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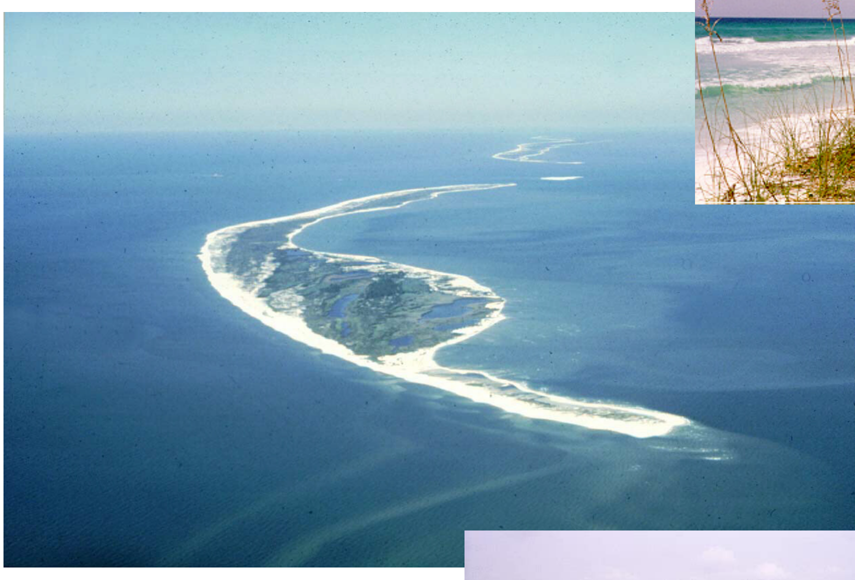
Technical Report NPS/NRWRD/NRTR-2005/330

ASSESSMENT OF COASTAL WATER RESOURCES AND WATERSHED CONDITIONS AT GULF ISLANDS NATIONAL SEASHORE (FLORIDA AND MISSISSIPPI)

Sarah M. Anderson, Armin Feldmen, Andrew James,
Christine Katin, and William R. Wise



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Assessment of Coastal Water Resources and Watershed Conditions at Gulf Islands National Seashore (Florida and Mississippi)

Sarah M. Anderson, Armin Feldmen, Andrew James,
Christine Katin, and William R. Wise

Department of Environmental Engineering Sciences
University of Florida
Gainesville, FL

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WATER RESOURCES DIVISION

National Park Service - Department of the Interior
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Executive Summary

The U.S. Department of the Interior, National Park Service (USDOI/NPS) commissioned this report to determine the current condition and possible impairments of the water resources of Gulf Islands National Seashore (GUIS). Stated objectives of the project included: evaluating the current level of knowledge about the condition of the park's water resources; rendering a best possible judgment of the condition of the park's water resources; identifying any information gaps that hinder the assessment or limit determination of whether or not those waters are degraded or impaired; identifying water resource parameters that are degraded based on currently available information and indicate possible sources of degradation; and identifying studies necessary to: a) evaluate current condition of the park's coastal waterbodies and watersheds, or b) identify existing factors negatively impacting those resources, or c) quantify potential threats. The tasks required to develop this report included the collection and review of relevant existing data, information, and reports concerning the condition of the park's coastal waterbodies from USDOI/NPS, state, local, federal, and private sources.

GUIS extends 260 km (160 miles) from Cat Island in MS to the eastern tip of Santa Rosa Island in FL. Hydrology and water-related issues are of central importance because 80% of the park is submerged land. Land use in the contributing watersheds strongly influences the biology, chemistry, and ecology of the park. These land use patterns have contributed to problems such as pollutant loading in stormwater runoff, changes in groundwater recharge rates, oil and gas emissions from watercraft, atmospheric deposition of heavy metals, sewage effluent disposal, and loss of submerged aquatic vegetation due to degraded water quality. Currently, GUIS is utilized for recreational activities including camping, hiking, fishing, biking, swimming, boating, and birdwatching. Although GUIS-MS is largely uninhabited, increased urbanization near the FL section of the park has impacted water quality. The FL section of the park is accessible by various bridges connecting Santa Rosa Island to the mainland, while access to the MS section is limited to one passenger ferry that operates between Gulfport, MS, and Ship Island and private boats. Today, FL's Gulf Breeze peninsula is experiencing rapid urbanization. Most of the urban and commercial development is occurring on Santa Rosa Island and along U.S. Highway 98.

The water quality of the gulf is affected by river outflows, runoff from neighboring land, and the cycling of the Loop Current. The eastern shelf of the Gulf of Mexico (GOM) is influenced by the outflow of the Mississippi River. The Loop Current is a warm current that flows northward into the GOM through the Yucatan Channel then turns eastward before exiting through the Florida Straits. This current affects hydrology by producing numerous eddies, meanders, and intrusions.

The MS-AL shelf is characterized by fine sediments and suspended materials that originate in the Mississippi River outflow. The West FL shelf has little sediment input and is primarily composed of high-carbonate sands offshore and quartz sands nearshore. The impact of the Mississippi River outflow is rarely observed in FL, which possesses greater water clarity. Hypoxia is not common; however, low dissolved oxygen (DO) concentrations have been observed.

The Clean Water Act (CWA) requires states to develop a list of waters not supporting their designated uses or not meeting water quality standards. This list is termed the 303(d) list after the section of the CWA that addresses its completion. Water segments to the north of the park have been classified as impaired due to copper, lead, mercury, biological oxygen demand (BOD), DO, nutrients, turbidity, total suspended solids (TSS), coliforms, and color. A section of GUIS-FL located in Okaloosa County is listed as impaired for mercury levels in fish tissue and fecal coliforms based on the number of beach closures.

The majority of water quality data discussed in this report for GUIS-FL was retrieved from the Modernized USEPA STOrage and RETrieval (STORET) database. A 3.2-km (2-mile) buffer around the authorized boundary of GUIS was used to generate a bounding box based on latitude and longitude. The buffer zone size was based on that used for similar watershed studies such as the USDOI/NPS Horizon Water Quality Reports. To represent current water quality issues, data were retrieved from January 1, 1993 to June 30, 2004. Ten years of data were selected as the basis for this report because it is the time frame utilized for developing the planning list of potentially impaired waters. Data were downloaded from Modernized STORET, which includes all measurements after 1999 and a limited amount of earlier data that has been transferred. For this reason, most of the data prior to 1999 were not included in this assessment. Legacy STORET data were generally not included due to the data processing required to put the information in a format that would allow for use in a geographic information system (GIS). However, a limited amount of nutrient data from 1996-1999 was included in the analysis. The data were contributed by the Northwest FL Water Management District (NWFWMD), FL Fish and Wildlife Conservation Commission (FWCC), FL LAKEWATCH, FL Department of Environmental Protection (FDEP), FWCC Fish and Wildlife Research Institute, Division of Environmental Health (Bureau of Water Programs), and the Choctawhatchee Basin Alliance.

Water quality data for GUIS-MS were obtained from the MS Department of Environmental Quality (MDEQ). Data from the Coastal Streams and Pascagoula River Basins from January 1993 through August 2003 were utilized for the assessment. Additional data were collected as part of the USEPA Environmental Monitoring and Assessment Program (EMAP). EMAP routinely sampled stations located in MS Sound near the barrier islands of GUIS. The data collected from 1991-1994 for these stations are available at the USEPA EMAP website.

The amount of water quality data available for the waters within and surrounding GUIS allows general evaluations of the park's waters to be made. These data indicate that the estuarine waters are generally in a stressed and/or threatened condition. However, there are concerns regarding certain parameters, such as fecal coliforms and mercury which have recently led to segments being classified as impaired. In addition, sampling for specific parameters, such as nutrients, and adding new locations, especially in the upland ponds and marine waters, is required for further evaluation of these resources.

A fair amount of sampling has been conducted by multiple agencies in the estuarine waters, which is placed into the USEPA's Modernized STORET database or maintained in the MDEQ's database. The limitations of these data are the lack of recent nutrient data (possibly due to upload lag time), lack of contaminants and metals data, and differences in analytical procedures and sampling techniques. The nutrient data (GUIS-FL) included in this assessment was obtained from STORET; dating from 1999 through May 2003. There is a time lag associated with processing and uploading the data into the STORET database. Due to this delay, data from summer 2003 to the present were not available at the time of this report's publication.

There were a limited number of stations sampled within the study area established around GUIS-MS. Although the majority of the population is located near the MS coast, monitoring of the waters surrounding the barrier islands is recommended. If possible, nutrient parameters (total nitrogen, nitrite + nitrate, ammonia, total phosphorus, orthophosphorus) and chlorophyll *a* should be sampled quarterly. Certain government agencies, such as the MS DMR measure field parameters as part of their shellfish monitoring program, perhaps nutrient sampling could be added to their routine. There is a lack of metals and contaminants data available, especially within the park boundaries. Some of this information will be provided by the USEPA's National Coastal Assessment (NCA) program. At the program's completion in 2005, the data collected in MS waters will be analyzed and pollution sources identified. Preliminary results indicated that there were several areas of possible isolated water quality problems in the coastal waters of MS.

Twenty-four hour sampling should be considered to minimize the effects of the time of day on monitoring data, especially DO. The FDEP's Northwest District Office is developing a "real-time" water quality monitoring network within the Pensacola Bay watershed to fill in some of these inconsistencies. The results are presented online with water quality reports that are updated hourly. Twenty-four hour sampling is also recommended for stations in MS Sound, specifically near the Davis Bayou area. A 12-hour sampling cycle was conducted in the summer of 2004 for stations located along the shoreline; however, additional sampling is planned for summer 2005 to obtain data for a dry period.

Shoreline changes in the southeast have been studied extensively in recent years. Application of a coastal vulnerability index (CVI) to approximately 145 km (90 miles) of the seashore found that 24% was classified as having very high vulnerability due to sea-level rise, 18% as having high vulnerability, 36% as possessing moderate vulnerability, and 21% as possessing low vulnerability (Pendleton 2004). The calculated CVI values showed that GUIS-MS may be more vulnerable than GUIS-FL to predicted sea-level rise. The U.S. Geological Survey (USGS) plans to measure the changes in shoreline every 5 to 10 years along the GOM Coast.

Seagrass coverage should continue to be monitored and mapped within the park boundaries. It is recommended that aerial photographs continue to be taken at regular intervals, such as every five years, to identify newly affected areas, monitor seagrass recovery, and protect areas at risk for seagrass loss. If the proposed rule for personal watercraft use is approved, the impacts of these craft on seagrass beds should also be monitored as part of this effort.

An optical model has been developed that established threshold values for chlorophyll *a* and TSS based on water quality data. The model was not calibrated for the waterbodies surrounding GUIS, but it can be used as a general indicator of water quality concerns. Application of the model revealed that TSS levels at representative stations were approaching or exceeding the thresholds estimated for Santa Rosa Sound, Big Lagoon, and MS Sound. The presence of seagrasses in all of these systems indicates that the water quality has not degraded below the levels required for survival; however, these systems should be monitored as development of the surrounding land continues.

There is little information available concerning the nearshore marine waters of GUIS. The accumulation, abundance, and composition of marine debris were examined over a five-year period (1989-1993). Marine debris is not considered to be a major issue for GUIS, especially in comparison to some of the other parks located on the GOM, such as South Padre Island National Seashore.

Fecal coliforms are regularly measured as part of the FL and MS beach monitoring programs. Beach closings have occurred in both FL and MS during recent years, indicating that fecal coliforms are of concern for the park's waters. In addition, a segment of the seashore is listed as impaired water due to fecal coliforms.

There are few USEPA STORET stations located in the GOM. It is recommended that some of the bacteria monitoring stations also measure field parameters DO, salinity, conductivity, pH, water temperature, nutrients (total nitrogen, nitrite + nitrate, ammonia, total phosphorus, orthophosphorus), and chlorophyll *a* to fill in the data gaps. Additional monitoring stations should also be added in the waters surrounding the MS barrier islands. The abundances of algae should continue to be measured, especially during the summer months when recreational usage is high. This will provide sufficient time for public warnings if red tide conditions are present.

The upland ponds and lagoons of GUIS have been studied fairly extensively; however, the majority of these studies have focused on parameters such as salinity, with only a few measuring water quality parameters such as nutrients and DO. Permanent stations should be established in the ponds that are known to hold water the majority of the year. These stations should be routinely sampled (quarterly or semiannually) for field parameters, such as DO, salinity, conductivity, pH, water temperature) and nutrients (total nitrogen, nitrite + nitrate, ammonia, TP, orthophosphorus) and chlorophyll *a*. In addition, ponds which dry out should be studied intensively when water is present to determine impacts on wildlife utilizing the areas for habitat.

For areas where surveys have been completed and locations of ponds mapped, this information should be transferred to a GIS. This would be especially useful following catastrophic events, such as Hurricane Ivan. Physical parameters of the ponds and their locations following the hurricane will provide useful information on the effects and subsequent recovery of the system. In the future, the locations and physical characteristics of the ponds can be observed and the effects of storm events noted. Changes in floral and faunal composition following tropical storms and hurricanes should be documented to observe changes in water chemistry and the effects of sand inundation and shore erosion.

There is little information concerning dissolved and sediment metals information in the ponds and lagoons. However, the preliminary results of a contamination study indicate that mercury may be a potential problem in the park's ponds. Additional sampling is required to determine if other types of contamination are present. If these samples do not indicate contamination and there are no suspected sources in the area, more intensive investigation is not necessary. The ponds should continue to be analyzed for metals and contaminants on a less frequent basis to avoid future water quality issues. Bacterial monitoring is not necessary because these waters are not utilized for recreation or drinking water, so useful information would not be provided from this testing.

There are limited data available concerning the groundwater resources of GUIS. Some of the wells have displayed levels of sodium, chloride, magnesium, and calcium indicative of the presence of seawater. These resources should be studied to obtain recent information on the groundwater quality and to identify sources of contamination.

Regular monitoring should be conducted to determine if the species retrieved from the USGS Nonindigenous Aquatic Species Database are present within the park boundaries. These species should be monitored to document their abundance and effects on the park's ecosystems. MS Sound should be monitored for invasive mollusk species (zebra mussel), especially the waters near the ship channels and the Intracoastal Waterway. Chinese tallow should continue to be managed by the park service to prevent further expansion.

The water quality of GUIS may be classified as stressed. To the north of the park, many of the inland waterbodies are classified as impaired; however, the waters immediately surrounding the park do not carry this designation with the exception of two portions of Pensacola Bay. MS Sound is listed as impaired for total toxics in six areas 3.2 km (2 miles) in diameter around stations located between the MS coastline and the GUIS-MS barrier islands. Some of these stations are located near Ship and Petit Bois Islands. Mixing from tidal and wind-driven mechanisms and biological activity may provide sufficient dilution to mitigate the impacts of stressors upstream from the park. These mechanisms may not be sufficient in the future given the increasing development of the surrounding land.

Acknowledgements

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A. Park Description

A1. Background

A1a. Location and Setting

Gulf Islands National Seashore (GUIS) extends 260 km (160 miles) from Cat Island in MS to the eastern tip of Santa Rosa Island in FL (**Figures 1** and **2**[1]). The MS section of the park includes a portion of Cat Island, West and East Ship Islands (commonly referred to as Ship Island), Horn Island, Petit Bois Island, and the Davis Bayou area located on the mainland. The FL portion includes the Fort Pickens area, the Naval Live Oaks Recreation area, the Pensacola Forts, the Perdido Key area, the Okaloosa area, and the Santa Rosa area. The ICWW and ship channels are excluded from the national seashore. The boundary of the barrier islands extends north to the southern edge of the ICWW and south one mile from the low-tide line of the island (USDOI/NPS, 1978). The lands between the mean high and low water lines, islands within navigable waters, and lands extending three marine leagues into the GOM are considered sovereign submerged lands, which are held in public trust by the state (Florida Constitution, Article X, Section 11).

The park is located in Harrison and Jackson Counties in MS and Escambia, Okaloosa, and Santa Rosa Counties in FL. Most of MS lies in the East Gulf Coastal Plain, which also includes the western panhandle of FL. This region is characterized by flat to rolling topography, which is broken by streams and river bottoms. The uplands were originally dominated by longleaf (*Pinus palustris*) and slash pine (*P. elliottii*) in the southern part of the region (BLM, 2005). The FL panhandle can be further classified to include two physiographic regions, the Gulf Coastal Lowlands and the Western Highlands. The Gulf Coastal Lowlands region contains sand dunes, beach ridges, and wave-cut bluffs along the coast, with swamps and flatwoods a few miles inland. The elevation of these areas is generally between sea level and 30 m (100 ft) (Guvansen, 2000). The lowlands are a series of parallel terraces that rise from the coast. These terraces were formed during the melting and growth of ice caps (Thorpe et al., 1997). The Western Highlands region consists primarily of sand hills cut by streams that usually occupy deep, narrow ravines. This region ranges in altitude from 15 to 61 m (50 to 200 ft) above sea level (Puri and Vernon, 1964).

Santa Rosa Island, the site of Fort Pickens and the Santa Rosa and Okaloosa areas in GUIS-FL, is the second longest barrier island on the Gulf Coast. It is approximately 84 km (52 miles) long with an average width of 300-500 m (980-1,600 feet) (Otvos, 1982). It is composed of Holocene quartz sands that are 4.5-9 m (15-30 feet) thick (Thorpe et al., 1997). The island is characterized by wide beaches on the GOM side and narrow beaches on the

[1] These figures are based on the administrative boundaries of the park. The larger, congressionally-established (or "authorized") boundaries were utilized for database retrieval from the USEPA STOrage and RETrieval (STORET) and USGS National Water Information System (NWIS) databases.

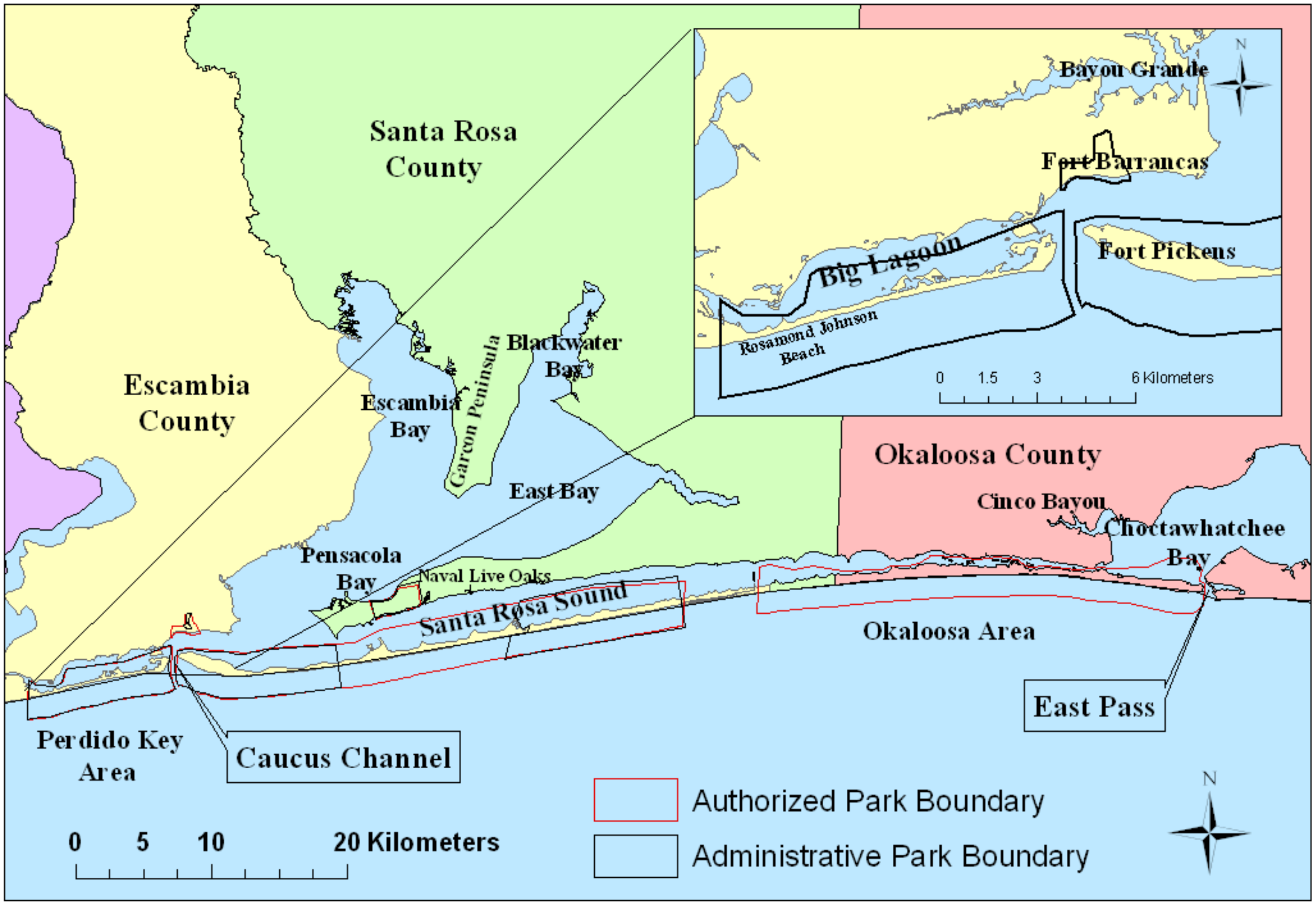

Figure 1. FL section of Gulf Islands National Seashore.

(Data Sources: County - FDEP (1:24,000, Automated 1997), Authorized Park Boundary – USDOI/NPS (1992), Administrative Park Boundary – USDOI/NPS)

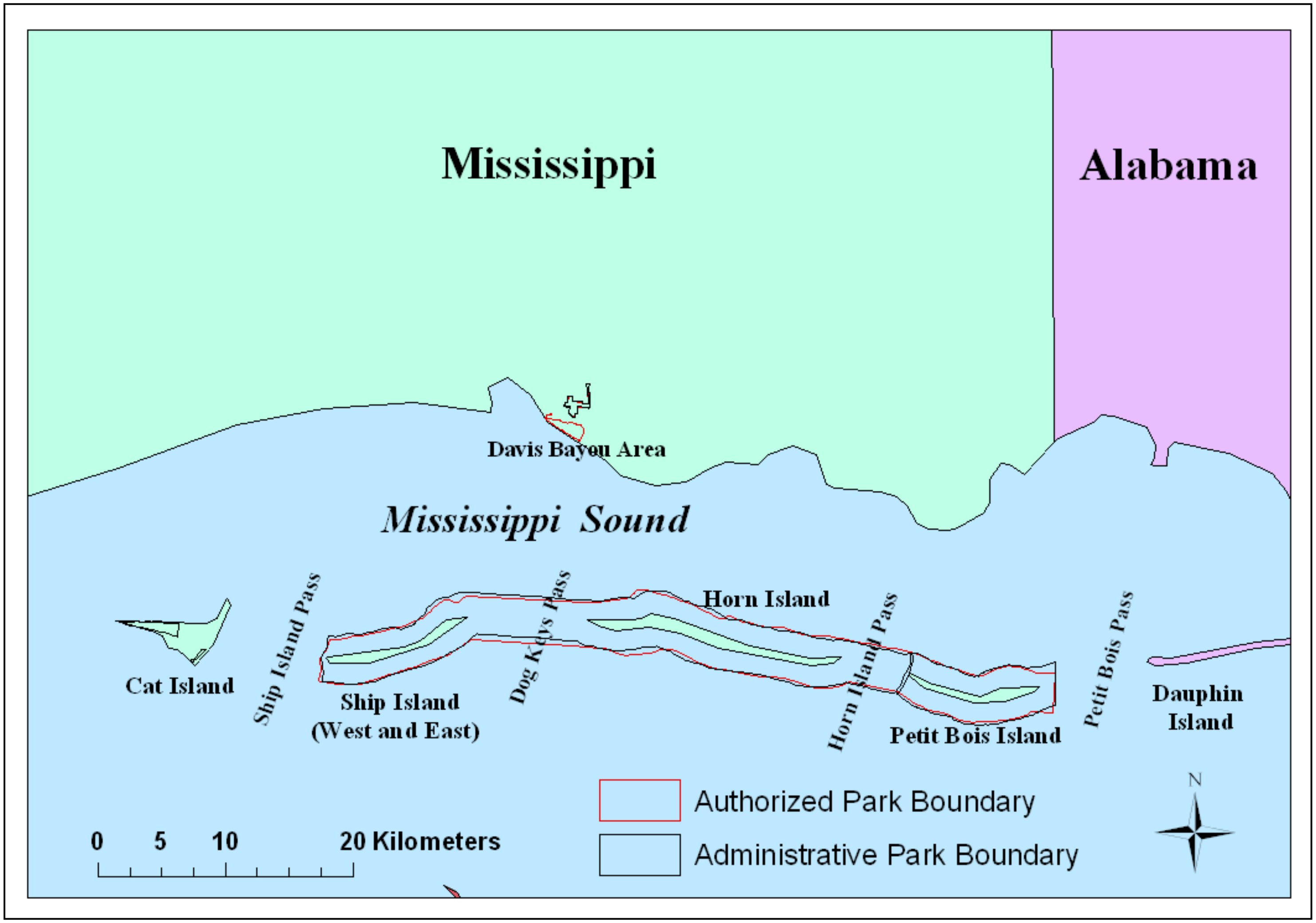

Figure 2. MS section of Gulf Islands National Seashore.

Administrative Park

(Data Sources: State – US Census Bureau (1:5,000,000, 1990), Authorized Park Boundary – USDOI/NPS (1992), Boundary – USDOI/NPS).

*Cat Island is not included in the authorized boundary obtained from USDOI/NPS Inventory and Monitoring web page (http://science.nature.nps.gov/nrftp/ftparchive.cfm). Approximately 2,000 acres of the 2,150-acre island are included in authorized boundary of the national seashore.

Santa Rosa Sound. The sand dunes on the island reach heights of 16.8 m (55 feet) above sea level. These dunes are primarily located on the western tip of the island where denser vegetation has been established. This island is separated from the mainland by Santa Rosa Sound to the north, Choctawhatchee Bay to the east, and Pensacola Bay to the west. Santa Rosa Sound is approximately 0.4 – 3.3 km (1,300-11,000 ft) wide with depths ranging from 0.4 to 7.5 m (1.3-25 ft) (Otvos, 1982).

Barrier islands are constantly changing environments due to wind and wave action. Dominant ocean currents from the southeast erode the eastern ends of these islands and build up the western ends. Santa Rosa Island is unique because its westward movement has been halted by the high tidal current velocities and depth of the Pensacola Bay entrance channel, which is maintained by dredging (Otvos, 1982). This entrance channel also produces higher salinities (> 25 ppt, parts per thousand) in Pensacola Bay and Santa Rosa Sound (Otvos, 1982).

The eastern MS barrier islands (Petit Bois and Horn) appear to exhibit a shoal to island geology (Otvos, 1970a;1970b) and the main source of sediment is from the AL mainland coast (Otvos, 1985). Within the last 300 years, the eastern islands have had a dominantly translational - longshore drift movement, such that they are not moving landward but rather along the coast (Schmid, 2001). Cat Island has had very little translational movement, instead eroding in place (Schmid, 2001). East and West Ship Islands lie somewhere in the middle of the spectrum (Schmid, 2001). In particular, West Ship Island is rare island because it has experienced shoreline advance and an in increase in area between 1966 (prior to Hurricane Camille) and 1986 (McBride and Byrnes, 1995). Ship Island has historically been associated with rotation instability as opposed to translation; it is the only northeastern GOM barrier island with this type of geomorphic classification (Byrnes et al., 1991; McBride et al., 1995).

Schmid (2001) described the island change of Ship Island preceding Hurricane Georges (1998), the change caused by the hurricane, and the changes during recovery. This report combined new shoreline data including Light Detection and Ranging, Global Positioning System (GPS) surveys, and cross-shore profiles with traditional data sources such as aerial photography, sediment cores, and bathymetry to accomplish this comparison (Schmid, 2001). In addition to the natural forces that act on the island, another important factor is the maintenance of the Ship Island channel. According to Schmid (2001), sediment that would form the sand platform is lost into the channel. This sand was returned to the system by pumping in the 1970s, but is now removed from the system (Henry and Giles, 1975). Fort Massachusetts is located on West Ship Island. It was originally built on the western tip of the island, but now lies over 1 km (0.6 miles) from the western tip (Schmid, 2001). Erosion has threatened the fort several times and renourishment projects have been completed to protect it. The National Park Service (USDOI/NPS) works closely with the U.S. Army Corps of Engineers (USACOE) to obtain dredge material from the maintenance of ship channels in the area, including those off Ship and Petit Bois Islands, to protect the fort (USDOI/NPS, 2003b). Characteristics of the MS and FL barrier islands that compose GUIS are included in **Table 1**.

Table 1. Characteristics of barrier islands, beaches, and associated waterbodies along the barrier islands of Gulf Islands National Seashore.

Characteristics	Cat Island	Ship Island	Horn Island	Petit Bois Island	Perdido Key	Santa Rosa Island
Beach Type	Regressive Barrier Island	Regressive Barrier Island	Regressive Barrier Island	Regressive Barrier Island	Regressive Barrier Island	Transgressive Barrier Island
Dimensions	8 km X 2 km	13 km X 1.6 km	21 km X 1 km	10 km X 1 km	22 km X 0.6 km	84 km X 1.6 km
Shore/Island Profile	High-profile	High-profile	High-profile	High-profile	High-profile	Low-profile
Dune Topography	Continuous	Continuous	Continuous	Continuous	Continuous	Low discontinuous
Dimensions	3.0-6.0 m height	3.0-6.0 m height	3.0-6.0 m height	3.0-6.0 m height	3.0-6.0 m height	4.0-5.0 m height
Island Migration	Stable to laterally west	Laterally west	Laterally west	Laterally west	Laterally west	Laterally west
Littoral Transport	SW	W	W	W	W	W
Shoreline Change	Erosion/ Accretion 0.5 -1.0 m/yr	Erosion/ Accretion 0.5 -1.0 m/yr	Erosion 0.5 -1.0 m/yr	Erosion/ Accretion 0.5 -1.0 m/yr	Erosion to stable 0-1.0 m/yr	Erosion to stable 0-1.0 m/yr
Tidal Inlets	Few. Occur locally adjacent to barriers					
Type	Wave-dominated					
Dimensions	5.0-15.0 m depth	5.0-15.0 m depth	5.0-15.0 m depth	5.0-15.0 m depth	18.0 m depth	9.0-12.0 m depth
Frequency	Widely-separated					
Washovers	Local fans and channels					
Tidal Deltas	Occur locally					
Flood	Well-developed					
Ebb	Small					
Shoals	Lagoonal and adjacent to barriers					
Associated Bay/Lagoons	MS Sound	MS Sound	MS Sound	MS Sound	Perdido Bay	Santa Rosa Sound
Depth	4.0 -6.0 m	4.0 -6.0 m	4.0 -6.0 m	4.0 -6.0 m	1.5 m	6.0 m
Sediment Source	Pleistocene Shoals	Pleistocene Shoals	Pleistocene Shoals	Pleistocene Shoals	Pleistocene deltaic Headlands/ shoals	Pleistocene deltaic Headlands/ shoals
Nearshore	Sand, shells					
Beach	Sand, shells					
Back Barrier	Sand, mud, peat	Sand, mud, peat	Sand, mud, peat	Sand, mud, peat	Sand, silt, mud	Sand, silt, mud
Bay	Sand, mud	Sand, mud	Sand, mud	Sand, mud	Silt, mud, sand	Silt, mud, sand

Source: Wicker et al., 1989.

Hydrology and water-related issues are of central importance because 80% of the park is submerged land. Land use in the contributing watersheds strongly influences the biology, chemistry, and ecology of the park. These land use patterns have contributed to problems such as pollutant loading in stormwater runoff, changes in groundwater recharge rates, oil and gas emissions from watercraft, atmospheric deposition of heavy metals, sewage effluent disposal, and loss of submerged aquatic vegetation due to degraded water quality.

Water quality issues are also important to the park because its waters are classified as Outstanding FL Waters (OFW) that are to be preserved in a non-degraded state and protected for the public. OFW generally include waters in National Parks, Preserves, Memorials, Wildlife Refuges, and Wilderness Areas (unless named as Outstanding National Resource Waters). This designation is also carried by other waters in the area including the Blackwater and Shoal Rivers, Blackwater River State Park, Escambia Bay Bluffs Program Area, Milton to Whiting Field Program Area, Fort Pickens State Park Aquatic Preserve, and the Yellow River Marsh Aquatic Preserve. This classification is intended to afford the highest level of protection to existing high quality waters.

Data for this project were collected using a number of geographic scales including Hydrologic Unit Codes (HUCs), counties, specific waterbodies, and the national seashore boundaries. The FL section of GUIS is located in the Pensacola Bay (03140105), Perdido Bay (03140107), and Choctawhatchee Bay (03140102) HUCs. Other units that feed into this bay system include Escambia River (03140305), Blackwater River (03140104), Perdido River (03140106), and Yellow River (03140103) (**Figure 3**). For GUIS-MS, the park lies in the Jourdan (03170009) unit. The Escatawpa River (03170008) and Pascagoula River (03170006) also contribute water to MS Sound near the park (**Figure 4**).

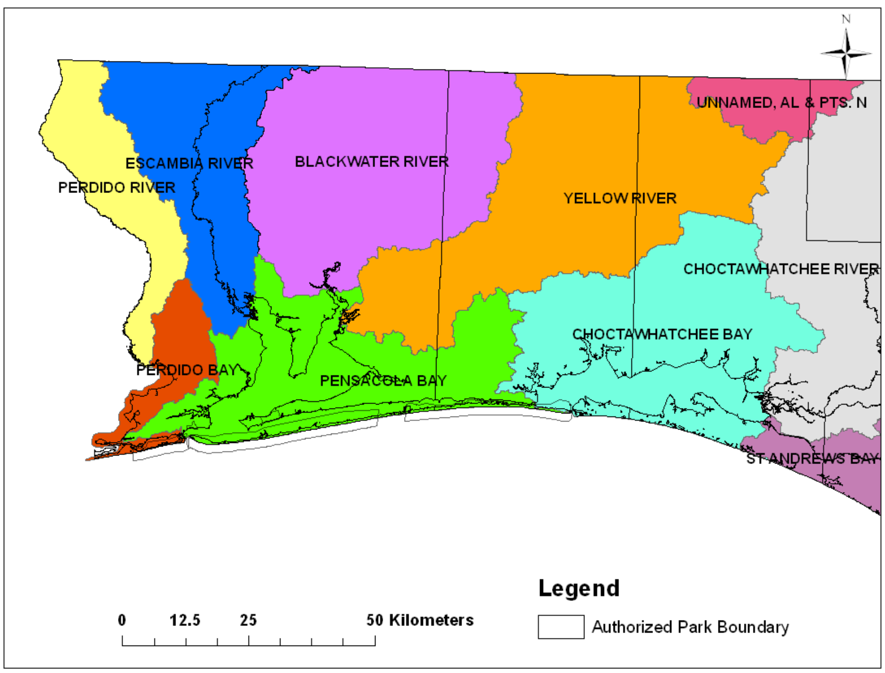

Figure 3. Hydrologic unit codes of northwest FL.

(Data Sources: County - FDEP (1:24,000, Automated 1997), Authorized Park Boundary – USDOI/NPS (1992), HUC – FDEP (1:24,000))

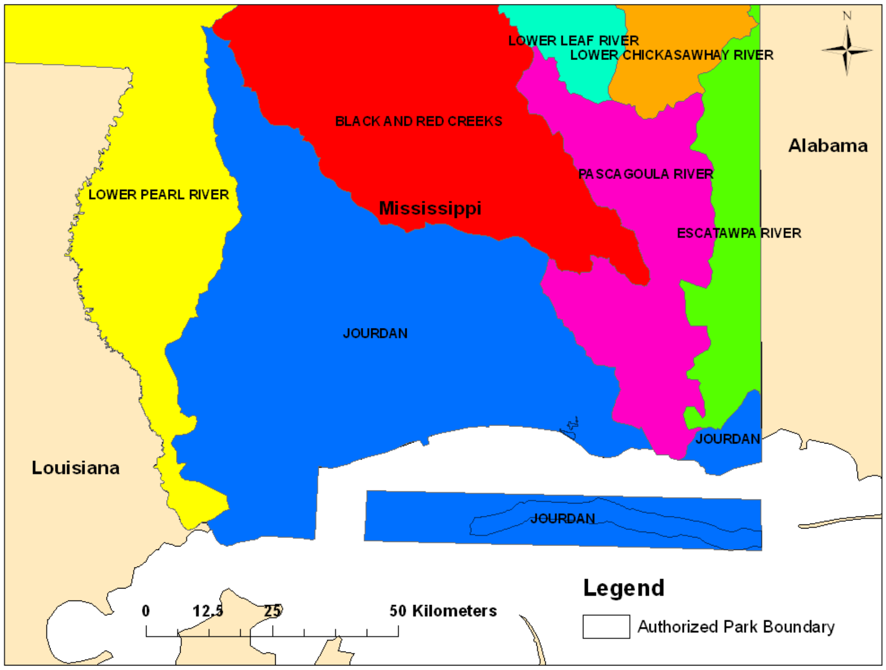

Figure 4. Hydrologic unit codes of southern MS.

(Data Sources: State - US Census Bureau (1:5,000,000, 1990), Authorized Park Boundary – USDOI/NPS (1992), and HUC – U.S. Dept. of Agriculture – Soil Conservation Service, MS Automated Resource Information System Technical Center (1:250,000, 1989))

A1b. Land Use/Land Cover

Land use in the watershed surrounding the Pensacola Bay system (PBS) includes urban development, recreation, conservation, agriculture, and silviculture (**Figures 5 and 6**). The western portion of the watershed is primarily urban, exhibiting industrial, commercial, and residential development, while the eastern portion is primarily low-density, rural, undeveloped land (Thorpe et al., 1997). The numerous industrial and manufacturing facilities located along the waterfront and railroad lines have a significant impact on the water quality of the system. There is an increasing amount of seasonal residential growth in Escambia and Santa Rosa Counties, primarily on Santa Rosa Island and Perdido Key (Thorpe et al., 1997).

Active and inactive U.S. Naval Reservations are located within the Pensacola urban area, including the Naval Air Station Pensacola located northwest of Santa Rosa Island. The air station covers approximately 22.7 km^2 (5,600 acres) on the western shore of Pensacola Bay. Whiting Field encompasses 14.5 km^2 (3,595 acres) in neighboring Santa Rosa County (Thorpe et al., 1997). Northwest of the city of Pensacola, the primary land use is forestry. The limited amount of agriculture in the area consists of row crops (Thorpe et al., 1997). In the eastern section of the watershed, Eglin Air Force Base occupies over 1,900 km^2 (470,000 acres) in Santa Rosa, Okaloosa, and Walton Counties. The major land uses in Okaloosa County and the AL portion of the watershed are agriculture and silviculture (Thorpe et al., 1997).

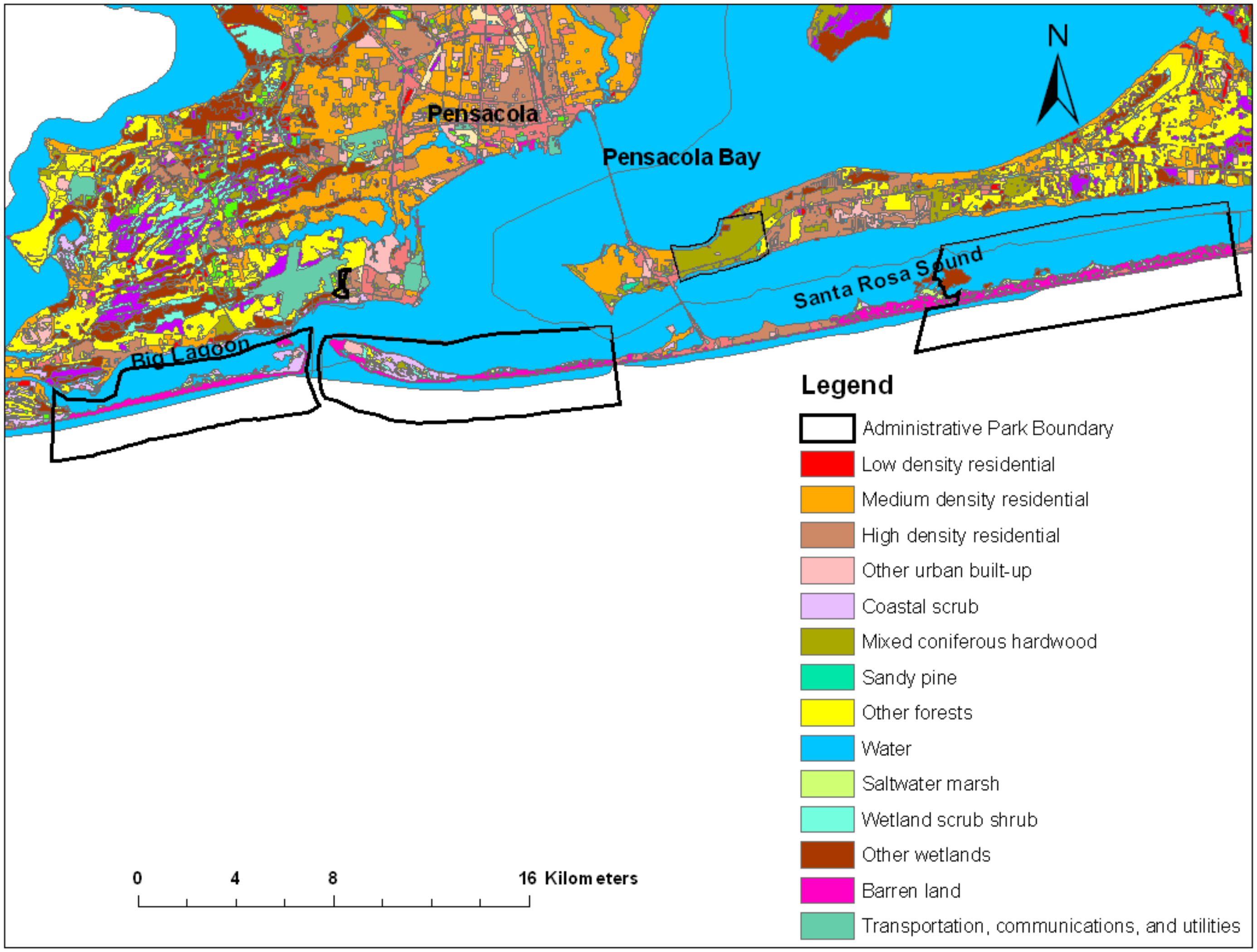

Figure 5. Land cover/use surrounding western portion of Gulf Islands National Seashore-FL.

(Data Sources: County - FDEP (1:24,000, Automated 1997), Land use - FDEP (1:24,000, Automated 1995) and Administrative Park Boundary – USDOI/NPS).

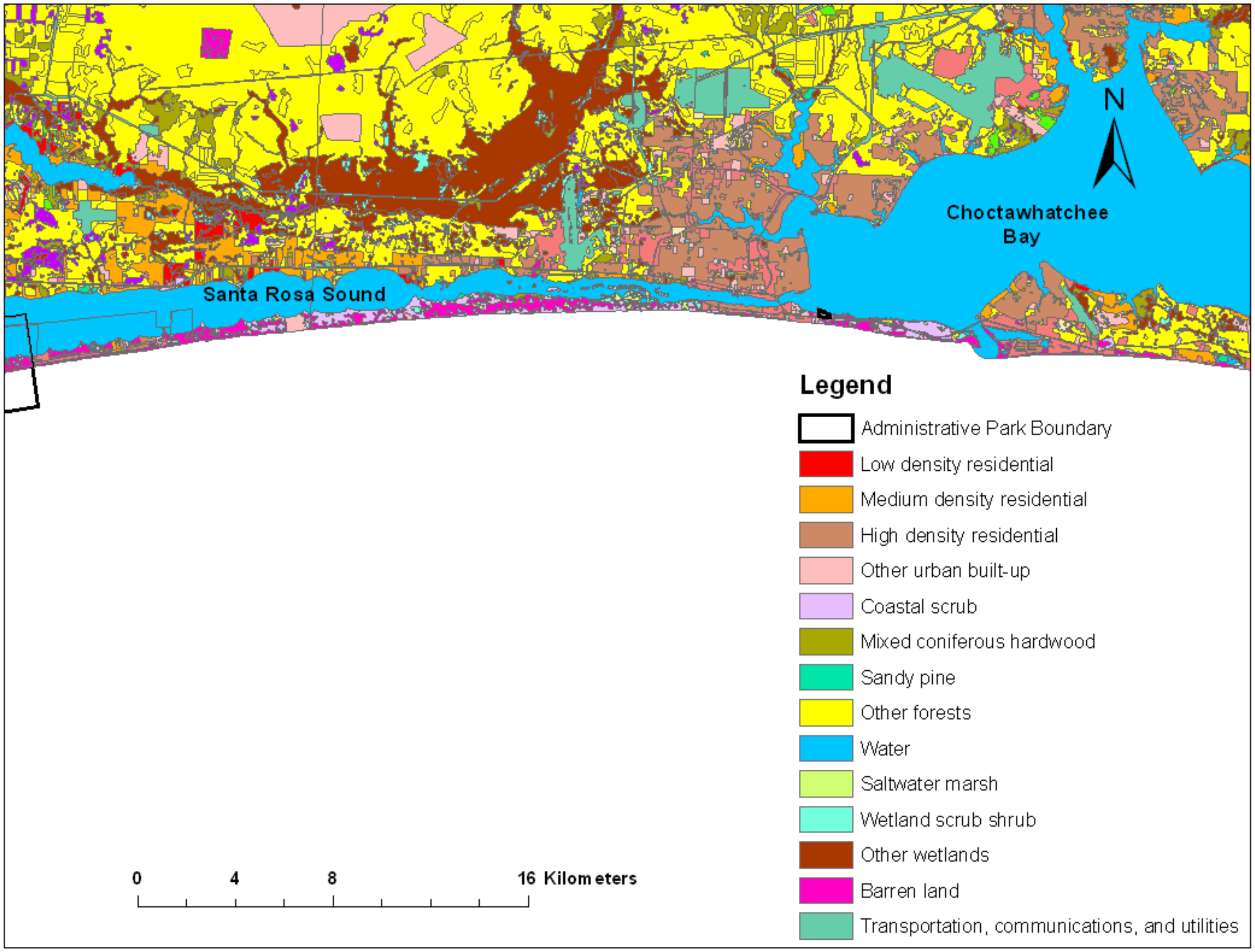

Figure 6. Land cover/use surrounding eastern portion of Gulf Islands National Seashore-FL.

(Data Sources: County - FDEP (1:24,000, Automated 1997), Land use - FDEP (1:24,000, Automated 1995), and Administrative Park Boundary – USDOI/NPS).

The land use/land cover distribution within the park boundaries (GUIS-FL) was determined using ArcGIS 9.0 (Environmental System Research, Inc (ESRI), 2004) and 1995 land use data (1: 24,000) automated by the FDEP (**Figure 7**). The administrative boundaries for GUIS-FL and GUIS-MS were used for the data analysis; however, the larger authorized boundaries were utilized for water quality data retrieval and analysis. The FL Land Use, Cover and Forms Classification System separates land use/cover data into multiple codes. The general divisions, such as urban and built-up, agriculture, wetlands, etc., were used unless an area of interest important to the park was identified. Analysis of the data yielded the results found in **Table 2**.

Table 2. Land use/cover distribution for Gulf Islands National Seashore-FL based on administrative boundary.

Description		Area (ha)	Percent of Total Park Area (GUIS-FL)
Urban and built-up			
	Low density residential	2.7	< 0. 1
	Medium density residential	0.03	< 0. 1
	High density residential	0.6	< 0. 1
	Commercial and services	13.4	0.2
	Other urban built-up	60.1	0.8
Rangeland			
	Coastal scrub	400.7	5.3
	Other rangeland	0.0	< 0. 1
Upland forests			
	Sandy pines	6.0	0.1
	Mixed coniferous hardwood	470.0	6.2
	Other forests	60.9	0.8
Water			
	Streams-reservoirs	13.7	0.2
	Ocean-embayments	5,308.6	70.0
Wetlands			
	Saltwater marsh	78.6	1.0
	Wetland scrub shrub	46.4	0.6
	Other wetland	123.1	1.6
Barren land		978.9	12.9
Transportation, communications, and utilities		16.3	0.2
Total		**7,580**	**100**

Source: FDEP, Automated 1995 (1:24,000).

As expected, the majority (~ 70%) of GUIS-FL is made up of water. The park boundaries extend approximately 1.6 km (1 mile) into the surrounding waterbodies and water was incorporated when calculating the total area. However, these calculations do not include all of the water that is part of GUIS-FL because the land use data only extends 322 m (0.2 miles) into the GOM, whereas the park boundary extends 1.6 km (1 mile). Therefore, the percentage of water is underestimated. Barren land makes up approximately 13% of the total area, which

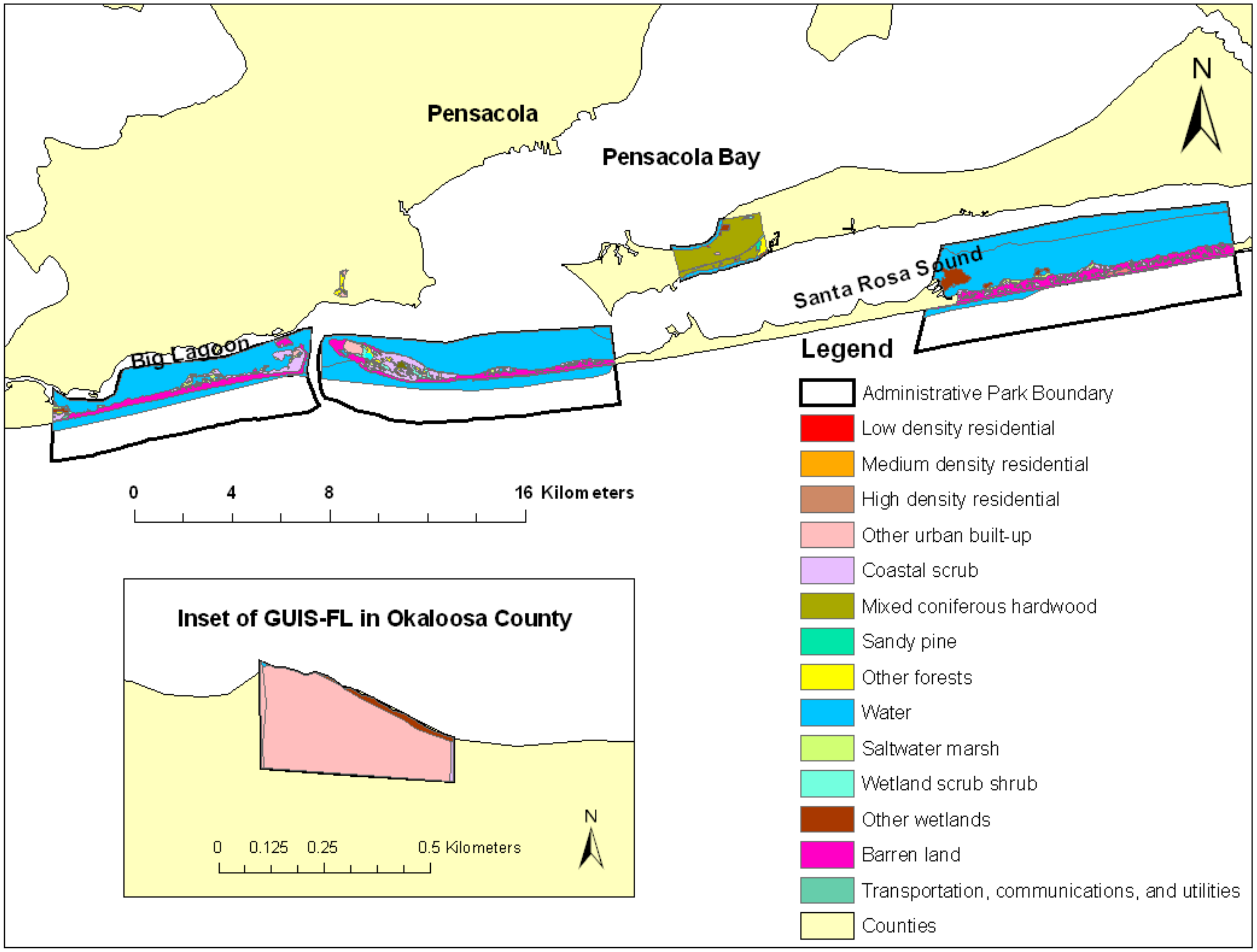

Figure 7. Land cover/use for Gulf Islands National Seashore-FL.

(Data Sources: County - FDEP (1:24,000, Automated 1997), Land use - FDEP (1:24,000, Automated 1995), and Administrative Park Boundary – USDOI/NPS).

includes beaches, sand other than beaches, and disturbed land. Approximately 5% of the area is classified as coastal scrub. Saltwater marshes (1%), wetland scrub shrub (0.6%), sandy pines (0.1%), and mixed coniferous hardwood (6.2%) were selected because they are important ecological habitats. Although the relative percent areas of these categories are small, they provide essential habitats for certain plant and animal species.

The MS Department of Environmental Quality (MDEQ) manages water resources based on a river basin approach. The barrier islands of the MS section of the park are located in the Coastal Streams Basin. The Coastal Streams Basin includes all or part of six MS counties and the drainage area is about 400 km^2 (545 $mile^2$) (MDEQ, 2004b). The inland area of the basin is primarily rural with the majority of the land used for agriculture and silviculture. The concentrated urban, industrial, and recreational uses are along the coast (MDEQ, 2004b). The Pascagoula River Basin is located near the Coastal Streams Basin and the land use information has also been summarized. In the Pascagoula River Basin, the majority of the area is covered with forests and a region of pine with scattered areas of hardwoods, called the Pine Belt, runs through the central portion of the basin (MDEQ, 2004b). Other land uses in the basin include oil and gas production, agriculture, recreation, and urban development (MDEQ, 2004b).

The administrative boundary of GUIS-MS was utilized to determine the relative percentages of specific land uses within the park. A figure of the land use surrounding the park was not included because the GUIS-MS barrier islands are surrounded by water. Similar to GUIS-FL, the dominant land cover was water, accounting for 88.7% of the total area. Barren land comprises 6.3% of the park land followed by wet scrub/shrub at 2%. Additional habitats of interest include upland scrub/shrub, upland pine forest, pine savanna, bottomland hardwood forest, and tidal marsh. The medium and high density residential areas were located within the Davis Bayou unit. The contribution of each land use/land cover is included in **Table 3**. These calculations are based on the data displayed in **Figures 8 and 9**.

A1c. History and human utilization

GUIS has a rich military history dating back to the 1800s. The Naval Live Oaks area was originally established to ensure an ample supply of timber for shipbuilding. The wood from live oaks (*Quercus virginiana*) was ideal for shipbuilding because of its resistance to decay and disease. With the advent of iron and steel warships, wood ship timber was no longer needed, but these areas were preserved to recognize the importance of live oaks to the nation's history (USDOI/NPS, 2003a). Four forts were built to protect Pensacola Bay and its naval yard from attack. The largest of these is Fort Pickens. Additional structures include Fort Barrancas and its advanced redoubt and Fort McRee at the east end of Perdido Key.

The barrier islands of GUIS-MS also have military significance. British forces anchored between Ship and Cat Islands to stage an attack on New Orleans during the War of 1812. Ship Island is the only deep-water harbor between Mobile Bay and the Mississippi River. Fort Massachusetts was used by Confederate and Union forces during the Civil War. During the war, more than 40 buildings were constructed including a hospital, barracks, a mess hall, and a bakery. At this time, the fort was given the name "Massachusetts," probably after the Union ship of the same

Table 3. Land use/cover distribution for Gulf Islands National Seashore-MS based on administrative boundary.

Description		Area (ha)	Percent of Total Park Area (GUIS-MS)
Urban			
	Medium density residential	5.1	< 0.1
	High density residential	1.6	< 0.1
Cropland/pasture/grassland		0.6	< 0.1
Upland scrub shrub		80.9	0.4
Forests			
	Upland pine forest	168.7	0.7
	Other upland forests	32.0	0.1
	Wet pine forest/pine savanna	165.6	0.7
	Bottomland hardwood forest	32.8	0.1
Surface water		19,951.7	88.7
Wetlands			
	Tidal marsh	164.8	0.7
	Wetland scrub shrub	451.3	2.0
	Swamp	3.0	< 0.1
Barren land		1,418.1	6.3
Burned area		24.8	0.1
Total		**22,501**	**100**

Source: Landsat 7 Imagery, 1999.

name. The USACOE continued work on the fort until 1866, when it was turned over to a civilian fort keeper, C.H. "Pop" Stone. Later, an ordinance-sergeant was responsible for upkeep of the fort until 1903, when the Ship Island lighthouse keeper became the fort's caretaker (USDOI/NPS, 2003b). In addition, the barrier islands are also important culturally. Ship Island was inhabited by a group of French Canadians led by Pierre Le Moyne d'Iberville during the late 1600s. The goals of the expedition were to establish the colony of Louisiana, explore the northern coast of the GOM, and find the mouth of the Mississippi River. In 1721, three ships of women arrived to increase the colony's population.

One of the first black regiments in the U.S. Army was stationed on Ship Island for three years during the Civil War. The first Escambia County resident to die in the Korean War was Rosamond Johnson, Jr., on July 26, 1950. He joined the military at 15 years old and died at 17, receiving the Purple Heart posthumously. A beach area on Perdido Key is named after Rosamond Johnson and was added to the park on May 8, 1973. A permanent monument was erected on June 10, 1996, to recognize his bravery (USDOI/NPS, 2003a).

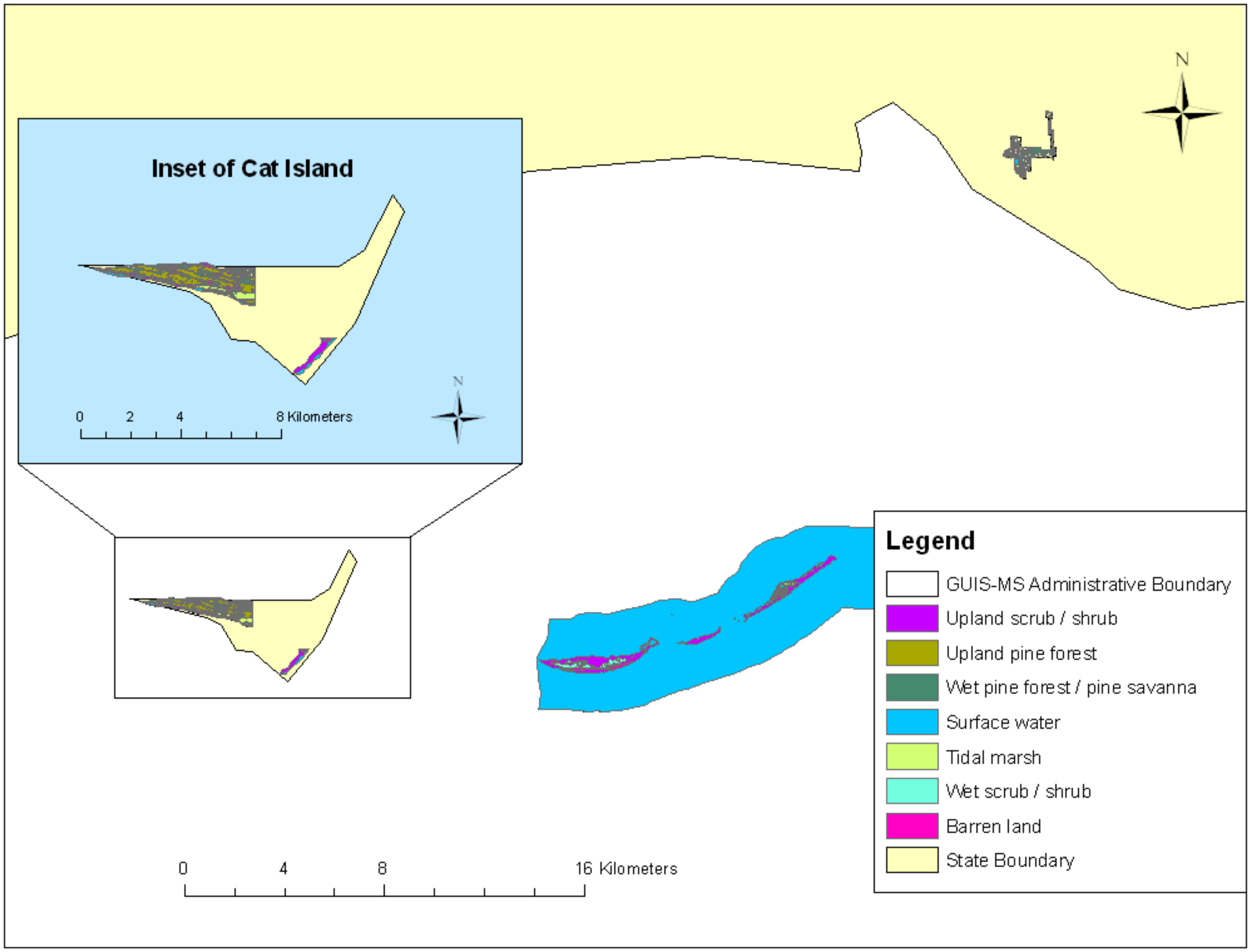

Figure 8. Land cover/use for Cat and Ship Islands of Gulf Islands National Seashore-MS.

(Data Sources: State - US Census Bureau (1:5,000,000, 1990), Land use – Based on Landsat 7 Imagery (1999), and Administrative Park Boundary – USDOI/NPS)

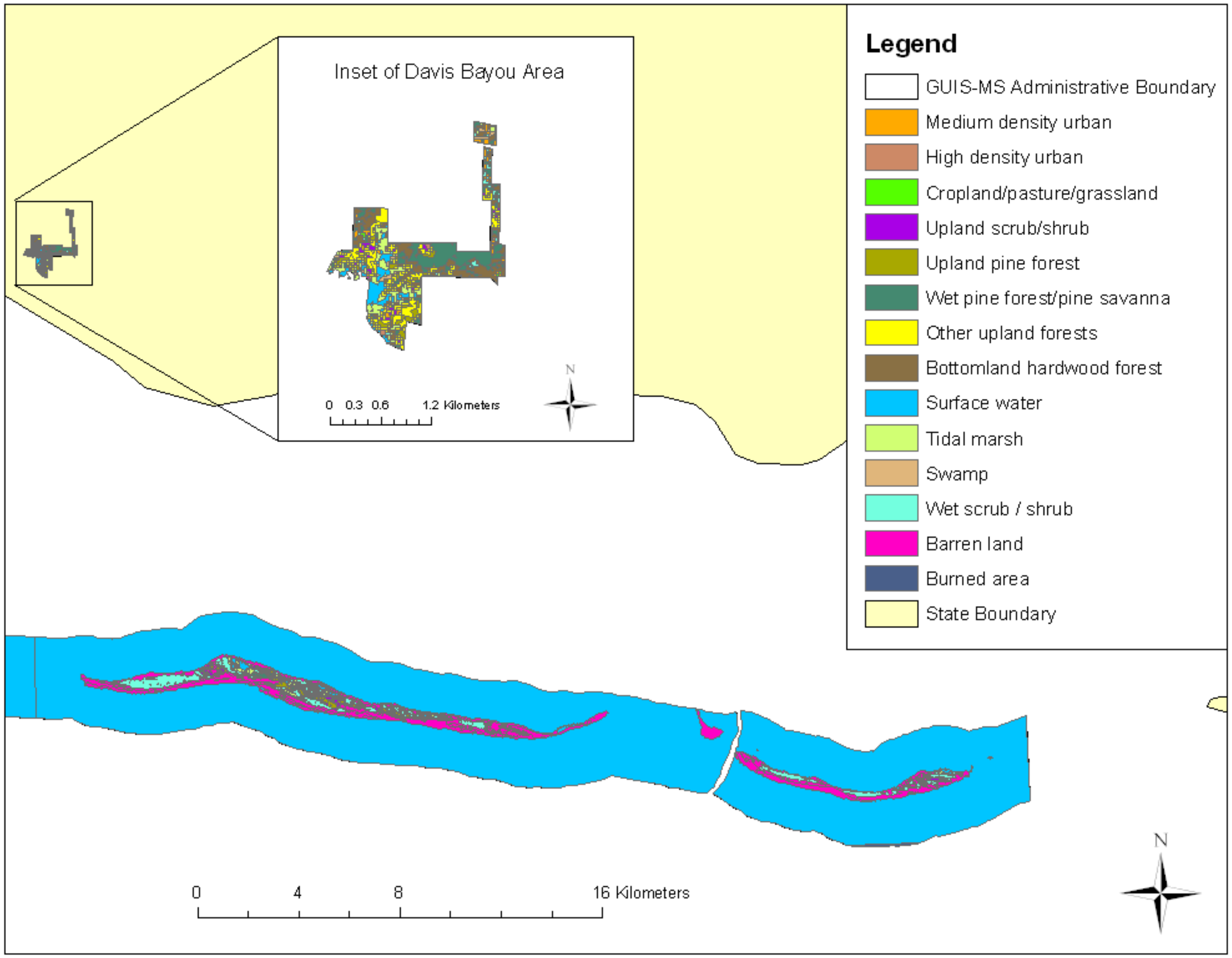

Figure 9. Land cover/use for Horn and Petit Bois Islands and Davis Bayou area of Gulf Islands National Seashore-MS.

(Data Sources: State - US Census Bureau (1:5,000,000, 1990), Land use – Based on Landsat 7 Imagery (1999), and Administrative Park Boundary – USDOI/NPS)

Currently, GUIS is utilized for recreational activities including camping, hiking, fishing, biking, swimming, boating, and birdwatching. Fishing activities within the park are limited to sports anglers; however, commercial fishing does take place adjacent to the park. Although GUIS-MS is largely uninhabited, increased urbanization near the FL section of the park has impacted water quality. The FL section of the park is accessible by various bridges connecting Santa Rosa Island to the mainland, while access to the MS section is limited to one passenger ferry that operates between Gulfport, MS, and Ship Island and private boats.

Today, the Gulf Breeze peninsula is experiencing rapid urbanization. Most of the urban and commercial development is occurring on Santa Rosa Island and along U.S. Highway 98 (Thorpe et al., 1997). All three counties (Escambia, Okaloosa, and Santa Rosa) have experienced population growth from 1970-2004 (**Figure 10**). According to the FL Legislature's Office of Economic and Demographic Research (2004), the population is projected to increase through 2030. Santa Rosa County was named one of the 100 fastest growing counties in the US in 2003 based on the percent change in population from 2000 to 2003. The county grew by approximately 13% from a population of 117,743 in 2000 to 133,092 in 2003 (U.S. Census Bureau, 2004).

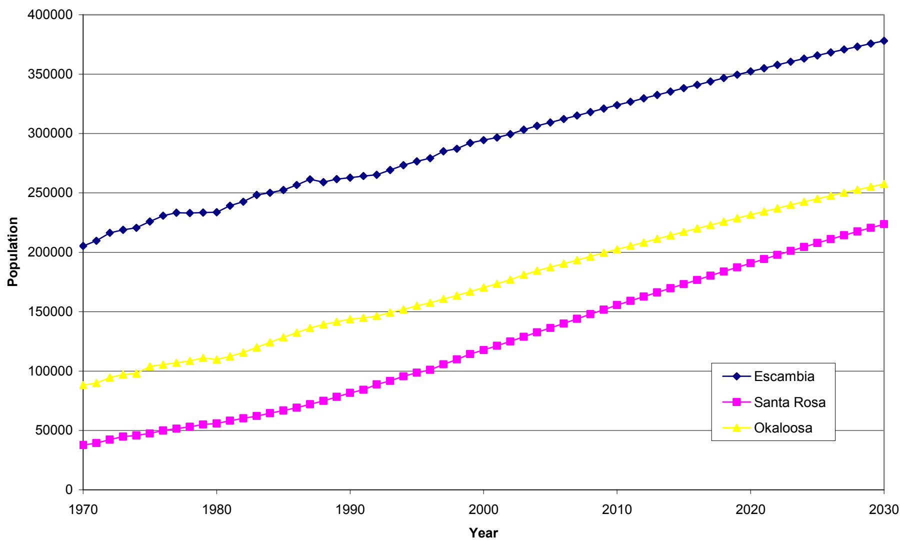

Figure 10. Populations of Escambia, Okaloosa, and Santa Rosa Counties, 1970-2030.

(Source: U.S. Census Bureau, 2004).

A1d. Coastal management issues

Human development places environmental stress on the neighboring ecosystems and impacts water quality. These activities generate shoreline trash which impacts water quality. Recreational activities, such as the use of off-road vehicles and personal watercraft, impact GUIS. Marine transportation and maintenance activities also affect water quality and biota. Examples of these activities are dredging to maintain navigation channels, human alterations to the shoreline, such as jetty construction and beach nourishment, and ballast water discharged from ships.

Marine debris

Marine debris not only affects the aesthetic quality of GUIS, but also the water quality and biota of the park. Debris can include hazardous substances and medical wastes that pose risks to humans as well as wildlife (Miller and Jones, 2003). Marine and terrestrial animals can also become entangled in the debris or die from ingestion of these materials (Miller and Jones, 2003). The types and quantities of litter collected from an approximately 18-km (11-mile) stretch of beach on Santa Rosa Island were described by Lott (1992). This report also provided recommendations for litter management (Cooper et al., 2004). GUIS was also selected for a five-year marine debris study that monitored the abundance, composition, and accumulation of marine debris (Bishop, 1989; 1990; 1991; 1992; 1993).

Off-road vehicles and personal watercraft (PWC)

The use and management of off-road vehicles have been the foci of several reports regarding GUIS. This is an important issue because it demonstrates the difficulty of hosting recreational activities on the park land while maintaining the ecological integrity of the landscape. Studies have been conducted that summarize the usage of off-road vehicles and their environmental impacts on Perdido Key, FL (Shabica, 1979; Shabica and Shabica, 1978; and Shabica et al., 1979; Cousens, 1987; 1988). The impacts of vehicle paths and the subsequent recovery of vegetation were discussed in these reports; management recommendations were also provided.

Watercraft and motorized boats have been utilized in the park since its establishment in 1971. The use of PWC began in the 1980s and has increased in recent years according to observations by park personnel (USDOI/NPS, 2004). By mandate of a national regulation, GUIS was closed to PWC use in April 2002. PWC use can be reinstated by completion of a special regulation. This possibility was discussed in a 2004 report that presented a range of alternatives and strategies for managing PWC while protecting the park's resources (USDOI/NPS, 2004). The report describes the environmental impacts of this watercraft, addressing issues such as air and water quality, noise levels, possible effects on vegetation, wildlife, cultural resources, and other park visitors (USDOI/NPS, 2004). The report concluded that the environmentally preferred alternative would be to reinstate PWC use under a special USDOI/NPS regulation with additional management prescriptions (USDOI/NPS, 2004). In March 2005, a proposed rule for PWC use within seashore boundaries was published in the Federal Register (USDOI/NPS, 2005).

Shoreline changes

Shoreline changes have occurred in the southeastern U.S. states bordering the GOM and the Atlantic Ocean as a result of natural processes and human activities. The physical factors with the most influence on this land loss are reductions in sediment supply, relative sea level rise, and frequent storms (Morton, 2003). Critical human activities are sediment excavation, river modification, and coastal construction (Morton, 2003). Morton et al. (2004) discussed shoreline changes, with an emphasis on shoreline erosion of the states bordering the GOM. The average long-term rate for the west coast of FL was low (-0.8 ± 0.9 m yr^{-1}) compared to some of the other states due to the low wave energy. However, more than 50% of the shoreline is experiencing both long-term and short-term erosion (Morton et al., 2004). In areas where beach nourishment is common, such as Perdido Key, trends have shifted from long-term erosion to short-term stability or accretion. A shift from long-term stability to short-term erosion was noted for Santa Rosa Island, most likely due to the effects of Hurricane Opal in 1995 (Morton et al., 2004).

The long-term land loss for the MS Sound mainland shores was determined to be relatively low, due to the extensive armoring and beach nourishment projects (Canis et al., 1985). However, the erosion of the MS barrier islands is rapid, demonstrated by an average long-term rate of -3.1 ± 1.8 m yr^{-1} which applies to 80% of the shoreline (Morton et al., 2004). The short-term average rate of 60% of the shoreline is greater at -5.8 m yr^{-1}. According to Larson et al. (1980), over one-third of the MS mainland coast has been modified to support wide sand beaches created in front of seawalls by pumping material from nearshore waters. Shabica et al. (1984) calculated the mean rates of shoreline change for the MS barrier islands using data presented by Waller and Marlbrough (1976). These rates were -1.4 m yr^{-1} for Ship Island, -0.7 m yr^{-1} for Horn Island, and $+0.6$ m yr^{-1} for Ship Island. Byrnes et al. (1991) noted that the systematic pattern of updrift erosion and downdrift deposition of the MS barrier islands transfers sand from east to west, promoting the westward migration and reducing the island areas by about one third since the 1850s (Byrnes et al., 1991). These rates were quantified as 11.7 m yr^{-1} for Ship Island, 38.1 m yr^{-1} for Horn Island, and 35.9 m yr^{-1} for Petit Bois Island (Otvos, 1970a, 1979; Waller and Malbrough, 1976).

Morton et al. (2004) also described technical responses from the state's that would mitigate land loss due to erosion. These measures can be categorized into the following areas: hard structures, beach nourishment, sand bypassing at inlets, and retreat. The USGS plans to report on the shoreline changes for the GOM Coast every 5 to 10 years (Morton et al., 2004). Accurate and up-to-date information concerning shorelines is important to the park's resource management to balance the management of upland property, while conserving beach resources.

Shoreline rate changes for Santa Rosa and Escambia Counties are discussed in a report by Foster et al. (1999). Escambia County contains portions of two barrier islands, Perdido Key and Santa Rosa Island. Two moderately developed areas located on Perdido Key between GUIS and the AL state line. There is also moderate development in the cities of Pensacola Bay and Navarre Beach on Santa Rosa Island. Major renourishment projects occurred on Perdido Key in 1985 and between 1989 and 1991. The erosion rates on the eastern end of Perdido Key before renourishment were about -0.3 to -2.7 m yr^{-1} (-1 to -9 ft yr^{-1}). The shoreline change rates for Santa Rosa Island were much lower at 0.0 to -0.3 m yr^{-1} (0.0 to -1 ft yr^{-1}); however, near the Fort Pickens area of GUIS the rates were 1.1 m yr^{-1} (3.5 ft yr^{-1}) near the inlet. On both sides of Pensacola Pass, random, unpredictable large-scale changes have occurred (Foster et al., 1999).

Dredging activities and coastline modifications

The first modification of Pensacola Pass occurred in 1878 when construction of a 7.3-m (25-ft) deep entrance channel was authorized. In 1959, the channel was widened and deepened to 11.3 m (37 ft) with disposal of the dredged material on Santa Rosa Island (FDEP, 2000). The latest dredging project in 1991 deepened the channel to 14.6 m (48 ft) and 244 m (800 ft) in width to accommodate a Navy aircraft carrier (Browder and Dean, 1999). The dredge material was placed on Perdido Key (FDEP, 2000). In total, approximately 35 million m^3 (45.8 million yd^3) of material have been removed from the channel and only 14.2 million m^3 (18.6 million yd^3) of that volume were disposed on or near the adjacent shoreline (Browder and Dean, 1999).

According to Browder and Dean (1999), the dredging has reduced the volume of the ebb shoals surrounding the inlet and created an overall loss of sediment from the littoral system. In ebb shoal systems, it has been noted that random changes in shoal location, size, shape, elevation, and other characteristics can alter the areas exposed to wave attack in the neighboring beaches and change the sand supply where shoals combine with the shoreline (Foster et al., 1999).

There has been no maintenance dredging of the Pensacola Pass entrance channel since 1991, because the aircraft carrier homeporting at Pensacola was not utilized (FDEP, 2000). The sedimentation rate of the channel is approximately 229,000 $m^3\ yr^{-1}$ (300,000 $yd^3\ yr^{-1}$) and the depth of the channel was approximately 12.2 m (40 ft) in 1997 (FDEP, 2000). When required, the channel will be dredged to maintain a depth of 10.7 m (35 ft) (FDEP, 2000).

Ship Island Pass was established by the River and Harbor Act of 1899 which provided for a 7.9-m (26-ft) deep channel. The channel was deepened to 9.75 m (32 ft) from 1948 to 1950 to accommodate Navy ships (Boom et al., 1991). In a 1989 study conducted by the USACOE, it was discovered that the western tip of Ship Island has migrated westward approximately 11.6 $m\ yr^{-1}$ (38 $ft\ yr^{-1}$) since 1848 (Boom et al., 1991). It is possible that the dredging of Ship Island Pass has halted this migration (Boom et al., 1991). Dredging activities also occur at Horn Island Pass, which lies on the west end of Petit Bois Island. Boom et al. (1991) recommended that this area be investigated to determine the effects of dredging on the westward migration of the island. In addition, it should be determined if similar problems such as those which have plagued Ship Island Pass could impact this system (Boom et al., 1991).

Two small jetties are located on the Perdido Key side of Pensacola Pass. The effects of these structures are believed to be minimal because of their relatively small size and location, well back in the inlet throat (Dean et al., 2005). The first nourishment project on Perdido Key (1985) placed almost 1.9 million m^3 (2.5 million yd^3) of sand along a distance of about 1,219 m (4,000 ft) (Browder and Dean, 1999). From the fall of 1989 to the fall of 1990, approximately 4.1 million m^3 (5.4 million yd^3) of sediment were placed over a distance of about 7,240 m (4.5 miles) (Browder and Dean, 1999). In 1990-1991, about 2.98 million m^3 (3.9 million yd^3) of sand was placed offshore at depths ranging from 5.8-6.1 m (19-20 ft) (Browder and Dean, 1999).

The effects of the Perdido Key beach nourishment on macrobenthic assemblages were studied by Rakocinski et al. (1996). This study found although there were some persistent changes in macrobenthic assemblages from restoration activities, there was appreciable recovery within the post-nourishment period (greater than two years) (Rakocinski et al., 1996). Near the beach, fairly rapid macrobenthic recovery occurred, suggesting that a finer time scale was required to closely monitor the recovery (Rakocinski et al., 1996). However, Rakocinski et al. (1996) state that one long-term impact of beach nourishment at several nearshore stations was the development of assemblages characteristic of deep nearshore profiles.

Ballast water

The sediment and water transported in ships' ballast tanks can disperse aquatic organisms including jellyfish, clams, crabs, fish, snails, bacteria, and viruses (Ache et al., 2000b). In 1998, Battelle (1998) estimated the discharge of ballast water for five GOM ports based on three different ship types. The Ports of Houston (including the Houston Ship Channel), Lower MS (including the ports of New Orleans, South Louisiana, and Baton Rouge), Gulfport, Mobile, and Tampa were included in the study based on 1996 data. The Lower MS Ports accounted for 79.3% of the ballast released from the five ports in 1996; however, all of the ship types for all five ports were found to contribute significant amounts of ballast to the GOM (Battelle, 1998). In addition to water quality concerns, ballast releases can introduce invasive species to the area.

The primary contributors of foreign and open-water ballast waters to the Port of Gulfport were assumed to be the overseas exports. It was estimated that the total ballast water released from these vessels in 1996 was 17.8 thousand metric tons (4.7 million gallons). Regarding the Port of Mobile, the total ballast water released from ocean-going vessels in 1996 was estimated to be 1.1 million tons (293 million gallons). Ballast water releases are expected to increase in the future based on trend data which shows annual increases in the volume of cargo shipped and current and planned port expansions (Battelle, 1998). Based on this information, ballast water management is an important issue, especially concerning the introduction of nonindigenous species into the GOM waters.

To reduce the number of species introduced during ballasting, several control options are being considered. One option is to avoid ballasting in waters that may contain undesirable organisms, such as those with high sediment loads or sewage discharges nearby (Ache et al., 2000b). Additional options are shipboard and shore-based treatment of ballast water. Despite the challenges of shipboard treatment, it provides the most flexibility for managing ballast water (Ache et al., 2000b). The high cost, possible delays in ship schedules, and lack of available land makes shore-based treatment prohibitive (Ache et al., 2000b). The best option to reduce the number of nonindigenous species introductions is the open ocean exchange of ballast. However, it is a voluntary practice in most countries and would require the implementation of international regulations to yield consistent measures in all countries (Ache et al., 2000b).

Sea-level rise

Sea-level rise is an important applied problem in coastal geology because of the land loss impacts and subsequent relationships to coast development and biological habitat. Potential effects of sea-level rise include coastal erosion, saltwater intrusion into groundwater resources, inundation of wetlands and estuaries, and threats to historic and cultural resources (Thieler and Hammar-Klose, 2000). Thieler and Hammar-Klose (2000) described the relative vulnerability of different environments along the GOM Coast to sea-level rise. Pendleton et al. (2004) used a CVI to map the relative vulnerability of GUIS to future sea-level rise. The CVI ranks six characteristics in terms of their physical contribution to sea-level rise-related coastal change. These factors include geomorphology, regional coastal slope, rate of relative sea-level rise, shoreline change rates, mean tidal range, and mean wave height (Pendleton et al., 2004). Index values were calculated for 1-minute grid cells covering the park. The index identified regions which are expected to be impacted the greatest by the physical effects of sea-level rise. The study evaluated approximately 145 km (90 miles) of the seashore and of this total, 24% was classified as having very high vulnerability due to sea-level rise, 18% as possessing high vulnerability, 36% as having moderate vulnerability, and 21% as having low vulnerability (Pendleton et al., 2004). The CVI values calculated for both sections of the park show that GUIS-MS may be more vulnerable to predicted sea-level rise (Pendleton et al., 2004).

The differences between the calculated indices for the two sections are related to the geologic variables, which include the geomorphology, regional coastal slope, and shoreline erosion and accretion rates (Pendleton et al., 2004). The calculated shoreline change rates from 1855-2001 are much higher for the MS islands. Very high erosion rates are produced on the east end of the barrier islands due to the strong westward alongshore transport system (Pendleton et al., 2004). Santa Rosa Island and Perdido Key were shown to have relatively stable shorelines over the last 150 years based on shoreline change data (Pendleton et al., 2004). In addition, the CVI calculated for Perdido Key was influenced by the beach nourishment that occurred from 1989-1990 (Pendleton et al., 2004). After eight years, Perdido Key had maintained 56% of the original 4.1 million cubic meters that was placed on the beach, and the beach was an average of 53 m wider than it was pre-nourishment (Browder and Dean, 2000). However, the long-term effects of nourishment on mitigating erosion are not known (Pendleton et al., 2004).

A2. Hydrologic Information

A2a. Estuarine Setting

GOM

The water quality of the Gulf is affected by river outflows, runoff from neighboring land, and the cycling of the Loop Current (MMS, 2003). The eastern shelf of the GOM is influenced by the outflow of the Mississippi River. Under typical conditions, the Mississippi River outflow extends 75 km (45 miles) east of the river mouth (Vitter and Associates, Inc., 1985). The Loop Current intrudes on the shelf at irregular intervals, producing both highly stratified and well-mixed conditions (Minerals Management Service (MMS), 2003). The Loop Current is a warm current that flows northward into the GOM through the Yucatan Channel then turns eastward before exiting through the FL Straits. The current occupies a band that is 90 to 150 km (56 to 93 miles) wide and transports 25 to 30 million m^3 of water per second (33 to 39 million $yd^3\ s^{-1}$) (Vitter and Associates, Inc., 1985). This current affects hydrology by producing numerous eddies, meanders, and intrusions (USEPA, 2004). The circulation patterns in the GOM are displayed in **Figures 11-13**. These figures show the results of three drifter deployments that occurred in 2002 (Dr. Alan Blumberg, Stevens Institute of Technology, pers. comm.).

Four factors strongly influence circulation on the continental shelf: open Gulf circulation (e.g. Loop Current), winds, tides, and freshwater discharge from rivers (Vitter and Associates, Inc., 1985). The Loop Current is the dominant force driving circulation when it is located on the shelf; when it is further offshore, it may drive counterclockwise circulation (Vitter and Associates, Inc., 1985). The inner shelf circulation is primarily driven by sustained winds. The current pattern and vertical characteristics of the water column along nearshore MS and AL is considered a two season event with transitional periods (Kjerfve and Sneed, 1984). In the winter, the water column is well-mixed due to storm events and low discharge from rivers. The dominant current pattern is alongshore toward the west during winter months. In the spring, the water column is partially stratified due to less frequent and intense storms and increased freshwater discharges from rivers. The reversal and reduction in prevailing winds to onshore conditions can reverse the regional circulation patterns to exhibit alongshore movement to the east (Kjerfve and Sneed, 1984).

The MS-AL shelf is characterized by fine sediments and suspended materials that result from the Mississippi River outflow (MMS, 2003). This shelf is characterized by a bottom nepheloid layer and surface lenses of suspended particles that originate from river outflow (MMS, 2003). The MS-AL shelf is a triangular-shaped region that extends from the Mississippi River delta eastward to the DeSoto Canyon (Vittor and Associates, Inc., 1985). The shelf's width varies from 128 km (77.7 miles) on the west to 56 km (34.8 miles) on the east (Vittor and Associates, Inc., 1985). The sediments are terrigenous to the west and integrate to carbonate sediments near DeSoto Canyon (FMC, 1998). The shelf and shelf break are characterized by low-relief hardbottom features termed "pinnacles" by Ludwick and Walton (1957). The pinnacles are composed of "hard, rigidly cemented, irregularly-shaped aggregates of calcareous organic structures" (Continental Shelf Associates, Inc., 1992). Ludwick and Walton (1957) found the average height of the pinnacles to be approximately 9 m (29.5 ft) and the average water depth to the top of the pinnacles to be 99 m (325 ft). Studies conducted in the northeastern GOM, specifically individual hardbottom features, have found greater species occurrence and diversity with increasing vertical relief (Continental Shelf Associates, Inc. 1992; Brooks, 1991).

Ludwick (1964) identified six broad sediment zones within the Tuscaloosa Trend study area of the report completed by Vittor and Associates, Inc. (1985). The Tuscaloosa Trend area is located primarily in the MS-AL shelf forming a transitional region between the West FL shelf and the Mississippi River delta. The report includes information for an area extending from the coastal marshes to a depth of 200 m (656 ft) (Vittor and Associates, Inc., 1985). The sediment zones nearest GUIS are the MS-AL sand facies and the nearshore fine-grained facies. The MS-AL sand facies are heterogeneous and variations over relatively short distances are observed (Pyle et al., 1975). The heterogeneity is attributed to the reworking of these sediments by wave activity and bioturbation (Vittor and Associates, Inc., 1985). The surface sediments of the MS-AL sand facies are quartz sands with less than 25% carbonates (Vittor and Associates, Inc., 1985). The sources of the heavy mineral suites (kyanite, staurolite, hematite, pyroxenes, and amphiboles) in the sediments have been identified as the southern Appalachians and the Mississippi River (Van Andel, 1960; Doyle and Sparks, 1980).

The West FL shelf has little sediment input and is primarily composed of high-carbonate sands offshore and quartz sands nearshore (MMS, 2003). The sediments are in the form of quartz-shell sand (> 50% quartz), shell-quartz sand (< 50% quartz), shell sand, and algal sand (FMC, 1998). The shelf bottom is made up of a flat limestone table with relief due to relict reef or erosional structures (FMC, 1998). There are several benthic habitat types including low relief hardbottom, thick sand bottom, coralline algal nodules, coralline algal pavement, and shell rubble (FMC, 1998). The west FL shelf is significant because of the number of fish and shellfish populations that inhabit the area (FMC, 1998). Commercially important species include striped mullet (*Mugil cephalus*), spotted seatrout (*Cynoscion nebulosus*), Spanish mackerel (*Scomberomorus maculata*), king mackerel (*S. cavalla*), Florida pompano (*Trachinotus carolinus*), snappers (*Lutjanus* spp.), and groupers (*Epinephelus* spp. and *Myctoperca* spp.) (FMC, 1998). This is attributed, in part, to the abundance of scattered rock outcrops and sponge bottoms that provide fish habitat (Darcy and Gutherz, 1984). The impact of the river outflow is rarely observed in FL, which possesses greater water clarity (MMS, 2003). Hypoxia is not common; however, low DO concentrations (2.93-2.99 mg/L) have been observed (Brooks, 1991).

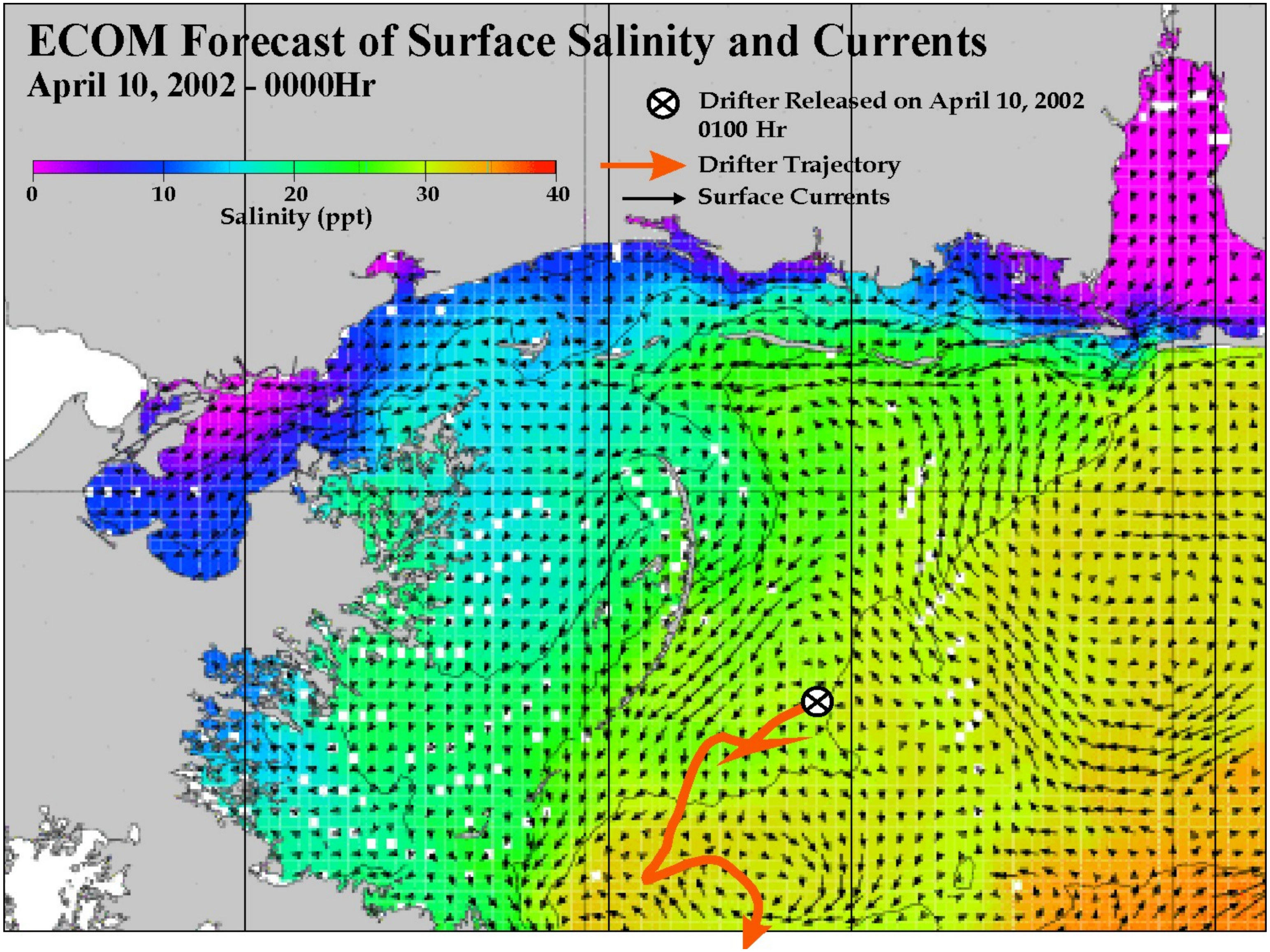

Figure 11. Gulf of Mexico surface salinity and currents, drifter released April 10, 2002, 0100 hr.

(Source: Dr. Alan Blumberg, Stevens Institute of Technology, pers. comm.)

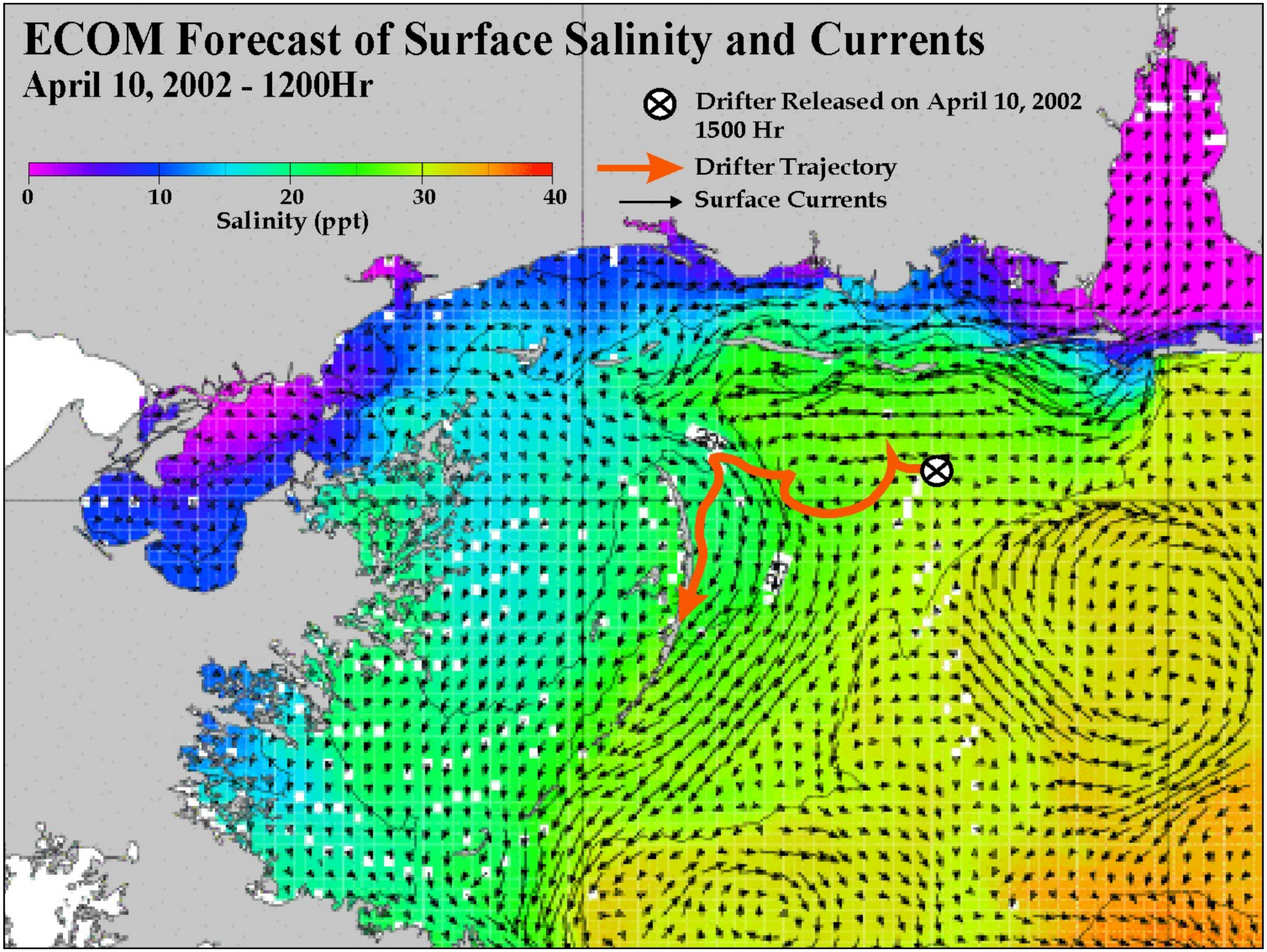

Figure 12. Gulf of Mexico surface salinity and currents, drifter released April 10, 2002, 1500 hr.

(Source: Dr. Alan Blumberg, Stevens Institute of Technology, pers. comm.)

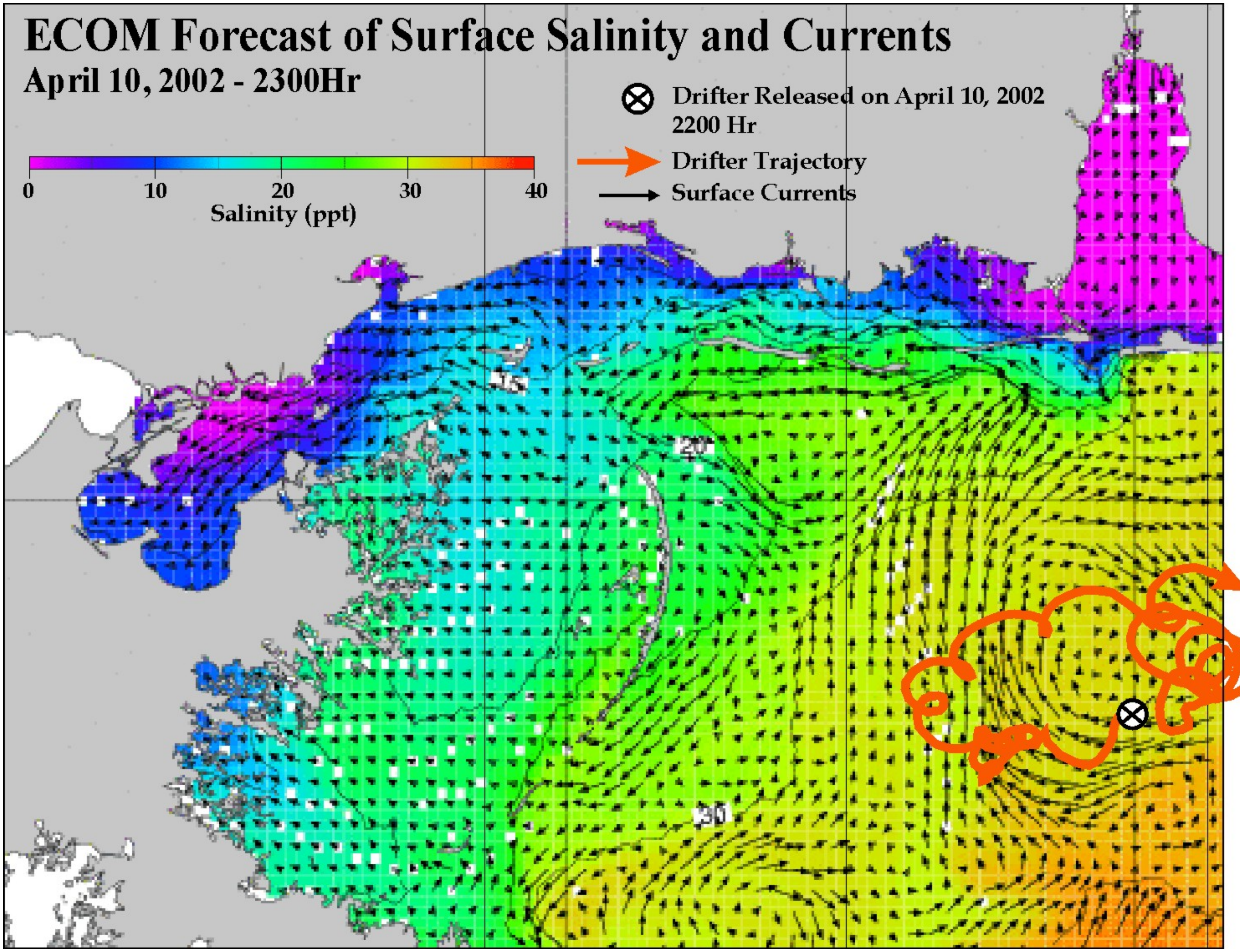

Figure 13. Gulf of Mexico surface salinity and currents, drifter released April 10, 2002, 2200 hr.

(Source: Dr. Alan Blumberg, Stevens Institute of Technology, pers. comm.

From 1974 to 1977, a large-scale baseline study was conducted in the Eastern GOM to gain an environmental overview of the MS, AL, and FL (MAFLA) outer continental shelf environment to 200 m (0.12 mile) (SUSIO, 1977; Dames and Moore, 1979). Analysis of water, sediments, and biota for hydrocarbons indicated that the MAFLA area is pristine, with some influence of anthropogenic and petrogenic hydrocarbons from river sources. The study also investigated trace metal contamination for nine metals, including barium, cadmium, chromium, copper, iron, lead, nickel, vanadium, and zinc, which also showed no contamination. The continental shelf off the coasts of MS and AL was revisited ten years later by Brooks (1991). This study sampled bottom sediments for high-molecular-weight hydrocarbons and heavy metals (Brooks, 1991). The sources of high-molecular-weight hydrocarbons are natural petroleum seeps at the seafloor or recent biological production in addition to anthropogenic sources. For the MS-AL shelf, the source of petroleum hydrocarbons and terrestrial plant material originates from the Mississippi River. The higher levels of hydrocarbons coincided with the increased river influx in the late spring. However, the hydrocarbon levels were low in winter months, indicating that they were washed away later in the year (Brooks, 1991). No trace metal contamination was observed (Brooks, 1991).

The primary factors affecting climate in the area include latitude and proximity to the GOM (Thorpe et al., 1997). Monthly average temperature ranges from 11°C (52°F) in January to 29°C (85°F) in July and August (Thorpe et al., 1997). There are two general wind patterns in the MS Sound and FL panhandle regions. Near MS Sound, the movement of the Bermuda High toward the GOM produces predominantly southeasterly winds in the spring (Wicker et al., 1989). The retreat of the high in the fall and winter leads to an increase in air masses from the north and west (Wicker et al., 1989). In the FL panhandle, the winds are generally from the north/northwest in the fall and winter, while during the summer, they are from the south/southwest (Thorpe et al., 1997). Humidity averages about 74% with an average annual rainfall of 163 cm (64 inches) in northwest FL. Rainfall events are heaviest in July, August, and September and lightest in October and November. Surface water flow is affected by extended and shorter droughts, the latter being more common (Thorpe et al., 1997).

Hurricanes and tropical storms are another major factor in northwest FL and coastal MS. Forty-eight hurricanes have come ashore on the FL panhandle between 1885 and 1985 (Wolfe et al., 1988). According to Muller and Stone (2001), Gulfport, MS, experienced 21 tropical storms and ten hurricanes (Categories 1-5) from 1901 to 2000. Ship Island was breached in 1969 during Hurricane Camille, resulting in the formation of two separate islands (East and West Ship) that appear to be evolving separately (Schmid, 2001). Recent hurricanes impacting the area include Hurricanes Ivan (2004), Opal (1995), and Erin (1995). The storm surge associated with Hurricanes Opal and Ivan caused considerable damage to property, coastal dunes, and associated habitats on Santa Rosa Island. The effects of Hurricane Ivan continue to be felt in the area. At the publishing of this report, the Fort Pickens and Santa Rosa areas of the park remain closed due to damages caused by Hurricane Ivan on September 16, 2004.

The response of beaches to cold fronts along the northern GOM were investigated by Stone et al. (2004) and Stone and Wang (1999). The data from these studies indicate that barrier islands can conserve mass during catastrophic hurricanes (e.g. Hurricane Opal, category 4 near landfall), less severe hurricanes can promote rapid dune and berm aggradation and contribute sediment to the entire barrier system, cold fronts play an integral role in the poststorm adjustment of the barrier, and the northern GOM systems do not necessarily enter an immediate poststorm recovery phase, despite the sediment-reach nearshore environments. Stone et al. (2004) also report that cold fronts are more effective in reworking sediments following extreme weather events, such as hurricanes.

Pensacola Bay System (PBS)

The PBS is composed of five interconnected estuarine embayments: Blackwater Bay, East Bay, Escambia Bay, Pensacola Bay, and Santa Rosa Sound, and three major river systems: the Blackwater, Escambia, and Yellow Rivers (**Figure 14**) (Thorpe et al., 1997). Characteristics of the estuarine components are provided in **Table 4**. The contributing watershed area is about 18,130 m^2 (7,000 $mile^2$) and includes the majority of Escambia, Santa Rosa, and Okaloosa Counties as well as portions of Walton County and southern AL (Thorpe et al., 1997). The entire system discharges into the GOM through a half-mile pass at the mouth of Pensacola Bay called the Caucas Channel.

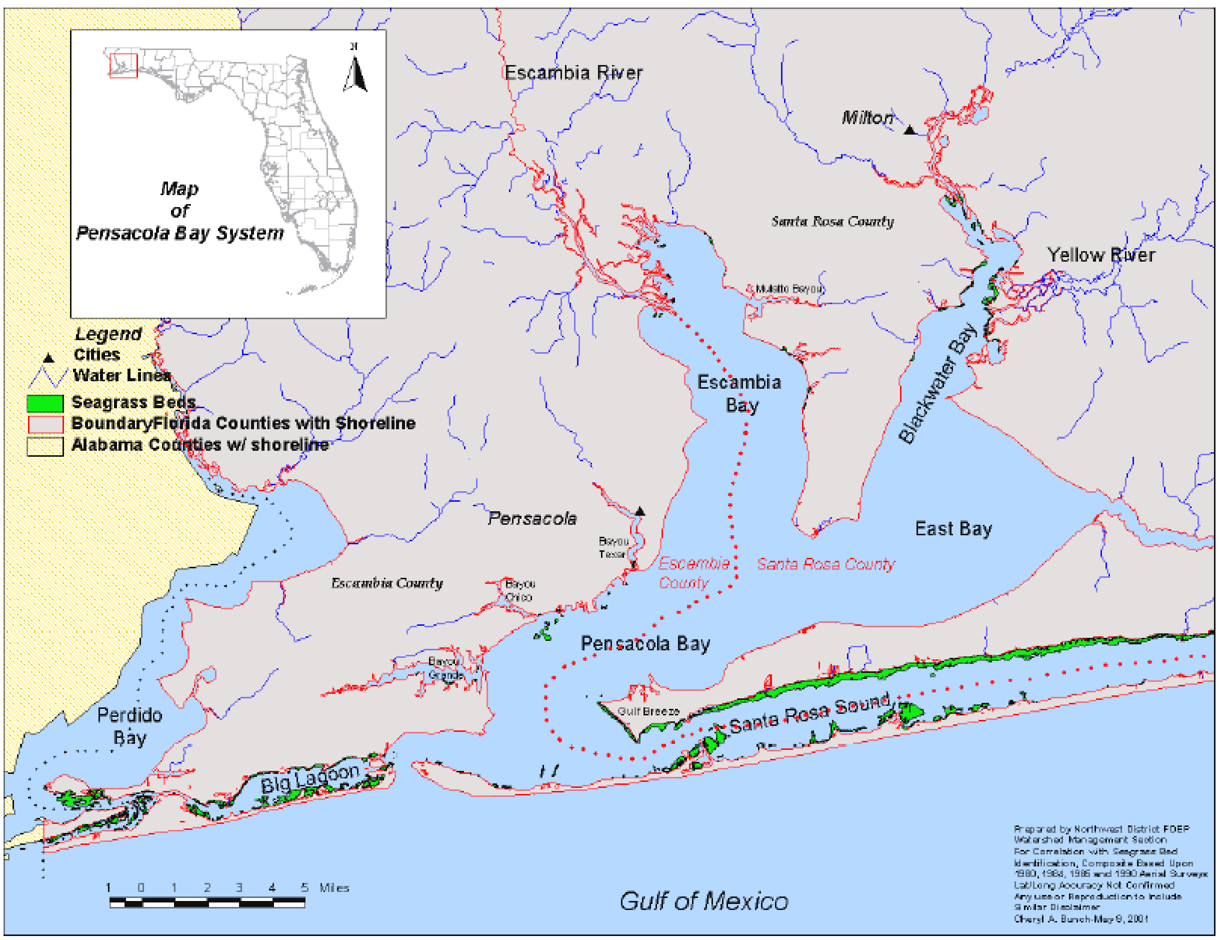

Figure 14. Geographic and political boundaries of the Pensacola Bay System.

(Figure obtained from Schwenning, 2001).

Table 4. Surface area and mean depth of the bays and selected bayous of the Pensacola Bay System.

Waterbody	Surface Area (km^2)	Mean Depth (m)
Pensacola Bay	140.0	5.9
Bayou Grande	3.9	2.7
Bayou Chico	1.0	1.8
Bayou Texar	1.6	1.9
East Bay	114.0	2.4
Easy Bay Bayou	4.4	1.2
Escambia Bay	93.2	2.4
Mulatto Bay	0.8	1.5
Blackwater Bay	25.4	1.9
Catfish Basin	0.8	1.2
Santa Rosa Sound	110.0	2.7

Adapted from Olinger et al., 1975.

The PBS is best classified as a microtidal system with a maximum tidal range of about 0.5 m (1.6 ft) (Collard, 1991). The average annual significant wave height is about 0.61 m (2 ft) or less, the mean period is between 1.3 and 1.5 m (4.3 and 5.0 ft), and the predominant wave direction is from the southeast (Browder and Dean, 1999). For these systems, tidal currents are important at the mouth of the system and at inlets, such as bayous. Sediment transport is primarily through wind- and wave-driven currents. Sandy sediments are located near river mouths and deltas, while finer silts and clays are found in deeper, central areas of the system. The tides are irregular and cannot be classified as diurnal, semidiurnal, or mixed (Collard, 1991).

Due to the small tidal prism and weak tidal currents, the energy required for mixing must be supplied by the wind. The flushing rates are low, with the exception of lower Pensacola Bay, when little wind is present (Collard, 1991). Contaminants entering the system from rivers and bayous remain for long periods because of this poor flushing. Increased river flow and intense solar radiation coupled with the weak tidal currents produce a highly stratified system during summer months. The hydrodynamics of the system are not understood well enough to predict the fate of an introduced contaminant (Thorpe et al., 1997). This is not only due to the lack of hydrodynamic information but also because little is known about the chemical processes that occur in the benthos or the methods of sediment deposition from the overlying water column (Thorpe et al., 1997).

Pensacola Bay

Pensacola Bay is bordered by the city of Pensacola to the north, Escambia Bay to the east, Big Lagoon to the west, and Santa Rosa Island and the Gulf Breeze peninsula to the south. The average depth of the bay is approximately 5.9 m (19.5 ft) (Olinger, 1975).

Pensacola Bay is often strongly stratified with surface salinities of approximately 0.6 ppt near the Pensacola municipal pier and bottom salinities of up to 25 ppt (McNulty et al., 1972). Circulation in Pensacola Bay is not as well documented as Escambia Bay, but it is known that tidal flushing is more pronounced than in Escambia, East, and Blackwater Bays (Thorpe et al., 1997). The path of incoming (high) tides is eastward along the southern part of the bay with outgoing (low) tides traveling toward the pass from the northern and western portions of the bay (Reidenauer and Shambaugh, 1986). Circulation in the bay is strongly influenced by surface winds and the effects are not limited to the upper water layers (Olinger, 1975).

Currently, the Northwest District Office of the FDEP is developing a “real-time” water quality monitoring network within the Pensacola Bay watershed (FDEP, 2004a). Stations within the network are located in the Escambia River, Blackwater River, Blackwater Bay, East Bay, Escambia Bay, and Pensacola Bay (FDEP, 2004a). The results collected are presented online with water quality reports that are updated hourly. Due to the impacts of Hurricane Ivan, the network is offline and redeployment of the data collection devices is pending (FDEP, 2004a).

Escambia Bay

Escambia Bay is surrounded by the City of Pensacola to the west, the Garcon Point peninsula to the east, and the Escambia River delta to the northwest. The bay receives water from the Escambia River, Mulatto Bayou, Trout Bayou, Indian Bayou, and Bayou Texar basins (Thorpe et al., 1997). The circulation pattern is considered counterclockwise as the Escambia River discharges and flows southward along the western shore while more saline waters enter on the eastern shore (Hudson and Wiggins, 1996). Circulation is influenced by railroad and highway bridges as well as surface winds (Thorpe et al., 1997).

Escambia Bay receives non-point source pollution from the City of Pensacola and the surrounding coastal areas. In the past, it has also received substantial inputs from industrial and domestic wastewater discharges, which have stressed the system (Thorpe et al., 1997).

Blackwater and East Bays

Blackwater Bay receives discharge from the Blackwater River. The Garcon Point peninsula borders it to the west. East Bay is downstream and receives discharges from the Yellow and East Rivers in addition to Blackwater Bay (Thorpe et al., 1997). Circulation is counterclockwise and strongly influenced by winds, especially during periods of low flow (Hudson and Wiggins, 1996).

These bays are considered the least impacted by anthropogenic sources in the PBS, but the most vulnerable to future activities. This vulnerability results from the lower energy and tidal flushing of Blackwater and East Bays compared to other estuaries of the system (Collard, 1991). Population growth in Santa Rosa County may also affect the system by increasing non-point source pollution.

Santa Rosa Sound

Santa Rosa Sound is a lagoon between mainland FL and Santa Rosa Island. The sound extends approximately 57.9 km (36 miles) in an east-west direction and varies from 0.32 to 3.5 km (0.2 to 2.2 miles) in width (FDEP, 1993). Shellfish harvesting in the sound was discontinued in 1991-92 due to low demand; however, this change is not reflected in the Florida Administrative Code (FAC 62-302.400) (Chris Knight, Division of Aquaculture, pers. comm.). There is moderate commercial barge traffic in the ICWW. The sound supports some of the most stable and diverse seagrass beds in the PBS and receives little freshwater inflow. The water quality threats to the lagoon include non-point source pollution and habitat loss due to the increasing urbanization in the area. The sound also receives runoff from several neighboring golf courses (Thorpe et al., 1997).

The Navarre Bridge Causeway divides the sound into two sections of approximately the same size, the eastern and western sections. This leads to a bi-directional tidal flow (FDEP, 1993). The salinity and depth of the sound are uniform with mean annual values of 24 ppt and 2.7 m (8.9 ft) (Hand et al., 1996).

Big Lagoon

Big Lagoon covers a surface area of approximately 46 km^2 (18 mi^2) and connects Pensacola and Perdido Bays. The majority of the southern portion lies within FL Aquatic Preserve boundaries, classifying it as an OFW. Despite this classification, the system receives stormwater containing heavy metals and nutrients (Schwenning, 2001).

Perdido Key and Perdido Bay

Perdido Key forms a natural barrier island that is 23 km (14 miles) long along the northern GOM (Rakocinski et al., 1996). The easternmost 11 km (6.8 miles) of the island are owned by the USDOI/NPS and managed as part of GUIS. Lunar tides are diurnal and average about 0.5 m (1.6 ft). The surf conditions are considered moderate and usually do not reach heights greater than 2.5 m (8.2 ft), with the exception of storm events and fronts (Rakocinski et al., 1996).

Perdido Key is characterized by flat erosional sandy beaches common to the northeastern Gulf Coast (Rakocinski et al., 1996). The unrestored foreshore beach slopes are generally shallow, ranging from 5 to 10 degrees (Rakocinski et al., 1996). Typically, there are one to two distinct nearshore sandbars located near the breaker zone, which is approximately 50 to 75 m (164 to 246 ft) from the shore. These sandbars are parallel to the beach under natural conditions (Rakocinski, 1996). The natural intertidal and subtidal sediments are composed of primarily (> 94%) medium to well-sorted fine to medium-grain quartz sand (200-400 µm median diameter) with small amounts of shell hash and organic matter (< 6%) (Rakocinski et al., 1993).

With the creation of Pensacola Pass, the littoral sediment drift of Perdido Key was interrupted, which resulted in the erosion of Perdido Key at a rate of 0.5 m yr^{-1} (1.6 ft) for over 125 years (Stone et al., 1992). As one method to offset this trend, the USACOE conducted a two-phase project involving beach and profile nourishment. The dredge material for both of these phases originated from Pensacola Pass. During beach nourishment, the 4.1 million m^3 (5.4 million yd^3) of dredge material was hydraulically applied along 7 km (4.35 mile) of shoreline using a movable pipeline system (Otay and Dean, 1993). The profile nourishment phase involved applying 3.0 million m^3 (3.92 million yd^3) of dredge material subtidally by hopper dredge. The elevation of the sea floor was raised by more than 2 m (6.6 ft) over much of the subtidal disposal area (Otay and Dean, 1993).

Perdido Bay has a surface area of approximately 6,973 ha (26.9 miles^2) and an average depth of about 2.4 m (7.9 ft) (Wicker et al., 1989). Bault (1972) reported the presence of salinity stratification in the bay, although it was less pronounced than other nearby systems, such as

Mobile Bay, AL. The surface salinities of the water in the bay range from 10 ppt in January to 22 ppt in October, based on measurements from the middle of the bay. The average salinity based on integration of samples from throughout the water column is about 20 ppt (Bault, 1972).

Choctawhatchee Bay

The Choctawhatchee Bay system receives water from a drainage area of approximately 330 km^2 (129 $mile^2$). The primary freshwater input is the Choctawhatchee River, which contributes about 85% of the freshwater into the bay (Jones and Huang, 1994). The bay extends 43 km (27 miles) in an east-west direction and is 1.6 to 9.7 km (1 to 6 miles) wide. The depth of the bay ranges from 3 to 13 m (10 to 43 ft) (Thorpe and Ryan, 1996). The bay is connected to the GOM through East Pass, which is located directly south of Destin, FL. The diurnal tide range is approximately 0.15 m (0.5 ft) (Jones and Huang, 1994).

Choctawhatchee Bay is classified as a stratified system due to a halocline that separates lower salinity surface water from denser, high salinity water (Livingston, 1986). The high salinity waters are generally found in deeper areas of the western and central bay and can become hypoxic during summer months (Livingston, 1986). There is limited flushing of the system, which is dominated by river discharge (Jones and Huang, 1994).

MS Sound

MS Sound is bordered to the south by a series of barrier islands, including Cat, Ship, Horn, and Petit Bois Islands, that are separated by wide, shallow passes. Ship channels are maintained off the west ends of Petit Bois and Ship Islands where deeper water is found. Major drainages into the sound include the Pascagoula and Pearl Rivers. The average depth of the sound is 3 m (9.9 ft) (Eleuterius, 1976). The tides in MS Sound are diurnal with a range of approximately 0.45 m (1.5 ft) and a mean tide level equal to 0.24-0.27 m (0.8-0.9 ft). The tides are strongly influenced by the prevailing winds, which are northerly to northeasterly during the winter and southerly to southeasterly during the summer (Christmas, 1973). They progress eastward and westward from Horn Island Pass with the majority of water exchange occurring through Cat Island Channel, Dog Keys Pass, and Petit Bois Pass (USACE/MOB, 1983). The two principal diurnal components of the tide are K_1[2] and O_1[3] with periods of 23.93 and 25.84 hours.

Wave heights generally follow the same trends as wind speed; therefore, mean wave heights are at a minimum in the summer and a maximum during the winter (Vittor and Associates, 1985). The average annual wave heights, based on visual near breaker observations, are approximately 0.42 to 0.52 m along the North Central Gulf Coast (Thompson, 1977). Wave measurements recorded by the USACOE Coastal Engineering Research Center at the Destin, FL, Pier found that 90% of the wave heights were less than 0.9 m. Stone et al. (2004) reported calculated modal breaker wave heights of 0.7 m (2.3 ft) near Santa Rosa Island and wave heights of approximately 50% of this value for the MS barriers. Wave heights on the MS-AL shelf have been reported to be 3.6 m (11.8 ft) throughout the year, with maximum observations of 6 m (19.7 ft) during the winter (TerEco, 1979).

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[2] Luni-solar diurnal tide component.
[3] Principal lunar diurnal tide component.

The salinity of the system varies seasonally and annually (Christmas et al., 1966). Christmas et al. (1966) reported average salinities of 28.0 and 11.3 ppt on the north side of the barrier islands in May 1963 and May 1964. At the same time, the average salinities for stations on the mainland were 20.4 and 5.6 ppt, respectively. The salinity at the west end of the sound is consistently lower due to freshwater input from the Pearl River and Lake Pontchartrain drainages (located in eastern LA) (Christmas et al., 1966).

A study completed by Eleuterius (1976) described the general patterns of flow for MS Sound based on circulation and salinity regimes. The report states that in east MS Sound, all of the water contributed by Mobile Bay enters the sound through Petit Bois Pass (Eleuterius, 1976). The outflow from the west passage of the Pascagoula River flows along the MS shoreline until it turns southwest and then exits through Dog Keys Pass (Eleuterius, 1976). The east passage of the river is directed seaward by spoil placed along the western side of the channel. In the central section of MS Sound, the circulation and corresponding salinity patterns are dominated by the tidal flow through Dog Keys and Ship Island passes (Eleuterius, 1976). The western section of MS Sound displayed a lower salinity regime compared to the other sections. The water column is uniform and there is little exchange between the waters of the sound and the GOM (Eleuterius, 1976).

Kjerfve (1983) also described the circulation patterns in MS Sound based on data collected from an extensive program conducted for the USACOE by Raytheon (1981). It was stated that the general circulation pattern of MS Sound is induced by the tides and that the wind significantly affects these tidal currents (Kjerfve, 1983). Kjerfve (1983) described that as the diurnal tide enters MS Sound at Horn Island Pass; it bifurcates and divides the Sound into two areas. During flood tide, the currents enter and split with a portion traveling east to Mobile Bay and the remainder westward to Lake Borgne. This process is reversed during ebb tide when flow exits through these passes (Kjerfve, 1983).

Recently, the hydrodynamics of MS Sound and the adjoining rivers, bays, and shelf waters have been modeled as part of the Northern GOM Littoral Initiative which is a multi-agency program headed by NAVOCEANO and the USEPA's GOM Program (Ahsan et al., 2002; Blumberg et al., 2000). The model was calibrated and validated using field observations from September 2002. Comparison between the model results and field data are reasonably good, indicating that the overall circulation and mixing patterns are being represented accurately (Ahsan et al., 2002). Another goal of the project was to assess the model's sensitivity to variations in input parameters such as bathymetry, freshwater flows, wind forcing, temperature, and salinity boundary conditions. This analysis revealed that the model was very sensitive to bathymetry and freshwater inflows (Ahsan et al., 2002).

The composition of the sediments in MS Sound varies spatially. In the central portion of the sound, the dominant sediments are silt and clay muds (less than 62 μm) (Upshaw et al., 1966). This area encompasses a 4.8 to 14.5-km (5-9 mile) wide region from Gulfport to Ship Island and a 4.8 to 8.0-km (3-5 mile) wide region between Bellefontaine Point and the east tip of Horn Island (Otvos, 1973a). Additional areas with muddy sediments are located near the mouths of the Back Bay of Biloxi and the Pascagoula River (Otvos, 1973a). Combinations of sand and mud are located between Biloxi Bay and Dog Keys Pass, between Pascagoula and eastern Horn

Island, and west of Cat Island (Otvos, 1973a). In the open sound, the majority of the sands are fine to very fine (62-250 μm) with the exception of the areas between Round and Horn Islands which possess medium to coarse sands (Upshaw et al., 1966). Medium to coarse sands are also found on the mainland beaches west of the Pascagoula River and along the GUIS-MS barrier islands (Upshaw et al., 1966). The sediments near the mainland east of the Pascagoula River are characterized as fine sands, silts, and clays (Upshaw et al., 1966).

St. Louis Bay

St. Louis Bay is 8 km (5 miles) wide and extends 6.4 km (4 miles) inland. The Jourdan and Wolf Rivers, Bayous La Croix and Portage, and several smaller bayous empty into St. Louis Bay. Although there are no marsh islands in St. Louis Bay and extensive marshes are not associated with either the Jourdan or Wolf Rivers, Bayous La Croix and Portage are bordered by marsh (Christmas, 1973).

The Jourdan and Wolf Rivers and Bayous La Croix and Portage are Gulf Ecological Management Sites (GEMS) and MS Coastal Preserves. The Jourdan and Wolf River Preserves are approximately 26 km^2 (6,423 acres) and 10 km^2 (2,426 acres), respectively. The Bayou La Croix and Portage Preserves are approximately 6 km^2 (1,478 acres) and 5 km^2 (1,137 acres), respectively. General threats to the integrity of these preserves are residences with open septic systems (Bayous Portage and La Croix and Jourdan River) and land development (Wolf River) (MS DMR, 1998).

Biloxi Bay system

Biloxi Bay is located between Deer Island and the MS mainland and covers an approximate area of 41 km^2 (16 $miles^2$) (Christmas, 1973). The Biloxi and Tchoutacabouffa Rivers initially empty into Big Lake, which is separated by a natural channel from the Back Bay of Biloxi to the east. The Back Bay of Biloxi then joins Biloxi Bay to the southeast (Renick, 2001). The Back Bay of Biloxi, Old Fort Bayou, and Davis Bay empty into Biloxi Bay. Davis, Heron, Stark, and Simmons Bayous subsequently empty fresh water into Davis Bay; each drains adjacent marshes and contains freshwater areas near the origin. Seawater from MS Sound passes through Biloxi Bay (Christmas, 1973).

The Back Bay of Biloxi is 13 km (8 miles) long and varies in width from 1.2 to 1.6 km (0.75 to 1 mile) (Christmas, 1973). Six marsh islands are located in the Back Bay; additional marsh expanses are associated with the Biloxi and Tchoutacabouffa River systems and Old Fort and Bernard Bayous. The Biloxi Peninsula separates the narrow, shallow estuarine embayment formed by the Biloxi Bay and the Back Bay of Biloxi from the more saline MS Sound.
The Biloxi River Marsh, Davis Bayou, Old Fort Bayou, and Escatawpa River Marsh are GEMS and MS Coastal Preserves. Their respective areas are 16 km^2 (4,020 acres), 6 km^2 (1,410 acres), 6 km^2 (1,459 acres), and 11 km^2 (2,826 acres). A cause for concern to the health of the preserves is residences with open septic systems (MS DMR, 1998).

A2b. Hydrology

FL

The primary river systems in the PBS are the Escambia, Blackwater, and Yellow Rivers. These rivers and their tributaries generally flow south from the FL panhandle to the estuaries described above. The predominant land uses in this area include forestry, military, agriculture, public conservation and recreation, and some residential and urban development. The river systems vary in length, basin size, and type (**Table 5**).

Table 5. Selected attributes for rivers of the Pensacola Bay System.

River	Length (km)	Watershed Area (km^2)	Average Annual Discharge (cms)	Floodplain Forest (ha)
Escambia	286	10,900	178[1]	16,254
Blackwater	100	2,227	9.7[2]	4,040
Yellow	177	3,535	33[3]	12,862
Shoal	80	1,292	31.3[4]	no data

[1]near Century [2]near Baker [3]near Milligan [4]near Crestview

Source: Fernald and Patton, 1984.

The Escambia River originates in Alabama as the Conecuh River and travels south approximately 386 km (240 miles) to Escambia Bay. Of the 11,000 km^2 (4,223 $mile^2$) drainage area, 1,100 km^2 (425 $mile^2$) are in FL. Tidal influence on the river extends at least 16 km (10 miles) upstream (Thorpe et al., 1997). The river is classified as a classic alluvial river, meaning that there is a heavy sediment load and substantial fluctuations in flow rates (Fernald and Patton, 1984). The river provides a number of aquatic and wetland habitats. Most of the habitat is provided by snags, exposed tree roots, and undercut banks due to the minimal amount of in-stream vegetation (Bass, 1990).

The Blackwater River originates in Bradley, AL, and travels south 98 km (62 miles) to discharge in Escambia Bay. Most of the watershed area (approximately 88%) lies in FL (Fernald and Patton, 1984). Flow originates predominately from groundwater with some contribution from surface runoff (Livingston et al., 1988). The Blackwater River is designated an OFW and is used for a variety of recreational activities. The river is a reddish color due to the presence of tannic and organic acids from the acidic flatwoods and other wetlands that the river and its tributaries drain (FREAC, 1989).

The Yellow River originates in AL and travels 148 km (92 miles) to Blackwater Bay. Approximately 2,230 km^2 (860 $mile^2$) of the 3,500 km^2 (1,365 $mile^2$) drainage basin is in FL. Tidal effects have been observed as far as 31 km (19 miles) upstream. It is described as a sand bottom river with clear-tan waters (Thorpe et al., 1997). The main tributary of the Yellow River is the Shoal River, which originates in Walton County, FL. The Shoal River, the lower portion of the Yellow River, and portions of Blackwater and East Bays are designated OFW. All except the Shoal River are included in the Yellow River Marsh Aquatic Preserve (Thorpe et al., 1997).

MS

The significant freshwater inflows to MS Sound are the Pontchartrain Basin, the Pearl and Pascagoula Rivers, and the St. Louis and Biloxi Bays. The Pontchartrain Basin and the Pearl River contribute approximately 56% of the total freshwater inflow, the Pascagoula River 37.5%, and the basins of St. Louis and Biloxi Bays 6.5% (Wicker et al., 1989). In addition, some of the inflow from Mobile Bay is diverted into MS Sound through Pass aux Herons (Wicker et al., 1989).

The Pascagoula River Basin covers most of southeastern MS and part of southwestern AL. At approximately 264 km (164 miles) long and 135 km (84 miles) wide, it is the second largest basin in MS. The Leaf and Chickasawhay Rivers, which converge to form the Pascagoula River, are the two largest headwater streams in the Pascagoula River system. This system receives water from a drainage area of approximately 35,100 km^2 (9,700 $mile^2$) and is the last major river system that is unimpeded in the lower 48 states (MDEQ, 2000). The river then continues km 129 km (80 miles) south before eventually draining into the GOM (Strom, 1998) The drainage areas near the GOM are marshlands, low-lying flat lands, and forested wetland (MDEQ, 2000).

The Pascagoula River discharges 430 cms (15,200 cfs) into MS Sound. This provides freshwater, nutrients, and sediments, making the basin an important contributor to the maintenance of the salt marsh habitat and the discharge of nutrients into coastal waters (Christmas, 1973; MDEQ, 2000).

The Pascagoula River Marsh is a GEMS and MS Coastal Preserve. The brackish coastal marsh associated with the mouth of the Pascagoula River, roughly 85 km^2 (21,000 acres), accounts for approximately 35% of the total marsh habitat in Coastal MS; the preserve houses 45 km^2 (11,150 acres) of that marsh habitat (MDEQ, 2000; MS DMR, 1998). Although some areas south of the Escatawpa River are affected by industrial pollution associated with that river, the majority of the preserve area is relatively unspoiled. Future water quality problems associated with residential and industrial development, such as saltwater intrusion or northward expansion of the marsh, may be imminent if water continues to be diverted from the Pascagoula River and its tributaries (MS DMR, 1998).

Groundwater

Groundwater hydrology is also important because of interactions with surface water and wetlands. Two studies were conducted involving groundwater quality near Fort Pickens. One study investigated the water quality of drinking wells in the area and reported that most met FL state drinking water quality requirements (Cooper et al., 2004). Two wells exhibited high levels of total dissolved solids, while several had high levels of *Enterococcus* sp. and fecal coliforms (Bortone and White, 1996). DeBusk (1998) investigated the effects of a septic system leachfield on groundwater and surface waters over a one-year period. These waters were tested for bacterial and nutrient contamination.

Although there is not much information available about the groundwater resources of GUIS, characteristics of the region have been described (Cooper et al., 2004). The sand-and-gravel aquifer underlies much of northwest FL, extending from central Walton County northwest into AL and south to the GOM. The sand-and-gravel aquifer is made up of the Pliocene Citronelle Formation, Pleistocene terrace deposits, and Miocene coarse clastics. It is located at depths of 15.2 to 91.4 m (50 to 300 feet) below land surface. Below this aquifer is the Intermediate System, which is a confining unit with thicknesses ranging from 91.4 to 365.8 m (300 to 1,200 feet) in Escambia County. There is an aquifer located in this layer but the depth and poor water quality prohibit its use for water supply. Under this layer, is the Floridan Aquifer, which is separated into two layers by a Bucatunna Clay confining unit (Escambia County, 1999).

The sand-and-gravel aquifer is the primary source of drinking water in Escambia and Santa Rosa Counties and a secondary source in Okaloosa and Walton Counties (Katz and Choquette, 1991). However, increasing water demands on the Floridan Aquifer have increased the importance of the sand-and-gravel aquifer as a water source in Walton and Okaloosa Counties (Guvansen, 2000).

The recharge zone for this region is north of the site. Recharge is primarily from infiltration of rainfall (Guvansen, 2000). The regional slope of the aquifer is to the west-southwest with lenses and layers of gravel, silt, and clay. The "main-producing" zone of the aquifer in central and southern Escambia County is 30 to 90 m (98 to 295 ft) below land surface. Studies have shown that regional groundwater flow is strongly affected by pumping. Near Pensacola, water levels dropped 7 to 8 m (23 to 26 ft) between 1940 and 1973 in areas with heavily pumped well fields (Trapp, 1975). Nearby streams also showed decreased baseflow, indicating that some of the water was intercepted by nearby wells (Katz and Choquette, 1991).

The water quality of the sand-and-gravel aquifer is considered exceptionally good. The water is some of the softest and least mineralized in FL because of the relatively insoluble quartz that makes up the aquifer (Marsh, 1966). The hardness is generally less than 25 ppm, chloride levels range from 3 to 15 ppm, and dissolved solids from 20 to 80 ppm (Marsh, 1966). The abundance and high water quality of groundwater in the area has attracted numerous industries. Industrial plants located in the Pensacola area currently or in the past include Champion International Corporation (pulp and paper mill), Solutia, Inc. (synthetic fiber manufacturer), Air Products and Chemicals, Inc. (chemical manufacturer), and Gulf Power (electric company) (Marsh, 1966). The impacts of these facilities on water resources are discussed in section B3a.

Escambia and Santa Rosa Counties contain many springs that supply small streams that are notched into the edges of the flat upland (Marsh, 1966). These streams often originate in canyons called steepheads (Sellards, 1918). Steepheads are unique formations caused when groundwater leaks out from a slope composed of very porous sediment at the head of a stream catchment. According to Marsh (1966), many of the springs at the head of these steepheads are located along extensive layers of clay or hardpan. Examples of steepheads are found on the Eglin AFB in southeastern Santa Rosa County. The largest spring in the two counties is Chumuckla Mineral Springs in northwest Santa Rosa County (Marsh, 1966).

The geologic units that contain freshwater near the Davis Bayou unit of GUIS-MS are of the upper Miocene to Recent in age (Christmas, 1973). The freshwater is located in layers of sand that occur irregularly and at depths ranging from 366 to 914 m (1,200 to 3,000 ft) below the surface (USDOI/NPS, 1978). Below these depths, warmer saline water is present, as salinity generally increases with depth (Christmas, 1973). Freshwater is located in geologic strata of approximately the same age under the MS barrier islands (USDOI/NPS, 1978). Artesian water is provided from the sand beds and lenses of the Miocene formation at depths of about 180 to 244 m (590 to 800 ft) below sea level. Below these depths, warmer, saline water is also found with varying mineral content (USDOI/NPS, 1978).

A2c. Upland water resources

The discussion thus far has focused on water resources surrounding the park, but there are inland saline, brackish, and fresh waterbodies that have also been studied. Waterbodies located in the park are not all permanent and can be filled in with windblown sand (Snyder et al., 1997). The ponds are formed by hurricane storm surges that hollow out shallow depressions. Swales are also formed by wind activity that scours to the groundwater table. The ponds located within the boundaries of GUIS have varying salinities depending on their primary water source (rainfall, groundwater, inflow from Pensacola Bay, etc.). The majority of the studies involving these ponds have investigated the Fort Pickens area, Horn Island, and Petit Bois Island.

Snyder et al. (1997) investigated the salinity of three ponds after the storm surge of Hurricane Opal. The authors noted that at that time, the Fort Pickens area contained four major waterbodies, numerous smaller ponds, permanent wetlands, and temporary wetlands in dune blow outs (swales). All three ponds tested were brackish. The salinities of four ponds located near Fort Pickens ranged from 0 to 30 ppt (Snyder et al., 1997). During the study period, the salinity of the GOM ranged from 27 to 36 ppt and the salinity of the groundwater was recorded at 0 ppt (Snyder et al., 1997).

The report states that the origin of these ponds is unknown but formation mechanisms include former breeches of the barrier island during severe storms or focused sand overwash and transport. One of the ponds had a continuous narrow berm separating it from Pensacola Bay, another had a direct connection via a small inlet, and the third had the highest, widest berm separating it from the bay. Two of the three ponds closely tracked the salinity of Pensacola Bay, while the third had a low, steady salinity after the salt brought in with the storm surge dissipated. The report also described the results of floral and faunal surveys of the ponds and wetlands (Snyder et al., 1997). Fish species collected in the four ponds are included in **Table 6**.

Snyder et al. (1997) observed three main vegetation zones in the ponds and wetlands in the Fort Pickens area. The perimeter of the ponds was marked by southern narrow-leafed cattail (*Typha angustifolia*) or black needlerush (*Juncus roemerianus*) with sawgrass (*Cladium* spp.) in a landward zone when groundwater was available (Snyder et al., 1997). Shoreward of the emergent vegetation, a transitional scrub zone of wax myrtle (*Myrica cerifera*) was noted (Snyder et al., 1997). The zone graded into upland stands of wax myrtle mixed with live oaks (*Quercus virginiana*) and slash pine (*Pinus elliottii*), which transitioned from one pond to another (Snyder et al., 1997).

Another study completed by Boyd et al. (1995) documented the current biodiversity and ecological features within GUIS pond and lagoon fauna. In this study, 10 ponds were visited seasonally with an additional 12 visited on one or two occasions. The sampling sites included two ponds in the Naval Live Oaks area, two ponds in the Fort Pickens area, two in the Perdido Key area, two on Petit Bois Island, nine on Horn Island, three on West Ship Island, and two ponds in the Davis Bayou area. The pond habitats were characterized according to water quality, bottom type, associated vegetation, and some of the major faunal components (Boyd et al., 1995). Measured parameters included temperature, salinity, DO, pH, water depth, bottom substrate composition, wind, and cloud cover (Boyd et al., 1995). It was discovered that the oligohaline ponds had high pH readings which were attributed to high dissolved calcium carbonate in the waters (Boyd et al., 1995). The report encouraged further study of this phenomenon (Boyd et al., 1995).

The study concluded that the ponds of GUIS provide valuable, although often temporary, habitat for a number of plant and animal species (Boyd et al., 1995). Boyd et al. (1995) documented over 140 different vertebrate and invertebrate species during their study. The most common animal species encountered in the ponds were the hydrobiid snail (*Littoridinops monroensis*) and the peocilid fish (*Gambusia affinis/holbrooki*). Boyd et al. (1995) recommended that certain ponds be monitored at least once a year, preferably in the fall, to document changes in faunal species and/or water quality and following a catastrophic event, the ponds should be monitored for changes in flora and fauna composition, water chemistry, and the effects of sand inundation and shore erosion (Boyd et al., 1995). The report also stated the need for monitoring the changes in biotic and abiotic conditions when ponds are formed or destroyed (Boyd et al., 1995). Studies similar to Snyder et al. (1997) have addressed some of these topics.

The previous studies regarding Fort Pickens and Horn and Petit Bois Islands can provide useful information for data comparison; if the ponds still exist. Permanent stations should be established in the ponds that are known to hold water the majority of the year. These stations should be routinely sampled (quarterly or semiannually) for field parameters, such as DO, salinity, conductivity, pH, water temperature) and nutrients (total nitrogen, nitrite + nitrate, ammonia, TP, orthophosphorus) and chlorophyll *a*. In addition, ponds which dry out should be studied intensively when water is present to determine impacts on wildlife utilizing the areas for habitat.

For areas where surveys have been completed and locations of ponds mapped, this information should be transferred to a GIS. These data will be especially useful following catastrophic events, such as Hurricane Ivan. Physical parameters of the ponds and their locations following the hurricane will provide useful information on the effects and subsequent recovery of the system. In the future, the locations and physical characteristics of the ponds can be observed and the effects of storm events noted.

There is little information concerning dissolved and sediment metals information in the ponds and lagoons. However, the preliminary results of a contamination study indicate that mercury may be a potential problem in the park's ponds (Riley Hoggard, USDOI/NPS, pers. comm.). Additional sampling is required to determine if other types of contamination are present. If these samples do not indicate contamination and there are no suspected sources in the area, more intensive investigation is not necessary. The ponds should continue to be analyzed for metals and contaminants on a less frequent basis to avoid future water quality issues.

Bacterial monitoring is not necessary because these waters are not utilized for recreation or drinking water, so useful information would not be provided from this testing.

Table 6. Fish species collected in the four major ponds of the Fort Pickens area of Gulf Islands National Seashore.

Species	Common Name
Brevoortia patronus	Gulf Menhaden
Opsanus beta	Gulf Toadfish
Strongylura marina	Atlantic Needlefish
Fundulus similis	Longnose Killifish
Fundulus grandis	Gulf Killifish
Fundulus pulvereus	Bayou Killifish
Cyprinodon variegatus	Sheephead Minnow
Adinia xenica	Diamond Killifish
Lucania parva	Rainwater Killifish
Poecilia latipinna	Sailfin Molly
Gambusia affinis	Mosquitofish
Menidia beryllina	Tidewater Silverside
Syngnathus scovelli	Gulf pipefish
Eucinostomus argenteus	Spotfin Mojarra
Lagodon rhomboides	Pinfish
Bairdiella chrysura	Silver Perch
Leostomus xanthurus	Spot
Cynoscion nebulosus	Spotted Seatrout
Mugil cephalus	Mullet
Sphyraena barracuda	Barracuda
Gobiosoma bosci	Naked Goby
Microgobius gulosus	Clown Goby
Prionotus tribulus	Sea Robin

Source: Snyder et al., 1997.

The ponds and lagoons of Horn and Petit Bois Islands were surveyed by Shabica and Watkins (1982) and Cofer-Shabica (1989). Shabica and Watkins (1982) determined the locations and sizes of the ponds and provided recommendations for future research. Cofer-Shabica's (1989) study included geophysical descriptions of the ponds, their evolution, and salinity. It was reported that there were 63 ponds on Horn Island that covered 5.8% of the island's landmass and on 17 ponds that covered 3.2% of the land mass of Petit Bois Island. The waterbodies ranged from brackish to saline depending on the strength of several factors including washover, connection to the MS Sound, rainwater, and percolation (Cofer-Shabica, 1989).

A3. Biological resources

There have been numerous reviews of the flora and fauna of GUIS and the surrounding estuaries. A research review was recently completed by investigators from the University of Georgia (Cooper et al., 2004) that summarizes the biological resources and ecosystem studies completed involving GUIS. This review in conjunction with the Pensacola Bay Surface Water Improvement and Management Plan (Thorpe et al., 1997), the Final Environmental Statement –

Gulf Islands National Seashore (USDOI/NPS, 1978) and the Ecological Characterization of the FL Panhandle (Wolfe et al., 1988) are used to describe the species associated with the different habitats of GUIS. A report prepared for Gulf Islands National Seashore by the Coastal Research and Extension Center (CREC) of Mississippi State University describes the vegetation communities and associated species that are specific to the Davis Bayou area of GUIS-MS (CREC, 2002). Additional information on estuarine fauna in the vicinity of Pensacola can be found in a report published by the FL Department of Natural Resources Marine Research Laboratory (Cooley, 1978). This report provides a listing of species with information on their seasonal occurrence, abundance, and habitats. Wolfe et al. (1988) also provided a list of the plants classified as endangered, threatened, commercially exploited, or under review and vertebrates classified as threatened, endangered, under review, or of special concern in the panhandle regions. Peterson and Waggy (n.d.) compiled a field guide to the aquatic habitats and common fauna of the northern GOM which lists the species located in several habitats including the muddy/sandy bottoms of waterbodies, seagrass beds, oyster reefs, salt marshes, and surf zones.

A3a. Marine habitats

Offshore waters

The GOM provides habitat for numerous fish species, turtles, and marine mammals, including dolphins and whales. No large scale fish surveys have been conducted by GUIS, but over 200 species of fish have been documented in the waters in and around GUIS (USDOI/NPS, 2003b). Common fish and shark species found in the GOM are included in **Table 7**.

Choctawhatchee Bay was sampled in 2002 as part of Florida's Inshore Marine Monitoring and Assessment Program (IMAP). IMAP is a collaborative project between the USEPA and the FL Marine Research Institute designed to assess the ecological condition of Florida's inshore waters using a set of ecological indicators. As part of this project, fish sampling was conducted (both trawls and seines) in the summer of 2002. The results are shown in **Table 8**.

The types of threatened and endangered sea turtle species near the park include loggerheads (*Caretta caretta*), green (*Chelonia mydas*), Kemp's Ridley (*Lepidochelys kempii*), and leatherbacks (*Dermochelys coriacea*). The nesting activities of sea turtles have been monitored and recorded in several reports (Zimmerman and Hopkins, 1992; Reinhold, 1994; Nicholas and Jacks, 1996). Sea turtles continue to be researched and monitoring of their nesting habitats is ongoing. Each summer, GUIS biologists and volunteers mark, date, and observe sea turtle nests over a 34-km (21-mile) stretch of FL beaches. To prevent hatchlings from becoming disoriented, volunteers watch and intervene, when needed, to move the hatchlings toward the GOM waters (USDOI/NPS, 2003a).

Atlantic bottle-nosed (*Tursiops truncatus*) and spotted (*Stenella plagiodon*) dolphins are common to the area. Rare marine mammals include small whales and West Indian manatees (*Trichechus manatus*) (USDOI/NPS, 2003a).

Table 7. Common fish and shark species found in FL and MS estuarine open waters.

Group	Species	Common Name
Fish	*Anchoa hepsetus*	Striped anchovy
	Anchoa mitchilli	Bay anchovy
	Archosargus probatocephalus	Sheepshead
	Arius felis	Sea catfish
	Bagre marinus	Gafftopsail catfish
	Bairdiella chrysoura	Silver perch
	Brevoortia patronus	Gulf menhaden
	Cynoscion arenarius	Sand seatrout
	Cynoscion nebulosus	Spotted seatrout
	Echeneis naucrates	Remora
	Elops saurus	Ladyfish
	Leiostomus xanthurus	Spot
	Menidia beryllina	Silverside
	Menticirrhus americanus	Southern kingfish
	Menticirrhus littoralis	Gulf kingfish
	Micropogonias undulatus	Atlantic croaker
	Monocanthus hispidus	Planehead filefish
	Mugil cephalus	Striped mullet
	Pogonias cromis	Black drum
	Sciaenops ocellatus	Red drum
	Urophycis floridana	Southern hake
Sharks	*Carcharhinus acronotus*	Blacknose shark
	Carcharhinus isodon	Finetooth shark
	Carcharhinus leucas	Bull shark
	Carcharhinus limbatus	Blacktip shark
	Rhizoprionodon terraenovae	Atlantic sharpnose shark
	Sphyrna lewini	Scalloped hammerhead
	Sphyrna tiburo	Bonnethead

Sources: Wolfe et al., 1988 and Peterson and Waggy, n.d.

Table 8. Results of Inshore Marine Monitoring and Assessment Program (IMAP) fish sampling (seines and trawls combined) for Choctawhatchee Bay, summer 2002.

Category	NUMSETS*	MNABUN	PCTSETS	TOTNUM
Callinectes sapidus	31	28	19.75	83
Lagodon rhomboides	15	27	9.55	82
Leiostomus xanthurus	15	132	9.55	395
Callinectes similis	12	13	7.64	40
Cynoscion arenarius	9	7	5.73	20
No gear set[1]	9	0	5.73	0
Farfantepenaeus duorarum	6	5	3.82	14
Trinectes maculatus	6	5	3.82	14
Farfantepenaeus aztecus	5	4	3.18	11
Synodus foetens	5	3	3.18	8
Micropogoias undulatus	4	2	2.55	7
Prionotus scitulus	4	3	2.55	9
Anchoa mitchilli	3	7	1.91	20
Etropus crossotus	3	1	1.91	4
Gobiosoma bosc	3	2	1.91	6
Paralichthys albigutta	3	1	1.91	4
Bagre marinus	2	2	1.27	6
Chaetodipterus faber	2	1	1.27	2
Citharichthys macrops	2	1	1.27	2
Citharichthys spilopterus	2	2	1.27	6
Etropus microstomus	2	3	1.27	10
Eucinostomus harengulus	2	1	1.27	2
Gobionellus boleosoma	2	2	1.27	7
Symphurus plagiusa	2	1	1.27	2
Ancylopsetta quadrocellata	1	0	0.64	1
Brevoortia spp.	1	1	0.64	3
Chilomycterus schoepfi	1	0	0.64	1
Litopenaeus setiferus	1	1	0.64	3
Menticirrhus americanus	1	1	0.64	3
Monacanthus ciliatus	1	0	0.64	1
No fish[2]	1	0	0.64	0
Ortopristis chrysoptera	1	1	0.64	2

*NUMSETS = number of sets by sampling unit in which the listed species was caught;
MNABUN = mean abundance per set;
PCTSETS = percent of total sets by sampling unit containing the listed species;
TOTNUM = total number of individuals caught by species and sampling unit.

[1]Various conditions existed which rendered a site unsamplable for fish including high algal bycatch, bottom obstructions, unsafe seining or trawling conditions, or unsuitable depths (too deep or too shallow.

[2]No fish were obtained during sampling.

Source: McRae et al., 2003.

Seagrass ecosystem

Seagrass beds provide protection for juvenile fish species, filtration of suspended materials from the overlying water column, and colonizing surfaces for epiphytic algae and benthic invertebrates. Seagrasses generally occur in isolated patches less than several hundred acres in size in GUIS's protected waters. In the turbid MS Sound waters, seagrasses are rarely found in waters deeper than 1.8 m (6 ft), while in the clearer waters of Santa Rosa Sound, seagrass beds can be found in depths up to 3.7 m (12 ft) (USDOI/NPS, 1978). Preliminary monitoring results conducted by the FDEP demonstrated that seagrass grows to greater depths in Santa Rosa Sound than in Big Lagoon. The monitoring also showed that as one moves toward Pensacola Pass, the depths of beds increase. Seagrasses are found at greater depths in Santa Rosa Sound because of the greater average depth of the system and possibly the increased flushing and better overall water quality compared to Big Lagoon (Schwenning, 2001). The water quality of Big Lagoon has been impacted by stormwater runoff and increased turbidity, decreasing the light available to seagrasses (Schwenning, 2001).

The major seagrasses found in Santa Rosa Sound are shoal grass (*Halodule wrightii*) and turtle-grass (*Thalassia testudinum*). The predominant species in Perdido Bay are widgeon grass (*Ruppia maritima*) and shoal grass (Handley, 1995). Beds of shoal grass are also located along the northern shorelines of Ship, Horn, and Petit Bois Islands as well as to the west and north of Cat Island (Moncreiff et al., 1998). Tape-grass (*Vallisneria americana*) is also located in the brackish waters of GUIS (USDOI/NPS, 1978).

Declines in seagrass distribution and diversity have been observed in the waters surrounding and within GUIS. Seagrass beds were once abundant (1949) in the PBS, but since 1975, these beds have receded or been destroyed (FDEP, 1998). Habitat loss was also reported by Moncreiff et al. (1998) in MS Sound, specifically near Ship Island and Dog Keys Pass. The same report noted that shoal grass beds located along the barrier islands of GUIS-MS once supported stands of manatee-grass (*Syringodum filiforme*), turtle-grass, and star grass (*Halophila engelmannii*). Widgeon grass is also found in isolated, well-developed patches along the coastline and in some of the shoal grass beds along the MS barrier islands (Moncreiff et al., 1998). It was estimated that the seagrass coverage decreased 66%, from 416 ha (1,029 acres) of seagrasses to 140 ha (345 acres), along the MS gulf coast between 1956 and 1987 (Handley, 1995). According to Handley (1995), the largest concentration of seagrasses was found on the north side of Horn Island, where 169 ha (417 acres) in 1956 declined to 56 ha (138 acres) by 1987, and to 6 ha (14 acres) by 1992.

A three-year study conducted by Heck et al. (1996) found that there were constant coverages of *H. wrightii* and *T. testudinum* in Santa Rosa Sound and Big Lagoon, but the density and aboveground biomass decreased over the study period. In the lower portion of Perdido Bay, changes in seagrass density occurred, and the seagrass coverage declined from 486 ha (1,201 acres) in 1940-41 to 251 ha (619 acres) in 1987 (Handley, 1995). During this period, some areas in USGS quadrangles lost as much as 82% of the seagrasses. These changes were due to increased turbidity (dredging and boat traffic), shoreline modifications, degrading water quality and sedimentation from increasing development, and the effects of Hurricane Frederick (1979) (Handley, 1995).

Moncreiff et al. (1998) documented areas of submerged aquatic vegetation (SAV) in MS Sound to determine the changes in distribution from 1969 to 1992. The areas near the barrier islands of GUIS-MS are included in **Table 9**. Also included is the area identified as suitable habitat for seagrasses. For Ship Island and Dog Keys Pass, the potential seagrass habitat is less than the historical (1969) area of seagrass habitat, which indicates habitat loss. Habitat loss occurred in areas that have experienced coastal erosion and long-term sand movement (Otvos, 1981). Decreases in water clarity and differences in mapping techniques were also cited as reasons for the loss of SAV (Moncreiff et al., 1998).

Table 9. Estimated areas of submerged aquatic vegetation (SAV) in MS Sound in 1969 and 1992 with potential seagrass habitat.

	1969	1992	Potential Seagrass Habitat
Cat Island	242 ha 598 acres	68 ha 169 acres	2,075 ha 5,128 acres
Ship Island	621 ha 1,536 acres	103 ha 253 acres	648 ha 1,603 acres
Dog Keys Pass	841 ha 2,079 acres	0 ha 0 acres	465 ha 1,149 acres
Horn Island	2,253 ha 5,567 acres	215 ha 530 acres	1,760 ha 4,350 acres
Petit Bois Island	684 ha 1,690 acres	147 ha 364 acres	732 ha 1,810 acres

Source: Moncreiff et al., 1998.

These losses have occurred as the result of human activities and natural events. The primary cause of seagrass disappearance is considered to be an overall decline in water quality (Moncreiff et al., 1998). Anthropogenic activities affecting seagrass communities include propeller scarring and increased turbidity resulting from dredging. Nutrients and pollutants transported in runoff lead to increased turbidity by promoting algal blooms and suspended materials in the water column. Research in Big Lagoon demonstrated that increased nutrients can stimulate epiphytic growth, limiting the light available to the seagrass (Wear et al., 1999). Heck et al. (1996) proposed that turbid water, epiphyte growth, and stressful salinities were the reasons behind the declines in density and aboveground biomass in Big Lagoon.

Historically, sewage and industrial waste discharges from point sources have impacted seagrass habitats the most. However, in recent years, non-point sources of pollution are increasing due to coastal development (Schwenning, 2001). The major threats to the seagrasses in Santa Rosa Sound are increased stormwater runoff and development pressure from neighboring communities (Schwenning, 2001). The Sound also receives discharge from the Navarre and Pensacola Beach wastewater treatment plants and runoff from spray irrigation for disposal of treated municipal wastewater (FDEP 1998). Recently, a seagrass survey of GUIS-FL was completed by the USEPA Gulf Ecology Division in Gulf Breeze, FL. The results are currently under review for publication (Dr. Michael Lewis, USEPA Gulf Ecology Division, pers. comm.).

Seagrass beds are also impacted by marine transportation, specifically sediments stirred up by activities related to shipping, such as barge traffic and channel dredging, and propeller scarring. Propeller scarring damages seagrass beds by destroying both aboveground and belowground (rhizomes and roots) biomass (Schwenning, 2001). Scarring occurs most often in areas that are less than 1-m (3.3-ft) deep at low tide (Schwenning, 2001). If the scarring is widespread, the amount of productive seagrass habitat can be greatly reduced (FDEP, 1998). Aerial photographs taken during the spring and fall of 2000 indicate that there are areas of light to moderate scarring in Santa Rosa Sound and Big Lagoon (Schwenning, 2001). Boaters can prevent future scarring by being aware of propeller depths and seagrass beds and avoiding areas where propeller scarring is likely to occur (FDEP, 1998). It is recommended that aerial photos be taken at regular intervals, such as every five years, to identify newly affected areas, monitor seagrass recovery, and protect areas at risk for seagrass loss. If the proposed rule for PWC use is approved, the impacts of these craft on seagrass beds should also be monitored as part of this effort.

Natural events causing seagrass loss include disease, storm events, salinity fluctuations, and hypoxic events (Moncreiff et al., 1998). Eleuterius and Miller (1976) estimated that approximately 30% (2,428 ha) of the seagrasses in MS Sound were destroyed as a result of the impacts of Hurricane Camille (1969) and the lower salinity waters which resulted from increased freshwater inputs. In addition, hurricanes can lead to seagrass bed destruction through burial and increased water turbulence (USDOI/NPS, 1978). Monitoring conducted by the FDEP Ecosystem Restoration Section from 20 sites in Santa Rosa Sound and Big Lagoon found that the increased turbidity and nutrient enrichment effects from stormwater runoff can impact the amount of photosynthetically active radiation (PAR) available to seagrasses for several days (Schwenning, 2001) (**Figure 15**). Moncreiff et al. (1998) reported that the primary mechanisms responsible for

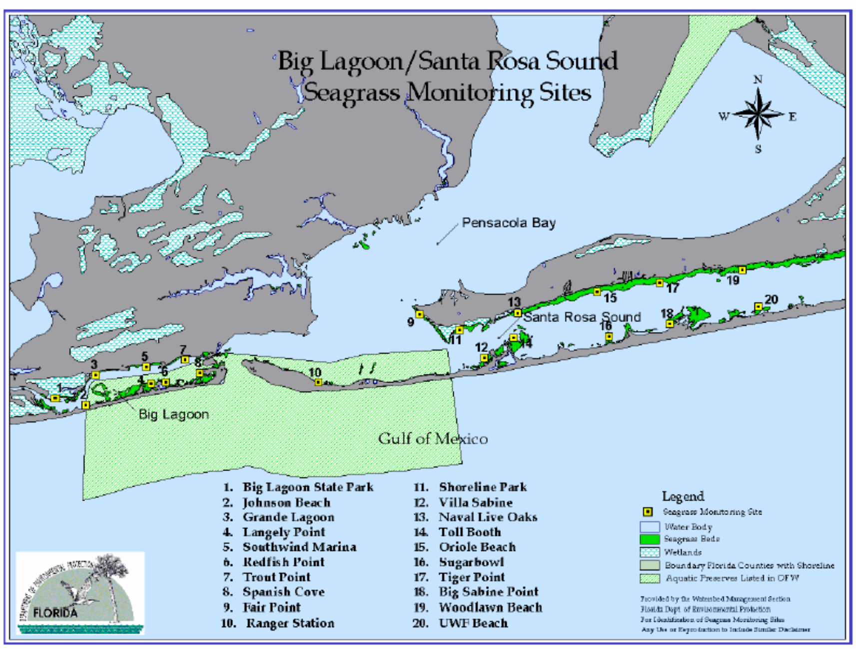

Figure 15. Seagrass monitoring sites of the FL Department of Environmental Protection Ecosystem Restoration Section in Big Lagoon and Santa Rosa Sound.

(Figure obtained from Schwenning, 2001).

the disappearance of seagrasses are most likely an overall decline in water quality, extended periods of depressed salinities, and physical disturbances, such as hurricanes and tropical storms.

Oyster beds

The PBS is classified differently during the winter and spring/fall for shellfish harvesting (**Appendix B1**). Harvesting is prohibited in Pensacola Bay north of I-10, Blackwater Bay north of Escribano Point, and the East Bay Bayou throughout the year (FDACS, 2004). During the spring and fall, most of Escambia Bay is classified as conditionally approved by the FDEP with the exception of a portion of northwest bay, which is classified as prohibited (FDACS, 2004). During the winter, most of the bay is classified as conditionally restricted with the exception of certain areas along the eastern bay, which are classified as conditionally approved (FDACS, 2004). The majority of East Bay is classified as conditionally approved during winter months with the exception of the northwest portion, which is conditionally restricted (FDACS, 2004).

The oyster industry in the PBS has been described as "marginal and subject to wide swings in production" (Thorpe et al., 1996). Scallops and shrimp are also found in the system; however, bay scallops are only found in the limited areas where stable seagrass communities have been established.

The oyster bed communities found in Choctawhatchee Bay are populated by the American oyster (*Crassostrea virginica* Gmelin). The heaviest concentration of oyster beds is located on the southern shore of the bay in Walton County. Shellfish harvesting in Choctawhatchee Bay has been limited due to water quality and bacterial contamination issues. The area classified for shellfish harvesting (Class II) extends east of White Point in the north and Santa Rosa Island in the south, excluding Alaqua and LaGrange bayous (Burch, 1983).

A3b. Intertidal habitats

Beach and dune systems

The beach dune community is made up of two major plant groups, the hardy pioneer plants located close to the water and the plants on the protected side of the dune. Plants including sea oats (*Uniola paniculata*), sea rocket (*Cakile lanceolata*), dune elder (*Iva imbricata*), sea purslane (*Sesuvium portulacastrum*), railroad vine (*Ipomoea pes-caprae*), and evening primrose (*Oenothera humifusa*) are typically found on the seaward side of the dunes (Thorpe et al., 1997; Wolfe et al., 1988). These hardy plants are able to withstand alkaline soil, salt spray, strong winds, and wide temperature fluctuations (USDOI/NPS, 1978). Sea oats aid in dune stabilization because of their extensive root system. On the protected side of the dunes, Spanish bayonet (*Yucca aloifolia*), myrtle oak (*Quercus myrtifolia*), prickly-pear cactus (*Opuntia humifusa*), greenbriar (*Smilax auriculata*), and saw palmetto (*Serenoa repens*) are present (Thorpe et al., 1997).

Santa Rosa Island has steep beaches on the GOM side (5% slope) with gently sloping beaches on the Santa Rosa Sound side. In addition, there are over 20 cuspate spits on the sound side (USDOI/NPS, 1978). The beach is composed of pure white quartz sand with a median diameter of approximately 0.25 mm (Wolfe et al., 1988). At wider sections of the island, there are longitudinal dunes aligned with the dominant summer wind. Also, located in the depressions among these dunes are ponds. These dunes serve a number of functions including protection from wind, salt spray, and overwash (USDOI/NPS, 1978). The sediments of Santa Rosa Sound differ from the other bays in the PBS due to their coarser mean grain size and lower average silt-clay content (Wolfe et al., 1988). The origins of these sediments are most likely offshore sources rather than fluvial (Wolfe et al., 1988).

The MS barrier islands are characterized by four environments: interior dunes, coastal marshes, interior brackish ponds and creeks, and interior sand flats. The ocean beaches, which face higher-energy waves, are much wider and better developed than those that face MS Sound. Ponds and small lakes form in the depressions between the steep interior sand dunes. The majority of the dunes are below 4 m (13 feet), but some ridges on Horn Island reach up to 8 m (26 feet) (USDOI/NPS, 1978).

The MS island foreshore and nearshore deposits are well- to very well-sorted fine and medium sand (medians commonly between 0.25 and 0.49 mm) (Otvos, 1973a). The average grain size is coarser on the lower energy (north side) of the islands due to the differential transportation of the fine fraction (Otvos, 1973b). The foreshore sands are generally near-symmetrical or finely-skewed, while the inshore and breaker-step samples are coarsely- or strongly coarsely-skewed (Otvos, 1973a). The shoal areas between the islands are composed of well- and very well-sorted medium sands (Otvos, 1973a).

The fauna that inhabit the beaches and sand dunes must also be adapted to the harsh conditions. Reptiles do especially well in coastal communities and the following species are common to the FL panhandle: garter snake (*Thamnophis sirtalis*), black racer (*Coluber constrictor*), coachwhip (*Masticophis flagellum*), cottonmouth (*Agkistrodon piscivorus*), and pygmy rattlesnake (*Sistrurus miliarius*) (Wolfe et al., 1988). Mammals encountered include eastern moles (*Scalopus aquaticus*), beach mice (*Peromyscus polionotus* subsp.), rice rats (*Oryzomys palustris*), cotton rats (*Sigmodon hispidus*), cottontails (*Sylvilagus floridanus*), and marsh rabbits (*Sylvilagus palustris*) (Thorpe et al., 1996). Birds that inhabit these beaches include the black skimmer (*Rynchops nigra*), common tern (*Sterna hirundo*), brown pelican (*Pelecanus occidentalis carolinensis*), and laughing gull (*Larus atricilla*) (Thorpe et al., 1996).

Almost all major groups of invertebrates are found in the marine fauna of GUIS, but species diversity is limited (USDOI/NPS, 1978). There are a few species of sponges in the park's waters and the redbeard sponge (*Microciona prolifera*) is most obvious to casual observers. The Anthozoan fauna is limited to a few species of corals, sea anemones, sea pens, and sea pansies because of the seashore's temperature and salinity. Representatives from the classes Hydrozoa (hydroids), Scyphozoa (large jellyfish), and Anthozoa (sea anemones and stony corals) are included as the seashore's fauna. Flatworms that are free-living, commensal, and parasitic can be found in the park's waters. *Cerebratulus lacteus* are found in shallow waters, *Polychaetes* are abundant, and *Calcareous serpulid* tubes occur on solid surfaces (USDOI/NPS, 1978).

The distribution of mollusks is strongly related to salinity. One hundred sixty three species of mollusks have been found in MS Sound. The largest native gastropods are conch shells and other native snails include oyster drill (*Thais haemastoma*), moon shell (*Polinices* spp.), and several species of olive shells (*Olivella* spp. and *Oliva* spp.). The coquina clam

(*Donax variabilis*) can be found in local, dense concentrations and cockle shells are commonly washed ashore (USDOI/NPS, 1978).

Many crustacean species are abundant in the seashore; in fact, more species are classified in the phylum Arthropoda than any other. Brown (*Penaeus aztecus)*, white (*Penaeus setiferus*), and pink (*Penaeus duorarum*) shrimp are found in MS Sound, while pink shrimp are more abundant than the other two species in Santa Rosa Sound. A variety of crab species are also native to the park such as blue (*Callinectes sapidus*), stone (*Menippe mercenaria*), wharf (*Sesarma cinereum*), ghost (*Ocypode quadrata*), horseshoe (*Limulus polyphemus*), spider (*Libinia emarginata*), and several species of fiddler crabs (*Uca* spp.) Arthropod landforms include centipedes, insects, spiders, mites, and ticks, such as the black widow spider (*Latrodectus mactans*), the wood tick, the rabbit tick, and the chigger. Mosquitoes (*Aedes taeniorhynchus* and *Aedes sollicitans*), sandflies (*Culicoides* spp.), deerflies (*Tabanidae* spp.), and dogflies (*Tabanidae* spp.) are also present in large numbers periodically during the summer months (USDOI/NPS, 1978).

GUIS provides habitat for endangered and/or threatened plant and animals including the Perdido Key Beach Mouse (*Peromyscus polionotus trissyllepsis*), several species of turtles, and numerous shorebirds (**Table 10**). The Perdido Key Beach Mouse once inhabited an area stretching from Perdido Bay, AL, to Pensacola Bay, FL. Now its range is limited to two protected areas, the Perdido Key State Recreation Area and GUIS's Johnson Beach (USDOI/NPS, 2003a). Habitat loss results from anthropogenic activities as well as natural events such as hurricanes and other severe storms. Hurricanes can wash away the dunes and plants that provide these animals with needed shelter and food.

Salt marshes

Salt marsh areas are located in the protected waters of all the offshore islands and several of the mainland sections of GUIS. Saltmarshes cover an area of 2.24 km^2 (554 acres) near Petit Bois Island, 2.40 km^2 (594 acres) near Horn Island, 1.04 km^2 (258 acres) near East and West Ship Islands, and 1.21 km^2 (300 acres) near Santa Rosa Island. These marshes are generally divided into three categories: high marsh, brackish marsh, and tidal marsh. The high marsh occupies land that is 1 meter (3.3 ft) above mean sea level and is only inundated during the highest tides. The soil remains moist because of shading provided by dense mats of hurricane grass (*Fimbristylis spathacea)*. The tidal marsh is inundated by tides once a day. The majority of vegetation includes black rush (*Juncus roemerianus*), marsh spikegrass (*Distichlis spicata*), and saltwort (*Batis maritima)* (USDOI/NPS, 1978).

An extensive tidal marsh community is located in the Davis Bayou section of the park. The organic matter and nutrients produced in these marshes support marine invertebrates and decomposers in nearby bays and estuaries (USDOI/NPS, 1978). Low marsh, mid-elevation marsh, and high marsh examples of tidal marshes are present in the area. Low marsh, cordgrass-dominated (*Spartina alterniflora)* areas are relatively extensive in the Davis Bayou section of the park; mid marsh, black needlerush-dominated areas are common and more extensive; and high marsh, salt marsh hay-dominated *(Spartina patens)* areas occur in upland or wetland transition

Table 10. Federal and state listed species that have been documented or are possible inhabitants of Gulf Islands National Seashore (adapted from USDOI/NPS GUIS website and past research).

Species	Scientific Name	Status[1]
Plants		
Florida perforated cladonia	*Cladonia perforata*	Federally Endangered; FL-CI
Mammals		
Perdido beach mouse	*Peromyscus polionotus trissyllepsis*	Federally Endangered; FL Endangered
Red wolf	*Canis rufus*	Federally Endangered
Reptiles		
Loggerhead turtle	*Caretta caretta*	Federally Threatened; FL Threatened; MS-CI
Leatherback turtle	*Dermochelys coriacea*	Federally Endangered; FL Endangered
Kemp's Ridley sea turtle	*Lepidochelys kempii*	Federally Endangered; FL Endangered; MS-CI
Green sea turtle	*Chelonia mydas*	Federally Endangered; FL Endangered
Gopher tortoise	*Gopherus polyphemus*	FL-SSC; MS Imperiled
American alligator	*Alligator mississippiensis*	Federally Threatened (S/A); FL-SSC
Alligator snapping turtle	*Macroclemys temminckii*	FL-SSC
Indigo snake	*Drymarchon corais couperi*	Federally Threatened; FL Threatened; MS-CI
Amphibians		
No documented or suspected species		
Birds		
Piping plover	*Charadrius melodus*	Federally Threatened; FL Threatened
Bald eagle	*Haliaeetus leucocephalus*	Federally Threatened; FL Threatened; MS-CI
Peregrine falcon	*Falco peregrinus*	FL Endangered
Red-cockaded woodpeckers	*Picoides borealis*	Federally Endangered; FL-SSC; MS-CI
Snowy plover	*Charadrius alexandrinus*	FL Threatened; MS-CI
Least tern	*Sterna antillarum*	FL Threatened
Southeastern American kestrel	*Falco sparverius paulus*	FL Threatened
American oystercatcher	*Haematopus palliatus*	FL-SSC
Brown pelican	*Pelecanus occidentalis*	FL-SSC; MS-CI
Black skimmer	*Rynchops niger*	FL-SSC
Reddish egret	*Egretta rufescens*	FL-SSC
Snowy egret	*Egretta thula*	FL-SSC
Little blue heron	*Egretta caerulea*	FL-SSC
Tricolored heron	*Egretta tricolor*	FL-SSC
White ibis	*Eudocimus albus*	FL-SSC
Burrowing owl	*Athene cunicularia*	FL-SSC
Fish		
Gulf sturgeon	*Acipenser oxyrinchus desotoi*	Federally Threatened; FL-SSC
Invertebrates		
No documented or suspected species		

[1]S/A - similarity of appearance to a threatened taxon
SSC- species of special concern   CI - critically imperiled
Source: Cooper et al., 2004

zones as narrow bands. Additionally, the following supratidal sites are known to occur in the area: high salt panne *(*sparsely vegetated sand flats*)*, shrub/marsh, and supratidal marsh/shrub/forest. Salt hay, groundsel *(Baccharis halimifolia)*, and other grasses are present at these sites (CREC, 2002).

Intertidal flats

Intertidal flats are the areas located between the high and low tide water levels of estuaries, bays, lagoons, and river mouths. They are unvegetated and therefore considered barren and unproductive (Thorpe et al., 1997). However, there is a benthic microalga present that is consumed by benthic invertebrates, forming an integral connection for consumers higher in the food web (Thorpe et al., 1997).

These communities include infaunal macroinvertebrates such as polychaete and oligochaete worms and mollusks. A variety of shellfish also live in the substrate, including southern quahog clams (*Mercenaria campechiensis*) and marsh clams (*Rangia cuneata*). These clams can be harvested if the water quality conditions do not pose health risks and they are available in numbers that allow commercial harvesting (Thorpe et al., 1996). The intertidal flats are also inhabited by numerous birds (**Table 11**).

Table 11. Common birds of the coastal FL and MS intertidal flats.

Guild	Common Name
Waders	Herons
	Egrets
	Ibises
	Yellowlegs
Shallow-probing, surface-searching	Sandpipers
	Plovers
	Knots
Deep-probing	Godwits
	Willets
	Curlews
Aerial-searching	Terns
	Gulls
	Skimmers
	Pelicans
Floating/diving	Ducks
	Geese
	Grebes
	Cormorants
Birds of prey	Osprey
	Eagles

Source: Stout, 1984.

A3c. Upland habitats

The Naval Live Oaks area is described as a mixed coastal forest ecosystem with eight different community types. The predominant communities based on percentage of total land area include sand pine, live oak hammock, sandhill, and scrub. Within the Davis Bayou unit, there are upland and lowland hardwood and pine communities.

Sand pine association

This association is found in the Naval Live Oaks area and the Pensacola forts unit. Sand pine (*Pinus clausa*) is the dominant tree in conjunction with turkey oak (*Q. laevis*), and myrtle oak (*Q. myrtifolia*). The major shrubs found in this association are wax myrtle (*Myrica cerifera*), smilax (*Smilax* spp.), rosemary (*Ceratiola ericoides*), saw palmetto (*Serenoa repens*), and dwarf huckleberry (*Gaylussacia dumosa*) (USDOI/NPS, 1978).

Live oak hammock

This community is dominated by live oaks (*Q. virginiana*) with other tree species, including pignut hickory (*Carya glabra*), laurel oak (*Q. laurifolia*), bullbay (*Magnolia grandiflora*), and red cedar (*Juniperus silicicola*). Shrubs include sparkleberry (*Vaccinium arboreum*), saw palmetto, and wild olive (*Amarolea americana*) (USDOI/NPS, 1978).

Sandhill community

The dominant tree species in this community are second growth turkey oak and sand pine. The understory includes species such as rosemary, wax myrtle, scrub live oak, and muscadine grape (*Vitis rotundifolia*) (USDOI/NPS, 1978). Vertebrate animals found in the sandhills include the eastern spadefoot toad (*Scaphiopus holbrookii*), efts of the newt (*Notophthalmus viridescens*), eastern tiger salamander (*Ambystoma tigrinum*), eastern diamondback rattlesnake (*Crotalus ademanteus*), six-lined racerunner (*Cnemidophorus sexlineatus*), southern fence lizard (*Sceloporus undulatus*), fox squirrel (*Sciurus niger*), old field mouse (*Peromyscus polionotus*), cotton mouse (*P. gossypinus*), short-tailed shrew (*Blarina brevicauda*), mole (*Scalopus aquaticus*), least shrew (*Cryptotis parva*), and eastern cottontail (*Sylvilagus floridanus*) (Wolfe et al., 1988).

Scrub oak communities

Scrub oak communities are located behind coastal dunes or in areas that are sandy, hot, and dry. The plants found here are often stunted due to the environmental stresses of the harsh environment. Tree species include sand pine (*P. clausa*), slash pine (*P. elliottii*), sand-live oak (*Q. virginiana geminata*), and southern magnolia (*Magnolia grandiflora*). Understory species are nettles (*Cnidoscolus stimulosus*), jointweed (*Polygonella polygama*), fetterbush (*Lyonia lucida*), poison oak (*Toxicodendron quercifolium*), yaupon (*Ilex vomitoria*), and royal fern (*Osmunda regalis*) (Thorpe et al., 1997).

Pine/palmetto flatwoods community

This community is comprised of longleaf (*P. palustris*), slash (*P. elliottii*), or pond pines (*P. serotina*) with an understory made up of saw palmetto, wax myrtle, gallberry (*Ilex coriacea*), runner oak (*Q. pumila*), fetterbush, and wiregrass (Thorpe et al., 1997). The mixed pine/hardwood community is similar, but in these areas fires have been prevented for an extended period, which allows hardwood trees to enter. In addition to pines, live oak and sweet gum (*Liquidambar styraciflua*) are present (USDOI/NPS, 1978).

The pine flatwoods communities in the Davis Bayou section of the park occur on the flat terraces of the coastal plain. Longleaf pine, loblolly pine *(Pinus taeda)*, black gum *(Nyssa sylvatica)*, and sweet bay magnolia *(Magnolia virginiana)* are the most frequently occurring tree species in the area; sweet bay magnolia (saplings) and large gallberry are the most common species in the shrub layer; and edible blueberry *(Vaccinium elliottii)*, tree huckleberry *(V. arboretum),* large gallberry, and red chokeberry *(Pyrus arbutifolia)* are the most commonly-occurring species in the herbaceous layer. The absence of periodic fires has contributed to declining species diversity in the community; the hardwood species have become more dominant in these areas (CREC, 2002).

Upland hardwood community

The hardwoods found in this community include magnolia, oak, and hickory. In the transition zones on the sides of the ridges, dogwood (*Cornus florida*), sourwood (*Oxydendrum arboreum*), and tulip tree (*Liriodendron tulipifera*) are frequently found (USDOI/NPS, 1978).

A related community is the lowland hardwood community located in depressions or swamps in estuaries. These areas are subject to frequent changes in water level and organic matter accumulation. The dominant trees include ash (*Fraxinus* spp.), bay, maple (*Acer* spp.), sweet gum, and cypress (*Taxodium* spp.) (USDOI/NPS, 1978).

Southern Mixed Hardwood Forest (or Mixed Pine/Hardwood Community)

The southern mixed hardwood forest is a pine-dominated upland habitat that occurs on well-drained soils of a variety of types and includes both hardwood species and various trees and shrubs. In the absence of periodic fires, many species of hardwood trees and shrubs that were formerly restricted to isolated areas have become more common throughout forest communities that were previously dominated by fire-adapted longleaf pines (CREC, 2002).

In the Davis Bayou section of the park, the most frequently occurring tree species are pignut hickory, laurel oak *(Quercus hemispherica)*, loblolly pine, southern red oak *(Quercus falcata)*, sweet gum, water oak *(Quercus nigra)*, and black cherry *(Prunus serotina)*; the most commonly encountered shrub species are laurel oak (saplings), squaw huckleberry *(Vaccinium stamineum)*, and horsesugar *(Symplocus tinctoria)*; and commonly found vines are muscadine and catbriar *(Smilax bona-nox)*. Grasses are absent from the Davis Bayou section. The absence of longleaf pine from the area is attributed to fire suppression, tree harvesting, and the re-growth of faster growing pines and hardwoods (CREC, 2002).

A4. Nonindigenous species

Some of the species within the park are undesirable invasives that must be eradicated to maintain the health of the ecosystem. Invasive plants rapidly colonize areas by out-competing native species, which do not impose on their range or reproduce as rapidly. These species limit the space available to native species. Invasive plant species of concern for GUIS are cogon grass (*Imperata cylindrica*), Chinese tallow tree (*Sapium sebiferum*), Japanese privet (*Ligustrum japonicum*), Japanese honeysuckle (*Lonicera japonica*), and Japanese climbing fern (*Lygodium *japonicum*) (USDOI/NPS, 2003a). The species most common to GUIS are cogon grass and Chinese tallow (USDOI/NPS, 2003a).

There are several efforts underway to remove Chinese tallow from GUIS. In 1997-98, over 28,500 plants were removed from the park. To minimize environmental impacts, most of the trees were hand-pulled and only the largest were treated with herbicides for removal. This work has been completed by resource management staff, volunteer groups, and the U.S. Marine Corps (USDOI/NPS, 2003a).

The effects of feral hogs on the vegetation and stability of Horn Island have also been investigated (Brent and Corcoran, 1977; Baron, 1979, 1982). Baron (1979, 1982) determined the vegetation types that were most affected and found that the damage to these plants was not as severe as expected (Cooper et al., 2004). Exotic mammals that have been documented in GUIS include nine-banded armadillos *(Dasypus novemcinctus*), Norway rats *(Rattus norvegicus*), black rats (*Rattus rattus*), hispid cotton rats *(Sigmodon hispidus*), coyotes *(Canis latrans*), nutria *(Myocastor coypus*), and red foxes (*Vulpes vulpes*) (USDOI/NPS, 2003a).

Ache et al. (2000b) published a report that discusses the aquatic invasive species present in the GOM region, which includes TX, LA, MS, AL, and FL. This initial survey focused on fish, non-insect aquatic invertebrates, aquatic mammals, aquatic microbes, and aquatic and semi-aquatic plants. The number of nonindigenous organisms in each category in FL and MS can be found in **Table 12**. These estimates were based on database queries and interviews with several experts in the region.

Table 12. Number of nonindigenous organisms present (or have occurred) in FL and MS.

	Aquatic Microbes	Aquatic Invertebrates (non-Insect)	Aquatic Vertebrates	Aquatic Plants
FL	10	64	149	70
MS	2	5	23	33

Source: Survey conducted by Ache et al., 2000b.

One of the primary databases used for compilation of this list was the Database of Nonindigenous Aquatic Species maintained by the USGS (http://nas.er.usgs.gov) that is searchable by state or drainage area (USGS, 2005). A search of the plant and animal species databases for coastal FL and MS yielded the results presented in **Tables 13 and 14**.

All of the states discussed in the report have implemented management strategies to control and limit these invasive species. Summaries of the aquatic species management priorities for aquatic and semi-aquatic plant species and aquatic animal species in FL and MS are included in **Tables 15 and 16**. The first report of zebra mussels (*Dreissena polymorpha*) in MS occurred in February 2002 in the waters of MS Sound between Cat Island and Gulfport, MS (GOM Regional Panel, 2002). The specimens were found next to the Gulf ICWW south of the Gulfport ship channel. Additional monitoring and comparison with other coastal river systems led to the conclusion that the mussels originated in the Mississippi River and were knocked off the hull of a vessel (GOM Regional Panel, 2002). The University of Southern MS's (USM's) Center for Fisheries Research and Development has also published a fact sheet about the three invasive mollusk species found in the northern GOM (the zebra mussel, the blue mussel (*Mytilus edulis*) and the Santo Domingo mussel (*Brachidontes domingensis*)) (GOM Regional Panel, 2002). In 2000, two exotic species of jellyfish bloomed in the northern GOM: the Australian spotted jellyfish (*Phyllorhiza punctata*) and "the big pink jellyfish" (*Drymonema dalmatinum*) (Dauphin Island Sea Lab, 2005).

Table 13. Nonindigenous plants found in coastal FL and MS.

Scientific Name	Common Name
Florida	
Alternanthera philoxeroides	alligatorweed
Brachiaria mutica	para grass
Ceratopteris thalictroides	water sprite
Colocasia esculenta	wild taro
Egeria densa	Brazilian waterweed
Eichhornia crassipes	water-hyacinth
Hydrilla verticillata	hydrilla
Ipomoea aquatica	water-spinach
Landoltia (Spirodela) punctata	dotted duckweed
Ludwigia hexapetala	Uruguay seedbox
Luziola peruviana	Peruvian watergrass
Marsilea minuta	small water-clover
Murdannia keisak	marsh dewflower
Myriophyllum aquaticum	parrot-feather
Myriophyllum spicatum	Eurasian water-milfoil
Najas minor	brittle naiad
Nasturtium officinale	water-cress
Ottelia alismoides	duck-lettuce
Panicum repens	torpedo grass
Pistia stratiotes	water-lettuce
Sagittaria montevidensis	long-lobed arrow-head
Salvinia minima	water spangles
Mississippi	
Alternanthera philoxeroides	alligatorweed
Eichhornia crassipes	water-hyacinth
Myriophyllum aquaticum	parrot-feather
Najas minor	brittle naiad
Nymphoides peltata	yellow floating-heart
Panicum repens	torpedo grass
Salvinia minima	water spangles
Salvinia molesta	giant salvinia

Source: USGS Nonindigenous Aquatic Species Database, http://nas.er.usgs.gov.

Table 14. Nonindigenous animals found in coastal FL and MS.

Group	Scientific Name	Common Name
Florida		
Amphibians-Frogs	*Eleutherodactylus planirostris*	greenhouse frog
Fishes	*Astronotus ocellatus*	oscar
Fishes	*Ctenopharyngodon idella*	grass carp
Fishes	*Cyprinus carpio*	common carp
Fishes	*Hyphessobrycon serpae*	serpae tetra
Fishes	*Hypophthalmichthys nobilis*	bighead carp
Mammals	*Myocastor coypus*	nutria
Mollusks-Bivalves	*Corbicula fluminea*	Asian clam
Mississippi		
Amphibians-Frogs	*Eleutherodactylus planirostris*	greenhouse frog
Coelenterates-Scyphozoan	*Phyllorhiza punctata*	Australian spotted jellyfish (North America)
Crustaceans-Crabs	*Callinectes bocourti*	Bocourt Swimming Crab, red blue crab
Fishes	*Ctenopharyngodon idella*	grass carp
Fishes	*Cyprinus carpio*	common carp
Fishes	*Hypophthalmichthys nobilis*	bighead carp
Fishes	*Oreochromis niloticus*	Nile tilapia
Fishes	*Piaractus brachypomus*	pirapatinga, red-bellied pacu
Mollusks-Bivalves	*Corbicula fluminea*	Asian clam
Mollusks-Bivalves	*Dreissena polymorpha*	zebra mussel
Mollusks-Gastopods	*Pomacea canaliculata*	channeled applesnail
Mollusks-Gastropods	*Cipangopaludina japonica*	Japanese mysterysnail
Reptiles-Lizards	*Hemidactylus turcicus*	Mediterranean gecko

Source: USGS Nonindigenous Aquatic Species Database, http://nas.er.usgs.gov.

The AL-MS Rapid Assessment Team (AMRAT) was formed in 2003 to search and catalogue non-native species found in the coastal waters of AL and MS (GCRL, 2005). In the summer of 2004, the group concentrated its efforts on MS Sound and its adjacent waters. In addition to cataloguing the species, the assessment will also provide information on the distribution and abundance of these exotic species (GCRL, 2005). The results of this sampling can be obtained from the Gulf States Marine Fisheries Commission website which maintains a database of the AL and MS Rapid Assessment Program results (GSMFC, 2005). A search of the stations in MS Sound yielded seven additional non-native species not included in the previous tables. These species are hydrilla (*Hydrilla verticillata*), Eurasian water milfoil (*Myriophyllum spicatum*), wand lythrum (*Lythrum lineare*), bermuda grass (*Cynodon dactylon*), common reed (*Phragmites australis*), and small Chinese tallow tree (*Triadica sebifera*) (GSMFC, 2005).

Table 15. Current and potential future management priorities in FL and MS, September 2000: invasive aquatic and semi-aquatic plant species.

Scientific Name	Common Name	FL	MS
Alternanthera philoxeroides	alligatorweed	X	
Aureoumbra lagunensis	brown tide algae		
Brachiaria mutica	paragrass	X	
Casuarina equisetifolia	Australian pine	X	
Caulerpa toxifolia	tropical green algae	P	
Colocasia esculenta	wild taro	X	
Cylindrospermopsis raciborskii	blue-green algae	P	
Eichhornia crassipes	water hyacinth	X	X
Hydrilla verticillata	hydrilla	X	X
Hygrophila polysperma	Indian swampweed	X	
Hymenachne amplexicaulis	West Indian marshgrass	X	
Imperata cylindrica	cogongrass		
Ipomoea aquatica	water spinach	X	
Lythrum salicaria	purple loosestrife		
Melaleuca quinquenervia	paperbark (melaleuca)	X	
Mimosa pigra	catclaw mimosa	X	
Panicum repens	torpedograss	X	
Pistia stratiotes	water lettuce	X	
Pueraria montana	kudzu		
Salvinia minima	common salvinia		
Salvinia molesta	giant salvinia	X	X
Sapium sebiferum	Chinese tallow tree		X
Schinus terebinthifolius	peppertree	X	
Solanum tampicense	wetland nightshade	X	

Source: Ache et al., 2000b. Developed based on information provided by representatives of Gulf State agencies and organizations on the Gulf of Mexico Program Invasive Species Focus Team. The list is intended to be a representative, rather than comprehensive list of management priorities.
X = Current management priority in state
P = Potential future management priority for the state

Table 16. Current and potential future management priorities in FL and MS, September 2000: invasive aquatic animal species.

Scientific Name	Common Name	FL	MS
Anguillicola crassus	exotic nematode on American eels		
Belonesox belizanus	pike killifish	X	
Callinectes bocourti	chocolate brown crab		
Carcinus maenus	green crab		
Charybdis helleri	marine swimming crab	X	
Cichlasoma cyanoguttatum	Rio Grande cichlid		
Cichlasoma urophthalmus	Mayan chiclid	X	
Cittarium pica	West Indian trochid	X	
Clarias batrachus	walking catfish	X	
Corbicula fluminea	Asian clam	X	
Crassostrea gigas	Japanese (or Pacific giant) oyster	P	
Ctenopharyngodon idella	grass carp	P[a]	
Dreissena polymorpha	zebra mussel	P	X
Drymonema dalmatinum	jellyfish		
Eriocheir sinensis	Chinese mittencrab		
Glossodoris sedna	marine nudibranch	X	
Hypophthalmichthys molitrix	silver carp		
Hypophthalmichthys nobilis	bighead carp		
Limnoperna fortunei	freshwater mussel	P	
Litopeneaus vannamei	Pacific white (or whiteleg) shrimp	P	
Monopterus albus	swamp eel	X	P
Mylopharyngodon piceus	black carp		P
Myocastor coypus	nutria		X
Mytilopsis leucophaeata	Conrad's (or dark) falsemussel	X	
Mytilopsis sallei	Salle's (or Santo Domingo) falsemussel	X[b]	
Neogobius melanostomus	round goby		P
Oreochromis aureus	blue tilapia	P	
Oreochromis mossambicus	Mozambique tilapia	X	
Oreochromis niloticus	Nile tilapia		X
Perna perna	brown (or Mexihalo) mussel		
Perna viridis	green mussel	X	
Phyllorhiza punctata	spotted jellyfish		X
Pinctada margaritifera	black-lipped (or Pacific) pearl oyster	P	
Platychirograpsus spectabilis	saber crab	X	
Pomacea canaliculata	channeled applesnail		
Rapana venosa	veined rapa whelk	P	
Sarotherodon melanotheron	blackchin tilapia	X	
Taura Syndrome Virus	shrimp virus		
Tilapia mariae	spotted tilapia	X	
Tridacna spp.	giant clams	P	
White Spot Syndrome Virus	shrimp virus		

Source: Ache et al., 2000b. Developed based on information provided by representatives of Gulf state agencies and organizations of the Gulf of Mexico Program Invasive Species Focus Team. The list is intended to be a representative, rather than comprehensive list of management priorities.

X = Current management priority in state.

P = Potential future management priority for the state.

[a] = Diploid stocks only

[b] = Cryptogenic (a species whose status as indigenous or nonindigenous remains unresolved).

B. Water Resources Assessment

B1. Water Quality

B1a. Data sources

Information about the water quality of GUIS is available from a number of sources including park personnel, USDOI/NPS reports, and various federal, state, local, and academic organizations. Background information on GUIS and water quality concerns was also provided by Riley Hoggard, Natural Resource Specialist for GUIS.

The majority of water quality data discussed in this report was retrieved from the USEPA STORET database. STORET is a "user-beware" water quality database system. For data analysis, it was assumed that data quality assurance/quality control procedures were implemented by the agency generating the data. There is some concern that inaccurate data may enter the system due to inappropriate measurement techniques, sample mistreatment, and other reasons. In addition, all of the measurements for a given parameter were grouped together, regardless of sampling depth, measurement technique, and analysis procedure.

To retrieve STORET data, a 3.2-km (2-mile) buffer around the authorized boundary of GUIS was used to generate a bounding box based on latitude and longitude. For the GUIS-MS barrier islands, a 3.2-km (2-mile) buffer around each island was created using ArcGIS 9.0 (ESRI, 2004). The buffer zone size was based on that used for similar watershed studies such as the USDOI/NPS Horizon Water Quality Reports. In these reports, an area extending at least 4.8 km (3 miles) upstream and 1.6 km (1 mile) downstream from the park boundary is used. These distances are somewhat arbitrary, but an approach that is easy to automate and limits the data retrieved to that most relevant to the park was needed. For GUIS, an intermediate distance of 3.2 km (2 miles) was selected to form the buffer around the park. After drawing a bounding box around GUIS-FL, a box extending from a longitude of -87.455 W and -86.481 W and latitudes of 30.439 N and 30.251 N were obtained.

To represent current water quality issues, data were retrieved from January 1, 1993 to June 30, 2004. This time frame is based on the guidelines for the Impaired Waters Rule, Chapter 62-303, FL Administrative Code. According to this rule, data older than 7.5 years were considered “not representative of current water quality.” Ten years of data were used as the basis for this report because it is the cut-off point for developing the planning list of potentially impaired waters. Data were downloaded from Modernized STORET, which includes all measurements after 1999 and a limited amount of earlier data that has been transferred. For this reason, most of the data prior to 1999 were not included in this analysis. Legacy STORET data were generally not included due to the data processing required to put the data in a format that would allow for use in a GIS. However, a limited amount of nutrient data from 1996-1999 was included in the analysis. The data were contributed by the NWFWMD, FWCC, FL LAKEWATCH, FDEP, FWCC Fish and Wildlife Research Institute, Division of Environmental Health (Bureau of Water Programs), and the Choctawhatchee Basin Alliance.

Water quality data for GUIS-MS were retrieved from direct communication with the MDEQ (Steve Goff, MDEQ, pers. comm.). Data from the Coastal Streams and Pascagoula River Basins from January 1993 through August 2003 were obtained. The 3.2-km (2-mile) buffer area was utilized in ArcGIS 9.0 (ESRI, 2004) to retrieve the desired data. Additional data were collected as part of the USEPA EMAP. The EMAP routinely sampled stations located in MS Sound near the barrier islands of GUIS (**Figure 16**). The data collected from 1991-1994 for these stations are available at the USEPA EMAP website. The sampling protocol included water quality profile data, sediment data, benthic data, and fish/invertebrate data. EMAP's NCA includes all the estuarine and coastal sampling done by EMAP beginning in 1990 (USEPA-NCA, 2004). This data consists of that done in the biogeographic provinces as well as data from the Regional EMAP studies done by USEPA Regional Offices (USEPA-NCA, 2004). The results of a portion of these data are discussed in section B2a.

There are few USEPA STORET stations located in the GOM. It is recommended that some of the bacteria monitoring stations also measure field parameters (DO, salinity, conductivity, pH, water temperature), nutrients (total nitrogen, nitrite + nitrate, ammonia, total phosphorus, orthophosphorus), and chlorophyll *a* to fill in the data gaps. Additional monitoring stations should also be added in the waters surrounding the MS barrier islands.

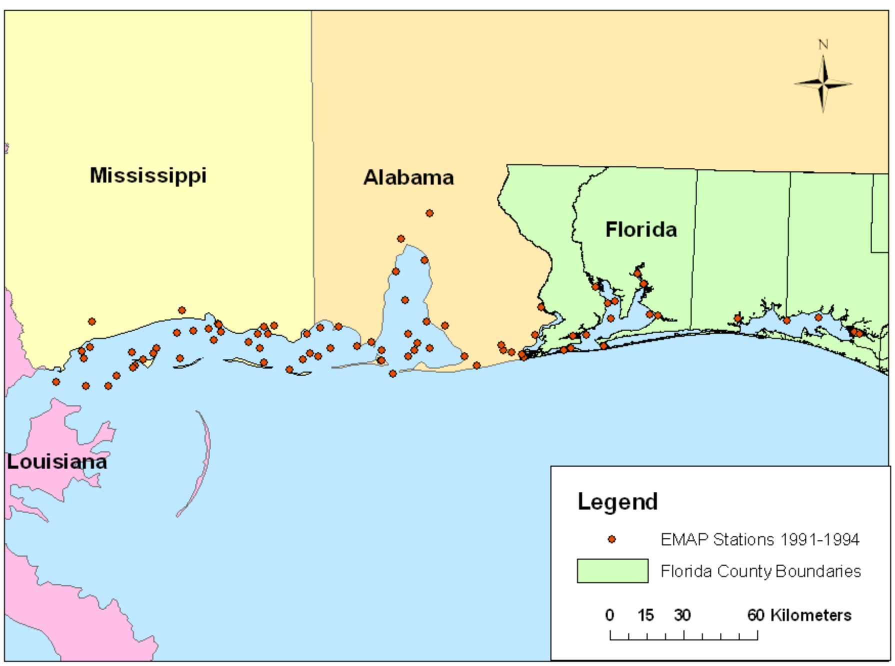

Figure 16. Environmental monitoring and assessment program stations located near Gulf Islands National Seashore, 1991-1994.

(Data Sources: USEPA- EMAP (2004), Counties - FDEP (1:24,000, Automated 1997), and States - US Census Bureau (1:5,000,000, 1990))

B1b. Water quality in seashore and surrounding estuarine areas

Water quality data were compared to FL and MS standards. These standards are located in **Appendix A**. The standards vary depending on the designated use of the waterbody. All surface waters in the state of FL are classified based on designated uses in the following categories according to instructions in the Federal Water Pollution Control Act (Section 303):

Class I	Potable Water Supplies
Class II	Shellfish Propagation or Harvesting
Class III	Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife
Class IV	Agricultural Water Supplies
Class V	Navigation, Utility, and Industrial Use

The surface waters of the State of FL are classified by default as Class III – Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife, except for certain waters which are described in subsection 62-302.400(12) of the FL Administrative Code (FAC). The waters classified as Class II Shellfish Propagation and Harvesting are included in **Appendix B**.

All surface waters in the state of MS are classified according to their designated uses in the following categories based on instructions in the Federal Water Pollution Control Act (Section 303): Public Water Supply, Shellfish Harvesting, Recreation, Fish and Wildlife, and Ephemeral Stream. The surface waters of MS are classified by default as Fish and Wildlife, except for certain waters, which are described in Section IV of the Water Quality Criteria for Intrastate, Interstate, and Coastal Waters (WPC-2). The waters with classifications other than Fish and Wildlife near GUIS are included in **Appendix B**.

Nutrients

FL

The nutrient data (nitrate + nitrite, ammonia, total Kjeldahl nitrogen (TKN), and total phosphorus (TP)) were obtained from the USEPA Modernized STORET database using a 3.2-km (2-mile) buffer around GUIS-FL. The data were recorded from January 1999 to May 2003. The number of stations varied from 54 to 64 depending on the parameter (**Figure 17**). There are no USEPA standards for nutrient concentrations and the FL nutrient criterion is narrative only, so comparison to previously collected data was relied upon for assessment. The nutrient criterion for FL states that the nutrient concentrations of a body of water shall not be altered so as to cause an imbalance in natural populations of aquatic flora or fauna. To analyze the data and determine if nutrient levels were of concern, these results were compared to those collected from stations in FL estuaries from 1980-1989 (Friedemann and Hand, 1989). Another method for comparison involved the South Carolina Estuarine Coastal Assessment Program (SCECAP), which evaluated nutrient concentrations in tidal creeks (n=57) and open waters (n=59) in comparison with measurements taken between 1993 and 1997, which comprised a historical database (Van Dolah et al., 2002). This study considered observations that exceeded the 75th percentile of all observations to be moderately enriched and those that exceeded the 90th

percentile to be very enriched. Only the open water measurements were considered for comparison with GUIS data.

The average nitrogen concentrations for all stations within the GUIS-FL study area are summarized in **Table 17.** The nitrite + nitrate average concentration for these stations (0.011 mg l^{-1} as N) was consistent with the average value of 0.04 mg-N l^{-1} as reported in the SCECAP study for the open water stations. The average TKN value of 0.41 mg l^{-1} is consistent with recent studies of Blackwater and East Bays, which yielded TKN values up to 1.15 mg l^{-1} (mean of 0.38 mg l^{-1}) in Blackwater Bay and up to 0.34 mg l^{-1} (mean 0.21 mg l^{-1}) in East Bay (Young, 1981).

Table 17. Nitrogen concentrations for all stations within Gulf Islands National Seashore-FL study area, 1999-2003.

Parameter	Average ± Std. Deviation
Ammonia (mg l^{-1} as NH_3)	0.018 ± 0.032
Nitrite + Nitrate (mg l^{-1} as N)	0.011 ± 0.030
Total Kjeldahl Nitrogen (mg l^{-1})	0.41 ± 0.23

Source: USEPA-STORET, 2004.

The SCECAP data classified total phosphorus (TP) concentrations between 0.09 and 0.17 mg l^{-1} as moderately enriched and those greater than 0.17 mg l^{-1} as very enriched. The average for all of the stations within the GUIS-FL region was 0.017 ± 0.016 mg l^{-1}, which is much lower than the enriched value for SCECAP. This value was also below the guideline of 0.05 mg l^{-1}, which is the amount of TP sufficient for nuisance algal blooms (Thorpe et al., 1997). Compared to 1,500 stations in other FL estuaries, approximately 90% have greater TP concentrations than those included in this study. These results indicate that the SCECAP data may not be a reliable tool for comparison based on geographical differences between FL and SC estuaries. Algal growth in the waters surrounding GUIS is considered to be phosphorus limited because nitrogen is present in excessive amounts (FDER, 1988).

These measurements are instantaneous and may not accurately represent the spatial and temporal variability of the system. The standard deviations are often greater than the average, indicating the high degree of variability associated with the values. These factors and the lack of synoptic sampling data complicate analysis of the data.

To analyze the changes in nutrient levels (ammonia, TKN, and TP) during recent years, three sites were selected (Stations 32010A10, 320100A5, and 3201BE28) (**Figure 18**) for additional analysis. Stations 32010A10 and 320100A5 were located in Santa Rosa Sound and 3201BE28 was located in Cinco Bayou, which is on the western end of Choctawhatchee Bay. The average concentrations (± standard deviation) using data from 1996 to 2003 are presented in **Table 18**. The average nutrient concentrations for the stations were relatively close, despite their different locations. It was expected that the nutrient concentrations in the bayou would be elevated because of the system's limited flushing capacity and increased anthropogenic inputs; however, this was not the case. The standard deviations are large with respect to the averages, indicating the high variability of the data.

The data for each station were plotted for the time period from 1996 to May 2003. For the two stations in Santa Rosa Sound there are gaps in the data from 1996, 1997, and 1998. Sampling was conducted infrequently making it difficult to discern trends in the nutrient levels. There do not appear to be any seasonal trends in the data (Figures 19-21). To determine trends, measurements taken at approximately the same time each year for several years are required.

A water quality study conducted by Moshiri et al. (1980) found that Santa Rosa Sound did not exhibit serious degradation when compared to other local estuarine systems such as Escambia Bay. The study revealed that nutrient concentrations were similar to Catfish Basin, a bayou located on the eastern side of Blackwater Bay that has been considered an example of a relatively pristine system (Adams, 1970). The study found that Little Sabine Bay demonstrated signs of eutrophication such as increased nutrient concentrations, lower water transparency, and increased primary productivity and algal populations (Moshiri et al., 1980). It was recommended that future inputs to the Bay be minimized due to the limited flushing and restricted circulation in the system (Moshiri et al., 1980).

Several studies have examined how changes in water quality affect seagrass beds (Lores et al., 2000). Lores et al. (2000) conducted research to map and monitor the SAV in the Escambia- PBS. Big Lagoon was the only study area that demonstrated an overall loss in SAV coverage. They summarized water quality data, including phosphate and total nitrogen (TN), collected quarterly for 2 years (Lores et al., 2000). The initial results of the study suggested that nutrients, especially TN, were related to changes in SAV beds in this system. Big Lagoon had the highest nitrite + nitrate concentration and the lowest level of mean light at 1 m (3.3 ft) of the areas included in the study (Lores et al., 2000). The specific reasons for the decline are unknown but possible mechanisms are increased stormwater runoff caused by housing developments, closing of an old channel, and sediment resuspension from boat traffic. Suggestions for future research included longer studies and more comprehensive statistical analysis (Lores et al., 2000).

MS

Nutrient data relevant to GUIS-MS were obtained from the MDEQ for the period from January 1994 to August 2003. The nutrient parameters measured included ammonia (mg l^{-1} as NH_3), TKN (mg l^{-1} as N), nitrate + nitrite (mg l^{-1} as N), and TP (mg l^{-1} as P). Nineteen stations, with the exception of ammonia which had 20 stations, were located within the 3.2-km (2-mile) study area established around GUIS-MS (**Figure 22**). These stations were located in Biloxi Bay, Biloxi Bay (Davis Bayou), Mississippi Sound, Heron Bayou, and Tidewater Bayou. For ammonia and nitrate + nitrite, there were a number of instances when the levels were not detectable. To gain an accurate representation of the data, the averages and standard deviations were calculated by using both zero and the minimum detection limit because the actual value is somewhere between the two. The TKN and TP measurements did not have a significant number of non-detects and this procedure was not needed. T

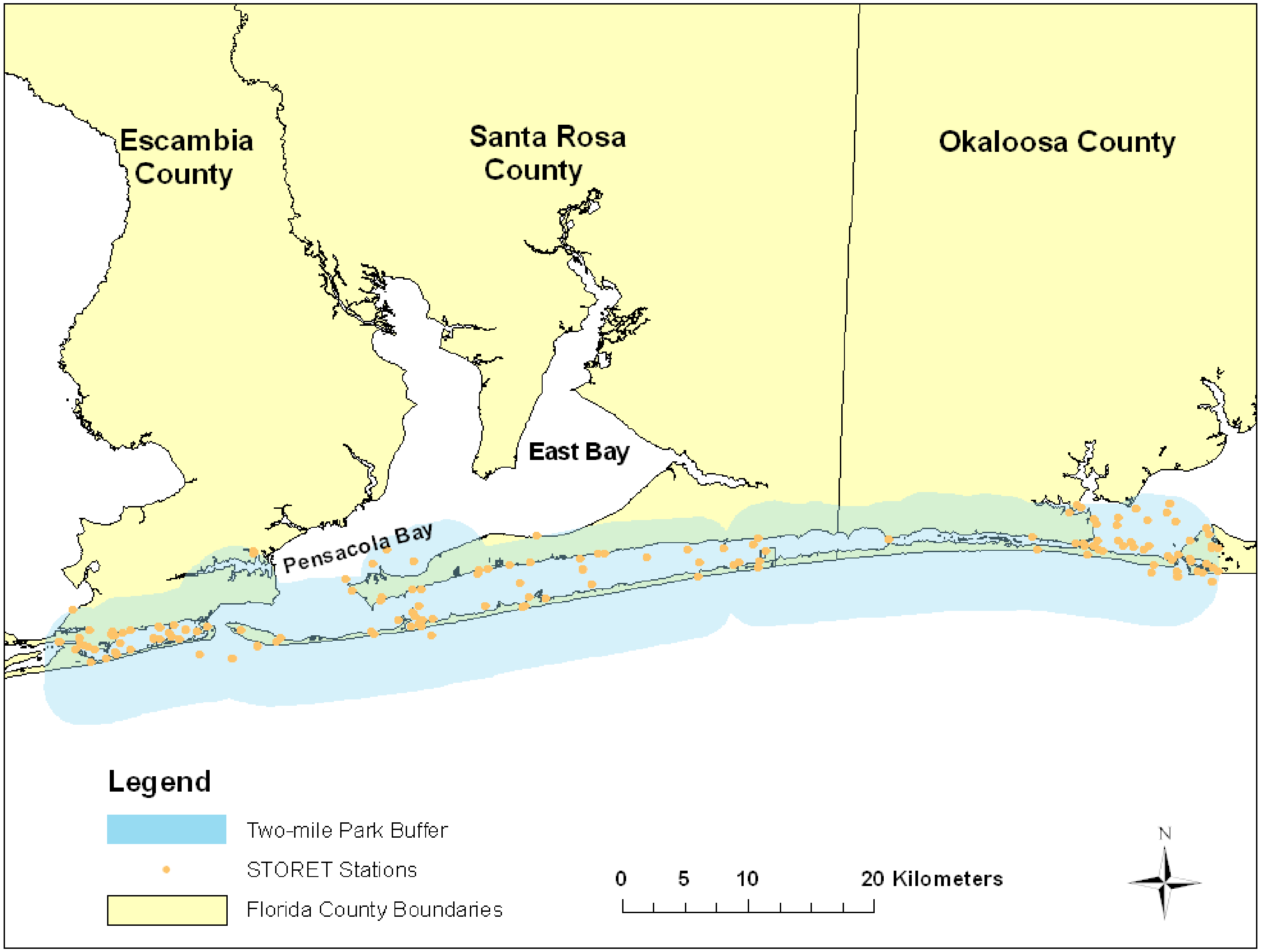

Figure 17. STORET stations within 3.2-km (2-mile) buffer of Gulf Islands National Seashore-FL, 1993-2004.

(Data Sources: STORET Stations – USEPA-STORET (2004), County - FDEP (1:24,000, Automated 1997) and Authorized Park Boundary – USDOI/NPS (1992)).

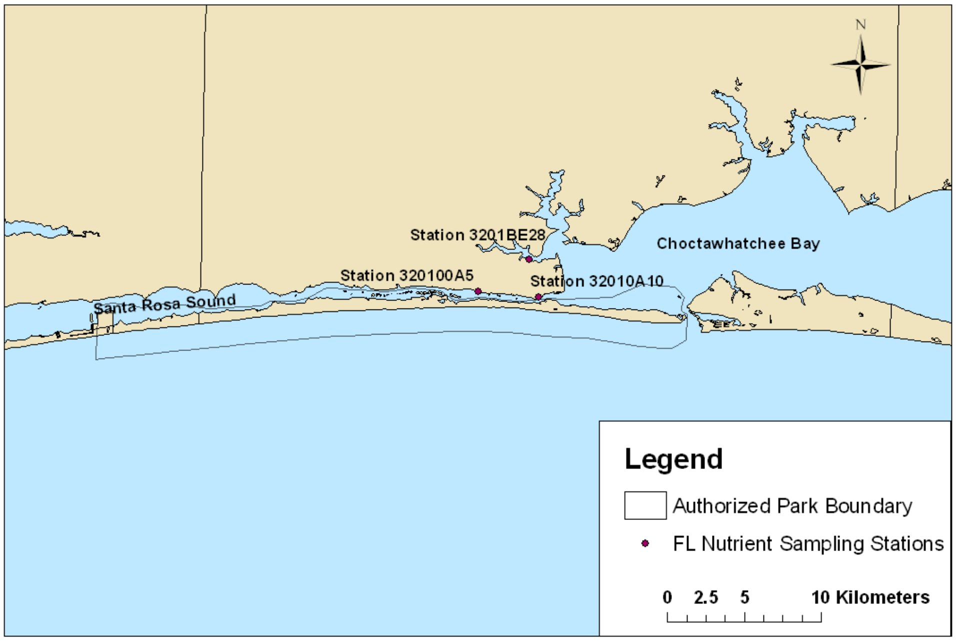

Figure 18. Locations of selected FL nutrient sampling stations.

(Data Sources: STORET Stations – USEPA-STORET (2004), County - FDEP (1:24,000, Automated 1997) and Authorized Park Boundary – USDOI/NPS (1992)).

Table 18. Nutrient concentrations for three stations located near Gulf Islands National Seashore-FL, 1996-2003.

		Average ± Standard Deviation		
Station ID	**Location**	**TKN (mg l^{-1})**	**TP (mg l^{-1})**	**Ammonia (mg l^{-1} as NH_3)**
32010A10	Santa Rosa Sound	0.38 ± 0.17	0.013 ± 0.010	0.024 ± 0.067
320100A5	Santa Rosa Sound	0.39 ± 0.17	0.016 ± 0.012	0.023 ± 0.026
3201BE28	Cinco Bayou	0.36 ± 0.14	0.011 ± 0.012	0.013 ± 0.020

Data Source: USEPA-STORET, 2004; USEPA, 2005.

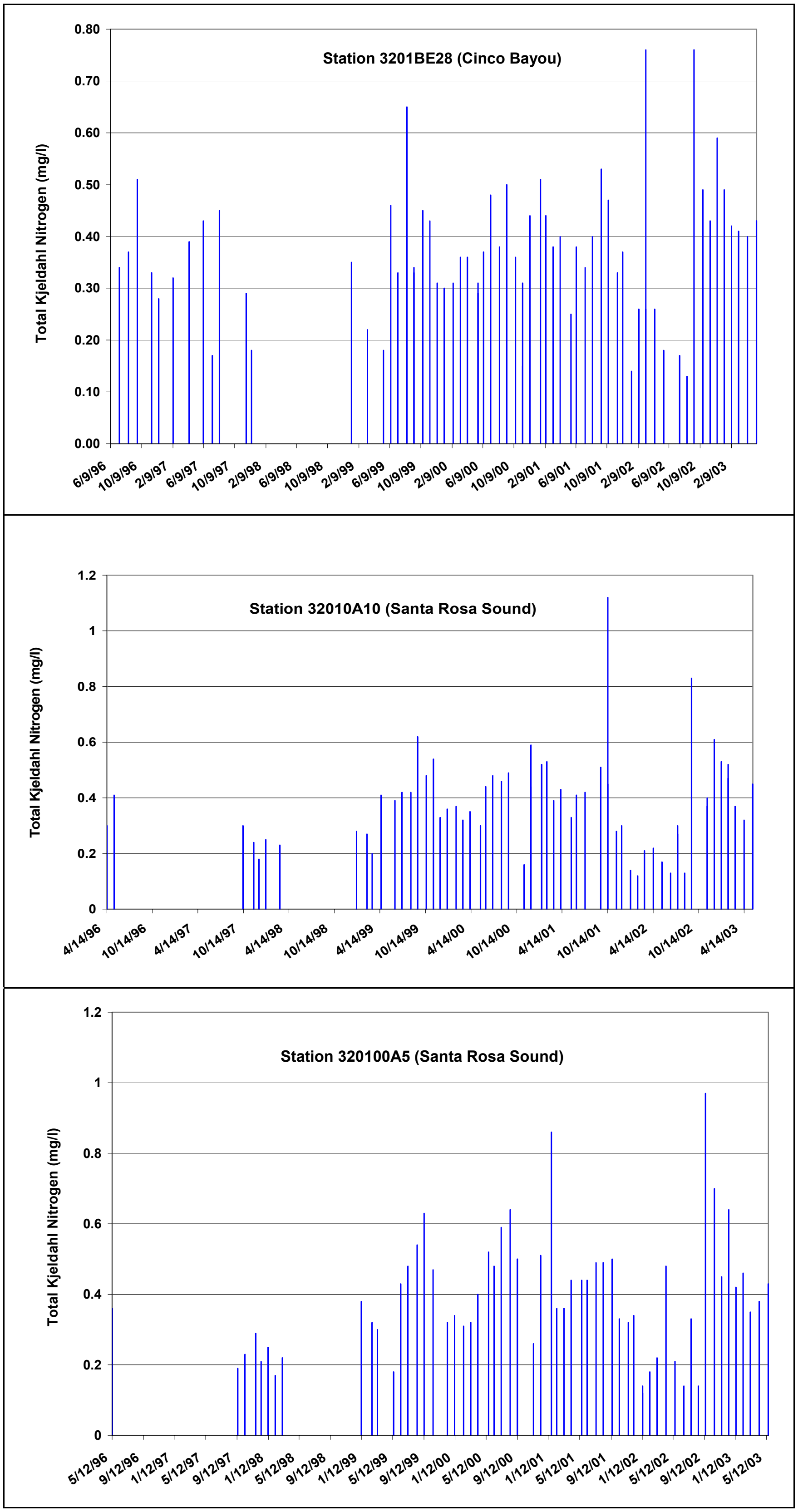

Figure 19. Total Kjeldahl nitrogen data for three stations located near Gulf Islands National Seashore-FL, 1996-2003.

(Data Source: USEPA – STORET, 2004; USEPA, 2005).

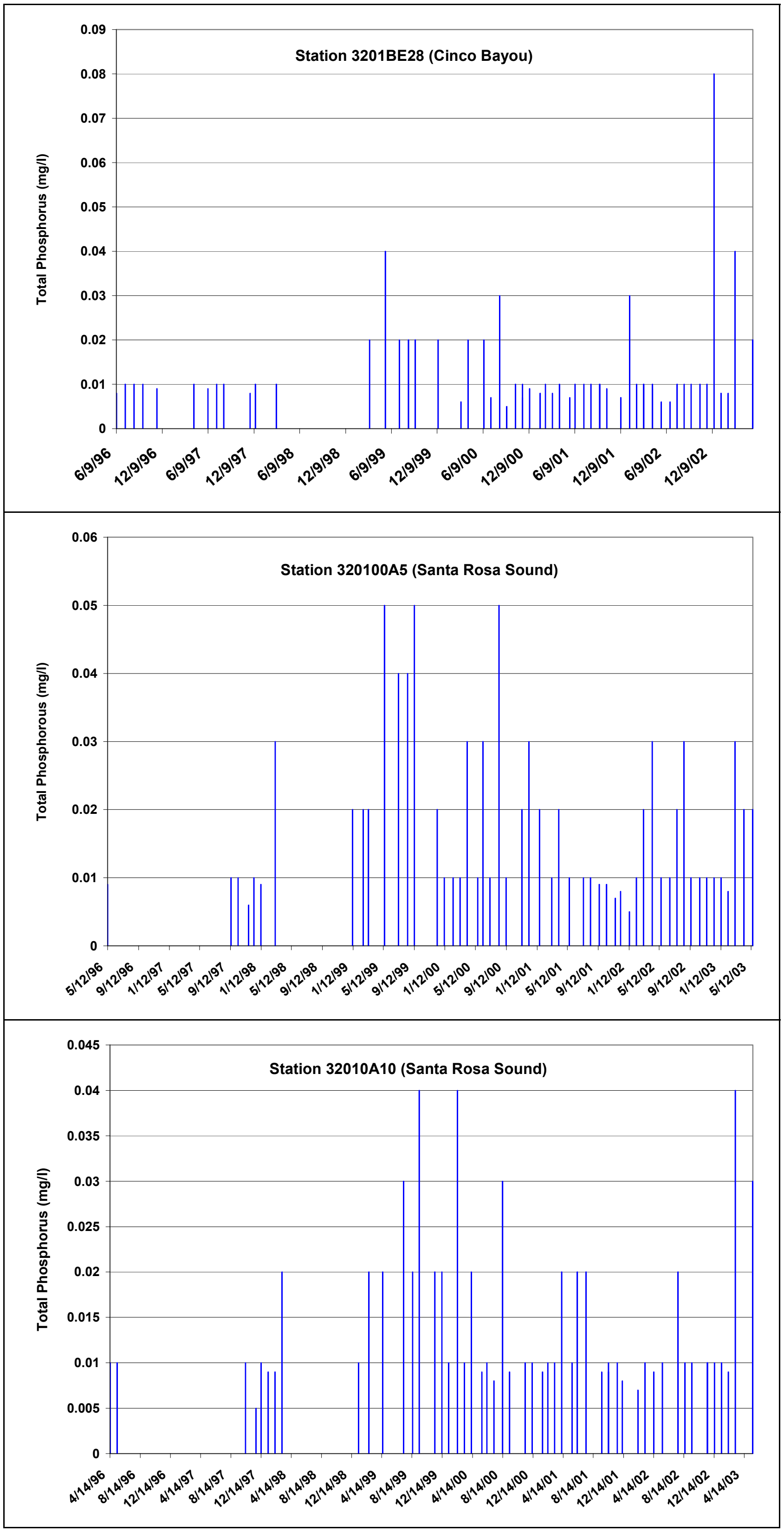

Figure 20. Total phosphorus data for three stations located near Gulf Islands National Seashore-FL , 1996-2003.

(Data Source: USEPA- STORET, 2004; USEPA, 2005).

South Carolina Estuarine and Coastal Assessment Program criteria for phosphorous: moderately enriched if 0.09 < TP ≤ 0.017 mg/L; very enriched if TP > 0.17 mg/L.

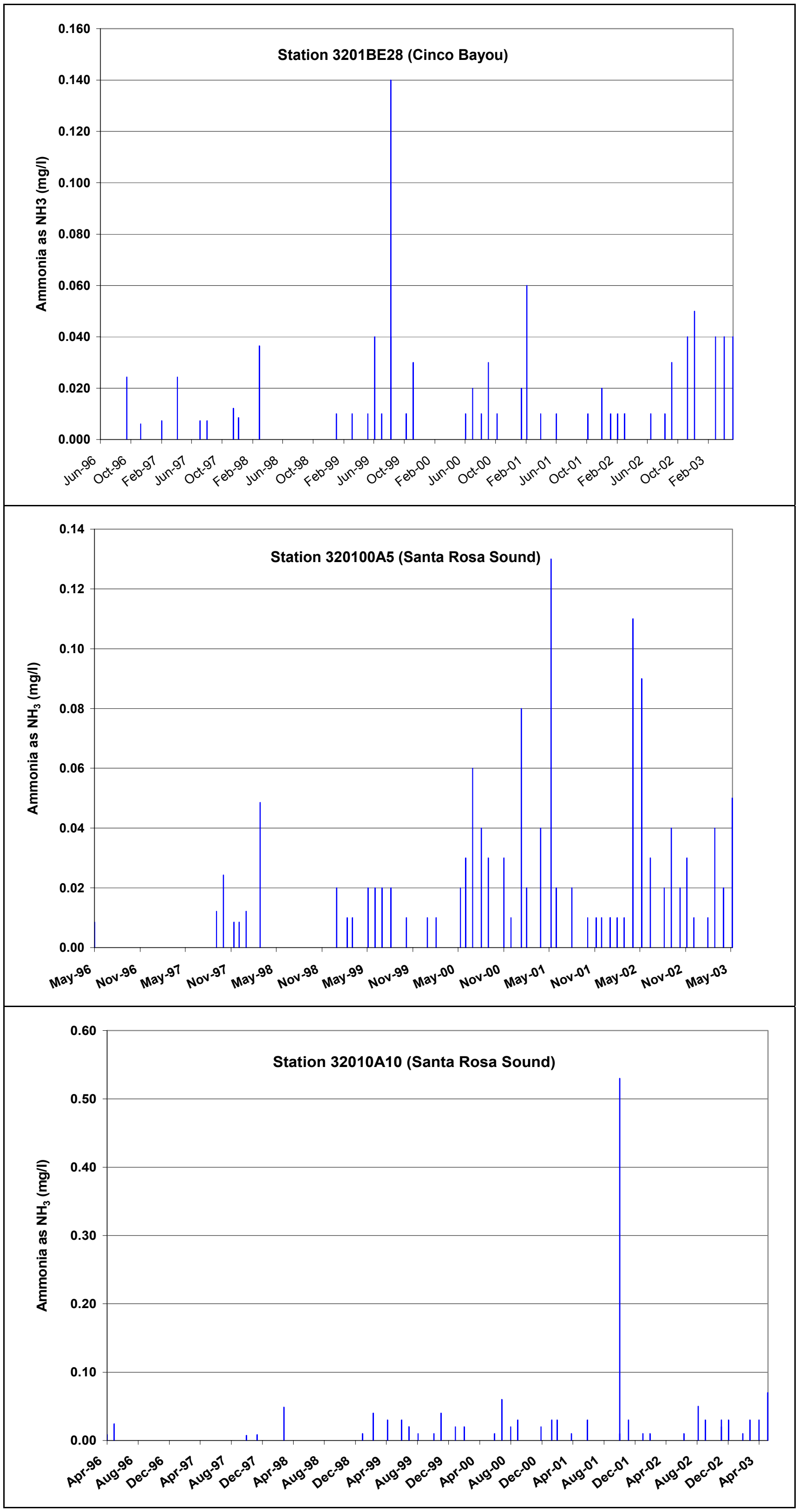

Figure 21. Ammonia data for three stations located near Gulf Islands National Seashore-FL, 1996-2003.

(Data Source: USEPA – STORET, 2004; USEPA, 2005).

The averages and standard deviations for these parameters are displayed in **Table 19**.

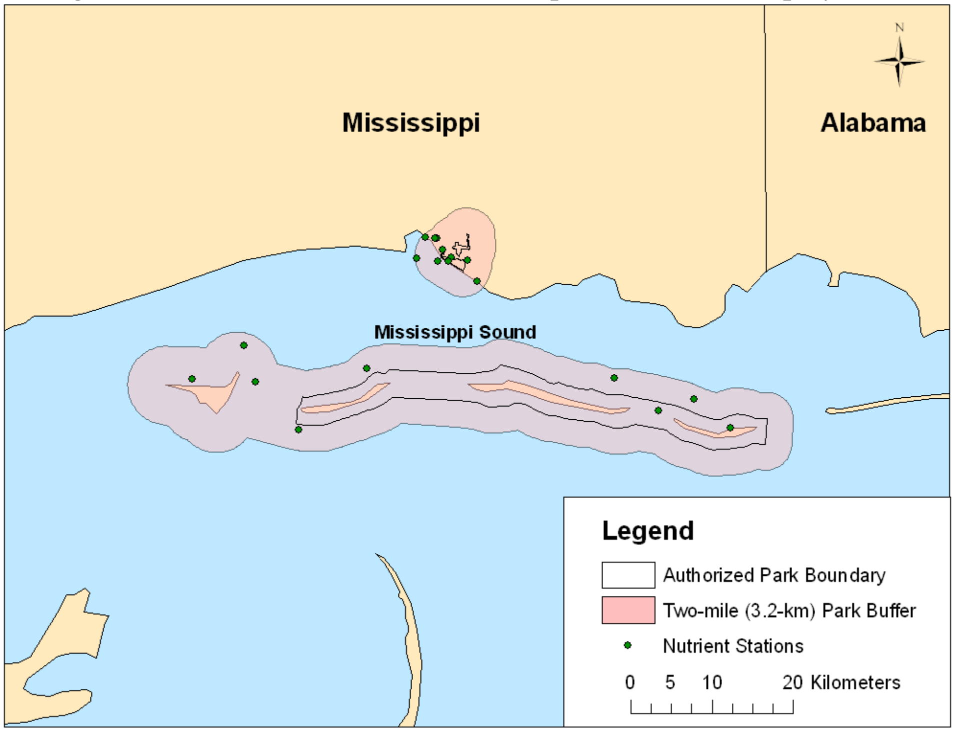

Figure 22. Selected MS nutrient sampling stations, 1993-2004.

(Data Sources: Nutrient Stations – MDEQ (2004), State -US Census Bureau (1:5,000,000, 1990), and Authorized Park Boundary – USDOI/NPS (1992)).

Table 19. Nutrient concentrations for all stations within Gulf Islands National Seashore-MS study area, January 1994-August 2003.

Parameter	Average ± Std. Deviation[1]	Average ± Std. Deviation[2]
Ammonia (mg l^{-1} as NH_3)*	0.33 ± 0.33	0.28 ± 0.36
Nitrate + Nitrite (mg l^{-1} as N)*	0.037 ± 0.039	0.030 ± 0.043
Total Kjeldahl Nitrogen (mg l^{-1})	1.05 ±1.12	N/A
Total Phosphorus (mg l^{-1} as P)	0.19 ± 0.33	N/A

*Due to the high number of non-detects, two averages and standard deviations were calculated for ammonia and nitrate + nitrite. One method replaced the non-detects with zero (2) and the other with the minimum detection limit (1). This procedure was not required when calculating the values for TKN and TP.
Data Source: MDEQ Database, 2004.

For all of the nutrient parameters, the levels in GUIS-MS are much higher than those measured in the area surrounding GUIS-FL. The ammonia concentrations are an order of magnitude higher in GUIS-MS than GUIS-FL. The MS state standard for ammonia is dependent on pH, temperature, and/or salinity. The state of MS evaluates ammonia toxicity according to the USEPA guidelines published in the *1999 Update of Ambient Water Quality Criteria for Ammonia* and the *Ambient Water Quality Criteria for Ammonia (Saltwater) – 1989*. Ammonia levels were highest in MS Sound, followed by Biloxi Bay, and then Davis Bayou. The majority of the MS Sound data were not collected near the barrier islands, but adjacent to the coast near the Davis Bayou section of the park. These data indicate that there may be a problem with ammonia toxicity in Biloxi Bay and Davis Bayou. Future monitoring is recommended to determine if the problem is persistent and is negatively affecting the biota.

Based on the laboratory methods used in the SCECAP, TN is considered to be best represented by the sum of nitrate-nitrite and TKN. Using historic data, TN values above 1.29 mg l^{-1} are considered to be highly enriched because they represent the upper 90^{th} percentile of the historical records and values between 0.95 mg l^{-1} and 1.29 mg l^{-1} are categorized as moderately enriched because they are above the 75^{th} percentile of the historical records but below the 90^{th} percentile of those same records (Van Dolah et al., 2002). The historic database consists of data compiled over a five-year period (1993-1997) by the South Carolina Department of Health and Environmental Control (SCDHEC) Bureau of Water as part of their routine ambient surface water monitoring program (SCDHEC, 1998). Using the average values for TKN and nitrate + nitrite, without incorporating the standard deviations, the TN levels near GUIS-MS are considered moderately enriched. However, the standard deviations are larger than the averages, indicating the high variability of the data. The nitrite + nitrate average concentration for these stations was consistent with the average value of 0.04 mg-N l^{-1} reported in the SCECAP study for the open water stations. The highest TKN values were reported at one of the MS Sound stations, which is located near Ocean Springs, MS.

The SCECAP data classified TP concentrations between 0.09 and 0.17 mg l^{-1} as moderately enriched and those greater than 0.17 mg l^{-1} as highly enriched (Van Dolah et al., 2002). Based on the average TP value (0.19 mg l^{-1}) for all of the stations, comparison with the SCECAP yields a highly enriched classification. TP levels were the highest at Station 640MSDB15A located near Ocean Springs, MS. There were four instances when the TP values measured were greater than 1 mg l^{-1}. The TP levels near the MS barrier islands were much lower, generally below 0.05 mg l^{-1}. It may be appropriate to analyze the water quality concerns for the barrier islands separate from Davis Bayou in Phase II of this project, as the mainland section is much more influenced by urban and industrial land uses. Based on this analysis, the pollutants generated from the coastal urban areas appear to be effectively diluted or removed from the system before reaching the barrier islands.

There were a limited number of stations sampled within the study area established around GUIS-MS. Although the majority of the population is located near the MS coast, monitoring of the waters surrounding the barrier islands is recommended. If possible, nutrient parameters (total nitrogen, nitrite + nitrate, ammonia, total phosphorus, orthophosphorus) and chlorophyll *a* should be sampled quarterly. Certain government agencies, such as the MS DMR measure field parameters as part of their shellfish monitoring program, perhaps nutrient sampling could be added to their routine.

Dissolved oxygen

DO measurements were recorded at a number of locations within and near the park boundaries. These are instantaneous measurements taken at a specified water depth, generally at 0.15 m (0.5 ft), using an oxygen probe. To gain an accurate representation of DO trends in the park, one or two stations located in each of the Perdido Key, Santa Rosa, and Okaloosa sections were analyzed (**Figure 22**). Stations were selected based on the length of record because many of the stations were only sampled on three or four occasions.   To view the seasonal trends in DO levels, stations with at least one year of data were selected. The data for Station 33020M20 located near the Perdido Key section, Stations 33030GA1 and 33030G83 in the Santa Rosa area, and Station 32010C11 in the Okaloosa area are included as **Figures 23-25**.

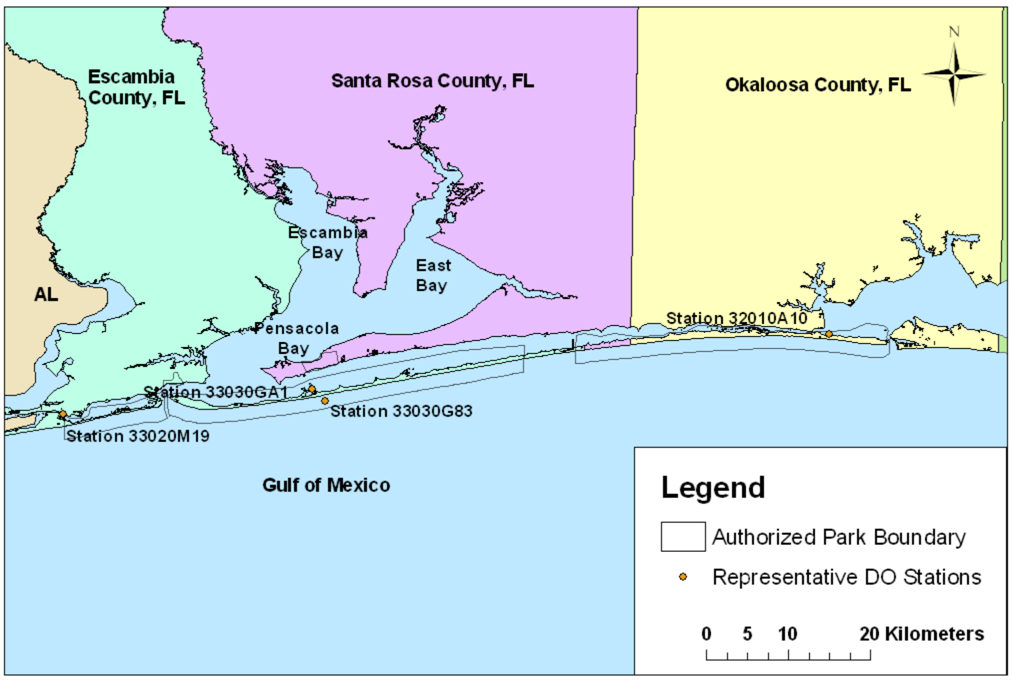

Figure 23. Locations of representative dissolved oxygen sampling stations near Gulf Islands National Seashore-FL.

(Data Sources: STORET Stations – USEPA-STORET (2004), County - FDEP (1:24,000, Automated 1997) and Authorized Park Boundary – USDOI/NPS (1992)).

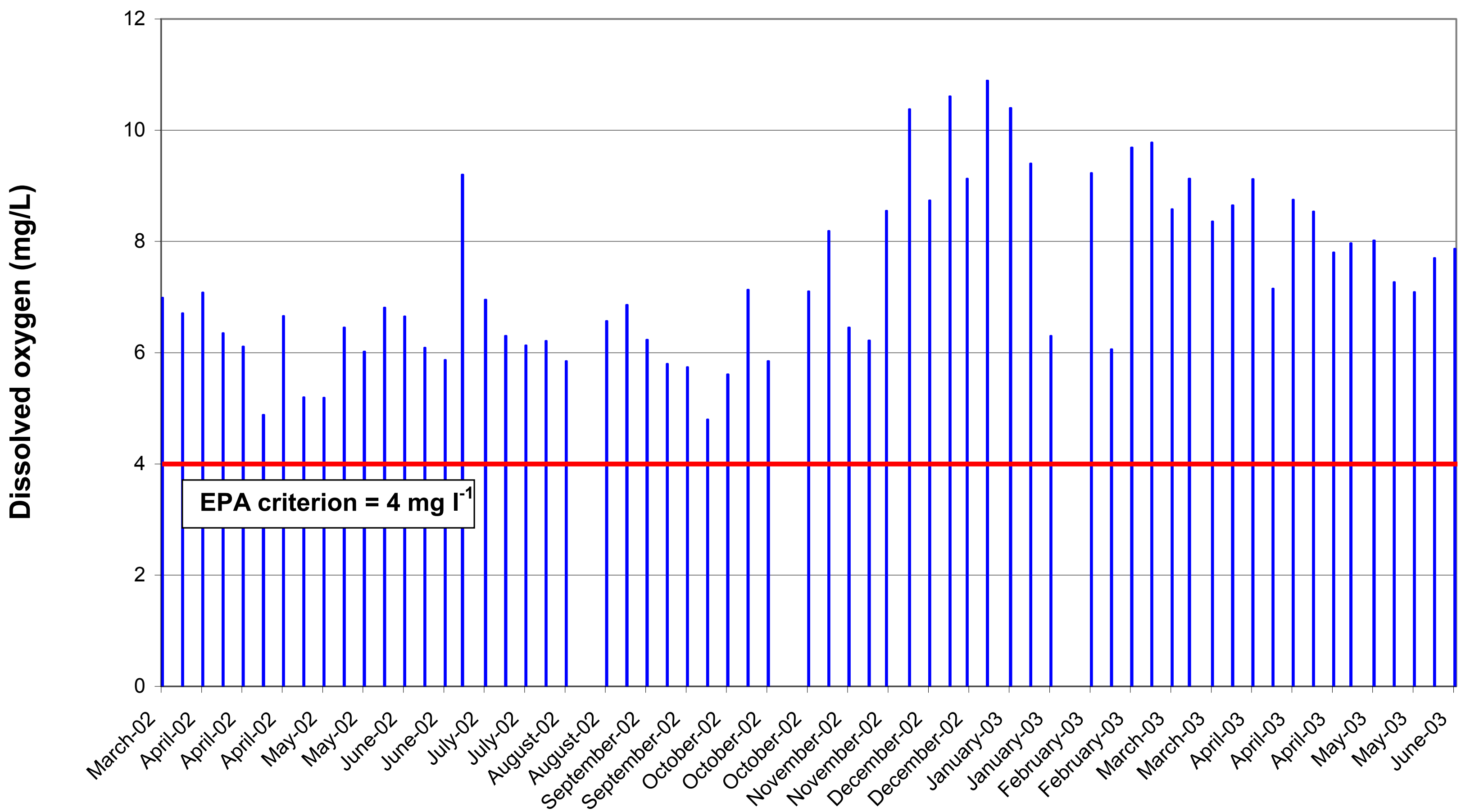

Figure 24. Dissolved oxygen levels for Station 33020M20 located near Perdido Key section of Gulf Islands National Seashore-FL, March 2002 – June 2003.

(Data Source: USEPA-STORET, 2004)

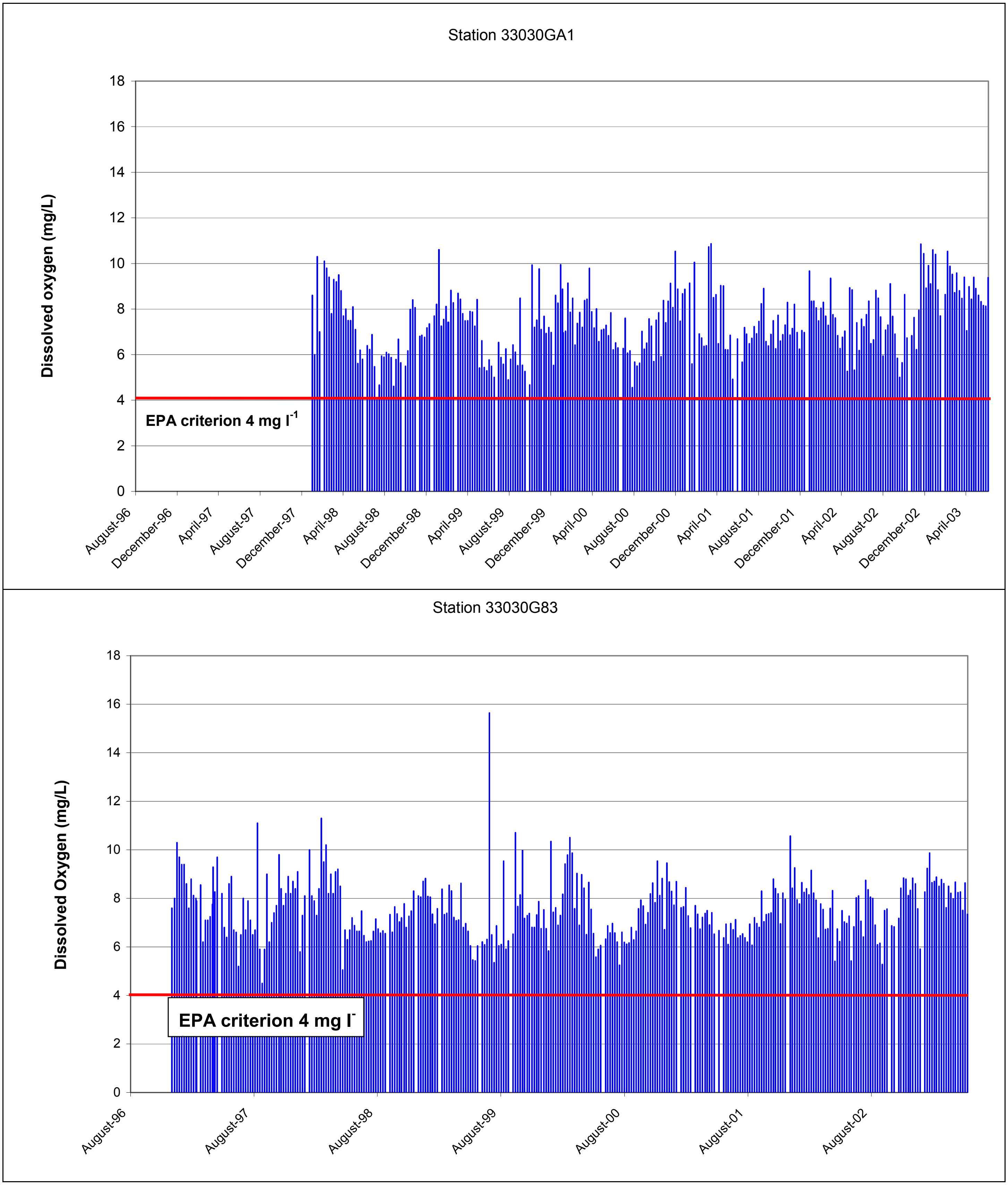

Figure 25. Dissolved oxygen levels for Stations 33030GA1 and 33030G83 near Santa Rosa area of Gulf Islands National Seashore-FL.
(Data Source: USEPA-STORET, 2004)

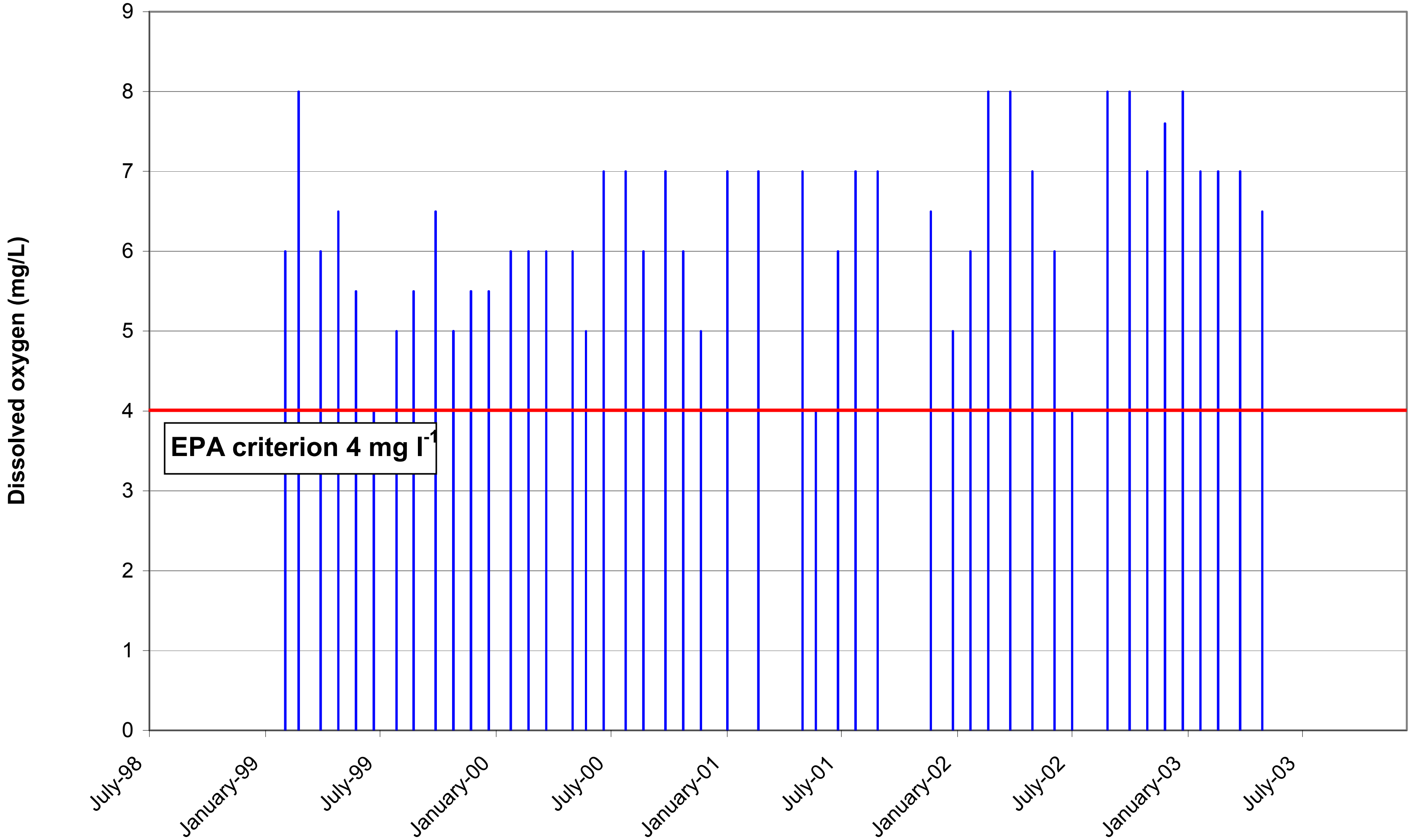

Figure 26. Dissolved oxygen levels for Station 32010C11 near Okaloosa section of Gulf Islands National Seashore-FL.

(Data Source: USEPA-STORET, 2004)

With the exception of the Okaloosa station, there was seasonal cycling with summer minima and winter maxima. These results were expected based on the levels of algae and photosynthetic activity in the summer as compared to the winter. For the entire data set, there were no instances when DO values were below the USEPA criterion of 4 mg l^{-1}. However, there were three instances when the DO measurement equaled this value at the Okaloosa station and one instance at one of the Santa Rosa stations (33030GA1). These occurrences were in June and July. The lows for the other stations were most common in the summer months of May, June, July, August, and September.

DO measurements were obtained from the MDEQ and the EMAP. However, the monitoring efforts of the MDEQ are focused on the Coastal Streams located on the mainland which are largely outside of the study area with the exception of those located within two miles of the Davis Bayou park boundary. DO measurements are included for one station located in Davis Bayou (Station 640BBY02) and one in MS Sound (640MSDB15A) (**Figure 26**). Both stations display the seasonality (summer minima and winter maxima) often associated with DO measurements (**Figures 27 and 28**). In 2002 and 2003, several instances were recorded when the DO levels fell below the USEPA criterion of 4 mg l^{-1}.

Figure 27. Locations of selected dissolved oxygen sampling stations near Gulf Islands National Seashore-MS.

(Data Sources: DO Stations – MDEQ (2004), State -US Census Bureau (1:5,000,000, 1990), and Authorized Park Boundary – USDOI/NPS (1992)).

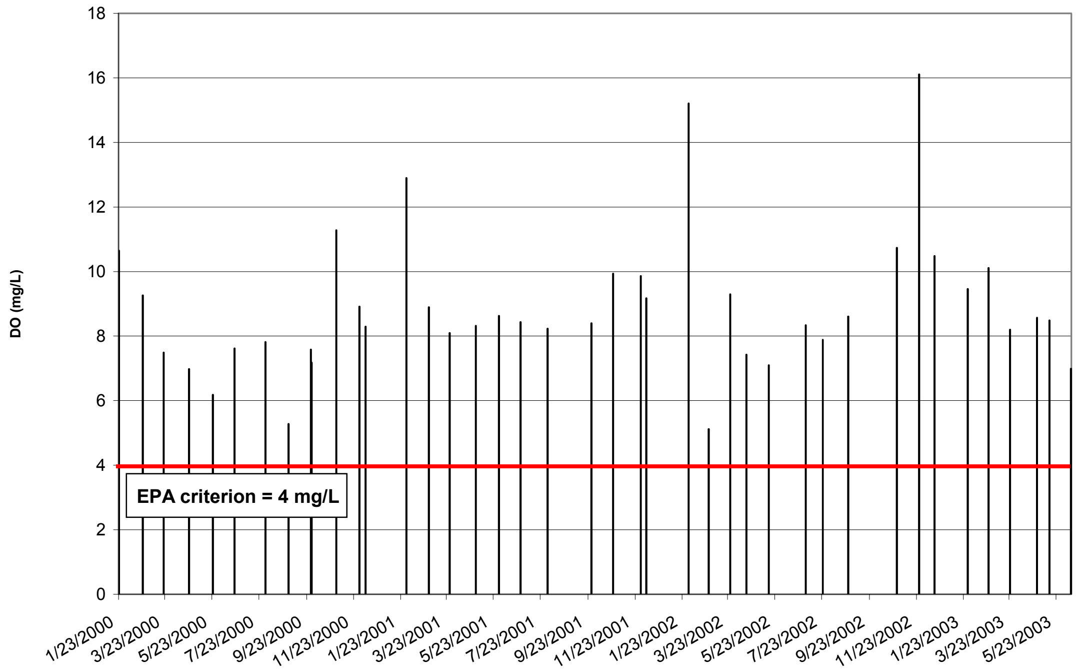

Figure 28. Dissolved oxygen levels for Station 640BBY02 (Davis Bayou) located near Gulf Islands National Seashore-MS, January 2000 – June 2003.

(Source: MDEQ Database, 2004).

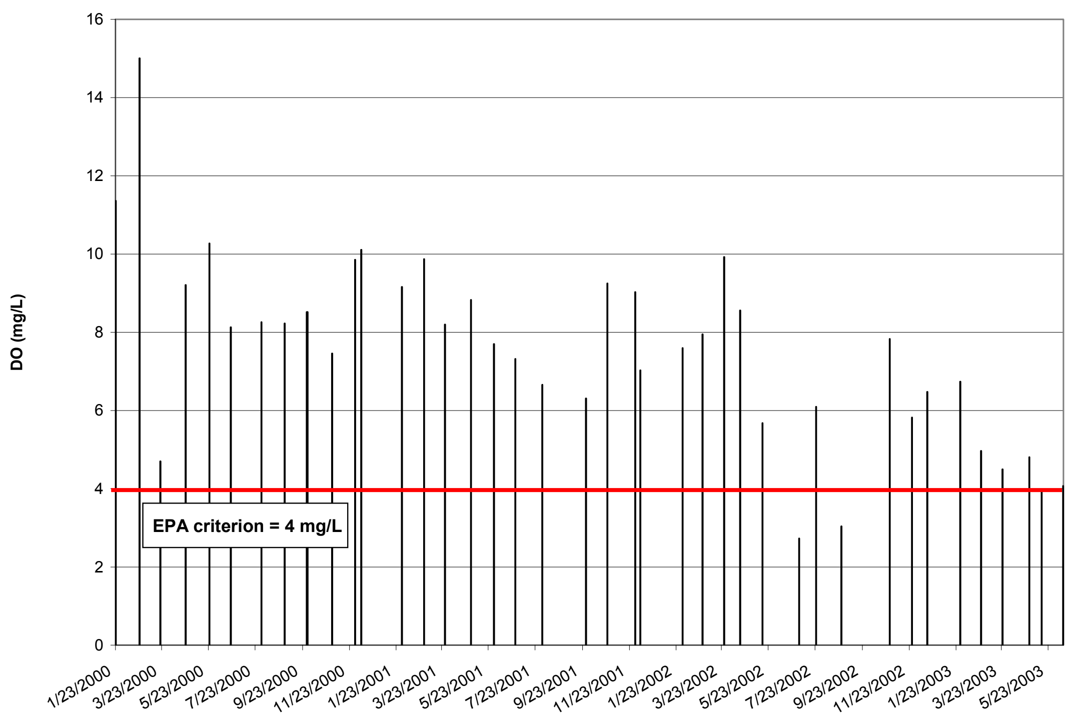

Figure 29. Dissolved oxygen levels for Station 640MSBD15A (MS Sound) located near Gulf Islands National Seashore-MS, January 2000 – June 2003.

(Source: MDEQ Database, 2004).

In addition, 12 stations that were sampled as part of the EMAP from 1991 to 1994 are shown in **Figure 30**. There was one instance when the DO measurement was below the USEPA criterion of 4 mg l^{-1}. A value of 3.0 mg l^{-1} was measured off the coast of Ship Island in 1991. This was a bottom sample obtained from a depth of approximately 5.3 m (17 ft). DO levels from a station sampled by the MDEQ in 2003 near Horn Island were above 8.0 mg l^{-1} for depths ranging from 0 to 2.5 m (0 to 8.2 ft) (MDEQ, 2003).

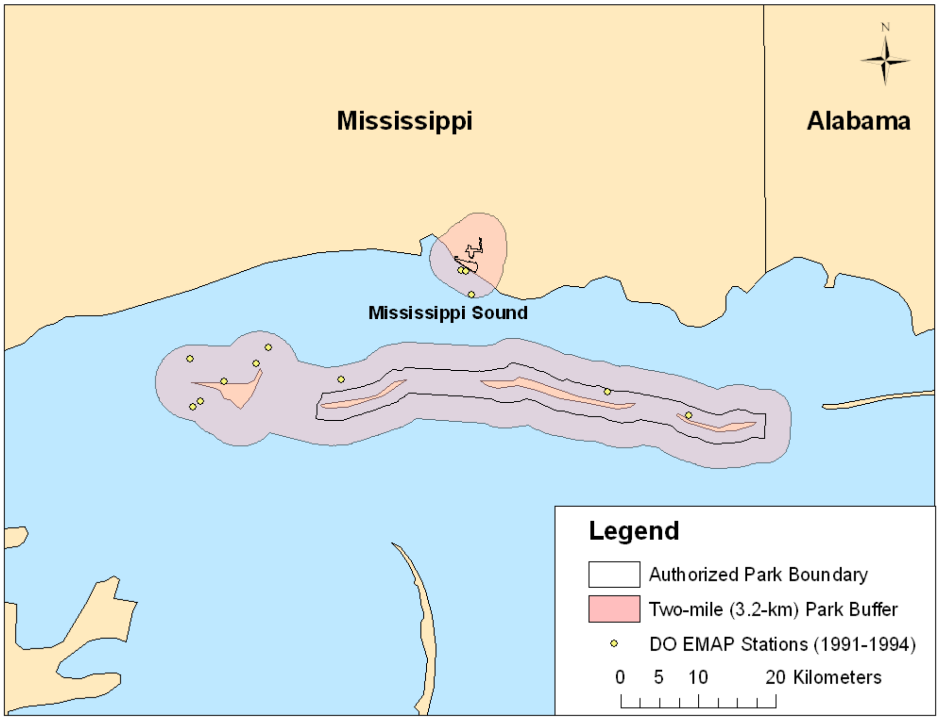

Figure 30. Dissolved oxygen Environmental Monitoring and Assessment Program (EMAP) Stations within study area surrounding GUIS.

(Data Sources: USEPA- EMAP (2004), State -US Census Bureau (1:5,000,000, 1990), and Authorized Park Boundary – USDOI/NPS (1992)).

It should be emphasized that these are instantaneous measurements taken at different times of the day and do not represent the average concentration at a particular site. Measurements are rarely taken just after dawn when the daily minimum occurs. The measurements for the majority of the FL stations were taken during late morning or afternoon hours with the exception of the Perdido Key station where most of the measurements were recorded early in the morning (between 8 and 10 o'clock). Most of the MS data were recorded in the morning, between 9 o'clock and noon. These results indicate that DO levels are not below hypoxic levels (< 2.0 mg l^{-1}), which would adversely affect estuarine organisms; however, there are some areas, specifically near the Davis Bayou area, that should be monitored more extensively. Twenty-four hour sampling in MS Sound is recommended to accomplish this task. A 12-hour sampling cycle was conducted in the summer of 2004 for stations located along the shoreline; however, additional sampling is planned for summer 2005 to obtain data for a dry period (Barbara Viskup, MDEQ, pers. comm.).

Bacterial contamination

FL – Shellfish harvesting

Bacteria levels are monitored as part of the shellfish sanitation and the beach water quality sampling programs in FL and MS. Class II waters have more stringent limitations on bacteriological and fluoride pollution than Classes III-V. To protect individuals from shellfish-borne illnesses and maximize shellfish harvest, the FDACS classifies shellfishing areas. This is accomplished through regular monitoring of fecal coliform and water quality parameters at stations throughout FL's shellfish harvesting areas. For areas to be classified approved or conditionally approved, the level of fecal coliform in subsurface water samples must meet the National Shellfish Sanitation Program (NSSP) 14/43 standard[4]. For areas to be classified restricted or conditionally restricted, the level of fecal coliform in subsurface water samples must meet the NSSP 88/260 standard[5].

The Shellfish Environmental Assessment Section (SEAS) in the Bureau of Aquaculture Environmental Services is responsible for classifying and managing FL shellfish harvesting areas. The FDACS monitors stations throughout Pensacola and Choctawhatchee Bays to ensure that the shellfish harvested are safe and do not pose health risks to consumers. Seven of these stations (502, 504, 524, 532, 790, 850, and 860) are located within 3.2 km (2 miles) of the park (**Figures 31 and 32**). The majority are located in the western end of Choctawhatchee Bay near the Okaloosa section of GUIS-FL. The fecal coliform measurements are based on the most probable number (MPN) per 100 ml. Of the 1043 observations recorded from 1993 to 2004 for the seven stations, none of the 30-day geometric means and medians was above the 14/43 standard.

MS – Shellfish harvesting

The MDEQ assessed the Shellfish Consumption Use for coastal waters in the 2004 305(b) report. Data obtained by the MS DMR from the NSSP were used in addition to the MDEQ Beach Monitoring Program data. Approximately 23 km^2 (9 $mile^2$) of the Coastal Streams Basin are not attaining their designated use (Shellfish Consumption) and an additional 11 km^2 (28 $mile^2$) are not meeting their designated use and considered impaired. TMDLs for pathogens have been completed for the 73 km^2 (28 $mile^2$) that are impaired (MDEQ, 2004b). Sampling stations located near Cat Island and Davis Bayou are tested approximately once a month as part of the water quality monitoring conducted by the MS DMR. These stations are monitored less frequently because Davis Bayou is classified as a conditionally restricted area and the waters surrounding Cat Island have a higher salinity, which limits the oyster population (Scott Gordon, MS DMR, pers. comm.).

[4] NSSP 14/43 standard: The fecal coliform media or geometric mean must not exceed 14 MPN/100 ml, and not more than 10 percent may exceed 43 MPN/100 ml.
[5] NSSP 88/260 standard: The fecal coliform media or geometric mean must not exceed 88 MPN/100 ml, and not more than 10 percent may exceed 260 MPN/100ml.

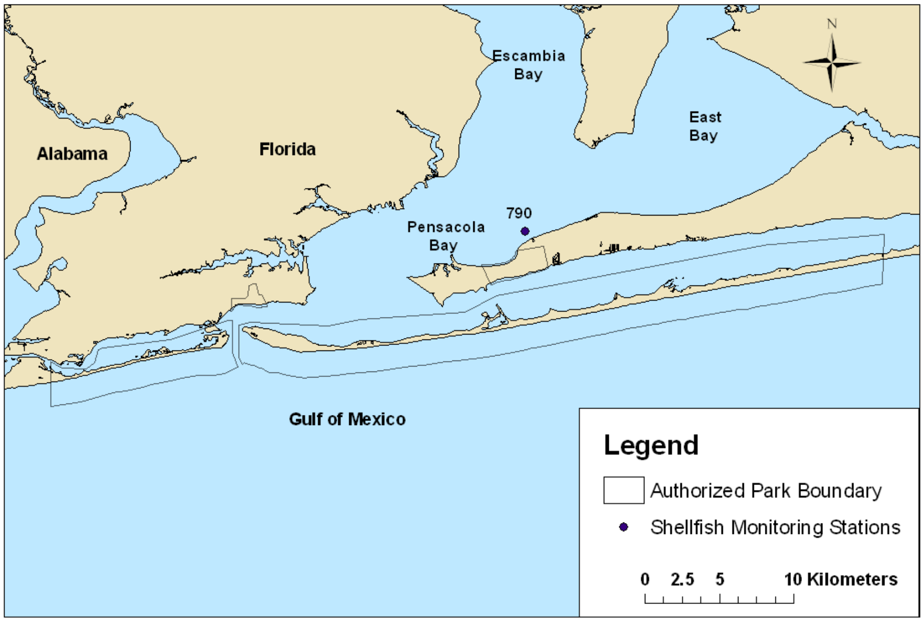

Figure 31. Shellfish monitoring stations within 3.2-km (2-mile) buffer of western Gulf Islands National Seashore-FL.

(Data Sources: Shellfish Stations – FL DACS (2004), County - FDEP (1:24,000, Automated 1997) and Authorized Park Boundary – USDOI/NPS (1992)).

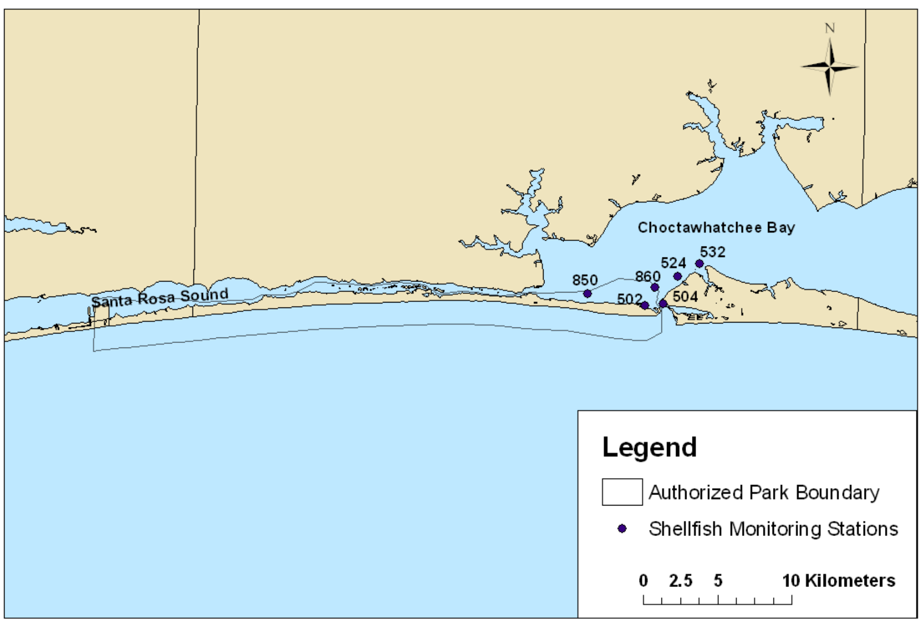

Figure 32. Shellfish monitoring stations within 3.2-km (2-mile) buffer of eastern Gulf Islands National Seashore-FL.

(Data Sources: Shellfish Stations – FL DACS (2004), County - FDEP (1:24,000, Automated 1997) and Authorized Park Boundary – USDOI/NPS (1992)).

FL – Beach monitoring

The FL Healthy Beaches Program began in 1998 with a pilot program that included 11 coastal counties that conducted beach water sampling every two weeks. In August 2000, the beach water sampling program was expanded to include 34 counties. There are 14 stations located in Escambia County, 7 in Santa Rosa County, and 12 in Okaloosa County. Several of the stations are within GUIS boundaries or in close proximity to the park. The coastal beach water samples collected by the county health departments are analyzed for enterococci bacteria and fecal coliform. The results are categorized as good, moderate, or poor based on the number of organisms per 100 mL of marine water and the geometric mean of five weeks of results. Advisories/warnings indicate that contact with the water at this site may pose an increased risk of infectious disease, particularly for susceptible individuals. A poor rating may result in a resampling event to confirm poor conditions, otherwise a health advisory or warning will be issued immediately. These values corresponding with a poor rating are 104 or greater enterococci per 100 ml of marine water, 35 or greater enterococcus geometric mean, and 400 or greater fecal coliform per 100 ml of marine water.

The results for 14 stations located within the GUIS-FL boundary are discussed in this section (**Figures 33 and 34)**. These stations were selected by identifying the STORET stations that were sampled by the Division of Environmental Health, Bureau of Water Programs. Not all of these stations are monitored as part of the healthy beaches program; however, the healthy beaches guidelines were used to assess water quality. In addition, the FL standard for fecal coliforms is 800 colony forming units (CFUs) per 100 ml on any one day. Four observations were above this standard. These instances occurred at the Escambia99, Okaloosa200 (twice), and Okaloosa323 stations.

The data collected for beach monitoring programs are single observations that cannot be used for regulatory purposes because the standards are written to reflect 30-day geometric means. To analyze one-time measurements, the instances when a warning would be issued based on 400 or greater fecal coliform per 100 ml will be used. This guideline was exceeded on 13 occasions from July 2000 to December 2003 for all stations. The distribution of these occurrences shows that exceedance was most common in the summer months of June to September (**Figures 35 and 36**). This indicates that bacterial contamination may be a problem in localized areas and could pose a health risk to swimmers. Sources of fecal coliform include improperly functioning septic systems, stormwater runoff, wastewater treatment plants, and agricultural runoff. The predominant species in the fecal coliform group is *E. coli,* which indicates fecal coliform pollution and the possible presence of enteric pathogens. For enterococci, the threshold of 104 CFUs per 100 ml of marine water was exceeded 11 times during the same period. The majority of these instances occurred between May and July (**Figures 37 and 38**). This supports the previous results, which indicate that these waters may pose health risks to swimmers during peak recreation times.

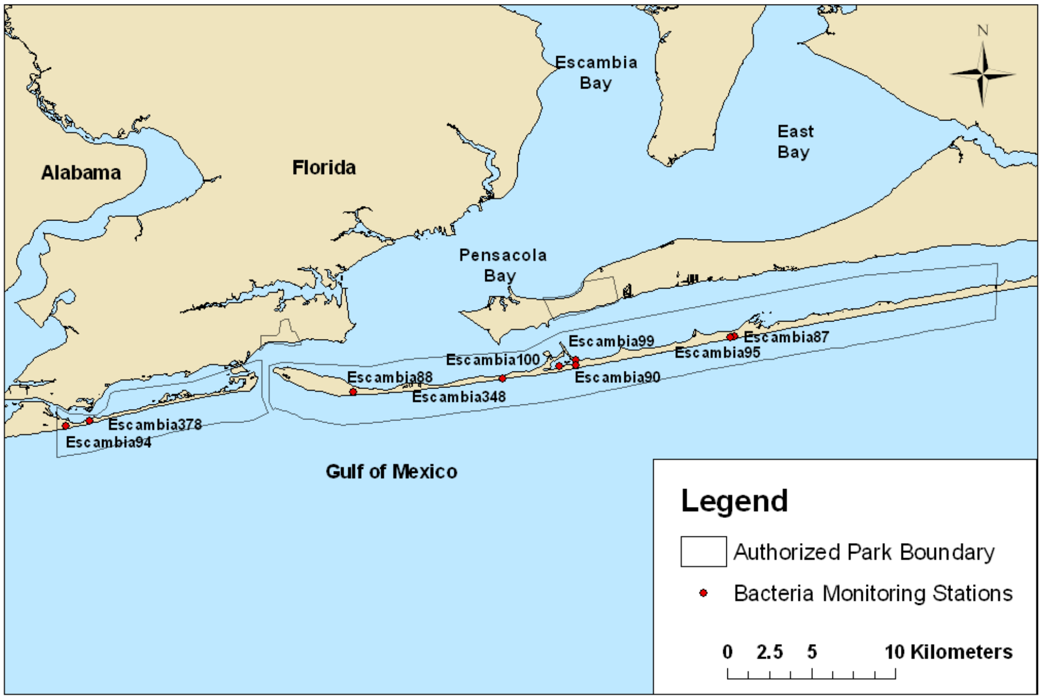

Figure 33. Selected bacteria sampling stations located within Gulf Islands National Seashore-FL boundaries (western section).

(Data Sources: STORET Stations – USEPA-(2004), County - FDEP (1:24,000, Automated 1997) and Authorized Park Boundary – USDOI/NPS (1992)).

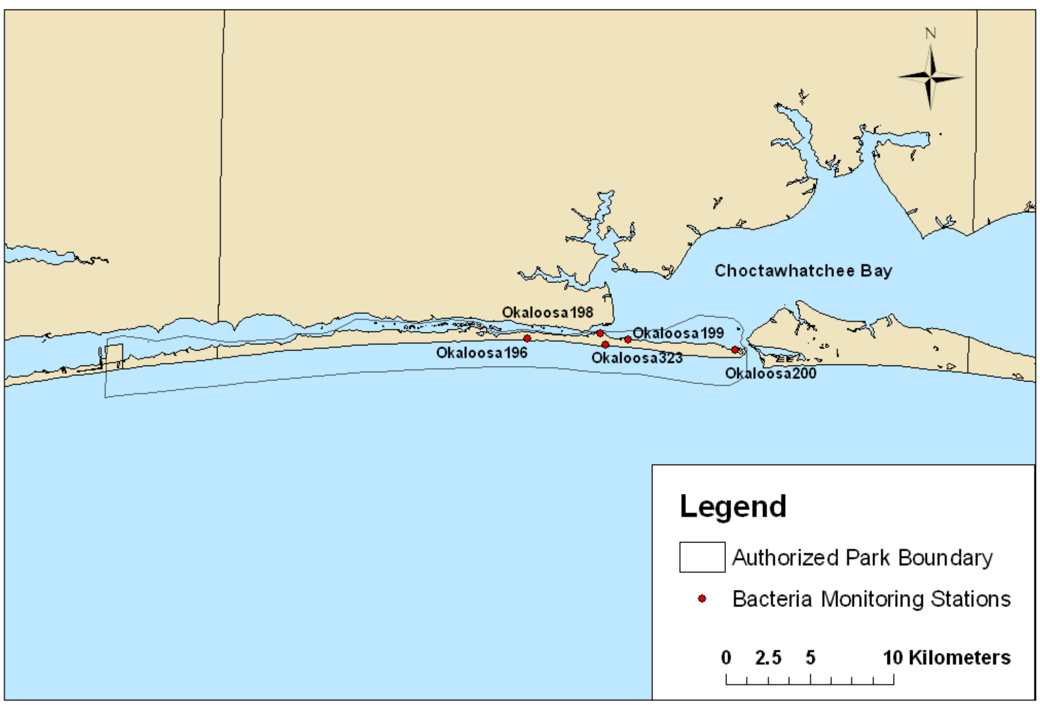

Figure 34. Selected bacteria sampling stations located within Gulf Islands National Seashore-FL boundaries (Okaloosa section).

(Data Sources: STORET Stations – USEPA-STORET (2004), County - FDEP (1:24,000, Automated 1997) and Authorized Park Boundary – USDOI/NPS (1992)).

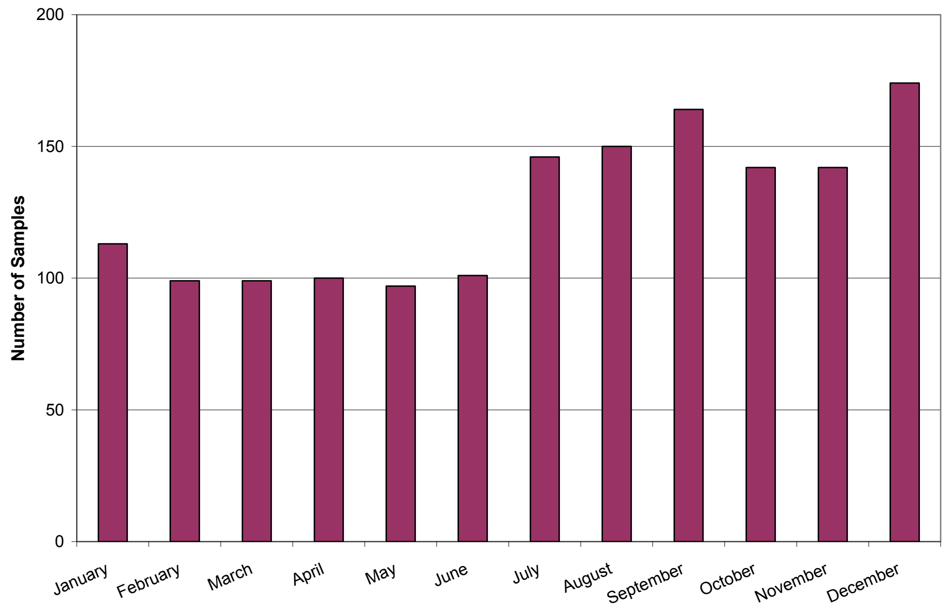

Figure 35. Number of fecal coliform samples for 14 stations located in Gulf Islands National Seashore-FL, July 2000-December 2003.

(Data Source: USEPA-STORET, 2004).

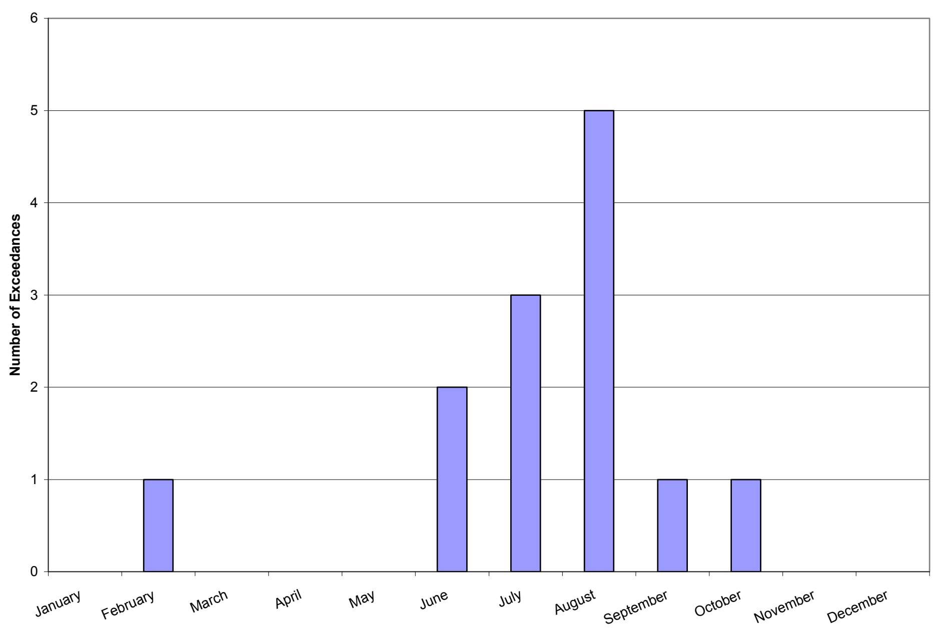

Figure 36. Fecal coliform observations > 400 per 100 ml for 14 stations located in Gulf Islands National Seashore-FL, July 2000-December 2003.

(Data Source: USEPA-STORET, 2004).

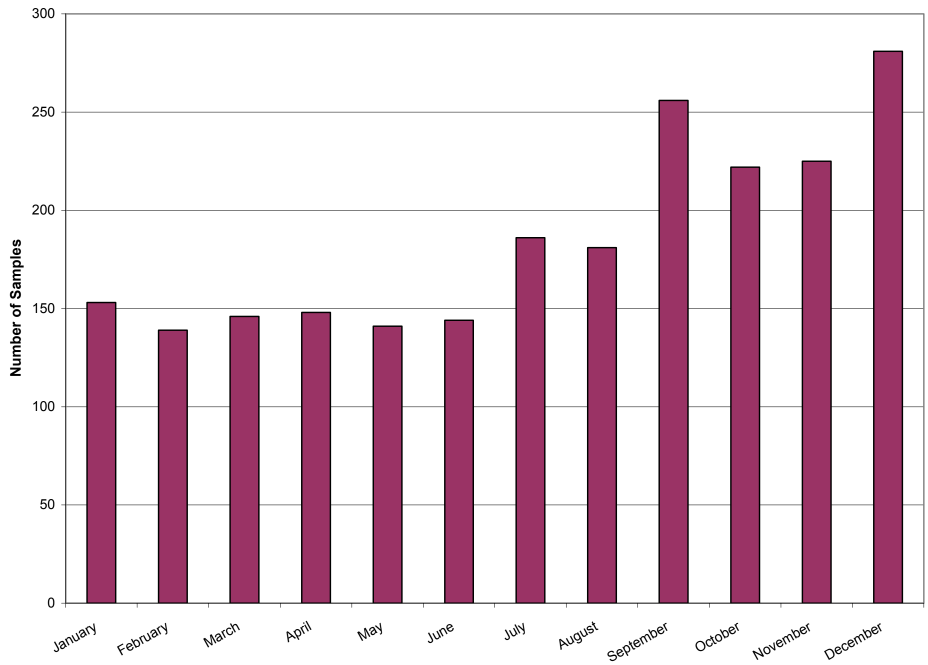

Figure 37. Number of enterococci observations for 14 stations located in Gulf Islands National Seashore-FL, July 2000-December 2003.

(Data Source: USEPA-STORET, 2004).

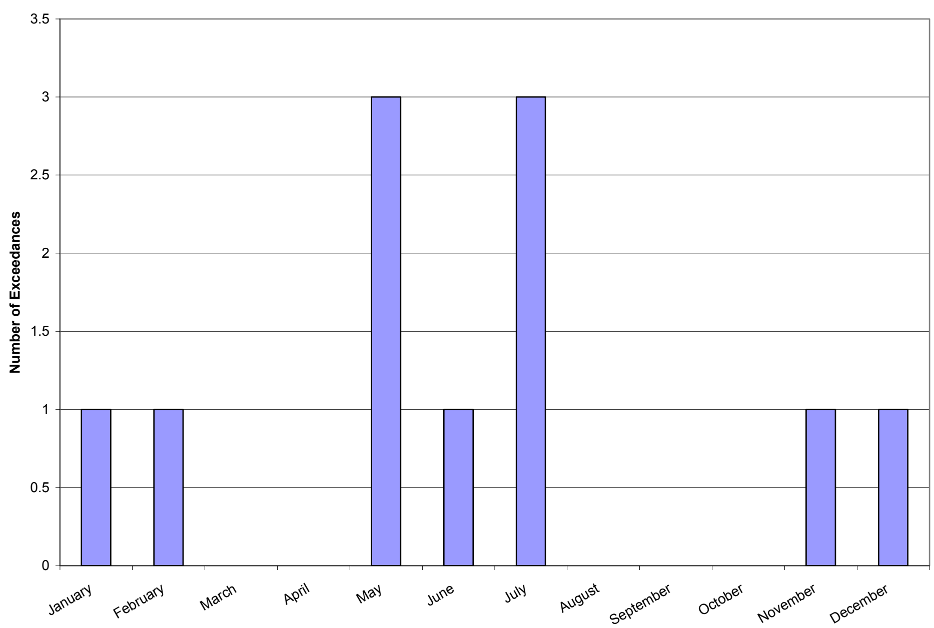

Figure 38. Enterococci observations > 104 per 100 ml for 14 stations located in Gulf Islands National Seashore-FL, July 2000-December 2003. (Data Source: USEPA-STORET, 2004).

MS – Beach monitoring

The suitability of the GUIS-MS waters for recreation, specifically swimming, is monitored by the Gulf Coast Research Laboratory (GCRL) in conjunction with the MDEQ. The Jackson and Harrison county stations provide data for beach conditions in MS Sound (**Figure 39**). Samples are collected from eighteen stations that range from the MS-LS state line to the MS-AL state line. During the "summer" months of March through the end of October, the sampling regime is rigorous (4-5 days per week). During the "winter" months of November through the end of February the sampling is less intense (2-4 days per week). These stations have been monitored since January 2000. There is one station located on Ship Island that is monitored by the USDOI/NPS since June 2001.

Fecal coliforms and enterococci are measured at a station located on the south swimming beach of West Ship Island. The number of samples collected and instances when the fecal coliform counts exceeded 400 units per 100 ml are presented in **Table 20**. For enterococci, the threshold of 104 CFUs per 100 ml of marine water was applied. These data indicate that there are instances when contact could result in health risks to the public.

Table 20. Bacteria monitoring data for West Ship Island, MS.

	Number of Samples		Number of Exceedances	
Year	Fecal coliform	Enterococci	Fecal coliform	Enterococci
2001	7	24	0	1
2002	0	24	N/A	1
2003	0	24	N/A	2
2004	0	12	N/A	0
2005	0	1	N/A	0

Source: Dick Zani, USDOI/NPS, pers. comm.

There were 11 beach closures at seven different beaches in Harrison County and three closures at three different beaches in Jackson County in 2003. Six of the beach closures in Harrison County were due to high bacteria levels, three due to sewage spills, and two because of ruptured sewer force mains. The three closures in Jackson County were due to high bacteria levels. The applicable MS standard states that fecal coliform shall not exceed a geometric mean of 200 per 100 ml based on a minimum of five samples taken over a 30-day period with no less than twelve hours between individual samples, nor shall the samples examined during a 30-day period exceed 400 per 100 ml more than 10% of the time.

The beaches are categorized as Tier I and Tier II based on the level of usage. Tier I beaches are those that have high usage and Tier II have less frequent usage and low accessibility. Two Tier I stations in Harrison County were selected as representative stations, one with a history of closures and one without. Since there was only one beach closure in 2004, the stations were separated based on historical data. The 2004 data for these two stations are included as **Figure 40**. Station 11, located at Cowan/Lorraine Rd in Gulfport, MS, was closed four times in 2003 due to sewage spills and high bacteria levels. Compared to Station 13, located at Chalmers

Drive in Biloxi, MS, the fecal coliform counts are much higher, although the MS standard for recreational usage was not exceeded for either station in 2004.

The 2004 fecal coliform data for all Tier I stations in Jackson County, MS, are included in **Figure 41**. The majority of the data were consistently low, under 200 fecal coliform per 100 ml, with the exception of a few points for Stations 14 (Front Beach, Ocean Springs, MS) and 20 (Pascagoula Beach East, Pascagoula, MS). These spikes occurred primarily in the summer and winter months. The elevated levels during the summer months are of concern because of high beach usage. In 2004, enterococci counts were added for each station.

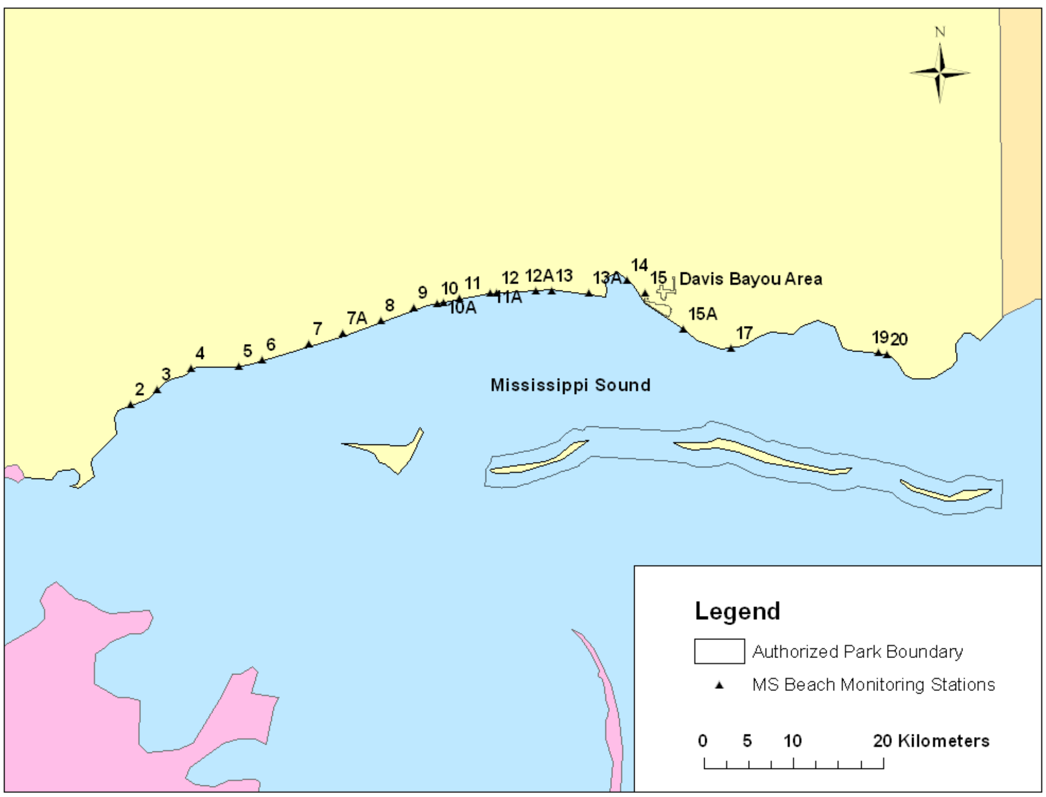

Figure 39. MS beach monitoring stations in Hancock, Harrison, and Jackson Counties.

(Data Sources: State - US Census Bureau (1:5,000,000, 1990), Beach Stations –MS Beach Monitoring Program (http://www.usm.edu/gcrl/msbeach/index.cgi), and Authorized Park Boundary –USDOI/NPS (1992))

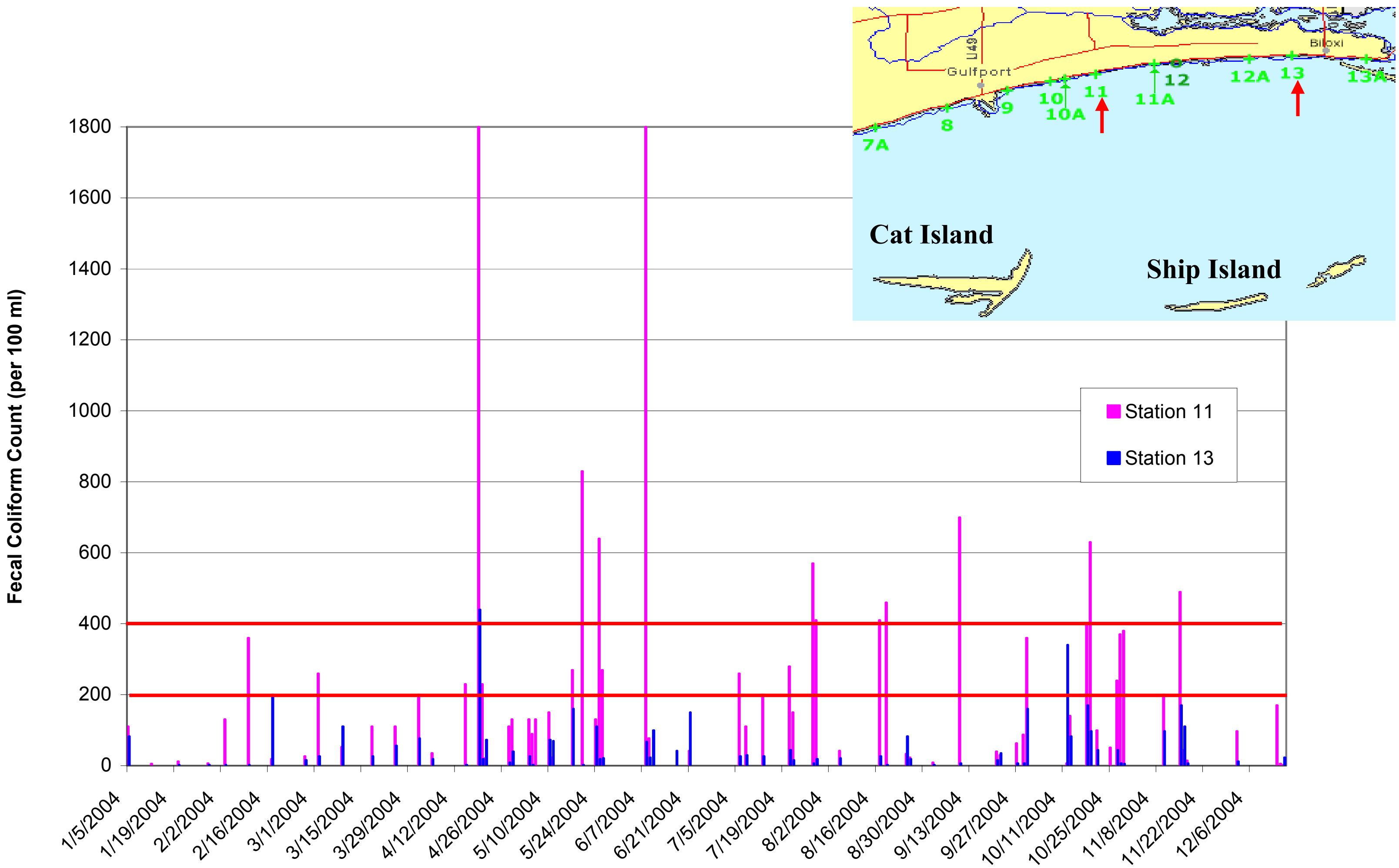

Figure 40. 2004 Fecal coliform data for Stations 11 and 13 in Harrison County, MS.

(Source: http://www.coms.usm.edu/msbeach/harbmon.cgi)

MS standard: Fecal coliform shall not exceed a geometric mean of 200 per 100 ml based on a minimum of five samples taken over a 30-day period with no less than twelve hours between individual samples, nor shall the samples examined during a 30-day period exceed 400 per 100 ml more than ten percent (10%) of the time.

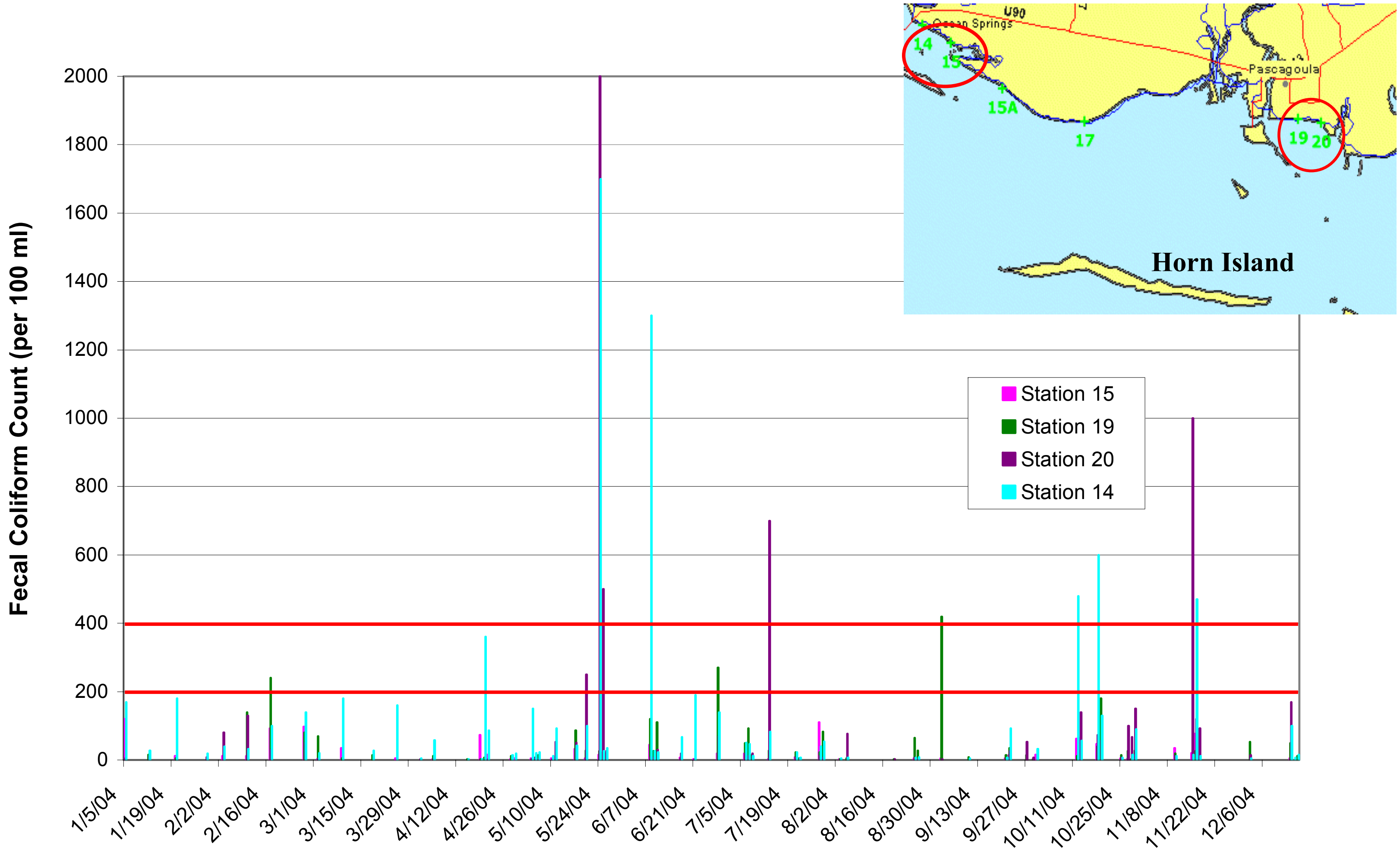

Figure 41. 2004 Fecal coliform data for Tier I beaches (Stations14, 15, 19, and 20) in Jackson County, MS.

(Source: http://www.coms.usm.edu/msbeach/jacbmon.cgi)

MS standard: Fecal coliform shall not exceed a geometric mean of 200 per 100 ml based on a minimum of five samples taken over a 30-day period with no less than twelve hours between individual samples, nor shall the samples examined during a 30-day period exceed 400 per 100 ml more than ten percent (10%) of the time.

Contaminants

Water samples were collected and analyzed for various metals including cadmium, chromium, copper, iron, lead, nickel, and zinc. These samples were collected as part of two programs. One conducted by the NWFWMD involved sampling for cadmium, chromium, copper, lead, nickel, and zinc from 1999 to 2003. The FWCC measured iron in water samples from 1996 to 1997. None of the stations were located within the 3.2-km (2-mile) buffer established for data retrieval. These samples were obtained from bayous near Pensacola and Choctawhatchee Bays as well as sites further upstream in the watersheds. The majority of the measurements were below the detection limits with the exception of iron. For cadmium, 8% of the measurements (5 out of 63 observations) were at levels detectable by the analytical procedure. For chromium, 6% (4 out of 63 observations) of the measurements were detectable and for copper 32% (20 out of 63 observations) were detectable. Lead was detected in quantifiable amounts in 50% of the samples (29 out of 58 observations), nickel in 32% (20 out of 63 observations), and zinc in 49% (31 out of 63 observations). The detection limits based on analytical procedure are included in **Table 21**.

Table 21. Detection limits for analytical procedures utilized to determine metal concentrations in water ($\mu g\ l^{-1}$).

	Analytical Procedure ID	
Parameter	**USEPA 200.8 (W)**	**USEPA 200.7 (W)**
Cadmium	0.025-0.05	0.30
Chromium	2.0	0.60
Copper	0.4-1.2	2.0
Lead	0.05-0.30	2.0
Nickel	0.25-0.60	1.2
Zinc	2.0-6.0	2.0-8.0

Source: USEPA-STORET, 2004.

None of the measurements of cadmium, chromium, nickel, and zinc exceeded FL Standards for Class III Marine Waters. There was one instance when the standard for lead (5.6 $\mu g\ l^{-1}$) was exceeded. The results indicate that copper and iron may be problematic in the bayous near Pensacola and Choctawhatchee Bays. Considering the detectable measurements, the standard for copper (2.9 $\mu g\ l^{-1}$) was exceeded 55% of the time with a maximum value of 62 $\mu g\ l^{-1}$. None of these measurements was obtained within the park boundaries; these data cannot be used to determine if there is a problem with metals within GUIS. For iron, the standard of 0.3 mg l^{-1} was exceeded 97% (28 out of 29 observations) of the time. This is not uncommon as iron often occurs regionally, causing waters to exceed standards.

Research on the levels of contaminants such as pesticides, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs) in addition to metals has also been conducted. Lewis et al. (2001b) conducted a study from 1993-1995 to determine the water and sediment quality in three bayous (Chico, Grande, and Texar) located near Pensacola. The study found that the surface water concentrations of heavy metals, organochloride pesticides, PAHs, and PCBs were generally below method detection limits. One exception was copper, which consistently exceeded FL and national acute and chronic water quality criteria (Lewis et al., 2001b). Cadmium, chromium, and nickel intermittently exceeded their respective criteria. Sediment contamination was site specific and included a number of chemicals (Lewis et al., 2001b). The concentrations of up to 17 compounds, including cadmium, copper, chromium, zinc, total PAHs, anthracene, pyrene, total PCBs and DDT, and chlordane, exceeded the numerical effects-based guidelines proposed for FL sediment quality (FDER, 1994). The study also noted that sediment quality generally improved seaward (Lewis et al., 2001b). The report cited the probable source of these contaminants as stormwater runoff from contributing urbanized watersheds (Lewis et al., 2001b).

The MDEQ database contains data for numerous metals and phenols. These metals are arsenic, cadmium, chromium, copper, mercury, lead, nickel, selenium, and zinc. Most of the samples were collected from Station 647BBY02 located in Biloxi Bay, with the exception of the zinc measurements which were collected near the barrier islands as well as along the coast. Station 647BBY02 station is located at Ocean Springs, MS, off Marsh Point. The samples were recorded from 1997 to 2000. The results from the samples collected at this station are presented in **Table 22**.

Table 22. Selected metal concentrations at Station 647BBY02 located in Biloxi Bay, MS.

Parameter	Total Observations	Detection Limit (µg l^{-1})	Number of Observations Exceeding Detection Limit	Maximum Detected Value (µg l^{-1})
Arsenic	28	5	3	84
Cadmium	28	1	3	3
Chromium	28	1	15	78
Copper	28	5	2	42
Mercury	28	0.5	1	0.5
Lead	28	5	1	5
Selenium	28	5	6	33
Nickel	28	5	1	5

Source: MDEQ Database, 2004.

Comparison of the metal concentrations to the MS state standards is not direct. The standards are presented in terms of total dissolved concentrations whereas the data are total recoverable concentrations. Conversion factors for dissolved metals are provided in the USEPA's publication *National Recommended Water Quality Criteria: 2002*. Exceedances of the criteria should be interpreted with caution due to the potential for sampling contamination. There was one instance in Biloxi Bay when the total arsenic concentration (84 µg l^{-1}) exceeded the acute (69 µg l^{-1}) and chronic (36 µg l^{-1}) criteria for total dissolved arsenic (III) in saltwaters. This was also the case for copper (35 µg l^{-1}) with the corresponding standards of 4.8 µg l^{-1} (acute) and 3.1 µg l^{-1} (chronic) for total dissolved copper in saltwaters. The standards (acute and chronic) for total dissolved selenium in saltwaters were not exceeded. Station 647BBY02 was also analyzed for phenols; all of the samples except for one were less than 0.05 µg l^{-1}. The results from this station indicate that metal contamination is not a chronic problem; however, a definite conclusion as to the water quality should not be made based on the results of one site.

In addition to the station located in Biloxi Bay, there were stations located in Heron and Tidewater Bayous which were sampled on one or two occasions for a number of metals. There was one sample from Heron Bayou that displayed a chromium concentration of 18 $\mu g\ l^{-1}$ and one from Tidewater Bayou with a selenium concentration of 11 $\mu g\ l^{-1}$. Forty four stations were sampled for zinc and none of the measurements exceeded state acute or chronic standards for dissolved zinc.

Information on the sediment quality of the GOM estuaries is provided in the USEPA *National Coastal Condition, Part II* (2004). This report is based on data collected as part of the 2000 NCA surveys. According to this report, 12% of the Gulf Coast estuarine sediments exceeded the thresholds for sediment toxicity, sediment contaminants, or sediment total organic carbon (TOC) (USEPA, 2004). The sediment toxicity for these sites based on amphipod toxicity was also classified as good (≥ 80% survival). Sediment contaminant concentrations were not above the Effects Range Median and Low values for the MS and FL waters of GUIS (Long et al., 1995). Two percent of the Gulf Coast estuaries had levels of TOC that were considered high (TOC > 5%). Some of the sites located in northwest FL and southern MS were classified as fair (2-5%) (USEPA, 2004). For the entire Gulf Coast, the benthic communities were classified as fair to poor. A benthic index developed by Engle and Summers (1999) was utilized to assess the condition of the Gulf Coast estuaries. The index differentiates between reference and degraded communities by integrating measures of species diversity and populations of indicator species (USEPA, 2004). Poor benthic conditions often occurred with poor water and sediment quality. Low benthic diversity areas along the MS and FL coast co-occurred with poor sediment quality, poor sediment and water quality, or neither of these conditions (USEPA, 2004).

Ache et al. (2000a) performed a study of the fishery resources of the GOM in 1999 at the request of the GOM Program to provide detailed information on the occurrence of mercury in these resources. The first section of the report addressed the most common fish and shellfish species harvested commercially and recreationally from the GOM. The six species with the greatest average annual commercial fisheries landings, in pounds, from the GOM (from 1995 to 1997) were Atlantic menhaden, brown shrimp, white shrimp, blue crab, pink shrimp, and eastern oyster (Ache et al., 2000a). The six species with the greatest average annual recreational fisheries landings, in pounds, from the GOM (from 1995 to 1997) were red drum, spotted seatrout, dolphin, king mackerel, sheepshead, and red snapper (Ache et al., 2000a).

The study compiled the existing regional mercury results into a database called the Gulfwide Mercury in Tissue Database (Ache et al., 2000a). It is composed of datasets acquired from eight different agencies/programs, representing the work of many different monitoring programs (Ache et al., 2000a). There are some differences in sampling programs that should be clarified including the purpose of the study, sampling protocol (unbiased vs. known sites of contamination), and frequency of sampling (Ache et al., 2000a). The study found that mercury is commonly found in the edible tissues of the GOM estuarine/marine fish and shellfish. About 77% of the 24 commonly-harvested groups had a Gulfwide mean mercury concentration between 0.2 and 1.0 ppm (Ache et al., 2000a). None of these groups yielded a Gulfwide mean mercury concentration over 1.0 ppm (Ache et al., 2000a). The study concluded that king mackerel demonstrated elevated levels of mercury independent of sampling location in the GOM (Ache et al., 2000a).

Heavy metal contamination is an issue for GUIS with a current shellfish advisory for the consumption of king mackerel due to mercury levels for the entire GOM. Additional concerns about heavy metals result from the industrial activities near Pensacola, FL, and the urbanized areas of the MS coastline. In addition, the mouth of Pensacola Bay is listed as impaired for copper and lead. Most likely, the heavy metal contamination issues are related to non-point source pollution and continuing coastal development. The distance from Superfund sites makes them an unlikely source of contaminants to the park. There are essentially no dissolved metals data from the USEPA STORET database within the park boundaries and a limited amount available from the MDEQ. Additional sampling is required within the park boundaries to determine if localized areas of metal contamination exist.

Harmful Algal Blooms (HABs)

Historically, the GOM coastal systems have experienced HABs. HABs are the rapid growth of a harmful algal species that contains toxins or a species that negatively affects humans or natural resources. Most of the HABs in the GOM are caused by high numbers of *Karenia brevis* (Pennock et al., 2004). Red tides occur when higher than normal populations of this alga a.k.a. *Ptychodiscus brevis* and *Gymnodinium breve* are present. These organisms produce a toxin that may affect the central nervous systems of fish, leading to fish kills. The toxin is also transported by wind and can lead to respiratory irritation in humans. These tides can appear red, green, brown, purple, or have no color associated with them. HABS also affect the economies of coastal communities by shellfish closures, fish kills, and beach advisories that reduce tourism and affect the public's confidence in seafood products (Pennock et al., 2004).

The Harmful Algal BloomS Observing System (HABSOS) final report (2004) includes case studies for FL, AL, MS, LA, and TX. The objective of this report was to conduct a retrospective case study to recreate the environmental conditions and track *K. brevis* movements during 1996, 1997, and 2000 (Pennock et al., 2004). These years were selected because they include bloom and non-bloom periods, facilitating comparison between the origins, movement, and termination of the events (Pennock et al., 2004). The report discusses two HABs in the FL panhandle and one in MS. The information provided includes the trigger event, the state's event response strategy, the chronology of the event (spatial and temporal), the data collected, and inadequacies in the data collected (Pennock et al., 2004). FMRI maintains a database of HAB events in FL (FWCC, 2005). According to this database, there have been 64 instances of red tide in the combined areas of Escambia, Okaloosa, and Santa Rosa Counties from 1997 to 2005. The most recent occurrence was on September 11, 2001, in Pensacola Bay.

Light attenuation parameters

If the required nutrient levels are available, the growth of seagrasses or SAV is limited by light. The amount of sunlight available for seagrasses to photosynthesize is affected by algal and suspended particles in the water column. Color and chlorophyll *a* can be used to indicate if increased algae that result from excessive nutrients are present (Schwenning, 2001). Algae attached to plants, or epiphytes, affect the amount of light available to SAV. Epiphytes are also affected by grazers and nutrient availability (Lores et al., 2000). Increases in turbidity can also result from stormwater runoff or other stirring mechanisms, such as boating (Schwenning, 2001).

Two representative stations (330300G9 and 33030GA1) were selected to analyze water quality parameters affecting seagrass growth (**Figure 42**). These stations were selected based on the amount of data available and the parameters sampled. The parameters of interest included TSS, turbidity, true color, and chlorophyll *a* (corrected for pheophytin). Approximately two years of data (June 2001 to June 2003) were analyzed to determine recent trends. Significant trends generally require over ten years of data unless the system has drastically changed. This level of data is not available through Modernized STORET. Currently, there are no numeric standards for chlorophyll *a*, color, and TSS in FL surface waters; however, these measurements can be compared to values reported for stations in other FL estuaries (Friedemann and Hand, 1989). The applicable standard for turbidity is ≤ 29 Nephelometric Turbidity Units (NTU) above natural background conditions.

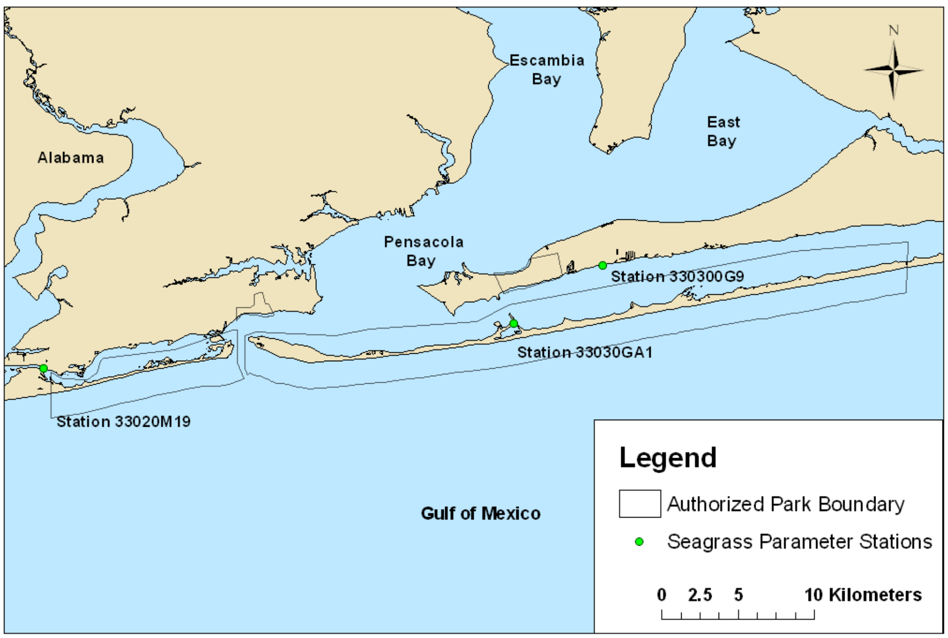

Figure 42. Seagrass sampling stations near Gulf Islands National Seashore-FL selected for analysis of light parameters.

(Data Sources: STORET Stations – USEPA-STORET (2004), County - FDEP (1:24,000, Automated 1997) and Authorized Park Boundary – USDOI/NPS (1992)).

The true color measurements for both stations fluctuated around an average value of approximately 12-15 platinum cobalt units (PCU) (**Figures 43 and 44**). Compared to 1,189 other estuarine stations in FL, 60-70% has more color. The chlorophyll *a* trends are similar for both stations. For the majority of the year, the chlorophyll *a* level was relatively constant at about 5 $\mu g\ l^{-1}$; however, there was a spike in late summer due to increased algal production (**Figures 45 and 46**). The detection limit of 5 $\mu g\ l^{-1}$ makes it difficult to discern trends because it is a relatively high value when considering seagrass health (Dr. Patrick Biber, USM, pers. comm.). Generally, chlorophyll *a* values ranging from 0 to 14 $\mu g\ l^{-1}$ indicate oligotrophic conditions (Friedemann and Hand, 1989).

TSS and NTU were used to measure turbidity. The measurements showed an overall decrease in TSS in water samples from 2002 to 2003 (**Figures 47 and 48**). Adverse effects due to increased turbidity include greater oxygen demand and deposition and reduced light availability for seagrasses. The TSS levels approached values below 10 mg/l for both stations in 2003. The turbidity measurements follow a similar trend. Both stations showed an overall decrease over the analysis period to values below 5 NTU (**Figures 49 and 50**).

As both of these stations were located in or near Santa Rosa Sound, an additional station (33020M19) located in Big Lagoon was also analyzed. The chlorophyll *a* levels measured at the station were approximately 5 $\mu g\ l^{-1}$ for most of the year with peaks during the late summer months (July to September). The chlorophyll *a* values ranged from 5 to 10 $\mu g\ l^{-1}$ from March 1999 to March 2002 (**Figure 51**). The average value for color from March 1998 to March 2002 was 17 ± 8.7 PCU (**Figure 52**). This value is slightly higher than that observed for the two stations located in Santa Rosa Sound. The average TSS concentration was 30.2 ± 14.5 mg l^{-1} from December 1998 to December 2000 (**Figure 53**). From March 1998 to March 2002, the average turbidity was 2.5 ± 2.6 mg l^{-1} NTU (**Figure 54**).

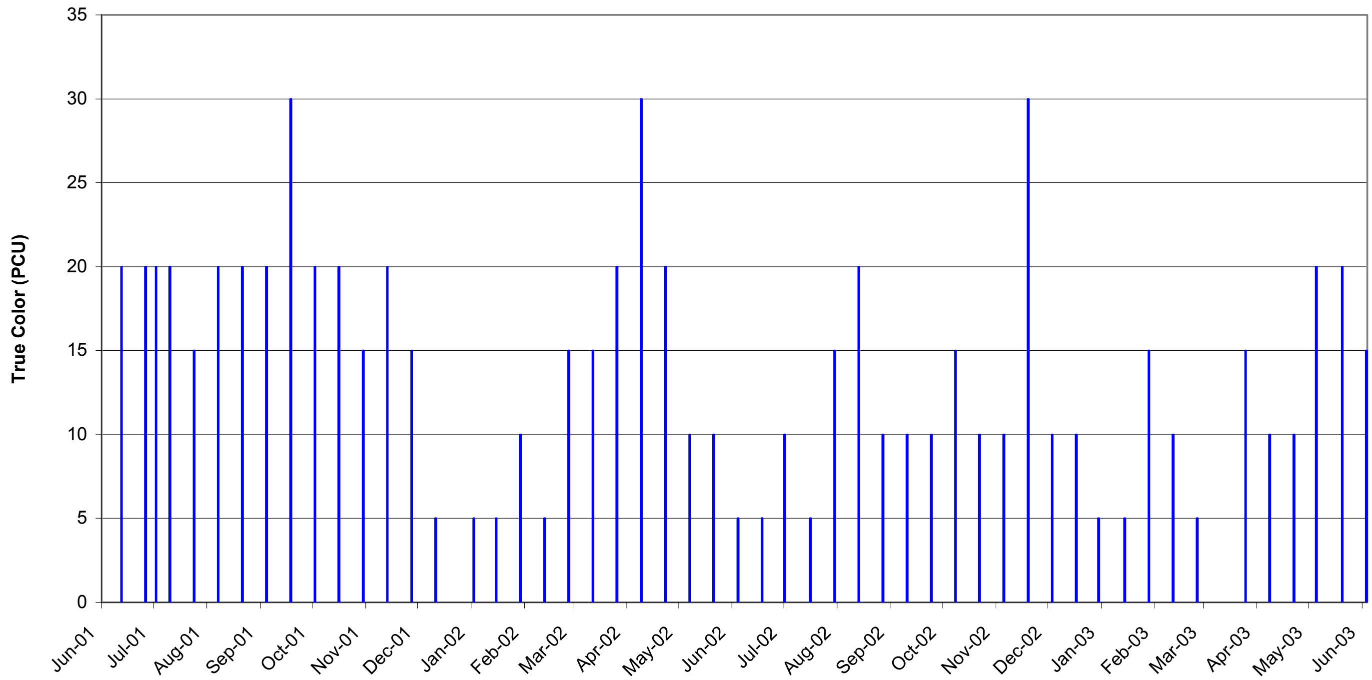

Figure 43. True color measurements for Station 330300G9 located in Santa Rosa Sound, June 2001 – June 2003.

(Data Source: USEPA-STORET, 2004).

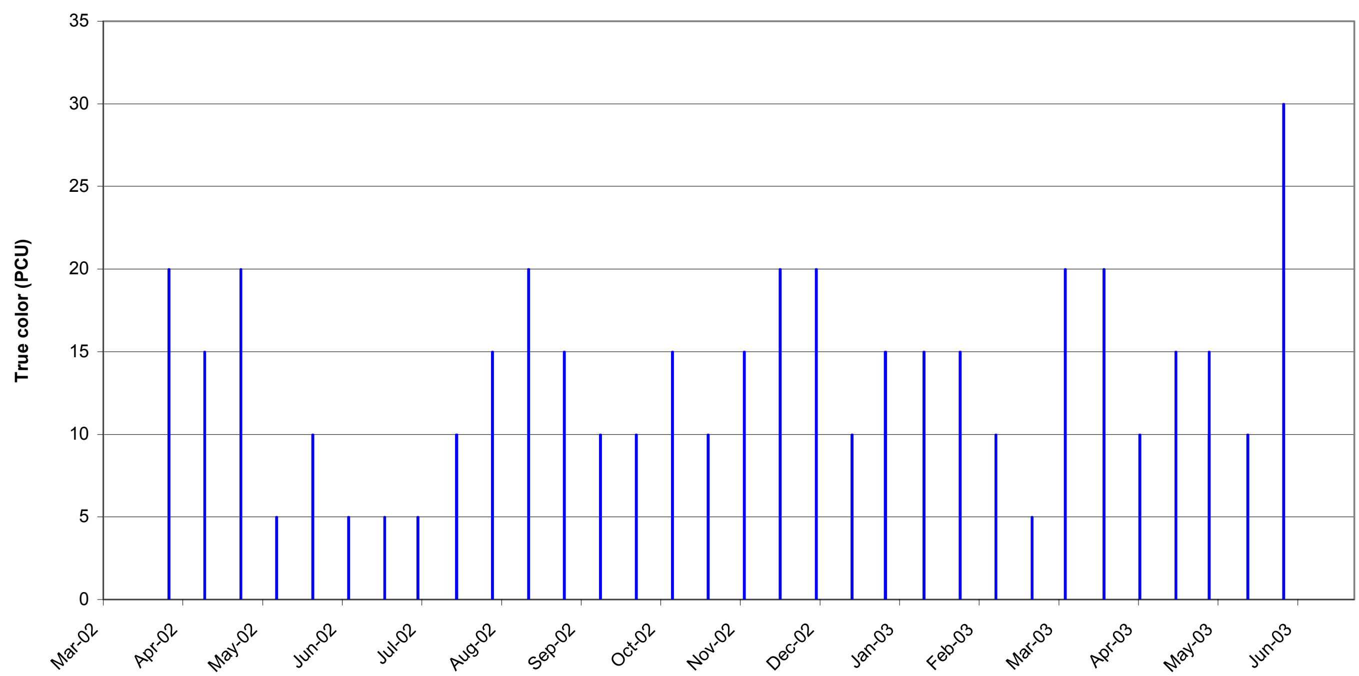

Figure 44. True color measurements for Station 33030GA1 located in Little Sabine Bay, March 2002 – March 2003.

(Data Source: USEPA-STORET, 2004).

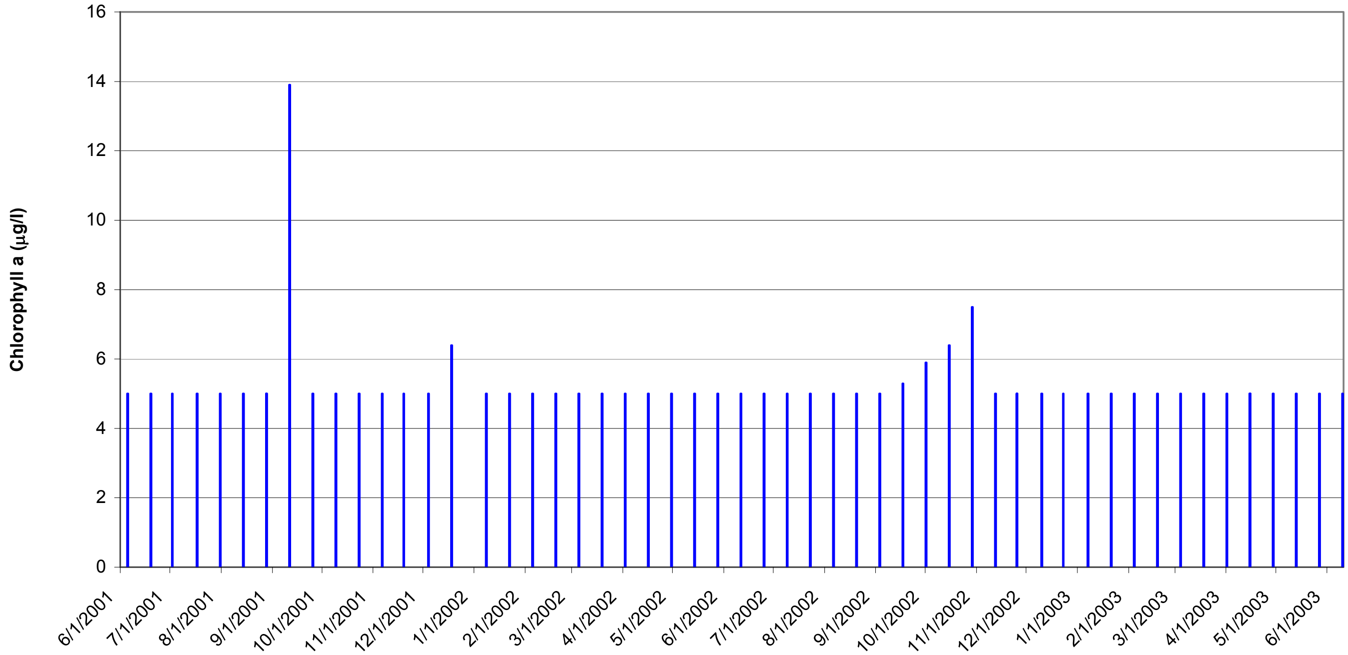

Figure 45. Chlorophyll *a* (corrected for pheophytin) data for Station 330300G9 located in Santa Rosa Sound, June 2001 – June 2003.

(Data Source: USEPA-STORET, 2004).

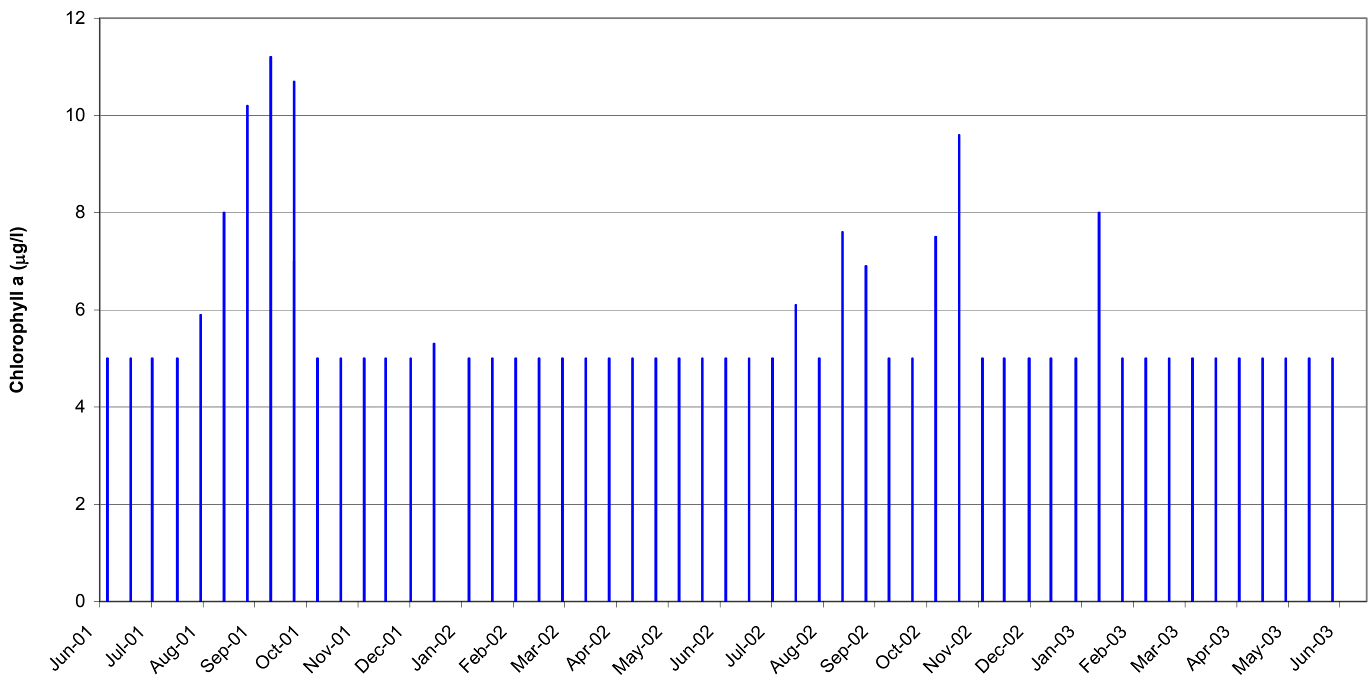

Figure 46. Chlorophyll *a* (corrected for pheophytin) data for Station 33030GA1 located in Little Sabine Bay, June 2001 – June 2003.

(Data Source: USEPA-STORET, 2004).

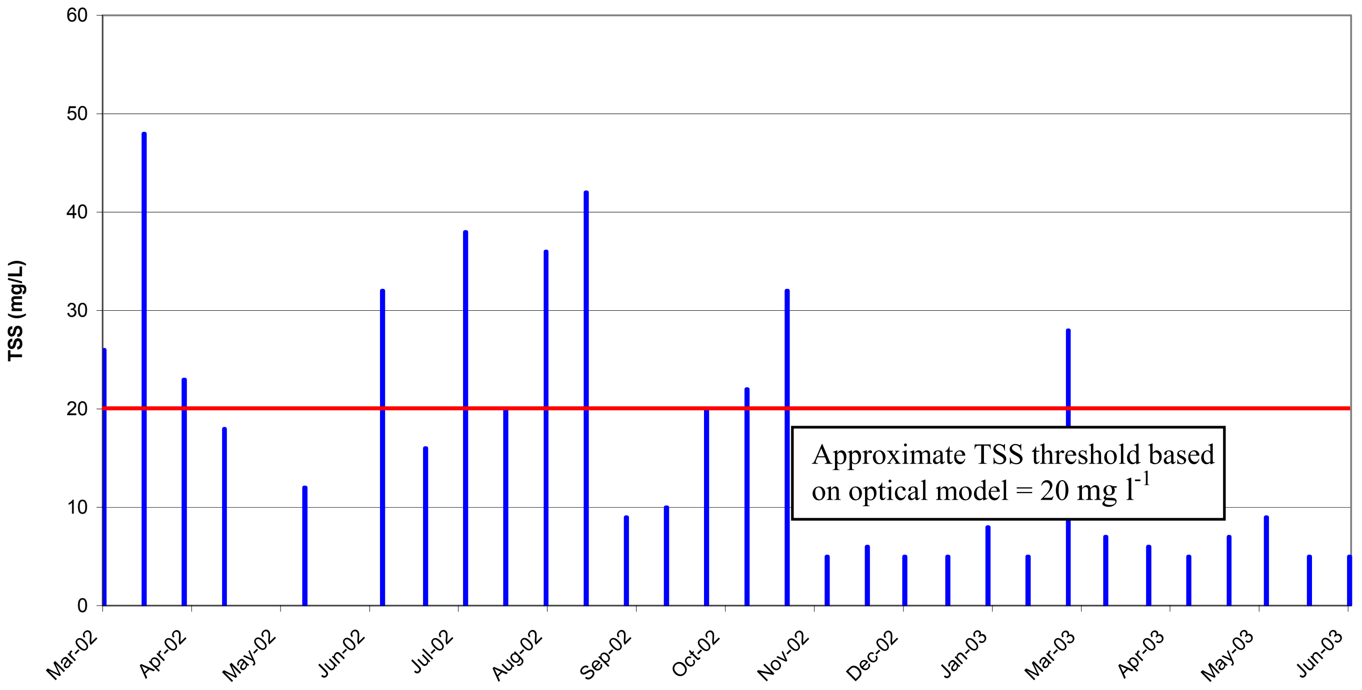

Figure 47. Total suspended solids data for Station 330300G9 located in Santa Rosa Sound, March 2002 – June 2003.

(Data Source: USEPA-STORET, 2004).

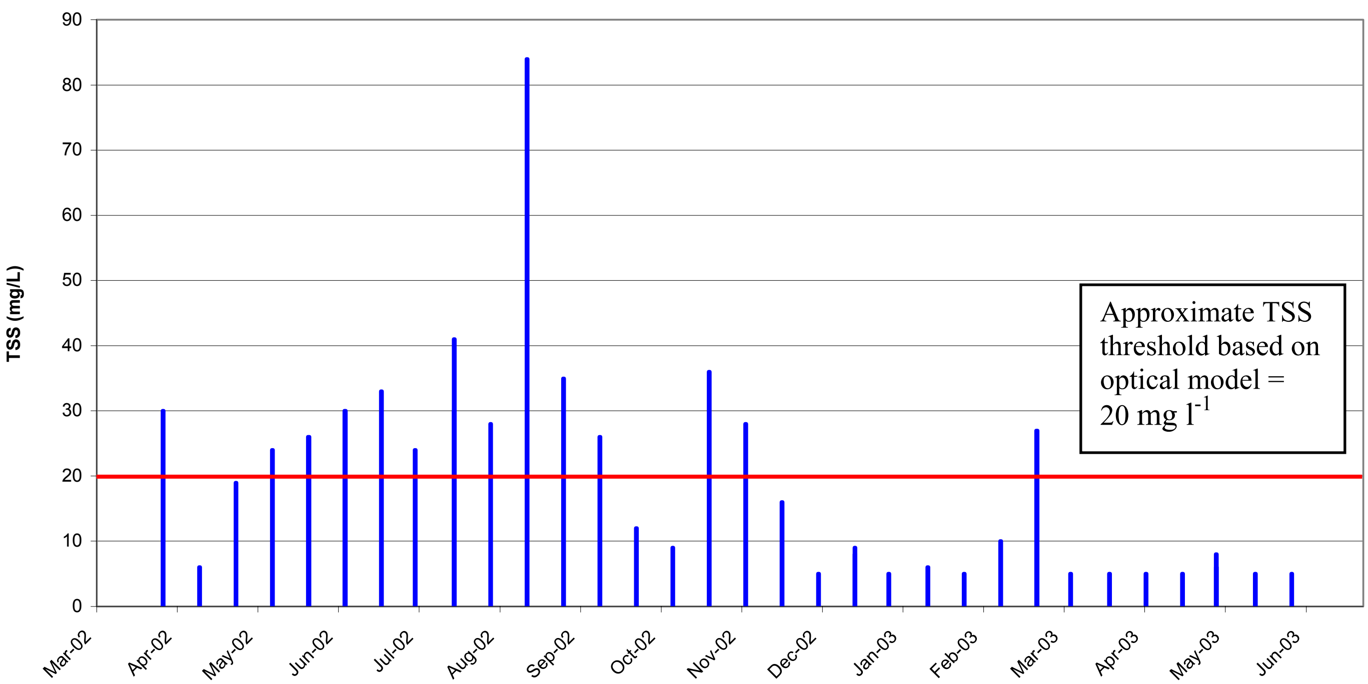

Figure 48. Total suspended solids data for Station 33030GA1 located in Little Sabine Bay, March 2002 – June 2003.

(Data Source: USEPA-STORET, 2004).

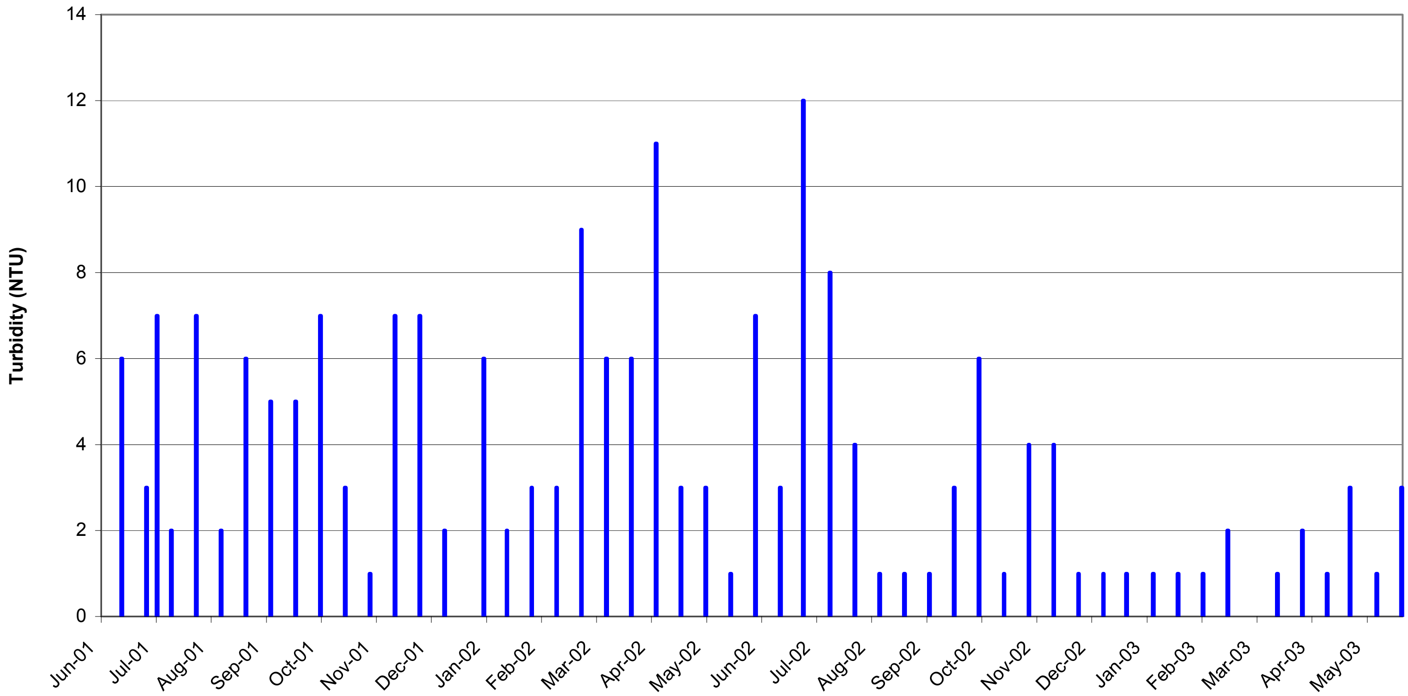

Figure 49. Turbidity data for Station 330300G9 located in Santa Rosa Sound, June 2001 – June 2003.

(Data Source: USEPA-STORET, 2004).

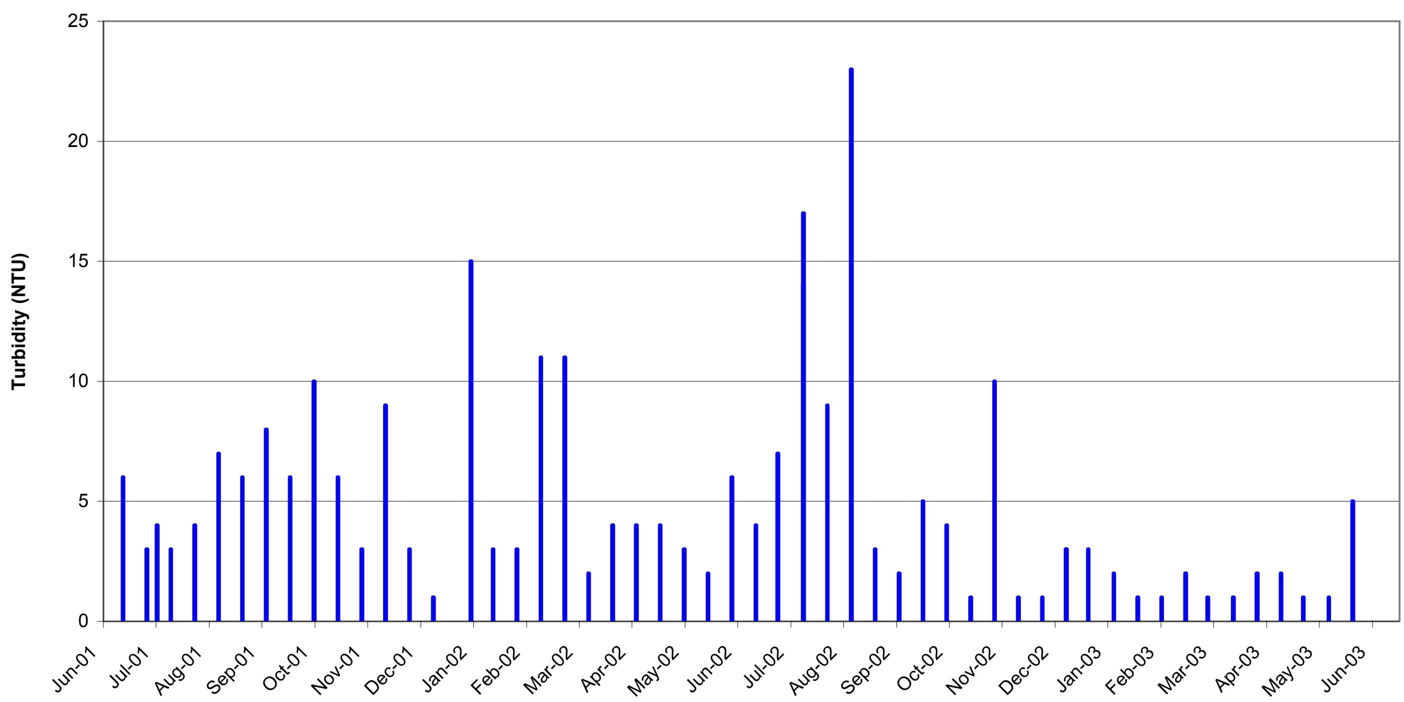

Figure 50. Turbidity data for Station 33030GA1 located in Little Sabine Bay, June 2001 – June 2003.

(Data Source: USEPA-STORET, 2004).

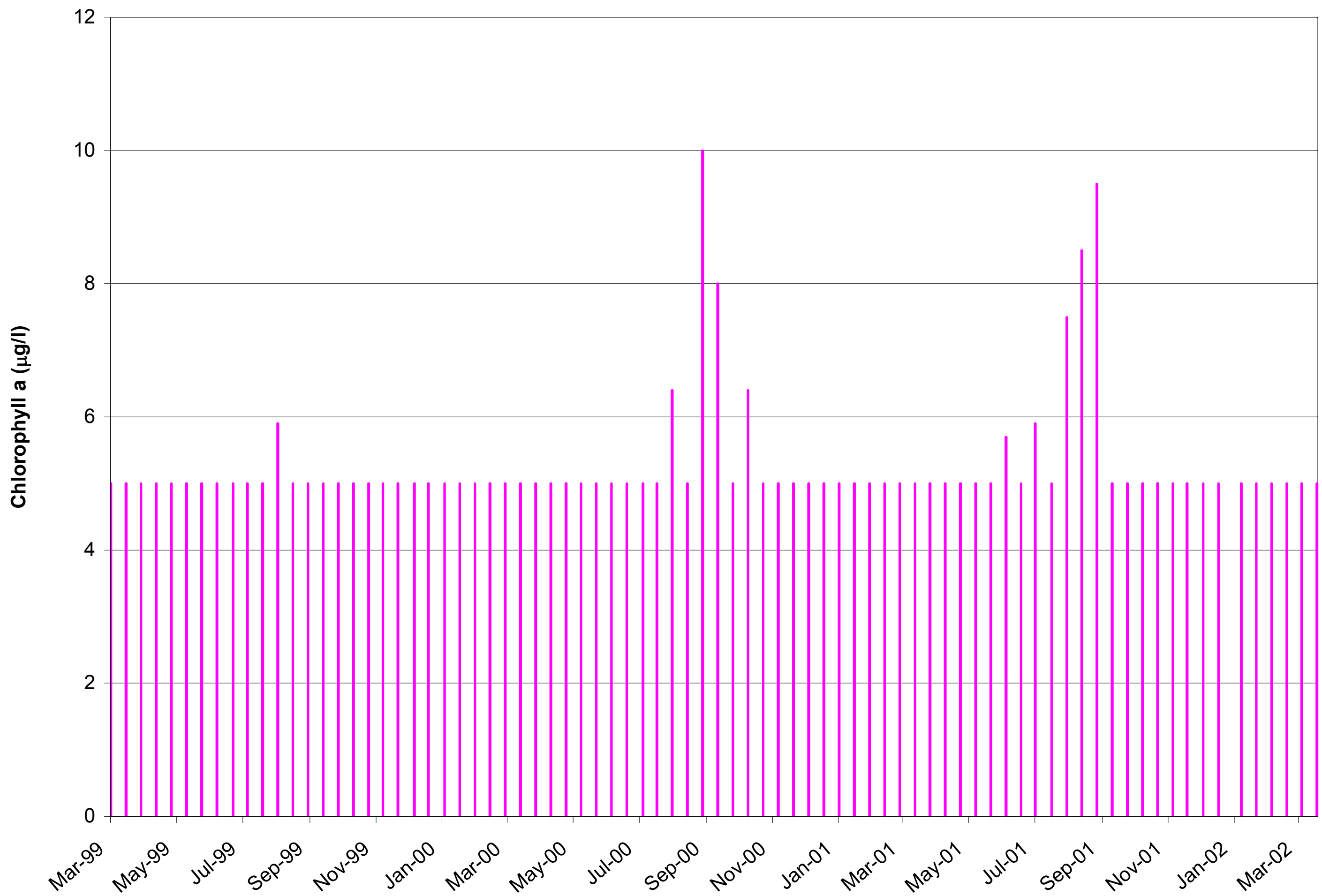

Figure 51. Chlorophyll *a* measurements (corrected for pheophytin) for Station 33020M19 located in Big Lagoon, March 1999 – March 2002.

(Data Source: USEPA-STORET, 2004).

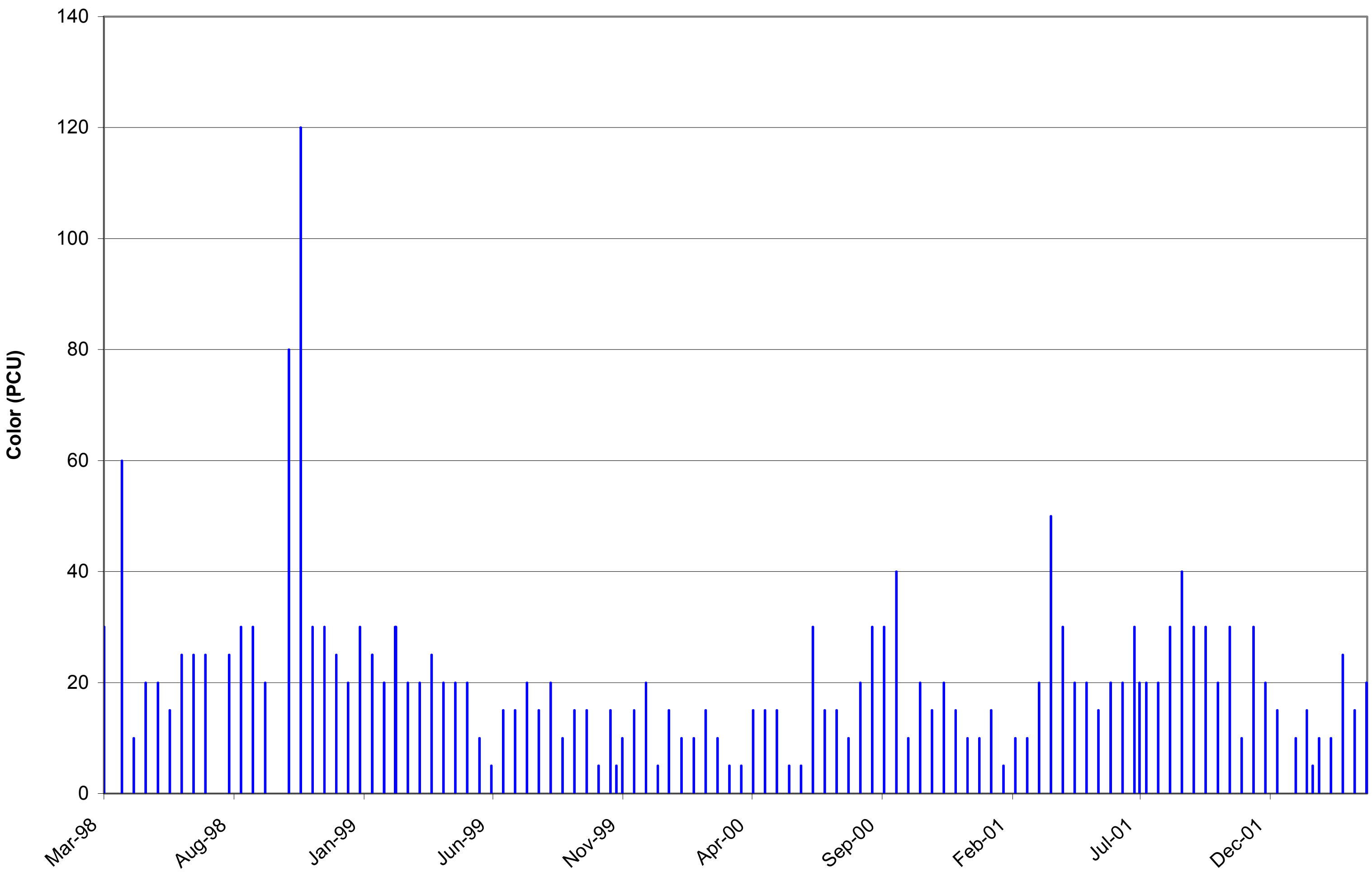

Figure 52. Color measurements for Station 33020M19 located in Big Lagoon, March 1998 – March 2002.

(Data Source: USEPA-STORET, 2004).

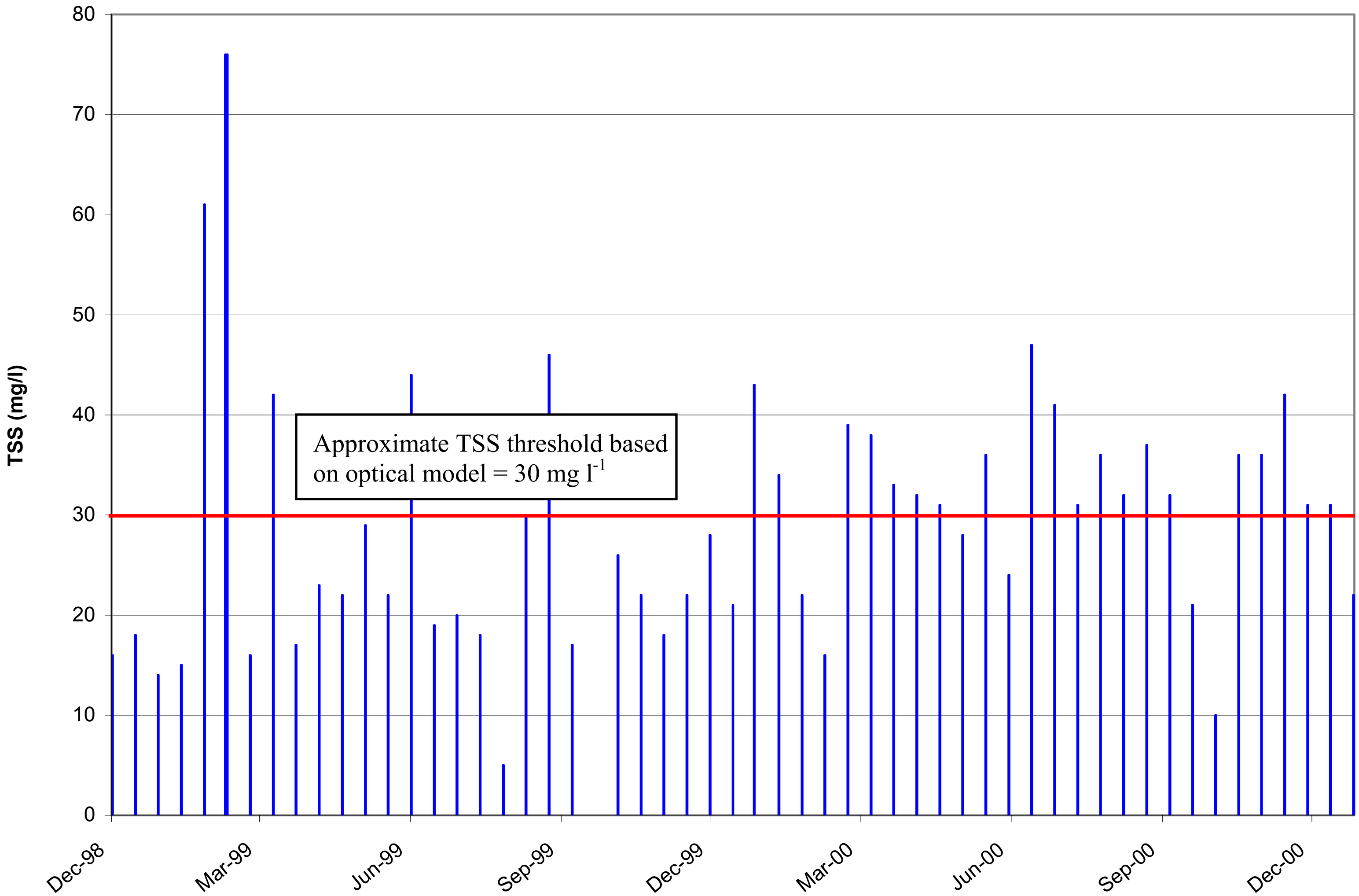

Figure 53. TSS measurements for Station 33020M19 located in Big Lagoon, December 1998 – December 2000.

(Data Source: USEPA-STORET, 2004).

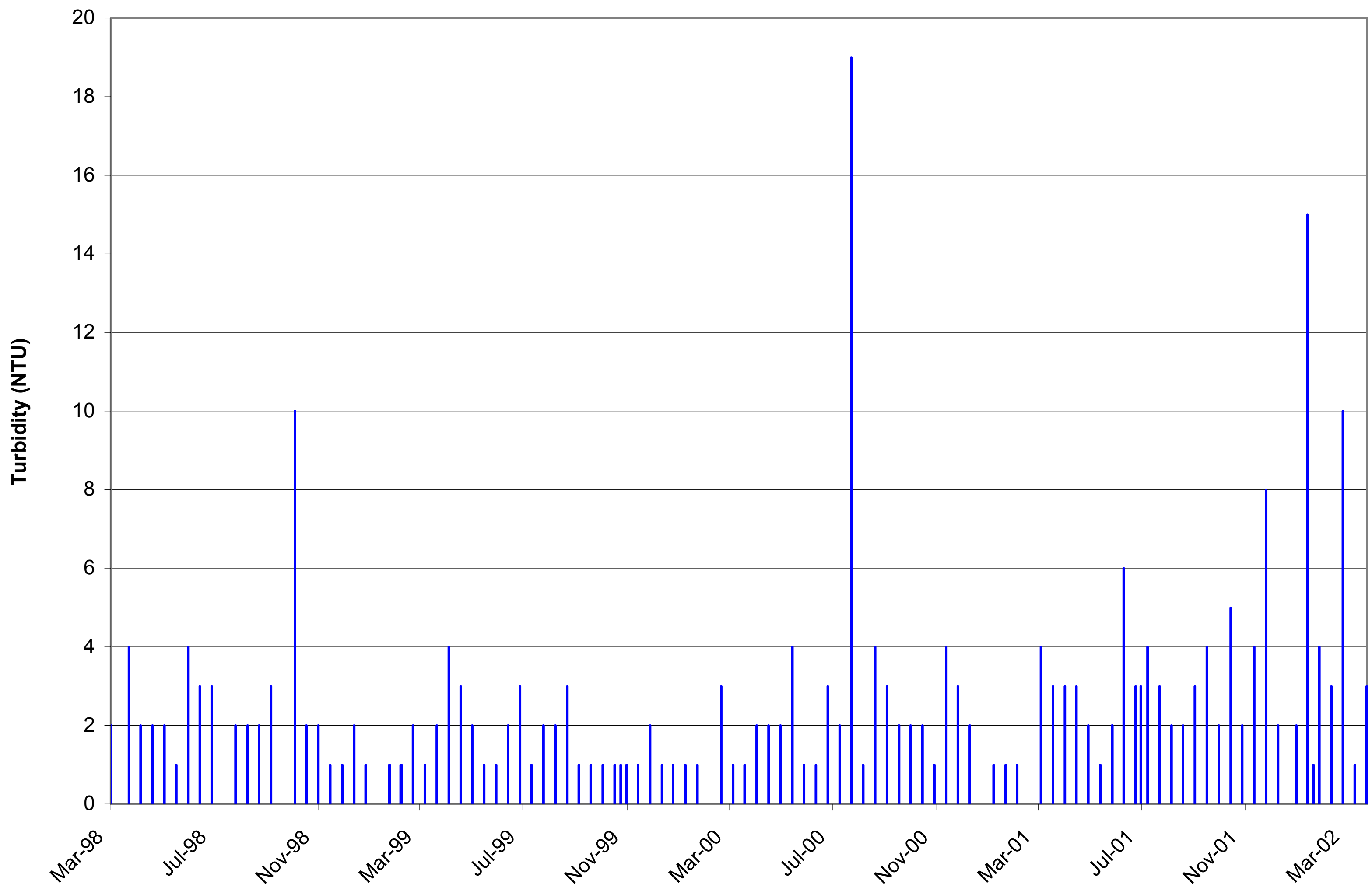

Figure 54. Turbidity measurements for Station 33020M19 located in Big Lagoon, March 1998 – March 2002.

(Data Source: USEPA-STORET, 2004).

An optical model has been developed which establishes threshold values for chlorophyll *a* and TSS based on water quality data (Gallegos, 1994). This model has been applied to several systems including Chesapeake Bay, Indian River Lagoon, and the North River in NC. These values are included in **Table 23** for MS and FL seagrasses based on analysis completed by Dr. Patrick Biber (Dr. Patrick Biber, USM, pers. comm.). The FL values are based on the Indian River Lagoon thresholds (Gallegos and Kenworthy, 1996), while the MS values are based on Chesapeake Bay. Chesapeake Bay was selected because the more turbid, higher chlorophyll *a* environment is more similar to MS Sound. Currently, there is a project underway to calibrate the model for MS Sound and GOM waters; however, Dr. Biber projects that these results will not be available until 2006.

Table 23. Threshold concentrations of chlorophyll *a* and total suspended solids for MS and FL seagrasses using an optical model.

	MS Seagrasses		FL Seagrasses	
Depth (m)	**Chl *a* (μg/l)**	**TSS (mg/l)**	**Chl *a* (μg/l)**	**TSS (mg/l)**
0.5	211	57	219	116
1	97	25	101	50
1.5	60	15	62	30
2	42	10	43	20
3	24	5.7	25	12
5	11	2.7	12	5.6

Source: Dr. Patrick Biber, USM, pers. comm..

The threshold concentrations vary with depth because light penetration is depth dependent. According to Schwenning (2001), the average depths of seagrass beds in Big Lagoon and Santa Rosa Sound are 1.4 m (4.6 ft) and 2.2 m (7.22 ft), respectively. For these depths, the applicable chlorophyll *a* concentrations would be approximately 62 μg l^{-1} for seagrasses in Big Lagoon and 43 μg l^{-1} for seagrasses in Santa Rosa Sound. The corresponding TSS concentrations are 30 mg l^{-1} for Big Lagoon and 20 mg l^{-1} for Santa Rosa Sound. In MS Sound, seagrasses are generally found to depths of about 1 m (3.3 ft). This depth yields a threshold of 97 μg l^{-1} for chlorophyll *a* and about 25 mg l^{-1} for TSS.

These thresholds can be applied to the three stations described above to determine if water quality conditions are a concern for seagrass health. For all three FL stations, the chlorophyll *a* (corrected for pheophytin) detection limit was 5 μg l^{-1}. The chlorophyll *a* concentrations for all three stations were at this level with periodic spikes during summer and fall months. The average TSS measurements (1998-2003) for the Santa Rosa Sound stations were 24.1 ± 12.2 mg l^{-1} (Station 330300G9) and 24.2 ± 14.7 mg l^{-1} (Station 33030GA1). These values are greater than the threshold of 20 mg l^{-1} described above. The average TSS concentration was 30.2 ± 14.5 mg l^{-1} from December 1998 to December 2000 for the Big Lagoon station. This is similar to the threshold of 30 mg l^{-1} set by the optical model.

TSS levels in Santa Rosa Sound show that decreases in seagrass growth may be attributed to increased turbidity; however, the optical model has not been calibrated for this particular system and should only be used as a general indicator of water quality concerns. There is also a degree of uncertainty associated with the values that must be taken into consideration when applying the thresholds to water quality data. The presence of seagrass beds in Santa Rosa

Sound indicates that the water quality has not declined below the levels required for survival (Schwenning, 2001). Water quality problems associated with nutrients and some heavy metals are of concern for the sound (Schwenning, 2001). Stormwater and nutrient inputs from municipal sources must be addressed through action plans to maintain the water quality and prevent degradation (Schwenning, 2001).

Stations with chlorophyll *a* records are found in MS Sound, the GOM, and Biloxi Bay. The data are limited because there is generally only one sampling event for each station. The averages for each waterbody are as follows: 32.5 (± 25.8) $\mu g\ l^{-1}$ for Biloxi Bay, 0.29 (± 0.15) $\mu g\ l^{-1}$ for the GOM[6], and 1.21 (± 1.40) $\mu g\ l^{-1}$ for MS Sound. None of these averages exceeds the threshold recommended value of 97 $\mu g\ l^{-1}$. The TSS levels in MS Sound and the GOM were 25.7 (± 15.2) $mg\ l^{-1}$ and 23.0 (± 11.4) $mg\ l^{-1}$ based on samples collected between 2000 and 2002. The average values are near the seagrass threshold of 25 $mg\ l^{-1}$. These results indicate that seagrass beds may not receive enough light due to attenuation by particles suspended in the water column.

The turbidity measurements recorded at the stations located in Davis Bayou yielded an average value of 21.7 (± 16.7) NTU. This value is similar to those calculated for Biloxi Bay (16.9 ± 14.8 NTU) and Tidewater Bayou (14.1 ± 4.3 NTU); however, the average for MS Sound was much higher (127 ± 161 NTU). The average for MS Sound was based on the records of one station (640MSDB15A) during 2000 and 2001. This station is located near the coast and may be impacted by boat traffic or stormwater runoff during storm events. These activities could increase the stirring of sediments, suspending material in the water column, limiting light availability.

B1c. Groundwater quality

As mentioned in section A2b, study of the groundwater resources of GUIS has been limited. This research includes two studies that investigated groundwater quality near Fort Pickens, FL (Cooper et al., 2004). One of these studies (Bortone and White, 1996) found wells in the area that exhibited high levels of total dissolved solids, enterococci, and fecal coliforms. According to the USGS NWIS database (USGS, 2003), there are 40 wells located within the park boundaries in FL and MS (**Appendix C**). The wells have water quality data, groundwater data (including levels), or both types of data associated with them. Unfortunately, there were a limited number of records available for the majority of the wells and the available data were not recent in some instances. The stations with greater than 10 water quality or groundwater data counts were selected for data retrieval. Within the park boundaries, five wells were included: B-8101 No. 1 Eglin AFB (302317086313001), B-8552 Eglin Hurlbut Field A6 (302351086382901), N0073 Jackson (302357088473801), USAF Eglin A15 B12516 (302330086482001), and Wayside Park (302338086352601).

Groundwater samples were obtained from three wells located in the Floridan Aquifer (B-8552 Eglin Hur Field A6, USAF Eglin A15 B12516, and Wayside Park) and one in the Northwestern FL sand-and-gravel aquifer (B-8101 No. 1 Eglin AFB System). N0073 Jackson is located in the Graham Ferry Formation and did not have any water quality records associated with it. However, the water level in this well was measured 74 times between 1938 and 1990.

[6] Average is based on three measurements at one station.

Well N0073 Jackson is located within the Davis Bayou section of GUIS-MS. The water level below the land surface was measured from 1938 to 1990. In the late 1950s, the water level was approximately 0.6-1.2 m (2-4 ft) below the land surface and in the late 1980s, the level was approximately 21.3-24.4 m (70-80 ft) below the land surface. The largest change occurred during the 1970s when the level dropped from approximately 7.0 m (23 ft) in 1971 to 19.5 m (64 ft) in 1980.

The groundwater quality samples did not exceed USEPA maximum contaminant levels with the exception of that for sodium. The standard of 160 mg l^{-1} was exceeded by water obtained from USAF Eglin A15 B12516 (A15) on multiple occasions in the 1960s. A conclusion about the current water quality cannot be made as recent data are not available. Samples from the Eglin Air Force Base (AFB) lands exceeded secondary drinking water standards for color, chloride, fluoride, iron, and pH. Station No. 1 in the sand-and-gravel aquifer exceeded the secondary drinking water standards for color (15 color units) and iron (0.3 mg l^{-1}) on one occasion. These samples were taken in 1959 and 1966. Station A15 recorded multiple instances when the standard for chloride (250 mg l^{-1}) was exceeded between 1959 and 1979. The only water quality parameters measured at Wayside Park were specific conductance and chloride concentration. Samples did not exceed the secondary drinking water standard for chloride and there is no standard for specific conductance. Musgrove et al. (1965) reported that two wells on the western end of Santa Rosa Island displayed sodium, chloride, magnesium, and calcium levels consistent with the presence of seawater. The water was also characterized by a pH slightly above neutral and a relatively high carbonate concentration (95 ppm) for the area (Musgrove et al., 1965). These characteristics were attributed to the action of acidic water on fossil shells (Musgrove et al., 1965).

There is a limited amount of groundwater quality data available regarding the barrier islands; however, there are wells on Cat, Ship, and Horn Islands. These stations have a relatively small number of records (fewer than 10). Three wells, M0622 Harrison (301218088570001), M0202 Harrison (301218088570001), and O0049 Jackson (301405088411201), were selected to represent the groundwater quality of the barrier islands. M0622 Harrison is located on West Ship Island, M0202 Harrison on East Ship Island, and O0049 Jackson on Horn Island. All three wells exceeded the secondary drinking water standard for color (15 Pt-Co color units). There are not consistent measurements for any of these wells and the data are not recent, the latest measurement was taken in 1993. Additional sampling is needed to determine the current groundwater quality of the barrier islands.

B2. Water quality impairments

B2a. Near-field impairments in seashore and surrounding estuarine areas

"Near-field" includes the waterbodies located within the 3.2-km (2-mile) study area established around the park. "Far-field" relates to the waterbodies outside the study area, but within the same counties in which the park is located.

FL

GUIS-FL is located in the Pensacola Bay (03140105), Perdido Bay (03140107), and Choctawhatchee Bay (03140102) HUCs. The 1998 303(d) list cited five impaired water segments in the Choctawhatchee Bay HUC, 12 segments in the Perdido Bay HUC, and 20 segments in the Pensacola Bay HUC. These impaired water segments and those in Escambia, Santa Rosa, and Okaloosa Counties are displayed in **Figures 55-57**. The locations of these impaired water segments in relationship to GUIS-FL are shown in **Figure 58**.

The parameters of concern, priority level, and projected year of TMDL development for water segments within the 3.2-km (2-mile) buffer around GUIS are included in **Appendix E**. Revised draft verified lists were recently produced for the Group 3 Basins, including Choctawhatchee/St. Andrew's Bay. For this reason, some of the waterbodies included in **Figure 57** are no longer considered impaired and have been delisted. There are also some additions, including two listings for a segment of coastline located in GUIS-FL. These updates have been considered in the data presented in **Appendix E**. Verified lists for Group 4, which includes the Pensacola basin group, and Group 5, which includes Perdido basin group, basins are not available, so the planning period lists are included.

The impaired waters in Escambia County relevant to GUIS include Bayou Garcon, Bayou Grande, direct runoff to Big Lagoon, and a portion of Pensacola Bay. Bayou Garcon, Bayou Grande, and the direct runoff to Big Lagoon are included due to DO levels, while Bayou Grande and Pensacola Bay are impaired because of coliforms. Another parameter of concern for Bayou Garcon is color. Increased siltation at Bayou Garcon's mouth was attributed to new development in the areas west of Pensacola (Hand et al., 1994).

The waters impaired in Santa Rosa County include East River Bay and the mouth of Pensacola Bay. The listed parameters of concern for East River Bay are coliforms and turbidity. East River Bay also lies in Okaloosa County and appears on the 303(d) list for that county, too. The mouth of Pensacola Bay is considered a high priority and is listed for multiple parameters including copper, lead, BOD, nutrients, turbidity, and TSS. According to the 303(d) list, this parameter listing is based on numerous studies involving Escambia Bay and Santa Rosa Sound conducted by the USGS, National Oceanic and Atmospheric Administration (NOAA), US MMS, USEPA, and Champion International.

The impaired water segments for Okaloosa County were recently updated and include listings for Choctawhatchee Bay, GUIS, and East Pass. The draft list for Choctawhatchee/ St. Andrew's Bay has been verified using data from January 1997 through June 30, 2004. The majority of Choctawhatchee Bay is listed due to concerns about mercury levels in fish tissue and fecal coliforms. In addition, a segment of GUIS is impaired for bacteria levels. Bacteria were listed as a parameter of concern because beach closures exceeded 21 days per year for 2003. For mercury in fish tissue, the data were verified to be within the past 7.5 years and recent data confirmed coastal fish advisories for king mackerel, shark, spotted seatrout, little tunny, cobia, greater amberjack, bluefish, crevalle jack, and gafftopsail catfish. Impaired water segments

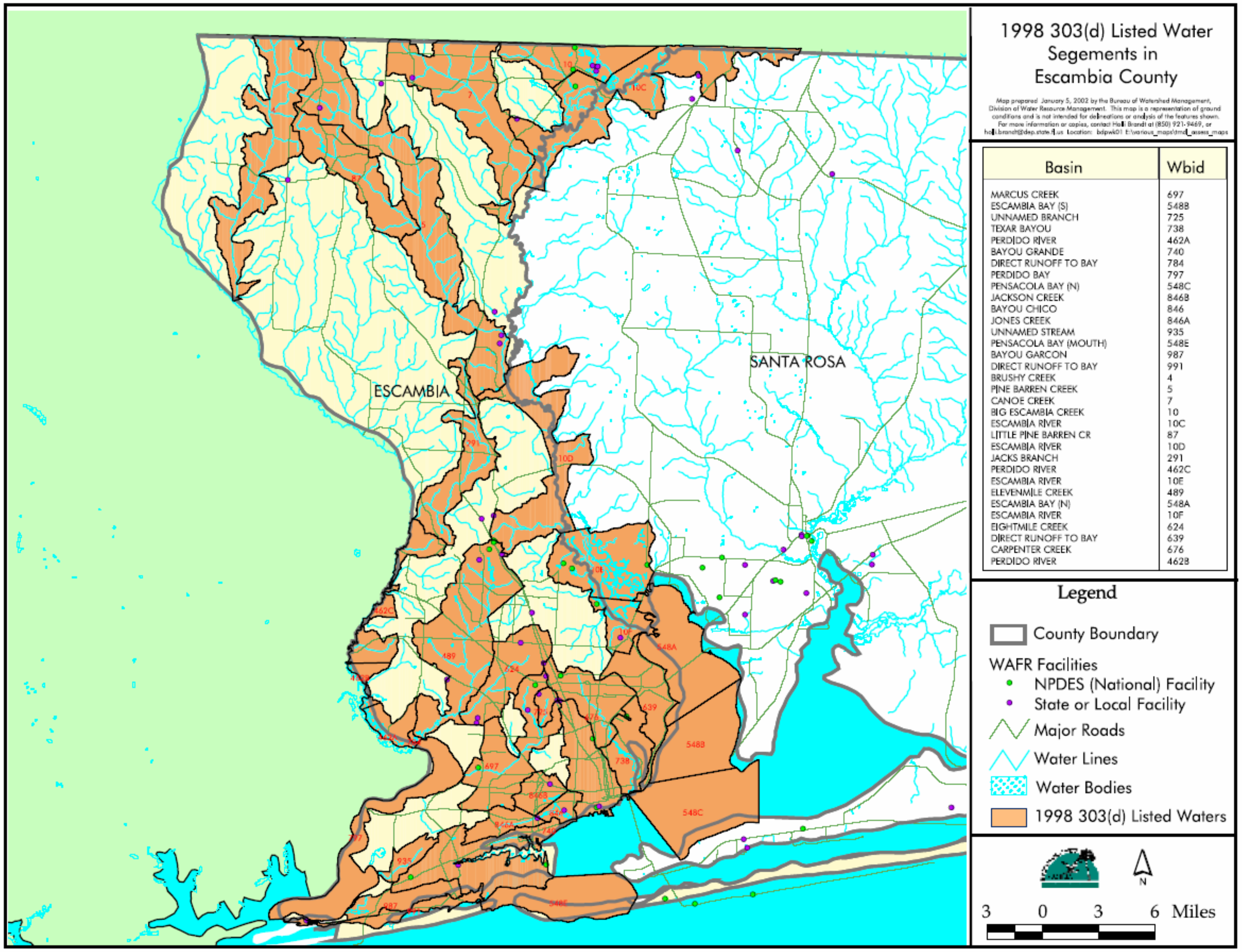

Figure 55. 1998 303(d) listed water segments in Escambia County.

(Source: http://www.dep.state.fl.us/water/tmdl/303dmap.htm)

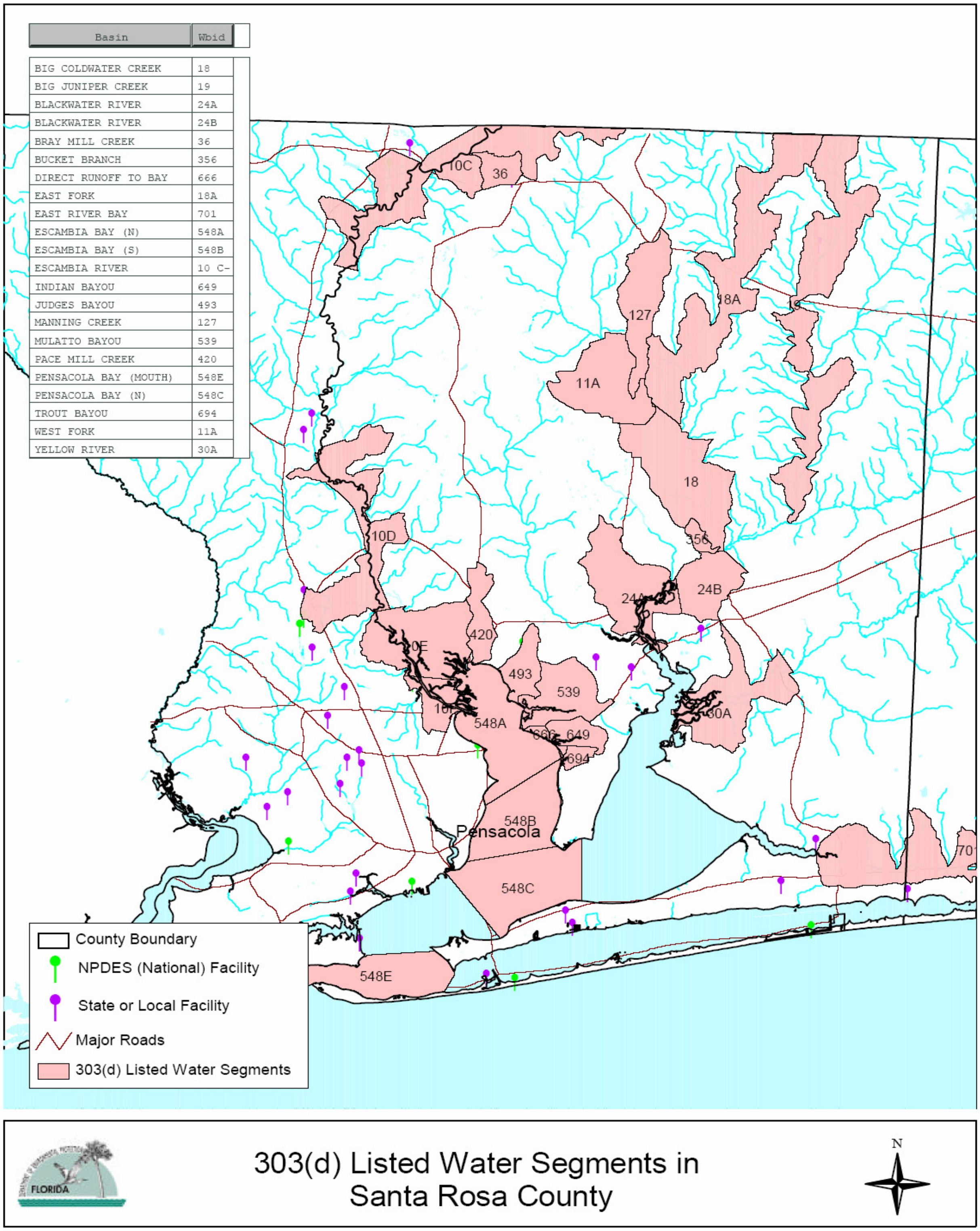

Figure 56. 1998 303(d) listed water segments in Santa Rosa County.

(Source: http://www.dep.state.fl.us/water/tmdl/303dmap.htm)

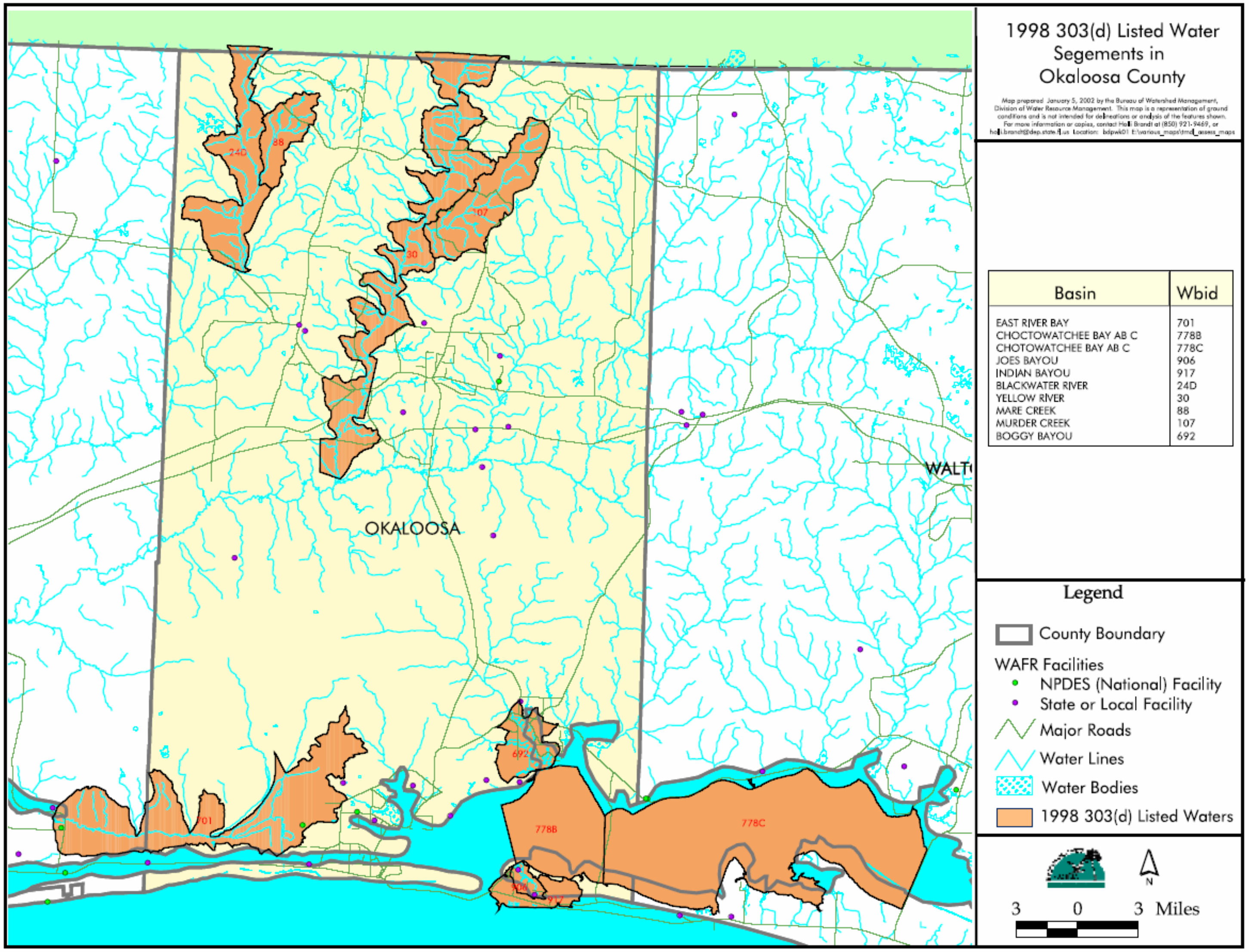

Figure 57. 1998 303(d) listed water segments in Okaloosa County.

(Source: http://www.dep.state.fl.us/water/tmdl/303dmap.htm)

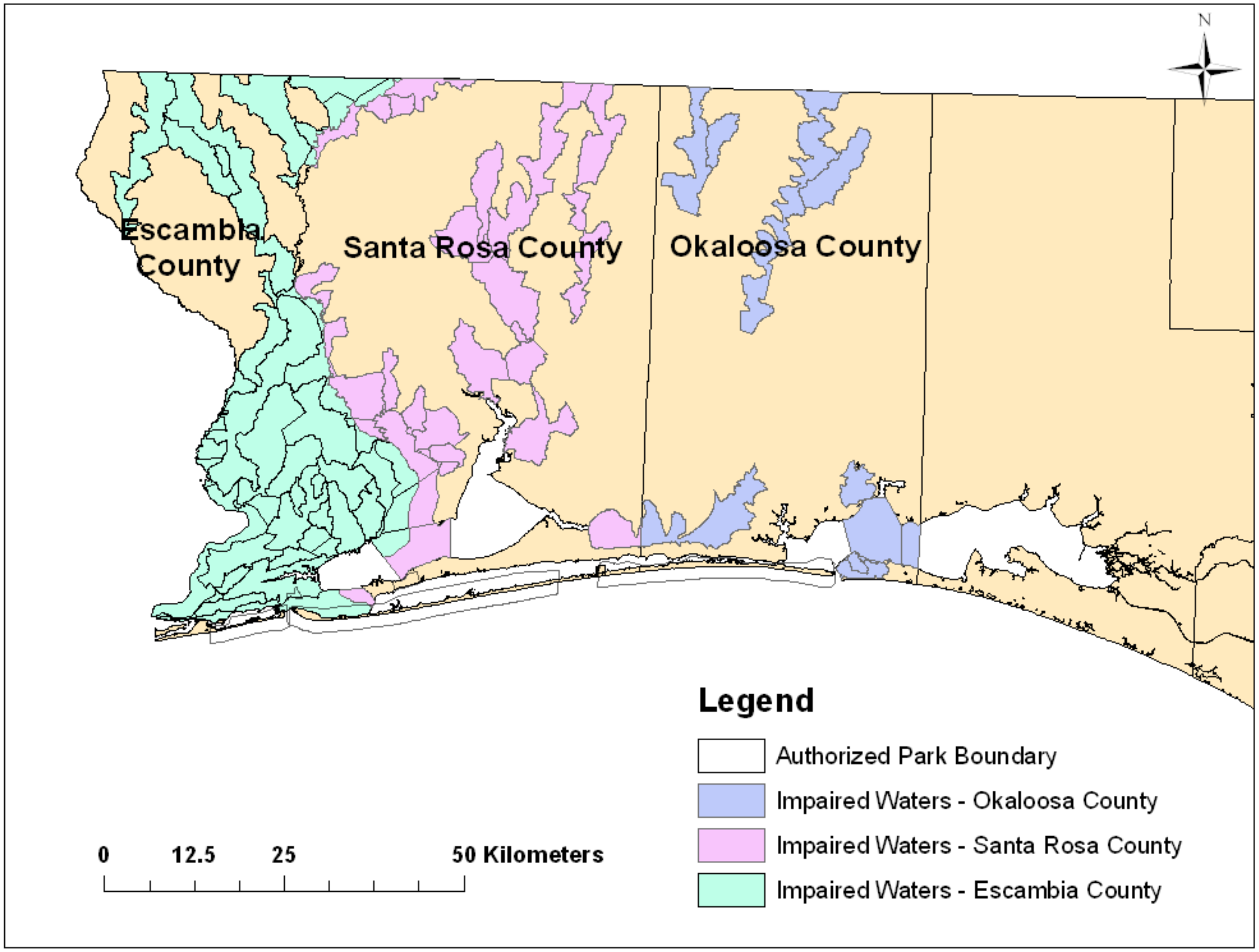

Figure 58. 1998 303(d) listed water segments in the Escambia, Okaloosa, and Santa Rosa Counties.

(Data Sources: County – FDEP (1:24,000, Automated 1997), Impaired Waters - FDEP (1:24,000 Automated 1999), and Authorized Park Boundary – USDOI/NPS (1992)).

*The 303(d) list for the Choctawhatchee/St. Andrew's Bay Basin was updated in 2004, so the data for this region in the above figure (Okaloosa County) is out of date. An updated figure is available at http://www.dep.state.fl.us/water/basin411/csa/status/Fig3-4.pdf.

located on the western end of Choctawhatchee Bay include Boggy Bayou, Rocky Bayou, and Garnier's Park. These segments are impaired due to mercury in fish tissue and bacteria levels. The fecal coliform listings are based on downgrades in shellfish harvesting classification for some portion of the Class II waterbody (Choctawhatchee Bay).

Several water segments near the park have been recommended for delisting based on analysis of the planning (January 1992 through December 2001) and verification period (January 1997 through June 30, 2004) data. These include Indian Bayou, Joe's Bayou, and portions of Choctawhatchee Bay. Joe's Bayou and Indian Bayou were removed based on chlorophyll *a* data that did not exceed annual means of 11 μg/l. Indian Bayou was also delisted for DO because data from the planning period showed that only two out of 50 samples exceeded the standard and three out of 73 samples from the verified period.

Bayous are especially susceptible to inputs of pollutants for several reasons. The lower surface area and narrow shape limit the size of waves that can be generated, decreasing the amount of mixing and promoting stratification (Thorpe and Ryan, 1996). This problem is also emphasized if the bayou has a restricted inlet. When stratification occurs, oxygen is not transported among layers, often leading to anoxia in lower layers (Thorpe and Ryan, 1996). Bayous provide important habitat and serve as a food source for juvenile fish and invertebrates. Loss of this habitat affects the biological productivity of the entire ecosystem. Several of the bayous that are part of the PBS (Bayou Chico, Bayou Texar, and Mulatto Bayou) have exhibited degraded water quality due to stormwater runoff and industrial discharges. The bayous near Choctawhatchee Bay have also shown elevated levels of nitrogen, phosphorus, and fecal coliform bacteria as well as depressed oxygen levels and sediment contamination (Thorpe and Ryan, 1996).

MS

In 2000, the MDEQ began focusing each 305(b) report on a particular river basin. The basins of interest for GUIS-MS are the Coastal Streams and Pascagoula River Basins. The 2000 report discussed the Pascagoula River Basin. MS's Section 303(d) List of Impaired Waterbodies identifies impaired waterbodies and establishes a priority ranking for such waters, taking into account the severity of the pollution and designated uses of the waterbodies. The 2004 updates to this list are currently under review by the USEPA. The TMDL reports include the suspected sources of impairment and predict a reduction of the pollutants necessary to restore the waterbody to its intended use. The completed TMDLs for the Coastal Rivers and Pascagoula River Basins are listed in **Appendix D** with links to the full reports.

Waterbodies in MS are placed in two categories: monitored and evaluated segments. Monitored segments have water quality data and measurements associated with them. Evaluated segments are those for which the use support decision is based on information other than site-specific monitoring data (MDEQ, 2004a). Information includes land use surveys, incidents of pollution spills/fish kills, point source discharge data, and monitoring data greater than 5 years old (MDEQ, 2004a). These data generally have a greater degree of uncertainty in characterizing water quality condition than assessments based upon site-specific monitoring data (MDEQ, 2004a). To improve the accuracy of the 303(d) list, MS has undertaken an extensive monitoring effort to assess the water quality of many of the evaluated segments (MDEQ, 2004a). For the most part, the state's monitoring used biological indicators to focus on stream health. The biota of a waterbody reflect the physical, chemical, and biological integrity of the system and are considered to be direct indicators of aquatic life use support (MDEQ, 2004a).

MS Sound is listed as an impaired waterbody for several parameters including arsenic, pH, toxics, organic enrichment, low DO, and metals according to the 2002 303(d) list (Cooper et al., 2004). This listing is based on the waterbody's classification as an evaluated segment with a limited amount of monitoring data. Some waterbodies listed as evaluated in 2002 have not yet been monitored and assessed, especially those in the MS Delta (MDEQ, 2004b). The required TMDLs for these waterbodies will be completed by the MDEQ or USEPA as their deadlines approach, even without monitoring data to determine if the impairment actually exists. The most recent 303(d) draft list, completed in 2004, includes MS Sound as impaired in six areas that are 3.2-km (2 miles) in diameter around specific monitoring stations located between the MS coastline and the barrier islands. This listing is for total toxics because the aquatic life support designated use is not being met. Heron Bayou is also included as an impaired waterbody without monitoring data (evaluated water) due to nutrients, sediment/siltation, and turbidity. A TMDL was completed in 2002 for Heron Bayou addressing pathogen levels.

The data collected as part of the EMAP (1991-1994) were summarized in the Ecological Condition of Estuaries in the GOM report (USEPA, 1999). According to the USEPA (1999) report, MS Sound had high total dissolved nitrogen levels (>1 mg l^{-1}) (**Figure 60**) and high chlorophyll concentrations (>20 µg l^{-1}, <60 µg l^{-1}) (**Figure 61**). Instances of hypoxia (DO< 2 mg l^{-1}) were also recorded as part of EMAP and NOAA's Estuarine Eutrophication Survey. The EMAP found that hypoxia occurred in the Louisianian province in 10% of the bottom waters during summer sampling conducted from 1991 to 1994. The NOAA survey reported hypoxia in 30 of 37 estuaries (25% of the estuarine area). The discrepancies between the two studies were attributed to differences in design and sampling. Mobile Bay, AL, is of particular concern because more than 50% of the bottom water areas measured in the low DO range during the summers of 1993 and 1994. Periodic hypoxia is considered a natural part of the system due to salinity patterns and the amount of water column stratification (USEPA, 1999).

MS has participated in the NCA program since 2000. This program will allow all of the state's estuarine waters to be assessed (MDEQ, 2004b). The NCA project will be completed in 2005 and at that time, the data collected in MS waters will be analyzed and pollution sources identified (MDEQ, 2004b). The National Coast Condition Report published by the USEPA (2001) analyzed the first year of sampling data collected in the entire GOM. This analysis indicated that there were several areas of possible isolated water quality problems in the coastal waters of MS (MDEQ, 2004b).

Figure 59. 2004 303(d) listed impaired waterbodies located in the Coastal Streams Basin, MS.

(Data Sources: State - US Census Bureau (1:5,000,000, 1990), Impaired Waters – MDEQ (2004), and Authorized Park Boundary - NPS (1992))

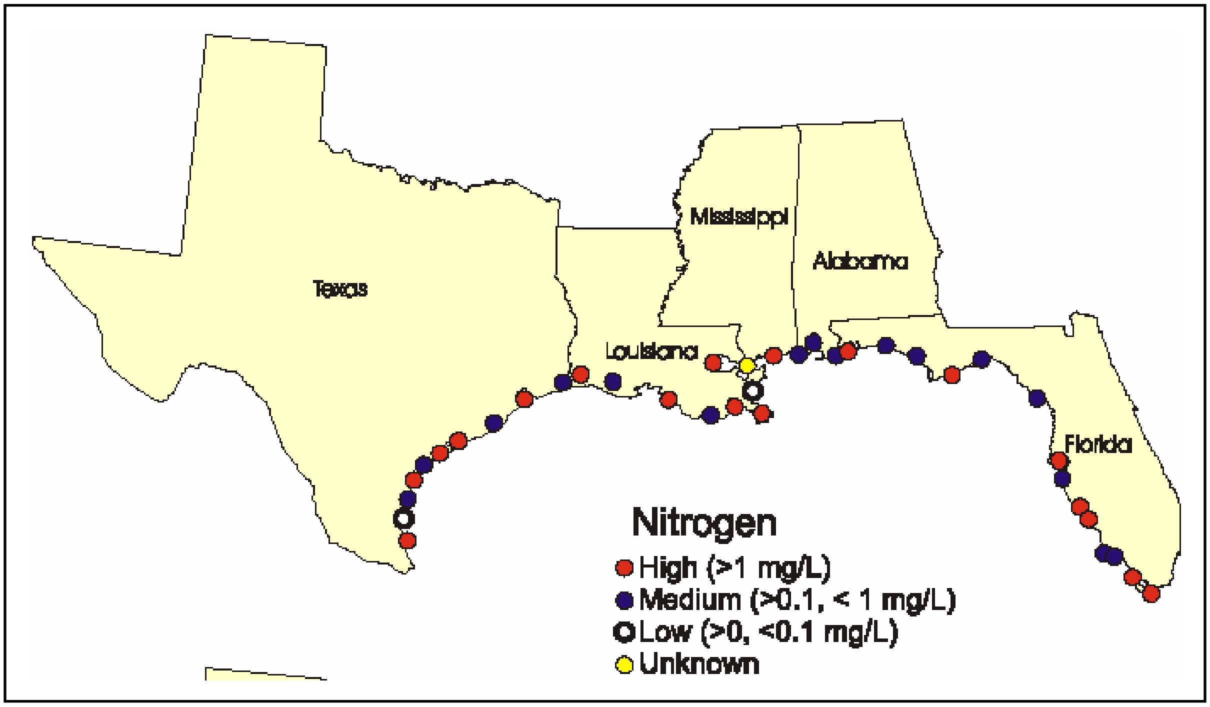

Figure 60. Concentrations of nitrogen (mg l^{-1}) observed in Gulf of Mexico estuaries based on the Estuarine Eutrophication Survey.

(Source: Cited NOAA, 1997, in USEPA, 1999)

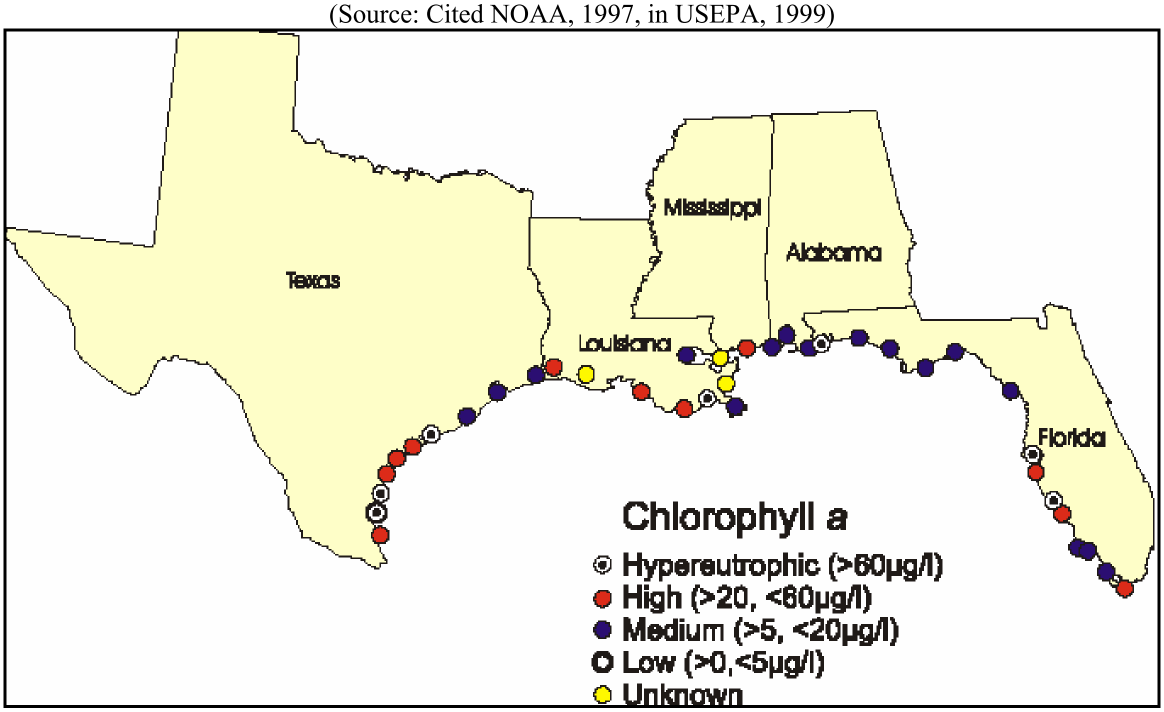

Figure 61. Concentrations of chlorophyll *a* (µg l^{-1}) observed in Gulf of Mexico estuaries based on the Estuarine Eutrophication Survey.

(Source: Cited NOAA, 1997, in USEPA, 1999)

B2b. Far-field impairments in seashore and surrounding estuarine areas

Escambia County

The 1998 303(d) list for Escambia County contains 32 water segments. These water segments are located in multiple HUCs including Pensacola Bay (03140105), Perdido Bay (03140107), Escambia River (03140305), and Perdido River (03140106). Excluding the segments described in the near-field section, nine are located in the Pensacola Bay HUC, six in the Perdido Bay HUC, eight in the Escambia River HUC, and five in the Perdido River HUC. GUIS-FL is located in the Pensacola Bay and Perdido Bay HUCs, while the Escambia River and Perdido River HUCs are further upstream from the park. In the Pensacola Bay HUC, four of the listings are for DO, coliforms, nutrients, and turbidity, two for coliforms alone, and one for coliforms, nutrients, and DO. In the Perdido Bay HUC, the parameters of concern include coliforms, DO, nutrients, and turbidity. One of the segments (Elevenmile Creek) is listed because of nutrients, turbidity, TSS, BOD, DO, coliforms, and unionized ammonia. According to Hand et al. (1994), the poor water quality in the creek is reflected in low density, diversity, and species richness values for benthic fauna. Further upstream in the Escambia and Perdido River HUCs, water quality impairment is predominantly due to coliforms, TSS, turbidity, mercury (due to fish consumption advisories), and DO.

Santa Rosa County

The 1998 Section 303(d) list contains 22 water segments that are located in the Escambia River, Pensacola Bay, Blackwater River (03140104), and Yellow River (03140103) HUCs. The segments included in the Escambia River HUC were described in the Escambia County section and are not included in this description. Eight segments lie in the Blackwater River HUC and seven segments list coliforms as one of the parameters of concern. Turbidity, TSS, and mercury are also included as parameters of concern. A segment of the Yellow River is listed because of DO, turbidity, and mercury. For the segments listed for the Pensacola Bay HUC, coliforms, DO, nutrients, TSS, and turbidity are cited as the reasons for impairment.

Okaloosa County

The 1998 303(d) list contains 10 impaired water segments in Okaloosa County located in the Blackwater River, Pensacola Bay, Choctawhatchee Bay, and Yellow River HUCs. As mentioned in section B2a, this list was verified in 2004 and recommendations for segments to be delisted were made. In the 2004 list, most of the segments applicable to GUIS are located near or include sections of Choctawhatchee Bay. The remaining impaired segments are located near the FL-AL border and are included in the Blackwater and Yellow River HUCs. The segments located in the Blackwater River HUC list DO and turbidity (Mare Creek) and coliforms and mercury (Blackwater River) as parameters of concern. In the Yellow River HUC, coliforms are listed for both segments in addition to DO for Murder Creek and turbidity and mercury for a segment of the Yellow River.

MS

Using the USEPA Assessment database (ADB), the MDEQ reported that the majority of assessed stream and river miles in the Coastal Streams Basin fell into two categories of use support, categories 2 and 3 (**Table 24**). Approximately 18% of the Coastal stream and river miles were placed in category 2 for attaining some uses, but lacking the necessary information to assess another use (MDEQ, 2004b). Waters classified as category 4 for not attaining one or more designated uses without requiring a TMDL made up 1% of the total. Waters that are not attaining their designated use that required a TMDL comprised 2% of the assessed waterbodies (MDEQ, 2004b). The status of the remaining 79% of waterbodies in the Coastal Streams Basin was unknown and these waters are placed in category 3. All of the waters in category 5 (34 km or 21 miles) were assessed as being biologically impaired (MDEQ, 2004b). Biological impairment was discovered during monitoring but the exact pollutant cause was unknown. Stressor identification studies are planned to determine the actual cause and source of the impairment for these waters (MDEQ, 2004b). The ADB assigns each waterbody to only one category, even if the segment has multiple designated uses. If a waterbody is attaining one use but is not attaining another use, it is assigned to one of the nonattainment categories (Category 4 or 5). Therefore, the water segments attaining their designated uses are under-represented (MDEQ, 2004b).

Table 24. Description of water quality classes for USEPA Assessment database.

Category	Description
1	Attaining some uses
2	Attaining some uses but insufficient information for assessment of other uses
3	Insufficient information to assess any use
4	Not attaining a use but a TMDL is not necessary
5	Not attaining a use and a TMDL is needed

Source: MDEQ, 2004b.

The majority of the segments on the 303(d) list for the Coastal Streams Basin are impaired based on biological impairment, nutrients, and organic enrichment/DO. Additional pollution causes include sediment/siltation, turbidity, and unknown toxicity. The evaluated segments are scheduled for monitoring and review by the end of 2005.

None of the impaired water segments is located on the barrier islands of GUIS-MS. The impaired waterbodies are located on the mainland and include some of the streams, creek, and rivers that flow into MS Sound. The list also contains several bayous located along the coast. Examples of these segments are Back Bay, Biloxi Bay, Bayou Casotte, Bayou Cumbast, Bernard Bayou, and Tidewater Bayou (**Figure 59**). Completed TMDLs for these water segments include pathogens, phenol, toxicity, and nutrients (**Appendix D**). Streams and rivers within the Pascagoula River Basin that have completed TMDLs include Black Creek, Bouie Creek, Chickasawhay River, Escatawpa River, Leaf River, Pascagoula River, Tallahala Creek, and Red Creek. The majority of these waters were impaired for pathogens (**Appendix D**), but additional parameters include pesticides and nutrient enrichment.

B3. Sources of Pollutants

B3a. Point sources

The majority of the point sources of pollution that threaten GUIS are located in the surrounding watersheds. The highest concentration of these sources is located near Pensacola, FL. The following discussion is focused primarily on GUIS-FL with supplemental information about GUIS-MS. GUIS-MS is located approximately 12.9 km (8 miles) from mainland MS, so the point sources discussion is focused on the Davis Bayou section of GUIS-MS. The sites that are most relevant to GUIS water quality are located in southern sections of the following counties: Escambia, Okaloosa, and Santa Rosa in FL and Jackson and Harrison in MS.

Superfund and National Priorities List (NPL)

The Superfund program was initiated in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act. This act was updated in 1986 by the Superfund Amendments and Reauthorization Act. Sites placed on the NPL are given high priority for remediation and evaluation because of potential health and environmental risks. There are seven sites associated with the NPL in Escambia County, FL, one in Santa Rosa County, FL, and one proposed site in Harrison County, MS. Four of the seven FL sites are currently on the NPL. Three sites (Pioneer Sand Co., Beulah Landfill, and DuBose Oil Products and Co.) have been deleted from the NPL.

The NPL sites are located in the same counties as the park but not within the study area established around the park. The contamination at these sites includes metals (lead and arsenic), polychlorinated biphenyls (PCBs), and other organic compounds (creosote, pentachlorophenol, and dioxin). Detailed information about each site is included in **Table 25**. Sites of particular interest are described in detail based on information from the USEPA's NPL website (USEPA-NPL, 2004).

Activities at the Naval Air Station Pensacola have generated wastes such as oils and solvents, paints, electroplating wastes, radium paint waste, and insecticides (USEPA-NPL, 2004). This site is of special concern because approximately 15,000 individuals on the station and 30,000 customers of Peoples' Water Company rely on water pumped from wells within 4.8 km (3 miles) of the hazardous substances on this site (USEPA-NPL, 2004). The contaminants also pose risks to nearby Pensacola Bay and Bayou Grande, which are utilized for fishing and other recreational activities. During remediation, over 459 m^3 (600 yd^3) of contaminated soils (contaminated with arsenic, dieldrin, PCBs, and lead) have been removed and additional wells have been installed to treat groundwater contaminated with VOCs (USEPA-NPL, 2004).

Another site of interest due to possible groundwater contamination is Escambia Wood-Pensacola. The facility operated as a wood preserving plant from 1942 to 1982 and used chemicals such as creosote and pentachlorophenol (USEPA-NPL, 2004). The site was added to the NPL in December 1994. Following closure, three open surface impoundments and one backfilled surface impoundment remained on the 11-ha site (USEPA-NPL, 2004). Sludges have been removed from the three surface impoundments and approximately 168,200 m^3 (220,000 yd^3) of contaminated soil have been excavated from the site (USEPA-NPL, 2004). There are about 20 public supply wells and numerous private wells located within 6.4 km (4 miles) of the facility. The wells are completed in the sand-and-gravel aquifer and provide water to approximately 130,000 people (USEPA-NPL, 2004).

The Agrico Chemical Co. occupies an area of 2.4 ha (6 acres) in Pensacola, approximately 3.2 km (2 miles) southwest of the Pensacola Municipal Airport. Initially, the site was used by a company that produced sulfuric acid from iron pyrite (USEPA-NPL, 2004). From 1920 to 1959, Agrico Chemical Co. produced fertilizer from phosphate rock (USEPA-NPL, 2004). When the facility ceased operations in 1959, the buildings were demolished. Currently, the site consists of the foundations of five buildings and four storage ponds. The USEPA detected lead, sulfuric acid, and fluorides in waters from the pond in 1983; the site was subsequently placed on the NPL in 1989 (USEPA-NPL, 2004). The sand-and-gravel aquifer underlies the site with a highly permeable layer of poorly sorted, coarse-grained quartz sand (USEPA-NPL, 2004). The USEPA has recently discovered that this contamination plume has combined with that from the Escambia Treating Company and reached Bayou Texar (Escambia County, 1999). There are also 13 wells operated by the Escambia County Utilities Authority within 4.8 km (3 miles) of the site. Remediation efforts include the removal of lead-contaminated soil and sludge, construction of a slurry wall and multimedia cover system, and excavation and consolidation of soils contaminated with high levels of fluoride (USEPA-NPL, 2004).

The site proposed for addition to the NPL located near Gulfport, MS, is Chemfax, Inc. The company began operations in 1955, producing petroleum hydrocarbon resins from a paraffin wax blending process (USEPA-NPL, 2004). There have been several fires in the past, one of which melted paraffin wax that then flowed into a cooling water pond. The USEPA found high levels of benzene, toluene, ethyl benzene, and styrene through air sampling conducted in May 1990 (USEPA-NPL, 2004). The benzene levels were over 180 times the USEPA's health based benchmarks. Approximately 60 employees and 45,000 residents within a 6.4-km (4-mile) area are exposed to these contaminants (USEPA-NPL, 2004). This site was proposed for addition to the list in June 1993.

National Pollution Discharge Elimination System (NPDES)

The NPDES program was initiated as part of the Clean Water Act to monitor point-source discharges from industrial and municipal facilities. The USEPA keeps records of NPDES permit-holders and instances of enforcement. The FDEP maintains downloadable records of domestic, industrial, and stormwater NPDES facilities that are updated monthly. These records show that there are 22 domestic and industrial permitted facilities in Escambia County, 10 in Okaloosa County, and 13 in Santa Rosa County. Details about each of these facilities are included in **Appendix F**. In Escambia County, the permits are for a variety of facility types including domestic wastewater treatment plants (WWTP), concrete batch plants, industrial wastewater facilities, and petroleum cleanup generating plants. Nine out of the 10 permits in Okaloosa County are for concrete batch plants. The facilities in Santa Rosa County include concrete batch plants, domestic WWTP, and industrial wastewater facilities. There are also 215 stormwater NPDES facilities in Escambia County, 142 in Okaloosa County, and 107 in Santa Rosa County.

Table 25. Sites associated with the National Priorities List located near Gulf Islands National Seashore.

Location	Site Name	USEPA ID	Contaminants of Concern
Escambia Co. FL			
Pensacola	Pensacola Naval Air Station	FL9170024567	waste oils or solvents, paints, electroplating wastes, radium paint waste and insecticides
Pensacola	American Creosote Works	FLD008161994	volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), pentachlorophenol, and dioxin
Pensacola	Agrico Chemical Co.	FLD980221857	lead, fluoride, and arsenic
Pensacola	Escambia Wood	FLD008168346	creosote, pentachloropenol, and dioxin
Cantonment*	DuBose Oil Products Co.	FLD000833368	organic chemicals
Pensacola*	Beulah Landfill	FLD980494660	volatile organic compounds, semi-VOCs, pesticides, and metals
Warrington*	Pioneer Sand Co.	FLD056116965	phenols and resin compounds
Santa Rosa Co. FL			
Milton	Whiting Field Naval Air Station	FL2170023244	fuel components and spent solvents
Harrison Co. MS			
Gulfport**	Chemfax, Inc.	MSD008154486	benzene, toluene, xylenes, ethyl benzene, and styrene

*Deleted from National Priorities List.
**Proposed site
Source: http://www.epa.gov/superfund/sites/npl/fl.htm#Dubose_Oil_Products_Co.

The USEPA Permit Compliance System (PCS) has records for 164 NPDES permittees in Harrison County, MS, and 81 in Jackson County, MS. To limit the search to the facilities located nearest Davis Bayou, the results were then restricted to the following areas: Biloxi, D'Iberville, Keesler Air Force Base (AFB), and Ocean Springs (**Appendix G**). Data available from the FL Geographic Data Library (FGDL) and the PCS database showed one active permittee located within the GUIS park boundary. The permit was issued to the USEPA Gulf Breeze Research Laboratory. There is doubt as to whether this facility is actually within the park boundary or if there is some error associated with the spatial analysis.

The USEPA maintains the Enforcement and Compliance History Online program, which provides information on the number of federally reportable inspections conducted over the past 3 years, the number of quarters that a facility has been in violation during the last 3 years, and the number of enforcement actions taken against the facility within the last 3 years. The domestic and industrial facilities listed as major discharges (11) in FL were entered into this program to determine their compliance in recent years (**Appendix H**). In addition, the 128 permit numbers for the facilities located near Davis Bayou in GUIS-MS were entered into the system (**Appendix I**). This search found that six facilities have faced formal enforcement actions within the past 3 years. These facilities include Air Products and Chemicals Incorporated, Escambia County Utilities Authority, Naval Air Station Pensacola, Santa Rosa Island/ Pensacola Beach STP, Solutia, Inc, and the HC/West Biloxi Publicly Owned Treatment Works (POTW). Major dischargers of concern include Champion International Corporation (pulp and paper mill), Solutia, Inc. (synthetic fiber manufacturer), Air Products and Chemicals, Inc. (chemical manufacturer), and Gulf Power (electric company).

Champion International Corporation operates a pulp and paper mill in Cantonment, FL. It was estimated in 1999 that approximately 425,000 tons of uncoated paper and 130,000 tons of market pulp are produced each year (Escambia County, 1999). The plant is a bleach kraft paper mill using as much as 30 million gallons per day (MGD) of water. Discharged water comes from several sources including the bleaching cycles, the paper machines, recausticizing, and other processes (Escambia County, 1999). The average discharge into Elevenmile Creek and the receiving waters of Perdido Bay is approximately 23 MGD. Elevenmile Creek is listed as an impaired water segment because of nutrients, turbidity, TSS, BOD, DO, coliforms, and unionized ammonia. The effluent from Champion reportedly contains a high concentration of nutrients, specific conductance compounds, suspended solids, and chlorinated compounds (Escambia County, 1999). To comply with existing and future discharge permits, Champion has explored a variety of alternatives. They have considered relocating their discharge point to the Escambia River or Perdido Bay and using alternative technologies to meet effluent standards. At the time of a special grand jury investigation conducted by Escambia County (1999), the plant was still operating under a pending operating permit. In the permit application, Champion aimed to meet water quality standards by instituting a two-phase process. This process included plans to reclaim and recycle chemicals and raw materials and add a tertiary waste treatment system.

The discharge from the Champion kraft mill plant has been linked to biological effects on fish. Masculinized female mosquitofish (*Gambusia affinis*) were observed downstream of the paper mill in Elevenmile Creek (Howell et al., 1980). The effluent from the mill contained high levels of plant steroids including sitosterol and stigmastanol. The mechanism that produced this response is not understood (Olsson et al., 1998).

Solutia, Inc., formerly known as Monsanto and Chemstrand Co., manufactures nylon fibers, industrial yarns, chemical intermediates, polymers, and plastics (Escambia County, 1999). It is located on the Escambia River north of the entrance to Upper Escambia Bay. In 1965, Chemstrand was ordered to stop discharging wastewater, with the exception of cooling water, into the Escambia River due to the degraded water quality in Escambia Bay (Escambia County, 1999). Today, most of the water used by Solutia is recycled (about 91%) and approximately 2.8 MGD are deep well injected into the lower Floridan aquifer (Escambia County, 1999). Monitoring wells have shown that the injected waste is within 3.2 km (2 miles) of the injection point after 30 years. It is predicted that the wastewater will not migrate into ground or surface waters in the future (Escambia County, 1999).

Air Products and Chemicals, Inc., formerly known as Escambia Chemical Co., is located in Pace, FL, on Escambia Bay. The facility was built in 1955 to manufacture fertilizer (Escambia County, 1999). Air Products and Chemicals purchased the company in 1969 to manufacture methyl amines, methyl alcohol, and dimethyl urea. The company discharges approximately 1.3 MGD of treated process wastewater into the Escambia River. In 1986, the groundwater underlying this facility (202 ha or 500 acres) was found to be contaminated with dinitrotoluene (DNT) (Escambia County, 1999). To remedy the situation, Air Products must install wells to pump the water to the surface, filter out the DNT, and then inject it into deep wells in the lower Floridan aquifer (Escambia County, 1999). This project is estimated to take 20 years and cost $40 million. Escambia Chemical, who owned the company during the period of contamination (1966-1972) is not liable for the clean up costs because it is no longer in business (Escambia County, 1999).

Gulf Power operates the Crist Steam Plant, which is the electric generating plant for the area. It is located near Solutia, Inc. on the Escambia River. The plant withdraws large quantities of water from the Escambia River (average of 24.1 MGD) for use as cooling water. Most of this water is returned to the river following its use (Escambia County, 1999).

In addition to NPDES permit holders, there are a number of facilities in the area that produce air emissions, toxic releases, or participate in hazardous waste activities. These facilities are listed in the USEPA's Envirofacts website, which compiles information from multiple databases. A search of the counties relevant to GUIS yielded the results displayed in **Table 26**.

Table 26. Number of facilities with air emissions, toxic releases, and hazardous waste activities listed in USEPA's Envirofacts database.

Pollution Activities	Escambia Co. (FL)	Okaloosa Co. (FL)	Santa Rosa Co. (FL)	Harrison Co. (MS)	Jackson Co. (MS)
Air emissions	60	27	28	46	40
Toxic releases	25	12	6	26	23
Hazardous waste activities	694	255	149	409	227

Source:www.epa.gov/enviro/index_java.html

Domestic WWTP in the area include the Main Street, Pensacola Beach, and Bayou Marcus facilities. Other Escambia County plants are City of Century water treatment plant (WTP) and NAS Pensacola WTP. Facilities in Santa Rosa County are the South Santa Rosa Utility, Navarre Beach WTP, Holley-Navarre WTP, City of Milton WTP, Pace Utilities, and Jay WTP (Escambia County, 1999). Many of these plants have converted to use methods such as spray irrigation, pert ponds, drainfields, and wetlands discharge instead of discharging directly into surface waterbodies. Most of the large WWTP continue to discharge into surface bodies such as the Main Street Pensacola Beach, NAS Pensacola, Century, Navarre Beach, and the City of Milton WTP (Escambia County, 1999).

Landfills

There are multiple landfills located in Escambia, Okaloosa, and Santa Rosa Counties (**Table 27**). Landfills are considered point sources of contamination because the point where contaminants enter the environment can be identified with a reasonable amount of certainty. Landfill leachate can contain a variety of chemicals including metals and organic compounds that can contaminate soil or groundwater if not contained properly.

The Beulah Landfill is a Superfund site deleted from the NPL in June 1998. It is a 32-ha (80-acre) site that was operated by Escambia County from 1950 to 1984 (USEPA-NPL, 2004). The site includes two landfills that were run independently. One landfill accepted municipal trash, while the other received domestic septic tank wastes, demolition debris, industrial waste, and municipal sludges (USEPA-NPL, 2004). USEPA found that wastes on the site contained chlordane, copper, and zinc; however, the baseline risk assessment concluded that there was no unacceptable risk to human health or the environment at the site. The groundwater continues to be monitored to ensure that no action is needed to protect humans and the environment (USEPA-NPL, 2004).

There are no landfills located on the barrier islands of GUIS-MS. It is unlikely that the landfills located on mainland MS pose a water quality threat to the park because they are located about 12.9 km (8 miles) from the shore. A report completed by the Eastern Research Group, Inc. (1994) found that there were 16 industrial and construction and demolition (C & D) waste landfills in Jackson and Harrison Counties. The MS state list included commercial rubbish disposal facilities and unrecognized rubbish disposal facilities as C & D landfills. An additional search yielded two other landfills in the area. There are no landfills located near Ocean Springs, MS, which could impact the water quality of Davis Bayou.

Table 27. Landfills located in Escambia, Okaloosa, and Santa Rosa Counties, FL.

County	Facility Name	Permitee
Escambia	Auto Shred Industrial Landfill	Auto Shred Recycling, LLC
Escambia	Beulah Landfill	Escambia County
Escambia	Camp Five Landfill	Escambia County
Escambia	Mobile Highway Landfill	Escambia County
Escambia	Perdido S Landfill	Escambia County
Okaloosa	Baker Landfill	Okaloosa County
Okaloosa	Laurel Hill Landfill	Okaloosa County
Okaloosa	Wright Landfill	Okaloosa County
Santa Rosa	Santa Rosa Central Landfill	Santa Rosa County
Santa Rosa	Santa Rosa Class III Landfill	Santa Rosa County
Santa Rosa	Santa Rosa Holley Landfill	Santa Rosa County
Santa Rosa	Santa Rosa Northwest Landfill	Santa Rosa County

Source: FDEP, 2004b.

Transportation

There are several airports located in Escambia, Okaloosa, and Santa Rosa Counties. There are two airports that provide commercial airline service, the Pensacola and Okaloosa County Regional Airports. General aviation airports in Pensacola are the Furguson Municipal Airport and the Coastal Airport. The general aviation airports in Okaloosa County are the Bob Sikes Airport (Crestview, FL) and the Destin Airport (Destin, FL). In Santa Rosa County, there is the Peter Prince Airport in Milton, FL. Even though these airports receive limited traffic they could have environmental impacts. These effects include increases in impervious areas due to building and runway construction, impacts on air and water quality, and possible risks associated with fuel or other chemical spills.

The airports in Harrison County, MS, are the Keesler AFB, Kennedy Executive Airport, and the Lundys Airport in Biloxi, and the Gulfport-Biloxi Regional Airport in Gulfport. In Jackson County, air transportation is provided by the Trent Lott International Airport in Pascagoula and the Ocean Springs Airport in Ocean Springs.

The Port of Pensacola is a deep-water port that was established in the mid-1700s. The 20-ha (50-acre) facility includes eight warehouses which encompass over 37, 160 m^2 (400,000 ft^2), eight berths that range in depth from 4.9 to 10 m (16 to 33 ft), and 23,200 m^2 (250,000 ft^2) of open, outside storage area (Port of Pensacola, 2004). Important commodities include bagged agricultural products, forest products, asphalt, sulfur, lime, steel products, and automobiles (Port of Pensacola, 2004). The port will add a dry cement import and distribution terminal, frozen foods warehouse, and cruise terminal in the future. It is estimated that these three new additions will generate over a half million tons of combined cargo throughput and up to 100,000 new visitors each year (Port of Pensacola, 2004).

Three ports are located on the Gulf Coast of MS near GUIS. These ports include the Port of Pascagoula, the Port of Biloxi, and the Port of Gulfport. Pascagoula's primary cargo is steel, wood pulp, refrigerated meat, plywood, chemicals, bulk grains, and natural rubber. The mean depth of the channel is 11.6 m (38 ft) and there is a hard surface loading area of approximately 0.043 km^2 (10.6 acres) (MDOT, 2005). The Port of Biloxi's main channel is 3.7-m (12 ft) deep and the port offers services such as mooring assistance, fuel, repairs, and divers. The port cargo handled at the Port of Gulfport includes petroleum products, paper products, sand, rock, stone, wood products, grain, and equipment machinery (MDOT, 2005). The main channel is approximately 76.2 m (250 ft) wide and maintained at a depth of 11 km (36 ft). As part of the port's long-range expansion plan, which extends through 2010, the possibility of deepening the channel and harbor to a depth of 12.8 m (42 ft) is being considered (Battelle, 1998).

Ports can introduce nonindigenous species through the discharge of ballast water. This can disrupt ecosystems and result in habitat loss for native species. The dredging activities associated with maintaining waterways disrupt sediments and may release toxic chemicals into the overlying water column. The oil and gas emissions also contribute additional contaminants to the atmosphere and waters.

B3b. Non-point source pollution

Non-point source pollution is the type of pollution that is transported to a receiving waterbody in a dispersive or diffuse manner. Pollutants included in non-point source are nutrients, sediment, bacteria, heavy metals, pesticides, oil, and grease. Non-point source includes stormwater runoff containing heavy metals and sediment, leaky septic systems or animal waste applications that can contribute organic matter and fecal coliforms, nutrients from fertilizers applied to lawns or golf courses, atmospheric deposition of compounds such as mercury or lead, and herbicides or pesticides in runoff from golf courses or agricultural fields. Marinas contribute non-point source pollution during construction and operation. Some of the pollutants associated with marinas and boats include hydrocarbons (fuel and grease) from boat exhaust and fuel spills, solid waste from trash, solvents associated with boat cleaning, heavy metal contamination from paints and other chemicals, and bacteria from boat head facilities (Thorpe et al., 1997).

Urban stormwater

Urban stormwater runoff is of particular concern in the highly urbanized areas of the watersheds, especially the PBS and the highly developed bayous in the western Choctawhatchee Bay watershed (Thorpe et al., 1996 and 1997). Stormwater from urban areas tends to be high in nitrogen, phosphorus, BOD, suspended solids, zinc, and lead (Harper, 1992). According to Schwenning (2001), untreated stormwater contributes nine times more oxygen demanding substances than most point sources and 80-95% of the heavy metals that reach waterbodies. Traditional approaches to stormwater management have focused on handling the quantity of the wastewater without addressing the quality. Measures that can be employed to minimize environmental impacts include buffer zones, limiting impervious areas, grassed waterways, minimizing pesticide applications, and using best management practices (BMPs) for construction sites.

Septic systems

Septic systems are common in the unincorporated areas surrounding GUIS. The leachate from these systems can contaminate surface and groundwater with nutrients and bacteria when not installed or maintained properly. These impacts are especially important near bays and bayous where shellfish harvesting or recreational activities are common. Inadequate treatment often results when the soil absorption is poor or the soil porosity is excessive, as with coastal sandy soils (Thorpe et al., 1996). As development along the coast continues, the number of residences relying on septic systems will increase and proper installation and maintenance will be required to protect nearby water resources.

Agricultural runoff

There is agricultural land in the watersheds near Pensacola and Choctawhatchee Bays. Agricultural activities contribute runoff that contains sediments, pesticides, herbicides, and nutrients from fertilizer application. In the Choctawhatchee River and Bay SWIM Plan (Thorpe and Ryan, 1996), the U.S. Department of Agriculture's National Resources Conservation Service (USDA/SCS, 1993) reported that approximately 5 metric tons (5.5 million tons) of eroded sediment reaches tributary waters of the Choctawhatchee River each year with an estimated 540,000 metric tons (600,000 tons) reaching the bay. Agricultural BMPs, which have been implemented, may reduce effects on surface water. Forestry operations can also increase sedimentation in waterbodies and disrupt pH (Thorpe et al., 1997). The removal of trees from the banks of waterbodies increases solar radiation, raising water temperature, and disrupting the ecological balance of aquatic systems (Thorpe et al., 1997).

Atmospheric deposition

Another nonpoint source is atmospheric deposition. An airshed is defined as the area responsible for emitting 75% of the air pollution that reaches a specific waterbody (USEPA, 2003). Due to differences in the ways chemicals react in the atmosphere, airsheds vary based on the pollutant. Mathematical models are used to determine the airshed for a particular waterbody. The USEPA has identified five categories of pollutants with the greatest potential to harm water quality. They include nitrogen compounds, mercury, other metals, pesticides, and combustion emissions (USEPA, 2003). Nitrogen, in particular, is of concern because high levels produce eutrophic conditions, or harmful increases in algal growth in surface waters. Modeling found that utility and mobile (automobile exhaust) sources are approximately equal contributors of nitrogen via atmospheric deposition (Appleton, 1995).

Information on the park's air quality can be obtained from a variety of sources. Historical and current air quality data are available at the MDEQ and FDEP websites, but there are multiple programs that assess air quality specifically. One of these is the National Atmospheric Deposition Program (NADP)/National Trends Network. The sites closest to GUIS are LA30 (Washington Parish, LA), FL23 (Sumatra, FL), AL24 (Bay Road/Mobile County, AL), and AL02 (Delta Elementary/Baldwin County, AL). These sites are monitored for a number of constituents including calcium, magnesium, potassium, sodium, ammonium, nitrate, inorganic nitrogen, chloride, sulfate, and hydrogen. The nearest sites measured for the Mercury Deposition Network (MDN) are the sites at MS22 (Oak Grove, MS), AL24 (Bay Road /Mobile County, AL), and AL02 (Delta Elementary/Baldwin County, Alabama). There are no MDN stations located in the FL panhandle. The 2003 total wet deposition rates for these three stations were 24.6, 16.1, and 26.8 $\mu g\ m^{-2}$, respectively. These values are in the upper range of those graphed on the national map of 2003 wet deposition rates of mercury across the nation (NADP, 2004).

The state of MS also monitors air toxics at four locations in the state. These toxic compounds, also called hazardous air pollutants, are known or suspected carcinogens or mutagens (Cooper et al., 2004). These chemicals pose health and environmental risks. The Gulfport and Pascagoula sites are near GUIS-MS. These sites monitor the 33 pollutants that are part of the USEPA's Urban Air Toxics Monitoring Program (Cooper et al., 2004).

Golf courses

Golf courses are considered non-point sources of pollution because the contaminants enter the environment in runoff carried to neighboring waterbodies during storms. Golf courses are of environmental concern because of the large quantities of pesticides and fertilizers applied and the common use of treated or reclaimed municipal wastewater for irrigation. As the population near coastal areas continues to grow, the number of recreational sites, including golf courses, is also expected to increase. The chemical and biological impacts of golf courses on coastal systems are not well understood and their environmental impacts may be significant (Lewis et al., 2002). For these reasons, the effects of a coastal golf complex on water quality, periphyton, seagrass, and sediments are addressed in a series of reports by Lewis et al. (2001a; 2002; 2004).

The golf course complex included in the study is located near Gulf Breeze, FL, adjacent to Santa Rosa Sound. The facility consists of two, 18-hole golf courses that are approximately 16 years old. During the study period, the application rate of treated domestic wastewater for irrigation was 3800 $m^3\ d^{-1}$ (1×10^6 gallons per day). Stormwater enters Santa Rosa Sound through a series of interconnected fairway ponds that drain through coastal wetlands before entering the Sound. There is also a subterranean drainage system that delivers stormwater directly into Santa Rosa Sound from low-lying areas that are subject to excessive ponding during rainfall events.

Fourteen sampling stations were selected in the treated wastewater storage pond (located on-site), three fairway ponds, a residential bayou, three coastal wetlands, and four locations in

Santa Rosa Sound adjacent to the wetlands that receive golf complex runoff (**Figure 62**). Two reference stations were located approximately 2 km (1.2 miles) east and west of the golf course in Santa Rosa Sound within the boundaries of GUIS (Lewis et al., 2002). The impacts of the coastal golf complex on the chemical and biological qualities of the surrounding surface waters were analyzed over a two-year period. Results summarizing the impacts on water quality, periphytic algae, and seagrass are discussed first, followed by the impacts on sediments.

The report states that the golf course complex had near-field impacts on water quality that did not generally extend into the adjacent coastal area. Most of the water quality parameters for the Santa Rosa Sound reference and nonreference sites were similar. These results were attributed to the buffering effects of the bayou and adjacent wetlands (Lewis et al., 2002). Concerning metals, all of the nonreference sampling sites exceeded the FL ($\leq 5.6\ \mu g\ l^{-1}$) and U.S. ($8.1\ \mu g\ l^{-1}$) criterion for lead, while lead was not detectable at the reference sites (Lewis et al., 2002). The mean mercury concentrations for the reference and all other locations exceeded the FL criterion for the protection of marine life ($\leq 0.025\ \mu g\ l^{-1}$) but not the national criterion to protect saltwater life ($0.94\ \mu g\ l^{-1}$). Atrazine was detected but did not exceed the national criterion value of $11.0\ \mu g\ l^{-1}$ proposed by the USEPA for the protection of marine life (Lewis et al., 2002).

The study also found that nutrient levels in the golf course-impacted areas were high compared to 690 stations located in FL estuaries summarized by Friedemann and Hand (1989). For chlorophyll *a*, the values near the golf course were greater than 90 to 95% of the estuarine stations (Lewis et al., 2002). The only statistically significant biological effect was the reduction of seagrass biomass in Santa Rosa Sound adjacent to the golf course. However, the cause(s) for this decline could not be determined. Proposed mechanisms included the presence of potential phytotoxicants such as copper and atrazine, decreased light penetration due to heavy phytoplankton density and/or epiphytic growth, and water depth (Lewis et al., 2002).

Data were also collected to determine the sediment chemical contamination and toxicity. Samples were collected from the same fourteen stations and two reference stations located in Santa Rosa Sound with the addition of a reference station in a freshwater pond (located approximately 2 km from the complex) (Lewis et al., 2001a). Lewis et al. (2001a) reported that some of the sediments were contaminated from the golf course runoff; however, the contamination was limited to near-field areas with decreasing seaward concentrations. The samples did not exceed sediment quality guidelines indicative of biological risk the majority of the time (Lewis et al., 2001a). The bayou area was the most chemically contaminated and biologically impacted. This is not surprising because the bayou receives the wastewater storage pond overflow, runoff from the golf course, and inputs from the nearby residential area (Lewis et al., 2001a). Impacts from the residential area include leachate from poorly maintained septic systems and runoff from lawns. The residential effects were not quantified (Lewis et al., 2001a).

The total trace metal and total chlorinated pesticides from this study were compared to a study of three urbanized bayous and several wastewater outfalls nearby. The collection, handling, and analytical procedures for all samples were identical (Lewis et al., 2001a). The average total pesticide concentrations for the urbanized bayous (range = 29-59 ng g^{-1}) were greater than those associated with the point source discharges (range = < 1-10 ng g^{-1}) and, with the exception of the bayou, the golf complex-impacted areas (range = 2-14 ng g^{-1}) (Lewis et al., 2001a). Pesticide contamination may be less than that associated with urban runoff but greater than that in some wastewaters (Lewis et al., 2001a). Analysis of the total trace metal concentrations (**Table 28**) indicated that the sediment metal contamination from golf courses may be less than that attributed to other coastal sources, such as urban runoff.

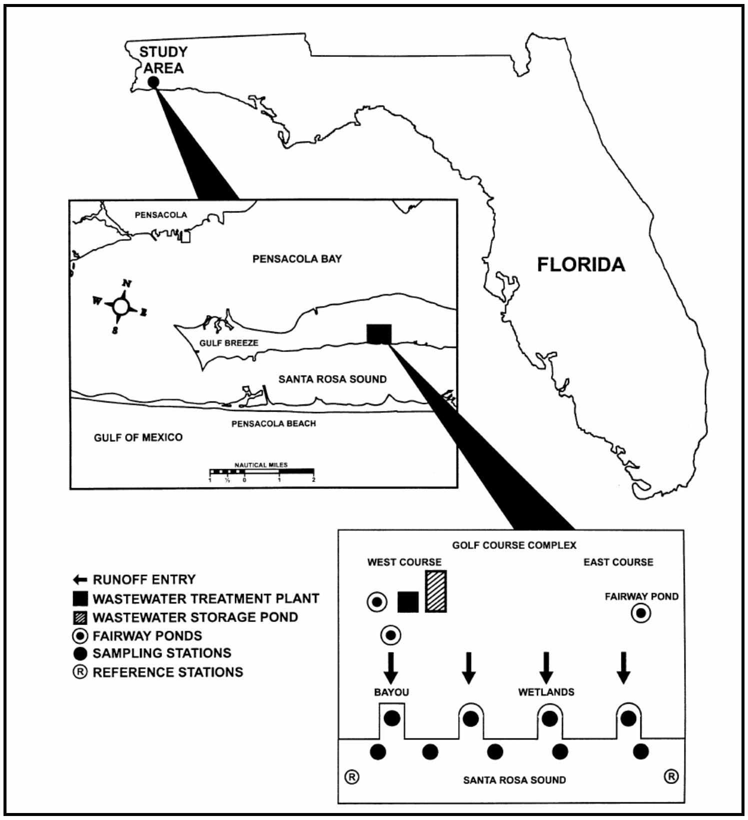

Figure 62. Location of golf course complex in northwest FL near Gulf Breeze.

(Source: Lewis et al., 2002).

Table 28. Average total trace metal concentrations in μg g^{-1} (dry weight).

Location	Range
Bayous	372 (± 200) to 725 (± 325)
Golf Course Runoff	2 (± 5) to 137 (± 46)
Outfalls	6 (± 1) to 256 (± 51)

Source: Lewis et al., 2001a.

It was also investigated whether the golf complex was a significant source of bioavailable contaminants to the adjacent coastal water. The study conducted by Lewis et al. (2004) discovered that this was not the case, at least, for the parameters considered in their report. This conclusion was based on several findings. First, chlorinated pesticides and PCB cogeners were rarely detected in biota (*Ruppia maritima* – widgeon grass, *Callinectes sapidus* Rathbun – blue crab, and *Crassostrea virginica* Gmelin – Eastern oyster) (Lewis et al., 2004). This contrasted with the detection of trace metals, which was more frequent; however, the trace metal residues for the biota were not significantly different when comparing the reference and nonreference sites (Lewis et al., 2004). These results were also compared to trace metal residues in periphyton that receive treated wastewater discharges and urban stormwater runoff. The trace metal residues in the periphyton from the golf course were similar or less than those from the areas impacted by anthropogenic sources (wastewater discharges and stormwater) (Lewis et al., 2004). The report concluded that the golf complex is not a significant source of bioavailable contaminants (several trace metals) for periphyton at the local or watershed scale (Lewis et al., 2004).

Although these reports showed that the golf course runoff has not degraded water quality to a significant extent in Santa Rosa Sound, several historical events have suggested possible environmental effects. In the summer of 1993, fish kills were reported by citizens and the GUIS park supervisor in the sound near the golf complex (Hand et al., 1994). During the summer and fall of 1991, crabs were found dying in traps in Santa Rosa Sound. The die-off was attributed to high nutrient runoff from the golf complex and low DO levels (Hand et al., 1994).

The study conducted by Lewis et al. (2002) utilized sites within GUIS as reference sites, indicating that the water quality was relatively pristine. However, mercury was found to exceed the FL criterion for the protection of marine life at these reference sites. Due to the limited amount of development within the park, anthropogenic influences (most likely, non-point source pollution) outside the boundaries are influencing the levels mercury levels in the park's waters. The environmental impacts of the golf course were generally relegated to the water immediately adjacent to the course and did not extend into Santa Rosa Sound. However, it is suggested that more sensitive techniques be utilized to determine if contaminant levels are affecting the park's biota.

C. Conclusions and Recommendations

The amount of water quality data available for the waters within and surrounding GUIS allows general evaluations of the park's waters to be made. These data indicate that the estuarine waters are generally in a stressed and/or threatened condition. However, there are concerns regarding certain parameters, such as fecal coliforms and mercury which have recently led to segments being classified as impaired. In addition, sampling for specific parameters, such as nutrients, and adding new locations, especially in the upland ponds and marine waters, is required for further evaluation of these resources. **Tables 29 and 30** indicate stressor levels for the FL and MS sections of GUIS.

C1. Impaired waters

Impaired waterbodies within the park boundaries were identified based on the most recent 303(d) lists for MS and FL. The updated list for the Choctawhatchee/St. Andrew's Bay (FL) includes a segment called GUIS, which is impaired for bacteria and mercury (in fish tissue). The segment is located along the northern portion of Santa Rosa Island bordering Choctawhatchee Bay. Additional segments located close to the park boundaries include Pensacola Bay (mouth and northern section) and direct runoff to Perdido Bay. These segments have not been verified but are listed for DO (Perdido Bay), copper, lead, BOD, TSS, turbidity, and nutrients (Pensacola Bay – mouth), and coliforms (Pensacola Bay – north). The Pensacola Bay mouth section borders the Fort Pickens unit of GUIS-FL. This segment is a major water quality concern due to the number of impaired parameters. Although these listings have not been verified, preliminary analysis indicates that most of the waters immediately surrounding the park, with the exception of the mouth of Pensacola Bay, do not carry this designation. Mixing from tidal and wind-driven mechanisms and biological activity may provide sufficient dilution to mitigate the impacts of stressors upstream from the park. These mechanisms may not be sufficient in the future given the increasing development of the Gulf Breeze peninsula and Santa Rosa Island.

According to the 2004 303(d) list, MS Sound is impaired for total toxics in six areas 3.2 km (2 miles) in diameter around specific stations located between the MS coastline and the GUIS-MS barrier islands. Some of these stations are located near Ship and Petit Bois Islands. Evaluated segments are those for which the use support decision is based on information other than site-specific monitoring data (MDEQ, 2004a). Information includes land use surveys, incidents of pollution spills/fish kills, point source discharge data, and monitoring data greater than 5 years old (MDEQ, 2004a). An additional concern is DO levels in MS Sound near the Davis Bayou section of GUIS-MS. Several DO measurements at a station located in MS Sound (Station 640MSBD15A) were below the USEPA criterion of 4 mg l^{-1} during 2002-2003.

C2. Current level of knowledge

Changes in seagrass communities have been documented by a number of studies conducted in the waters within and surrounding GUIS. A three-year study conducted by Heck et al. (1996) found that there were constant coverage of *H. wrightii* and *T. testudinum* in Santa Rosa Sound and Big Lagoon, but the density and aboveground biomass decreased over the study period. In the lower portion of Perdido Bay, changes in seagrass density occurred, and the seagrass coverage declined from 486 ha (1,201 acres) in 1940-41 to 251 ha (619 acres) in 1987 (Handley, 1995). During this period, some areas in U.S. Geological Survey quadrangles lost as much as 82% of the seagrasses. These changes were due to increased turbidity (dredging and boat traffic), shoreline modifications, degrading water quality and sedimentation from increasing development, and the effects of Hurricane Frederick (1979) (Handley, 1995).

It was estimated that the seagrass coverage decreased 66%, from 416 ha (1,029 acres) of seagrasses to 140 ha (345 acres), along the MS gulf coast between 1956 and 1987 (Handley, 1995). The primary cause of seagrass disappearance is considered to be an overall degradation in water quality (Moncreiff et al., 1998). A number of anthropogenic and natural factors contribute to this degradation. Important factors are increased turbidity resulting from dredging and boat traffic, propellor scarring, shoreline modifications, increasing development, and the effects of natural events, such as hurricanes. The primary threats to seagrasses in Santa Rosa Sound are increased stormwater runoff and development pressure from neighboring communities (Schwenning, 2001). A seagrass survey of GUIS-FL was recently completed by the USEPA Gulf Ecology Division that will provide information on the current distribution of seagrasses and is currently under review for publication (Dr. Michael Lewis, USEPA, pers. comm.).

An optical model has been developed that established threshold values for chlorophyll *a* and TSS based on water quality data (Gallegos, 1994). Although the model was not calibrated for the waterbodies surrounding GUIS, it can be used as a general indicator of water quality concerns (Dr. Patrick Biber, USM, pers. comm.). Application of the model revealed that TSS levels at representative stations were approaching or exceeding the thresholds estimated for Santa Rosa Sound, Big Lagoon, and MS Sound. The presence of seagrasses in all of these systems indicates that the water quality has not degraded below the levels required for survival; however, these systems should continue to be monitored as development of the surrounding land continues.

Shoreline changes in the southeast have been studied extensively in recent years. Application of a coastal vulnerability index to approximately 145 km (90 miles) of the seashore found that 24% was classified as very high vulnerability due to sea-level rise, 18% as high vulnerability, 36% as moderate vulnerability, and 21% as low vulnerability (Pendleton et al., 2004). The calculated CVI values showed that GUIS-MS may be more vulnerable than GUIS-FL to predicted sea-level rise (Pendleton et al., 2004). Changes in shoreline will continue to be measured by the USGS every 5 to 10 years along the GOM Coast (Morton et al., 2004). This information is important for park personnel who must balance the management of upland property with the conservation of beach resources.

Navigation channels maintained by dredging near GUIS are Pensacola, Ship Island, and Horn Island Passes. Dredging activities may have impacted the western migration of Ship and Petit Bois Islands and additional study has been recommended (Boom et al., 1991). Dredge material from Pensacola Pass has been placed on Perdido Key as part of a beach nourishment project. The effects of beach nourishment on macrobenthic assemblages were studied by Rakocinski et al. (1996). This study found although there were some persistent changes in macrobenthic assemblages from restoration activities, there was appreciable recovery within the post-nourishment period (greater than two years) (Rakocinski et al., 1996).

Ballast water can affect water quality via the discharge of sediments and other pollutants as well as the introduction of nonindigenous species to an area. A search of the USGS Nonindigenous Aquatic Species Database yielded 22 nonindigenous aquatic plant species in coastal FL and 8 in coastal MS. A similar search produced 8 nonindigenous animal species in coastal FL and 13 in coastal MS. These numbers indicate that exotic aquatic species are a concern for GUIS. In 2000, two exotic species of jellyfish bloomed in the northern GOM: the Australian spotted jellyfish (*Phyllorhiza punctata*) and "the big pink jellyfish" (*Drymonema dalmatinum*) (Dauphin Island Sea Lab, 2005). Programs such as AMRAT are important in the documentation of species; however, research focused on the effects of these species on water quality is needed. Additional studies should also be conducted to assess the impacts of nonindigenous species on the displacement of native species.

The FMRI maintains a database of HABs in FL. According to this database, there have been 64 instances of red tide in the combined areas of Escambia, Okaloosa, and Santa Rosa Counties from 1997 to 2005. The most recent occurrence was on September 11, 2001, in Pensacola Bay. Early detection of these events is important to warn park visitors and prevent adverse health effects. **Table 29** addresses red tide as a stressor for these areas.

C3. Identification of data gaps and monitoring recommendations

Significant amounts of data were obtained for FL from Modernized STORET; however, there were some gaps in data and inconsistencies in sampling techniques. In addition, there is a time lag associated with processing and uploading the data into the STORET database. Due to this delay, data from summer 2003 to the present were not available at the time of this report's publication. The differences in laboratory and field procedures also complicated data analysis. In the field, the measurements were recorded at different times of the day and water depths. The detection levels also varied from one agency to another based on the instruments and analytical procedures utilized.

C3a. Estuarine waters

A fair amount of sampling has been conducted by multiple agencies in the estuarine waters; the data have been entered into the USEPA's STORET database or maintained in the MDEQ's database. The limitations of these data are the lack of recent nutrient data (possibly due to upload lag time), lack of contaminants and metals data, and differences in analytical procedures and sampling techniques. The nutrient data included in this assessment were obtained from STORET dating from 1999 through May 2003. Additional nutrient data collected from 1996-1998 were obtained from the USEPA Nutrient Database (USEPA, 2005). There were a limited number of stations sampled within the study area established around GUIS-MS (**Figure 22**), which affects the ability to determine the stress on water quality (see **Table 30)**. Although the majority of the population is located near the MS coast, monitoring of the waters surrounding the barrier islands is recommended. If possible, nutrient parameters (total nitrogen, nitrite + nitrate, ammonia, total phosphorus, orthophosphorus) and chlorophyll *a* should be sampled quarterly. Certain government agencies, such as the MS DMR measure field parameters as part of their shellfish monitoring program, perhaps nutrient sampling could be added to their routine.

Table 29. Current and potential stressors that are affecting or may affect Gulf Islands National Seashore-FL environments.

Gulf Islands National Seashore - FL

Stressor	Gulf of Mexico	Santa Rosa Sound (Santa Rosa Island)	Big Lagoon (Perdido Key)	Pensacola Bay	Western Portion Choctawhatchee Bay (Okaloosa Area)	Inland Ponds
Harmful Algal Blooms (HABs)[1]	HP	PP	PP	PP	MP	ND
Nutrient Loading	ND	HP	HP[2]	HP[2]	HP[3]	ND
Excessive fecal bacteria	LP	HP[4]	HP[4,5]	HP[2]	HP[2]	ND
Metals contamination	PP (Hg)[6]	PP[7]	HP (Hg)[8]	HP[2]	HP (Hg)[2]	PP[9]
Toxic compounds	ND	ND	ND	PP[10]	PP[11]	ND
Invasive species	MP[12]	PP	PP	PP[13]	PP[13]	HP[14]
Habitat disruption	MP[15]	HP (vehicles)	HP (vehicles)	HP	HP	ND
Loss of SAV* habitat	ND	HP	HP	HP	HP	ND
Hypoxia	ND	MP[16]	HP[2]	HP[2]	PP[17]	ND
Trash	PP	PP	PP	PP	PP	PP

*SAV - Submerged aquatic vegetation

Definitions: HP-high concern problem, MP - moderate concern problem, LP-low concern or no problem, PP - potential problem, ND - insufficient data to make judgment

Table developed with guidance from Riley Hoggard, National Park Service, pers. comm..

Footnotes on following page:

[1]Based on regional HAB events (primarily red tide)

[2]Based on impaired water listing (FL Department of Environmental Protection)

[3]Based on population growth and increased urban runoff

[4]Based on Health Department Advisories (no water contact within 3 days of significant rainfall)

[5]Based on 303(d) listing for Perdido River

[6]Based AL offshore fish consumption advisory

[7]Due to location near Pensacola Bay and possible localized effects of golf courses and urbanization

[8]Based on fish consumption advisory for Perdido River

[9]Based on preliminary results of University of Florida (UF) Mercury Contamination Study (Contact: Dr. Jean-Claude Bonzongo, UF.)

[10]Based on heavy industry, Superfund sites, and information presented in Pensacola Bay Surface Water Improvement and Management (SWIM) Plan

[11]Based on sediment contamination information presented in Choctawhatchee Bay SWIM Plan

[12]Based on shipping traffic, Port of Mobile, and presence of exotic jellyfish

[13]Based on search of US Geological Survey nonindigenous aquatic species database (http://nas.er.usgs.gov)

[14]Most common Chinese tallow tree (*Sapium sebiferum*) - habitat change and water quantity

[15]Based on dredging and beach nourishment activities

[16]Based on HP listings for Big Lagoon and Pensacola Bay

[17]Based on low DO levels (< 4 mg l^{-1})

Table 30. Current and potential stressors that are affecting or may affect Gulf Islands National Seashore-MS environments.

Gulf Islands National Seashore - MS

Stressor	MS Sound	Davis Bayou	Inland Ponds
Harmful Algal Blooms (HABs)	PP[1]	LP-PP	ND
Nutrient Loading	HP[2]	MP	PP[3]
Excessive fecal bacteria	PP[4]	PP[4]	PP[3]
Metals contamination	HP[5]	PP[6]	PP[7]
Toxic compounds	HP[4]	ND	ND
Invasive species	HP[8]	HP[8]	HP[9]
Habitat disruption	HP	HP	ND
Loss of SAV* habitat	HP	LP	ND
Hypoxia	HP[2]	PP[10]	ND
Trash	PP	PP	PP

*SAV - Submerged aquatic vegetation

Definitions: HP-high concern problem, MP - moderate concern problem, LP-low concern or no problem, PP - potential problem, ND - insufficient data to make judgment

Table developed with guidance from Riley Hoggard, National Park Service, pers. comm.

Footnotes on following page:

[1]Based on regional HAB events (primarily red tide)

[2]Based on Environmental Monitoring and Assessment Program data (high levels of dissolved nitrogen and chlorophyll *a*)

[3]Based on adjacent septic systems/leachfields

[4]Based on MS beach monitoring program data

[5]Based on impaired water listing (MS Department of Environmental Quality)

[6]Based on exceedances in nearby Biloxi Bay

[7]Based on preliminary findings of University of Florida (UF) Mercury Contamination Study (Contact: Dr. Jean-Claude Bonzongo, UF)

[8]Development of AL-MS Rapid Assessment Team (conducted rapid assessment of non-native species in MS Sound, Summer 2004)

[9]Prevalence of Chinese tallow tree (*Sapium sebiferum*)

[10]Based on low DO levels (< 4 mg l^{-1})

Few metals and contaminants data are available, especially within the park boundaries. Some of this information will be provided by the USEPA's NCA program. These data are available online; however, detailed analysis of the MS Sound data is not available. The USEPA *National Coastal Condition, Report II* (2004) identified the Gulf Coast estuaries as having poor benthic communities. Low benthic diversity areas along the coasts of FL and MS co-occurred with poor sediment quality, poor sediment and water quality, or neither of these conditions (USEPA, 2004). Some of the NCA data were included in the retrieval from the MDEQ. The majority of the data were recorded at a single station in Biloxi Bay which cannot be utilized to characterize the entire system, and so there is potential stress on parts of the park removed from sampling (see **Table 30**). At this station, there was one exceedance of the MS standard for total dissolved arsenic (III) and dissolved copper in saltwaters; however, these results should be interpreted with caution due to the possibility of sample contamination. The results of the NCA will determine the sampling frequency required thereafter. Contamination will likely prompt the MDEQ or another agency to investigate possible causes and institute long-term monitoring. Lewis et al. (2002) reported mean mercury concentrations for sites located within GUIS-FL that exceeded the FL criterion for the protection of marine life (≤ 0.025 µg l^{-1}) but not the national criterion to protect saltwater life (0.94 µg l^{-1}). This area should be monitored to determine the extent of the contamination and possible effects on aquatic biota. As sportfishing is very popular in the region, mercury contamination should be closely monitored.

Twenty-four hour sampling should be considered to minimize the effects of the time of day on monitoring data, especially DO. The FDEP's Northwest District Office is developing a "real-time" water quality monitoring network within the Pensacola Bay watershed to fill in some of these inconsistencies (FDEP, 2004a). The results are presented online with water quality reports that are updated hourly (FDEP, 2004a). Twenty-four hour sampling is also recommended for stations in MS Sound, specifically the two stations mentioned above in the Davis Bayou area. A 12-hour sampling cycle was conducted in the summer of 2004 for stations located along the shoreline; however, additional sampling is planned for summer 2005 to obtain data for a dry period (Barbara Viskup, MDEQ, pers. comm.).

Seagrasses

Seagrass coverage should continue to be monitored and mapped within the park boundaries. Aerial photographs taken during the spring and fall of 2000 indicate that there are areas of light to moderate scarring in Santa Rosa Sound and Big Lagoon (Schwenning, 2001). It is recommended that these aerial photographs continue to be taken at regular intervals, such as every five years, to identify newly affected areas, monitor seagrass recovery, and protect areas at risk for seagrass loss. If the proposed rule for PWC use is approved, the impacts of these craft on seagrass beds should also be monitored as part of this effort.

C3b. Nearshore marine waters

There is little information available concerning the nearshore marine waters of GUIS. The accumulation, abundance, and composition of marine debris were examined over a five-year period (1989-1993) (Bishop, 1989; 1990; 1991; 1992; 1993). Lott (1992) also studied the types and quantities of litter collected from a stretch of Santa Rosa Island. Marine debris is not considered to be a major issue for GUIS, especially in comparison to some of the other parks located on the GOM, such as Padre Island National Seashore (**Tables 29 and 30**).

Fecal coliforms are regularly measured as part of the FL and MS beach monitoring programs. Beach closings have occurred in both FL and MS during recent years, indicating that fecal coliforms are of concern for the park's waters. In addition, a segment of the seashore is listed as impaired water due to fecal coliforms, resulting in concern over the issue (**Tables 29 and 30**).

There are few USEPA STORET stations located in the GOM. It is recommended that some of the bacteria monitoring stations also measure field parameters (DO, salinity, conductivity, pH, water temperature), nutrients (total nitrogen, nitrite + nitrate, ammonia, total phosphorus, orthophosphorus), and chlorophyll *a* to fill in the data gaps. Additional monitoring stations should also be added in the waters surrounding the MS barrier islands. The abundances of algae should continue to be measured, especially during the summer months when recreational usage is high to allow ample time for public warnings if red tide conditions are present.

C3c. Upland ponds

The upland ponds and lagoons of GUIS have been studied fairly extensively. The studies have focused on the ecology, geologic formation, and water quality of these waterbodies. The ponds located near Fort Pickens have been the subject of several studies ranging from characterization (Hardy, 1992) to the assessment of damages cause by Hurricane Opal (Snyder et al., 1997). The ponds of Horn and Petit Bois Islands have also been surveyed (Shabica and Watkins, 1982; Cofer-Shabica, 1989). The majority of these studies have focused on parameters such as salinity, with only a few that measured water quality parameters such as nutrients and DO. Unfortunately, the effects of Hurricane Ivan and the limited availability of these reports prevented much of the information from being assimilated into this report. The information that is available (Boyd et al., 1995) indicates that there is a need for additional research concerning the water quality of these waterbodies, as indicated in **Tables 29 and 30**.

The previous studies regarding Fort Pickens and Horn and Petit Bois Islands can provide useful information for data comparison, if the ponds still exist. Permanent stations should be established in the ponds that are known to hold water the majority of the year as these ponds are important habitat for a variety of plant and animal species. These stations should be routinely sampled (quarterly or semiannually) for field parameters, such as DO, salinity, conductivity, pH, water temperature) and nutrients (total nitrogen, nitrite + nitrate, ammonia, TP, orthophosphorus) and chlorophyll *a*. Boyd et al. (1995) recommended that certain ponds be monitored at least once a year, preferably in the fall, to document changes in faunal species and/or water quality. In addition, ponds which dry out should be studied intensively when water is present to determine impacts on wildlife utilizing the areas for habitat.

For areas where surveys have been completed and locations of ponds mapped, this information should be transferred to a GIS. This would be especially useful following catastrophic events, such as Hurricane Ivan. Physical parameters of the ponds and their locations following the hurricane will provide useful information on the effects and subsequent recovery of the system. In the future, the locations and physical characteristics of the ponds can be observed and the effects of storm events noted. Boyd et al. (1995) recommended that following a catastrophic event, such as a hurricane, the ponds should be monitored for changes in floral and faunal composition, water chemistry, and the effects of sand inundation and shore erosion.

There is little information concerning dissolved and sediment metals in the ponds and lagoons. However, the preliminary results of a contamination study indicate that mercury may be a potential problem in the park's ponds (Riley Hoggard, USDOI/NPS, pers. comm.). Additional sampling is required to determine if other types of contamination are present. If these samples do not indicate contamination and there are no suspected sources in the area, more intensive investigation is not necessary. The ponds should continue to be analyzed for metals and contaminants on a less frequent basis to avoid future water quality issues. Bacterial monitoring is not necessary because these waters are not utilized for recreation or drinking water, so useful information would not be provided from this testing.

C3d. Groundwater

There are limited data available concerning the groundwater resources of GUIS. A query of the USGS NWIS database retrieved 40 wells located within the park boundaries; however, many of these wells did not have a significant (10) number of records associated with them. The groundwater quality records are also out-of-date, as they were recorded in the 1960s and 1970s. There are some records from the early 1990s recorded at the MS barrier islands. Some of the wells have displayed levels of sodium, chloride, magnesium, and calcium indicative of the presence of seawater. These resources should be studied to obtain recent information on the groundwater quality and to identify sources of contamination.

C3e. Nonindigenous species

Regular monitoring should be conducted to determine if these species retrieved from the USGS Nonindigenous Aquatic Species Database are present within the park boundaries. These species should be monitored to document their abundance and effects on the park's ecosystems. The results of cataloguing efforts, such as AMRAT, give important insight into the invasive species in the area and should be reviewed prior to management decisions. MS Sound should continue to be monitored for invasive mollusk species (zebra mussel), especially the waters near the ship channels and the ICWW. The Australian spotted jellyfish is also of concern. Chinese tallow should continue to be managed by the park service to prevent further expansion. **Tables 29 and 30** delineate these problems throughout the park.

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Appendices

Appendix A1 – Florida Water Quality Standards

Appendix A2 - Mississippi Water Quality Standards

Appendix B1 - Class II Shellfish Harvesting Waters in Florida

Appendix B2 – Class II Shellfish Harvesting Waters in Mississippi

Appendix C - US Geological Survey Documented Wells Located within Two Miles of Gulf Islands National Seashore

Appendix D – Total Maximum Daily Loads for the Coastal Rivers and Pascagoula River Basins

Appendix E – 303(d) List of Impaired Waters Located near Gulf Islands National Seashore-FL

Appendix F – Domestic and Industrial National Pollutant Discharge Elimination System Permittees in Escambia, Santa Rosa, and Okaloosa Counties.

Appendix G – National Pollutant Discharge Elimination System Permittees in Biloxi, D'Iberville, Keesler Air Force Base (AFB), and Ocean Springs from Permit Compliance System (PCS)

Appendix H – Compliance History of Major National Pollutant Discharge Elimination System Dischargers in Escambia, Santa Rosa, and Okaloosa Counties

Appendix I – Compliance History of National Pollutant Discharge Elimination System Dischargers in Harrison and Jackson Counties, MS

Appendix J – Sources of Water Quality Data Information for Gulf Islands National Seashore

Appendix A1 – Florida Water Quality Standards

http://www.dep.state.fl.us/legal/rules/shared/62-302t.pdf

Appendix A2– Mississippi Water Quality Standards

Numeric Criteria for All Waters (μg/L)

Parameter	Fresh Water		Salt Water		Human Health	
	Acute	Chronic	Acute	Chronic	Organisms Only	Water & Organisms
Aldrin	3.0		1.3		0.00014	0.00013
Ammonia	[g]	[g]	[g]	[g]		
Arsenic (III), Total Dissolved	340[f]	150[f]	69	36		
Arsenic, Total Dissolved					24 [i]	0.078 [i]
Cadmium, Total Dissolved	1.74 [b,f]	0.62 [b,f]	43	9.3	168	5
Chlordane	2.4	0.0043	0.09	0.004	0.0022	0.0021
Chlorine	19	11	13	7.5		
Chromium (Hex), Total Dissolved	16 [f]	11 [f]	1100	50	1470	98
Chromium (III), Total Dissolved	323 [buff]	42 [b,f]			140468	100
Copper, Total Dissolved	7.0 [b,f]	5.0 [b,f]	4.8	3.1	1000	1000
Cyanide	22.0[h]	5.2[h]	1.0[h]	1.0[h]	220000	200
4,4 DDT	1.1	0.001	0.13	0.001	0.00059	0.00059
Dieldrin	0.24	0.056	0.71	0.0019	0.000144	0.000135
2,3,7,8 TCDD					1.0 ppq[d]	1.0 ppq[d]
Endosulfan	0.22[j]	0.056 [j]	0.034 [j]	0.0087 [j]	240 [k]	110 [k]
Endrin	0.086	0.036	0.037	0.0023	0.814	0.76
Heptachlor	0.52	0.0038	0.053	0.0036	0.000214	0.000208
Hexachlorocyclohexane(Lindane)	0.95	0.08	0.16		0.0625	0.0186
Lead, Total Dissolved	30 [b,f]	1.18 [b,f]	210	8.1		15
Mercury (II), Total Dissolved	2.1[f]	0.012	1.8	0.025		
Mercury					0.153	0.151
Nickel, Total Dissolved	260 [b,f]	29 [b,f]	75	8.3	4584	607
			167 [e]	18.5 [e]		
Phenol	300	102	300	58	300	300
Pentachlorophenol	8.7 [c]	6.7 [c]	13 [c]	7.9 [c]	8.2	0.28
PCB 1242	0.2	0.014	1.0	0.03		
PCB 1254	0.2	0.014	1.0	0.03		
PCB 1221	0.2	0.014	1.0	0.03		
PCB 1232	0.2	0.014	1.0	0.03		
PCB 1248	0.2	0.014	1.0	0.03		
PCB 1260	0.2	0.014	1.0	0.03		
PCB 1016	0.2	0.014	1.0	0.03		

Total PCB					0.00035	0.00035
Selenium, Total Dissolved	11.8 [a,f]	4.6 [f]	290 [f]	71 [f]	3365	50
Silver, Total Dissolved	1.05 [b,f]		1.9			100
Toxaphene	0.73	0.0002	0.21	0.0002	0.00075	0.00073
Zinc, Total Dissolved	65 [b,f]	65 [b,f]	90	81	5000	5000

a = The CMC = 1/[(f1/CMC1) + (f2/CMC2)] where f1 and f2 are the fractions of total selenium that are treated as selenite and selenate, respectively, and CMC1 and CMC2 are 185.9 µg/L and 12.83 µg/L. The value in the table is calculated assuming a worst case scenario in which all selenium is present as selenate.
b = Hardness dependent parameter. All criteria are as indicated at hardness of 50 mg/L as CaCO3 . If hardness exceeds 50 mg/L as $CaCO_3$, then criteria is equal to result of hardness based equations as found in *Quality Criteria for Water*.
c = Criteria for pentachlorophenol are based on a pH dependent equation as found in *Quality Criteria for Water* . Values listed are for a pH of 7.0 s.u.
d = Criteria for 2,3,7,8 TCDD based on a risk factor of one in one hundred thousand (10^{-5}).
e = Site specific criteria for Mississippi Sound.
f = Parameter subject to water effects ratio equations where "CMC = WER * Acute" and "CCC = WER * Chronic".
g = Ammonia criteria are dependent on pH, temperature and/or salinity. See Section II.10.C.
h = Expressed as µg free cyanide (as CN)/L.
i = Refers to the inorganic form only.
j = Applies to the sum of a and b isomers.
k = Applies to individual isomers of Endosulfan including a, b , and Endosulfan Sulfate.

SECTION III. SPECIFIC WATER QUALITY CRITERIA:
1. PUBLIC WATER SUPPLY:

Water in this classification is for use as a source of raw water supply for drinking and food processing purposes. The water treatment process shall be approved by the Mississippi State Department of Health. The raw water supply shall be such that after the approved treatment process, it will satisfy the regulations established pursuant to Section 1412 of the Public Health Service Act as amended by the Safe Drinking Water Act (Pub. L. 93-523). Waters that meet the Public Water Supply criteria shall also be suitable for secondary contact recreation. Secondary contact recreation is defined as incidental contact with the water during activities such as wading, fishing and boating, that are not likely to result in full body immersion. In considering the acceptability of a proposed site for disposal of bacterially-related wastewater in or near waters with this classification, the Permit Board shall consider the relative proximity of the discharge to water supply intakes.

A. Bacteria : For the months of May through October, when water contact recreation activities may be expected to occur, fecal coliform shall not exceed a geometric mean of 200 per 100 ml based on a minimum of five (5) samples taken over a 30-day period with no less than twelve (12) hours between individual samples, nor shall the samples examined during a 30-day period exceed 400 per 100 ml more than ten percent (10%) of the time.

For the months of November through April, when incidental recreational contact is not likely, fecal coliform shall not exceed 2000/100 ml as a geometric mean (either MPN or MF count) based on at least five samples taken over a 30-day period with no less than twelve (12) hours between individual samples, nor shall the samples examined during a 30-day period exceed 4000/100 ml more than ten percent (10%) of the time.

B. Chlorides (Cl) : There shall be no substances added which will cause the chloride content to exceed 230 mg/L in freshwater streams.

C. Specific Conductance : There shall be no substances added to increase the conductivity above 500 micromhos/cm for freshwater streams.

D. Dissolved Solids : There shall be no substances added to the waters that will cause the dissolved solids to exceed 500 mg/L for freshwater streams.

E. Threshold Odor : There shall be no substances added which will cause the threshold odor number to exceed 24 (at 60E C) as a daily average.

F. Radioactive Substances : There shall be no radioactive substances added to the waters which will cause the gross beta activity (in the known absence of Strontium-90 and alpha emitters) to exceed 1000 picocuries per liter at any time.

G. Specific Chemical Constituents : In addition to the provisions in Section II.4. and 10., the following concentrations (dissolved) shall not be exceeded at any time:

Constituent Concentration (mg/L)
Barium 2.0
Fluoride 2.0
Lead 0.015
Nitrate (as N) 10.0

2. SHELLFISH HARVESTING

Waters classified for this use are for propagation and harvesting shellfish for sale or use as a food product. These waters shall meet the requirements set forth in the latest edition of the National Shellfish Sanitation Program, Manual of Operations, Part I, Sanitation of Shellfish Growing Areas , as published by the U. S. Public Health Service. Waters that meet the Shellfish Harvesting Area Criteria shall also be suitable for recreational purposes. In considering the acceptability of a proposed site for disposal of bacterially-related wastewater in or near waters with this classification, the Permit Board shall consider the relative proximity of the discharge to shellfish harvesting beds.

A. Bacteria : The median fecal coliform MPN (Most Probable Number) of the water shall not exceed 14 per 100 ml, and not more than ten percent (10%) of the samples shall ordinarily exceed an MPN of 43 per 100 ml in those portions or areas most probably exposed to fecal contamination during most unfavorable hydrographic and pollutional conditions.

3. RECREATION:

Waters in this classification are to be suitable for recreational purposes, including such water contact activities as swimming and water skiing. In considering the acceptability of a proposed site for disposal of bacterially-related wastewater in or near waters with this classification, the Permit Board shall consider the relative proximity of the discharge to areas of actual water contact activity.

A. Bacteria : Fecal coliform shall not exceed a geometric mean of 200 per 100 ml based on a minimum of five (5) samples taken over a 30-day period with no less than twelve (12) hours between individual samples, nor shall the samples examined during a 30-day period exceed 400 per 100 ml more than ten percent (10%) of the time.

B. Specific Conductance : There shall be no substances added to increase the conductivity above 1000 micromhos/cm for freshwater streams.

C. Dissolved Solids : There shall be no substances added to the water to cause the dissolved solids to exceed 750 mg/L as a monthly average value, nor exceed 1500 mg/L at any time for freshwater streams.

4. FISH AND WILDLIFE:

Waters in this classification are intended for fishing and for propagation of fish, aquatic life, and wildlife. Waters that meet the Fish and Wildlife Criteria shall also be suitable for secondary contact recreation. Secondary contact recreation is defined as incidental contact with the water during activities such as wading, fishing and boating, that are not likely to result in full body immersion.

A. Bacteria : For the months of May through October, when water contact recreation activities may be expected to occur, fecal coliform shall not exceed a geometric mean of 200 per 100 ml based on a minimum of five (5) samples taken over a 30-day period with no less than twelve (12) hours between individual samples, nor shall the samples examined during a 30-day period exceed 400 per 100 ml more than ten percent (10%) of the time.

For the months of November through April, when incidental recreational contact is not likely, fecal coliform shall not exceed a geometric mean of 2000 per100 ml based on a minimum of five (5) samples taken over a 30-day period with no less than twelve (12) hours between individual samples, nor shall the samples examined during a 30-day period exceed 4000/100 ml more than ten percent (10%) of the time.

B. Specific Conductance : There shall be no substances added to increase the conductivity above 1000 micromhos/cm for freshwater streams.

C. Dissolved Solids : There shall be no substances added to the waters to cause the dissolved solids to exceed 750 mg/L as a monthly average value, nor exceed 1500 mg/L at any time for freshwater streams.

5. EPHEMERAL STREAM:

Waters in this classification do not support a fisheries resource and are not usable for human consumption or aquatic life. Ephemeral streams normally are natural watercourses, including natural watercourses that have been modified by channelization or manmade drainage ditches, that without the influent of point source discharges flow only in direct response to precipitation or irrigation return-water discharge in the immediate vicinity and whose channels are normally above the groundwater table. These streams may contain a transient population of aquatic life during the portion of the year when there is suitable habitat for fish survival. Normally, aquatic habitat in these streams is not adequate to support a reproductive cycle for fish and other aquatic life. Wetlands are excluded from this classification.

Waters in this classification shall be protective of wildlife and humans that may come in contact with the waters. Waters contained in ephemeral streams shall also allow maintenance of the standards applicable to all downstream waters.

A. Provisions 1,2,3 and 5 of Section II (Minimum Conditions Applicable to All Waters) are applicable except as they relate to fish and other aquatic life. All aspects of provisions 4 and 10 of Section II concerning toxicity will apply to ephemeral streams, except for domestic or compatible domestic wastewater discharges which will be required to meet toxicity requirements in downstream waters not classified as ephemeral. Alternative methods may be utilized to determine the potential toxic effect of ammonia. Acutely toxic conditions are prohibited under any circumstances in waters in this classification.

B. Dissolved Oxygen : The DO shall be maintained at an appropriate level to avoid nuisance conditions.

C. Bacteria : The Permit Board may assign bacterial criteria where the probability of a public health hazard or other circumstances so warrants.

D. Definitions:

1. Fisheries resources is defined as any waterbody which has a viable gamefish population as documented by the Mississippi Department of Wildlife Conservation or has sufficient flow or physical characteristics to support the fishing use during times other than periods of flow after precipitation events or irrigation return water discharge.

2. "Not usable for human consumption or aquatic life" means that sufficient flow or physical characteristics are not available to support these uses.

3. "Flow only in response to precipitation or irrigation return water" means that without the influence of point source discharges the stream will be dry unless there has been recent rainfall

or a discharge of irrigation return water.

4. "Protective of wildlife and humans that may come in contact with the waters" means that toxic pollutants shall not be discharged in concentrations that will endanger wildlife or humans.

5. "Nuisance conditions" means objectionable odors or aesthetic conditions that may generate complaints from the public.

Recommendations for assignment of the Ephemeral Stream classification shall be made to the Commission on Environmental Quality by the Permit Board after appropriate demonstration of physical and hydrological data. The Ephemeral Stream classification shall not be assigned where environmental circumstances are such that a nuisance or hazardous condition would result or public health is likely to be threatened. Alternate discharge points shall be investigated before the Ephemeral Stream classification is considered.

Appendix B1 – Shellfish Harvesting Waters in Florida

Escambia County

Escambia Bay – Louisville and Nashville Railroad Trestle south to Pensacola Bay (Line from Emanuel Point east northeasterly to Garcon Point).
Pensacola Bay – East of a line connecting Emanuel Point on the north to the south end of the Pensacola Bay Bridge (U.S. Highway 98).
Santa Rosa Sound – East of a line connecting Gulf Breeze approach to Pensacola Beach (Bascule Bridge), and Sharp Point with exception of the Navarre Beach area from a north-south line through Channel Marker 106 to Navarre Bridge.

Santa Rosa County

Blackwater Bay – From a line connecting Robinson's Point to Broad River south to East Bay (line due west from Escribano Point).
East Bay and Tributaries – Blackwater Bay (line due west from Escribano Point) southerly to Pensacola Bay (line from Garcon Point on the north to Redfish Point on the south).
Escambia Bay – Louisville and Nashville Railroad Trestle south to Pensacola Bay (Line from Emanuel Point east northeasterly to Garcon Point).
Pensacola Bay – East of a line connecting Emanuel Point on the north to the south end of the Pensacola Bay Bridge (U.S. Highway 98).
Santa Rosa Sound – From a line connecting Gulf Breeze approach to Pensacola Beach, (Bascule Bridge), and Sharp Point, east to Santa Rosa/Okaloosa County line with exception of the Navarre Beach area from a north-south line through Channel Marker 106 eastward to Navarre Beach Toll Road.

Okaloosa County

Choctawhatchee Bay and Tributaries – From a line from White Point southwesterly through Fl. Light Marker 2 of the Intracoastal Waterway, eastward to the county line, including East Pass.
Rocky Bayou – Choctawhatchee Bay (from a line extending due east from Shirk Point) to Rocky Creek.
Santa Rosa Sound – From a north-south line through Manatee Point west to the Santa Rosa County Line.

Shellfish may only be harvested from approved or conditionally approved areas, unless under special permit and supervision. Shellfish areas under the conditionally approved category are reopened when the appropriate NSSP standards are met and adequate time has elapsed for purification to occur. No shellfish may be harvested from prohibited and unclassified areas. Shellfish harvesting classifications for the Pensacola Bay and Choctawhatchee Bay areas are included in the following table.

Shellfish Harvesting Classifications

Approved	Normally open to shellfish harvesting, may be temporarily closed under extraordinary circumstances such as red tides, hurricanes, and sewage spills. The 14/43 standard must be met for all combinations of defined adverse pollution conditions (tide, rainfall, river, tide/rainfall, tide/river, and tide/rainfall/river).
Conditionally Approved	Periodically closed to shellfish harvesting based on pollution events such as rainfall or increased river flow
Restricted	Normally open to relaying or controlled purification, allowed only by special permit and supervision; may be temporarily closed under extraordinary circumstances, such as red tides, hurricanes, or sewage spills
Conditionally Restricted	Periodically, relay and controlled purification activity is temporarily suspended based on pollution events, such as rainfall or increased river flow.
Prohibited	Shellfish harvesting is not permitted due to actual or potential pollution
Unclassified (Unapproved)	Shellfish harvesting is not permitted pending bacteriological and sanitary surveys

Based on classifications from Florida Department of Agriculture and Consumer Sciences.

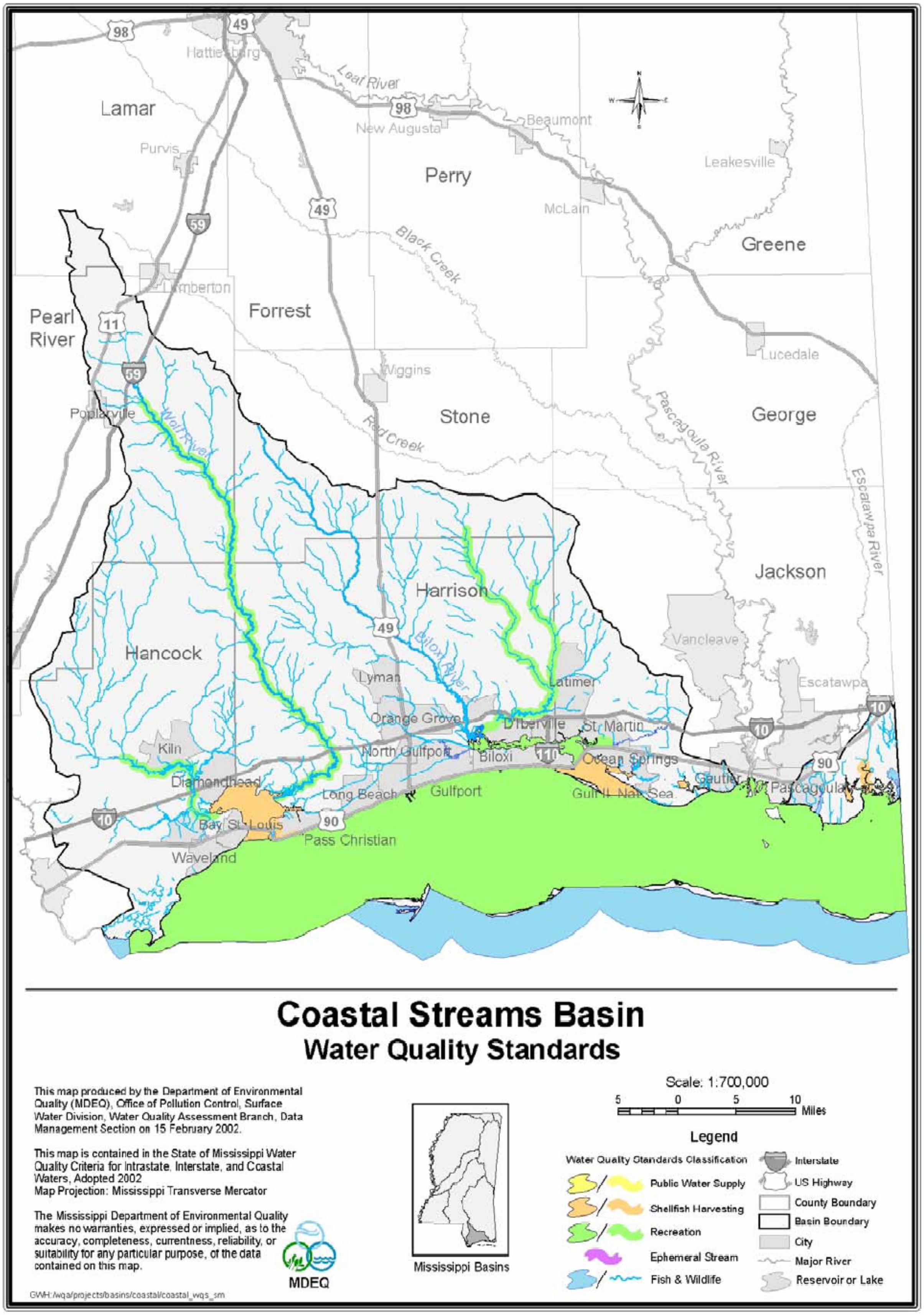
Detailed shellfish harvesting area classification maps for Pensacola and Choctawhatchee Bays can be found on the DACS website.
(http://www.floridaaquaculture.com/SEAS/SEAS_SHAmap.htm)

Appendix B2 – Shellfish Harvesting Waters in Mississippi

Coastal Streams Basin

Waters	From	To	Classification
Back Bay of Biloxi	Popps Ferry Bridge	Biloxi Bay	Recreation
Bangs Lake	Headwaters	Miss. Sound	Shellfish Harvesting
Bayou Cumbest	Headwaters	Miss. Sound	Shellfish Harvesting
Big Lake	Bernard Bayou	Popps Ferry Bridge	Recreation
Biloxi Bay	Headwaters U.S. Hwy 90 Bridge	Miss. Sound	Shellfish Harvesting
Davis Bayou	Headwaters	Biloxi Bay	Shellfish Harvesting
Graveline Bay	Headwaters	Graveline Bayou	Shellfish Harvesting
Graveline Bayou	Graveline Bay	Miss. Sound	Shellfish Harvesting
Jourdan River	Confluence of Bacon Bayou and Catahoula Creek	St. Louis Bay	Recreation
Mallini Bayou	St. Louis Bay	St. Louis Bay	Shellfish Harvesting
Miss. Sound	Contiguous	Miss. Coastline	Recreation
Old Fort Bayou	Bayou Talla	Biloxi Bay	Recreation
Pass Christian Reef-off Henderson Point	Miss. Sound		Shellfish Harvesting
St. Louis Bay	Harrison-Hancock Counties		Shellfish Harvesting
Tchoutacabouffa River	Headwaters	Back Bay of Biloxi	Recreation
Tuxachanie Creek	Headwaters	Tchoutacabouffa River	Recreation
Wolf River	Ms. Hwy. 26	St. Louis Bay	Recreation

Source: Mississippi Commission on Environmental Quality Regulation WPC-2: Water Quality Criteria for Intrastate, Interstate, and Coastal Waters.

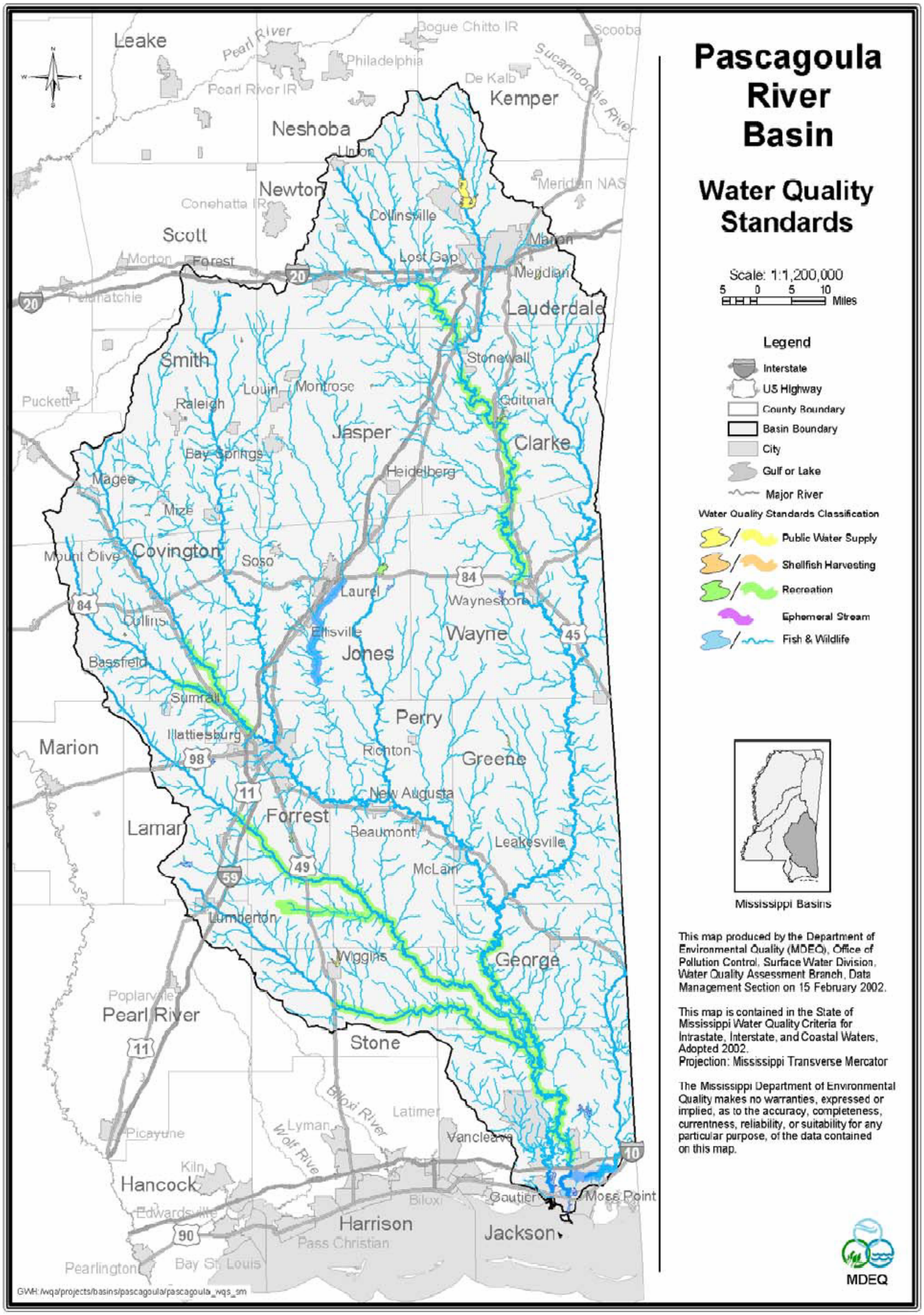

Lamar
Hattiesburg
Leaf River
New Augusta
Beaumont
Leakesville
Perry
McLain
Purvis
Greene
Black Creek
Lumberton
Pearl
River
Forrest
Lucedale
Wiggins
Poplarville
Wolf River
Stone
George
Red Creek
Pascagoula River
Escatawpa River
Jackson
Harrison
Hancock
Vancleave
Biloxi River
Lyman
Latimer
Escatawpa
Orange Grove
D'Iberville
St. Martin
Kiln
North Gulfport
Biloxi
Ocean Springs
Diamondhead
Gautier
Pascagoula
Long Beach
Gulfport
Gulf Hills
Bay St. Louis
Pass Christian
Waveland
Coastal Streams Basin
Water Quality Standards
This map produced by the Department of Environmental Quality (MDEQ), Office of Pollution Control, Surface Water Division, Water Quality Assessment Branch, Data Management Section on 15 February 2002.
This map is contained in the State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters, Adopted 2002
Map Projection: Mississippi Transverse Mercator
The Mississippi Department of Environmental Quality makes no warranties, expressed or implied, as to the accuracy, completeness, currentness, reliability, or suitability for any particular purpose, of the data contained on this map.
MDEQ
Mississippi Basins
Scale: 1:700,000
5 0 5 10 Miles
Legend
Water Quality Standards Classification
Public Water Supply
Shellfish Harvesting
Recreation
Ephemeral Stream
Fish & Wildlife
Interstate
US Highway
County Boundary
Basin Boundary
City
Major River
Reservoir or Lake
GWH:/wqa/projects/basins/coastal/coastal_wqs_sm

Pascagoula River Basin

Waters	From	To	Classification
Archusa Reservoir	Clarke County		Recreation
Beaverdam Creek	Headwaters Perry-Forrest Counties	Black Creek	Recreation
Black Creek	Highway 11	Pascagoula River	Recreation
Bonita Reservoir	Lauderdale County		Public Water Supply
Bowie Creek	Ms. Hwy. 589	Bowie River	Recreation
Bowie River	Bowie Creek	Interstate 59	Recreation
Chickasawhay River	Stonewall Ms.	Hwy. 84	Recreation
Chunky River	U.S. Hwy. 80	Chickasawhay River	Recreation
Clarke State Park	Clarke County		Recreation
Dry Creek Lake Site #3	W/S SCS	Covington County	Recreation
Escatawpa River	Mile 10	Pascagoula River	Fish and Wildlife[1]
Flint Creek Reservoir	Stone County		Public Water Supply & Recreation
Lake Bogue Homa	Jones County		Recreation
Lake Claude Bennett	Jasper County		Recreation
Lake Geiger	Forrest County		Recreation
Lake Marathon	Smith County		Recreation
Lake Mike Conner	Covington County		Recreation
Lake Perry	Perry County		Recreation
Lake Ross Barnett	Smith County		Recreation
Lake Shongela	Smith County		Recreation
Lakeland Park Lake	Wayne County		Recreation
Long Creek Reservoir	Lauderdale County		Public Water Supply
Okatibbee Reservoir	Lauderdale County		Public Water Supply & Recreation
Okatoma Creek	Seminary (MS Hwy 590)	Bowie River	Recreation
Pascagoula River	6 mile. North of MS Hwy 26 George County	Smear Bayou Jackson County	Recreation
Red Creek	U.S. Hwy. 49	Big Black Creek	Recreation
Tallahala Creek	1 mile N. of Hwy.15	Tallahoma Creek	Fish and Wildlife[2]
Turkey Fork Reservoir	Greene County		Recreation

[1] The following DO standard is applicable: The DO shall not be less than 3.0 mg/L.
[2] The following DO standard is applicable: The DO shall not be less than 3.5 mg/L at flows greater than or equal to the 7-day, 10-year low flow.

Source: Mississippi Commission on Environmental Quality Regulation WPC-2: Water Quality Criteria for Intrastate, Interstate, and Coastal Waters.


Pascagoula River Basin
Water Quality Standards
Scale: 1:1,200,000
Miles
Legend
Interstate
US Highway
County Boundary
Basin Boundary
City
Gulf or Lake
Major River
Water Quality Standards Classification
Public Water Supply
Shellfish Harvesting
Recreation
Ephemeral Stream
Fish & Wildlife
Mississippi Basins
This map produced by the Department of Environmental Quality (MDEQ), Office of Pollution Control, Surface Water Division, Water Quality Assessment Branch, Data Management Section on 15 February 2002.
This map is contained in the State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters, Adopted 2002.
Projection: Mississippi Transverse Mercator
The Mississippi Department of Environmental Quality makes no warranties, expressed or implied, as to the accuracy, completeness, currentness, reliability, or suitability for any particular purpose, of the data contained on this map.
MDEQ
Leake
Neshoba
Kemper
Newton
Scott
Lauderdale
Smith
Jasper
Clarke
Covington
Jones
Wayne
Marion
Perry
Greene
Lamar
Forrest
George
Pearl River
Stone
Hancock
Harrison
Jackson
Meridian
Laurel
Hattiesburg
Waynesboro
Wiggins
Lumberton
Leakesville
Moss Point
Gautier
Pascagoula
Pearl River
Biloxi River
Wolf River
GWH:/wqa/projects/basins/pascagoula/pascagoula_wqs_sm

Appendix C – U.S. Geological Survey Documented Wells Located within Gulf Islands National Seashore

Station Name	Latitude	Longitude	HUC	Aquifer Code	Well Depth	Water Quality Begin Date	Water Quality End Date	Water Quality Data Count	Groundwater Begin Date	Groundwater Data End Date	Ground water Data Count
B-8101 NO. 1 EGLIN AFB	30.38881156	-86.5235619	3140105	120NFSG	25.0	1956-06-25	1973-03-19	10	0000-00-00	0000-00-00	0
B-8101 NO. 2 EGLIN AFB	30.38881156	-86.5235619	3140105	120NFSG	25.0	1957-05-23	1965-08-16	6	0000-00-00	0000-00-00	0
B-8201 EGLIN AFB FLA	30.38964485	-86.53022873	3140105	120NFSG	23.0	1957-05-23	1965-07-29	6	0000-00-00	0000-00-00	0
B-8304 EGLIN OFC CLUB 1	30.39325576	-86.55550713	3140105	120NFSG	29.0	1960-08-23	1973-03-18	9	0000-00-00	0000-00-00	0
B-8304 EGLIN OFC CLUB 2	30.39325576	-86.55550713	3140105	120NFSG	28.0	1959-02-01	1971-10-20	5	0000-00-00	0000-00-00	0
B-8552 EGLIN HUR FLD A6	30.39769972	-86.64134255	3140105	120FLRD	880	1959-02-04	1971-10-26	16	0000-00-00	0000-00-00	0
CAROSEL	30.39714429	-86.61606416	3140105	120FLRD	915	1978-07-07	1978-11-28	2	1973-01-01	1978-11-28	3
DOCIE BASS HOT-WATER	30.39881099	-86.59828595	3140105	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
EGLIN AFB HULBURT FLD A5	30.39769992	-86.59495253	3140105	120NFSG	24.0	1960-10-03	1965-07-28	4	0000-00-00	0000-00-00	0
FT.PICKENS PK.GATEHOUSE	30.3257556	-87.18274654	3140105	120NFSG	12.0	1970-10-28	1970-10-28	1	0000-00-00	0000-00-00	0
L0199 HARRISON	30.2127	-89.0842022	03170009	121GRMF	366	0000-00-00	0000-00-00	0	N/A	N/A	2
L0200 HARRISON	30.2127	-89.08448	03170009	121GRMF	530	1976-07-22	1976-07-22	2	7/22/1976	12/19/1985	2
L0662 HARRISON	30.2238111	-89.08198	3170009	121GRMF	380	0000-00-00	0000-00-00	0	1/1/1968	1/1/1968	1
M0001 HARRISON	30.22853389	-88.8958622	3170009	121GRMF	727.	10/12/1965	9/10/1981	4	1965-01-01	1985-12-04	3
M0201 HARRISON	30.21408944	-88.9328078	3170009	121GRMF	770	8/31/1919	7/24/1943	4	1900-01-01	1900-01-01	1

Station Name	Latitude	Longitude	HUC	Aquifer Code	Well Depth	Water Quality Begin Date	Water Quality End Date	Water Quality Data Count	Groundwater Begin Date	Groundwater Data End Date	Ground water Data Count
M0202 HARRISON	30.22797833	-88.8972511	3170009	121GRMF	730	8/31/1919	6/19/1979	7	1901-01-01	1985-12-04	4
M0203 HARRISON	30.24603389	-88.8555833	03170009	121GRMF	867	0000-00-00	0000-00-00	0	1928-03-01	1928-03-01	1
M0204 HARRISON	30.21158944	-88.9714203	3170009	121GRMF	750	1974-03-20	1979-06-19	2	1985-12-04	1985-12-04	1
M0622 HARRISON	30.2118672	-88.9686425	3170009	121GRMF	436.	1977-07-13	1993-07-13	4	1974-04-18	1985-12-04	2
M0792 HARRISON	30.212145	-88.9780872	03170009	121GRMF	480	0000-00-00	0000-00-00	0	1997-05-16	1997-05-16	1
N0073 JACKSON	30.39936556	-88.7939156	03170009	121GRMF	536	1956-06-22	1956-06-22	1	1938-04-08	1990-04-18	74
N0294 JACKSON	30.40936556	-88.7791928	03170009	121GRMF	504	0000-00-00	0000-00-00	0	1970-10-01	1970-10-01	1
N0440 JACKSON	30.3960322	-88.7797483	03170006	122MOCN	546	0000-00-00	0000-00-00	0	1973-04-01	1973-04-01	1
N0454 JACKSON	30.39519889	-88.7889153	03170009	121GRMF	441	0000-00-00	0000-00-00	0	1969-03-01	1969-03-01	1
N0475 JACKSON	30.39186556	-88.7905819	03170009	121GRMF	560	1979-06-08	1979-06-08	1	1978-06-20	1978-06-20	1
N0490 JACKSON	30.39658778	-88.7894708	03170009	121GRMF	560	0000-00-00	0000-00-00	0	1980-12-16	1980-12-16	1
N0686 JACKSON	30.37186583	-88.7836372	03170009	121GRMF	499	0000-00-00	0000-00-00	0	1984-10-23	1984-10-23	1
O0047 JACKSON	30.2529786	-88.718078	03170006	122PCGL	1140	0000-00-00	0000-00-00	0	1984-08-28	1984-08-28	1
O0048 JACKSON	30.25270083	-88.7172447	03170009	122PCGL	810	1944-07-06	1977-07-14	3	1974-06-06	1986-03-07	3
O0049 JACKSON	30.23492306	-88.6866875	03170009	122PCGL	836	1944-07-06	1981-09-10	5	1974-06-06	1986-03-07	3
O0316 JACKSON	30.23464528	-88.6691867	03170009	121GRMF	510	1993-07-13	1993-07-13	1	1991-05-29	1991-05-29	1
O0392 JACKSON	30.2343675	-88.6694644	03170009	122PCGL	835	0000-00-00	0000-00-00	0	1994-12-01	1994-12-01	1

Station Name	Latitude	Longitude	HUC	Aquifer Code	Well Depth	Water Quality Begin Date	Water Quality End Date	Water Quality Data Count	Groundwater Begin Date	Groundwater Data End Date	Ground water Data Count
S.ROSA ISL.AUTHORITY	30.33853325	-87.11413363	3140105	120FLRD	1370	1954-07-31	1954-07-31	1	1954-07-01	1954-07-01	1
SANTA ROSA LIFE BOAT STATION WELL	30.3185334	-87.25524853	3140105	N/A	419	0000-00-00	0000-00-00	0	1949-02-01	1949-02-01	1
USAF EGLIN A15 B12516	30.39186596	-86.80551358	3140105	120FLRD	756	1959-02-02	1979-07-10	11	1966-05-06	1978-07-06	3
USN F.SHRMN TEST WELL 3	30.34769955	-87.30969533	3140105	120NFSG	N/A	1953-05-01	1953-05-08	3	1953-05-01	1953-05-08	3
USN F.SHRMN TEST WELL 4	30.35353272	-87.29636153	3140105	120NFSG	N/A	0000-00-00	0000-00-00	0	1953-05-20	1953-05-20	1
USNAS HOVEY	30.35158832	-87.29636152	3140105	120NFSG	240	1971-09-28	1971-09-28	1	1969-01-01	1969-01-01	1
WAYSIDE PARK	30.39408892	-86.59050798	3140105	120FLRD	696	1968-10-24	1990-05-16	84	1967-01-19	1990-05-16	85

Aquifer Codes
120NFSG = Northwestern Florida Sand-and-Gravel Aquifer,
120FLRD = Floridan Aquifer System
121GRMF = Graham Ferry Formation
122MOCN = Miocene Series
122PCGL = Pascagoula Formation

Appendix D – Total Maximum Daily Loads for the Coastal Rivers and Pascagoula River Basins

TMDLs for Coastal Streams Basin

Waterbody Name	Pollutant of Concern	Final Approval Date
Back Bay & Biloxi Bay	Pathogens	January 17, 2002
Bayou Casotte	Phenol	May 24, 2002
Bayou Cumbast & Bangs Lake	Pathogens	May 5, 2000
Bernard Bayou & Industrial Seaway	Nutrients	June 29, 2001
Bernard Bayou & Industrial Seaway	Phenol	May 24, 2002
Bernard Bayou & Industrial Seaway	Toxicity	October 31, 2003
Biloxi River	Pathogens	December 15, 1999
Jourdan River	Pathogens	December 15, 2000
St. Louis Bay, Jourdan River, & Wolf River	Pathogens	July 2, 2001
Tchoutacabouffa River	Pathogens	December 15, 1999
Tidewater Bayou	Organic Enrichment Toxics	March 28, 2002
Turkey Creek	Pathogens	July 24, 2003
Turkey Creek	pH	December 15, 2000
Tuxachanie Creek	Pathogens	February 23, 2000
Wolf Creek	Pathogens	December 15, 2000

Source: Mississippi Department of Environmental Quality, Contact Steve Goff.

TMDLs for Pascagoula River Basin

Waterbody Name	Pollutant of Concern	Final Approval Date
Black Creek	Pathogens	December 15, 1999
Bouie Creek	Pathogens	December 15, 1999
Chickasawhay River	Pathogens	December 15, 1999
Country Club Lake	PCPs- Dioxins	June 27, 2000
Cypress Creek	Pathogens	October 29, 1999
Escatawpa River	Mercury	June 29, 2000
Leaf River	Pathogens	April 27, 2000
Long Branch	Conductivity	January 12, 2004
Okatibbee Creek	Pathogens	December 15, 1999
Okatoma Creek	Pathogens	December 15, 1999
Pascagoula River	Pathogens	December 15, 1999
Pascagoula River Basin	Pesticides	January 13, 2004
Red Creek	Pathogens	December 15, 1999
Richardson Mill Creek & Potterchitto Creek	Organic Enrichment Ammonia Toxicity	June 29, 2000
Tallahala Creek	Biochemical Oxygen Demand	September 22, 1999
Tallahala Creek	Pathogens	December 15, 1999

Source: Mississippi Department of Environmental Quality, Contact Larry Estes.

Appendix E – 303(d) List of Impaired Waters Located near Gulf Islands National Seashore-FL

County	HUC Name	Water Segment	WBID	Parameters of Concern	Priority	Projected Year of TMDL Development
Escambia	Pensacola Bay	Bayou Garcon	987	DO, Color	High	2006
Escambia	Pensacola Bay	Bayou Grande	740	Coliforms, DO	High	2006
Escambia	Perdido Bay	Direct Runoff to Bay (Big Lagoon)	991	DO	Low	2011
Escambia	Pensacola Bay	Pensacola Bay*	548C	Coliforms	High	2006
Santa Rosa	Pensacola Bay	East River Bay**	701	Coliforms, Turbidity	Low	2011
Santa Rosa	Pensacola Bay	Pensacola Bay	548E	Copper, Lead, BOD, Nutrients, Turbidity, TSS	High	2006
Okaloosa	Choctawhatchee Bay	Choctawhatchee Bay	778A	Fecal Coliform (Shellfish Harvesting)	Medium	2009
Okaloosa	Choctawhatchee Bay	Choctawhatchee Bay	778A	Mercury (in Fish Tissue)	Low	2011
Okaloosa	Choctawhatchee Bay	East Pass	778AB	Mercury (in Fish Tissue)	Low	2011
Okaloosa	Choctawhatchee Bay	Choctawhatchee Bay	778B	Coliforms	High	2004
Okaloosa	Choctawhatchee Bay	Choctawhatchee Bay	778B	Mercury (in Fish Tissue)	Low	2011
Okaloosa	Choctawhatchee Bay	Gulf Island National Seashore	778AC	Mercury (in Fish Tissue)	Low	2011
Okaloosa	Choctawhatchee Bay	Gulf Island National Seashore	778AC	Bacteria	Medium	2009

*Also located in Santa Rosa County.
**Also located in Okaloosa County.

Appendix F – Industrial and domestic National Pollutant Dicharge Elimination System Permittees in Escambia, Santa Rosa, and Okaloosa Counties.

COUNTY	FACILITY ID	Name	Major or Minor Discharge	Facility Type	City	Treatment Process Summary	Permitted Capacity (MGD)	Domestic Wastewater Class
ESCAMBIA	FL0031801	BAYOU MARCUS WATER RECLAMATION FACILITY	MA	Domestic WWTP	PENSACOLA	AWT PRETREATMNT, EQUALIZATION, NITR/DENI, CLARIF, FILTR TO BAYOU MARCUS	8.2	2B
ESCAMBIA	FLG110354	CEMEX - PENSACOLA	MI	Concrete Batch GP	PENSACOLA	monitor deadline 12/15/02		UK
ESCAMBIA	FL0032468	CENTURY, TOWN OF	MI	Domestic WWTP	CENTURY	EXTENDED AERATION W/ EQUALIZATION TANKS, POST AERATION, DECHLORINATION, & EFFLUENT DISCHARGE TO THE ESCAMBIA RIVER	0.45	UK
ESCAMBIA	FL0184624	CLARK/SAND & DIRT ROLLING HILLS PIT	MI	Industrial Wastewater	PENSACOLA	Sand & Dirt responsible for discharge limits/monitoring		UK
ESCAMBIA	FLG830419	ESCAMBIA COUNTY SHERIFFS DEPT	MI	Petroleum Cleanup GP (long term)	PENSACOLA			UK
ESCAMBIA	FLG911515	GROCERY SUPPLY COMPANY	MI	Petroleum Cleanup GP (long term)	PENSACOLA			
ESCAMBIA	FL0002275	GULF POWER CRIST STEAM	MA	Industrial Wastewater	PENSACOLA	WASTEWATER FROM COOLING TOWER & BOILER BLOWDOWN, AIR PREHEATER WASH, BOTTOM ASH SLUICE & OTHER MINOT PROCESS STREAMS ARE DISCHARGED INTO THE ESCAMBIA RIVER AFTER PRETREATMENT IN A ASH POND. CONDENSER COOLING WATER & COAL PILE SUMP OVERFLOWS ARE DISCHARGED DIRECTLY INTO THE RIVER.		UK
ESCAMBIA	FLG911000	HAPPY STORE #521	MI	Petroleum Cleanup GP (long term)	CANTONMENT			UK
ESCAMBIA	FL0002526	INTERNATIONAL PAPER COMPANY	MA	Industrial Wastewater	CANTONMENT	Primary settling basin, nutrient feed system and series of aeration ponds. Discharge is to Eleven Mile Creek.		UK
ESCAMBIA	FLG911464	JORDANS EXXON	MI	Petroleum Cleanup GP (long term)	CENTURY			

COUNTY	FACILITY ID	Name	Major or Minor Discharge	Facility Type	City	Treatment Process Summary	Permitted Capacity (MGD)	Domestic Wastewater Class
ESCAMBIA	FL0021440	MAIN STREET A WWT STP	MA	Domestic WWTP	PENSACOLA	AWT PURE OXYGEN ACTIVATED SLUDGE WWTF, W/ MECHANICAL CLEANED BAR SCREENS, AERATED GRIT CHAMBER, ALUM ADDITION FOR PHOS. REMOVAL, PRIMARY CLARIFICATION, LIME ADDITION, NITRIFICATION & BIOL. DENITRIF., POLYMER ADDITION, FINAL CLARIFICATION, CHLOR/DECHLOR & DISCHARGE TO PENSACOLA BAY	20	2A
ESCAMBIA	FL0038318	NITROUS OXIDE CORP	MI	Industrial Wastewater	CANTONMENT	collection, neutralization and discharge.	0.0006	UK
ESCAMBIA	FL0024007	PENSACOLA BEACH WWTP	MA	Domestic WWTP	PENSACOLA BEACH	AS	2.4	2B
ESCAMBIA	FLG110343	PENSACOLA READY MIX - PORTOFINO	MI	Concrete Batch GP	PENSACOLA BEACH	no Type II system		UK
ESCAMBIA	FLG110453	PENSACOLA READY MIX - SORRENTO RD	MI	Concrete Batch GP	PENSACOLA	Series of concrete sedimentation basins for recycling	0.216	UK
ESCAMBIA	FLG110432	PENSACOLA READY MIX - US HWY 29	MI	Concrete Batch GP	PENSACOLA			UK
ESCAMBIA	FLG110289	RINKER MATERIALS - PENSACOLA	MI	Concrete Batch GP	PENSACOLA			UK
ESCAMBIA	FL0002488	SOLUTIA INC	MA	Industrial Wastewater	GONZALEZ	17 acre holding pond,	27	UK
ESCAMBIA	FLG910249	SOUTHERN PIT STOP	MI	Petroleum Cleanup GP (long term)	CENTURY			UK
ESCAMBIA	FL0296643	TEST	MA	Industrial Wastewater	PPP			
ESCAMBIA	FL0044377	US EPA LABORATORY - SABINE ISLAND	MI	Industrial Wastewater	GULF BREEZE	flow through of non-contaminated fish tank water		UK
ESCAMBIA	FL0002500	US NAVAL AIR STATION PENSACOLA	MA	Domestic WWTP	PENSACOLA	ACTIVATED SLUDGE WITH PRETREATMENT, FILTRATION W/ DENITRIFICATION, DECHLORIN - COMBINED INDUSTRIAL & DOMESTIC WASTEWATER TREATMNT TO PENSACOLA BAY	2.35	UK

COUNTY	FACILITY ID	Name	Major or Minor Discharge	Facility Type	City	Treatment Process Summary	Permitted Capacity (MGD)	Domestic Wastewater Class
OKALOOSA	FLG110441	CEMEX - CRESTVIEW	MI	Concrete Batch GP	CRESTVIEW	monitor deadline 12/15/02		UK
OKALOOSA	FLG110357	CEMEX - DESTIN	MI	Concrete Batch GP	DESTIN	COLLECTION,SEDIMENTATION WITH OVERLAND FLOW THROUGH GRASSY SWALE TO PERC POND		UK
OKALOOSA	FLG110382	CEMEX - FT WALTON BEACH	MI	Concrete Batch GP	FT WALTON BEACH			UK
OKALOOSA	FLG110582	COUCH READY MIX - FT WALTON BEACH	MI	Concrete Batch GP	FT WALTON BEACH			
OKALOOSA	FLG110434	FORT WALTON CONCRETE - CRESTVIEW	MI	Concrete Batch GP	CRESTVIEW	offset deadline 06/07/00		UK
OKALOOSA	FLG110435	FORT WALTON CONCRETE - FT WALTON BEACH	MI	Concrete Batch GP	FORT WALTON BEACH	offset deadline 06/07/00		UK
OKALOOSA	FLG110436	FORT WALTON CONCRETE - VALPARAISO	MI	Concrete Batch GP	VALPARAISO	offset deadline 06/07/00		UK
OKALOOSA	FL0003174	HURLBURT FIELD AIR FORCE BASE	MA	Domestic WWTP	HURLBURT FIELD	ADVANCED WWTF W/ DISCHARGE TO A 700-ACRE RECEIVING WETLAND	1	UK
OKALOOSA	FLG110035	RINKER MATERIALS - CRESTVIEW	MI	Concrete Batch GP	CRESTVIEW			UK
OKALOOSA	FLG110442	RINKER MATERIALS - FT WALTON BEACH	MI	Concrete Batch GP	FT WALTON BEACH	monitor deadline 12/22/02		UK
SANTA ROSA	FL0002313	AIR PRODUCTS & CHEMICALS INC	MA	Industrial Wastewater	PACE	EXTENDED AERATION, NEUTRALIZATION, ANAEROBIC TREATMENT, AND BIO-OXIDATION PONDS. PONDS DISCHARGE TO ESCAMBIA BAY.		UK
SANTA ROSA	FLG110376	CEMEX - NAVARRE	MI	Concrete Batch GP	NAVARRE	monitor deadline 12/15/02		UK
SANTA ROSA	FLG911201	DOUBLE G #1	MI	Petroleum Cleanup GP (long term)	NAVARRE			UK

COUNTY	FACILITY ID	Name	Major or Minor Discharge	Facility Type	City	Treatment Process Summary	Permitted Capacity (MGD)	Domestic Wastewater Class
SANTA ROSA	FL0021903	MILTON, CITY OF (STP)	MA	Domestic WWTP	MILTON	OXIDATION DITCH/AERATION BASIN W/ DISCHARGE TO BLACKWATER RIVER TO BLACKWATER BAY TO EAST BAY	2.5	3B
SANTA ROSA	FLG911452	NAVARRE BEACH CABINS	MI	Petroleum Cleanup GP (long term)	NAVARRE			
SANTA ROSA	FL0023981	NAVARRE BEACH STP	MI	Domestic WWTP	NAVARRE BEACH	OXIDATION DITCH W/ FLOW EQUALIZATION, TERTIARY FILTERS, CHLORINATION, DECHLORINATION, & DISCHARGE TO CLASS III ZONE OF SANTA ROSA SOUND	0.9	3C
SANTA ROSA	FLG830355	NUGGET STORE #33	MI	Petroleum Cleanup GP (long term)	PEA RIDGE/MILTON			UK
SANTA ROSA	FL0102202	PACE WATER SYSTEM, INC WWTP #1	MA	Domestic WWTP	PACE	OXIDATION DITCHES (NIT-DENIT), CLARIFICATION, FILTRATION, W/ SLOW RATE SPRAYFIELD IRRIGATION (0.45 MGD) AND 504,000 GAL. REJECT POND.	1	UK
SANTA ROSA	FLG110227	PENSACOLA READY MIX - MIDWAY	MI	Concrete Batch GP	GULF BREEZE	generic permit for concrete batch plants		UK
SANTA ROSA	FLG110002	PENSACOLA READY MIX - MILTON	MI	Concrete Batch GP	MILTON	COVERED UNDER A GENERIC PERMIT FOR DISCHARGES FROM CONCRETE BATCH PLANTS.		UK
SANTA ROSA	FLG110445	RINKER MATERIALS - MILTON	MI	Concrete Batch GP	MILTON	monitor deadline 12/22/02		UK
SANTA ROSA	FL0002593	STERLING FIBERS, INC	MA	Industrial Wastewater	PACE	BIOLOGICAL OXIDATION,OXIDATION/POLISHING POND,CHLORINATION,DEEP WELL INJECTION. DISCHG TO ESCAMBIA BAY & SPRAY IRRIGATION.		UK
SANTA ROSA	FLG110210	WPR, INC	MI	Concrete Batch GP	MILTON			UK

Appendix G – National Pollutant Dischage Elimination System Permittees in Biloxi, D'Iberville, Keesler Air Force Base (AFB), and Ocean Springs from Permit Compliance System (PCS).

NPDES	NAME	CITY	COUNTY	PERMIT ISSUE DATE	PERMIT EXPIRED DATE	RECEIVING WATERS	FLOW (MGD)
MS0040169	APPLE VALLEY TRAILER PARK	BILOXI	HARRISON	22-Oct-99	30-Sep-04	TRIBUTARY OF BILOXI RIVER	0.012
MS0040169	APPLE VALLEY TRAILER PARK	BILOXI	HARRISON	22-Oct-99	30-Sep-04	TRIBUTARY OF BILOXI RIVER	0.012
MS0036854	BUDS MOBILE HOMES INC	BILOXI	HARRISON	13-May-04	30-Apr-09	COASTAL STREAMS BASIN	0.02
MS0036854	BUDS MOBILE HOMES INC	BILOXI	HARRISON	13-May-04	30-Apr-09	COASTAL STREAMS BASIN	0.02
MS0037028	C J DAVIS SLAUGHTERHOUSE INC	BILOXI	HARRISON	22-Dec-00	30-Nov-05	HOWARD CREEK	0.002
MS0037028	C J DAVIS SLAUGHTERHOUSE INC	BILOXI	HARRISON	22-Dec-00	30-Nov-05	HOWARD CREEK	0.002
MS0037028	C J DAVIS SLAUGHTERHOUSE INC	BILOXI	HARRISON	22-Dec-00	30-Nov-05	HOWARD CREEK	0.002
MSU097191	CAL REALTY GROUP	BILOXI	HARRISON	23-Jun-04	31-May-09	NO DISCHARGE	0
MSU097191	CAL REALTY GROUP	BILOXI	HARRISON	23-Jun-04	31-May-09	NO DISCHARGE	0
MS0058378	CAR WASHES OF AMERICA	BILOXI	HARRISON	7-Oct-02	30-Sep-07	UNNAMED DITCH THENCE TURKEY CREEK	0.009
MS0058378	CAR WASHES OF AMERICA	BILOXI	HARRISON	7-Oct-02	30-Sep-07	UNNAMED DITCH THENCE TURKEY CREEK	0.009

NPDES	NAME	CITY	COUNTY	PERMIT ISSUE DATE	PERMIT EXPIRED DATE	RECEIVING WATERS	FLOW (MGD)
MS0058378	CAR WASHES OF AMERICA	BILOXI	HARRISON	7-Oct-02	30-Sep-07	UNNAMED DITCH THENCE TURKEY CREEK	0.009
MSU000108	CATES MOBILE HOME PARK	BILOXI	HARRISON	3-Jul-01	31-Mar-06		0.009
MSU000108	CATES MOBILE HOME PARK	BILOXI	HARRISON	3-Jul-01	31-Mar-06		0.009
MSG110068	COAST MATERIALS COMPANY INC	BILOXI	HARRISON	10-May-04	30-Apr-09	UNNAMED DITCH/BILOXI BAY	0.001
MSG110068	COAST MATERIALS COMPANY INC	BILOXI	HARRISON	10-May-04	30-Apr-09	UNNAMED DITCH/BILOXI BAY	0.001
MSU098130	COMSTOCK GROCERY & DELI	BILOXI	HARRISON	6-Aug-98	31-Jul-03		0.0017
MSU098130	COMSTOCK GROCERY & DELI	BILOXI	HARRISON	6-Aug-98	31-Jul-03		0.0017
MS0042218	COUNTRY LIVING MOBILE HOME PRK	BILOXI	HARRISON	10-Jul-00	30-Apr-05	HOWARD CREEK	0.023
MS0042218	COUNTRY LIVING MOBILE HOME PRK	BILOXI	HARRISON	10-Jul-00	30-Apr-05	HOWARD CREEK	0.023
MS0045004	CUSTOM PACK INC	BILOXI	HARRISON	27-May-04	30-Apr-09	BACK BAY OF BILOXI	0.063
MS0045004	CUSTOM PACK INC	BILOXI	HARRISON	27-May-04	30-Apr-09	BACK BAY OF BILOXI	0.063
MS0045004	CUSTOM PACK INC	BILOXI	HARRISON	27-May-04	30-Apr-09	BACK BAY OF BILOXI	0.063
MS0052400	DAVID GOLLOT SEAFOOD INC	BILOXI	HARRISON	28-Sep-01	31-Aug-06	BACK BAY OF BILOXI	0.081
MS0052400	DAVID GOLLOT SEAFOOD INC	BILOXI	HARRISON	28-Sep-01	31-Aug-06	BACK BAY OF BILOXI	0.081
MS0052400	DAVID GOLLOT SEAFOOD INC	BILOXI	HARRISON	28-Sep-01	31-Aug-06	BACK BAY OF BILOXI	0.081
MS0053252	DENNIS STIEFFLE RV PARK	BILOXI	HARRISON				
MS0053252	DENNIS STIEFFLE RV PARK	BILOXI	HARRISON				
MS0039250	DESTINATION RV PARK	BILOXI	HARRISON	20-Jul-99	30-Jun-04	TUXACHANIE CREEK	0.003

NPDES	NAME	CITY	COUNTY	PERMIT ISSUE DATE	PERMIT EXPIRED DATE	RECEIVING WATERS	FLOW (MGD)
MS0039250	DESTINATION RV PARK	BILOXI	HARRISON	20-Jul-99	30-Jun-04	TUXACHANIE CREEK	0.003
MS0040142	GOLDEN GULF COAST PACKING CO	BILOXI	HARRISON	15-Apr-04	31-Mar-09	BACK BAY OF BILOXI	0.134
MS0040142	GOLDEN GULF COAST PACKING CO	BILOXI	HARRISON	15-Apr-04	31-Mar-09	BACK BAY OF BILOXI	0.134
MS0040142	GOLDEN GULF COAST PACKING CO	BILOXI	HARRISON	15-Apr-04	31-Mar-09	BACK BAY OF BILOXI	0.134
MS0047597	GOLLOTT BROTHERS SEAFOOD CO	BILOXI	HARRISON	18-Dec-01	30-Nov-06	BACK BAY OF BILOXI	0.069
MS0047597	GOLLOTT BROTHERS SEAFOOD CO	BILOXI	HARRISON	18-Dec-01	30-Nov-06	BACK BAY OF BILOXI	0.069
MS0047597	GOLLOTT BROTHERS SEAFOOD CO	BILOXI	HARRISON	18-Dec-01	30-Nov-06	BACK BAY OF BILOXI	0.069
MSG110063	GULF CONCRETE COMPANY	BILOXI	HARRISON	18-May-04	1-Apr-09	HOWARD CREEK	0
MSG110063	GULF CONCRETE COMPANY	BILOXI	HARRISON	18-May-04	1-Apr-09	HOWARD CREEK	0
MSG110087	GULF CONCRETE LLC	BILOXI	HARRISON	18-May-04	1-Apr-09	TRIBUTARY OF BILOXI BAY	0
MSG110087	GULF CONCRETE LLC	BILOXI	HARRISON	18-May-04	1-Apr-09	TRIBUTARY OF BILOXI BAY	0
MS0039276	GULF PRIDE ENTERPRISES INC	BILOXI	HARRISON	2-Jun-04	31-May-09	BACK BAY OF BILOXI	0.062
MS0039276	GULF PRIDE ENTERPRISES INC	BILOXI	HARRISON	2-Jun-04	31-May-09	BACK BAY OF BILOXI	0.062
MS0039276	GULF PRIDE ENTERPRISES INC	BILOXI	HARRISON	2-Jun-04	31-May-09	BACK BAY OF BILOXI	0.062
MSG110181	GULF STATES READY MIX PLANT 15	BILOXI	HARRISON	1-Apr-04	30-Apr-09	BY PIPE INTO TCHOUTACABOUFFA RIVER	0
MSG110181	GULF STATES READY MIX PLANT 15	BILOXI	HARRISON	1-Apr-04	30-Apr-09	BY PIPE INTO TCHOUTACABOUFFA RIVER	0

NPDES	NAME	CITY	COUNTY	PERMIT ISSUE DATE	PERMIT EXPIRED DATE	RECEIVING WATERS	FLOW (MGD)
MS0050938	GUTIERREZ RV PARK	BILOXI	HARRISON	10-Jul-00	30-Apr-05	HOWARD CREEK	0.0227
MS0050938	GUTIERREZ RV PARK	BILOXI	HARRISON	10-Jul-00	30-Apr-05	HOWARD CREEK	0.0227
MS0030333	HC/WEST BILOXI POTW	BILOXI	HARRISON	9-Jan-03	31-Dec-07	BACK BAY OF BILOXI	11.7
MS0030333	HC/WEST BILOXI POTW	BILOXI	HARRISON	9-Jan-03	31-Dec-07	BACK BAY OF BILOXI	11.7
MSU096136	HONEY DIPPER OF BILOXI CORP	BILOXI	HARRISON	24-May-04	30-Apr-09	EX CEM	0
MSU096136	HONEY DIPPER OF BILOXI CORP	BILOXI	HARRISON	24-May-04	30-Apr-09	NO DISCHARGE	0
MS0052230	JIG'S FISH CAMP	BILOXI	HARRISON	22-Apr-04	31-Mar-09	BILOXI RIVER	0.0005
MS0052230	JIG'S FISH CAMP	BILOXI	HARRISON	22-Apr-04	31-Mar-09	BILOXI RIVER	0.0005
MSG110174	LAFARGE BLDG MATERIALS INC BI	BILOXI	HARRISON	1-Apr-04	1-Apr-09	UNNAMED DITCH TO BILOXI BAY	0
MSG110174	LAFARGE BLDG MATERIALS INC BI	BILOXI	HARRISON	1-Apr-04	1-Apr-09	UNNAMED DITCH TO BILOXI BAY	0
MS0044466	M & M SHRIMP COMPANY INC	BILOXI	HARRISON	28-Sep-01	31-Aug-06	BACK BAY OF BILOXI	0.044
MS0044466	M & M SHRIMP COMPANY INC	BILOXI	HARRISON	28-Sep-01	31-Aug-06	BACK BAY OF BILOXI	0.044
MS0044466	M & M SHRIMP COMPANY INC	BILOXI	HARRISON	28-Sep-01	31-Aug-06	BACK BAY OF BILOXI	0.044
MS0039594	MAZALEA TRAVEL PARK	BILOXI	HARRISON	27-Jul-04	30-Jun-09	TCHOUTACABOUFFA RIVER	0.016
MS0039594	MAZALEA TRAVEL PARK	BILOXI	HARRISON	27-Jul-04	30-Jun-09	TCHOUTACABOUFFA RIVER	0.016
MSG110153	METRO CONCRETE LLC	BILOXI	HARRISON	3-May-04	1-Apr-09	BY PIPE INTO TUXACHANIE CREEK	0
MSG110153	METRO CONCRETE LLC	BILOXI	HARRISON	3-May-04	1-Apr-09	BY PIPE INTO TUXACHANIE CREEK	0

NPDES	NAME	CITY	COUNTY	PERMIT ISSUE DATE	PERMIT EXPIRED DATE	RECEIVING WATERS	FLOW (MGD)
MS0045772	MUNRO TERMINAL INC	BILOXI	HARRISON	18-Apr-03	31-Mar-08	BACK BAY OF BILOXI	0.073
MS0045772	MUNRO TERMINAL INC	BILOXI	HARRISON	18-Apr-03	31-Mar-08	BACK BAY OF BILOXI	0.073
MS0047520	OLE BILOXI SEAFOOD CO	BILOXI	HARRISON	7-Dec-01	30-Nov-06	BACK BAY OF BILOXI	0.226
MS0047520	OLE BILOXI SEAFOOD CO	BILOXI	HARRISON	7-Dec-01	30-Nov-06	BACK BAY OF BILOXI	0.226
MS0047520	OLE BILOXI SEAFOOD CO	BILOXI	HARRISON	7-Dec-01	30-Nov-06	BACK BAY OF BILOXI	0.226
MS0047201	PANTRY INC	BILOXI	HARRISON	14-Apr-03	31-Mar-08	BACK BAY OF BILOXI	0.001
MS0047201	PANTRY INC	BILOXI	HARRISON	14-Apr-03	31-Mar-08	BACK BAY OF BILOXI	0.001
MS0047201	PANTRY INC	BILOXI	HARRISON	14-Apr-03	31-Mar-08	BACK BAY OF BILOXI	0.001
MS0052159	PARKER'S LANDING RV PARK ALT	BILOXI	HARRISON	25-Aug-03	31-Jul-08	TCHOUTABUFFA RIVER	0.012
MS0052159	PARKER'S LANDING RV PARK ALT	BILOXI	HARRISON	25-Aug-03	31-Jul-08	TCHOUTABUFFA RIVER	0.012
MS0001589	R A FAYARD SEAFOOD COMPANY INC	BILOXI	HARRISON	15-Sep-00	30-Aug-05	BACK BAY OF BILOXI	0.099
MS0001589	R A FAYARD SEAFOOD COMPANY INC	BILOXI	HARRISON	15-Sep-00	30-Aug-05	BACK BAY OF BILOXI	0.099
MS0001589	R A FAYARD SEAFOOD COMPANY INC	BILOXI	HARRISON	15-Sep-00	30-Aug-05	BACK BAY OF BILOXI	0.099
MS0037656	R A LESSO SEAFOOD COMPANY INC	BILOXI	HARRISON	28-Sep-01	31-Aug-06	BACK BAY OF BILOXI	0.007
MS0037656	R A LESSO SEAFOOD COMPANY INC	BILOXI	HARRISON	28-Sep-01	31-Aug-06	BACK BAY OF BILOXI	0.007
MS0037656	R A LESSO SEAFOOD COMPANY INC	BILOXI	HARRISON	28-Sep-01	31-Aug-06	BACK BAY OF BILOXI	0.007
MSU000151	SACRED GROUNDS LLC	BILOXI	HARRISON	28-Jan-02	30-Nov-06	NO DISCHARGE	0.002
MS0036315	SEYMOUR & SONS SEAFOOD INC	BILOXI	HARRISON	28-Sep-01	31-Aug-06	BACK BAY OF BILOXI	0.042

NPDES	NAME	CITY	COUNTY	PERMIT ISSUE DATE	PERMIT EXPIRED DATE	RECEIVING WATERS	FLOW (MGD)
MS0036315	SEYMOUR & SONS SEAFOOD INC	BILOXI	HARRISON	28-Sep-01	31-Aug-06	BACK BAY OF BILOXI	0.042
MS0036315	SEYMOUR & SONS SEAFOOD INC	BILOXI	HARRISON	28-Sep-01	31-Aug-06	BACK BAY OF BILOXI	0.042
MSU099025	SHELL QUICK STOP	BILOXI	HARRISON	4-Mar-99	28-Feb-04		0.001
MSU099025	SHELL QUICK STOP	BILOXI	HARRISON	4-Mar-99	28-Feb-04		0.001
MSU010018	SOUTHERN HERITAGE PERSONEL CAR	BILOXI	HARRISON	25-Jan-02	31-Dec-06	NO DISCHARGE	0.001
MSU010018	SOUTHERN HERITAGE PERSONEL CAR	BILOXI	HARRISON	25-Jan-02	31-Dec-06	NO DISCHARGE	0.001
MS0054356	SUNNY OAKS MOBILE HOME PARK	BILOXI	HARRISON	10-Mar-98	28-Feb-03	TRIBUTARY OF TCHOUTACABOUFFA RIVER	0.009
MS0054356	SUNNY OAKS MOBILE HOME PARK	BILOXI	HARRISON	10-Mar-98	28-Feb-03	TRIBUTARY OF TCHOUTACABOUFFA RIVER	0.009
MSG110194	TINDALL CORP	BILOXI	HARRISON	31-Aug-04	1-Apr-09	BY PIPE INTO BACK BAY OF BILOXI	0
MSG110194	TINDALL CORP	BILOXI	HARRISON	31-Aug-04	1-Apr-09	BY PIPE INTO BACK BAY OF BILOXI	0
MSU099084	TRUCK STOP @ CEDAR LAKE & I-10	BILOXI	HARRISON	8-Jun-99	31-May-04		0.007
MSU099084	TRUCK STOP @ CEDAR LAKE & I-10	BILOXI	HARRISON	8-Jun-99	31-May-04		0.007
MSG120059	W L BURLE ENGINEERS PA	BILOXI	HARRISON	25-Mar-04	31-Mar-06	UNNAMED TRIBUTARY OF BILOXI RIVER	0.02
MSG120059	W L BURLE ENGINEERS PA	BILOXI	HARRISON	25-Mar-04	31-Mar-06	UNNAMED TRIBUTARY OF BILOXI RIVER	0.02

NPDES	NAME	CITY	COUNTY	PERMIT ISSUE DATE	PERMIT EXPIRED DATE	RECEIVING WATERS	FLOW (MGD)
MS0001759	WEEMS BROTHERS SEAFOOD	BILOXI	HARRISON	28-Sep-01	31-Aug-06	BACK BAY OF BILOXI	0.001
MS0001759	WEEMS BROTHERS SEAFOOD	BILOXI	HARRISON	28-Sep-01	31-Aug-06	BACK BAY OF BILOXI	0.001
MS0001759	WEEMS BROTHERS SEAFOOD	BILOXI	HARRISON	28-Sep-01	31-Aug-06	BACK BAY OF BILOXI	0.001
MSU096105	WOOLMARKET BAPTIST CHURCH	BILOXI	HARRISON	16-Jun-04	31-May-09	NO DISCHARGE	0
MSU096105	WOOLMARKET BAPTIST CHURCH	BILOXI	HARRISON	16-Jun-04	31-May-09	NO DISCHARGE	0
MS0002861	C F GOLLOTT & SON SEAFOOD CO	D'IBERUILLE	HARRISON	29-Nov-99	31-Oct-04	BACK BAY OF BILOXI	0.059
MS0002861	C F GOLLOTT & SON SEAFOOD CO	D'IBERUILLE	HARRISON	29-Nov-99	31-Oct-04	BACK BAY OF BILOXI	0.059
MS0002861	C F GOLLOTT & SON SEAFOOD CO	D'IBERUILLE	HARRISON	29-Nov-99	31-Oct-04	BACK BAY OF BILOXI	0.059
MS0001562	R FOURNIER & SONS SEAFOOD INC	D'IBERUILLE	HARRISON	15-Sep-00	30-Aug-05	BACK BAY OF BILOXI	0.01
MS0001562	R FOURNIER & SONS SEAFOOD INC	D'IBERUILLE	HARRISON	15-Sep-00	30-Aug-05	BACK BAY OF BILOXI	0.01
MS0001562	R FOURNIER & SONS SEAFOOD INC	D'IBERUILLE	HARRISON	15-Sep-00	30-Aug-05	BACK BAY OF BILOXI	0.01
MS0034410	U-WASH-M CARWASH	D'IBERUILLE	HARRISON	17-Jul-03	30-Jun-08	TRIB THENCE ST MARTIN BAYOU	0.001
MS0034410	U-WASH-M CARWASH	D'IBERUILLE	HARRISON	17-Jul-03	30-Jun-08	TRIB THENCE ST MARTIN BAYOU	0.001
MS0034410	U-WASH-M CARWASH	D'IBERUILLE	HARRISON	17-Jul-03	30-Jun-08	TRIB THENCE ST MARTIN BAYOU	0.001
MS0059234	KEESLER AIR FORCE BASE	HARRISON COUNTY	HARRISON	1-Jun-04	31-May-06	BACK BAY OF BILOXI	1.728
MS0059234	KEESLER AIR FORCE BASE	HARRISON COUNTY	HARRISON	1-Jun-04	31-May-06	BACK BAY OF BILOXI	1.728

NPDES	NAME	CITY	COUNTY	PERMIT ISSUE DATE	PERMIT EXPIRED DATE	RECEIVING WATERS	FLOW (MGD)
MS0045926	AQUACULTURE CORP OF AMERICA	OCEAN SPRINGS	JACKSON	16-Sep-02	31-Aug-07	SIMMONS BAYOU	0.5
MSP090507	GULF COAST RESEARCH LABORATORY	OCEAN SPRINGS	JACKSON	11-Apr-03	31-Mar-08	MS0045446 - GC/WEST JACKSON POTW	0.009
MSP090507	GULF COAST RESEARCH LABORATORY	OCEAN SPRINGS	JACKSON	11-Apr-03	31-Mar-08	MS0045446 - GC/WEST JACKSON POTW	0.009
MSG110104	GULF CONCRETE - OCEAN SPRINGS	OCEAN SPRINGS	JACKSON	18-May-04	1-Apr-09	OLD FORK BAYOU	0
MSG110104	GULF CONCRETE - OCEAN SPRINGS	OCEAN SPRINGS	JACKSON	18-May-04	1-Apr-09	OLD FORK BAYOU	0
MSG120047	HAZCLEAN ENVIRONMENTAL CONSULT	OCEAN SPRINGS	JACKSON	7-May-03	31-Mar-06	MS0045446 - GC/WEST JACKSON CO	0.02
MSG120047	HAZCLEAN ENVIRONMENTAL CONSULT	OCEAN SPRINGS	JACKSON	7-May-03	31-Mar-06	MS0045446 - GC/WEST JACKSON CO	0.02
MSU097022	HOUSTON ESTATE UTILITIES	OCEAN SPRINGS	JACKSON	3-Dec-02	30-Nov-05	NO DISCHARGE	0.073
MSU097022	HOUSTON ESTATE UTILITIES	OCEAN SPRINGS	JACKSON	3-Dec-02	30-Nov-05	NO DISCHARGE	0.073
MS0041629	KOA KAMPGROUND	OCEAN SPRINGS	JACKSON	17-Sep-99	31-Aug-04	OLD FORT BAYOU	0.008
MS0041629	KOA KAMPGROUND	OCEAN SPRINGS	JACKSON	17-Sep-99	31-Aug-04	OLD FORT BAYOU	0.008
MSG110040	METRO CONCRETE	OCEAN SPRINGS	JACKSON	7-May-04	1-Apr-09	BY PIPE INTO DAVIS BAYOU	0
MSG110040	METRO CONCRETE	OCEAN SPRINGS	JACKSON	7-May-04	1-Apr-09	BY PIPE INTO DAVIS BAYOU	0
MSU085050	MISSISSIPPI GULF COAST REGIONA	OCEAN SPRINGS	JACKSON	23-Oct-02	30-Sep-07	NO DISCHARGE	0
MSU085050	MISSISSIPPI GULF COAST REGIONA	OCEAN SPRINGS	JACKSON	23-Oct-02	30-Sep-07	NO DISCHARGE	0

NPDES	NAME	CITY	COUNTY	PERMIT ISSUE DATE	PERMIT EXPIRED DATE	RECEIVING WATERS	FLOW (MGD)
MS0037001	OCEAN SPRINGS SEAFOOD CO INC	OCEAN SPRINGS	JACKSON	28-Sep-01	31-Aug-06	BACK BAY OF BILOXI	0.042
MS0037001	OCEAN SPRINGS SEAFOOD CO INC	OCEAN SPRINGS	JACKSON	28-Sep-01	31-Aug-06	BACK BAY OF BILOXI	0.042
MS0037001	OCEAN SPRINGS SEAFOOD CO INC	OCEAN SPRINGS	JACKSON	28-Sep-01	31-Aug-06	BACK BAY OF BILOXI	0.042

Source: http://www.epa.gov/Region4/r4data/pcs/index.htm

Appendix H – Compliance History of Major National Pollutant Discharge Elimination System Dischargers in Escambia, Santa Rosa, and Okaloosa Counties, FL

Facility ID	Facility Name	Database	Inspections (3yrs)	Qtrs Alleged Non Compliance (3yrs)	Alleged Current Significant Violations	Informal Enforcement Actions (3yrs)	Formal Enforcement Actions (3yrs)	Federally required to be reported to EPA
1211300004	AIR PRODUCTS & CHEMICALS INCORPORATED	AFS	3		no		1	yes
FLR05B114		PCS	1	n/a	n/a	i*	i	no
FL0002313		PCS	6	2	no		i	yes
FLD008155673		RCR	3		no		i	yes
FLL031801	BAYOU MARCUS WATER RECLAMATION	PCS		n/a	n/a	i	i	no
FL0031801		PCS	5	5	no		i	yes
1203300067	ESCAMBIA COUNTY UTILITIES AUTHORITY	AFS		9	no		i	yes
04-2004-4515		ICI			no		1	yes
FLL021440		PCS		n/a	n/a	i	i	no
FL0021440		PCS	12	11	no	1	3	yes
FLD984171298		RCR	1	2	no	2	1	yes
1203300045	GULF POWER GEN WAREHOUSE FAC	AFS	3	12	yes		i	yes
FLR05C161		PCS		n/a	n/a	i	i	no
FL0002275		PCS	6	2	yes		i	yes
FLD006923429		RCR			no		i	yes
1203300042	INTERNATIONAL PAPER COMPANY	AFS	2		no		i	yes
FL0002526		PCS	4	12	no		i	yes
FLD008166639		RCR			no		i	yes
FLD982122681		RCR			no		i	yes

Facility ID	Facility Name	Database	Inspections (3yrs)	Qtrs Alleged Non Compliance (3yrs)	Alleged Current Significant Violations	Informal Enforcement Actions (3yrs)	Formal Enforcement Actions (3yrs)	Federally required to be reported to EPA
FLL021903	MILTON, CITY OF (STP)	PCS		n/a	n/a	i	i	no
FL0021903		PCS	7	2	no		i	yes
1203300082	NAVAL AIR STATION PENSACOLA	AFS	2		no		i	yes
1203300084		AFS			no		i	yes
FLR04E058		PCS		n/a	n/a	i	i	no
FLR05F507		PCS		n/a	n/a	i	i	no
FL0002500		PCS	6	10	no		1	yes
FL0000964973		RCR			no		i	yes
FL2170023715		RCR			no		i	yes
FL9170024567		RCR	4	2	no	2	1	yes
FL0102202	PACE WATER SYSTEM, INC. WWTP #	PCS	4	n/a	n/a	i	i	no
FLL024007	SANTA ROSA ISLAND PENSACOLA BEACH STP	PCS		n/a	n/a	i	i	no
FL0024007		PCS	11	10	yes	1	1	yes
1203300040	SOLUTIA INCORPORATED	AFS	3		no	1	i	yes
04-2004-2013		ICI			no		1	yes
FLL002488		PCS		n/a	n/a	i	i	no
FLR05A104		PCS		n/a	n/a	i	i	no
FLR05B137		PCS		n/a	n/a	i	i	no
FLR05C602		PCS		n/a	n/a	i	i	no
FLR10J068		PCS		n/a	n/a	i	i	no
FL0002488		PCS	5	7	yes		i	yes
FLD071951966		RCR	25	12	no		i	yes
FL0296643	TEST	PCS		n/a	n/a	i	i	no

Facility ID	Facility Name	Database	Inspections (3yrs)	Qtrs Alleged Non Compliance (3yrs)	Alleged Current Significant Violations	Informal Enforcement Actions (3yrs)	Formal Enforcement Actions (3yrs)	Federally required to be reported to EPA
1209100064	U.S. AIR FORCE HURLBURT FIELD FL - INSTALLATION RA	AFS	1		no		i	yes
FLR04E002		PCS		n/a	n/a	i	i	no
FLR05B132		PCS		n/a	n/a	i	i	no
FL0003174		PCS	4	n/a	n/a	i	i	no
FL7570024375		RCR	1		no		i	yes

*i= Indicates that the database shows no formal USEPA or state enforcement action. Note that enforcement actions that are in process are not publicly available.
AFS = Air Facility System, tracks compliance and enforcement data under the Clean Air Act.
ICIS = Integrated Compliance Information System. Tracks federal enforcement actions.
PCS = Permit Compliance System. Tracks compliance and enforcement data under the Clean Water Act.
RCRAInfo = Trace enforcement and compliance data under the Resource Conservation and Recovery Act.

Appendix I – Compliance History of National Pollutant Discharge Elimination System Dischargers in Harrison and Jackson Counties, MS

Facility ID	Facility Name	Database	Inspections (3yrs)	Qtrs Alleged Non Compliance (3yrs)	Alleged Current Significant Violations	Informal Enforcement Actions (3yrs)	Formal Enforcement Actions (3yrs)	Federally required to be reported to EPA
MS0040169	APPLE VALLEY TRAILER PARK	PCS	1	n/a	n/a	i	i	no
MS0036854	BUDS MOBILE HOMES INC	PCS	1	n/a	n/a	i	i	no
MS0037028	C J DAVIS SLAUGHTERHOUSE INC	PCS	2	n/a	n/a	i	i	no
MSU097191	CAL REALTY GROUP WOOLMARKET MOBILE HOME PARK	PCS	1	n/a	n/a	i	i	no
MS0058378	CAR WASHES OF AMERICA WAL MART NO 969	PCS		n/a	n/a	i	i	no
MSU000108	CATES MOBILE HOME PARK	PCS		n/a	n/a	i	i	no
MSU098130	COMSTOCK GROCERY & DELI	PCS	1	n/a	n/a	i	i	no
MS0042218	COUNTRY LIVING MOBILE HOME PRK	PCS	1	n/a	n/a	i	i	no
MS0045004	CUSTOM PACK INC	PCS	2	n/a	n/a	i	i	no
MS0052400	DAVID GOLLOT SEAFOOD INC	PCS	2	n/a	n/a	i	i	no
MS0053252	DENNIS STIEFFLE RV PARK	PCS		n/a	n/a	i	i	no
MS0039250	DESTINATION RV PARK	PCS	1	n/a	n/a	1	i	no
MS0040142	GOLDEN GULF COAST PACKING CO	PCS	2	n/a	n/a	i	i	no
MS0047597	GOLLOTT BROTHERS SEAFOOD CO	PCS	2	n/a	n/a	2	i	no

MSG110063	GULF CONCRETE COMPANY	PCS		n/a	n/a	i	i	no

Facility ID	Facility Name	Database	Inspections (3yrs)	Qtrs Alleged Non Compliance (3yrs)	Alleged Current Significant Violations	Informal Enforcement Actions (3yrs)	Formal Enforcement Actions (3yrs)	Federally required to be reported to EPA
MSG110068	GULF CONCRETE LLC	PCS		n/a	n/a	i	i	no
MSG110087	GULF CONCRETE LLC	PCS		n/a	n/a	i	i	no
MS0039276	GULF PRIDE ENTERPRISES INC	PCS	1	n/a	n/a	1	i	no
MSG110181	GULF STATES READY MIX PLANT 15	PCS		n/a	n/a	i	i	no
MS0050938	GUTIERREZ RV PARK	PCS	1	n/a	n/a	i	i	no
MS0030333	HC/WEST BILOXI POTW	PCS	4	7	no	1	1	yes
MSU096136	HONEY DIPPER OF BILOXI CORP CEDAR LAKE DEVELOPMENT	PCS	1	n/a	n/a	i	i	no
MS0052230	JIG'S FISH CAMP	PCS	1	n/a	n/a	i	i	no
MSG110174	LAFARGE BLDG MATERIALS INC BILOXI PLANT	PCS		n/a	n/a	i	i	no
MS0044466	M & M SHRIMP COMPANY INC	PCS	2	n/a	n/a	i	i	no
MS0039594	MAZALEA TRAVEL PARK	PCS	1	n/a	n/a	i	i	no
MSG110153	METRO CONCRETE LLC	PCS		n/a	n/a	i	i	no
MS0045772	MUNRO TERMINAL INC	PCS	2	n/a	n/a	i	i	no

*i= Indicates that the database shows no formal EPA or state enforcement action. Note that enforcement actions that are in process are not publicly available.

Appendix J – Sources of Water Quality Data Information for Gulf Islands National Seashore

Florida

Florida 2002 305(b) Report - http://www.dep.state.fl.us/water/docs/2002_305b.pdf
Florida 1998 303(d) List - http://www.dep.state.fl.us/water/tmdl/303drule.htm
2002 Update to Florida's 303(d) List -
http://www.dep.state.fl.us/water/tmdl/2002_303d_update.htm
Florida TMDL in Florida Administrative Code (FAC) –
http://election.dos.state.fl.us/fac/index.shtml

Mississippi

Mississippi 1998 305(b) Report -
http://www.deq.state.ms.us/MDEQ.nsf/pdf/FS_305b1998/$File/305b1998.pdf?OpenElement
Pascagoula River Basin 2000 305(b) Report –
http://www.deq.state.ms.us/MDEQ.nsf/pdf/FS_305b_2000Final/$File/305b_2000Final.pdf?OpenElement
Mississippi 2002 303(d) List -
http://www.deq.state.ms.us/MDEQ.nsf/pdf/TWB_2002_303dList/$File/MS2002303dListEV.pdf?OpenElement
2004 Update to Mississippi's 303(d) List -
http://www.deq.state.ms.us/MDEQ.nsf/pdf/TWB_2004-303dList/$File/MS2004303dList.pdf?OpenElement
Completed TMDLs for Coastal Streams Basin -
http://www.deq.state.ms.us/MDEQ.nsf/page/TWB_coastalststatusrep?OpenDocument
Completed TMDLs for Pascagoula River Basin -
http://www.deq.state.ms.us/MDEQ.nsf/page/TWB_pascastatrep?OpenDocument

USEPA Modernized STORET - http://www.epa.gov/STORET/

STORET is a repository for water quality, biological, and physical data and is used by state environmental agencies, USEPA and other federal agencies, universities, private citizens, and many others. All data supplied to USEPA since January 1, 1999 have been placed in the Modernized STORET System. Modernized STORET is currently receiving new data on a regular basis, and will continue to do so for the foreseeable future.

Data availability for Florida in Modernized STORET is good; however, portions of Mississippi and Alabama that affect GUIS do not have Modernized STORET data. Water quality data for Mississippi were obtained through contact with the Mississippi Department of Environmental Quality.

US Geological Survey (USGS) – http://waterdata.usgs.gov/nwis/qw

The USGS collects and analyzes chemical, physical, and biological properties of water, sediment, and tissue samples from across the U.S. The NWISWeb discrete sample database is a compilation of over 4.2 million historical water quality analyses in the USGS district databases through September 2003. It contains a large and complex set of data that has been collected by a variety of projects ranging from national programs to studies in small watersheds. At selected surface water and groundwater sites, the USGS maintains instruments that continuously record physical and chemical characteristics including pH, specific conductance, temperature, DO, and percent DO saturation. Supporting data such as air temperature and barometric pressure are also available at some sites. At sites where this information is transmitted automatically, data are available from the real-time data system.

Data from the USGS site can be downloaded using a bounding box of latitude and longitude coordinates. For GUIS, there were a number of sampling sites located within or near the park; however, most of the water-quality data from field and/or laboratory analysis of water, biological tissue, stream sediments, and other environmental samples were greater than 10 years old. Further analysis of these data are needed to determine if the results can be used as indicators of current water quality threats or if the information is outdated.

Florida Geographic Data Library (FGDL) – www.fgdl.org

The FGDL maintains most static coverage layers for the state of Florida. This includes roads, land use, vegetation, 303(d) listed impaired waterbodies, soils, political boundaries, USGS hydrologic unit codes (HUCs), and numerous other data sources. Aerial photographs for Florida are available at the Land Boundary Information System (http://data.labins.org/2003/index.cfm).

Weeks Bay Reserve Foundation - http://www.weeksbay.org/

The Weeks Bay Reserve Foundation is a non-profit organization formed to support the Weeks Bay National Estuarine Research Reserve located in Baldwin County, Alabama. Current research projects include fecal coliform monitoring, E. coli sampling, and several water quality monitoring programs. The reserve is also part of a national system-wide monitoring project to obtain baseline data for estuarine modeling of water quality and atmospheric data. Parameters measured for this project include DO levels, saturation, specific conductivity, salinity, temperature, depth, pH, and turbidity.

Mississippi Beach Monitoring Data - http://www.usm.edu/gcrl/msbeach/index.cgi

Samples are collected from eighteen stations from the Mississippi-Louisiana state line to the Mississippi-Alabama state line by the Gulf Coast Research Laboratory in conjunction with the MDEQ. During the "summer" months of March through the end of October, the sampling regime is rigorous (4-5 days per week). During the "winter" months of November through the end of February the sampling is less intense (2-4 days per week). The water is tested for fecal coliform, E. coli , and enterococci. Archived data beginning in January 2000 is available at the website referenced above.

National Estuarine Research Reserve System (NERRS) – http://cdmo.baruch.sc.edu/

The NERR System-wide monitoring program was established to form local networks of continuous water quality monitoring stations in representative estuarine ecosystems and to develop a nation-wide database on baseline environmental conditions in this monitoring network. Two sites are located near GUIS: Weeks Bay, Alabama, and Grand Bay, Mississippi. Water quality data including water temperature, conductivity, salinity, DO concentration and saturation, water depth, pH, and turbidity are available from 1995-2003 for both sites. For 2001-2003, meteorological measurements such as temperature, relative humidity, barometric pressure, wind speed and direction, rainfall, and photosynthetic radiation are also available. The data are reviewed for quality assurance/quality control to identify data set outliers and other erroneous measurements.

Florida Department of Health (Beach Sampling Data) - http://apps3.doh.state.fl.us/env/beach/webout/default.cfm

Beginning with a 1998 pilot program, 11 Florida coastal counties began conducting beach water sampling every two weeks and reporting the results. In August 2000, the beach water sampling program was expanded to include 34 counties. There are 14 stations located in Escambia County, 7 in Santa Rosa, and 12 in Okaloosa. Several of the stations are within GUIS boundaries or in close proximity to the park. The coastal beach water samples collected by the county health departments are analyzed for enterococci and fecal coliform bacteria. The results are categorized as good, moderate, or poor based on the number of organisms per 100 mL of marine water and the geometric mean.

USEPA National Coastal Assessment Program – http://www.epa.gov/emap/nca/index.html

The NCA addresses broad-scale questions concerning coastal systems in the continental U.S. The types of available data include water column parameters, sediment chemistry and toxicity, benthic communities, and fish contaminants. Regional concerns are addressed by programs in specific geographic areas that are conducted over a shorter time scale than national projects. Regional examples are studies conducted in the Gulf of Mexico, Southeast, and Northeast U.S.

Toxic Release Inventory – *USEPA* http://www.epa.gov/tri/

The Toxics Release Inventory (TRI) is a publicly available USEPA database that contains information on toxic chemical releases and other waste management activities reported annually by certain covered industry groups as well as federal facilities. The information is provided by the facility and includes the location of the facility, estimated quantities of chemicals released, and on-site source reduction and recycling efforts. Data are available through the Florida Geographic Data Library.

Permit Compliance System – *USEPA* http://www.epa.gov/enviro/html/pcs/pcs_query_java.html

The Permit Compliance System (PCS) provides information on companies which have been issued permits to discharge wastewater into rivers. Available information includes the date of issuance and expiration, discharge limits, and the actual monitoring data showing what the company has discharged. This database also includes the discharges from municipal and industrial wastewater treatment facilities that are put into navigable waters of the U.S. The automated system allows for easy entry, updating, and retrieval of National Pollutant Discharge Elimination System (NPDES) information.

Minerals Management Service - http://www.gomr.mms.gov/index.html

The Minerals Management Service (MMS) is responsible for the regulation of oil and gas wells on the Gulf of Mexico Outer Continental Shelf (OCS). Federal jurisdiction of submerged OCS lands begins at the outer limit of state waters (approximately 10.4 miles off Florida's Gulf coast) and extends to 200 nautical miles from the coast. Data are available through the Florida Geographic Data Library.

As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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