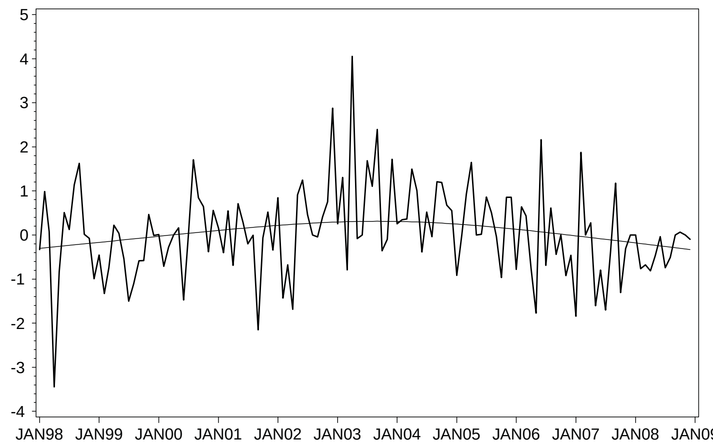

U=Upper  95% Confidence Limit   L=Lower 95% Confidence Limit

Zero Reference Line Shown

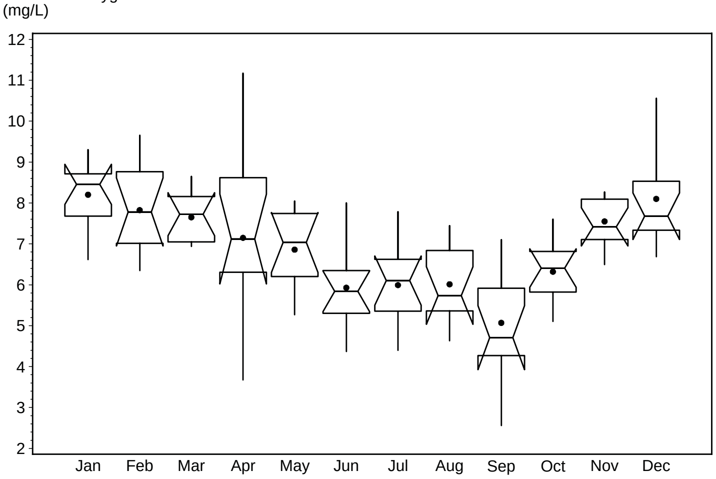
Matlacha Pass Trends Appendix - Display 11
Monthly Data Time Series
for Bottom Dissolved Oxygen
Not Adjusted for Seasonal Medians




Matlacha Pass Trends Appendix - Display 12
Monthly Data Time Series
for Bottom Dissolved Oxygen
Adjusted for Seasonal Medians




Matlacha Pass Trends Appendix - Display 13
Seasonal Univariate Statistics
for Bottom Dissolved Oxygen



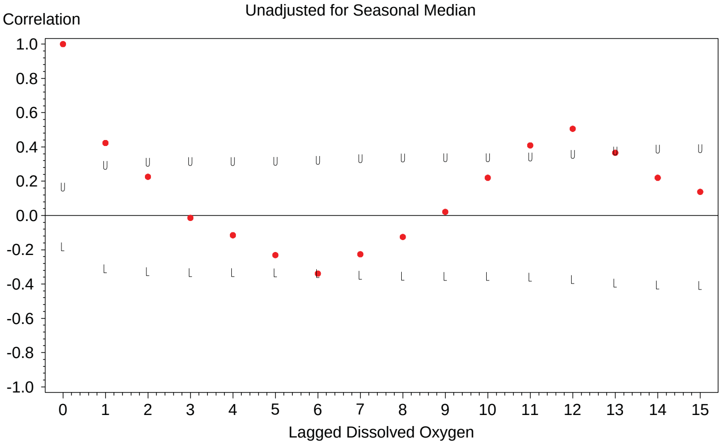

Matlacha Pass Trends Appendix - Display 14
Autocorrelation Statistics for Bottom Dissolved Oxygen

Unadjusted for Seasonal Medians

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.423 | 0.151 | 0.302 | -0.302 |
| 2 | 0.226 | 0.159 | 0.319 | -0.319 |
| 3 | -0.014 | 0.162 | 0.324 | -0.324 |
| 4 | -0.115 | 0.162 | 0.324 | -0.324 |
| 5 | -0.231 | 0.163 | 0.325 | -0.325 |
| 6 | -0.339 | 0.165 | 0.330 | -0.330 |
| 7 | -0.226 | 0.170 | 0.340 | -0.340 |
| 8 | -0.125 | 0.172 | 0.345 | -0.345 |
| 9 | 0.021 | 0.173 | 0.346 | -0.346 |
| 10 | 0.220 | 0.173 | 0.346 | -0.346 |
| 11 | 0.409 | 0.175 | 0.350 | -0.350 |
| 12 | 0.506 | 0.182 | 0.365 | -0.365 |
| 13 | 0.366 | 0.193 | 0.385 | -0.385 |
| 14 | 0.220 | 0.198 | 0.396 | -0.396 |
| 15 | 0.138 | 0.200 | 0.399 | -0.399 |

Matlacha Pass Trends Appendix - Display 15
Correlogram for Bottom Dissolved Oxygen

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Matlacha Pass Trends Appendix - Display 16

Seasonal Kendall Tau Trend Test Statistics
for Bottom Dissolved Oxygen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.03 | 0.669 | 0.776 | -0.01 |

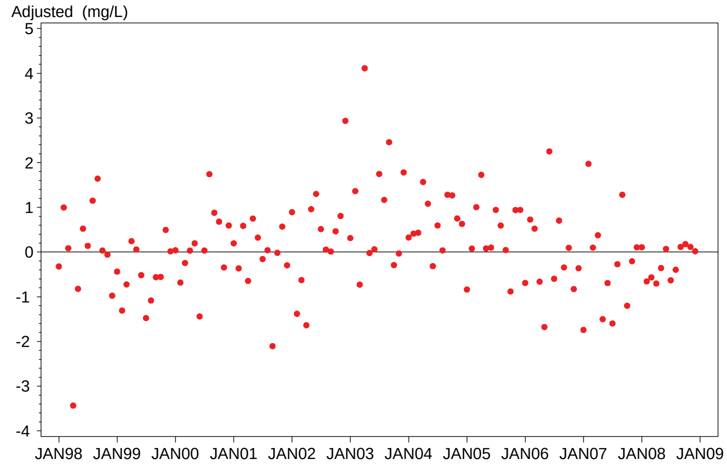
Matlacha Pass Trends  Appendix - Display 17

Seasonal Kendall Tau Trend Test Statistics
for Bottom Dissolved Oxygen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.030303 | 0.66938 | 0.77606 | -.00983333 |

Matlacha Pass Trends Appendix - Display 18
Time Series Plot of Bottom Dissolved  Oxygen Data Adjusted for Season and Detrended




Zero Reference Line Shown

Matlacha Pass Trends  Appendix - Display 19

Autocorrelation Statistics for Bottom Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.102 | 0.151 | 0.302 | -0.302 |
| 2 | 0.102 | 0.151 | 0.303 | -0.303 |
| 3 | 0.023 | 0.152 | 0.304 | -0.304 |
| 4 | 0.164 | 0.152 | 0.304 | -0.304 |
| 5 | 0.171 | 0.153 | 0.306 | -0.306 |
| 6 | 0.129 | 0.155 | 0.309 | -0.309 |
| 7 | 0.268 | 0.155 | 0.311 | -0.311 |
| 8 | 0.205 | 0.159 | 0.318 | -0.318 |
| 9 | 0.100 | 0.161 | 0.322 | -0.322 |
| 10 | 0.100 | 0.161 | 0.323 | -0.323 |
| 11 | 0.053 | 0.162 | 0.324 | -0.324 |
| 12 | 0.057 | 0.162 | 0.324 | -0.324 |
| 13 | -0.014 | 0.162 | 0.324 | -0.324 |

Matlacha Pass Trends  Appendix - Display 19

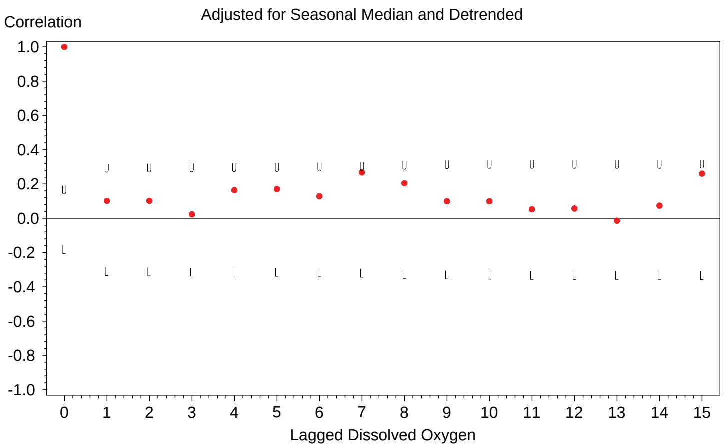
Autocorrelation Statistics for Bottom Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | 0.074 | 0.162 | 0.324 | -0.324 |
| 15 | 0.261 | 0.162 | 0.325 | -0.325 |

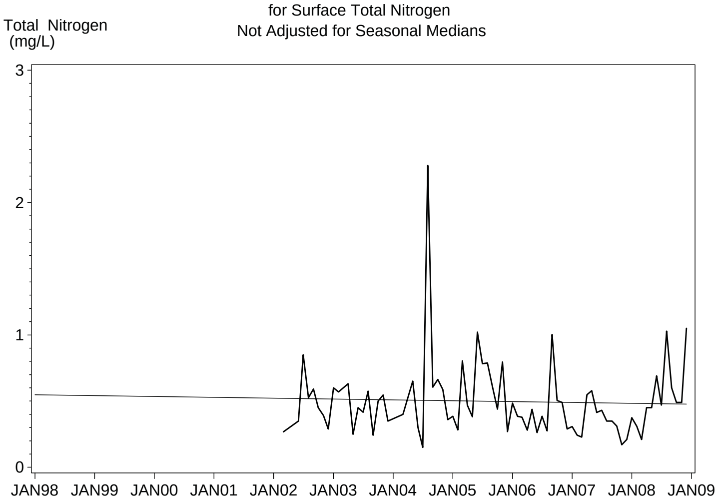
Matlacha Pass Trends Appendix - Display 20
Correlogram for Bottom Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

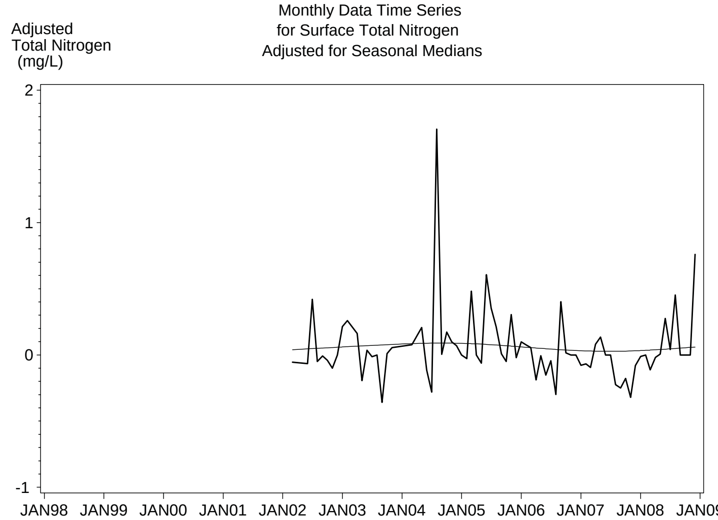



U=Upper  95% Confidence Limit   L=Lower 95% Confidence Limit
Zero Reference Line Shown

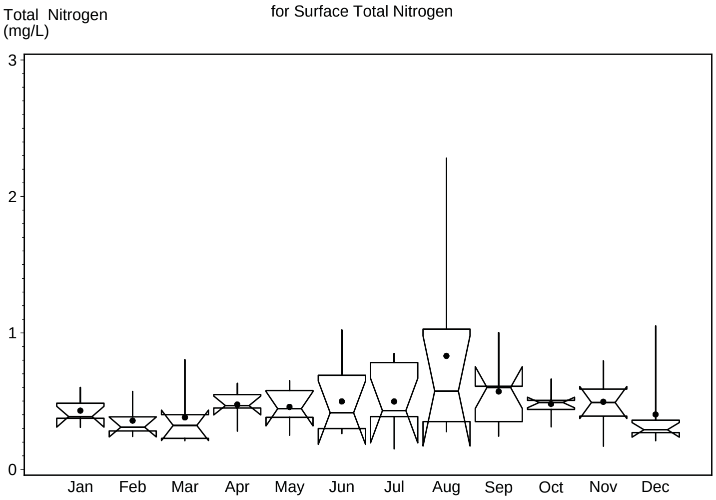
Matlacha Pass Trends Appendix - Display 21
Monthly Data Time Series
for Surface Total Nitrogen
Not Adjusted for Seasonal Medians




Matlacha Pass Trends Appendix - Display 22
Monthly Data Time Series
for Surface Total Nitrogen
Adjusted for Seasonal Medians




Matlacha Pass Trends Appendix - Display 23
Seasonal Univariate Statistics
for Surface Total Nitrogen



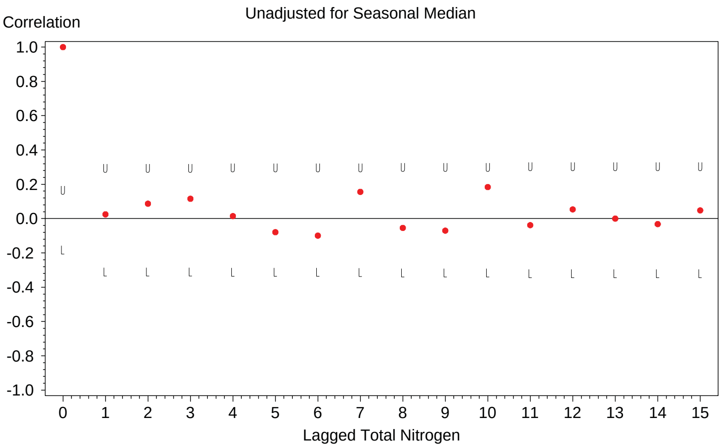

Matlacha Pass Trends Appendix - Display 24
Autocorrelation Statistics for Surface Total Nitrogen

Unadjusted for Seasonal Medians

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.025 | 0.151 | 0.302 | -0.302 |
| 2 | 0.087 | 0.151 | 0.302 | -0.302 |
| 3 | 0.116 | 0.151 | 0.302 | -0.302 |
| 4 | 0.015 | 0.152 | 0.304 | -0.304 |
| 5 | -0.079 | 0.152 | 0.304 | -0.304 |
| 6 | -0.099 | 0.152 | 0.304 | -0.304 |
| 7 | 0.156 | 0.153 | 0.305 | -0.305 |
| 8 | -0.054 | 0.154 | 0.308 | -0.308 |
| 9 | -0.070 | 0.154 | 0.308 | -0.308 |
| 10 | 0.184 | 0.154 | 0.308 | -0.308 |
| 11 | -0.038 | 0.156 | 0.312 | -0.312 |
| 12 | 0.054 | 0.156 | 0.312 | -0.312 |
| 13 | 0.000 | 0.156 | 0.312 | -0.312 |
| 14 | -0.032 | 0.156 | 0.312 | -0.312 |
| 15 | 0.048 | 0.156 | 0.312 | -0.312 |

Matlacha Pass Trends Appendix - Display 25
Correlogram for Surface Total Nitrogen

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Matlacha Pass Trends Appendix - Display 26

Seasonal Kendall Tau Trend Test Statistics
for Surface Total Nitrogen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.063 | 0.556 | 0.655 | -.006 |

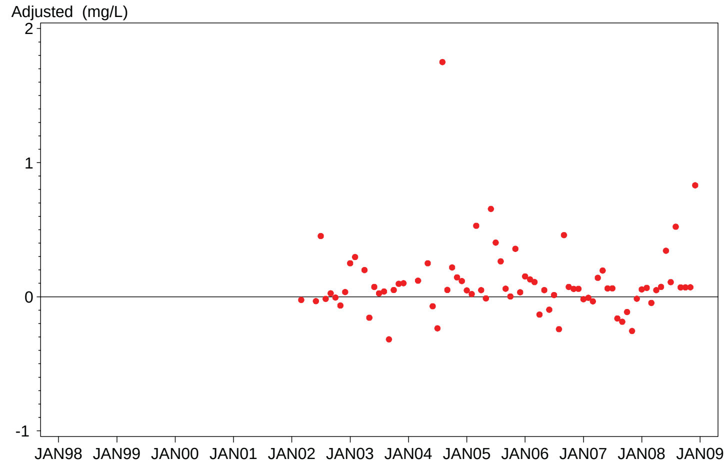
Matlacha Pass Trends  Appendix - Display 27

Seasonal Kendall Tau Trend Test Statistics
for Surface Total Nitrogen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.062802 | 0.55582 | 0.65509 | -.006 |

Matlacha Pass Trends Appendix - Display 28
Time Series Plot of Surface Total Nitrogen  Data Adjusted for Season and Detrended




Zero Reference Line Shown

Matlacha Pass Trends  Appendix - Display 29

Autocorrelation Statistics for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | -0.058 | 0.151 | 0.302 | -0.302 |
| 2 | 0.046 | 0.151 | 0.302 | -0.302 |
| 3 | 0.089 | 0.151 | 0.302 | -0.302 |
| 4 | 0.119 | 0.151 | 0.303 | -0.303 |
| 5 | -0.004 | 0.152 | 0.304 | -0.304 |
| 6 | 0.027 | 0.152 | 0.304 | -0.304 |
| 7 | 0.226 | 0.152 | 0.304 | -0.304 |
| 8 | -0.004 | 0.155 | 0.309 | -0.309 |
| 9 | -0.093 | 0.155 | 0.309 | -0.309 |
| 10 | 0.181 | 0.155 | 0.310 | -0.310 |
| 11 | -0.107 | 0.157 | 0.313 | -0.313 |
| 12 | -0.068 | 0.157 | 0.315 | -0.315 |
| 13 | -0.092 | 0.157 | 0.315 | -0.315 |

Matlacha Pass Trends  Appendix - Display 29

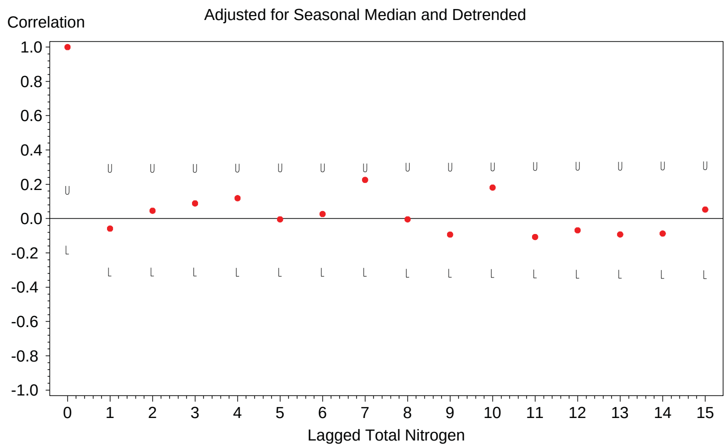
Autocorrelation Statistics for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | -0.087 | 0.158 | 0.316 | -0.316 |
| 15 | 0.053 | 0.158 | 0.317 | -0.317 |

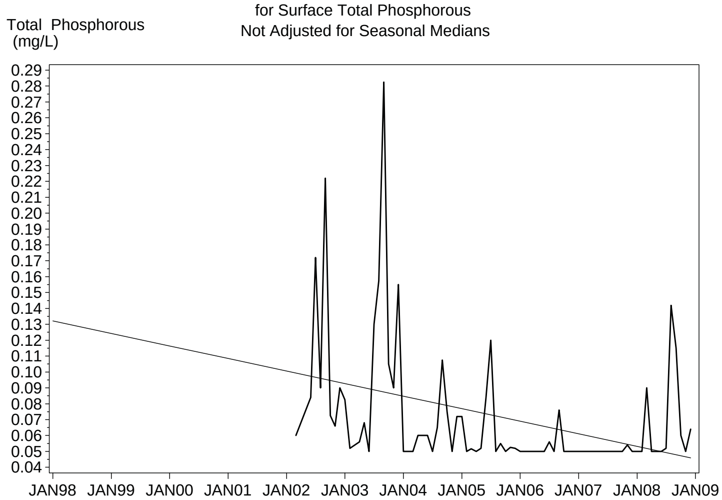
Matlacha Pass Trends Appendix - Display 30
Correlogram for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

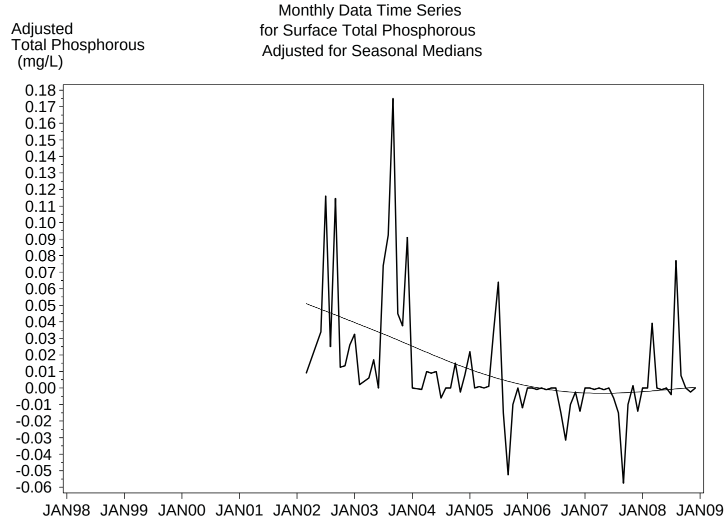



U=Upper  95% Confidence Limit   L=Lower 95% Confidence Limit
Zero Reference Line Shown

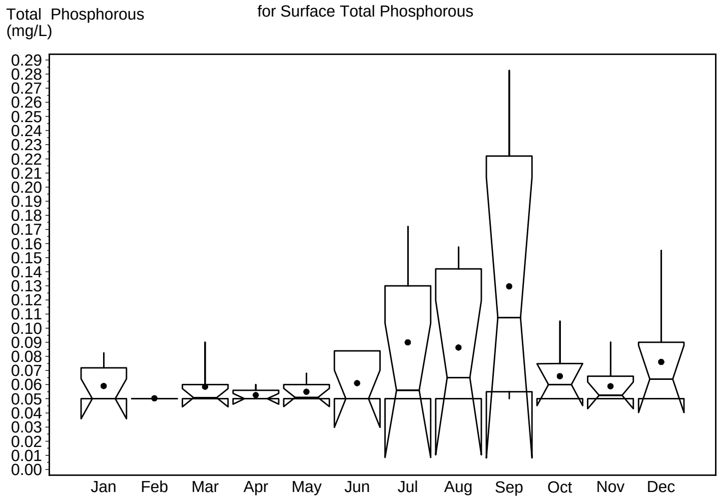
Matlacha Pass Trends Appendix - Display 31
Monthly Data Time Series
for Surface Total Phosphorous
Not Adjusted for Seasonal Medians




Matlacha Pass Trends Appendix - Display 32
Monthly Data Time Series
for Surface Total Phosphorous
Adjusted for Seasonal Medians




Matlacha Pass Trends Appendix - Display 33
Seasonal Univariate Statistics
for Surface Total Phosphorous



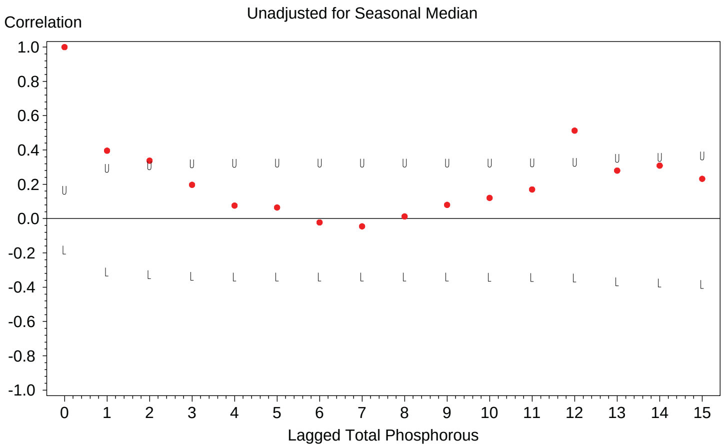

Matlacha Pass Trends Appendix - Display 34
Autocorrelation Statistics for Surface Total Phosphorous

Unadjusted for Seasonal Medians

| Lagged Total Phosphorous | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.396 | 0.151 | 0.302 | -0.302 |
| 2 | 0.338 | 0.158 | 0.317 | -0.317 |
| 3 | 0.197 | 0.164 | 0.328 | -0.328 |
| 4 | 0.076 | 0.166 | 0.331 | -0.331 |
| 5 | 0.065 | 0.166 | 0.332 | -0.332 |
| 6 | -0.022 | 0.166 | 0.332 | -0.332 |
| 7 | -0.045 | 0.166 | 0.332 | -0.332 |
| 8 | 0.013 | 0.166 | 0.332 | -0.332 |
| 9 | 0.080 | 0.166 | 0.332 | -0.332 |
| 10 | 0.121 | 0.166 | 0.333 | -0.333 |
| 11 | 0.170 | 0.167 | 0.334 | -0.334 |
| 12 | 0.513 | 0.168 | 0.337 | -0.337 |
| 13 | 0.280 | 0.180 | 0.360 | -0.360 |
| 14 | 0.309 | 0.183 | 0.366 | -0.366 |
| 15 | 0.232 | 0.187 | 0.374 | -0.374 |

Matlacha Pass Trends Appendix - Display 35
Correlogram for Surface Total Phosphorous

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Matlacha Pass Trends Appendix - Display 36

Seasonal Kendall Tau Trend Test Statistics
for Surface Total Phosphorous

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.429 | 0 | 0.048 | -.003 |

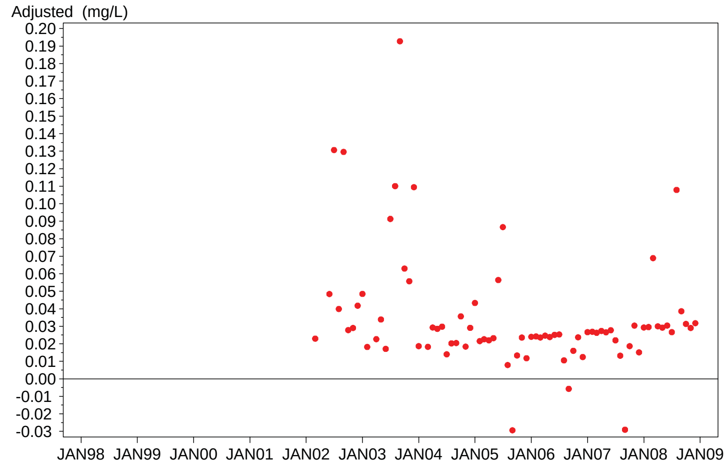
Matlacha Pass Trends Appendix - Display 37

Seasonal Kendall Tau Trend Test Statistics
for Surface Total Phosphorous

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.42857 | .000002761 | 0.048049 | -.00266667 |

Matlacha Pass Trends Appendix - Display 38
Time Series Plot of Surface Total Phosphorous Data Adjusted for Season and Detrended




Zero Reference Line Shown

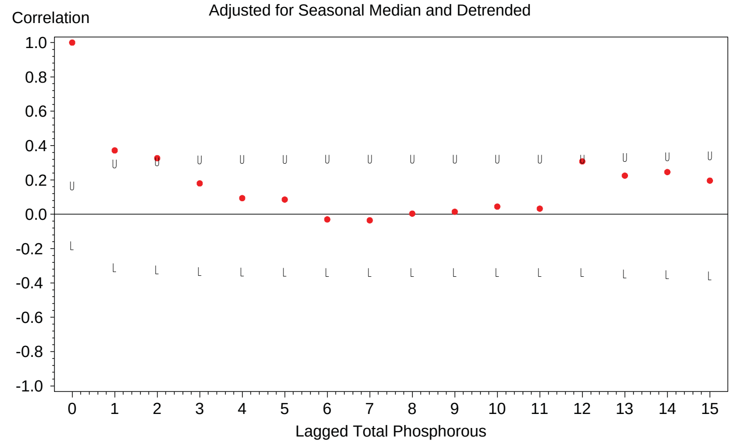
Matlacha Pass Trends Appendix - Display 39
Autocorrelation Statistics for Surface Total Phosphorous

Adjusted for Seasonal Median and Detrended

| Lagged Total Phosphorous | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.372 | 0.151 | 0.302 | -0.302 |
| 2 | 0.327 | 0.158 | 0.315 | -0.315 |
| 3 | 0.180 | 0.163 | 0.325 | -0.325 |
| 4 | 0.094 | 0.164 | 0.328 | -0.328 |
| 5 | 0.086 | 0.165 | 0.329 | -0.329 |
| 6 | -0.030 | 0.165 | 0.330 | -0.330 |
| 7 | -0.035 | 0.165 | 0.330 | -0.330 |
| 8 | 0.004 | 0.165 | 0.330 | -0.330 |
| 9 | 0.015 | 0.165 | 0.330 | -0.330 |
| 10 | 0.045 | 0.165 | 0.330 | -0.330 |
| 11 | 0.033 | 0.165 | 0.330 | -0.330 |
| 12 | 0.308 | 0.165 | 0.330 | -0.330 |
| 13 | 0.225 | 0.169 | 0.339 | -0.339 |
| 14 | 0.246 | 0.172 | 0.343 | -0.343 |
| 15 | 0.196 | 0.174 | 0.349 | -0.349 |

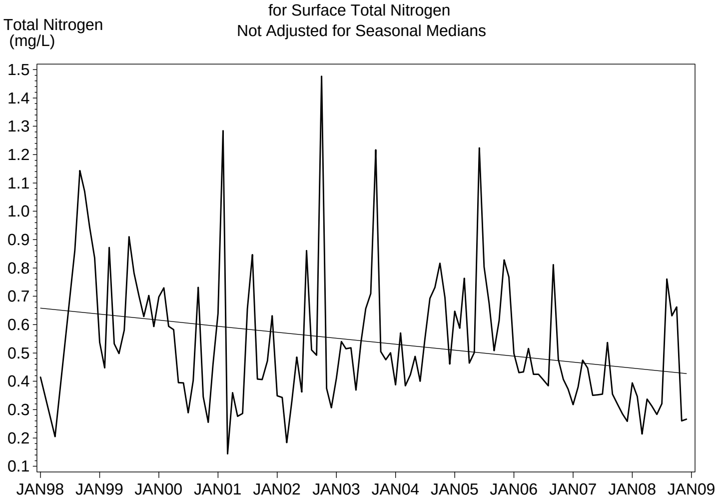
Matlacha Pass Trends Appendix - Display 40
Correlogram for Surface Total Phosphorous

Adjusted for Seasonal Median and Detrended

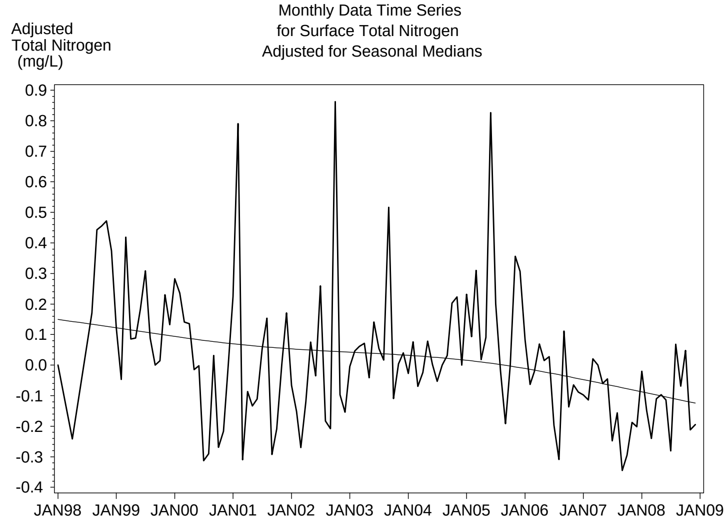



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

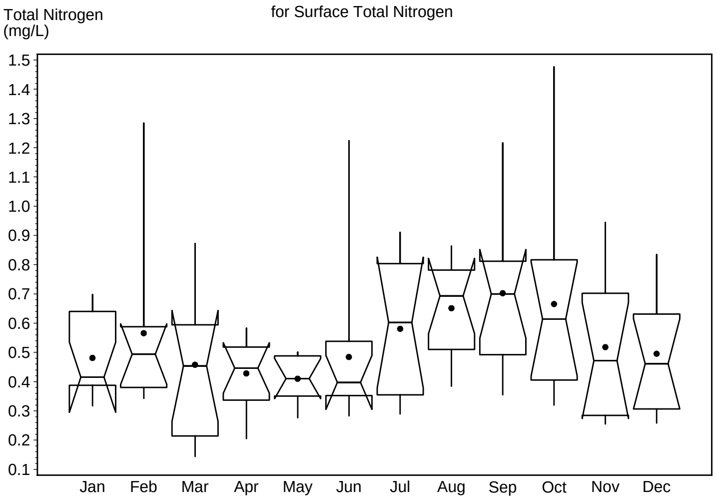
San Carlos Bay Trends Appendix - Display 1
Monthly Data Time Series
for Surface Total Nitrogen
Not Adjusted for Seasonal Medians




San Carlos Bay Trends Appendix - Display 2
Monthly Data Time Series
for Surface Total Nitrogen
Adjusted for Seasonal Medians




San Carlos Bay Trends Appendix - Display 3
Seasonal Univariate Statistics
for Surface Total Nitrogen



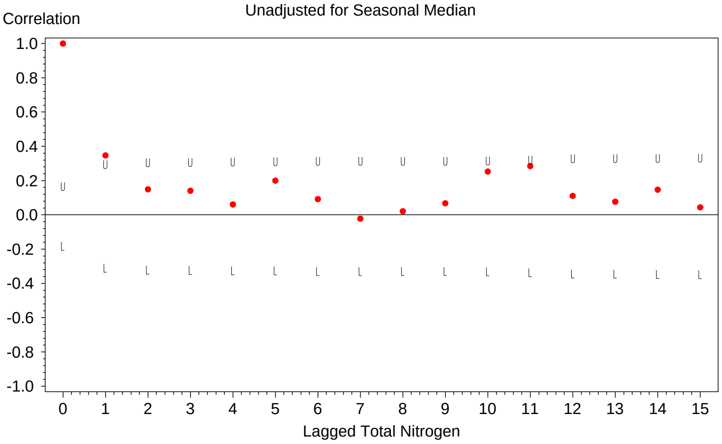

San Carlos Bay Trends Appendix - Display 4
Autocorrelation Statistics for Surface Total Nitrogen

Unadjusted for Seasonal Medians

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.347 | 0.151 | 0.302 | -0.302 |
| 2 | 0.149 | 0.157 | 0.313 | -0.313 |
| 3 | 0.141 | 0.158 | 0.315 | -0.315 |
| 4 | 0.061 | 0.159 | 0.317 | -0.317 |
| 5 | 0.200 | 0.159 | 0.318 | -0.318 |
| 6 | 0.092 | 0.161 | 0.322 | -0.322 |
| 7 | -0.022 | 0.161 | 0.322 | -0.322 |
| 8 | 0.021 | 0.161 | 0.322 | -0.322 |
| 9 | 0.068 | 0.161 | 0.322 | -0.322 |
| 10 | 0.253 | 0.161 | 0.323 | -0.323 |
| 11 | 0.285 | 0.164 | 0.329 | -0.329 |
| 12 | 0.111 | 0.168 | 0.336 | -0.336 |
| 13 | 0.077 | 0.169 | 0.337 | -0.337 |
| 14 | 0.147 | 0.169 | 0.338 | -0.338 |
| 15 | 0.044 | 0.170 | 0.340 | -0.340 |

San Carlos Bay Trends Appendix - Display 5
Correlogram for Surface Total Nitrogen

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

San Carlos Bay Trends Appendix - Display 6
Seasonal Kendall Tau Trend Test Statistics
for Surface Total Nitrogen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.259 | 0 | 0.056 | -0.022 |

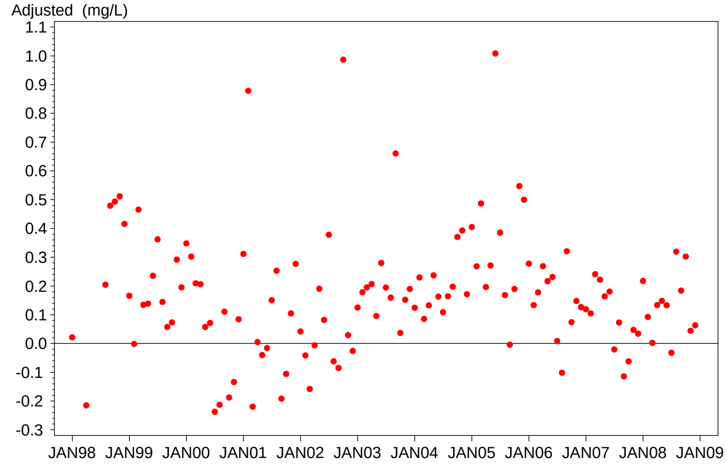
San Carlos Bay Trends Appendix - Display 7

Seasonal Kendall Tau Trend Test Statistics
for Surface Total Nitrogen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.26066 | .000179925 | 0.054496 | -0.021675 |

San Carlos Bay Trends Appendix - Display 8
Time Series Plot of Surface Total Nitrogen Data Adjusted for Season and Detrended




Zero Reference Line Shown

San Carlos Bay Trends Appendix - Display 9

Autocorrelation Statistics for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.210 | 0.151 | 0.302 | -0.302 |
| 2 | 0.042 | 0.153 | 0.306 | -0.306 |
| 3 | 0.120 | 0.153 | 0.306 | -0.306 |
| 4 | 0.082 | 0.154 | 0.308 | -0.308 |
| 5 | 0.234 | 0.154 | 0.308 | -0.308 |
| 6 | 0.082 | 0.157 | 0.313 | -0.313 |
| 7 | -0.045 | 0.157 | 0.314 | -0.314 |
| 8 | 0.028 | 0.157 | 0.314 | -0.314 |
| 9 | 0.033 | 0.157 | 0.314 | -0.314 |
| 10 | 0.178 | 0.157 | 0.315 | -0.315 |
| 11 | 0.177 | 0.159 | 0.318 | -0.318 |
| 12 | -0.036 | 0.160 | 0.321 | -0.321 |
| 13 | -0.032 | 0.160 | 0.321 | -0.321 |

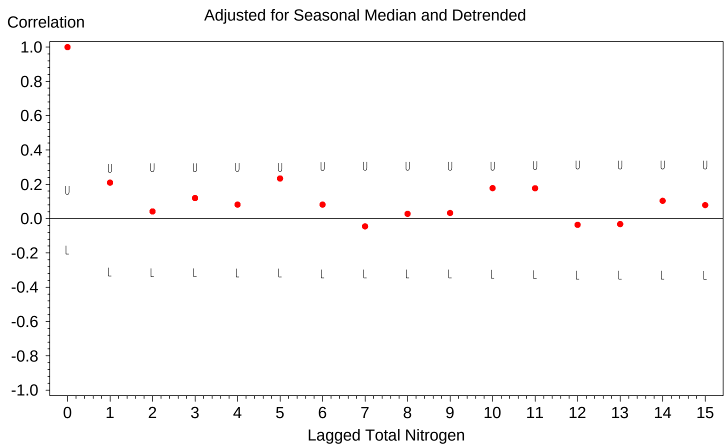
San Carlos Bay Trends Appendix - Display 9
X

Adjusted for Seasonal Median and Detrended

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | 0.104 | 0.160 | 0.321 | -0.321 |
| 15 | 0.079 | 0.161 | 0.322 | -0.322 |

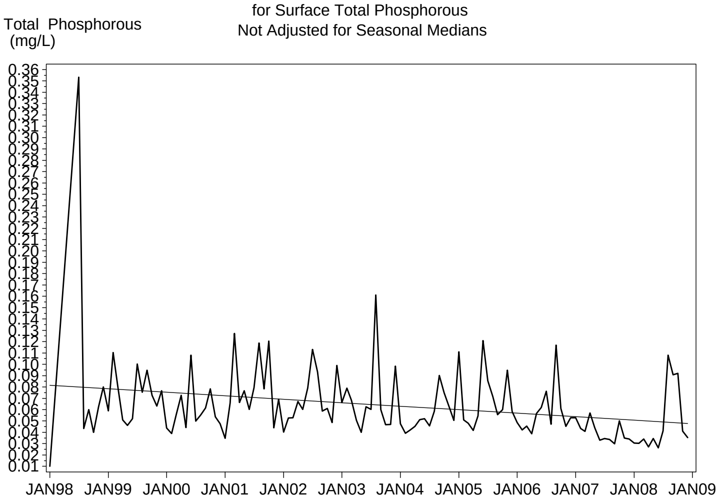
San Carlos Bay Trends Appendix - Display 10
Correlogram for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

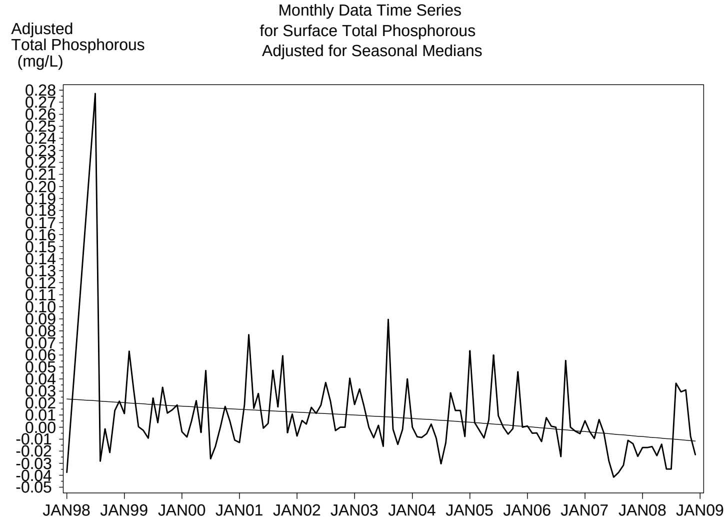



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

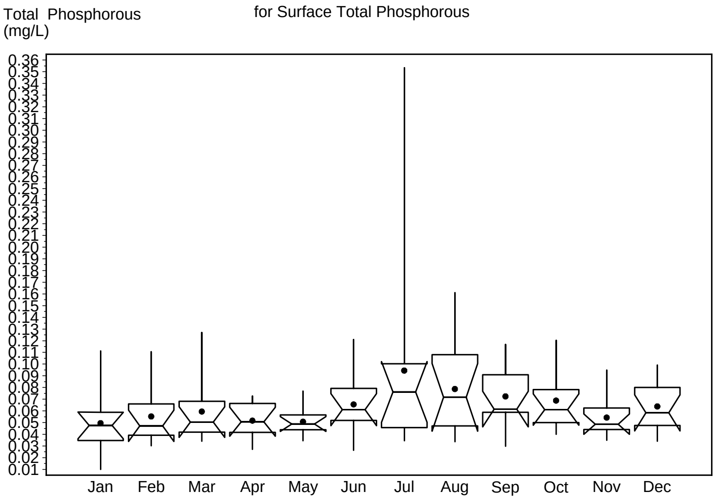
San Carlos Bay Trends Appendix - Display 11
Monthly Data Time Series
for Surface Total Phosphorous
Not Adjusted for Seasonal Medians




San Carlos Bay Trends Appendix - Display 12
Monthly Data Time Series
for Surface Total Phosphorous
Adjusted for Seasonal Medians




San Carlos Bay Trends Appendix - Display 13
Seasonal Univariate Statistics
for Surface Total Phosphorous



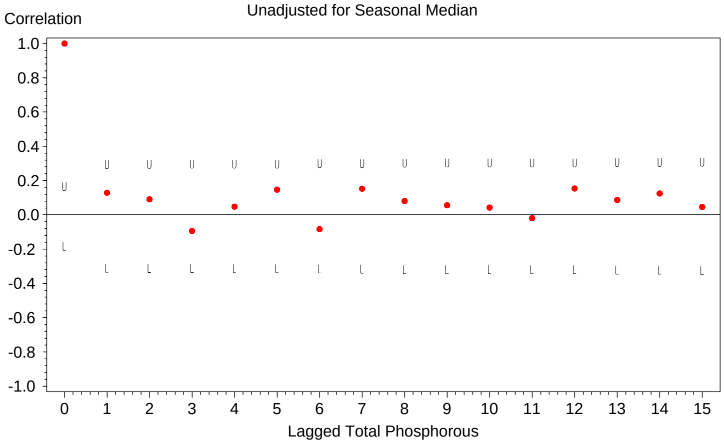

San Carlos Bay Trends Appendix - Display 14
Autocorrelation Statistics for Surface Total Phosphorous

Unadjusted for Seasonal Medians

| Lagged Total Phosphorous | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.129 | 0.151 | 0.302 | -0.302 |
| 2 | 0.091 | 0.152 | 0.303 | -0.303 |
| 3 | -0.094 | 0.152 | 0.304 | -0.304 |
| 4 | 0.048 | 0.152 | 0.305 | -0.305 |
| 5 | 0.147 | 0.153 | 0.305 | -0.305 |
| 6 | -0.083 | 0.154 | 0.307 | -0.307 |
| 7 | 0.153 | 0.154 | 0.308 | -0.308 |
| 8 | 0.081 | 0.155 | 0.310 | -0.310 |
| 9 | 0.056 | 0.155 | 0.311 | -0.311 |
| 10 | 0.043 | 0.156 | 0.311 | -0.311 |
| 11 | -0.019 | 0.156 | 0.311 | -0.311 |
| 12 | 0.154 | 0.156 | 0.311 | -0.311 |
| 13 | 0.087 | 0.157 | 0.314 | -0.314 |
| 14 | 0.125 | 0.157 | 0.314 | -0.314 |
| 15 | 0.046 | 0.158 | 0.316 | -0.316 |

San Carlos Bay Trends Appendix - Display 15
Correlogram for Surface Total Phosphorous

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

San Carlos Bay Trends Appendix - Display 16
Seasonal Kendall Tau Trend Test Statistics
for Surface Total Phosphorous

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.274 | 0 | 0.02 | -.003 |

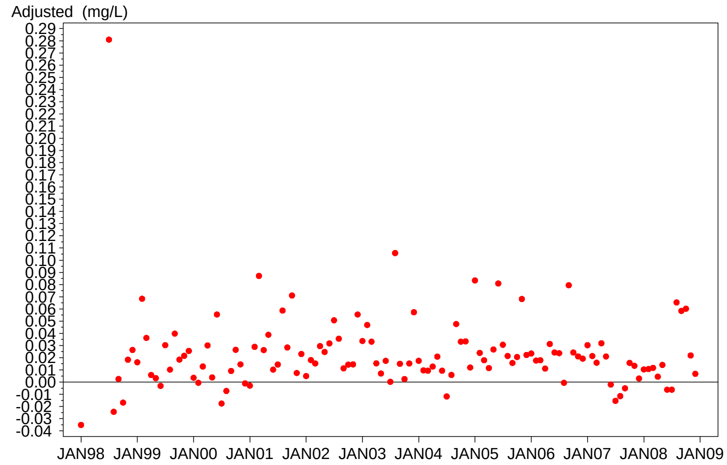
San Carlos Bay Trends Appendix - Display 17

Seasonal Kendall Tau Trend Test Statistics
for Surface Total Phosphorous

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.27869 | .000058426 | 0.017734 | -.0025 |

San Carlos Bay Trends Appendix - Display 18
Time Series Plot of Surface Total Phosphorous Data Adjusted for Season and Detrended




Zero Reference Line Shown

San Carlos Bay Trends Appendix - Display 19

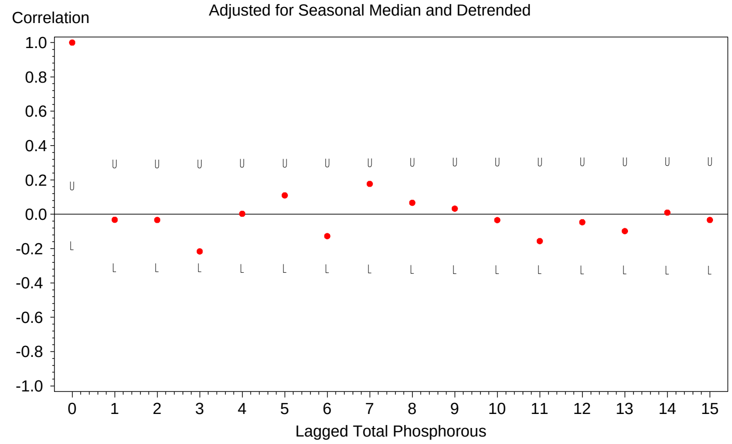
Autocorrelation Statistics for Surface Total Phosphorous

Adjusted for Seasonal Median and Detrended

| Lagged Total Phosphorous | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | -0.032 | 0.151 | 0.302 | -0.302 |
| 2 | -0.033 | 0.151 | 0.302 | -0.302 |
| 3 | -0.216 | 0.151 | 0.302 | -0.302 |
| 4 | 0.003 | 0.153 | 0.306 | -0.306 |
| 5 | 0.110 | 0.153 | 0.306 | -0.306 |
| 6 | -0.127 | 0.154 | 0.308 | -0.308 |
| 7 | 0.177 | 0.155 | 0.309 | -0.309 |
| 8 | 0.067 | 0.156 | 0.312 | -0.312 |
| 9 | 0.033 | 0.156 | 0.313 | -0.313 |
| 10 | -0.034 | 0.156 | 0.313 | -0.313 |
| 11 | -0.156 | 0.156 | 0.313 | -0.313 |
| 12 | -0.046 | 0.158 | 0.315 | -0.315 |
| 13 | -0.098 | 0.158 | 0.315 | -0.315 |
| 14 | 0.010 | 0.158 | 0.316 | -0.316 |
| 15 | -0.033 | 0.158 | 0.316 | -0.316 |

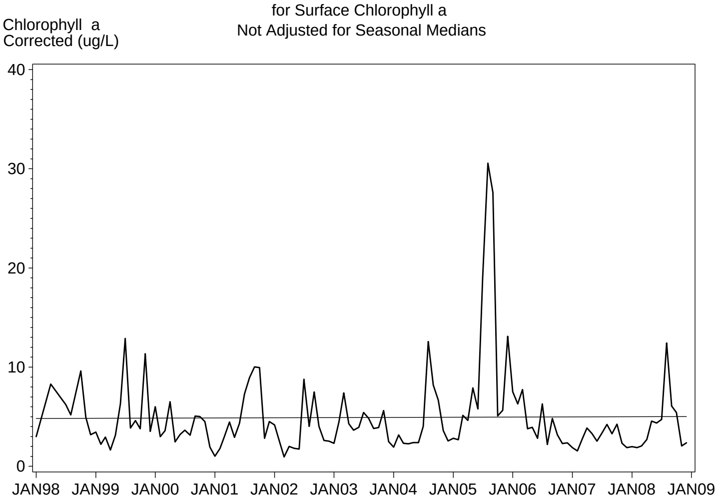
San Carlos Bay Trends Appendix - Display 20
Correlogram for Surface Total Phosphorous

Adjusted for Seasonal Median and Detrended

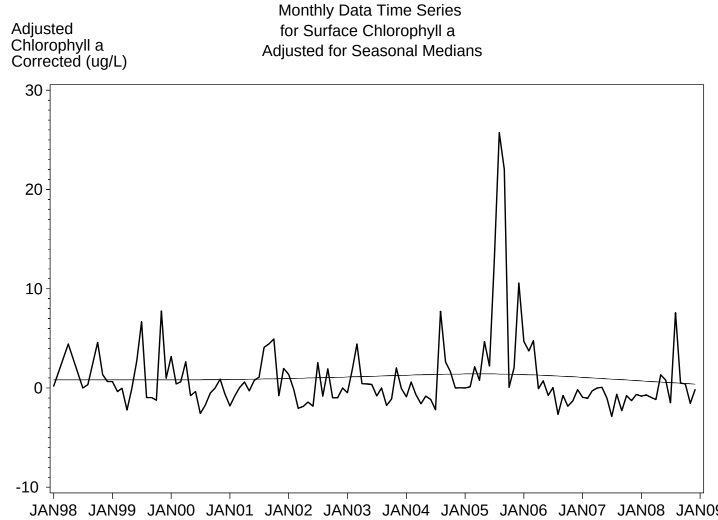



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

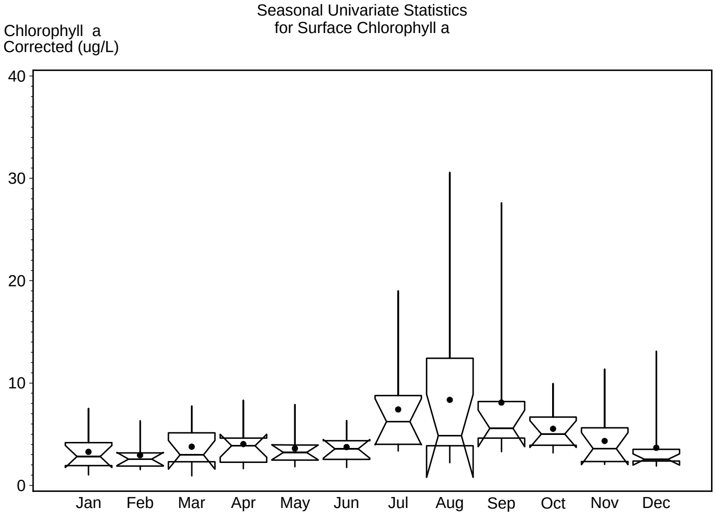
San Carlos Bay Trends Appendix - Display 21
Monthly Data Time Series
for Surface Chlorophyll a
Not Adjusted for Seasonal Medians




San Carlos Bay Trends Appendix - Display 22
Monthly Data Time Series
for Surface Chlorophyll a
Adjusted for Seasonal Medians




San Carlos Bay Trends Appendix - Display 23
Seasonal Univariate Statistics
for Surface Chlorophyll a



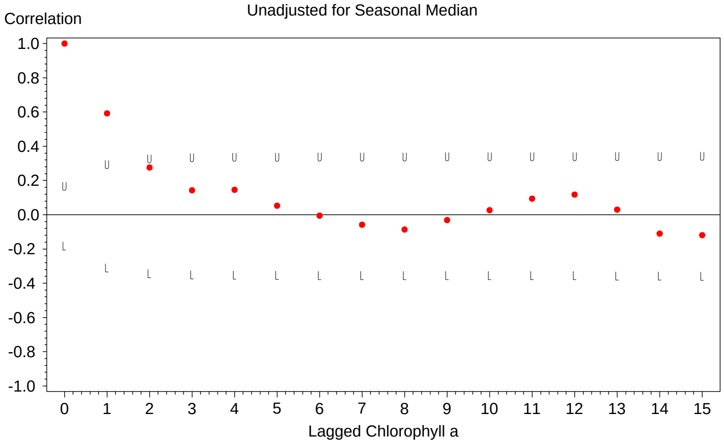

San Carlos Bay Trends Appendix - Display 24
Autocorrelation Statistics for Surface Chlorophyll a

Unadjusted for Seasonal Medians

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.592 | 0.151 | 0.302 | -0.302 |
| 2 | 0.276 | 0.167 | 0.335 | -0.335 |
| 3 | 0.143 | 0.171 | 0.342 | -0.342 |
| 4 | 0.146 | 0.172 | 0.344 | -0.344 |
| 5 | 0.053 | 0.173 | 0.345 | -0.345 |
| 6 | -0.005 | 0.173 | 0.346 | -0.346 |
| 7 | -0.058 | 0.173 | 0.346 | -0.346 |
| 8 | -0.086 | 0.173 | 0.346 | -0.346 |
| 9 | -0.031 | 0.173 | 0.347 | -0.347 |
| 10 | 0.027 | 0.173 | 0.347 | -0.347 |
| 11 | 0.094 | 0.173 | 0.347 | -0.347 |
| 12 | 0.118 | 0.174 | 0.347 | -0.347 |
| 13 | 0.030 | 0.174 | 0.349 | -0.349 |
| 14 | -0.110 | 0.174 | 0.349 | -0.349 |
| 15 | -0.119 | 0.175 | 0.350 | -0.350 |

San Carlos Bay Trends Appendix - Display 25
Correlogram for Surface Chlorophyll a

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

San Carlos Bay Trends Appendix - Display 26

Seasonal Kendall Tau Trend Test Statistics
for Surface Chlorophyll a

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.092 | 0.192 | 0.423 | -0.086 |

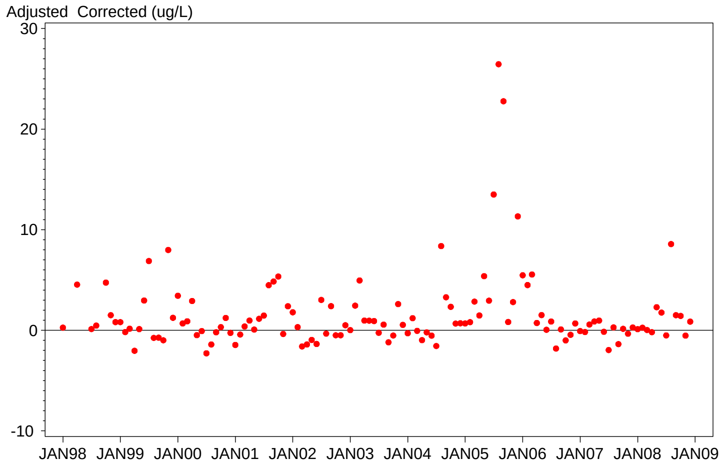
San Carlos Bay Trends  Appendix - Display 27

Seasonal Kendall Tau Trend Test Statistics
for Surface Chlorophyll a

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.091803 | 0.19236 | 0.42293 | -0.085857 |

San Carlos Bay Trends Appendix - Display 28
Time Series Plot of Surface  Chlorophyll a Data Adjusted for Season and Detrended




Zero Reference Line Shown

San Carlos Bay Trends  Appendix - Display 29

Autocorrelation Statistics for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.087 | 0.174 | -0.174 |
| 1 | 0.555 | 0.151 | 0.302 | -0.302 |
| 2 | 0.262 | 0.166 | 0.331 | -0.331 |
| 3 | 0.206 | 0.169 | 0.337 | -0.337 |
| 4 | 0.254 | 0.171 | 0.341 | -0.341 |
| 5 | 0.180 | 0.173 | 0.347 | -0.347 |
| 6 | 0.126 | 0.175 | 0.350 | -0.350 |
| 7 | 0.050 | 0.175 | 0.351 | -0.351 |
| 8 | -0.018 | 0.176 | 0.351 | -0.351 |
| 9 | 0.006 | 0.176 | 0.351 | -0.351 |
| 10 | -0.024 | 0.176 | 0.351 | -0.351 |
| 11 | -0.017 | 0.176 | 0.351 | -0.351 |
| 12 | -0.017 | 0.176 | 0.351 | -0.351 |
| 13 | -0.087 | 0.176 | 0.351 | -0.351 |

San Carlos Bay Trends  Appendix - Display 29

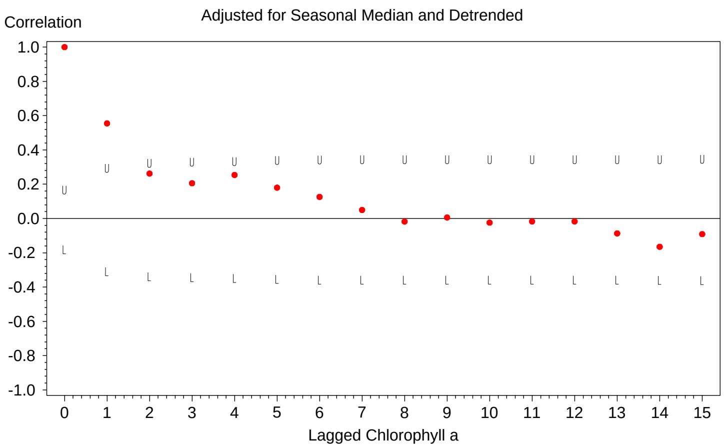
Autocorrelation Statistics for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | -0.165 | 0.176 | 0.352 | -0.352 |
| 15 | -0.091 | 0.177 | 0.354 | -0.354 |

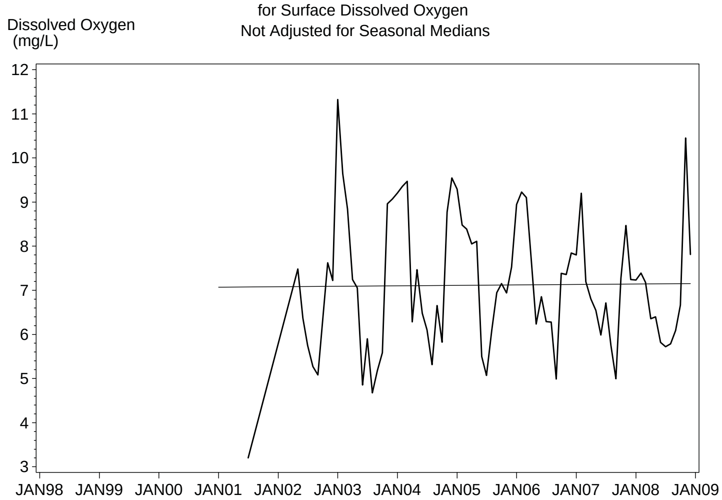
San Carlos Bay Trends Appendix - Display 30
Correlogram for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended

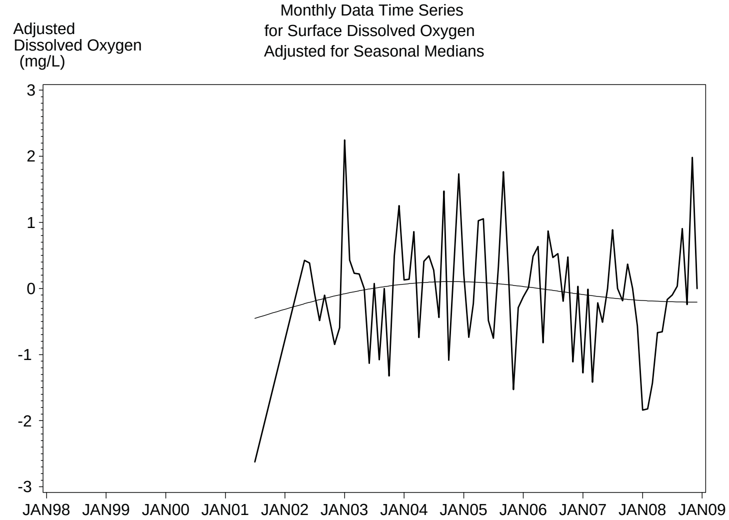



U=Upper 95%  Confidence Limit   L=Lower 95% Confidence Limit
Zero Reference Line Shown

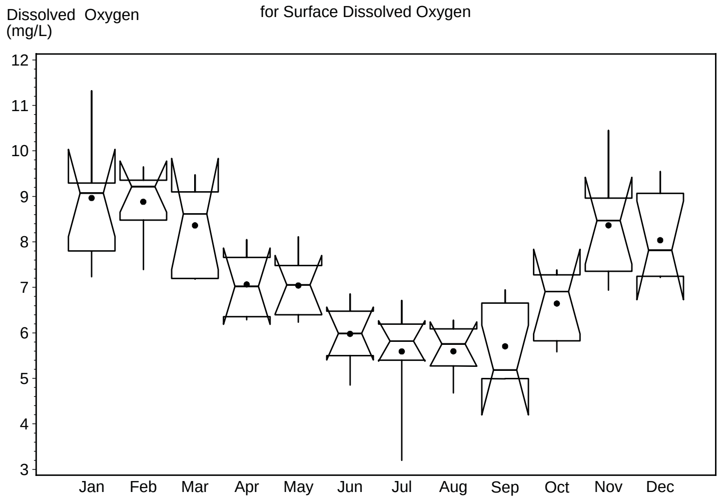
Tidal Caloosahatchee Trends Appendix - Display 1
Monthly Data Time Series
for Surface Dissolved Oxygen
Not Adjusted for Seasonal Medians




Tidal Caloosahatchee Trends Appendix - Display 2
Monthly Data Time Series
for Surface Dissolved Oxygen
Adjusted for Seasonal Medians




Tidal Caloosahatchee Trends Appendix - Display 3
Seasonal Univariate Statistics
for Surface Dissolved Oxygen



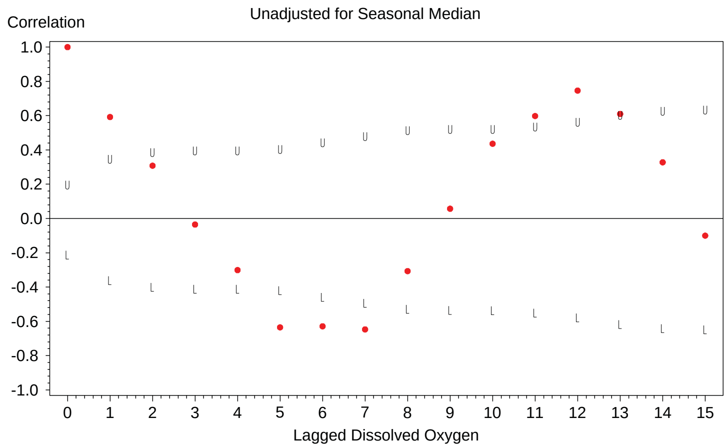

Tidal Caloosahatchee Trends Appendix - Display 4
Autocorrelation Statistics for Surface Dissolved Oxygen

Unadjusted for Seasonal Medians

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.102 | 0.204 | -0.204 |
| 1 | 0.592 | 0.177 | 0.354 | -0.354 |
| 2 | 0.308 | 0.196 | 0.393 | -0.393 |
| 3 | -0.035 | 0.201 | 0.403 | -0.403 |
| 4 | -0.301 | 0.201 | 0.403 | -0.403 |
| 5 | -0.635 | 0.206 | 0.412 | -0.412 |
| 6 | -0.629 | 0.226 | 0.451 | -0.451 |
| 7 | -0.647 | 0.243 | 0.486 | -0.486 |
| 8 | -0.307 | 0.260 | 0.521 | -0.521 |
| 9 | 0.057 | 0.264 | 0.528 | -0.528 |
| 10 | 0.436 | 0.264 | 0.529 | -0.529 |
| 11 | 0.598 | 0.272 | 0.543 | -0.543 |
| 12 | 0.746 | 0.285 | 0.570 | -0.570 |
| 13 | 0.610 | 0.305 | 0.610 | -0.610 |
| 14 | 0.328 | 0.317 | 0.634 | -0.634 |
| 15 | -0.100 | 0.321 | 0.641 | -0.641 |

Tidal Caloosahatchee Trends Appendix - Display 5
Correlogram for Surface Dissolved Oxygen

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Tidal Caloosahatchee Trends Appendix - Display 6
Seasonal Kendall Tau Trend Test Statistics
for Surface Dissolved Oxygen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.048 | 0.646 | 0.638 | -0.022 |

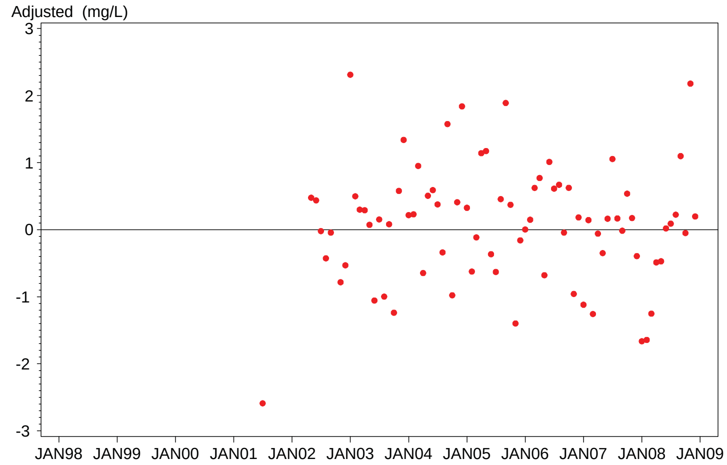
Tidal Caloosahatchee Trends Appendix - Display 7

Seasonal Kendall Tau Trend Test Statistics
for Surface Dissolved Oxygen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.048035 | 0.64566 | 0.63847 | -0.02225 |

Tidal Caloosahatchee Trends Appendix - Display 8
Time Series Plot of Surface Dissolved Oxygen Data Adjusted for Season and Detrended




Zero Reference Line Shown

Tidal Caloosahatchee Trends Appendix - Display 9

Autocorrelation Statistics for Surface Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.102 | 0.204 | -0.204 |
| 1 | 0.119 | 0.177 | 0.354 | -0.354 |
| 2 | 0.033 | 0.178 | 0.355 | -0.355 |
| 3 | 0.016 | 0.178 | 0.355 | -0.355 |
| 4 | 0.124 | 0.178 | 0.355 | -0.355 |
| 5 | -0.143 | 0.179 | 0.357 | -0.357 |
| 6 | -0.071 | 0.180 | 0.360 | -0.360 |
| 7 | -0.302 | 0.180 | 0.360 | -0.360 |
| 8 | -0.131 | 0.185 | 0.371 | -0.371 |
| 9 | -0.039 | 0.186 | 0.372 | -0.372 |
| 10 | 0.110 | 0.186 | 0.373 | -0.373 |
| 11 | 0.007 | 0.187 | 0.374 | -0.374 |
| 12 | 0.187 | 0.187 | 0.374 | -0.374 |
| 13 | 0.098 | 0.189 | 0.378 | -0.378 |

Tidal Caloosahatchee Trends Appendix - Display 9

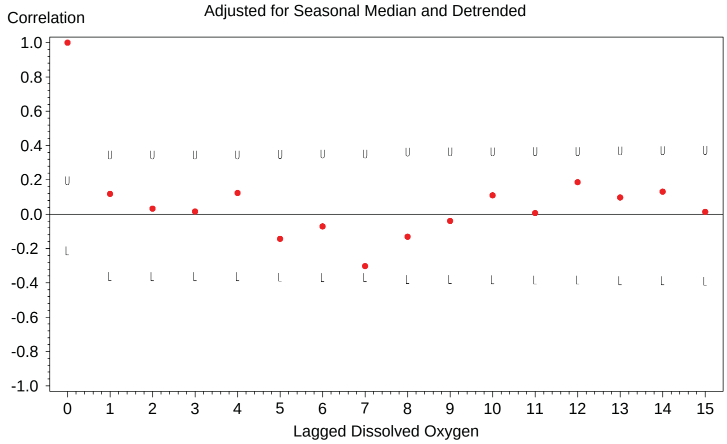
Autocorrelation Statistics for Surface Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | 0.132 | 0.189 | 0.379 | -0.379 |
| 15 | 0.014 | 0.190 | 0.381 | -0.381 |

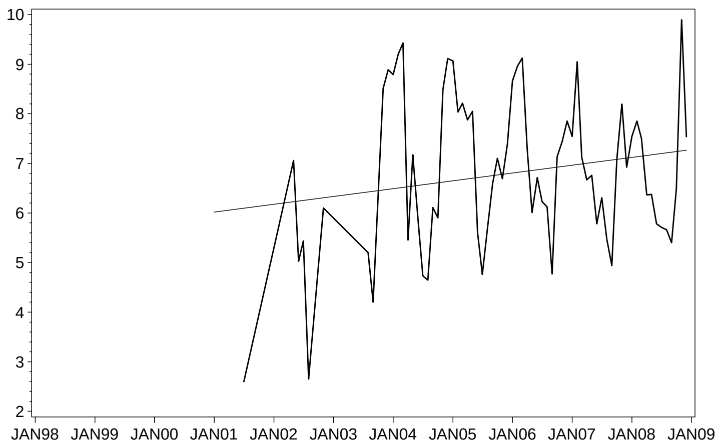
Tidal Caloosahatchee Trends Appendix - Display 10
Correlogram for Surface Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

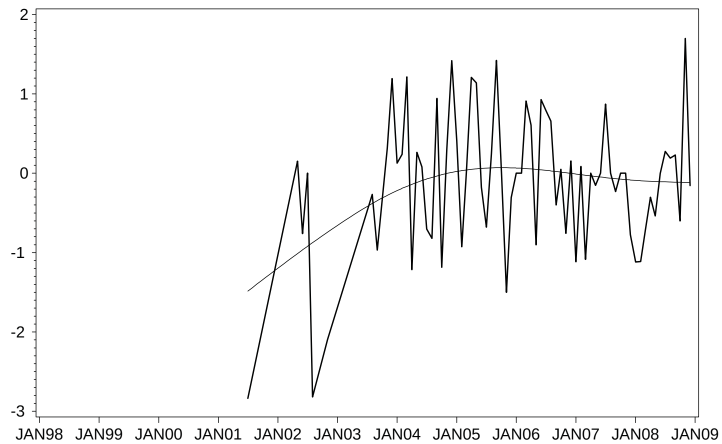



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

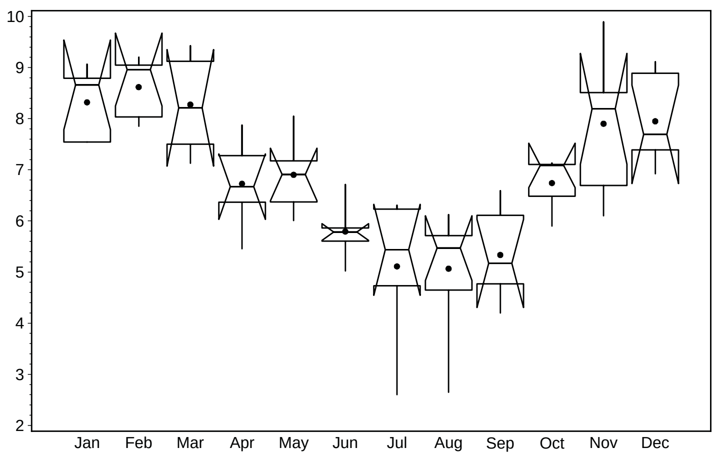
Tidal Caloosahatchee Trends Appendix - Display 11
Monthly Data Time Series
for Bottom Dissolved Oxygen
Not Adjusted for Seasonal Medians




Tidal Caloosahatchee Trends Appendix - Display 12
Monthly Data Time Series
for Bottom Dissolved Oxygen
Adjusted for Seasonal Medians




Tidal Caloosahatchee Trends Appendix - Display 13
Seasonal Univariate Statistics
for Bottom Dissolved Oxygen



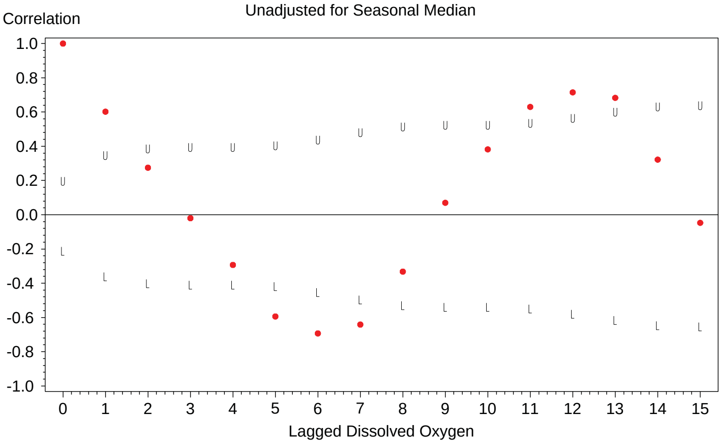

Tidal Caloosahatchee Trends Appendix - Display 14
Autocorrelation Statistics for Bottom Dissolved Oxygen

Unadjusted for Seasonal Medians

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.102 | 0.204 | -0.204 |
| 1 | 0.602 | 0.177 | 0.354 | -0.354 |
| 2 | 0.275 | 0.197 | 0.394 | -0.394 |
| 3 | -0.020 | 0.201 | 0.402 | -0.402 |
| 4 | -0.293 | 0.201 | 0.402 | -0.402 |
| 5 | -0.594 | 0.205 | 0.411 | -0.411 |
| 6 | -0.693 | 0.223 | 0.445 | -0.445 |
| 7 | -0.641 | 0.244 | 0.488 | -0.488 |
| 8 | -0.332 | 0.261 | 0.522 | -0.522 |
| 9 | 0.070 | 0.265 | 0.531 | -0.531 |
| 10 | 0.382 | 0.266 | 0.531 | -0.531 |
| 11 | 0.630 | 0.271 | 0.542 | -0.542 |
| 12 | 0.715 | 0.286 | 0.572 | -0.572 |
| 13 | 0.683 | 0.304 | 0.608 | -0.608 |
| 14 | 0.322 | 0.320 | 0.639 | -0.639 |
| 15 | -0.047 | 0.323 | 0.646 | -0.646 |

Tidal Caloosahatchee Trends Appendix - Display 15
Correlogram for Bottom Dissolved Oxygen

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Tidal Caloosahatchee Trends Appendix - Display 16
Seasonal Kendall Tau Trend Test Statistics
for Bottom Dissolved Oxygen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.029 | 0.826 | 0.822 | 0.046 |

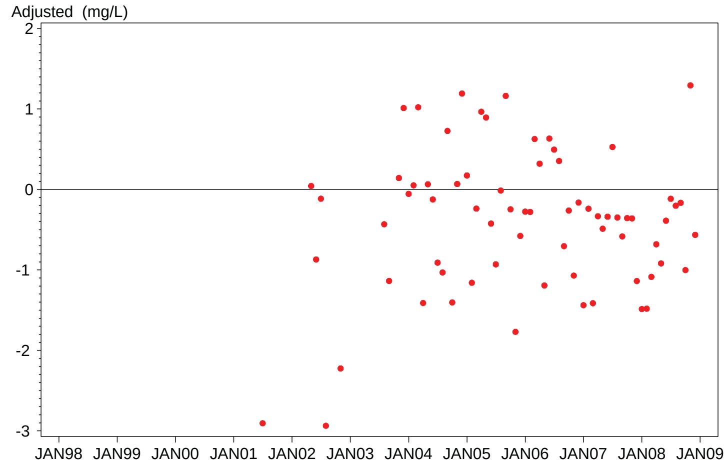
Tidal Caloosahatchee Trends Appendix - Display 17

Seasonal Kendall Tau Trend Test Statistics
for Bottom Dissolved Oxygen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.028902 | 0.82563 | 0.82187 | 0.045833 |

Tidal Caloosahatchee Trends Appendix - Display 18
Time Series Plot of Bottom Dissolved Oxygen Data Adjusted for Season and Detrended




Zero Reference Line Shown

Tidal Caloosahatchee Trends Appendix - Display 19

Autocorrelation Statistics for Bottom Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.102 | 0.204 | -0.204 |
| 1 | 0.054 | 0.177 | 0.354 | -0.354 |
| 2 | -0.019 | 0.177 | 0.354 | -0.354 |
| 3 | 0.143 | 0.177 | 0.354 | -0.354 |
| 4 | 0.172 | 0.178 | 0.356 | -0.356 |
| 5 | -0.009 | 0.180 | 0.360 | -0.360 |
| 6 | -0.039 | 0.180 | 0.360 | -0.360 |
| 7 | -0.251 | 0.180 | 0.360 | -0.360 |
| 8 | -0.195 | 0.184 | 0.367 | -0.367 |
| 9 | 0.080 | 0.186 | 0.371 | -0.371 |
| 10 | 0.122 | 0.186 | 0.372 | -0.372 |
| 11 | 0.083 | 0.187 | 0.374 | -0.374 |
| 12 | 0.057 | 0.187 | 0.375 | -0.375 |
| 13 | 0.248 | 0.187 | 0.375 | -0.375 |

Tidal Caloosahatchee Trends Appendix - Display 19

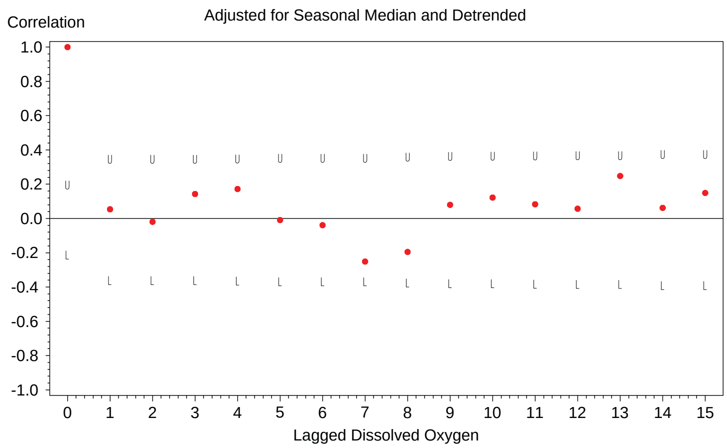
Autocorrelation Statistics for Bottom Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | 0.062 | 0.191 | 0.382 | -0.382 |
| 15 | 0.149 | 0.191 | 0.382 | -0.382 |

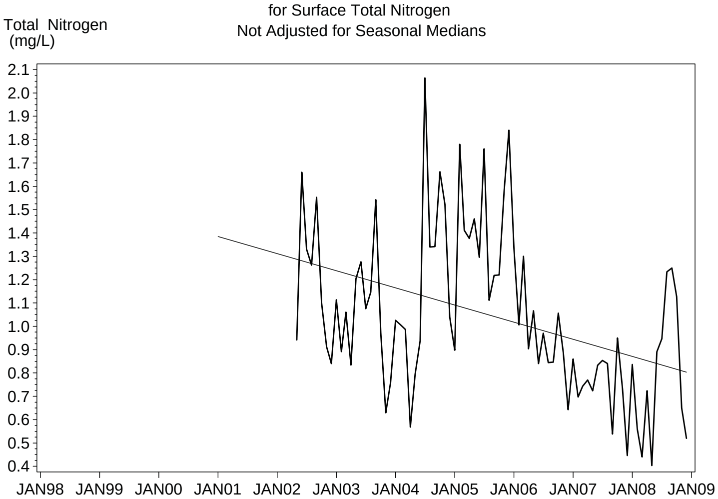
Tidal Caloosahatchee Trends Appendix - Display 20
Correlogram for Bottom Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

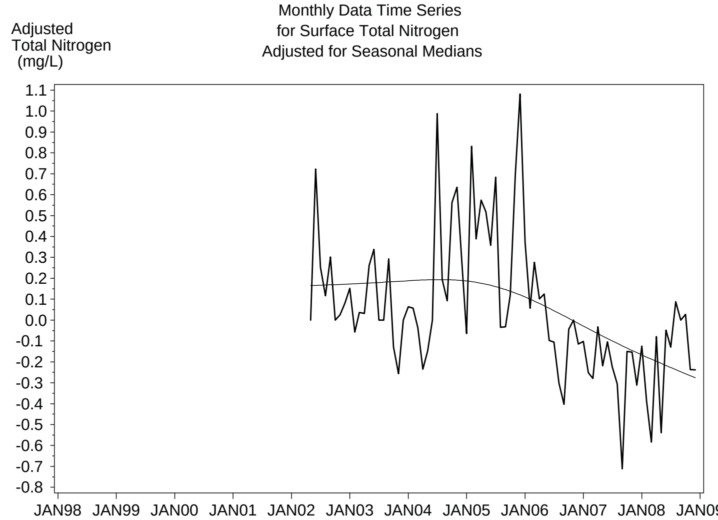



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

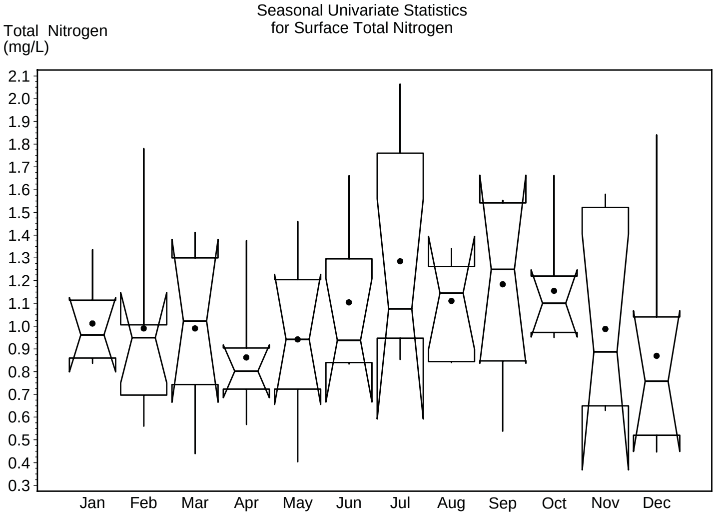
Tidal Caloosahatchee Trends Appendix - Display 21
Monthly Data Time Series
for Surface Total Nitrogen
Not Adjusted for Seasonal Medians




Tidal Caloosahatchee Trends Appendix - Display 22
Monthly Data Time Series
for Surface Total Nitrogen
Adjusted for Seasonal Medians




Tidal Caloosahatchee Trends Appendix - Display 23
Seasonal Univariate Statistics
for Surface Total Nitrogen



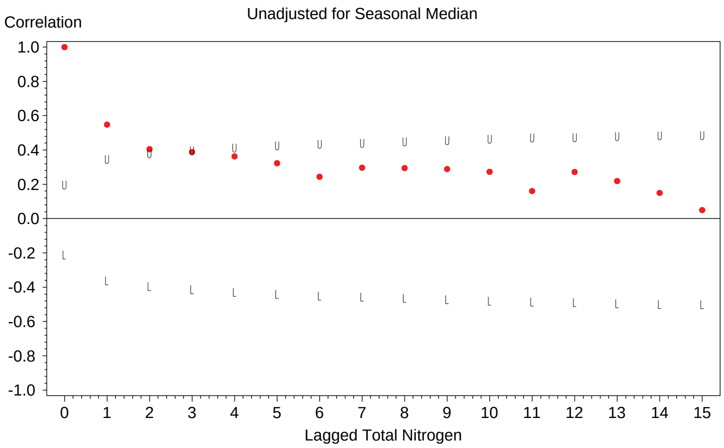

Tidal Caloosahatchee Trends Appendix - Display 24
Autocorrelation Statistics for Surface Total Nitrogen

Unadjusted for Seasonal Medians

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.102 | 0.204 | -0.204 |
| 1 | 0.548 | 0.177 | 0.354 | -0.354 |
| 2 | 0.405 | 0.194 | 0.387 | -0.387 |
| 3 | 0.388 | 0.202 | 0.405 | -0.405 |
| 4 | 0.363 | 0.210 | 0.420 | -0.420 |
| 5 | 0.323 | 0.216 | 0.433 | -0.433 |
| 6 | 0.244 | 0.221 | 0.443 | -0.443 |
| 7 | 0.297 | 0.224 | 0.448 | -0.448 |
| 8 | 0.295 | 0.228 | 0.456 | -0.456 |
| 9 | 0.289 | 0.232 | 0.464 | -0.464 |
| 10 | 0.273 | 0.236 | 0.472 | -0.472 |
| 11 | 0.161 | 0.239 | 0.478 | -0.478 |
| 12 | 0.272 | 0.240 | 0.480 | -0.480 |
| 13 | 0.219 | 0.243 | 0.487 | -0.487 |
| 14 | 0.150 | 0.245 | 0.491 | -0.491 |
| 15 | 0.050 | 0.246 | 0.493 | -0.493 |

Tidal Caloosahatchee Trends Appendix - Display 25
Correlogram for Surface Total Nitrogen

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Tidal Caloosahatchee Trends Appendix - Display 26

Seasonal Kendall Tau Trend Test Statistics
for Surface Total Nitrogen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.434 | 0 | 0.05 | -0.077 |

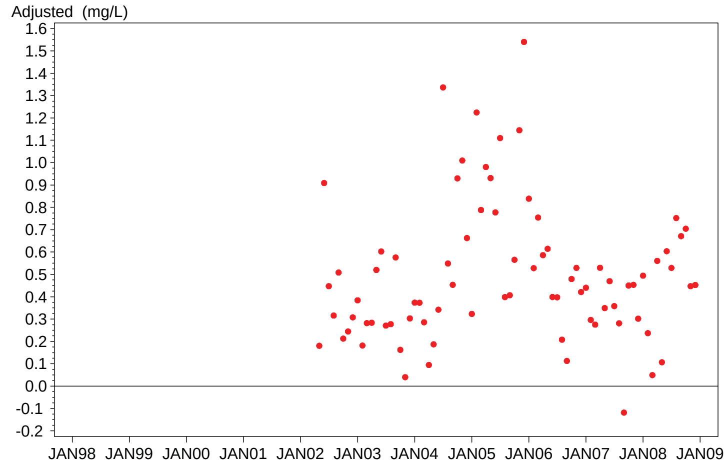
Tidal Caloosahatchee Trends Appendix - Display 27

Seasonal Kendall Tau Trend Test Statistics
for Surface Total Nitrogen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.43421 | .000005861 | 0.050470 | -0.077475 |

Tidal Caloosahatchee Trends Appendix - Display 28
Time Series Plot of Surface Total Nitrogen Data Adjusted for Season and Detrended




Zero Reference Line Shown

Tidal Caloosahatchee Trends Appendix - Display 29

Autocorrelation Statistics for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.102 | 0.204 | -0.204 |
| 1 | 0.430 | 0.177 | 0.354 | -0.354 |
| 2 | 0.273 | 0.187 | 0.375 | -0.375 |
| 3 | 0.299 | 0.191 | 0.383 | -0.383 |
| 4 | 0.297 | 0.196 | 0.393 | -0.393 |
| 5 | 0.311 | 0.201 | 0.402 | -0.402 |
| 6 | 0.202 | 0.206 | 0.412 | -0.412 |
| 7 | 0.251 | 0.208 | 0.416 | -0.416 |
| 8 | 0.186 | 0.211 | 0.422 | -0.422 |
| 9 | 0.157 | 0.213 | 0.425 | -0.425 |
| 10 | 0.119 | 0.214 | 0.428 | -0.428 |
| 11 | -0.003 | 0.215 | 0.429 | -0.429 |
| 12 | 0.111 | 0.215 | 0.429 | -0.429 |
| 13 | 0.053 | 0.215 | 0.430 | -0.430 |

Tidal Caloosahatchee Trends Appendix - Display 29

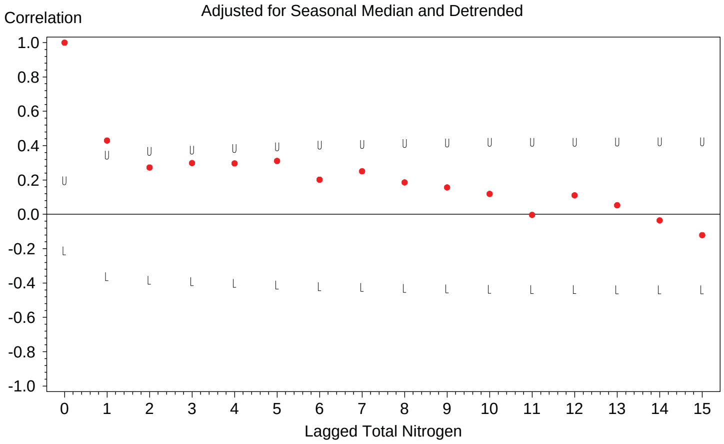
Autocorrelation Statistics for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | -0.035 | 0.215 | 0.431 | -0.431 |
| 15 | -0.121 | 0.215 | 0.431 | -0.431 |

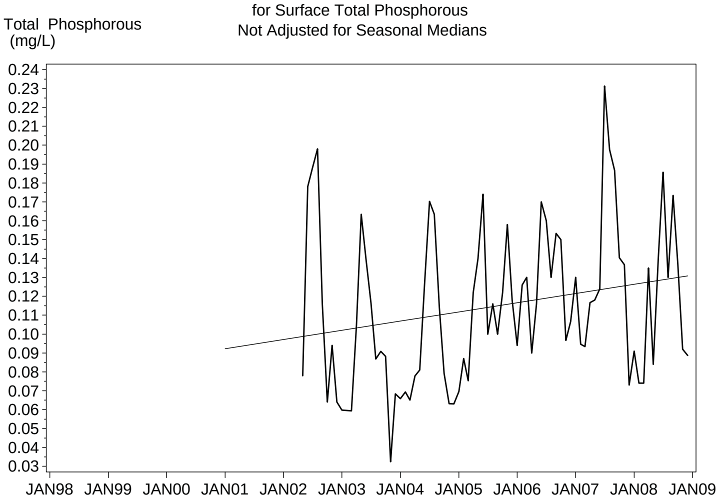
Tidal Caloosahatchee Trends Appendix - Display 30
Correlogram for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

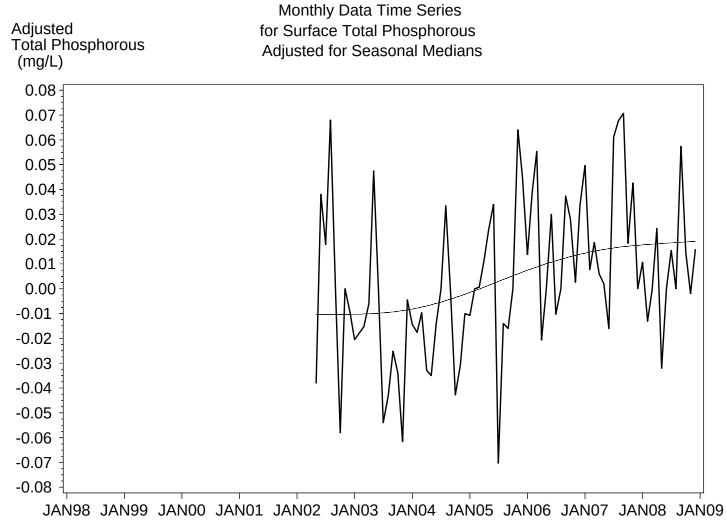



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

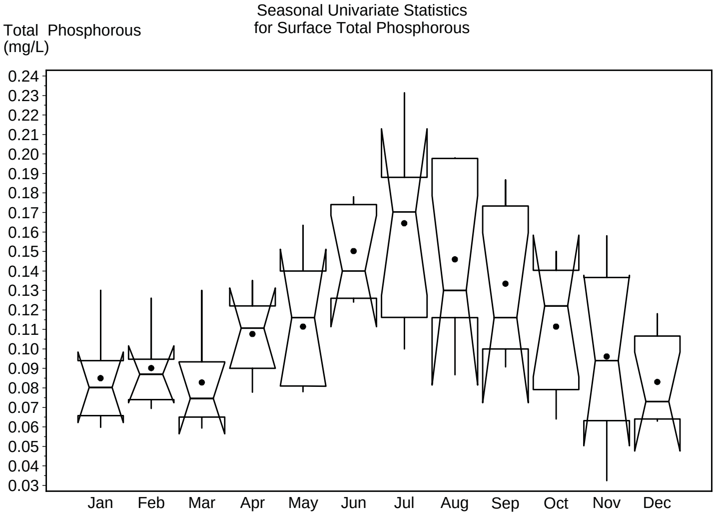
Tidal Caloosahatchee Trends Appendix - Display 31
Monthly Data Time Series
for Surface Total Phosphorous
Not Adjusted for Seasonal Medians




Tidal Caloosahatchee Trends Appendix - Display 32
Monthly Data Time Series
for Surface Total Phosphorous
Adjusted for Seasonal Medians




Tidal Caloosahatchee Trends Appendix - Display 33
Seasonal Univariate Statistics
for Surface Total Phosphorous



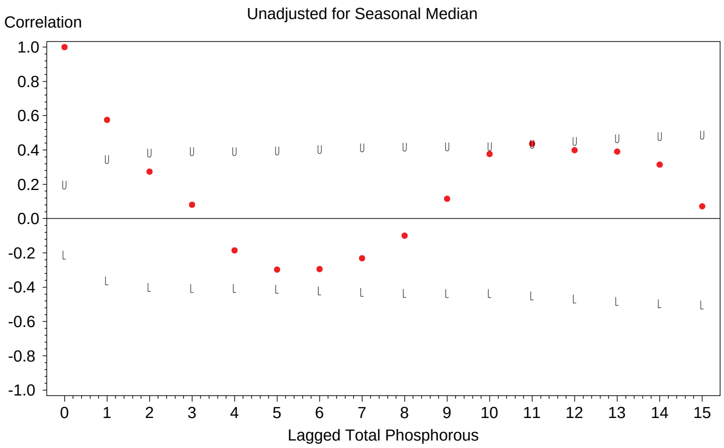

Tidal Caloosahatchee Trends Appendix - Display 34
Autocorrelation Statistics for Surface Total Phosphorous

Unadjusted for Seasonal Medians

| Lagged Total Phosphorous | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.102 | 0.204 | -0.204 |
| 1 | 0.576 | 0.177 | 0.354 | -0.354 |
| 2 | 0.274 | 0.195 | 0.391 | -0.391 |
| 3 | 0.081 | 0.199 | 0.399 | -0.399 |
| 4 | -0.185 | 0.200 | 0.399 | -0.399 |
| 5 | -0.297 | 0.201 | 0.403 | -0.403 |
| 6 | -0.294 | 0.206 | 0.412 | -0.412 |
| 7 | -0.231 | 0.210 | 0.421 | -0.421 |
| 8 | -0.099 | 0.213 | 0.426 | -0.426 |
| 9 | 0.116 | 0.213 | 0.427 | -0.427 |
| 10 | 0.377 | 0.214 | 0.428 | -0.428 |
| 11 | 0.437 | 0.221 | 0.442 | -0.442 |
| 12 | 0.399 | 0.230 | 0.459 | -0.459 |
| 13 | 0.391 | 0.237 | 0.474 | -0.474 |
| 14 | 0.315 | 0.243 | 0.487 | -0.487 |
| 15 | 0.072 | 0.248 | 0.495 | -0.495 |

Tidal Caloosahatchee Trends Appendix - Display 35
Correlogram for Surface Total Phosphorous

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Tidal Caloosahatchee Trends Appendix - Display 36

Seasonal Kendall Tau Trend Test Statistics
for Surface Total Phosphorous

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.269 | .006 | 0.135 | .006 |

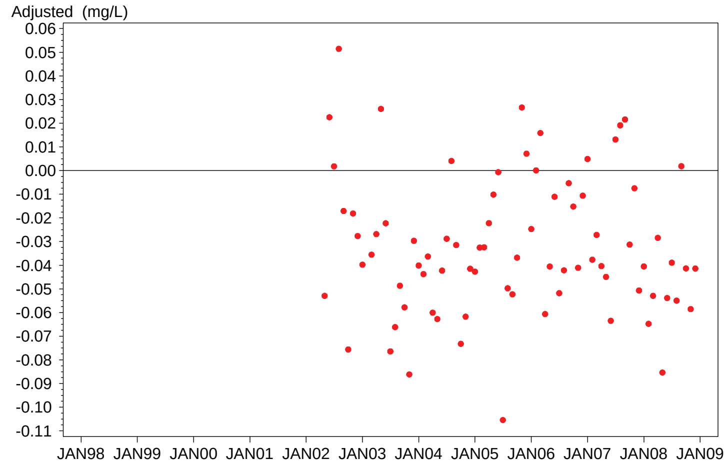
Tidal Caloosahatchee Trends Appendix - Display 37

Seasonal Kendall Tau Trend Test Statistics
for Surface Total Phosphorous

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.26906 | .00558746 | 0.13465 | .0064 |

Tidal Caloosahatchee Trends Appendix - Display 38
Time Series Plot of Surface Total Phosphorous Data Adjusted for Season and Detrended




Zero Reference Line Shown

Tidal Caloosahatchee Trends Appendix - Display 39

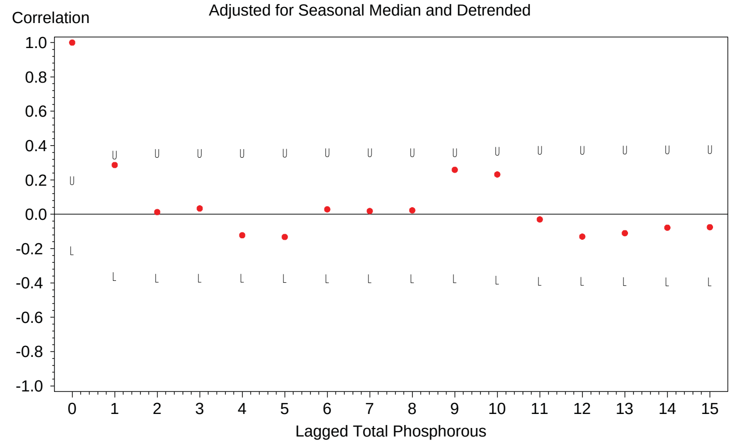
Autocorrelation Statistics for Surface Total Phosphorous

Adjusted for Seasonal Median and Detrended

| Lagged Total Phosphorous | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.102 | 0.204 | -0.204 |
| 1 | 0.287 | 0.177 | 0.354 | -0.354 |
| 2 | 0.013 | 0.182 | 0.363 | -0.363 |
| 3 | 0.034 | 0.182 | 0.363 | -0.363 |
| 4 | -0.122 | 0.182 | 0.363 | -0.363 |
| 5 | -0.132 | 0.182 | 0.365 | -0.365 |
| 6 | 0.029 | 0.183 | 0.367 | -0.367 |
| 7 | 0.019 | 0.184 | 0.367 | -0.367 |
| 8 | 0.023 | 0.184 | 0.367 | -0.367 |
| 9 | 0.259 | 0.184 | 0.367 | -0.367 |
| 10 | 0.232 | 0.187 | 0.375 | -0.375 |
| 11 | -0.030 | 0.190 | 0.381 | -0.381 |
| 12 | -0.130 | 0.190 | 0.381 | -0.381 |
| 13 | -0.110 | 0.191 | 0.383 | -0.383 |
| 14 | -0.078 | 0.192 | 0.384 | -0.384 |
| 15 | -0.075 | 0.192 | 0.385 | -0.385 |

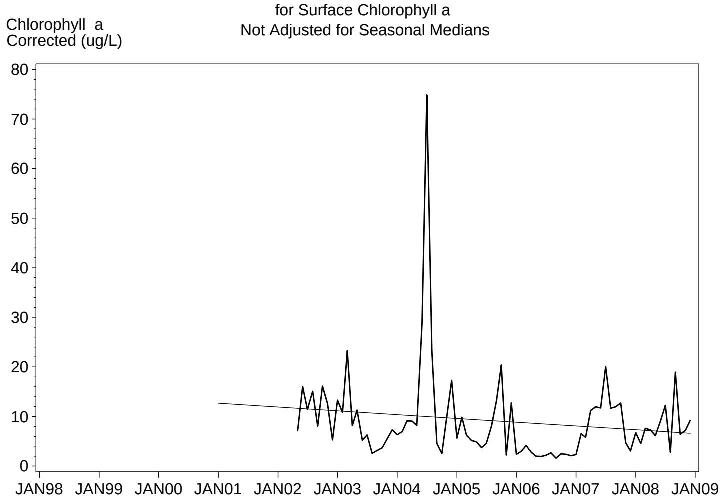
Tidal Caloosahatchee Trends Appendix - Display 40
Correlogram for Surface Total Phosphorous

Adjusted for Seasonal Median and Detrended

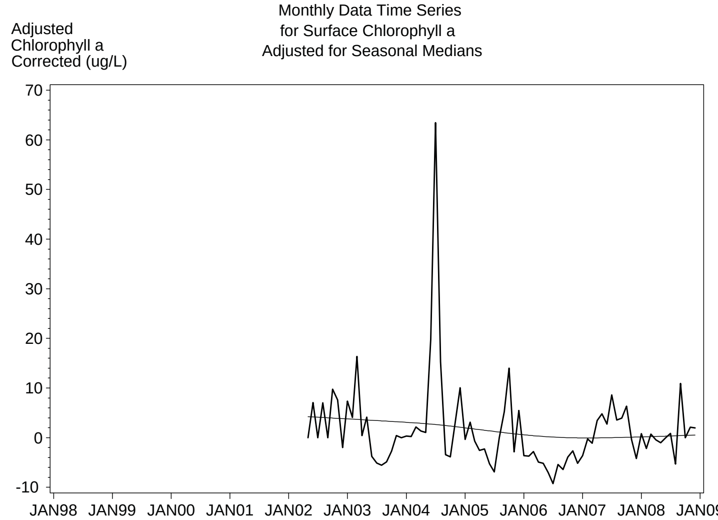



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

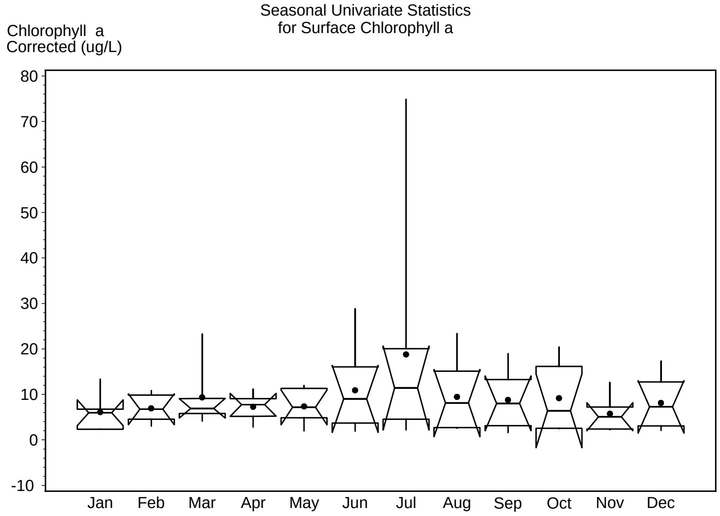
Tidal Caloosahatchee Trends Appendix - Display 41
Monthly Data Time Series
for Surface Chlorophyll a
Not Adjusted for Seasonal Medians




Tidal Caloosahatchee Trends Appendix - Display 42
Monthly Data Time Series
for Surface Chlorophyll a
Adjusted for Seasonal Medians




Tidal Caloosahatchee Trends Appendix - Display 43
Seasonal Univariate Statistics
for Surface Chlorophyll a



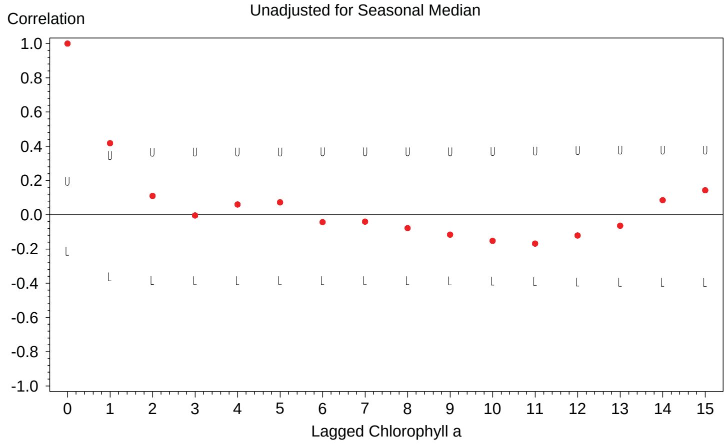

Tidal Caloosahatchee Trends Appendix - Display 44
Autocorrelation Statistics for Surface Chlorophyll a

Unadjusted for Seasonal Medians

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.102 | 0.204 | -0.204 |
| 1 | 0.418 | 0.177 | 0.354 | -0.354 |
| 2 | 0.110 | 0.187 | 0.374 | -0.374 |
| 3 | -0.004 | 0.187 | 0.375 | -0.375 |
| 4 | 0.060 | 0.187 | 0.375 | -0.375 |
| 5 | 0.073 | 0.188 | 0.375 | -0.375 |
| 6 | -0.043 | 0.188 | 0.376 | -0.376 |
| 7 | -0.040 | 0.188 | 0.376 | -0.376 |
| 8 | -0.078 | 0.188 | 0.376 | -0.376 |
| 9 | -0.116 | 0.188 | 0.377 | -0.377 |
| 10 | -0.152 | 0.189 | 0.378 | -0.378 |
| 11 | -0.168 | 0.190 | 0.381 | -0.381 |
| 12 | -0.121 | 0.192 | 0.384 | -0.384 |
| 13 | -0.064 | 0.193 | 0.386 | -0.386 |
| 14 | 0.085 | 0.193 | 0.386 | -0.386 |
| 15 | 0.143 | 0.193 | 0.387 | -0.387 |

Tidal Caloosahatchee Trends Appendix - Display 45
Correlogram for Surface Chlorophyll a

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Tidal Caloosahatchee Trends Appendix - Display 46
Seasonal Kendall Tau Trend Test Statistics
for Surface Chlorophyll a

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.153 | 0.121 | 0.449 | -0.684 |

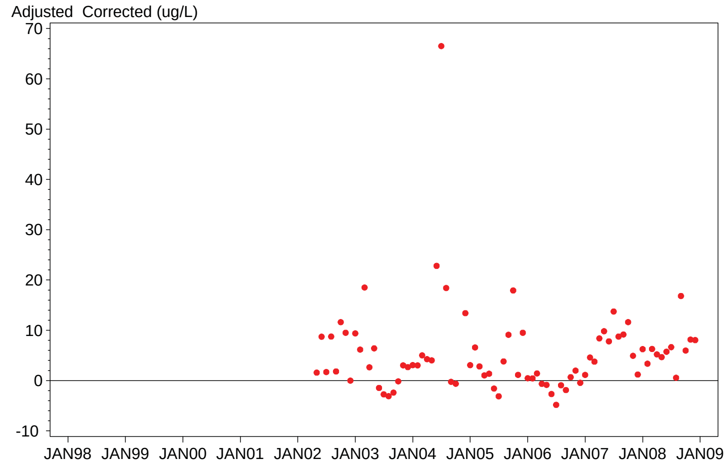
Tidal Caloosahatchee Trends Appendix - Display 47

Seasonal Kendall Tau Trend Test Statistics
for Surface Chlorophyll a

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.15315 | 0.12062 | 0.44948 | -0.6836 |

Tidal Caloosahatchee Trends Appendix - Display 48
Time Series Plot of Surface Chlorophyll a Data Adjusted for Season and Detrended




Zero Reference Line Shown

Tidal Caloosahatchee Trends Appendix - Display 49
Autocorrelation Statistics for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.102 | 0.204 | -0.204 |
| 1 | 0.405 | 0.177 | 0.354 | -0.354 |
| 2 | 0.095 | 0.186 | 0.372 | -0.372 |
| 3 | -0.033 | 0.187 | 0.373 | -0.373 |
| 4 | 0.041 | 0.187 | 0.374 | -0.374 |
| 5 | 0.075 | 0.187 | 0.374 | -0.374 |
| 6 | -0.039 | 0.187 | 0.374 | -0.374 |
| 7 | -0.041 | 0.187 | 0.374 | -0.374 |
| 8 | -0.080 | 0.187 | 0.375 | -0.375 |
| 9 | -0.149 | 0.188 | 0.375 | -0.375 |
| 10 | -0.194 | 0.189 | 0.378 | -0.378 |
| 11 | -0.243 | 0.191 | 0.382 | -0.382 |
| 12 | -0.244 | 0.194 | 0.388 | -0.388 |
| 13 | -0.119 | 0.197 | 0.395 | -0.395 |

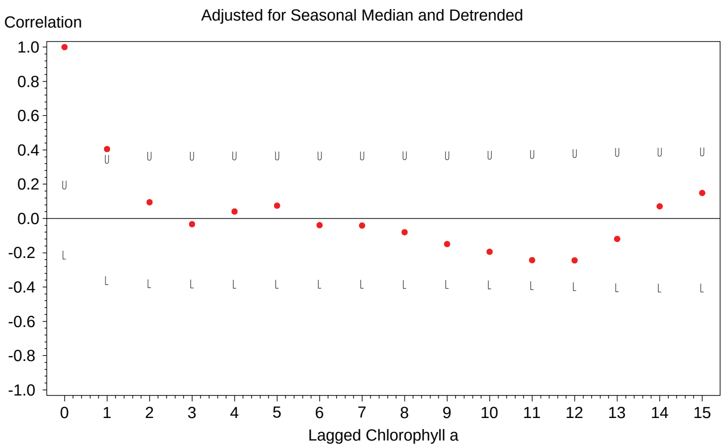
Tidal Caloosahatchee Trends Appendix - Display 49
Autocorrelation Statistics for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | 0.071 | 0.198 | 0.396 | -0.396 |
| 15 | 0.149 | 0.198 | 0.397 | -0.397 |

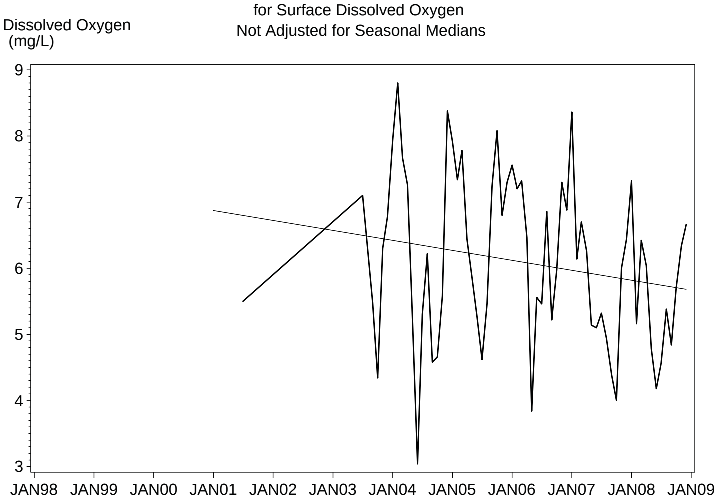
Tidal Caloosahatchee Trends Appendix - Display 50
Correlogram for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended

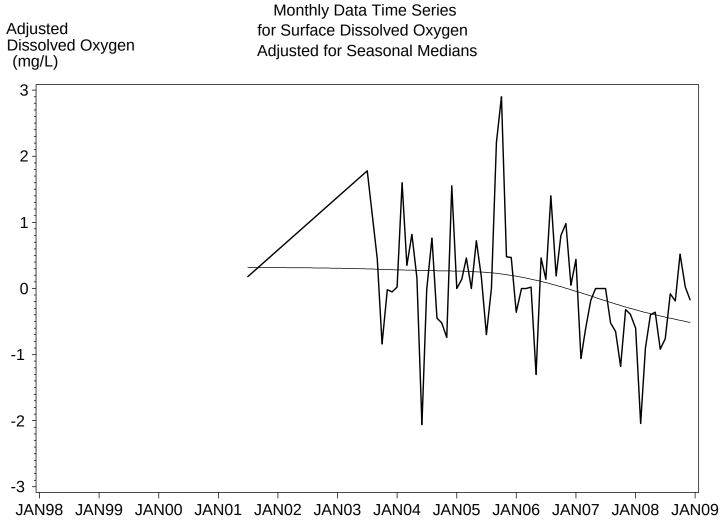



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

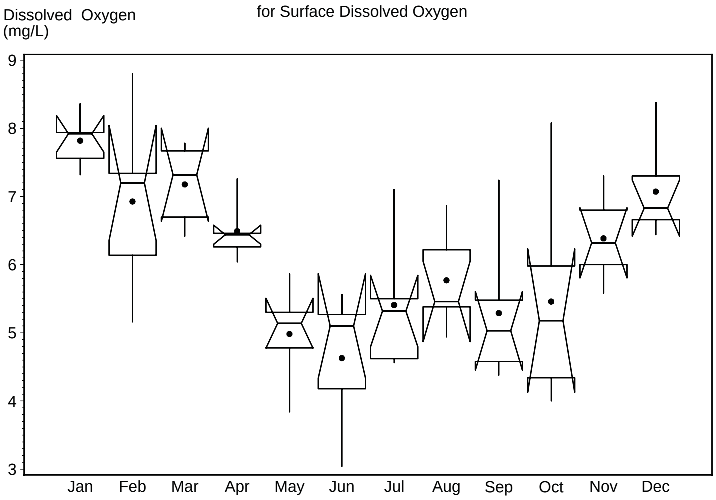
Estero Bay Trends Appendix - Display 1
Monthly Data Time Series
for Surface Dissolved Oxygen
Not Adjusted for Seasonal Medians




Estero Bay Trends Appendix - Display 2
Monthly Data Time Series
for Surface Dissolved Oxygen
Adjusted for Seasonal Medians




Estero Bay Trends Appendix - Display 3
Seasonal Univariate Statistics
for Surface Dissolved Oxygen



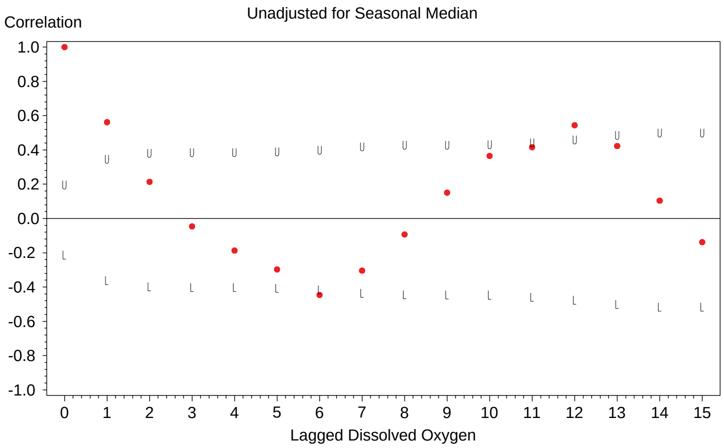

Estero Bay Trends Appendix - Display 4
Autocorrelation Statistics for Surface Dissolved Oxygen

Unadjusted for Seasonal Medians

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.102 | 0.204 | -0.204 |
| 1 | 0.562 | 0.177 | 0.354 | -0.354 |
| 2 | 0.214 | 0.194 | 0.389 | -0.389 |
| 3 | -0.046 | 0.197 | 0.394 | -0.394 |
| 4 | -0.187 | 0.197 | 0.394 | -0.394 |
| 5 | -0.297 | 0.199 | 0.398 | -0.398 |
| 6 | -0.446 | 0.203 | 0.407 | -0.407 |
| 7 | -0.304 | 0.213 | 0.427 | -0.427 |
| 8 | -0.093 | 0.218 | 0.436 | -0.436 |
| 9 | 0.151 | 0.218 | 0.437 | -0.437 |
| 10 | 0.365 | 0.219 | 0.439 | -0.439 |
| 11 | 0.416 | 0.226 | 0.451 | -0.451 |
| 12 | 0.544 | 0.233 | 0.467 | -0.467 |
| 13 | 0.423 | 0.246 | 0.493 | -0.493 |
| 14 | 0.104 | 0.254 | 0.508 | -0.508 |
| 15 | -0.138 | 0.254 | 0.508 | -0.508 |

Estero Bay Trends Appendix - Display 5
Correlogram for Surface Dissolved Oxygen

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Estero Bay Trends Appendix - Display 6
Seasonal Kendall Tau Trend Test Statistics
for Surface Dissolved Oxygen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.377 | .001 | 0.068 | -0.19 |

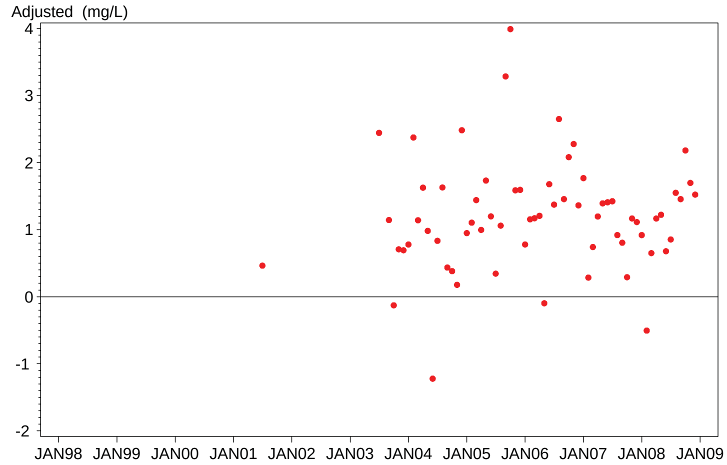
Estero Bay Trends Appendix - Display 7

Seasonal Kendall Tau Trend Test Statistics
for Surface Dissolved Oxygen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.37748 | .000722275 | 0.068309 | -0.19 |

Estero Bay Trends Appendix - Display 8
Time Series Plot of Surface Dissolved Oxygen Data Adjusted for Season and Detrended




Zero Reference Line Shown

Estero Bay Trends Appendix - Display 9

Autocorrelation Statistics for Surface Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.102 | 0.204 | -0.204 |
| 1 | 0.294 | 0.177 | 0.354 | -0.354 |
| 2 | 0.031 | 0.182 | 0.364 | -0.364 |
| 3 | -0.101 | 0.182 | 0.364 | -0.364 |
| 4 | -0.024 | 0.182 | 0.365 | -0.365 |
| 5 | 0.079 | 0.182 | 0.365 | -0.365 |
| 6 | -0.114 | 0.183 | 0.366 | -0.366 |
| 7 | -0.090 | 0.184 | 0.367 | -0.367 |
| 8 | -0.018 | 0.184 | 0.368 | -0.368 |
| 9 | 0.108 | 0.184 | 0.368 | -0.368 |
| 10 | 0.248 | 0.185 | 0.369 | -0.369 |
| 11 | -0.106 | 0.188 | 0.376 | -0.376 |
| 12 | -0.060 | 0.189 | 0.377 | -0.377 |
| 13 | 0.105 | 0.189 | 0.378 | -0.378 |

Estero Bay Trends Appendix - Display 9

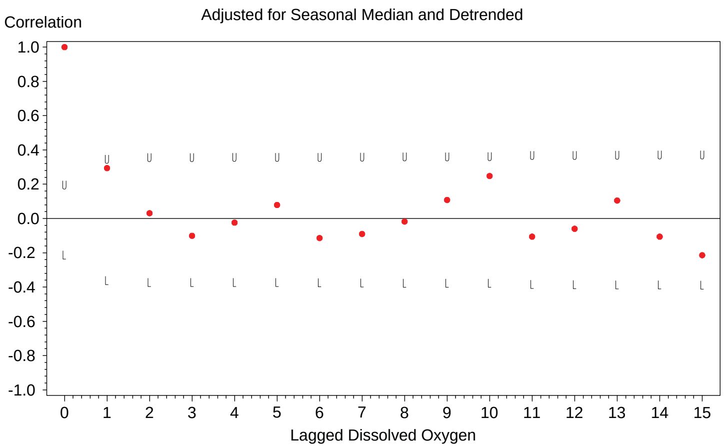
Autocorrelation Statistics for Surface Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

| Lagged Dissolved Oxygen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | -0.106 | 0.190 | 0.379 | -0.379 |
| 15 | -0.214 | 0.190 | 0.380 | -0.380 |

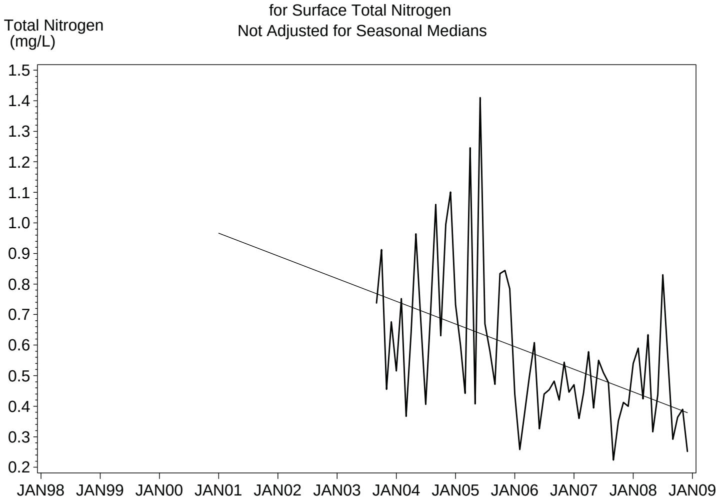
Estero Bay Trends Appendix - Display 10
Correlogram for Surface Dissolved Oxygen

Adjusted for Seasonal Median and Detrended

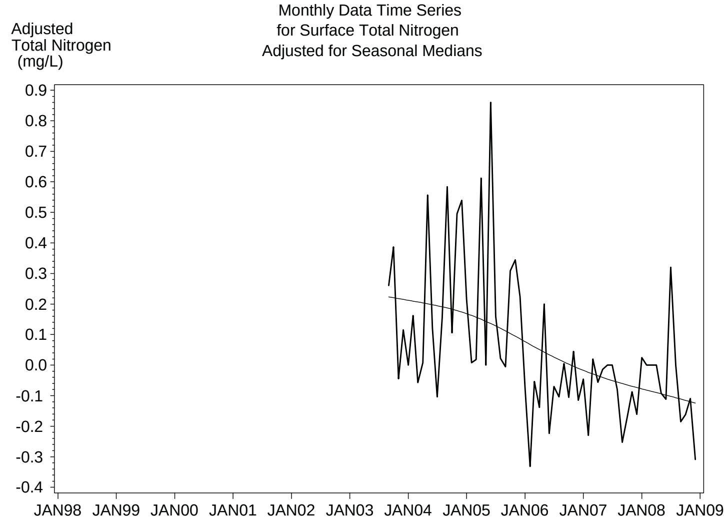



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

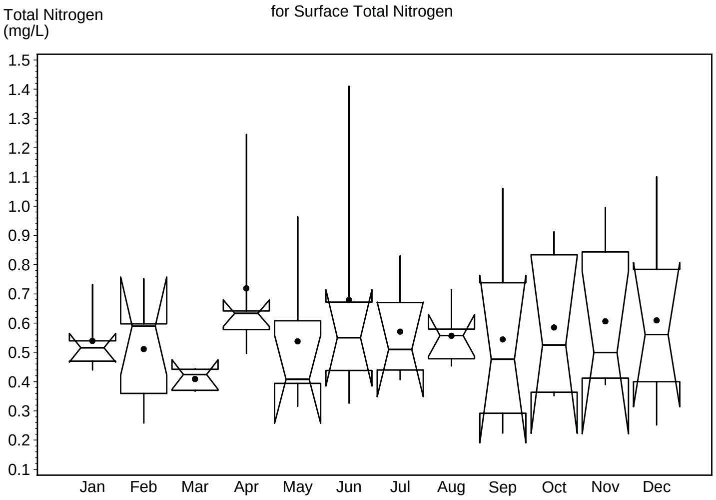
Estero Bay Trends Appendix - Display 11
Monthly Data Time Series
for Surface Total Nitrogen
Not Adjusted for Seasonal Medians




Estero Bay Trends Appendix - Display 12
Monthly Data Time Series
for Surface Total Nitrogen
Adjusted for Seasonal Medians




Estero Bay Trends Appendix - Display 13
Seasonal Univariate Statistics
for Surface Total Nitrogen



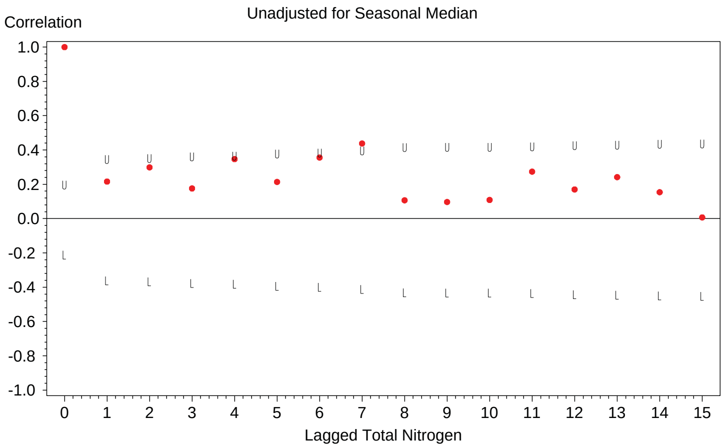

Estero Bay Trends Appendix - Display 14
Autocorrelation Statistics for Surface Total Nitrogen

Unadjusted for Seasonal Medians

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.102 | 0.204 | -0.204 |
| 1 | 0.216 | 0.177 | 0.354 | -0.354 |
| 2 | 0.299 | 0.180 | 0.359 | -0.359 |
| 3 | 0.176 | 0.185 | 0.369 | -0.369 |
| 4 | 0.347 | 0.186 | 0.373 | -0.373 |
| 5 | 0.214 | 0.193 | 0.386 | -0.386 |
| 6 | 0.356 | 0.195 | 0.391 | -0.391 |
| 7 | 0.438 | 0.202 | 0.404 | -0.404 |
| 8 | 0.107 | 0.212 | 0.423 | -0.423 |
| 9 | 0.097 | 0.212 | 0.425 | -0.425 |
| 10 | 0.109 | 0.213 | 0.425 | -0.425 |
| 11 | 0.274 | 0.213 | 0.427 | -0.427 |
| 12 | 0.170 | 0.217 | 0.434 | -0.434 |
| 13 | 0.242 | 0.218 | 0.437 | -0.437 |
| 14 | 0.154 | 0.221 | 0.442 | -0.442 |
| 15 | 0.007 | 0.222 | 0.444 | -0.444 |

Estero Bay Trends Appendix - Display 15
Correlogram for Surface Total Nitrogen

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Estero Bay Trends Appendix - Display 16
Seasonal Kendall Tau Trend Test Statistics
for Surface Total Nitrogen

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.371 | .001 | 0.114 | -0.071 |

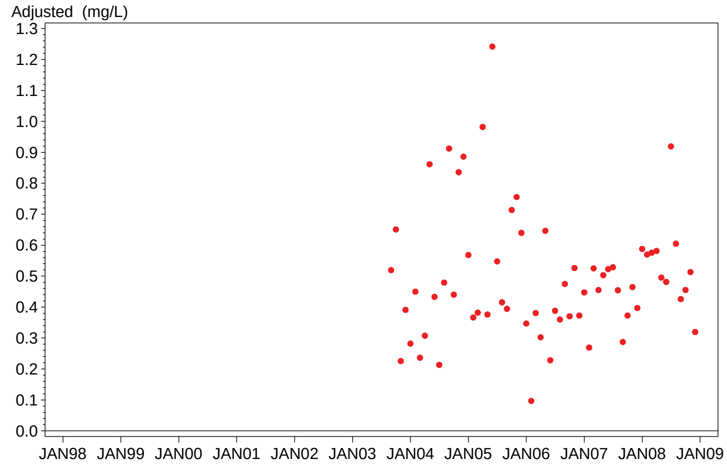
Estero Bay Trends Appendix - Display 17

Seasonal Kendall Tau Trend Test Statistics
for Surface Total Nitrogen

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.37143 | .00116531 | 0.11424 | -0.0705 |

Estero Bay Trends Appendix - Display 18
Time Series Plot of Surface Total Nitrogen Data Adjusted for Season and Detrended




Zero Reference Line Shown

Estero Bay Trends Appendix - Display 19

Autocorrelation Statistics for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.102 | 0.204 | -0.204 |
| 1 | 0.079 | 0.177 | 0.354 | -0.354 |
| 2 | 0.085 | 0.177 | 0.354 | -0.354 |
| 3 | -0.024 | 0.178 | 0.355 | -0.355 |
| 4 | 0.154 | 0.178 | 0.355 | -0.355 |
| 5 | 0.014 | 0.179 | 0.358 | -0.358 |
| 6 | 0.196 | 0.179 | 0.358 | -0.358 |
| 7 | 0.273 | 0.181 | 0.362 | -0.362 |
| 8 | -0.193 | 0.185 | 0.371 | -0.371 |
| 9 | -0.158 | 0.188 | 0.375 | -0.375 |
| 10 | -0.191 | 0.189 | 0.378 | -0.378 |
| 11 | 0.119 | 0.191 | 0.382 | -0.382 |
| 12 | -0.148 | 0.192 | 0.383 | -0.383 |
| 13 | 0.134 | 0.193 | 0.386 | -0.386 |

Estero Bay Trends Appendix - Display 19

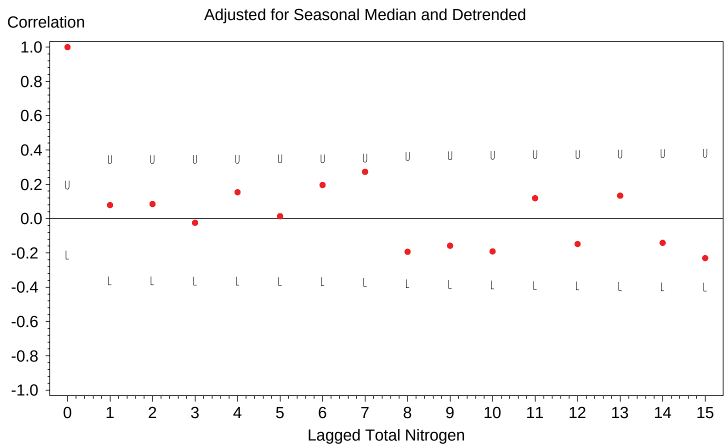
Autocorrelation Statistics for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

| Lagged Total Nitrogen | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | -0.141 | 0.194 | 0.388 | -0.388 |
| 15 | -0.230 | 0.195 | 0.390 | -0.390 |

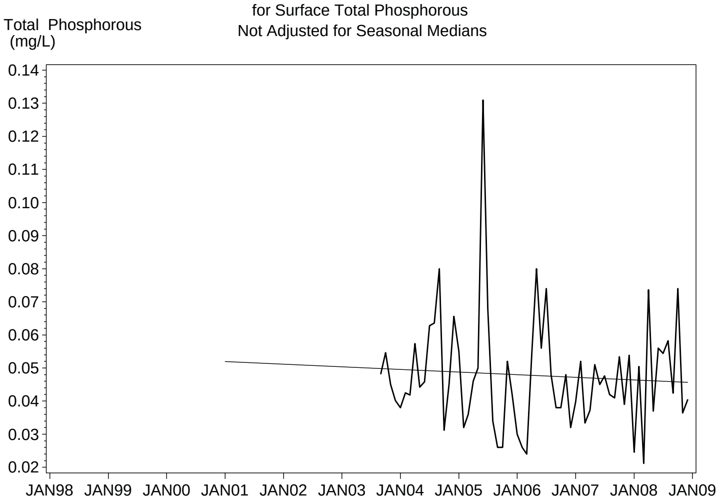
Estero Bay Trends Appendix - Display 20
Correlogram for Surface Total Nitrogen

Adjusted for Seasonal Median and Detrended

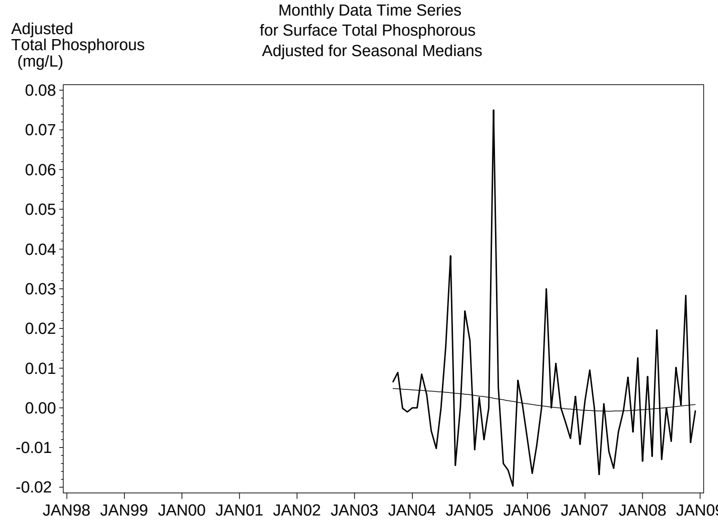



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

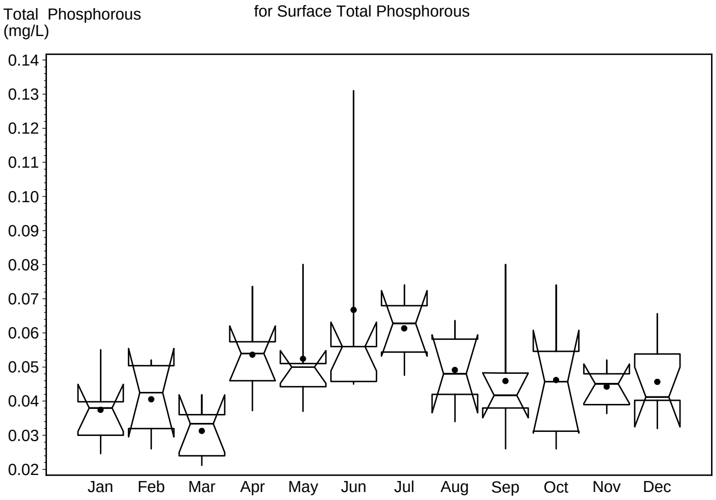
Estero Bay Trends Appendix - Display 21
Monthly Data Time Series
for Surface Total Phosphorous
Not Adjusted for Seasonal Medians




Estero Bay Trends Appendix - Display 22
Monthly Data Time Series
for Surface Total Phosphorous
Adjusted for Seasonal Medians




Estero Bay Trends Appendix - Display 23
Seasonal Univariate Statistics
for Surface Total Phosphorous



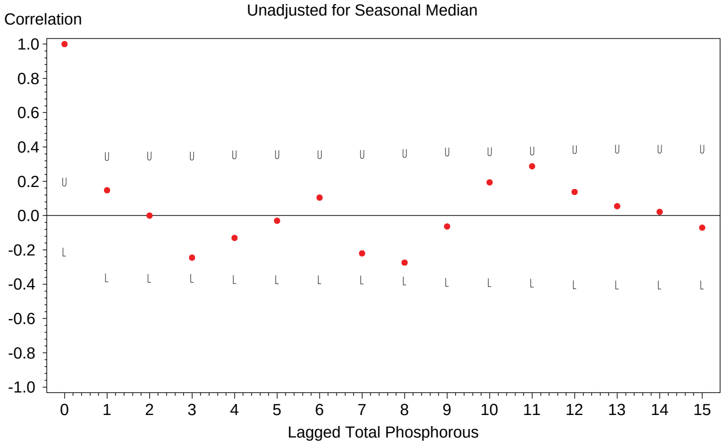

Estero Bay Trends Appendix - Display 24
Autocorrelation Statistics for Surface Total Phosphorous

Unadjusted for Seasonal Medians

| Lagged Total Phosphorous | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.102 | 0.204 | -0.204 |
| 1 | 0.148 | 0.177 | 0.354 | -0.354 |
| 2 | 0.000 | 0.178 | 0.356 | -0.356 |
| 3 | -0.245 | 0.178 | 0.356 | -0.356 |
| 4 | -0.130 | 0.182 | 0.363 | -0.363 |
| 5 | -0.030 | 0.183 | 0.365 | -0.365 |
| 6 | 0.105 | 0.183 | 0.365 | -0.365 |
| 7 | -0.220 | 0.183 | 0.366 | -0.366 |
| 8 | -0.274 | 0.186 | 0.372 | -0.372 |
| 9 | -0.063 | 0.190 | 0.380 | -0.380 |
| 10 | 0.194 | 0.190 | 0.381 | -0.381 |
| 11 | 0.288 | 0.192 | 0.385 | -0.385 |
| 12 | 0.138 | 0.197 | 0.394 | -0.394 |
| 13 | 0.055 | 0.198 | 0.396 | -0.396 |
| 14 | 0.022 | 0.198 | 0.396 | -0.396 |
| 15 | -0.070 | 0.198 | 0.396 | -0.396 |

Estero Bay Trends Appendix - Display 25
Correlogram for Surface Total Phosphorous

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Estero Bay Trends Appendix - Display 26
Seasonal Kendall Tau Trend Test Statistics
for Surface Total Phosphorous

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.121 | 0.305 | 0.131 | -.002 |

Estero Bay Trends Appendix - Display 27

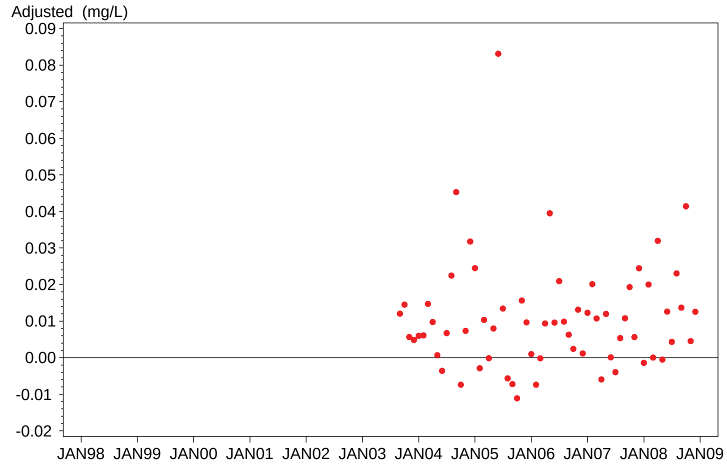
Seasonal Kendall Tau Trend Test Statistics for Surface Total Phosphorous

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| -0.12143 | 0.30537 | 0.13114 | -.0015 |

Estero Bay Trends Appendix - Display 28

Time Series Plot of Surface Total Phosphorous Data Adjusted for Season and Detrended




Zero Reference Line Shown

Estero Bay Trends Appendix - Display 29

Autocorrelation Statistics for Surface Total Phosphorous

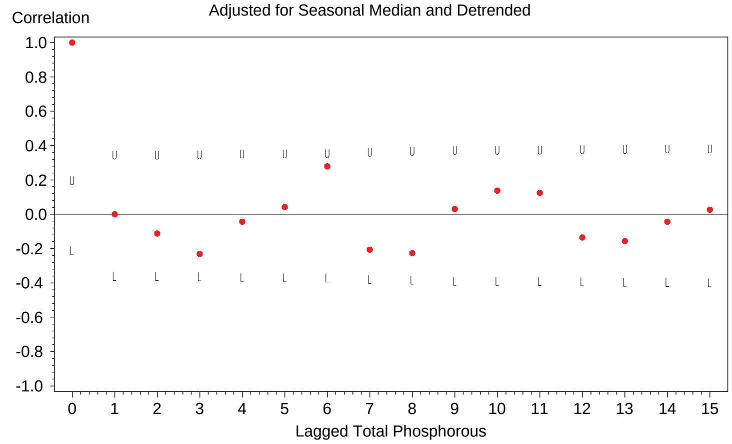
Adjusted for Seasonal Median and Detrended

| Lagged Total Phosphorous | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.102 | 0.204 | -0.204 |
| 1 | 0.000 | 0.177 | 0.354 | -0.354 |
| 2 | -0.112 | 0.177 | 0.354 | -0.354 |
| 3 | -0.231 | 0.178 | 0.355 | -0.355 |
| 4 | -0.043 | 0.181 | 0.361 | -0.361 |
| 5 | 0.042 | 0.181 | 0.361 | -0.361 |
| 6 | 0.279 | 0.181 | 0.362 | -0.362 |
| 7 | -0.206 | 0.185 | 0.370 | -0.370 |
| 8 | -0.226 | 0.188 | 0.375 | -0.375 |
| 9 | 0.031 | 0.190 | 0.381 | -0.381 |
| 10 | 0.138 | 0.190 | 0.381 | -0.381 |
| 11 | 0.125 | 0.192 | 0.383 | -0.383 |
| 12 | -0.135 | 0.192 | 0.385 | -0.385 |
| 13 | -0.156 | 0.193 | 0.387 | -0.387 |
| 14 | -0.043 | 0.195 | 0.389 | -0.389 |
| 15 | 0.027 | 0.195 | 0.390 | -0.390 |

Estero Bay Trends Appendix - Display 30

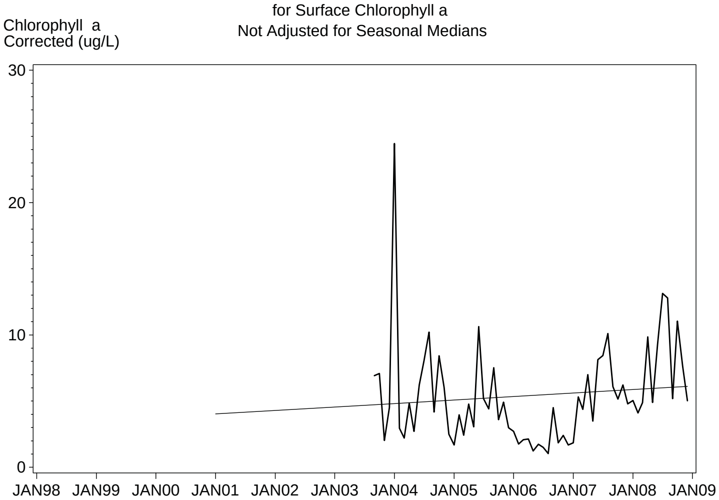
Correlogram for Surface Total Phosphorous

Adjusted for Seasonal Median and Detrended

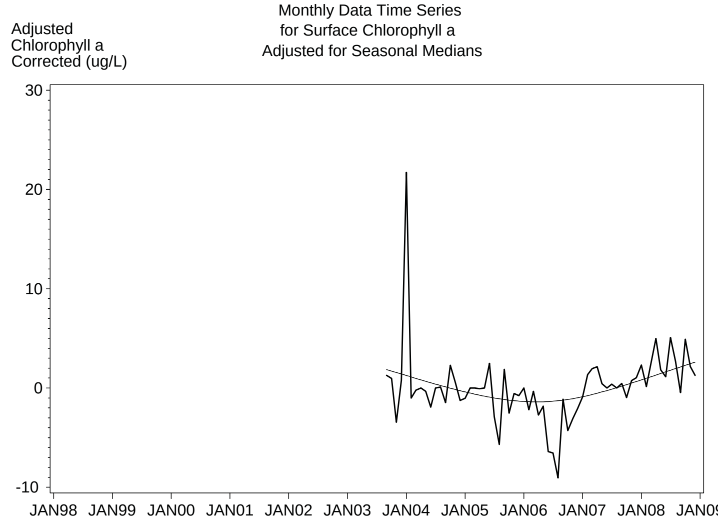



U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

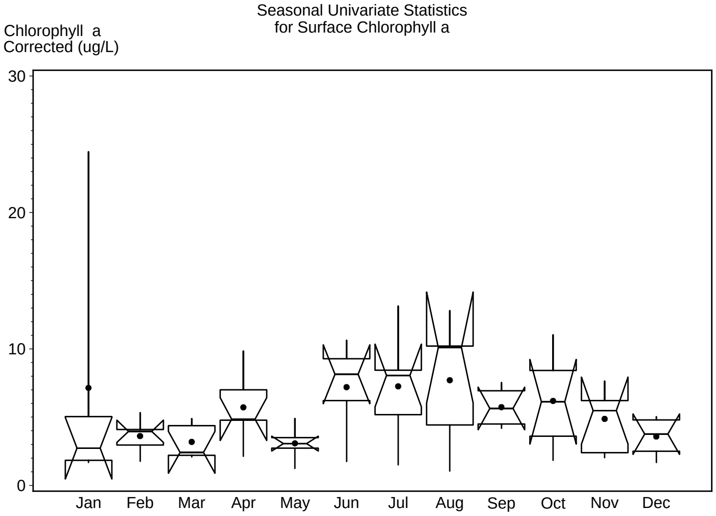
Estero Bay Trends Appendix - Display 31
Monthly Data Time Series
for Surface Chlorophyll a
Not Adjusted for Seasonal Medians




Estero Bay Trends Appendix - Display 32
Monthly Data Time Series
for Surface Chlorophyll a
Adjusted for Seasonal Medians




Estero Bay Trends Appendix - Display 33
Seasonal Univariate Statistics
for Surface Chlorophyll a



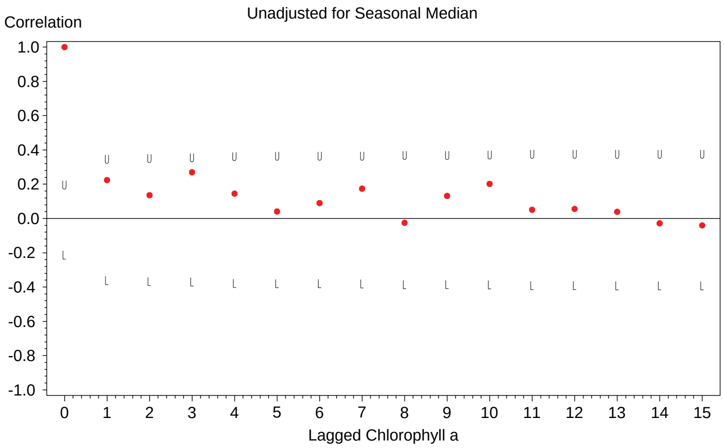

Estero Bay Trends Appendix - Display 34
Autocorrelation Statistics for Surface Chlorophyll a

Unadjusted for Seasonal Medians

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.102 | 0.204 | -0.204 |
| 1 | 0.224 | 0.177 | 0.354 | -0.354 |
| 2 | 0.136 | 0.180 | 0.359 | -0.359 |
| 3 | 0.270 | 0.181 | 0.362 | -0.362 |
| 4 | 0.145 | 0.185 | 0.370 | -0.370 |
| 5 | 0.041 | 0.186 | 0.372 | -0.372 |
| 6 | 0.090 | 0.186 | 0.372 | -0.372 |
| 7 | 0.174 | 0.187 | 0.373 | -0.373 |
| 8 | -0.025 | 0.188 | 0.377 | -0.377 |
| 9 | 0.132 | 0.188 | 0.377 | -0.377 |
| 10 | 0.202 | 0.189 | 0.379 | -0.379 |
| 11 | 0.051 | 0.192 | 0.383 | -0.383 |
| 12 | 0.056 | 0.192 | 0.383 | -0.383 |
| 13 | 0.039 | 0.192 | 0.384 | -0.384 |
| 14 | -0.028 | 0.192 | 0.384 | -0.384 |
| 15 | -0.040 | 0.192 | 0.384 | -0.384 |

Estero Bay Trends Appendix - Display 35
Correlogram for Surface Chlorophyll a

Unadjusted for Seasonal Median




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

Estero Bay Trends Appendix - Display 36
Seasonal Kendall Tau Trend Test Statistics
for Surface Chlorophyll a

Unadjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.3 | .009 | 0.297 | 0.579 |

Estero Bay Trends Appendix - Display 37

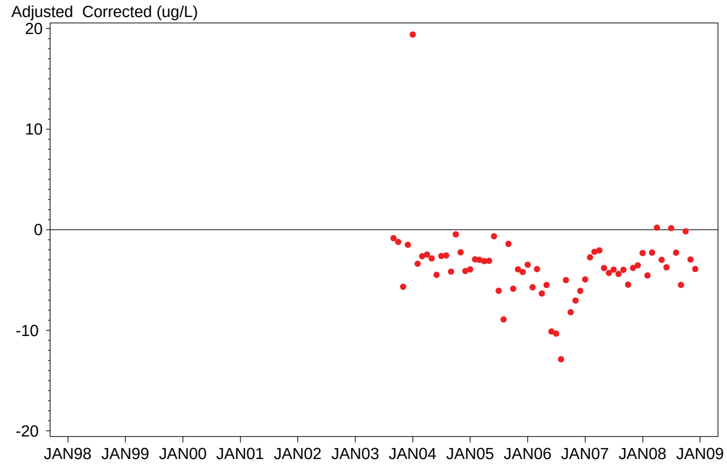
Seasonal Kendall Tau Trend Test Statistics
for Surface Chlorophyll a

Adjusted for Seasonal Medians

| Tau Statistic | P-Value Without Serial Correlation | P-Value With Serial Correlation | Slope Statistic |
|---|---|---|---|
| 0.3 | .00904 | 0.29738 | 0.57917 |

Estero Bay Trends Appendix - Display 38

Time Series Plot of Surface Chlorophyll a Data Adjusted for Season and Detrended




Zero Reference Line Shown

Estero Bay Trends Appendix - Display 39

Autocorrelation Statistics for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 0 | 1.000 | 0.102 | 0.204 | -0.204 |
| 1 | 0.246 | 0.177 | 0.354 | -0.354 |
| 2 | 0.144 | 0.180 | 0.361 | -0.361 |
| 3 | 0.279 | 0.182 | 0.363 | -0.363 |
| 4 | 0.232 | 0.186 | 0.372 | -0.372 |
| 5 | 0.055 | 0.189 | 0.378 | -0.378 |
| 6 | 0.173 | 0.189 | 0.378 | -0.378 |
| 7 | 0.124 | 0.191 | 0.381 | -0.381 |
| 8 | 0.009 | 0.192 | 0.383 | -0.383 |
| 9 | 0.113 | 0.192 | 0.383 | -0.383 |
| 10 | 0.135 | 0.192 | 0.385 | -0.385 |
| 11 | 0.061 | 0.193 | 0.386 | -0.386 |
| 12 | 0.069 | 0.193 | 0.387 | -0.387 |
| 13 | 0.076 | 0.194 | 0.387 | -0.387 |

Estero Bay Trends Appendix - Display 39

Autocorrelation Statistics for Surface Chlorophyll a

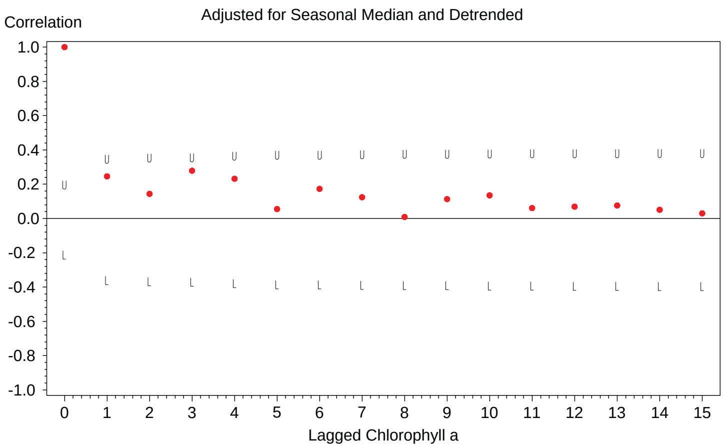
Adjusted for Seasonal Median and Detrended

| Lagged Chlorophyll a | Correlation | Standard Error | Upper Limit | Lower Limit |
|---|---|---|---|---|
| 14 | 0.051 | 0.194 | 0.388 | -0.388 |
| 15 | 0.030 | 0.194 | 0.388 | -0.388 |

Estero Bay Trends Appendix - Display 40

Correlogram for Surface Chlorophyll a

Adjusted for Seasonal Median and Detrended




U=Upper 95% Confidence Limit L=Lower 95% Confidence Limit
Zero Reference Line Shown

# Appendix 4 – Changepoint Methods

Once the TN changepoint was determined using the decision tree approach, a proposed NNC was developed for TN using the following methods.

- The primary split was used to identify two sub populations of chlorophyll *a* values. These sub populations are displayed in the distribution boxplots of the changepoint analysis graphic.
- The exceedance frequency of the TN changepoint, The grand average chlorophyll *a*, and the conditional chlorophyll *a* averages were calculated.
- Three chlorophyll a threshold values were identified; the seagrass chlorophyll *a* threshold, the FDEP state chlorophyll *a* threshold, and the reference period threshold
- Monte Carlo simulation was then used to:
  - Simulate the empirical distribution of chlorophyll in each sub-population
  - Iteratively adjust the exceedance frequency by mixing the two sub population distributions at different proportions using the expected annual sampling frequency.
  - Calculate the annual average chlorophyll of each mixed distribution
  - Find the exceedance frequency that results in a chlorophyll average at each threshold value
  - Calculate the annual TN that corresponds to that exceedance frequency

That expected annual average TN value is then proposed to serve as a potential numeric nutrient criterion. The individual steps are described in more detail using an example in the following paragraphs.

**Step 1: Identify a "changepoint" value:** The figure below summarizes the results of a hypothetical decision tree analysis to detect a changepoint in chlorophyll *a* response as a function of the TN concentrations. A natural changepoint was detected at a TN value of 0.50 mg/l. The boxplots in the graph display the distribution of chlorophyll *a* values in each group (i.e. above and below the TN changepoint value). One can see that the left boxplot has a lower distribution of values and a lower median value (horizontal line).

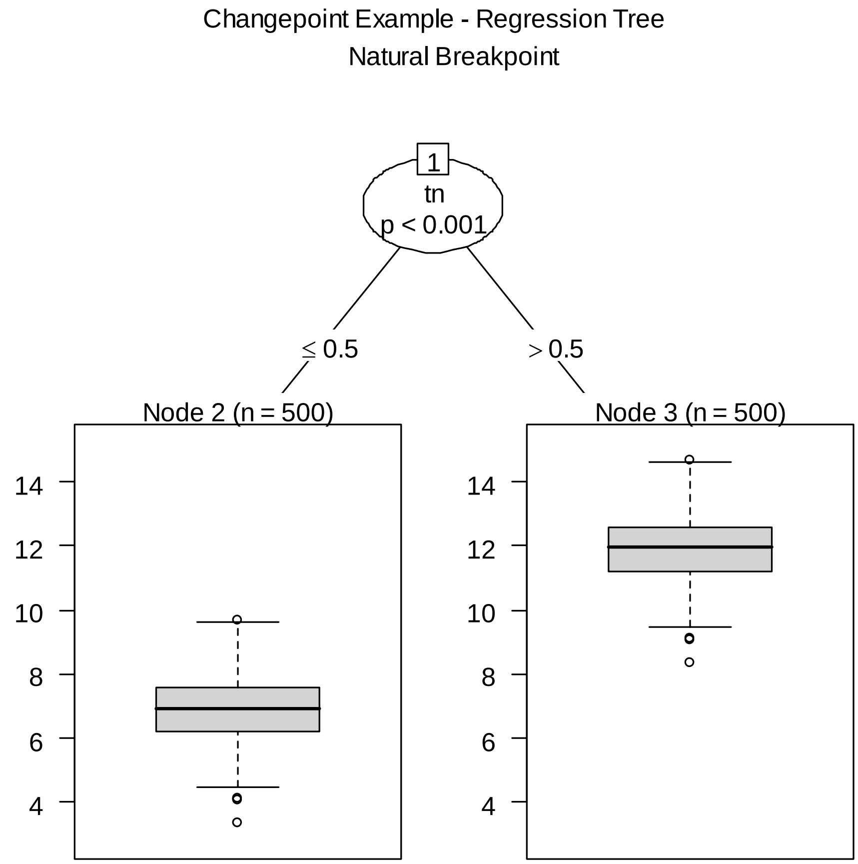



**Figure 1.** **Results of changepoint analysis on hypothetical distribution of chlorophyll *a* and TN concentrations values. Boxplots represent the distribution of chlorophyll *a* values above and below the changepoint TN value.**

**Step 2: Identify the empirical exceedance frequency and chlorophyll thresholds:** The mean chlorophyll in the left group was 7.0 µg/l and the mean in the right group was 12.0 µg/l. In this example, the changepoint value of 0.50 mg/l was exceeded 50% of the time and the overall grand average chlorophyll *a* was 9.42 µg/l. The chlorophyll distributions are normally distributed and as such we could expect that with a 50% exceedance rate the simulation results would suggest that the chlorophyll average would be very close to 9.42. As stated, we used three chlorophyll thresholds described in the document. For the purposes of this example, those threshold values are chosen to be 8 ug/l, 9.5 ug/l, and 11 ug/l.

**Step 3 Create simulation datasets:** To determine what the annual average TN value would be that would result in an overall chlorophyll meeting the three chlorophyll threshold values, Monte Carlo simulation (a randomized permutation technique) was used to create two large data pools that have the exact properties of the empirical data depicted in each of the boxplots above. By creating simulation datasets, experiments can be performed that can determine the mixture of the two distributions that will result in an average chlorophyll value equivalent to the predetermined threshold value. The distributional properties of the empirical and simulated data are equivalent; however; the number of observations in the simulated data is greatly increased. This allows for experimental testing using the Monte Carlo approach.

**Step 4. Monte Carlo Simulation:** The objective of this step is to simulate an annual collection of data using the simulation datasets to determine the exceedance frequency that would be expected to result in an annual average chlorophyll concentration at the threshold value. The process begins by

- Step 1-randomly selecting data from the two simulation datasets at various exceedance rates using a sample size reflective of the expected annual sampling frequency. For example, using a 20% exceedance rate, and 60 samples per year, 80%of 60 samples (48 samples) would be pulled from the left group in the changepoint figure above and 20% (12 samples) from the right group.
- Step 2 – calculate the chlorophyll average from that random subset. Repeat 1000 times using random subsets and calculate an overall average value.
- Step 3 - Increase the exceedance frequency by 1 percent and repeat
- Step 4 – Stop when the average chlorophyll value reaches the threshold value
- Calculate the TN value and the 95 percent confidence intervals associated with the 1000 randomized trials at each threshold exceedance rate.

**Step 5: Report the TN value** - The proposed potential numeric nutrient criterion for each chlorophyll threshold value is reported based exceedance rate which results in an annual average chlorophyll value at each threshold . Some of the changepoint evaluations were performed on the raw data in which case an the annual sampling frequency of 60 samples was used in the analysis. Other analyses were conducted on the monthly average values in which the annual sampling frequency was assumed to be 12 samples. When TN concentrations were used in the changepoint analysis, the proposed criterion was an annual average TN concentration. When TN loadings were used in the analysis, the sum of the monthly TN loads was used as the proposed numeric nutrient criterion.

## Appendix 5.1 – Draft Results Dona and Roberts Bays

## 5.1 Dona and Roberts Bays

### 5.1.1 Relationships Between Chlorophyll *a* and Concentrations and Loads

In addition to the time series plots, a series of bivariate plots were examined to investigate relationships between chlorophyll *a* and nutrient loads and concentrations. These plots included chlorophyll *a* versus TN concentration, TP concentration, TN loads, TP loads, and hydrologic loads (Figures 1 through 5, respectively). Additional bivariate plots between chlorophyll *a* and pulse residence time, 2-month, 3-month, 4-month, 5-month, and 6-month average loads were examined. TN concentrations appeared to best explain the variability in chlorophyll *a* concentrations in Dona and Roberts Bays. As can be seen in Figure 1, with the exception of a few outliers, there is a distinct pattern of increasing chlorophyll *a* concentrations with increasing TN concentrations.

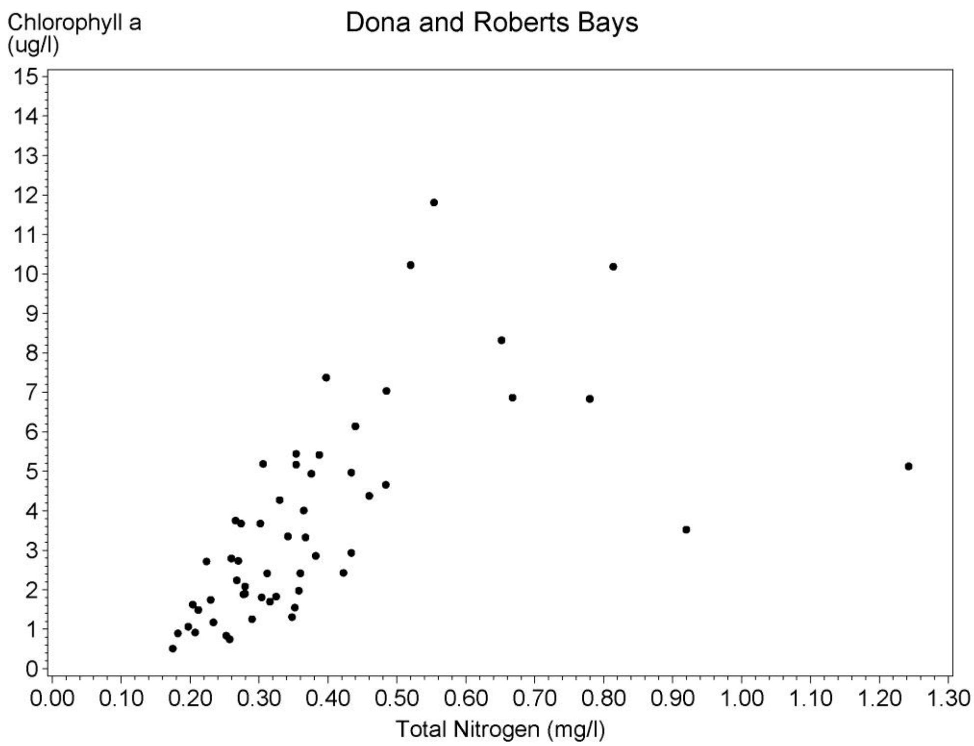



**Figure 1. Relationship between chlorophyll *a* and TN concentrations for Dona and Roberts Bays.**

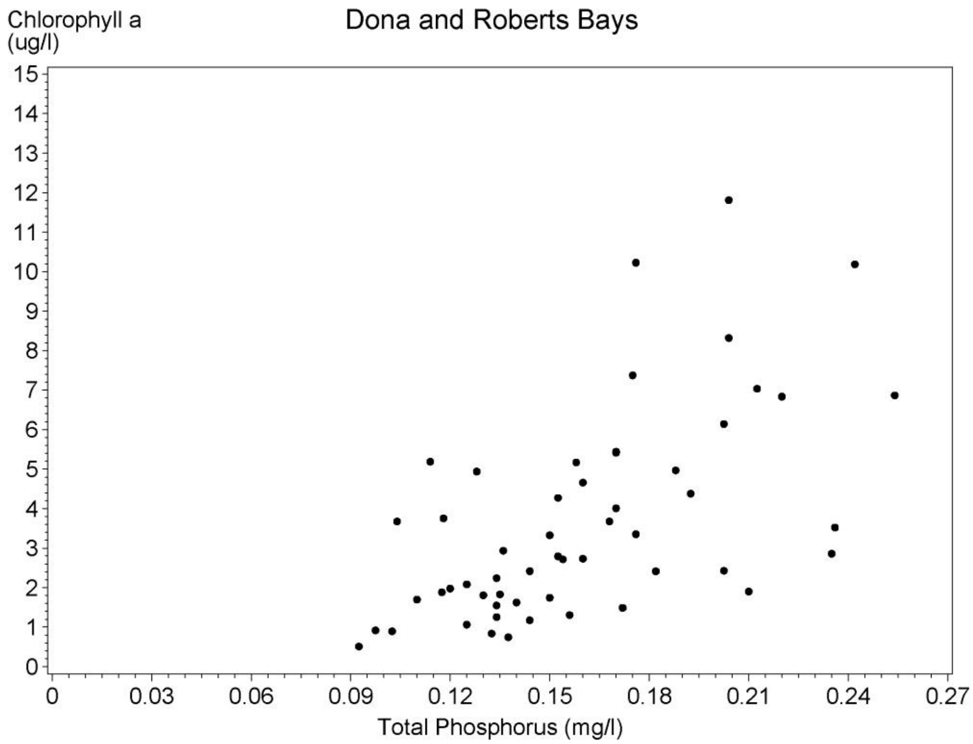



**Figure 2.** **Relationship between chlorophyll *a* and TP concentrations for Dona and Roberts Bays.**

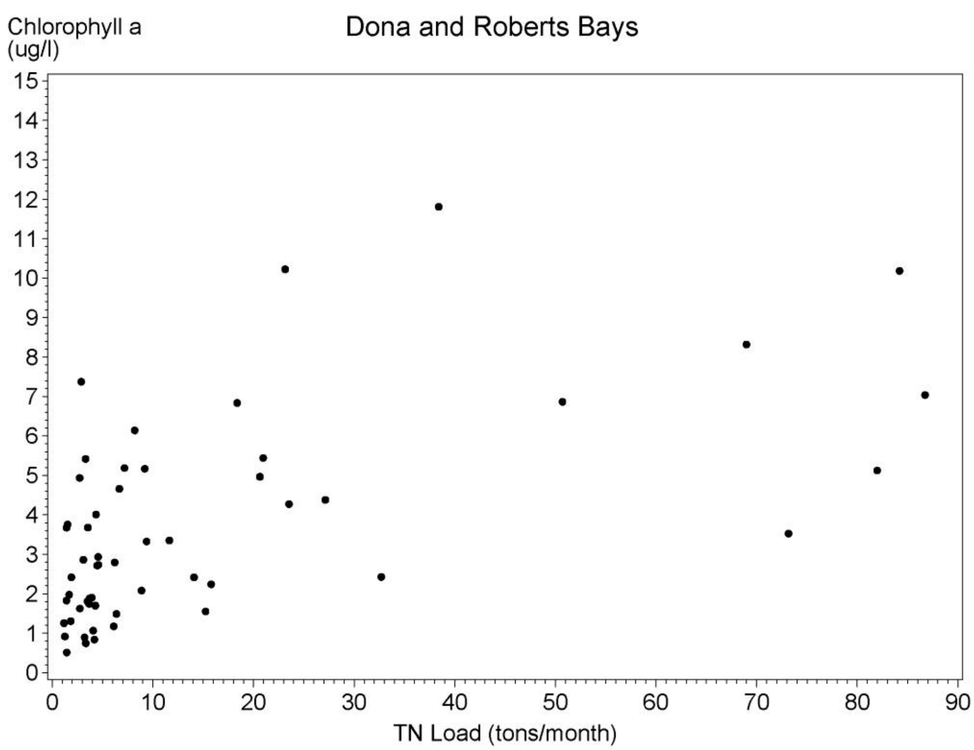



**Figure 3.** **Relationship between chlorophyll *a* and TN loads for Dona and Roberts Bays.**

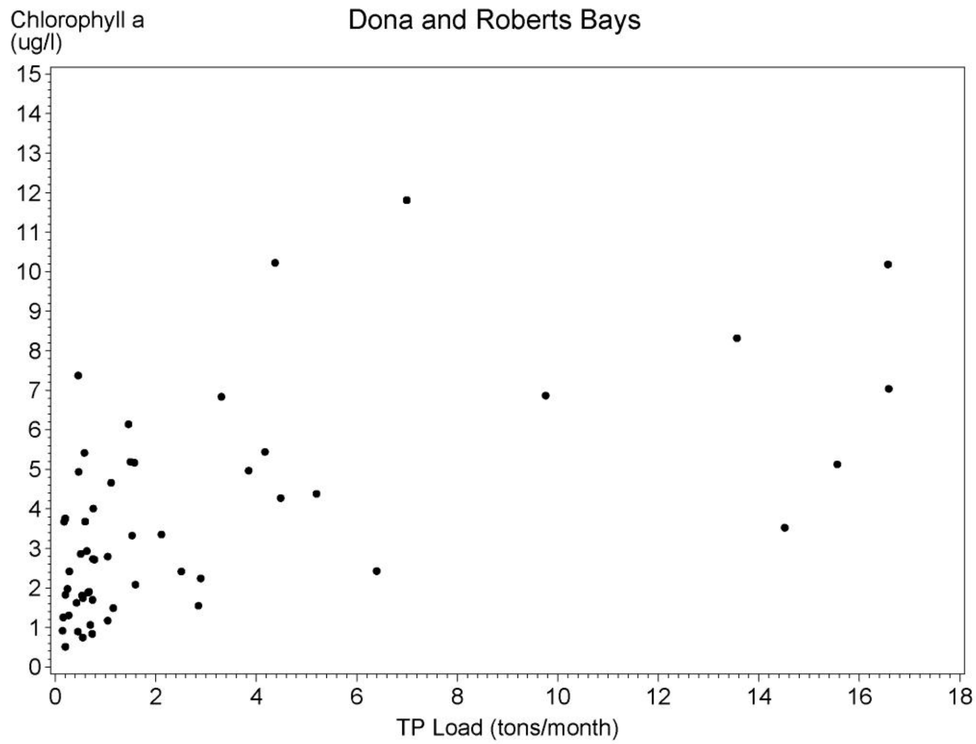



**Figure 4.** **Relationship between chlorophyll *a* and TP loads for Dona and Roberts Bays.**

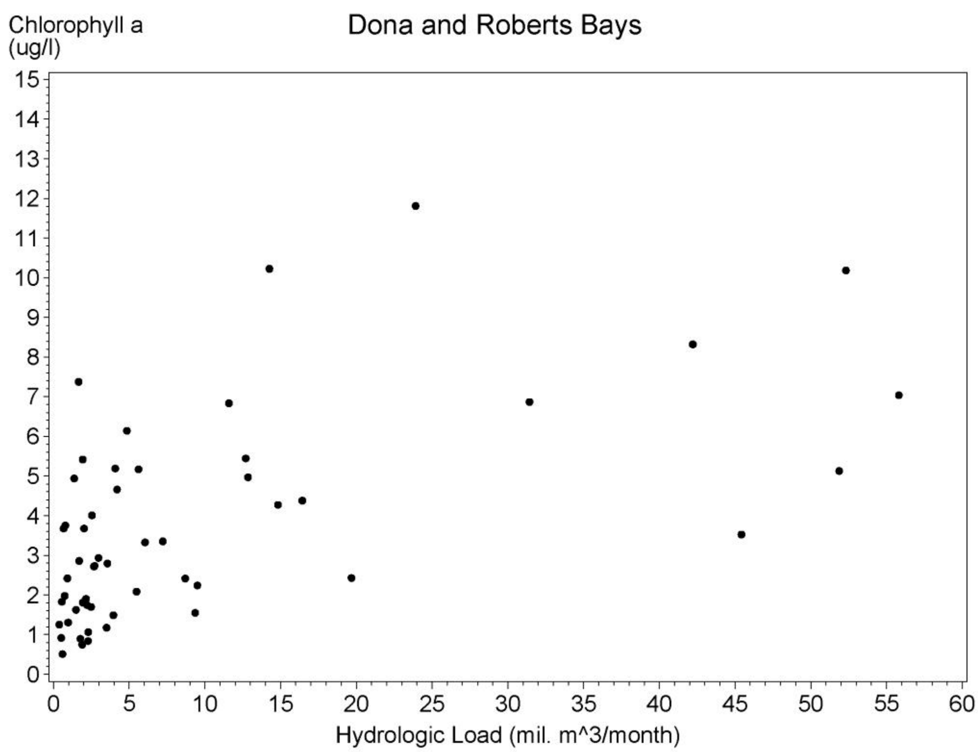



**Figure 5.** **Relationship between chlorophyll *a* and hydrologic loads for Dona and Roberts Bays.**

A regression model between the Box-Cox transformed chlorophyll *a* and Log transformed TN concentrations was developed and the residuals from this model were examined to identify any other explanatory variables that might contribute to the overall variance accounted for by the model. The residual analysis revealed a seasonal difference in residuals. Specifically, given the same TN concentrations, higher chlorophyll *a* concentrations can be expected during the wetter, warmer summer months (July-October) than during the remainder of the year. Therefore, a seasonal term was added to the regression equation. The season term is a dummy variable which equals one during July-October and zero other months of the year. The final regression equation is:

**Transformed [Chlorophyll *a*] = 2.81 + (1.50 * Log [TN]) + (0.57 * season)**

The model was fit with 76 observations and resulted in an $R^2$ value of 0.57. The regression was highly significant with a probability of a greater |F| value of < 0.0001. The slope and parameter coefficients were also highly significant. A plot of predicted versus observed chlorophyll *a* concentrations is presented in Figure 6.

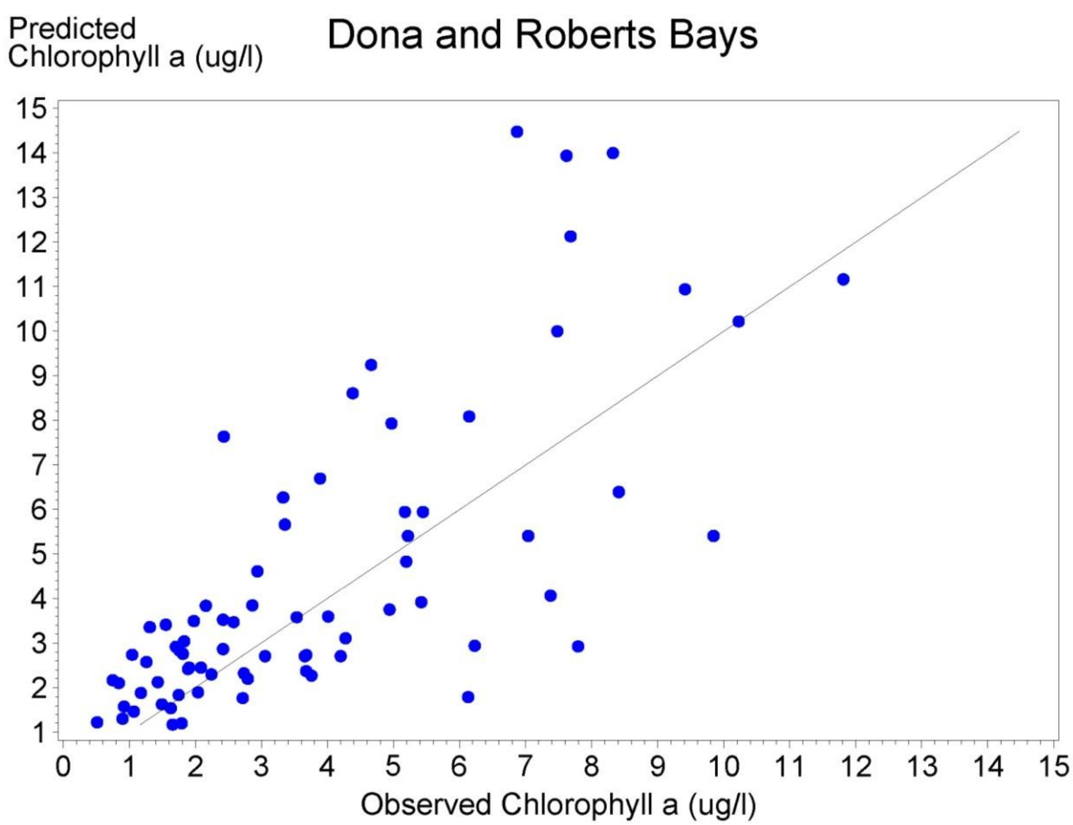



**Figure 6.** **Predicted versus observed chlorophyll *a* concentrations based on regression equation developed for Dona and Roberts Bays.**

### 5.1.2 Candidate Criteria - Dona and Roberts Bays

The above regression equation was used to estimate the TN concentrations that correspond to the chlorophyll *a* thresholds identified for Dona and Roberts Bays. As Dona and Roberts Bays is classified as "restoration" for seagrass, the mean plus ½ standard deviation (4.9 µg/l) was applied. The TN concentration corresponding to this threshold was then calculated for each season. The annual geometric mean of the seasonally-specific TN concentrations was calculated by weighting the seasonal values. The annual geometric mean TN concentration, 0.47 mg/l, is the TN concentration based on the Reference Period Method. Including estimates of uncertainty, the 95% confidence intervals are 0.34 -0.63 mg/l. Assuming the Regulatory Method threshold (11 µg/l), the same procedure was used to calculate the TN concentration that corresponds to the 11 µg/l chlorophyll *a* threshold. The annual geometric mean TN concentration was 1.05 mg/l. Including estimates of uncertainty, the 95% confidence intervals are 0.79 – 1.39 mg/l. There is no Optical Model Method threshold for Dona and Roberts Bays.

A comparison of the candidate numeric TN concentration criteria based on the Regulatory and Reference Period methods is presented in Figure 7.

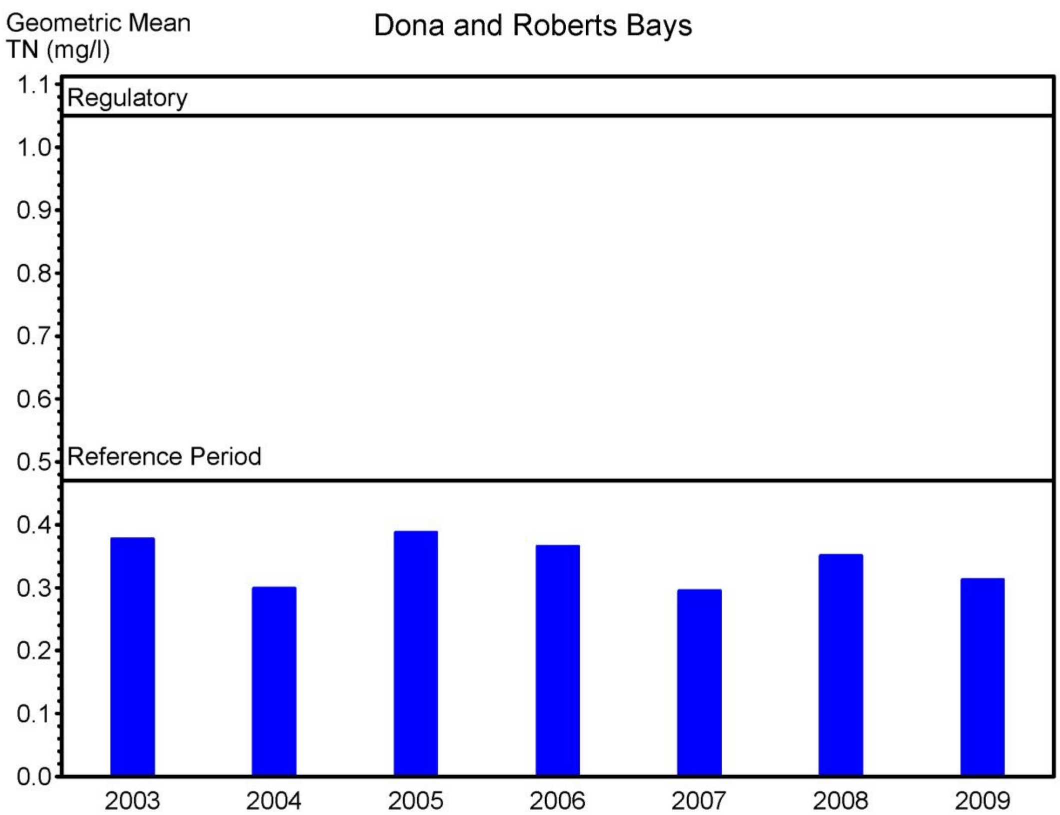



**Figure 7. Comparison of the potential TN criteria to observed TN concentrations (expressed as geometric means) in Dona and Roberts Bays.**

# Appendix 5.2 – Draft Results Lemon Bay

## 5.2 Lemon Bay

### 5.2.1 Relationship Between Chlorophyll *a* and Concentrations and Loads - Lemon Bay

In addition to the time series plots, a series of bivariate plots were examined to investigate relationships between chlorophyll *a* and other potential explanatory variables. These plots included chlorophyll *a* versus TN concentration, TP concentration, TN loads, TP loads, and Hydrologic loads (Figures 1 through 5, respectively). Additional bivariate plots were run between chlorophyll *a* and pulse residence time, 2-month, 3-month, 4-month, 5-month, and 6-month average loads (TN, TP, and hydrologic). TN concentration was identified as the variable that contributes to explaining the variability in chlorophyll *a* concentrations in Upper Lemon Bay. As can be seen in Figure 1, there is a pattern of increasing chlorophyll *a* concentrations with increasing TN concentrations.

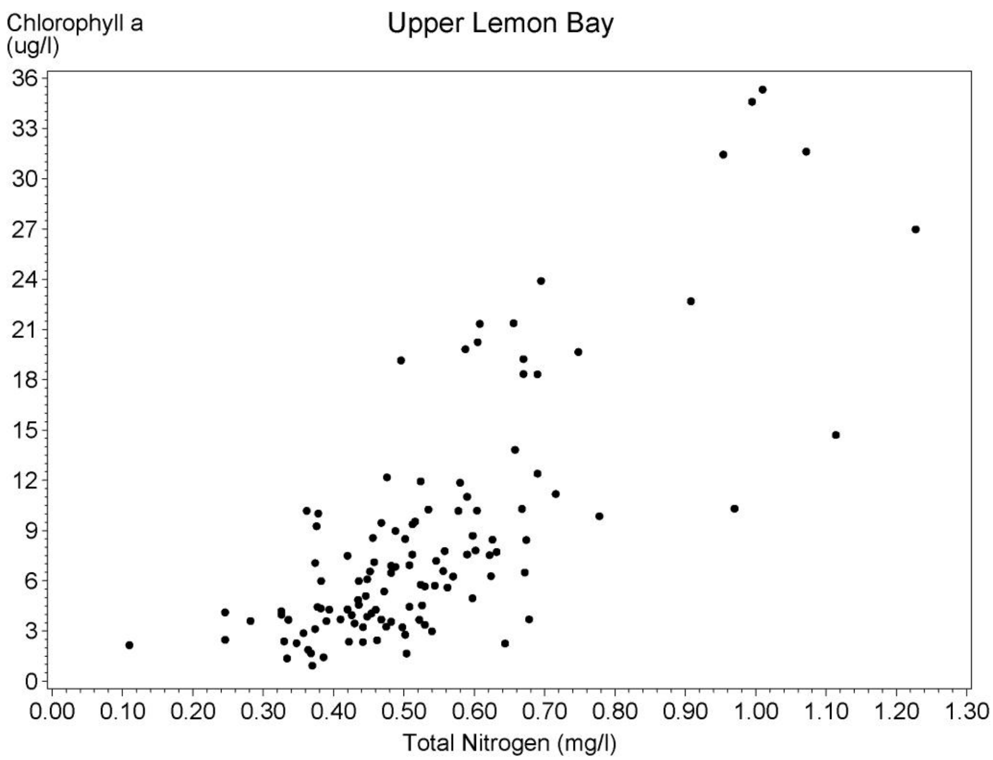



**Figure 1. Relationship between chlorophyll *a* and TN concentrations for Upper Lemon Bay.**

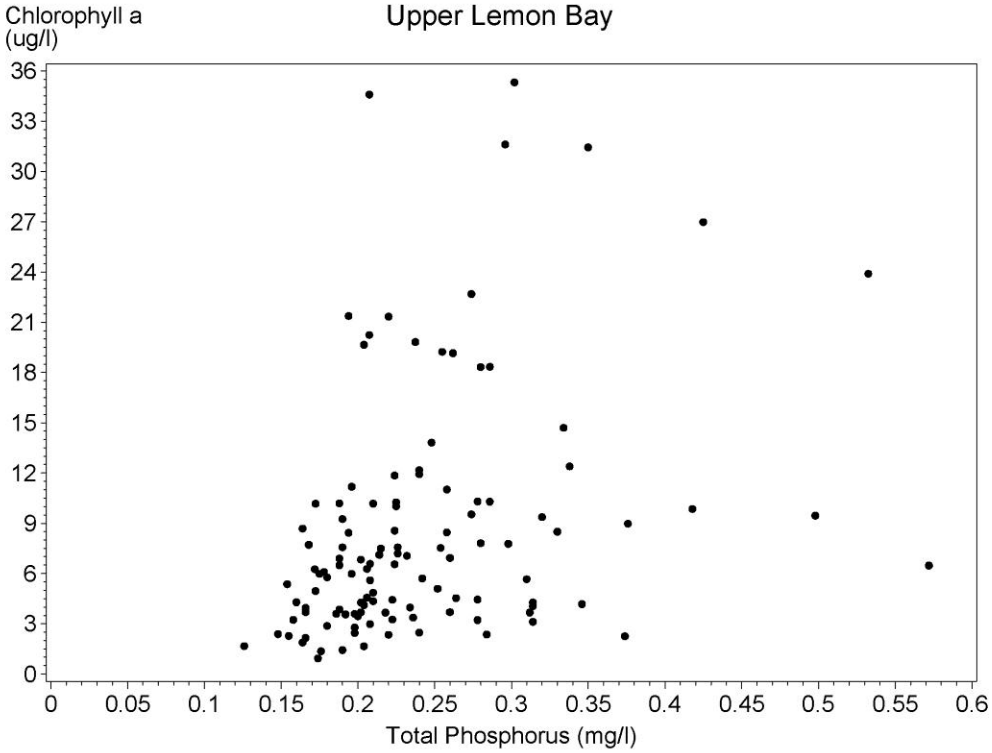



**Figure 2.** **Relationship between chlorophyll *a* and TP concentrations for Upper Lemon Bay.**

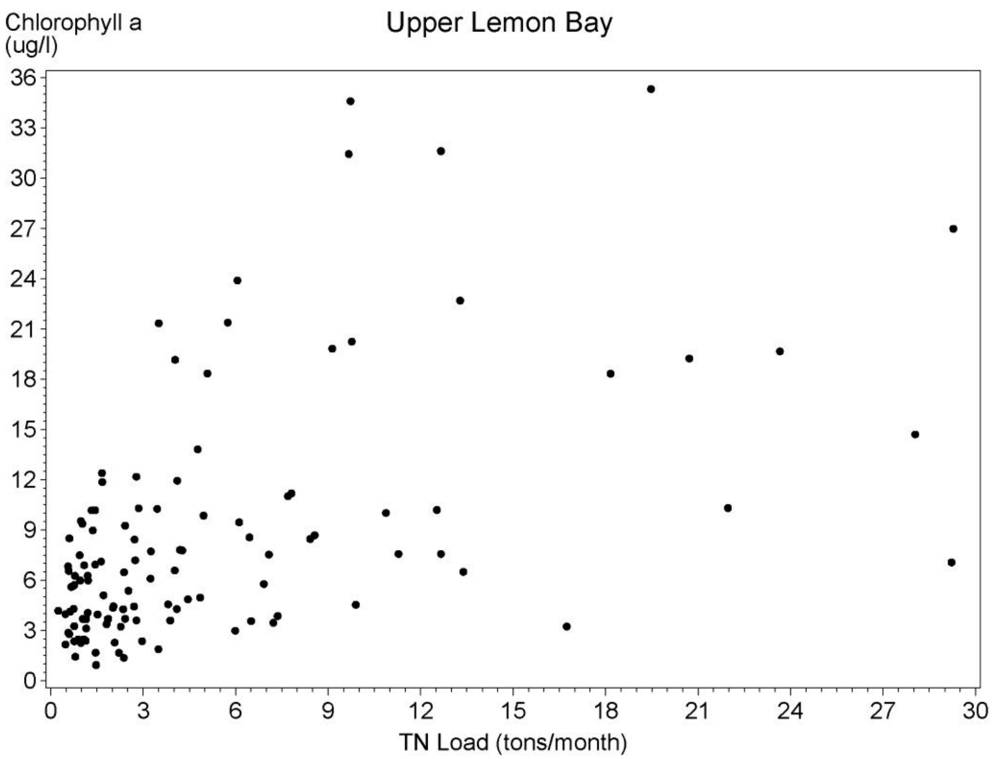



**Figure 3.** **Relationship between chlorophyll *a* and TN loads for Upper Lemon Bay.**

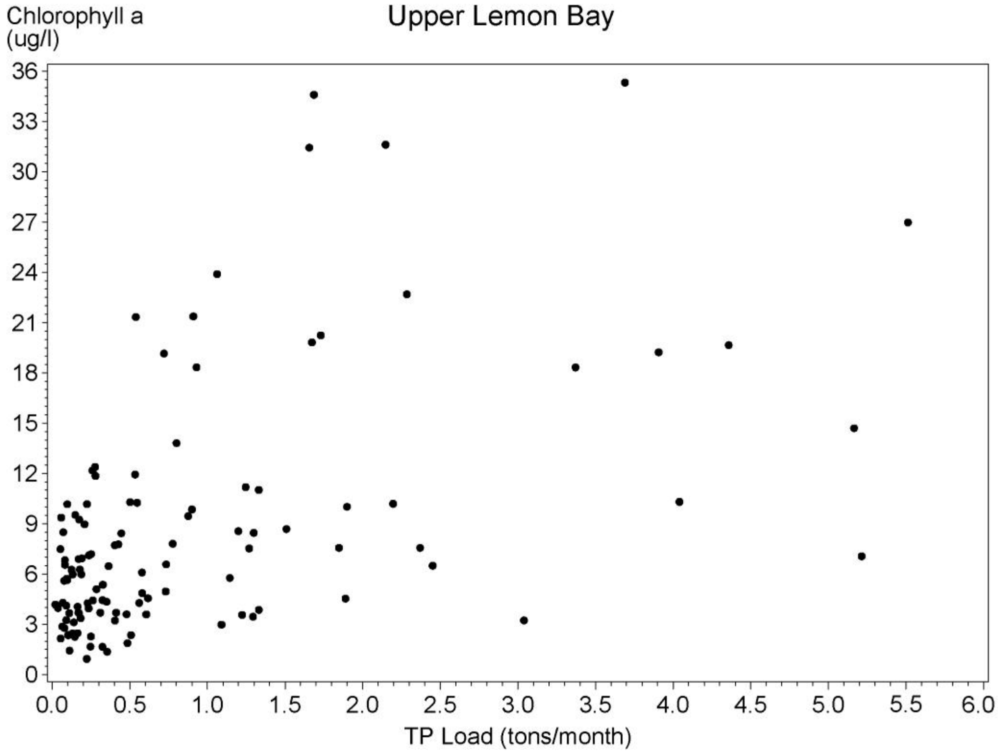



**Figure 4. Relationship between chlorophyll *a* and TP loads for Upper Lemon Bay.**

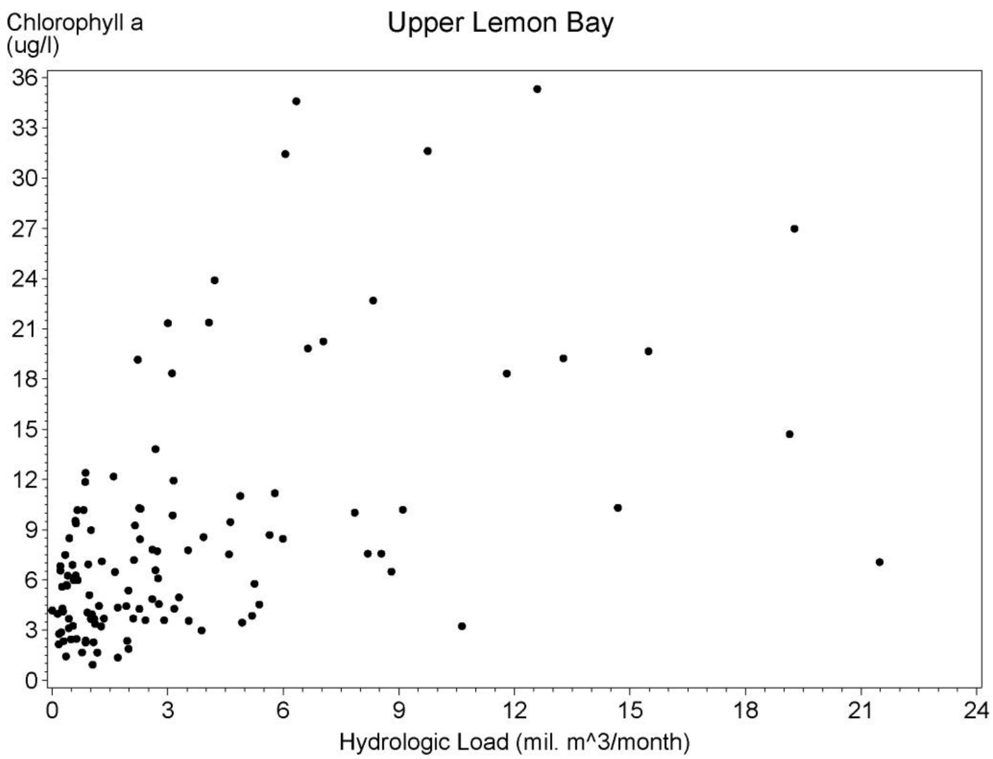



**Figure 5. Relationship between chlorophyll *a* and hydrologic loads for Upper Lemon Bay.**

A regression model between the Box-Cox transformed chlorophyll *a* and Log transformed TN  and color concentrations was developed and the residuals from this model were examined to identify any other explanatory variables that might contribute to the overall variance accounted for by the model.  The residual analysis revealed a seasonal difference in residuals.  Therefore, a seasonal term was added to the regression equation.  The season term is a dummy variable which equals one during July-October and zero other months of the year.  The final regression equation is:

**Transformed[Chlorophyll *a*] = 2.15 + (1.05 * Log[TN]) + (0.02 * color) + (0.57 * season)**

The model was fit with 136 observations and resulted in an $R^2$ value of 0.59.  The regression was highly significant with a probability of a greater |F| value of < 0.0001.  The slope and parameter coefficients were also highly significant.  A plot of predicted versus observed chlorophyll *a* concentrations is presented in Figure 6.

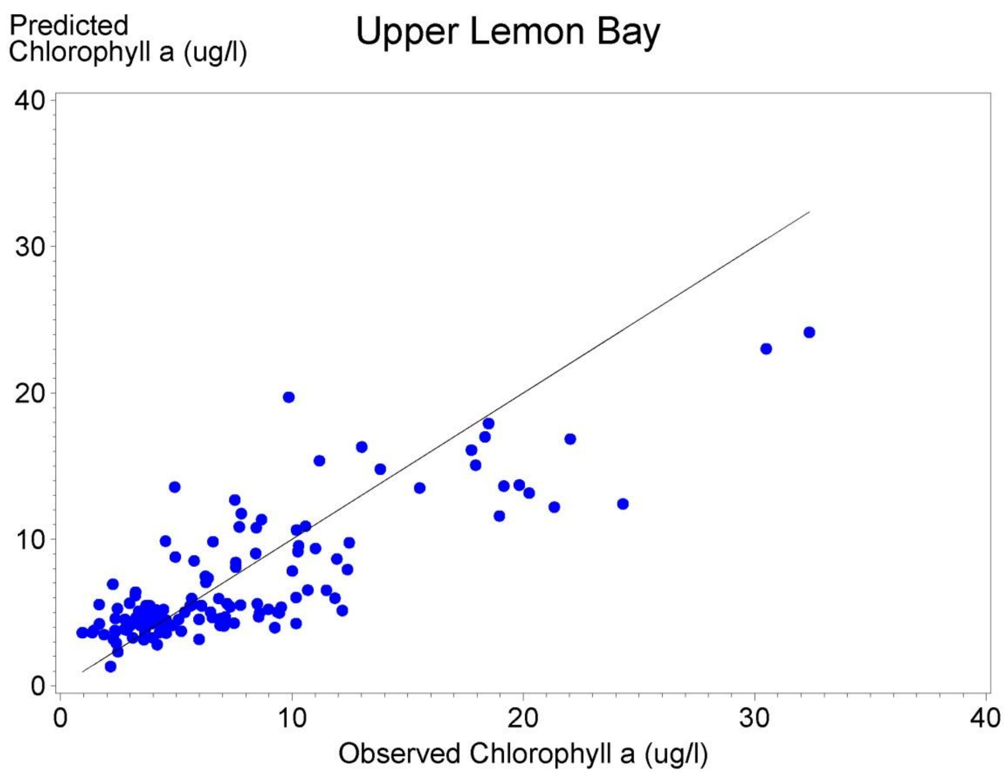



**Figure 6.** **Predicted versus observed chlorophyll *a* concentrations based on regression equation developed for Upper Lemon Bay.**

In addition to the time series plots, a series of bivariate plots were examined to investigate relationships between chlorophyll *a* and other potential explanatory variables in Lower Lemon Bay.  These plots included chlorophyll *a* versus TN concentration, TP concentration, TN loads, TP loads, and Hydrologic loads (Figures 7 through 11, respectively).  Additional bivariate plots were run between chlorophyll *a* and pulse residence time, 2-month, 3-month, 4-month, 5-month, and 6-month average loads (TN, TP, and hydrologic). In addition to the time series plots, a series of bivariate plots were examined to investigate relationships between chlorophyll *a* and other potential explanatory variables. Unlike Upper Lemon Bay, where a defensible linear relationship between chlorophyll *a* and TN exists, no defensible linear relationship between chlorophyll *a* and concentrations or loads was identified in Lower Lemon Bay. Given the proximity to Upper Lemon Bay, the relationship developed for Upper Lemon Bay was applied to Lower Lemon Bay.

### 5.2.2 Candidate Criteria - Lemon Bay

The above regression equation was used to estimate the TN concentrations that correspond to the Reference Period Method for Upper Lemon Bay (8.9 µg/l). This resulted in an estimated TN concentration for each season. The annual geometric mean of the seasonally-specific TN concentrations was then calculated. This annual geometric mean TN concentration, 0.69 mg/l, is the TN concentration that corresponds to the Reference Period Method for Upper Lemon Bay. Including estimates of uncertainty, the 95% confidence intervals are 0.54 – 0.89 mg/l. Assuming the Regulatory Method threshold (11 µg/l ), the same procedure was used to calculate the TN concentration that corresponds to the 11 µg/l Regulatory threshold. The annual geometric mean TN concentration was 0.85 mg/l. Including estimates of uncertainty, the 95% confidence interval is 0.69 – 1.02 mg/l.

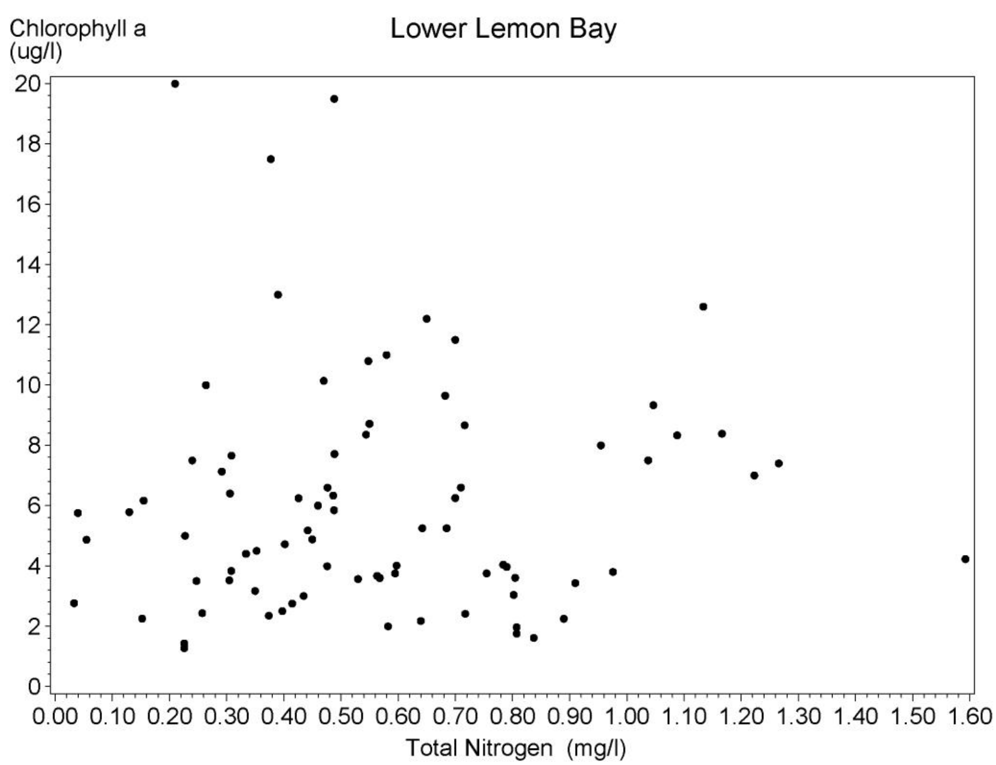



**Figure 7. Relationship between chlorophyll *a* and TN concentrations for Lower Lemon Bay.**

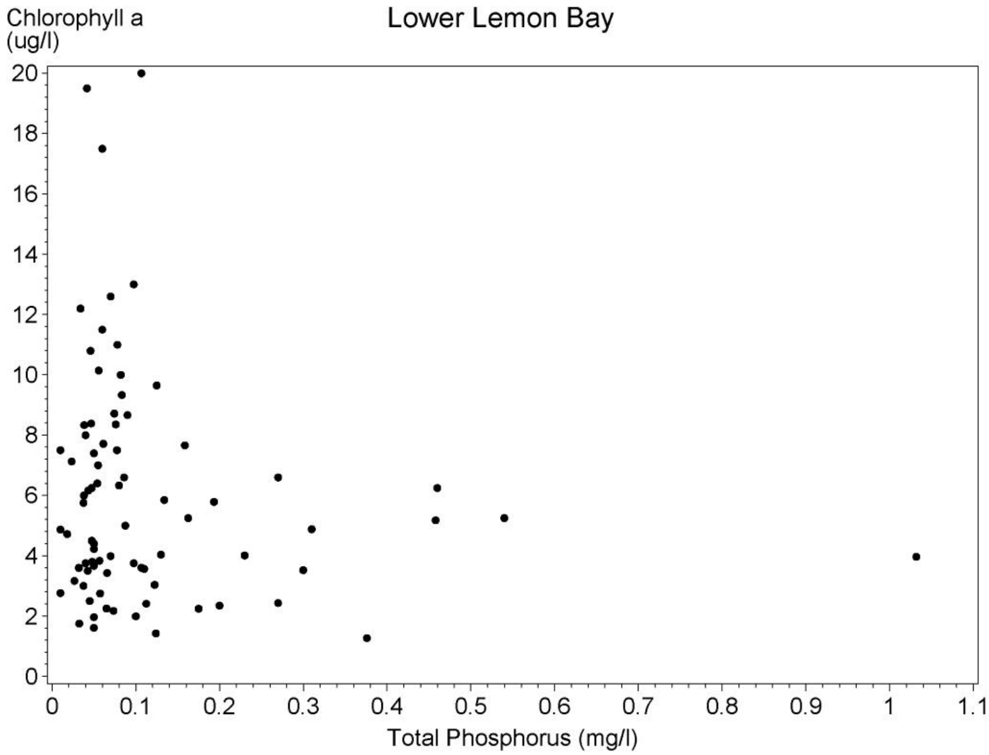



**Figure 8. Relationship between chlorophyll *a* and TP concentrations for Lower Lemon Bay.**

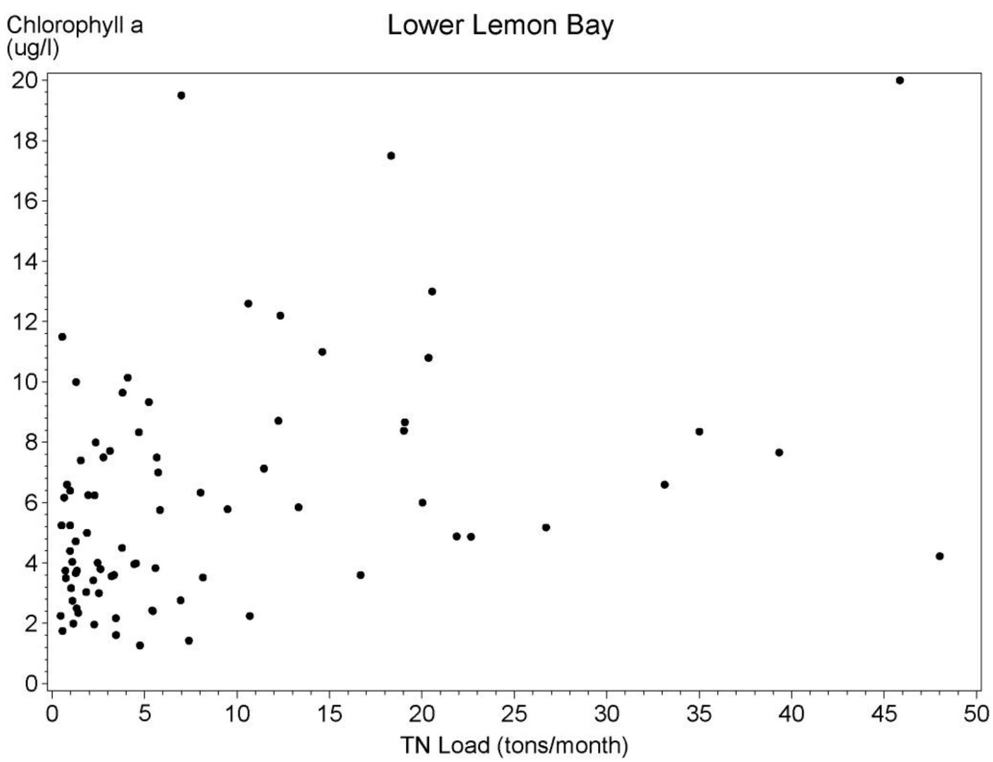



**Figure 9. Relationship between chlorophyll *a* and TN loads for Lower Lemon Bay.**

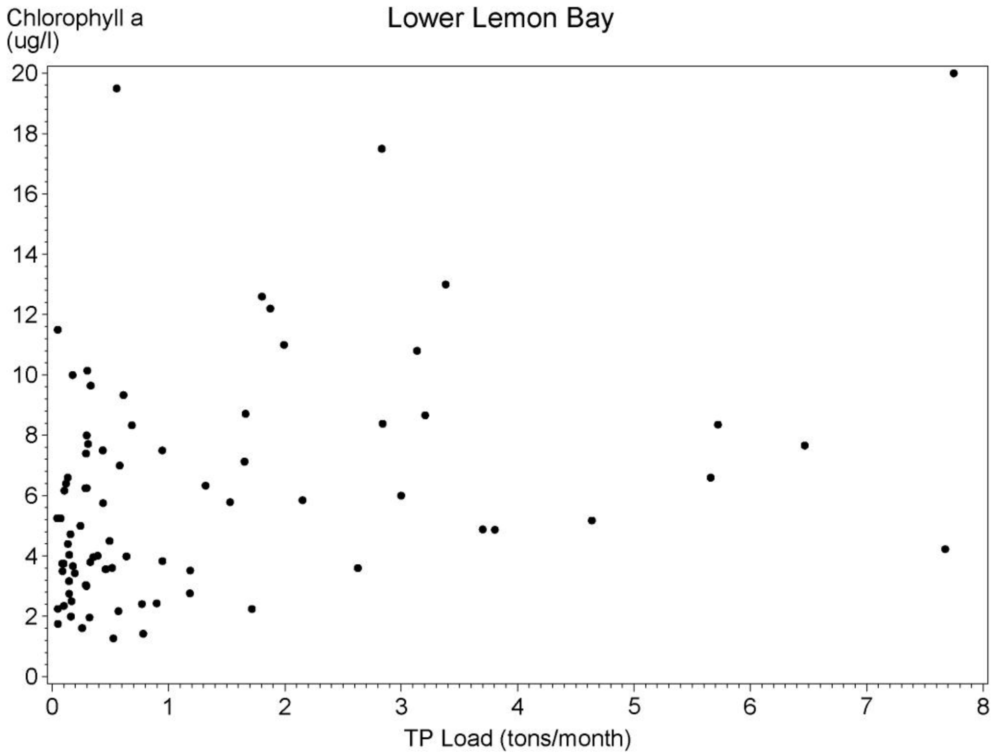



**Figure 10. Relationship between chlorophyll *a* and TP loads for Lower Lemon Bay.**

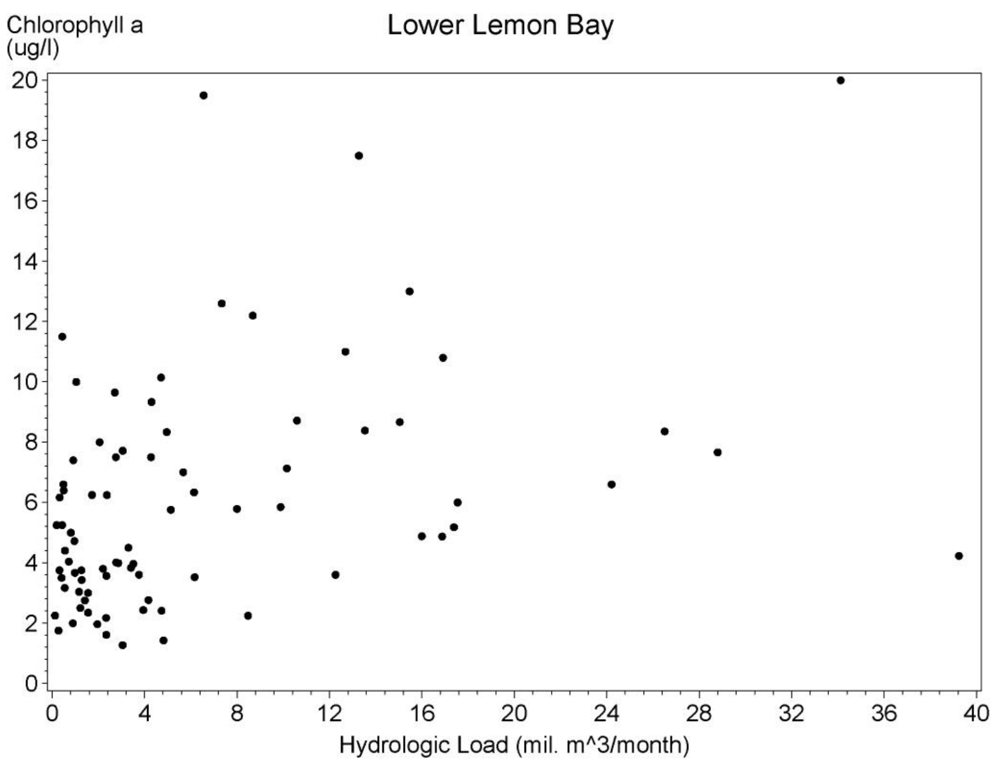



**Figure 11. Relationship between chlorophyll *a* and hydrologic loads for Lower Lemon Bay.**

In addition to the values based on the Reference Period and Regulatory thresholds, two methods were attempted using the Optical Model Method (Table 3-3). In the first method, it was assumed that color and turbidity were equal to zero and the chlorophyll intercepts were used (Table 3-3). The TN target was calculated using the same procedure as was used for the two previously mentioned methods. Given a chlorophyll *a* target of 8.2 µg/l for Lemon Bay, the annual geometric mean TN concentration was 0.63 mg/l. Including estimates of uncertainty, the 95% confidence intervals are 0.54 – 0.76 mg/l. Lastly, an attempt was made to use the mean monthly values of color and turbidity to calculate the monthly target TN values. However, this resulted in negative chlorophyll targets and corresponding negative TN targets in eleven of the twelve months.

A comparison of the candidate numeric TN concentration criteria based on Regulatory, Optical Model, and Reference Period methods is presented in Figure 12 for Upper Lemon Bay.

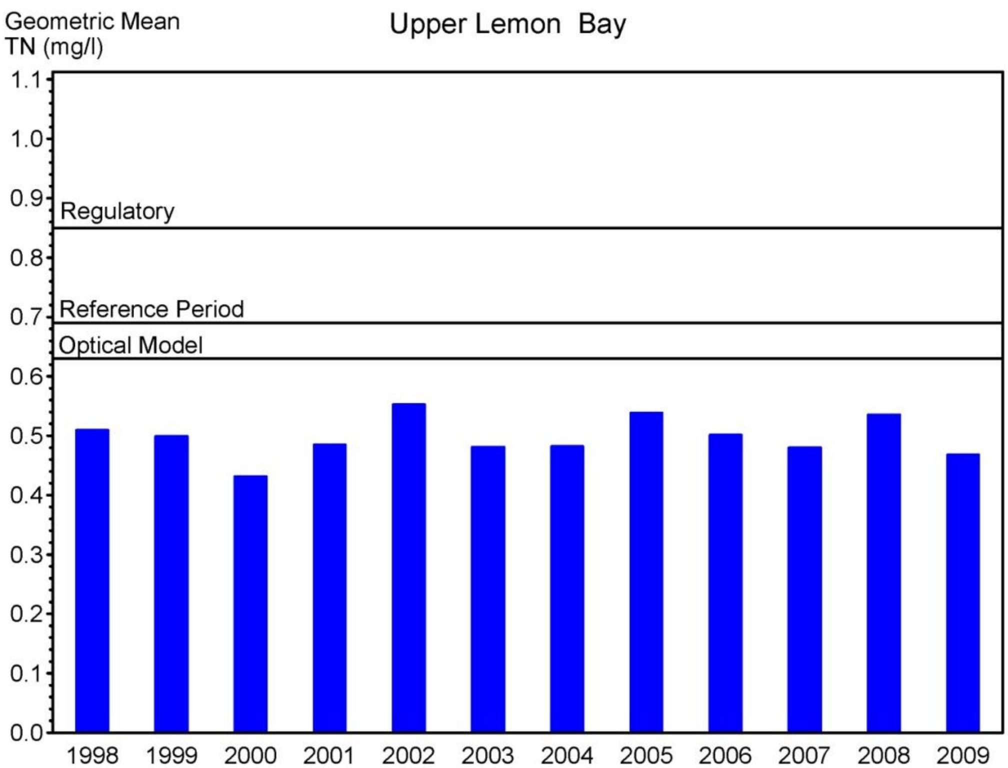



**Figure 12. Comparison of the potential TN criteria to observed TN concentrations (expressed as geometric means) in Upper Lemon Bay.**

The regression equation developed for Upper Lemon Bay was used to estimate the TN concentrations that correspond to the Reference Period Method for Lower Lemon Bay (6.1 µg/l). This resulted in an estimated TN concentration for each season. The annual geometric mean of the seasonally-specific TN concentrations was then calculated. This annual geometric mean TN concentration, 0.48 mg/l, is the TN concentration that corresponds to the Reference Period Method for Lower Lemon Bay. Including estimates of uncertainty, the 95% confidence intervals are 0.41 – 0.56 mg/l. Assuming the Regulatory Method threshold (11 µg/l ), the same procedure was used to calculate the TN concentration that corresponds to the 11 µg/l Regulatory threshold. The annual geometric mean TN concentration was 0.85 mg/l. Including estimates of uncertainty, the 95% confidence interval is 0.69 – 1.02 mg/l.

In addition to the values based on the Reference Period and Regulatory thresholds, two methods were attempted using the Optical Model Method (Table 3-3). In the first method, it was assumed that color and turbidity were equal to zero and the chlorophyll intercepts were used (Table 3-3). The TN target was calculated using the same procedure as was used for the two previously mentioned methods. Given a chlorophyll *a* target of 8.2 µg/l for Lemon Bay, the annual geometric mean TN concentration was 0.63 mg/l. Including estimates of uncertainty, the 95% confidence intervals are 0.54 – 0.76 mg/l. Lastly, an attempt was made to use the mean monthly values of color and turbidity to calculate the monthly target TN values. However, this resulted in negative chlorophyll targets and corresponding negative TN targets in eight of the twelve months.

A comparison of the candidate numeric TN concentration criteria based on Regulatory, Optical Model, and Reference Period methods is presented in Figure 13 for Lower Lemon Bay.

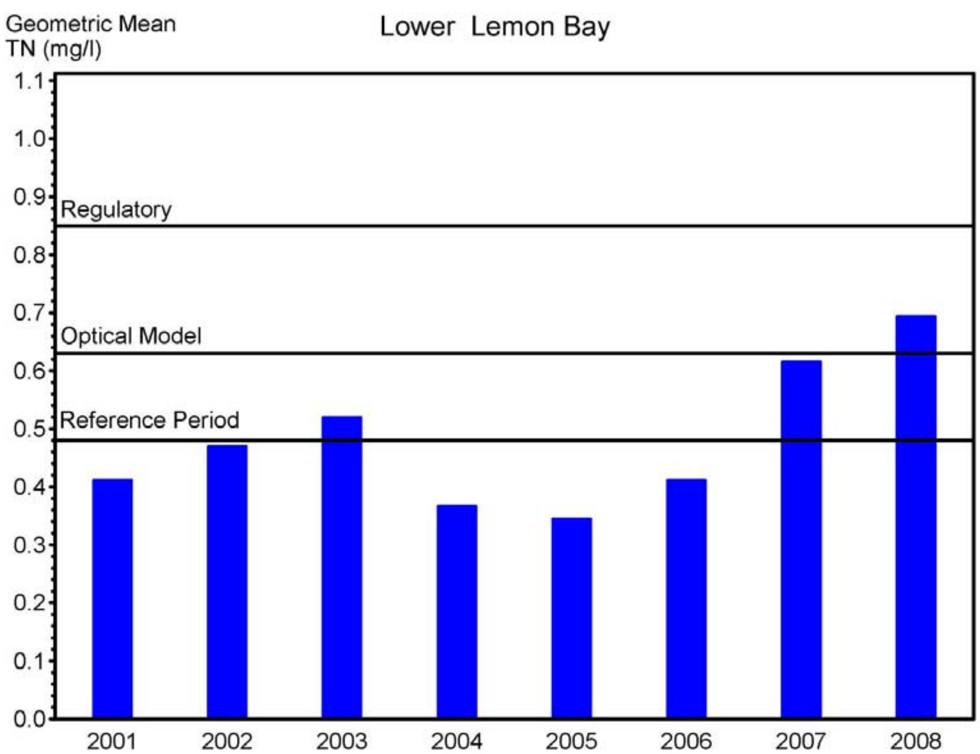



**Figure 13.** **Comparison of the potential TN criteria to observed TN concentrations (expressed as geometric means) in Lower Lemon Bay.**

## Appendix 5.3 – Draft Results Charlotte Harbor Proper

## 5.3 Charlotte Harbor Proper

### 5.3.1 Relationship Between Chlorophyll *a* and Concentrations and Loads - Charlotte Harbor Proper

In addition to the time series plots, a series of bivariate plots were examined to investigate relationships between chlorophyll *a* and other potential explanatory variables. These plots included chlorophyll *a* versus TN concentration, TP concentration, TN loads, TP loads, and Hydrologic loads (Figures 1 through 5, respectively). Additional bivariate plots were run between chlorophyll *a* and pulse residence time, 2-month, 3-month, 4-month, 5-month, and 6-month average loads (TN, TP, and hydrologic). TN concentration was identified as the main variable that contributes to explaining the variability in chlorophyll *a* concentrations in Charlotte Harbor Proper, though this relationship was not as strong as seen in other areas.

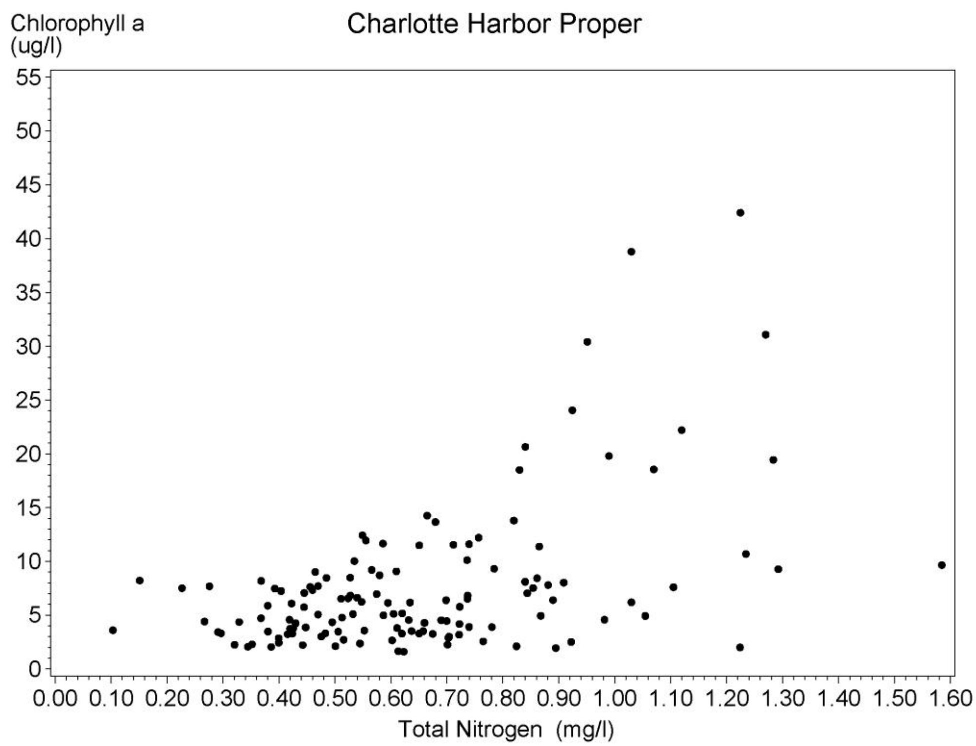



**Figure 1. Relationship between chlorophyll *a* and TN concentrations for Charlotte Harbor Proper.**

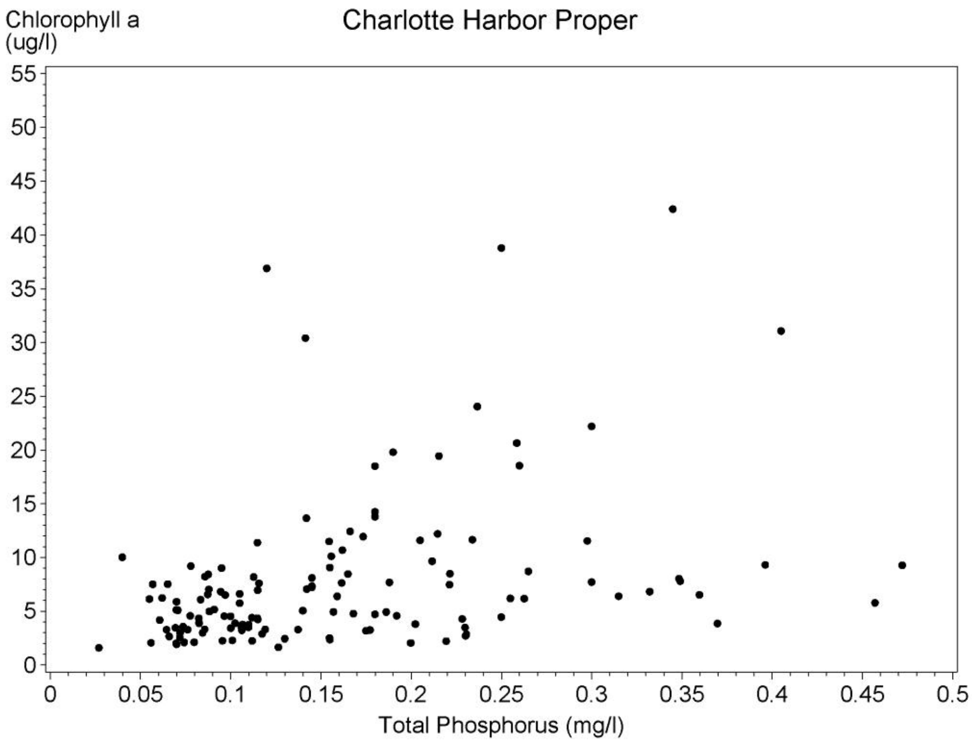



**Figure 2.** **Relationship between chlorophyll *a* and TP concentrations for Charlotte Harbor Proper.**

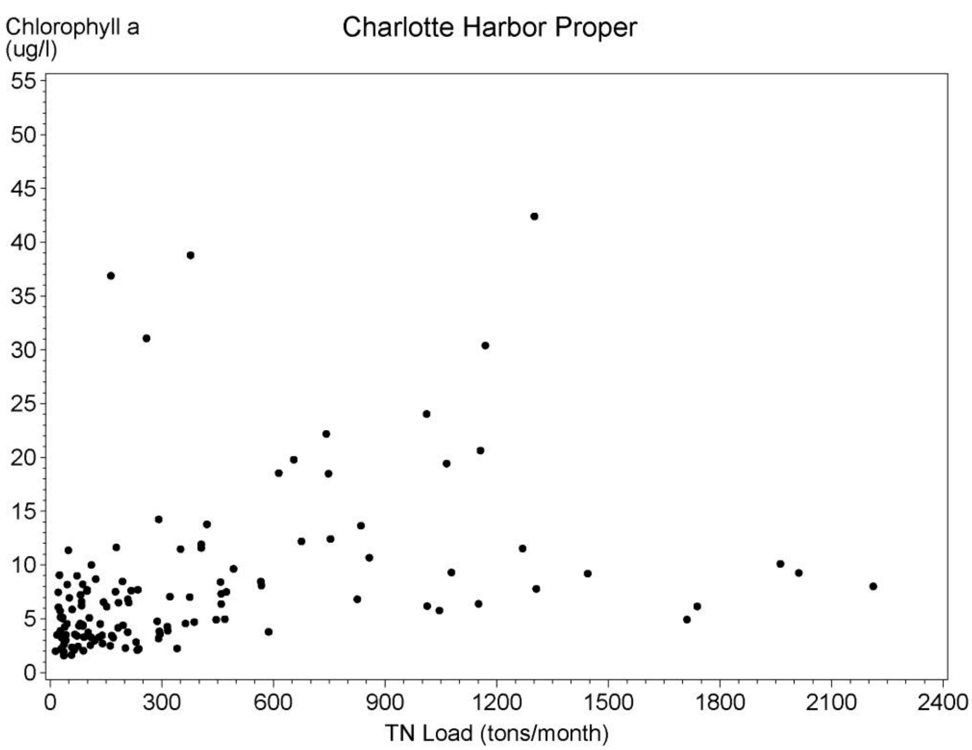



**Figure 3.** **Relationship between chlorophyll *a* and TN loads for Charlotte Harbor Proper.**

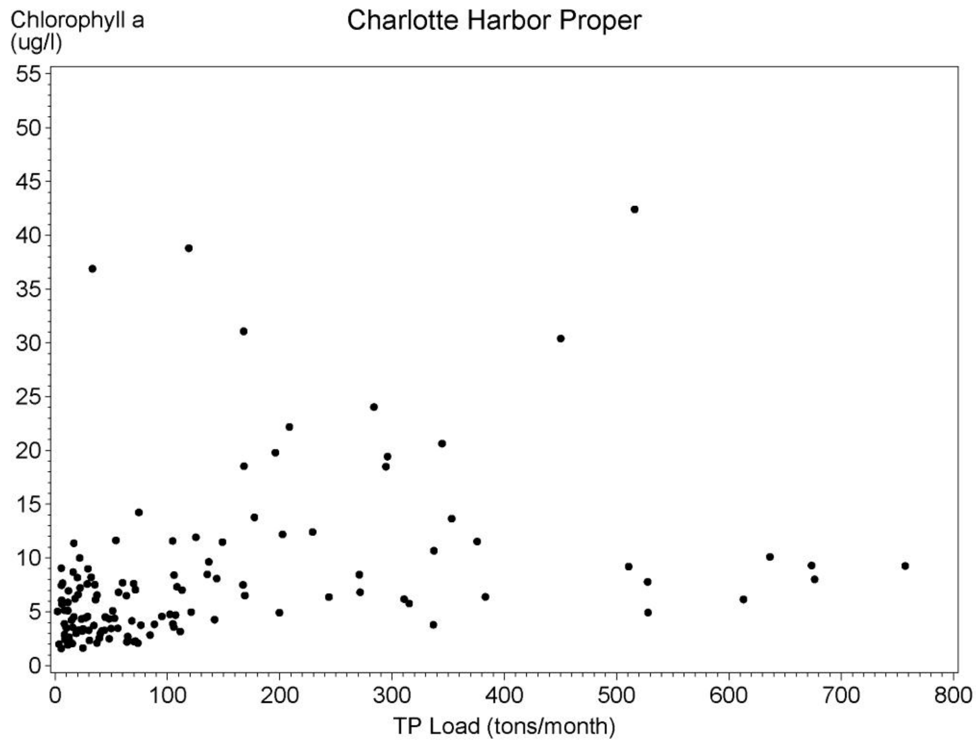



**Figure 4.** **Relationship between chlorophyll *a* and TP loads for Charlotte Harbor Proper.**

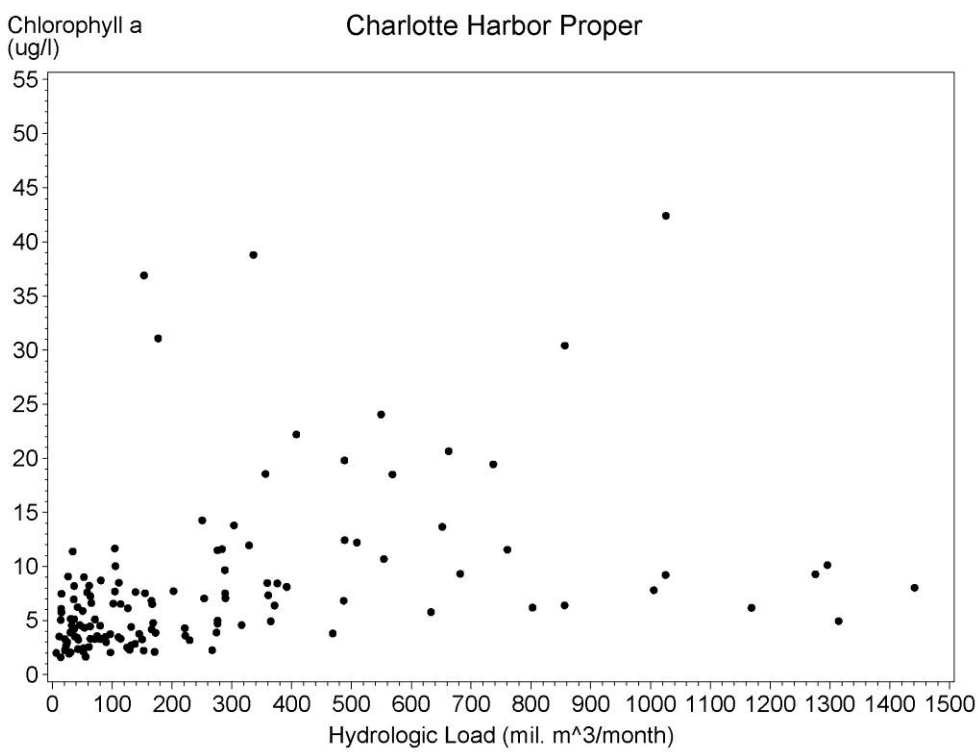



**Figure 5.** **Relationship between chlorophyll *a* and hydrologic loads for Charlotte Harbor Proper.**

A regression model between the chlorophyll *a* and TN concentrations was developed and the residuals from this model were examined to identify any other explanatory variables that might contribute to the overall variance accounted for by the model. The final regression equation is:

**[Chlorophyll *a*] = 1.20 + (8.20 * [TN])**

The model was fit with 88 observations and resulted in an $R^2$ value of 0.18. The regression was highly significant with a probability of a greater |F| value of < 0.0001. The slope coefficient was not significant, but the parameter coefficient (TN concentration) was highly significant. A plot of predicted versus observed chlorophyll *a* concentrations is presented in Figure 6.

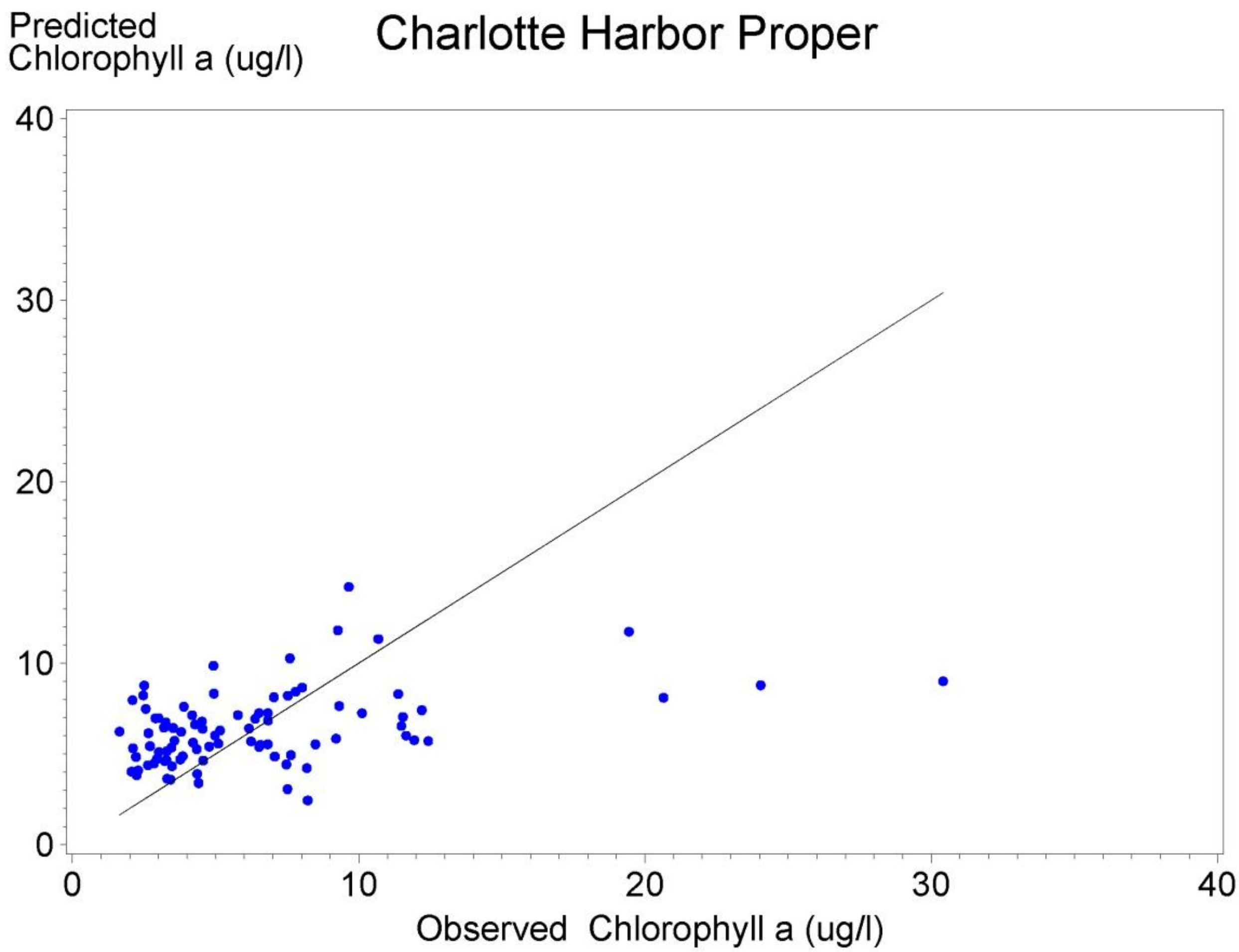



**Figure 6. Predicted versus observed chlorophyll *a* concentrations based on regression equation developed for Charlotte Harbor Proper.**

Although the regression analysis produced a significant relationship, the amount of variation explained by the regression was quite low. Therefore, changepoint analysis was also investigated. As discussed above, the intent of this analysis was to develop relationships between the grand average monthly chlorophyll *a* concentration in Charlotte Harbor Proper and the grand average monthly concentration of TN in Charlotte Harbor Proper. A TN concentration changepoint of 0.82 mg/l was identified using the changepoint analysis on these data (Figure 7). The overall average of the mean chlorophyll concentrations in Charlotte Harbor was 6.1 µg/l. The chlorophyll *a* average when TN was below 0.82 mg/l was 5.27 µg/l and the chlorophyll average when TN was above 0.82 mg/l was 11.08 µg/l. The TN changepoint of 0.82 mg/l was exceeded in 19 percent of the empirical observations.

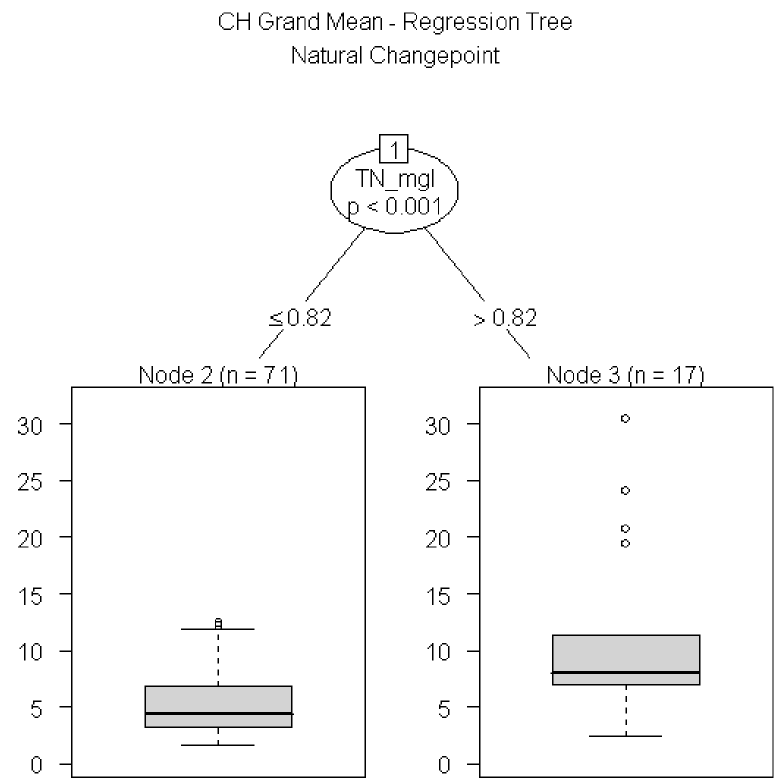



**Figure 7. Results of changepoint analysis using TN and chlorophyll concentrations averaged monthly across Charlotte Harbor Proper.**

### 5.3.2 Candidate Criteria - Charlotte Harbor Proper

The above regression equation was used to estimate the TN concentrations that correspond to the Reference Period Method for Charlotte Harbor Proper (6.1 µg/l). This resulted in an estimated TN concentration. The annual geometric mean TN concentration, 0.60 mg/l, is the TN concentration that corresponds to the Reference Period Method for Charlotte Harbor Proper. Including estimates of uncertainty, the 95%

confidence intervals are 0.48 - 0.73 mg/l. Assuming the Regulatory Method threshold (11 µg/l), the same procedure was used to calculate the TN concentration that corresponds to the 11 µg/l Regulatory threshold. The annual geometric mean TN concentration was 1.19 mg/l. Including estimates of uncertainty, the 95% confidence intervals are 0.92 – 1.49 mg/l.

In addition to the values based on the Reference Period and Regulatory thresholds, two methods were attempted using the Optical Model Method (Table 3-3). In the first method, it was assumed that color and turbidity were equal to zero and the chlorophyll intercepts were used (Table 3-3). The TN target was calculated using the same procedure as was used for the two previously mentioned methods. Given a chlorophyll *a* target of 10.15 µg/l for Charlotte Harbor Proper, the annual geometric mean TN concentration was 1.09 mg/l. Including estimates of uncertainty, the 95% confidence intervals are 0.85 -1.33 mg/l. Lastly, an attempt was made to use the mean monthly values of color and turbidity to calculate the monthly target TN values. However, this resulted in negative chlorophyll targets and corresponding negative TN targets in six of the twelve months.

Because of the weakness of the regression approach for Charlotte Harbor Proper, potential numeric nutrient criteria were developed based on the changepoint analysis described above that correspond to the three methods for Charlotte Harbor Proper. Monte Carlo simulation was used to identify the TN concentration that was expected to result in an average chlorophyll concentration in Charlotte Harbor equivalent to each of the three threshold values. A detailed description of how Monte Carlo methods were used to derive potential numeric nutrient criteria from the changepoint analysis is described in Appendix 4. The distribution of TN concentrations above and below the changepoint is presented in Figure 8. The average monthly TN concentration below the changepoint was 0.54 mg/l and the average above the changepoint was 1.01 mg/l. The TN concentration that resulted in an expected annual average chlorophyll equivalent to the Reference Period threshold of 6.1 µg/l based on monthly sampling was 0.62 mg/l. Including estimates of uncertainty, the 95% confidence intervals are 0.53 mg/l – 0.73 mg/l. The TN concentration expected to result in annual average chlorophylls for the Optical Model Method threshold of 10.1 µg/l was 0.81 mg/l with 95% confidence intervals of 0.72-0.91 mg/l. The TN concentration expected to result in annual average chlorophylls for the Regulatory threshold of 11 µg/l was 1.0 mg/l with 95% confidence intervals of 0.90-1.12 mg/l.

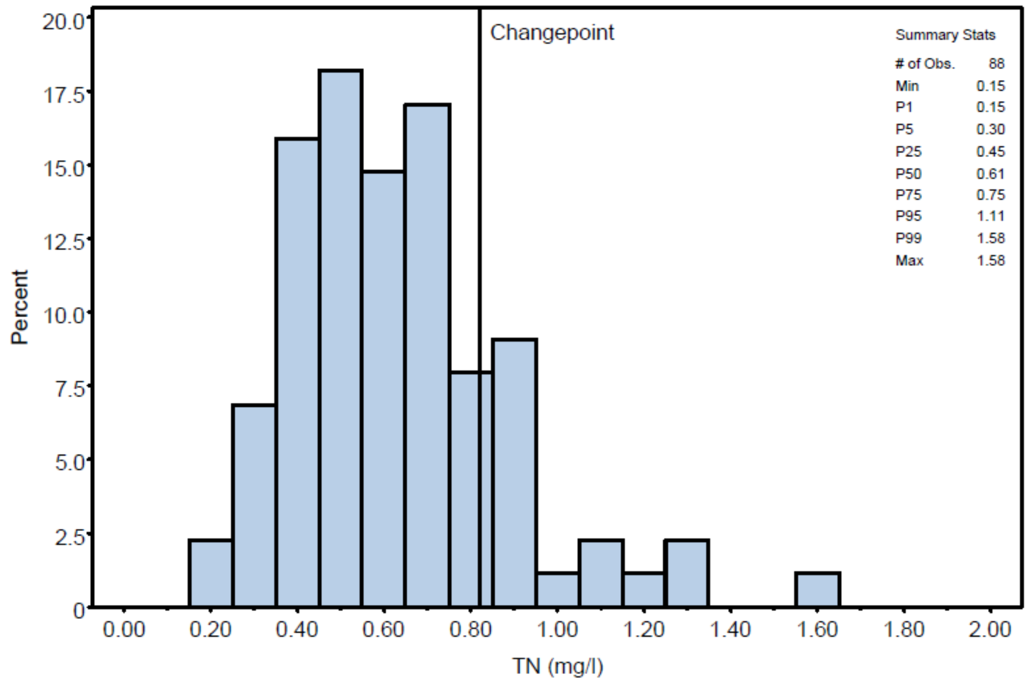



**Figure 8.** **Histogram of monthly average TN concentrations in Charlotte Harbor corresponding to the water quality data with changepoint identified as solid vertical line.**

Implementation of this proposed TN criterion will require assessing the influence of inter-annual hydrologic variation and residence times on the target exceedance frequencies and the annual average chlorophyll and TN concentrations. Using the confidence interval provides one mechanism by which this might be accomplished.

A comparison of the candidate TN concentrations arrived at using the regression approach and the changepoint analysis, reveals a weight of evidence as both methods result in similar values, 0.60 mg/l for the regression approach versus 0.62 mg/l for the changepoint approach. Since both values are well within the uncertainty estimates, the value generated using the changepoint approach is considered as the better candidate for the TN criterion for Charlotte Harbor Proper.

A comparison of the candidate numeric TN concentration criteria based on Regulatory, Optical Model, and Reference Period methods is presented in Figure 9 for Charlotte Harbor Proper.

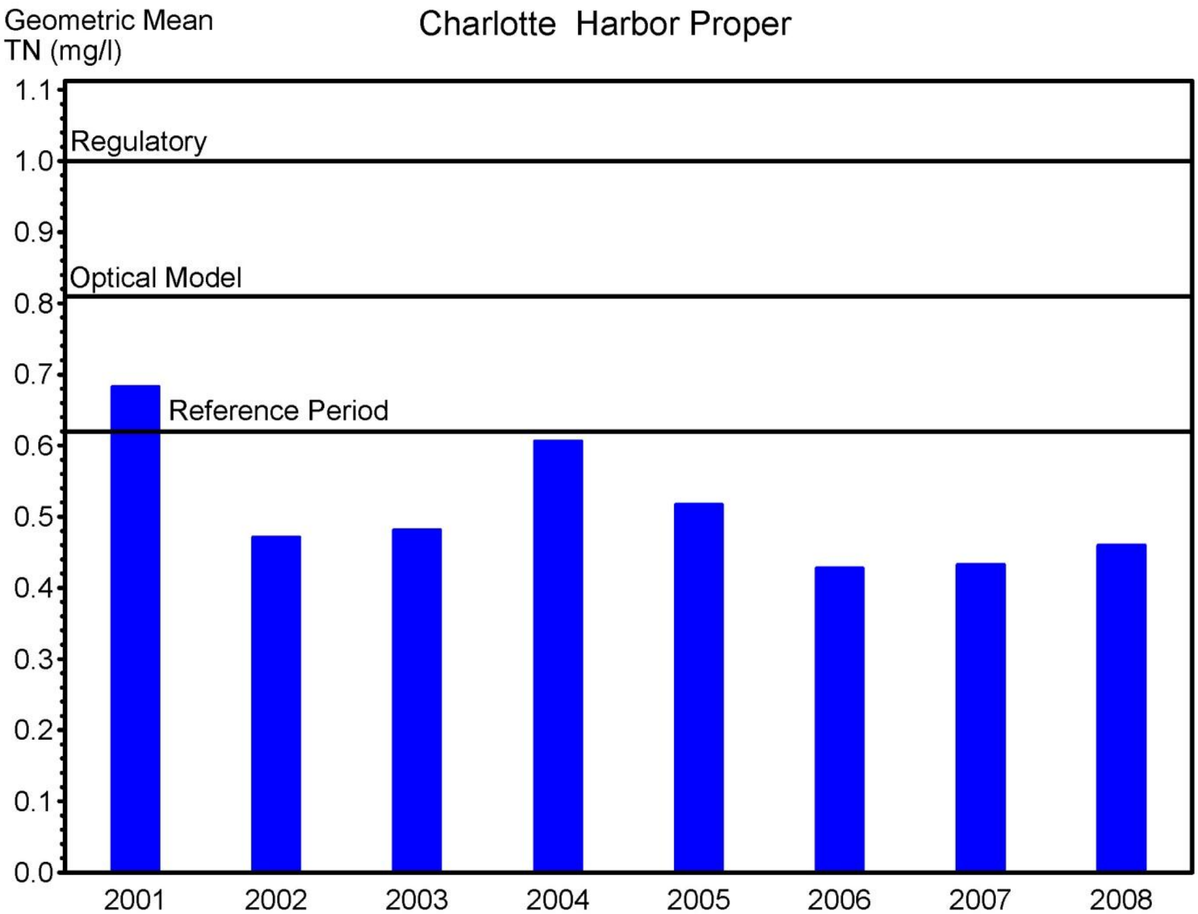



**Figure 9.** **Comparison of the potential TN criteria to observed TN concentrations (expressed as geometric means) in Charlotte Harbor Proper.**

# Appendix 5.4 – Draft Results Tidal Myakka

## 5.4 Tidal Myakka

### 5.4.1 Relationship Between Chlorophyll *a* and Concentrations and Loads - Tidal Myakka

In addition to the time series plots, a series of bivariate plots were examined to investigate relationships between chlorophyll *a* and other potential explanatory variables. These plots included chlorophyll *a* versus TN concentration, TP concentration, TN loads, TP loads, and Hydrologic loads (Figures 1 through 5, respectively). Additional bivariate plots were run between chlorophyll *a* and pulse residence time, 2-month, 3-month, 4-month, 5-month, and 6-month average loads (TN, TP, and hydrologic). No statistically defensible relationships were found for Tidal Myakka chlorophyll *a* concentrations and other water quality parameters or loadings in Tidal Myakka.

Therefore, a downstream compliance area was investigated. This included using the average chlorophyll a concentration for Charlotte Harbor Proper (as described in Section 5.3) and loading and concentrations from Tidal Myakka.

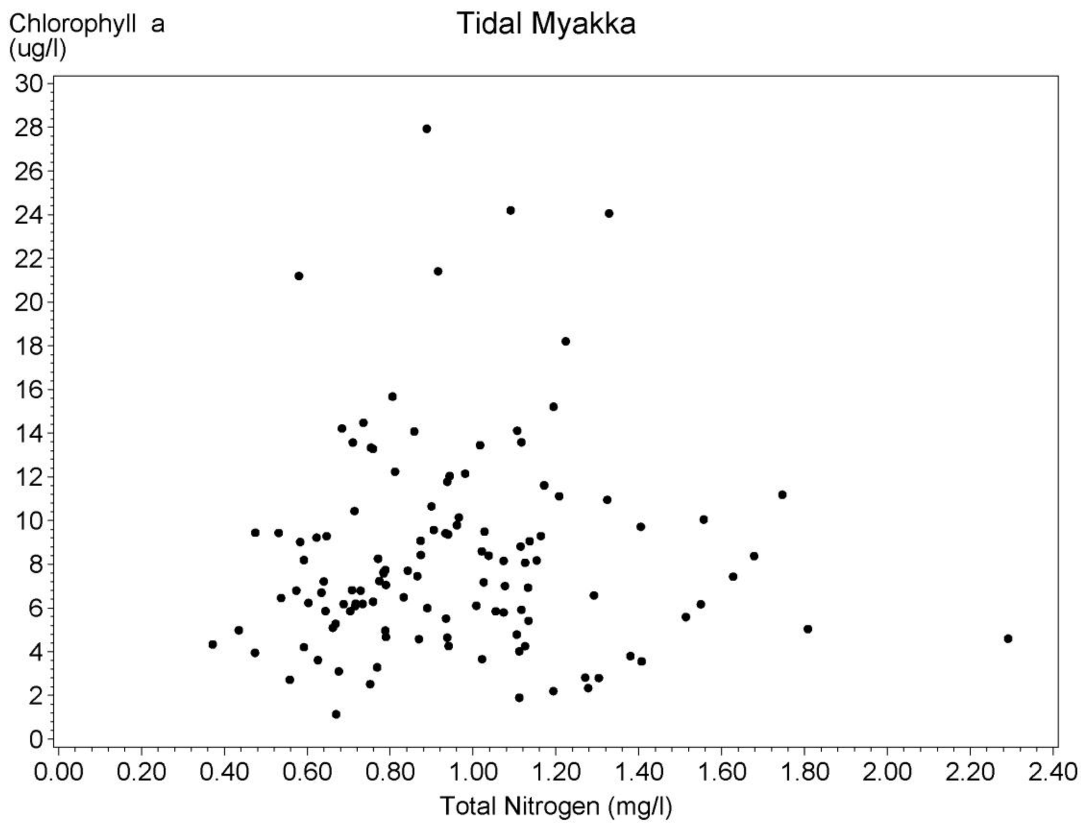



**Figure 1. Relationship between chlorophyll *a* and TN concentrations for Tidal Myakka.**

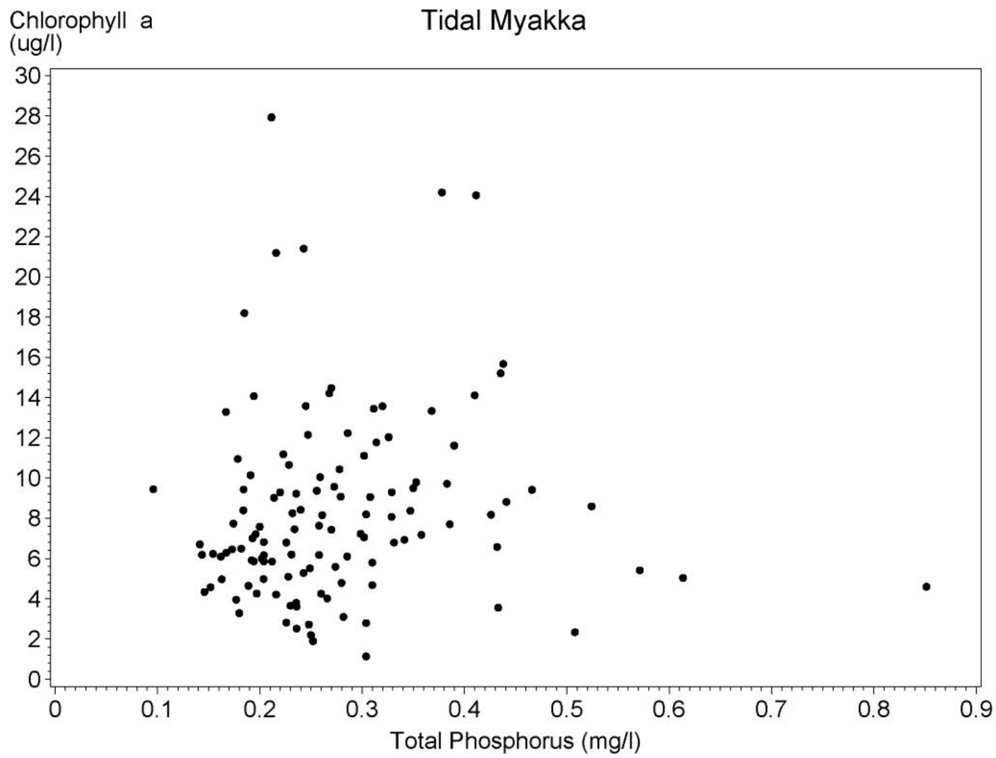



**Figure 2.** **Relationship between chlorophyll *a* and TP concentrations for Tidal Myakka.**

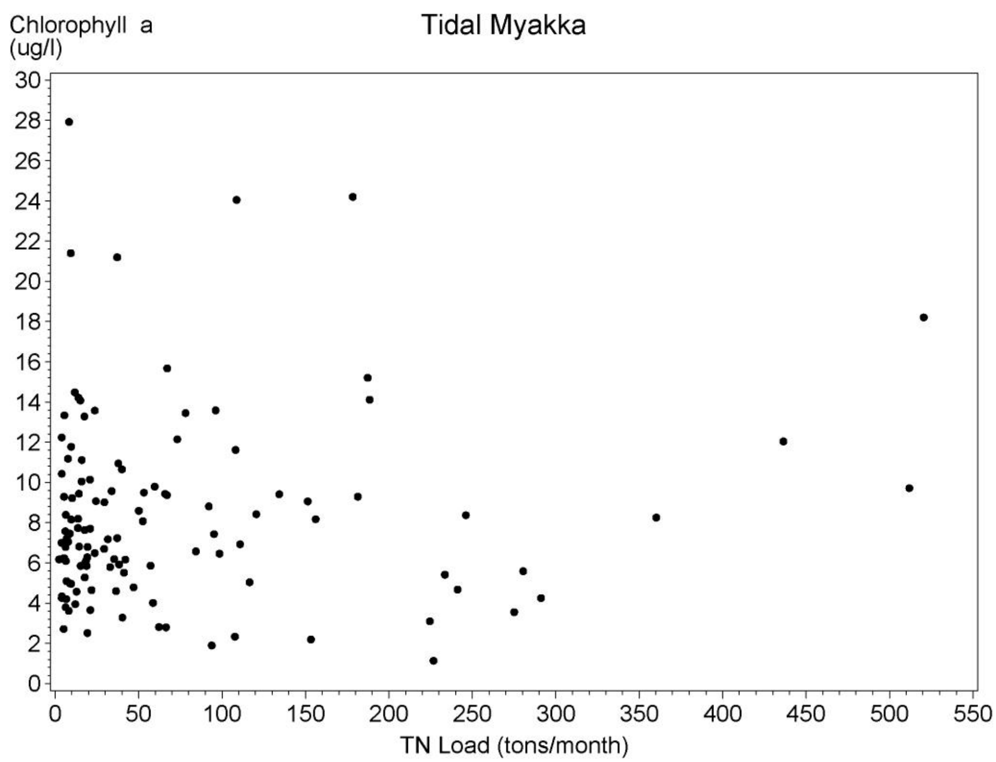



**Figure 3.** **Relationship between chlorophyll *a* and TN loads for Tidal Myakka.**

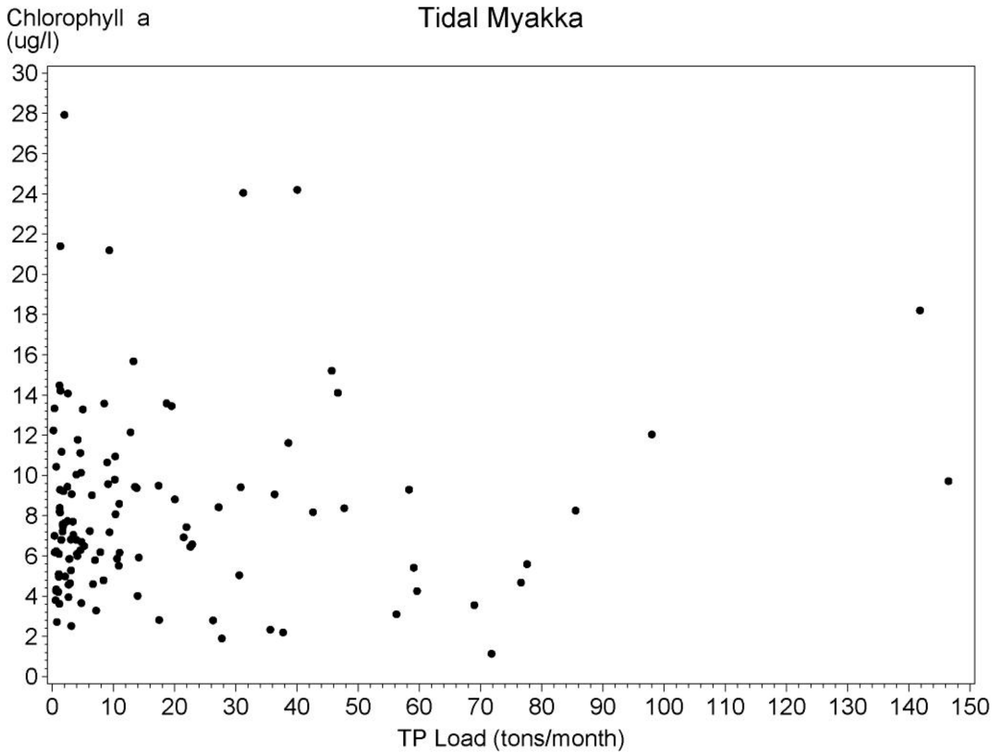



**Figure 4.** **Relationship between chlorophyll *a* and TP loads for Tidal Myakka.**

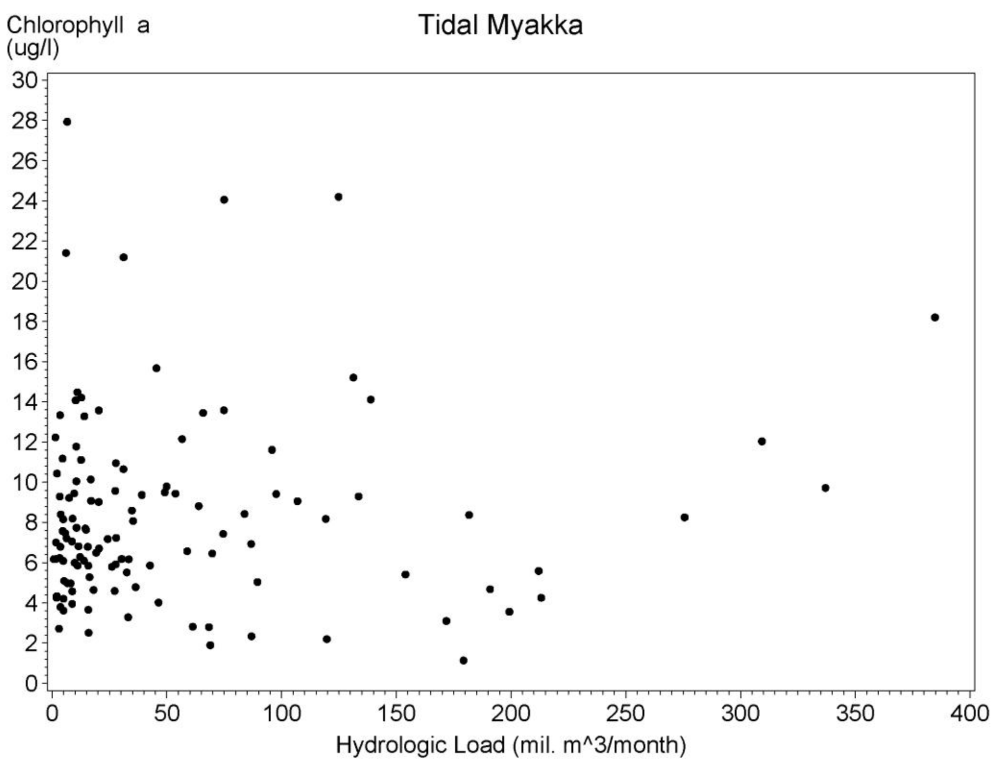



**Figure 5.** **Relationship between chlorophyll *a* and hydrologic loads for Tidal Myakka.**

A regression model between the chlorophyll *a* in Charlotte Harbor Proper and TN loads from the Tidal Myakka was developed and the residuals from this model were examined to identify any other explanatory variables that might contribute to the overall variance accounted for by the model. The residual analysis revealed a seasonal difference in residuals. Therefore, a seasonal term was added to the regression equation. The season term is a dummy variable which equals one during January-June and zero other months of the year. The final regression equation is:

**[Chlorophyll *a*] = 6.83 + (0.0072 * Myakka TN load) + (-3.23 * season)**

The model was fit with 78 observations and resulted in an $R^2$ value of 0.46. The regression was highly significant with a probability of a greater |F| value of < 0.0001. The slope and parameter coefficients were all significant. A plot of predicted versus observed chlorophyll *a* concentrations is presented in Figure 6.

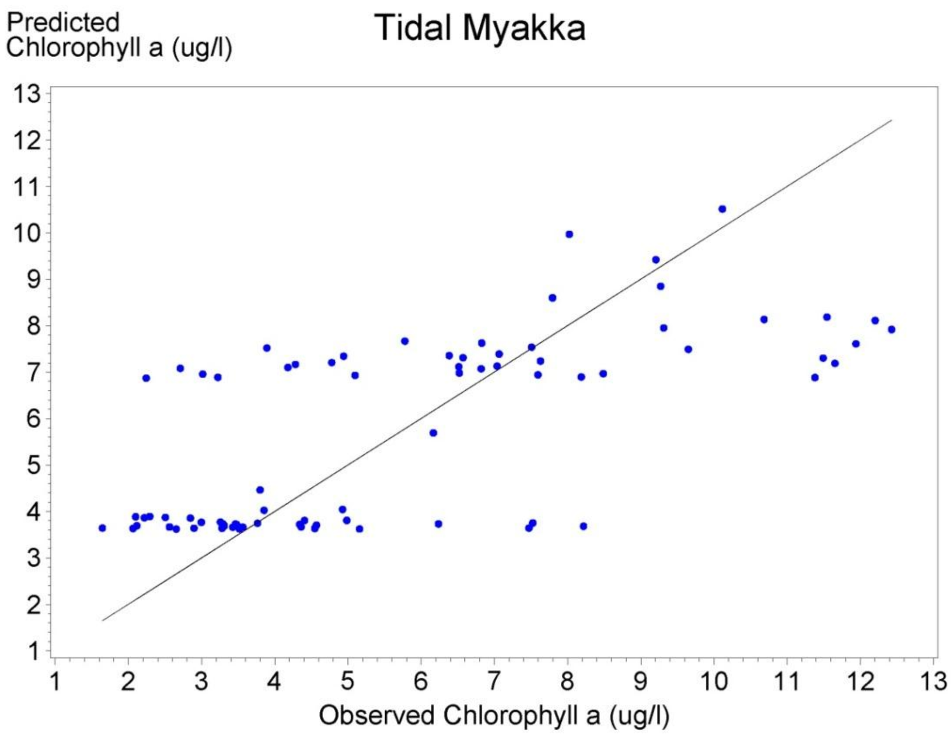



**Figure 6.** **Predicted versus observed chlorophyll *a* concentrations based on regression equation developed for Tidal Myakka.**

Although the regression analysis produced a significant relationship, the amount of variation explained by the regression was low. Therefore, changepoint analysis was also investigated. As discussed above, the intent of this analysis was to develop relationships between the grand average monthly chlorophyll *a* concentration in Charlotte Harbor Proper and TN loads from the Myakka River. A TN changepoint of 120 tons per month was identified using the changepoint analysis on these data (Figure 7). The overall average of the mean chlorophyll concentrations in Charlotte Harbor was 6.39 µg/l . The chlorophyll *a* average when TN was below 120 tons per month was 4.93

μg/l and the chlorophyll average when TN was above 120 tons per month was 11.72 μg/l. The TN changepoint of 120 tons per month was exceeded in 21 percent of the empirical observations.

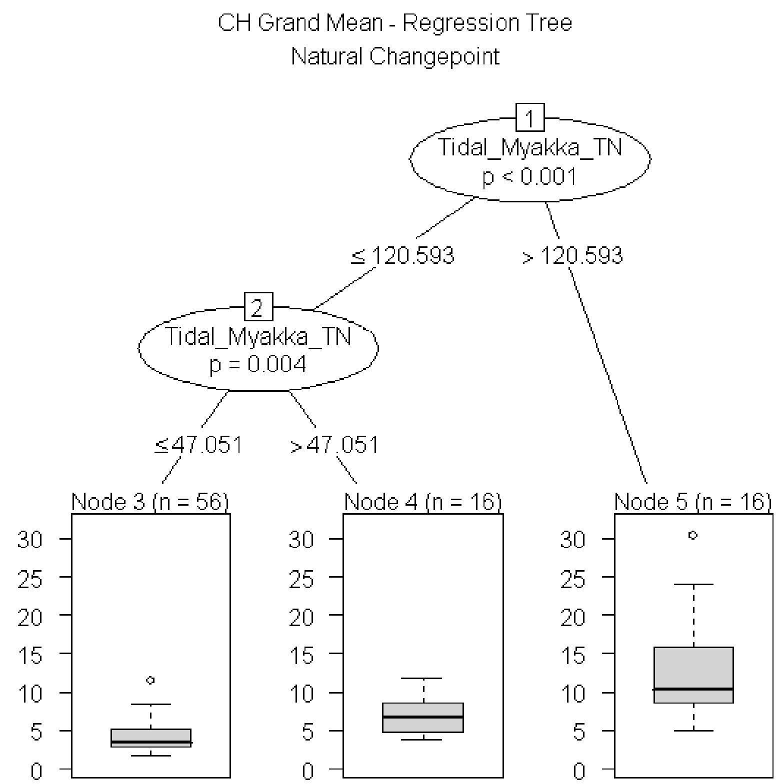



**Figure 7.** **Results of changepoint analysis for Charlotte Harbor chlorophyll and Myakka River Loads.**

### 5.4.2 Candidate Criteria - Tidal Myakka

The above regression equation was used to estimate the TN concentrations that correspond to the chlorophyll threshold value for the Reference Period Method for Charlotte Harbor Proper (7.3 μg/l). Note that this is the "protection" level for chlorophyll in Charlotte Harbor proper because the Tidal Myakka River is classified as "protection" for seagrass. This resulted in an annual TN load. This annual TN load, 2,570 tons/year, is the annual TN load from Tidal Myakka that corresponds to the Reference Period Method. Including estimates of uncertainty, the 95% confidence intervals are 1,350 – 3,820 tons/year. Assuming the Regulatory Method threshold (11 μg/l), the same procedure was used to calculate the TN concentration that corresponds to the 11 μg/l Regulatory threshold. The annual TN load was 8,750 tons/year. Including estimates of uncertainty, the 95% confidence intervals are 5,420 – 12,100 tons/year.

In addition to the values based on the Reference Period and Regulatory thresholds, two methods were attempted using the Optical Model Method (Table 3-3). In the first method, it was assumed that color and turbidity were equal to zero and the chlorophyll intercepts were used (Table 3-3). The TN target was calculated using the same procedure as was used for the two previously mentioned methods. Given a chlorophyll *a* target of 10.1 µg/l for Charlotte Harbor Proper, the TN load was 7,300 tons/year. Including estimates of uncertainty, the 95% confidence intervals are 4,300 – 10,300 tons/year. Lastly, an attempt was made to use the mean monthly values of color and turbidity to calculate the monthly target TN values. However, this resulted in negative chlorophyll targets and corresponding negative TN targets in six of the twelve months.

Potential numeric nutrient criteria were developed based on the changepoint analysis described above that corresponded to the different methods for Charlotte Harbor Proper. Monte Carlo simulation was used to identify the annual Myakka River load that was expected to result in an average chlorophyll concentration in Charlotte Harbor equivalent to each of the three threshold values. A detailed description of how Monte Carlo methods were used to derive potential numeric nutrient criteria from the changepoint analysis is described in Appendix 4. The TN loading distribution above and below the changepoint is presented in Figure 8. The average monthly TN load below the changepoint was 33 tons and the average above the changepoint was 267 tons. The annual TN loading that resulted in an expected annual average chlorophyll equivalent to the Reference Period threshold of 7.3 µg/l based on monthly sampling was1,330 tons per year. Including estimates of uncertainty, the 95% confidence intervals are 930 tons – 1,844 tons. The annual TN loading that resulted in an expected annual average chlorophyll equivalent to the Optical Model threshold of 10.2 µg/l based on monthly sampling was 2,279 tons per year. Including estimates of uncertainty, the 95% confidence intervals are 1,707 tons – 3,004 tons. The annual TN loading that resulted in an expected annual average chlorophyll equivalent to the Regulatory threshold of 11 µg/l based on monthly sampling was 2,759 tons per year. Including estimates of uncertainty, the 95% confidence intervals are 2,065 tons – 3,570 tons.

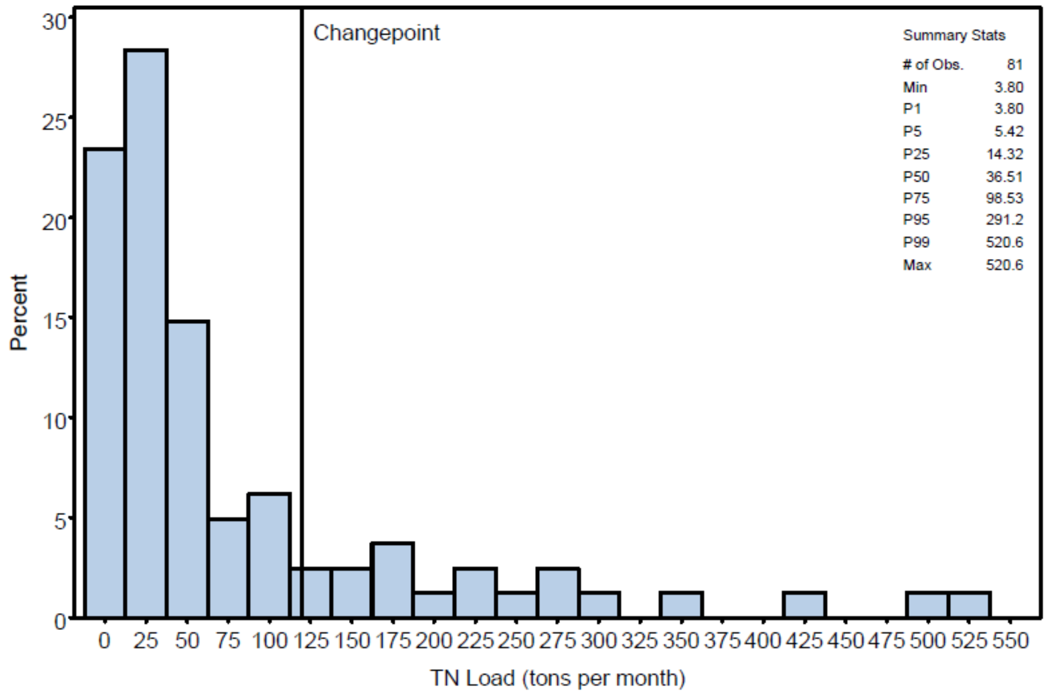



**Figure 8.** **Histogram of TN loadings from the Myakka River corresponding to the water quality data with changepoint identified as solid vertical line.**

Implementation of this proposed TN criterion will require assessing the influence of inter-annual hydrologic variation and residence times on the target exceedance frequencies. Using the confidence interval provides one mechanism by which this might be accomplished. The effect of seasonality on these relationships is also not accounted for explicitly via the simulation; however, the resulting estimate is likely conservative given that higher loads during colder months would likely not elicit the same water quality response given the colder water temperatures and reduced photoperiod. Chlorophyll biomass may also be mitigated by other factors associated with higher loads such as the light limiting effects of colored dissolved organic matter which deserves further consideration. The combination of Peace and Myakka loads was not evaluated and should be explored in the implementation phase.

A comparison of the target TN loads arrived at using the regression approach and the changepoint analysis, reveals that the changepoint approach results in a load that is more protective of Charlotte Harbor Proper, 1,330 tons/year for the changepoint approach versus 2,570 tons/year for the regression approach. Therefore, 1,330 tons/year was selected as the TN load criterion for Tidal Myakka.

A comparison of the candidate numeric TN concentration criteria based on Regulatory, Optical Model, and Reference Period methods is presented in Figure 9 for Tidal Myakka.

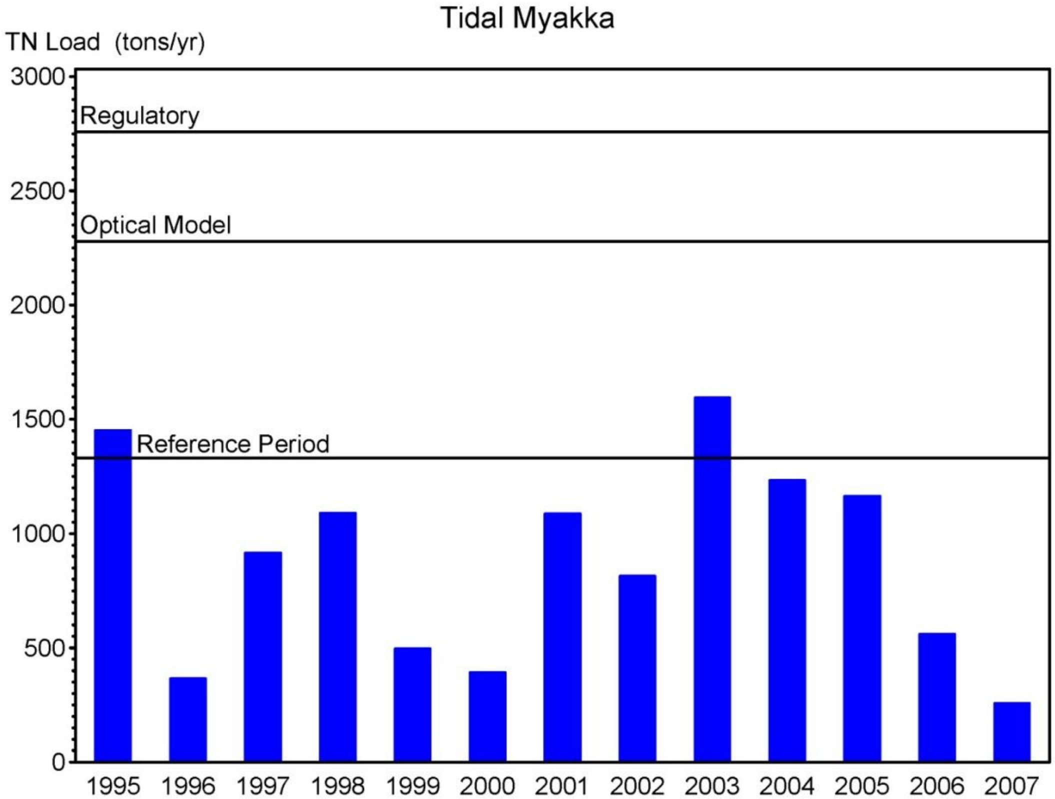



**Figure 9. Comparison of the potential TN criteria to observed TN loads in Tidal Myakka.**

# Appendix 5.5 – Draft Results Tidal Peace

## 5.5 Tidal Peace

### 5.5.1 Relationship Between Chlorophyll *a* and Concentrations and Loads - Tidal Peace

In addition to the time series plots, a series of bivariate plots were examined to investigate relationships between chlorophyll *a* and other potential explanatory variables. These plots included chlorophyll *a* versus TN concentration, TP concentration, TN loads, TP loads, and Hydrologic loads (Figures 1 through 5, respectively). Additional bivariate plots were run between chlorophyll *a* and pulse residence time, 2-month, 3-month, 4-month, 5-month, and 6-month average loads (TN, TP, and hydrologic). The scatterplots and linear regression analysis used to assess the bivariate relationship between TN concentrations or loads and chlorophyll *a* concentrations in Tidal Peace suggested a lack of a linear relationship.

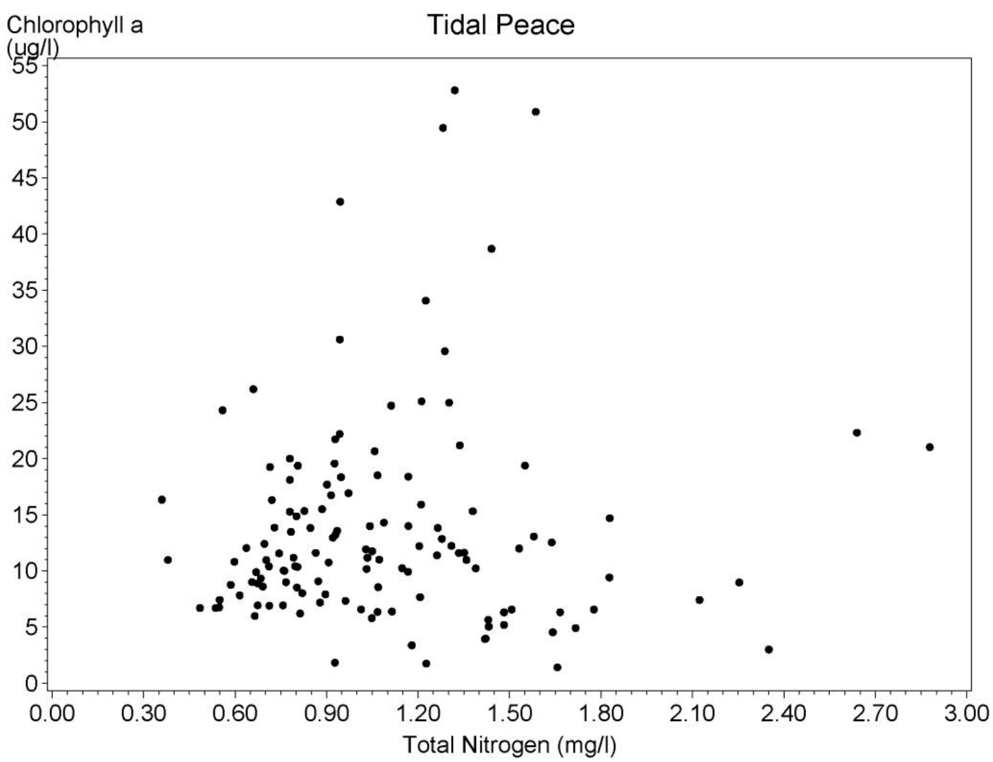



**Figure 1. Relationship between chlorophyll *a* and TN concentrations for Tidal Peace.**

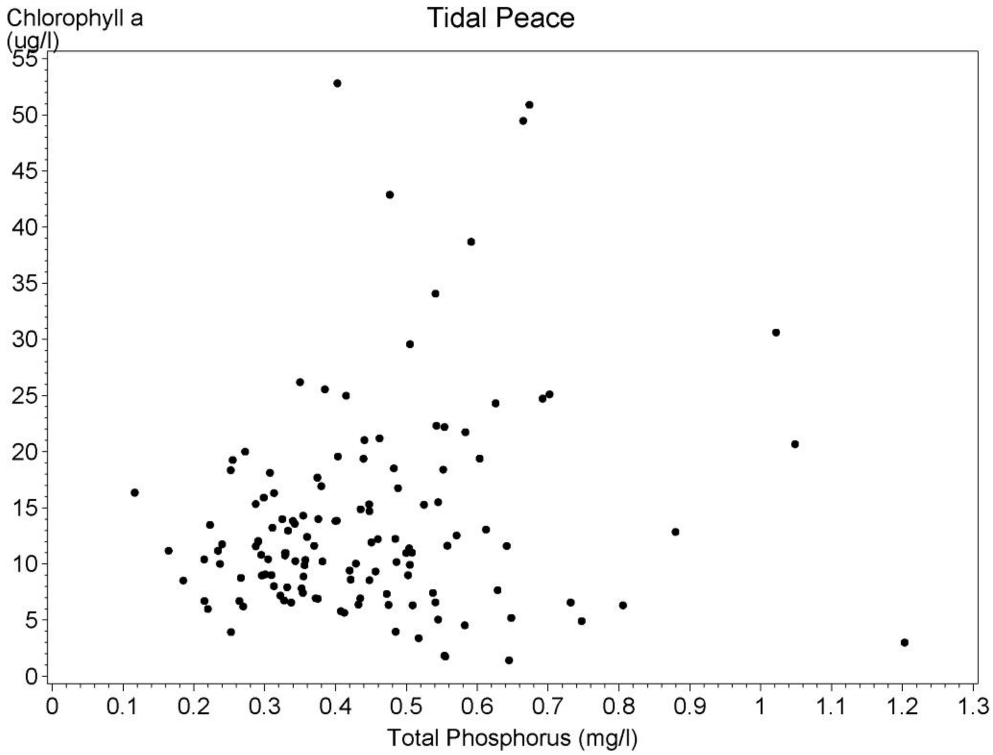



**Figure 2.** **Relationship between chlorophyll *a* and TP concentrations for Tidal Peace.**

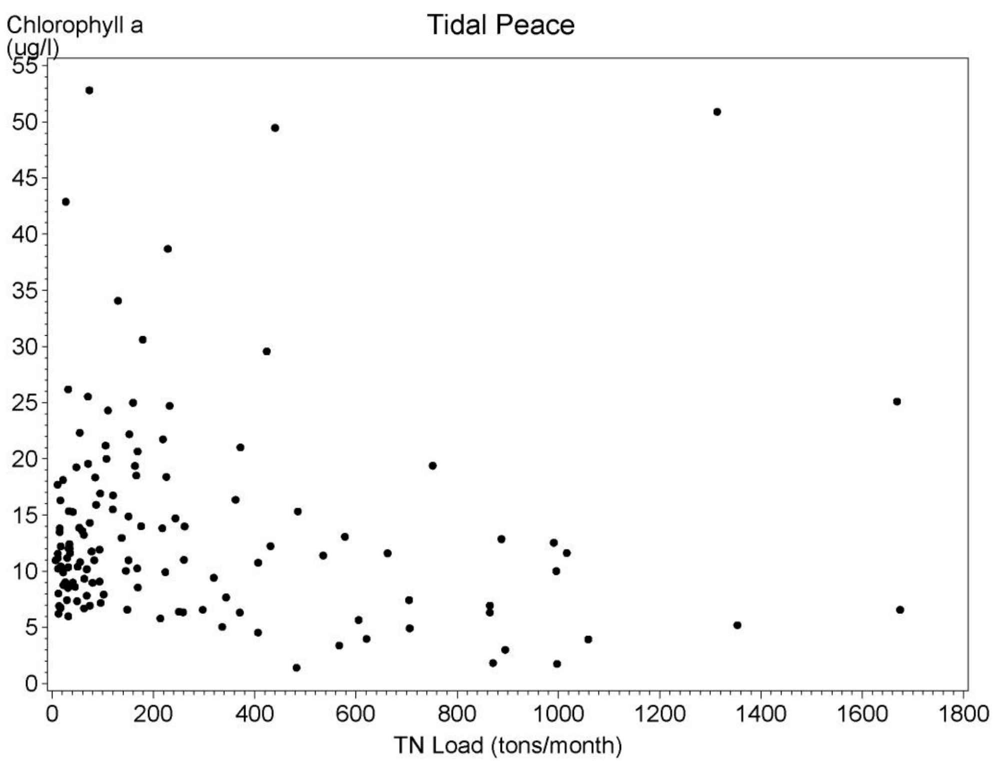



**Figure 3.** **Relationship between chlorophyll *a* and TN loads for Tidal Peace.**

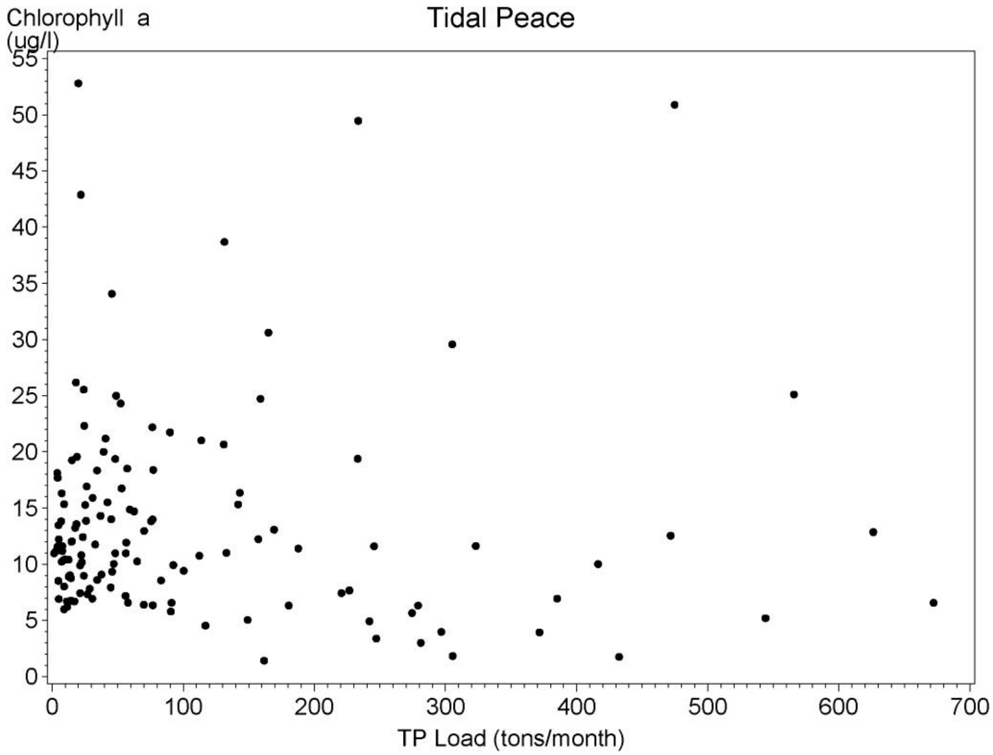



**Figure 4.** **Relationship between chlorophyll *a* and TP loads for Tidal Peace.**

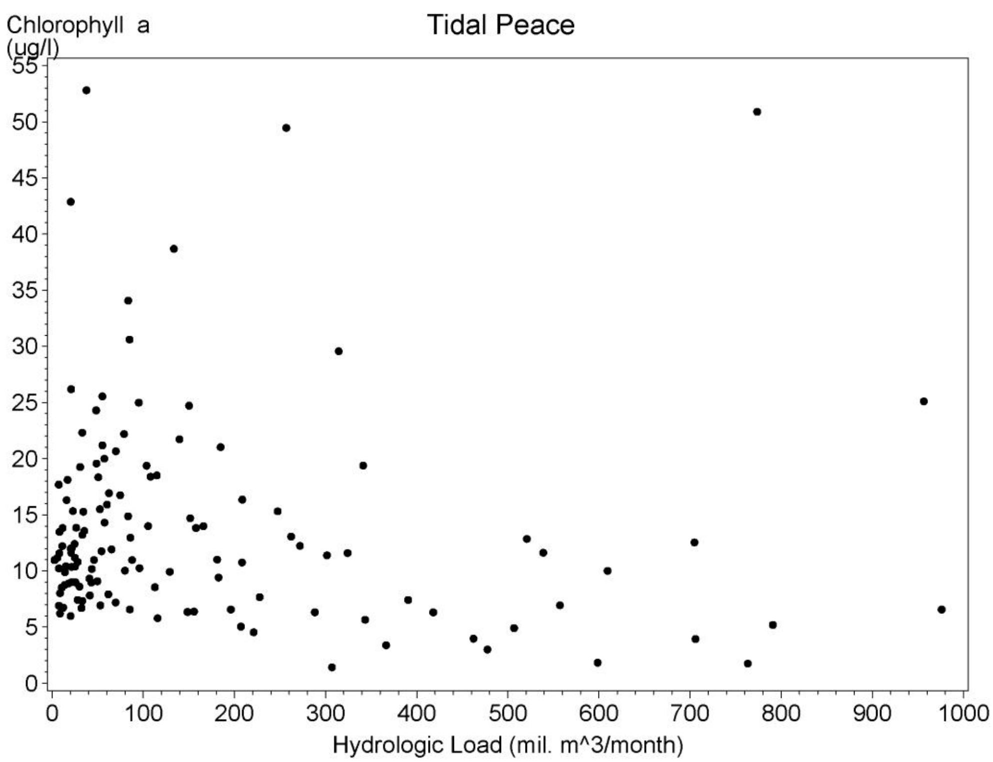



**Figure 5.** **Relationship between chlorophyll *a* and hydrologic loads for Tidal Peace.**

Therefore, a downstream compliance area was investigated. This included using the average chlorophyll *a* concentration for Charlotte Harbor Proper (as described in Section 5.3) and loading and concentrations from Tidal Peace.

A regression model between the chlorophyll *a* in Charlotte Harbor Proper and TN loads from the Tidal Peace was developed and the residuals from this model were examined to identify any other explanatory variables that might contribute to the overall variance accounted for by the model. The final regression equation is:

**[Chlorophyll *a*] = 4.77 + (0.00596 * Peace TN load)**

The model was fit with 78 observations and resulted in an $R^2$ value of 0.23. The regression was highly significant with a probability of a greater |F| value of < 0.0001. The slope and parameter coefficients were all significant. A plot of predicted versus observed chlorophyll *a* concentrations is presented in Figure 6.

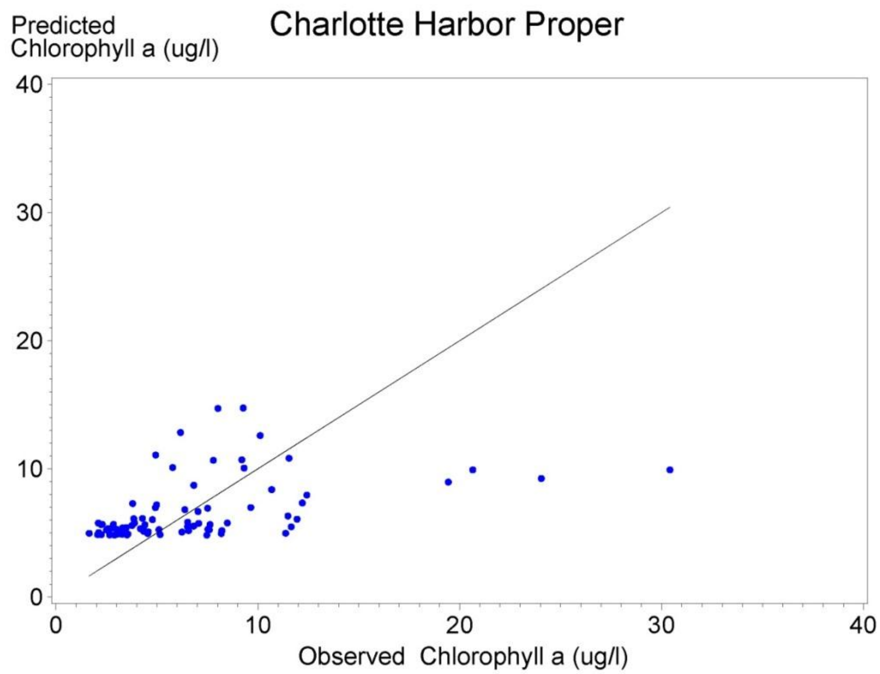



**Figure 6.** **Predicted versus observed chlorophyll *a* concentrations based on regression equation developed for Charlotte Harbor Proper.**

In addition to regression analysis, changepoint analysis was also investigated. As discussed above, the intent of this analysis was to develop relationships between the grand average monthly chlorophyll *a* concentration in Charlotte Harbor Proper and TN loads from the Peace River. A TN changepoint of 424 tons per month was identified using the changepoint analysis on these data (Figure 7). The overall average of the mean chlorophyll concentrations in Charlotte Harbor was 6.39 µg/l. The chlorophyll *a* average when TN was below 424 tons per month was 4.93 µg/l and the chlorophyll average when TN was above 424 tons per month was 11.72 µg/l. The TN changepoint of 424 tons per month was exceeded in 21 percent of the empirical observations.

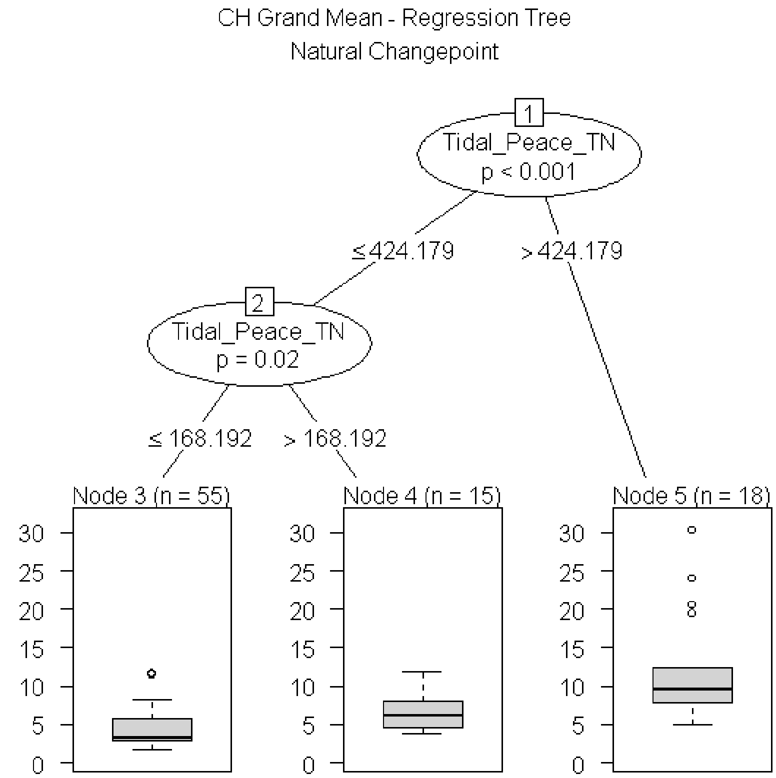



**Figure 7.** **Results of changepoint analysis for Charlotte Harbor chlorophyll and Peace River Loads.**

### 5.5.2 Candidate Criteria - Tidal Peace

The above regression equation was used to estimate the TN concentrations that correspond to the Reference Period Method for Charlotte Harbor Proper (6.1 µg/l). Unlike Tidal Myakka where the protection level was used for Charlotte Harbor chlorophyll, the restoration value of 6.1 µg/l was used for Tidal Peace River as the system is classified as restoration. This annual TN load, 2,688 tons/year, is the TN load that corresponds to the Reference Period Method for Tidal Peace. Including estimates of uncertainty, the 95% confidence intervals are 714 – 4,700 tons/year. Assuming the Regulatory Method threshold (11 µg/l ), the same procedure was used to calculate the TN concentration that corresponds to the 11 µg/l Regulatory threshold. The annual TN load was 12,550 tons/year. Including estimates of uncertainty, the 95% confidence intervals are 8,425 – 16,620 tons/year.

In addition to the values based on the Reference Period and Regulatory thresholds, two methods were attempted using the Optical Model Method (Table 3-3). In the first method, it was assumed that color and turbidity were equal to zero and the chlorophyll intercepts were used (Table 3-3). The TN target was calculated using the same procedure as was used for the two previously mentioned methods. Given a chlorophyll *a* target of 10.15 µg/l for Charlotte Harbor Proper, the TN load was 10,840 tons/year. Including estimates of uncertainty, the 95% confidence intervals are 7,320 – 14,325 tons/year. Lastly, an attempt was made to use the mean monthly values of color and turbidity to calculate the monthly target TN values. However, this resulted in negative chlorophyll targets and corresponding negative TN targets in six of the twelve months.

Potential numeric nutrient criteria were developed based on the changepoint analysis described above that correspond to the methods described for the regression above for Charlotte Harbor Proper. Monte Carlo simulation was used to identify the annual Peace River load that was expected to result in an average chlorophyll concentration in Charlotte Harbor equivalent to each of the three threshold values. A detailed description of how Monte Carlo methods were used to derive potential numeric nutrient criteria from the changepoint analysis is described in Appendix 4. The TN loading distribution above and below the changepoint is presented in Figure 8. The average monthly TN load below the changepoint was 119 tons and the average above the changepoint was 931 tons. The annual TN load that resulted in an expected annual average chlorophyll concentration equivalent to the Reference Period threshold of 6.1 µg/l based on monthly sampling was 3,018 tons per year. Including estimates of uncertainty, the 95% confidence intervals are 2,005 tons – 4,227 tons. The annual TN load that resulted in an expected annual average chlorophyll concentration equivalent to the Optical Model threshold of 10.2 µg/l based on monthly sampling was 9,619 tons per year. Including estimates of uncertainty, the 95% confidence intervals are 7,596 tons – 12,085 tons. The annual TN load that resulted in an expected annual average chlorophyll concentration equivalent to the Regulatory threshold of 11.0 µg/l based on monthly sampling was 10,423 tons per year. Including estimates of uncertainty, the 95% confidence intervals are 8,348 tons – 12,909 tons.

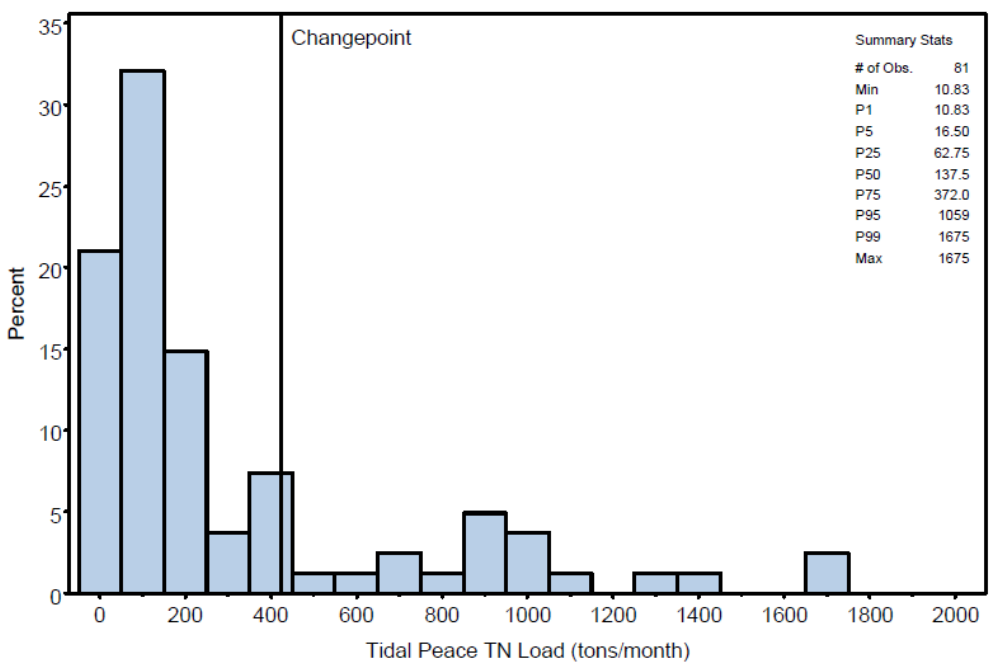



**Figure 8.** **Histogram of TN loadings from the Peace River corresponding to the water quality data with changepoint identified as solid vertical line.**

Implementation of this proposed TN criterion will require assessing the influence of inter-annual hydrologic variation and residence times on the target exceedance frequencies. Using the confidence interval provides one mechanism by which this might be accomplished. The effect of seasonality on these relationships is also not accounted for explicitly via the simulation; however, the resulting estimate is likely conservative given that higher loads during colder months would likely not elicit the same water quality response given the colder water temperatures and reduced photoperiod. Chlorophyll biomass may also be mitigated by other factors associated with higher loads such as the light limiting effects of colored dissolved organic matter which deserves further consideration. The combination of Peace and Myakka loads was not evaluated and should be explored in the implementation phase.

A comparison of the target TN loads arrived at using the regression approach and the changepoint analysis, reveals that the changepoint approach results in an annual load that is more protective of Charlotte Harbor Proper, 3,018 tons/year than the regression approach (5,085 tons/year). Therefore, the more protective load, 3,018 tons TN/year is proposed as the TN criterion for Tidal Peace.

A comparison of the candidate numeric TN concentration criteria based on Regulatory, Optical Model, and Reference Period methods is presented in Figure 9 for Tidal Peace.

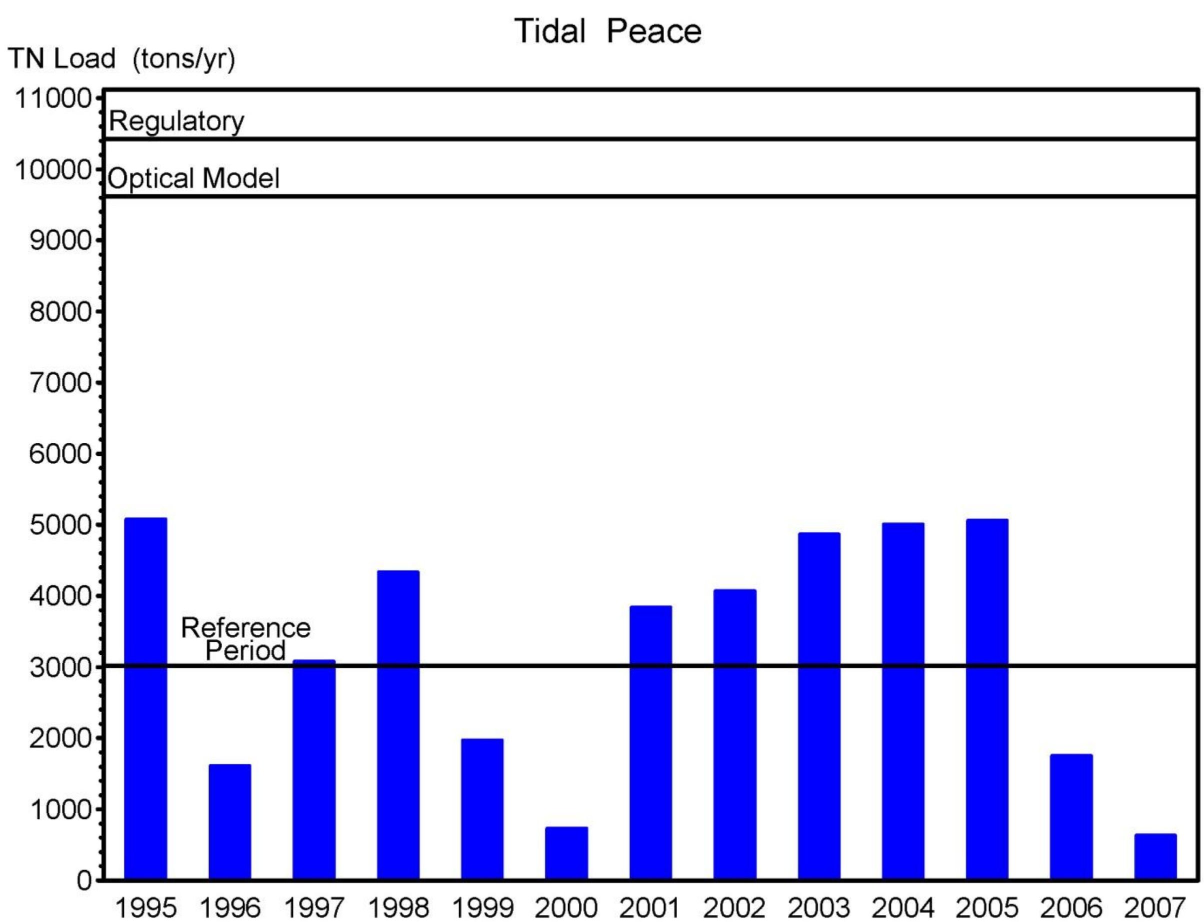



**Figure 9.** **Comparison of the potential TN criteria to observed TN loads in Tidal Peace.**

## Appendix 5.6 – Draft Results Pine Island Sound and Matlacha Pass

## 5.6 Pine Island Sound and Matlacha Pass

### 5.6.1 Relationship Between Chlorophyll *a* and Concentrations and Loads - Pine Island Sound and Matlacha Pass

In addition to the time series plots, a series of bivariate plots were examined to investigate relationships between chlorophyll *a* and other potential explanatory variables. These plots included chlorophyll *a* versus TN concentration, TP concentration, TN loads, TP loads, and hydrologic loads (Figures 1 through 5, respectively). Additional bivariate plots were run between chlorophyll *a* and pulse residence time, 2-month, 3-month, 4-month, 5-month, and 6-month average loads (TN, TP, and hydrologic). In addition to the time series plots, a series of bivariate plots were examined to investigate relationships between chlorophyll *a* and other potential explanatory variables. As can be seen in these plots, no strong linear relationships were identified. However, TN concentration explained a reasonable amount of the variation in chlorophyll *a*.

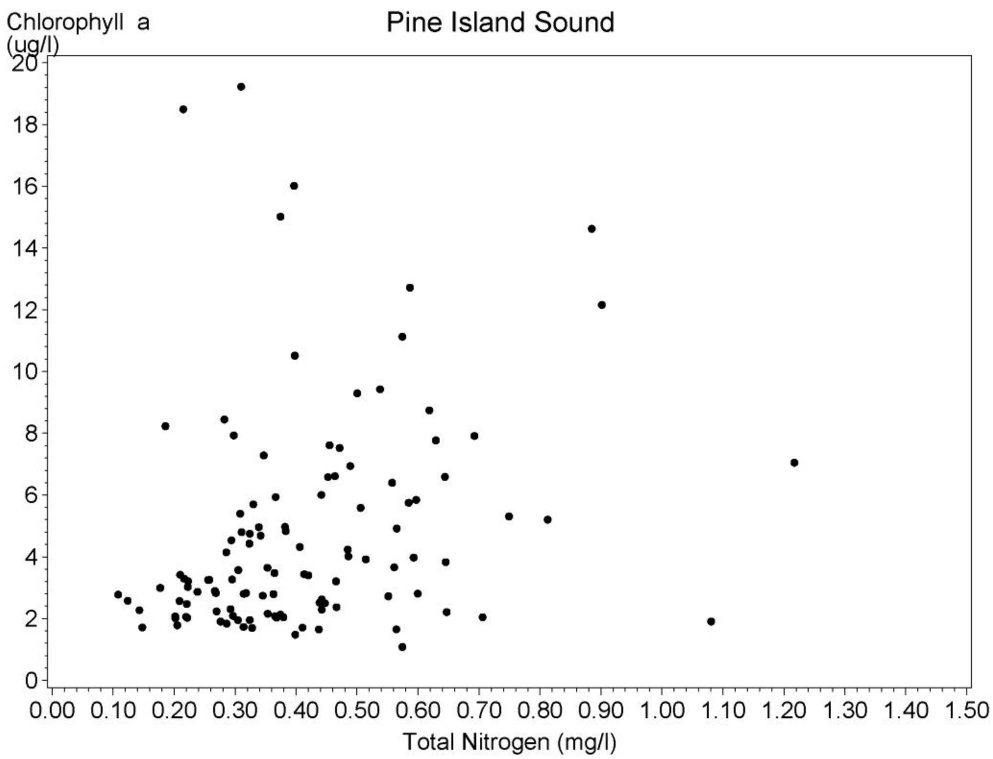



**Figure 1. Relationship between chlorophyll *a* and TN concentrations for Pine Island Sound.**

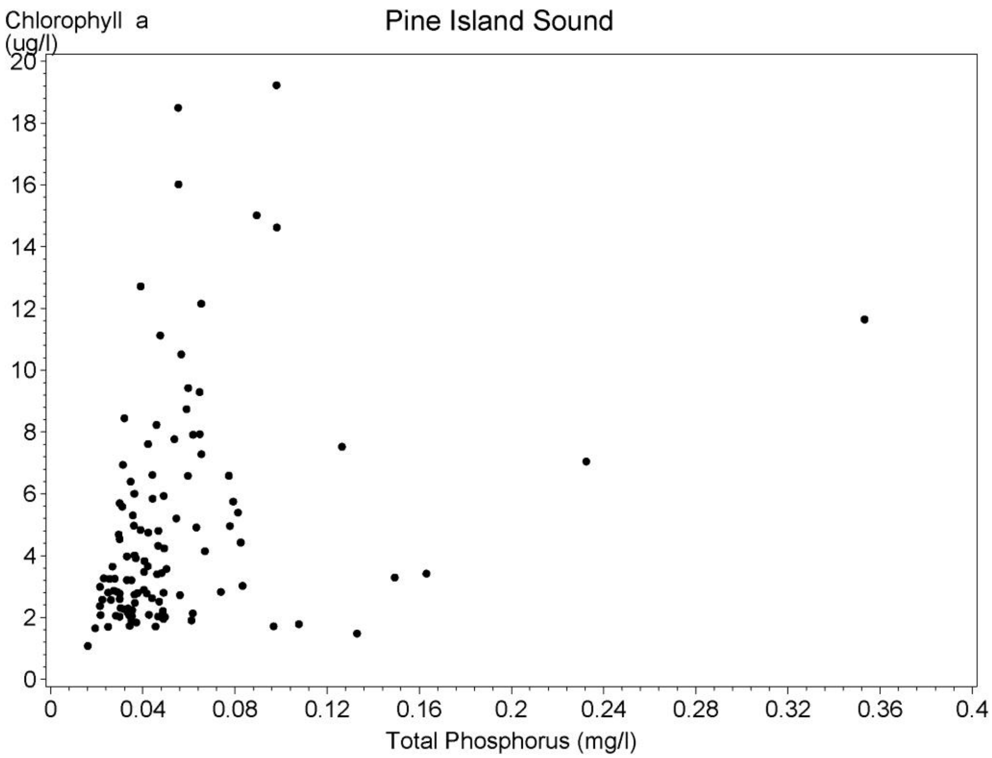



**Figure 2. Relationship between chlorophyll *a* and TP concentrations for Pine Island Sound.**

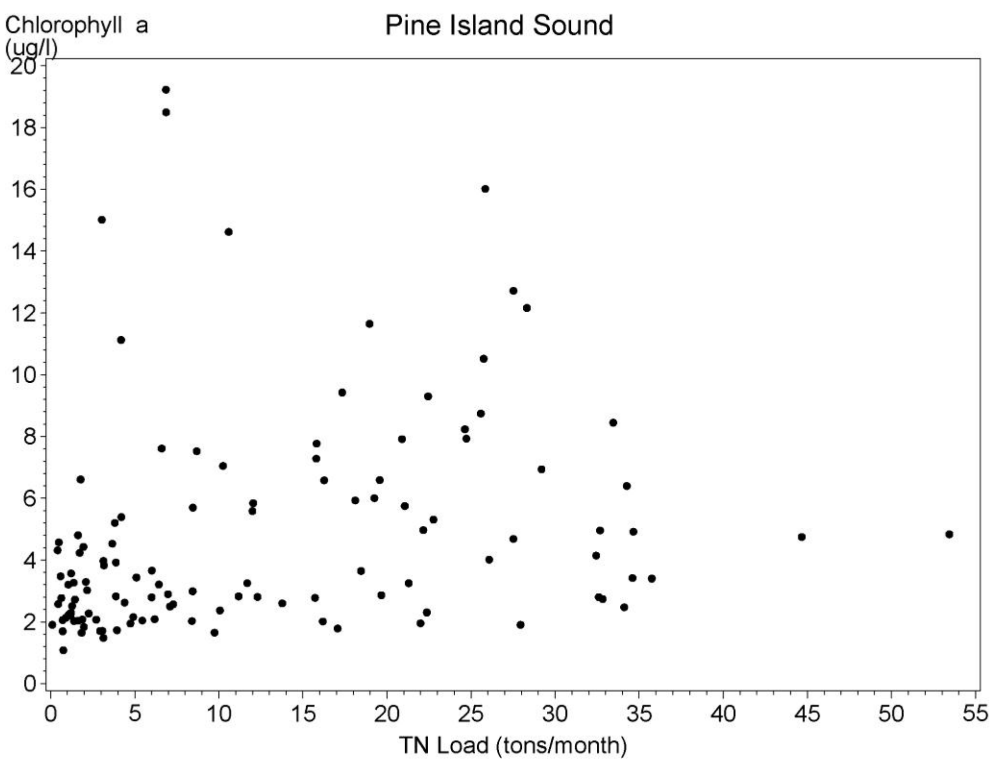



**Figure 3. Relationship between chlorophyll *a* and TN loads for Pine Island Sound.**

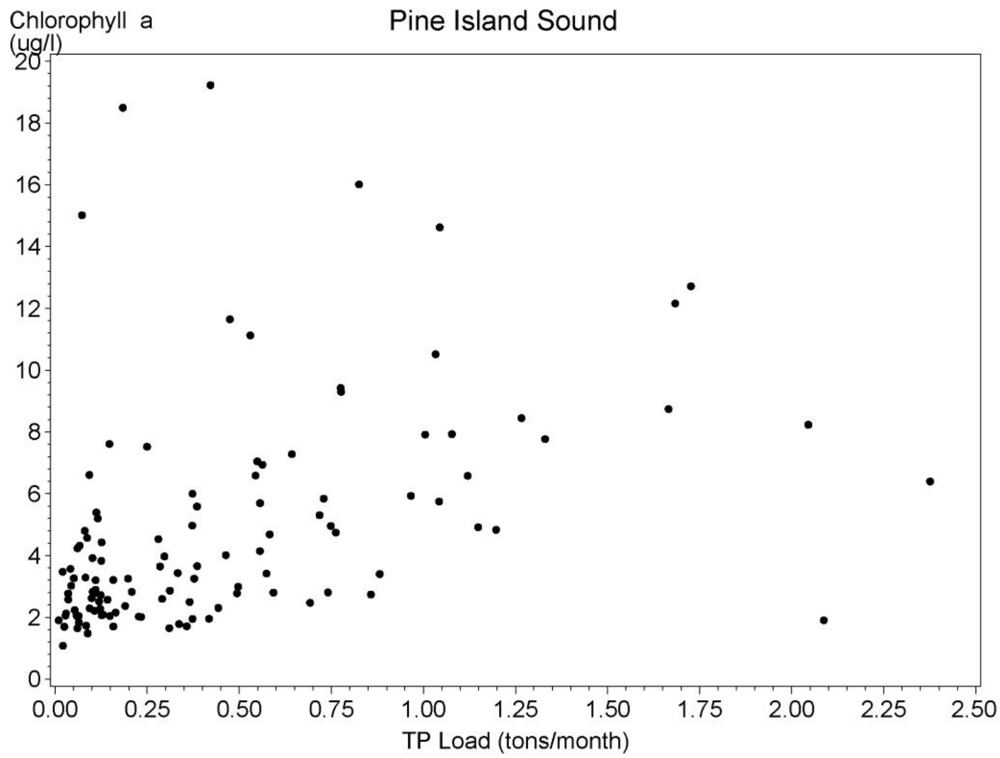



**Figure 4. Relationship between chlorophyll *a* and TP loads for Pine Island Sound.**

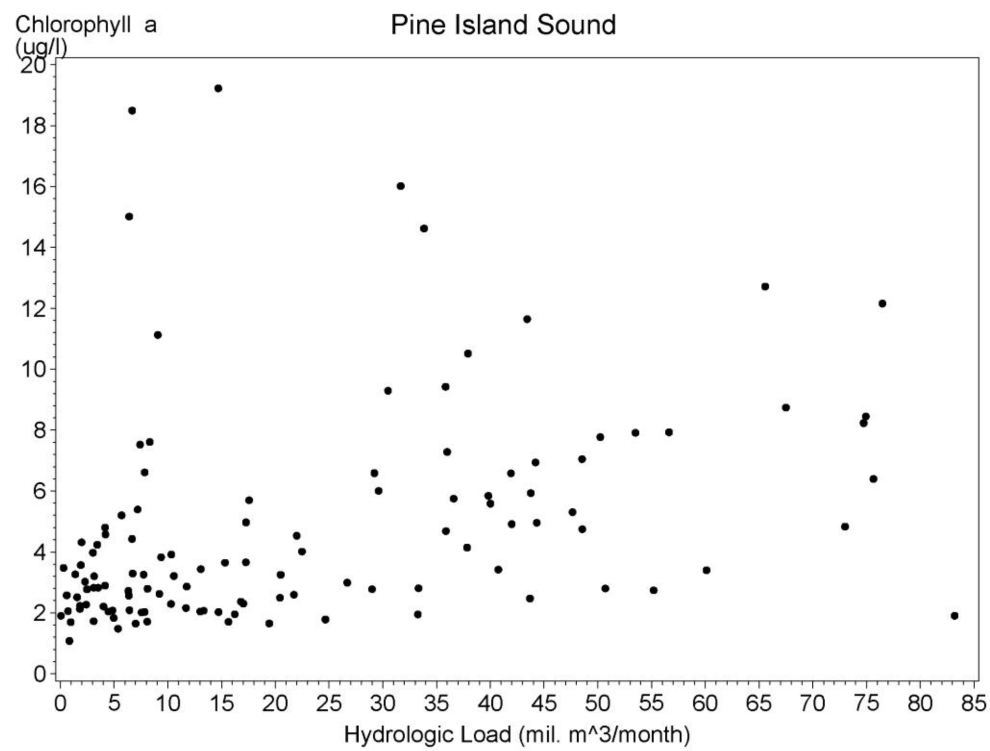



**Figure 5. Relationship between chlorophyll *a* and hydrologic loads for Pine Island Sound.**

A regression model between the log transformed chlorophyll *a* and TN concentrations was developed and the residuals from this model were examined to identify any other explanatory variables that might contribute to the overall variance accounted for by the model. Analysis of the residuals revealed a seasonal difference in residuals. Specifically, given the same TN concentrations, higher chlorophyll *a* concentrations can be expected during the wetter, warmer summer months (July-October) than during the remainder of the year. Therefore, a seasonal term was added to the regression equation. The season term is a dummy variable which equals one during July-October and zero other months of the year. The final regression equation is:

**Log [Chlorophyll *a*] = 0.25 + (0.52*TN concentration) + (0.34*season)**

The model was fit with 118 observations and resulted in an $R^2$ value of 0.49. The regression was highly significant with a probability of a greater |F| value of < 0.0001. The parameter coefficients were also highly significant. A plot of predicted versus observed chlorophyll *a* concentrations is presented in Figure 6.

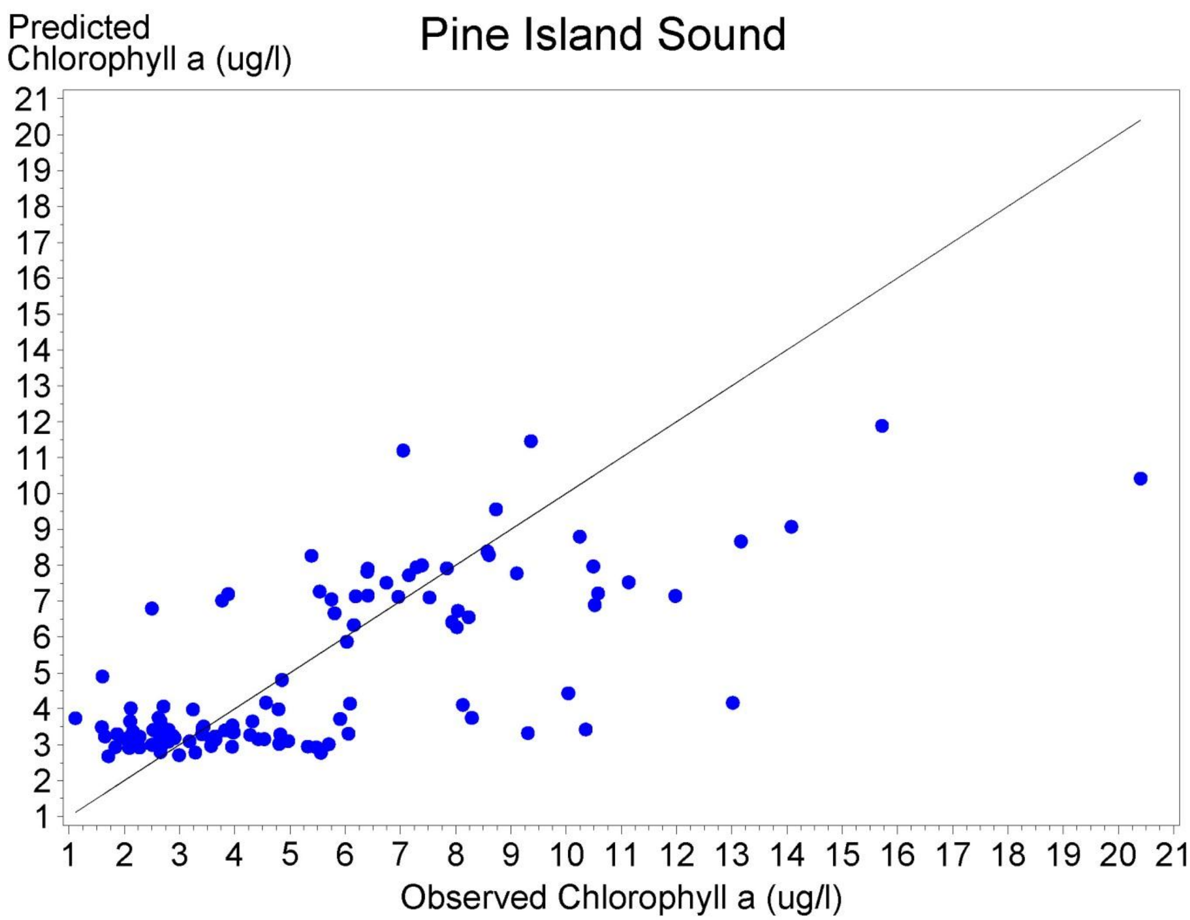



**Figure 6.** **Predicted versus observed chlorophyll *a* concentrations based on regression equation developed for Pine Island Sound.**

In addition to the time series plots, a series of bivariate plots were examined to investigate relationships between chlorophyll *a* and other potential explanatory variables in Matlacha Pass. These plots included chlorophyll *a* versus TN concentration, TP concentration, TN loads, TP loads, and hydrologic loads (Figures 7 through 11, respectively). Additional bivariate plots were run between chlorophyll *a* and pulse residence time, 2-month, 3-month, 4-month, 5-month, and 6-month average loads (TN, TP, and hydrologic). In addition to the time series plots, a series of bivariate plots were examined to investigate relationships between chlorophyll *a* and other potential explanatory variables. As can be seen in these plots, no strong linear relationships were identified. However, the 2-month average log transformed TN load explained a reasonable amount of the variation in chlorophyll *a*.

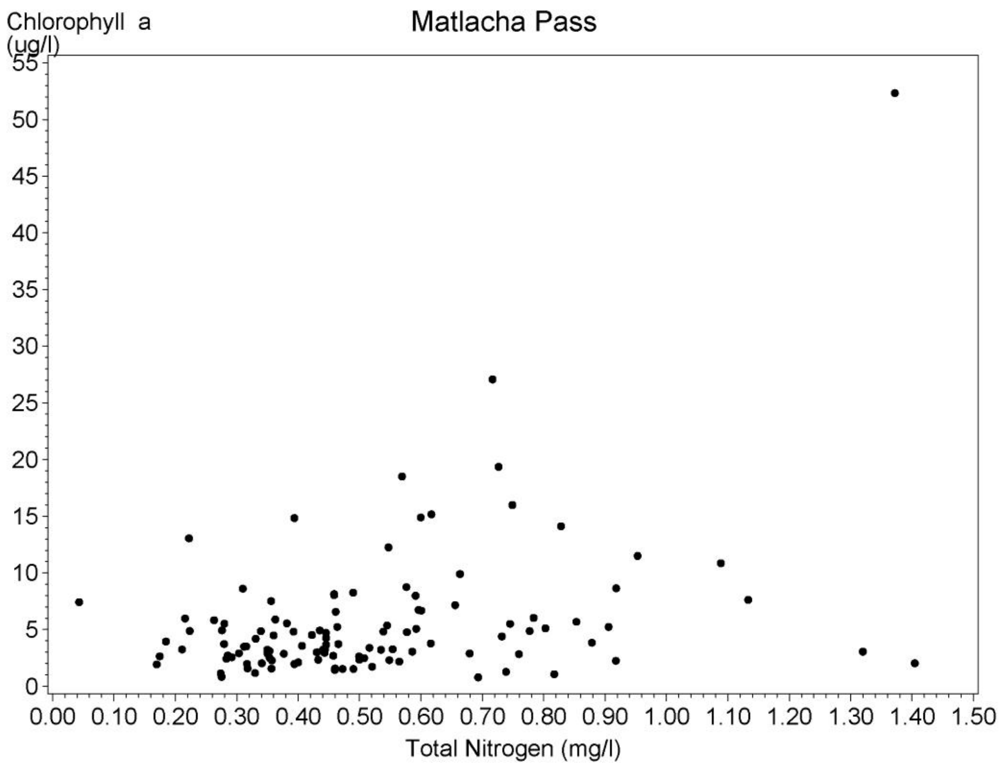



**Figure 7. Relationship between chlorophyll *a* and TN concentrations for Matlacha Pass.**

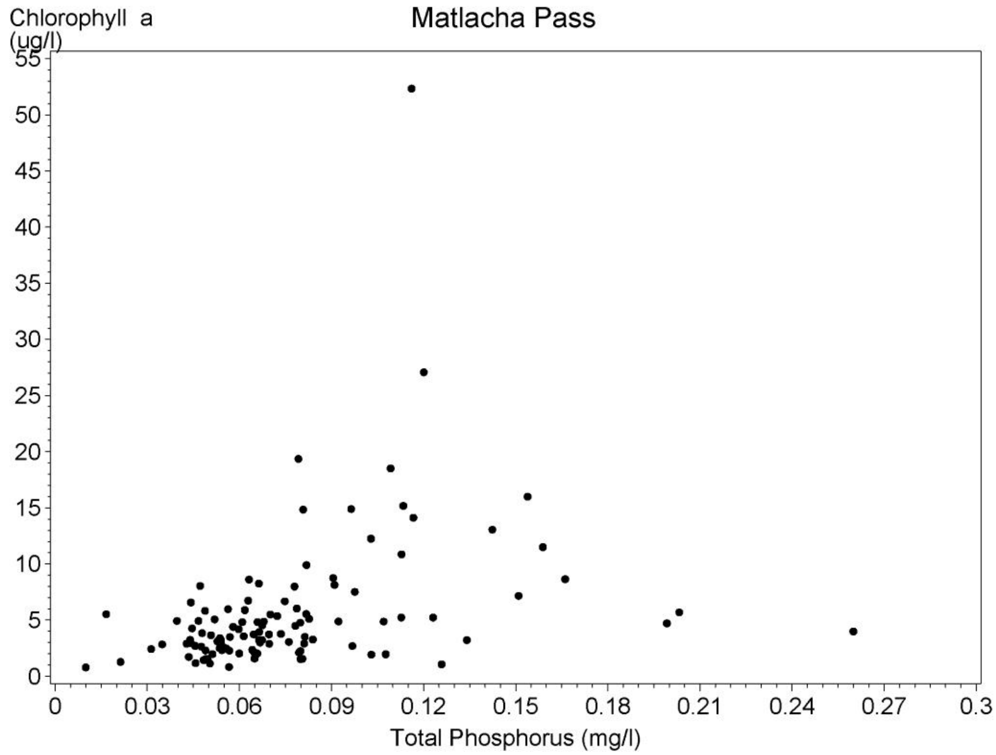



**Figure 8.** **Relationship between chlorophyll *a* and TP concentrations for Matlacha Pass.**

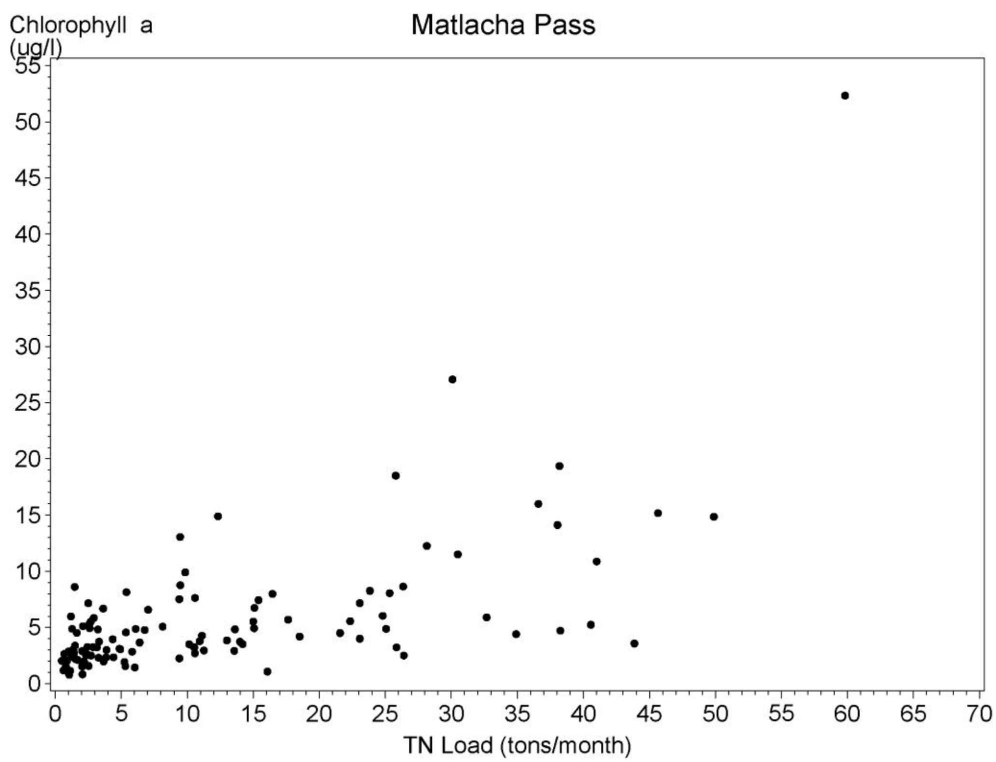



**Figure 9.** **Relationship between chlorophyll *a* and TN loads for Matlacha Pass.**

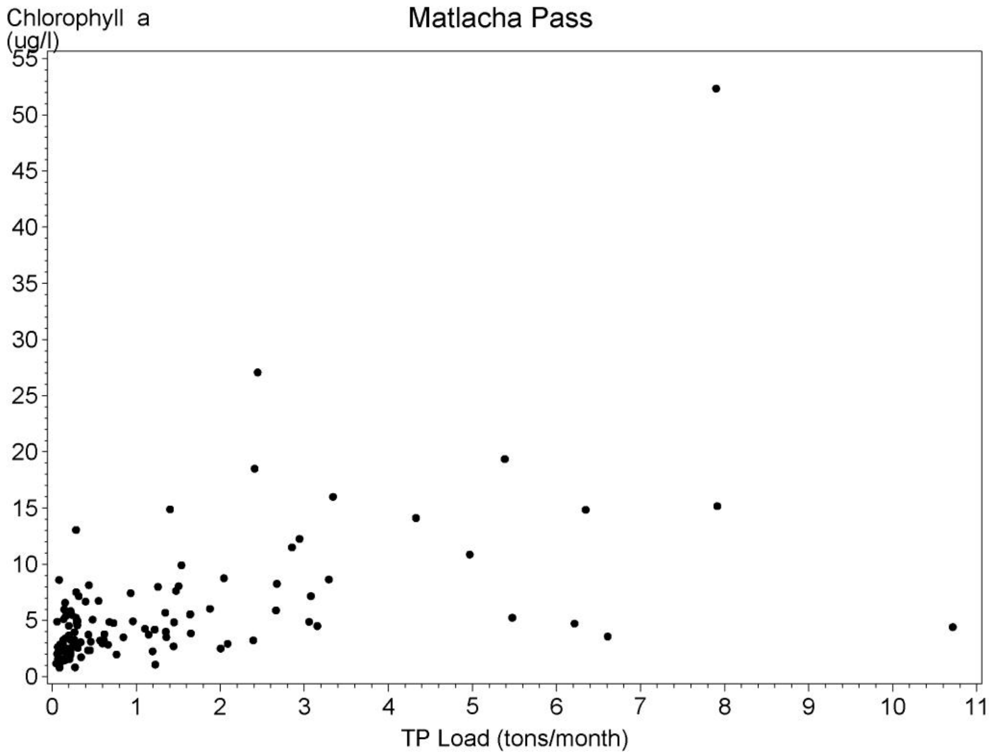



**Figure 10.** **Relationship between chlorophyll *a* and TP loads for Matlacha Pass.**

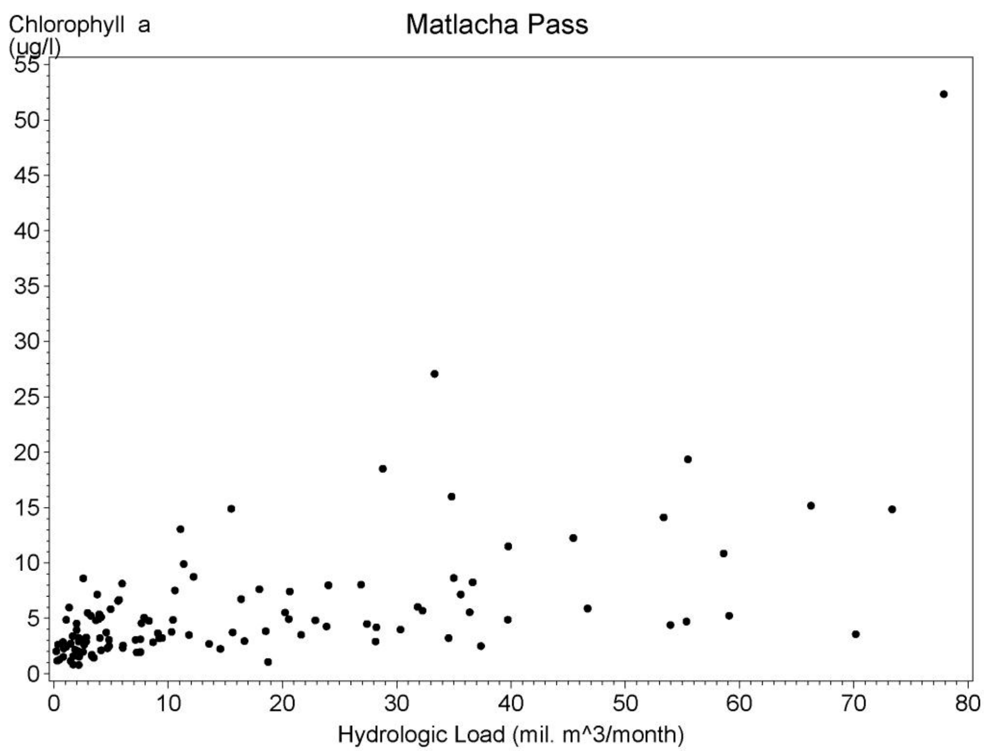



**Figure 11.** **Relationship between chlorophyll *a* and hydrologic loads for Matlacha Pass.**

A regression model between the Box-Cox transformed chlorophyll *a* and Log transformed 2-month cumulative TN load was developed and the residuals from this model were examined to identify any other explanatory variables that might contribute to the overall variance accounted for by the model. The final regression equation is:

**Transformed[Chlorophyll *a*] = 0.43 + (0.28 * Log 2-month TN load)**

The model was fit with 139 observations and resulted in an $R^2$ value of 0.54. The regression was highly significant with a probability of a greater |F| value of < 0.0001. The slope and parameter coefficients were also highly significant. A plot of predicted versus observed chlorophyll *a* concentrations is presented in Figure 12.

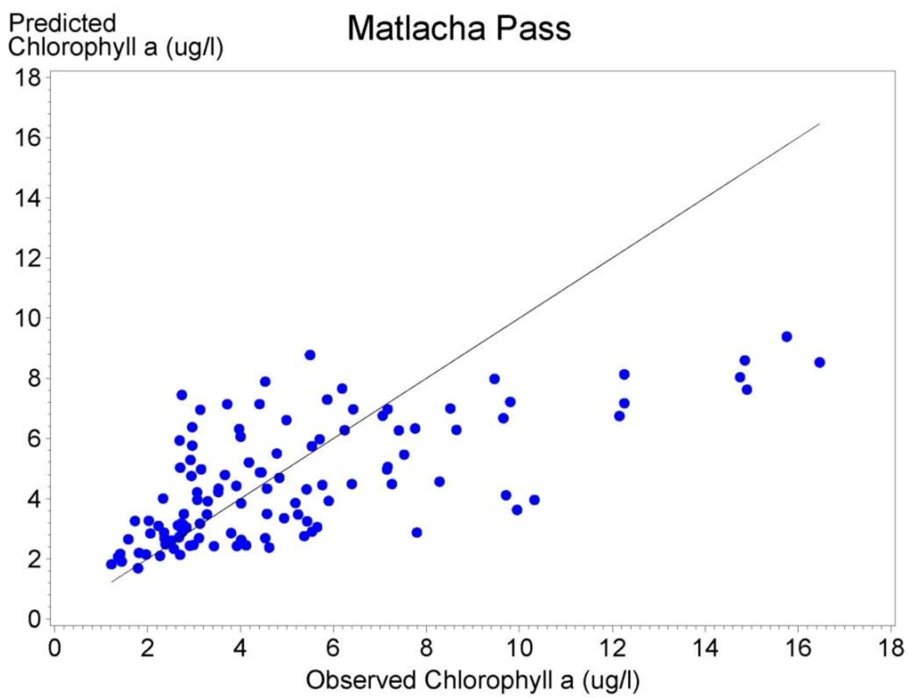



**Figure 12. Predicted versus observed chlorophyll *a* concentrations based on regression equation developed for Matlacha Pass.**

### 5.6.2 Candidate Criteria - Pine Island Sound and Matlacha Pass

The above regression equation was used to estimate the TN concentrations that correspond to the Reference Period Method for Pine Island Sound (6.5 µg/l). The annual geometric mean TN concentration, 0.99 mg/l, is the TN concentration that corresponds to the Reference Period Method for Pine Island Sound. Including estimates of uncertainty, the 95% confidence intervals are 0.50 – 1.36 mg/l. Assuming the Regulatory Method threshold (11 µg/l ), the same procedure was used to calculate the TN concentration that corresponds to the 11 µg/l Regulatory threshold. The annual geometric mean TN concentration was 2.14 mg/l. Including estimates of uncertainty, the 95% confidence interval is 1.36 – 2.68 mg/l.

In addition to the values based on the Reference Period and Regulatory thresholds, two methods were attempted using the Optical Model Method (Table 3-3). In the first method, it was assumed that color and turbidity were equal to zero and the chlorophyll intercepts were used (Table 3-3). The TN target was calculated using the same procedure as was used for the two previously mentioned methods. Given a chlorophyll *a* target of 6.9 µg/l for Pine Island Sound, the annual geometric mean TN concentration was 1.14 mg/l. Including estimates of uncertainty, the 95% confidence intervals are 0.81 – 1.44 mg/l. Lastly, an attempt was made to use the mean monthly values of color and turbidity to calculate the monthly target TN values. However, this resulted in negative chlorophyll targets and corresponding negative TN targets in seven of the twelve months.

A comparison of the candidate numeric TN concentration criteria based on Regulatory, Optical Model, and Reference Period methods is presented in Figure 13 for Pine Island Sound.

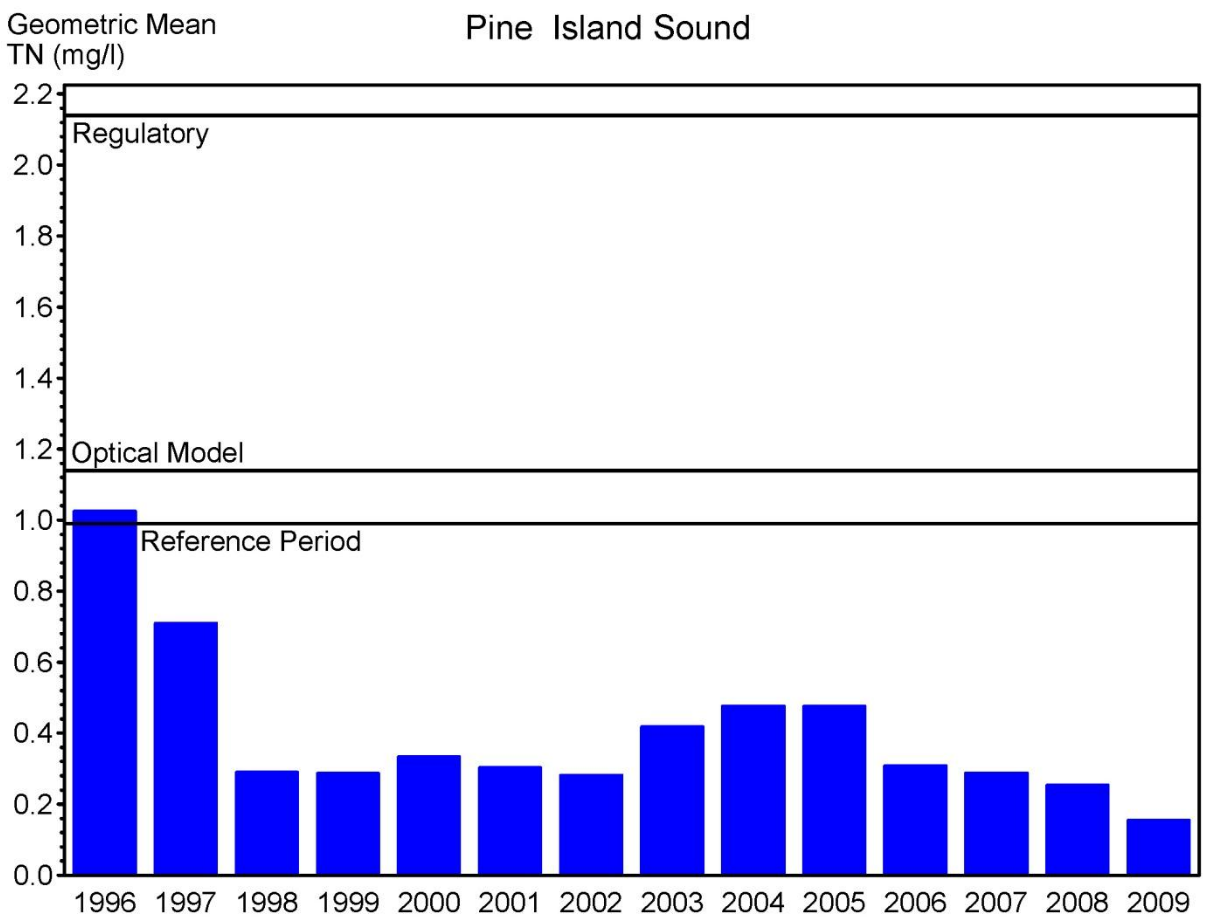



**Figure 13. Comparison of the potential TN criteria to observed TN concentrations (expressed as geometric means) in Pine Island Sound.**

The above regression equation was used to estimate the TN concentrations that correspond to the Reference Period Method for Matlacha Pass (6.1 µg/l). This resulted in an estimated annual TN load to Matlacha Pass. The annual TN load, 228 tons/year, is the TN load that corresponds to the Reference Period Method for Matlacha Pass. Including estimates of uncertainty, the 95% confidence intervals are 182 – 282 tons TN per year. Assuming the Regulatory Method threshold (11 µg/l ), the same procedure was used to calculate the TN concentration that corresponds to the 11 µg/l Regulatory threshold. The annual TN load was 798 tons TN/year. Including estimates of uncertainty, the 95% confidence intervals are 581 – 1,087 tons TN per year.

In addition to the values based on the Reference Period and Regulatory thresholds, two methods were attempted using the Optical Model Method (Table 3-3). In the first method, it was assumed that color and turbidity were equal to zero and the chlorophyll intercepts were used (Table 3-3). The TN target was calculated using the same procedure as was used for the two previously mentioned methods. Given a chlorophyll *a* target of 8.2 µg/l for Matlacha Pass, the annual TN load was 437 tons/year. Including estimates of uncertainty, the 95% confidence intervals are 330 – 589 tons TN per year. Lastly, an attempt was made to use the mean monthly values of color and turbidity to calculate the monthly target TN values. However, this resulted in negative chlorophyll targets and corresponding negative TN targets in six of the twelve months.

A comparison of the candidate numeric TN concentration criteria based on Regulatory, Optical Model, and Reference Period methods is presented in Figure 14 for Matlacha Pass.

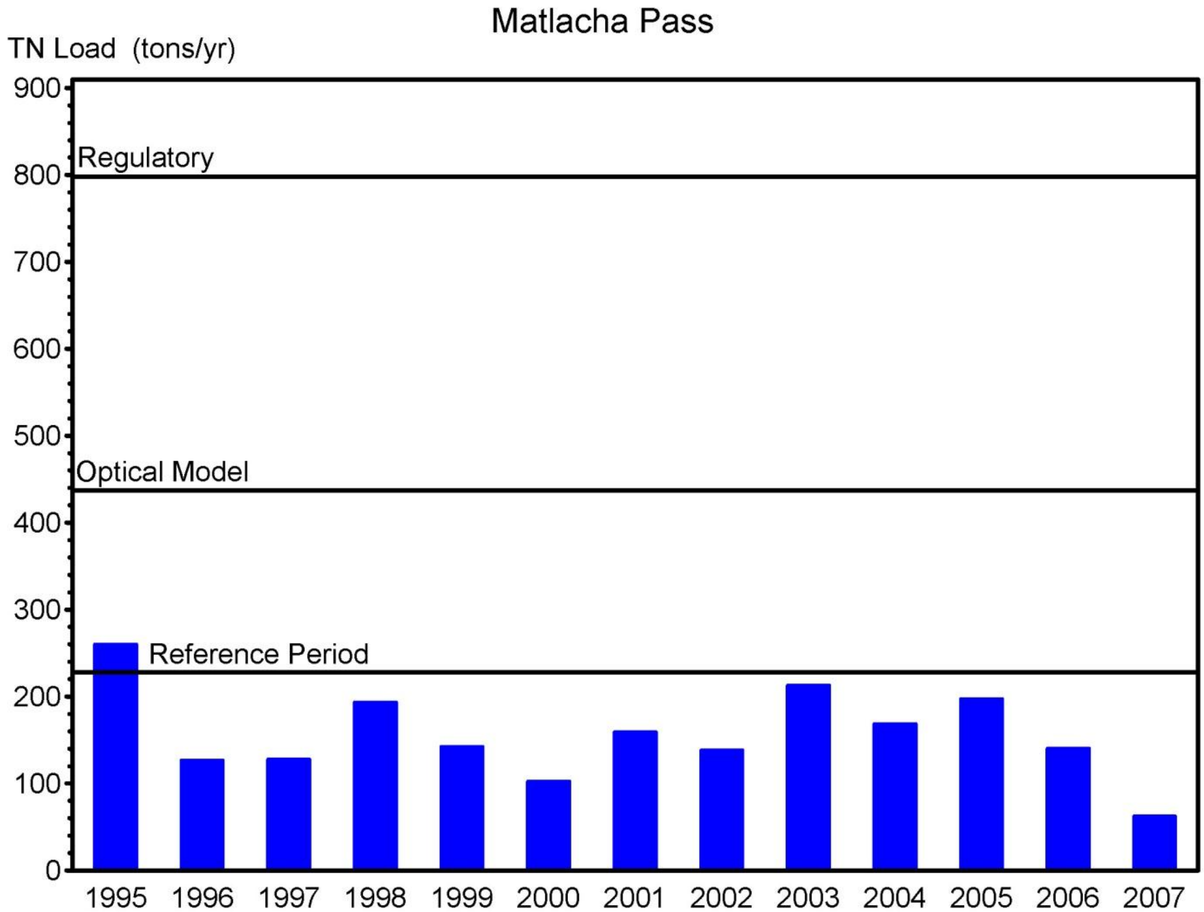



**Figure 14.** **Comparison of the potential TN criteria to observed TN concentrations (expressed as geometric means) in Matlacha Pass.**

# Appendix 5.7 – Draft Results San Carlos Bay and Tidal Caloosahatchee

## 5.7 San Carlos Bay and Tidal Caloosahatchee

### 5.7.1 Relationship Between Chlorophyll *a* and Concentrations and Loads - San Carlos Bay and Tidal Caloosahatchee

In addition to the time series plots, a series of bivariate plots were examined to investigate relationships between chlorophyll *a* and other potential explanatory variables in San Carlos Bay. These plots included chlorophyll *a* versus TN concentration, TP concentration, TN loads, TP loads, and hydrologic loads (Figures 1 through 5, respectively). Additional bivariate plots of chlorophyll *a* and pulse residence time, 2-month, 3-month, 4-month, 5-month, and 6-month average loads (TN, TP, and hydrologic) were produced and analyzed. As can be seen in these plots, no strong linear relationships were identified for San Carlos Bay.

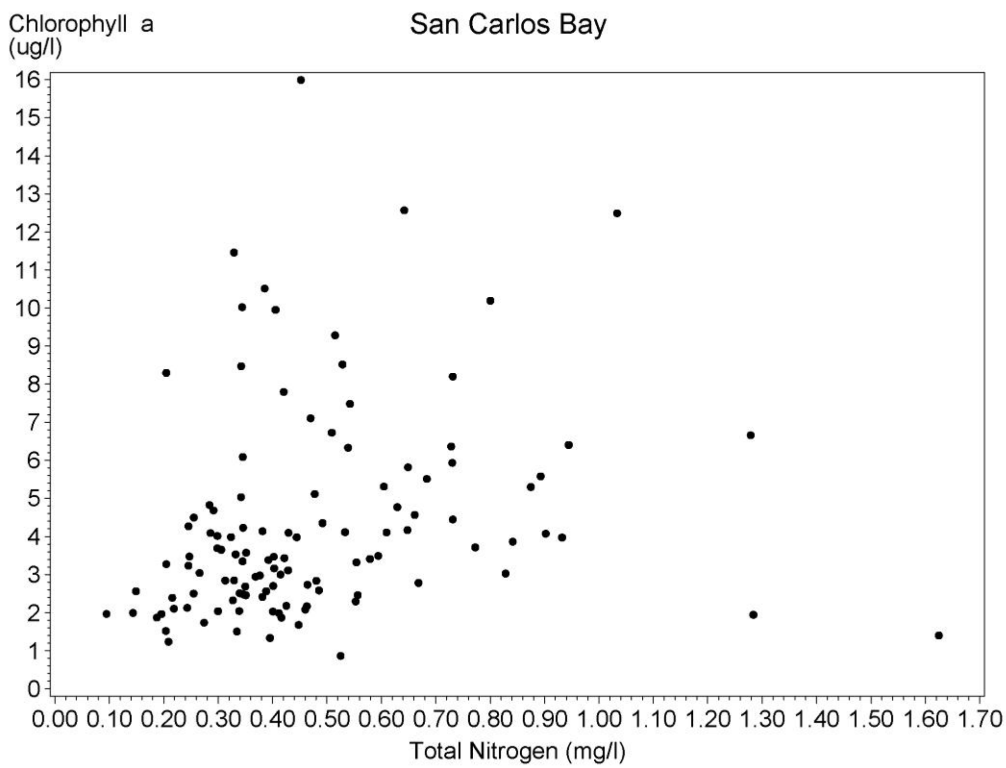



**Figure 1. Relationship between chlorophyll *a* and TN concentrations for San Carlos Bay.**

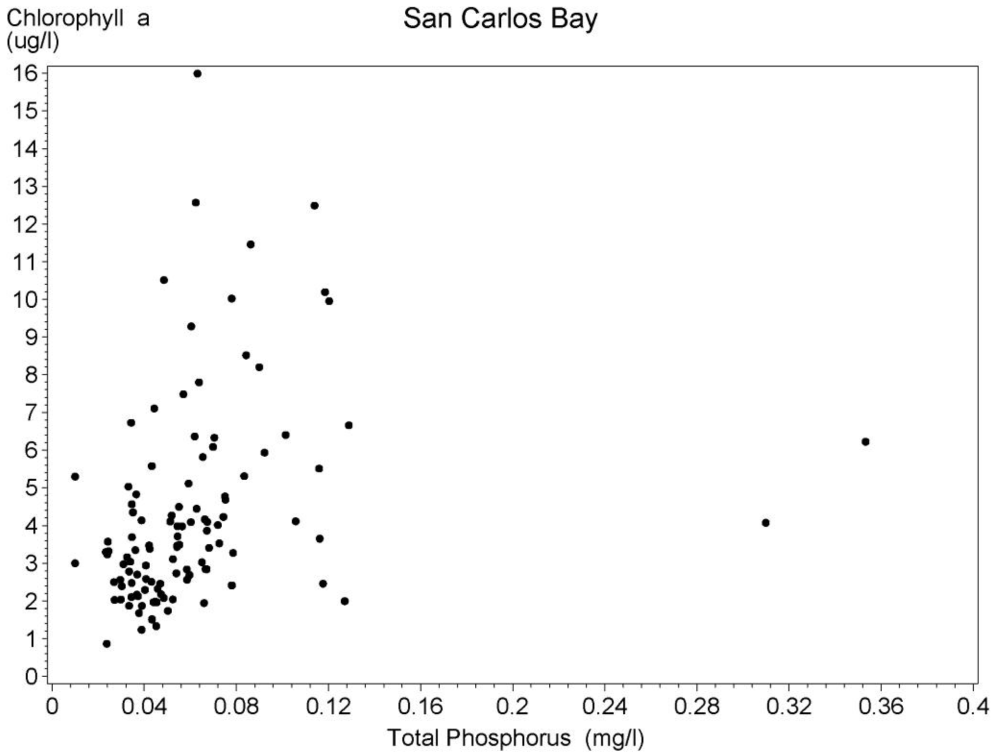



**Figure 2.** **Relationship between chlorophyll *a* and TP concentrations for San Carlos Bay.**

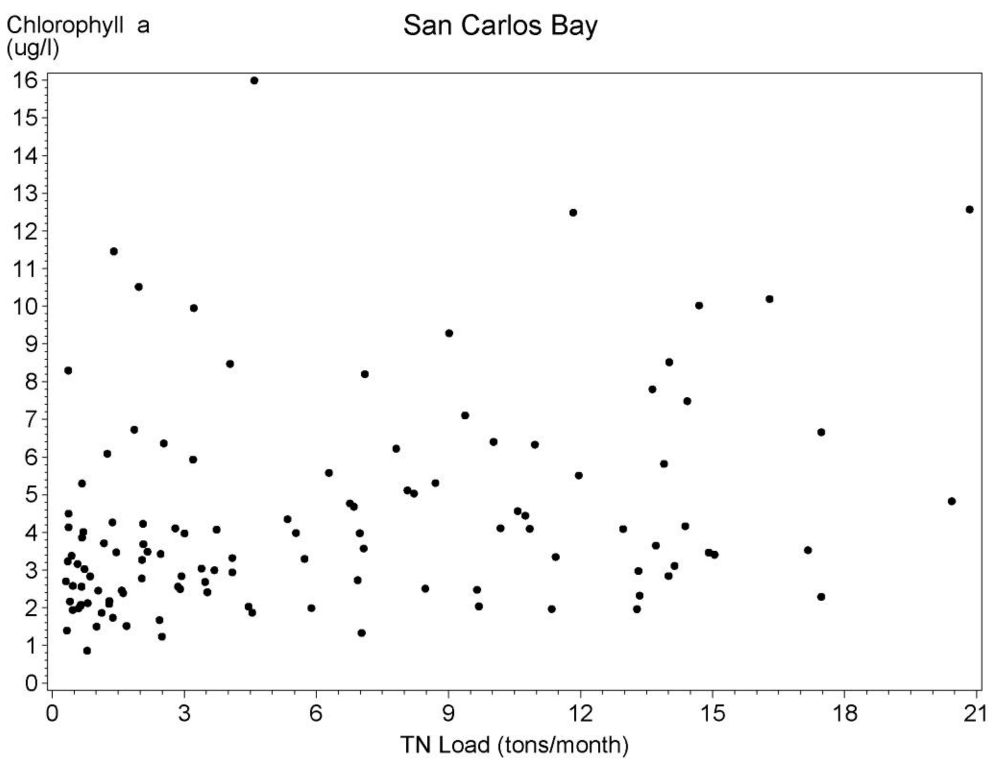



**Figure 3.** **Relationship between chlorophyll *a* in San Carlos Bay and TN loads from San Carlos Bay.**

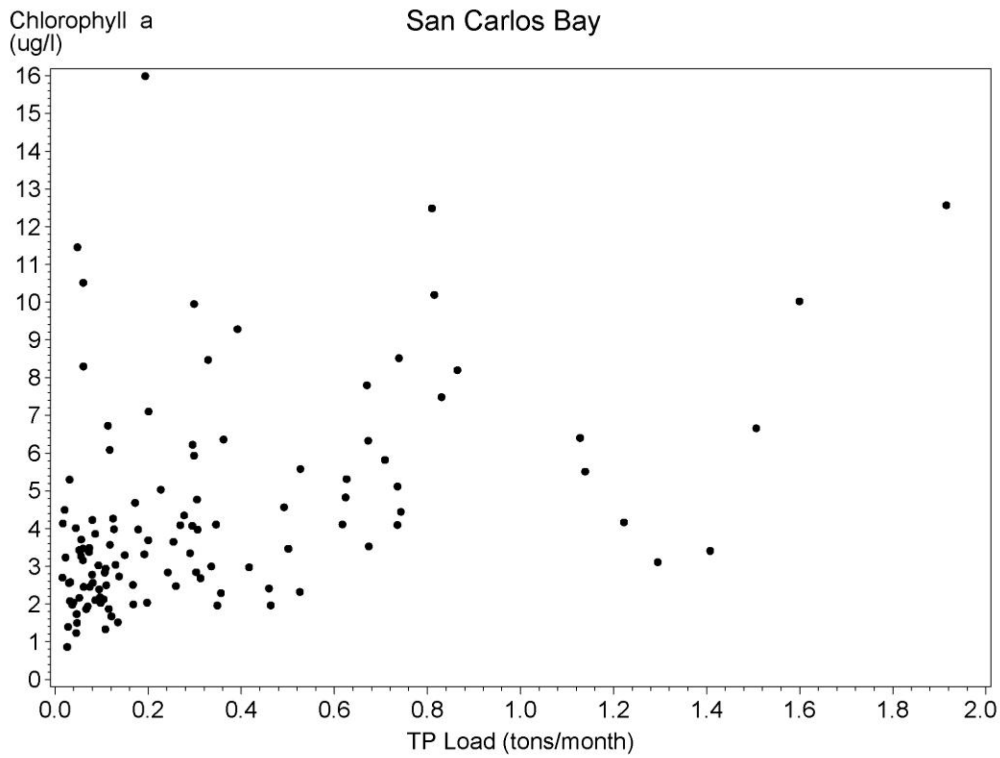



**Figure 4.** **Relationship between chlorophyll *a* in San Carlos Bay and TP loads from San Carlos Bay.**

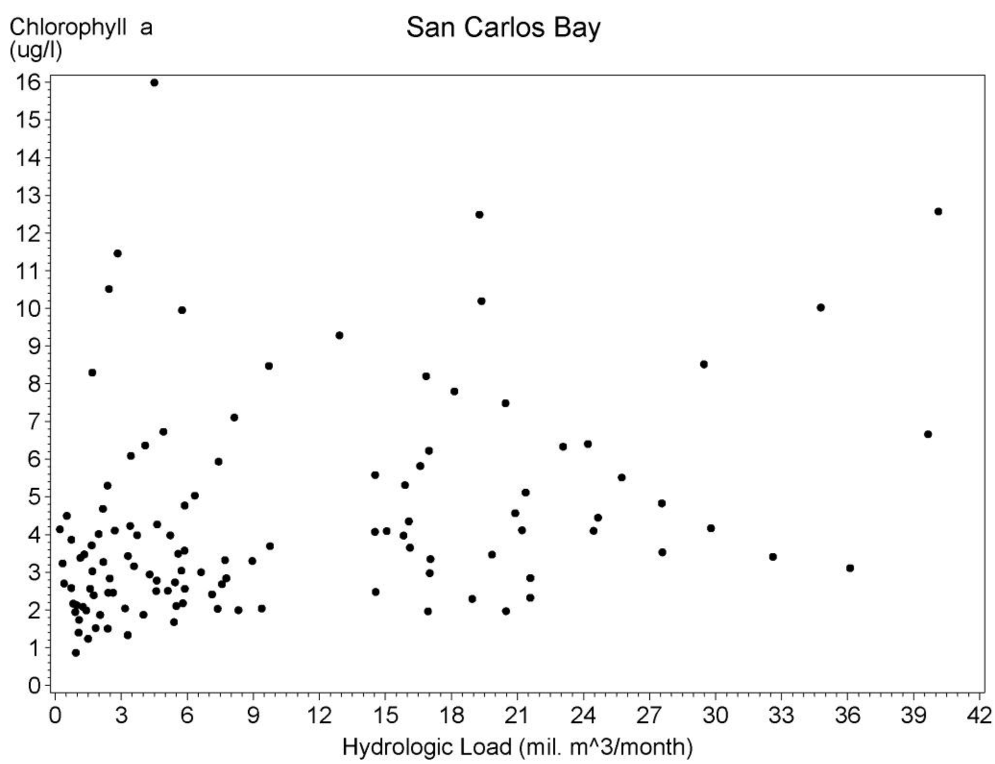



**Figure 5.** **Relationship between chlorophyll *a* in San Carlos Bay and hydrologic loads from San Carlos Bay.**

In addition to the time series plots, a series of bivariate plots were examined to investigate relationships between chlorophyll *a* and other potential explanatory variables in the Tidal Caloosahatchee. These plots included chlorophyll *a* versus TN concentration, TP concentration, TN loads, TP loads, and hydrologic loads (Figures 6 through 10, respectively). Additional bivariate plots were run between chlorophyll *a* and pulse residence time, 2-month, 3-month, 4-month, 5-month, and 6-month average loads (TN, TP, and hydrologic). As can be seen in these plots, no strong linear relationships were identified. Various transformations were applied to the data to determine if a statistically significant relationship could be identified. But, this did not yield positive results.

Members of the Technical Advisory Committee recommended investigating subsets of the data as numerous stations are close to the shoreline where they may be influenced by canals and other tributaries. A buffer was applied to the shoreline in order to eliminate stations that were close to the shoreline. Additionally, separate attempts were made to use only samples from random sampling programs or only samples from fixed station sampling programs. None of these efforts yielded positive results as there are confounding factors which affect the relationship between loads and chlorophyll spatially.

As was documented by Doering *et al.* (2006), significant relationships were identified between Tidal Caloosahatchee loads and chlorophyll *a* concentrations when the data were divided into regions (Figure 11). Doering *et al.* (2006) identified positive correlations between Tidal Caloosahatchee TN loads and chlorophyll concentrations in the lower portion of the Tidal Caloosahatchee and San Carlos Bay. They also found no significant relationship between TN loads and chlorophyll in the middle portion of the Tidal Caloosahatchee and a significant negative correlation between TN load and chlorophyll concentrations in the upper portion of the Tidal Caloosahatchee. Because significant positive correlations have been identified by Doering *et al.* (2006) for the lower portion of the Tidal Caloosahatchee, a series of bivariate plots were examined to investigate relationships between chlorophyll *a* in the lower Tidal Caloosahatchee and other potential explanatory variables. Plots included chlorophyll *a* versus TN concentration, TP concentration, TN loads, TP loads, and hydrologic loads (Figures 12 through 16, respectively).

The Tidal Caloosahatchee is a highly managed system, with Lake Okeechobee flows being diverted through the C-43 canal to the Tidal Caloosahatchee. Further investigation revealed an inflection point in the loadings above which chlorophyll concentrations began to decline (Figures 17 to 19). Doering *et al.* (2006) documented declines in chlorophyll concentrations in the Tidal Caloosahatchee above certain flows at S-79. Due to geomorphic differences in the system, the inflection point varies spatially. As expected, chlorophyll concentrations begin to decline as a result of smaller loads (200 tons/month) in the upper region as this portion of the system is narrower and has a smaller volume relative to the downstream region. Given that the volume and tidal mixing are greater downstream, the inflection point occurs at higher loads (400 tons/month for the middle region and 600 tons/month for lower region).

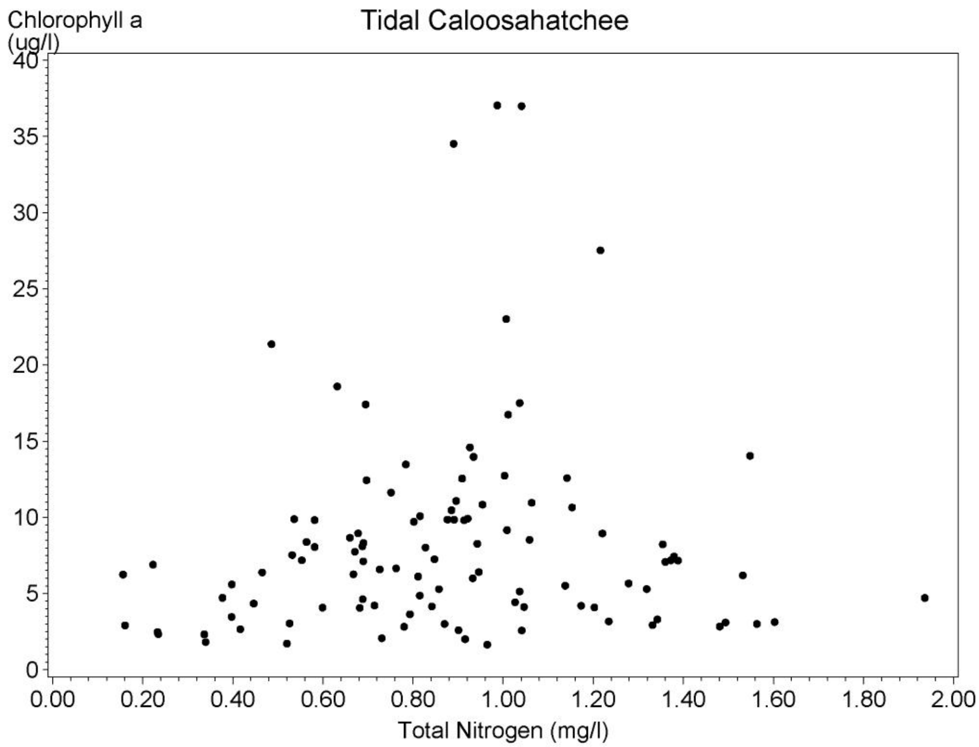



**Figure 6. Relationship between chlorophyll *a* and TN concentrations for Tidal Caloosahatchee.**

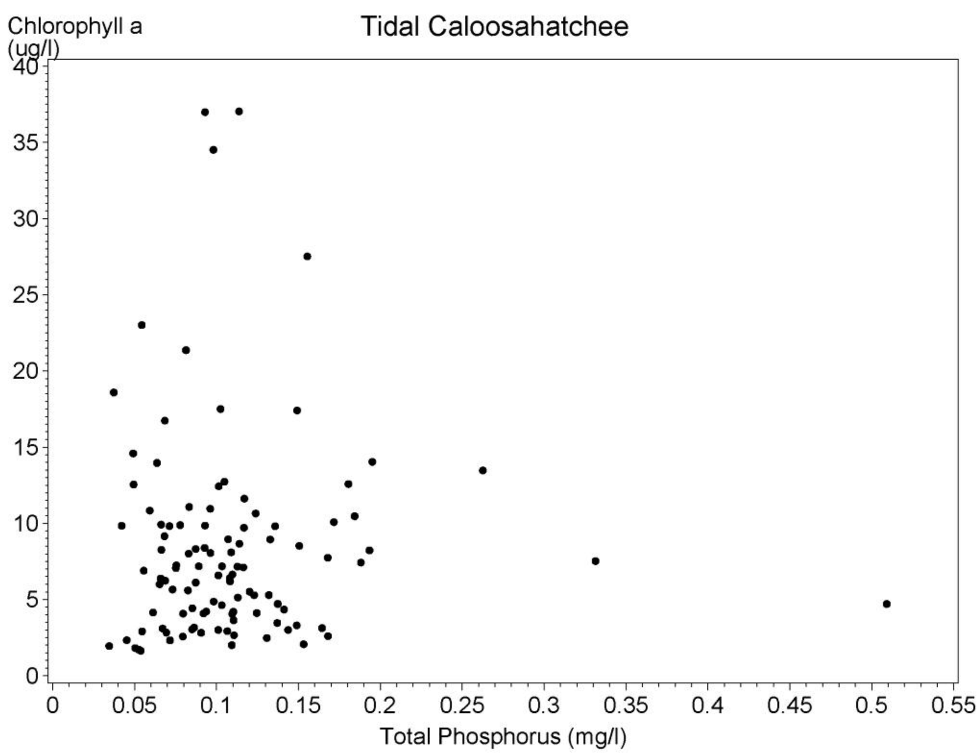



**Figure 7. Relationship between chlorophyll *a* and TP concentrations for Tidal Caloosahatchee.**

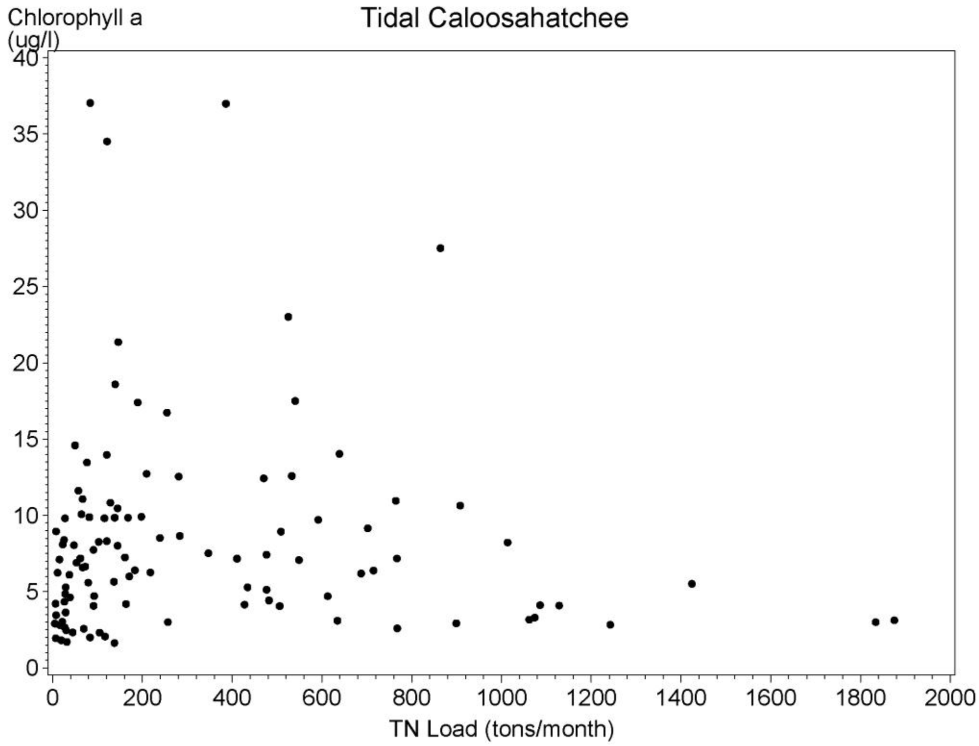



**Figure 8. Relationship between chlorophyll *a* and TN loads for Tidal Caloosahatchee.**

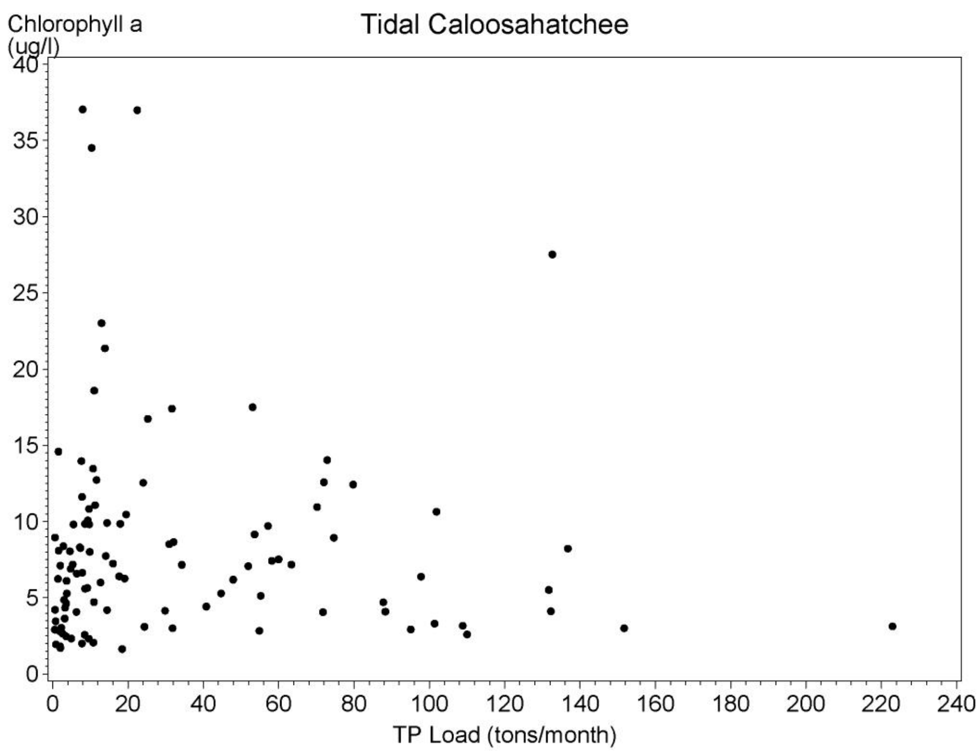



**Figure 9. Relationship between chlorophyll *a* and TP loads for Tidal Caloosahatchee.**

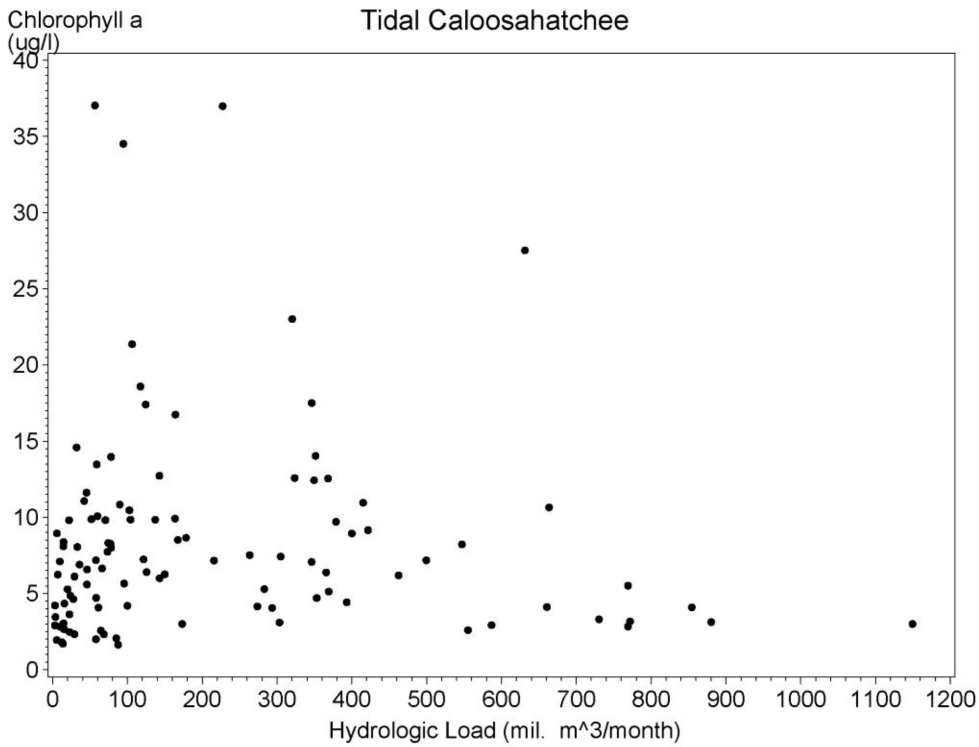



**Figure 10. Relationship between chlorophyll *a* and hydrologic loads for Tidal Caloosahatchee.**

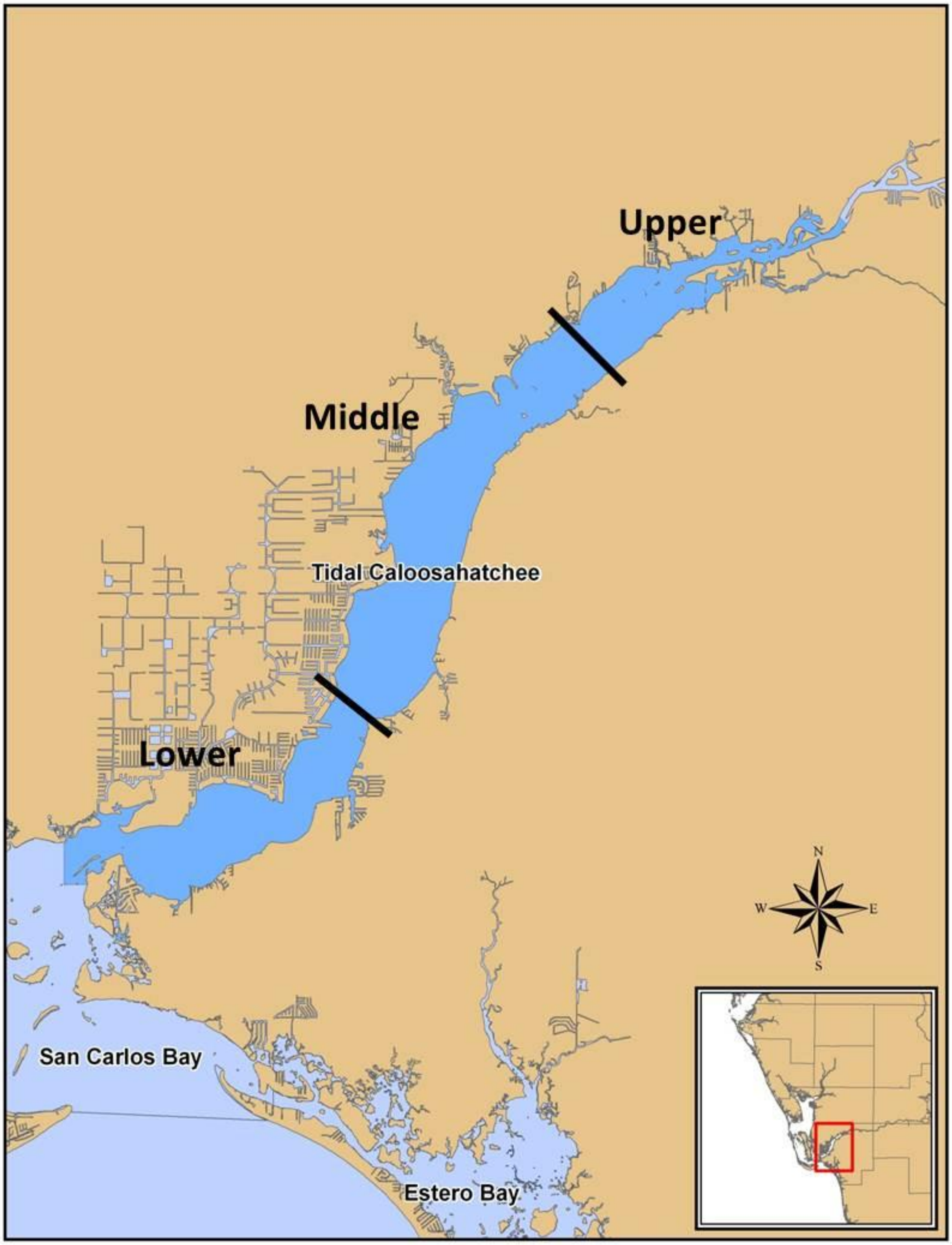



**Figure 11. Tidal Caloosahatchee water segment, including regional divisions from Doering *et al.* (2006).**

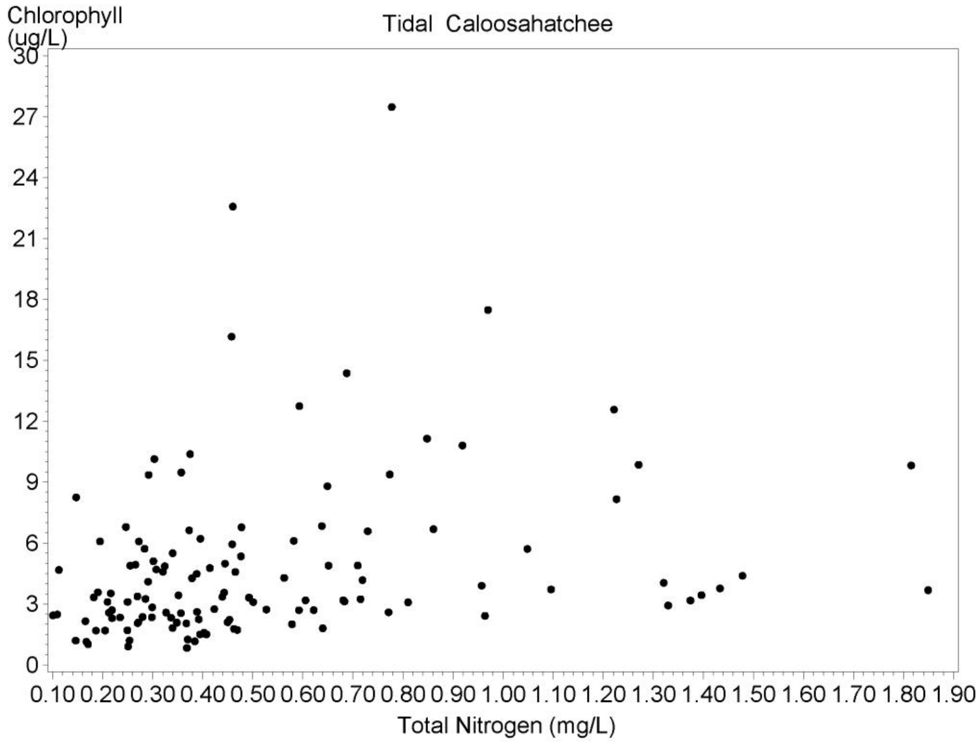



**Figure 12. Relationship between chlorophyll *a* and TN concentrations for the lower portion of the Tidal Caloosahatchee.**

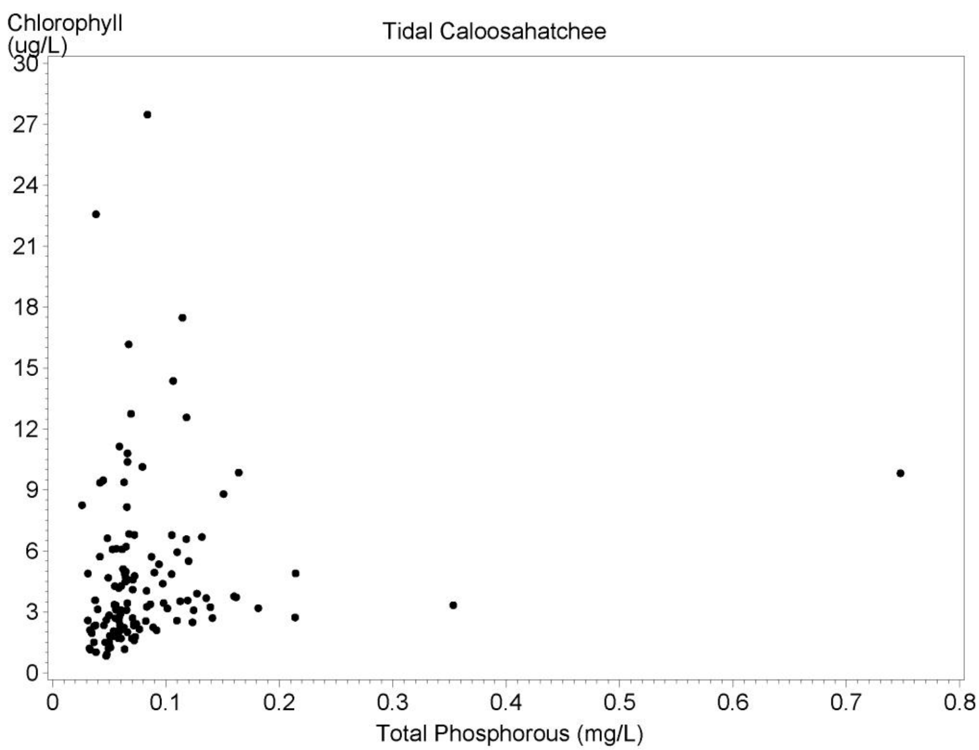



**Figure 13. Relationship between chlorophyll *a* and TP concentrations for the lower portion of the Tidal Caloosahatchee.**

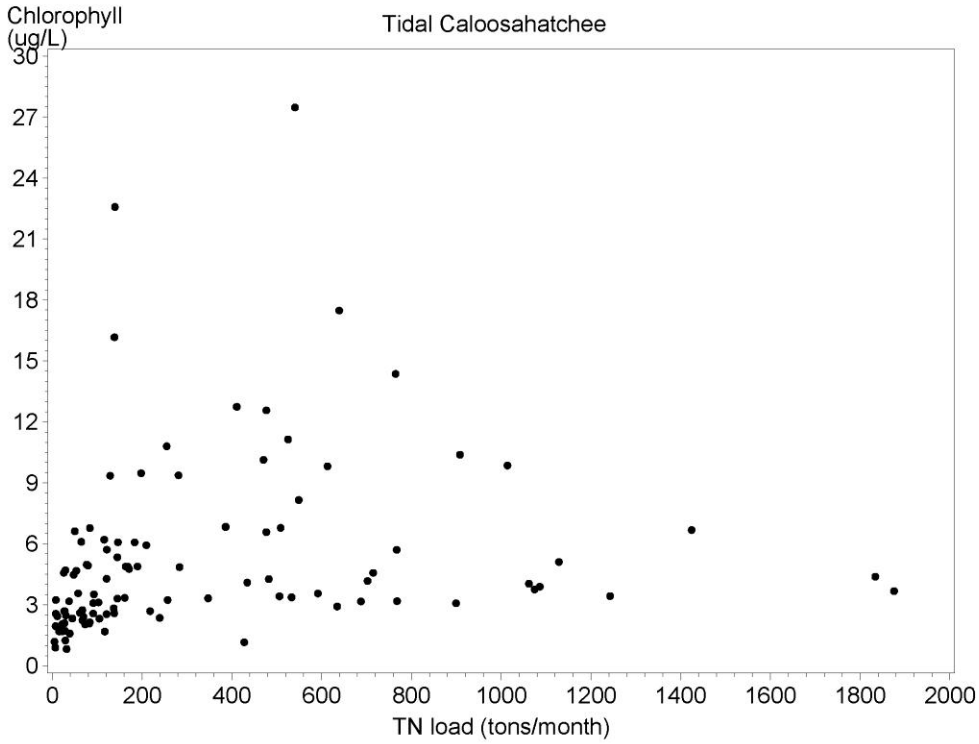



**Figure 14. Relationship between chlorophyll *a* and TN loads for the lower portion of the Tidal Caloosahatchee.**

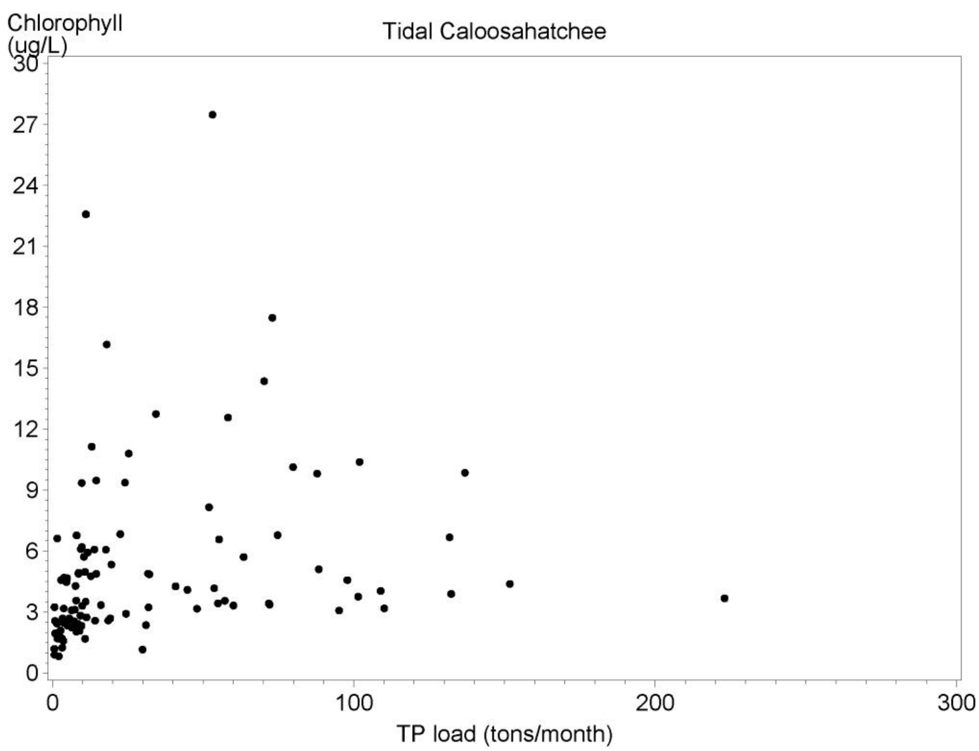



**Figure 15. Relationship between chlorophyll *a* and TP loads for the lower portion of the Tidal Caloosahatchee.**

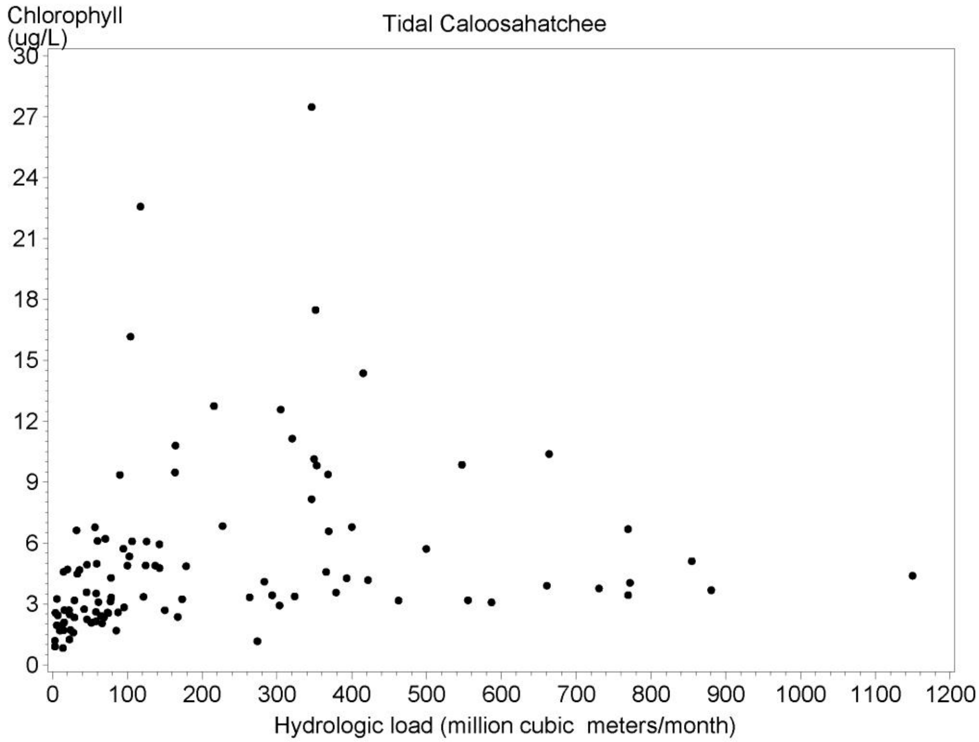



**Figure 16.** **Relationship between chlorophyll *a* and hydrologic loads for the lower portion of the Tidal Caloosahatchee.**

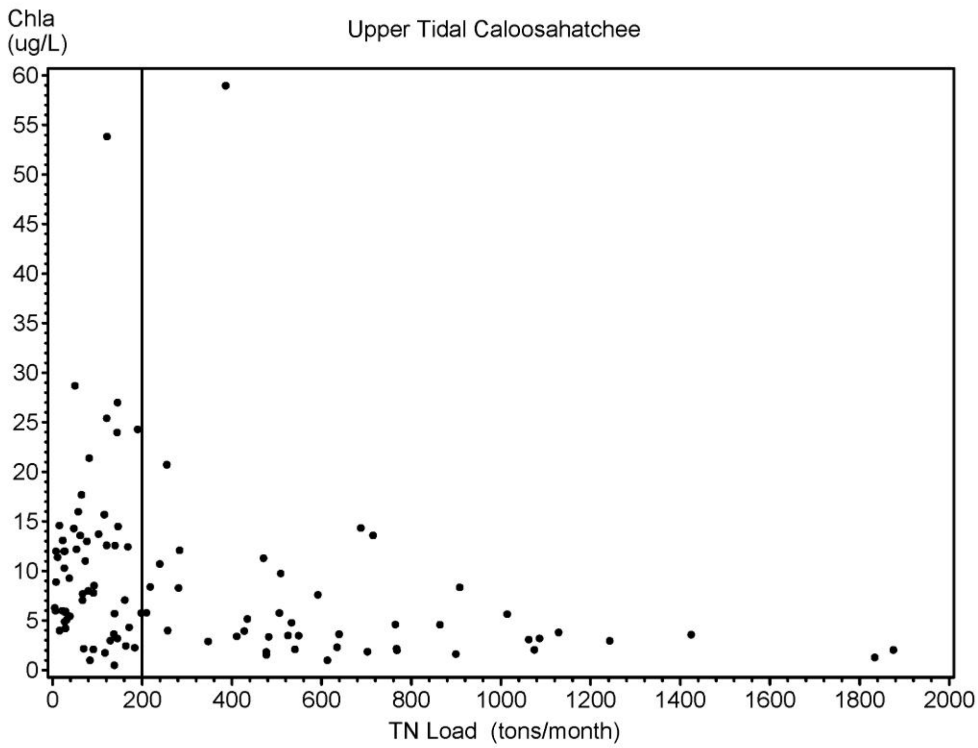



**Figure 17.** **Relationship between chlorophyll *a* and TN loads for the upper portion of the Tidal Caloosahatchee.**

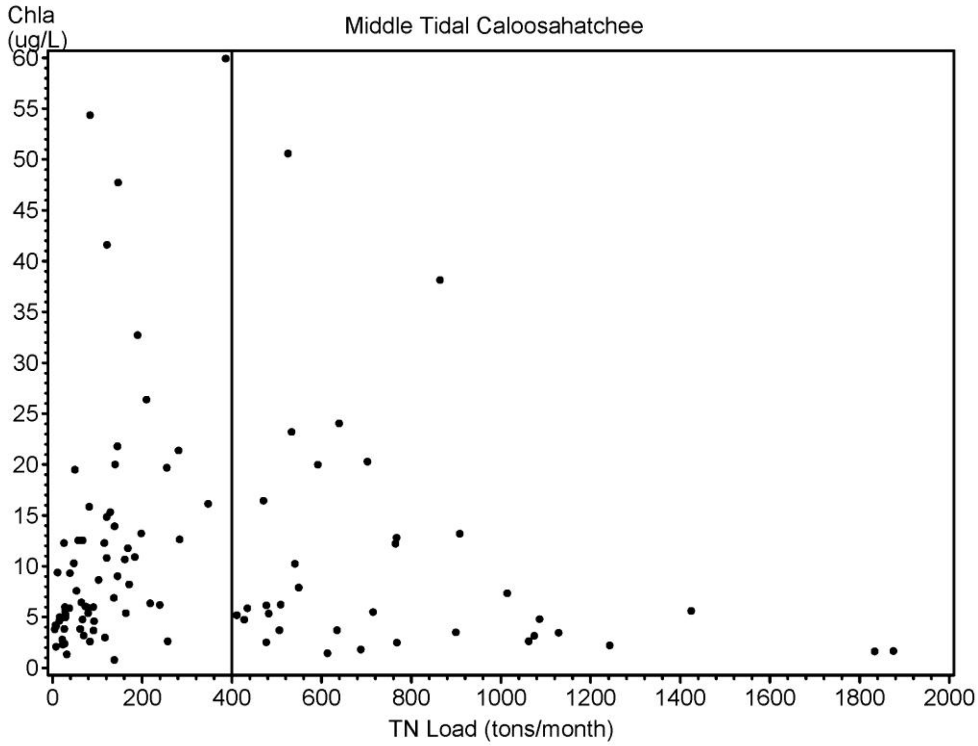



**Figure 18. Relationship between chlorophyll *a* and TN loads for the middle portion of the Tidal Caloosahatchee.**

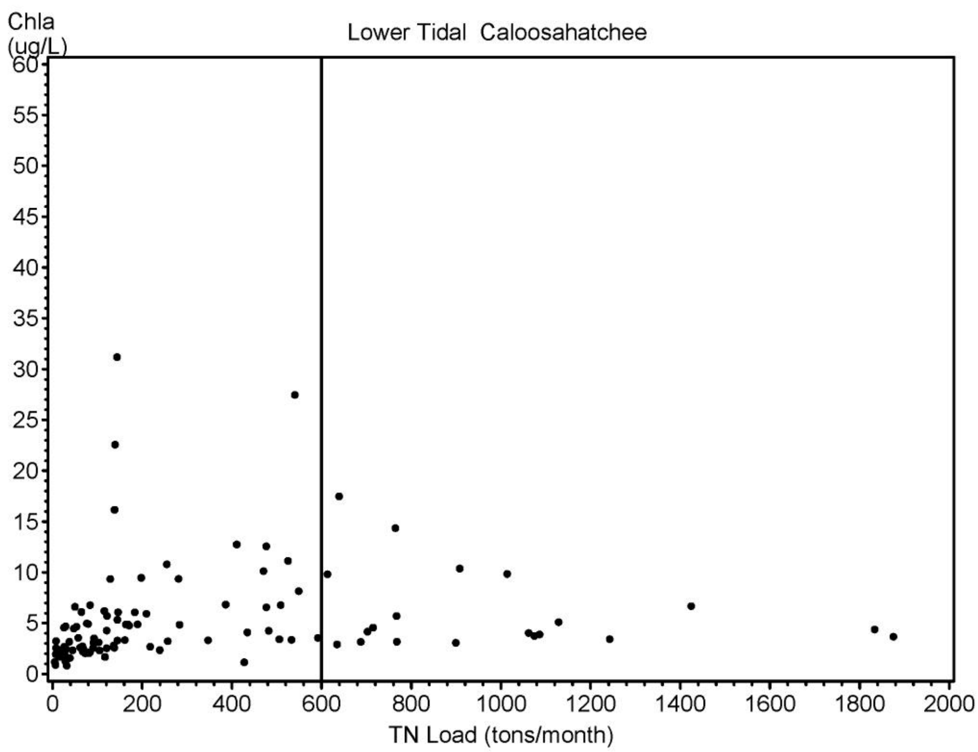



**Figure 19. Relationship between chlorophyll *a* and TN loads for the lower portion of the Tidal Caloosahatchee.**

A regression model between chlorophyll *a* in the lower portion of Tidal Caloosahatchee and TN load in the Tidal Caloosahatchee was developed. Because of the inflection point in the data, this relationship was developed for TN loads between 0 and 600 tons. The residuals from this model were examined to identify any other explanatory variables that might contribute to the overall variance accounted for by the model. As a result of this analysis, color was added to the regression equation. The final regression equation is:

$$\ln [\text{Chlorophyll } a] = -0.305 + (0.294 * \text{Log (TN load)}) + (0.00889 * \text{color})$$

The model was fit with 57 observations and resulted in an $R^2$ value of 0.57. The regression was significant with a probability of a greater |F| value of < 0.0001. The slope and parameter coefficients were also significant. A plot of predicted versus observed chlorophyll *a* concentrations is presented in Figure 20.

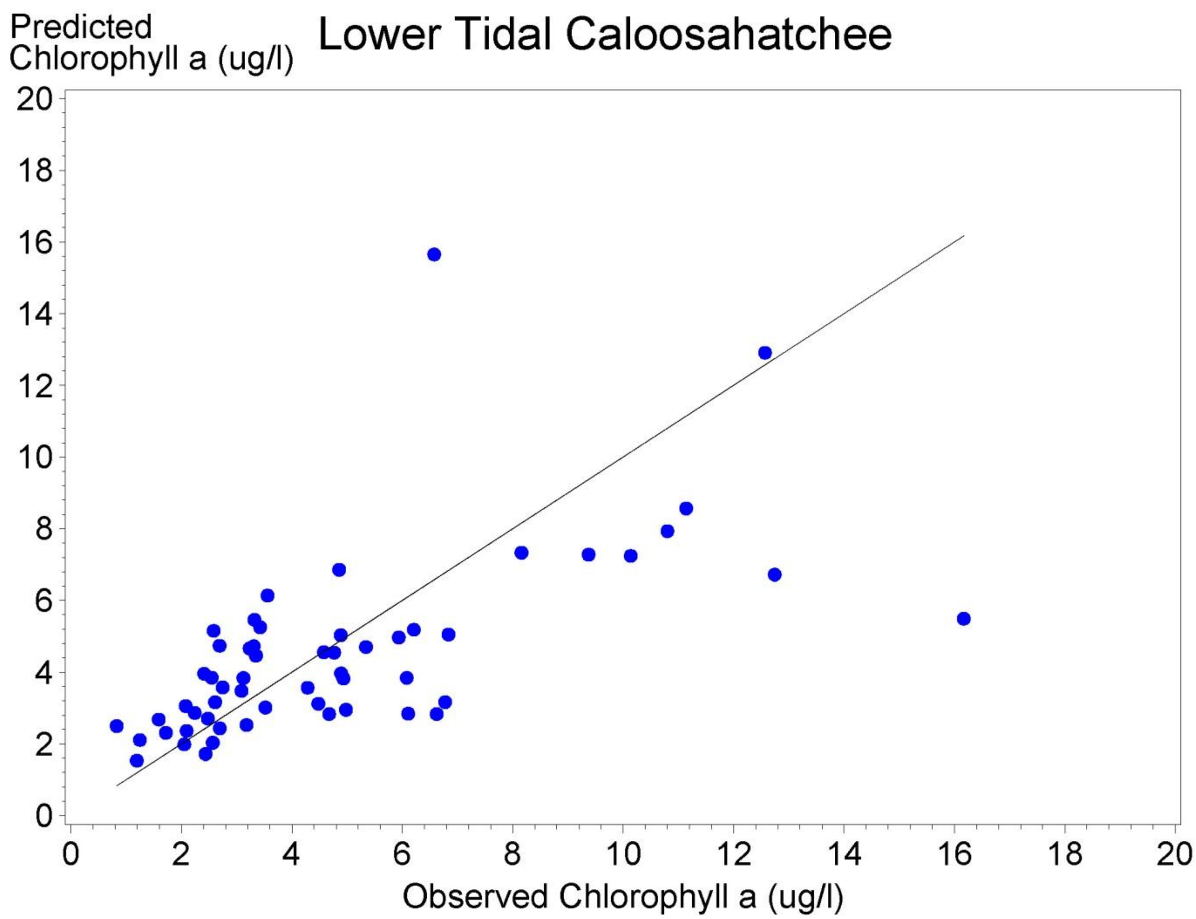



**Figure 20.** **Predicted versus observed chlorophyll *a* concentrations based on regression equation developed for the lower portion of the Tidal Caloosahatchee.**

### 5.7.2 Candidate Criteria - San Carlos Bay and Tidal Caloosahatchee

As mentioned above, no defensible relationships were identified between chlorophyll concentrations in San Carlos Bay and load and/or concentrations in San Carlos Bay and Tidal Caloosahatchee. However, as documented in this report, San Carlos Bay has seen a strong trend in seagrass growth over the last decade. In fact, the most recent seagrass estimate of 6,469 acres is well above the seagrass target range for San Carlos Bay (3,709–5,376 acres). Since the seagrass population in San Carlos Bay has been steadily increasing over the past decade and is currently exceeding the target range, the water quality in San Carlos Bay has obviously been supportive of seagrasses in San Carlos Bay. Therefore, it is recommended to use the reference period approach (Subsection 3.3.3) to identify the TN threshold concentration which has been supportive of seagrass growth. This is calculated by taking the annual average TN concentration in San Carlos Bay during the reference period (2003-2007) and adding an estimate of inter-annual variability (1 standard deviation of the annual mean TN concentrations for the period of record). The TN threshold (0.56 mg/l) for San Carlos Bay is the target (0.46 mg/l) plus one standard deviation (0.10 mg/l).

A comparison of the candidate numeric TN criterion based on the Reference Period method is presented in Figure 21 for San Carlos Bay.

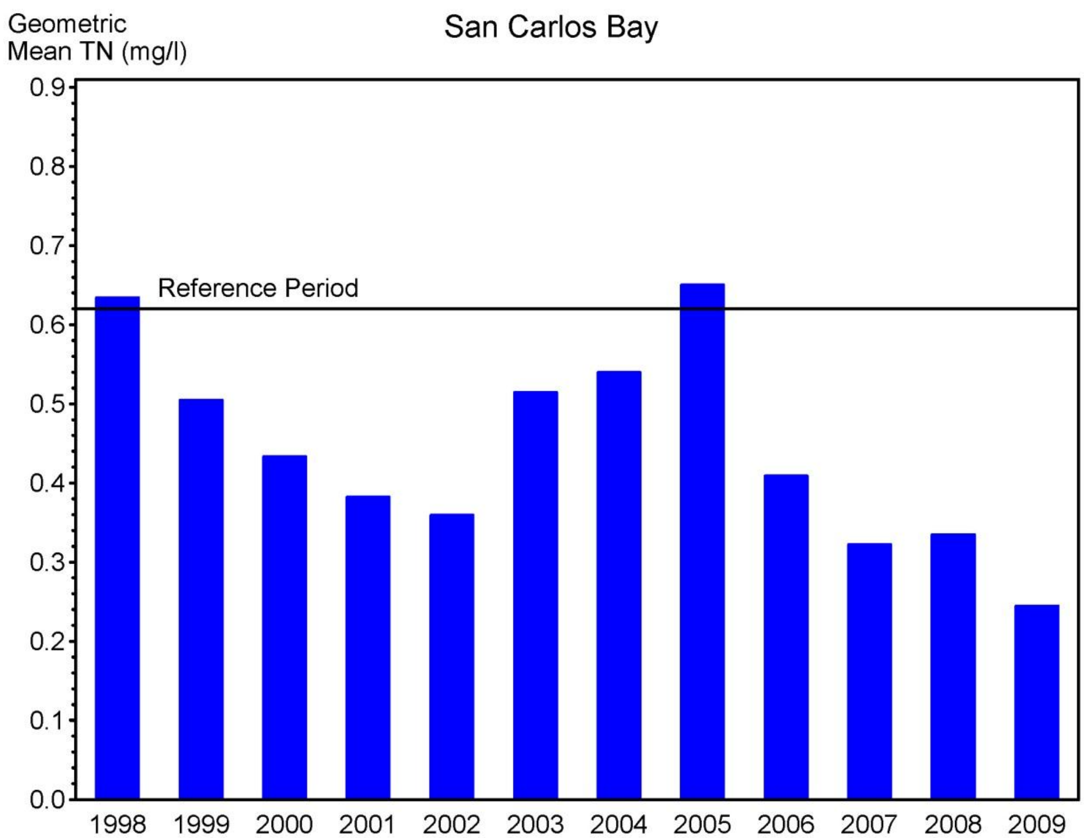



**Figure 21. Comparison of the potential TN criterion to observed TN concentrations in San Carlos Bay.**

In order to estimate the TN load criteria for the Tidal Caloosahatchee, an acceptable chlorophyll target is necessary. Because the system has been identified as impaired, it is inappropriate to use the Reference Period approach based on Tidal Caloosahatchee chlorophyll concentrations. As mentioned above, a relationship was developed between chlorophyll concentrations in the lower portion of the Tidal Caloosahatchee and the TN loads and color in the lower Tidal Caloosahatchee. A significant positive correlation between the variables was identified ($r^2$=0.57). Since the chlorophyll concentrations in the lower Tidal Caloosahatchee are greater than the chlorophyll concentrations in San Carlos Bay on average, the San Carlos Bay chlorophyll threshold (3.5 µg/l) was used. This is conservative as the chlorophyll concentrations in San Carlos Bay are less than those in Tidal Caloosahatchee. Because color is included in the regression, the annual TN load criteria were calculated for each year based on the observed color data in each year. The annual TN criteria loads for the period 1999 to 2007 ranged between 1,834 and 4,056 tons/year. These are the TN load criteria from Tidal Caloosahatchee that corresponds to the Reference Period chlorophyll in San Carlos Bay.

A comparison of the candidate numeric TN criteria (grey bars) and the annual loads (blue bars) is presented in Figure 22 for Tidal Caloosahatchee.

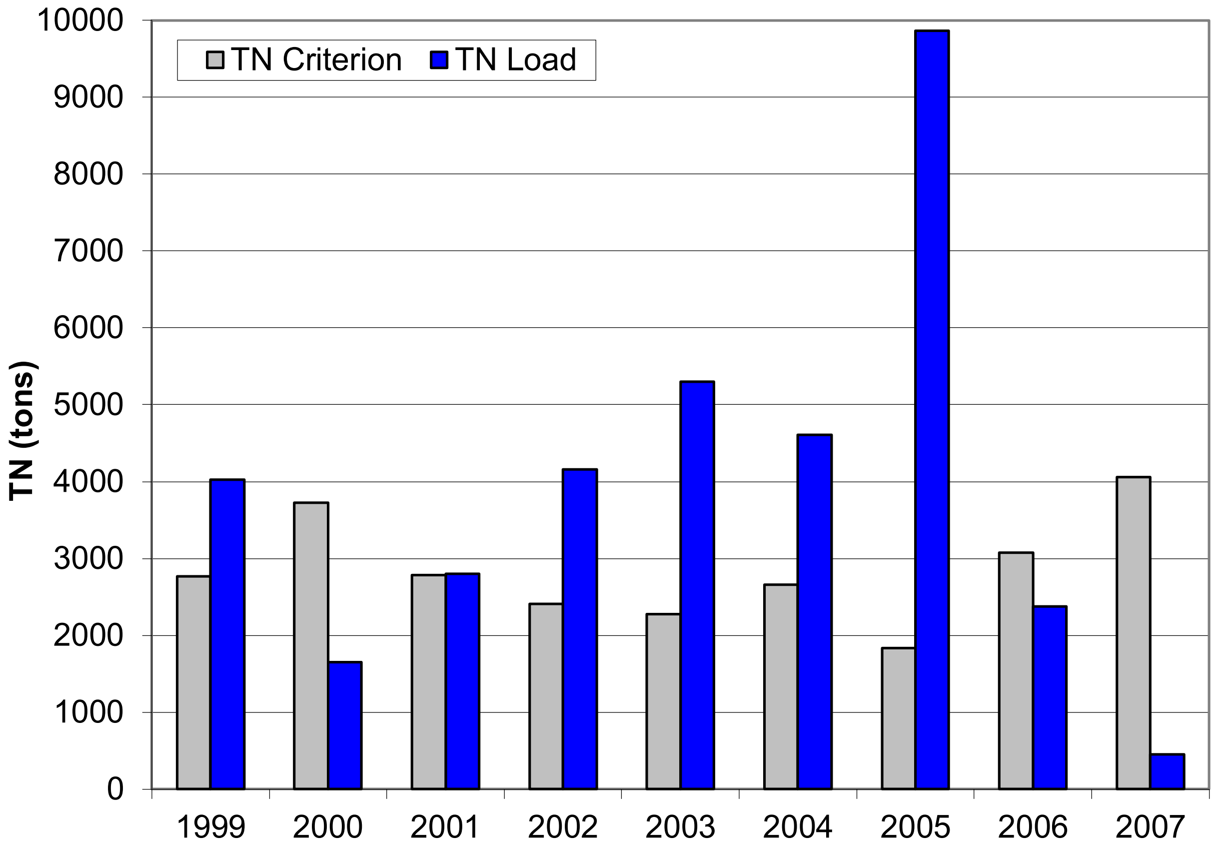



**Figure 22. Comparison of the potential TN criterion (grey bars) to observed TN loads (blue bars) in Tidal Caloosahatchee.**

## Appendix 5.8 – Draft Results Estero Bay

## 5.8 Estero Bay

### 5.8.1 Relationship Between Chlorophyll *a* and Concentrations and Loads - Estero Bay

In addition to the time series plots, a series of bivariate plots were examined to investigate relationships between chlorophyll *a* and other potential explanatory variables. These plots included chlorophyll *a* versus TN concentration, TP concentration, TN loads, TP loads, and hydrologic loads (Figures 1 through 5, respectively). As can be seen in these plots, no strong linear relationships were identified. Additional bivariate plots were run between chlorophyll *a* and pulse residence time, 2-month, 3-month, 4-month, 5-month, and 6-month average loads (TN, TP, and hydrologic) with a similar conclusion of no strong linear relationships.

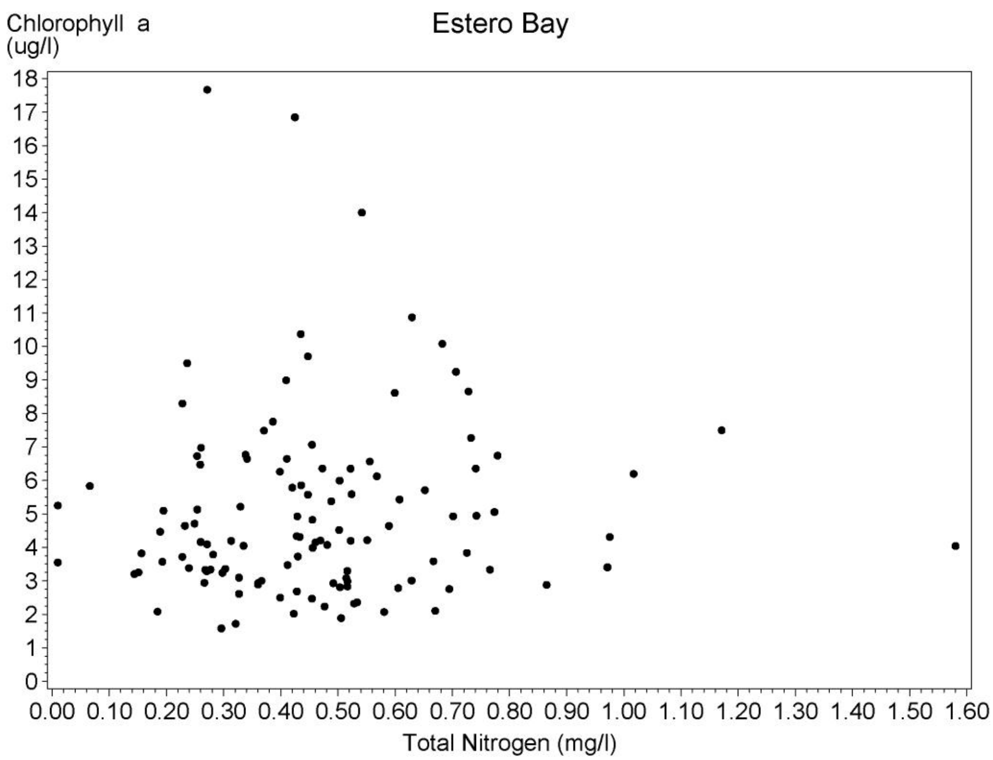



**Figure 1. Relationship between chlorophyll *a* and TN concentrations for Estero Bay.**

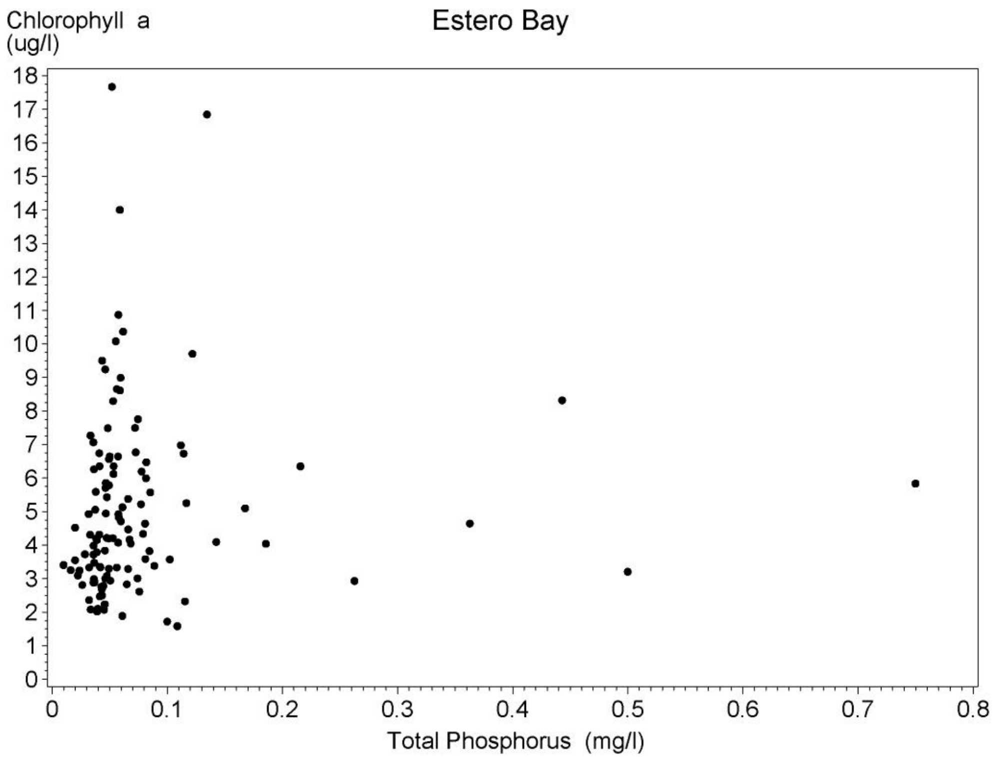



**Figure 2. Relationship between chlorophyll *a* and TP concentrations for Estero Bay.**

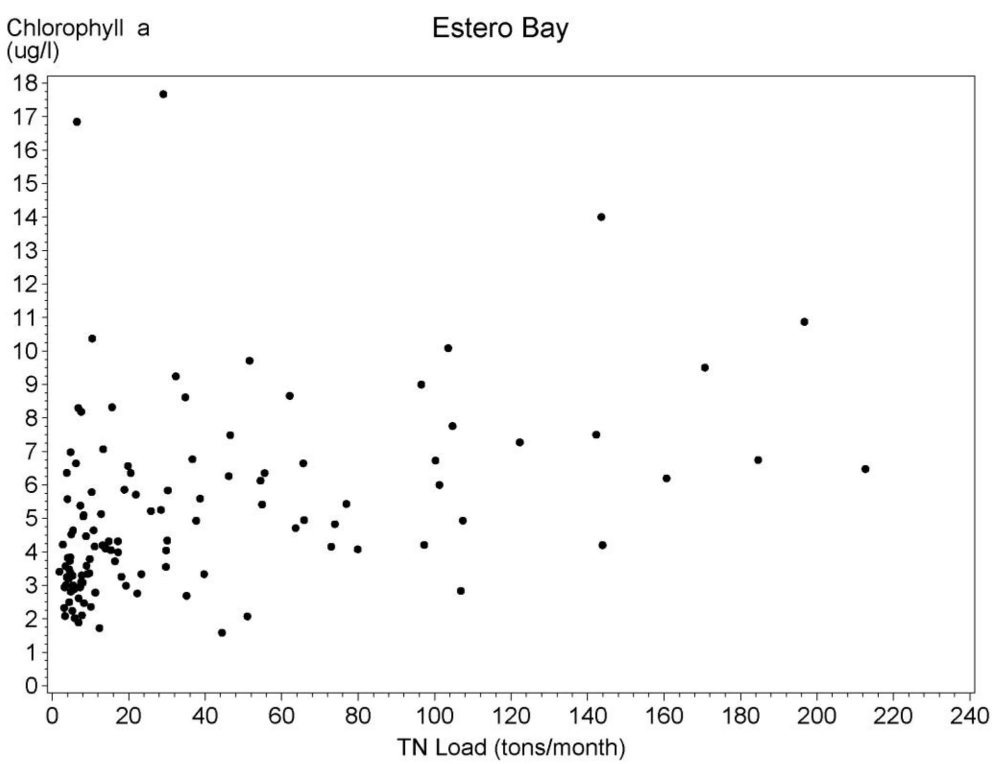



**Figure 3. Relationship between chlorophyll *a* and TN loads for Estero Bay.**

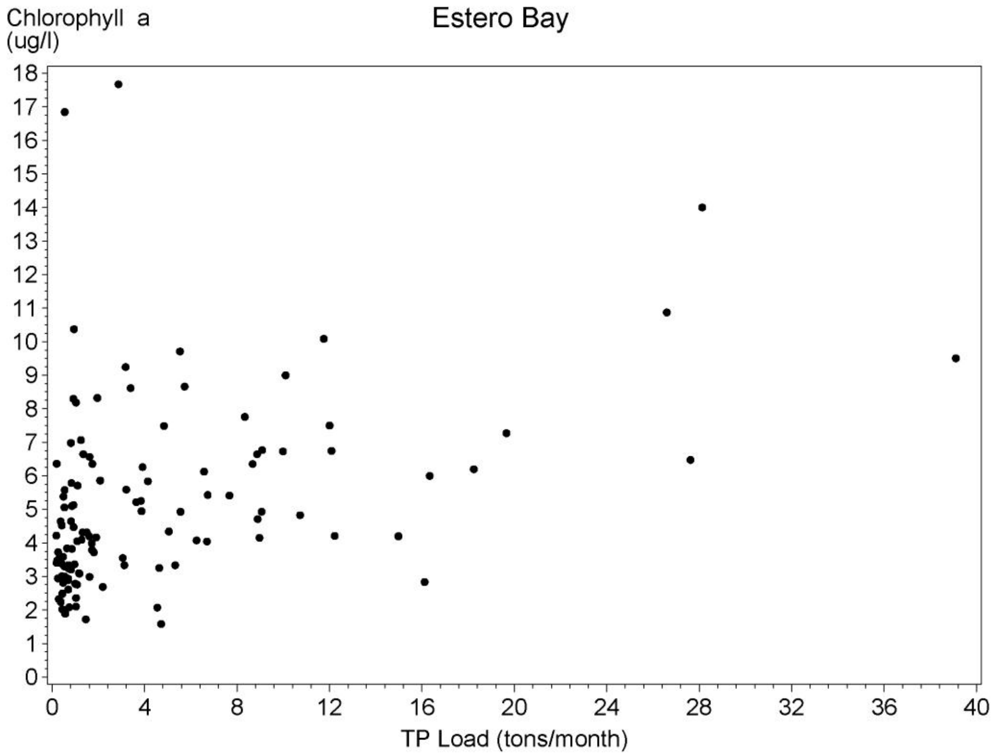



**Figure 4.** **Relationship between chlorophyll *a* and TP loads for Estero Bay.**

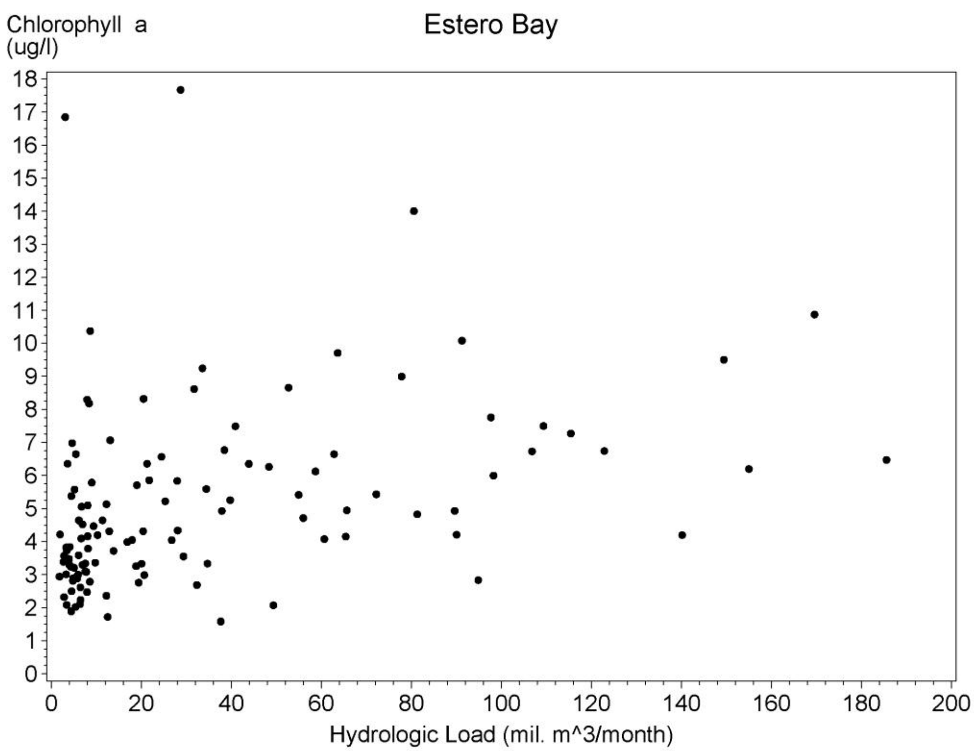



**Figure 5.** **Relationship between chlorophyll *a* and hydrologic loads for Estero Bay.**

An alternative method was then employed with the intent on identifying a changepoint value that characterized the chlorophyll *a* distributions as distinct populations. The changepoint analysis was employed on a subset of data collected in Estero Bay representing the more open water areas within Estero Bay. Estero Bay is a large, shallow embayment with extensive mangrove islands and complex hydrology. The data used for analysis is displayed in (Figure 6).

Based on this subset of data in Estero Bay, a changepoint was detected using TN loads from the Estero Bay watershed at a TN load value of 23.36 tons (Figure 7). The grand average chlorophyll *a* concentration was 5.08 µg/l and the conditional means were 4.36 µg/l and 6.60 µg/l as presented under the chlorophyll distribution boxplots of Figure 16.3.2. Thirty two percent of the data were above the 23.36 TN load changepoint.

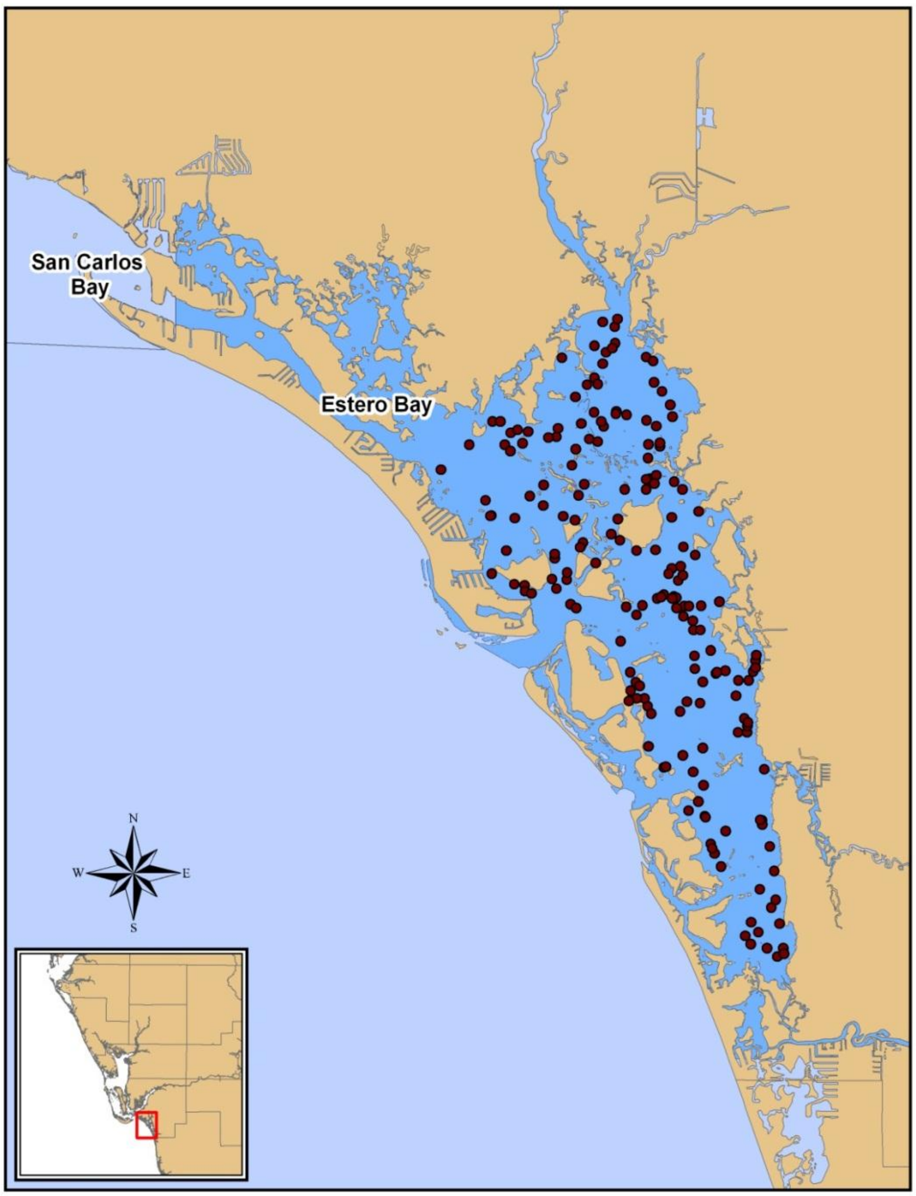



**Figure 6. Map of Estero Bay water quality sampling stations used in changepoint analysis.**

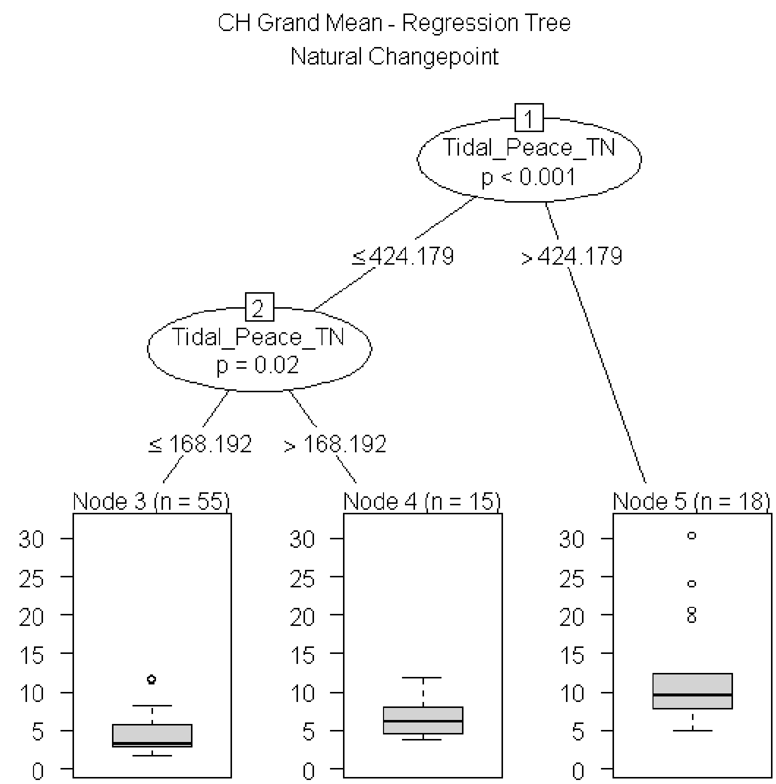



**Figure 7. Results of changepoint analysis for Estero Bay chlorophyll and Loads.**

### 5.8.2 Candidate Criteria - Estero Bay

The conditional mean of 5.9 µg/l for the chlorophyll distribution above the changepoint is not expected to be exceeded based on the empirical data given the TN loads from that distribution remain similar. This chlorophyll value is below all thresholds including the Reference Period threshold as well as the Regulatory threshold. Therefore, the proposed numeric nutrient criterion for Estero Bay is the expected annual average TN load of the higher condition mean. The empirical distribution of TN loads above and below the identified changepoint is presented in Figure 8. These distributions are clearly different in magnitude with a mean distribution below the changepoint of 9 tons per month and the mean above the changepoint of 78 tons per month. To develop the criterion value only the distribution of values above the changepoint is used since the conditional chlorophyll mean when TN loads are above 23 tons is 5.9 (µg/l). The Monte Carlo method was used to randomly select 12 samples from the simulated conditional distribution above the changepoint and calculate the annual sum of the TN load. Based on 1000 replicates, the expected annual TN load was 660 tons per year. The 95% confidence intervals were calculated as between 410 tons – 950 tons.

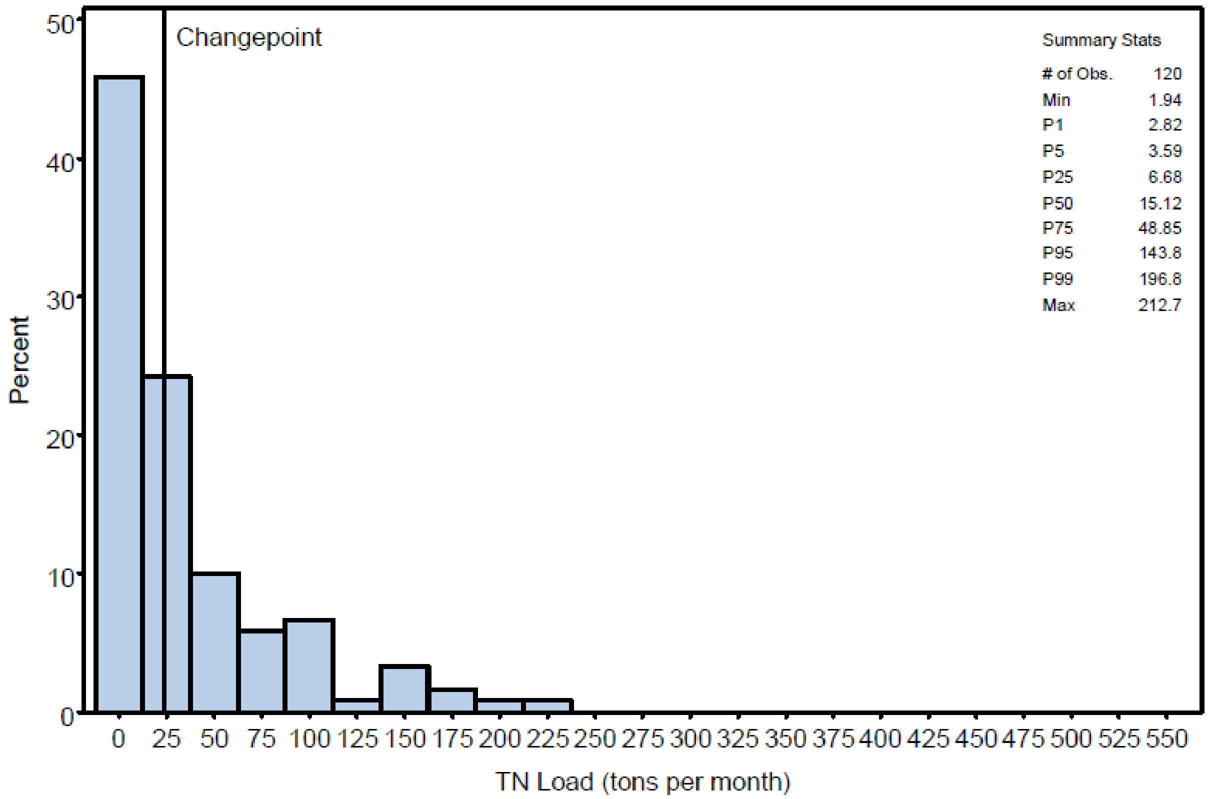



**Figure 8.** **Histogram of TN loadings from Estero Bay corresponding to the water quality data with identified changepoint.**

Implementation of this proposed TN criterion will require accounting for the influence of inter-annual hydrologic variation and residence times on the target exceedance frequencies. Using the confidence interval provides one mechanism by which this might be accomplished. The effect of seasonality on these relationships is also not accounted for explicitly via the simulation; however, the resulting estimate is likely conservative given that higher loads during colder months would likely not elicit the same water quality response given the colder water temperatures and reduced photoperiod.

A comparison of the candidate numeric TN concentration criteria based on Reference Period method is presented in Figure 9 for Estero Bay.

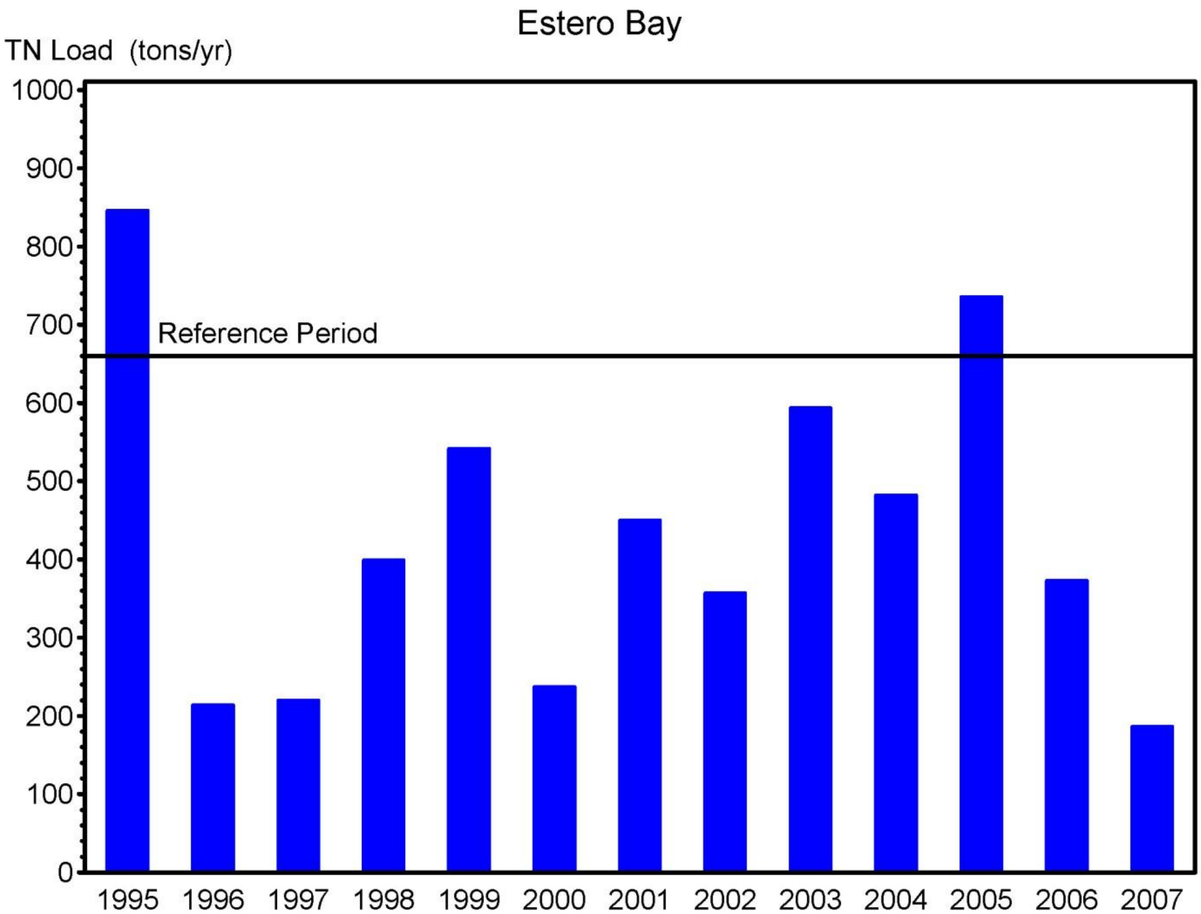



**Figure 9. Comparison of the potential TN criteria to observed TN loads in Estero Bay.**