

An aerial photograph of Charlotte Harbor and Estero Bay, showing the intricate waterways and surrounding green land. The water is a deep blue, while the land is a vibrant green. The text is overlaid on the right side of the image.

**CHARLOTTE HARBOR & ESTERO BAY
AQUATIC PRESERVES
WATER QUALITY STATUS & TRENDS FOR 1998-2005**

Final Report

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September 11, 2007

CHAPs Technical Report #2

**Charlotte Harbor Estuaries
Volunteer Water Quality Monitoring Network
7 Year Results**



Charlotte Harbor & Estero Bay Aquatic Preserves Water Quality Status & Trends for 1998 - 2005

Charlotte Harbor Estuaries Volunteer Water Quality Monitoring Network 7 Year Results

Final Report September 11, 2007

**Florida Department of Environmental Protection
Charlotte Harbor Aquatic Preserves Office
Punta Gorda, FL**

**In Cooperation with:
Charlotte Harbor National Estuary Program
Estero Bay Aquatic Preserves
Charlotte Harbor Environmental Center**

**Report Prepared by:
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The Charlotte Harbor National Estuary Program 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 4,400 square mile study area. Many of these partners also financially support the Program, which, in turn, affords the Program opportunities to fund projects such as this. The entities that have financially supported the Program include the following:

U.S. Environmental Protection Agency
Southwest Florida Water Management District
South Florida Water Management District
Florida Department of Environmental Protection
Florida Coastal Zone Management Program
Peace River/Manasota Regional Water Supply Authority
Polk, Sarasota, Manatee, Lee, Charlotte, DeSoto, and Hardee Counties
Cities of Sanibel, Cape Coral, Fort Myers, Punta Gorda, North Port, Venice,
Fort Myers Beach, and Winter Haven
and the Southwest Florida Regional Planning Council.

Charlotte Harbor Estuaries Volunteer Water Quality Monitoring Network Partners

Supporting Partners

Charlotte Harbor & Estero Bay Aquatic Preserves - Program Support
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Charlotte Harbor National Estuary Program - Grant & Technical Support
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Stephanie Erickson/Estero Bay Aquatic Preserves - Estero Bay

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Terry Frohm, FDEP
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Special Thanks

Betty Staugler, Charlotte County Sea Grant - Program Support
Katie Fuhr, City of Naples Natural Resources - Program Support

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Executive Summary

This report presents water quality status and trends from the Charlotte Harbor Estuaries Volunteer Water Quality Monitoring Network (CHEVWQMN) from 1998 through 2005 across the five Charlotte Harbor Aquatic Preserves (CHAPs) and the Estero Bay Aquatic Preserve (EBAP). Eleven water quality parameters were measured across forty eight sites grouped into nine estuary regions characterized by homogenous hydrologic conditions. These water quality parameters reflect and affect the health and sustainability of the Charlotte Harbor estuaries.

The Charlotte Harbor estuaries region extends from Venice south to Bonita Springs, encompassing 708 km² (175,000 acres) of productive submerged habitats. The six designated Florida Aquatic Preserves in the region include: Lemon Bay, Gasparilla Sound/Charlotte Harbor, Cape Haze, Pine Island Sound, Matlacha Pass and Estero Bay. These Aquatic Preserves are managed by the Florida Department of Environmental Protection (FDEP), CHAPs, and EBAP offices in Punta Gorda and Fort Myers Beach, respectively.

The CHEVWQMN was established in 1996 and is a partnership of the FDEP CHAPs, EBAP and South District Laboratory, Charlotte Harbor Environmental Center (CHEC), and the Charlotte Harbor National Estuary Program (CHNEP). The goal of the CHEVWQMN is to obtain consistent, technically sound, monthly water quality data from defined sites in the Aquatic Preserves and to direct resource management activities towards the most critical parameters, locations and trends. The water quality parameters evaluated include: dissolved oxygen, water clarity, salinity, nutrients, chlorophyll a, and fecal coliform bacteria.

To characterize water quality as it relates to estuarine health, CHEVWQMN results were compared both within the region and to other estuaries across the state of Florida. Additional comparisons were made to numerical criteria to aid in the interpretation of water quality results. A seasonal, nonparametric trend test was used to detect trends in water quality from 1998 through 2005 for each estuary region. Analyses of the relationships among selected water quality parameters were conducted to aid in the understanding of water quality conditions and trends across the region. Summaries of status and trend results for each parameter and estuary region are presented.

Across the Charlotte Harbor and Estero Bay Aquatic Preserves, CHEVWQMN results indicated generally average conditions compared to other Florida estuaries, although results varied seasonally, spatially and over time. Dissolved oxygen was typically lower than average compared to Florida's estuaries, with frequent exceedances below Florida Surface Water Criteria of 4.0 and 5.0 mg/L. However, these criteria are currently under evaluation in order to take into account shallow estuarine water bodies with naturally low dissolved oxygen. Chlorophyll a median values were average to lower than average compared to Florida estuaries. However, annual means above the 11 µg/L Florida Impaired Waters Rule were observed at sites in Lemon Bay, Upper Charlotte Harbor and Pine Island Sound. Salinity median values were lowest in Upper Charlotte Harbor, Matlacha Pass and Upper Lemon Bay, indicating the strongest freshwater influences in the region. Upper Lemon Bay and Upper Charlotte Harbor also had the highest nutrient and bacteria concentrations within the region. Significant decreasing trends in salinity, turbidity, total Kjeldahl nitrogen and an increasing trend in

Executive Summary, *cont.*

color were observed in many estuaries from 1998 through 2005. Significant relationships among light-limiting factors and water clarity, nutrients and phytoplankton, were also observed, although results varied across the nine estuary regions.

Status and trends results presented in this report convey the spatial and temporal variability of water quality conditions across the Charlotte Harbor and Estero Bay Aquatic Preserves. CHEVWQMN results are used to characterize the relationships between water quality parameters and factors affecting estuarine health, including changes in freshwater inflows and influences from watershed land uses. The primary use of the dataset is to set resource management goals for the six Aquatic Preserves in order to preserve the health and sustainability of the system. The CHEVWQMN is a critical and cost effective program for understanding long term water quality trends and their causes within the region. Having a large volunteer program has the added benefit of promoting citizen support for the Aquatic Preserves resource management activities.

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Appendix B: Water Quality Comparisons

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Appendix D: Water Quality Relationships

Appendix E: Rainfall Relationships

List of Acronyms

AMO: Atlantic Multidecadal Oscillation
APHA: American Public Health Association
CAMA: Coastal and Aquatic Managed Areas
CCHMN: Coastal Charlotte Harbor Monitoring Network
CFU: colony forming unit
CHAPs: Charlotte Harbor Aquatic Preserves
CHEC: Charlotte Harbor Environmental Center
CHEVWQMN: Charlotte Harbor Estuaries Volunteer Water Quality Monitoring Network
CHNEP: Charlotte Harbor National Estuary Program
DO: Dissolved Oxygen
EBAP: Estero Bay Aquatic Preserve
ENSO: El Nino-Southern Oscillation
FAC: Florida Administrative Code
FDEP: Florida Department of Environmental Protection
FGCU: Florida Gulf Coast University
FWC: Florida Fish and Wildlife Conservation Commission
FWS: Fish and Wildlife Service
MDL: Minimum Detection Level
NELAC: National Environmental Laboratory Accreditation Conference
NOAA: National Oceanographic and Atmospheric Administration
NOX: Nitrate plus nitrite
NTU: Nephelometric units
PCU: platinum cobalt units
ppm: parts per million
ppt: parts per thousand
SFWMD: South Florida Water Management District
SPSS: Statistical Package for Social Sciences
STORET: Storage and Retrieval database
SWFWMD: Southwest Florida Water Management District
TMDL: Total Maximum Daily Load
TN: Total Nitrogen
TKN: Total Kjeldahl nitrogen
TP: Total Phosphorus
USACE: United States Army Corps of Engineers
USEPA: United States Environmental Protection Agency
USGS: United States Geological Survey

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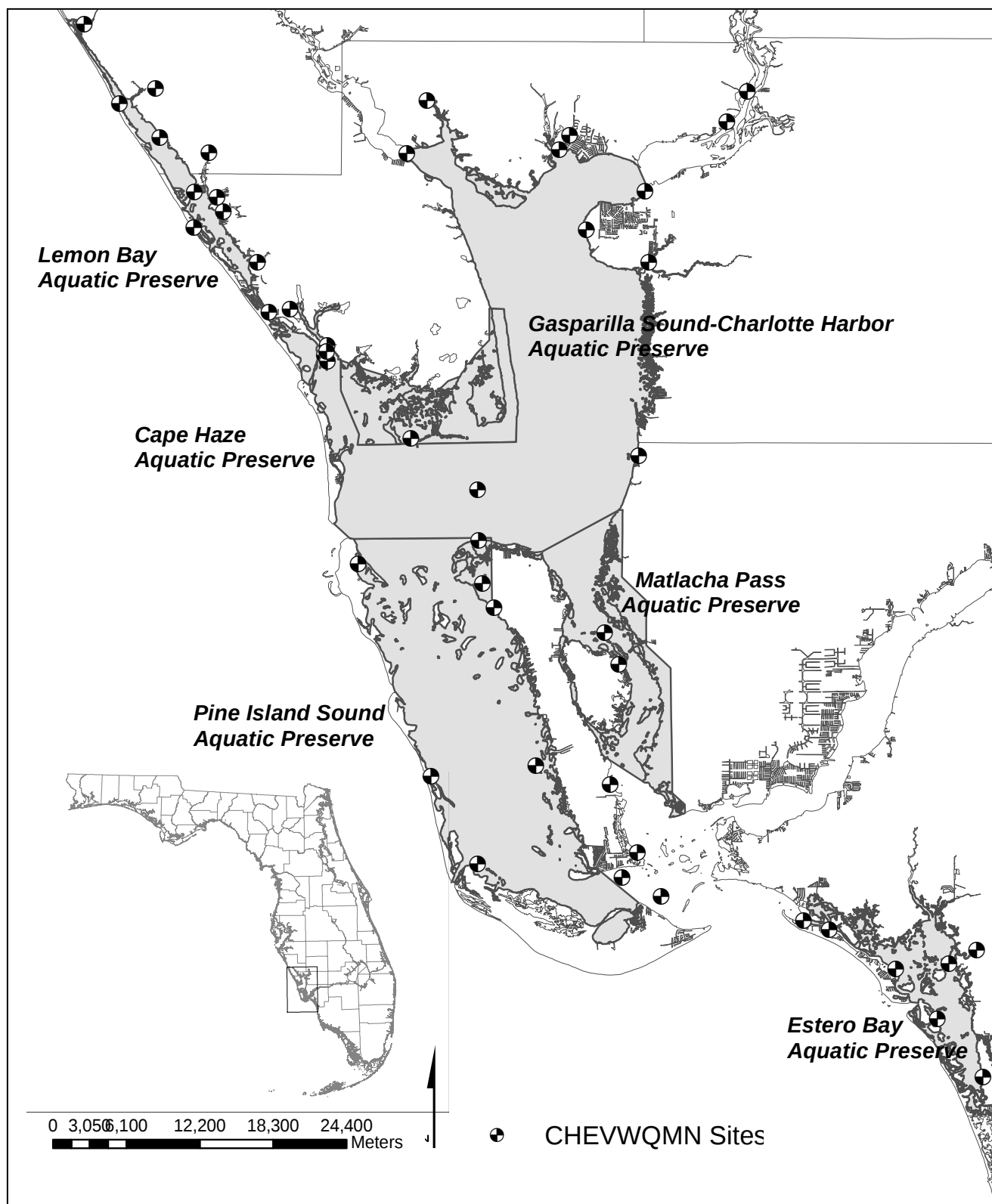


Figure 1.1: CHEVWQMN sites and Aquatic Preserves of the Charlotte Harbor region.

Charlotte Harbor & Estero Bay Aquatic Preserves

Water Quality Status & Trends for 1998 - 2005

I. Introduction

The purpose of this report is to describe water quality conditions throughout the Charlotte Harbor estuaries region of southwest Florida. The Charlotte Harbor region includes six Florida Aquatic Preserves crossing eight interconnected estuary regions. Water quality data used in the analyses were collected by the Charlotte Harbor Estuaries Volunteer Water Quality Monitoring Network (CHEVWQMN) from 1998 through 2005.

The Charlotte Harbor estuaries region extends from Venice south to Bonita Springs, encompassing over 700 km² (~175,000 acres) of diverse, productive submerged habitats (Fig. 1.1). North to south, the six designated Florida Aquatic Preserves include: Lemon Bay, Gasparilla Sound/Charlotte Harbor, Cape Haze, Pine Island Sound, Matlacha Pass and Estero Bay.

The legislative mission of the Aquatic Preserve Program is to preserve Florida's exceptional submerged resources in their natural condition for future generations to enjoy. The primary activities of the Aquatic Preserve Program are resource monitoring, resource management in the estuaries and watershed, and public education and outreach. The Aquatic Preserve Program is administered through the Florida Department of Environmental Protection (FDEP), Office of Coastal and Aquatic Managed Areas (CAMA). The local Aquatic Preserve offices include the Charlotte Harbor Aquatic Preserves (CHAPs) and the Estero Bay Aquatic Preserve (EBAP).

The CHEVWQMN conducts water quality monitoring throughout the region each month. The CHEVWQMN was established in 1996 as a partnership of the FDEP, CHAPs, the Charlotte Harbor Environmental Center (CHEC), and local citizens. Since 1998, The Charlotte Harbor National Estuary Program (CHNEP), EBAP, and FDEP South District Laboratory have been active partners in supporting the CHEVWQMN. The monitoring program is administered through the CHAPs office in Punta Gorda, Florida.

The primary goal of the CHEVWQMN is to provide consistent, technically sound water quality data throughout the six Charlotte Harbor and Estero Bay Aquatic Preserves each month within a synoptic time period. These water quality data are used to guide effective estuary resource management by identifying the most critical water quality parameters, locations and trends within and throughout the region. The most critical water quality parameters are those that directly affect and reflect estuarine health, including: dissolved oxygen, water clarity, salinity, nutrients, chlorophyll a, and fecal coliform bacteria.

This report summarizes 1998 - 2005 water quality data throughout the Charlotte Harbor region and relates the findings to the general health of the individual estuaries. The analyses display water quality relationships both spatially and temporally as a means of highlighting regions and parameters of concern. The report comprises descriptions of the Charlotte Harbor estuaries regions (Section II), the CHEVWQMN

(Section III), and the methods used (Section IV). The eight-year trends for each parameter are given in Section V, followed by relationships between the parameters in Section VI. Summaries of water quality and management considerations for each estuary are given in Section VII, followed by conclusions in Section VIII. Detailed tables of data analysis results are given in the appendices.

Aquatic Preserves & Watersheds of the Charlotte Harbor Region

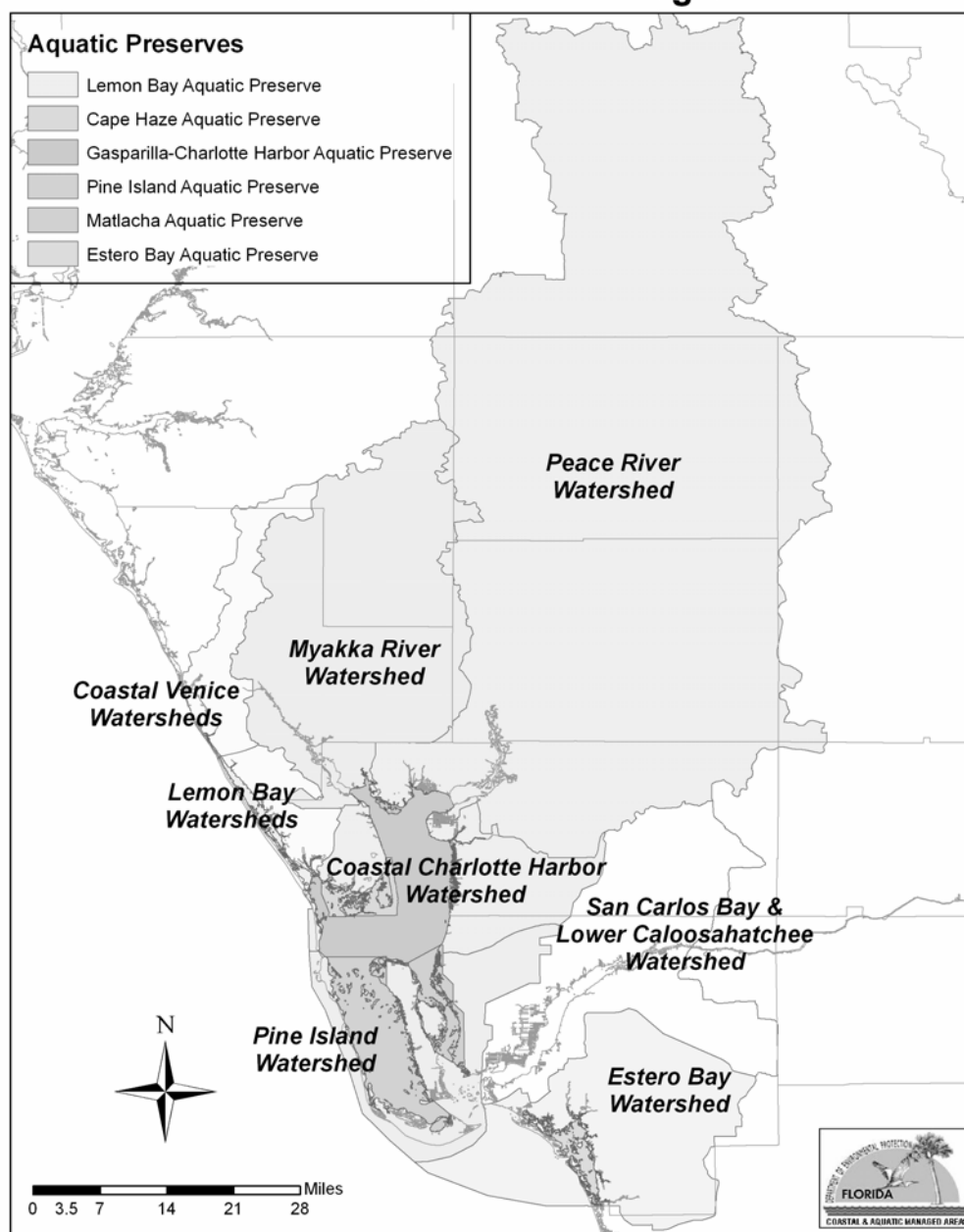


Figure 2.1: Aquatic Preserves & watersheds for the Charlotte Harbor region.

II. Description of the Charlotte Harbor Estuaries Region

The Charlotte Harbor estuaries region (Figure 1.1), located in southwest Florida, is large, productive, complex and diverse. The Charlotte Harbor estuaries extend from Venice south to Bonita Springs, cross many political boundaries and encompass over 700 km² (~175,000 acres) of exceptional coastal and estuarine habitats. The greater Charlotte Harbor watershed is almost 10,000 km² (~4,000 mi²) in size, ranking among the largest watersheds in Florida. The watershed, as defined by CHNEP, extends from the headwaters of the Peace River north of Bartow, Florida and the Franklin Locks on the Caloosahatchee River downstream to the Charlotte Harbor estuaries (Figure 2.1).

The Charlotte Harbor estuaries are located within the boundaries of many government agencies, research and educational institutions, non profit organizations and citizen groups. The estuaries cover parts of three counties, including Sarasota, Charlotte and Lee counties, as well as eight communities, including Englewood, Punta Gorda, Cape Coral, Fort Myers, Sanibel and Bonita Springs. The estuaries also include two Florida Department of Environmental Protection Districts (South and Southwest) and two Water Management Districts (South [SFWMD] and Southwest [SWFWMD]). There are six Florida Aquatic Preserves designated within the region: Lemon Bay, Gasparilla Sound/Charlotte Harbor, Cape Haze, Pine Island Sound, Matlacha Pass and Estero Bay. Additionally, the region is also part of the CHNEP and the National Wildlife Refuge System (Figure 1.1 and Table 2.1).

Table 2.1: Florida Aquatic Preserves within the Charlotte Harbor Estuaries Region

Estuary Management Program	Date Designated	Estuary Location (counties)	Estuary Area Managed (Acres)
Lemon Bay Aquatic Preserve	1986	Sarasota, Charlotte	7,667
Gasparilla Sound/Charlotte Harbor Aquatic Preserve	1975	Charlotte, Lee	79,168
Cape Haze Aquatic Preserve	1978	Charlotte	11,284
Pine Island Sound Aquatic Preserve	1970	Lee	54,176
Matlacha Pass Aquatic Preserve	1972	Lee	12,511
Estero Bay Aquatic Preserve.	1966	Lee	9,834
Charlotte Harbor National Estuary Program	1995	Sarasota, Charlotte, Lee	173,000

To ensure the long term sustainability of the estuary resources and water quality, the Charlotte Harbor estuaries are cooperatively managed by a number of regional governmental and natural resource agencies. A strong partnership of organizations is critical to the long term management and sustainability of the natural resources and water quality of the Charlotte Harbor estuaries. These partners include county agencies (Lee, Charlotte, Hardee, DeSoto, Manatee and Sarasota), federal agencies (CHNEP, United States Environmental Protection Agency [USEPA], United States Geological Survey [USGS], Fish and Wildlife Service [FWS], National Oceanographic and Atmospheric Administration [NOAA], United States Army Corps of Engineers [USACE]), and state agencies (FDEP, Florida Fish and Wildlife Conservation Commission [FWC], SFWMD, SWFWMD), along with research institutions such as Mote Marine Laboratory, educational institutions, such as Florida Gulf Coast University (FGCU), and non-profit organizations, such as the CHEC. These partnerships support the long term water

quality monitoring of the CHEVWQMN. The CHEVWQMN is managed by the FDEP Charlotte Harbor Aquatic Preserve office in Punta Gorda, Florida.

The Charlotte Harbor region (Figure 1.1) includes eight interconnected estuaries, including (from north to south): Lemon Bay, Gasparilla Sound, Cape Haze, Charlotte Harbor, Pine Island Sound, Matlacha Pass, San Carlos Bay and Estero Bay. These estuaries are separated from the Gulf of Mexico by a chain of ten barrier islands from Manasota Key south to Little Hickory Island. Gulf of Mexico waters enter the estuarine complex through nine passes, from Stump Pass south to Big Hickory Pass. Estuary waters mix with freshwater inflows from three major rivers - Myakka, Peace and Caloosahatchee Rivers. In addition to the larger rivers, there are over 15 smaller tributaries from Alligator Creek in northern Lemon Bay, to the Imperial River in southern Estero Bay. The water exchange between these passes and tributaries creates a large variation in salinity and water quality conditions around the region by season and year. The unique physical and hydrological characteristics of each of these estuaries help sustain the complex habitats found throughout the region.

Many of the diverse submerged habitats of the Charlotte Harbor estuaries region include mangroves, salt marshes, tidal flats, seagrasses, and unvegetated submerged areas. The complex habitats support a vast food web, including invertebrates, shellfish, finfish, sharks, reptiles, birds and aquatic mammals. Endangered and threatened species also depend on the local estuary for food and shelter. The fragile balance between estuarine habitat and the health of these species depends largely on the water quality and factors affecting estuarine water conditions, including human uses of the system and watershed influences.

Humans interact with and influence the health of these coastal and estuarine habitats. Daily human interactions with estuarine species are important both commercially and recreationally. Commercial harvests of shrimp, clams, food fish and baitfish contribute significantly to the local economy. In 2004, nearly 4500 metric tons (~10 million lbs) of fish and shellfish were taken from the watershed (BEBR 2005). In addition, recreational fishing, boating, kayaking and nature watching are valuable pastimes that depend on the health of the estuary and its water quality. In 1993, 1.6 million tourists visited the three counties located along the estuary (Sarasota, Charlotte, and Lee) and spent more than \$1.1 billion dollars (Martin *et al* 1996).

Along with recreational and commercial uses of the estuary, water quality and quantity within the Charlotte Harbor estuaries depend on land uses and activities within the adjacent watersheds. The severity of the impacts of land use on water quality depends on both the intensity of the use as well as its proximity to surface water. Land uses in the Charlotte Harbor watershed include: rangeland, agriculture, mining, residential, commercial and industrial. The type and degree of land use and distance to the estuary vary for each sub-basin of the greater Charlotte Harbor watershed - from residential use near the small tributaries adjacent to Lemon and Estero Bays, to phosphate mining miles up the Peace River, to agricultural use in the upper watersheds. The watershed and rainfall/runoff conditions throughout the region strongly influence the downstream biological conditions of each estuary.

III. Description of Charlotte Harbor Estuaries Volunteer Water Quality Monitoring Network

The CHEVWQMN is a region-wide, fixed station, monthly water quality monitoring program. The CHEVWQMN is a partnership of the CHAPs, EBAP, CHEC, CHNEP, and local citizens.

The monitoring program was initiated in 1996 in response to aquatic preserve managers' needs for baseline resource information and citizens' concerns for the health of local estuaries. Originally, CHEC received a grant from the SWFWMD to start sampling ten sites in northern Charlotte Harbor for ten field parameters. In 1997 and subsequent years, the CHAPs received additional grants from the CHNEP to expand and maintain the monitoring program region-wide and increase the number of parameters to include laboratory analyses.

The primary purpose of the CHEVWQMN is to collect consistent, technically sound water quality data throughout the Charlotte Harbor estuaries region. Prior to the development of the CHEVWQMN, much of the water quality monitoring within the Charlotte Harbor region was limited to programs that occurred infrequently, were short-term or covered only partial areas of the estuaries. Data resulting from these historical monitoring programs were challenging to integrate, analyze and use to identify critical resource concerns.

The CHEVWQMN was designed to characterize baseline water quality conditions throughout the region. The original design was developed by the CHAPs, with assistance from CHEC, the Three Creek Watch citizen group in Lemon Bay and the USEPA. The details of CHEVWQMN methods are described in the Comprehensive Quality Assurance Project Plan for the CHEVWQMN (FDEP, 1997) and summarized in Section IV of this report. The project plan was approved by the FDEP, CHNEP and USEPA.

The six specific objectives of the CHEVWQMN are:

- Describe baseline water quality conditions throughout the six aquatic preserves
- Identify the most critical, regional water quality locations, parameters and trends relative to estuarine health, fish and wildlife habitat, and human health
- Complement other CHAP seagrass and regional water quality monitoring program results to define aquatic preserve resource management needs
- Enhance community understanding and stewardship of the aquatic preserves
- Improve aquatic preserves managers' understanding of community concerns regarding local estuaries
- Encourage the development of a partnership of agencies to conduct uniform water monitoring throughout the region.

To accomplish these objectives, the CHEVWQMN program follows a rigorous monitoring design. The sampling frequency provides a monthly synoptic snap-shot of water quality. CHEVWQMN citizen and agency water monitors are highly trained in the classroom and field, have standard sampling equipment and are generally assigned to work in pairs at a specific site. In addition, water monitors are required to attend region-wide quality assurance sampling practice sessions twice a year to receive updated supplies and equipment, validate techniques, and correct any problems that are identified. Each water monitor contributes over 35 hours a year, plus automobile and

boat gasoline to the success of the CHEVWQMN. Without their support, this long-term, region-wide, water quality data would not be available to guide estuary resource management in the Charlotte Harbor estuaries.

Management and analysis of the CHEVWQMN data is conducted using Microsoft Access and Excel and Statistical Package for Social Sciences (SPSS) following specific data management criteria. The data are also entered into the federal water quality database (Storage and Retrieval database [STORET]) to allow access by other scientists and resource managers.

The on-going CHEVWQMN also provides baseline water quality data to other agencies, partners and citizen groups who request them. To date, the CHEVWQMN results have been used within the region to:

- Identify Florida's impaired waters
- Determine water quality and seagrass relationships
- Establish resource based water quality targets
- Establish resource management priorities and goals
- Encourage and evaluate effectiveness of adaptive management practices;
- Describe water quality conditions to the public
- Evaluate the effects of biological and physical events, such as hurricanes and algal blooms, on estuary conditions
- Allow citizens and agency staff to assess potential adverse resource impacts from proposed development projects

It is intended that the CHEVWQMN analyses of the data will be used to determine resource management objectives for each of the six Charlotte Harbor and Estero Bay Aquatic Preserves.

IV. Methods Used by the CHEVWQMN

A. Introduction

To provide consistent, technically sound water quality data, the CHEVWQMN follows rigorous monitoring protocols. The quality assurance, field and laboratory methods are described in detail in the Comprehensive Quality Assurance Project Plan for the CHEVWQMN (FDEP 1997, Updated 1999) and summarized here. The Quality Assurance Project Plan was approved by the FDEP, CHNEP and the USEPA. In addition, the stringent data preparation and analysis guidelines used by the CHEVWQMN to evaluate data results are also described below. These strong project management methods link the scientific and citizen monitoring communities by assuring the accuracy and precision of the data so they can be used confidently by resource managers and scientists. The approved methods also allow the CHEVWQMN data to be used to determine Florida Impaired Waters and to be entered into the federal STORET water quality data base, making them accessible nationwide.

B. Sampling Design

Monthly sampling was made at 48 fixed sites that are widely distributed throughout the Charlotte Harbor estuaries region (Figure 4.1 and Table 4.1). The sites were chosen to represent general water quality conditions throughout the region, as well as to be accessible in a safe and timely manner for samples to be collected and transported to the laboratory within holding times. The sampling locations emphasize shallower, near shore coastal areas, with limited sampling in the deeper, open water portions of Charlotte Harbor. A result of this sampling bias of shallower waters is that water clarity values cannot be determined for shallow sites and times when clarity exceeds water depth.

At each site, during the monthly sampling time, surface water samples are collected and field measurements are made for ten physical and chemical parameters: wind speed and direction, wave height, tide stage, water depth, Secchi depth, water temperature, pH, dissolved oxygen and salinity. Water samples are collected for seven additional laboratory parameters: chlorophyll *a*, turbidity, color, total phosphorus, total Kjeldahl nitrogen, nitrate/nitrite, and fecal coliform bacteria. These are key water quality parameters needed to determine overall estuary health as it relates to seagrass, fish and wildlife needs. For quality assurance purposes, duplicate and blank laboratory parameters are collected each month at 10% of the sampling sites. Additional quality assurance measures are detailed in the next section.

To assist with interpreting the results and identifying resource conditions for each estuary, sampling sites were grouped into nine estuary regions with similar hydrologic conditions (Table 4.2). These nine regions are based on 13 hydrologic regions (strata) established by the CHNEP for the interagency Coastal Charlotte Harbor Monitoring Network (CCHMN). Four strata (Tidal Myakka River, Tidal Peace River, West Wall of Charlotte Harbor and East Wall of Charlotte Harbor), as defined by CCHMN, were grouped into the Upper Charlotte Harbor region for this study. The CCHMN strata were

designed to describe relatively homogeneous hydrologic regions based on the best available information and professional judgment of scientists throughout the Charlotte Harbor estuaries. Grouping the CHEVWQMN sites into the hydrologic strata allows the data to be compared to the CCHMN open water sampling results, the CHAPs seagrass monitoring results and to determine estuary specific resource management concerns and solutions.

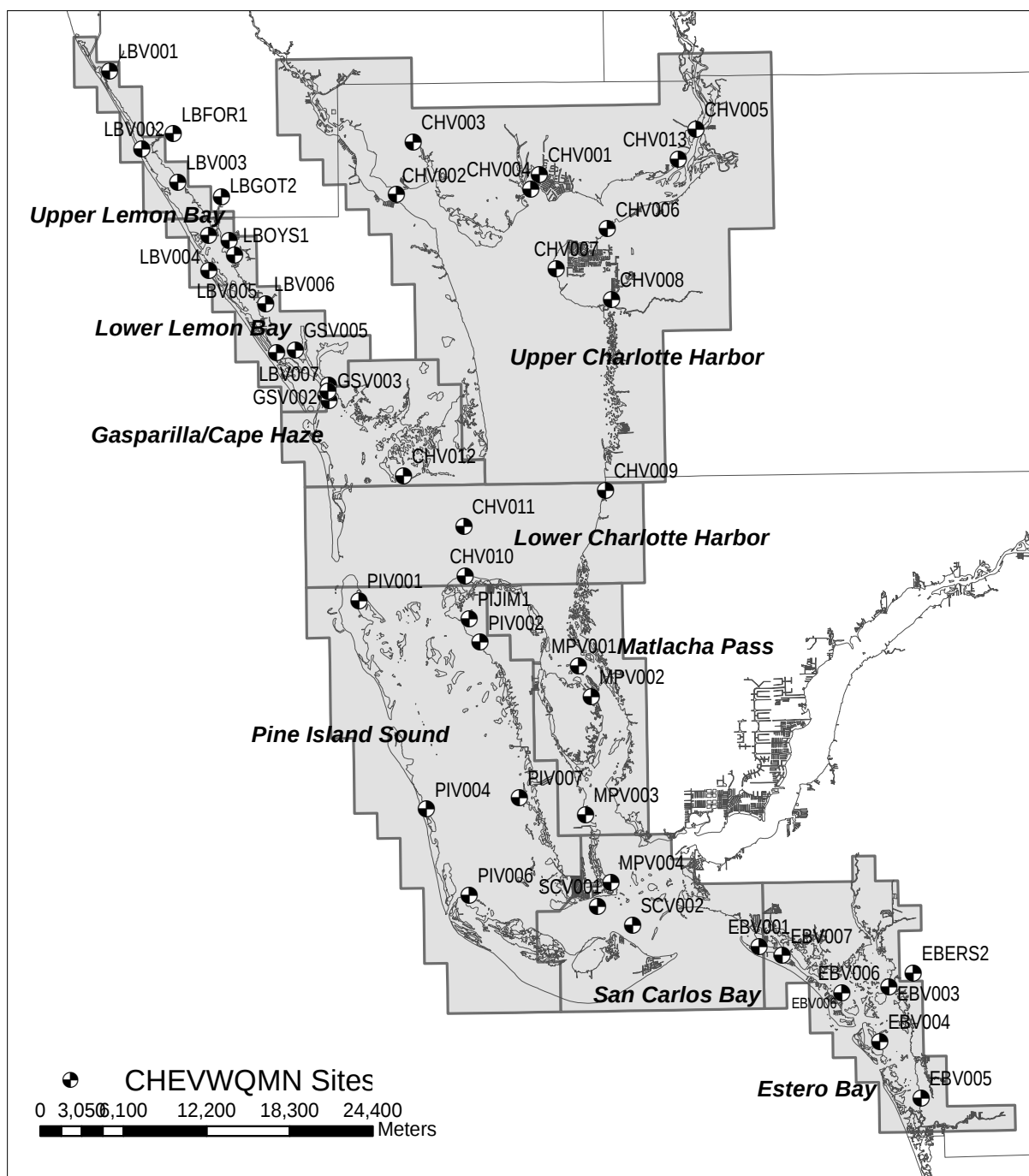


Figure 4.1: CHEVWQMN site map and estuary region delineation

Table 4.1: CHEVWQMN site description and estuary region delineation

Estuary Region	CHEVWQMN Site	Station Name	Start Date	CCHMN Strata	Aquatic Preserve	# of Sites
Upper Lemon Bay	LBFOR1	Forked Creek	Apr-00	Outside Strata	Lemon Bay	5
	LBGOT2	Gottfried Creek	Nov-98	Outside Strata	Lemon Bay	
	LBV001	Alligator Creek	Jul-98	Upper Lemon Bay	Lemon Bay	
	LBV002	Lemon Bay	Jul-98	Upper Lemon Bay	Lemon Bay	
	LBV003	Lemon Bay	Jul-98	Upper Lemon Bay	Lemon Bay	
Lower Lemon Bay	GSV002	Gasparilla Sound	Nov-97	Lower Lemon Bay	Lemon Bay	7
	LBANG1	Ainger Creek	Sep-99	Lower Lemon Bay	Lemon Bay	
	LBOYS1	Oyster Creek	Feb-99	Lower Lemon Bay	Lemon Bay	
	LBV004	Lemon Bay	Jul-98	Lower Lemon Bay	Lemon Bay	
	LBV005	Ski Alley	Jul-98	Lower Lemon Bay	Lemon Bay	
	LBV006	Buck Creek	Jan-99	Lower Lemon Bay	Lemon Bay	
	LBV007	Lemon Bay	Sep-99	Lower Lemon Bay	Lemon Bay	
Upper Charlotte Harbor	CHV001	Sunrise Waterway	Nov-96	Tidal Peace	Gasp. Sound/Charlotte Harbor	9
	CHV002	Myakka River	Nov-96	Tidal Myakka	Gasp. Sound/Charlotte Harbor	
	CHV003	Sam Knight Creek	Nov-96	Tidal Myakka	Gasp. Sound/Charlotte Harbor	
	CHV004	Charlotte Harbor	Nov-96	Tidal Peace	Gasp. Sound/Charlotte Harbor	
	CHV005	Peace River	Nov-96	Tidal Peace	Gasp. Sound/Charlotte Harbor	
	CHV006	Charlotte Harbor	Nov-96	Tidal Peace	Gasp. Sound/Charlotte Harbor	
	CHV007	Ponce de Leon Inlet	Nov-96	West Wall	Gasp. Sound/Charlotte Harbor	
	CHV008	Alligator Creek	Nov-96	Outside Strata	Gasp. Sound/Charlotte Harbor	
	CHV013	Peace River	Jul-01	Tidal Peace	Gasp. Sound/Charlotte Harbor	
Lower Charlotte Harbor	CHV009	Burnt Store Entrance	Feb-98	Lower Charlotte Harbor	Gasp. Sound/Charlotte Harbor	3
	CHV010	Charlotte Harbor	Feb-98	Lower Charlotte Harbor	Gasp. Sound/Charlotte Harbor	
	CHV011	Charlotte Harbor	Feb-98	Lower Charlotte Harbor	Gasp. Sound/Charlotte Harbor	
Gasparilla/Cape Haze	CHV012	Bull Bay	Jun-98	Cape Haze	Cape Haze	4
	GSV001	Coral Creek	Nov-97	Cape Haze	Gasp. Sound/Charlotte Harbor	
	GSV003	Gasparilla Sound	Jan-98	Cape Haze	Gasp. Sound/Charlotte Harbor	
	GSV004	Gasparilla Sound	Jul-04	Cape Haze	Gasp. Sound/Charlotte Harbor	
Pine Island Sound	PIJIM1	Big Jim Creek	Jan-01	Pine Island Sound	Pine Island Sound	6
	PIV001	Pelican Bay	Sep-99	Pine Island Sound	Pine Island Sound	
	PIV002	Pine Island Sound	Feb-98	Pine Island Sound	Pine Island Sound	
	PIV004	Redfish Pass	Jan-00	Pine Island Sound	Pine Island Sound	
	PIV006	Pine Island Sound	Feb-98	Pine Island Sound	Pine Island Sound	
	PIV007	Pine Island Sound	Jan-99	Pine Island Sound	Pine Island Sound	
Matlacha Pass	MPV001	Matlacha Pass	Feb-98	Matlacha Pass	Matlacha Pass	3
	MPV002	Matlacha Pass	Feb-98	Matlacha Pass	Matlacha Pass	
	MPV003	Matlacha Pass	Feb-98	Matlacha Pass	Matlacha Pass	
San Carlos Bay	EBV001	Matanzas Pass	Mar-98	San Carlos Bay	Estero Bay	4
	MPV004	Matlacha Pass	Feb-98	San Carlos Bay		
	SCV001	San Carlos Bay	Feb-98	San Carlos Bay		
	SCV002	San Carlos Bay	Feb-98	San Carlos Bay		
Estero Bay	EBERS2	Estero River	Sep-01	Outside Strata	Estero Bay	6
	EBV003	Estero Bay	Jun-98	Estero Bay	Estero Bay	
	EBV004	Estero Bay	Mar-98	Estero Bay	Estero Bay	
	EBV005	Estero Bay	Mar-98	Estero Bay	Estero Bay	
	EBV006	Estero Bay	Feb-00	Estero Bay	Estero Bay	
	EBV007	Estero Bay	Sep-01	Estero Bay	Estero Bay	
None	GSV005	Coral Creek	Jun-98	Lower Lemon Bay	Lemon Bay	1

C. Quality Assurance Methods

Consistent with the CHEVWQMN Quality Assurance Project Plan, extensive measures are taken to ensure the precision and accuracy of the CHEVWQMN data by guiding field sample collection, laboratory analyses and data management. Specific quality assurance procedures include:

- Classroom and field training are provided for each water monitor
- Quality assurance practice sessions are required for all monitors
- Uniform sampling equipment and up-to-date supplies are used at all sites
- Sampling is conducted synoptically for all sites within one hour of sunrise on first Monday of each month
- Specific water monitors and equipment are assigned to each site
- Written field procedures and data sheets are used by all water monitors
- Duplicate dissolved oxygen tests are conducted at each site each month
- Duplicate and blank field samples are collected for laboratory analyzed parameters at 10% of sites each month
- Samples are transported to the laboratory within maximum sample holding times
- Chain-of-custody procedures are used to track samples
- Laboratory analyses are conducted by FDEP and National Environmental Laboratory Accreditation Conference (NELAC) certified laboratories. Beginning in 2003, FDEP required NELAC certification and laboratories were given 18 months to comply. Prior to that date laboratory analyses were conducted following APHA Standard Methods which became the basis for NELAC protocols.
- Replicate and blank laboratory analyses are conducted on 10% of samples each month
- Data are reviewed by water monitors and staff for transcription errors

D. Field Methods

In compliance with the Quality Assurance Project Plan, written field procedures are followed by the water monitors. The procedures are described in detail in the CHEVWQMN Field Methods Manual (1998, updated 2005) and summarized in Table 4.3. During monthly sampling, field measurements are made for ten parameters and water samples are collected for laboratory analyses of seven additional analytes from each of the 48 sites. CHEVWQMN field procedures used during monthly sampling events include:

- Site specific equipment (cleaned according to instructions), updated supplies and the CHEVWQMN field methods manual and data sheet are used
- Monitoring activities are started within one hour of sunrise
- Sampling start, stop and sunrise times are recorded on the data sheet
- Surface water "grab" samples are collected in clean, site specific sampling buckets
- No bottom water samples are collected and no water column depth profiles are conducted
- Weather and water conditions are recorded on the data sheet: wind speed and direction, cloud cover, wave height, and tide stage
- Six physical and chemical parameters measured are in situ, including: water depth, water clarity (0.2 m Secchi and calibrated line), temperature (calibrated thermometer), pH (colorimetric test kit), dissolved oxygen (Winkler titration test kit) and salinity (based on specific gravity using a hydrometer)
- Surface water samples are collected in clean sample bottles (pre-acidified as needed) for laboratory analysis of seven parameters, including: color, turbidity and chlorophyll a (brown polyethylene bottle), total phosphorus, total Kjeldahl nitrogen and nitrate plus nitrite (white Nalgene 500 ml bottle), and fecal coliform bacteria (sterile whirl pack)
- Water samples are stored on ice and transported to the laboratory within the maximum holding times

Table 4.2: Field Method Summary

	Depth (m)	Secchi depth (m)	Temperature (deg C)	DO (mg/l)	pH	Salinity (ppt)
		Secchi disk (LaMotte #0171)				
		0.20 m disc calibrated at 0.10 m	Armored thermometer (LaMotte #1066)	Winkler Titration Test Kit (LaMotte #7414)	Colorimetric test kit CresolRed (LaMotte #2111)	HACH #2234-00, Hydrometer (LaMotte #30025)
Method	weighted line	intervals				
		value missing when Secchi depth was equal to or greater than total depth	immediate sample	average of two determinations	immediate sample	determined by temperature and specific gravity
Comments						

E. Laboratory Methods

Water samples collected by CHEVWQMN monitors require laboratory analysis for seven parameters using methods described in the Quality Assurance Project Plan and summarized in Table 4.3. All laboratories utilized by the CHEVWQMN are NELAC and state certified, except as noted in Section IV Part C, and use the following procedures to conduct the monthly analyses:

- Duplicate and blank samples for laboratory parameters are collected in the field for 10% of the sites and analyzed in the laboratory.
- Additional replicate and blank laboratory analyses are conducted for 10% of the samples.
- Apparent color is measured in platinum cobalt units (PCU) and determined by visual comparison without filtration using the platinum cobalt method (APHA 2120B and USEPA 110.2).
- Turbidity is measured in Nephelometric units (NTU) using the Nephelometric method and is estimated by comparing the amount of light scattered through the sample to a reference standard under the same conditions (APHA 2130 B and USEPA 180.1).
- Chlorophyll *a* is measured in ug/l and determined spectrophotometrically without pheophytin correction (APHA SM10200 H). Due to time and funding constraints, chlorophyll *a* analyses were not conducted from December 2001 through December 2002.
- Total phosphorus samples are preserved with acid in the field, then measured in mg/l as the combination of orthophosphate, condensed phosphates and organically bound phosphates (USEPA 365.4 and APHA 4500 P-E).
- Total Kjeldahl nitrogen samples are preserved with acid in the field, then measured in mg/l as the sum of organic nitrogen and ammonia (USEPA 351.2 and APHA 4500-N_{org} B).
- Nitrate and nitrite samples are preserved in the field with acid, then measured collectively in mg/l (USEPA 353.2 and APHA 4500-NO₃ B).
- Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate plus nitrite values.
- Fecal coliform bacteria value is measured as colony forming units (cfu) per 100 ml and derived from counts of colony forming units per 100 ml aliquot incubated for 24 hours in an elevated temperature environment (APHA 9222 D).

Table 4.3: Laboratory Analysis Summary

	11/98-9/01		11/01-12/02		2/02-12/03		1/04-12/05	
	Lab*	Method	Lab*	Method	Lab*	Method	Lab*	Method
Total Kjeldahl Nitrogen (ppm)	DEP South ¹	USEPA 351.2	Cape Coral ²	APHA 4500-NOR(B)	Tri-Tech ³	USEPA 351.2	Dep Central ⁴	USEPA 351.2
Nitrate plus Nitrite (ppm)	DEP South ¹	USEPA 353.2	Cape Coral ²	APHA 4500-NO3(B)	Tri-Tech ³	USEPA 353.2	Dep Central ⁴	USEPA 353.2
Phosphorus (ppm)	DEP South ¹	USEPA 365.4	Cape Coral ²	APHA 4500 P-E	Tri-Tech ³	USEPA 365.4	Dep Central ⁴	USEPA 365.4
Chlorophyll a (µg/l)	DEP South ¹	APHA 10-2000-H	Cape Coral ²	APHA 10-2000-H	Tri-Tech ³	APHA 10-2000-H	DEP South ¹	APHA 10-2000-
Fecal Coliform (cfu/100ml)	DEP South ¹	APHA 9222 D	Cape Coral ²	APHA 9222 D	Tri-Tech ³	APHA 9222 D	DEP South ¹	APHA 9222 D
Turbidity(NTU)	DEP South ¹	USEPA 180.1	Cape Coral ²	APHA 2130 B	Tri-Tech ³	USEPA 180.1	DEP South ¹	USEPA 180.1
Color (PCU)	DEP South ¹	APHA 2120 B	Cape Coral ²	APHA 2120 B	Tri-Tech ³	APHA 2120 B	DEP South ¹	USEPA 110.2

¹Florida Department of Environmental Protection South District Laboratory, 28000 A-10 Airport Road Punta Gorda, FL 33982

²City of Cape Coral Laboratory, 3310 SW 20th Avenue Cape Coral, FL 33914

³Tri-Tech Laboratories, 7240 Old Cheney Hwy Orlando, FL 32807

⁴Florida Department of Environmental Protection Central District Laboratory, 2600 Blair Stone Road Tallahassee, FL 32399

F. Data Preparation and Exploratory Analysis

After field sampling and laboratory analyses have been completed according to quality assurance procedures, CHEVWQMN data are entered into a database. For this report, data were compiled for the eight-year period from 1998 to 2005 and for each designated rainy and dry season. The dry seasons were defined as the months of November through May and the rainy seasons were June through October (Montgomery 2005). Average annual rainfall data were collected for the region using DBHYDRO from SFWMD (2007) and from the USGS Drainage Basin Total Summaries provided by SFWMD (2007). Data preparation and exploratory analyses were conducted to: 1) screen for errors 2) determine the suitability for statistical applications and 3) group sites into estuary regions for further analysis. Data preparation, storage and analysis of results were conducted using SPSS and Microsoft Access and Excel.

Once the compiled dataset was screened for errors and outliers, results were deemed invalid and not used for analysis if they met at least one of two conditions: 1) were outside the minimum and maximum detection limits for laboratory or field methods, 2) were values not possible to occur under natural conditions for each parameter and site. After the data were screened for outliers, accommodations were made for values reported as the minimum detection limits (MDLs) for each parameter. It is recognized that the true values fall somewhere between the MDL and 0. Therefore, to characterize values below laboratory detection limits for nutrients, chlorophyll *a* and turbidity, all values reported as the MDL for these parameters were divided by 2 and the adjusted values were used in these analyses. Similarly, apparent color values reported as the MDL were adjusted to 1 PCU and fecal coliform bacteria MDL values were adjusted to 1 cfu/100 ml. A summary of MDLs for each parameter and laboratory for the study period are included in Table 4.4.

Table 4.4: Summary of values reported as the minimum detection limit (MDL)

Parameter	TKN (ppm)	NOX (ppm)	TP (ppm)	ChlA (µg/l)	Coliform (cfu/100ml)	Turbidity (NTU)	Color (PCU)
Minimum MDL	0.080	0.004	0.004	0.03	1	0.02	1
Maximum MDL	0.500	0.100	0.050	2.00	2	1.40	5

After the dataset was prepared, the distribution of the data was assessed to determine the need to use parametric or nonparametric statistical methods. Visual assessment of histograms and quantitative assessment of skewness were conducted. Similar to patterns found in other typical water quality datasets, multiple sampling levels (by estuary region, season, year etc.) exhibited non-normal distributions. Because the data were not normally distributed and there were large outlying values, nonparametric statistics were used to make comparisons between groups, quantify relationships between variables, and estimate trends. In general, nonparametric tests are less affected by outlying values, normal distribution violations, and minimal censoring of laboratory results.

Following adjustments to the MDLs and evaluation of data distribution, the CHEVWQMN sampling sites were grouped into nine estuary regions for data analysis.

The purpose of grouping the CHEVWQMN sites by estuary region was to facilitate interpretation of the water quality results so that estuary specific resource conditions and management needs could be determined. The nine estuary regions represent areas of relatively uniform hydrologic conditions based upon the 13 hydrologic strata defined by the interagency CCHMN established by the CHNEP. The CCHMN hydrologic strata were developed using the best available information and professional judgment of scientists throughout the Charlotte Harbor estuaries. In Northern Charlotte Harbor, four CCHMN strata (Tidal Myakka River, Tidal Peace River, West Wall of Charlotte Harbor and East Wall of Charlotte Harbor) were grouped together and are referred to in this report as the Upper Charlotte Harbor estuary region. The nine estuary regions used for this report were chosen to most accurately represent spatial relationships between biological and physical parameters and watershed influences for each estuary, as well as reflect resource management jurisdictions for each aquatic preserve.

To characterize homogeneity of site conditions within each estuary region and reinforce estuary region delineations, an exploratory k-means cluster analysis was conducted using SPSS. Sites in the Upper Charlotte Harbor region were grouped to maximize sample size and characterize variability in that region. The nine estuary regions include sites from six aquatic preserves as shown in Table 4.1 and Figure 4.1.

G. Methods Used to Determine Water Quality Status

1. Introduction

The status of water quality parameters across the study region was evaluated to guide interpretation of water quality as it relates to estuary health. Water quality status was evaluated by comparing results between regions within the CHEVWQMN program as well as comparing results to additional estuarine baseline datasets and regulatory criteria. Summary statistics are provided for each estuary region including sample size (N) minimum, maximum, mean, standard error (SE) and median. Standard error is a measure of spread within the data and is the standard deviation divided by the sample size. Estuary medians were also ranked in ascending order to demonstrate the relative relationships between estuaries for a given parameter. Estuary results are compared to water quality classifications as described below and displayed in tables by parameter in the Results section.

2. Comparisons of Water Quality Conditions within the Charlotte Harbor Estuaries

The first method, used to describe regional water quality status based on CHEVWQMN results, quantified the relationship between regions and seasons for each parameter. To estimate differences across all estuary regions within the entire region the Kruskal-Wallis test was used. The Kruskal-Wallis test is a nonparametric one-way between-subjects analysis of variance (ANOVA) which compares differences between two or more groups. To quantify differences between individual estuaries, a post hoc comparison was conducted using the Mann-Whitney U test. The Mann-Whitney U test is a nonparametric version of the between-subjects t-test which compares differences between medians of two groups. The Mann-Whitney U test was also used to detect significant differences between the rainy and dry season for each estuary region. Box plots are provided for a visual analysis of seasonal and regional comparisons. Each box represents the upper and lower quartiles with the median value given within each box. Box plot data tables are provided in the following sections with detailed results included in Appendix B.

3. Comparison of Water Quality Conditions in the Charlotte Harbor Region to Typical Florida Estuaries

As a second guide to interpreting estuary health relative to water quality conditions, CHEVWQMN results were compared to estuaries across the state. To interpret CHEVWQMN results relative to Florida estuaries, results for each estuary and site were compared to baseline water quality conditions for over 20 estuaries around the state. The publication *Typical Water Quality Values for Florida's Lakes, Streams, and Estuaries* (Hand 2004) was chosen as the source of baseline comparison. The publication was chosen because of the large number of samples (over 20,000), consistent sampling period (1990 - 2003), and complete set of parameters. Because of its uniform, continuous and reliable dataset, *Typical Water Quality Values for Florida's Lakes, Streams, and Estuaries* appears to be the most representative source of estuary

conditions across the state. However, it should be emphasized that the data contained within *Typical Water Quality values for Florida's Lakes, Streams, and Estuaries* represent two climactic regions and five biogeographic regions. See Table 4.5 for a brief description of the length of the dataset and sample sizes.

To characterize the water quality in the Charlotte Harbor estuaries, median values for each parameter were compared to percentile distributions compiled from *Typical Water Quality Values for Florida's Lakes, Streams, and Estuaries* (Hand 2004). To facilitate the use of statewide, water quality values for estimating estuary health, the percentile distributions were grouped to represent above average, average and below average estuary health conditions. The percentiles were grouped based on values used in Florida's Trophic State Indices to describe general health categories for Florida's lakes, streams and estuaries. For this report, the following percentile categories were used to interpret CHEVWQMN results: below average = 10 through 30, average = 31 through 69, and above average = 70 and greater. Resulting percentile categories for each estuary are included in tables in the Results section. Site specific results and percentiles are included Appendix A.

Table 4.5: Percentile distributions and sample sizes for 'Typical Florida Estuarine Water Quality' (Hand 2004) used to interpret CHEVWQMN status

		Secchi (m)	Temp (C)	DO (mg/l)	pH	Salinity (ppt)	TN (ppm)	TP (ppm)	Chl a (µg/l)	Coliform (cfu/100ml)	Turbidity (NTU)	Color (PCU)
below average (≤30)	10	0.0875	10.6	4	7.43	6.6	0.19	0.01	1.5	1	0.87	5
	20	0.5	16.38	5.01	7.62	13.7	0.32	0.023	2.7	1	1.4	7
	30	0.7	18.9	5.62	7.75	17.8	0.44	0.048	3.8	1	1.9	10
average (30<, ≥60)	40	0.9	21	6.1	7.83	21.1	0.55	0.069	5	2	2.4	14
	50	1	23	6.5	7.9	23.8	0.67	0.096	6.13	5	3.1	20
	60	1.2	25.1	6.9	8	26.1	0.79	0.12	7.842	8	4.1	25
above average (>60)	70	1.35	27.2	7.31	8.07	28.2	0.93	0.16	10.1	17	5.8	36
	80	1.6	28.8	7.88	8.15	30.5	1.1	0.22	13.4	33	8.9	55
	90	2.1	30	8.67	8.3	32.9	1.39	0.33	20.2	80	15.6	100
# observations		75,987	392,487	321,526	346,718	331,440	20,410	58,587	68,144	168,532	250,890	41,556

4. Comparison to Regulatory Criteria

The third method used to describe the status of Charlotte Harbor water quality conditions compared CHEVWQMN results to available Florida water quality criteria and standards. Florida Surface Water Regulations (Chapter 62-302.530, Florida Administrative Code [FAC]) and Impaired Waters Rule (Chapter 62-303.353, FAC) served as comparison sources for dissolved oxygen, chlorophyll a, turbidity, and fecal coliform bacteria. For some CHEVWQMN parameters, estuaries and sites, insufficient numbers of samples were available to allow for direct comparison of the results to a specific regulation. Where insufficient data were available, general comparisons were made to the numerical water quality criterion. Comparisons are included in the Results section of this report for each parameter. This analysis is a tool for quantifying water quality status and in no means represents methods, findings or decisions resulting from the Florida's Impaired Waters and Total Maximum Daily Load Programs. Regulatory criteria are summarized in Table 4.6.

Table 4.6: Description of regulations used to determine water quality status

Source Description	Parameter	Criteria Summary
Impaired Waters Rule 62-303.353	Chlorophyll a	Annual mean must not exceed 11 ug/l or not have increased by more than 50% in two or more consecutive years
Florida Surface Water Regulations 62-302.530 Class III Fresh and Marine	Fecal Coliform	Monthly average must not exceed 200 cfu/100ml
		10% of samples must not exceed 400 cfu/100ml
		Must not exceed 800 cfu/100ml on any given day
	DO	Daily average must be greater than 5 mg/l and never less than 4 mg/l
	Turbidity	Must not exceed 29 NTU or above natural background conditions

H. Analysis Methods Used to Determine Trends

To quantify changes in water quality over time for each estuary, the seasonal Kendall trend test was used. The seasonal Kendall trend test is commonly used for trend analysis of water quality conditions to accommodate seasonal distribution of values. In addition, the nonparametric test is used for its robustness to deviations from a normal distribution and outlying values. In addition, the test is somewhat robust to censored values and missing data within the series. The seasonal Kendall trend test is a modification of the Mann-Kendall test that adjusts for seasonality across the time series. The test, developed by Hirsch, Slack and Smith in 1982, has evolved extensively over the years to account for serial correlation, spatial variation across sites and various anomalies within the dataset (e.g. Hirsch, Slack and Smith 1982; Hirsch and Slack 1984; Hirsch, Alexander and Smith 1991; Helsel and Hirsch 2002).

The seasonal Kendall trend test ranks the differences between seasonal data pairs to calculate the test statistic and variance which produces the correlation coefficient *tau* and respective significance value. For this report, a season was defined as one month. The test statistic (S) is the sum of differences between all months across the series, in which January is only compared to January, February to February, etc, for the study period. The test statistic is then standardized and divided by the standard deviation to estimate the correlation coefficient and two tailed significance value. When a significant trend ($p < 0.05$) is detected, the slope of the trend line is estimated. The trend slope is the median of all slopes of the monthly data pairs used to estimate the initial test statistic (S).

For trend analysis of the CHEVWQMN data, the seasonal Kendall trend test was conducted using the USGS, "Computer Program for the Kendall Family of Trend Tests". The USGS program was created and interpreted by Dennis R. Helsel, David K. Mueller, and James R. Slack (2006). The package is a Microsoft DOS based program which produces the seasonal Kendall trend test statistic, standard normal deviate, significance value and trend equation. For this report, a "water year" includes the months of October through September.

Interpreting the results of the seasonal Kendall trend test is limited by the amount of censoring of laboratory results, study duration and underlying patterns in the data. These conditions may increase the possibility of Type I or Type II errors in the results. Prediction of the significance value of a trend depends on the absence of serial correlation in the time series (Helsel and Hirsch 2002). Serial correlation (or autocorrelation) is defined as the degree to which the previous result influences the subsequent result. Autocorrelation can exist both intra-annually as a seasonal type affect, and inter-annually as serial correlation across the time series. When autocorrelation does exist, it is necessary to adjust the series for seasonal or inter-annual effects. To accurately determine autocorrelation, as a means to adjust the significance value of the trend, the dataset must contain at least ten years of data (Helsel and Hirsch 2002). Because only eight years (seven complete water years plus two incomplete water years) of CHEVWQMN data were analyzed in this study, autocorrelation could not be accurately quantified either seasonally or across the full time series. Therefore, it is important to note that autocorrelation may exist within the time series, affecting the overall trend significance. Because some autocorrelation may

exist, the results are presented in this report as a preliminary indicator of possible water quality trends, which will be reevaluated following collection of three more years of data.

Two additional considerations for interpreting trends in the CHEVWQMN results are the frequency of laboratory results reported as the MDL and the percent of Secchi depths observed as greater than total depth. The seasonal Kendall trend test is robust to censoring of data only if the MDLs do not change during the study. In this study, the MDL changed frequently for all laboratory parameters, primarily as a function of changes in laboratories conducting the analyses. Therefore, for trend analyses only, within this report all values reported as MDL were set equal to the highest MDL reported for each parameter during the eight-year study duration. In addition, trend analyses were not conducted on parameters where greater than 50% of the data as reported was the MDL. These conditions are summarized in Table 4.7.

A similar method for qualifying Secchi depth for trend analysis was conducted. Frequent observations, in which Secchi depth exceeds total depth, artificially influence trend results. As a result, trend analysis was not conducted when Secchi depth was equal to or greater than bottom depth for over 50% of the samples for each estuary. See Table 4.8.

Monthly results for each site were aggregated by estuary region to determine the median value by parameter for each month. All estuaries had a minimum of 60 samples over the complete time series for each parameter. Trend outputs include: results summary table, time series plots per parameter over the complete time series and monthly box plots. The monthly box plots visually display seasonal relationships and the time series plots provide a visual reference for long-term trends within the series.

The seasonal Kendall trend test was not conducted for chlorophyll *a* in response to 12 months of missing data in 2002 due to funding constraints and changes in lab methods. To estimate changes in chlorophyll *a* from 1998 through 2005 the Mann-Whitney U test was used. The Mann-Whitney U test is a nonparametric version of the between-subjects t-test which compares differences between medians of two groups. The collective chlorophyll *a* results from 1998 through 2001 were compared to the collective results from 2002 through 2005 for each estuary region.

Table 4.7: Summary of values reported as equal to the maximum MDL

	% Reported as MDL**	Minimum MDL	Maximum MDL	Trend Threshold
Total Nitrogen* (ppm)	na	na	na	na
Total Kjeldahl Nitrogen (ppm)	22%	0.080	0.500	0.500
Nitrate + Nitrite (ppm)	93%	0.004	0.100	na
Phosphorus (ppm)	22%	0.004	0.050	0.050
Chlorophyll <i>a</i> (µg/l)	20%	0.030	2.000	2.000
Fecal Coliform (cfu/100ml)	34%	1	2	2
Turbidity (NTU)	15%	0.02	1.40	1.40
Color (PCU)	6.5	1	5	5

*Total nitrogen is the calculated sum of total Kjeldahl nitrogen and nitrate plus nitrite

**Values in bold do not qualify for trend analysis due to > 50% of values are reported as the MDL

Table 4.8: Summary of depth and secchi depth results for each aquatic preserve

	average sample depth (m)	average secchi depth (m)	total sample results	total valid cases	total greater than bottom	% greater than bottom*
Upper Lemon Bay	1.0	0.9	378	161	217	57%
Lower Lemon Bay	1.4	1.3	525	230	295	56%
Upper Charlotte	1.5	0.9	653	394	259	40%
Lower Charlotte	2.1	1.8	248	105	143	58%
Gasparilla/Cape Haze	1.6	1.5	195	86	109	56%
Pine Island Sound	1.7	1.4	379	167	212	56%
Matlacha Pass	3.2	1.6	257	202	55	21%
San Carlos Bay	3.7	1.5	330	327	3	1%
Estero Bay	1.2	1.2	348	177	171	49%
All Sites	1.8	1.3	3313	1849	1464	44%

**values in bold are greater than 50% and not used for trend analysis

I. Methods Used to Determine Relationships between Water Quality Parameters

An additional analysis was conducted to describe the relationships between water quality variables for each estuary collectively and for each season. Relationships between water quality variables were quantified using both the Spearman's rho correlation test and stepwise linear regressions. Spearman's rho is a nonparametric correlation analysis that characterizes relationships using ordered ranking of results. Reported statistics include sample size, significance value and Spearman's correlation coefficient. Spearman's rho correlation coefficient describes the strength and direction of the relationship ranging from -1 to 1, where -1 indicates a strong negative relationship, +1 indicates a strong positive relationship and 0 indicates no relationship. Evaluation of relationships was conducted on selected parameters for the entire study region and for each estuary. Results are included in tables and scatter plots in Section VI and Appendix D.

As a means of describing estuarine health and water clarity for seagrass growth, forward stepwise regression analyses were conducted to quantify contributions of selected parameters to changes in Secchi depth and chlorophyll a values. A stepwise regression differs from a linear regression in that only parameters that contribute significantly to changes in the dependent variable are added to the regression equation. Addition of parameters into the regression model was set at $p < 0.05$ and parameters were removed from the regression when $p > 0.10$. Statistics reported include: F, R, R^2 , R^2 adjusted, R^2 change, and SE. R^2 describes the percent of variability in the dependent variable that is described for the given parameter. R^2 values range from 0 to 1, with 1 meaning 100% of the variability in the dependent variable is described by that parameter. The adjusted R^2 adjusts R^2 based on the number of independent variables added to the regression equation. The SE describes the accuracy of the regression estimate, as SE increases the reliability of the regression results decreases.

V. Water Quality Status and Trends Results for the CHEVWQMN from 1998-2005

A. Introduction

The following section describes the water quality status and trends results of the CHEVWQMN from 1998 - 2005. Thirteen parameters were analyzed for each estuary and are included in this section with the site specific results given in Appendix A. To characterize water quality status as it relates to estuarine health, median values for each parameter were compared to typical Florida estuarine water quality values, as listed in Hand 2004, and available regulatory criteria. Summary statistics and status results are provided in tables included in the sections for each parameter. Seasonal and spatial comparisons are included to describe significant differences between estuaries and seasons for each parameter. Comparison results are reported in box plots for visual reference with detailed results included in Appendix B. Trend analyses were conducted for each estuary and the results are shown in graphs and tables in each of the following parameter sections.

To accurately interpret CHEVWQMN water quality status and trends results, consideration should be given to watershed influences and hydrologic effects outside of the estuarine system. Specifically, land uses in the adjacent watersheds affect water quality conditions and trends in each of the Charlotte Harbor estuary regions to varying degrees. The intensity of the land use and proximity to surface water, as well as hydrologic conditions determines the magnitude of water quality impacts. For example, excess fertilizer application, septic system leachate, stormwater runoff, and phosphate mining have the potential to contribute to increased turbidity, nitrogen and phosphorus loads to the estuaries, thereby affecting certain response variables such as chlorophyll a, water clarity and dissolved oxygen. Altering hydrologic regimes, such as increases in channelization and impervious surfaces in the watershed, as well as changes to the Caloosahatchee River discharges and Peace River withdrawals, also affect water quality and estuarine health.

In addition to watershed influences, when interpreting water quality results, it is also important to understand weather patterns which occurred during the study period and their potential effects on water quality in the Charlotte Harbor estuary regions, such as the El Nino-Southern Oscillation (ENSO). In particular, for the study period from 1998 through 2005, the weather pattern known as the Atlantic Multidecadal Oscillation (AMO) affected the southwest Florida area (Enfield et al. 2001). The AMO describes a cycle of warmer, drier weather patterns followed by cooler periods with increased intensity and variability in rainfall. Historically, warmer phases included the time periods from 1860 -1880 and 1940 -1960, while cooler phases included 1905 -1925 and 1970-1990. Since 1995, studies indicate that a warmer AMO phase is beginning, resulting in increased global temperatures and rainfall (Enfield et al. 2001). Increases in rainfall in southwest Florida associated with the warmer AMO phase could potentially increase the volume of freshwater entering surface tributaries and discharging into the region. During the study period, an ENSO event was documented, as well. The result of which caused drought conditions for the entire state from 1998-2002 (Verdi et al 2006). The

combined effect of these two large scale weather patterns was to essentially split the study into two periods of differing hydrologic conditions. The first period, 1998-2000, represented a period of decreasing precipitation, leading into drought conditions. The later period, 2001-2005, was represented by increasing rainfall, and subsequently increasing discharge to the estuaries. See Table 5.1 and Figure 5.1 for annual average rainfall and Appendix E for correlations of rainfall and study parameters.

In addition, impacts from Hurricane Charley in August of 2004 have had serious immediate and long-term effects on water quality and estuarine health of the Charlotte Harbor region. Although the exact nature of these effects is still being examined, studies have indicated that specific impacts from Hurricane Charley on water quality in the Charlotte Harbor watershed include: immediate, short-term hypoxia in Charlotte Harbor and within the Peace River (Tomasko et al. 2006, Stevens et al. 2006), increased organic matter (Tomasko et al. 2006) and increased nutrients and fecal pollution (Mallin and Corbett 2006).

Increases in the amount of freshwater inflow can potentially have various effects on water quality parameters, including increases in dissolved organic matter, nutrient, pollutant and sediment loads and decreases in pH and salinity. As a result, large scale temporal patterns in climate, and subsequently hydrological conditions, can have significant impacts upon the status and trends results presented within the report. Therefore, the reader should keep in mind the larger scale influences, particularly changes climate and precipitation, on water quality results presented here.

Table 5.1: Average annual rainfall (m) by watershed region.

	Peace	Lemon Bay	Myakka	Charlotte Harbor	Tidal Caloosahatchee	Estero Bay
1998	1.41	1.45	1.45	1.30	1.68	1.46
1999	1.22	1.30	1.42	1.05	1.32	1.46
2000	0.78	0.84	0.95	0.92	1.00	1.22
2001	1.23	1.20	1.35	1.24	1.46	1.53
2002	1.51	1.37	1.48	1.39	1.40	1.40
2003	1.34	1.55	1.61	1.47	1.70	1.75
2004	1.59	1.33	1.59	1.40	1.59	1.19
2005	1.59	1.55	1.72	1.68	1.86	1.56

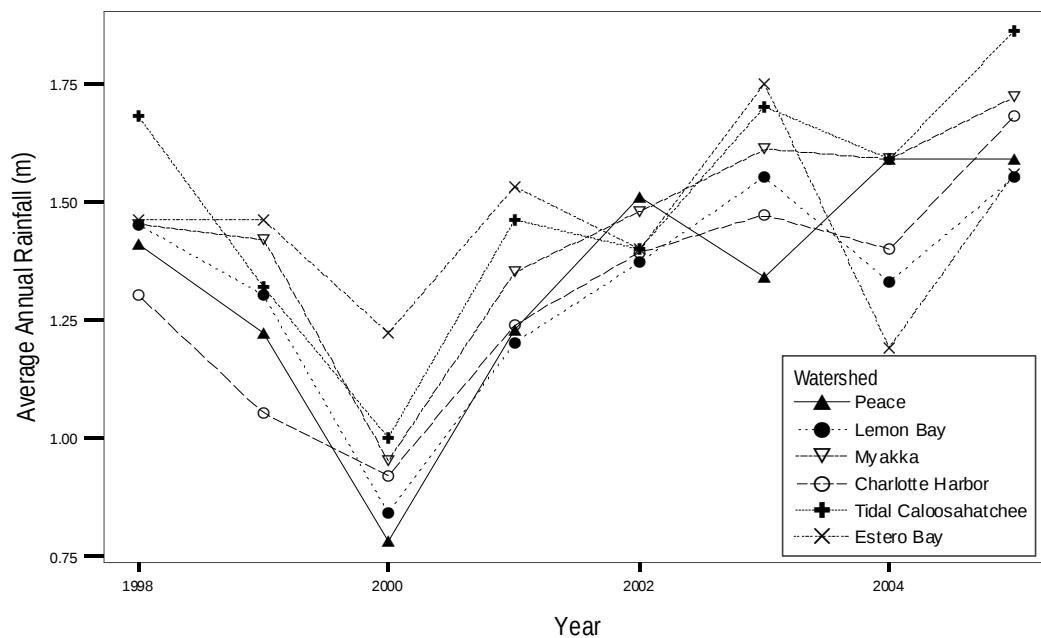


Figure 5.1: Average annual rainfall by watershed region.

B. Secchi Depth

1. Background

Secchi depth can be used to provide an estimate of water clarity in aquatic systems (Kirk 1983). Water clarity, as measured by Secchi depth, is a function of light absorption from seawater, dissolved organic and inorganic matter, suspended organic matter (i.e. plant biomass and phytoplankton abundance) and suspended inorganic matter (i.e. turbidity and total suspended solids; McPherson and Miller 1987). As water clarity decreases, Secchi depth decreases. Evaluating the status and trends of water clarity as measured by Secchi depth is a useful tool in aquatic resource management. Studies in southwest Florida have shown that decreases in water clarity may result in decreased seagrass abundance (e.g. EPA 1993).

CHEVWQMN Secchi depth values may be affected by shallow sample depths at some sites and tide stages, as well as the early morning, low sunlight sampling time. As a result, analysis of CHEVWQMN Secchi depth results was limited to sites and dates when water depth exceeded Secchi depth. For this report, when Secchi depth was greater than water depth, the value was considered missing and not used for analysis. In addition, it is also important to remember that Secchi depth is a measure of image or visual attenuation and not a direct measure of diffuse light in the water column, nor does it take into account specific wavelengths that may be required for seagrass photosynthesis (Kirk 1983). As a result, Secchi depth should serve as an estimate of light available for photosynthetic growth. Results were not corrected for tidal stage or wind speed/direction.

2. Status and Trends Results

Secchi depth summary statistics and status results from the CHEVWQMN for 1998 - 2005 throughout the Charlotte Harbor region are shown in Tables 5.2 and 5.3 and Figures 5.2-5.4. For the entire region and the study period, Secchi depth values ranged from less than 0.1 m to 4.5 m, with a median value of 0.9 m and a mean value of 1.3 m. Secchi depth varied significantly between all estuary regions ($p < 0.05$). The estuary region with the highest median Secchi depth value was Matlacha Pass at 1.6 m. The lowest estuary regional median values were found in Upper Charlotte Harbor and Upper Lemon Bay with median values of 0.9 m. Compared to Typical Florida Water Quality Values (Hand 2004), higher than average median Secchi depth values, indicating above average water clarity conditions, were found in six of the estuary regions including: Lower Lemon Bay, Lower Charlotte Harbor, Cape Haze, Pine Island Sound, Matlacha Pass and San Carlos Bay. Average Secchi depth values were found in three regions: Upper Lemon Bay, Upper Charlotte Harbor and Estero Bay. Because there is no water quality criteria for Secchi depth established in Florida, no regulatory comparisons were made. For site specific Secchi depth summary statistic and status results, see Appendix A.

Seasonally, Secchi depth varied significantly ($p < 0.05$), with a region wide median value of 1.2 m in the dry season and 1.1 m in the rainy season. Dry season Secchi depth values were significantly higher ($p < 0.05$) than rainy season values in five estuary

regions: Upper Lemon Bay, Upper Charlotte Harbor, Lower Charlotte Harbor, Matlacha Pass and San Carlos Bay. There were no significant differences between rainy season and dry season Secchi values in four estuary regions: Cape Haze, Estero Bay, Lower Lemon Bay and Pine Island Sound. For a visual comparison of seasonal results, see Figure 5.3 with detailed statistical results in Appendix B.

Secchi depth trend analysis was only conducted for estuary regions when at least 50% of Secchi depth observations were less than water depth. See Section IV-H for an overview of censoring and criteria for trend analysis. Four estuary regions qualified for trend analyses: Upper Charlotte Harbor, Matlacha Pass, San Carlos Bay and Estero Bay. Of these, only San Carlos and Estero Bays showed a significant ($p < 0.05$) change in Secchi depth over the study period, increasing at approximately 0.07 and 0.05 m per year, respectively. For visual trend assessment time series plots are included in Figure 5.4, with detailed analysis results in Table 5.3.

3. Discussion

Throughout the study region and period, water clarity, as measured by Secchi depth, varied greatly. Values ranged from higher than average to lower than average compared to typical Secchi depth values for Florida's estuaries. The highest Secchi depth values often occurred at deeper sites, further offshore. Secchi depth values were typically lower in regions with strong freshwater flow, including Upper Charlotte Harbor and Upper Lemon Bay. Lowest Secchi depth values occurred at sites near the Tidal Peace River, Tidal Myakka River and smaller tributaries to Upper Lemon Bay. Also, because trend analysis was only conducted for estuaries where a minimum of 50% of Secchi depth samples resulted in measurable values, only estuaries with the greatest sample depths (Matlacha Pass and San Carlos Bay) or particularly low water clarity (Upper Charlotte Harbor) qualified for trend analysis.

In the Charlotte Harbor region, changes in Secchi depth can be attributed to fluctuations in dissolved organic matter (i.e. color), phytoplankton and non-algal suspended matter (Kirk 1983, Dixon and Kirkpatrick 1999, Ott et. al. 2006, McPherson and Miller 1994, McPherson and Miller 1987), as well as changes in the light field at the time of measurement (Corbett 2006, personal communication). As a result, increases in one or more of these constituents may result in decreased water clarity and Secchi depth. Color, chlorophyll *a*, and turbidity levels can be influenced by various changes in the estuarine environment and watershed, including: 1) freshwater inputs from major rivers, such as the Peace, Myakka and Caloosahatchee Rivers, as well as smaller tributaries (Doering and Chamberlain 1999, Doering et. al. 2006, McPherson and Miller 1990, McPherson et. al 1990); 2) resuspension of sediment or particulates from dredging and wave action; and 3) point and non-point source watershed runoff (Doering and Chamberlain 1999).

Table 5.2: Summary and status of Secchi depth (m) results for each estuary region

	N	Min	Max	Mean	SE	Median	Average Depth of region‡	Median Rank within the Charlotte Harbor Estuaries*	Median compared to Typical FL Estuary Percentiles**	Status Relative to Typical FL Estuaries***
Upper Lemon Bay	161	0.4	1.6	0.9	0.0	0.9	1.2	1	40	average
Lower Lemon Bay	230	0.5	3.3	1.3	0.0	1.3	1.8	4	70	higher than average
Upper Charlotte	394	0.1	2.7	0.9	0.0	0.9	2.5	1	40	average
Lower Charlotte	105	0.5	4.5	1.8	0.1	1.5	3.0	7	80	higher than average
Gasparilla/Cape Haze	86	0.0	3.2	1.5	0.1	1.5	1.3	7	80	higher than average
Pine Island Sound	167	0.1	3.9	1.4	0.0	1.3	1.7	4	70	higher than average
Matlacha Pass	202	0.4	3.8	1.6	0.0	1.6	1.9	9	80	higher than average
San Carlos Bay	327	0.5	3.9	1.5	0.0	1.4	2.1	6	80	higher than average
Estero Bay	177	0.3	2.9	1.2	0.0	1.1	1.1	3	60	average
All Sites	1849	0.0	4.5	1.3	0.0	0.9	2.0		40	average

*Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

**Median value compared to typical Florida estuarine water quality percentile distributions (Hand 2004)

***below average < 40, 40 ≤ average < 70, above average ≥ 70

‡Average depth calculated from bathymetry maps

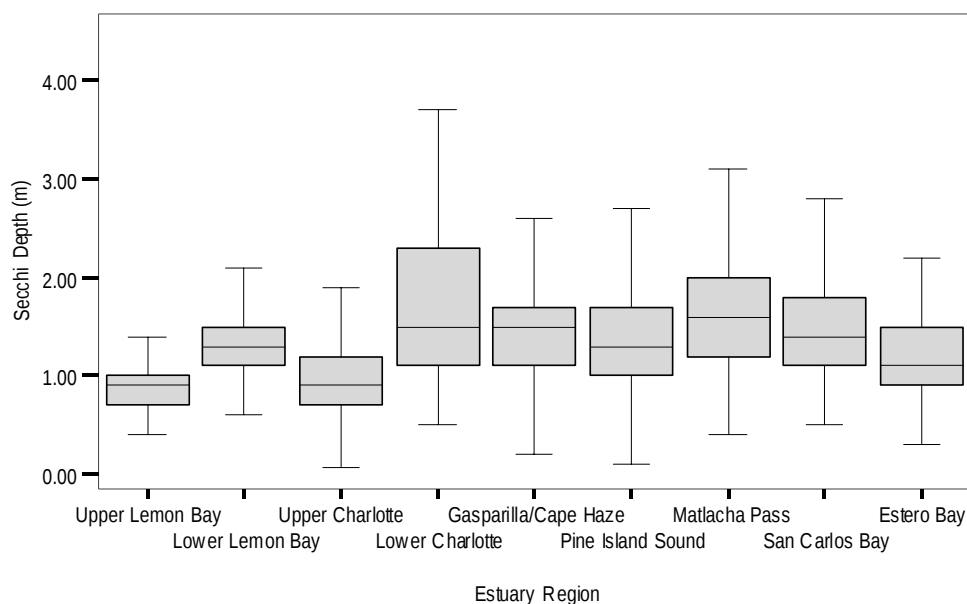


Figure 5.2: Secchi depth Box plot results for each estuary region. Outliers and extremes are not shown.

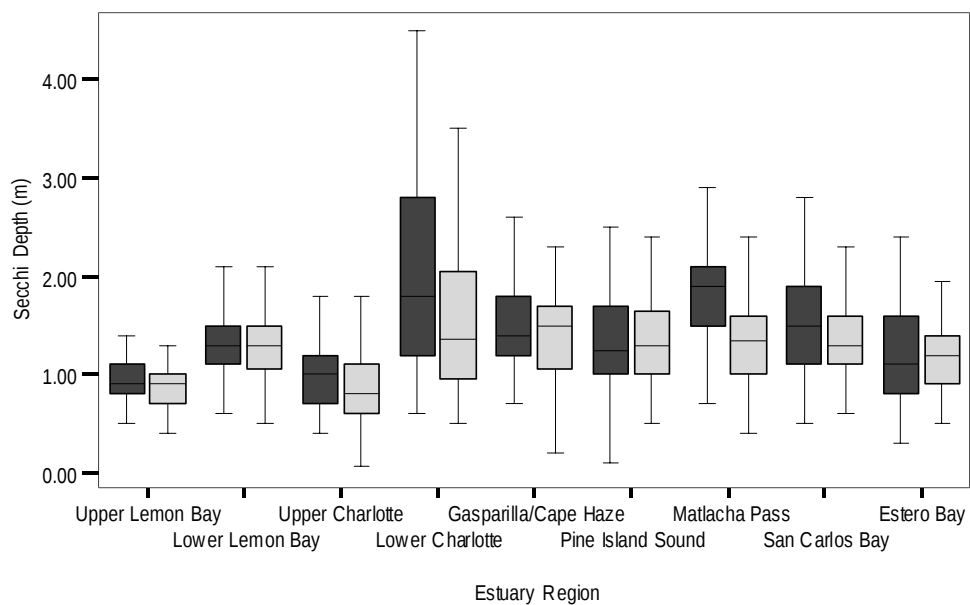


Figure 5.3: Seasonal Secchi depth Box plot results for each estuary region. Outliers are not shown. ■ Dry Season ■ Rainy Season

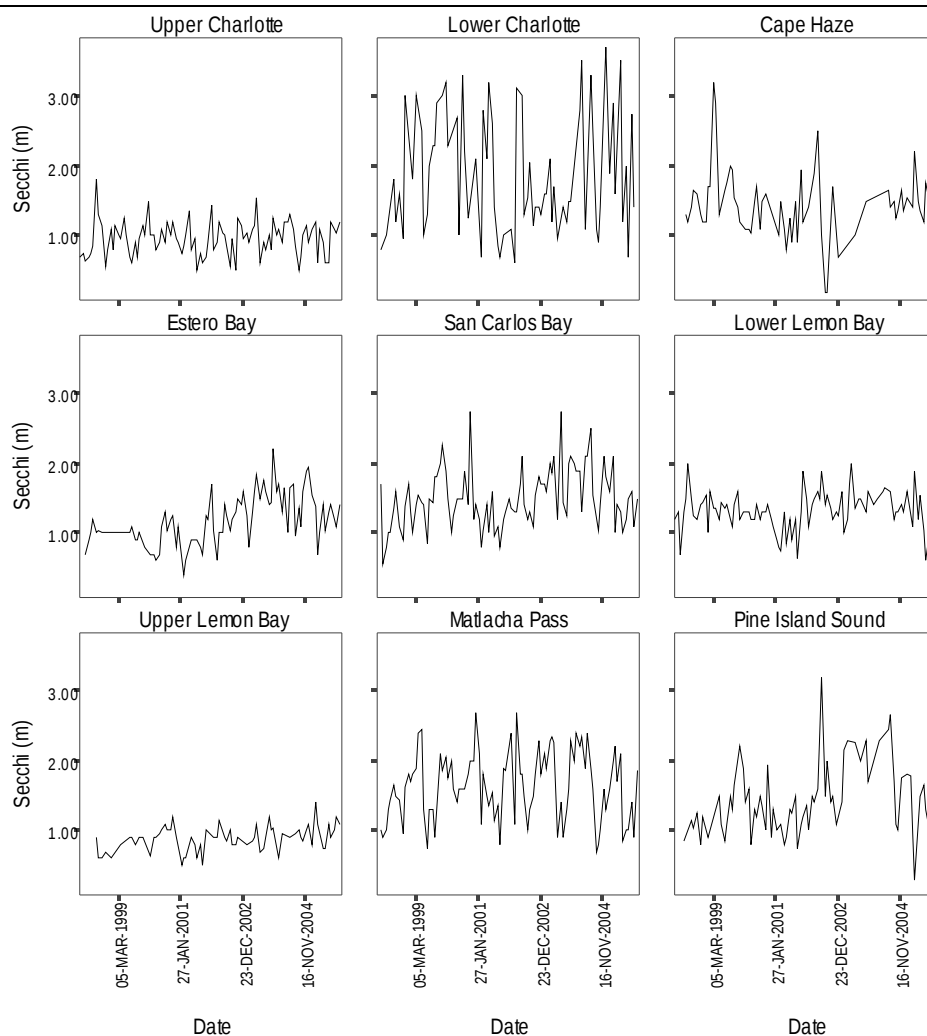


Figure 5.4: Time series plot of Secchi (m) for 1998 through 2005. Each line/point represents the monthly median from all sites in each aquatic preserve.

Table 5.3: Secchi depth (m) trends results

	Data Points Read	Kendall's Test Statistic	z	correlation coefficient	p (2 tailed)	slope	intercept
Upper Lemon Bay	*	*	*	*	*		
Lower Lemon Bay	*	*	*	*	*		
Upper Charlotte	96	53	1.887	0.158	0.0592		
Lower Charlotte	*	*	*	*	*		
Gasparilla/Cape Haze	*	*	*	*	*		
Pine Island Sound	*	*	*	*	*		
Matlacha Pass	95	7	0.2190	0.0210	0.8269		
San Carlos Bay	94	80	2.9290	0.2480	0.0034	0.0683	1.1430
Estero Bay	85	52	2.14	0.195	0.0324	0.05	1.025

Bold values significant at the .05 level

* does not meet data disposition requirements, See section IV-H

C. Temperature

1. Background

Temperature is an important, controlling factor in a variety of biological and chemical processes in estuaries and may serve as a predictor of biological activity. For example, temperature plays a key role in seasonal seagrass and phytoplankton productivity and triggers life stage changes in many fishery and shellfish species. In estuaries in general, and in Charlotte Harbor specifically, temperature varies with depth, mixing by tidal currents and wind action, season, time of day and anthropogenic influences (EPA 1993). Seasonal temperature stratification occurs in the deeper areas of the Harbor, associated with summer salinity stratification due to increased freshwater inflows.

2. Status and Trends Results

Temperature summary statistics and status results from the CHEVWQMN for 1998 - 2005 throughout the Charlotte Harbor region are shown in Tables 5.4 and 5.5 and Figures 5.5-5.7. Throughout the study region and period, temperature ranged from 4° - 32° C, with a median value of 24° C and a mean value of 23.8° C. Temperature did not vary significantly between estuaries, with median values ranging from 24.0° - 25.0° C. Compared to Typical Florida Water Quality Values (Hand 2004), average median temperature values were found in all nine of the regions. In addition, since there are no temperature water quality criteria in the Charlotte Harbor area, no regulatory comparisons were made. For site specific temperature summary statistic and status results, see Appendix A.

Dry season temperature values were significantly ($p < 0.05$) lower than rainy season values in all nine estuary regions and the region as a whole. For the entire region, the median dry season temperature was 21.0° C and the median rainy season value was 28° C. For a visual comparison of seasonal results, see Figure 5.6, with detailed statistical results in Appendix B.

Adequate temperature sample sizes were collected, throughout the study region and period to conduct trend analyses for each estuary. Three regions (Matlacha Pass, San Carlos Bay, and Estero Bay) showed significant ($p < 0.05$) decreases in temperature, and ranged from -0.1 to -0.2 degrees per year. For visual trend assessment, time series plots are included in Figure 5.7, with detailed analysis results in Table 5.5.

Table 5.4: Summary and status of temperature (deg. C) results for each estuary region

	N	Min	Max	Mean	SE	Median	Median Rank within the Charlotte Harbor Estuaries*	Median compared to Typical FL Estuary Percentiles**	Status Relative to Typical FL Estuaries***
Upper Lemon Bay	381	12.0	32.0	23.7	0.2	24.5	3	60	average
Lower Lemon Bay	525	10.0	32.0	23.6	0.2	24.0	1	60	average
Upper Charlotte	657	4.0	31.5	23.6	0.2	24.0	1	60	average
Lower Charlotte	252	13.0	31.5	23.9	0.3	24.5	3	60	average
Gasparilla/Cape Haze	192	7.5	31.5	24.2	0.3	25.0	8	60	average
Pine Island Sound	400	10.5	31.0	23.6	0.2	24.5	3	60	average
Matlacha Pass	261	13.5	31.0	24.0	0.3	24.5	3	60	average
San Carlos Bay	340	10.0	31.0	24.1	0.3	24.8	7	60	average
Estero Bay	361	14.0	31.0	23.6	0.2	25.0	8	60	average
All Sites	3369	4.0	32.0	23.8	0.1	24.0		60	average

*Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

**Median value compared to typical Florida estuarine water quality percentile distributions (Hand 2004)

***lower than average < 40, $40 \leq$ average < 70, higher than average ≥ 70

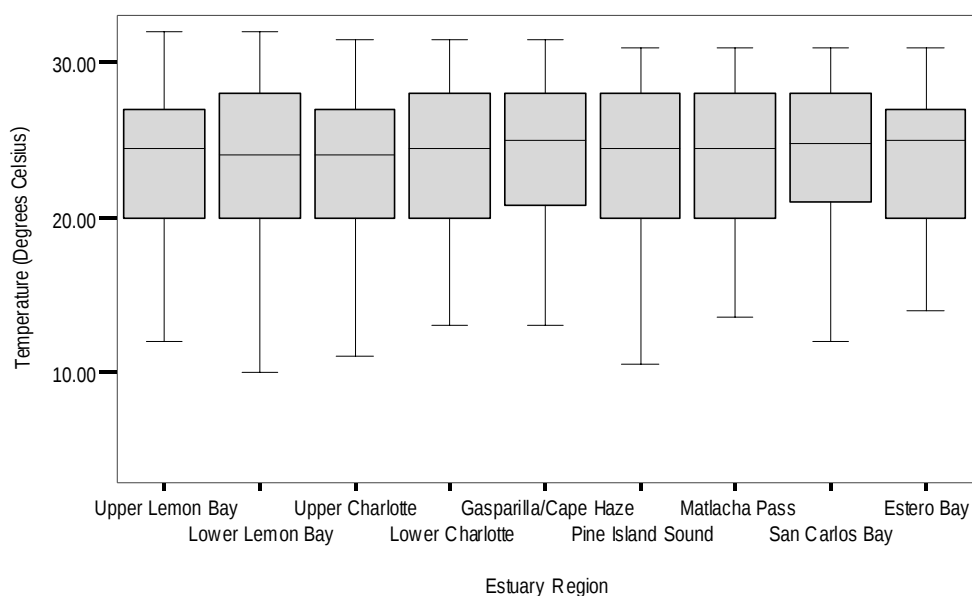


Figure 5.5: Temperature Box plot results for each estuary region. Outliers and extremes are not shown.

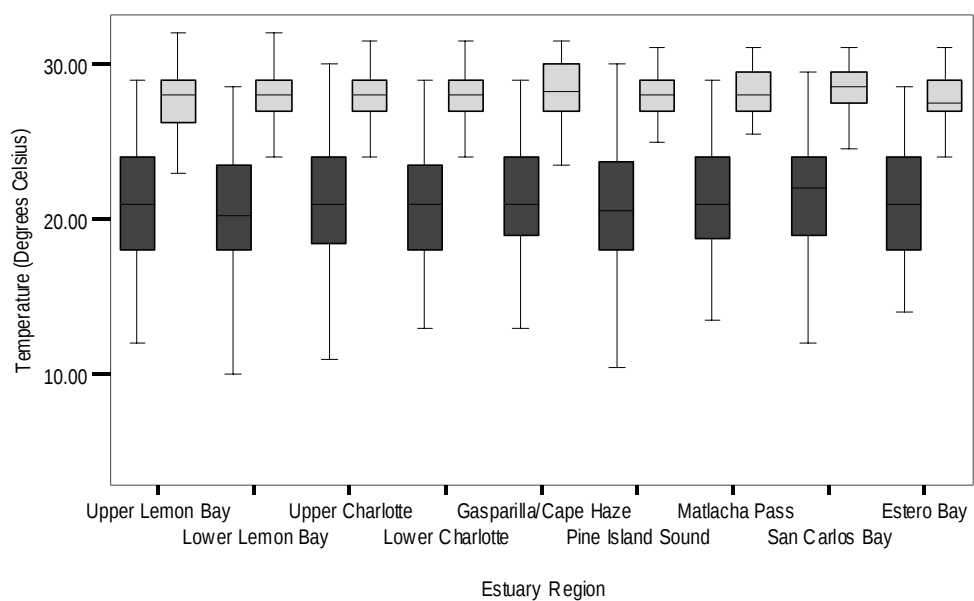


Figure 5.6: Seasonal temperature Box plot results for each estuary region. Outliers are not shown. ■ Dry Season ■ Rainy Season

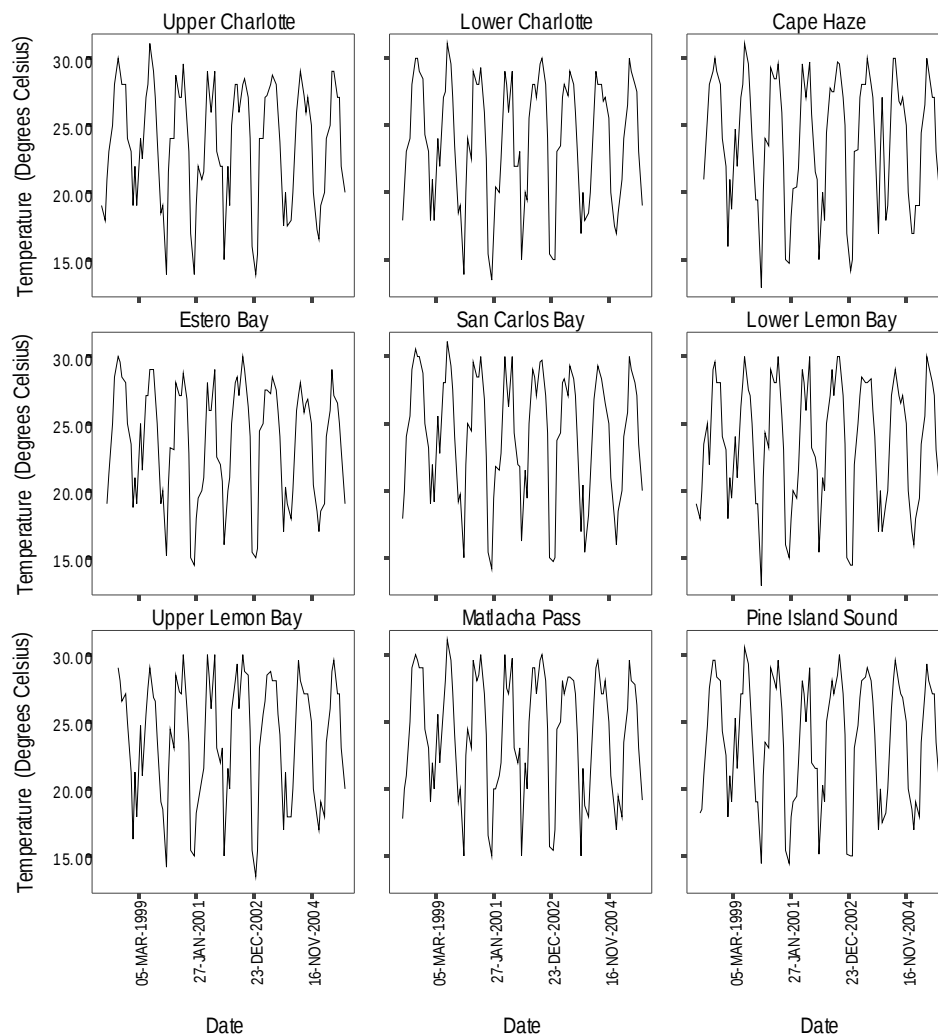


Figure 5.7: Time series plot of temperature (°C) for 1998 through 2005. Each line/point represents the monthly median from all sites in each aquatic preserve.

Table 5.5: Temperature (deg. C) trends results

	Data Points	Kendall's		correlation			
	Read	Test Statistic	z	coefficient	p (2 tailed)	slope	intercept
Upper Lemon Bay	90	0	0.0000	0.0000	1.0000		
Lower Lemon Bay	96	-23	-0.8090	-0.0680	0.4184		
Upper Charlotte	96	-48	-1.718	-0.143	0.0858		
Lower Charlotte	94	-35	-1.2730	-0.1090	0.2029		
Gasparilla/Cape Haze	93	-24	-0.8770	-0.0760	0.3806		
Pine Island Sound	95	-22	-0.7770	-0.0670	0.4374		
Matlacha Pass	95	-55	-2.0010	-0.1670	0.0454	-0.125	25.06
San Carlos Bay	94	-67	-2.4470	-0.2080	0.0144	-0.1937	25.62
Estero Bay	94	-56	-2.0540	-0.1740	0.0400	-0.2	25.9

Bold values significant at the .05 level

D. Dissolved Oxygen

1. Background

Dissolved oxygen (DO) is critical for sustaining most aquatic life. It is a measure of the amount of gaseous oxygen dissolved in the water column and is required for metabolism for all aerobic organisms, including estuarine shellfish, crustaceans and fishes. In estuaries, DO is produced by photosynthesis of phytoplankton, seagrasses, macro algae, as well as other macrophytes, and may serve as an indicator of biotic productivity and estuarine health. In the water column, DO also enters from dissolution from the atmosphere (Stickney 1984) and through wind and wave action. There is a maximum amount of oxygen that can be dissolved in the water (i.e. saturation; approximately 8 mg/L in south Florida estuaries), which depends on water temperature and salinity, though super saturation can occur due to high rates of photosynthesis and surface mixing caused by wind and wave activity. The DO is utilized, and therefore reduced by respiration of aquatic organisms and decomposition of organic matter. Levels of DO vary on a daily cycle in response to higher mid-day photosynthesis rates, followed by night time respiration, resulting in lowest values immediately prior to sunrise. The magnitude of the diurnal cycle of DO indicates if the aquatic system is well balanced or over-productive due to elevated nutrient and phytoplankton levels (e.g. Stickney 1984).

Stratification of DO can occur when bottom and surface water layers remain separated due to density differences associated with salinity or temperature variations (Camp et al. 1998). Once stratification is established, decreased oxygen in the lower layer occurs as a result of benthic respiration and decomposition of organic material. In Charlotte Harbor, low oxygen (hypoxia) conditions occur in the deeper areas during summer stratification (Morrison, et al. 1998, Camp et. al. 1998).

2. Status and Trends Results

The DO concentrations summary statistics and status results from the CHEVWQMN for 1998 - 2005 throughout the Charlotte Harbor region are shown in Tables 5.6-5.9 and Figures 5.8-5.10. Throughout the study region and period, DO values ranged from 0.6 mg/L to 10.0 mg/L, with a median value of 5.2 mg/L and a mean value of 5.1 mg/L. The DO values varied significantly ($p < 0.05$), across the nine regions, with median values ranging from 5.9 mg/L in Pine Island Sound and San Carlos Bay to 3.9 mg/L in Upper Lemon Bay. Compared to Typical Florida Water Quality Values (Hand 2004), above-average median DO values were not found in any of the regions. Average median DO values were found in Pine Island Sound and San Carlos Bay, with below average values found in the other seven estuary regions. For site specific DO summary statistic and status results, see Appendix A.

Throughout the region, dry season median DO values (5.7 mg/L) were significantly higher ($p < 0.05$) than rainy season median values (4.3 mg/L). In addition, estuary median DO values were significantly higher in the dry season in all estuary regions. For a visual comparison of seasonal results, see Figure 5.9, with detailed statistical results in Appendix B.

To characterize the status of DO in the region, CHEVWQMN DO results were compared to Florida Surface Water Quality Standards for DO. For fresh and marine, fishable and swimmable waters (Class III), the DO standards are given in Florida Administrative Code Chapter 62-302.530 FAC as:

“dissolved oxygen shall not be less than 5.0 mg/L for fresh waters, and shall not average less than 5.0 mg/L in a 24 hour period and shall never be less than 4.0 mg/L in marine waters, with maintenance of normal daily and seasonal fluctuations”.

In estuarine waters, the use of fresh or marine DO criteria is dependent on salinity. Due to the strong tidal and seasonal fluctuation of salinity in the Charlotte Harbor estuaries, a generalized comparison to both standards of 4.0 and 5.0 mg/L was made. In addition, because of the monthly sampling frequency, daily DO averages could not be obtained. However, samples with median values less than 5.0 and 4.0 mg/L for each site and estuary were analyzed.

During the study period, DO levels were frequently observed below the state standards of 5.0 mg/L (45% of samples) and 4.0 mg/L (24% of samples). The highest DO observations were reported at sites in San Carlos Bay with only 16% of samples less than 5.0 mg/L and 2% less than 4.0 mg/L. The most observations below state standards occurred in Upper Charlotte Harbor, Estero Bay, Gasparilla/Cape Haze and Lower and Upper Lemon Bay (in increasing order). The DO levels in Upper Lemon Bay were below 5.0 mg/L for 74% of samples and below 4.0 mg/L for 50% of samples. Seasonally, DO concentrations across all sites were lower than both the 5.0 and 4.0 mg/L standards nearly twice as often during the rainy season. Results comparing DO concentrations to regulatory criteria for each estuary are included in Tables 5.7 and 5.8, with site specific results in Appendix C.

Six significant trends in DO were detected across the nine estuary regions. The DO concentrations significantly increased in Upper Charlotte Harbor, Lower Charlotte Harbor, Pine Island Sound, Matlacha Pass and San Carlos Bay at a rate of increase ranging from less than 0.1 mg/L to approximately 0.2 mg/L per year. However, DO values significantly decreased in Gasparilla Sound/Cape Haze at a rate of -0.2 mg/L per year. For visual trend assessment, time series plots are included in Figure 5.10, with detailed analysis results in Table 5.9.

3. Discussion

When interpreting the CHEVWQMN DO results, it is important to remember that all samples were taken at sunrise near the water surface and are based on duplicate field measurements at each site. Additionally, many of the sites are located in shallow waters near shore. Because of this sampling design, the results represent the lowest daily DO values found following night-time absence of photosynthesis combined with community respiration. In addition, shallow, near shore DO results may exhibit low values as a result of consumption of oxygen via decomposition of organic materials from shoreline vegetation. In general, DO concentrations for the Charlotte Harbor region were below average compared to typical Florida estuarine water quality values and were frequently observed below the state standards of 5.0 and 4.0 mg/L. However, the DO standards are generally interpreted as the 24 hour diel average and not a single sampling event (Beever 2006, personal communication). Although collective results for

the entire study duration indicate below average DO conditions, an increasing trend in DO concentrations were observed for many of the estuaries.

In Charlotte Harbor, DO values lower than other typical Florida estuaries may be due to the synergistic effects of high water temperature, high water color due to tannins, high dissolved organic substances and high amounts of decomposition of detritus in shallow near-shore waters and anthropogenic sources of nutrients and other materials, as well as sampling design (Morrison et al. 1998, Camp et. al. 1998). Additional diurnal monitoring of DO to measure daily fluctuations would enhance the understanding of whether Charlotte Harbor's relatively low DO values reflect natural estuarine levels or adverse anthropogenic impacts which may be detrimental to overall estuarine health.

Table 5.6: Summary and status of dissolved oxygen (mg/L) results for each estuary region

	N	Min	Max	Mean	SE	Median	Median Rank within the Charlotte Harbor Estuaries*	Median compared to Typical FL Estuary Percentiles**	Status Relative to Typical FL Estuaries***
Upper Lemon Bay	373	1.0	8.8	4.1	0.1	3.9	1	10	lower than average
Lower Lemon Bay	515	0.6	8.2	4.7	0.1	4.8	3	20	lower than average
Upper Charlotte	650	0.6	9.9	5.2	0.1	5.2	5	30	lower than average
Lower Charlotte	247	2.4	9.1	5.4	0.1	5.5	6	30	lower than average
Gasparilla/Cape Haze	188	1.4	7.3	4.6	0.1	4.6	2	20	lower than average
Pine Island Sound	392	0.6	9.0	5.7	0.1	5.9	8	40	average
Matlacha Pass	252	2.0	9.0	5.5	0.1	5.5	6	30	lower than average
San Carlos Bay	334	2.8	8.7	5.9	0.1	5.9	8	40	average
Estero Bay	356	1.2	10.0	4.7	0.1	4.8	3	20	lower than average
All Sites	3307	0.6	10.0	5.1	0.0	5.2		30	lower than average

*Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

**Median value compared to typical Florida estuarine water quality percentile distributions (Hand 2004)

***below average < 40, 40 ≤ average < 70, above average ≥ 70

Table 5.7: Number and % of dissolved oxygen samples under 5 mg/L per Florida Surface Water Regulations

	ALL			DRY			RAIN		
	Under	Total	%	Under	Total	%	Under	Total	%
Upper Lemon	277	373	74%	136	218	62%	141	155	91%
Lower Lemon	274	515	53%	123	312	39%	151	203	74%
Upper Charlotte	290	650	45%	82	387	21%	208	263	79%
Lower Charlotte	88	247	36%	31	141	22%	57	106	54%
Gasparilla/Cape Haze	108	188	57%	55	109	50%	53	79	67%
Pine Island	100	392	26%	37	232	16%	63	160	39%
Matlacha Pass	83	252	33%	22	149	15%	61	103	59%
San Carlos	52	334	16%	10	199	5%	42	135	31%
Estero Bay	202	356	57%	83	210	40%	119	146	82%
Total	1474	3307	45%	579	1957	30%	895	1350	66%

Table 5.8: Number and % of dissolved oxygen samples under 4 mg/L per Florida Surface Water Regulations

	ALL			DRY			RAIN		
	Under	Total	%	Under	Total	%	Under	Total	%
Upper Lemon	188	373	50%	66	218	30%	122	155	79%
Lower Lemon	145	515	28%	55	312	18%	90	203	44%
Upper Charlotte	132	650	20%	13	387	3%	119	263	45%
Lower Charlotte	42	247	17%	10	141	7%	32	106	30%
Gasparilla/Cape Haze	59	188	31%	25	109	23%	34	79	43%
Pine Island	54	392	14%	25	232	11%	29	160	18%
Matlacha Pass	32	252	13%	4	149	3%	28	103	27%
San Carlos	6	334	2%	1	199	1%	5	135	4%
Estero Bay	97	356	27%	22	210	10%	75	146	51%
Total	755	3307	23%	221	1957	11%	534	1350	40%

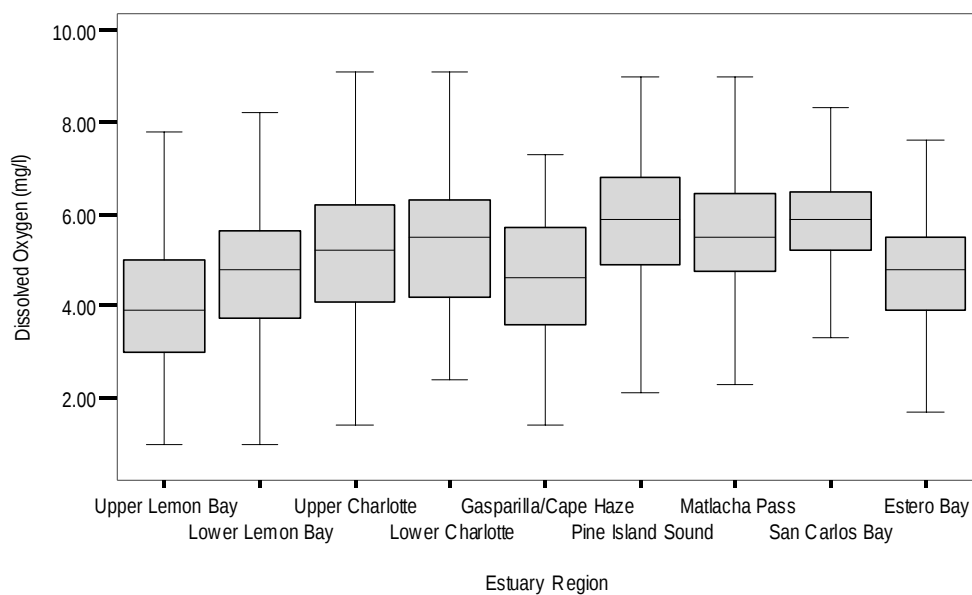


Figure 5.8: Dissolved oxygen Box plot results for each estuary region. Outliers and extremes are not shown.

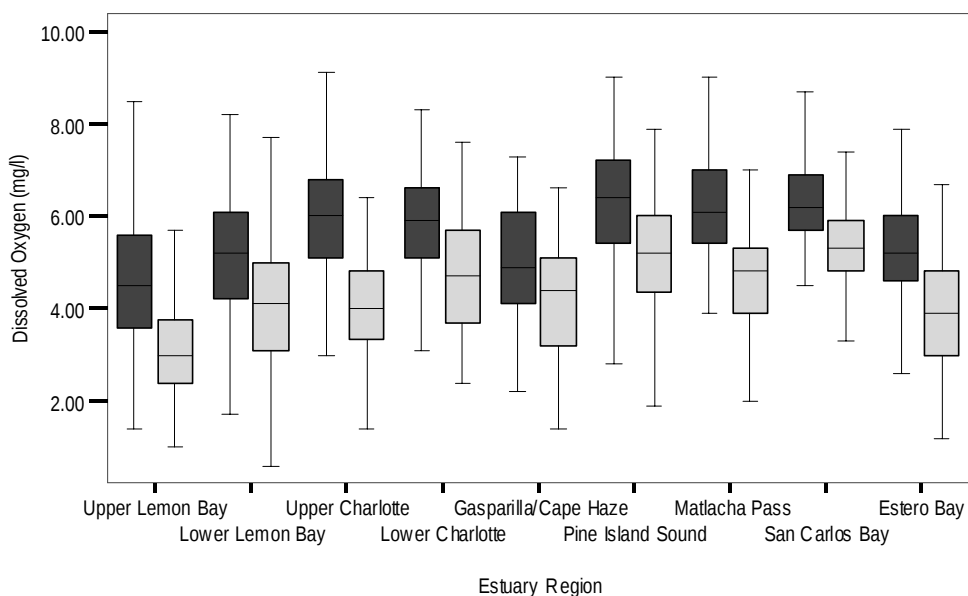


Figure 5.9: Seasonal dissolved oxygen Box plot results for each estuary region. Outliers are not shown. ■ Dry Season ■ Rainy Season

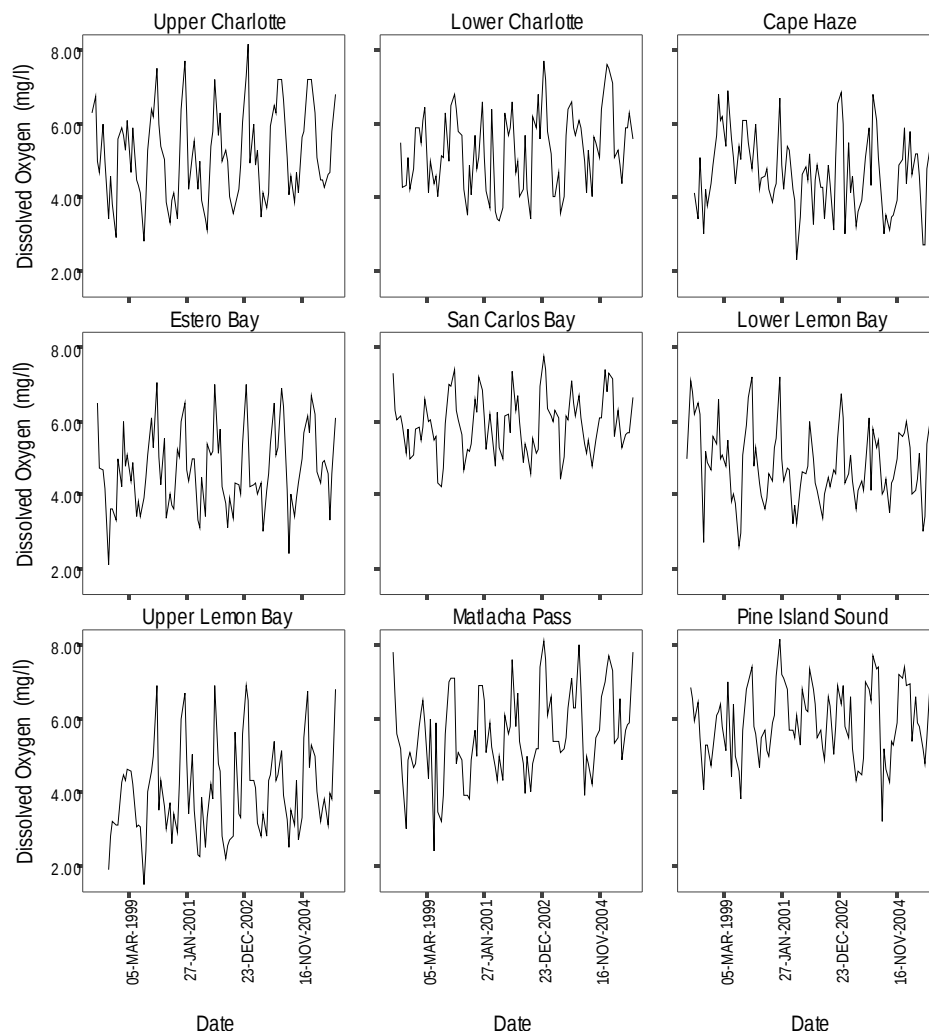


Figure 5.10: Time series plot of dissolved oxygen (mg/L) for 1998 through 2005. Each line/point represents the monthly median from all sites in each aquatic preserve.

Table 5.9: Dissolved oxygen (mg/L) trends results

	Data Points	Kendall's		correlation			
	Read	Test Statistic	z	coefficient	p (2 tailed)	slope	intercept
Upper Lemon Bay	90	64	2.463	0.218	0.0138	0.1000	3.350
Lower Lemon Bay	96	-17	-0.577	-0.051	0.5638		
Upper Charlotte	96	74	2.631	0.220	0.0085	0.0775	4.676
Lower Charlotte	92	60	2.243	0.195	0.0249	0.1000	4.850
Gasparilla/Cape Haze	93	-46	-1.679	-0.146	0.0931		
Pine Island Sound	95	48	1.718	0.146	0.0858		
Matlacha Pass	94	120	4.380	0.373	0.0000	0.1750	4.763
San Carlos Bay	94	55	1.995	0.171	0.0461	0.0375	5.831
Estero Bay	94	35	1.258	0.109	0.2086		

Bold values significant at the .05 level

E. pH

1. Background

An important component of estuarine water quality that affects many biological and chemical processes is pH (Stickney 1984). It is a measure of the acidity or alkalinity of an aqueous solution. The scale for pH ranges from 0 (acidic) to neutral (7.0) to basic (14.0). The pH of natural surface waters is close to neutral and varies primarily with salinity, with fresh waters having lower pH (7.0 - 7.5) than seawater (8.0-8.6; EPA 1993). Because estuaries have wide ranges of salinities depending on the mixing of freshwater from rivers with salt water from oceans, pH varies spatially, daily and seasonally in estuaries, generally ranging from 7.5 - 8.8 (Day et al 1989, EPA 1993). The pH also fluctuates as a result of other natural and artificial events including: photosynthesis, bacterial activity and anthropogenic sources (EPA 1993). Photosynthesis strongly affects pH by removing carbon dioxide from the water and reducing carbonic acid levels within the water, which, in turn, raises the pH (Stickney 1984). Levels of primary productivity influence diurnal changes in pH and excess phytoplankton, and other organisms that photo-respire, may dramatically increase pH (Stickney 1984). In addition, pH is influenced by the local geology and inflow from tributaries. Weathering of carbonate rocks increase pH (Boggs 2006), while the decomposition of organic matter will generally lower it (Stickney 1984).

Water is naturally well buffered against changes in acidity or alkalinity, with saltier water having greater buffering capacity than freshwater. The pH affects concentrations of a variety of biological and chemical substances (Stickney 1984). Most aquatic organisms are adapted to narrow pH ranges, with optimal pH ranges for many fish being about 6.5-8.5 (NOAA 2005). Molluscs and other organisms with calcareous exoskeletons need a pH greater than 7.0 in order to avoid calcium dissolution. Metals within the estuary may also be affected, as well - as pH decreases, metals re-dissolve from anoxic bottom sediments, but as pH increases, metal oxides precipitate out of the water column (Stickney 1984). In addition, ammonia toxicity to aquatic organisms increases as pH increases. Abnormal pH values have direct and indirect detrimental effects upon the estuarine ecosystem and changes in pH should be investigated (Day et al 1989).

2. Status and Trends Results

The pH summary statistics and status results from the CHEVWQMN for 1998 - 2005 are shown in Tables 5.10 and 5.11 and Figures 5.11-5.13. Throughout the region and the study period, pH values ranged from 6.4 to 9.0, with a median value of 7.8 and mean of 8.1. Between the nine regions, pH varied significantly ($p < 0.05$). Pine Island Sound had the highest median pH value (8.4) and Upper Charlotte Harbor had the lowest median pH (7.8). Compared to Typical Florida Water Quality Values (Hand in press 2004), average pH values were found in two estuary regions, Upper Lemon Bay and Upper Charlotte Harbor. Higher than average pH values were found in the other seven estuary regions, with Pine Island Sound ranked in the top 100th percentile of Florida's estuaries. For site-specific pH summary statistics and status results, see Appendix A.

The seasonal variation of pH for the region, as a whole, showed interesting results. The median dry and rainy season pH values, as well as the mean dry season value were each 8.2. However, the mean rainy season pH was 8.1, proving to be statistically significantly lower than the dry season. The pH was significantly higher ($p < 0.05$) in the dry season for five estuary regions: Upper Lemon Bay, Lower Lemon Bay, Upper Charlotte Harbor, Lower Charlotte Harbor, and Matlacha Pass. For a visual comparison of seasonal results, see Figure 5.12, with detailed statistical results given in Appendix B.

Florida Surface Water Quality Standards for pH state that:

“shall not vary more than one unit above or below natural background conditions and not below 6.0 units or above 8.5 units for predominantly fresh waters, or more than two tenths of a unit above or below natural background conditions and not below 6.5 or above 8.5 units in open waters”

Because natural background pH levels have not been quantified for the Charlotte Harbor estuarine region, a detailed status analysis compared to pH regulatory criteria was not conducted. However, only two samples were observed below 6.5 and less than 15% of samples were reported above 8.5.

Significant pH trends were found in six of the Charlotte Harbor estuary regions. The pH decreased significantly in Upper Lemon Bay, Lower Charlotte Harbor, Gasparilla/Cape Haze and Estero Bay, at rates less than 0.05 standard unit per year. However, pH increased significantly in Pine Island Sound and Matlacha Pass, at rates of less than 0.05 standard unit per year. For visual trend assessment, time series plots are included in Figure 5.13, with detailed analysis results in Table 5.11.

3. Discussion

Higher than average pH values were observed across the region. In general, estuaries with higher salinity and less freshwater influence had higher pH results. Sites with the lowest pH values were found closest to freshwater sources, particularly near the Tidal Peace and Tidal Myakka Rivers and the tributary creeks to Upper and Lower Lemon Bay. Changes in pH in aquatic systems are strongly associated with variations in salinity and photosynthesis (Stickney 1984, Day et. al. 1989). As both salinity and photosynthesis increase, pH also increases. As a result, the higher pH results from the CHEVWQMN may be linked to above average salinities and/or chlorophyll a levels at specific sampling sites or times, or due to the carbonate bedrock found within southwest Florida. In addition, due to the strong relationship between pH and salinity, the pH trends found over the study region and period could be a result of changes in salinity over the time period.

Table 5.10: Summary and status of pH results for each estuary region

	N	Min	Max	Mean	SE	Median	Median Rank within the Charlotte Harbor Estuaries*	Median compared to Typical FL Estuary Percentiles**	Status Relative to Typical FL Estuaries***
Upper Lemon Bay	377	7.2	8.8	8.0	0.0	8.0	2	60	average
Lower Lemon Bay	520	7.2	9.0	8.3	0.0	8.3	8	90	higher than average
Upper Charlotte	657	6.4	8.6	7.7	0.0	7.8	1	40	average
Lower Charlotte	249	7.4	8.6	8.3	0.0	8.2	3	90	higher than average
Gasparilla/Cape Haze	194	7.2	8.6	8.3	0.0	8.2	3	90	higher than average
Pine Island Sound	388	7.0	8.8	8.4	0.0	8.4	9	100	higher than average
Matlacha Pass	250	7.4	8.6	8.2	0.0	8.2	3	90	higher than average
San Carlos Bay	339	7.4	8.6	8.3	0.0	8.2	3	90	higher than average
Estero Bay	357	7.2	8.8	8.1	0.0	8.2	3	90	higher than average
All Sites	3331	6.4	9.0	8.1	0.0	7.8		40	average

*Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

**Median value compared to typical Florida estuarine water quality percentile distributions (Hand 2004)

***lower than average < 40, 40 ≤ average < 70, higher than average ≥ 70

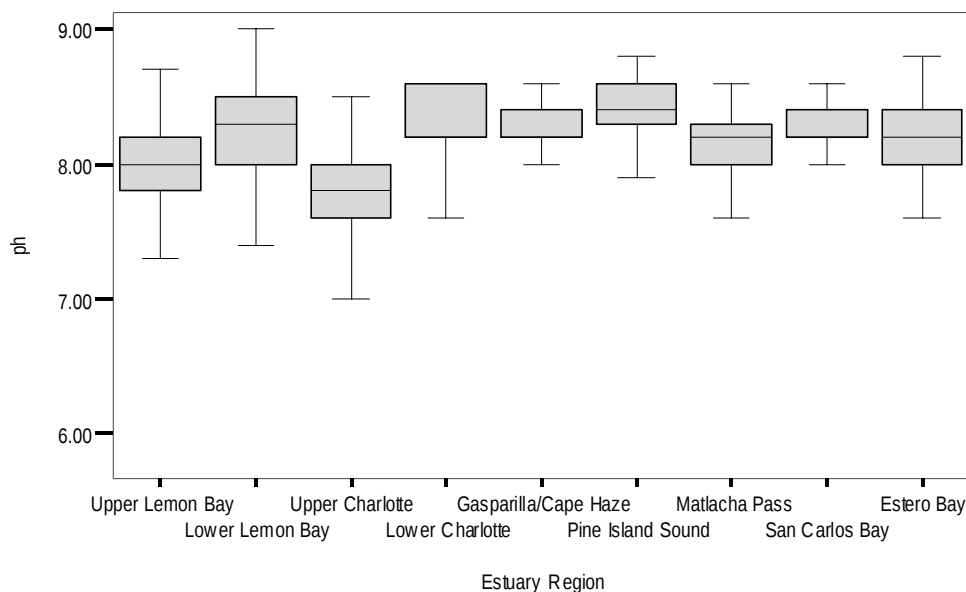


Figure 5.11: pH Box plot results for each estuary region. Outliers and extreme values are not shown

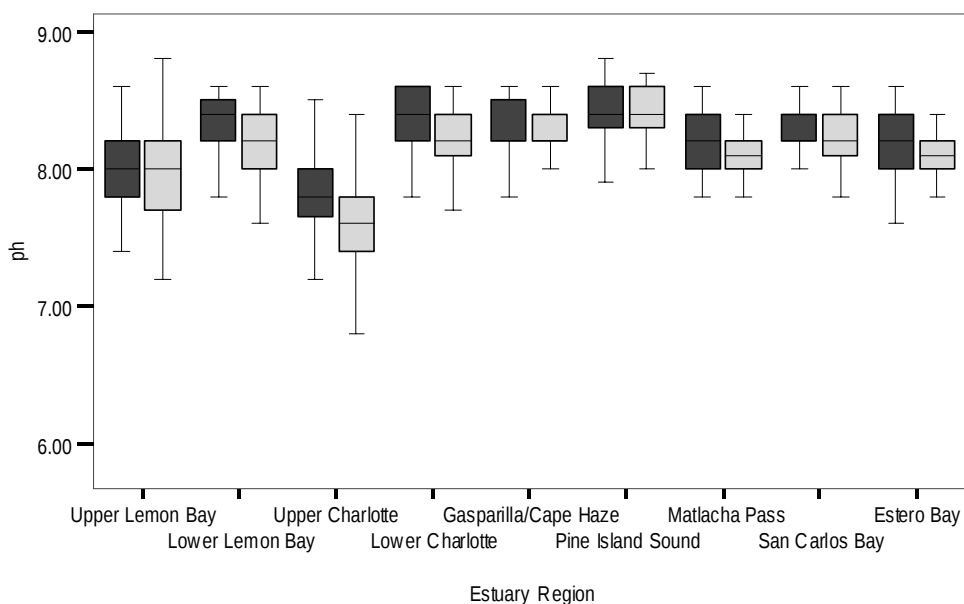


Figure 5.12: Seasonal pH Box plot results for each estuary region. Outliers are not shown. ■ Dry Season □ Rainy Season

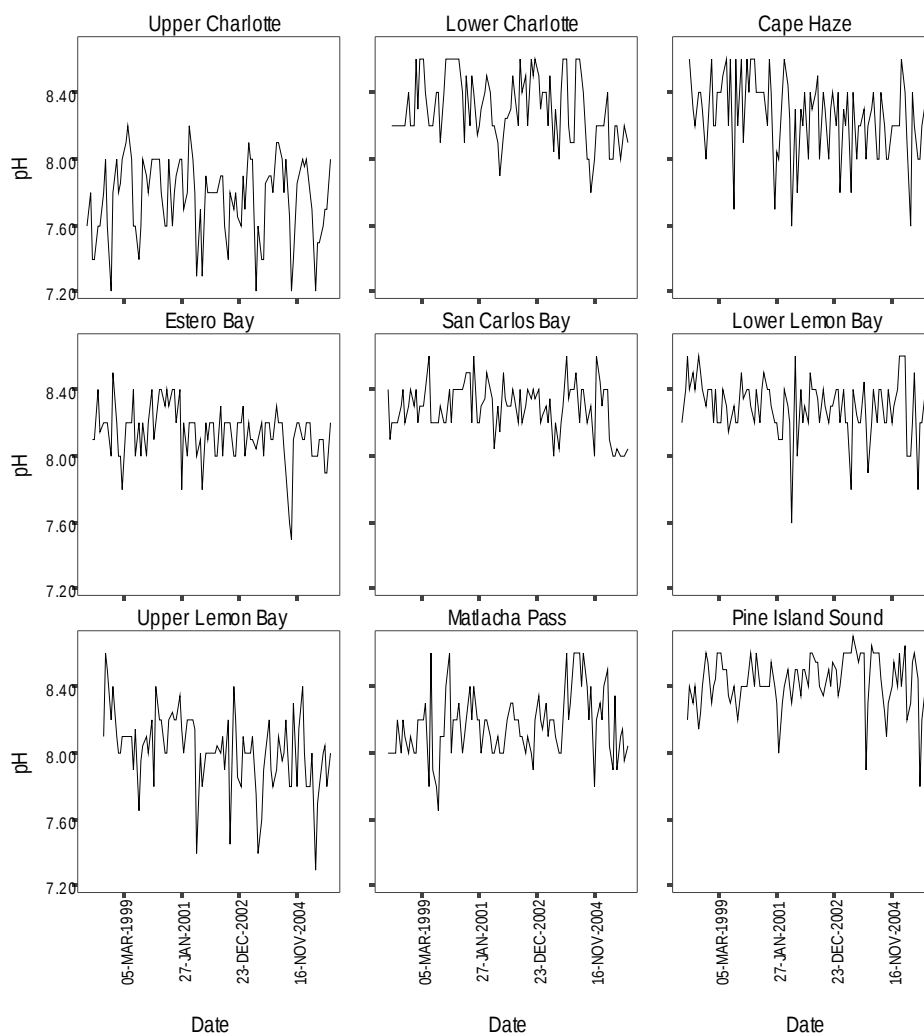


Figure 5.13: Time series plot of pH for 1998 through 2005. Each line/point represents the monthly median from all sites in each aquatic preserve.

Table 5.11: pH trends results

	Data Points	Kendall's		correlation			
	Read	Test Statistic	z	coefficient	p (2 tailed)	slope	intercept
Upper Lemon Bay	90	-99	-3.918	-0.337	0.0001	-0.0400	8.180
Lower Lemon Bay	96	-42	-1.553	-0.125	0.1205		
Upper Charlotte	96	2	0.037	0.006	0.9704		
Lower Charlotte	93	-59	-2.259	-0.187	0.0239	-0.0167	8.325
Gasparilla/Cape Haze	93	-82	-3.198	-0.260	0.0014	-0.0286	8.429
Pine Island Sound	94	62	2.340	0.193	0.0193	0.0113	8.349
Matlacha Pass	95	64	2.380	0.195	0.0173	0.0200	8.110
San Carlos Bay	94	-19	-0.686	-0.059	0.4927		
Estero Bay	94	-67	-2.595	-0.208	0.0095	-0.0121	8.255

Bold values significant at the .05 level

F. Salinity

1. Background

Salinity is the driving influence in many chemical, physical and biological processes in estuaries (Stickney 1984). Large variations in salinity have shown to be characteristic of many estuaries (e.g. McPherson *et al* 1996). Open ocean salinity ranges between 33 and 37 parts per thousand (ppt; Colling 2004)), while estuaries typically vary from 0.6 to greater than 40 ppt (Stickney 1984). Salinities over 32 ppt often occur in areas with minimal freshwater influence and increased evaporation. Sources of freshwater in estuaries include runoff from the surrounding watershed, direct freshwater inflows from rivers, creeks or canals, and precipitation. During the summer rainy season within Charlotte Harbor, vertical salinity stratification occurs due to density differences between marine waters and increased freshwater inflows (Stoker 1992). In some parts of Charlotte Harbor, a difference of up to 20 parts per thousand may be observed between the fresher water remaining at the surface and the saltier water trapped below (Stoker 1992).

Changes in salinity affect many biological, chemical and physical processes within the estuarine system. Many estuarine keystone species are adapted to particular salinity ranges including fish (Bortone *et. al.* 2006), seagrass (Greenawalt *et. al.* 2006; Corbett *et. al* 2005; Chamberlain and Doering 1998) and shellfish (Baker *et al.* 2002). Salinity may also influence concentrations of DO, pH and nutrients (Stickney 1984). Additionally, salinity patterns resulting from freshwater inflows may indicate sources of nutrients, dissolved organic matter and solids entering the estuarine system (Stickney 1984).

2. Status and Trends Results

Salinity summary statistics and status results from 1998-2005 for the CHEVWQMN are given in Tables 5.12 and 5.13 and Figures 5.14-5.16. Throughout the study period and region, salinity ranged from less than 0.1 to 42.0 ppt, with a median value of 17.9 ppt and mean salinity of 26.1 ppt. Salinity was significantly different ($p < 0.05$) between estuaries. Lower Lemon Bay had the highest median salinity (33.5 ppt), whereas Upper Charlotte Harbor had the lowest salinity (17.9 ppt). Upper Lemon Bay (25.3 ppt), Matlacha Pass (22.1 ppt) and Upper Charlotte Harbor (17.9 ppt) had the three lowest salinity median values and were average compared to typical Florida estuaries (Hand 2004). The remaining six estuaries had higher than average salinities compared to other Florida estuaries. Two estuaries regions ranked within the top 100% of samples for Florida's estuaries, Lower Lemon Bay and Gasparilla Sound/Cape Haze described in Hand, 2004. Variation in salinity over the entire study duration was greatest in Upper and Lower Lemon Bay, Upper Charlotte Harbor and Estero Bay. Salinity variability from 1998 through 2005 was lowest in Lower Charlotte Harbor and Gasparilla/Cape Haze. For site specific summary statistic and status results, see Appendix A.

Throughout the region, salinity during the dry season (median 30.1 ppt) was significantly higher ($p < 0.05$) than salinity in the rainy season (median 25.9 ppt).

Between the estuaries, salinity was significantly higher in the dry season in all of the nine estuaries. For a visual comparison of seasonal results, see Figure 5.15, with detailed statistical results given in Appendix B.

CHEVWQMN data were not compared to a regulatory standard, because there are no water quality criteria specific to salinity in Florida surface waters.

From 1998 through 2005, salinity significantly decreased in all estuary regions except Lower Lemon Bay. Rates of annual decrease during the study period ranged from approximately 0.3 ppt in Gasparilla/Cape Haze to approximately 1.3 ppt in Upper Lemon Bay. For visual trend assessment, time series plots are included in Figure 5.16, with detailed analysis results given in Table 5.13.

3. Discussion

Salinity in the Charlotte Harbor region was generally above the average salinity range for Florida's estuaries. However, a significant decrease in salinity was observed over the study duration for eight of the nine estuary regions. Salinity was lowest at sites in or near the Tidal Peace and Tidal Myakka Rivers and the smaller tributaries to Lemon and Estero Bays. Seasonal fluctuation in salinity concentrations, characterized by significantly lower salinity during the rainy season, can be attributed to freshwater inflow to Charlotte Harbor (Stoker 1992). Sources of freshwater inflow to Charlotte Harbor include the Peace, Myakka and Caloosahatchee Rivers (Stoker 1992, Hammet 1990, McPherson et. al. 1996). Freshwater enters the Estero Bay estuary primarily via the Caloosahatchee (Byrne and Flanigin 2005), Estero and Imperial Rivers, as well as Ten Mile Canal and Hendry Creek, among others (Estero Bay Marine Laboratory 1996). In Lemon Bay, freshwater enters the bay through smaller tributaries, including Forked Creek, Gottfried Creek, and Oyster Creek. In contrast, higher salinity concentrations are a function of tidal flow from the Gulf through passes and inlets throughout Charlotte Harbor (Stoker 1992).

Salinity in estuaries varies as a result of freshwater inflow to the system which can be a function of a variety of natural and artificial factors. Natural factors causing increased freshwater flow to the estuaries is primarily the caused by variability and intensity of rainfall to region. Rainfall and subsequently flow can be heavily influenced by weather patterns and storm events within the region. Weather patterns such as the ENSO events or the AMO (Enfield et al. 2001) could account for increased rainfall to the Charlotte Harbor region during the study period. Impacts from major storms, particularly Hurricane Charley, could have increased rainfall and flow, ultimately impacting salinity variability over the study period, particularly in the Fall of 2004. Additional influences on salinity variability with the Charlotte Harbor estuaries include alterations in hydrologic regimes including changes in runoff due to increased watershed development, hydrologic alterations (Stoker 1992) and discharges from the Caloosahatchee River (Chamberlain and Doering 1998). Disruptions in natural salinity regimes pose a risk to the physical and chemical nature of the estuarine system and biological communities that are narrowly adapted to specific salinity ranges (Stoker 1992, Doering and Chamberlain 1998, Greenawalt et. al. 2006).

Table 5.12: Summary and status of salinity (ppt) results for each estuary region

	N	Min	Max	Mean	SE	Median	Median Rank within the Charlotte Harbor Estuaries*	Median compared to Typical FL Estuary Percentiles**	Status Relative to Typical FL Estuaries***
Upper Lemon Bay	376	<0.1	40.7	22.4	0.6	25.3	3	60	average
Lower Lemon Bay	518	2.1	40.7	31.7	0.3	33.5	9	100	higher than average
Upper Charlotte	649	0.0	37.1	17.3	0.4	17.9	1	40	average
Lower Charlotte	248	8.5	39.1	28.2	0.4	29.0	4	80	higher than average
Gasparilla/Cape Haze	192	10.0	40.7	31.5	0.4	33.2	8	100	higher than average
Pine Island Sound	399	4.5	42.0	32.2	0.2	32.9	7	90	higher than average
Matacha Pass	258	2.9	39.8	21.7	0.5	22.1	2	50	average
San Carlos Bay	339	8.8	41.4	29.1	0.4	30.6	6	90	higher than average
Estero Bay	357	0.2	39.8	27.5	0.5	30.4	5	80	higher than average
All Sites	3336	<0.1	42.0	26.1	0.2	17.9		40	average

*Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

**Median value compared to typical Florida estuarine water quality percentile distributions (Hand 2004)

***lower than average < 40, 40 ≤ average < 70, higher than average ≥ 70

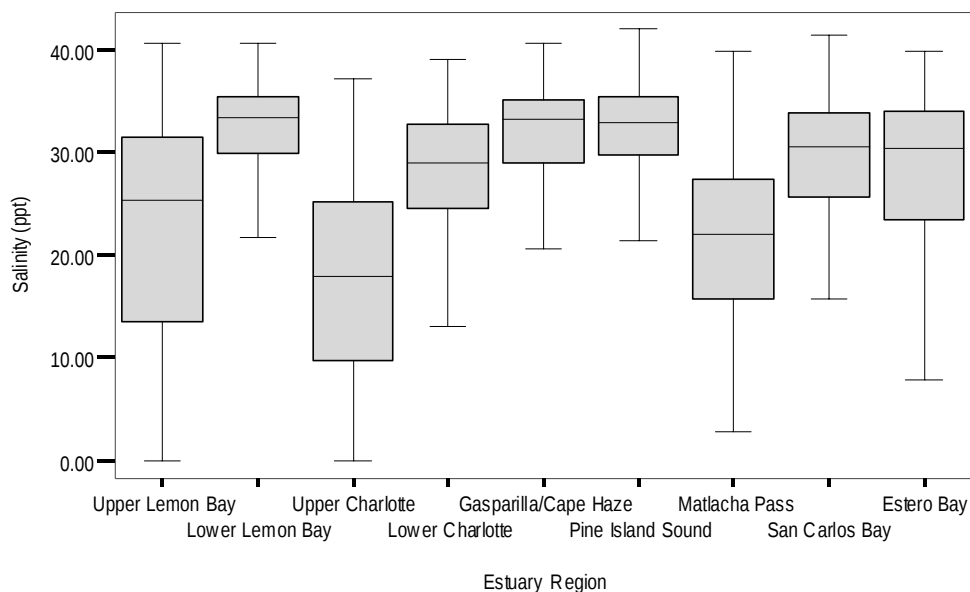


Figure 5.14: Salinity Box plot results for each estuary region. Outliers are not shown.

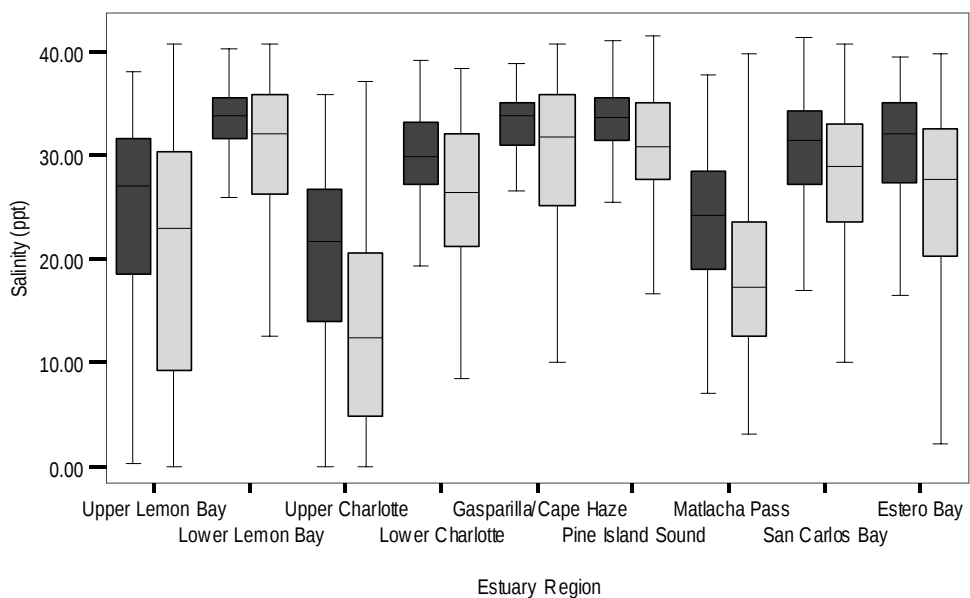


Figure 5.15: Seasonal salinity Box plot results for each estuary region. Outliers are not shown. ■ Dry Season ■ Rainy Season

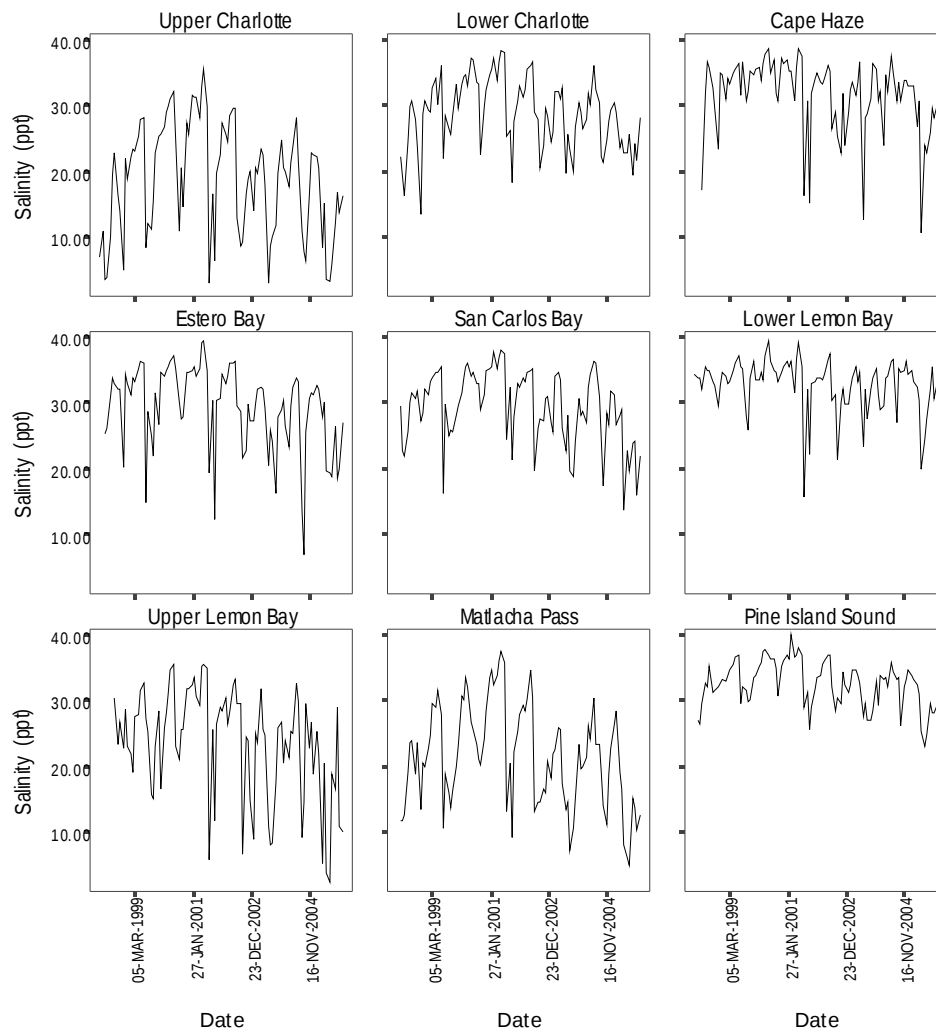


Figure 5.16: Time series plot of salinity (ppt) for 1998 through 2005. Each line/point represents the monthly median from all sites in each aquatic preserve.

Table 5.13: Salinity (ppt) trends results

	Data Points	Kendall's		correlation			
	Read	Test Statistic	z	coefficient	p (2 tailed)	slope	intercept
Upper Lemon Bay	90	-91	-3.511	-0.310	0.0004	-1.258	31.06
Lower Lemon Bay	96	-42	-1.468	-0.125	0.1421		
Upper Charlotte	96	-65	-2.287	-0.193	0.0222	-0.800	23.55
Lower Charlotte	94	-98	-3.566	-0.304	0.0004	-0.607	31.93
Gasparilla/Cape Haze	93	-87	-3.207	-0.276	0.0013	-0.425	34.81
Pine Island Sound	95	-93	-3.339	-0.283	0.0008	-0.450	34.93
Matlacha Pass	95	-76	-2.721	-0.231	0.0065	-0.950	25.58
San Carlos Bay	94	-65	-2.351	-0.202	0.0187	-0.467	32.85
Estero Bay	94	-107	-3.894	-0.332	0.0001	-0.823	34.40

Bold values significant at the .05 level

G. Nitrogen

1. Background

Nutrients, including nitrogen and phosphorus, are critical components of estuarine health. Dissolved nitrogen exists in estuaries in one of two forms; organic and inorganic (Stickney 1984). The nitrogen cycle in estuaries is complex due to the quick uptake of inorganic nitrogen by photosynthetic organisms and constant remineralization within the water column. In estuaries, nitrogen primarily enters the system through freshwater inflow, the decomposition of organic matter, or the fixation of atmospheric nitrogen by cyanobacteria and some bacteria. When nitrogen is fixed, it is converted from gaseous nitrogen (N_2) to ammonia. The ammonia is then oxidized through nitrification to nitrite by *Nitrosomonas* spp., then to nitrate by *Nitrobacter* spp. (Stickney 1984). Under anoxic conditions, nitrate can be reduced through denitrification back to nitrite, ammonia, nitrogen gas, or occasionally nitrous oxide (Senga, et al 2006). Dissolved Nitrate is readily taken up by aquatic plants and phytoplankton and converted to organic nitrogen. These plants and phytoplankton are subsequently ingested by primary consumers. Inorganic nitrogen, in the form of ammonia, is then excreted as a waste product by some species and converted once again into nitrate by bacteria (Stickney 1984). Within the Charlotte Harbor watershed, the most common source of anthropogenic nitrogen is from fertilizers (Castro et al 2003).

The concentration of dissolved nitrogen in estuaries is determined by other physical and chemical influences within the system, as well as the proximity of sources and sinks. For example, decreases in DO concentrations may inhibit the nitrification of ammonia and nitrite to organic nitrate by bacteria, resulting in increased concentrations of nitrite and ammonia (EPA 1993). Nitrogen is also influenced by salinity concentrations, with observed decreases in nitrite and nitrate at salinities higher than 20 ppt (McPherson and Miller 1990).

For this study, total nitrogen is the calculated sum of organic nitrogen (plus inorganic ammonia) measured as total Kjeldahl nitrogen (TKN), plus inorganic nitrogen (minus ammonia) measured as nitrite plus nitrate.

2. Status and Trends Results

The proportion of total nitrogen, in organic or inorganic forms, was assessed to help guide the interpretation of total nitrogen results. The percent of organic nitrogen plus ammonia, as measured by TKN, was fairly consistent across all estuaries ranging from approximately 90% to 95% of the total nitrogen throughout the region (Table 5.13). High levels of organic nitrogen may be a possible result of the short residence time of inorganic nitrogen within the water column due to quick uptake of by photosynthetic organisms (Stickney 1984).

Table 5.14: Percent of total nitrogen in organic form plus ammonia (TKN)

Upper Charlotte Harbor	Lower Charlotte Harbor	Cape Haze	Estero Bay	San Carlos Bay	Lower Lemon Bay	Upper Lemon Bay	Matlacha Pass	Pine Island Sound	Total
93.19%	94.11%	94.49%	92.10%	90.41%	93.72%	94.81%	93.46%	91.36%	92.92%

Total nitrogen summary statistics and status results are given in Tables 5.15 and 5.16 and Figures 5.17-5.19. Total nitrogen varied significantly ($p < 0.05$) across the study area, ranging from 0.032 to 4.6 parts per million (ppm). The total nitrogen median value of 0.98 ppm for all sites is higher than average compared to water quality results from selected Florida estuaries (Hand 2004). Median nitrogen concentrations were highest in Upper Lemon Bay and Upper Charlotte Harbor, ranking in the 80th percentile of Florida estuaries as described in Hand, 2004. For site specific summary statistic and status results, see Appendix A.

Total nitrogen varied seasonally throughout the region. Total nitrogen was significantly higher ($p < 0.05$) during the rainy season for each estuary region. The difference between the rainy season (0.95 ppm) median and the dry season median (0.78 ppm) was approximately 0.18 ppm. For a visual comparison of seasonal results, see Figure 5.18, with detailed statistical results given in Appendix B.

CHEVWQMN total nitrogen data were not compared to a regulatory standard, because there are no numerical criteria for nitrogen in Florida surface waters.

Trend analysis was not conducted on total nitrogen because over 50% of nitrate plus nitrite values (a component of total nitrogen) were reported as equal to or lesser than the highest MDL (Table 5.8). As a result, trend analysis for nitrogen for this study was conducted on TKN only, however which constitutes almost 95% of nitrogen within the system. The TKN significantly decreased in four of the nine estuary regions: Upper and Lower Lemon Bay, Lower Charlotte Harbor and Pine Island Sound. Rates of decrease during the study period ranged from approximately 0.04 ppm in Lower Lemon Bay and Gasparilla/Cape Haze to 0.05 ppm in Upper Lemon Bay and Lower Charlotte Harbor. For visual trend assessment, time series plots are shown in Figure 5.19, with detailed analysis results given in Table 5.16.

3. Discussion

In general, total nitrogen values from the CHEVWQMN data were average to higher than average compared to typical Florida estuarine water quality. Significant seasonal variation was observed, as well as a decreasing trend in TKN over the study period. The distribution and quantity of nitrogen in the region is largely the result of input from tidal flushing, recycling processes, including large biogenic contributions from fish-kills, algal decay, vascular plant debris, and freshwater sources (Froelich et.al. 1985; McPherson and Miller, 1990). Nitrogen primarily enters Charlotte Harbor via freshwater inflow from major rivers including the Peace (55%), Caloosahatchee (40%) and Myakka River (5%; Hammett 1990), with additional contributions from smaller tributaries and runoff.

Sources of excess nitrogen in the Charlotte Harbor region may include point and nonpoint sources of urban runoff, fertilizer runoff from agricultural applications and

atmospheric deposition (Castro et al. 2003). Excess nitrogen could have serious impacts on the Charlotte Harbor estuaries, primarily due to increased photosynthetic production within the water column (Doering et. al 2006, Montgomery et al. 1991, Jaworski 1981), which may result in decreased water clarity due to increased suspended algal matter (Doering et. al 2006), and consequently lower the amount of light available for seagrass growth (Corbett 2005)

Table 5.15: Summary and status of total nitrogen (ppm) results for each estuary region

	N	Min	Max	Mean	SE	Median	Median Rank within the Charlotte Harbor Estuaries*	Median compared to Typical FL Estuary Percentiles**	Status Relative to Typical FL Estuaries***
Upper Lemon Bay	219	0.075	2.750	1.035	0.031	1.005	9	80	higher than average
Lower Lemon Bay	265	0.075	2.560	0.790	0.025	0.767	5	60	average
Upper Charlotte	505	0.032	4.602	1.040	0.022	0.975	8	80	higher than average
Lower Charlotte	207	0.055	2.300	0.792	0.028	0.755	3	60	average
Gasparilla/Cape Haze	141	0.075	2.526	0.906	0.042	0.806	6	70	higher than average
Pine Island Sound	309	0.055	4.302	0.808	0.027	0.752	1	60	average
Matlacha Pass	194	0.032	3.840	0.905	0.032	0.851	7	70	higher than average
San Carlos Bay	249	0.055	2.930	0.755	0.025	0.753	2	60	average
Estero Bay	276	0.053	4.046	0.790	0.027	0.762	4	60	average
All Sites	2365	0.032	4.602	0.881	0.010	0.975		80	higher than average

*Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

**Median value compared to typical Florida estuarine water quality percentile distributions (Hand 2004)

***above average conditions < 40, 40 ≤ average < 70, below average conditions ≥ 70

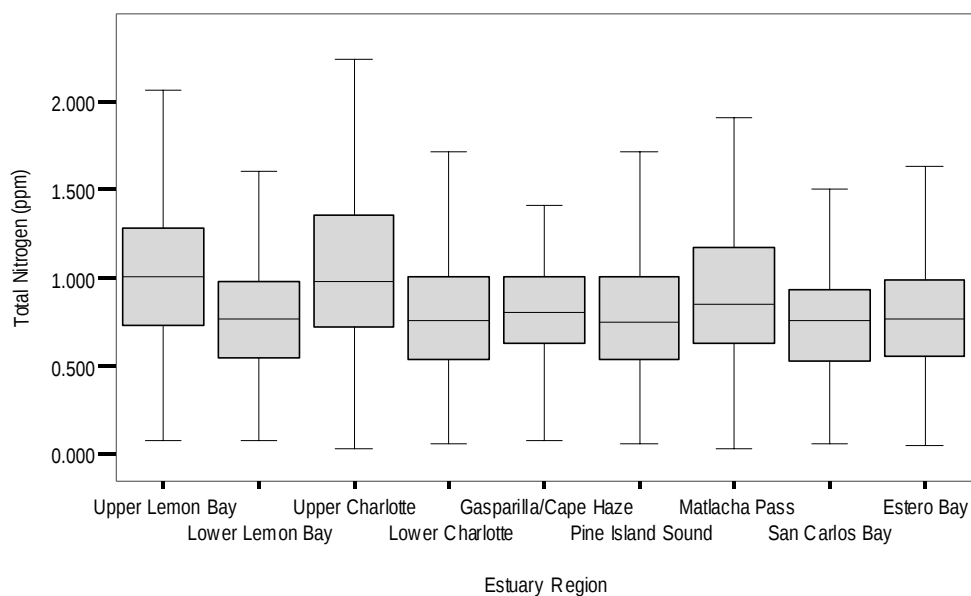


Figure 5.17: Total nitrogen Box plot results for each estuary region. Outliers are not shown.

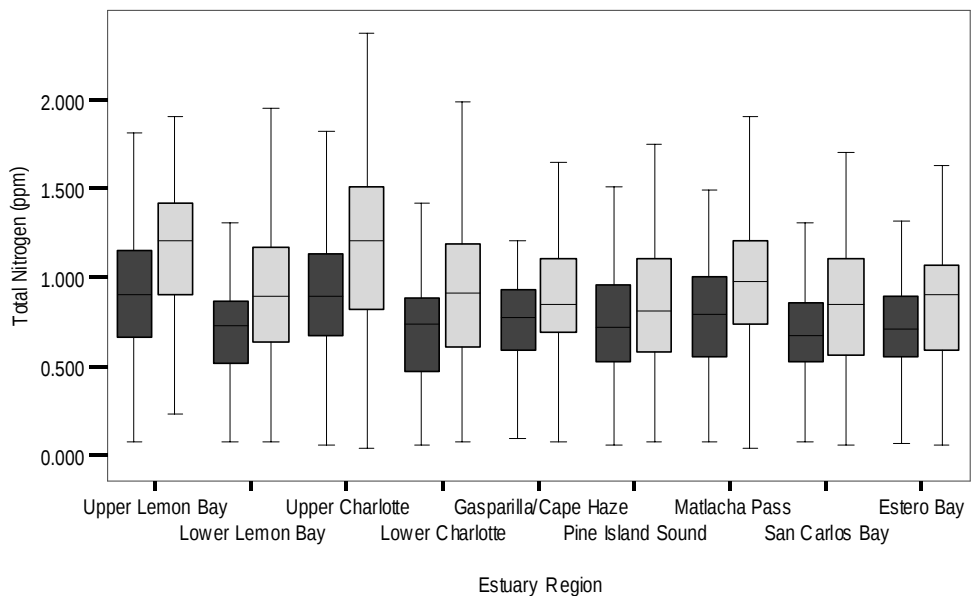


Figure 5.18: Seasonal total nitrogen Box plot results for each estuary region. Outliers are not shown. ■ Dry Season ■ Rainy Seas

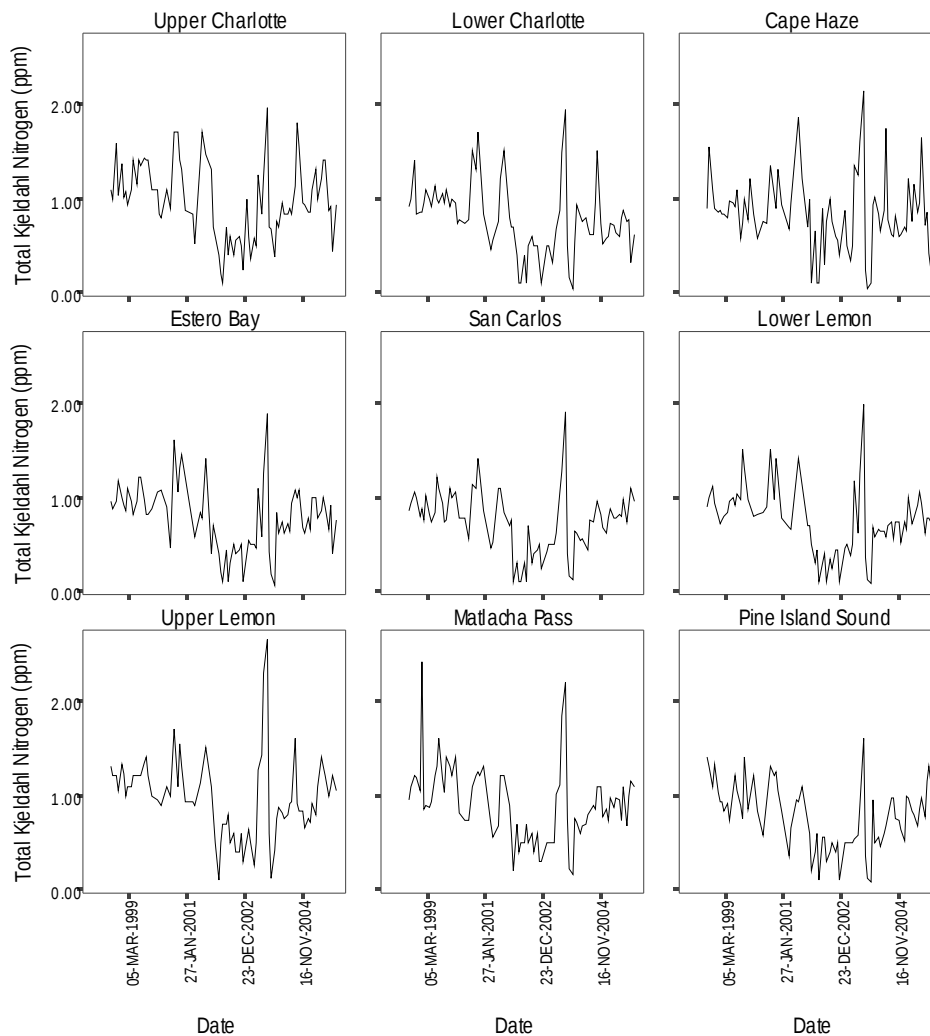


Figure 5.19: Time series plot of total Kjeldahl nitrogen (ppm) for 1998 through 2005. Each line/point represents the monthly median from all sites in each aquatic preserve.

Table 5.16: Total Kjeldahl nitrogen (ppm) trends results

	Data Points	Kendall's		correlation			
	Read	Test Statistic	z	coefficient	p (2 tailed)	slope	intercept
Upper Lemon Bay	80	-47	-2.095	-0.203	0.0362	-0.0535	1.2410
Lower Lemon Bay	81	-47	-2.065	-0.197	0.0389	-0.0380	0.9210
Upper Charlotte	83	-35	-1.484	-0.141	0.1378		
Lower Charlotte	83	-69	-2.989	-0.277	0.0028	-0.0500	1.0050
Gasparilla/Cape Haze	81	-39	-1.711	-0.165	0.0870		
Pine Island Sound	80	-44	-1.978	-0.190	0.0479	-0.0400	1.0250
Matlacha Pass	81	-42	-1.860	-0.178	0.0629		
San Carlos Bay	81	-33	-1.461	-0.140	0.1440		
Estero Bay	80	-32	-1.400	-0.136	0.1614		

Bold values significant at the .05 level

J. Phosphorus

1. Background

Phosphorus, like nitrogen, is an essential nutrient for aquatic life yet, in excess, poses a threat to water quality and estuary health. All organisms require phosphorus for growth and energy transport, and phosphorus is considered to be the ultimate limiting nutrient over long (geological) time scales, due to its long residence time in the world's oceans (Benitez-Nelson 2000). However, due to soil and bedrock chemistry within the Charlotte Harbor Watershed, Charlotte Harbor and the surrounding region are phosphorus enriched (Froelich et al 1985). The phosphorus cycle in aquatic environments is somewhat more complex than that of nitrogen due to the constant remineralization. Phosphorus enters the aquatic system mostly in the inorganic form (P_2O_4 and PO_4^{3-}) from riverine sources due to the weathering of crustal materials and from anthropogenic sources such as deforestation and fertilizer use. To a much lesser extent, inorganic phosphorus also enters the aquatic environment via atmospheric deposition. This inorganic phosphorus is then available for plant uptake and subsequently converted to its organic form within the plant tissue which may then be consumed by primary consumers. Finally, organic waste products are once again converted to inorganic phosphorus by bacterial remineralization within the microbial food web and deposited in the sediment or re-suspended into the water column. This process can be extremely rapid and the phosphorus may be recycled from inorganic to organic numerous times prior to being burial or flushed from the estuarine system (Benitez-Nelson 2000). For this study, phosphorus is the total concentration of organic and inorganic forms of phosphorus.

Like nitrogen, phosphorus levels in estuaries are a function of physical processes that occur naturally within the aquatic environment. For example, when under low DO conditions, phosphorus that is bound to sediment particles is released back into the water column, resulting in excess of dissolved phosphorus (EPA 1993). In most aquatic systems, photosynthetic production is limited by the concentration of phosphorus in the water column. However, in the coastal Charlotte Harbor region, the availability of nitrogen, rather than phosphorus, limits photosynthetic production, although the relationship varies seasonally and spatially (Montgomery et al 1991). Although phosphorus is not the primary nutrient limiting photosynthetic growth, excess phosphorus in the system could pose serious risks in the Charlotte Harbor region (Martin and Kim 1977).

2. Status and Trends Results

Phosphorus summary statistics and status results are given in Tables 5.17 and 5.18 and Figures 5.20-5.22. Total phosphorus (TP) varied significantly ($p < 0.05$) across the study area ranging from 0.005 to 1.5 ppm. The median TP value (0.24 ppm) from all sites was higher than average, ranking in the top 90th percentile of Florida's estuaries (Hand 2004). Upper Lemon Bay (0.18 ppm) and Upper Charlotte Harbor (0.24 ppm) had the highest TP median values compared to other Charlotte Harbor estuaries and were higher than average compared to typical Florida estuaries (Hand 2004). The TP values across the remaining estuary regions were average relative to values from

estuaries across the state of Florida (Hand 2004). For site specific summary statistic and status results, see Appendix A.

Region wide phosphorus varied seasonally across during the study period ($p < 0.05$). The TP was significantly higher ($p < 0.05$) during the rainy season in Upper Lemon Bay, Upper and Lower Charlotte Harbor and Matlacha Pass. Alternatively, TP was significantly higher during the dry season in Estero Bay. There were no significant seasonal differences in TP in Gasparilla/Cape Haze, San Carlos Bay, Lower Lemon Bay and Pine Island Sound. For a visual comparison of seasonal results, see Figure 5.21, with detailed statistical results given in Appendix B.

There are no numerical criteria for phosphorus for Florida's estuaries, therefore CHEVWQMN TP results were not compared to any defined water quality standards.

Only one significant trend in total phosphorus was detected across the nine estuary regions. The TP values significantly increased in Upper Charlotte Harbor at a rate of 0.01 ppm per year from 1998 through 2005. For visual trend assessment, time series plots are included in Figure 5.22, with detailed analysis results given in Table 5.18.

3. Discussion

The TP in the Charlotte Harbor region was generally average compared to typical Florida values, with higher than average phosphorus in Upper Lemon Bay and Upper Charlotte Harbor. The TP levels significantly increased in Upper Charlotte Harbor from 1998 through 2005. Sources of phosphorus in estuaries include fertilizers, agricultural and urban land uses, phosphate mining, waste water treatment and storm water runoff, as well as natural deposits within the Charlotte Harbor Watershed (EPA 1993, Fourqurean and Cai 2001). In the Charlotte Harbor region, freshwater flow from major rivers is a source for phosphorus entering the estuary (Morrison et al 1998). The Peace River watershed contributes about 85% of total phosphorus loads into the Charlotte Harbor estuaries (Hammett 1990).

Table 5.17: Summary and status of total phosphorus (ppm) results for each estuary region

	N	Min	Max	Mean	SE	Median	Median Rank within the Charlotte Harbor Estuaries*	Median compared to Typical FL Estuary Percentiles**	Status Relative to Typical FL Estuaries***
Upper Lemon Bay	228	0.010	1.080	0.199	0.007	0.180	8	80	higher than average
Lower Lemon Bay	275	0.010	0.420	0.084	0.003	0.070	4	50	average
Upper Charlotte	532	0.010	1.500	0.305	0.009	0.240	9	90	higher than average
Lower Charlotte	215	0.005	0.420	0.114	0.005	0.100	7	60	average
Gasparilla/Cape Haze	150	0.005	0.350	0.093	0.005	0.080	6	50	average
Pine Island Sound	330	0.005	0.900	0.073	0.004	0.060	1	40	average
Matlacha Pass	212	0.010	0.290	0.084	0.003	0.076	5	50	average
San Carlos Bay	263	0.005	0.270	0.069	0.002	0.060	1	40	average
Estero Bay	297	0.005	0.500	0.070	0.003	0.060	1	40	average
All Sites	2502	0.005	1.500	0.140	0.003	0.240		90	higher than average

*Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

**Median value compared to typical Florida estuarine water quality percentile distributions (Hand 2004)

***above average conditions < 40 , $40 \leq$ average < 70 , below average conditions ≥ 70

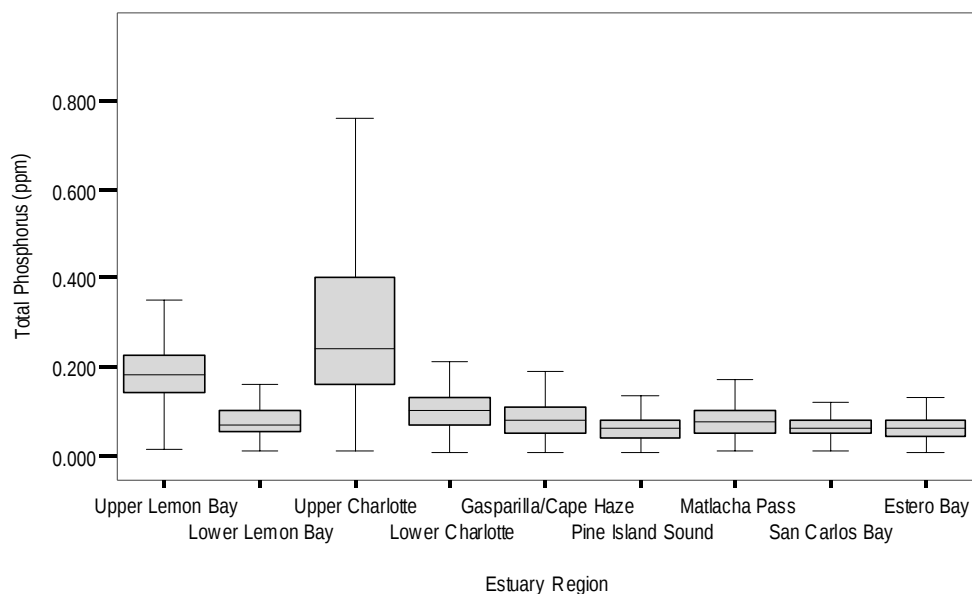


Figure 5.20: Total phosphorus box plot results for each estuary region. Outliers are not shown.

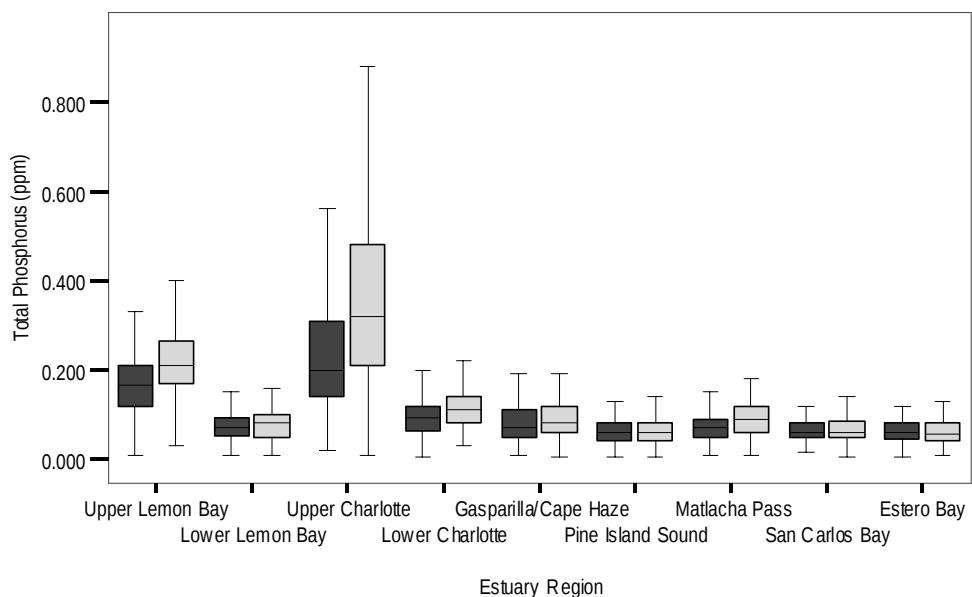


Figure 5.21: Seasonal total phosphorus box plot results for each estuary region. Outliers are not shown. ■ Dry Season ■ Rainy Season

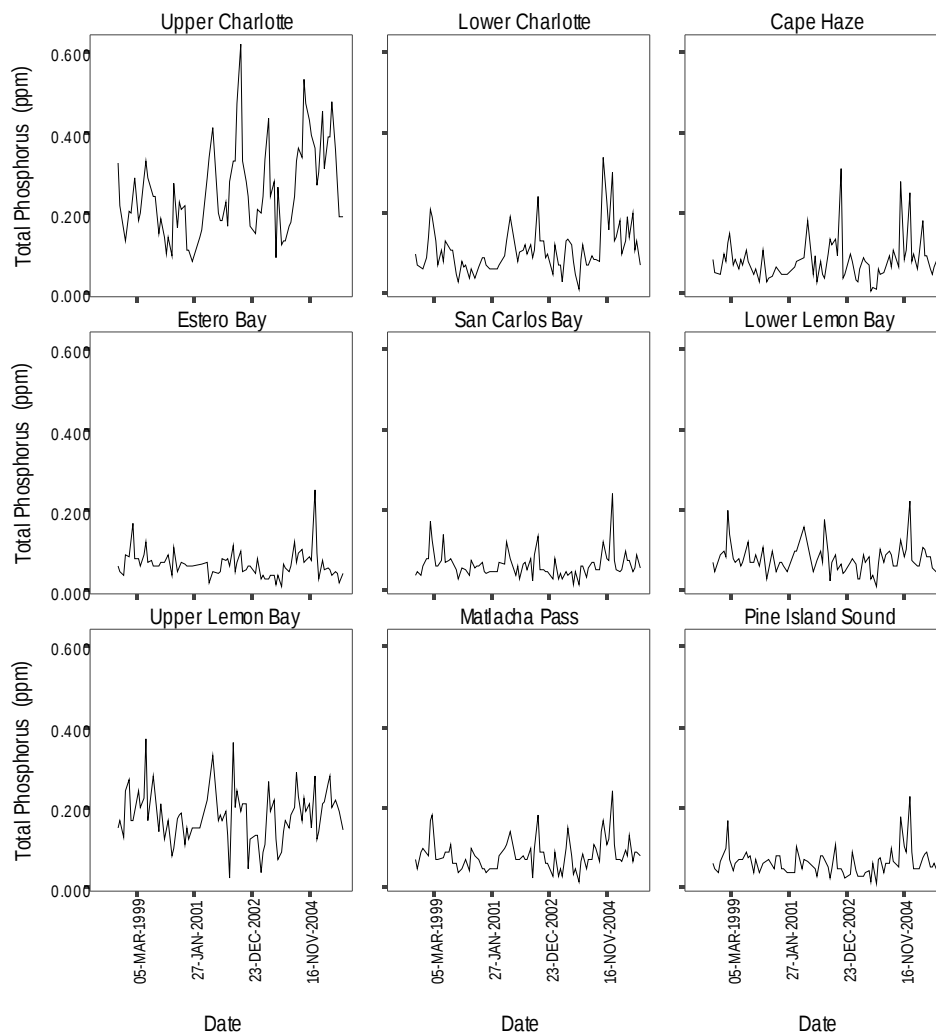


Figure 5.22: Time series plot of total phosphorus (ppm) for 1998 through 2005. Each line/point represents the monthly median from all sites in each aquatic preserve.

Table 5.18: Total phosphorus (ppm) trends results

	Data Points	Kendall's		correlation			
	Read	Test Statistic	z	coefficient	p (2 tailed)	slope	intercept
Upper Lemon Bay	81	19	0.824	0.081	0.4098		
Lower Lemon Bay	81	-33	-1.497	-0.140	0.1344		
Upper Charlotte	83	50	2.141	0.201	0.0323	0.01	0.225
Lower Charlotte	82	34	1.487	0.140	0.1371		
Gasparilla/Cape Haze	80	-9	-0.369	-0.390	0.7120		
Pine Island Sound	81	-19	-0.873	-0.080	0.3826		
Matlacha Pass	82	15	0.634	0.061	0.5261		
San Carlos Bay	82	-16	-0.693	-0.066	0.4884		
Estero Bay	83	-27	-1.219	-0.114	0.2229		

Bold values significant at the .05 level

K. Chlorophyll a

1. Background

Chlorophyll is a group of green pigments found in plants and is responsible for photosynthetic production. Chlorophyll a concentrations within the water column are used to estimate the amount of phytoplankton within a water body, which is an indirect measure of primary production occurring within the system. The amount of chlorophyll a in estuaries varies seasonally and spatially in response to temperature, nutrient levels and light availability. Increased levels of chlorophyll a generally bloom as a result of increased photosynthesis in the water column stimulated by excess nutrients, primarily nitrogen in the Charlotte Harbor estuaries (Montgomery et al. 1991). Because photosynthetic production is limited by the availability of nutrients in the system, chlorophyll a concentrations are commonly used to estimate the degree of eutrophication, or nutrient enrichment, within the estuary (e.g., Doering et. al. 2006).

For this study, chlorophyll a concentrations were estimated without correction for pheophytin. Pheophytin is a byproduct of chlorophyll a degradation that can be observed during analysis at the same absorption spectrum as chlorophyll a but is not used in photosynthesis. Subsequently chlorophyll a that is uncorrected for pheophytin may overestimate total chlorophyll a concentrations when the amount of pheophytin is substantial. It is also important to remember that, due to funding constraints, chlorophyll a levels were not analyzed from January 2002 through December of 2002.

2. Status and Trends Results

Chlorophyll a concentration summary statistics and status results from the CHEVWQMN are given in Tables 5.19-5.22 and Figures 5.23-5.25. Chlorophyll a levels were significantly different ($p < 0.05$) across the study region and period, ranging from 0.01 to 114.00 $\mu\text{g/L}$. Chlorophyll a results were generally average to lower than average compared to typical Florida estuarine values (Hand 2004) with the median value (4.74 $\mu\text{g/L}$) for all sites ranking in the 40th percentile of Florida estuaries. Upper Lemon Bay and Upper Charlotte Harbor had the highest chlorophyll a values of all nine estuary regions, with median values greater than 6.00 $\mu\text{g/L}$. Chlorophyll a concentrations were lowest in Gasparilla Sound/Cape Haze, Matlacha Pass and San Carlos Bay, with median values lower than average compared to typical Florida estuaries (Hand 2004). For site specific summary statistics and status results, see Appendix A.

Chlorophyll a varied seasonally across the study region. During the rainy season the chlorophyll a median value of 6.02 $\mu\text{g/L}$ was significantly higher ($p < 0.05$) than the dry season median value of 3.97 $\mu\text{g/L}$ for all estuary regions combined. Surprisingly, chlorophyll a concentrations did not vary seasonally in Upper Charlotte Harbor. For a visual comparison of seasonal results, see Figure 5.24, with detailed statistical results given in Appendix B.

Chlorophyll a results were compared to state regulatory criteria to characterize the status of CHEVWQMN results. The Impaired Waters Rule, 62-303.353 FAC states that waters shall be impaired if annual mean chlorophyll a levels exceed 11 $\mu\text{g/L}$, or data indicate an increase of 50% or more from historical values for at least two

consecutive years. Annual mean exceedances, as well as frequency and percent exceedances over 11 µg/L were analyzed for each site and estuary region.

Chlorophyll a annual means exceeded 11 µg/L at sites in Upper Lemon Bay, Lower Lemon Bay, Upper Charlotte Harbor, Pine Island Sound and Estero Bay. Annual means exceeded 11 µg/L most frequently in 1998, with no exceedances in 2001 or 2003. For all sites, 15% of samples exceeded 11 µg/L with exceedances occurring more frequently in the rainy season (19%) than the dry season (13%). Sites in Upper Lemon Bay and Upper Charlotte Harbor most frequently exceeded chlorophyll a standards with 28% and 25% of samples exceeding 11 µg/L, respectively. Exceedances occurred least frequently (less than 10%) at sites in Gasparilla/Cape Haze, Matlacha Pass, Estero Bay, San Carlos and Lower Lemon Bay. For annual means exceeding 11 µg/L, see Table 5.20 for detailed estuary and site specific exceedances, see Appendix C.

Changes in chlorophyll a from 1998 through 2005 for each estuary region were estimated using the seasonal Kendall trend test and the Mann-Whitney U test. There were no significant trends in chlorophyll a throughout the study region. However, it should be noted that chlorophyll a results were not available for January 2002 to December 2002 because of financial constraints, which may decrease the ability to detect significant trends. Therefore, an additional analysis was conducted using the Mann-Whitney U test. The Mann-Whitney U test was used to compare differences between the collective results from 1998 to December 2001, with the collective results from January 2003 through December 2005. For all sites across the study area, chlorophyll a results from 1998 through 2001 were significantly lower ($p < 0.05$) than the collective results from 2003-2005. However, a post hoc analysis by estuary region revealed only two significant differences between the time period groups in Upper and Lower Charlotte Harbor. For visual trend assessment, time series plots are included in figure 5.25, with detailed analysis results given in Table 5.21. For Mann-Whitney results, see Table 5.22.

3. Discussion

Chlorophyll a concentrations were generally below average compared to typical Florida estuaries (Hand, 2004), although concentrations were frequently observed above state regulatory criteria of 11 µg/L. Upper Charlotte Harbor and Upper Lemon Bay had the highest median chlorophyll a concentrations and exceeded 11 µg/L most often. No significant trends were detected during the time period. However, for all sites collectively, chlorophyll a results during the first portion of the study duration (1998-2001) were significantly lower than the second part of the study period (2003-2005). Although these findings alone cannot indicate a significant trend, results indicate that a possible increase in chlorophyll a may have occurred from 1998 through 2005.

In the Charlotte Harbor region, past studies indicate that increased chlorophyll a concentrations are primarily due to increased inorganic nitrogen and vary in response to available light within the water column (Montgomery et al. 1991, McPherson et al 1996, Doering et. al. 2006). Chlorophyll a concentrations in southwest Florida vary spatially and seasonally with nutrient concentrations, tidal circulation, freshwater discharges and light attenuating constituents (Doering et al. 2006, Montgomery et al. 1991) affecting

other estuarine responses. Effects of increased chlorophyll a levels in the Charlotte Harbor estuaries include: 1) increased light attenuation due to increased phytoplankton within the water column (Doering et al 2006, Ott et. al. 2006) and 2) hypoxia due to increased utilization of DO for decomposition of photosynthetic material (Doering et al 2006).

Table 5.19: Summary and status of chlorophyll a ($\mu\text{g/L}$) results for each estuary region

	N	Min	Max	Mean	SE	Median	Median Rank within the Charlotte Harbor Estuaries*	Median compared to Typical FL Estuary Percentiles**	Status Relative to Typical FL Estuaries***
Upper Lemon Bay	209	0.50	52.30	9.22	0.60	6.30	9	60	average
Lower Lemon Bay	255	0.01	79.46	5.55	0.42	3.92	4	40	average
Upper Charlotte	482	0.01	88.50	9.48	0.50	6.16	8	60	average
Lower Charlotte	198	0.01	34.18	5.61	0.35	4.42	6	40	average
Gasparilla/Cape Haze	145	0.50	18.20	4.49	0.31	3.58	3	30	lower than average
Pine Island Sound	298	0.01	39.70	6.52	0.34	4.98	7	40	average
Matlacha Pass	187	0.25	72.50	5.42	0.52	3.50	2	30	lower than average
San Carlos Bay	245	0.01	28.35	4.41	0.25	3.43	1	30	lower than average
Estero Bay	263	0.01	114.00	5.75	0.50	4.39	5	40	average
All Sites	2282	0.01	114.00	6.67	0.17	4.74		40	average

*Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

**Median value compared to typical Florida estuarine water quality percentile distributions (Hand 2004)

***above average conditions < 40, $40 \leq$ average < 70, below average conditions ≥ 70

Table 5.20: Chlorophyll a annual means greater than 11 $\mu\text{g/L}$ per Florida's Impaired Waters Rule

		1998		1999		2000		2001*		2003		2004		2005	
		N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
	LBFOR1													6	15.09
Upper	LBV001	4	13.81												
Lemon Bay	LBV002	4	22.45	12	11.01										
	LBV003	5	23.75	11	14.48	9	11.61								
Lower	LBV004	5	12.54												
Lemon Bay	LBV005					4	23.67								
	CHV001	5	25.60			8	12.33					10	13.95	12	17.24
	CHV002	5	13.39	11	11.54										
Upper	CHV004	5	13.40											10	11.44
Charlotte	CHV005	5	19.04	11	20.71	11	19.27								
	CHV006	5	26.23												
	CHV007	5	11.05												
	CHV013											11	16.92	12	17.03
Pine Island	PIJIM1													8	11.91
Sound	PIV002	5	12.34												
	PIV004	1	39.70												
Estero Bay	EBERS2													12	13.13
	GSV005											10	13.08		

*chlorophyll a was not collected from January 2002 through December of 2002

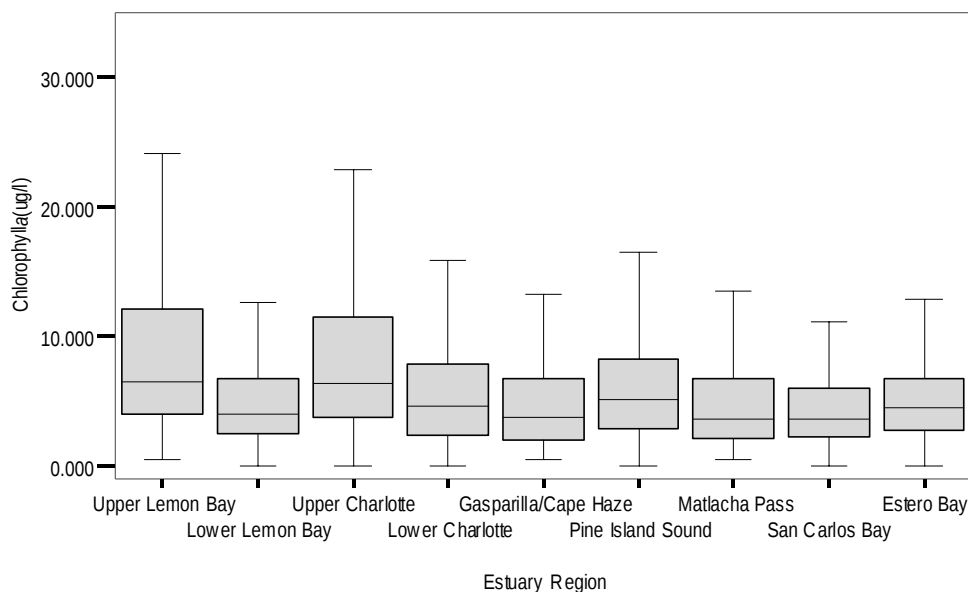


Figure 5.23: Chlorophyll a Box plot results for each estuary region. Outliers are not shown.

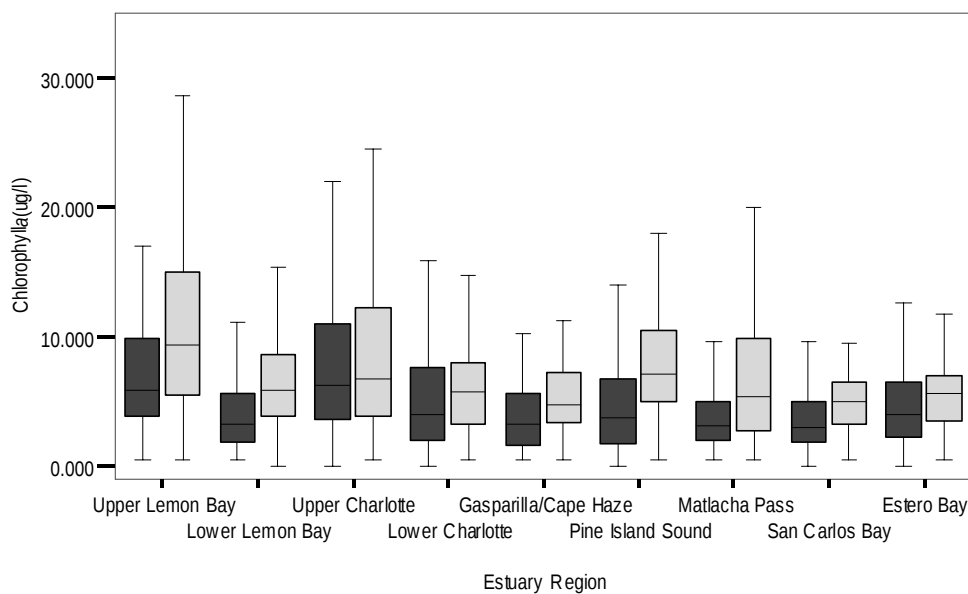


Figure 5.24: Seasonal chlorophyll a Box plot results for each estuary region. Outliers are not shown. ■ Dry Season □ Rainy Season

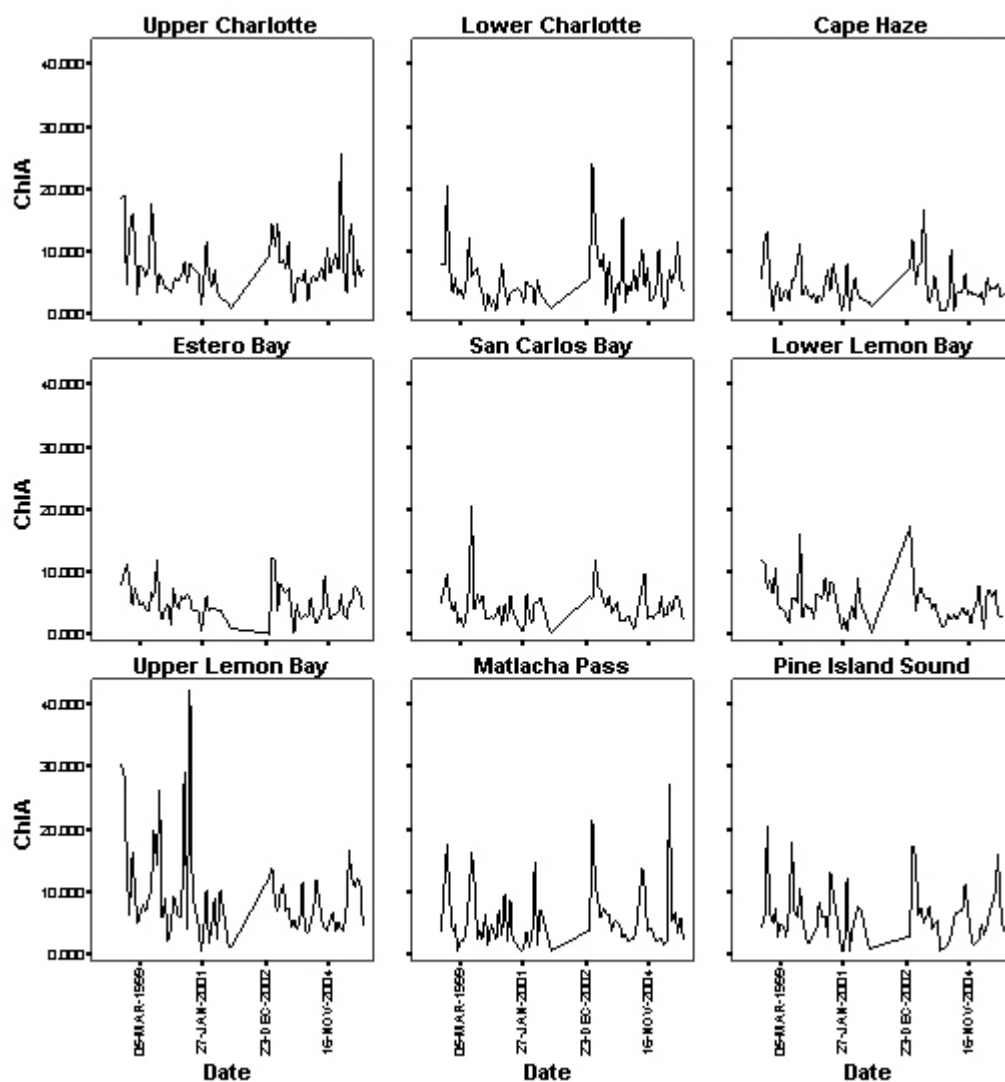


Figure 5.25: Time series plots of chlorophyll a ($\mu\text{g/L}$) for 1998 through 2005. Each line/point represents the monthly median from all sites in each aquatic preserve.

Table 5.21: Chlorophyll a ($\mu\text{g/L}$) trends results

	Data Points	Kendall's		correlation			
	Read	Test Statistic	z	coefficient	p (2 tailed)	slope	intercept
Upper Lemon Bay	79	-28	-1.257	-0.125	0.2087		
Lower Lemon Bay	79	-30	-1.350	-0.134	0.1770		
Upper Charlotte	79	16	0.698	0.071	0.4849		
Lower Charlotte	79	-7	-0.280	-0.031	0.7797		
Gasparilla/Cape Haze	79	-17	-0.751	-0.076	0.4525		
Pine Island Sound	79	-3	-0.093	-0.013	0.9257		
Matlacha Pass	79	-7	-0.283	-0.032	0.7772		
San Carlos Bay	79	-11	-0.472	-0.050	0.6372		
Estero Bay	79	-21	-0.943	-0.096	0.3456		

Bold values significant at the .05 level

Table 5.22: Mann Whitney between subjects results of chlorophyll a from 1998-2001 compared to chlorophyll a from 2003-2005

		N	Mean Rank	Sum of Ranks	Mann-Whitney U	Wilcoxon W	Z	p
All Sites	1998-2001	1128	1098.58	1239198	602442	1239198	-4.01	0.0000
	2003-2005	1182	1209.82	1430007				
Upper Lemon Bay	1998-2001	103	105.31	10847	5427	11098	-0.73	0.9420
	2003-2005	106	104.7	11098				
Lower Lemon Bay	1998-2001	111	131.67	14615.5	7584.5	18024.5	-0.70	0.4850
	2003-2005	144	125.17	18024.5				
Upper Charlotte	1998-2001	242	220.85	53445	24042	53445	-3.27	0.0010
	2003-2005	240	262.33	62958				
Lower Charlotte	1998-2001	103	89.29	9196.5	3840.5	9196.5	-2.61	0.0090
	2003-2005	95	110.57	10504.5				
Gasparilla/Cape Haze	1998-2001	107	98.94	10586.5	4808.5	10586.5	-0.54	0.5920
	2003-2005	94	103.35	9714.5				
Pine Island Sound	1998-2001	140	145.18	20325.5	10455.5	20325.5	-0.81	0.4150
	2003-2005	158	153.33	24225.5				
Matlacha Pass	1998-2001	99	87.44	8657	3707	8657	-1.76	0.0790
	2003-2005	88	101.38	8921				
San Carlos Bay	1998-2001	133	116.87	15544	6633	15544	-1.48	0.1400
	2003-2005	112	130.28	14591				
Estero Bay	1998-2001	114	131.04	14939	8384	14939	-0.18	0.8580
	2003-2005	149	132.73	19777				

Bold values significant at the .05 level

L. Fecal Coliform Bacteria

1. Background

Fecal coliform bacteria are microorganisms that live in the digestive track of humans and other warm blooded animals. The presence of fecal coliform bacteria in the water column is an important predictor of fecal pollution and may indicate the presence of pathogens and viruses that pose serious human health risks. The concentration of fecal coliform in coastal waters is controlled by a variety of physical, chemical and biological factors. The persistence of coliform bacteria in the estuarine environment decreases as salinity and temperature increase (Rhode and Kator 1988). Additionally, increased sunlight light penetrating the water column reduces fecal coliform bacteria viability and decreased light mitigates this affect (Fujioka et al 1981). Also, competition from other microbiological communities may limit the presence and productivity of fecal coliforms in estuarine waters (Rhode and Kator 1988). As a result, survival and presence of fecal coliforms may be greater in areas exhibiting lower light availability, salinity and temperature conditions.

2. Status and Trends Results

Fecal coliform bacteria summary statistics and status results from 1998 - 2005 are given in Tables 5.23-5.25 and Figures 5.26-5.28. Fecal coliform counts varied significantly ($p < 0.05$) across the study region and period, ranging from 1 to 1,156 cfu/100mL. Fecal coliform bacteria counts were below minimum detection limits (1 to 2 cfu/100mL) for almost 30% of samples during the study duration. The median coliform value, 24 cfu/100mL, of all sites was higher than average compared to Typical Florida estuaries (Hand 2004). Upper Lemon Bay and Upper Charlotte Harbor had the highest median coliform values of 35 and 24 cfu/100mL, respectively, ranking in the 90th and 80th percentiles, respectively. Pine Island Sound, San Carlos Bay and Lower Charlotte Harbor had the lowest fecal coliform medians of 3 cfu/100mL or less.

Across the study region, fecal coliform counts were not significantly different between rainy season and dry season. For a visual comparison of results, see Figure 5.27 with detailed seasonal comparisons in Appendix B.

Additional analysis comparing results to state regulatory criteria was conducted to characterize the status of fecal coliform bacteria for each estuary region and site. Florida's Surface Water Quality Standards state that fecal coliform bacteria counts per 100 mL:

“shall not exceed a monthly average of 200 nor exceed 400 in 10% of the samples nor exceed 800 on any one day for Class III marine and fresh waters.” Because monthly averages could not be obtained at the site level, a general summary of exceedances over 200 cfu/100mL was provided. A summary of fecal coliform bacteria status results for each site and estuary region, as it relates to Florida Surface Water Quality Standards, is provided in Table 5.24.

Frequent exceedances of all bacteria standards of 200, 400 and 800 cfu/100mL were observed over the duration of the study. A total of 3% of samples across all sites exceeded 200 cfu/100mL with 19% exceeding 400 cfu/100mL and less than 1% of samples exceeding the 800 cfu/100mL standard. Sites in Upper Lemon Bay had the

highest percent of samples exceeding 200, 400 and 800 cfu/100mL. Sites GSV005 (not within a defined estuary region) and LBV001 in Upper Lemon Bay had the highest percent exceedances over 200 cfu/100mL of all sites. There was only one sample exceeding 200 cfu/100mL in Lower Charlotte Harbor and no exceedances in Matlacha Pass.

Fecal coliform counts significantly changed from 1998 through 2005 in one estuary region. Coliform counts significantly decreased in Pine Island Sound at less than 1 cfu/100mL per year. For visual trend assessment, time series plots are included in Figure 5.28, with detailed analysis results given in Table 5.25.

3. Discussion

Fecal coliform bacteria were generally below detection limits for most sites across the Charlotte Harbor estuaries for the study period. Individual fecal coliform bacteria counts exceeded average state standards in Upper and Lower Lemon Bay, Upper Charlotte Harbor and Estero Bay. No significant difference was observed between seasonal medians or seasonal exceedances of numerical criteria. Although one trend in fecal coliform was observed from 1998 through 2005, the rate of change was less than 1 cfu/100mL.

In the Upper Lemon Bay estuary, faulty septic systems and urban storm water outfalls located close to sampling sites, may be the source of above average fecal coliform concentrations and require future investigations. The relationship between sources of fecal pollution and the presence of fecal coliform bacteria within the estuarine environment are not well understood in the Charlotte Harbor region. A thorough examination of these relationships is essential in assessing the effects of fecal pollution as it relates to estuarine and human health.

Table 5.23: Summary and status of fecal coliform bacteria (cfu/100mL) results for each estuary region

	N	Min	Max	Mean	SE	Median	Median Rank within the Charlotte Harbor Estuaries*	Median compared to Typical FL Estuary Percentiles**	Status Relative to Typical FL Estuaries***
Upper Lemon Bay	252	1	1156	98	10	35	9	90	higher than average
Lower Lemon Bay	302	1	800	41	5	8	6	60	average
Upper Charlotte	587	1	800	48	4	24	8	80	higher than average
Lower Charlotte	234	1	372	13	2	3	3	50	average
Gasparilla/Cape Haze	169	1	280	20	3	6	5	60	average
Pine Island Sound	383	1	352	13	2	2	1	40	average
Matlacha Pass	234	1	106	9	1	4	4	50	average
San Carlos Bay	310	1	364	12	2	2	1	40	average
Estero Bay	331	1	800	44	5	10	7	70	higher than average
All Sites	2802	1	1156	35	2	24		70	higher than average

*Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

**Median value compared to typical Florida estuarine water quality percentile distributions (Hand 2004)

***above average conditions < 40, 40 ≤ average < 70, below average conditions ≥ 70

Table 5.24: Fecal coliform exceedances per Florida Surface Water Regulations for each estuary

		Coliform > 200 cfu/100mL			Coliform > 400 cfu/100mL			Coliform > 800 cfu/100mL		
		# over	N	%	# over	N	%	# over	N	%
Upper Lemon Bay	Rain	14	104	13%	4	104	4%	1	104	1%
	Dry	22	148	15%	9	148	6%	2	148	1%
	Total	36	252	14%	13	252	5%	3	252	1%
Lower Lemon Bay	Rain	6	120	5%	4	120	3%			
	Dry	5	182	3%						
	Total	11	302	4%	4	302	1%			
Upper Charlotte	Rain	8	239	3%	4	239	2%			
	Dry	12	348	3%	2	348	1%			
	Total	20	587	3%	6	587	1%			
Lower Charlotte	Rain	1	98	1%						
	Dry									
	Total	1	234	0%						
Gasparilla/Cape Haze	Rain	1	67	1%						
	Dry	1	102	1%						
	Total	2	169	1%						
Pine Island Sound	Rain	2	158	1%						
	Dry	2	225	1%						
	Total	4	383	1%						
San Carlos Bay	Rain	1	125	1%						
	Dry	1	185	1%						
	Total	2	310	1%						
Estero Bay	Rain	3	137	2%						
	Dry	10	194	5%	4	194	2%			
	Total	13	331	4%	4	331	1%			
Total	Rain	36	1143	3%	12	1143	1%	1	1143	< 1%
	Dry	53	1659	3%	15	1659	1%	2	1659	< 1%
	Total	89	2802	3%	27	2802	1%	3	2802	< 1%

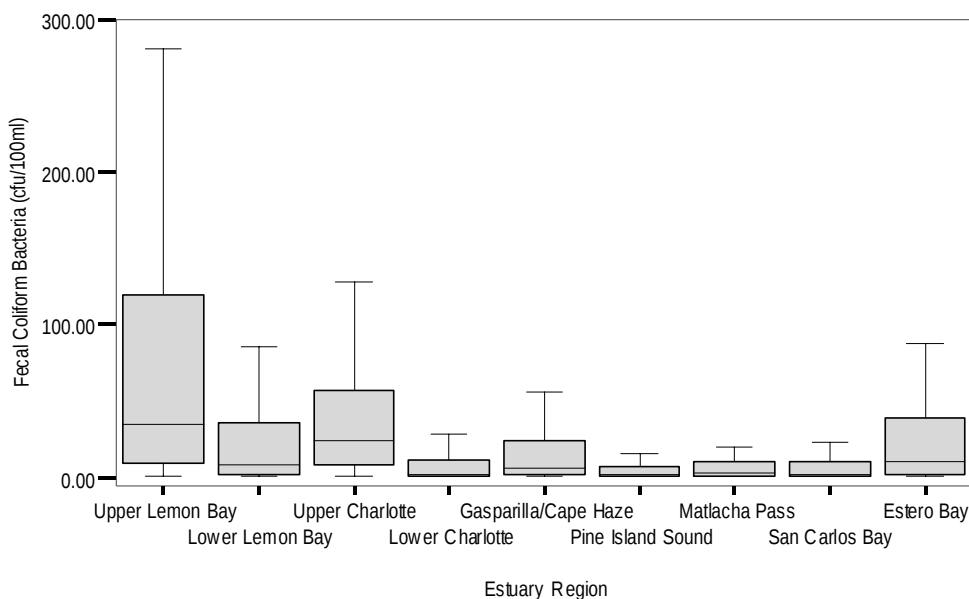


Figure 5.26: Fecal coliform bacteria Box plot results for each estuary region. Outliers are not shown.

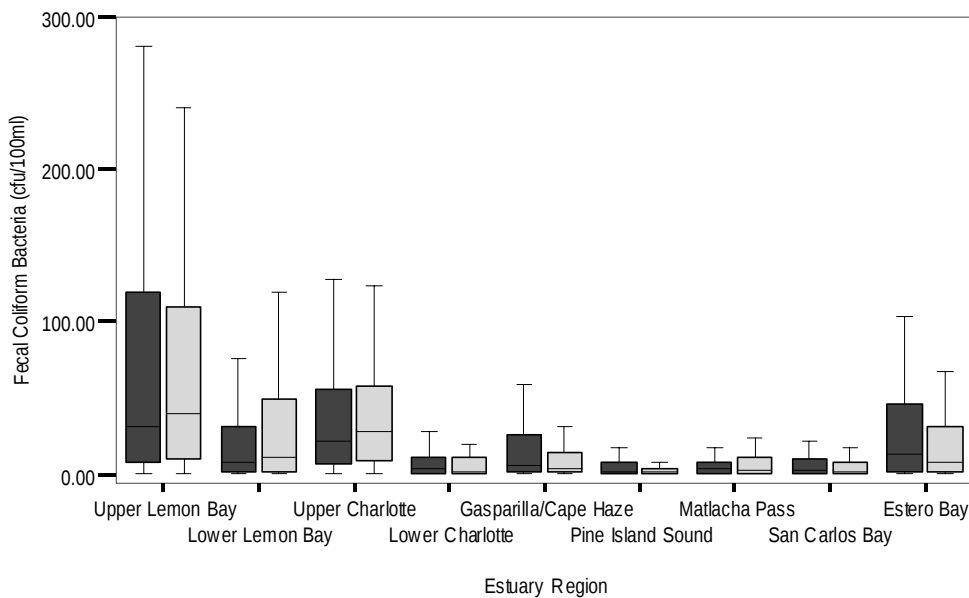


Figure 5.27: Seasonal fecal coliform bacteria Box plot results for each estuary region. Outliers are not shown. ■ Dry Season ■ Rainy Season

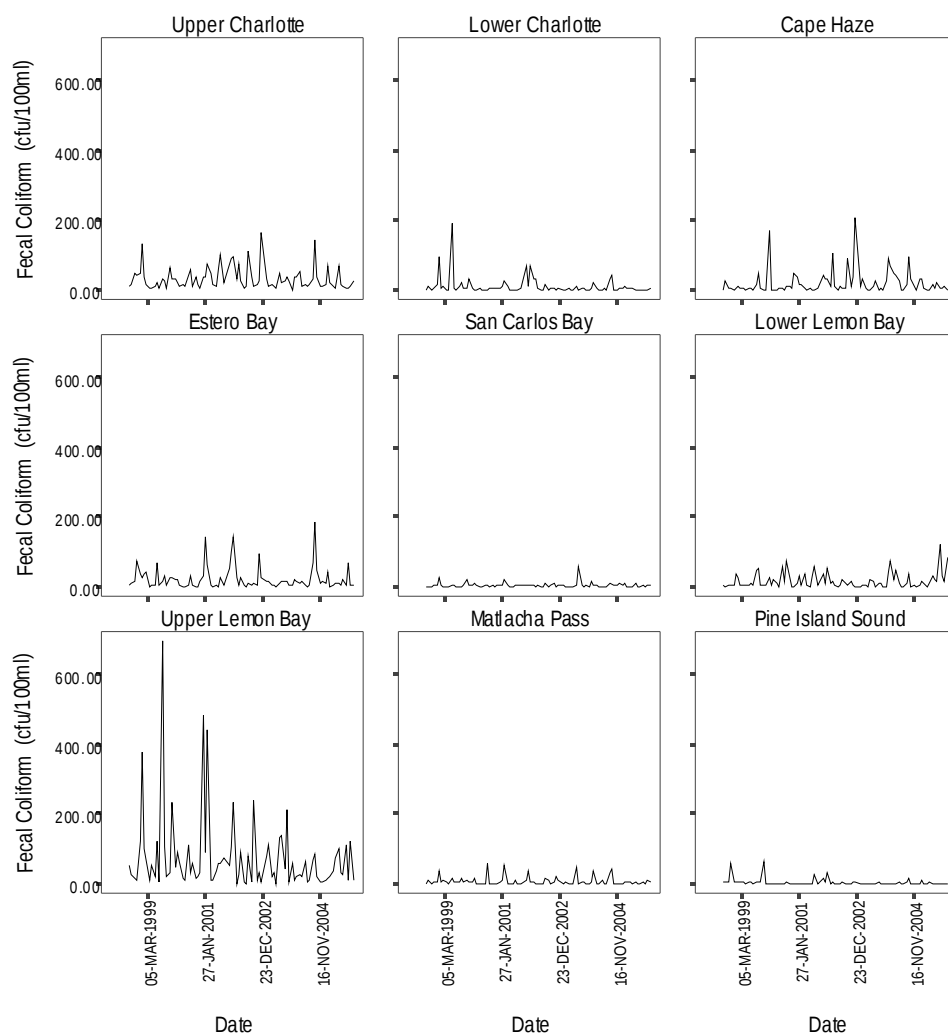


Figure 5.28: Time series plot of fecal coliform (cfu/100mL) for 1998 through 2005. Each line/point represents the monthly median from all sites in each aquatic preserve.

Table 5.25: Fecal coliform bacteria (cfu/100mL) trends results

	Data Points	Kendall's		correlation			
	Read	Test Statistic	z	coefficient	p (2 tailed)	slope	intercept
Upper Lemon Bay	87	-25	-0.9840	-0.0910	0.3252		
Lower Lemon Bay	86	21	0.8330	0.0780	0.4051		
Upper Charlotte	87	-21	-0.827	-0.077	0.408		
Lower Charlotte	87	-39	-1.5950	-0.1420	0.1107		
Gasparilla/Cape Haze	87	42	1.7230	0.1530	0.0848		
Pine Island Sound	87	-100	-4.3670	-0.3650	0.0000	-0.2500	3.1250
Matlacha Pass	87	-39	-1.6000	-0.1420	0.1097		
San Carlos Bay	86	3	0.0870	0.0110	0.9303		
Estero Bay	87	-7	-0.2470	-0.0260	0.8047		

Bold values significant at the .05 level

M. Turbidity

1. Background

Turbidity measures the amount of suspended particulate matter within the water column including both organic and inorganic material. Increased turbidity in estuaries can be a result of estuarine bottom sediments from wind and wave action, storm water runoff from the watershed, erosion and others. Excessive turbidity in estuaries has a variety of physical and biological effects, including decreased light availability for seagrass (Kirk 1983, McPherson and Miller 1994, Ott et al 2006), as well as potentially decreasing productivity, growth and survival of shellfish (Volety and Encomio 2006).

2. Status and Trends Results

Turbidity summary statistics and status results from the 1998-2005 CHEVWQMN are given in Tables 5.26-5.28 and Figures 5.29-5.31. Turbidity levels varied significantly ($p < 0.05$) over the study region and period and ranged from 0.1 to 120.00 NTU. The median value, 2.7 NTU, from all sites was average compared to typical Florida values (Hand, 2004). Estero Bay had the highest median turbidity value of 4.2 NTU and ranked in the 70th percentile of Florida estuaries.

Turbidity levels varied seasonally across the Charlotte Harbor region. For all sites, the median turbidity value of 2.7 NTU in the dry season was significantly higher ($p < 0.05$) than the rainy season median of 2.6 NTU. Although turbidity varied seasonally across the entire study region, post hoc comparisons revealed only Estero Bay and Matlacha Pass exhibited significant ($p < 0.05$) seasonal differences. For visual comparison of seasonal results, see Figure 5.30, with detailed seasonal comparisons in Appendix B.

A generalized analysis comparing results to state regulatory criteria was conducted to characterize the status of turbidity for each site. Results are shown in Table 5.27. Florida Surface Water Quality Standards state that turbidity shall never exceed 29 NTU above natural background conditions. Due to the absence of defined background turbidity levels in the Charlotte Harbor region, a general comparison the median results for all sites plus 29 NTU (i.e. 31.7 NTU) was provided for the regulatory analyses. Only three samples across the study region exceeded the 31.7 NTU standard, at three different sites in Upper Lemon, San Carlos and Estero Bays.

Turbidity trends varied significantly from 1998 through 2005 in six of the nine estuary regions. Significant decreases ($p < 0.05$) were detected in Upper and Lower Lemon Bay, Lower Charlotte Harbor, Gasparilla/Cape Haze, Pine Island Sound and San Carlos Bay. Rates of annual decrease ranged from approximately 0.1 to 0.3 NTU. For visual trend assessment, time series plots are included in Figure 5.31, with detailed analysis results given in Table 5.28.

3. Discussion

Suspended sediments within the water column come from a variety of sources including sediment loading from freshwater inflows, coastal erosion, resuspension from wave and boat action, tidal influences, and dredging. The contribution of these factors

to turbidity levels varies temporally and spatially. Freshwater inflows from the Peace, Myakka and Caloosahatchee Rivers are primary sources of sediment loading into Charlotte Harbor (Hammett 1990), with nonpoint sources contributing almost 97% of the total suspended solids load (Squires et. al. 1997). However, resuspension of sediments due to wind action may be the primary cause for increased turbidity in shallow estuaries (de Jorge and Beusekom 1995). The degree to which each of these contributes to the variability of turbidity within the system is largely determined by the water depth, sediment type, tidal influences and stratification of the water column.

Across the study region, turbidity values were generally average compared to other estuaries across the state of Florida. Turbidity was highest in Estero Bay, a shallow estuary, where wind and wave action may contribute to resuspension of bottom sediments. Although freshwater flow may carry sediments and solids into the estuary (Hammett 1990, Squires et al. 1997), results of this study indicate that dilution from inflow may be a large influence on turbidity concentrations within the study region.

Table 5.26: Summary and status of turbidity (NTU) results for each estuary region

	N	Min	Max	Mean	SE	Median	Median Rank within the Charlotte Harbor Estuaries*	Median compared to Typical FL Estuary Percentiles**	Status Relative to Typical FL Estuaries***
Upper Lemon Bay	240	0.5	66.0	2.9	0.3	2.5	3	50	average
Lower Lemon Bay	296	0.5	9.7	3.1	0.1	2.6	4	50	average
Upper Charlotte	556	0.5	24.0	3.2	0.1	2.7	6	50	average
Lower Charlotte	226	0.1	21.0	2.5	0.2	2.1	1	40	average
Gasp./Cape Haze	162	0.6	30.0	3.3	0.2	2.7	6	50	average
Pine Island Sound	368	0.3	28.0	3.7	0.2	2.6	4	50	average
Matlacha Pass	221	0.1	10.5	2.5	0.1	2.1	1	40	average
San Carlos Bay	294	0.5	120.0	4.2	0.4	3.2	8	60	average
Estero Bay	319	0.1	52.0	5.6	0.3	4.2	9	70	higher than average
All Sites	2682	0.1	120.0	3.5	0.1	2.7		50	average

*Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

**Median value compared to typical Florida estuarine water quality percentile distributions (Hand 2004)

***above average conditions < 40, 40 ≤ average < 70, below average conditions ≥ 70

Table 5.27: Sites with turbidity samples exceeding median (2.7 NTU) plus 29 NTU per Florida Surface Waters Criteria

Estuary Region	Site	# over	value	N	% over
Upper Lemon Bay	LBV003	1	66	64	108.20%
Estero Bay	EBV005	1	52	65	64.04%
San Carlos Bay	EBV001	1	120	66	278.55%

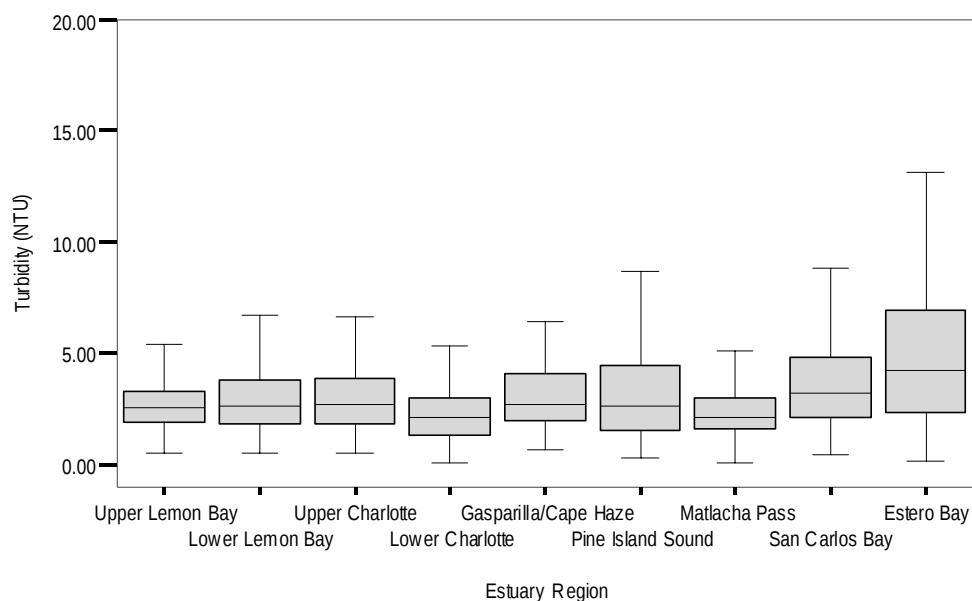


Figure 5.29: Turbidity Box plot results for each estuary region. Outliers are not shown.

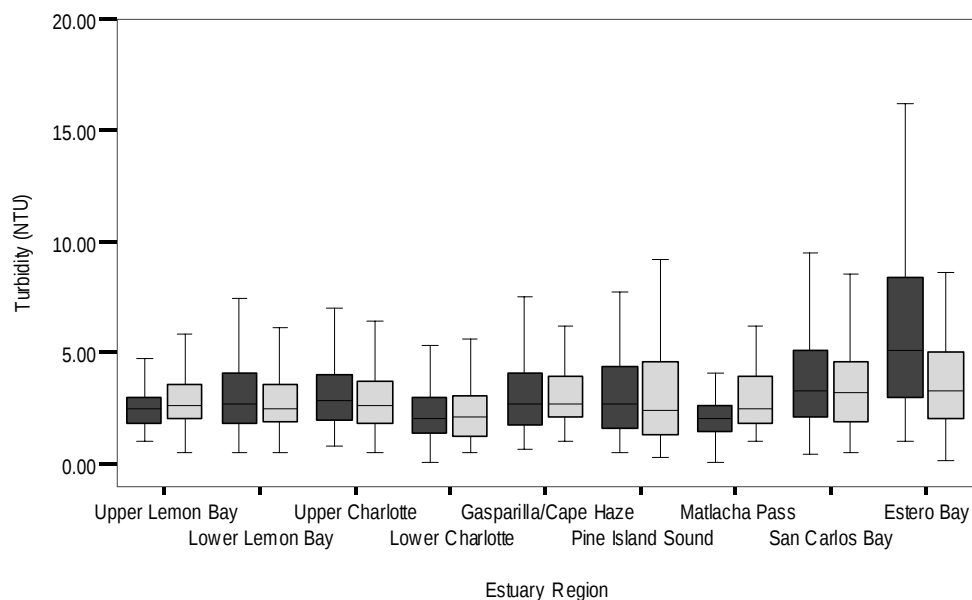


Figure 5.30: Seasonal turbidity Box plot results for each estuary region. Outliers are not shown. ■ Dry Season ■ Rainy Season

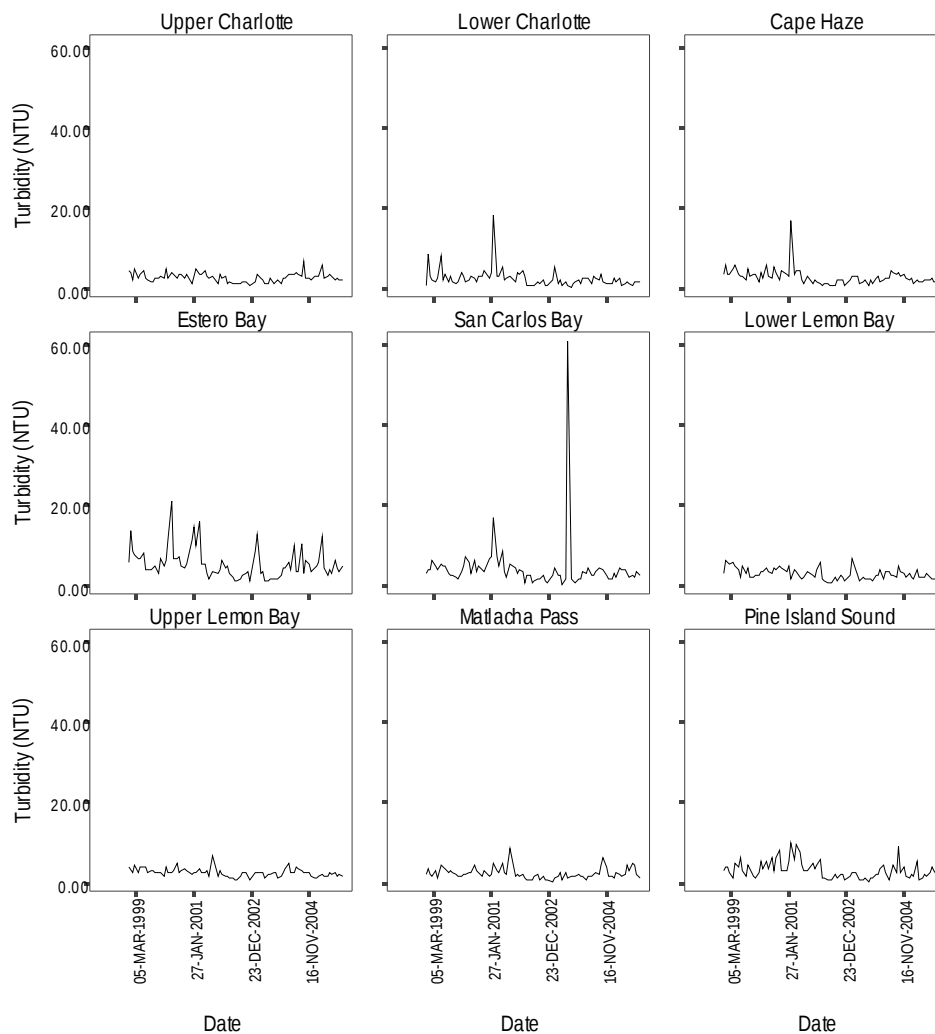


Figure 5.31: Time series plot of turbidity (NTU) for 1998 through 2005. Each line/point represents the monthly median from all sites in each aquatic preserve.

Table 5.28: Turbidity (NTU) trends results

	Data Points	Kendall's		correlation			
	Read	Test Statistic	z	coefficient	p (2 tailed)	slope	intercept
Upper Lemon Bay	81	-80	-3.591	-0.339	0.0003	-0.1850	3.3400
Lower Lemon Bay	82	-85	-3.753	-0.353	0.0002	-0.2917	4.0670
Upper Charlotte	82	-16	-0.671	-0.066	0.5023		
Lower Charlotte	82	-62	-2.834	-0.264	0.0046	-0.1000	2.5900
Gasparilla/Cape Haze	82	-69	-3.032	-0.286	0.0024	-0.2971	3.9640
Pine Island Sound	82	-65	-2.880	-0.270	0.0040	-0.2250	3.8000
Matlacha Pass	82	-34	-1.485	-0.141	0.1376		
San Carlos Bay	81	-63	-2.815	-0.268	0.0049	-0.2500	4.4000
Estero Bay	82	-42	-1.826	-0.174	0.0678		

Bold values significant at the .05 level

N. Apparent Color

1. Background

Apparent color is a visual assessment of dissolved and suspended matter within the water column. Dissolved matter may include metal ions, humus or peat, plankton, aquatic vegetation, and industrial wastes (APHA 1998). Dissolved organic matter, as measured by apparent color, is largely the result of tannins leached from vegetation in upland and submerged habitats. In southwest Florida, mangroves and salt marshes are the primary contributors to tannins. This tannin-rich water, appearing brownish in color, enters the estuary primarily via freshwater inflow from major tributaries and rivers, as well as direct runoff from the adjacent watershed. High color, occurring at low salinities, is a significant reducer of light available for photosynthetic growth, primarily seagrasses (Kirk 1983, McPherson and Miller 1994, Ott et al. 2006). For this reason, color is an indicator of salinity and freshwater inflow quantity as it relates to estuarine health.

2. Status and Trends Results

Color summary statistics and status results from the 1998 - 2005 CHEVWQMN are given in Tables 5.29 and 5.30 and Figures 5.32-5.34. Color varied significantly ($p < 0.05$) across the nine estuary regions ranging from 1 to 400 PCU. The median color value (25 PCU) for all sites across the Charlotte Harbor study area was average and ranked in the 60th percentile compared to Florida estuaries. Upper Charlotte Harbor had the highest color median of 50 PCU. Color concentrations in Upper Lemon Bay, Matlacha Pass and Estero Bay were also higher than average with median values of 30 PCU. Lower Lemon Bay had the lowest color median value of 15 PCU, ranking in the 50th percentile of Florida's estuaries.

For all sites across the region, color concentrations were significantly higher during the rainy season with a median value of 40 PCU which is double the dry season median value of 20 PCU. Seasonal differences were observed for each estuary region, with differences between seasonal medians ranging from 10 PCU in Pine Island Sound, Lower Lemon Bay and San Carlos Bay to 30 PCU in Upper Charlotte Harbor. For visual assessment of seasonal differences, see Box plot results in Figure 5.33 and for detailed seasonal comparisons, see Appendix B.

Color values varied significantly during the study period from 1998 through 2005 for seven of the nine estuary regions. Color concentrations significantly increased during this period in all estuary regions, except Upper Lemon Bay and Pine Island Sound. Rates of annual increase ranged from approximately 1 PCU in Lower Lemon Bay to 4 PCU in Upper Charlotte Harbor. For visual trend assessment, time series plots are included in Figure 5.34 with detailed analysis results given in Table 5.30.

3. Discussion

Apparent color across the study region was generally average with highest median values occurring in estuaries with greatest freshwater influence, including Upper Charlotte Harbor, Upper Lemon Bay, Matlacha Pass and Estero Bay. Color values were highest in the tidal portions of the Peace and Myakka Rivers and at sites near smaller freshwater tributaries. Significant seasonal differences in color concentrations

found in the CHEVWQMN results reinforce previous studies documenting that color concentrations are driven by freshwater influences and vary temporally as a result of increased flow from rainfall during the summer months (e.g. McPherson and Miller 1987; McPherson and Miller 1994; Dixon and Kirkpatrick 1999; Doering and Chamberlain 1999; Tomasko and Hall 1999). Additionally, increasing trends in color from 1998 through 2005 correspond to decreasing salinity patterns and increased freshwater flow during study period. The increases in flow correspond to increases in rainfall associated with weather patterns that have affected the Charlotte Harbor region during recent years.

Above-average color conditions and increasing color trends, play an important role in characterizing estuarine health within the Charlotte Harbor region, especially as this relates to salinity and freshwater input. Regionally color can serve as an indicator of freshwater influence and is a primary constituent in water quality components affecting light attenuation within the water column (Kirk 1983, McPherson and Miller 1987; McPherson and Miller 1994; Dixon and Kirkpatrick 1999; Doering and Chamberlain 1999; Tomasko and Hall 1999, Ott et al. 2006). In the Charlotte Harbor region, a better understanding is needed of the relationships between color in the estuaries and dissolved organic matter input from the adjacent watershed.

Table 5.29: Summary and status of color (PCU) results for each estuary region

	N	Min	Max	Mean	SE	Median	Median Rank within the Charlotte Harbor Estuaries*	Median compared to Typical FL Estuary Percentiles**	Status Relative to Typical FL Estuaries***
Upper Lemon Bay	239	4	240	38	2	30	6	70	higher than average
Lower Lemon Bay	296	1	240	25	2	15	1	50	average
Upper Charlotte	557	4	400	70	3	50	9	80	higher than average
Lower Charlotte	226	1	140	30	2	24	5	60	average
Gasparilla/Cape Haze	162	3	120	24	1	20	3	50	average
Pine Island Sound	369	1	200	25	1	18	2	50	average
Mattacha Pass	221	1	160	37	2	30	6	70	higher than average
San Carlos Bay	294	1	160	27	1	20	3	50	average
Estero Bay	319	1	140	31	1	30	6	70	higher than average
All Sites	2683	1	400	38	1	25		60	average

*Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

**Median value compared to typical Florida estuarine water quality percentile distributions (Hand 2004)

***lower than average < 40, 40 ≤ average < 70, higher than average ≥ 70

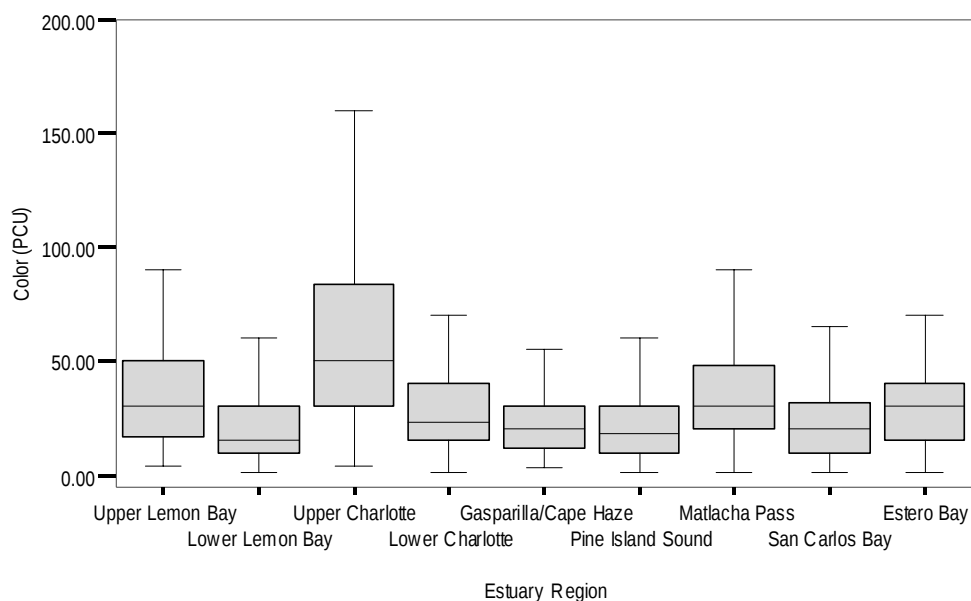


Figure 5.32: Color Box plot results for each estuary region. Outliers are not shown.

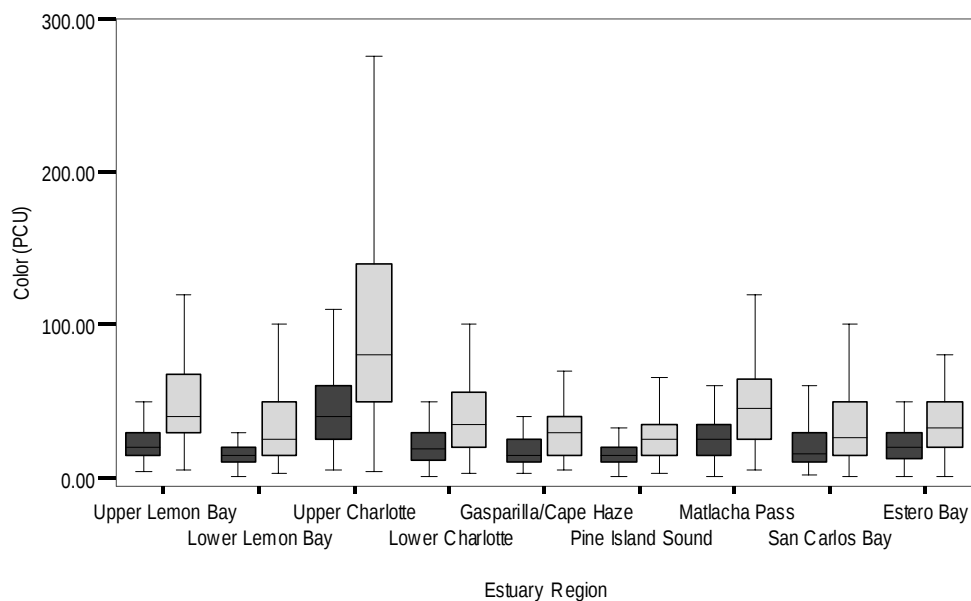


Figure 5.33: Seasonal color Box plot results for each estuary region. Outliers are not shown. ■ Dry Season ■ Rainy Season

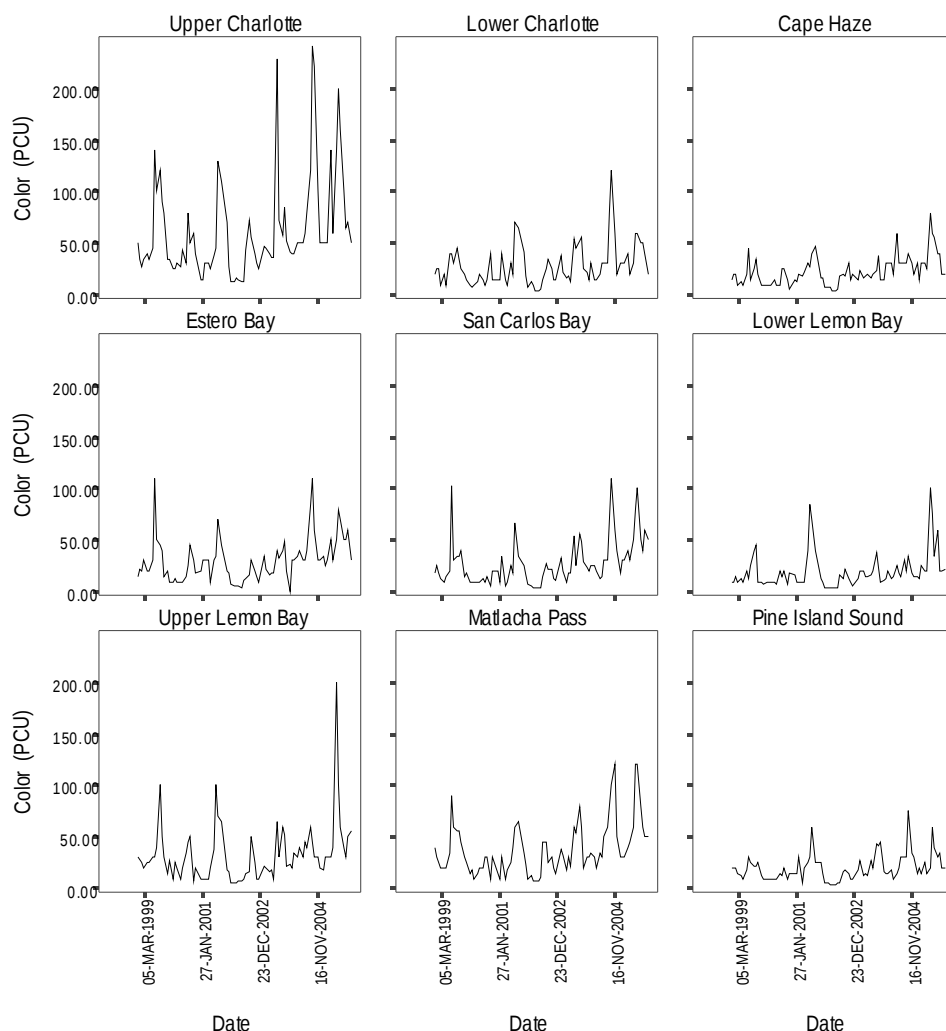


Figure 5.34: Time series plot of color (PCU) for 1998 through 2005. Each line/point represents the monthly median from all sites in each aquatic preserve.

Table 5.30: Color (PCU) trends results

	Data Points	Kendall's		correlation			
	Read	Test Statistic	z	coefficient	p (2 tailed)	slope	intercept*
Upper Lemon Bay	81	28	1.226	0.119	0.2204		
Lower Lemon Bay	82	56	2.490	0.232	0.0128	1.250	10.00
Upper Charlotte	82	57	2.509	0.237	0.0121	4.000	34.00
Lower Charlotte	82	59	2.637	0.245	0.0084	2.000	15.50
Gasparilla/Cape Haze	82	87	3.876	0.361	0.0001	2.333	10.67
Pine Island Sound	82	42	1.853	0.174	0.0638		
Matlacha Pass	82	72	3.223	0.299	0.0013	3.250	17.00
San Carlos Bay	81	64	2.870	0.272	0.0041	3.333	6.67
Estero Bay	82	68	3.033	0.282	0.0024	2.500	20.00

Bold values significant at the .05 level

VI. Results of Water Quality Relationships within the CHEVWQMN

A. Introduction

Identifying relationships among water quality parameters is essential for understanding the dynamic biotic and abiotic interactions within the estuarine system. These relationships differ both spatially and seasonally, allowing for the characterization of both regional and temporal affects upon water quality within the Charlotte Harbor estuary regions. Furthermore, the presence of significant trends and above or below state average conditions from the CHEVWQMN results emphasizes the need to investigate these relationships. Nonparametric correlation analyses were conducted to quantify relationships between parameters of interest for both rainy and dry seasons for each estuary. Additional stepwise regressions were conducted to quantify the contribution of nutrients to changes in phytoplankton production as well as the contribution of light limiting parameters to changes in water clarity. A stepwise regression limits entry into the regression equation to parameters that contribute significantly to changes in the dependent variables, which are, for these analyses, salinity, chlorophyll a or Secchi depth. Spearman's rho correlation coefficients range from -1, strong negative relationship, to 1, strong positive relationship. R^2 values are also given to guide interpretation of regression results. R^2 describes the amount of variability explained by the independent variables, the higher the R^2 the more variability is explained. Correlation and regression results for specific water quality relationships are presented in tables throughout the text, with detailed results in Appendix D.

Water quality relationships were analyzed for four major water quality interactions: 1) relationships between average annual rainfall and selected parameters, 2) the interactions between salinity and selected parameters, 3) the relationships between nutrients and phytoplankton productivity represented by chlorophyll a concentrations, and 4) the relationships between light-limiting factors and water clarity represented by Secchi disk depths. Significant relationships were detected for many parameters for all estuaries collectively and for each individual estuary region in both the rainy and dry seasons. Although relationships between many parameters were significant, the strength of these relationships, as described by the correlation coefficient, varied and was often minimal. For this reason, when interpreting water quality correlations, attention should be given both to the significance of the relationship, as well as to the strength and direction of the relationship.

B. Relationship between Rainfall and Selected Parameters

1. Background

Within aquatic systems, variations in rainfall quantities have the ability to alter many physical and chemical processes. Many times this variation is the result of large-scale weather patterns. During the early portion of the study period, 1998-2002, southwest Florida experienced a drought due to the La Niña portion of an ENSO event. In addition, the region had entered the warming phase of an AMO event. These factors combined created essentially two periods within the study, with regard to regional hydrologic conditions. The first period, from 1998 to 2000, was typified by a decrease in precipitation. The later part of the study, 2001-2005, was characterized by an increase in rainfall. This alteration in the patterns of precipitation has the potential to influence water quality parameters such as: salinity, pH, while increasing runoff, nutrients, fecal contaminants, and turbidity. Therefore it is important to understand these relationships in order to monitor the health of an estuary.

Correlation analyses were conducted to quantify the relationship between rainfall and salinity, pH, nutrients, fecal coliform bacteria and factors affecting water clarity. These relationships create the foundation upon which the other correlations in the study are based. In addition, because rainfall, runoff, and land use are related, it is important to understand the relationships between rainfall and factors that affect water quality and how they may be related to land use.

2. Results

Average annual rainfall was significantly and negatively correlated (correlation coefficient -0.86) to salinity throughout the entire region. As the quantity of rain increased, freshwater inputs increased and salinity decreased. This was true of all estuary regions, with the exception of Estero Bay. The pH within the Charlotte Harbor estuaries was also significantly negatively correlated (correlation coefficient -0.91). However, post hoc comparisons showed rainfall and pH to be significantly correlated in Lower Charlotte Harbor, Gasparilla/Cape Haze, Pine Island Sound and San Carlos Bay. See Appendix E for detailed results.

Nutrients were not found to be significantly correlated to rainfall within the region as a whole, based on the CHEVWQMN results. However, post hoc comparisons did show a significant correlation between total phosphorus and rainfall within Upper Charlotte Harbor (correlation coefficient 0.88). No other significant relationships were found for nutrients and rainfall within the region, nor were there any relationships with fecal coliform bacteria. See Appendix E for detailed results.

Within the Charlotte Harbor estuaries, no significant correlations were found for factors affecting water clarity and rainfall. However, post hoc comparisons did show color to be significantly correlated to rainfall for both Pine Island Sound and Matlacha Pass (correlation coefficients 0.80 and 0.71, respectively). See Appendix E for detailed results.

3. Discussion

Average annual rainfall was significantly and negatively correlated to changes in salinity and pH throughout the study period and region. Results varied spatially, particularly for pH for those estuary regions with direct connections to the Gulf of Mexico, i.e. Cape Haze/Gasparilla Sound, San Carlos Bay, etc. These results suggest that rainfall has a greater impact on pH for those estuary regions with limited influence from freshwater tributaries. Salinity decreased as rainfall increased for the entire region, with the exception of Estero Bay. In Estero Bay, with relatively small tributaries feeding into it, rainfall may exert less influence over salinity regimes. Upper Charlotte Harbor was the only estuary region to show a positive correlation between TP and rainfall. This indicates that with increased rainfall, the runoff carries the phosphate-rich soils within the watershed to the estuary region while flow resuspends the sediments, creating an increase in TP loads. In addition, due to the relationship between color and freshwater flow, significant increases in color can be explained for both Pine Island Sound and Matlacha Pass by the increased rainfall from 2001 to 2005.

C. Relationship between Salinity and Selected Parameters

1. Background

As previously discussed, salinity has a major influence on many chemical, physical and biological estuarine processes. Natural variability in salinity occurs tidally, seasonally and as a function of increased flow from major tributaries and rivers, as well as from runoff and the degree of mixing within the water column. Artificial alterations of natural hydrologic regimes such as altering the flow of major tributaries can also have serious deleterious effects on water quality and the biological communities that are adapted to narrow salinity ranges. For these reasons, understanding the potential effects of changes in salinity on other water quality parameters is essential in describing the health of the Charlotte Harbor estuary regions.

Correlation analyses were conducted to quantify the relationships between salinity and parameters that vary as a result of changes in salinity, including color, nutrients, turbidity and fecal coliform bacteria. Strong relationships between salinity and these variables help characterize the nature of these physical and chemical interactions within estuarine waters. Additionally, because decreases in salinity are related to increased flow from the watersheds, strong relationships between salinity and other parameters may link watershed uses and influences to the water quality within the estuaries.

2. Results

Salinity was significantly negatively correlated (correlation coefficient -0.71) to color across the Charlotte Harbor estuaries. As salinity decreased, color increased for both seasons and for all estuary regions. The negative correlation between color and salinity was strongest during the rainy season (correlation coefficient -0.72) and in estuaries with greater salinity variability, including Upper and Lower Lemon Bay, Upper Charlotte Harbor, and Estero Bay. See Figure 6.1 with detailed results in Appendix D.

Nitrogen and phosphorus concentrations were significantly correlated ($p < 0.05$) to salinity, a factor which can influence nutrient concentrations. Concentrations of TP were also significantly and negatively correlated with salinity. Total nitrogen concentrations decreased along an increasing salinity gradient, although this relationship was weaker than for salinity and phosphorus. The correlation between nitrogen and salinity was stronger during the rainy season (-0.37) and in estuaries with strong freshwater influence including Upper Lemon Bay (-0.39) and Upper Charlotte Harbor (-0.44). See Figures 6.2 and 6.3 and Appendix D for detailed results.

Salinity was also significantly and negatively correlated to turbidity (correlation coefficient 0.20), although the relationship was weaker compared to other significant salinity correlations. However, post hoc comparisons revealed that turbidity levels were not significantly correlated to salinity in regions with strong freshwater influence, such as Upper Charlotte Harbor and Matlacha Pass. See Figure 6.4 and Appendix D for detailed results.

Fecal coliform was significantly and negatively correlated with changes in salinity. As salinity increased, fecal coliform decreased across the entire study region (correlation coefficient -0.34) and for both the rainy (correlation coefficient -0.40) and dry seasons (correlation coefficient -0.32). However, further analyses revealed that coliform was not significantly correlated to salinity in estuary regions with minimal occurrence of fecal bacteria, including Lower Charlotte Harbor, Gasparilla Sound/Cape Haze, Pine Island Sound, Matlacha Pass, and San Carlos Bay. See Figure 6.5 and Appendix D for detailed analyses.

3. Discussion

Salinity was significantly and negatively correlated to changes in color, nutrients (including both nitrogen and phosphorus), turbidity and fecal coliform bacteria. Results varied both seasonally and spatially as a possible result of increases in salinity variability during the rainy season. Results varied in some estuary regions as well, particularly Upper Lemon Bay, Upper Charlotte Harbor and Matlacha Pass. These results indicate that increases in color are significantly related to salinity declines resulting from increases in tannin-rich freshwater inflows to the estuary. Similar to previous findings, significant decreases in nutrients and bacteria, along an increasing salinity gradient, may be an indicator of the persistence of nutrients (e.g. Hammett 1990) and fecal coliform bacteria (e.g. Fujioka et al. 1981) in a tidally influenced system. In addition, due to the strong relationship between color, turbidity and salinity, a decreasing trend in turbidity, as well as an increasing color trend from 1998 through 2005, could be explained by a significantly decreasing trend in salinity across the study region.

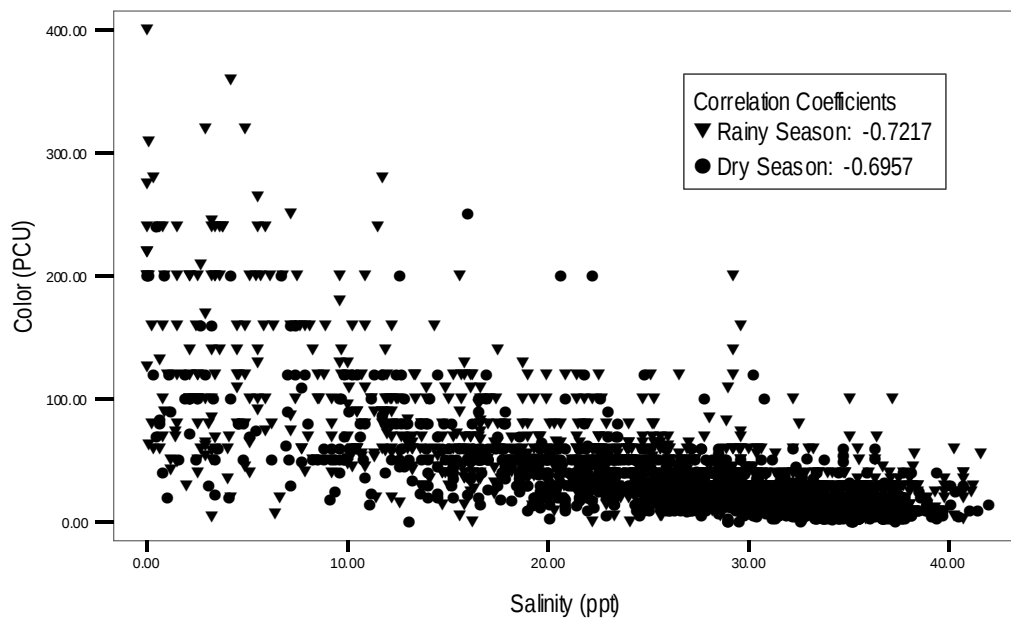


Figure 6.1: Scatter plot results of color as predicted by salinity.

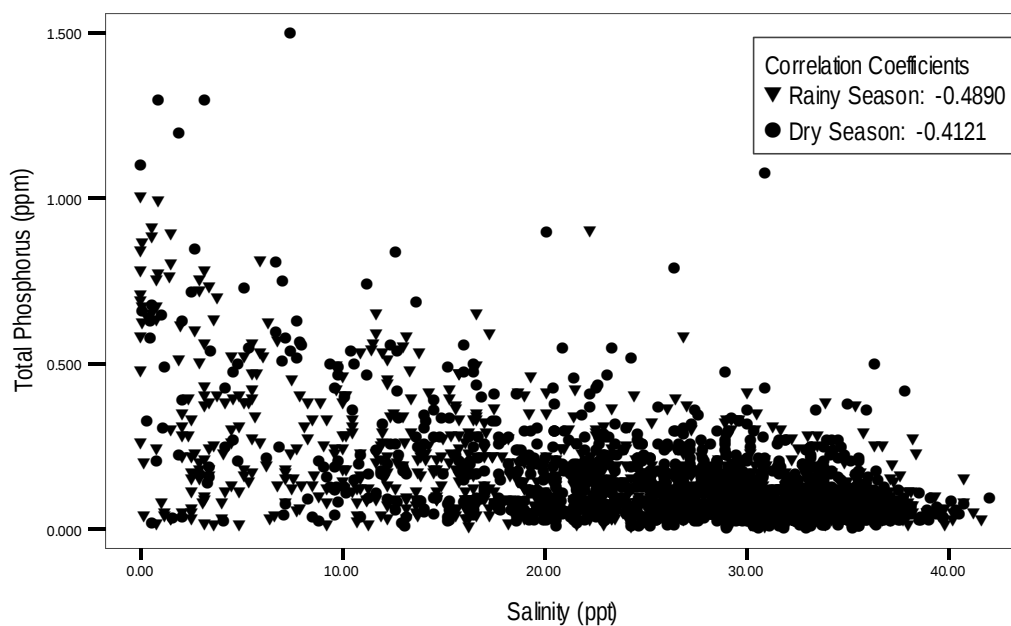


Figure 6.2: Scatter plot results of total phosphorus as predicted by salinity.

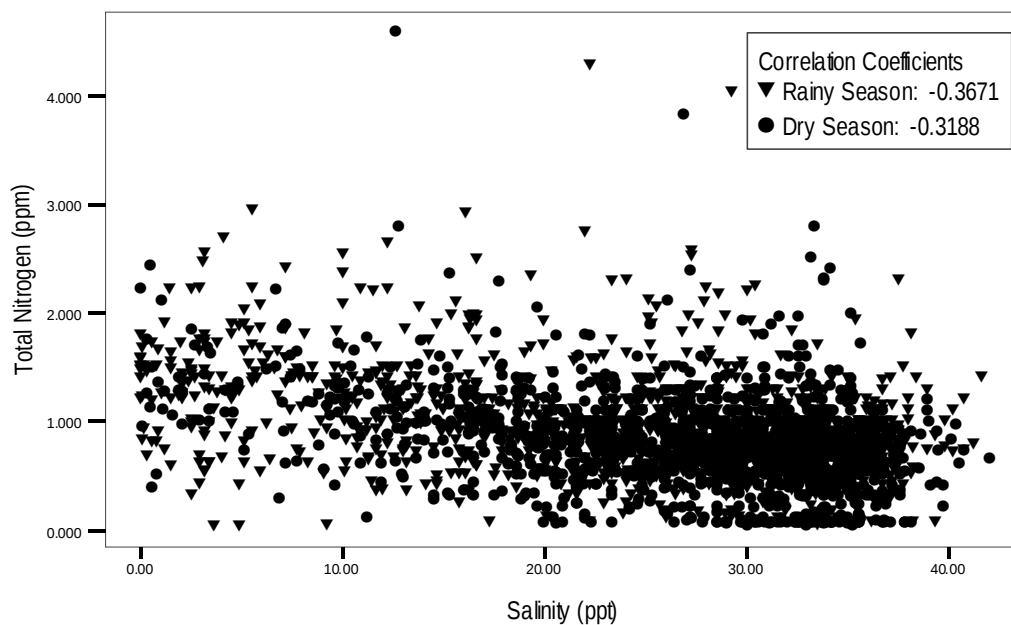


Figure 6.3: Scatter plot results of total nitrogen as predicted by salinity.

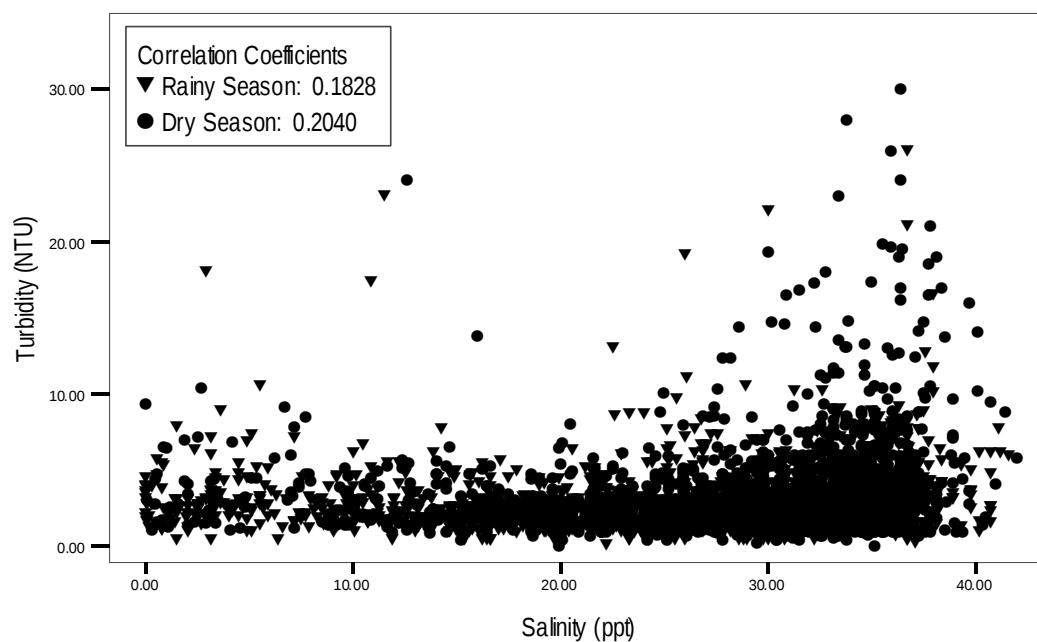


Figure 6.4: Scatter plot results of turbidity as predicted by salinity.

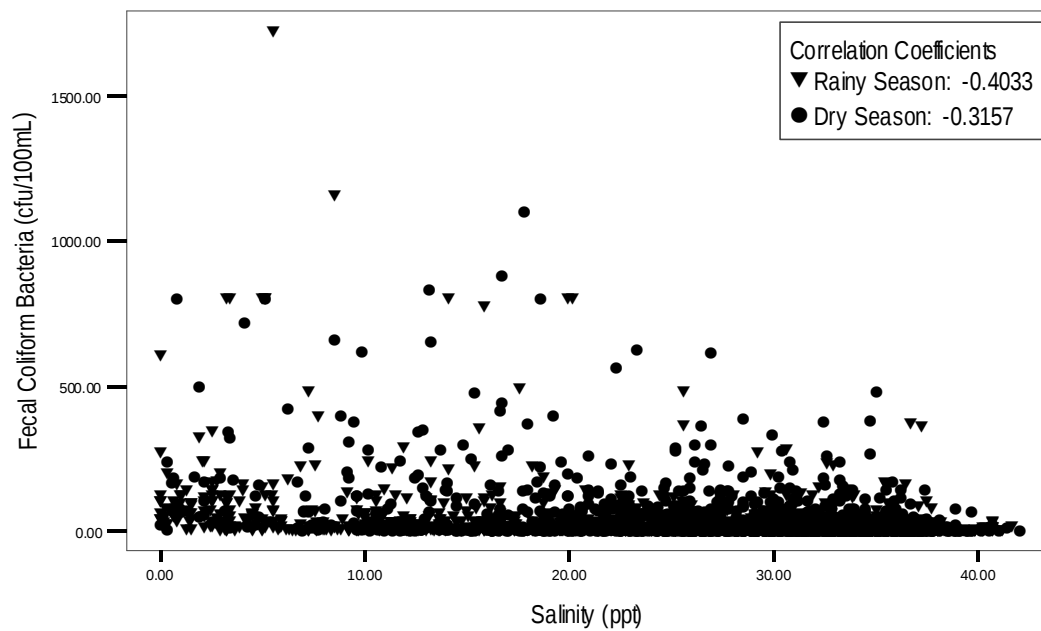


Figure 6.5: Scatter plot results of fecal coliform bacteria as predicted by salinity.

D. Nutrient and Chlorophyll a Relationships

1. Background

In the Charlotte Harbor region, nitrogen and phosphorus loadings have been shown to significantly increase phytoplankton production and harmful algal blooms, thereby affecting chlorophyll a concentrations, resulting in decreased water clarity. For these reasons, chlorophyll a is a useful tool in characterizing nutrient enrichment in the Charlotte Harbor estuaries (e.g. Doering et al 2006). Determining the effects of nutrients on chlorophyll a concentrations as an indicator of phytoplankton production is essential in managing the water quality of the nine estuary regions. Quantifying the contribution of nitrogen and/or phosphorus to changes in chlorophyll a may allow resource management efforts to target either nutrient as a means to reduce chlorophyll a levels.

2. Results

The relationship between nutrients and chlorophyll a varied seasonally and spatially across the nine estuary regions during the study period. It should be noted, however, that the strength of these relationships was minimal. Across the study area, chlorophyll a concentrations significantly increased as both total nitrogen and TP increased. For all sites, the relationship between TP and chlorophyll a (correlation coefficient 0.28) was slightly stronger than nitrogen correlations (correlation coefficient 0.23) and changes in phosphorus levels explained the most variability ($R^2 \sim 10\%$) in chlorophyll a. However, during the rainy season, total nitrogen ($\sim 4\%$) contributed statistically to most of the changes in chlorophyll a, while phosphorus ($\sim 16\%$) statistically contributed the most in the dry season. Total nitrogen was the only parameter maximizing explained variation in chlorophyll a concentrations in Upper and Lower Lemon Bay (4%), Pine Island Sound ($\sim 7\%$) and Estero Bay ($\sim 3\%$). Alternately, in Upper Charlotte Harbor phosphorus concentrations ($\sim 13\%$) statistically contributed most to changes in chlorophyll a. Neither nutrient contributed significantly to changes in chlorophyll a concentrations in Lower Charlotte Harbor, Cape Haze, Matlacha Pass and San Carlos Bay. For visual reference of nutrient relationships see Figures 6.6 and 6.7, with detailed results for each estuary regions and season in Appendix D. For regression results, see Table 6.1.

3. Discussion

Over the study region, phosphorus maximized the explained variability in chlorophyll a concentrations, although a detailed post hoc analysis revealed that nutrient relationships varied both seasonally and spatially. Montgomery et al (1991) stated that nitrogen is the known limiting nutrient in the Charlotte Harbor estuaries, although relationships between nutrients and phytoplankton production vary spatially and over time. However, the results of this study fail to indicate conclusively that nitrogen is the primary nutrient limiting chlorophyll a concentrations across the study region from 1998-2005. As a result, a stronger observed relationship between phosphorus and chlorophyll a may be more indicative of: 1) the seasonal, temporal and spatial variability of the relationship between nutrients and phytoplankton production;

and 2) an inability to accurately quantify volatile nitrogen components within the water column. Therefore, management activities aimed at reducing phytoplankton, via nutrient reductions, should consider the variability of these relationships within the Charlotte Harbor estuaries.

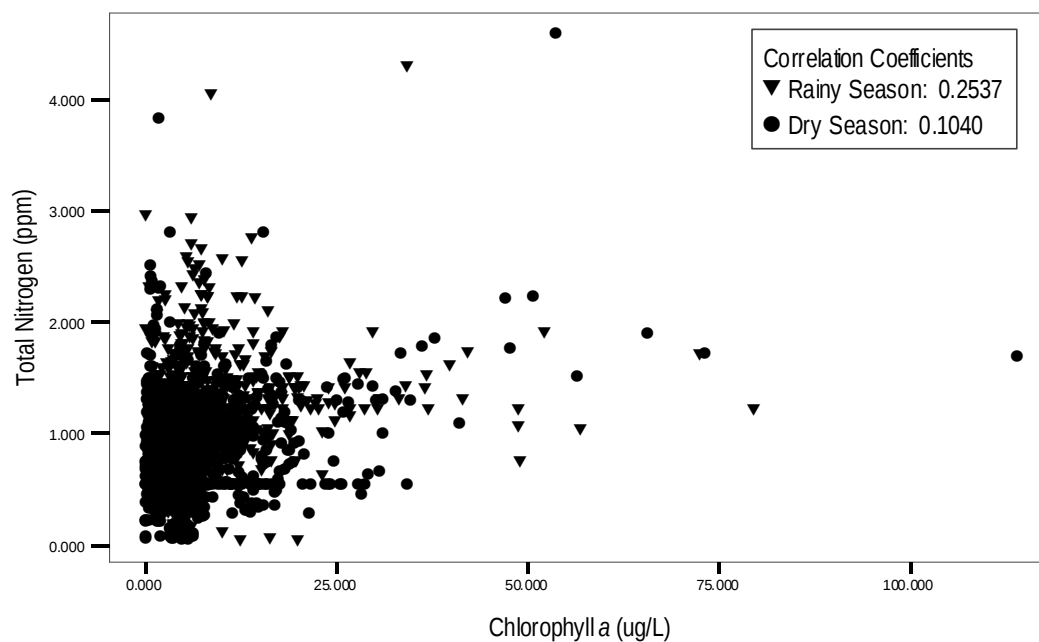


Figure 6.6: Scatter plot results of chlorophyll a as predicted by total nitrogen.

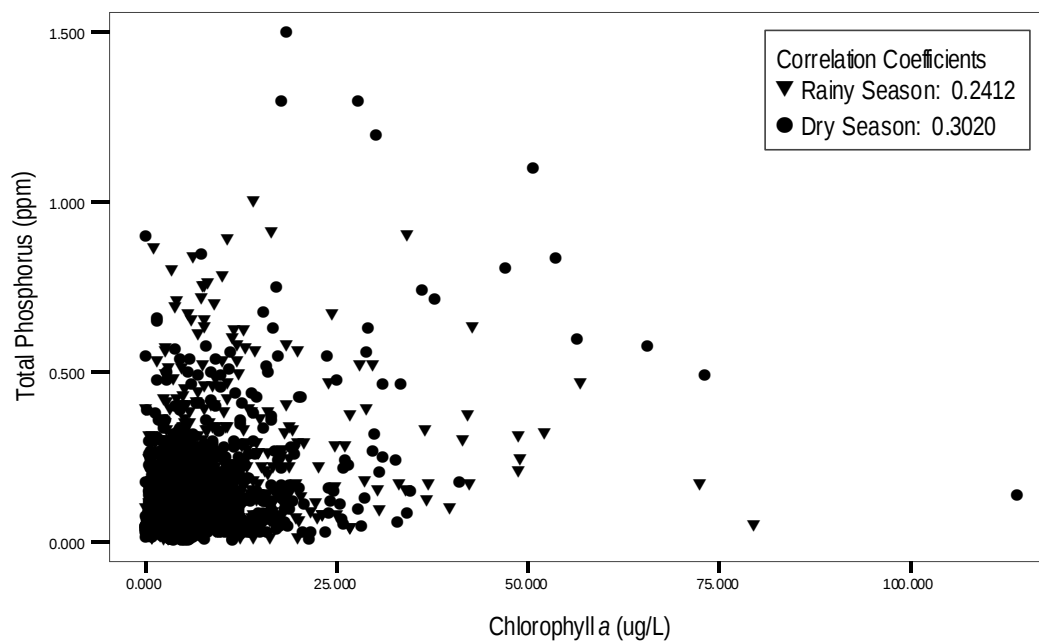


Figure 6.7: Scatter plot results of chlorophyll a as predicted by total phosphorus.

Table 6.1: Stepwise regression results of chlorophyll a as predicted by total nitrogen and total phosphorus

	Model Order ¹	Parameter	F	R	R ²	R ² Change	Adjusted R ²	SE	Regression Equation
All	1	TP	212.872	0.322	0.104		0.104	7.459	4.688 + 16.602*TP
	2	TP, TN	181.843	0.345	0.119	0.015	0.118	7.398	2.754 + 13.326*TP + 2.528*TN
Dry Season	1	TP	227.979	0.405	0.164		0.163	6.900	3.577 + 21.029*TP
	2	TP, TN	218.787	0.413	0.171	0.007	0.169	6.876	1.946 + 18.299*TP + 2.333*TN
Rainy Season	1	TN	25.734	0.192	0.037		0.036	8.091	4.719 + 3.174*TN
	2	TN, TP	15.501	0.227	0.051	0.015	0.049	8.036	4.669 + 2.245*TN + 6.792*TP
Upper Lemon Bay	1	TN	7.441	0.202	0.041		0.035	8.500	5.268 + 4.133*TN
Lower Lemon Bay	1	TN	9.546	0.206	0.043		0.038	7.083	2.681 + 3.725*TN
Upper Charlotte Harbor	1	TP	58.945	0.362	0.131		0.129	9.436	4.841 + 15.950*TP
	2	TP, TN	47.747	0.394	0.155	0.024	0.151	9.315	1.978 + 11.710*TP + 3.744*TN
Pine Island Sound	1	TN	16.383	0.258	0.066		0.062	5.931	3.239 + 4.060*TN
Estero Bay	1	TN	7.296	0.182	0.033		0.028	8.556	2.697 + 4.025*TN

¹Only parameters that contribute significantly (p<.05) are added to the regression equation

*In Lower Charlotte Harbor, Gasparilla/Cape Haze, Matlacha Pass and San Carlos Bay nitrogen or phosphorus did not contribute significantly to changes in chlorophyll a

E. Relationships between Light Limiting Parameters

1. Background

In the Charlotte Harbor region, changes in water clarity can be attributed to fluctuations in dissolved organic matter and suspended particulates such as phytoplankton (Kirk 1983, McPherson and Miller 1987, McPherson and Miller 1994, Dixon and Kirkpatrick 1999, Ott et. al. 2006). Increases in color, turbidity and chlorophyll *a* will result in increased light attenuation within the water column. Water clarity in estuarine systems is essential for submerged aquatic plant growth and depth distribution of seagrass beds (Tomasko and Hall 1999)., As a result, characterizing the relationships between light limiting parameters and water clarity is important for seagrass management within the Charlotte Harbor estuary regions as well as the implementation of numeric water quality targets for this region (Corbett and Hale 2006).

The relationships between water clarity, as described by Secchi depth, and light limiting parameters including apparent color, turbidity, and chlorophyll *a*, were examined. Correlation analyses were conducted to describe the strength and significance of relationships between these light-limiting parameters and clarity, as well as to characterize the relationships between these light-limiting factors. Additional stepwise regression analysis was conducted to quantify the effects of light-limiting parameters on changes in water clarity. These analyses were performed separately for each season and estuary to demonstrate the seasonal and spatial variability of these relationships. Results are provided in both tables and figures throughout the text, with detailed results provided in Appendix D.

2. Results

Initial analyses of the relationships between light limiting factors were conducted to evaluate if covariance exists between chlorophyll *a*, turbidity and color, in addition to the cumulative contribution of these factors to changes in water clarity. However, it should be noted that chlorophyll *a* and turbidity are components of color. Chlorophyll *a* concentrations were positively and significantly correlated to color (correlation coefficient 0.32) and turbidity (correlation coefficient 0.19). The relationship between color and chlorophyll *a* was strongest during the dry season (correlation coefficient 0.34) but was not significant in Upper Lemon Bay or Estero Bay. Chlorophyll *a* was not significantly correlated with turbidity in Upper Charlotte Harbor or San Carlos Bay. Although color and turbidity were significantly and positively correlated (correlation coefficient 0.04) for the entire study duration and across all sites, further analysis showed that the relationship was not significant during the dry season and in Lower Lemon Bay, Lower Charlotte Harbor, Gasparilla/Cape Haze, Pine Island Sound, San Carlos Bay and Estero Bay. For visual reference of relationships between light limiting factors, see Figures 6.8-6.10, with detailed results for each estuary region and season in Appendix D.

Color was the primary factor limiting water clarity across all sites and seasons ($R^2 = 0.21$). The addition of chlorophyll *a* and turbidity maximized the total variability in the regression model, although increased explained variation was minimal (change in $R^2 = 0.02$ and change in $R^2 = 0.03$, respectively). In the rainy season, color and chlorophyll *a* ($R^2 \sim 0.3$) were the only parameters that contributed significantly to changes in Secchi

depth. Alternately, during the dry season, color ($R^2 = 0.14$), followed by the addition of turbidity, maximized the variation in Secchi depth.

The primary constituent controlling changes in water clarity varied spatially across the region. Color explained the most variation in Secchi depth in Upper (28%) and Lower Charlotte Harbor (35%), Gasparilla/Cape Haze (5%), San Carlos Bay (7%) and Matlacha Pass (32%). Turbidity was the primary factor influencing changes in water clarity in Estero Bay (30%), Pine Island Sound (22%), Lower Lemon Bay (16%) and Upper Lemon Bay (10%). The addition of turbidity and chlorophyll *a* into the regression models for each varied across the region although the additional explained variation in clarity was minimal. See Table 6.2 for detailed regression results and Figures 6.11-6.13 for visual comparison of water clarity as predicted by color, chlorophyll *a*, and turbidity, with detailed results in Appendix D.

3. Discussion

Across the Charlotte Harbor region, with the exceptions of Estero Bay, Pine Island Sound and Upper and Lower Lemon Bay, and across the study period, color was the primary contributor in changes in water clarity. The contributions of turbidity and chlorophyll *a* varied spatially and seasonally. However, these results indicate that turbidity is the primary component of light attenuation in estuary regions with 1) lower than average regional color conditions, a function of minimal freshwater influence in areas like Pine Island Sound and Lower Lemon Bay or 2) above average turbidity conditions in shallow estuaries such as Upper Lemon Bay and Estero Bay.

These results indicate that management activities aimed at increasing light availability, primarily for seagrass growth, should consider both the spatial and seasonal variability of these light-limiting factors. As previously discussed, a better understanding is needed of the relationships between clarity, color and the effects of dissolved organic matter from freshwater flow and watershed runoff. Additional consideration should be given to the effects of watershed influences and estuarine processes affecting light-limiting factors. Specifically, increases in color, turbidity and chlorophyll *a* concentrations can result from: 1) freshwater inputs from major rivers including the tidal Peace, Myakka and Caloosahatchee Rivers, as well as from smaller tributaries (McPherson and Miller 1987, McPherson and Miller 1990; Dixon and Kirkpatrick 1999; Doering and Chamberlain 1999, Tomasko and Hall 1999; Doering et. al. 2006); 2) resuspension of estuary bed sediments or particulates (McPherson and Miller 1987); and 3) increases in nutrient and sediment loads from point source and non-point source watershed runoff (Doering and Chamberlain 1999, Hammett 1990).

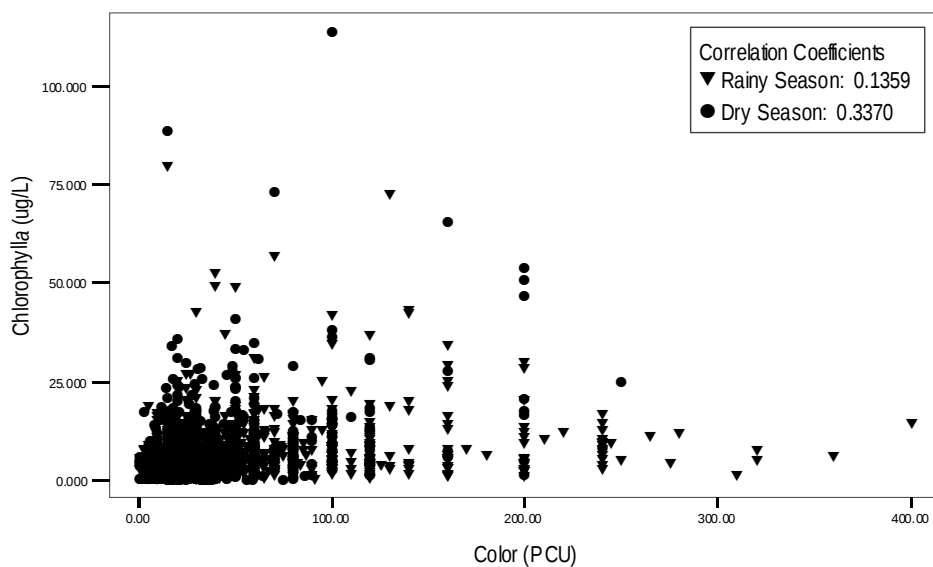


Figure 6.8: Scatter plot results of chlorophyll a as predicted by color.

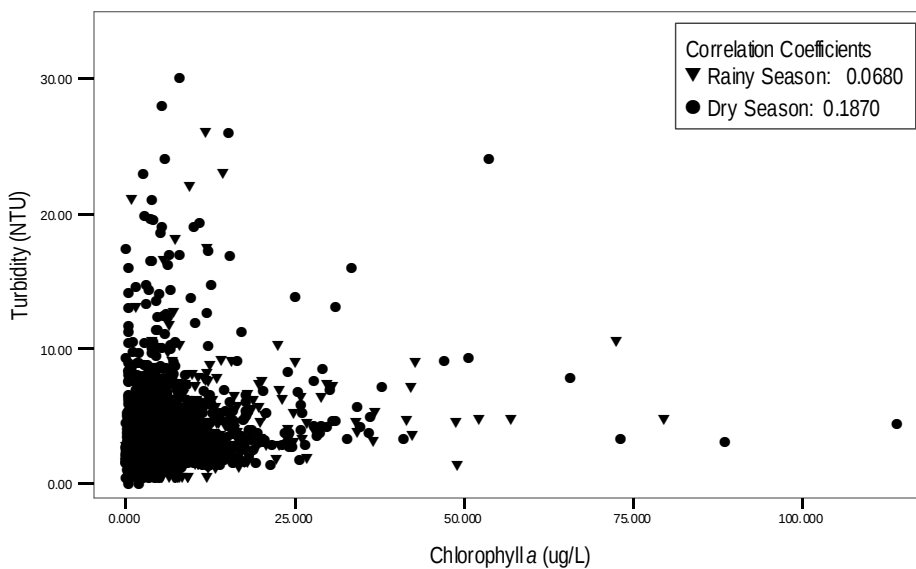


Figure 6.9: Scatter plot results of chlorophyll a as predicted by turbidity.

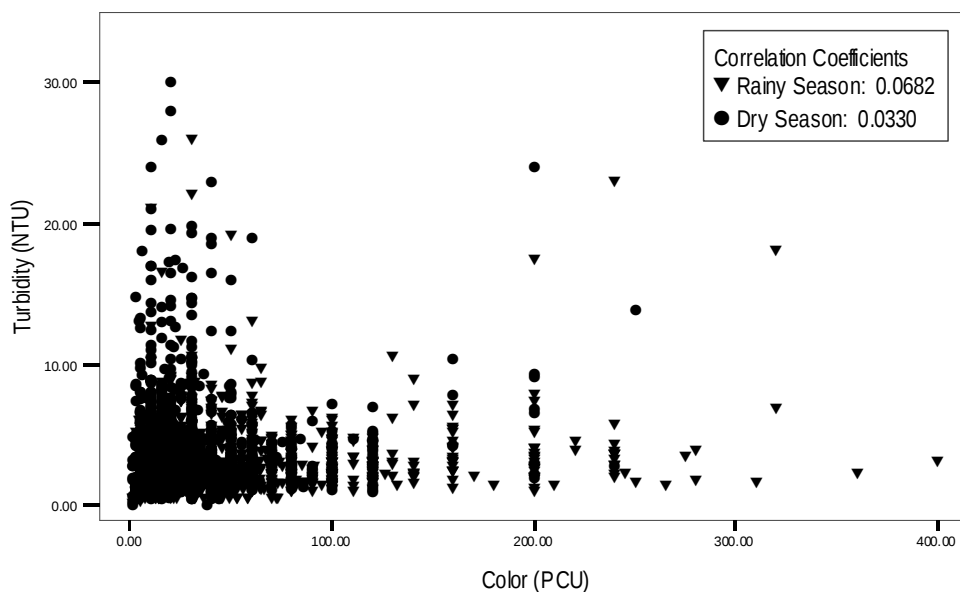


Figure 6.10: Scatter plot results of turbidity as predicted by color.

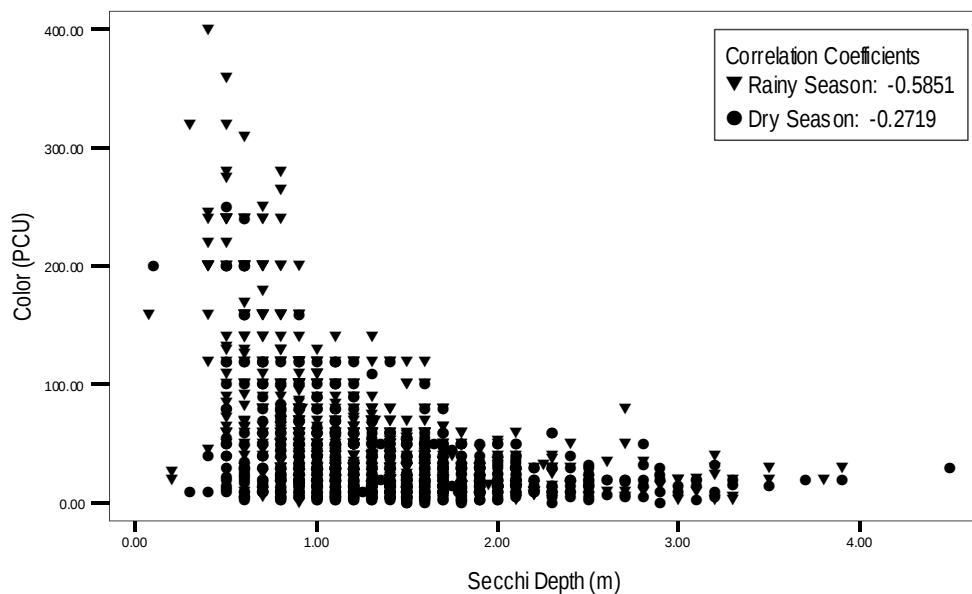


Figure 6.11: Scatter plot results of Secchi depth as predicted by color.

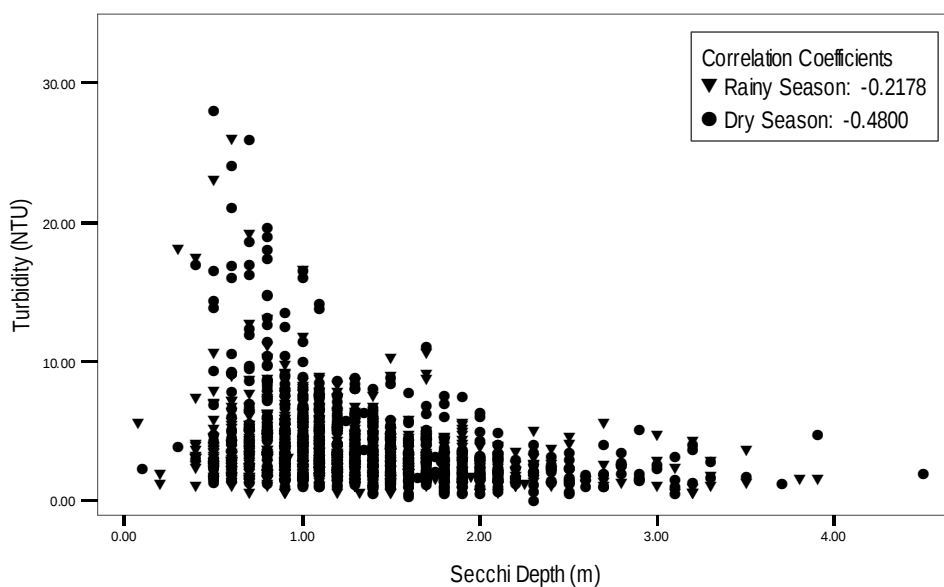


Figure 6.12: Scatter plot results of Secchi depth as predicted by turbidity.

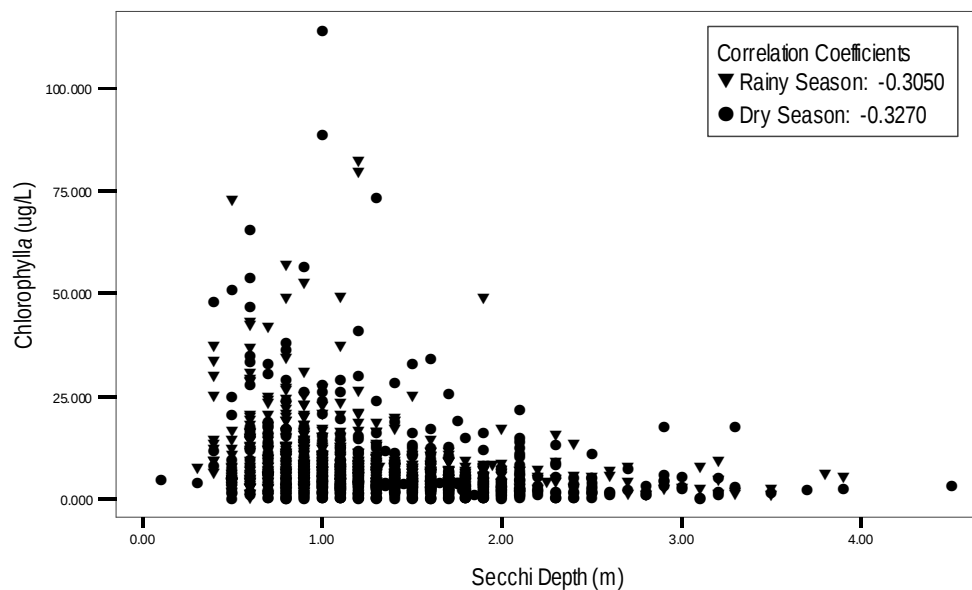


Figure 6.13: Scatter plot results of Secchi depth as predicted by chlorophyll a.

Table 6.2: Stepwise regression results of secchi as predicted by color, turbidity and chlorophyll a

	Model Order ¹	Parameter	F	R	R ²	R ² Change	Adjusted R ²	SE	Regression Equation
All	1	Color	313.385	0.458	0.210	0.210	0.209	0.524	1.600 - 0.005*color
	2	Color, Chla	37.218	0.484	0.234	0.024	0.233	0.516	1.658 - 0.005*color - 0.010* chla
	3	Color, Chla, Turbidity	48.080	0.514	0.236	0.030	0.263	0.506	1.673 - 0.005*color - 0.010*chla - 0.004*turbidity
Dry	1	Color	105.842	0.376	0.142	0.142	0.140	0.555	1.650 - 0.006*color
	2	Color, Turbidity	177.742	0.573	0.328	0.187	0.326	0.492	1.667 - 0.006*color - 0.005*turbidity
Rainy	1	Color	199.351	0.521	0.271	0.271	0.270	0.482	1.560 - 0.005*color
	2	Color, Chla	36.954	0.565	0.318	0.047	0.316	0.466	1.669 - 0.005*color - 0.015*chla
Upper Lemon Bay	1	Turbidity	9.432	0.316	0.100	0.100	0.089	0.205	1.029 - 0.039*turbidity
	2	Turbidity, Color	7.305	0.415	0.172	0.072	0.152	0.198	1.164 - 0.053*turbidity - 0.001*color
Lower Lemon Bay	1	Turbidity	24.127	0.393	0.155	0.155	0.148	0.348	1.588 - 0.063*turbidity
	2	Turbidity, Color	21.118	0.521	0.272	0.117	0.261	0.324	1.740 - 0.074*turbidity - 0.004*color
Upper Charlotte Harbor	1	Color	122.718	0.531	0.282	0.282	0.279	0.313	1.266 - 0.003*color
	2	Color, Turbidity	9.298	0.550	0.302	0.021	0.298	0.309	1.339 - 0.003*color - 0.024*turbidity
Lower Charlotte Harbor	1	Color	39.417	0.595	0.354	0.354	0.345	0.716	2.531 - 0.017*color
	2	Color, Turbidity	10.254	0.660	0.435	0.082	0.419	0.674	2.805 - 0.017 color - 0.095*turbidity
	3	Color, Turbidity, Chla	6.242	0.694	0.482	0.046	0.459	0.650	2.923 - 0.015*color - 0.086*turbidity - 0.036*chla
Gasparilla/ Cape Haze	1	Color	5.782	0.221	0.049	0.049	0.040	0.446	1.652 - 0.005*color
	2	Color, Turbidity	4.810	0.296	0.088	0.039	0.072	0.439	1.952 - 0.007*color - 0.065*turbidity
Pine Island Sound	1	Turbidity	43.271	0.473	0.224	0.224	0.219	0.560	1.719 - 0.061*turbidity
	2	Turbidity, Color	16.370	0.548	0.301	0.077	0.291	0.533	1.995 - 0.070*turbidity - 0.008*color
Matlacha Pass	1	Color	78.572	0.563	0.317	0.317	0.313	0.468	2.216 - 0.011*color
	2	Color, Turbidity	10.174	0.597	0.356	0.039	0.349	0.456	2.340 - 0.009*color - 0.113*turbidity
San Carlos Bay	1	Color	19.968	0.258	0.067	0.067	0.063	0.510	1.713 - 0.006*color
Estero Bay	1	Turbidity	67.604	0.549	0.301	0.301	0.297	0.348	1.570 - 0.058*turbidity
	2	Turbidity, Color	0.971	0.553	0.305	0.004	0.296	0.348	1.740 - 0.064*turbidity - 0.003*color

¹Only parameters that contribute significantly (p<.05) are added to the regression equation

VII. Summaries of Status and Trends Results for each Estuary

A. Introduction

Water quality status and trends were characterized for eleven parameters from 1998 through 2005 across the Charlotte Harbor and Estero Bay Aquatic Preserves. Across the region, 48 sampling sites were grouped into nine estuary regions and analyzed in this report. This section characterizes water quality conditions for each estuary region based on CHEVWQMN results. An additional summary of influences from the adjacent watersheds is provided based on the land uses and vegetative cover as described by the CHNEP's Synthesis of Existing Information (1999). Management considerations are also provided based on the unique hydrologic conditions and interactions within each estuary.

For this summary, the nine estuary regions are grouped based on Aquatic Preserve boundaries and watershed influences into five Aquatic Preserve management areas, including: Lemon Bay, Gasparilla Sound-Charlotte Harbor and Cape Haze, Pine Island Sound and Matlacha Pass, San Carlos Bay and Estero Bay. Lemon Bay Aquatic Preserve includes both the Upper and Lower Lemon Bay estuary regions. Gasparilla Sound-Charlotte Harbor Aquatic Preserve includes the Gasparilla/Cape Haze, Upper Charlotte Harbor and Lower Charlotte Harbor estuary regions. Pine Island Sound and Matlacha Pass were grouped because both are affected by the same watershed basin. A summary of the San Carlos Bay estuary region is also included even though the sites and waterbody are not within the Aquatic Preserves.

B. Lemon Bay Aquatic Preserve

Including: Upper Lemon Bay and Lower Lemon Bay Estuary Regions

1. Background

Lemon Bay Aquatic Preserve extends from Alligator Creek in south Sarasota County to the Boca Grande Bridge. The Bay is separated from the Gulf of Mexico by a series of barrier islands. There are seven tributaries (Alligator, Forked, Gottfried, Ainger, Oyster, Buck and Lemon Creeks), two Gulf passes (Stump Pass and Little Gasparilla) and connections to the Gulf of Mexico through the Venice Bypass Canal to the north and Placida Harbor to the south. The aquatic preserve boundary follows the mean high waterline of the Bay and the tributaries upstream to SR 776/SR 775. Lemon Bay is approximately 24 km (~15 mi) long and averages 1 km (~3/4 mile) wide, with an area of 31 km² (7,667 acres). The Bay is narrow and shallow, averaging 1.8 m deep at mean high water. Within the estuary, the largest submerged habitat is seagrass, comprising over 11 km² (2,700 acres) growing to approximately 1.7 m deep. The Aquatic Preserve includes two counties (Sarasota and Charlotte) and the urban areas of South Venice, Englewood and Placida.

The watershed for Lemon Bay extends downstream from the headwaters of the seven tributaries in Sarasota and Charlotte Counties and is approximately 184 km² (45,500 acres) in size. The 1990 and 2010 projected land uses in the watershed are shown in Table 7.1. The ratio of watershed land area to open water estuary area is approximately 6:1. Based on the 1990 data, the largest land use in the watershed is urban (26%), followed by rangeland (24%) and upland forest (20%), with very little agriculture (2%). Of the urban area, the majority is in residential use located adjacent to the estuary and tributaries. The most significant projected change in future land use is a very large increase (>240%) in residential acres. There are approximately 37 domestic wastewater discharges, five industrial wastewater discharges, three public water supplies and several industrial water supplies permitted within the Lemon Bay watershed. There is also a high demand for golf course and landscape irrigation (CHNEP 1999).

2. Water Quality Status and Trends Results in Upper Lemon Bay

In the Upper Lemon Bay region, CHEVWQMN results indicated generally below average water quality conditions and ranked below average compared to other estuaries in the Charlotte Harbor region as well as other estuaries across the state. Upper Lemon Bay ranked in the 70th, or greater, percentile of Florida estuaries for all nutrients and fecal coliform bacteria, in addition to ranking in the bottom 10th percentile for DO. Results showed frequent exceedances of Florida Surface Water Standards for DO, chlorophyll *a*, fecal coliform bacteria and turbidity. Trends in the Upper Lemon Bay region indicate a decrease in TKN, turbidity, salinity and pH, and an increase in DO. The primary factors contributing to light attenuation are turbidity and color. Water quality status and trends results for Upper Lemon Bay are shown in Table 7.2

Sampling site LBV001 exhibited the most degraded water quality in Upper Lemon Bay possibly affecting the collective results for the region. The site had one of

the greatest percentages of DO values that were less than 4.0 and 5.0 mg/L, as well as the only site to have fecal coliform bacteria exceedances greater than both 400 and 800 cfu/100mL. The site is located near a smaller tributary and is the northernmost site in Upper Lemon Bay. Site LBV003 was the only site within the region to have turbidity (greater than 31.7 NTU) exceedances. Site LBGOT2, a site located about 3 km (2 mi) upstream in Gottfried Creek, also exhibited above average color, fecal coliform bacteria and total phosphorus values. Site specific water quality status results are shown in Appendix A.

3. Water Quality Status and Trends Results for Lower Lemon Bay

Water quality in Lower Lemon Bay ranged from above average to below average depending on the parameter of interest. The pH and salinity within the region were relatively high with median values of 8.3 and 33.5, respectively, ranking in the top 90th and 100th percentiles, respectively, of Florida estuaries. Secchi depth was above average in Lower Lemon Bay ranking in the 70th percentile of Florida estuaries. DO concentrations were typically low in Lower Lemon Bay, ranking in the 20th percentile of all Florida estuaries and frequently below Florida Surface Water Standards of 4.0 and 5.0 mg/L. Significant trends include decreasing TKN and turbidity and increasing color. As in Upper Lemon Bay, turbidity and color are the primary light attenuating parameters. Water quality status and trends results for Lower Lemon Bay are shown in Table 7.3

Site LBV006 had the lowest water quality status in general of all sites in Lower Lemon Bay. LBV006, located in Buck Creek, had frequent exceedances of regulatory criteria including dissolved oxygen, chlorophyll *a*, and fecal coliform bacteria. Fecal coliform bacteria levels for sites LBV006 and LBANG1 were above the typical Florida estuarine water quality average, ranking in the 100th percentile of Florida estuaries. Site LBV007 generally exhibited the highest water quality, with frequent status rankings below the 50th percentile of Florida estuaries and with the smallest percent of regulatory exceedances. Site specific water quality status results are shown in Appendix A.

4. Discussion

CHEVWQMN results indicate below-average water quality across the Lemon Bay region, particularly in tributaries located in Upper Lemon Bay. Below average DO conditions that frequently exceeded Florida Surface Water Criteria are of one of the most critical water quality issues across Lemon Bay. Regulatory exceedances of fecal coliform bacteria in the region, particularly near tributaries, are additional concerns. Results, however, indicate that fecal coliform bacteria exceedance events were isolated, indicating that causes of increased bacteria are site- and event-specific. In the Lemon Bay estuary, turbidity explained the most variability in water clarity.

Effective resource management goals for Lemon Bay Aquatic Preserve should focus on improving DO, fecal coliform, turbidity and chlorophyll *a* levels in the estuary. Reducing turbidity levels would contribute to improving water clarity, thereby enhancing seagrass growth. Potential natural and anthropogenic sources of turbidity, such as wind-driven, boating-related, and storm-water velocity, should be investigated and quantified. Additionally, elevated nutrient and fecal coliform bacteria levels associated

with growing urban land uses, such as septic systems and stormwater runoff, should be identified, quantified, prioritized and remediated.

Table 7.1: Land uses in the Lemon Bay watershed

Land Use ^{1, 2, 3, 4}	1990		2010 Projected		Projected Change
	acres	%	acres	%	
Urban					
Residential	10,428	23%	38,051	84%	
Commercial/Industrial/Institutional	1,313	3%	2,304	5%	
SubTotal	11,741	26%	40,355	89%	244%
Mining	286	1%	0	0%	-100%
Agriculture					
Row Crops/Groves/Nursery	186	0%			
Pasture/Feedlot	749	2%			
Sub Total	935	2%	529	1%	-43%
Open Land, Wetlands, Water					
Forest/Range/Barren/Preserve	20,461	45%	4,614	10%	
Wetlands	4,641	10%			
Open Water	7,434	16%			
Sub Total	32,536	71%	4,614	10%	-86%
TOTAL	45,498	100%	45,498	100%	

¹Includes Lemon Bay Aquatic Preserve.

²Includes Upper Lemon Bay and Lower Lemon Bay Estuary Regions.

³Includes Lemon Bay Watershed.

⁴From "Synthesis of Existing Information", Charlotte Harbor National Estuary Program 1999.
Based on SWFWMD, SFWMD and Southwest Florida Regional Planning Council data.

Table 7.2: Status and Trends Summary for Upper Lemon Bay

	N	Min	Max	Mean	SE	Median	Median Rank within the Charlotte Harbor Estuaries ¹	Median compared to Typical FL Estuary Percentiles ²	Status Relative to Typical FL Estuaries	Trend Results ³
Secchi (m)	161	0.4	1.6	0.9	0.0	0.9	1	40	average	
Temp (deg. C)	381	12.0	32.0	23.7	0.2	24.5	3	50	average	
DO (mg/L)	373	1.0	8.8	4.1	0.1	3.9	1	10	lower than average	↑
pH	377	7.2	8.8	8.0	0.0	8.0	2	60	average	↓
Salinity (ppt)	376	0.0	40.7	22.4	0.6	25.3	3	50	average	↓
TN (ppm)	219	0.075	2.750	1.035	0.031	1.0	9	70	higher than average	↓ ⁴
TP (ppm)	228	0.010	1.080	0.199	0.007	0.2	8	70	higher than average	
Chl a (ug/L)	209	0.50	52.30	9.20	0.60	6.3	9	50	average	
Coliform (cfu/100mL)	252	1	1156	98	10	35.0	9	80	higher than average	
Turbidity (NTU)	240	0.5	66.0	2.9	0.1	2.5	3	40	average	↓
Color (PCU)	239	4	240	38	2	30.0	6	60	average	

¹ Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

² Median value compared to typical Florida estuarine water quality percentile distributions (Hand in press 2004)

³ ↓ Significantly decreasing at the .05 level ³ ↑ Significantly increasing at the .05 level

⁴ Trend results of total Kjeldahl nitrogen

Table 7.3: Status and Trends Summary for Lower Lemon Bay

	N	Min	Max	Mean	SE	Median	Median Rank within the Charlotte Harbor Estuaries ¹	Median compared to Typical FL Estuary Percentiles ²	Status Relative to Typical FL Estuaries	Trend Results ³
Secchi (m)	230	0.5	3.3	1.3	0.0	1.3	4	60	average	
Temp (deg. C)	525	10.0	32.0	23.6	0.2	24.0	1	50	average	
DO (mg/L)	515	0.6	8.2	4.7	0.1	4.8	3	10	lower than average	
pH	520	7.2	9.0	8.3	0.0	8.3	8	100	higher than average	
Salinity (ppt)	518	2.1	40.7	31.7	0.3	33.5	9	100	higher than average	
TN (ppm)	265	0.075	2.560	0.790	0.025	0.767	5	50	average	↓ ⁴
TP (ppm)	275	0.010	0.420	0.084	0.003	0.070	4	40	average	
Chl a (ug/L)	259	0.01	79.46	5.55	0.42	3.92	4	30	lower than average	
Coliform (cfu/100mL)	302	1	800	41	5	8	6	60	average	
Turbidity (NTU)	296	0.5	9.7	3.1	0.1	2.6	4	40	average	↓
Color (PCU)	296	1	240	25	2	15	1	40	average	↑

¹ Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

² Median value compared to typical Florida estuarine water quality percentile distributions (Hand in press 2004)

³ ↓ Significantly decreasing at the .05 level ³ ↑ Significantly increasing at the .05 level

⁴ Trend results of total Kjeldahl nitrogen

C. Gasparilla Sound–Charlotte Harbor and Cape Haze Aquatic Preserves

Including Gasparilla/Cape Haze, Upper Charlotte Harbor and Lower Charlotte Harbor Estuary Regions

1. Background

The Gasparilla Sound-Charlotte Harbor and Cape Haze Aquatic Preserves are discussed together in the following section because the two aquatic preserves share a common estuary and watershed. Together, the two aquatic preserves extend from the Myakka and Peace River mouths southwest to Boca Grande Pass. The boundary of the aquatic preserves follows the mean high water line of the Harbor and tributaries upstream to tidal influence. Additionally, the aquatic preserves are bounded in Punta Gorda by the US 41 S Bridge, in El Jobean by the SR776 Bridge, in Placida by the Boca Grande causeway, and in the south by the north tips of Cayo Costa and Pine Island. Charlotte Harbor is approximately 26 km (16 mi) long and 19 km (12 mi) wide at its maximum extents, covering over 368 km² (91,052 acres) of submerged waters. Charlotte Harbor proper is the largest and deepest of the local estuaries, exceeding 6 m deep in the central depressions and 15 m deep at Boca Grande Pass. The two major tributaries are the Myakka and Peace Rivers, along with several smaller tributaries, including Alligator, Catfish and Whidden Creeks and Yucca Pen. Charlotte Harbor and Cape Haze Aquatic Preserves are located in Charlotte and Lee Counties, adjacent to the communities of Punta Gorda, Port Charlotte, Placida and Boca Grande.

Seagrass is a critical submerged habitat within the Gasparilla Sound-Charlotte Harbor and Cape Haze Aquatic Preserves, occurring along the shallow shoreline areas, comprising over 63 km² (15,678 acres). Throughout the estuary, the average deep edge of seagrass growth varies from 0.8 m near the Myakka River, to 1.4 m along the east and west shores of the Harbor, to 1.9 m in Cape Haze. The maximum depth of seagrass growth increases with proximity towards Boca Grande Pass and Gulf of Mexico Waters (CHNEP 2006).

The watershed for Gasparilla Sound-Charlotte Harbor and Cape Haze Aquatic Preserves begins for the Peace River at Lake Hancock in Polk County and for the Myakka River at Flatford Swamp in Sarasota County. Including the seven tributaries and rivers, the watershed area is approximately 8008 km² (1,978,800 acres) in size. The land to water ratio is 22:1. The 1990 and 2010 projected land uses in the watershed are shown in Table 7.4. The land uses vary greatly throughout the ten sub-basins, but watershed-wide, the largest land uses are pasture (27%), rangeland (16%) and upland forest (12%). Urban land use and mining comprise 7% and 6% of the watershed, respectively. A large percent of the estuary shoreline is preserved and managed as the Charlotte Harbor Preserve State Park. Urban areas are centered adjacent to the estuary at Punta Gorda and Port Charlotte, along the Peace River at Arcadia and Bartow, and near Lake Hancock. The most critical changes in predicted future land uses are a >125% increase in mining and nearly a 300% increase in residential areas. There are over 181 domestic wastewater point source discharges, 202 industrial wastewater discharges, 22 public water supplies and 26 industrial/mining

water uses permitted in the watershed, as well as high agricultural demand (CHNEP 1999).

2. Water Quality Status and Trends Results for Upper Charlotte Harbor

Water quality in Upper Charlotte Harbor was generally below average compared to other estuaries in the region and across the state of Florida. Upper Charlotte Harbor was tied with Upper Lemon Bay for the lowest median Secchi value and had the highest median total phosphorus and color of all estuary regions. The TP in Upper Charlotte Harbor had significantly increased over the study period and the median value for all years was higher than average compared to Florida's estuaries, ranking in the 70th percentile or above. Fecal coliform bacteria levels were also high in the area and frequently exceeded Florida Surface Waters Criteria at 200, 400 and 800 cfu/100mL. Salinity in Upper Charlotte Harbor significantly decreased over the study duration and was the lowest recorded median value across all estuary regions. Decreasing salinity levels may correspond to an increasing trend in color concentrations that was also detected in the region. Additional significant trends included an increase of DO at a rate of approximately 0.1 mg/L. Status and trends results for Upper Charlotte Harbor are shown in Table 7.5.

Site-specific water quality varied throughout the Upper Charlotte Harbor estuary region. Sites CHV005 and CHV013 ranked among the sites having the lowest salinity and highest nutrients and chlorophyll *a*. Both sites had higher than average status results for total phosphorus compared to typical Florida estuarine water quality. Fecal coliform was high at both sites, particularly in the rainy season, with frequent exceedances of state standards. Sites CHV005 and CHV013 are the most upstream sites in the Tidal Peace River. Site-specific water quality status results are shown in Appendix A.

3. Water Quality Status and Trends Results for Lower Charlotte Harbor

Lower Charlotte Harbor had fair to good water quality for all water quality parameters. Turbidity values in Lower Charlotte Harbor significantly decreased during the study period, and were tied with Matlacha Pass for the lowest median value observed across all estuary regions. The median Secchi depth value was above average in comparison to typical values for Florida estuaries. Salinity significantly decreased in the region, possibly corresponding to a significant decrease in pH and an increase in color concentrations. Additional significant trends include an increase in DO and a decrease in TKN. Status and trends results for Lower Charlotte Harbor are shown in Table 7.6

Site CHV011 exhibited above average water quality compared to other sites in the CHEVWQMN and across Florida estuaries. This open water site is located in the center of Lower Charlotte Harbor and had the deepest average depth of all the sites (3.8 m). Site CHV011 had the highest median Secchi value (2.3 m) for all sites in the CHEVWQMN and was the only site that ranked in the 100th percentile of all Florida estuaries. The site had the lowest median total nitrogen and turbidity across all sites in the CHEVWQMN, and fecal coliform bacteria was tied for the lowest. Site CHV011 also

had the lowest percent regulatory exceedances of DO less than 5.0 mg/L within the region. Site specific water quality status results are shown in Appendix A.

4. Water Quality Status and Trends Results for Gasparilla Sound/Cape Haze

Water quality in Gasparilla Sound/Cape Haze had many parameters falling within the 40th to 60th percentiles of Florida's estuaries and moderate rankings within the CHEVWQMN. Secchi depth was relatively high, with a median value of 1.5 m, which fell within the 70th percentile of Florida's estuaries. Chlorophyll a concentrations were very low in the region, with few regulatory exceedances. The DO levels were generally low, with frequent regulatory exceedances of 4.0 and 5.0 mg/L. Cape Haze was the only estuary region in which DO appeared to be significantly decreasing. Other significant observed trends included a significant increase in color concentrations, as well as decreases in salinity, pH and turbidity values. Status and trends results for Gasparilla Sound/Cape Haze are shown in Table 7.7

Water quality was relatively consistent across the four sites located in Cape Haze, ranging from below to above average depending on the parameter of interest. Sites GSV001 and GSV004 had the most DO samples below state regulatory criteria of 4.0 and 5.0 mg/L. Median values for GSV001 and GSV004 were also below the 4.0 mg/L standard, at 4.0 and 3.6 mg/L, respectively. Additionally, GSV001 had the lowest chlorophyll a median value (2.16 µg/L) across all sites in the CHEVWQMN. Site GSV003 had the lowest color value of all sites in the CHEVWQMN, with a median value of 10 PCU and ranking in the 30th percentile of Florida's estuaries. Site specific water quality status results are shown in Appendix A.

5. Discussion

CHEVWQMN results indicated that overall water quality in the Gasparilla Sound, Cape Haze and Charlotte Harbor Aquatic Preserves was average based upon the parameter and region of interest. Water clarity was average to higher than average in the Upper Charlotte region, with color concentrations being the primary parameter contributing most to light attenuation across the region, followed by turbidity. Nutrients, including nitrogen and phosphorus, were higher than average, particularly in the Upper Charlotte Harbor region. Below-average DO values, as well as frequent observations below state standards of 4.0 and 5.0 mg/L, are also cause for concern across these preserves.

Due to the complex nature of the Gasparilla Sound-Charlotte Harbor and Cape Haze Aquatic Preserves and their watershed, effective resource management goals should be multi-faceted, focusing on: a) identifying and reducing sources of high nutrients to minimize chlorophyll a contributions to attenuation of seagrass growth; b) restoring and maintaining natural surface and ground water hydrology, to sustain the complex interconnectedness of life stages of finfish and shellfish throughout the Harbor; c) identifying, quantifying, minimizing and remediating water quantity and quality impacts from current and future mining and agriculture activities; and d) developing a better understanding of the role and natural variability of color in the estuary.

Table 7.4: Land use types in the Charlotte Harbor, Gasparilla Sound and Cape Haze watershed

Land Use ^{1,2,3,4}	1990		2010		Projected Change
	acres	%	acres	%	
Urban					
Residential	103,196	5%	470,864	24%	
Commercial/Industrial/Institutional	31,816	2%	65,003	3%	
Sub Total	135,012	7%	535,867	27%	297%
Mining	126,746	6%	286,484	14%	126%
Agriculture					
Row Crops/Groves/Nursery	201,960	10%	0	0%	
Pasture/Feedlot	539,534	27%	0	0%	
Sub Total	741,494	37%	939,044	47%	27%
Open Land, Wetlands, Water					
Forest/Range/Barren/Preserve	552,607	28%	182,110	9%	
Wetlands	359,606	18%	35,302	2%	
Open Water	63,341	3%	0	0%	
Sub Total	975,554	49%	217,411	11%	-78%
TOTAL	1,978,806	100%	1,978,806	100%	

¹Includes Gasparilla Sound/Charlotte Harbor and Cape Haze Aquatic Preserves.

²Includes Upper Charlotte Harbor, Lower Charlotte Harbor and Gasparilla Sound/Cape Haze Estuary Region.

³Includes Upper Myakka R, Lower Myakka R, Peace R/Bartow, Peace R/Zolfo Springs, Peace R/Arcadia, Peace R/Lower, Payne Cr, Charlie Cr, Horse Cr, Joshua Cr, Shell Cr and Charlotte Harbor Sub-Watershed.

⁴From "Synthesis of Existing Information", Charlotte Harbor National Estuary Program 1999.
Based on SWFWMD, SFWMD and Southwest Florida Regional Planning Council data.

Table 7.5: Status and Trends Summary for Upper Charlotte Harbor

	N	Min	Max	Mean	SE	Median	Median Rank within the Charlotte Harbor Estuaries ¹	Median compared to Typical FL Estuary Percentiles ²	Status Relative to Typical FL Estuaries	Trend Results ³
Secchi (m)	394	0.1	2.7	0.9	0.0	0.9	1	40	average	
Temp (deg. C)	657	4.0	31.5	23.6	0.2	24.0	1	50	average	
DO (mg/L)	650	0.6	9.9	5.2	0.1	5.2	5	20	lower than average	↑
pH	657	6.4	8.6	7.7	0.0	7.8	1	30	lower than average	
Salinity (ppt)	649	0.0	37.1	17.3	0.4	17.9	1	30	lower than average	↓
TN (ppm)	505	0.032	4.602	1.040	0.022	0.975	8	70	higher than average	
TP (ppm)	532	0.010	1.500	0.305	0.009	0.240	9	80	higher than average	↑
Chl a (ug/L)	482	0.01	88.50	9.48	0.50	6.16	8	50	average	
Coliform (cfu/100mL)	587	1	800	48	4	24	8	70	higher than average	
Turbidity (NTU)	556	0.5	24.0	3.2	0.1	2.7	6	40	average	
Color (PCU)	557	4	400	70	3	50	9	70	higher than average	↑

¹ Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

² Median value compared to typical Florida estuarine water quality percentile distributions (Hand in press 2004)

³ ↓ Significantly decreasing at the .05 level ³ ↑ Significantly increasing at the .05 level

Table 7.6: Status and Trends Summary for Lower Charlotte Harbor

	N	Min	Max	Mean	SE	Median	Median Rank within the Charlotte Harbor Estuaries ¹	Median compared to Typical FL Estuary Percentiles ²	Status Relative to Typical FL Estuaries	Trend Results ³
Secchi (m)	105	0.5	4.5	1.8	0.1	1.5	7	70	higher than average	
Temp (deg. C)	252	13.0	31.5	23.9	0.3	24.5	3	50	average	
DO (mg/L)	247	2.4	9.1	5.4	0.1	5.5	6	20	lower than average	↑
pH	249	7.4	8.6	8.3	0.0	8.2	3	80	higher than average	↓
Salinity (ppt)	248	8.5	39.1	28.2	0.4	29.0	4	70	higher than average	↓
TN (ppm)	207	0.055	2.300	0.792	0.028	0.755	3	50	average	↓ ⁴
TP (ppm)	215	0.005	0.420	0.114	0.005	0.100	7	50	average	
Chl a (ug/L)	198	0.01	34.18	5.88	0.35	4.42	6	30	lower than average	
Coliform (cfu/100mL)	234	1	372	13	2	3	3	40	average	
Turbidity (NTU)	226	0.1	21.0	2.5	0.2	2.1	1	30	lower than average	↓
Color (PCU)	226	1	140	30	2	24	5	50	average	↑

¹ Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

² Median value compared to typical Florida estuarine water quality percentile distributions (Hand in press 2004)

³ ↓ Significantly decreasing at the .05 level ³ ↑ Significantly increasing at the .05 level

⁴ Trend results of total Kjeldahl nitrogen

Table 7.7: Status and Trends Summary for Gasparilla Sound/Cape Haze

	N	Min	Max	Mean	SE	Median	Median Rank within the Charlotte Harbor Estuaries ¹	Median compared to Typical FL Estuary Percentiles ²	Status Relative to Typical FL Estuaries	Trend Results ³
Secchi (m)	86	0.0	3.2	1.5	0.1	1.5	7	70	higher than average	
Temp (deg. C)	192	7.5	31.5	24.2	0.3	25.0	8	60	average	
DO (mg/L)	188	1.4	7.3	4.6	0.1	4.6	2	10	lower than average	↓
pH	194	7.2	8.6	8.3	0.0	8.2	3	80	higher than average	↓
Salinity (ppt)	192	10.0	40.7	31.5	0.4	33.2	8	100	higher than average	↓
TN (ppm)	141	0.075	2.526	0.906	0.042	0.806	6	60	average	
TP (ppm)	150	0.005	0.350	0.093	0.005	0.080	6	40	average	
Chl a (ug/L)	145	0.50	18.20	4.49	0.31	3.58	3	20	lower than average	
Coliform (cfu/100mL)	169	1	280	20	3	6	5	50	average	
Turbidity (NTU)	162	0.6	30.0	3.3	0.2	2.7	6	40	average	↓
Color (PCU)	162	3	120	24	1	20	3	50	average	↑

¹ Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

² Median value compared to typical Florida estuarine water quality percentile distributions (Hand in press 2004)

³ ↓ Significantly decreasing at the .05 level ³ ↑ Significantly increasing at the .05 level

D. Pine Island Sound and Matlacha Pass Aquatic Preserves

Including Pine Island Sound and Matlacha Pass Estuary Regions

1. Background

Pine Island Sound and Matlacha Pass surround Pine Island from north to south and are bordered by barrier islands and Pine Island to the west. Pine Island Sound Aquatic Preserve extends from Boca Grande Pass south to Sanibel, between Pine Island and four barrier islands. There is one primary tributary (Caloosahatchee River) and four Gulf passes (Boca Grande, Captiva, Red Fish and Blind). The aquatic preserve boundary follows the mean high waterline of the Sound. Pine Island Sound is approximately 29 km (18 mi) long and 8 km (5 mi) wide, with an area of approximately 219 km² (54,176 acres). It is the second largest and second deepest of the estuaries in the region. The aquatic preserves are located in Lee County and the City of Sanibel is the only incorporated area on the Sound.

Matlacha Pass Aquatic Preserve is located between Pine Island and Cape Coral, extending north-south along the length of the island. The primary tributary is the Caloosahatchee River, as well as overland flow from preserve lands to the east. The aquatic preserve boundary follows the mean high waterline of the Pass, with the exclusion of a small area to the south. Matlacha Pass is approximately 21 km (13 mi) long and 5 km (3 mi) wide, with an area of approximately 50 km² (12,511 acres). It is the most sinuous of the estuaries in the region. The aquatic preserve is located in Lee County and the primary adjacent urban area is Cape Coral (CHNEP 1999).

Within both estuaries, the largest submerged habitat is seagrass, comprising approximately 142 km² (35,170 acres) of the estuarine area. The average deep edge of seagrass growth is approximately 1.9 m in Pine Island Sound and 1.5 m in Matlacha pass (CHNEP 1999).

The Pine Island Sound and Matlacha Pass watershed includes the coastal areas of northern Lee and southern Charlotte Counties, Pine Island and the lower Caloosahatchee River drainage area. The watershed is approximately 355 km² (87,850 acres) in size. The ratio of watershed land area to open water estuary area is slightly over 1:1. The 1990 and 2010 projected land uses in the watershed are shown in Table 7.8. Based on the 1990 data, the largest land use in the watershed is rangeland (33%) and upland forest (16%). Urban uses make up a relatively small percent (14%) of the overall watershed, but it is concentrated in the City of Cape Coral to the east of Matlacha Pass. A large percent of the estuary shoreline is managed for preservation under the Charlotte Harbor Preserves State Park, "Ding" Darling National Wildlife Refuge and the nonprofit Calusa Land Trust. The most significant projected change in future land use is the very large increase (almost 350%) in urban uses. The urban areas are concentrated on the east side of Matlacha Pass in Cape Coral, but are increasing rapidly on Sanibel and Pine Island. There are 57 domestic wastewater discharges, seven industrial wastewater discharges and three public water supplies permitted in the watershed, along with significant demand for landscape and golf course irrigation (CHNEP 2006).

2. Water Quality Status and Trends Results for Pine Island Sound

Results from the CHEVWQMN indicated that water quality in Pine Island Sound ranged from below average to above average compared to the typical water quality of Florida's estuaries and ranked very well compared to other estuary regions in the Charlotte Harbor area. The median Secchi depth value of 1.3 m was average compared to Florida's estuaries (Hand 2004). Pine Island Sound had the lowest median nutrient levels across the nine estuary regions. The TKN significantly decreased over the study duration. Additional significant trends included an increase in pH and decreases in salinity, fecal coliform bacteria and turbidity values. For water quality status and trends results in Pine Island Sound, see Table 4.9.

Water quality was relatively uniform across most sites in Pine Island Sound. Site PIJIM1 exhibited the lowest water quality across all sites. The site is located near Big Jim Creek on the northwestern side of Pine Island. It had the shallowest average depth of all sites, with high fecal coliform bacteria, low water clarity and DO values. The site had the lowest Secchi depth and DO median values of all sites in the CHEVWQMN, ranking in or below the lower 20th percentile of Florida's estuaries. The site is located near Big Jim Creek on the northwestern side of Pine Island and had the shallowest average depth of all sites. Sites PIV004 and PIV006 had the best relative water quality in comparison to sites within the Pine Island Sound region and across all sites in the region. These are both open water sites on the eastern side of Captiva and Sanibel Islands. Both sites had the highest DO levels across all sites, and Secchi depth at PIV004 was the second highest of all sites in the CHEVWQMN. Site specific water quality status results are shown in Appendix A.

3. Water Quality Status and Trends Results for Matlacha Pass

Water quality in Matlacha Pass ranked moderately compared to other estuary regions in the Charlotte Harbor estuarine complex. Secchi depth was high in the region with a median value of 1.6 m, ranking highest among CHEVWQMN regions and in the 80th percentile of Florida estuaries. Salinity varied seasonally in the region, was generally lower than other estuary regions and was average compared to salinity values for Florida's estuaries. Matlacha had the second lowest chlorophyll a median value across all estuary regions and had no annual means exceeding 11 µg/L per Florida's Impaired Waters Rule. Matlacha Pass was the only estuary region in the study area which had no site demonstrating exceedances of Florida's Surface Water Standards for fecal coliform bacteria at 200, 400 and 800 cfu/100mL. Color concentrations were average and significantly increased over the study duration. Other significant trends include an increase in DO and pH, and decreases in salinity and temperature. For water quality status and trends results in Matlacha Pass, see Table 7.10.

Water quality results were fairly uniform across the three sites located in Matlacha Pass. All sites were located in open water with a minimum average sample depth of 2 m. Site MPV003 had the second lowest median chlorophyll a value across all sites. Site MPV003 tied with PIV004 for the second highest Secchi depth across all sites in the CHEVWQMN. Site-specific water quality status results are shown in Appendix A.

4. Discussion

Water quality in Pine Island Sound and Matlacha Pass was average to above average compared to other regions within Charlotte Harbor and estuaries across the state. Color concentrations were higher than average in Matlacha Pass and was the primary factor contributing to decreases in water clarity. Secchi depth was average in Pine Island Sound with turbidity as the primary parameter causing light attenuation. Below average DO and nitrogen within Matlacha Pass are key water quality issues affecting this region.

To maintain the relatively good water quality conditions throughout Pine Island Sound and Matlacha Pass, resource management goals should focus on reducing nutrient runoff from the increasing urban and nursery areas on the islands. Due to the close proximity of both surface and ground water to upland activities on the islands, additional design considerations should be incorporated in storm water management measures. Additionally, natural and anthropogenic sources of turbidity in Pine Island Sound should be identified and quantified, and remediated as needed.

Table 7.8: Land uses in the Pine Island Sound and Matlacha Pass watershed

Land Use ^{1, 2, 3, 4}	1990		2010 Projected		Projected Change
	acres	%	acres	%	
Urban					
Residential	7,228	8%	45,477	52%	
Commercial/Industrial/Institutional	5,196	6%	10,355	12%	
Sub Total	12,424	14%	55,812	64%	349%
Mining	167	0%	0	0%	-100%
Agriculture					
Row Crops/Groves/Nursery	704	1%			
Pasture/Feedlot	2,009	2%			
Sub Total	2,713	3%	0	0%	-100%
Open Land, Wetlands, Water					
Forest/Range/Barren/Preserve	44,868	51%	32,036	36%	
Wetlands	23,174	26%			
Open Water	4,502	5%			
Sub Total	72,544	83%	32,036	36%	-56%
TOTAL	87,848	100%	87,848	100%	

¹Includes Pine Island Sound and Matlacha Pass Aquatic Preserves.

²Includes Pine Island Sound and Matlacha Pass Estuary Regions.

³Includes Pine Island Sound/Matlacha Pass Watershed.

⁴From "Synthesis of Existing Information", Charlotte Harbor National Estuary Program 1999.
Based on SWFWMD, SFWMD and Southwest Florida Regional Planning Council data.

Table 7.9: Status and Trends Summary for Pine Island Sound

	N	Min	Max	Mean	SE	Median	Median Rank within the Charlotte Harbor Estuaries ¹	Median compared to Typical FL Estuary Percentiles ²	Status Relative to Typical FL Estuaries	Trend Results ³
Secchi (m)	167	0.1	3.9	1.4	0.0	1.3	4	70	higher than average	
Temp (deg. C)	400	10.5	31.0	23.6	0.2	24.5	3	60	average	
DO (mg/L)	392	0.6	9.0	5.7	0.1	5.9	8	30	lower than average	
pH	388	7.0	8.8	8.4	0.0	8.4	9	100	higher than average	↑
Salinity (ppt)	399	4.5	42.0	32.2	0.2	32.9	7	90	higher than average	↓
TN (ppm)	309	0.055	4.302	0.808	0.027	0.752	1	50	average	↓ ⁴
TP (ppm)	330	0.005	0.900	0.073	0.004	0.060	1	30	lower than average	
Chl a (ug/L)	298	0.01	39.70	6.52	0.34	4.98	7	40	average	
Coliform (cfu/100mL)	383	1	352	13	2	2	1	40	average	↓
Turbidity (NTU)	368	0.3	28.0	3.7	0.2	2.6	4	40	average	↓
Color (PCU)	369	1	200	25	1	18	2	40	average	

¹ Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

² Median value compared to typical Florida estuarine water quality percentile distributions (Hand in press 2004)

³ ↓ Significantly decreasing at the .05 level ³ ↑ Significantly increasing at the .05 level

⁴ Trend results of total Kjeldahl nitrogen

Table 7.10: Status and Trends Summary for Matlacha Pass

	N	Min	Max	Mean	SE	Median	Median Rank within the Charlotte Harbor Estuaries ¹	Median compared to Typical FL Estuary Percentiles ²	Status Relative to Typical FL Estuaries	Trend Results ³
Secchi (m)	202	0.4	3.8	1.6	0.0	1.6	9	80	higher than average	
Temp (deg. C)	261	13.5	31.0	24.0	0.3	24.5	3	50	average	↓
DO (mg/L)	252	2.0	9.0	5.5	0.1	5.5	6	30	lower than average	↑
pH	250	7.4	8.6	8.2	0.0	8.2	3	80	higher than average	↑
Salinity (ppt)	258	2.9	39.8	21.7	0.5	22.1	2	40	average	↓
TN (ppm)	194	0.032	3.840	0.905	0.032	0.851	7	60	average	
TP (ppm)	212	0.010	0.290	0.084	0.003	0.076	5	40	average	
Chl a (ug/L)	187	0.25	72.50	5.42	0.52	3.50	2	20	lower than average	
Coliform (cfu/100mL)	234	1	106	9	1	4	4	40	average	
Turbidity (NTU)	221	0.1	10.5	2.5	0.1	2.1	1	30	lower than average	
Color (PCU)	221	1	160	37	2	30	6	60	average	↑

¹ Ranking of median value in ascending order compared to each estuary region median within the CHEVVQMN

² Median value compared to typical Florida estuarine water quality percentile distributions (Hand in press 2004)

³ ↓ Significantly decreasing at the .05 level ³ ↑ Significantly increasing at the .05 level

E. San Carlos Bay

Including San Carlos Bay Estuary Region

1. Background

San Carlos Bay, while not designated as an aquatic preserve itself, connects three adjacent aquatic preserves: Matlacha Pass, Pine Island Sound and Estero Bay Aquatic Preserves. It is located at the mouth of the Caloosahatchee River, its primary tributary. San Carlos Bay is approximately 6 km (4 mi) long and 5 km (3 mi) wide. It is located in Lee County and adjacent urban areas include Cape Coral, Fort Myers and Fort Myers Beach. Within the estuary, seagrasses are an important submerged habitat comprising approximately 20 km² (5,000 acres), growing to approximately 2.0 m deep, though the conditions vary annually, seasonally and with changes in hydrologic flows from the Caloosahatchee River (CHNEP2006).

The San Carlos Bay watershed includes the lower drainage area of the Caloosahatchee River and is approximately 937 km² (231,638 acres) in size. The 1990 and 2010 projected land uses in the watershed are shown in Table 7.11. Based on the 1990 data, the largest land use in the watershed is urban (33%), followed by pasture (21%). The most significant projected changes in future land uses are a large increase (80%) in urban area and a large decrease (74%) in wetland areas. A small portion of the estuary shoreline is in preserve use managed by the Charlotte Harbor Preserves State Park, "Ding" Darling National Wildlife Refuge and the nonprofit Calusa Land Trust. There are 76 domestic wastewater discharges, seven industrial wastewater discharges, five public water uses and an undetermined number of industrial uses permitted in the watershed, along with high demand for landscape and golf course irrigation (CHNEP 1999).

2. Water Quality Status and Trends Results

San Carlos Bay had above average water quality and ranked as having the highest water quality of all estuary regions in the CHEVWQMN study area. San Carlos and Estero Bays were the only estuaries exhibiting a significant increase in Secchi depth over the eight-year study duration, with the median value for all years ranking in the top 70th percentile of Florida's estuaries. Total nitrogen was average compared to Florida's estuaries, with total nitrogen and TKN median values ranking second across all estuaries within the Charlotte Harbor region. The median chlorophyll a value was lower than the average value for Florida's estuaries and was the lowest concentration of all estuary regions in the CHEVWQMN. No site within San Carlos Bay demonstrated chlorophyll a annual means exceeding the state criteria of 11 µg/L. San Carlos Bay tied for the lowest median fecal coliform bacteria concentrations across all estuary regions in the Charlotte Harbor study area. The DO and color values significantly increased over the study duration, while salinity, temperature and turbidity levels significantly decreased. For water quality status and trends results in San Carlos Bay see, Table 7.12.

Site-specific water quality results were generally uniform in San Carlos Bay. Sites SCV001 and SCV002 had the highest median DO values within the region, with

only four samples at each site under 5.0 mg/L per Florida's Surface Water Standards. San Carlos had the second deepest average depth of 3.7 m, with site depths ranging from 2.5 to 4.5 m. All sites in San Carlos Bay are located offshore, generally outside or bordering Aquatic Preserves boundaries. Site specific water quality status results are shown in Appendix A.

3. Discussion

CHEVWQMN results in San Carlos Bay indicate generally above average water quality conditions. Water quality conditions of concern include salinity variability, lower than average DO results and increases in color concentrations throughout the study duration. In San Carlos Bay, color was the primary parameter contributing most to changes in water clarity. In addition to these findings, previous studies have shown that artificially induced salinity variability and nutrient enrichment are important water quality issues in the San Carlos estuary (Doering and Chamberlain 1999; Doering et al. 2005, Greenawalt-Boswell et al. 2006). San Carlos Bay is located at the mouth of the Caloosahatchee River, which, during high discharge, is a major contributor of freshwater flow and nutrients to the entire Charlotte Harbor estuarine complex (Doering et al. 2005).

Water quality conditions in the San Carlos Bay estuary are strongly influenced by variability in freshwater flow via the Caloosahatchee River and subsequently changes within the Caloosahatchee watershed. A better understanding of the effects of changes in hydrologic regimes and watershed land uses is essential for sustaining and restoring the productive submerged habitats of San Carlos Bay, including seagrass meadows, shellfish communities and fisheries populations.

Table 7.11: Land uses in the San Carlos Bay watershed

Land Use ^{1, 2, 3, 4}	1999		2010		Projected Change
	total	%	total	%	
Urban					
Residential	67,351	29%	118,689	51%	
Comm/Indust/Institutional	8,432	4%	17,397	8%	
Sub Total	75,783	33%	136,086	59%	80%
Mining	1,629	1%	0	0%	-100%
Agriculture					
Row Crops/Groves/Nursery	3,170	1%	0	0%	
Pasture/Feedlot	49,074	21%	0	0%	
Sub Total	52,244	23%	68,921	30%	32%
Open Land, Wetlands, Water					
Forest/Barren/Range/Preserve	61,628	27%	26,631	11%	
Wetlands	38,615	17%	0	0%	
Open Water	1,739	1%	0	0%	
Sub Total	101,982	44%	26,631	11%	-74%
TOTAL	231,638	100%	231,638	100%	

¹Includes San Carlos Bay, which is not an Aquatic Preserve.

²Includes San Carlos Bay Estuary Region.

³Includes Lower Caloosahatchee, Telegraph Swamp and Orange River Watersheds.

⁴From "Synthesis of Existing Information", Charlotte Harbor National Estuary Program 1999.
Based on SWFWMD, SFWMD and Southwest Florida Regional Planning Council data.

Table 7.12: Status and Trends Summary for San Carlos Bay

	N	Min	Max	Mean	SE	Median	Median Rank within the Charlotte Harbor Estuaries ¹	Median compared to Typical FL Estuary Percentiles ²	Status Relative to Typical FL Estuaries	Trend Results ³
Secchi (m)	327	0.5	3.9	1.5	0.0	1.4	6	70	higher than average	↑
Temp (deg. C)	340	10.0	31.0	24.1	0.3	24.8	7	50	average	↓
DO (mg/L)	334	2.8	8.7	5.9	0.1	5.9	8	30	lower than average	↑
pH	339	7.4	8.6	8.3	0.0	8.2	3	80	higher than average	
Salinity (ppt)	339	8.8	41.4	29.1	0.4	30.6	6	80	higher than average	↓
TN (ppm)	249	0.055	2.930	0.755	0.025	0.753	2	50	average	
TP (ppm)	263	0.005	0.270	0.069	0.002	0.060	1	30	lower than average	
Chl a (ug/L)	245	0.01	28.35	4.41	0.25	3.43	1	20	lower than average	
Coliform (cfu/100mL)	310	1	364	12	2	2	1	40	average	
Turbidity (NTU)	294	0.5	120.0	4.2	0.4	3.2	8	50	average	↓
Color (PCU)	294	1	160	27	1	20	3	50	average	↑

¹ Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

² Median value compared to typical Florida estuarine water quality percentile distributions (Hand in press 2004)

³ ↓ Significantly decreasing at the .05 level ³ ↑ Significantly increasing at the .05 level

F. Estero Bay Aquatic Preserve

Including Estero Bay Estuary Region

1. Background

Estero Bay Aquatic Preserve includes Estero Bay from Fort Myers Beach south to Bonita Springs. There are six tributaries (Hendry, Mullock, and Spring Creeks, Caloosahatchee, Estero and Imperial Rivers) and four Gulf Passes (Matanzas, Big Carlos, New and Big Hickory). The aquatic preserve boundary follows the mean high waterline of the Bay and the tributaries up-stream to tidal influence. Estero Bay is approximately 14 km (9 mi) long and 3 km (2 mi) wide, with an area of approximately 40 km² (9,834 acres). It is the second smallest and shallowest of the estuaries in the region. The aquatic preserve is located in Lee County and is adjacent to the urban areas of Fort Myers, Fort Myers Beach and Bonita Springs. Seagrass is a critical submerged habitat in Estero Bay, comprising over 14 km² (3,400 acres), growing to an average depth of 1.0 m. Seagrass acreage in Estero Bay appears to have declined over the past decade (CHNEP 2006).

The Estero Bay watershed extends to the headwaters of the creeks and the lower drainage area of the Caloosahatchee River and is approximately 754 km² (186,200 acres) in size. The 1990 and 2010 projected land uses in the Estero Bay watershed are shown in Table 7.13. The ratio of watershed land area to open water estuary area is approximately 19:1. Based on the 1990 data, the largest land use in the watershed is forested and non-forested wetlands (37%), followed by forest and rangeland (24%) and pasture (18%). The most significant projected change in future land use is a large increase (253%) in urban area and a large decrease in wetlands and preserve lands. There is also a projected increase in the of acquisition public lands for preservation. The shoreline of the estuary is predominately urban use. There are 113 domestic wastewater discharges, fourteen industrial wastewater discharges, six public water uses and an undetermined number of industrial uses permitted in the watershed. In addition, there is a large demand for irrigation for golf courses, landscaping and some agriculture (CHNEP 1999).

2. Water Quality Status and Trends Results for Estero Bay

Water quality in Estero Bay ranked moderately compared to other estuary regions in the CHEVWQMN study region, with median values ranging from below to above typical Florida estuarine water quality values (Hand 2004). Estero Bay had the highest turbidity levels in the region, with a median value of 4.2 NTU, ranking in the 60th percentile of Florida's estuaries. The DO value was below average compared to typical Florida estuaries and was frequently observed below the Florida Surface Waters Standards of 4.0 and 5.0 mg/L. The pH, temperature and salinity levels significantly decreased over the study period, with significant increases in Secchi depth and color concentrations over the eight-year period. For water quality status and trends results in Estero Bay, see Table 7.14.

Sites EBV006, EBV004 and EBV005 had the highest median turbidity values of all sites in the CHEVWQMN. Turbidity at these sites ranked in the top 70th and 80th

percentiles of Florida's estuaries, resulting in an overall below average status rating. Site EBERS2, located at the mouth of the Estero River, had DO results that were below Florida's estuarine average and had the lowest median DO value (4.0 mg/L) in the estuary. Salinity and turbidity levels were also lowest at EBERS2. Site specific water quality status results are shown in Appendix A.

3. Discussion

Water quality conditions in Estero Bay were generally average. The CHEVWQMN results indicate that issues of concern in the region include: turbidity, fecal coliform bacteria and below-average DO concentrations. Estero Bay is a shallow wind-driven estuary in which turbid conditions are the primary result of resuspension of sediments within and from the Gulf of Mexico (Tapping et al. 2005). In addition, turbidity was the primary factor leading to light attenuation in Estero Bay. Regulatory exceedances of fecal coliform bacteria were spatially and temporally isolated indicating that causes of increased bacteria are site- and event-specific. Lower than average DO concentrations near the Estero River indicate that inflow from the river may be a source of degraded water quality within the estuary.

The most effective resource management goals for Estero Bay should address high turbidity levels, differentiating between natural and anthropogenic sources. Reductions in turbidity, along with restoration of natural salinity regimes would contribute to reestablishing seagrasses within the Bay. Continued acquisition and management of preserve lands in the watershed will help offset the rapidly increasing urbanization.

Table 7.13: Land uses in the Estero Bay watershed

Land Use ^{1, 2, 3, 4}	1990		2010 Projected		Projected Change
	acres	%	acres	%	
Urban					
Residential	19,417	10%	69,458	37%	
Commercial/Industrial/Institutional	6,359	3%	21,454	12%	
Sub Total	25,776	14%	90,912	49%	253%
Mining	1,889	1%	0	0%	-100%
Agriculture					
Row Crops/Groves/Nursery	11,500	6%			
Pasture/Feedlot	31,795	18%			
Sub Total	43,295	24%	52,721	28%	22%
Open Land, Wetlands, Water					
Forest/Range/Barren/Preserve	43,883	24%	42,528	23%	
Wetlands	69,259	37%			
Open Water	2,059	1%			
Sub Total	115,201	62%	42,528	23%	-63%
TOTAL	186,161	100%	186,161	100%	

¹Includes Estero Bay Aquatic Preserve.

²Includes Estero Bay Estuary Region.

³Includes Estero Bay Watershed.

⁴From "Synthesis of Existing Information", Charlotte Harbor National Estuary Program 1999.
Based on SWFWMD, SFWMD and Southwest Florida Regional Planning Council data.

Table 7.14: Status and Trends Summary for Estero Bay

	N	Min	Max	Mean	SE	Median	Median Rank within the Charlotte Harbor Estuaries ¹	Median compared to Typical FL Estuary Percentiles ²	Status Relative to Typical FL Estuaries	Trend Results ³
Secchi (m)	177	0.3	2.9	1.2	0.0	1.1	3	50	average	↑
Temp (deg. C)	361	14.0	31.0	23.6	0.2	25.0	8	50	average	↓
DO (mg/L)	356	1.2	10.0	4.7	0.1	4.8	3	10	lower than average	
pH	357	7.2	8.8	8.1	0.0	8.2	3	80	higher than average	↓
Salinity (ppt)	357	0.2	39.8	27.5	0.5	30.4	5	70	higher than average	↓
TN (ppm)	276	0.053	4.046	0.790	0.027	0.763	4	50	average	
TP (ppm)	297	0.005	0.500	0.070	0.003	0.060	1	30	lower than average	
Chl a (ug/L)	263	0.01	114.00	5.75	0.50	4.39	5	30	lower than average	
Coliform (cfu/100mL)	331	1	800	44	5	10	7	60	average	
Turbidity (NTU)	319	0.1	52.0	5.6	0.3	4.2	9	60	average	
Color (PCU)	319	1	140	31	1	30	6	60	average	↑

¹ Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

² Median value compared to typical Florida estuarine water quality percentile distributions (Hand in press 2004)

³ ↓ Significantly decreasing at the .05 level ³ ↑ Significantly increasing at the .05 level

VIII. Conclusions

This report presents water quality status and trends results from the CHEVWQMN from 1998 through 2005 across the six Charlotte Harbor and Estero Bay Aquatic Preserves. Seventeen water quality parameters were measured across 48 sampling sites grouped into nine estuary regions characterized by relatively homogenous hydrologic conditions. These water quality parameters reflect and affect the habitat health of the estuaries, including factors limiting light availability for seagrass growth and parameters potentially limiting the health and sustainability of fish and shellfish populations. Such factors include DO, turbidity and fecal coliform bacteria.

To characterize water quality as it relates to estuarine health, CHEVWQMN results were compared within the region and to other estuaries across the state of Florida. Median values ranking in the 31st to 60th percentiles of typical water quality values for Florida estuaries resulted in average water quality status. Additional comparisons were made to numerical criteria to aid in interpretation of water quality results. A seasonal, nonparametric trend test was used to detect trends in water quality from 1998 through 2005 for each estuary region. When interpreting results, consideration is given to the shallow near shore sampling site locations and sunrise sampling time, especially as it affects Secchi depth observations and may represent the lowest natural DO conditions.

Across the region, CHEVWQMN results indicated generally average conditions compared to Florida's estuaries although results varied by parameter seasonally, spatially and over time. The DO concentrations were typically below average compared to typical Florida estuaries values with frequent exceedances below Florida Surface Water Criteria of 4.0 and 5.0 mg/L. Significant decreasing trends in salinity, turbidity, total Kjeldahl nitrogen and increases in color concentrations were observed for many estuaries from 1998 through 2005. Significant relationships between light-limiting factors and clarity were observed. However, the percent contribution of each parameter varied across the region and between the rainy and dry seasons. Strong relationships between salinity and many other parameters including color, nutrients and bacteria were also observed and quantified.

Across the nine estuary regions analyzed in this report, water quality in Upper Lemon Bay and Upper Charlotte Harbor was below average compared to other estuary regions within the Charlotte Harbor area and across the state of Florida. Lower water clarity and DO, as well as higher color, nutrients and bacteria values were observed in these regions. A significant increase in TP was also observed in Upper Charlotte Harbor from 1998 through 2005. In Estero Bay, elevated color, turbidity and bacteria conditions were observed.

The CHEVWQMN successfully meets its intended goal of providing consistent, technically sound baseline water quality information throughout the six Charlotte Harbor and Estero Bay Aquatic Preserves, which facilitates data analysis. A rigorous quality assurance plan and extensive monitoring design allows for the accurate characterization of spatial and temporal water quality conditions across the region. The cost effective monitoring design includes synoptic sampling, representative fixed stations, a wide variety of field and lab parameters and a consistent, ongoing sampling duration.

The CHEVWQMN results are used to set resource management goals for the Charlotte Harbor Aquatic Preserves. Results from the CHEVWQMN also further resource managers' understanding of water quality conditions as a means to identify priority pollutants, potential impacts from proposed permitting activities and locating impaired waters within the Charlotte Harbor estuaries. The CHEVWQMN data is also used by partnering organizations including the CHNEP, CHEC, Sanibel Captiva Conservation Foundation and Mote Marine Laboratory for research and to guide resource management activities.

In the future, CHEVWQMN water quality data will be used to evaluate future water quality trends, as well as to compare with monthly CCHMN monthly sampling and continuous monitoring datasondes managed by the Aquatic Preserves. Additionally, the water quality results will be compared to seagrass health, tributary in-flows and watershed influences throughout the region as a means to assess habitat responses to management practices and land use changes. Additional needs for the CHEVWQMN include: 1) increasing the number of sites to include deeper locations and fill spatial gaps, such as the west wall of Charlotte Harbor; 2) ensuring consistent laboratory support; 3) establishing numerical water quality criteria for the Charlotte Harbor estuaries; 4) developing estuary trophic state indices; and 5) continuing the program in order to promote continuity of data.

The CHEVWQMN is made possible through the support of partnering agencies, staff and the invaluable contribution from citizen water monitors over the past ten years. The Charlotte Harbor and Estero Bay Aquatic Preserves would like to thank the many partnering agencies and volunteers as the CHEVWQMN celebrates its ten year anniversary in the fall of 2006.

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Table A.1: Seasonal summary statistics for all sites

		Secchi (m)	Temp (C)	DO (mg/L)	pH	Salinity (ppt)	TN (ppm)	TP (ppm)	ChlA (µg/L)	Coliform (cfu/100mL)	Turbidity (NTU)	Color (PCU)
All	N	1903	3438	3374	3400	3404	2402	2540	2310	2839	2720	2721
	Min	0.0	4.0	0.6	5.8	0.0	0.032	0.005	0.01	1	0.1	1
	Max	4.5	32.0	10.0	9.0	42.0	4.602	1.500	114.00	1720	120.0	400
	Median	1.2	24.5	5.1	8.2	28.9	0.827	0.090	4.79	8	2.7	26
	Mean	1.3	23.7	5.0	8.1	25.9	0.887	0.142	6.70	38	3.5	39
	SE	0.0	0.1	0.0	0.0	0.2	0.010	0.003	0.16	2	0.1	1
Rainy	N	925	1404	1374	1390	1390	956	1009	898	1156	1082	1083
	Min	0.0	20.0	0.6	6.7	0.0	0.032	0.005	0.01	1	0.1	1
	Max	3.9	32.0	8.9	9.0	41.6	4.302	1.000	82.10	1720	120.0	400
	Median	1.1	28.0	4.3	8.2	25.9	0.952	0.092	6.02	8	2.6	40
	Mean	1.2	27.9	4.2	8.1	23.6	1.019	0.159	8.02	38	3.3	54
	SE	0.0	0.0	0.0	0.0	0.3	0.017	0.005	0.27	3	0.1	2
Dry	N	978	2034	2000	2010	2014	1446	1531	1412	1683	1638	1638
	Min	0.1	4.0	0.6	5.8	0.0	0.053	0.005	0.01	1	0.1	1
	Max	4.5	30.0	10.0	9.0	42.0	4.602	1.500	114.00	1100	66.0	250
	Median	1.2	21.0	5.7	8.2	30.1	0.775	0.085	3.97	8	2.7	20
	Mean	1.3	20.9	5.6	8.2	27.6	0.800	0.131	5.87	37	3.6	28
	SE	0.0	0.1	0.0	0.0	0.2	0.011	0.004	0.20	2	0.1	1

Table A.2: Annual summary statistics for all sites

	Secchi (m)	Temp (C)	DO (mg/L)	pH	Salinity (ppt)	TN (ppm)	TP (ppm)	Chl a (µg/L)	Coliform (cfu/100mL)	Turbidity (NTU)	Color (PCU)
1998 N	190	289	282	283	284	136	117	137	149	31	31
Med	1.0	25.5	4.9	8.2	24.7	1.06	0.08	7.75	10	3.4	25
Min	0.4	15.5	1.2	7.0	0.0	0.67	0.01	0.50	1	0.8	10
Max	3.0	31.0	8.8	8.6	40.2	1.91	0.67	82.10	480	9.2	110
SE	0.0	0.2	0.1	0.0	0.6	0.02	0.01	0.94	5	0.4	4
1999 N	240	413	398	404	403	359	322	361	357	363	362
Med	1.2	24.5	5.1	8.2	29.4	1.00	0.11	4.91	8	3.3	25
Min	0.3	7.5	0.6	7.2	0.0	0.35	0.02	0.50	1	0.3	1
Max	3.2	31.5	7.8	8.7	40.3	3.84	0.72	73.10	1156	52.0	280
SE	0.0	0.2	0.1	0.0	0.5	0.02	0.01	0.46	6	0.2	2
2000 N	264	451	443	447	447	136	298	339	371	353	354
Med	1.3	24.0	5.1	8.3	32.8	0.88	0.07	4.65	4	3.6	15
Min	0.3	10.0	1.0	6.4	0.8	0.11	0.01	0.50	1	0.1	1
Max	3.3	32.0	9.0	8.7	41.0	2.00	0.75	79.46	776	24.0	250
SE	0.0	0.2	0.1	0.0	0.4	0.03	0.01	0.43	3	0.2	1
2001 N	257	431	426	427	426	149	164	291	330	334	334
Med	1.0	22.0	5.0	8.2	32.5	0.92	0.08	2.50	12	3.2	25
Min	0.4	12.0	1.4	5.8	0.0	0.08	0.01	0.25	1	0.6	3
Max	3.9	32.0	8.7	8.6	42.0	2.42	0.78	88.50	880	30.0	220
SE	0.0	0.2	0.1	0.0	0.5	0.04	0.01	0.40	5	0.2	2
2002 N	242	473	467	467	471	416	420		416	419	419
Med	1.3	25.5	5.0	8.2	30.0	0.52	0.09		8	1.6	13
Min	0.2	11.0	1.1	7.0	0.3	0.05	0.01		1	0.1	1
Max	3.3	32.0	8.7	8.8	41.6	2.40	1.08		800	18.1	132
SE	0.0	0.2	0.1	0.0	0.4	0.02	0.01		7	0.1	1
2003 N	230	467	459	461	464	374	375	374	375	375	376
Med	1.3	25.0	5.1	8.2	26.9	0.55	0.06	6.20	4	1.9	30
Min	0.4	4.0	0.6	7.0	0.0	0.06	0.00	0.01	1	0.1	1
Max	3.8	30.0	9.9	8.7	39.4	2.96	0.90	34.18	240	120.0	360
SE	0.0	0.2	0.1	0.0	0.4	0.03	0.01	0.30	2	0.4	2
2004 N	218	431	426	426	427	371	382	346	381	383	383
Med	1.3	25.0	5.1	8.2	27.7	0.81	0.11	3.72	10	2.9	30
Min	0.1	13.0	0.7	6.8	0.0	0.37	0.03	0.50	1	0.7	10
Max	3.5	31.5	10.0	8.8	40.7	4.60	1.50	53.70	1720	26.0	400
SE	0.0	0.2	0.1	0.0	0.5	0.02	0.01	0.32	6	0.1	3
2005 N	262	483	473	485	482	461	462	462	460	462	462
Med	1.1	23.5	5.4	8.0	23.8	0.92	0.11	4.61	8	2.3	50
Min	0.0	14.5	1.0	6.7	0.0	0.03	0.01	0.58	1	0.7	10
Max	4.5	31.0	9.1	9.0	37.2	4.30	1.30	114.00	1100	28.0	240
SE	0.0	0.2	0.1	0.0	0.5	0.02	0.01	0.40	4	0.1	2

Table A.3: Summary statistics for all sites in Upper Lemon Bay

		Secchi (m)	Temp (C)	DO (mg/L)	pH	Salinity (ppt)	TN (ppm)	TP (ppm)	Chl a (µg/L)	Coliform cfu/100mL	Turbidity (NTU)	Color (PCU)
All	N	161	381	373	377	376	219	228	209	252	240	239
	Mean	0.9	23.7	4.1	8.0	22.4	1.035	0.199	9.22	98	2.9	38
	Median	0.9	24.5	3.9	8.0	25.3	1.005	0.180	6.30	35	2.5	30
	SE	0.0	0.2	0.1	0.0	0.6	0.031	0.007	0.60	10	0.3	2
Rain	N	104	160	155	158	157	90	92	81	104	95	94
	Mean	0.8	27.6	3.2	7.9	20.0	1.226	0.227	12.63	94	2.9	55
	Median	0.9	28.0	3.0	8.0	22.9	1.205	0.210	9.28	40	2.6	40
	SE	0.0	0.2	0.1	0.0	1.0	0.054	0.010	1.23	16	0.1	5
Dry	N	57	221	218	219	219	129	136	128	148	145	145
	Mean	0.9	20.9	4.7	8.0	24.2	0.901	0.181	7.06	101	3.0	27
	Median	0.9	21.0	4.5	8.0	27.0	0.905	0.165	5.73	32	2.5	20
	SE	0.0	0.2	0.1	0.0	0.6	0.032	0.010	0.51	13	0.4	2
1998	N	10	19	19	19	18	13	12	13	13	3	3
	Mean	0.6	25.6	3.2	8.2	21.4	1.264	0.193	20.30	95	5.5	35
	Median	0.6	26.5	3.1	8.2	25.5	1.250	0.170	16.40	28	4.2	30
	SE	0.1	0.7	0.2	0.1	2.2	0.039	0.020	2.89	37	1.9	8
1999	N	19	48	46	48	48	35	29	34	34	32	31
	Mean	0.9	23.3	3.8	8.0	23.6	1.208	0.214	11.26	160	3.5	36
	Median	0.9	24.0	3.6	8.0	26.3	1.205	0.200	8.35	69	3.5	30
	SE	0.0	0.6	0.2	0.1	1.5	0.035	0.012	1.69	42	0.2	3
2000	N	20	53	52	53	52	12	25	28	32	29	29
	Mean	1.0	23.2	4.2	8.2	27.4	1.037	0.145	8.82	61	3.2	25
	Median	1.0	24.0	3.9	8.2	31.2	1.017	0.140	6.16	23	2.7	20
	SE	0.0	0.7	0.2	0.0	1.3	0.071	0.010	2.11	16	0.2	3
2001	N	26	52	51	52	50	16	18	28	30	32	32
	Mean	0.7	23.3	3.9	8.0	25.3	1.173	0.209	6.27	116	3.0	38
	Median	0.7	22.8	3.5	8.0	27.4	1.028	0.180	4.00	60	2.6	30
	SE	0.0	0.6	0.2	0.0	1.6	0.086	0.023	1.23	36	0.2	6
2002	N	20	51	51	49	51	34	34		34	34	34
	Mean	0.9	24.5	4.0	8.0	24.2	0.673	0.221		107	1.7	15
	Median	0.9	26.0	3.6	8.0	28.5	0.589	0.190		20	1.4	11
	SE	0.0	0.7	0.3	0.1	1.4	0.084	0.032		34	0.1	2
2003	N	24	54	51	53	54	30	30	30	30	30	30
	Mean	0.9	24.0	4.3	7.9	19.7	1.007	0.149	9.10	71	4.2	31
	Median	0.9	25.8	4.2	8.0	21.7	0.605	0.125	7.11	46	2.4	24
	SE	0.0	0.6	0.2	0.0	1.4	0.153	0.021	0.99	13	2.1	3
2004	N	13	48	48	48	48	32	33	29	33	33	33
	Mean	0.9	24.1	4.0	8.0	22.0	0.957	0.194	6.49	96	3.1	37
	Median	0.9	26.0	4.0	8.0	25.0	0.883	0.180	5.17	21	2.7	30
	SE	0.1	0.6	0.2	0.0	1.4	0.060	0.010	0.92	32	0.2	3
2005	N	29	56	55	55	55	47	47	47	46	47	47
	Mean	1.0	22.9	4.6	7.9	16.0	1.126	0.236	9.09	79	2.2	68
	Median	1.0	23.0	4.3	7.8	14.9	1.113	0.210	6.34	29	2.1	50
	SE	0.0	0.6	0.2	0.1	1.5	0.037	0.016	1.10	14	0.1	8

Table A.4: Summary statistics for all sites in Lower Lemon Bay

		Secchi (m)	Temp (C)	DO (mg/L)	pH	Salinity (ppt)	TN (ppm)	TP (ppm)	Chl a (µg/L)	Coliform cfu/100mL	Turbidity (NTU)	Color (PCU)
All	N	230	525	515	520	518	265	275	255	302	296	296
	Mean	1.3	23.6	4.7	8.3	31.7	0.790	0.084	5.55	41	3.1	25
	Median	1.3	24.0	4.8	8.3	33.5	0.767	0.070	3.92	8	2.6	15
	SE	0.0	0.2	0.1	0.0	0.3	0.025	0.003	0.42	5	0.1	2
Rain	N	116	209	203	206	207	109	108	101	120	118	118
	Mean	1.3	28.0	3.9	8.2	29.9	0.930	0.083	7.30	54	2.9	38
	Median	1.3	28.0	4.1	8.2	32.1	0.892	0.080	5.83	12	2.5	25
	SE	0.0	0.1	0.1	0.0	0.6	0.044	0.004	0.88	11	0.1	3
Dry	N	114	316	312	314	311	156	167	154	182	178	178
	Mean	1.3	20.7	5.1	8.3	32.9	0.692	0.084	4.40	32	3.2	16
	Median	1.3	20.3	5.2	8.4	33.8	0.725	0.070	3.20	8	2.7	15
	SE	0.0	0.2	0.1	0.0	0.2	0.027	0.004	0.37	4	0.1	1
1998	N	21	23	23	22	22	13	11	14	14	3	3
	Mean	1.3	25.5	5.1	8.4	33.1	0.955	0.077	8.14	9	3.8	12
	Median	1.4	25.0	5.4	8.4	33.8	0.905	0.080	7.12	5	3.4	10
	SE	0.1	0.8	0.3	0.0	0.5	0.042	0.007	1.55	4	0.4	2
1999	N	37	60	56	58	57	40	34	39	37	39	39
	Mean	1.4	24.3	4.5	8.2	33.0	1.003	0.093	5.79	42	4.4	21
	Median	1.3	24.8	4.8	8.2	33.9	0.970	0.075	3.92	8	3.8	15
	SE	0.1	0.5	0.2	0.0	0.6	0.044	0.008	1.03	18	0.4	3
2000	N	35	67	65	66	67	10	26	30	29	31	31
	Mean	1.3	23.0	4.7	8.3	34.6	0.963	0.070	8.21	40	3.9	16
	Median	1.3	23.5	5.1	8.4	35.0	0.845	0.070	5.21	8	3.7	10
	SE	0.0	0.6	0.2	0.0	0.4	0.122	0.005	2.54	11	0.3	2
2001	N	38	67	66	67	67	12	13	28	31	31	31
	Mean	1.1	22.7	4.7	8.2	32.2	0.897	0.091	4.82	40	3.4	32
	Median	1.0	22.0	4.7	8.2	35.0	0.783	0.080	2.75	12	2.8	19
	SE	0.1	0.6	0.2	0.0	0.9	0.093	0.014	1.31	11	0.4	6
2002	N	28	79	76	78	79	43	44		43	44	44
	Mean	1.5	24.0	4.5	8.3	31.1	0.437	0.080		63	2.3	10
	Median	1.5	25.0	4.5	8.3	32.1	0.425	0.070		8	1.8	9
	SE	0.1	0.6	0.2	0.0	0.6	0.057	0.010		26	0.3	1
2003	N	28	79	79	79	79	43	43	43	43	43	43
	Mean	1.4	23.9	4.7	8.2	31.3	0.767	0.059	6.98	26	2.8	21
	Median	1.3	26.0	4.7	8.2	33.2	0.550	0.060	5.56	3	2.4	17
	SE	0.1	0.6	0.2	0.0	0.7	0.092	0.006	0.78	7	0.3	2
2004	N	25	75	75	74	73	41	41	38	42	42	42
	Mean	1.4	23.5	4.5	8.2	31.7	0.697	0.094	2.89	35	3.2	24
	Median	1.4	26.0	4.5	8.2	33.5	0.614	0.087	2.18	11	2.9	20
	SE	0.1	0.5	0.2	0.0	0.7	0.035	0.005	0.36	8	0.2	3
2005	N	18	75	75	76	74	63	63	63	63	63	63
	Mean	1.3	22.8	4.8	8.3	28.1	0.891	0.097	4.67	48	2.4	42
	Median	1.2	23.0	5.1	8.4	31.4	0.805	0.081	3.87	16	2.1	30
	SE	0.1	0.5	0.2	0.0	1.0	0.042	0.007	0.41	8	0.1	5

Table A.5: Summary statistics for all sites in Upper Charlotte Harbor

		Secchi (m)	Temp (C)	DO (mg/L)	pH	Salinity (ppt)	TN (ppm)	TP (ppm)	Chl a (µg/L)	Coliform cfu/100mL	Turbidity (NTU)	Color (PCU)
All	N	394	657	650	657	649	505	532	482	587	556	557
	Mean	0.9	23.6	5.2	7.7	17.3	1.040	0.305	9.48	48	3.2	70
	Median	0.9	24.0	5.2	7.8	17.9	0.975	0.240	6.16	24	2.7	50
	SE	0.0	0.2	0.1	0.0	0.4	0.022	0.009	0.50	4	0.1	3
Rain	N	189	263	263	262	261	200	207	187	239	221	222
	Mean	0.9	27.7	4.1	7.6	13.7	1.202	0.363	9.68	51	3.1	104
	Median	0.8	28.0	4.0	7.6	12.4	1.206	0.320	6.73	28	2.6	80
	SE	0.0	0.1	0.1	0.0	0.6	0.035	0.014	0.76	6	0.2	5
Dry	N	205	394	387	395	388	305	325	295	348	335	335
	Mean	1.0	20.9	6.0	7.8	19.7	0.934	0.269	9.35	46	3.2	49
	Median	1.0	21.0	6.0	7.8	21.6	0.895	0.200	5.89	22	2.8	40
	SE	0.0	0.2	0.1	0.0	0.4	0.027	0.012	0.67	4	0.1	2
1998	N	63	83	81	83	81	31	23	34	34	7	7
	Mean	0.9	24.6	5.0	7.6	11.6	1.295	0.257	16.57	53	4.0	56
	Median	0.8	24.5	4.8	7.6	10.9	1.135	0.240	14.30	35	4.7	50
	SE	0.1	0.4	0.2	0.0	0.9	0.054	0.031	2.80	11	0.5	9
1999	N	51	81	78	78	78	82	71	81	81	78	78
	Mean	1.0	24.1	4.9	7.8	18.0	1.331	0.278	9.65	48	3.4	80
	Median	0.9	24.0	5.1	7.8	20.1	1.310	0.250	5.97	20	2.8	55
	SE	0.0	0.5	0.1	0.0	1.0	0.034	0.019	1.34	10	0.2	7
2000	N	48	79	79	79	79	33	72	67	73	70	70
	Mean	1.0	23.2	5.1	7.8	23.4	0.997	0.198	8.45	37	3.7	48
	Median	1.0	24.0	5.1	7.8	26.4	0.935	0.140	5.61	16	3.5	35
	SE	0.0	0.5	0.2	0.0	1.0	0.048	0.017	1.30	11	0.2	5
2001	N	42	79	80	79	78	31	36	60	70	71	71
	Mean	0.8	23.0	5.0	7.8	21.5	1.073	0.254	7.36	69	3.3	56
	Median	0.8	22.5	5.0	7.8	24.5	1.020	0.190	3.77	41	3.1	33
	SE	0.0	0.5	0.2	0.0	1.3	0.077	0.029	1.66	9	0.2	6
2002	N	39	80	81	81	79	81	81		80	81	81
	Mean	0.9	23.9	5.1	7.8	19.0	0.556	0.335		79	2.0	32
	Median	0.9	25.8	5.1	7.8	20.9	0.525	0.270		29	1.6	23
	SE	0.1	0.5	0.1	0.0	1.1	0.043	0.023		16	0.1	3
2003	N	42	78	77	79	78	71	71	70	71	71	72
	Mean	1.0	23.4	5.3	7.7	14.8	0.956	0.277	8.69	30	2.4	67
	Median	0.9	25.0	5.1	7.6	16.1	0.790	0.210	7.67	20	1.9	51
	SE	0.1	0.6	0.2	0.0	1.0	0.069	0.025	0.76	4	0.2	6
2004	N	51	88	88	88	87	87	88	80	88	88	88
	Mean	1.0	23.5	5.5	7.8	17.6	1.134	0.363	8.67	50	4.1	96
	Median	0.9	25.0	5.8	7.8	19.6	0.942	0.305	5.51	24	3.1	60
	SE	0.1	0.4	0.2	0.0	0.9	0.062	0.027	0.97	10	0.4	8
2005	N	58	89	86	90	89	89	90	90	90	90	90
	Mean	1.0	23.3	5.7	7.7	13.1	1.103	0.386	11.11	25	3.4	105
	Median	0.9	23.0	5.6	7.8	13.3	1.001	0.325	7.78	15	3.0	80
	SE	0.1	0.5	0.2	0.0	0.9	0.043	0.026	1.15	3	0.2	6

Table A.6: Summary statistics for all sites in Lower Charlotte Harbor

		Secchi (m)	Temp (C)	DO (mg/L)	pH	Salinity (ppt)	TN (ppm)	TP (ppm)	Chl a (µg/L)	Coliform cfu/100mL	Turbidity (NTU)	Color (PCU)
All	N	105	252	247	249	248	207	215	198	234	226	226
	Mean	1.8	23.9	5.4	8.3	28.2	0.792	0.114	5.61	13	2.5	30
	Median	1.5	24.5	5.5	8.2	29.0	0.755	0.100	4.42	3	2.1	24
	SE	0.1	0.3	0.1	0.0	0.4	0.028	0.005	0.35	2	0.2	2
Rain	N	60	109	106	106	107	84	85	80	98	92	92
	Mean	1.6	28.1	4.7	8.2	26.1	0.939	0.128	6.25	12	2.6	42
	Median	1.4	28.0	4.7	8.2	26.4	0.910	0.110	5.73	2	2.1	35
	SE	0.1	0.2	0.1	0.0	0.7	0.048	0.008	0.47	4	0.3	3
Dry	N	45	143	141	143	141	123	130	118	136	134	134
	Mean	2.0	20.8	5.8	8.3	29.9	0.692	0.104	5.17	13	2.5	21
	Median	1.8	21.0	5.9	8.4	29.8	0.735	0.094	3.49	4	2.0	19
	SE	0.1	0.3	0.1	0.0	0.4	0.030	0.005	0.49	2	0.2	1
1998	N	8	22	20	22	22	15	12	15	15	3	3
	Mean	1.4	26.8	4.8	8.3	25.5	1.020	0.084	9.20	25	1.2	22
	Median	1.1	28.3	5.0	8.2	27.6	1.005	0.080	7.80	4	1.0	20
	SE	0.3	0.7	0.2	0.0	1.2	0.060	0.008	1.61	11	0.3	4
1999	N	11	34	32	34	31	32	30	33	30	34	34
	Mean	2.1	24.3	5.2	8.4	27.6	1.049	0.122	4.61	23	3.4	28
	Median	2.1	24.0	5.1	8.4	29.2	1.005	0.110	3.98	4	2.4	25
	SE	0.2	0.7	0.2	0.0	1.3	0.048	0.010	0.59	12	0.6	2
2000	N	11	33	33	32	32	16	27	30	32	31	31
	Mean	2.2	23.3	5.4	8.5	32.7	0.890	0.066	3.63	9	3.0	16
	Median	2.3	24.0	5.7	8.6	33.5	0.870	0.060	3.45	2	2.6	15
	SE	0.3	0.9	0.2	0.0	0.7	0.080	0.005	0.49	2	0.4	2
2001	N	16	31	29	29	31	14	15	25	27	27	27
	Mean	1.5	22.9	4.8	8.2	31.4	0.826	0.092	4.54	18	3.8	31
	Median	1.2	22.5	5.1	8.2	33.8	0.815	0.080	4.30	4	3.2	20
	SE	0.2	0.8	0.3	0.0	1.2	0.092	0.010	0.64	6	0.6	5
2002	N	14	32	32	33	32	33	33		33	33	33
	Mean	1.6	24.7	5.4	8.4	30.0	0.490	0.126		14	1.8	15
	Median	1.4	27.0	5.5	8.4	30.4	0.525	0.120		4	1.1	14
	SE	0.2	0.9	0.3	0.0	1.0	0.071	0.010		5	0.2	2
2003	N	20	34	34	33	34	30	31	31	31	31	31
	Mean	1.5	23.2	5.5	8.3	26.7	0.707	0.078	8.08	5	1.9	33
	Median	1.4	24.5	5.8	8.3	27.5	0.550	0.070	7.31	2	1.7	30
	SE	0.1	0.8	0.3	0.0	0.9	0.104	0.008	1.29	1	0.2	3
2004	N	11	30	31	30	30	31	31	28	30	31	31
	Mean	1.8	24.0	5.5	8.2	27.1	0.796	0.143	5.63	10	2.2	43
	Median	1.4	25.8	5.6	8.2	28.2	0.746	0.095	3.90	3	2.2	30
	SE	0.3	0.7	0.2	0.1	1.1	0.058	0.017	0.85	3	0.2	7
2005	N	14	36	36	36	36	36	36	36	36	36	36
	Mean	2.1	23.4	5.9	8.1	24.5	0.756	0.156	6.02	6	1.9	42
	Median	1.7	23.5	6.0	8.2	24.5	0.741	0.135	4.51	1	1.6	30
	SE	0.3	0.8	0.2	0.0	0.8	0.046	0.013	0.78	2	0.2	4

Table A.7: Summary statistics for all sites in Gasparilla/Cape Haze

		Secchi (m)	Temp (C)	DO (mg/L)	pH	Salinity (ppt)	TN (ppm)	TP (ppm)	Chl a (µg/L)	Coliform cfu/100mL	Turbidity (NTU)	Color (PCU)
All	N	86	192	188	194	192	141	150	145	169	162	162
	Mean	1.5	24.2	4.6	8.3	31.5	0.906	0.093	4.49	20	3.3	24
	Median	1.5	25.0	4.6	8.2	33.2	0.806	0.080	3.58	6	2.7	20
	SE	0.1	0.3	0.1	0.0	0.4	0.042	0.005	0.31	3	0.2	1
Rain	N	44	82	79	83	82	58	60	57	67	65	65
	Mean	1.4	28.4	4.1	8.2	29.9	0.984	0.104	5.64	19	3.0	32
	Median	1.5	28.3	4.4	8.2	31.7	0.849	0.080	4.74	4	2.7	30
	SE	0.1	0.2	0.1	0.0	0.8	0.061	0.010	0.51	5	0.2	3
Dry	N	42	110	109	111	110	83	90	88	102	97	97
	Mean	1.6	21.1	5.0	8.3	32.7	0.851	0.085	3.74	21	3.5	19
	Median	1.4	21.0	4.9	8.2	33.8	0.775	0.070	3.02	6	2.7	15
	SE	0.1	0.4	0.1	0.0	0.4	0.057	0.006	0.36	4	0.3	1
1998	N	9	21	21	21	21	11	10	12	12	3	3
	Mean	1.4	26.6	4.1	8.3	32.1	1.017	0.075	6.39	10	3.3	18
	Median	1.3	28.0	4.2	8.2	32.5	0.895	0.075	5.43	4	3.7	15
	SE	0.1	0.7	0.3	0.0	1.1	0.103	0.009	1.25	4	0.6	6
1999	N	16	32	31	33	32	26	28	29	30	30	30
	Mean	1.9	24.2	5.3	8.3	33.1	0.864	0.099	5.14	13	4.0	20
	Median	1.7	25.0	5.9	8.4	33.9	0.855	0.095	3.87	4	3.8	15
	SE	0.1	0.9	0.3	0.1	0.6	0.035	0.009	0.78	3	0.4	3
2000	N	12	25	25	26	25	9	17	22	24	23	23
	Mean	1.3	24.3	4.7	8.4	35.5	0.779	0.058	4.13	14	4.4	13
	Median	1.2	24.0	4.6	8.4	36.3	0.775	0.050	3.10	3	3.5	10
	SE	0.1	0.9	0.2	0.0	0.6	0.064	0.007	0.67	7	0.6	1
2001	N	12	24	23	24	24	9	10	19	20	21	21
	Mean	1.3	23.0	4.5	8.2	32.0	1.239	0.082	3.79	17	4.4	23
	Median	1.2	21.8	4.5	8.2	34.4	0.955	0.080	2.40	5	3.0	20
	SE	0.1	1.0	0.3	0.1	1.5	0.223	0.013	0.84	6	1.3	3
2002	N	7	20	21	20	20	19	20		18	20	20
	Mean	1.3	24.4	4.5	8.3	30.8	0.571	0.093		49	1.5	13
	Median	1.4	26.5	4.5	8.3	32.3	0.625	0.065		16	1.1	11
	SE	0.3	1.1	0.3	0.0	1.2	0.077	0.018		17	0.1	2
2003	N	3	14	14	14	14	12	12	12	12	12	12
	Mean	1.1	23.0	4.9	8.2	30.6	0.828	0.051	6.68	11	2.4	20
	Median	1.0	24.5	4.5	8.2	31.7	0.550	0.050	6.40	9	2.4	18
	SE	0.2	1.5	0.4	0.1	1.6	0.193	0.010	1.24	3	0.3	2
2004	N	10	22	21	22	22	24	22	20	22	22	22
	Mean	1.5	25.3	4.3	8.2	31.8	0.967	0.112	3.48	39	3.3	34
	Median	1.5	26.3	3.9	8.2	32.2	0.744	0.087	3.34	13	3.4	30
	SE	0.1	0.8	0.3	0.0	1.0	0.109	0.017	0.62	13	0.2	4
2005	N	17	34	32	34	34	31	31	31	31	31	31
	Mean	1.5	23.3	4.5	8.2	26.9	1.030	0.117	4.19	12	2.6	38
	Median	1.6	24.0	4.6	8.2	28.2	0.806	0.095	3.59	4	2.2	30
	SE	0.1	0.8	0.2	0.1	1.1	0.110	0.013	0.63	2	0.2	4

Table A.8: Summary statistics for all sites in Pine Island Sound

		Secchi (m)	Temp (C)	DO (mg/L)	pH	Salinity (ppt)	TN (ppm)	TP (ppm)	Chl a (µg/L)	Coliform cfu/100mL	Turbidity (NTU)	Color (PCU)
All	N	167	400	392	388	399	309	330	298	383	368	369
	Mean	1.4	23.6	5.7	8.4	32.2	0.808	0.073	6.52	13	3.7	25
	Median	1.3	24.5	5.9	8.4	32.9	0.752	0.060	4.98	2	2.6	18
	SE	0.0	0.2	0.1	0.0	0.2	0.027	0.004	0.34	2	0.2	1
Rain	N	87	164	160	160	163	121	132	118	158	148	149
	Mean	1.5	27.8	5.1	8.4	30.6	0.904	0.079	8.87	11	3.5	31
	Median	1.3	28.0	5.2	8.4	30.8	0.805	0.060	7.07	2	2.4	25
	SE	0.1	0.1	0.1	0.0	0.5	0.050	0.008	0.58	3	0.3	2
Dry	N	80	236	232	228	236	188	198	180	225	220	220
	Mean	1.3	20.7	6.1	8.4	33.2	0.747	0.068	4.98	13	3.8	20
	Median	1.3	20.5	6.4	8.4	33.7	0.717	0.060	3.57	2	2.7	15
	SE	0.1	0.2	0.1	0.0	0.2	0.029	0.003	0.38	2	0.2	2
1998	N	9	21	21	19	21	14	11	12	14	2	2
	Mean	1.0	24.6	5.6	8.4	31.2	1.242	0.058	11.81	25	3.2	20
	Median	1.1	24.5	5.7	8.3	30.4	1.175	0.060	6.82	8	3.2	20
	SE	0.1	0.9	0.2	0.0	0.7	0.070	0.009	3.33	10	2.2	5
1999	N	14	37	37	33	37	36	33	37	37	38	38
	Mean	1.3	24.0	5.6	8.4	32.8	0.995	0.074	7.40	13	4.1	21
	Median	1.2	24.5	5.5	8.4	32.9	0.935	0.070	6.17	4	3.5	20
	SE	0.1	0.7	0.2	0.0	0.5	0.044	0.006	0.90	5	0.4	2
2000	N	28	57	57	57	57	13	35	50	56	52	53
	Mean	1.4	23.3	5.8	8.5	35.4	0.853	0.066	6.59	5	5.3	12
	Median	1.3	23.5	5.8	8.4	35.8	0.845	0.060	4.86	2	4.0	10
	SE	0.1	0.7	0.2	0.0	0.3	0.087	0.005	0.74	1	0.5	1
2001	N	32	52	52	50	52	21	22	41	48	47	47
	Mean	1.1	22.7	6.1	8.4	34.4	0.948	0.057	5.03	17	6.2	23
	Median	1.1	22.0	6.2	8.4	35.9	0.915	0.050	3.10	2	4.4	20
	SE	0.1	0.6	0.2	0.0	0.7	0.092	0.005	0.92	5	0.7	2
2002	N	32	68	63	66	68	67	67		67	67	67
	Mean	1.5	23.8	5.5	8.3	33.0	0.483	0.065		22	3.0	14
	Median	1.4	25.0	6.1	8.5	33.7	0.480	0.050		2	1.7	7
	SE	0.1	0.6	0.2	0.0	0.5	0.036	0.005		7	0.4	2
2003	N	15	65	62	62	64	60	60	60	60	60	60
	Mean	1.9	23.4	5.5	8.4	30.2	0.668	0.052	7.77	8	1.9	29
	Median	1.8	25.0	5.8	8.6	31.1	0.550	0.035	5.83	1	1.7	20
	SE	0.2	0.6	0.3	0.0	0.6	0.067	0.006	0.73	3	0.2	2
2004	N	12	40	41	41	40	37	41	37	40	41	41
	Mean	1.8	23.5	5.5	8.3	31.6	0.787	0.084	4.19	6	3.1	34
	Median	1.8	25.0	5.7	8.4	33.1	0.762	0.072	3.20	1	2.7	20
	SE	0.2	0.7	0.3	0.1	0.7	0.050	0.007	0.64	2	0.3	5
2005	N	25	60	59	60	60	61	61	61	61	61	61
	Mean	1.3	24.0	5.8	8.3	28.6	1.049	0.105	6.89	12	3.1	40
	Median	1.3	25.0	6.1	8.4	30.2	0.940	0.068	4.90	1	2.2	30
	SE	0.1	0.6	0.2	0.1	0.7	0.072	0.017	0.81	5	0.5	5

Table A.9: Summary statistics for all sites in Matlacha Pass

		Secchi (m)	Temp (C)	DO (mg/L)	pH	Salinity (ppt)	TN (ppm)	TP (ppm)	Chl a (µg/L)	Coliform cfu/100mL	Turbidity (NTU)	Color (PCU)
All	N	202	261	252	250	258	194	212	187	234	221	221
	Mean	1.6	24.0	5.5	8.2	21.7	0.905	0.084	5.42	9	2.5	37
	Median	1.6	24.5	5.5	8.2	22.1	0.851	0.076	3.50	4	2.1	30
	SE	0.0	0.3	0.1	0.0	0.5	0.032	0.003	0.52	1	0.1	2
Rain	N	84	106	103	104	105	76	86	71	95	85	85
	Mean	1.4	28.2	4.6	8.1	18.7	1.021	0.094	7.89	11	3.0	51
	Median	1.3	28.0	4.8	8.1	17.3	0.975	0.090	5.31	3	2.5	45
	SE	0.1	0.2	0.1	0.0	0.8	0.051	0.005	1.16	2	0.2	4
Dry	N	118	155	149	146	153	118	126	116	139	136	136
	Mean	1.8	21.1	6.1	8.2	23.7	0.831	0.076	3.90	8	2.1	28
	Median	1.9	21.0	6.1	8.2	24.2	0.793	0.070	3.00	4	2.0	25
	SE	0.0	0.3	0.1	0.0	0.6	0.041	0.004	0.38	1	0.1	2
1998	N	24	32	30	31	32	12	11	11	15	3	3
	Mean	1.3	25.5	4.9	8.1	18.1	1.089	0.073	7.33	9	2.2	42
	Median	1.4	25.3	4.9	8.0	19.3	1.105	0.070	5.31	8	2.1	40
	SE	0.1	0.7	0.2	0.0	1.0	0.033	0.006	1.84	2	0.2	2
1999	N	28	32	31	31	31	30	29	31	30	32	32
	Mean	1.7	23.9	5.2	8.1	21.7	1.224	0.099	6.91	10	2.9	42
	Median	1.7	23.5	5.6	8.1	20.4	1.167	0.080	3.10	4	2.5	30
	SE	0.1	0.7	0.3	0.0	1.3	0.103	0.009	2.33	3	0.3	5
2000	N	31	35	35	34	35	15	31	30	34	32	32
	Mean	1.7	24.0	5.3	8.3	26.2	1.018	0.062	4.50	9	2.7	20
	Median	1.7	24.0	5.1	8.2	26.8	0.905	0.053	3.20	2	2.4	20
	SE	0.1	0.8	0.2	0.0	0.8	0.072	0.005	0.54	3	0.2	2
2001	N	24	32	32	32	31	14	14	27	28	28	28
	Mean	1.6	23.4	5.4	8.1	27.5	0.952	0.076	3.75	14	3.1	29
	Median	1.6	22.3	5.3	8.2	31.1	0.923	0.070	2.30	6	2.6	24
	SE	0.1	0.8	0.2	0.0	1.7	0.110	0.008	0.87	3	0.3	3
2002	N	26	34	34	32	34	34	35		35	34	34
	Mean	1.7	24.7	5.4	8.1	23.6	0.532	0.093		10	1.6	19
	Median	1.6	26.5	5.3	8.2	26.5	0.525	0.080		3	1.1	14
	SE	0.1	0.9	0.3	0.0	1.3	0.040	0.009		3	0.2	2
2003	N	26	34	34	32	34	30	30	30	30	30	30
	Mean	1.8	23.5	6.1	8.2	18.4	0.848	0.059	7.64	5	1.9	39
	Median	1.8	24.8	6.0	8.2	20.0	0.550	0.045	5.58	1	1.6	33
	SE	0.1	0.9	0.2	0.0	1.1	0.120	0.008	1.09	3	0.2	4
2004	N	24	32	27	29	31	29	32	28	32	32	32
	Mean	1.6	24.2	5.6	8.3	21.3	0.856	0.094	4.11	10	2.6	50
	Median	1.8	25.0	5.8	8.4	21.8	0.793	0.085	3.38	2	2.3	40
	SE	0.1	0.7	0.3	0.0	1.0	0.048	0.006	0.63	3	0.3	6
2005	N	19	30	29	29	30	30	30	30	30	30	30
	Mean	1.4	22.7	6.4	8.1	16.3	0.963	0.102	5.05	5	2.7	60
	Median	1.4	23.0	6.5	8.1	15.3	0.967	0.086	2.65	4	2.2	50
	SE	0.1	0.8	0.2	0.1	1.4	0.049	0.010	1.22	1	0.2	6

Table A.10: Summary statistics for all sites in San Carlos Bay

		Secchi (m)	Temp (C)	DO (mg/L)	pH	Salinity (ppt)	TN (ppm)	TP (ppm)	Chl a (µg/L)	Coliform cfu/100mL	Turbidity (NTU)	Color (PCU)
All	N	327	340	334	339	339	249	263	245	310	294	294
	Mean	1.5	24.1	5.9	8.3	29.1	0.755	0.069	4.41	12	4.2	27
	Median	1.4	24.8	5.9	8.2	30.6	0.753	0.060	3.43	2	3.2	20
	SE	0.0	0.3	0.1	0.0	0.4	0.025	0.002	0.25	2	0.4	1
Rain	N	135	138	135	139	137	93	104	94	125	117	117
	Mean	1.4	28.4	5.3	8.3	27.4	0.869	0.069	5.58	12	4.5	36
	Median	1.3	28.5	5.3	8.2	28.9	0.845	0.061	4.89	2	3.2	26
	SE	0.0	0.1	0.1	0.0	0.6	0.046	0.003	0.43	3	1.0	3
Dry	N	192	202	199	200	202	156	159	151	185	177	177
	Mean	1.5	21.2	6.3	8.3	30.2	0.688	0.069	3.68	11	4.1	21
	Median	1.5	22.0	6.2	8.2	31.5	0.676	0.060	2.91	3	3.2	16
	SE	0.0	0.3	0.1	0.0	0.4	0.028	0.003	0.28	2	0.2	1
1998	N	35	39	39	39	39	13	14	15	18	4	4
	Mean	1.1	26.2	5.8	8.3	27.2	0.957	0.054	6.00	28	4.2	19
	Median	1.1	26.0	5.8	8.2	27.7	0.915	0.050	5.90	2	3.3	18
	SE	0.1	0.6	0.1	0.0	0.9	0.061	0.004	0.86	20	1.1	2
1999	N	42	45	45	45	45	43	37	42	44	45	45
	Mean	1.4	24.4	5.7	8.3	29.1	0.983	0.095	5.07	13	4.5	31
	Median	1.4	24.5	5.7	8.2	30.8	0.880	0.080	3.68	4	4.1	25
	SE	0.1	0.6	0.2	0.0	1.0	0.055	0.007	0.82	3	0.3	4
2000	N	47	48	44	47	47	14	31	43	47	44	44
	Mean	1.6	24.1	6.0	8.4	32.5	0.899	0.057	3.44	7	4.8	12
	Median	1.5	24.5	6.1	8.4	32.8	0.890	0.050	3.20	2	4.2	10
	SE	0.1	0.7	0.1	0.0	0.5	0.051	0.004	0.29	1	0.4	1
2001	N	43	44	44	44	44	20	20	33	40	40	40
	Mean	1.2	23.4	5.8	8.3	32.6	0.823	0.064	3.22	16	6.0	25
	Median	1.1	22.8	5.8	8.2	34.5	0.835	0.057	2.50	4	5.2	20
	SE	0.1	0.7	0.1	0.0	1.0	0.075	0.006	0.44	7	0.6	3
2002	N	43	44	44	44	44	45	45		45	45	45
	Mean	1.4	24.4	5.7	8.3	30.1	0.385	0.066		15	2.3	13
	Median	1.4	25.8	5.6	8.4	31.4	0.370	0.060		2	2.0	10
	SE	0.1	0.8	0.2	0.0	0.8	0.039	0.005		5	0.2	2
2003	N	40	43	42	43	42	39	39	39	39	39	39
	Mean	1.8	23.7	6.2	8.3	27.1	0.739	0.048	6.75	10	5.1	29
	Median	1.7	25.5	6.2	8.2	27.7	0.550	0.030	5.65	2	1.9	23
	SE	0.1	0.8	0.1	0.0	1.0	0.094	0.007	0.80	4	3.0	3
2004	N	35	37	36	35	37	33	35	31	35	35	35
	Mean	1.9	23.6	5.8	8.3	29.7	0.656	0.070	2.95	9	3.4	33
	Median	1.9	25.0	5.9	8.2	30.6	0.617	0.064	2.23	2	3.0	30
	SE	0.1	0.8	0.2	0.0	1.0	0.036	0.004	0.54	2	0.3	5
2005	N	42	40	40	42	41	42	42	42	42	42	42
	Mean	1.4	23.4	6.2	8.1	23.6	0.870	0.084	4.22	5	3.6	50
	Median	1.4	24.0	6.0	8.0	24.3	0.862	0.070	3.28	2	3.0	50
	SE	0.1	0.8	0.2	0.0	1.1	0.037	0.009	0.41	1	0.3	4

Table A.11: Summary statistics for all sites in Estero Bay

		Secchi (m)	Temp (C)	DO (mg/L)	pH	Salinity (ppt)	TN (ppm)	TP (ppm)	Chl a (µg/L)	Coliform cfu/100mL	Turbidity (NTU)	Color (PCU)
All	N	177	361	356	357	357	276	297	263	331	319	319
	Mean	1.2	23.6	4.7	8.1	27.5	0.790	0.070	5.75	44	5.6	31
	Median	1.1	25.0	4.8	8.2	30.4	0.762	0.060	4.39	10	4.2	30
	SE	0.0	0.2	0.1	0.0	0.5	0.027	0.003	0.50	5	0.3	1
Rain	N	82	148	146	147	147	113	122	101	137	128	128
	Mean	1.2	27.5	3.9	8.1	24.9	0.894	0.064	5.95	32	3.8	42
	Median	1.2	27.5	3.9	8.1	27.7	0.897	0.056	5.53	8	3.3	33
	SE	0.0	0.1	0.1	0.0	0.8	0.049	0.003	0.42	5	0.2	2
Dry	N	95	213	210	210	210	163	175	162	194	191	191
	Mean	1.2	20.9	5.3	8.2	29.4	0.718	0.074	5.63	52	6.7	25
	Median	1.1	21.0	5.2	8.2	32.0	0.707	0.061	3.90	14	5.1	20
	SE	0.0	0.2	0.1	0.0	0.5	0.028	0.004	0.78	8	0.4	1
1998	N	9	26	25	24	26	14	13	11	14	3	3
	Mean	1.0	26.2	4.0	8.2	30.0	1.068	0.062	7.74	29	6.5	20
	Median	1.0	28.0	4.3	8.2	31.9	0.982	0.050	7.69	20	6.1	15
	SE	0.1	0.7	0.3	0.0	1.0	0.068	0.006	0.86	8	0.9	5
1999	N	15	35	34	35	35	35	31	35	34	35	35
	Mean	1.0	24.2	4.6	8.1	29.3	0.963	0.096	6.32	43	7.4	35
	Median	1.0	25.0	4.8	8.2	31.5	0.965	0.080	4.97	10	5.2	30
	SE	0.0	0.7	0.2	0.0	1.2	0.029	0.009	0.88	14	1.4	5
2000	N	24	44	43	43	43	14	34	39	44	41	41
	Mean	1.0	23.2	4.9	8.3	32.7	0.961	0.071	5.25	14	7.7	19
	Median	1.0	23.3	4.9	8.2	34.6	0.925	0.065	4.65	4	6.6	15
	SE	0.1	0.7	0.2	0.0	0.7	0.119	0.005	0.82	3	0.7	2
2001	N	17	42	42	42	41	11	15	29	35	36	36
	Mean	0.9	22.6	4.6	8.1	29.5	0.977	0.053	4.07	65	7.4	35
	Median	0.8	22.0	4.7	8.2	31.6	0.735	0.060	3.20	16	5.3	30
	SE	0.1	0.6	0.2	0.0	1.5	0.193	0.004	0.70	18	0.9	4
2002	N	25	55	55	54	54	51	52		52	52	52
	Mean	1.2	24.2	4.5	8.1	28.4	0.441	0.074		69	3.1	14
	Median	1.2	25.5	4.4	8.2	30.6	0.425	0.065		11	2.7	12
	SE	0.1	0.6	0.2	0.0	1.2	0.049	0.006		22	0.3	1
2003	N	28	59	59	59	58	53	53	53	53	53	53
	Mean	1.5	23.8	4.8	8.1	25.6	0.723	0.040	6.70	25	3.7	27
	Median	1.6	25.0	4.6	8.2	28.5	0.550	0.030	5.74	8	2.2	22
	SE	0.1	0.6	0.2	0.0	1.3	0.069	0.004	0.78	5	0.6	2
2004	N	28	48	48	48	48	47	48	45	48	48	48
	Mean	1.4	23.1	4.9	8.1	25.8	0.811	0.085	4.65	44	5.9	41
	Median	1.5	24.5	4.9	8.1	28.3	0.730	0.075	3.05	14	4.6	35
	SE	0.1	0.5	0.2	0.1	1.5	0.032	0.010	0.75	10	0.7	3
2005	N	31	52	50	52	52	51	51	51	51	51	51
	Mean	1.3	22.7	5.1	8.0	22.2	0.905	0.071	6.83	53	5.4	50
	Median	1.2	23.0	5.0	8.0	25.3	0.882	0.050	4.20	7	4.4	50
	SE	0.1	0.6	0.2	0.0	1.5	0.072	0.009	2.17	16	0.6	3

Table A.12: Secchi depth (m) summary and status results for each site

	Site	N	Min	Max	Mean	SE	Median	Rank*	FL Estuaries**	Status***
Upper Lemon Bay	LBFOR1	45	0.5	1.4	0.9	0.0	0.9	11	40	average
	LBGOT2	27	0.5	1.3	0.9	0.0	0.8	5	40	average
	LBV001	37	0.5	1.2	0.9	0.0	0.9	11	40	average
	LBV002	33	0.4	1.6	0.8	0.0	0.8	5	40	average
	LBV003	19	0.4	1.3	0.8	0.1	0.8	5	40	average
Lower Lemon Bay	GSV002	53	0.6	2.0	1.4	0.0	1.5	37	80	higher than average
	LBANG1	25	0.6	1.5	1.1	0.0	1.2	27	60	average
	LBOYS1	16	0.7	3.3	1.3	0.1	1.2	27	60	average
	LBV004	37	0.7	2.1	1.1	0.1	1.2	27	60	average
	LBV005	59	0.5	2.2	1.4	0.1	1.4	33	80	higher than average
	LBV006	7	0.6	1.2	0.9	0.1	0.9	11	40	average
	LBV007	33	1.0	1.9	1.4	0.0	1.4	34	80	higher than average
Upper Charlotte Harbor	CHV001	83	0.6	2.3	1.3	0.0	1.2	27	60	average
	CHV002	50	0.4	2.3	1.0	0.1	0.9	11	40	average
	CHV003	15	0.5	1.0	0.8	0.0	0.7	3	30	lower than average
	CHV004	49	0.4	1.4	0.8	0.0	0.9	11	40	average
	CHV005	42	0.4	1.8	0.9	0.1	0.8	5	40	average
	CHV006	53	0.1	1.5	0.8	0.0	0.8	5	40	average
	CHV007	42	0.4	1.6	1.0	0.0	1.1	22	60	average
	CHV008	8	0.5	1.3	0.8	0.1	0.8	5	40	average
	CHV013	52	0.4	2.7	0.7	0.0	0.7	3	30	lower than average
Lower Charlotte Harbor	CHV009	20	0.7	1.5	1.1	0.1	1.1	22	60	average
	CHV010	26	0.5	2.1	1.2	0.1	1.1	22	60	average
	CHV011	59	0.7	4.5	2.3	0.1	2.3	48	100	higher than average
Gasparilla/Cape Haze	CHV012	46	0.2	2.5	1.4	0.1	1.5	37	80	higher than average
	GSV001	6	0.0	1.5	0.9	0.2	1.0	18	50	average
	GSV003	23	1.1	3.2	1.7	0.1	1.4	33	80	higher than average
	GSV004	11	1.0	1.8	1.5	0.1	1.5	37	80	higher than average
Pine Island Sound	PIJIM1	2	0.1	0.5	0.3	0.2	0.3	1	20	lower than average
	PIV001	40	0.8	2.3	1.4	0.1	1.4	33	80	higher than average
	PIV002	28	0.6	1.4	1.0	0.0	1.0	18	50	average
	PIV004	45	0.5	3.9	1.9	0.1	1.8	46	90	higher than average
	PIV006	46	0.4	2.0	1.2	0.1	1.2	27	60	average
	PIV007	6	0.8	1.5	1.1	0.1	1.0	18	50	average
Matlacha Pass	MPV001	52	0.8	2.7	1.6	0.1	1.6	42	80	higher than average
	MPV002	92	0.7	3.1	1.6	0.1	1.6	42	80	higher than average
	MPV003	58	0.4	3.8	1.7	0.1	1.8	46	90	higher than average
San Carlos Bay	EBV001	86	0.5	3.3	1.2	0.0	1.1	22	60	average
	MPV004	85	0.6	2.7	1.6	0.1	1.6	42	80	higher than average
	SCV001	89	0.7	3.5	1.5	0.1	1.5	37	80	higher than average
	SCV002	67	0.5	3.9	1.7	0.1	1.6	42	80	higher than average
Estero Bay	EBERS2	51	1.0	1.8	1.5	0.0	1.5	37	80	higher than average
	EBV003	16	0.6	1.1	0.8	0.0	0.9	11	40	average
	EBV004	45	0.4	1.8	1.0	0.0	1.0	18	50	average
	EBV005	20	0.3	1.6	0.8	0.1	0.9	11	40	average
	EBV006	15	0.6	1.7	1.0	0.1	1.1	22	60	average
	EBV007	30	0.5	2.9	1.4	0.1	1.3	32	80	higher than average
Outside of estuary	GSV005	54	0.3	0.9	0.6	0.0	0.6	2	30	lower than average
All sites		1903	0.0	4.5	1.3	0.0	1.2		60	average

*Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

**Median value compared to typical Florida estuarine water quality percentile distributions (Hand 2004)

***below average < 40, 40 < average < 70, above average > 70

Table A.13: Temperature (°C) summary and status results for each site

	Site	N	Min	Max	Mean	SE	Median	Rank*	FL Estuaries**	Status***
Upper Lemon Bay	LBFOR1	53	15.0	32.0	24.5	0.7	26.0	46	70	higher than average
	LBGOT2	71	13.5	30.0	23.3	0.5	25.0	30	60	average
	LBV001	85	15.5	30.0	24.1	0.5	24.5	19	60	average
	LBV002	87	13.5	30.0	23.4	0.5	24.5	19	60	average
	LBV003	85	12.0	32.0	23.3	0.5	24.0	4	60	average
Lower Lemon Bay	GSV002	77	14.0	31.0	23.7	0.6	24.0	4	60	average
	LBANG1	76	13.0	30.0	23.3	0.5	24.0	4	60	average
	LBOYS1	75	13.0	32.0	23.7	0.6	25.0	30	60	average
	LBV004	86	12.0	30.0	22.9	0.5	23.5	2	60	average
	LBV005	75	14.0	30.0	23.7	0.5	24.0	4	60	average
	LBV006	66	10.0	31.0	23.3	0.6	23.8	3	60	average
	LBV007	70	14.0	31.5	24.5	0.6	25.3	45	70	higher than average
Upper Charlotte Harbor	CHV001	86	11.0	31.0	23.9	0.5	24.0	4	60	average
	CHV002	49	14.0	30.0	23.5	0.6	24.0	4	60	average
	CHV003	64	13.0	29.0	23.4	0.5	25.0	30	60	average
	CHV004	88	4.0	30.0	23.4	0.5	24.8	28	60	average
	CHV005	42	14.0	31.5	24.1	0.7	24.3	16	60	average
	CHV006	88	9.0	30.5	23.4	0.5	24.0	4	60	average
	CHV007	96	14.0	31.0	23.4	0.5	24.0	4	60	average
	CHV008	90	15.0	31.5	24.1	0.5	24.5	19	60	average
	CHV013	54	14.0	29.5	23.4	0.6	24.5	19	60	average
Lower Charlotte Harbor	CHV009	85	13.5	31.0	23.8	0.5	25.0	30	60	average
	CHV010	87	13.0	31.5	23.6	0.5	24.0	4	60	average
	CHV011	80	13.5	31.5	24.5	0.5	25.0	30	60	average
Gasparilla/Cape Haze	CHV012	65	14.5	30.0	24.3	0.6	25.0	30	60	average
	GSV001	85	7.5	31.5	24.1	0.6	25.0	30	60	average
	GSV003	25	19.0	31.0	24.7	0.8	25.0	30	60	average
	GSV004	17	16.0	30.0	23.7	1.1	26.0	46	70	higher than average
Pine Island Sound	PIJIM1	35	13.0	30.0	23.0	0.8	25.0	30	60	average
	PIV001	65	14.0	30.0	23.4	0.6	24.5	19	60	average
	PIV002	93	14.0	31.0	23.5	0.5	24.5	19	60	average
	PIV004	61	15.0	30.5	24.0	0.6	24.0	4	60	average
	PIV006	83	14.0	30.5	24.1	0.5	24.5	19	60	average
	PIV007	63	10.5	31.0	23.1	0.6	25.0	30	60	average
Matlacha Pass	MPV001	88	14.5	30.5	23.7	0.5	24.3	16	60	average
	MPV002	94	13.5	31.0	24.1	0.5	24.8	28	60	average
	MPV003	79	14.0	31.0	24.1	0.5	25.0	30	60	average
San Carlos Bay	EBV001	89	13.0	31.0	24.3	0.5	25.0	30	60	average
	MPV004	88	14.0	31.0	24.1	0.5	24.3	16	60	average
	SCV001	87	10.0	31.0	23.3	0.5	24.5	19	60	average
	SCV002	76	14.5	31.0	24.9	0.5	25.0	30	60	average
Estero Bay	EBERS2	51	15.5	28.0	23.6	0.5	25.0	30	60	average
	EBV003	61	15.0	29.0	24.8	0.5	26.0	46	70	higher than average
	EBV004	87	14.0	30.5	23.3	0.5	24.0	4	60	average
	EBV005	92	14.5	31.0	23.2	0.5	24.0	4	60	average
	EBV006	23	14.5	28.5	21.9	1.0	23.0	1	50	average
	EBV007	47	14.5	31.0	24.1	0.7	25.0	30	60	average
Outside of estuary	GSV005	69	14.0	31.0	23.2	0.5	24.5	19	60	average
All sites		3438	4.0	32.0	23.8	0.1	24.5		60	average

*Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

**Median value compared to typical Florida estuarine water quality percentile distributions (Hand 2004)

***lower average < 40, 40 < average < 70, higher than average > 70

Table A.14: Dissolved oxygen (mg/L) summary and status results for each site

	Site	N	Min	Max	Mean	SE	Median	Rank*	FL Estuaries**	Status***
Upper Lemon Bay	LBFOR1	53	2.2	8.8	4.6	0.2	4.3	12	20	lower than average
	LBGOT2	67	1.0	8.6	3.6	0.2	3.4	5	10	lower than average
	LBV001	85	1.1	6.9	3.2	0.1	3.0	4	10	lower than average
	LBV002	85	2.2	8.3	4.9	0.2	4.9	18	20	lower than average
	LBV003	83	1.9	7.6	4.2	0.2	3.9	7	10	lower than average
Lower Lemon Bay	GSV002	73	1.5	7.7	5.2	0.1	5.2	28	30	lower than average
	LBANG1	75	1.0	8.2	4.2	0.2	3.9	7	10	lower than average
	LBOYS1	75	1.7	8.2	4.3	0.1	4.1	11	20	lower than average
	LBV004	85	2.7	7.8	4.9	0.1	4.9	18	20	lower than average
	LBV005	72	2.8	7.7	5.5	0.1	5.6	35	30	lower than average
	LBV006	63	0.6	5.3	2.8	0.2	2.3	2	10	lower than average
	LBV007	72	3.4	7.5	5.5	0.1	5.5	33	30	lower than average
Upper Charlotte Harbor	CHV001	84	2.3	8.6	5.1	0.1	5.0	24	20	lower than average
	CHV002	50	2.6	9.5	6.1	0.2	6.1	43	40	average
	CHV003	64	0.6	8.4	4.8	0.2	4.7	15	20	lower than average
	CHV004	86	2.5	8.7	5.4	0.1	5.3	29	30	lower than average
	CHV005	42	2.6	8.8	5.3	0.2	5.1	27	30	lower than average
	CHV006	89	2.8	8.6	5.7	0.1	5.8	39	40	average
	CHV007	93	2.7	7.8	5.0	0.1	4.9	18	20	lower than average
	CHV008	90	2.0	7.4	4.5	0.1	4.4	13	20	lower than average
	CHV013	52	1.4	9.9	5.1	0.2	4.9	18	20	lower than average
Lower Charlotte Harbor	CHV009	83	2.5	7.9	5.0	0.1	5.0	24	20	lower than average
	CHV010	86	2.4	7.9	4.8	0.1	4.9	18	20	lower than average
	CHV011	78	4.2	9.1	6.3	0.1	6.3	45	50	average
Gasparilla/Cape Haze	CHV012	63	2.0	7.2	5.4	0.1	5.6	35	30	lower than average
	GSV001	85	1.4	6.9	4.0	0.1	4.0	9	20	lower than average
	GSV003	23	3.4	7.3	5.5	0.2	5.4	32	30	lower than average
	GSV004	17	2.7	5.2	3.8	0.2	3.6	6	10	lower than average
Pine Island Sound	PIJIM1	32	0.6	5.9	2.1	0.2	1.7	1	10	lower than average
	PIV001	63	2.3	8.2	5.9	0.1	5.8	39	40	average
	PIV002	93	3.2	9.0	5.9	0.1	5.9	42	40	average
	PIV004	61	4.1	8.7	6.8	0.1	7.0	48	70	higher than average
	PIV006	82	3.8	8.9	6.5	0.1	6.6	47	60	average
	PIV007	61	2.5	7.3	4.7	0.1	4.8	16	20	lower than average
Matlacha Pass	MPV001	84	2.0	8.6	5.8	0.1	5.8	39	40	average
	MPV002	91	2.3	9.0	5.0	0.1	5.0	24	20	lower than average
	MPV003	77	3.4	8.6	5.9	0.1	5.6	35	30	lower than average
San Carlos Bay	EBV001	86	3.3	8.7	5.6	0.1	5.5	33	30	lower than average
	MPV004	87	2.8	8.3	5.6	0.1	5.6	35	30	lower than average
	SCV001	87	4.2	8.1	6.1	0.1	6.1	43	40	average
	SCV002	74	3.0	8.2	6.3	0.1	6.3	45	50	average
Estero Bay	EBERS2	51	1.5	7.0	4.0	0.2	4.0	9	10	lower than average
	EBV003	61	2.1	7.9	4.5	0.2	4.6	14	20	lower than average
	EBV004	86	1.2	7.5	4.9	0.1	4.9	18	20	lower than average
	EBV005	90	2.0	7.5	4.6	0.1	4.8	16	20	lower than average
	EBV006	22	4.2	10.0	5.7	0.3	5.3	29	30	lower than average
	EBV007	46	3.6	7.6	5.3	0.2	5.3	29	30	lower than average
Outside of estuary	GSV005	67	1.2	8.1	3.2	0.2	2.9	3	10	lower than average
All sites		3374	0.6	10.0	5.0	0.0	5.1		30	lower than average

*Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

**Median value compared to typical Florida estuarine water quality percentile distributions (Hand 2004)

***below average < 40, 40 < average < 70, above average > 70

Table A.15: pH summary and status results for each site

	Site	N	Min	Max	Mean	SE	Median	Rank*	FL Estuaries**	Status***
Upper Lemon Bay	LBFOR1	51	7.2	8.3	8.0	0.0	8.0	13	60	average
	LBGOT2	70	7.2	8.0	7.6	0.0	7.6	3	20	lower than average
	LBV001	85	7.2	8.2	7.8	0.0	7.8	8	50	average
	LBV002	86	7.3	8.8	8.3	0.0	8.3	33	90	higher than average
	LBV003	85	7.8	8.6	8.3	0.0	8.2	21	80	higher than average
Lower Lemon Bay	GSV002	72	7.8	8.6	8.3	0.0	8.4	34	100	higher than average
	LBANG1	76	7.2	8.6	8.1	0.0	8.2	21	90	higher than average
	LBOYS1	74	7.4	8.6	8.0	0.0	8.0	13	60	average
	LBV004	86	7.8	8.6	8.4	0.0	8.4	34	100	higher than average
	LBV005	75	8.1	8.6	8.5	0.0	8.6	46	100	higher than average
	LBV006	65	7.2	8.6	7.9	0.0	8.0	13	60	average
	LBV007	72	8.2	9.0	8.5	0.0	8.5	42	100	higher than average
Upper Charlotte Harbor	CHV001	86	7.0	8.0	7.7	0.0	7.8	8	40	average
	CHV002	50	7.2	8.6	7.9	0.1	8.0	13	60	average
	CHV003	64	7.2	8.0	7.6	0.0	7.6	3	20	lower than average
	CHV004	89	5.8	8.6	7.8	0.0	7.8	8	40	average
	CHV005	40	7.2	8.0	7.4	0.0	7.4	2	10	lower than average
	CHV006	88	6.4	8.6	7.9	0.0	8.0	13	60	average
	CHV007	96	7.2	8.6	7.9	0.0	7.9	12	50	average
	CHV008	90	7.0	8.3	7.8	0.0	7.8	8	40	average
	CHV013	54	6.7	8.1	7.4	0.0	7.3	1	10	lower than average
Lower Charlotte Harbor	CHV009	85	7.4	8.6	8.1	0.0	8.2	21	90	higher than average
	CHV010	85	8.0	8.6	8.4	0.0	8.4	34	100	higher than average
	CHV011	79	7.8	8.6	8.4	0.0	8.4	34	100	higher than average
Gasparilla/Cape Haze	CHV012	65	7.4	8.6	8.2	0.0	8.2	21	90	higher than average
	GSV001	87	7.2	8.6	8.2	0.0	8.2	21	90	higher than average
	GSV003	25	7.2	8.6	8.5	0.1	8.6	46	100	higher than average
	GSV004	17	7.6	8.6	8.2	0.1	8.2	21	90	higher than average
Pine Island Sound	PIJIM1	35	7.0	8.4	7.7	0.1	7.6	3	20	lower than average
	PIV001	66	7.9	8.7	8.5	0.0	8.5	42	100	higher than average
	PIV002	90	8.0	8.7	8.4	0.0	8.4	34	100	higher than average
	PIV004	60	7.4	8.7	8.4	0.0	8.5	42	100	higher than average
	PIV006	76	7.4	8.8	8.4	0.0	8.5	42	100	higher than average
	PIV007	61	8.0	8.7	8.5	0.0	8.6	46	100	higher than average
Matlacha Pass	MPV001	84	7.5	8.6	8.2	0.0	8.2	21	90	higher than average
	MPV002	89	7.4	8.6	8.1	0.0	8.1	20	80	higher than average
	MPV003	77	7.8	8.6	8.2	0.0	8.2	21	90	higher than average
San Carlos Bay	EBV001	89	7.8	8.6	8.2	0.0	8.2	21	90	higher than average
	MPV004	87	7.4	8.6	8.2	0.0	8.2	21	90	higher than average
	SCV001	89	8.0	8.6	8.4	0.0	8.4	34	100	higher than average
	SCV002	74	7.5	8.6	8.3	0.0	8.2	21	90	higher than average
Estero Bay	EBERS2	51	7.2	8.2	7.6	0.0	7.6	3	20	lower than average
	EBV003	57	7.6	8.4	8.0	0.0	8.0	13	70	average
	EBV004	87	8.0	8.8	8.4	0.0	8.4	34	100	higher than average
	EBV005	92	7.6	8.4	8.1	0.0	8.0	13	70	average
	EBV006	23	8.2	8.6	8.4	0.0	8.4	34	100	higher than average
	EBV007	47	8.0	8.7	8.3	0.0	8.2	21	90	higher than average
Outside of estuary	GSV005	69	7.2	8.4	7.6	0.0	7.6	3	20	lower than average
All sites		3400	5.8	9.0	8.1	0.0	8.2		90	higher than average

*Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

**Median value compared to typical Florida estuarine water quality percentile distributions (Hand 2004)

***lower average < 40, 40 < average < 70, higher than average > 70

Table A.16: Salinity (ppt) summary and status results for each site

	Site	N	Min	Max	Mean	SE	Median	Rank*	FL Estuaries**	Status***
Upper Lemon Bay	LBFOR1	53	1.0	35.5	22.9	1.4	26.5	18	70	higher than average
	LBGOT2	67	0.0	35.5	11.0	1.1	9.3	3	20	lower than average
	LBV001	85	1.4	33.0	16.5	0.9	17.9	8	40	average
	LBV002	87	6.4	38.1	28.1	0.7	29.6	21	70	higher than average
	LBV003	84	22.0	40.7	31.4	0.5	31.9	32	80	higher than average
Lower Lemon Bay	GSV002	77	20.6	38.9	33.6	0.4	34.5	44	100	higher than average
	LBANG1	76	3.1	39.3	29.6	0.8	32.2	33	80	higher than average
	LBOYS1	73	7.5	39.8	30.5	0.7	32.2	33	80	higher than average
	LBV004	85	15.8	39.8	32.5	0.4	33.4	39	100	higher than average
	LBV005	72	24.4	38.2	33.6	0.4	34.8	48	100	higher than average
	LBV006	65	2.1	40.7	27.5	1.2	30.0	25	70	higher than average
	LBV007	70	7.0	38.8	33.9	0.5	34.5	44	100	higher than average
Upper Charlotte Harbor	CHV001	85	2.4	33.0	18.0	0.8	18.7	9	40	average
	CHV002	49	1.1	28.5	13.8	1.1	13.4	5	20	lower than average
	CHV003	64	2.1	30.5	14.6	1.0	16.1	7	30	lower than average
	CHV004	86	2.1	36.3	19.8	1.0	20.8	11	40	average
	CHV005	42	0.0	24.4	6.9	1.1	4.2	2	10	lower than average
	CHV006	86	2.9	36.7	19.6	1.0	21.6	12	50	average
	CHV007	95	4.5	35.5	22.8	0.7	24.3	15	60	average
	CHV008	88	2.5	37.1	22.6	0.9	24.3	15	60	average
	CHV013	54	0.0	17.3	4.7	0.7	2.0	1	10	lower than average
Lower Charlotte Harbor	CHV009	83	8.5	38.3	26.0	0.8	26.9	19	70	higher than average
	CHV010	87	17.5	39.1	29.6	0.5	29.6	21	80	higher than average
	CHV011	78	9.7	38.4	29.1	0.7	30.4	27	80	higher than average
Gasparilla/Cape Haze	CHV012	65	16.2	38.9	29.6	0.6	29.8	24	80	higher than average
	GSV001	85	10.0	40.7	32.1	0.7	34.1	43	100	higher than average
	GSV003	25	32.2	40.2	35.1	0.4	34.5	44	100	higher than average
	GSV004	17	10.7	35.2	30.6	1.5	32.9	38	90	higher than average
Pine Island Sound	PIJIM1	34	4.5	41.6	28.7	1.3	29.6	21	80	higher than average
	PIV001	65	19.6	41.2	32.9	0.5	33.4	39	100	higher than average
	PIV002	93	22.5	41.1	32.4	0.4	32.5	36	90	higher than average
	PIV004	61	23.3	39.7	33.5	0.4	33.5	41	100	higher than average
	PIV006	83	16.6	40.1	30.6	0.6	31.3	31	90	higher than average
	PIV007	63	6.6	42.0	33.7	0.7	34.6	47	100	higher than average
Matlacha Pass	MPV001	85	7.2	39.8	22.8	0.8	23.3	14	50	average
	MPV002	94	2.9	35.8	20.1	0.8	20.1	10	40	average
	MPV003	79	4.9	37.5	22.4	0.9	22.9	13	50	average
San Carlos Bay	EBV001	89	18.3	41.4	32.0	0.5	32.2	33	90	higher than average
	MPV004	88	8.8	37.5	24.8	0.8	26.1	17	60	average
	SCV001	88	15.8	38.0	29.6	0.6	31.0	29	90	higher than average
	SCV002	74	16.2	38.9	30.1	0.6	31.0	29	90	higher than average
Estero Bay	EBERS2	51	0.2	33.2	12.3	1.4	10.9	4	20	lower than average
	EBV003	59	9.6	39.8	29.2	1.0	30.9	28	90	higher than average
	EBV004	85	21.2	39.3	32.9	0.4	33.7	42	100	higher than average
	EBV005	92	2.5	38.0	28.1	0.8	30.1	26	80	higher than average
	EBV006	23	26.9	37.8	32.7	0.7	32.6	37	90	higher than average
	EBV007	47	19.3	38.2	28.7	0.6	28.5	20	80	higher than average
Outside of estuary	GSV005	68	0.8	39.3	15.8	1.4	13.9	6	30	lower than average
All sites		3404	0.0	42.0	25.9	0.2	28.9		80	higher than average

*Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

**Median value compared to typical Florida estuarine water quality percentile distributions (Hand 2004)

***lower average < 40, 40 < average < 70, higher than average > 70

Table A.17: Total nitrogen (ppm) summary and status results for each site

	Site	N	Min	Max	Mean	SE	Median	Rank*	FL Estuaries**	Status***
Upper Lemon Bay	LBFOR1	6	0.905	1.724	1.230	0.122	1.163	45	90	higher than average
	LBGOT2	8	1.214	1.525	1.365	0.043	1.324	47	90	higher than average
	LBV001	70	0.180	2.690	1.102	0.050	1.137	44	90	higher than average
	LBV002	67	0.075	2.650	0.996	0.061	0.942	37	80	higher than average
	LBV003	68	0.075	2.750	0.946	0.057	0.887	34	70	higher than average
Lower Lemon Bay	GSV002	61	0.075	2.532	0.799	0.051	0.767	15	60	average
	LBANG1	7	0.712	1.305	0.941	0.078	0.868	28	70	higher than average
	LBOYS1	8	0.627	1.328	0.871	0.076	0.838	26	70	higher than average
	LBV004	68	0.075	2.130	0.731	0.046	0.726	9	60	average
	LBV005	62	0.075	1.850	0.641	0.046	0.590	2	50	average
	LBV006	51	0.075	2.560	1.004	0.071	0.975	39	80	higher than average
	LBV007	8	0.552	1.202	0.806	0.069	0.794	20	70	higher than average
Upper Charlotte Harbor	CHV001	67	0.075	2.550	1.027	0.056	1.005	40	80	higher than average
	CHV002	42	0.032	1.885	1.120	0.059	1.066	41	80	higher than average
	CHV003	50	0.075	2.230	0.933	0.057	0.871	31	70	higher than average
	CHV004	64	0.075	2.218	0.954	0.055	0.957	38	80	higher than average
	CHV005	25	0.297	2.440	1.400	0.081	1.460	48	100	higher than average
	CHV006	68	0.125	2.370	1.174	0.065	1.113	42	90	higher than average
	CHV007	73	0.053	2.400	0.878	0.055	0.812	22	70	higher than average
	CHV008	67	0.075	1.970	0.853	0.048	0.810	21	70	higher than average
	CHV013	49	0.075	4.602	1.337	0.099	1.310	46	90	higher than average
Lower Charlotte Harbor	CHV009	74	0.075	1.990	0.928	0.049	0.913	35	70	higher than average
	CHV010	67	0.075	2.300	0.806	0.049	0.762	14	60	average
	CHV011	66	0.055	1.710	0.625	0.037	0.561	1	50	average
Gasparilla/Cape Haze	CHV012	48	0.075	1.950	0.843	0.054	0.813	23	70	higher than average
	GSV001	62	0.075	2.526	1.041	0.081	0.868	28	70	higher than average
	GSV003	15	0.555	1.202	0.743	0.043	0.725	8	60	average
	GSV004	16	0.526	1.202	0.723	0.047	0.644	6	50	average
Pine Island Sound	PIJIM1	34	0.075	4.302	1.038	0.138	0.825	24	70	higher than average
	PIV001	51	0.075	1.975	0.697	0.052	0.602	4	50	average
	PIV002	68	0.075	1.970	0.760	0.041	0.739	11	60	average
	PIV004	49	0.070	1.845	0.772	0.071	0.771	18	60	average
	PIV006	61	0.065	2.510	0.875	0.059	0.935	36	80	higher than average
	PIV007	46	0.055	1.530	0.784	0.047	0.782	19	60	average
Matlacha Pass	MPV001	66	0.210	1.900	0.904	0.043	0.865	27	70	higher than average
	MPV002	70	0.032	2.470	0.914	0.050	0.872	32	70	higher than average
	MPV003	58	0.070	3.840	0.896	0.076	0.767	15	60	average
San Carlos Bay	EBV001	68	0.075	1.980	0.740	0.044	0.747	12	60	average
	MPV004	65	0.055	2.930	0.834	0.054	0.830	25	70	higher than average
	SCV001	65	0.075	1.930	0.744	0.042	0.738	10	60	average
	SCV002	51	0.075	2.815	0.690	0.062	0.630	5	50	average
Estero Bay	EBERS2	47	0.075	2.370	0.919	0.066	0.870	30	70	higher than average
	EBV003	46	0.075	2.005	0.839	0.066	0.876	33	70	higher than average
	EBV004	62	0.053	4.046	0.787	0.071	0.770	17	60	average
	EBV005	67	0.065	2.060	0.783	0.045	0.750	13	60	average
	EBV006	14	0.085	1.102	0.691	0.082	0.719	7	60	average
	EBV007	40	0.075	1.550	0.631	0.051	0.597	3	50	average
Outside of estuary	GSV005	37	0.380	2.960	1.240	0.094	1.125	43	90	higher than average
All sites		2402	0.032	4.602	0.887	0.010	0.827		70	higher than average

*Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

**Median value compared to typical Florida estuarine water quality percentile distributions (Hand 2004)

***above average < 40, 40 < average < 70, below average > 70

Table A.18: Total phosphorus (ppm) summary and status results for each site

	Site	N	Min	Max	Mean	SE	Median	Rank*	FL Estuaries**	Status***
Upper Lemon Bay	LBFOR1	6	0.160	0.700	0.297	0.083	0.220	40	80	higher than average
	LBGOT2	8	0.200	0.480	0.332	0.034	0.330	46	90	higher than average
	LBV001	74	0.010	0.610	0.207	0.011	0.205	39	80	higher than average
	LBV002	68	0.015	1.080	0.191	0.017	0.170	35	80	higher than average
	LBV003	72	0.025	0.380	0.176	0.009	0.170	36	80	higher than average
Lower Lemon Bay	GSV002	64	0.010	0.220	0.072	0.005	0.065	18	40	average
	LBANG1	7	0.078	0.180	0.107	0.014	0.090	28	50	average
	LBOYS1	8	0.049	0.120	0.078	0.008	0.077	23	50	average
	LBV004	70	0.025	0.270	0.086	0.005	0.080	25	50	average
	LBV005	65	0.010	0.420	0.070	0.007	0.060	8	40	average
	LBV006	53	0.015	0.270	0.113	0.008	0.100	30	60	average
	LBV007	8	0.038	0.086	0.058	0.007	0.055	5	40	average
Upper Charlotte Harbor	CHV001	70	0.090	0.790	0.289	0.016	0.260	43	90	higher than average
	CHV002	41	0.010	0.430	0.239	0.017	0.240	42	90	higher than average
	CHV003	53	0.060	0.500	0.187	0.013	0.180	37	80	higher than average
	CHV004	68	0.080	0.650	0.267	0.016	0.235	41	90	higher than average
	CHV005	29	0.230	0.750	0.509	0.025	0.510	47	100	higher than average
	CHV006	70	0.080	0.810	0.335	0.021	0.290	45	90	higher than average
	CHV007	78	0.040	0.900	0.226	0.016	0.200	38	80	higher than average
	CHV008	72	0.015	0.590	0.157	0.011	0.130	34	70	higher than average
	CHV013	51	0.250	1.500	0.731	0.034	0.680	48	100	higher than average
Lower Charlotte Harbor	CHV009	77	0.013	0.350	0.134	0.008	0.120	32	60	average
	CHV010	71	0.010	0.340	0.102	0.007	0.090	29	50	average
	CHV011	67	0.005	0.420	0.103	0.008	0.080	26	50	average
Gasparilla/Cape Haze	CHV012	49	0.025	0.350	0.131	0.010	0.120	33	60	average
	GSV001	68	0.005	0.310	0.072	0.006	0.064	16	40	average
	GSV003	17	0.030	0.130	0.070	0.008	0.060	9	40	average
	GSV004	16	0.025	0.240	0.086	0.012	0.083	27	50	average
Pine Island Sound	PIJIM1	35	0.015	0.900	0.158	0.028	0.100	31	60	average
	PIV001	57	0.025	0.250	0.082	0.006	0.070	20	50	average
	PIV002	70	0.005	0.230	0.068	0.005	0.060	10	40	average
	PIV004	52	0.010	0.100	0.050	0.003	0.050	3	40	average
	PIV006	65	0.010	0.170	0.061	0.004	0.058	6	40	average
	PIV007	51	0.005	0.220	0.048	0.005	0.040	1	30	lower than average
Matlacha Pass	MPV001	74	0.010	0.290	0.087	0.006	0.078	24	50	average
	MPV002	76	0.010	0.260	0.083	0.005	0.073	21	50	average
	MPV003	62	0.010	0.180	0.080	0.005	0.076	22	50	average
San Carlos Bay	EBV001	72	0.030	0.270	0.071	0.004	0.065	17	40	average
	MPV004	69	0.010	0.260	0.073	0.005	0.063	15	40	average
	SCV001	68	0.010	0.220	0.063	0.004	0.060	7	40	average
	SCV002	54	0.005	0.250	0.068	0.007	0.050	4	40	average
Estero Bay	EBERS2	48	0.008	0.140	0.051	0.004	0.045	2	30	lower than average
	EBV003	49	0.020	0.130	0.067	0.003	0.060	11	40	average
	EBV004	68	0.010	0.500	0.074	0.008	0.060	12	40	average
	EBV005	73	0.005	0.360	0.076	0.006	0.060	13	40	average
	EBV006	19	0.015	0.250	0.077	0.013	0.060	14	40	average
	EBV007	40	0.010	0.270	0.075	0.008	0.065	19	40	average
Outside of estuary	GSV005	38	0.080	0.530	0.286	0.017	0.270	44	90	higher than average
All sites		2540	0.005	1.500	0.141	0.003	0.090		50	average

*Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

**Median value compared to typical Florida estuarine water quality percentile distributions (Hand 2004)

***above average < 40, 40 < average < 70, below average > 70

Table A.19: Chlorophyll a (µg/L) summary and status results for each site

	Site	N	Min	Max	Mean	SE	Median	Rank*	FL Estuaries**	Status***
Upper Lemon Bay	LBFOR1	6	9.06	23.90	15.09	2.41	13.00	48	80	higher than average
	LBGOT2	8	1.38	14.50	5.21	1.52	4.13	20	40	average
	LBV001	65	0.50	48.73	8.43	1.02	6.00	36	50	average
	LBV002	66	0.50	30.30	8.48	0.83	6.88	42	60	average
	LBV003	64	1.40	52.30	10.75	1.35	6.32	37	60	average
Lower Lemon Bay	GSV002	56	0.01	18.73	3.88	0.43	3.10	6	30	lower than average
	LBANG1	7	0.71	9.54	5.73	1.10	5.94	35	50	average
	LBOYS1	8	0.71	7.03	3.38	0.81	2.91	3	30	lower than average
	LBV004	69	0.25	23.20	5.51	0.54	4.83	26	40	average
	LBV005	56	0.50	79.46	6.73	1.57	3.60	11	30	lower than average
	LBV006	51	0.25	34.60	6.54	0.79	5.51	32	50	average
	LBV007	8	0.71	11.00	4.97	1.24	3.82	13	40	average
Upper Charlotte Harbor	CHV001	62	0.01	65.60	12.69	1.56	8.83	44	70	higher than average
	CHV002	42	1.46	42.10	9.33	1.16	6.95	43	60	average
	CHV003	44	0.72	17.39	6.07	0.66	4.95	29	40	average
	CHV004	64	0.50	36.50	9.32	1.02	6.52	39	60	average
	CHV005	32	1.60	88.50	20.55	3.96	10.92	47	80	higher than average
	CHV006	63	0.50	82.10	9.37	1.56	6.73	40	60	average
	CHV007	72	0.01	28.68	6.91	0.68	5.14	30	50	average
	CHV008	66	0.50	15.89	4.22	0.39	3.30	8	30	lower than average
	CHV013	37	0.01	53.70	13.60	2.17	9.82	46	70	higher than average
Lower Charlotte Harbor	CHV009	66	0.01	24.12	7.09	0.58	6.34	38	60	average
	CHV010	68	0.01	21.20	5.19	0.51	4.01	18	40	average
	CHV011	64	0.01	34.18	4.52	0.69	3.06	5	30	lower than average
Gasparilla/Cape Haze	CHV012	49	0.50	17.70	5.95	0.54	4.91	28	40	average
	GSV001	61	0.50	16.65	3.31	0.42	2.16	1	20	lower than average
	GSV003	20	0.50	15.20	4.38	0.77	3.87	14	40	average
	GSV004	15	1.67	18.20	4.63	1.02	3.59	10	30	lower than average
Pine Island Sound	PIJIM1	23	0.88	34.30	8.93	1.55	6.79	41	60	average
	PIV001	53	0.50	27.87	4.92	0.62	4.00	17	40	average
	PIV002	68	0.50	26.70	7.48	0.82	5.36	31	50	average
	PIV004	46	0.25	39.70	5.36	0.93	4.16	22	40	average
	PIV006	62	0.01	25.64	6.66	0.70	5.69	33	50	average
	PIV007	46	0.50	26.00	6.70	0.71	5.86	34	50	average
Matlacha Pass	MPV001	63	0.50	34.10	5.56	0.64	4.37	23	40	average
	MPV002	70	0.25	25.43	5.62	0.66	3.62	12	30	lower than average
	MPV003	54	0.50	72.50	4.78	1.40	2.57	2	20	lower than average
San Carlos Bay	EBV001	66	0.25	28.35	5.13	0.50	4.15	21	40	average
	MPV004	63	0.25	18.80	3.76	0.44	3.04	4	30	lower than average
	SCV001	63	0.01	22.30	4.47	0.51	3.87	14	40	average
	SCV002	53	0.25	24.80	4.20	0.53	3.34	9	30	lower than average
Estero Bay	EBERS2	35	0.01	114.00	7.80	3.19	3.10	6	30	lower than average
	EBV003	46	0.50	26.67	4.85	0.68	3.98	16	40	average
	EBV004	66	0.01	11.92	5.21	0.36	4.81	25	40	average
	EBV005	65	0.01	33.00	6.06	0.80	4.07	19	40	average
	EBV006	19	0.50	15.20	5.22	0.82	4.65	24	40	average
	EBV007	32	0.01	23.56	5.61	0.88	4.89	27	40	average
Outside of estuary	GSV005	28	0.01	29.70	9.56	1.35	9.14	45	70	higher than average
All sites		2310	0.01	114.00	6.70	0.16	4.79		40	average

*Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

**Median value compared to typical Florida estuarine water quality percentile distributions (Hand 2004)

***above average < 40, 40 < average < 70, below average > 70

Table A.20: Fecal coliform bacteria (cfu/100mL) summary and status results for each site

	Site	N	Min	Max	Mean	SE	Median	Rank*	FL Estuaries**	Status***
Upper Lemon Bay	LBFOR1	6	8	120	78	22	106	44	100	higher than average
	LBGOT2	8	5	170	87	21	110	45	100	higher than average
	LBV001	80	1	1156	219	26	132	47	100	higher than average
	LBV002	80	1	240	35	6	12	25	70	higher than average
	LBV003	78	1	480	40	8	18	32	80	higher than average
Lower Lemon Bay	GSV002	67	1	130	18	3	10	24	70	higher than average
	LBANG1	7	12	180	97	22	120	46	100	higher than average
	LBOYS1	8	12	228	86	27	50	40	90	higher than average
	LBV004	79	1	232	16	4	4	15	50	average
	LBV005	70	1	58	7	1	3	14	50	average
	LBV006	63	1	800	128	20	84	42	100	higher than average
	LBV007	8	1	35	8	4	2	6	40	average
Upper Charlotte Harbor	CHV001	76	1	220	43	6	26	36	80	higher than average
	CHV002	43	1	48	9	2	4	15	50	average
	CHV003	57	1	288	54	8	36	38	90	higher than average
	CHV004	77	1	296	33	6	18	32	80	higher than average
	CHV005	34	2	776	104	24	60	41	90	higher than average
	CHV006	79	1	180	29	4	14	28	70	higher than average
	CHV007	87	1	288	42	5	30	37	80	higher than average
	CHV008	82	1	800	62	15	24	35	80	higher than average
	CHV013	52	1	800	89	19	49	39	90	higher than average
Lower Charlotte Harbor	CHV009	78	1	152	22	4	9	23	70	higher than average
	CHV010	82	1	98	10	2	4	15	50	average
	CHV011	74	1	372	7	5	1	1	10	lower than average
Gasparilla/Cape Haze	CHV012	60	1	162	8	3	2	6	40	average
	GSV001	72	1	248	30	5	16	31	70	higher than average
	GSV003	21	1	79	7	4	2	6	40	average
	GSV004	16	2	280	38	18	12	25	70	higher than average
Pine Island Sound	PIJIM1	34	1	352	44	12	18	34	80	higher than average
	PIV001	66	1	224	21	5	7	20	60	average
	PIV002	84	1	122	6	2	1	1	10	lower than average
	PIV004	63	1	144	9	4	1	1	10	lower than average
	PIV006	76	1	260	8	4	1	1	10	lower than average
	PIV007	60	1	68	4	1	1	1	10	lower than average
Matlacha Pass	MPV001	79	1	60	5	1	2	6	40	average
	MPV002	87	1	106	15	2	8	22	60	average
	MPV003	68	1	94	6	2	2	6	40	average
San Carlos Bay	EBV001	81	1	274	27	5	14	28	70	higher than average
	MPV004	81	1	364	11	5	4	15	50	average
	SCV001	80	1	98	4	1	2	6	40	average
	SCV002	68	1	16	3	0	2	6	40	average
Estero Bay	EBERS2	49	4	800	160	26	104	43	100	higher than average
	EBV003	58	1	186	32	6	12	25	70	higher than average
	EBV004	80	1	70	11	1	4	15	50	average
	EBV005	83	1	384	39	8	14	28	70	higher than average
	EBV006	21	1	34	7	2	2	6	40	average
	EBV007	40	1	120	13	3	7	20	60	average
Outside of estuary	GSV005	37	1	1720	278	61	148	48	100	higher than average
All sites		2839	1	1720	38	2	8		60	average

*Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

**Median value compared to typical Florida estuarine water quality percentile distributions (Hand 2004)

***above average < 40, 40 < average < 70, below average > 70

Table A.21: Turbidity (NTU) summary and status results for each site

	Site	N	Min	Max	Mean	SE	Median	Rank*	FL Estuaries**	Status***
Upper Lemon Bay	LBFOR1	6	2.0	3.6	2.7	0.2	2.7	28	50	average
	LBGOT2	8	1.1	3.0	1.7	0.2	1.6	2	30	lower than average
	LBV001	77	1.0	5.8	2.6	0.1	2.5	20	50	average
	LBV002	76	0.5	9.2	2.7	0.2	2.5	19	50	average
	LBV003	73	0.6	66.0	3.7	0.9	2.7	29	50	average
Lower Lemon Bay	GSV002	66	0.5	9.7	3.6	0.3	3.2	37	60	average
	LBANG1	7	1.4	3.6	2.4	0.3	2.2	11	40	average
	LBOYS1	8	1.8	3.6	2.4	0.2	2.2	12	40	average
	LBV004	77	0.5	9.0	3.0	0.2	2.9	30	50	average
	LBV005	68	0.5	8.9	3.3	0.3	2.6	24	50	average
	LBV006	62	1.0	9.7	2.7	0.2	2.3	13	40	average
	LBV007	8	1.3	2.7	1.8	0.2	1.7	3	30	lower than average
Upper Charlotte Harbor	CHV001	71	1.0	7.9	2.9	0.2	2.6	27	50	average
	CHV002	38	1.3	8.1	3.8	0.3	3.5	38	60	average
	CHV003	59	1.0	5.4	2.4	0.1	2.1	10	40	average
	CHV004	73	0.5	23.0	3.2	0.3	3.0	32	50	average
	CHV005	28	2.0	13.9	4.5	0.5	3.9	40	60	average
	CHV006	75	1.0	18.0	3.6	0.3	3.0	33	50	average
	CHV007	82	0.5	17.4	2.9	0.2	2.6	22	50	average
	CHV008	78	0.5	7.8	2.3	0.2	2.0	6	40	average
	CHV013	52	1.4	24.0	4.7	0.5	4.1	41	60	average
Lower Charlotte Harbor	CHV009	77	0.5	6.5	2.3	0.1	2.1	9	40	average
	CHV010	78	0.5	18.6	3.1	0.3	2.4	15	40	average
	CHV011	71	0.1	21.0	2.2	0.3	1.6	1	30	lower than average
Gasparilla/Cape Haze	CHV012	56	0.6	7.3	2.8	0.2	2.4	18	40	average
	GSV001	71	0.9	30.0	3.1	0.4	2.6	25	50	average
	GSV003	19	1.0	13.8	5.4	0.7	4.9	45	70	higher than average
	GSV004	16	1.6	6.4	3.3	0.3	3.2	36	60	average
Pine Island Sound	PIJIM1	35	1.0	6.0	1.9	0.2	1.7	4	30	lower than average
	PIV001	64	0.5	9.7	3.2	0.3	2.5	21	50	average
	PIV002	79	0.3	10.2	3.0	0.3	2.3	14	40	average
	PIV004	59	0.5	28.0	4.9	0.7	2.9	31	50	average
	PIV006	71	0.5	26.0	5.4	0.6	3.8	39	60	average
	PIV007	60	0.5	8.7	2.9	0.2	2.6	23	50	average
Matlacha Pass	MPV001	74	0.3	6.6	2.3	0.1	2.0	5	40	average
	MPV002	81	0.7	6.8	2.7	0.1	2.4	16	40	average
	MPV003	66	0.1	10.5	2.4	0.2	2.0	8	40	average
San Carlos Bay	EBV001	77	0.7	120.0	6.4	1.5	4.5	44	70	higher than average
	MPV004	78	0.5	8.8	3.0	0.2	2.6	26	50	average
	SCV001	75	0.5	14.7	3.9	0.3	3.1	35	50	average
	SCV002	64	0.4	13.3	3.5	0.3	3.0	34	50	average
Estero Bay	EBERS2	49	0.5	4.4	2.1	0.1	2.0	7	40	average
	EBV003	55	1.0	16.9	4.9	0.4	4.4	43	70	higher than average
	EBV004	75	1.0	24.0	6.2	0.5	5.2	47	70	higher than average
	EBV005	79	0.1	52.0	7.2	0.8	5.0	46	70	higher than average
	EBV006	21	1.0	26.0	8.9	1.4	6.7	48	80	higher than average
	EBV007	40	0.5	11.3	4.7	0.4	4.2	42	70	higher than average
Outside of estuary	GSV005	38	1.0	7.3	2.6	0.2	2.4	17	40	average
All sites		2720	0.1	120.0	3.5	0.1	2.7		50	average

*Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

**Median value compared to typical Florida estuarine water quality percentile distributions (Hand 2004)

***above average < 40, 40 < average < 70, below average > 70

Table A.22: Color (PCU) summary and status results for each site

	Site	N	Min	Max	Mean	SE	Median	Rank*	FL Estuaries**	Status***
Upper Lemon Bay	LBFOR1	6	30	240	78	33	50	37	80	higher than average
	LBGOT2	8	80	200	123	14	110	48	100	higher than average
	LBV001	77	10	120	47	3	45	35	80	higher than average
	LBV002	75	5	200	30	3	23	21	60	average
	LBV003	73	4	120	24	2	20	12	50	average
Lower Lemon Bay	GSV002	66	3	100	16	2	15	3	50	average
	LBANG1	7	20	240	77	29	50	37	80	higher than average
	LBOYS1	8	20	160	58	17	30	24	70	higher than average
	LBV004	77	3	120	21	3	15	3	50	average
	LBV005	68	1	60	15	1	12	2	40	average
	LBV006	62	3	100	39	3	30	24	70	higher than average
	LBV007	8	10	40	23	4	20	12	50	average
Upper Charlotte Harbor	CHV001	71	5	240	59	5	50	37	80	higher than average
	CHV002	38	25	320	103	12	75	45	90	higher than average
	CHV003	59	15	210	71	7	50	37	80	higher than average
	CHV004	73	10	245	62	6	50	37	80	higher than average
	CHV005	29	15	280	110	16	70	44	90	higher than average
	CHV006	75	10	320	72	7	50	37	80	higher than average
	CHV007	82	10	265	52	5	34	33	70	higher than average
	CHV008	78	4	200	44	4	34	33	70	higher than average
	CHV013	52	20	400	118	11	90	47	90	higher than average
Lower Charlotte Harbor	CHV009	77	10	120	39	3	30	24	70	higher than average
	CHV010	78	3	120	27	2	20	12	50	average
	CHV011	71	1	140	23	3	15	3	50	average
Gasparilla/Cape Haze	CHV012	56	3	100	26	3	20	12	50	average
	GSV001	71	5	70	24	2	20	12	50	average
	GSV003	19	5	15	9	1	10	1	30	lower than average
	GSV004	16	15	120	34	6	30	24	70	higher than average
Pine Island Sound	PIJIM1	35	19	200	71	8	54	43	80	higher than average
	PIV001	64	1	100	21	2	17	9	50	average
	PIV002	80	3	60	20	1	17	9	50	average
	PIV004	59	3	50	15	1	15	3	50	average
	PIV006	71	3	70	23	2	20	12	50	average
	PIV007	60	3	60	18	2	15	3	50	average
Matlacha Pass	MPV001	74	1	160	34	3	30	24	70	higher than average
	MPV002	81	6	120	39	3	33	32	70	higher than average
	MPV003	66	3	160	37	4	29	23	70	higher than average
San Carlos Bay	EBV001	77	3	120	26	2	20	12	50	average
	MPV004	78	2	160	35	4	25	22	60	average
	SCV001	75	3	140	26	3	20	12	50	average
	SCV002	64	1	95	21	2	15	3	50	average
Estero Bay	EBERS2	49	1	120	50	4	47	36	80	higher than average
	EBV003	55	5	110	32	3	30	24	70	higher than average
	EBV004	75	1	140	22	2	18	11	50	average
	EBV005	79	1	130	32	3	30	24	70	higher than average
	EBV006	21	1	40	20	2	20	12	50	average
	EBV007	40	1	100	30	3	30	24	70	higher than average
Outside of estuary	GSV005	38	17	360	96	11	80	46	90	higher than average
All sites		2721	1	400	39	1	26		70	higher than average

*Ranking of median value in ascending order compared to each estuary region median within the CHEVWQMN

**Median value compared to typical Florida estuarine water quality percentile distributions (Hand 2004)

***lower average < 40, 40 < average < 70, higher than average > 70

Appendix B: Water Quality Comparisons

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Table B.1: Non parametric ANOVA (Kruskal-Wallis) results between aquatic preserves for the entire study duration

	Secchi	Temp	DO	pH	Salinity	TN	TP	Chl a	Coliform	Turbidity	Color
Chi-Square	497	11	464	1109	1125	159	1198	157	630	209	518
df	8	8	8	8	8	8	8	8	8	8	8
p (2 tailed)	0.0000	0.2210	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Bold values significant at the .05 level

Table B.2: Non parametric t-test (Mann Whitney) results between the rainy and dry season

			Secchi	Temp	DO	pH	Salinity	TN	TP	Chl a	Coliform	Turbidity	Color
Upper	Mean	Rain	74.3	289.6	121.3	174.1	167.6	135.52	139.70	127.5	127	129.5	155
Lemon	Rank	Dry	93.2	119.6	233.7	199.8	203.5	92.19	97.46	90.8	126	114.6	97
Bay	Sum of	Rain	7727.0	46333.5	18801.0	27502.5	26313.5	12197.00	12852.00	10324.5	13196	12302.5	14566
	Ranks	Dry	5314.0	26437.5	50950.0	43750.5	44562.5	11893.00	13254.00	11620.5	18682	16617.5	14114
	Mann Whitney U		2267.0	1906.5	6711.0	14941.5	13910.5	3508.0	3938.0	3364.5	7656.0	6032.5	3529.0
	Z		-2.493	-14.886	-9.927	-2.280	-3.157	-4.979	-4.749	-4.272	-0.070	-1.626	-6.316
	p (2 tailed)*		0.0130	0.0000	0.0000	0.0226	0.0016	0.0000	0.0000	0.0001	0.9440	0.1040	0.0000
Lower	Mean	Rain	112.3	411.0	185.2	244.3	233.6	159.22	141.13	157.7	155	144.0	192
Lemon	Rank	Dry	118.7	165.1	305.4	271.1	276.7	114.68	135.97	108.5	149	151.5	120
Bay	Sum of	Rain	13031.0	85904.0	37600.0	50332.0	48352.5	17355.00	15242.50	15925.5	18626	16988.0	22611
	Ranks	Dry	13534.0	52171.0	95270.0	85128.0	86068.5	17890.00	22707.50	16714.5	27128	26968.0	21346
	Mann Whitney U		6245.0	2085.0	16894.0	29011.0	26824.5	5644.0	8679.5	4779.5	10474.5	9967.0	5414.5
	Z		-0.731	-18.212	-8.956	-2.024	-3.215	-4.656	-0.526	-5.204	-0.602	-0.742	-7.099
	p (2 tailed)*		0.4649	0.0000	0.0000	0.0430	0.0013	0.0000	0.5986	0.0000	0.5470	0.4580	0.0000
Upper	Mean	Rain	171.4	512.2	175.3	246.9	255.4	302.77	321.20	253.1	301	265.2	369
Charlotte	Rank	Dry	221.6	206.7	427.6	383.4	371.9	220.37	231.66	234.1	289	287.3	219
Harbor	Sum of	Rain	32390.0	134707.0	46099.5	64699.5	66646.0	60553.00	66488.00	47337.0	71999	58605.0	81893
	Ranks	Dry	45425.0	81446.0	165475.5	151453.5	144279.0	67212.00	75290.00	69066.0	100580	96241.0	73510
	Mann Whitney U		14435.0	3631.0	11383.5	30246.5	32455.0	20547.0	22315.0	25406.0	39853.5	34074.0	17230.0
	Z		-4.390	-20.247	-16.817	-9.142	-7.762	-6.206	-6.552	-1.461	-0.859	-1.588	-10.744
	p (2 tailed)*		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1440	0.3905	0.1123	0.0000
Lower	Mean	Rain	46.8	193.4	89.6	111.0	103.0	122.72	120.85	113.4	113	113.0	146
Charlotte	Rank	Dry	61.3	75.5	149.9	135.4	140.8	91.22	99.60	90.1	121	113.8	91
Harbor	Sum of	Rain	2807.5	21079.0	9495.5	11760.5	11018.0	10308.50	10272.50	9071.5	11094	10395.5	13422
	Ranks	Dry	2757.5	10799.0	21132.5	19364.5	19858.0	11219.50	12947.50	10629.5	16401	15255.5	12230
	Mann Whitney U		977.5	503.0	3824.5	6089.5	5240.0	3593.5	4432.5	3608.5	6243.0	6117.5	3184.5
	Z		-2.415	-12.740	-6.567	-2.707	-4.117	-3.716	-2.454	-2.810	-0.841	-0.096	-6.192
	p (2 tailed)*		0.0158	0.0000	0.0000	0.0068	0.0000	0.0002	0.0141	0.0050	0.4005	0.9232	0.0000
Gasparilla/	Mean	Rain	41.2	148.8	75.1	92.2	86.3	79.72	82.23	88.3	81	81.4	101
Cape	Rank	Dry	45.9	57.5	108.6	101.4	104.1	64.90	71.02	63.1	87	81.5	69
Haze	Sum of	Rain	1813.0	12203.5	5929.5	7655.5	7080.0	4624.00	4933.50	5030.0	5459	5293.5	6556
	Ranks	Dry	1928.0	6324.5	11836.5	11259.5	11448.0	5387.00	6391.50	5555.0	8907	7909.5	6647
	Mann Whitney U		823.0	219.5	2769.5	4169.5	3677.0	1901.0	2296.5	1639.0	3180.5	3148.5	1894.0
	Z		-0.875	-11.286	-4.172	-1.162	-2.187	-2.120	-1.550	-3.521	-0.765	-0.014	-4.337
	p (2 tailed)*		0.3815	0.0000	0.0000	0.2452	0.0287	0.0343	0.1210	0.0000	0.4440	0.9891	0.0000

*Bold values significant at the .05 level

Table B.2, *cont.*

			Secchi	Temp	DO	pH	Salinity	TN	TP	Chl a	Coliform	Turbidity	Color
Pine	Mean	Rain	86.4	309.1	145.4	189.9	166.2	170.38	167.47	195.8	189	178.1	223
Island	Rank	Dry	81.4	125.0	231.7	197.8	223.3	145.10	164.19	119.2	194	188.8	159
Sound	Sum of	Rain	7513.5	50697.0	23262.5	30375.5	27093.5	20616.00	22105.50	23101.5	29805	26354.0	33186
	Ranks	Dry	6514.5	29503.0	53765.5	45090.5	52706.5	27279.00	32509.50	21449.5	43732	41542.0	35080
	Mann Whitney U		3274.5	1537.0	10382.5	17495.5	13727.5	9513.0	12808.5	5159.5	17243.5	15328.0	10769.5
	Z		-0.660	-15.693	-7.419	-0.697	-4.863	-2.428	-0.306	-7.036	-0.526	-0.952	-5.625
	p (2 tailed)*		0.5092	0.0000	0.0000	0.4856	0.0000	0.0151	0.7594	0.0000	0.5991	0.3413	0.0000
Matlacha	Mean	Rain	73.0	204.0	77.6	105.5	101.3	113.30	123.94	117.5	118	133.2	143
Pass	Rank	Dry	121.8	81.1	160.3	139.7	148.8	87.32	94.60	79.7	117	97.1	91
	Sum of	Rain	6135.5	21618.5	7991.0	10976.0	10639.5	8611.00	10658.50	8339.0	11241	11326.0	12172
	Ranks	Dry	14367.5	12572.5	23887.0	20399.0	22771.5	10304.00	11919.50	9239.0	16254	13205.0	12360
	Mann Whitney U		2565.5	482.5	2635.0	5516.0	5074.5	3283.0	3918.5	2453.0	6524.0	3889.0	3043.5
	Z		-5.848	-12.931	-8.861	-3.780	-5.024	-3.147	-3.426	-4.062	-0.157	-4.091	-5.936
	p (2 tailed)*		0.0000	0.0000	0.0000	0.0002	0.0000	0.0016	0.0006	0.0000	0.8749	0.0000	0.0000
San	Mean	Rain	149.3	266.2	108.3	160.0	146.9	145.78	137.77	152.0	157	138.9	176
Carlos	Rank	Dry	174.3	105.1	207.7	176.9	185.7	112.61	128.23	104.9	154	153.2	129
Bay	Sum of	Rain	20157.5	36742.0	14616.5	22245.0	20120.0	13557.50	14328.00	14288.5	19678	16250.0	20541
	Ranks	Dry	33470.5	21228.0	41328.5	35385.0	37510.0	17567.50	20388.00	15846.5	28528	27115.0	22824
	Mann Whitney U		10977.5	725.0	5436.5	12515.0	10667.0	5321.5	7668.0	4370.5	11322.5	9347.0	7071.0
	Z		-2.360	-14.863	-9.239	-1.614	-3.580	-3.515	-0.998	-4.687	-0.317	-1.412	-4.618
	p (2 tailed)*		0.0183	0.0000	0.0000	0.1066	0.0003	0.0004	0.3185	0.0000	0.7516	0.1579	0.0000
Estero	Mean	Rain	90.3	279.8	114.1	167.3	147.4	157.23	137.21	152.6	155	125.1	197
Bay	Rank	Dry	87.9	112.3	223.3	187.2	201.2	125.51	157.22	119.2	174	183.4	135
	Sum of	Rain	7406.0	41411.5	16657.0	24591.0	21661.5	17768.00	16740.00	15410.5	21253	16012.5	25254
	Ranks	Dry	8347.0	23929.5	46889.0	39312.0	42241.5	20458.00	27513.00	19305.5	33694	35027.5	25787
	Mann Whitney U		3787.0	1138.5	5926.0	13713.0	10783.5	7092.0	9237.0	6102.5	11799.5	7756.5	7450.5
	Z		-0.319	-15.023	-9.850	-1.830	-4.847	-3.248	-1.980	-3.465	-1.742	-5.533	-5.933
	p (2 tailed)*		0.7500	0.0000	0.0000	0.0672	0.0000	0.0012	0.0477	0.0010	0.0814	0.0000	0.0000
All Aquatic	Mean	Rain	870	2664	1173	1578	1496	1392	1333	1354	1405	1325	1671
Preserves	Rank	Dry	1029	1068	2041	1785	1845	1075	1229	1029	1430	1384	1156
	Sum of	Rain	804897	3739879	1612162	2193928	2078909	1330995	1345419	1216037	1623964	1433380	1810166
	Ranks	Dry	1006760	2171763	4081463	3587772	3716402	1555009	1881652	1453169	2407417	2267180	1893115
	Mann Whitney U		376622	102168	667537	1227183	1112164	508828	708906	4555906	955218	847477	550774
	Z		-6.331	-46.406	-25.417	-6.090	-10.203	-10.961	-3.512	-11.417	-0.823	-1.930	-16.801
	p (2 tailed)*		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000	0.4104	0.0482	0.0000

*Bold values significant at the .05 level

Table B.3: Aquatic Preserve non parametric t-test (Mann Whitney) post hoc comparisons

	Mean Rank		Sum of Ranks		Mann-Whitney U	Z	p(2-tailed) *
	Upper Charlotte	Lower Charlotte	Upper Charlotte	Lower Charlotte			
Secchi	217.15	373.26	85558.00	39192.00	7743	-9.886	0.0000
Temp	449.09	470.40	295055.00	118540.00	78902	-1.097	0.2727
DO	440.40	471.63	286260.00	116493.00	74685	-1.613	0.1067
pH	353.83	716.49	232465.00	178406.00	16312	-18.764	0.0000
Salinity	369.23	657.76	239629.00	163124.00	28704	-14.918	0.0000
TN	388.66	278.04	196273.00	57555.00	36027	-5.063	0.0000
TP	450.00	185.95	239398.50	39979.50	16760	-15.147	0.0000
Chl a	364.61	281.82	175740.00	55800.00	36099	-4.869	0.0000
Coliform	478.38	241.97	280810.50	56620.50	29126	-12.920	0.0000
Turbidity	423.91	311.77	235692.50	70460.50	44810	-6.294	0.0000
Color	452.82	242.11	252219.50	54716.50	29066	-11.827	0.0000
	Upper Charlotte	Gasp/Cape Haze	Upper Charlotte	Gasp/Cape Haze			
Secchi	213.24	365.38	84017.00	31423.00	6202	-9.243	0.0000
Temp	416.28	454.84	273495.50	87329.50	57343	-1.920	0.0549
DO	438.86	352.56	285260.50	66280.50	48515	-4.307	0.0000
pH	350.65	681.16	230380.00	132146.00	14227	-16.595	0.0000
Salinity	343.60	682.63	222995.50	131065.50	12071	-16.989	0.0000
TN	338.60	269.43	170991.50	37989.50	27979	-3.891	0.0001
TP	400.82	131.10	213238.00	19665.00	8340	-14.812	0.0000
Chl a	340.54	225.77	164142.00	32736.00	22151	-6.690	0.0000
Coliform	413.56	256.73	242758.00	43388.00	29023	-8.235	0.0000
Turbidity	358.61	362.56	199386.00	58735.00	44540	-0.214	0.8309
Color	413.17	177.19	230134.50	28705.50	15503	-12.745	0.0000
	Upper Charlotte	Estero Bay	Upper Charlotte	Estero Bay			
Secchi	253.78	357.72	99989.50	63316.50	22175	-6.985	0.0000
Temp	511.21	506.39	335862.50	182808.50	117468	-0.250	0.8024
DO	536.25	443.70	348563.00	157958.00	94412	-4.832	0.0000
pH	401.34	702.87	263679.00	250926.00	47526	-15.811	0.0000
Salinity	397.71	695.82	258111.50	248409.50	47187	-15.572	0.0000
TN	435.31	309.92	219832.50	85538.50	47313	-7.425	0.0000
TP	547.60	177.49	291321.00	52714.00	8461	-21.345	0.0000
Chl a	407.83	309.16	196575.50	81309.50	46594	-5.981	0.0000
Coliform	496.08	394.62	291201.50	130619.50	75674	-5.573	0.0000
Turbidity	382.43	534.86	212629.50	170620.50	57784	-8.588	0.0000
Color	517.62	300.36	288312.00	95814.00	44774	-12.247	0.0000
	Upper Charlotte	San Carlos Bay	Upper Charlotte	San Carlos Bay			
Secchi	260.86	481.66	102779.00	157502.00	24964	-14.201	0.0000
Temp	485.61	524.88	319042.50	178460.50	102890	-2.045	0.0409
DO	440.32	594.05	286206.00	198414.00	74631	-8.037	0.0000
pH	358.44	769.94	235498.00	261008.00	19345	-21.564	0.0000
Salinity	377.98	717.58	245308.00	243258.00	34383	-17.759	0.0000
TN	422.94	285.35	213583.00	71052.00	39927	-8.158	0.0000
TP	515.91	159.49	274464.00	41946.00	7230	-20.596	0.0000
Chl a	411.21	271.11	198205.00	66423.00	36288	-8.503	0.0000
Coliform	541.68	273.50	317968.00	84785.00	36580	-14.782	0.0000
Turbidity	402.51	468.98	223794.50	137880.50	68949	-3.755	0.0002
Color	512.95	261.27	285713.00	76813.00	33448	-14.219	0.0000

* Bold values significant at the .05 level

Table B.3, *cont.*

	Mean Rank		Sum of Ranks		Mann-Whitney U	Z	p(2-tailed) *
	Upper Charlotte	Lower Lemon Bay	Upper Charlotte	Lower Lemon Bay			
Secchi	248.21	422.64	97793.50	97206.50	19979	-11.693	0.0000
Temp	592.09	590.76	389002.50	310150.50	172076	-0.066	0.9470
DO	629.81	523.92	409377.50	269817.50	136948	-5.337	0.0000
pH	397.29	831.21	261022.00	432231.00	44869	-21.914	0.0000
Salinity	373.22	848.09	242218.00	439310.00	31293	-23.915	0.0000
TN	427.90	304.69	216092.00	80743.00	45498	-7.303	0.0000
TP	519.86	179.87	276564.50	49463.50	11514	-19.643	0.0000
Chl a	405.84	299.36	195616.00	76337.00	43697	-6.792	0.0000
Coliform	482.82	371.49	283415.50	112189.50	66437	-6.129	0.0000
Turbidity	431.37	417.34	239844.00	123534.00	79578	-0.792	0.4281
Color	523.53	245.35	291607.50	72623.50	28668	-15.716	0.0000
	Upper Charlotte	Upper Lemon Bay	Upper Charlotte	Upper Lemon Bay			
	Upper Charlotte	Upper Lemon Bay	Upper Charlotte	Upper Lemon Bay			
Secchi	282.01	268.19	111111.50	43178.50	30138	-0.926	0.3540
Temp	518.54	521.16	340679.00	198562.00	124526	-0.136	0.8918
DO	590.93	374.45	384106.50	139669.50	69919	-11.282	0.0000
pH	444.59	644.55	292098.00	242997.00	75945	-10.470	0.0000
Salinity	455.78	611.77	295798.00	230027.00	84873	-8.131	0.0000
TN	362.14	363.33	182880.00	79570.00	55115	-0.071	0.9437
TP	414.60	300.93	220568.00	68612.00	42506	-6.544	0.0000
Chl a	341.89	355.49	164789.50	74296.50	48387	-0.823	0.4110
Coliform	398.92	469.10	234167.50	118212.50	61590	-3.847	0.0001
Turbidity	412.39	366.32	229289.50	87916.50	58997	-2.595	0.0090
Color	447.79	283.64	249416.50	67789.50	39110	-9.246	0.0000
	Upper Charlotte	Matlacha Pass	Upper Charlotte	Matlacha Pass			
	Upper Charlotte	Matlacha Pass	Upper Charlotte	Matlacha Pass			
Secchi	228.32	435.39	89956.50	87949.50	12142	-13.926	0.0000
Temp	452.99	475.89	297612.50	124208.50	81460	-1.183	0.2369
DO	434.63	495.01	282511.00	124742.00	70936	-3.124	0.0018
pH	366.13	684.91	240550.50	171227.50	24398	-16.536	0.0000
Salinity	421.97	534.57	273858.50	137919.50	62934	-5.840	0.0000
TN	367.07	305.57	185370.00	59280.00	40365	-3.606	0.0000
TP	462.12	147.60	245848.50	31291.50	8714	-18.023	0.0000
Chl a	366.56	253.66	176680.50	47434.50	29857	-6.781	0.0000
Coliform	482.30	232.13	283112.50	54318.50	26824	-13.673	0.0000
Turbidity	415.66	321.92	231108.00	71145.00	46614	-5.253	0.0000
Color	434.11	277.06	241800.50	61230.50	36700	-8.802	0.0000
	Upper Charlotte	Pine Island Sound	Upper Charlotte	Pine Island Sound			
	Upper Charlotte	Pine Island Sound	Upper Charlotte	Pine Island Sound			
Secchi	238.88	380.37	94118.50	63522.50	16304	-9.481	0.0000
Temp	528.95	529.08	347520.50	211632.50	131368	-0.007	0.9946
DO	477.70	594.12	310506.50	232896.50	98932	-6.051	0.0000
pH	363.09	793.77	238550.50	307984.50	22398	-22.404	0.0000
Salinity	355.99	798.59	231039.00	318637.00	20114	-22.986	0.0000
TN	453.90	331.67	229219.00	102486.00	54591	-7.198	0.0000
TP	576.38	197.93	306636.00	65317.00	10702	-21.698	0.0000
Chl a	415.07	350.76	200064.00	104526.00	59975	-3.874	0.0001
Coliform	608.50	296.98	357191.00	113744.00	40208	-17.027	0.0000
Turbidity	466.47	456.50	259359.50	167990.50	100095	-0.556	0.5779
Color	584.82	280.37	325746.00	103455.00	35190	-16.983	0.0000

* Bold values significant at the .05 level

Table B.3, *cont.*

	Mean Rank		Sum of Ranks		Mann-Whitney U	Z	p(2-tailed) *
	Lower Charlotte	Gasp/Cape Haze	Lower Charlotte	Gasp/Cape Haze			
Secchi	101.03	89.85	10608.50	7727.50	3987	-1.392	0.1638
Temp	218.28	228.04	55006.00	43784.00	23128	-0.796	0.4262
DO	244.67	182.95	60434.50	34395.50	16630	-5.074	0.0000
pH	225.52	217.48	56154.50	42191.50	23277	-0.671	0.5021
Salinity	186.68	264.18	46297.00	50723.00	15421	-6.341	0.0000
TN	166.05	186.90	34372.50	26353.50	12845	-1.898	0.0576
TP	201.89	155.93	43406.00	23389.00	12064	-4.100	0.0000
Chl a	181.12	159.54	35862.50	23133.50	12549	-1.992	0.0460
Coliform	185.96	224.21	43514.50	37891.50	16020	-3.296	0.0010
Turbidity	170.54	227.92	38542.50	36923.50	12892	-4.972	0.0000
Color	205.96	178.51	46547.50	28918.50	15716	-2.390	0.0168
	Lower Charlotte	Estero Bay	Lower Charlotte	Estero Bay			
Secchi	174.68	121.82	18341.50	21561.50	5809	-5.273	0.0000
Temp	317.77	299.48	80078.00	108113.00	42772	-1.260	0.2077
DO	349.59	268.98	86349.00	95757.00	32211	-5.589	0.0000
pH	359.57	264.39	89533.50	94387.50	30485	-6.704	0.0000
Salinity	292.11	310.57	72443.00	110872.00	41567	-1.277	0.2014
TN	242.28	241.79	50151.50	66734.50	28509	-0.038	0.9700
TP	332.51	201.48	71489.00	59839.00	15586	-9.906	0.0000
Chl a	232.38	229.96	46010.50	60480.50	25765	-0.192	0.8470
Coliform	225.26	323.82	52712.00	107183.00	25217	-7.119	0.0000
Turbidity	187.19	333.80	42304.00	106481.00	16653	-10.709	0.0000
Color	263.56	279.69	59563.50	89221.50	33913	-1.183	0.2370
	Lower Charlotte	San Carlos Bay	Lower Charlotte	San Carlos Bay			
Secchi	237.51	209.75	24939.00	68589.00	14961	-1.986	0.0471
Temp	290.81	300.72	73283.50	102244.50	41406	-0.698	0.4852
DO	250.80	320.73	61948.00	107123.00	31320	-4.966	0.0000
pH	302.98	288.27	75441.00	97725.00	40095	-1.064	0.2875
Salinity	276.46	306.83	68562.00	104016.00	37686	-2.143	0.0321
TN	234.15	223.80	48470.00	55726.00	24601	-0.836	0.4034
TP	305.43	185.60	65668.00	48813.00	14097	-9.450	0.0000
Chl a	238.96	208.29	47314.50	51031.50	20897	-2.507	0.0120
Coliform	274.63	270.89	64264.00	83976.00	35771	-0.281	0.7790
Turbidity	202.60	305.01	45788.00	89672.00	20137	-7.706	0.0000
Color	276.51	248.19	62492.00	72968.00	29603	-2.138	0.0325
	Lower Charlotte	Lower Lemon Bay	Lower Charlotte	Lower Lemon Bay			
Secchi	196.10	155.17	20590.50	35689.50	9125	-3.598	0.0003
Temp	401.55	382.98	101190.00	201063.00	62988	-1.081	0.2795
DO	448.60	349.32	110804.50	179898.50	47029	-5.829	0.0000
pH	396.69	379.40	98776.00	197289.00	61829	-1.029	0.3037
Salinity	283.11	431.56	70212.50	223548.50	39337	-8.689	0.0000
TN	236.67	236.37	48990.00	62638.00	27393	-0.023	0.9810
TP	290.11	210.62	62374.50	57920.50	19971	-6.175	0.0000
Chl a	232.44	222.77	46024.00	56807.00	24167	-0.780	0.4350
Coliform	221.27	305.10	51777.00	92139.00	24282	-6.267	0.0000
Turbidity	223.89	290.22	50598.50	85904.50	24948	-4.980	0.0000
Color	293.05	237.41	66230.00	70273.00	26317	-4.194	0.0000

* Bold values significant at the .05 level

Table B.3, *cont.*

	Mean Rank		Sum of Ranks		Mann-Whitney U	Z	p(2-tailed) *
	Lower Charlotte	Upper Lemon Bay	Lower Charlotte	Upper Lemon Bay			
Secchi	189.20	97.17	19866.00	15645.00	2604	-9.580	0.0000
Temp	325.19	311.58	81949.00	118712.00	45941	-0.918	0.3586
DO	401.90	249.97	99269.50	93240.50	23490	-10.341	0.0000
pH	402.29	254.86	100169.00	96082.00	24829	-10.076	0.0000
Salinity	366.26	277.04	90831.50	104168.50	33293	-6.050	0.0000
TN	176.89	248.10	36616.50	54334.50	15089	-5.967	0.0000
TP	153.36	286.73	32971.50	65374.50	9752	-10.967	0.0000
Chl a	174.18	232.25	34487.50	48540.50	14787	-4.978	0.0000
Coliform	163.36	317.91	38226.50	80114.50	10732	-12.170	0.0000
Turbidity	208.36	257.17	47090.00	61721.00	21439	-3.911	0.0001
Color	216.26	248.83	48874.50	59470.50	23224	-2.621	0.0088
	Lower Charlotte	Matlacha Pass	Lower Charlotte	Matlacha Pass			
Secchi	155.13	153.41	16288.50	30989.50	10487	-0.161	0.8722
Temp	256.46	257.52	64627.50	67213.50	32750	-0.081	0.9351
DO	242.29	257.56	59845.50	64904.50	29218	-1.183	0.2368
pH	287.42	212.73	71567.50	53182.50	21808	-5.901	0.0000
Salinity	316.03	193.39	78376.50	49894.50	16484	-9.433	0.0000
TN	185.31	217.74	38358.50	42242.50	16831	-2.801	0.0051
TP	246.77	180.77	53054.50	38323.50	15746	-5.533	0.0000
Chl a	201.83	183.66	39961.50	34343.50	16766	-1.602	0.1090
Coliform	235.80	233.20	55176.50	54569.50	27075	-0.212	0.8324
Turbidity	216.77	231.39	48990.50	51137.50	23340	-1.197	0.2314
Color	204.12	244.33	46130.50	53997.50	20480	-3.301	0.0010
	Lower Charlotte	Pine Island Sound	Lower Charlotte	Pine Island Sound			
Secchi	154.91	124.92	16266.00	20862.00	6834	-3.067	0.0022
Temp	335.70	320.71	84596.00	128282.00	48082	-0.991	0.3215
DO	286.92	340.84	70869.50	133610.50	40242	-3.596	0.0003
pH	269.15	350.99	67018.00	136185.00	35893	-5.570	0.0000
Salinity	245.09	373.04	60783.50	148844.50	29908	-8.466	0.0000
TN	258.55	258.47	53520.00	79866.00	31971	-0.006	0.9950
TP	355.97	218.94	76533.50	72251.50	17637	-9.941	0.0000
Chl a	236.28	256.62	46783.50	76472.50	27083	-1.548	0.1220
Coliform	338.11	291.21	79118.50	111534.50	37999	-3.292	0.0010
Turbidity	257.88	321.83	58281.50	118433.50	32631	-4.410	0.0000
Color	334.33	275.75	75558.00	101752.00	33487	-4.053	0.0001
	Gasp/Cape Haze	Estero Bay	Gasp/Cape Haze	Estero Bay			
Secchi	162.29	117.28	13957.00	20759.00	5006	-4.513	0.0000
Temp	295.41	267.21	56718.50	96462.50	31122	-1.979	0.0478
DO	267.70	275.04	50327.50	97912.50	32562	-0.518	0.6046
pH	326.87	248.36	63412.00	88664.00	24761	-5.645	0.0000
Salinity	321.34	250.08	61697.00	89278.00	25375	-5.020	0.0000
TN	224.34	201.16	31631.50	55521.50	17296	-1.857	0.0630
TP	261.84	204.89	39276.00	60852.00	16599	-4.409	0.0000
Chl a	187.51	213.87	27188.50	56247.50	16604	-2.162	0.0310
Coliform	221.63	265.24	37455.00	87795.00	23090	-3.206	0.0013
Turbidity	186.62	268.61	30233.00	85688.00	17030	-6.115	0.0000
Color	208.59	257.46	33791.50	82129.50	20589	-3.661	0.0003

* Bold values significant at the .05 level

Table B.3, *cont.*

	Mean Rank		Sum of Ranks		Mann-Whitney U	Z	p(2-tailed) *
	Gasp/Cape Haze	San Carlos Bay	Gasp/Cape Haze	San Carlos Bay			
Secchi	208.41	206.63	17923.00	67568.00	13940	-0.123	0.9020
Temp	268.25	265.51	51503.50	90274.50	32305	-0.197	0.8436
DO	171.55	312.13	32251.50	104251.50	14486	-10.226	0.0000
pH	268.92	265.90	52170.00	90141.00	32511	-0.224	0.8226
Salinity	309.43	241.40	59410.00	81836.00	24206	-4.909	0.0000
TN	216.04	183.87	30461.50	45783.50	14659	-2.708	0.0068
TP	238.11	189.26	35716.50	49774.50	15059	-4.009	0.0001
Chl a	196.60	194.85	28506.50	47738.50	17604	-0.148	0.8820
Coliform	272.27	222.41	46013.50	68946.50	20742	-3.822	0.0001
Turbidity	206.77	240.47	33497.00	70699.00	20294	-2.614	0.0089
Color	226.18	229.78	36641.00	67555.00	23438	-0.281	0.7791
	Gasp/Cape Haze	Lower Lemon Bay	Gasp/Cape Haze	Lower Lemon Bay			
Secchi	180.35	150.33	15510.00	34576.00	8011	-2.609	0.0091
Temp	382.48	350.41	73436.50	183966.50	45892	-1.839	0.0659
DO	347.16	353.77	65265.50	182190.50	47500	-0.382	0.7024
pH	357.80	357.39	69414.00	185841.00	50381	-0.025	0.9804
Salinity	343.95	359.78	66037.50	186367.50	47510	-0.914	0.3607
TN	219.19	195.15	30906.00	51715.00	16470	-1.966	0.0489
TP	219.90	209.24	32985.00	57540.00	19590	-0.857	0.3917
Chl a	188.80	207.15	27376.00	52824.00	16791	-1.527	0.1270
Coliform	214.76	247.88	36295.00	74861.00	21930	-2.545	0.0109
Turbidity	235.94	225.97	38223.00	66888.00	22932	-0.771	0.4407
Color	244.15	221.48	39552.50	65558.50	21603	-1.763	0.0778
	Gasp/Cape Haze	Upper Lemon Bay	Gasp/Cape Haze	Upper Lemon Bay			
Secchi	185.56	91.12	15958.00	14670.00	1629	-9.945	0.0000
Temp	303.21	278.83	58217.00	106234.00	33463	-1.666	0.0956
DO	328.97	256.82	61847.00	95794.00	26043	-4.978	0.0000
pH	369.26	243.16	71635.50	91670.50	20418	-8.740	0.0000
Salinity	387.72	231.79	74441.50	87154.50	16279	-10.712	0.0000
TN	153.65	197.79	21664.50	43315.50	11654	-3.928	0.0000
TP	108.84	242.57	16326.00	55305.00	5001	-11.648	0.0000
Chl a	134.12	207.59	19448.00	43387.00	8863	-6.643	0.0000
Coliform	147.47	253.60	24923.00	63908.00	10558	-8.785	0.0000
Turbidity	216.42	191.43	35059.50	45943.50	17024	-2.115	0.0340
Color	167.73	223.55	27171.50	53429.50	13969	-4.756	0.0000
	Gasp/Cape Haze	Matlacha Pass	Gasp/Cape Haze	Matlacha Pass			
Secchi	127.14	151.89	10934.00	30682.00	7193	-2.312	0.0208
Temp	232.07	223.27	44558.00	58273.00	24082	-0.709	0.4786
DO	176.68	253.19	33216.00	63804.00	15450	-6.245	0.0000
pH	256.55	196.08	49770.50	49019.50	17645	-5.047	0.0000
Salinity	314.87	158.99	60454.50	41020.50	7610	-12.576	0.0000
TN	162.51	171.99	22914.50	33365.50	12904	-0.884	0.3768
TP	184.67	179.26	27700.50	38002.50	15425	-0.486	0.6272
Chl a	164.21	168.27	23811.00	31467.00	13226	-0.382	0.7020
Coliform	226.40	184.38	38261.50	43144.50	15650	-3.620	0.0003
Turbidity	219.40	171.92	35542.50	37993.50	13463	-4.148	0.0000
Color	155.55	218.72	25198.50	48337.50	11996	-5.542	0.0000

* Bold values significant at the .05 level

Table B.3, *cont.*

	Mean Rank		Sum of Ranks		Mann-Whitney U	Z	p(2-tailed) *
	Gasp/Cape Haze	Pine Island Sound	Gasp/Cape Haze	Pine Island Sound			
Secchi	140.04	120.28	12043.50	20087.50	6060	-2.039	0.0415
Temp	314.42	287.90	60368.00	115160.00	34960	-1.769	0.0769
DO	208.37	329.89	39174.00	129316.00	21408	-8.176	0.0000
pH	231.70	321.40	44949.00	124704.00	26034	-6.168	0.0000
Salinity	291.07	298.37	55884.50	119051.50	37357	-0.487	0.6259
TN	243.95	217.08	34397.00	67078.00	19183	-2.033	0.0418
TP	284.26	220.61	42639.00	72801.00	18186	-4.668	0.0000
Chl a	190.66	237.25	27645.50	70700.50	17061	-3.595	0.0000
Coliform	338.84	248.99	57264.00	95364.00	21828	-6.291	0.0000
Turbidity	271.20	262.99	43934.00	96781.00	28885	-0.568	0.5698
Color	279.58	260.04	45292.50	95953.50	27689	-1.361	0.1737
	Estero Bay	San Carlos Bay	Estero Bay	San Carlos Bay			
Secchi	200.51	280.64	35489.50	91770.50	19737	-5.909	0.0000
Temp	336.15	366.77	121349.50	124701.50	56009	-2.003	0.0451
DO	255.67	441.25	91017.50	147377.50	27472	-12.226	0.0000
pH	297.26	402.46	106121.00	136435.00	42218	-7.070	0.0000
Salinity	343.73	353.53	122711.00	119845.00	58808	-0.643	0.5205
TN	268.86	353.53	122711.00	119845.00	32744	-0.932	0.3510
TP	278.29	283.00	82652.00	74428.00	38399	-0.344	0.7306
Chl a	272.26	235.43	71604.50	57681.50	27547	-2.826	0.0050
Coliform	377.67	260.50	125007.50	80753.50	32549	-8.073	0.0000
Turbidity	336.94	274.51	107484.50	80706.50	37342	-4.361	0.0000
Color	330.46	281.55	105416.00	82775.00	39410	-3.427	0.0006
	Estero Bay	Lower Lemon Bay	Estero Bay	Lower Lemon Bay			
Secchi	181.93	220.98	32202.00	50826.00	16449	-3.331	0.0009
Temp	441.54	444.85	159395.50	233545.50	94055	-0.189	0.8497
DO	436.30	435.79	155323.50	224432.50	91563	-0.029	0.9765
pH	371.28	485.49	132546.50	252456.50	68644	-6.671	0.0000
Salinity	360.97	491.09	128867.00	254383.00	64964	-7.485	0.0000
TN	271.19	270.80	74848.50	71762.50	36518	-0.029	0.9770
TP	255.60	319.88	75912.00	87966.00	31659	-4.656	0.0000
Chl a	265.01	253.82	69698.00	64723.00	32083	-0.851	0.3950
Coliform	321.70	311.85	106482.00	94179.00	48426	-0.679	0.4972
Turbidity	362.08	249.72	115504.00	73916.00	29960	-7.837	0.0000
Color	346.24	266.79	110449.00	78971.00	35015	-5.560	0.0000
	Estero Bay	Upper Lemon Bay	Estero Bay	Upper Lemon Bay			
Secchi	207.22	128.03	36677.50	20613.50	7573	-7.476	0.0000
Temp	368.60	374.25	133063.00	142590.00	67722	-0.360	0.7190
DO	418.85	313.61	149110.00	116975.00	47224	-6.746	0.0000
pH	405.11	331.89	144624.00	125121.00	53868	-4.732	0.0000
Salinity	423.90	312.97	151333.50	117677.50	46802	-7.090	0.0000
TN	209.64	296.34	57861.00	64899.00	19635	-6.698	0.0000
TP	167.00	388.06	49598.00	88477.00	5345	-16.561	0.0000
Chl a	204.08	277.29	53673.50	57954.50	18958	-5.793	0.0000
Coliform	249.48	347.85	82579.00	87657.00	27633	-6.994	0.0000
Turbidity	332.86	209.74	106183.50	50336.50	21417	-8.932	0.0000
Color	269.67	292.62	86025.00	69936.00	34985	-1.670	0.0950

* Bold values significant at the .05 level

Table B.3, *cont.*

	Mean Rank		Sum of Ranks		Mann-Whitney U	Z	p(2-tailed) *
	Estero Bay	Matlacha Pass	Estero Bay	Matlacha Pass			
Secchi	143.58	230.67	25414.00	46596.00	9661	-7.736	0.0000
Temp	303.53	322.53	109573.00	84180.00	44232	-1.304	0.1924
DO	262.43	363.93	93424.50	91711.50	29879	-7.021	0.0000
pH	297.17	313.75	106090.50	78437.50	42188	-1.172	0.2414
Salinity	365.64	228.25	130532.50	58887.50	25477	-9.463	0.0000
TN	218.95	259.05	60430.00	50255.00	22204	-3.151	0.0020
TP	228.21	292.53	67778.00	62017.00	23525	-4.874	0.0000
Chl a	235.74	211.10	62000.00	39475.00	21897	-1.981	0.0480
Coliform	326.28	221.77	108000.00	51895.00	24400	-7.550	0.0000
Turbidity	327.55	188.15	104488.50	41581.50	17051	-10.209	0.0000
Color	257.15	289.77	82031.50	64038.50	30992	-2.396	0.0166
	Estero Bay	Pine Island Sound	Estero Bay	Pine Island Sound			
Secchi	157.98	187.89	27963.00	31377.00	12210	-2.795	0.0052
Temp	379.23	382.60	136901.50	153039.50	71561	-0.212	0.8325
DO	294.59	447.07	104875.00	175251.00	41329	-9.641	0.0000
pH	273.49	464.56	97636.00	180249.00	33733	-12.243	0.0000
Salinity	320.46	430.43	114402.50	171743.50	50500	-6.913	0.0000
TN	292.63	293.33	80767.00	90638.00	42541	-0.049	0.9610
TP	319.31	309.22	94835.00	102043.00	47428	-0.698	0.4853
Chl a	266.54	293.33	70100.00	87541.00	35384	-1.985	0.0470
Coliform	445.45	281.49	147445.00	107810.00	34274	-10.775	0.0000
Turbidity	402.48	293.31	128391.00	107937.00	40041	-7.191	0.0000
Color	390.11	305.07	124443.50	112572.50	44308	-5.619	0.0000
	San Carlos Bay	Lower Lemon Bay	San Carlos Bay	Lower Lemon Bay			
Secchi	297.97	252.03	97437.00	57966.00	31401	-3.326	0.0009
Temp	453.21	419.91	154091.50	220453.50	82379	-1.917	0.0552
DO	557.17	339.28	186094.00	174731.00	41861	-12.651	0.0000
pH	427.73	431.48	145000.50	224369.50	87371	-0.221	0.8249
Salinity	352.18	479.27	119389.00	248264.00	61759	-7.350	0.0000
TN	251.70	262.95	62673.00	69682.00	31548	-0.858	0.3910
TP	240.28	297.45	63192.50	81798.50	28477	-4.273	0.0000
Chl a	237.92	262.58	58291.50	66958.50	28157	-1.908	0.0560
Coliform	256.70	357.62	79577.50	108000.50	31373	-7.128	0.0000
Turbidity	322.37	268.81	94777.50	79567.50	35612	-3.817	0.0001
Color	310.10	281.00	91170.00	83175.00	39219	-2.083	0.0373
	San Carlos Bay	Upper Lemon Bay	San Carlos Bay	Upper Lemon Bay			
Secchi	302.78	126.14	99007.50	20308.50	7268	-13.043	0.0000
Temp	374.25	349.18	127245.00	133036.00	60265	-1.615	0.1062
DO	482.99	238.50	161317.00	88961.00	19210	-15.894	0.0000
pH	446.46	279.41	151349.50	105336.50	34084	-10.937	0.0000
Salinity	425.92	296.76	144388.50	111581.50	40706	-8.350	0.0000
TN	191.33	283.59	47640.50	62105.50	16516	-7.364	0.0000
TP	149.80	356.97	39397.50	81388.50	4682	-16.147	0.0000
Chl a	182.61	280.12	44739.50	58545.50	14605	-7.894	0.0000
Coliform	199.25	382.68	61768.50	96434.50	13564	-13.390	0.0000
Turbidity	299.36	228.47	88012.50	54832.50	25913	-5.282	0.0000
Color	238.70	301.81	70178.00	72133.00	26813	-4.719	0.0000

* Bold values significant at the .05 level

Table B.3, *cont.*

	Mean Rank		Sum of Ranks		Mann-Whitney U	Z	p(2-tailed) *
	San Carlos Bay	Matlacha Pass	San Carlos Bay	Matlacha Pass			
Secchi	248.10	292.36	81128.50	59056.50	27501	-3.241	0.0012
Temp	304.84	295.99	103647.00	77254.00	43063	-0.620	0.5351
DO	316.36	263.20	105664.50	66326.50	34449	-3.765	0.0002
pH	331.18	245.94	112269.50	61485.50	30111	-6.181	0.0000
Salinity	368.45	207.74	124905.50	53597.50	20187	-11.278	0.0000
TN	201.06	248.88	50063.50	48282.50	18939	-3.901	0.0000
TP	212.69	269.40	55938.00	57112.00	21222	-4.486	0.0000
Chl a	214.12	219.62	52459.00	41069.00	22324	-0.454	0.6500
Coliform	272.12	273.00	84357.00	63883.00	36152	-0.066	0.9471
Turbidity	298.15	204.58	87657.00	45213.00	20682	-7.064	0.0000
Color	227.55	298.51	66899.00	65971.00	23534	-5.371	0.0000
	San Carlos Bay	Pine Island Sound	San Carlos Bay	Pine Island Sound			
Secchi	258.76	225.46	84613.00	37652.00	23624	-2.457	0.0140
Temp	386.06	357.28	131259.00	142911.00	62711	-1.828	0.0676
DO	368.54	359.20	123093.50	140807.50	63780	-0.598	0.5496
pH	297.06	422.48	100705.00	163923.00	43075	-8.163	0.0000
Salinity	311.71	418.60	105670.50	167020.50	48041	-6.788	0.0000
TN	272.26	285.33	67792.50	88168.50	36668	-0.952	0.3410
TP	305.88	289.92	80447.00	95674.00	41059	-1.130	0.2586
Chl a	238.47	299.57	58425.50	89270.50	28291	-4.516	0.0000
Coliform	374.00	325.15	115938.50	124532.50	50997	-3.310	0.0009
Turbidity	358.41	310.00	105374.00	114079.00	46183	-3.237	0.0012
Color	346.70	320.28	101931.00	118185.00	49920	-1.773	0.0762
	Lower Lemon Bay	Upper Lemon Bay	Lower Lemon Bay	Upper Lemon Bay			
Secchi	253.07	114.47	58206.50	18429.50	5389	-11.979	0.0000
Temp	452.16	455.34	237386.00	173485.00	99311	-0.181	0.8566
DO	493.43	376.95	254115.50	140600.50	70850	-6.681	0.0000
pH	526.66	341.89	273861.00	128892.00	57639	-10.655	0.0000
Salinity	555.24	299.07	287615.50	112449.50	41574	-14.644	0.0000
TN	204.48	288.50	54188.50	63181.50	18944	-6.578	0.0000
TP	163.23	359.07	44889.00	81867.00	6939	-15.052	0.0000
Chl a	197.06	275.73	50251.50	57628.50	17612	-6.288	0.0000
Coliform	232.07	331.95	70084.50	83650.50	24332	-7.323	0.0000
Turbidity	277.21	257.76	82054.00	61862.00	32942	-1.446	0.1480
Color	228.09	317.43	67515.00	75865.00	23559	-6.669	0.0000
	Lower Lemon Bay	Matlacha Pass	Lower Lemon Bay	Matlacha Pass			
Secchi	182.15	255.61	41895.00	51633.00	15330	-6.116	0.0000
Temp	386.89	406.79	203119.00	106172.00	65044	-1.159	0.2466
DO	343.65	466.46	176980.00	117548.00	44110	-7.212	0.0000
pH	415.67	322.74	216149.00	80686.00	49311	-5.524	0.0000
Salinity	480.00	204.78	248642.50	52833.50	19423	-16.114	0.0000
TN	213.60	252.40	56603.50	48966.50	21359	-3.096	0.0020
TP	241.33	247.46	66366.00	52462.00	28416	-0.477	0.6330
Chl a	227.72	213.02	58069.00	39834.00	22256	-1.196	0.2320
Coliform	307.35	218.36	92819.50	51096.50	23602	-6.652	0.0000
Turbidity	281.64	228.67	83366.00	50537.00	26006	-3.989	0.0001
Color	218.20	313.64	64588.50	69314.50	20633	-7.210	0.0000

* Bold values significant at the .05 level

Table B.3, *cont.*

	Mean Rank		Sum of Ranks		Mann-Whitney U	Z	p(2-tailed) *
	Lower Lemon Bay	Pine Island Sound	Lower Lemon Bay	Pine Island Sound			
Secchi	199.59	198.19	45905.50	33097.50	19070	-0.120	0.9041
Temp	462.79	463.27	242966.50	185308.50	104892	-0.027	0.9785
DO	376.46	555.88	193874.50	217903.50	61005	-10.220	0.0000
pH	398.19	529.97	207059.00	205627.00	71599	-7.605	0.0000
Salinity	463.20	453.54	239940.00	180963.00	101163	-0.548	0.5838
TN	286.90	288.01	76028.50	88996.50	40784	-0.080	0.9360
TP	342.29	270.25	94131.00	89184.00	34569	-5.056	0.0000
Chl a	258.06	293.20	65806.50	87374.50	33167	-2.578	0.0100
Coliform	424.99	278.35	128347.00	106608.00	33072	-9.821	0.0000
Turbidity	332.44	332.54	98403.50	122376.50	54448	-0.007	0.9946
Color	328.24	336.82	97160.00	124285.00	53204	-0.575	0.5651
	Upper Lemon Bay	Matlacha Pass	Upper Lemon Bay	Matlacha Pass			
Secchi	102.60	245.28	16518.50	49547.50	3478	-12.909	0.0000
Temp	315.88	329.71	120349.50	86053.50	47579	-0.929	0.3528
DO	244.71	414.09	91275.00	104350.00	21524	-11.506	0.0000
pH	279.89	365.44	105518.50	91359.50	34266	-5.861	0.0000
Salinity	331.26	297.45	124552.00	76743.00	43332	-2.283	0.0224
TN	225.99	185.56	49491.50	35999.50	17085	-3.435	0.0010
TP	303.70	131.02	69244.50	27775.50	5198	-14.242	0.0000
Chl a	233.98	158.85	48901.50	29704.50	12127	-6.522	0.0000
Coliform	321.26	159.75	80958.50	37382.50	9888	-12.719	0.0000
Turbidity	248.55	211.94	59651.50	46839.50	22309	-2.948	0.0030
Color	226.44	234.89	54119.50	51910.50	25440	-0.683	0.4945
	Upper Lemon Bay	Pine Island Sound	Upper Lemon Bay	Pine Island Sound			
Secchi	112.97	214.18	18188.00	35768.00	5147	-9.708	0.0000
Temp	392.10	389.95	149391.50	155979.50	75780	-0.134	0.8937
DO	273.67	487.03	102080.00	190915.00	32329	-13.350	0.0000
pH	265.99	496.70	100277.00	192718.00	29024	-14.536	0.0000
Salinity	272.15	497.17	102328.00	198372.00	31452	-13.986	0.0000
TN	314.49	229.07	68873.00	70783.00	22888	-6.339	0.0000
TP	414.78	186.03	94570.00	61391.00	6776	-16.486	0.0000
Chl a	284.80	232.40	59523.00	69255.00	24704	-3.965	0.0000
Coliform	450.93	230.54	113635.00	88295.00	14759	-15.028	0.0000
Turbidity	293.55	311.64	70453.00	114683.00	41533	-1.241	0.2150
Color	364.14	265.87	87030.50	98105.50	29841	-6.766	0.0000
	Matlacha Pass	Pine Island Sound	Matlacha Pass	Pine Island Sound			
Secchi	208.09	157.07	42034.50	26230.50	12203	-4.582	0.0000
Temp	341.02	324.46	89005.50	129785.50	49586	-1.091	0.2752
DO	300.26	336.80	75664.50	132025.50	43787	-2.433	0.0150
pH	216.76	385.70	54189.00	149652.00	22814	-11.428	0.0000
Salinity	180.99	424.71	46694.50	169458.50	13284	-16.074	0.0000
TN	276.40	236.68	53621.50	73134.50	25240	-2.984	0.0029
TP	315.26	243.39	66834.50	80318.50	25704	-5.224	0.0000
Chl a	216.23	259.80	40435.00	77420.00	22857	-3.333	0.0010
Coliform	337.23	291.75	78911.00	111742.00	38206	-3.191	0.0014
Turbidity	264.02	313.60	58349.50	115405.50	33819	-3.424	0.0006
Color	362.64	255.29	80144.00	94201.00	25936	-7.434	0.0000

Bold values significant at the .05 level

Appendix C: Comparison of Results to Numerical Water Quality Criteria

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Table C.1: Site exceedances of dissolved oxygen under 4 mg/L per site per Florida Surface Water Regulations

*	All			Dry Season			Rainy Season		
	Under	Total	%	Under	Total	%	Under	Total	%
PIJIM1	28	32	88	16	20	80	12	12	100
LBV001	63	85	74	27	49	55	36	36	100
LBV006	45	63	71	22	40	55	23	23	100
GSV005	47	67	70	24	43	56	23	24	96
LBGOT2	40	67	60	17	42	40	23	25	92
GSV004	10	17	59	3	9	33	7	8	88
LBANG1	38	75	51	13	45	29	25	30	83
LBV003	42	83	51	12	50	24	30	33	91
EBERS2	25	51	49	7	30	23	18	21	86
GSV001	41	85	48	16	50	32	25	35	71
CHV008	38	90	42	6	54	11	32	36	89
LBFOR1	19	53	36	4	28	14	15	25	60
LBOYS1	26	75	35	6	44	14	20	31	65
EBV005	31	90	34	9	53	17	22	37	59
CHV003	22	64	34	3	36	8	19	28	68
EBV003	19	61	31	3	32	9	16	29	55
PIV007	18	61	30	7	33	21	11	28	39
LBV002	24	85	28	6	49	12	18	36	50
CHV009	22	83	27	5	48	10	17	35	49
MPV002	23	91	25	4	54	7	19	37	51
CHV013	13	52	25	0	30	0	13	22	59
CHV007	23	93	25	2	54	4	21	39	54
CHV010	20	86	23	5	50	10	15	36	42
LBV004	19	85	22	5	51	10	14	34	41
CHV005	8	42	19		26	0	8	16	50
EBV004	15	86	17	1	51	2	14	35	40
EBV007	7	46	15	2	27	7	5	19	26
GSV003	3	23	13	3	15	20	0	8	0
GSV002	9	73	12	6	46	13	3	27	11
CHV001	10	84	12	1	52	2	9	32	28
CHV006	10	89	11	1	54	2	9	35	26
LBV005	7	72	10	2	43	5	5	29	17
MPV001	7	84	8	0	51	0	7	33	21
CHV012	5	63	8	3	35	9	2	28	7
CHV004	6	86	7	0	50	0	6	36	17
PIV002	4	93	4	1	55	2	3	38	8
CHV002	2	50	4	0	31	0	2	19	11
EBV001	3	86	3	0	50	0	3	36	8
PIV001	2	63	3	0	40	0	2	23	9
MPV003	2	77	3	0	44	0	2	33	6
PIV006	2	82	2	1	48	2	1	34	3
MPV004	2	87	2	1	52	2	1	35	3
LBV007	1	72	1	1	43	2	0	29	0
SCV002	1	74	1	0	44	0	1	30	3
CHV011	0	78	0	0	43	0	0	35	0
PIV004	0	61	0	0	36	0	0	25	0
SCV001	0	87	0	0	53	0	0	34	0
EBV006	0	22	0	0	17	0	0	5	0
Total	802	3374	24%	245	2000	12%	557	1374	41%

*ranked in descending order by total % exceedances

Table C.2: Site exceedances of dissolved oxygen under 5 mg/L per site per Florida Surface Water Regulations

*	All			Dry Season			Rainy Season		
	Under	Total	%	Under	Total	%	Under	Total	%
PIJIM1	31	32	97	19	20	95	12	12	100
GSV004	16	17	94	9	9	100	7	8	88
LBV001	79	85	93	43	49	88	36	36	100
LBV006	56	63	89	33	40	83	23	23	100
GSV005	59	67	88	35	43	81	24	24	100
LBGOT2	57	67	85	33	42	79	24	25	96
GSV001	69	85	81	36	50	72	33	35	94
LBOYS1	58	75	77	27	44	61	31	31	100
LBV003	62	83	75	31	50	62	31	33	94
EBERS2	38	51	75	17	30	57	21	21	100
EBV003	42	61	69	16	32	50	26	29	90
LBANG1	50	75	67	20	45	44	30	30	100
CHV008	58	90	64	22	54	41	36	36	100
LBFOR1	33	53	62	11	28	39	22	25	88
PIV007	34	61	56	13	33	39	21	28	75
CHV003	35	64	55	8	36	22	27	28	96
LBV002	46	85	54	18	49	37	28	36	78
EBV004	46	86	53	17	51	33	29	35	83
EBV005	47	90	52	21	53	40	26	37	70
CHV013	27	52	52	7	30	23	20	22	91
LBV004	44	85	52	16	51	31	28	34	82
CHV010	44	86	51	18	50	36	26	36	72
CHV007	47	93	51	12	54	22	35	39	90
CHV009	41	83	49	13	48	27	28	35	80
CHV001	41	84	49	16	52	31	25	32	78
MPV002	44	91	48	17	54	31	27	37	73
EBV007	22	46	48	7	27	26	15	19	79
CHV005	18	42	43	4	26	15	14	16	88
GSV002	30	73	41	13	46	28	17	27	63
CHV004	28	86	33	7	50	14	21	36	58
EBV006	7	22	32	5	17	29	2	5	40
CHV006	28	89	31	4	54	7	24	35	69
MPV004	25	87	29	6	52	12	19	35	54
CHV012	17	63	27	5	35	14	12	28	43
LBV005	19	72	26	7	43	16	12	29	41
GSV003	6	23	26	5	15	33	1	8	13
MPV001	21	84	25	4	51	8	17	33	52
LBV007	17	72	24	7	43	16	10	29	34
MPV003	18	77	23	1	44	2	17	33	52
EBV001	19	86	22	4	50	8	15	36	42
PIV001	12	63	19	2	40	5	10	23	43
CHV002	8	50	16	2	31	6	6	19	32
PIV002	13	93	14	2	55	4	11	38	29
PIV006	7	82	9	1	48	2	6	34	18
SCV002	4	74	5	0	44	0	4	30	13
PIV004	3	61	5	0	36	0	3	25	12
SCV001	4	87	5	0	53	0	4	34	12
CHV011	3	78	4	0	43	0	3	35	9
Total	1533	3374	45%	614	2000	31%	919	1374	67%

*ranked in descending order by total % exceedances

Table C.3: Exceedances of 11 ug/L chlorophyll a per Florida Impaired Waters Rule for each estuary region

		Upper Lemon Bay	Lower Lemon Bay	Upper Charlotte Charlotte	Lower Charlotte Charlotte	Gasparilla/ Cape Haze	Pine Island Sound	Matlacha Pass	San Carlos Bay	Estero Bay	Total
All	Over	60	21	125	28	10	47	18	13	22	344
	Total	209	255	482	198	145	298	187	245	263	2282
	%	29	8	26	14	7	16	10	5	8	15
Rain	Over	36	10	54	12	6	27	13	7	5	170
	Total	81	101	187	80	57	118	71	94	101	890
	%	44	10	29	15	11	23	18	7	5	19
Dry	Over	24	11	71	16	4	20	5	6	17	174
	Total	128	154	295	118	88	180	116	151	162	1392
	%	19	7	24	14	5	11	4	4	10	13
1998	Over	11	3	19	6	2	4	2	2	1	50
	Total	13	14	34	15	12	12	11	15	11	137
	%	85	21	56	40	17	33	18	13	9	36
1999	Over	10	4	21	4	3	6	4	3	3	58
	Total	34	39	81	33	29	37	31	42	35	361
	%	29	10	26	12	10	16	13	7	9	16
2000	Over	6	2	10	0	0	8	0	0	1	27
	Total	28	30	67	30	22	50	30	43	39	339
	%	21	7	15	0	0	16	0	0	3	8
2001	Over	5	2	7	1	1	6	2	0	3	27
	Total	28	28	60	25	19	41	27	33	29	290
	%	18	7	12	4	5	15	7	0	10	9
2003	Over	9	8	18	8	2	12	6	6	9	78
	Total	30	43	70	31	12	60	30	39	53	368
	%	30	19	26	26	17	20	20	15	17	21
2004	Over	5	0	20	4	0	2	2	1	3	37
	Total	29	38	80	28	20	37	28	31	45	336
	%	17	0	25	14	0	5	7	3	7	11
2005	Over	14	2	30	5	2	9	2	1	2	67
	Total	47	63	90	36	31	61	30	42	51	451
	%	30	3	33	14	6	15	7	2	4	15
Total	Over	58	20	121	26	9	45	15	13	22	344
	Total	207	254	478	196	144	296	184	245	263	2267
	%	28	8	25	13	6	15	8	5	8	15

Table C.4: Site exceedances of chlorophyll a over 11 µg/L per site per Florida Surface Water Regulations

*	All			Dry Season			Rainy Season		
	Under	Total	%	Under	Total	%	Under	Total	%
LBFOR1	4	6	67	2	3	67	2	3	67
CHV005	15	32	47	9	20	45	6	12	50
CHV013	16	38	42	13	24	54	3	14	21
CHV001	25	62	40	13	37	35	12	25	48
LBV003	21	64	33	7	42	17	14	22	64
GSV005	9	28	32	6	20	30	3	8	38
CHV002	13	42	31	8	26	31	5	16	31
PIV002	19	69	28	5	42	12	14	27	52
CHV004	17	63	27	7	39	18	10	24	42
LBV002	18	66	27	6	40	15	12	26	46
PIJIM1	6	24	25	4	15	27	2	9	22
CHV009	16	66	24	10	39	26	6	27	22
LBV001	16	66	24	8	40	20	8	26	31
CHV006	14	63	22	9	40	23	5	23	22
CHV007	13	73	18	6	44	14	7	29	24
CHV003	8	45	18	4	27	15	4	18	22
PIV006	10	62	16	3	36	8	7	26	27
MPV002	9	70	13	3	43	7	6	27	22
LBV005	7	56	13	2	35	6	5	21	24
PIV007	6	47	13	4	28	14	2	19	11
LBGOT2	1	8	13	1	4	25	0	4	0
CHV012	6	49	12	2	29	7	4	20	20
EBV005	8	66	12	5	41	12	3	25	12
LBV006	6	52	12	4	33	12	2	19	11
EBERS2	4	36	11	4	23	17	0	13	0
PIV004	4	46	9	2	28	7	2	18	11
CHV010	6	68	9	2	41	5	4	27	15
CHV011	6	64	9	4	38	11	2	26	8
EBV007	3	32	9	3	20	15	0	12	0
EBV003	4	46	9	2	25	8	2	21	10
LBV004	6	70	9	3	44	7	3	26	12
MPV001	5	63	8	0	39	0	5	24	21
MPV003	4	54	7	2	34	6	2	20	10
GSV004	1	15	7	1	8	13	0	7	0
MPV004	4	64	6	1	39	3	3	25	12
SCV001	4	64	6	2	40	5	2	24	8
CHV008	3	66	5	1	40	3	2	26	8
EBV006	1	19	5	1	14	7	0	5	0
GSV003	1	20	5	0	14	0	1	6	17
EBV001	3	67	4	2	41	5	1	26	4
PIV001	2	53	4	2	34	6	0	19	0
SCV002	2	54	4	1	35	0	1	19	0
GSV002	2	57	4	2	34	6	0	23	0
GSV001	2	61	3	1	37	3	1	24	4
EBV004	2	67	3	2	42	5	0	25	0
LBANG1	0	7	0	0	3	0	0	4	0
LBOYS1	0	8	0	0	4	0	0	4	0
LBV007	0	8	0	0	4	0	0	4	0
Total	352	2326	15%	179	1428	13%	173	898	19%

*ranked in descending order by total % exceedances

Table C.5: Site specific exceedances of fecal coliform bacteria per Florida Surface Water Regulations

		Coliform > 200 cfu/100mL			Coliform > 400 cfu/100mL			Coliform > 800 cfu/100mL		
		# over	N	%	# over	N	%	# over	N	%
Upper Lemon Bay	LBV001*	31	80	39%	12	80	15%	3	80	4%
	LBV002	3	80	4%						
	LBV003	2	78	3%	1	78	1%			
Lower Lemon Bay	LBOYS1	1	8	13%						
	LBV004	1	79	1%						
	LBV006	9	63	14%	4	63	6%			
Upper Charlotte Harbor	CHV001	2	76	3%						
	CHV003	3	57	5%						
	CHV004	2	77	3%						
	CHV005	4	34	12%	1	34	3%			
	CHV007	1	87	1%						
	CHV008	5	82	6%	3	82	4%			
	CHV013	3	52	6%	2	52	4%			
Lower Charlotte Harbor	CHV011	1	74	1%						
Gasparilla/Cape Haze	GSV001	1	72	1%						
	GSV004	1	16	6%						
Pine Island Sound	PIJIM1	2	34	6%						
	PIV001	1	66	2%						
	PIV006	1	76	1%						
San Carlos Bay	EBV001	1	81	1%						
	MPV004	1	81	1%						
Estero Bay	EBERS2	9	49	18%	4	49	8%			
	EBV005	4	83	5%						
	GSV005*	14	37	38%	8	37	22%	2	37	5%
	Total	103	2839	4%	35	2839	1%	5	2839	< 1%

*greater than 10% of samples exceeding 400 cfu/100mL

Appendix D: Water Quality Relationships

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Table D.1: Spearman's rho correlation for selected variables for the entire study region and duration

		Secchi	DO	Salinity	TN	TP	ChlA	Coliform	Turbidity	Color
Secchi	Coefficient		0.300	0.344	-0.375	-0.505	-0.349	-0.340	-0.343	-0.451
	p (2-tailed)		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	N	1903	1858	1879	1295	1368	1270	1575	1497	1497
DO	Coefficient	0.300		0.100	-0.196	-0.170	-0.177	-0.282	0.027	-0.260
	p (2-tailed)	0.000		0.000	0.000	0.000	0.000	0.000	0.165	0.000
	N	1858	3374	3329	2334	2477	2249	2768	2652	2652
Salinity	Coefficient	0.344	0.100		-0.370	-0.445	-0.233	-0.336	0.198	-0.711
	p (2-tailed)	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000
	N	1879	3329	3404	2354	2495	2270	2792	2675	2675
TN	Coefficient	-0.375	-0.196	-0.370		0.355	0.227	0.263	0.197	0.514
	p (2-tailed)	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
	N	1295	2334	2354	2402	2320	1908	2366	2281	2280
TP	Coefficient	-0.505	-0.170	-0.445	0.355		0.281	0.341	0.095	0.484
	p (2-tailed)	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000
	N	1368	2477	2495	2320	2540	2020	2508	2406	2406
ChlA	Coefficient	-0.349	-0.177	-0.233	0.227	0.281		0.089	0.187	0.323
	p (2-tailed)	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000
	N	1270	2249	2270	1908	2010	2310	2273	2170	2170
Coliform	Coefficient	-0.340	-0.282	-0.336	0.263	0.341	0.089		0.043	0.312
	p (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000		0.026	0.000
	N	1575	2768	2792	2366	2508	2273	2839	2674	2674
Turbidity	Coefficient	-0.343	0.027	0.198	0.197	0.095	0.187	0.043		0.041
	p (2-tailed)	0.000	0.170	0.000	0.000	0.000	0.000	0.026		0.033
	N	1497	2652	2675	2281	2406	2170	2674	2720	2719
Color	Coefficient	-0.451	-0.260	-0.711	0.514	0.484	0.323	0.312	0.041	
	p (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.033	
	N	1497	2652	2675	2280	2406	2170	2674	2719	2721

Bold values significant at the 0.05 level

Table D.2: Spearman's rho correlation for selected variables in the dry versus the rainy season for the entire study region

		Rainy season								
		Secchi	DO	Salinity	TN	TP	ChlA	Coliform	Turbidity	Color
Dry Season	Secchi	Coefficient	0.322	0.479	-0.421	-0.585	-0.305	-0.400	-0.218	-0.585
		p (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		N	978	904	913	611	649	597	757	703
	DO	Coefficient	0.219	0.129	-0.220	-0.247	0.020	-0.431	0.021	-0.217
		p (2-tailed)	0.000	0.000	0.000	0.000	0.552	0.000	0.488	0.000
		N	954	2000	1358	926	983	870	1124	1052
	Salinity	Coefficient	0.164	-0.041	-0.367	-0.489	-0.134	-0.403	0.183	-0.722
		p (2-tailed)	0.000	0.072	0.000	0.000	0.000	0.000	0.000	0.000
		N	966	1971	2014	937	990	882	1136	1064
	TN	Coefficient	-0.262	-0.042	-0.319	0.368	0.254	0.282	0.201	0.550
		p (2-tailed)	0.000	0.112	0.000	0.000	0.000	0.000	0.000	0.000
		N	684	1408	1417	1446	911	713	938	869
	TP	Coefficient	-0.408	-0.100	-0.412	0.339	0.241	0.395	0.142	0.560
		p (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		N	719	1494	1505	1409	1531	759	995	936
	ChlA	Coefficient	-0.327	-0.124	-0.226	0.104	0.302	0.101	0.230	0.136
		p (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000
		N	673	1379	1388	1195	1251	1412	881	818
	Coliform	Coefficient	-0.265	-0.248	-0.316	0.263	0.306	0.085	0.098	0.439
		p (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000
		N	818	1644	1656	1428	1513	1392	1683	1059
	Turbidity	Coefficient	-0.481	0.000	0.204	0.213	0.067	0.187	0.008	0.068
		p (2-tailed)	0.000	0.991	0.000	0.000	0.010	0.000	0.759	0.025
		N	794	1600	1611	1412	1470	1384	1615	1638
	Color	Coefficient	-0.272	-0.083	-0.696	0.430	0.430	0.337	0.271	0.033
		p (2-tailed)	0.000	0.001	0.000	0.000	0.000	0.000	0.181	
		N	794	1600	1611	1412	1470	1352	1615	1638

Bold values significant at the 0.05 level

Table D.3: Spearman's rho correlation for selected variables in Upper Lemon Bay

		Secchi	DO	Salinity	TN	TP	Chl a	Coliform	Turbidity	Color
Secchi	Coefficient		0.1794	0.0891	-0.1403	-0.1708	-0.2634	-0.0053	-0.2528	-0.1304
	p (2-tailed)		0.0241	0.2658	0.2004	0.1226	0.0215	0.9594	0.0175	0.2287
	N	161	158	158	85	83	76	96	88	87
DO	Coefficient	0.1794		0.2109	-0.2522	-0.3575	-0.1140	-0.2121	-0.0160	-0.3463
	p (2-tailed)	0.0241		0.0000	0.0002	0.0000	0.1040	0.0007	0.8060	0.0000
	N	158	373	369	216	225	206	250	237	236
Salinity	Coefficient	0.0891	0.2109		-0.3894	-0.3615	-0.0650	-0.5709	0.1350	-0.6865
	p (2-tailed)	0.2658	0.0000		0.0000	0.0000	0.3540	0.0000	0.0360	0.0000
	N	158	369	376	218	227	208	251	239	238
TN	Coefficient	-0.1403	-0.2522	-0.3894		0.4211	0.2470	0.2661	0.2970	0.5788
	p (2-tailed)	0.2004	0.0002	0.0000		0.0000	0.0010	0.0001	0.0000	0.0000
	N	85	216	218	219	212	177	215	206	205
TP	Coefficient	-0.1708	-0.3575	-0.3615	0.4211		0.1270	0.2894	0.1480	0.4892
	p (2-tailed)	0.1226	0.0000	0.0000	0.0000		0.0870	0.0000	0.0310	0.0000
	N	83	225	227	212	228	183	224	213	213
Chl a	Coefficient	-0.2634	-0.1140	-0.0650	0.2470	0.1270		0.0720	0.3880	0.1400
	p (2-tailed)	0.0215	0.1040	0.3520	0.0010	0.0870		0.3030	0.0000	0.0530
	N	76	206	208	177	183	209	204	193	192
Coliform	Coefficient	-0.0053	-0.2121	-0.5709	0.2661	0.2894	0.0720		0.0480	0.4395
	p (2-tailed)	0.9594	0.0007	0.0000	0.0001	0.0000	0.3030		0.4590	0.0000
	N	96	250	251	215	224	204	252	236	235
Turbidity	Coefficient	-0.2528	-0.0160	0.1350	0.2970	0.1480	0.3880	0.0480		0.2200
	p (2-tailed)	0.0175	0.8060	0.0360	0.0000	0.0310	0.0000	0.4590		0.0010
	N	88	237	239	206	213	193	236	240	239
Color	Coefficient	-0.1304	-0.3463	-0.6865	0.5788	0.4892	0.1400	0.4395	0.2200	
	p (2-tailed)	0.2287	0.0000	0.0000	0.0000	0.0000	0.0530	0.0000	0.0010	
	N	87	236	238	205	213	192	235	239	239

Bold values significant at the 0.05 level

Table D.4: Spearman's rho correlation for selected variables in Lower Lemon Bay

		Secchi	DO	Salinity	TN	TP	Chl a	Coliform	Turbidity	Color
Secchi	Coefficient		0.2380	0.1317	-0.2108	-0.2463	-0.2710	-0.2163	-0.3913	-0.2351
	p (2-tailed)		0.0003	0.0481	0.0220	0.0067	0.0030	0.0103	0.0000	0.0062
	N	230	224	226	118	120	118	140	134	134
DO	Coefficient	0.2380		0.2010	-0.2328	-0.2072	-0.2230	-0.4253	0.1029	-0.4576
	p (2-tailed)	0.0003		0.0000	0.0002	0.0007	0.0000	0.0000	0.0834	0.0000
	N	224	515	508	256	267	245	291	284	284
Salinity	Coefficient	0.1317	0.2010		-0.2180	-0.3063	-0.2360	-0.3316	0.1848	-0.4521
	p (2-tailed)	0.0481	0.0000		0.0004	0.0000	0.0000	0.0000	0.0016	0.0000
	N	226	508	518	260	270	249	297	290	290
TN	Coefficient	-0.2108	-0.2328	-0.2180		0.3052	0.2740	0.2615	0.0767	0.5015
	p (2-tailed)	0.0220	0.0002	0.0004		0.0000	0.0000	0.0000	0.2234	0.0000
	N	118	256	260	265	257	217	259	254	254
TP	Coefficient	-0.2463	-0.2072	-0.3063	0.3052		0.2550	0.3244	0.1974	0.3759
	p (2-tailed)	0.0067	0.0007	0.0000	0.0000		0.0000	0.0000	0.0013	0.0000
	N	120	267	270	257	275	223	267	263	263
Chl a	Coefficient	-0.2710	-0.2230	-0.2360	0.2740	0.2550		0.1910	0.1410	0.4180
	p (2-tailed)	0.0030	0.0000	0.0000	0.0000	0.0000		0.0030	0.0300	0.0000
	N	118	245	249	217	223	255	247	240	240
Coliform	Coefficient	-0.2163	-0.4253	-0.3316	0.2615	0.3244	0.1910		0.0455	0.3982
	p (2-tailed)	0.0103	0.0000	0.0000	0.0000	0.0000	0.0030		0.4433	0.0000
	N	140	291	297	259	267	247	302	286	286
Turbidity	Coefficient	-0.3913	0.1029	0.1848	0.0767	0.1974	0.1410	0.0455		-0.0121
	p (2-tailed)	0.0000	0.0834	0.0016	0.2234	0.0013	0.0300	0.4433		0.8355
	N	134	284	290	254	263	244	286	296	296
Color	Coefficient	-0.2351	-0.4576	-0.4521	0.5015	0.3759	0.4180	0.3982	-0.0121	
	p (2-tailed)	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.8355	
	N	134	284	290	254	263	240	286	296	296

Bold values significant at the 0.05 level

Table D.5: Spearman's correlation for selected variables in Upper Charlotte Harbor

		Secchi	DO	Salinity	TN	TP	Chl a	Coliform	Turbidity	Color
Secchi	Coefficient		0.1742	0.5457	-0.4034	-0.4700	-0.0258	-0.2263	-0.2544	-0.5517
	p (2-tailed)		0.0006	0.0000	0.0000	0.0000	0.6653	0.0000	0.0000	0.0000
	N	394	387	387	291	305	283	336	315	315
DO	Coefficient	0.1742		0.1667	-0.1395	-0.1219	0.0360	-0.0690	0.0925	-0.2799
	p (2-tailed)	0.0006		0.0000	0.0019	0.0053	0.4318	0.0977	0.0307	0.0000
	N	387	650	638	494	522	479	577	546	546
Salinity	Coefficient	0.5457	0.1667		-0.4394	-0.5787	-0.2954	-0.2179	-0.0606	-0.7445
	p (2-tailed)	0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.1585	0.0000
	N	387	638	649	491	519	479	575	543	543
TN	Coefficient	-0.4034	-0.1395	-0.4394		0.4150	0.2349	0.1396	0.3917	0.5741
	p (2-tailed)	0.0000	0.0019	0.0000		0.0000	0.0000	0.0018	0.0000	0.0000
	N	291	494	491	505	484	419	500	476	476
TP	Coefficient	-0.4700	-0.1219	-0.5787	0.4150		0.3602	0.0906	0.3163	0.5686
	p (2-tailed)	0.0000	0.0053	0.0000	0.0000		0.0000	0.0378	0.0000	0.0000
	N	305	522	519	484	532	436	526	504	504
Chl a	Coefficient	-0.0258	0.0360	-0.2954	0.2349	0.3602		-0.0205	0.3724	0.2433
	p (2-tailed)	0.6653	0.4318	0.0000	0.0000	0.0000		0.6529	0.0000	0.0000
	N	283	479	479	419	436	489	485	453	453
Coliform	Coefficient	-0.2263	-0.0690	-0.2179	0.1396	0.0906	-0.0205		0.0294	0.0723
	p (2-tailed)	0.0000	0.0977	0.0000	0.0018	0.0378	0.6529		0.4929	0.0907
	N	336	577	575	500	526	485	587	548	548
Turbidity	Coefficient	-0.2544	0.0925	-0.0606	0.3917	0.3163	0.3724	0.0294		0.2101
	p (2-tailed)	0.0000	0.0307	0.1585	0.0000	0.0000	0.0000	0.4929		0.0000
	N	315	546	543	476	504	453	548	556	556
Color	Coefficient	-0.5517	-0.2799	-0.7445	0.5741	0.5686	0.2433	0.0723	0.2101	
	p (2-tailed)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0907	0.0000	
	N	315	546	543	476	504	453	548	556	557

Bold values significant at the 0.05 level

Table D.6: Spearman's rho correlation for selected variables in Lower Charlotte Harbor

		Secchi	DO	Salinity	TN	TP	Chl a	Coliform	Turbidity	Color
Secchi	Coefficient		0.4226	0.5633	-0.3260	-0.3642	-0.5760	-0.5032	-0.2659	-0.5814
	p (2-tailed)		0.0000	0.0000	0.0028	0.0007	0.0000	0.0000	0.0104	0.0000
	N	105	101	102	81	83	79	96	92	92
DO	Coefficient	0.4226		-0.0467	-0.3340	-0.0830	-0.2140	-0.2384	-0.1348	-0.1889
	p (2-tailed)	0.0000		0.4694	0.0000	0.2285	0.0030	0.0003	0.0452	0.0048
	N	101	247	242	202	212	193	229	221	221
Salinity	Coefficient	0.5633	-0.0467		-0.3290	-0.4297	-0.2560	-0.1188	0.1900	-0.7352
	p (2-tailed)	0.0000	0.4694		0.0000	0.0000	0.0000	0.0734	0.0047	0.0000
	N	102	242	248	201	209	192	228	220	220
TN	Coefficient	-0.3260	-0.3340	-0.3290		0.2520	0.2220	0.2960	0.1790	0.4372
	p (2-tailed)	0.0028	0.0000	0.0000		0.0000	0.0000	0.0000	0.0120	0.0000
	N	81	202	201	207	200	170	201	195	195
TP	Coefficient	-0.3642	-0.0830	-0.4297	0.2520		0.2330	0.1014	-0.0223	0.5099
	p (2-tailed)	0.0007	0.2285	0.0000	0.0000		0.0020	0.1420	0.7512	0.0000
	N	83	212	209	200	215	176	211	204	204
Chl a	Coefficient	-0.5756	-0.1948	-0.2297	0.2220	0.2222		0.1528	0.2697	0.3337
	p (2-tailed)	0.0000	0.0064	0.0013	0.0040	0.0029		0.0330	0.0002	0.0000
	N	79	195	194	170	178	198	195	187	187
Coliform	Coefficient	-0.5032	-0.2384	-0.1188	0.2960	0.1014	0.1240		0.1753	0.1667
	p (2-tailed)	0.0000	0.0003	0.0734	0.0000	0.1420	0.0850		0.0092	0.0133
	N	96	229	228	201	211	193	234	220	220
Turbidity	Coefficient	-0.2659	-0.1348	0.1900	0.1790	-0.0223	0.2020	0.1753		0.0435
	p (2-tailed)	0.0104	0.0452	0.0047	0.0120	0.7512	0.0060	0.0092		0.5154
	N	92	221	220	195	204	185	220	226	226
Color	Coefficient	-0.5814	-0.1889	-0.7352	0.4372	0.5099	0.3980	0.1667	0.0435	
	p (2-tailed)	0.0000	0.0048	0.0000	0.0000	0.0000	0.0000	0.0133	0.5154	
	N	92	221	220	195	204	185	220	226	226

Bold values significant at the 0.05 level

Table D.7: Spearman's rho correlation for selected variables in Gasparilla/Cape Haze

		Secchi	DO	Salinity	TN	TP	Chl a	Coliform	Turbidity	Color
Secchi	Coefficient		0.1842	0.0355	-0.2860	-0.1644	-0.1760	0.0837	0.2325	-0.1934
	p (2-tailed)		0.0998	0.7455	0.0270	0.1941	0.1480	0.4722	0.0462	0.0988
	N	86	81	86	60	64	69	76	74	74
DO	Coefficient	0.1842		-0.1229	-0.0960	0.1414	0.0510	-0.2269	0.0198	-0.2226
	p (2-tailed)	0.0998		0.0957	0.2680	0.0910	0.5500	0.0036	0.8066	0.0052
	N	81	188	185	134	144	140	163	156	156
Salinity	Coefficient	0.0355	-0.1229		-0.1531	-0.4247	-0.2080	-0.0005	0.3341	-0.5491
	p (2-tailed)	0.7455	0.0957		0.0752	0.0000	0.0130	0.9953	0.0000	0.0000
	N	86	185	192	136	147	143	166	159	159
TN	Coefficient	-0.2860	-0.0960	-0.1531		0.2062	-0.0300	-0.0430	-0.0640	0.3240
	p (2-tailed)	0.0270	0.2680	0.0752		0.0157	0.7480	0.6170	0.4710	0.0000
	N	60	134	136	141	137	117	136	131	131
TP	Coefficient	-0.1644	0.1414	-0.4247	0.2062		0.2120	-0.1839	0.0245	0.3418
	p (2-tailed)	0.1941	0.0910	0.0000	0.0157		0.0180	0.0257	0.7723	0.0000
	N	64	144	147	137	150	124	147	142	142
Chl a	Coefficient	-0.1760	0.0510	-0.2080	-0.0300	0.2120		-0.1030	0.1800	0.2230
	p (2-tailed)	0.1480	0.5500	0.0130	0.7480	0.0180		0.2240	0.0360	0.0090
	N	69	140	143	117	124	145	142	136	137
Coliform	Coefficient	0.0837	-0.2269	-0.0005	-0.0430	-0.1839	-0.1030		-0.0545	0.0498
	p (2-tailed)	0.4722	0.0036	0.9953	0.6170	0.0257	0.2240		0.4978	0.5358
	N	76	163	166	136	147	142	169	157	157
Turbidity	Coefficient	-0.2325	0.0198	0.3341	-0.0640	0.0245	0.1800	-0.0545		-0.0451
	p (2-tailed)	0.0462	0.8066	0.0000	0.4710	0.7723	0.0360	0.4978		0.5685
	N	74	156	159	131	142	136	157	162	162
Color	Coefficient	-0.1934	-0.2226	-0.5491	0.3240	0.3418	0.2230	0.0498	-0.0451	
	p (2-tailed)	0.0988	0.0052	0.0000	0.0000	0.0000	0.0090	0.5358	0.5685	
	N	74	156	159	131	142	136	157	162	162

Bold values significant at the 0.05 level

Table D.8: Spearman's rho correlation for selected variables in Pine Island Sound

		Secchi	DO	Salinity	TN	TP	Chl a	Coliform	Turbidity	Color
Secchi	Coefficient		0.1479	0.0432	-0.1887	-0.3218	-0.2870	-0.0022	-0.5720	-0.1609
	p (2-tailed)		0.0587	0.5794	0.0425	0.0002	0.0010	0.9780	0.0000	0.0469
	N	167	164	167	116	126	121	160	152	153
DO	Coefficient	0.1479		0.0151	-0.1717	-0.1762	-0.4020	-0.1943	0.1488	-0.3338
	p (2-tailed)	0.0587		0.7668	0.0031	0.0016	0.0000	0.0002	0.0048	0.0000
	N	164	392	390	294	317	291	368	357	358
Salinity	Coefficient	0.0432	0.0151		-0.2228	-0.1254	-0.2190	-0.0310	0.2771	-0.4968
	p (2-tailed)	0.5794	0.7668		0.0001	0.0240	0.0000	0.5498	0.0000	0.0000
	N	167	390	399	301	324	293	375	364	365
TN	Coefficient	-0.1887	-0.1717	-0.2228		0.2459	0.1780	0.2077	0.1911	0.4128
	p (2-tailed)	0.0425	0.0031	0.0001		0.0000	0.0070	0.0002	0.0010	0.0000
	N	116	294	301	309	299	232	307	295	295
TP	Coefficient	-0.3218	-0.1762	-0.1254	0.2459		0.1520	0.2394	0.1608	0.3560
	p (2-tailed)	0.0002	0.0016	0.0240	0.0000		0.0160	0.0000	0.0043	0.0000
	N	126	317	324	299	330	250	329	313	313
Chl a	Coefficient	-0.2870	-0.4020	-0.2190	0.1780	0.1520		-0.0480	0.2040	0.3590
	p (2-tailed)	0.0010	0.0000	0.0000	0.0070	0.0160		0.4150	0.0010	0.0000
	N	121	291	293	232	250	298	295	283	284
Coliform	Coefficient	-0.0022	-0.1943	-0.0310	0.2077	0.2394	-0.0480		0.0215	0.1160
	p (2-tailed)	0.9780	0.0002	0.5498	0.0002	0.0000	0.4150		0.6824	0.0266
	N	160	368	375	307	329	295	383	364	365
Turbidity	Coefficient	-0.5720	0.1488	0.2771	0.1911	0.1608	0.2040	0.0215		-0.0581
	p (2-tailed)	0.0000	0.0048	0.0000	0.0010	0.0043	0.0010	0.6824		0.2667
	N	152	357	364	295	313	283	364	368	368
Color	Coefficient	-0.1609	-0.3338	-0.4968	0.4128	0.3560	0.3590	0.1160	-0.0581	
	p (2-tailed)	0.0469	0.0000	0.0000	0.0000	0.0000	0.0000	0.0266	0.2667	
	N	153	358	365	295	313	284	365	368	369

Bold values significant at the 0.05 level

Table D.9: Spearman's rho correlation for selected variables in Matlacha Pass

		Secchi	DO	Salinity	TN	TP	Chl a	Coliform	Turbidity	Color
Secchi	Coefficient		0.2769	0.5274	-0.3613	-0.3855	-0.3210	0.0323	-0.4121	-0.5237
	p (2-tailed)		0.0001	0.0000	0.0000	0.0000	0.0000	0.6665	0.0000	0.0000
	N	202	195	199	147	160	141	180	171	171
DO	Coefficient	0.2769		0.0670	-0.0883	-0.2256	-0.2500	-0.1036	-0.3778	-0.1723
	p (2-tailed)	0.0001		0.2921	0.2295	0.0012	0.0010	0.1203	0.0000	0.0116
	N	195	252	249	187	203	179	226	214	214
Salinity	Coefficient	0.5274	0.0670		-0.3255	-0.2146	-0.3050	-0.0792	-0.1227	-0.7282
	p (2-tailed)	0.0000	0.2921		0.0000	0.0019	0.0000	0.2317	0.0712	0.0000
	N	199	249	258	192	208	183	230	217	217
TN	Coefficient	-0.3613	-0.0883	-0.3255		0.2701	0.0680	0.2605	0.4056	0.5094
	p (2-tailed)	0.0000	0.2295	0.0000		0.0002	0.4100	0.0003	0.0000	0.0000
	N	147	187	192	194	187	149	191	184	184
TP	Coefficient	-0.3855	-0.2256	-0.2146	0.2701		0.0490	0.0704	0.2516	0.3566
	p (2-tailed)	0.0000	0.0012	0.0019	0.0002		0.5340	0.3111	0.0004	0.0000
	N	160	203	208	187	212	161	209	197	197
Chl a	Coefficient	-0.3210	-0.2500	-0.3050	0.0680	0.0490		-0.2020	0.2640	0.2170
	p (2-tailed)	0.0000	0.0010	0.0000	0.4100	0.5340		0.0060	0.0000	0.0040
	N	141	179	183	149	161	187	182	176	176
Coliform	Coefficient	0.0323	-0.1036	-0.0792	0.2605	0.0704	-0.2020		0.1830	0.1561
	p (2-tailed)	0.6665	0.1203	0.2317	0.0003	0.3111	0.0060		0.0069	0.0215
	N	180	226	230	191	209	182	234	217	217
Turbidity	Coefficient	-0.4121	-0.3778	-0.1227	0.4056	0.2516	0.2640	0.1830		0.3932
	p (2-tailed)	0.0000	0.0000	0.0712	0.0000	0.0004	0.0000	0.0069		0.0000
	N	171	214	217	184	197	176	217	221	221
Color	Coefficient	-0.5237	-0.1723	-0.7282	0.5094	0.3566	0.2170	0.1561	0.3932	
	p (2-tailed)	0.0000	0.0116	0.0000	0.0000	0.0000	0.0040	0.0215	0.0000	
	N	171	214	217	184	197	176	217	221	221

Bold values significant at the 0.05 level

Table D.10: Spearman's rho correlation for selected variables in San Carlos Bay

		Secchi	DO	Salinity	TN	TP	Chl a	Coliform	Turbidity	Color
Secchi	Coefficient		0.2182	0.0361	-0.1929	-0.2389	-0.1680	-0.2603	-0.4491	-0.2170
	p (2-tailed)		0.0001	0.5162	0.0029	0.0001	0.0100	0.0000	0.0000	0.0002
	N	327	319	325	237	251	234	297	282	282
DO	Coefficient	0.2182		0.0146	-0.0906	-0.1990	-0.0580	-0.0799	-0.0783	-0.1640
	p (2-tailed)	0.0001		0.7917	0.1581	0.0013	0.3710	0.1670	0.1875	0.0055
	N	319	334	331	244	257	237	301	285	285
Salinity	Coefficient	0.0361	0.0146		-0.3314	-0.0186	-0.1040	-0.0432	0.4109	-0.6108
	p (2-tailed)	0.5162	0.7917		0.0000	0.7661	0.1080	0.4515	0.0000	0.0000
	N	325	331	339	246	259	242	306	290	290
TN	Coefficient	-0.1929	-0.0906	-0.3314		0.2252	0.0440	0.1549	0.2260	0.4702
	p (2-tailed)	0.0029	0.1581	0.0000		0.0005	0.5480	0.0146	0.0004	0.0000
	N	237	244	246	249	237	191	248	240	240
TP	Coefficient	-0.2389	-0.1990	-0.0186	0.2252		-0.0890	0.1266	0.1769	0.1278
	p (2-tailed)	0.0001	0.0013	0.7661	0.0005		0.2090	0.0406	0.0052	0.0444
	N	251	257	259	237	263	202	262	248	248
Chl a	Coefficient	-0.1680	-0.5800	-0.1040	0.0440	-0.0890		0.0690	0.0310	0.2740
	p (2-tailed)	0.0100	0.3710	0.1080	0.5480	0.2090		0.2840	0.6430	0.0000
	N	234	237	242	191	202	245	243	231	231
Coliform	Coefficient	-0.2603	-0.0799	-0.0432	0.1549	0.1266	0.0690		0.1744	0.1168
	p (2-tailed)	0.0000	0.1670	0.4515	0.0146	0.0406	0.2840		0.0028	0.0462
	N	297	301	306	248	262	243	310	292	292
Turbidity	Coefficient	-0.4491	-0.0783	0.4109	0.2260	0.1769	0.0310	0.1744		-0.0128
	p (2-tailed)	0.0000	0.1875	0.0000	0.0004	0.0052	0.6430	0.0028		0.8275
	N	282	285	290	240	248	231	292	294	294
Color	Coefficient	-0.2170	-0.1640	-0.6108	0.4702	0.1278	0.2740	0.1168	-0.0128	
	p (2-tailed)	0.0002	0.0055	0.0000	0.0000	0.0444	0.0000	0.0462	0.8275	
	N	282	285	290	240	248	231	292	294	294

Bold values significant at the 0.05 level

Table D.11: Spearman's rho correlation for selected variables in Estero Bay

		Secchi	DO	Salinity	TN	TP	Chl a	Coliform	Turbidity	Color
Secchi	Coefficient		-0.0978	-0.3888	-0.0133	-0.3604	-0.2570	0.4268	-0.6045	0.1251
	p (2-tailed)		0.1953	0.0000	0.8799	0.0000	0.0030	0.0000	0.0000	0.1162
	N	177	177	176	131	146	130	165	159	159
DO	Coefficient	-0.0978		0.0793	-0.1539	0.0372	-0.2290	-0.0639	0.2583	-0.2236
	p (2-tailed)	0.1953		0.1382	0.0113	0.5265	0.0000	0.2497	0.0000	0.0001
	N	177	356	351	270	292	258	326	314	314
Salinity	Coefficient	-0.3888	0.0793		-0.2331	0.2954	-0.0220	-0.4179	0.4613	-0.6134
	p (2-tailed)	0.0000	0.1382		0.0001	0.0000	0.7260	0.0000	0.0000	0.0000
	N	176	351	357	272	294	260	327	315	315
TN	Coefficient	-0.0133	-0.1539	-0.2331		0.1748	0.1400	0.1974	0.1216	0.4567
	p (2-tailed)	0.8799	0.0113	0.0001		0.0040	0.0390	0.0010	0.0488	0.0000
	N	131	270	272	276	270	216	273	263	263
TP	Coefficient	-0.3604	0.0372	0.2954	0.1748		0.0900	-0.0386	0.4315	-0.0650
	p (2-tailed)	0.0000	0.5265	0.0000	0.0040		0.1690	0.5078	0.0000	0.2749
	N	146	292	294	270	297	234	296	284	284
Chl a	Coefficient	-0.2570	-0.2290	-0.0220	0.1400	0.0900		-0.0770	0.1240	0.0410
	p (2-tailed)	0.0030	0.0000	0.7260	0.0390	0.1690		0.2120	0.0490	0.5130
	N	130	258	260	216	234	263	262	252	252
Coliform	Coefficient	0.4268	-0.0639	-0.4179	0.1974	-0.0386	-0.0770		-0.1772	0.2752
	p (2-tailed)	0.0000	0.2497	0.0000	0.0010	0.5078	0.2120		0.0015	0.0000
	N	165	326	327	273	296	262	331	317	317
Turbidity	Coefficient	-0.6045	0.2583	0.4613	0.1216	0.4315	0.1240	-0.1772		-0.1084
	p (2-tailed)	0.0000	0.0000	0.0000	0.0488	0.0000	0.0490	0.0015		0.0530
	N	159	314	315	263	284	252	317	319	319
Color	Coefficient	0.1251	-0.2236	-0.6134	0.4567	-0.0650	0.0410	0.2752	-0.1084	
	p (2-tailed)	0.1162	0.0001	0.0000	0.0000	0.2749	0.5130	0.0000	0.0530	
	N	159	314	315	263	284	252	317	319	319

Bold values significant at the 0.05 level

Appendix E: Rainfall Relationships

	Page
Table E.1: Spearman's rho correlation for selected variables for the entire study region and duration_____	LVIII

Table E.1: Spearman's rho correlation for rainfall for the entire region and individual regions for the duration of the study

		Secchi	pH	Salinity	TN	TP	Chl a	Coliform	Turbidity	Color
Entire Region	Coefficient	-0.038	-0.911	-0.858	-0.116	0.493	0.276	0.182	-64.000	0.588
	p (2-tailed)	0.929	0.002	0.006	0.785	0.214	0.549	0.665	0.087	0.125
	N	8	8	8	8	8	7	8	8	8
Lower Lemon Bay	Coefficient	0.221	-0.228	-0.717	-0.506	0.079	-0.236	-0.172	-0.533	0.242
	p (2-tailed)	0.598	0.587	0.045	0.200	0.853	0.610	0.683	0.174	0.564
	N	8	8	8	8	8	7	8	8	8
Upper Lemon Bay	Coefficient	-0.072	-0.634	-0.861	0.190	0.406	0.272	0.084	0.146	0.413
	p (2-tailed)	0.865	0.092	0.006	0.965	0.318	0.555	0.844	0.731	0.310
	N	8	8	8	8	8	7	8	8	8
Lower Charlotte Harbor*	Coefficient	-0.383	-0.749	-0.769	-0.427	0.689	0.540	-0.211	-0.589	0.624
	p (2-tailed)	0.349	0.032	0.026	0.292	0.059	0.211	0.615	0.125	0.098
	N	8	8	8	8	8	7	8	8	8
Upper Charlotte Harbor*	Coefficient	-0.217	-0.575	-0.719	-0.089	0.878	0.249	-0.075	-0.217	0.509
	p (2-tailed)	0.605	0.136	0.044	0.834	0.004	0.591	0.860	0.606	0.198
	N	8	8	8	8	8	7	8	8	8
Gasparilla/Cape Haze*	Coefficient	-0.041	-0.728	-0.902	0.139	0.557	0.131	0.260	-0.697	0.668
	p (2-tailed)	0.924	0.041	0.002	0.742	0.151	0.780	0.534	0.055	0.070
	N	8	8	8	8	8	7	8	8	8
Pine Island Sound**	Coefficient	0.222	-0.838	-0.909	0.084	0.390	0.123	0.203	-0.655	0.801
	p (2-tailed)	0.598	0.009	0.002	0.844	0.340	0.793	0.629	0.078	0.017
	N	8	8	8	8	8	7	8	8	8
Matlacha Pass**	Coefficient	-0.417	-0.139	-0.762	-0.270	0.299	0.181	-0.467	-0.281	0.709
	p (2-tailed)	0.304	0.743	0.028	0.518	0.472	0.697	0.244	0.500	0.049
	N	8	8	8	8	8	7	8	8	8
San Carlos Bay***	Coefficient	-0.134	-0.797	-0.822	-0.034	0.008	0.375	0.121	-0.163	0.693
	p (2-tailed)	0.751	0.018	0.012	0.937	0.984	0.408	0.775	0.700	0.057
	N	8	8	8	8	8	7	8	8	8
Estero Bay	Coefficient	0.188	-0.366	-0.428	-0.055	-0.644	0.328	0.093	-0.385	0.139
	p (2-tailed)	0.655	0.372	0.291	0.898	0.085	0.472	0.826	0.347	0.742
	N	8	8	8	8	8	7	8	8	8

* Average annual rainfall for Charlotte Harbor + Myakka + Peace

** Average annual rainfall for Charlotte Harbor + Tidal Caloosahatchee

*** Average annual rainfall for Tidal Caloosahatchee

Bold values significant at the 0.05 level