An Ecological Characterization of Aquatic and Wetland Habitats in the Anclote River Estuary and Adjacent Inshore and Offshore Waters of West-Central Florida

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FOREWORD

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EXECUTIVE SUMMARY

A Master Water Plan, developed in response to continuing population growth within the Tampa Bay area, was adopted by the West Coast Regional Water Supply Authority (now Tampa Bay Water) in 1995. As part of the Agreement, Tampa Bay Water was required to submit a "New Water Plan" to the Southwest Florida Water Management District (SWFWMD) by July 1989. This Plan contains projects which must be permitted, constructed and operational for production of 85 MGD of new surface water supplies, other than groundwater, by the end of 2007. To help achieve the goal, seawater desalination has been selected as an additional source of regional water supply. Two locations for desalination plants have been proposed: the Big Bend Power Plant on Hillsborough Bay (where a desalination plant has been permitted and is currently operational) and the Anclote Power Station located near the mouth of the Anclote River (which is currently being assessed as a potential desalination plant site).

The Anclote River originates in south-central Pasco County and flows to the southwest, crossing a portion of Pinellas County before discharging into the Anclote Anchorage. As defined by the U.S. Geological Survey, the Anclote River watershed comprises approximately 112 square miles. Resource management areas in the study area include the Anclote Key State Preserve, the Pinellas County Aquatic Preserve, Outstanding Florida Waters, and Essential Fish Habitat.

An ecological characterization of aquatic (inshore and offshore) habitats of the Anclote River estuary and the Anclote Anchorage has been completed. This document presents details of the project area including climate and meteorology, wind patterns, hydrology and hydrodynamics, water quality, major habitat types, and biota. Historical data show that salinity in the offshore area, as expected, is relatively constant at 35-36 ppt. In the Anclote Anchorage area, the salinity is typically lower and more variable, ranging from 23 to 38 ppt during 2000-2001. Critical habitats in the offshore area include hard and soft bottoms. Hard bottom habitats contain sponges, clams, and corals. Seagrass beds represent critical habitat in the nearshore area.

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1. INTRODUCTION

A Master Water Plan, developed in response to continuing population growth within the Tampa Bay area, was adopted by the West Coast Regional Water Supply Authority (now Tampa Bay Water) in 1995. The Plan addresses the need to replace water from currently active wellfields with allowance for additional needs that may occur over the next 10-15 years. Approval of the Northern Tampa Bay New Water Supply and Groundwater Withdrawal Reduction Agreement occurred in May 1998. This agreement enables development of new water supply and reduction in pumpage from the 11 wellfields in Northern Tampa Bay, among other objectives. The Agreement specifies a reduction in wellfield pumping from wellfields in Northern Tampa Bay from 158 million gallons per day (MDG) in 1998 to 90 MGD by the end of 2007.

As part of the Agreement, Tampa Bay Water was required to submit a "New Water Plan" to the Southwest Florida Water Management District (SWFWMD) by July 1989. This Plan contains projects which must be permitted, constructed and operational for production of 85 MGD by the end of 2007. To help achieve the goal, seawater desalination has been selected as an additional source of regional water supply. This new source involves the use of membrane technology to produce freshwater from seawater. Two locations for desalination plants have been proposed: the Big Bend Power Plant on Hillsborough Bay (where a desalination plant has been permitted and is currently operational) and the Anclote Power Station located near the mouth of the Anclote River (which is currently being assessed as a potential desalination plant site). The second desalination plant is called the Gulf Coast Desalination Plant and is located near Holiday, just north of Tarpon Springs.

Estuaries are coastal water bodies that receive fresh water runoff from the land and salt water from the sea, producing a "mixing zone" environment with highly variable salinity. Although stressful to many organisms because of their salinity variations, estuaries are also highly productive areas that can support large populations of fish and wildlife and contribute substantially to the economy of coastal areas. As spawning, nursery, and feeding grounds, estuaries provide important habitats for a number of economically important fish and shellfish species. Estuarine-dependent species constitute more than 95 percent of the commercial fishery harvests from the Gulf of Mexico, and many important recreational fishery species depend on estuaries during some part of their life cycle (EPA 1998).

The purpose of this document is to provide an ecological characterization of aquatic (inshore and offshore) habitats of the Anclote River estuary and the Anclote Anchorage.

2. PROJECT AREA DESCRIPTION

The areas addressed in this report are located on the west central Gulf coast of Florida and include the lower Anclote River, the Anclote Anchorage, and adjacent waters of the Gulf of Mexico (Figure 2.1.). The lower Anclote River flows past the City of Tarpon Springs and enters the Anclote Anchorage from a southeasterly direction. The Progress Energy Corporation's Anclote Power Station is located on the river's northern shoreline, immediately upstream from the mouth (Figure 2.2.). The station includes a combination of oil-fired and natural gas-fired generators that are capable of producing up to 1,054 megawatts of electricity. Cooling water for the plant is taken from the mouth of the Anclote River, through an intake canal that is approximately 440 feet long, 227 feet wide and 9 to 12 feet deep. After passing through the station's cooling system, the heated water is discharged through a 4,600-foot outlet canal to the northeastern Anclote Anchorage and the Gulf of Mexico (Figure 2.2.). In addition to the outfall canal the plant uses a combination of on-site cooling towers and dilution pumps to reduce the temperature of the discharged water before it enters the receiving waters. The dilution pumps are capable of pumping up to 1,530 MGD from the intake canal directly to the outlet canal, bypassing the station's cooling system and reducing the temperature of water present in the discharge canal. The cooling towers and dilution pumps are used most heavily in the summer months, as the temperature of the intake water reaches the highest levels of its annual cycle.

The tidally-affected portion of the Anclote River extends about 13 miles upstream from the river mouth (Fernandez, 1990). Within this tidal reach the river's width is highly variable - about 1,800 feet at the mouth, narrowing to about 250 feet at Alternate U.S. 19 in Tarpon Springs, increasing to about 1,700 feet between Alternate 19 and U.S. 19, narrowing to about 400 feet at U.S. 19, and widening again to about 3,000 feet (an area that includes Salt Lake) upstream from U.S. 19. The wider sections contain extensive salt marshes and may act to delay and attenuate the effects of both incoming tides and outgoing freshwater runoff, perhaps influencing the salinity conditions that occur in the river's tidally-affected reach (Fernandez, 1990).

The Anclote Anchorage is an area of protected estuarine and marine water that lies west of the river mouth, between Anclote Key and the mainland (Figure 2.2.). The Anchorage is relatively shallow, particularly along its eastern and western sides where water depths generally range from 0 to 3 feet at mean lower low water (MLLW). Depths are greater in the central portion of the Anchorage, ranging between 3 and 12 feet at MLLW. Depths greater than 12 feet occur in a small area, within the narrow channel immediately north of Anclote Key that connects the Anchorage with the Gulf of Mexico. St. Joseph's Sound lies to the south of the project area and is a portion of the Pinellas County Aquatic Preserve. Open shelf waters of the Gulf of Mexico lie to the west and north. The coastal area to the north of Anclote Key is known as the "Springs Coast" (Wolfe, 1990), a marsh-dominated complex of spring-fed rivers and coastal estuaries that extends northward to

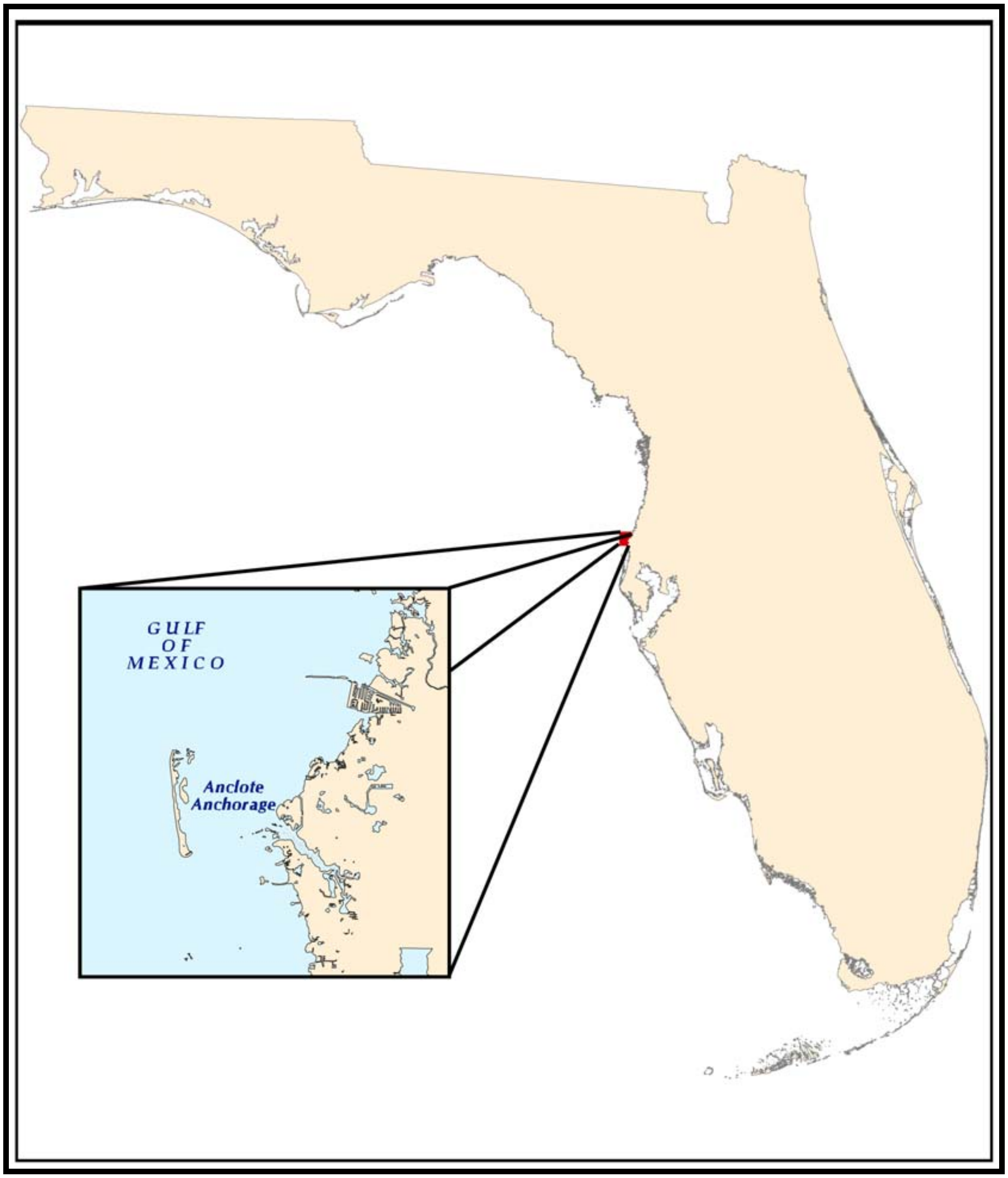

Figure 2.1. Location of the Anclote Anchorage area on the west central Gulf coast of Florida.

Figure 2.2. Anclote Anchorage area showing the location of the Anclote Power Station.

the Waccassassa River in Florida's Big Bend region (Wolfe, 1990). The seafloor west of the Springs Coast has a very gentle slope, inhibiting the propagation of large waves and producing an extremely low-energy shoreline (Hine and Belknap,1986). This low-energy estuarine and marine environment is conducive to the development of extensive shoreline marshes and nearshore seagrass meadows.

2.1. Physiography

The Anclote River originates in south-central Pasco County and flows to the southwest, crossing a portion of Pinellas County before discharging into Anclote Anchorage. As currently defined by the U.S. Geological Survey, the Anclote River watershed includes approximately 112 square miles (Fernandez, 1990). Under pre-development conditions the watershed also included a subterranean connection to Lake Tarpon and its watershed, which was hydrologically linked to Salt Lake via a sinkhole located on the western side of Lake Tarpon. The sinkhole has been sealed off, however, to prevent flows of brackish water from the lower Anclote River from entering Lake Tarpon.

The Anclote River watershed lies on the Tampa Plain, a physiographic unit within Florida's Ocala Uplift District (Brooks, 1982). The Tampa Plain, characterized by lowland karst features underlain by the Tampa Limestone formation, covers a large portion of western Hillsborough, northern Pinellas and western Pasco counties. Pine flatwoods dominate the inland portions of the plain, with relict dune systems and ancient shoreline features present near the coast (Wolfe and Drew, 1990).

The karst topography of the area is marked by sinkholes and other depressional features that have formed over thousands of years as the underlying limestone has been dissolved by rainfall and stormwater runoff. Sinkhole development is still occurring in the region, as fractures and underground solution caverns continue to form in the limestone bedrock. Many of these sinkholes penetrate the water table and fill with water, forming a direct connection between the land surface and the underlying aquifer system. Many of the isolated wetlands and cypress domes in the region are also karst features, which act to retard and store stormwater runoff prior to its infiltration to the underlying groundwater system (SWFWMD, 1998).

The ancient shorelines and dune systems in the region take the form of sandy terraces and scarps that run roughly parallel to the existing coastline. Crossing these features, the Anclote River basin rises from sea level at the river's mouth to 25 feet above mean sea level (MSL) at the Pamlico Terrace, 42 feet above MSL at the Talbot Terrace, and 70 feet above MSL at the Penholoway Terrace (PBS&J, 1999). Land surface elevation is about 80 feet above MSL in the headwaters region of the basin (PBS&J, 1999).

The Anclote River mouth and Anclote Anchorage lie in a transition zone of coastal morphology. A sand-rich coastline dominated by beaches and barrier islands extends southward from the area, and the sand-starved low-energy coastline of the Springs Coast, which is dominated by marshes and coastal hammocks, extends to the north. Until recently Anclote Key was the northernmost of the west-central Florida barrier islands, marking the transition point between the beach-dominated and marsh-dominated coastal zones (Hine and Belknap, 1986). Sand on the Gulf bottom is continuing to move northward in response to prevailing longshore currents, however, and a new barrier island has recently formed immediately north of the key (FDEP, 1998).

2.2. Land Use and Cover

Current land cover (Figure 2.3.) was estimated using digital maps obtained from the Southwest Florida Water Management District (SWFWMD). The SWFWMD maps were based on aerial photographs taken during 1999. The coastal area surrounding the mouth of the Anclote River is highly urbanized, containing a mix of residential housing, commercial/industrial and utility-related land uses. The most common non-urban land uses in this area are fresh and saltwater wetlands, upland hardwood and pine woodlands, recreational sites and pasture land (Figure 2.3). The islands within the Anclote Key State Preserve are non-urbanized, and are managed by the Florida Park Service to maintain a natural mix of native wetland and upland habitats as described in more detail in Section 2.4.1 below.

2.3. Resource Utilization

The Anclote Key Preserve State Park is utilized for many recreational activities. Recreational diving, boating, camping, fishing, hiking, shell collecting, and swimming take place within the preserve. Waters of the Anclote area also support a few commercial activities such as sponge fishing, live rock farming, and other minor commercial fisheries.

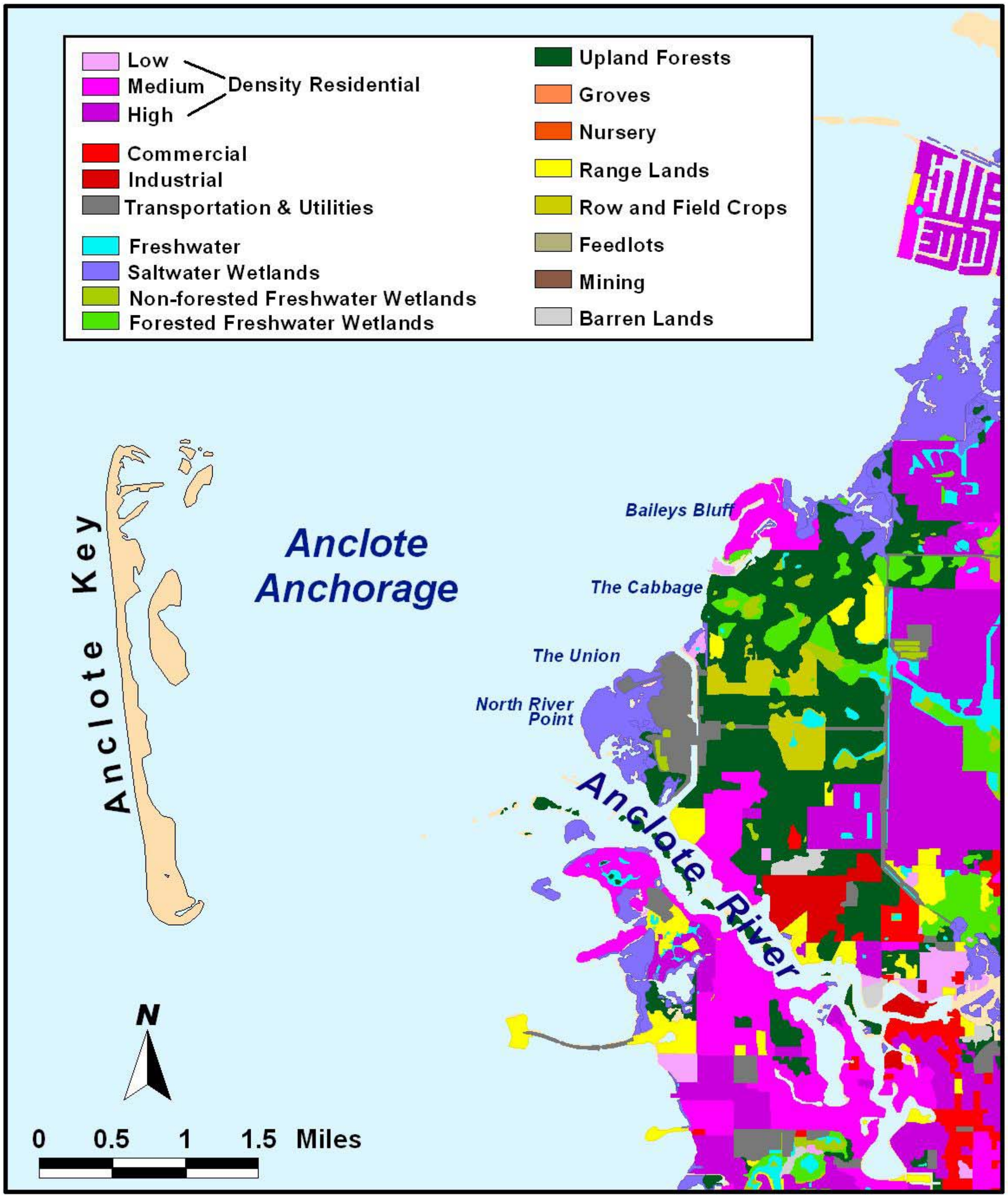

Figure 2.3. Current land use of the Anclote Anchorage area.

2.4. Resource Management Areas

2.4.1. Anclote Key State Preserve

The Anclote Key State Preserve includes Anclote Key, North Anclote Key, and Three Rooker Bar, a shoal area located about three miles south of Anclote Key. The Preserve forms the western boundary of the Anclote Anchorage (Figure 2.4.). Three Rooker Bar and the southern tip of Anclote Key fall within Pinellas County, while the remainder of Anclote Key and North Anclote Key are in Pasco County. The Preserve is a unit of Florida's Gulf Islands GEOPark (FDEP, 1998), which is administered by the Florida Department of Environmental Protection from offices located on Honeymoon Island. FDEP (1998) gives the following summary of the State's management objectives for the Preserve:

> "At Anclote Key State Preserve, resource preservation and enhancement is given priority. In fact, Three Rooker Bar is among the five most important shorebird nesting sites in the State (Douglass, 1997). Therefore, recreational uses should be primarily of a passive nature, and must be carefully attuned to wildlife uses via education, interpretation, and enforcement of rules and regulations. Access to the park is by boat only. Development is restricted to the minimum necessary for user safety and natural resource interpretation."

2.4.2. Pinellas County Aquatic Preserve

The inshore coastal waters immediately south of the study area fall within the Pinellas County Aquatic Preserve (Figure 2.4.). Aquatic preserves are established by the State of Florida — with the approval of the Governor and Cabinet, acting in their capacity as the Board of Trustees of the Internal Improvement Trust Fund — under the terms of the Florida Aquatic Preserve Act of 1975. The State's goals and policies for managing aquatic preserves are defined in Chapter 18-20 of the Florida Administrative Code (FAC).

Aquatic preserves are submerged lands, owned by the State of Florida, that are to be "preserved in their natural or existing condition so that their aesthetic, biological, and scientific values...may endure for the enjoyment of future generations" (Ch. 18-20 FAC). The preserves are administered and managed by the State in accordance with the following goals (Ch. 18-20 FAC):

- to preserve, protect, and enhance these...areas...by reasonable regulation of human activity...through the development and implementation of a comprehensive management program,

Figure 2.4. Resource management areas in the Anclote area. Resource management areas include the Anclote Key State Preserve, Pinellas County Aquatic Preserve, and Outstanding Florida Waters.

- to protect and enhance the waters of the preserves so that the public may continue to enjoy the traditional recreational uses of those waters such as swimming, boating, and fishing,

- to coordinate with federal, state, and local agencies to aid in carrying out the intent of the Legislature in creating the preserves,

- to use applicable federal, state, and local management programs, which are compatible with the intent and provisions of the act and these rules, and to assist in managing the preserves,

- to encourage the protection, enhancement or restoration of the biological, aesthetic, or scientific values of the preserves, including but not limited to the modification of existing manmade conditions toward their natural condition, and discourage activities which would degrade the aesthetic, biological, or scientific values, or the quality, or utility of a preserve, when reviewing applications, or when developing and implementing management plans for the preserves,

- to preserve, promote, and utilize indigenous life forms and habitats, including but not limited to: sponges, soft coral, hard corals, submerged grasses, mangroves, salt water marshes, fresh water marshes, mud flats, estuarine, aquatic, and marine reptiles, game and non-game fish species, estuarine, aquatic and marine invertebrates, estuarine, aquatic and marine mammals, birds, shellfish and molluscs,

- to acquire additional title interests in lands wherever such acquisitions would serve to protect or enhance the biological, aesthetic, or scientific values of the preserves, and

- to maintain those beneficial hydrologic and biologic functions, the benefits of which accrue to the public at large.

Most aquatic preserves are located along the coast and involve marine or estuarine environments. Many are associated with parks, wildlife refuges or other publicly-owned conservation lands. Within preserves human activities are regulated to ensure consistency with the environmental management goals listed above. Within an aquatic preserve, for example, a lease, easement or consent of use may be authorized only for the following activities:

1. a public navigation project,
2. maintenance of an existing navigational channel,
3. installation or maintenance of approved navigational aids,
4. creation or maintenance of a commercial/industrial dock, pier, or a marina,
5. creation or maintenance of private docking facilities to allow reasonable access by riparian property owners,

6. minimum dredging for navigation channels attendant to docking facilities,
7. creation or maintenance of a shore protection structure (except for restoration of a seawall or riprap at its previous location, which is exempted from any requirement to make application for consent of use),
8. installation or maintenance of oil and gas transportation facilities,
9. creation, maintenance, replacement, or expansion of facilities required for the provision of public utilities, and
10. other activities which are a public necessity or which are necessary to enhance the quality or utility of the preserve and which are consistent with State laws and codes.

2.4.3. Outstanding Florida Waters

All water bodies within the Anclote Key State Preserve and the Pinellas County Aquatic Preserve (Figure 2.4.) have been designated by the State as Outstanding Florida Waters (OFW). This designation increases the level of protection these water bodies receive under the State's environmental permitting processes, as summarized in Ch. 62-302 FAC. In general, the State will not allow permits for:

- direct pollutant discharges to an OFW which would lower existing water quality or

- indirect discharges which would significantly degrade an OFW.

In addition, permits issued for new dredging and filling within an OFW must "be clearly in the public interest" (Ch. 62-302 FAC). When determining whether a proposed project is in the public interest, the State must consider the following factors:

- whether the activity will adversely affect the public health, safety, or welfare or property of others,

- whether the activity will adversely affect the conservation of fish and wildlife, including endangered or threatened species, or their habitats,

- whether the activity will adversely affect navigation or the flow of water or cause harmful erosion or shoaling,

- whether the activity will adversely affect the fishing or recreational values or marine productivity in the vicinity of the activity,

- whether the activity will be of a temporary or permanent nature,

- whether the activity will adversely affect or will enhance significant historical and archaeological resources, and

- the current condition and relative value of functions being performed by areas affected by the proposed activity.

2.4.4. Essential Fish Habitat

In 1996 the U.S. Congress amended the Magnuson-Stevens Fishery Conservation and Management Act, establishing a new mandate for the National Marine Fisheries Service (NMFS), the regional Fishery Management Councils, and other federal agencies to identify and protect "essential fish habitat" (EFH). The NMFS (1999) defines EFH as "those waters and substrate necessary…for spawning, breeding, feeding, or growth to maturity" of marine fishes, and provides the following definitions of those terms:

- "waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate,

- "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities,

- "necessary" means the habitat required to upport a sustainable fishery and the managed species' contribution to a healthy ecosystem, and

- "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle.

The NMFS (1999b) views the EFH program as one that:

- enhances communication and coordination among the NMFS, regional Fishery Management Councils, and affected state and Federal agencies,

- provides a mechanism for information exchange,

- fosters interagency discussion and problem-solving, and

- enhances the ability of the agencies to sustain healthy and productive marine fishery habitats.

In each region of the United States, EFH areas are determined by the regional Fishery Management Councils through amendments to their fishery management plans. The Anclote Anchorage and adjacent marine waters fall under the jurisdiction of the Gulf of Mexico Fishery Management Council. The Council's management plans must be reviewed and approved by the U.S. Secretary of Commerce, acting through the NMFS. Federal agencies that fund, permit, or carry out activities that may adversely impact EFH areas are required to consult with NMFS regarding potential adverse effects of their actions on EFH, and respond in writing to NMFS and FMC recommendations. In addition, NMFS is directed to comment on any state agency activities that would impact EFH. In marine waters of the Gulf of Mexico, EFH is defined by the Gulf of Mexico Fisheries Management Council as all marine waters and substrates (i.e., mud, sand, shell, rock, hard bottom, and associated biological communities) from the shoreline to the seaward limit of the exclusive economic zone. All estuaries and estuarine habitats in the region are also considered EFH (GMFMC, 1998).

3. CLIMATE AND METEOROLOGY

The climate of the area is maritime temperate to sub-tropical, with relatively mild winters and long humid summers. Summer temperatures generally range between 70° and 90° F, with average temperatures slightly above 80°F. Winter temperatures generally range between 32° and 75° F, with monthly averages between 55° and 60° F. Occasional strong cold fronts, which occur approximately once per year, can cause temperatures to fall below freezing for several hours, a factor that restricts the distribution and abundance of tropical plants and animals within the region.

Average annual rainfall in the area, based on records from a National Weather Service monitoring station in Tarpon Springs for the years 1901 through 2000, is 52.2 inches per year. Rainfall amounts are highly variable from year to year, however, and both droughts and floods are relatively common events. During the period 1901–2000 annual rainfall amounts ranged between a minimum of 32.9 inches (in 1956) and a maximum of 83.2 inches (in 1959).

Precipitation in the area is produced by three types of weather systems: convective, tropical cyclonic, and frontal. In most years more than 50%of the annual rainfall occurs between the months of June and September. During these "rainy season" months convective thunderstorms can occur on an almost daily basis, producing intense rainfall for short periods over localized areas. Tropical cyclonic systems, which can occur during the same months, produce larger rainfall volumes and strong winds, which are spread over a larger geographic area. Rainfall during the remainder of the year is typically due to large-scale frontal systems and is distributed throughout the region.

4. WIND PATTERNS

This section briefly describes the wind patterns of the Anclote Anchorage area. Wind patterns serve as one of the forcing functions for circulation. Wind patterns show variation over various spatial and temporal scales. Near the coast, the wind and tides serve as the primary forcing mechanisms for transport, along with density differences arising from freshwater inflow. We analyzed data from the Tarpon Springs site, monitored by the Coastal Ocean Monitoring and Prediction System (COMPS) and obtained from the University of South Florida Marine Science Department, to provide an understanding of the local wind patterns affecting the Anchorage. These data cover the period May 2001-April 2002.

For this site, we examined the following:

- hourly mean wind speed and direction for each month, May 2001-April 2002,
- monthly mean wind speed and direction, May 2001-April 2002,
- univariate analysis of wind speed for the year, and
- univariate analysis of wind speed for each month.

The data at the Tarpon Springs site are reported at six-minute intervals. During the year of May 2001-April 2002, the median wind speed was 1.5 m/s (3.4 mph), the 25th percentile wind speed was 0.4 m/s (0.9 mph), and the 75th percentile wind speed was 2.6 m/s (5.8 mph).

The hourly mean wind speed and direction for each month is as follows:

- January - February: Winds are primarily from the northeast during the morning and early afternoon, then shifting to northwest in the evening. The strongest winds occur during early morning and late evening.

- March – April: Winds are from the northeast in the morning, and switch to the southwest in the late afternoon and evening. The strongest winds occur in the evening.

- May: Winds are from the northeast in the morning, and from the northwest in late afternoon and evening.

- June: Morning and early afternoon winds are from the southeast, with late afternoon and evening winds from the southwest.

- July – August: Winds are primarily from the south and southwest.

- September: Winds are from the northeast in the morning and early afternoon, shifting to the northwest in the evening.
- October – December: Winds are predominantly from the northeast, with some winds from the northwest during evening hours.

Table 4.1 summarizes the mean monthly wind speed and Table 4.2 summarizes the monthly wind speed distribution.

Table 4.1. Mean monthly wind speed and direction in the Anclote Anchorage.

Period	Wind Speed	Wind Direction
January	1.0 m/s (2.2 mph)	North-Northeast
February	1.0 m/s (2.2 mph)	North
March	0.2 m/s (0.4 mph)	North-Northeast
April	0.4 m/s (0.9 mph)	Southeast
May	0.9 m/s (2.0 mph)	North-Northwest
June	0.6 m/s (1.3 mph)	Southwest
August	0.1 m/s (0.2 mph)	West
September	0.7 m/s (1.6 mph)	North-Northeast
October	1.5 m/s (3.4 mph)	North-Northeast
November	1.2 m/s (2.7 mph)	North-Northeast
December	0.8 m/s (1.8 mph)	North-Northeast

Table 4.2. Monthly wind speed distribution in the Anclote Anchorage.

Month	25th Percentile	50th Percentile	75th Percentile
January	0.2 m/s (0.4 mph)	1.5 m/s (3.4 mph)	4.1 m/s (9.2 mph)
February	0.8 m/s (1.8 mph)	1.9 m/s (4.3 mph)	3.2 m/s (7.2 mph)
March	0.8 m/s (1.8 mph)	2.0 m/s (4.5 mph)	3.2 m/s (7.2 mph)
April	0.1 m/s (0.2 mph)	1.1 m/s (2.5 mph)	2.2 m/s (4.9 mph)
May	1.0 m/s (2.2 mph)	1.9 m/s (4.3 mph)	2.7 m/s (6.0 mph)
June	0.3 m/s (0.7 mph)	1.4 m/s (3.1 mph)	2.4 m/s (5.4 mph)
July	0.4 m/s (0.9 mph)	1.4 m/s (3.1 mph)	2.3 m/s (5.1 mph)
August	0.1 m/s (0.2 mph)	1.0 m/s (2.2 mph)	2.0 m/s (4.5 mph)
September	0.2 m/s (0.4 mph)	1.1 m/s (2.5 mph)	2.2 m/s (4.9 mph)
October	1.2 m/s (2.7 mph)	2.3 m/s (5.1 mph)	3.3 m/s (7.4 mph)
November	0.3 m/s (0.7 mph)	1.6 m/s (3.6 mph)	2.8 m/s (6.3 mph)
December	0.1 m/s (0.2 mph)	1.0 m/s (2.2 mph)	2.1 m/s (4.7 mph)

5. HYDROLOGY AND HYDRODYNAMICS

Estuaries are semi-enclosed coastal bodies of water that receive fresh water runoff from the land and salt water from the sea, producing a mixing zone with highly variable salinity. Salinity has traditionally been regarded as a central parameter for estuarine analysis, especially as an indicator of hydrography and habitat potential (Orlando et al., 1993). There are several reasons to study estuarine salinity:

- salinity is a direct measure of the relative influence of marine and freshwater sources,
- salinity is an outstanding hydrographic tracer, as it is a conservative property and illustrates the movement and exchange of water masses, and
- salinity dominates the density structure of an estuary and thus exerts significant controls on currents and turbulence (Orlando et al., 1993).

5.1. Freshwater Inflows

The Anclote Anchorage is an estuarine area where fresh water from several sources mixes with seawater from the Gulf of Mexico. Known and potential sources of fresh water include:

- Anclote River discharge,
- rain falling directly on the water surface,
- ground water discharged from the surficial and Floridian aquifers, and
- ground and surface water discharged from 'Springs Coast' rivers (from the Pithlachascotee to the Wacassassa) that is transported southward along the coast.

Annual median salinity levels in the Anchorage are only a few parts per thousand lower than full strength seawater, indicating that, on an annual basis, seawater from the Gulf contributes the largest proportion of the overall water budget. Streamflow in the Anclote River basin is monitored by the U.S. Geological Survey (USGS), whose most downstream monitoring station is located near the community of Elfers in Pasco County (Coffin and Fletcher, 1999) (Figure 5.1). The USGS has monitored river flow at the Elfers station continuously since May 1946.

The USGS flow records from the gage near Elfers were used to estimate the total discharge from the Anclote River watershed. The area of the watershed drained through this gage is listed by the USGS as approximately 72.5 square miles. The total area of the Anclote River watershed as estimated from the SWFWMD drainage basin coverage as approximately 113 square miles. The estimated discharge at Elfers was multiplied by the ratio of the total watershed area to that of the Elfers gaged watershed area (ratio is1.549) in order to obtain discharge values for the mouth of the Anclote River.

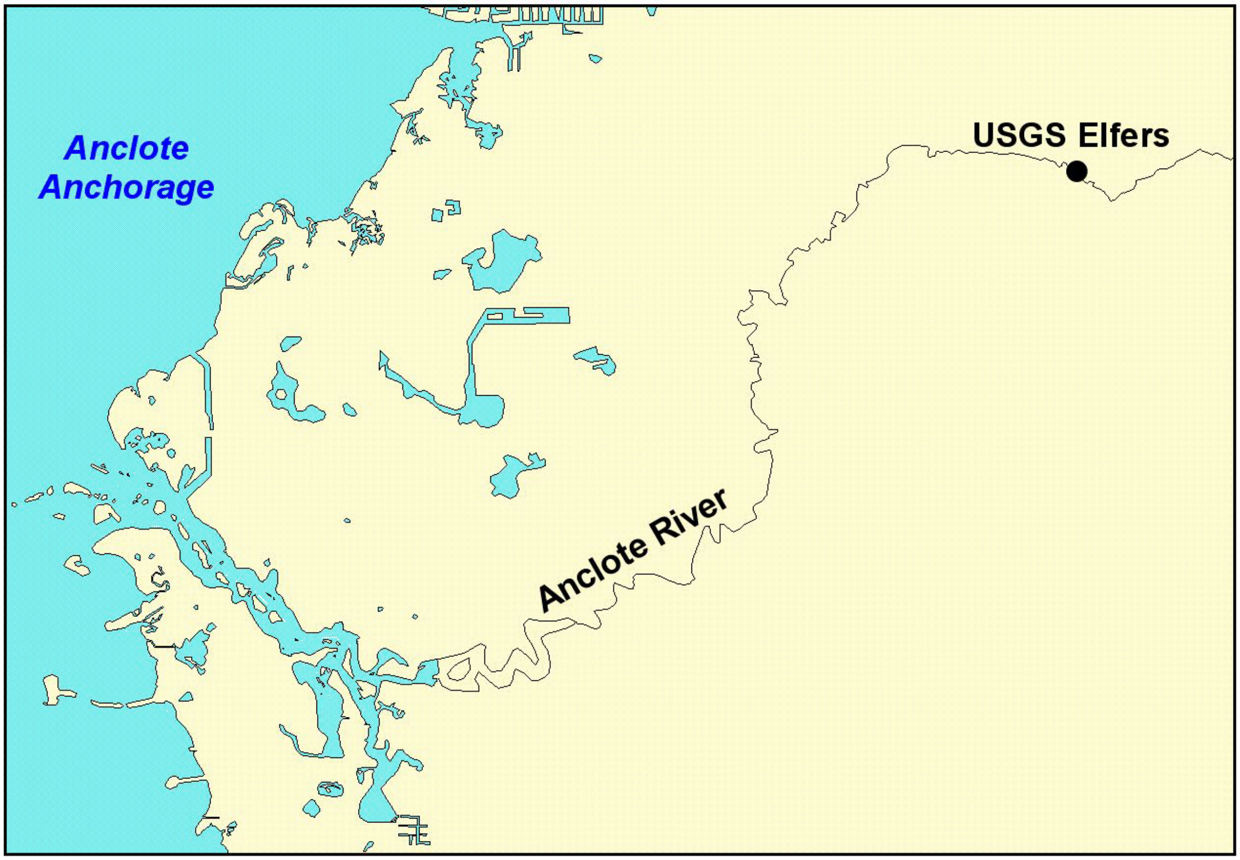

Figure 5.1. Location of USGS site near Elfers.

Estimates of monthly mean and mean annual discharges at the mouth of the river are shown in Figure 5.2 and Figure 5.3, respectively. Monthly mean discharge exhibits an obvious relationship with seasonal rainfall patterns, with low flows occurring in the latter part of dry season (May-June) and high flows occurring during the rainy season months of July through October. A secondary high-flow period also occurs in March, associated with frontal systems that often pass through the region in that month. Streamflow also shows pronounced year-to-year fluctuations, responding to annual variations in total rainfall. Between 1947 and 1999 the estimated annual mean discharge at the river mouth was 91 cubic feet per second (cfs), but mean flows during individual years ranged between 9.6 cfs (in the drought year of 1999) and 320 cfs (in 1959).

Fernandez (1990) used regression analysis to examine variations in annual flow at the Elfers monitoring station, and found a significant ($p<0.05$) statistical relationship between annual mean flow and the following independent variables:

- total annual volume of groundwater pumpage at the four public supply wellfields in the vicinity of the Anclote River basin (the Section 21, Eldridge-Wilde, South Pasco, and Starkey wellfields),
- annual rainfall at Tarpon Springs, lagged by one month, and
- annual rainfall at Saint Leo, lagged by two months.

A linear regression using these three independent variables explained 81% (R^2) of the variation in annual mean flow at the Elfers monitoring station (Fernandez, 1990). The presence of the groundwater pumpage term as a significant explanatory variable in the regression model implies that future reductions in pumpage at the four wellfields may provide a measurable increase in river flow.

Rain falling directly on the surface of the Anchorage is probably an insignificant component of the annual water budget. Evaporation rates in the central portion of the Florida peninsula are about 46 to 50 inches per year (Fernald and Purdum, 1998), while annual mean rainfall at Tarpon Springs is about 52.2 inches per year. It appears that the volume of fresh water falling as rain on the surface of the Anchorage each year is only slightly larger than the volume lost through evaporation.

Computation of a complete water budget for the Anchorage, including groundwater inputs and the volumes of fresh and salt water transported to the Anchorage from the 'Springs Coast' estuary and the Gulf of Mexico, is beyond the scope of this report. However, annual median salinities measured at a number of monitoring stations during the years 2000 and 2001 were only a few parts per thousand lower than full strength seawater, indicating that, on an annual basis, seawater from the Gulf contributes the largest proportion of the overall water budget.

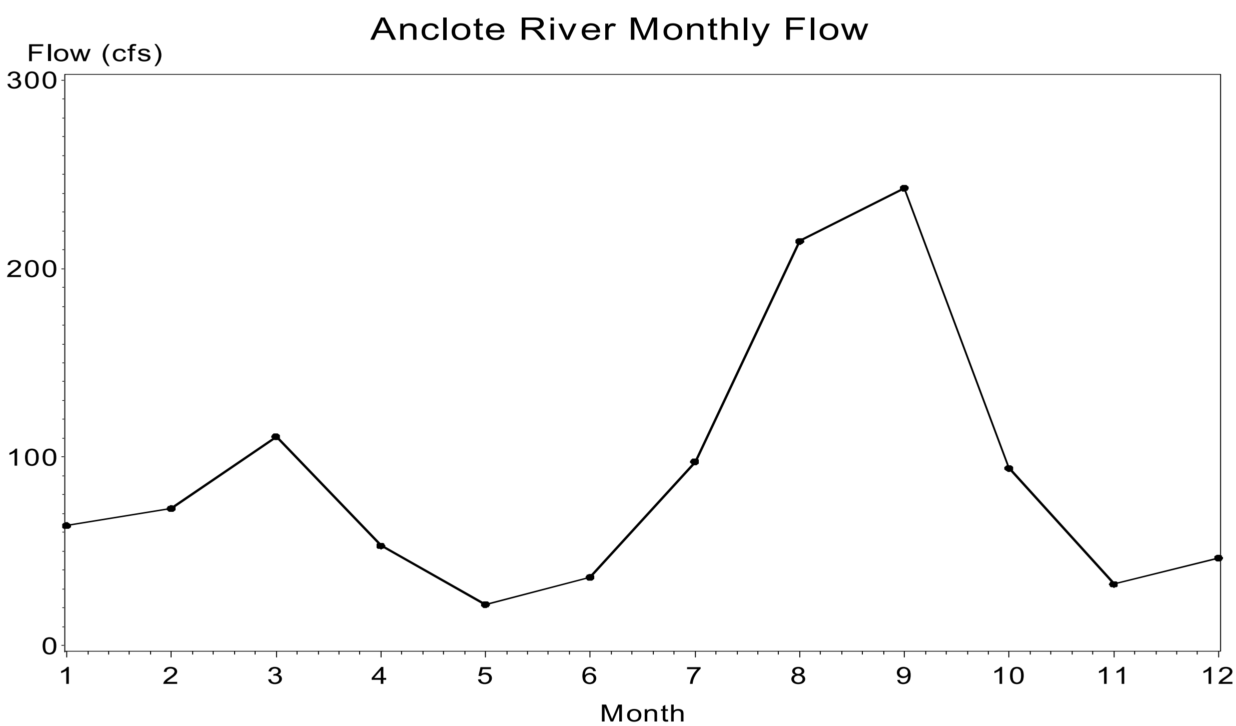

Figure 5.2. Anclote River estimated monthly mean discharge (cfs).

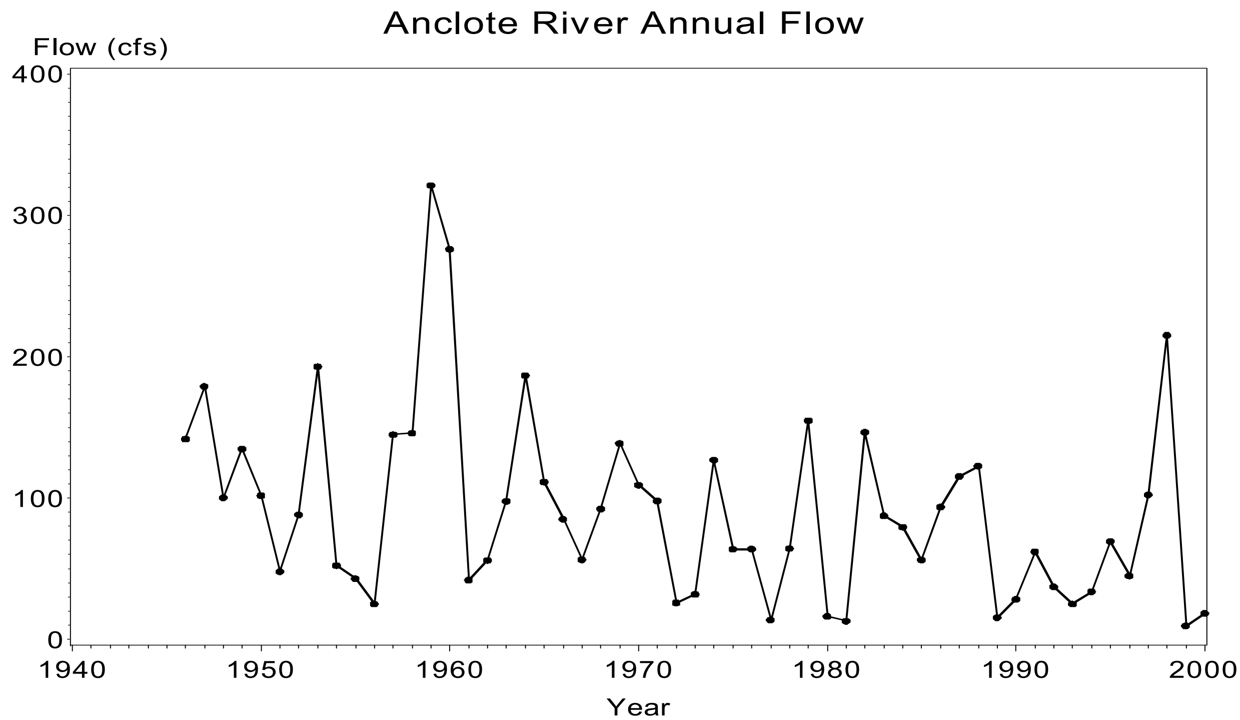

Figure 5.3. Anclote River estimated mean annual discharge (cfs).

5.2. Tides

Tides in the Anclote Anchorage area are "mixed" with approximately equal "diurnal" (one low water and one high water per day) and "semidiurnal" (two low waters and two high waters per day) influences. As a result, two unequal low and two unequal high tides usually occur each day (Fernandez 1990). An example of this type of tidal regime is shown in Figure 5.4. The tidal range in the area (i.e., the vertical difference between the lowest and highest tides on a given day) is low, usually between two and three feet.

5.3. Circulation Patterns

This section briefly describes the primary circulation features and associated forcing functions important for an understanding of circulation in the Anclote Anchorage. These circulation features and forcing functions occur over various spatial and temporal scales. Large-scale circulation features in the deeper Gulf of Mexico are linked to the overall circulation pattern of the North Atlantic, and evolve over monthly or longer time scales. The circulation along the eastern Gulf of Mexico continental slope and west Florida shelf is affected in turn by that in the main Gulf, with changes in circulation occurring at monthly time scales or less. Also affecting flows along the west Florida shelf are tides, winds, and density differences. Near the coast, the affects of the circulation of the deeper Gulf are not felt as strongly as along the outer and mid-shelf, and wind- and tidal-driven circulation serve as the primary forcing mechanisms for transport, along with density differences arising from freshwater inflow.

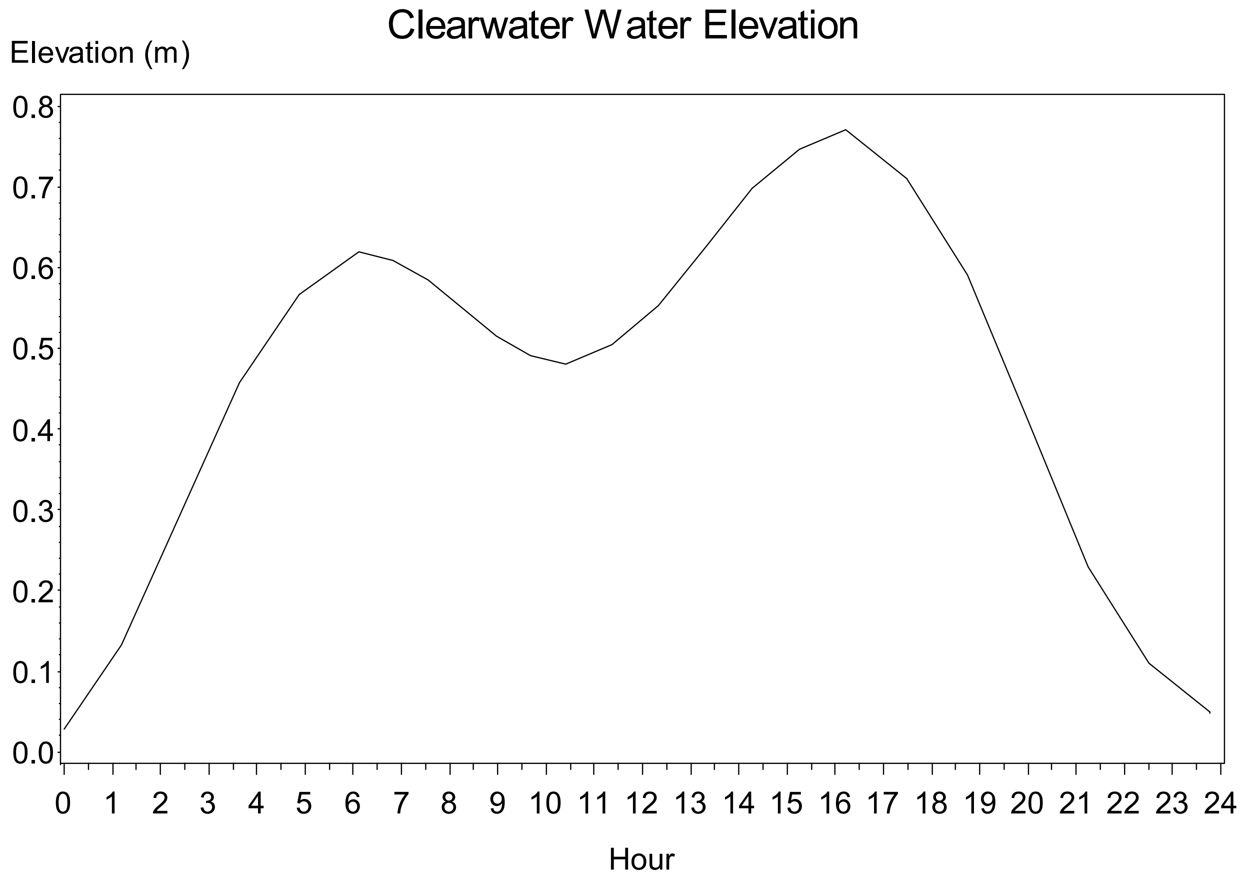

Figure 5.4. Illustration of a mixed semidiurnal tidal regime for Clearwater area.

Gulf of Mexico

Circulation in the Gulf of Mexico is dominated by the Loop Current and its related eddy fields. The Loop Current is part of the western boundary current for the North Atlantic Ocean. The Loop Current transports relatively warm water from the South Atlantic Ocean and the Caribbean Sea into the Gulf of Mexico through the Yucatan Straits. The Loop Current flows into the eastern Gulf of Mexico, and exits the Gulf through the Florida Straits. Over a typical period of six to thirteen months, the Loop Current extends northward into the central Gulf, sometimes as far as the continental slope and outer shelf south of the Mississippi River delta (Schmitz, 2002), then flows eastward and southward to the Florida Straits. The "loop" of warm water carried into the Gulf eventually "pinches off" from the main Loop Current, creating a large clockwise circulating (anti-cyclonic) eddy. When this happens, the main Loop Current moves directly from the Yucatan Straits to the Florida Straits, and out along the eastern continental slope of the U.S., where it becomes the Gulf Stream. Figures 5.5 through 5.10 show a typical evolution cycle of a Loop Current incursion into the Gulf of Mexico, with associated sea surface height and current velocities as derived from satellite altimetry.

Interactions of the Loop Current with the eastern Gulf of Mexico occur primarily when the current is extended northward into the Gulf. During these times, the Loop Current flows southward along the continental slope and outer shelf. The slope and outer shelf are about 200 km west of the west coast of central Florida. The interaction of the Loop Current with the slope and outer shelf may result in the creation of counter-clockwise circulating eddies. The effects of the Loop Current farther inshore are diminished, and the most inshore areas are typically not affected at all. Modeling studies have suggested that inshore of the 50-m isobath (the mid-shelf region) winds play the dominant role in circulation forcing (Yang and Weisberg, 1999). Drift studies at the mid-shelf region suggest a seasonal signal in surface circulation (Tolbert and Salsman, 1964; Williams et al., 1977) distinct from Loop Current cycles as well.

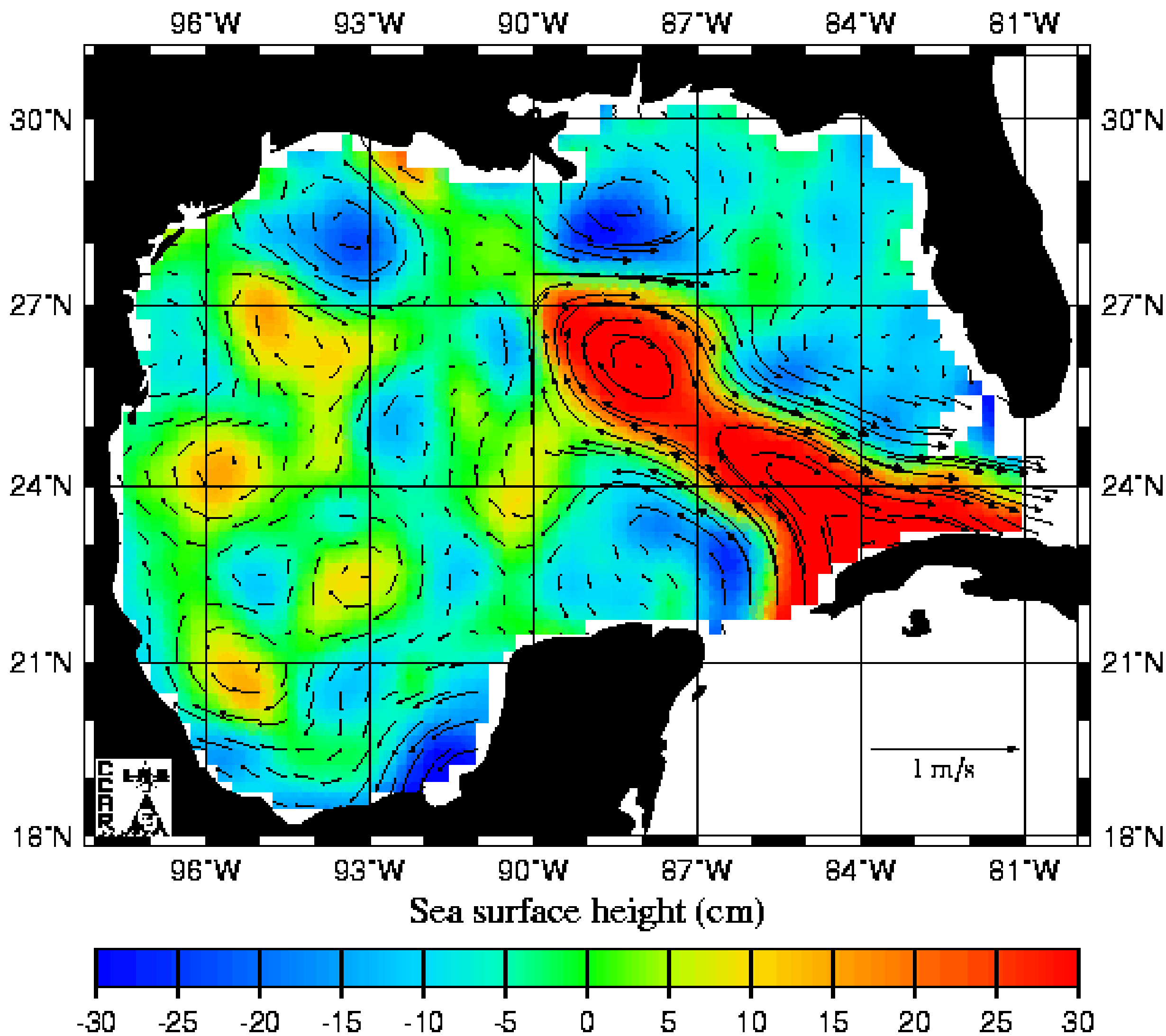

Figure 5.5. Sea surface height and current velocity, September 9, 1997, showing Loop Current intrusion into the Gulf of Mexico. Developed by Colorado Center for Astrodynamics Research (CCAR) from TOPEX and ERS-2 altimeter data.

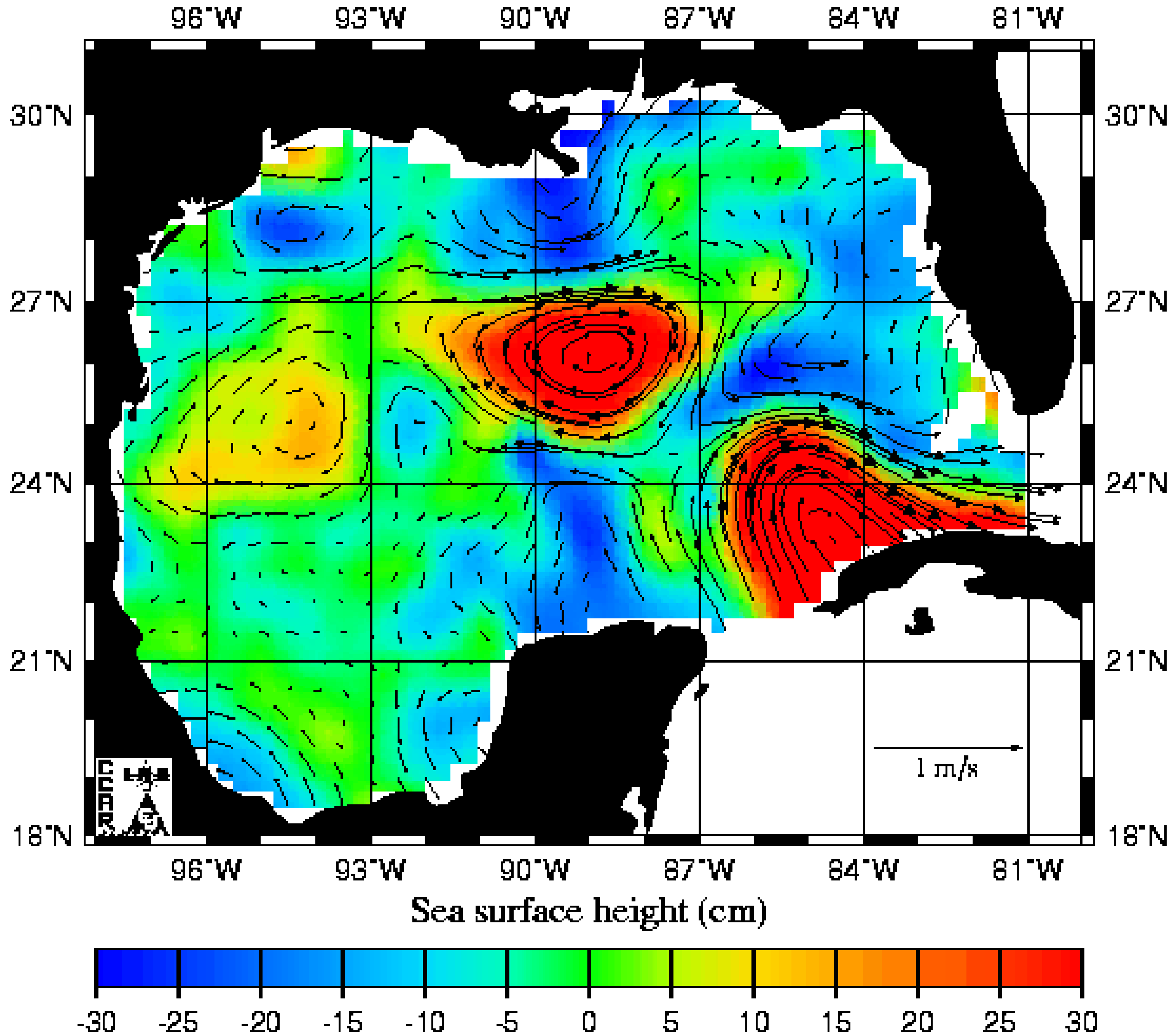

Figure 5.6. Sea surface height and current velocity, October 11,1997, showing eddy separation from Loop Current intrusion into the Gulf of Mexico. Developed by Colorado Center for Astrodynamics Research (CCAR) from TOPEX and ERS-2 altimeter data.

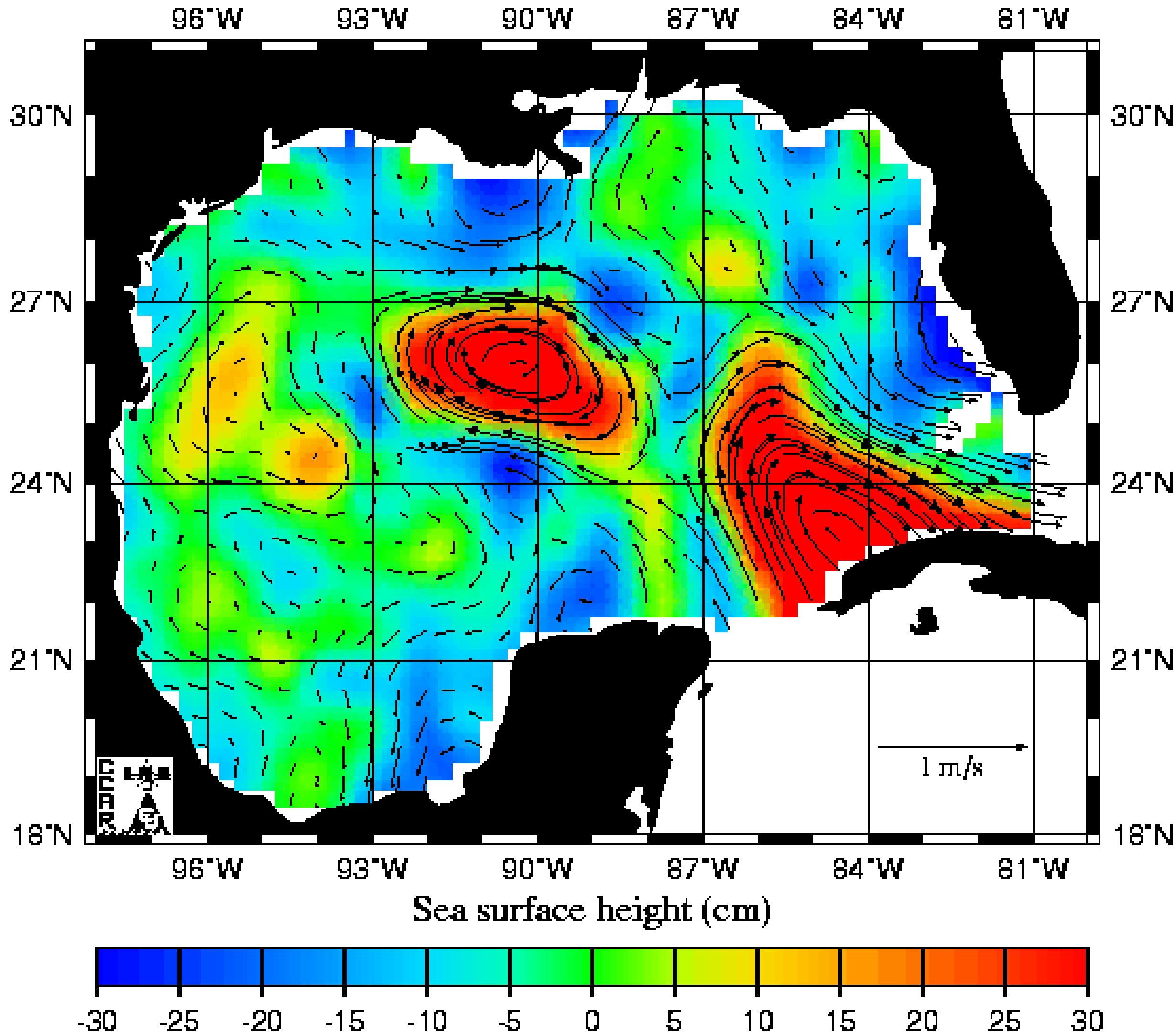

Figure 5.7. Sea surface height and current velocity, November 17, 1997, showing eddy movement to the west, with northward excursion of Loop Current into the Gulf of Mexico. Developed by Colorado Center for Astrodynamics Research (CCAR) from TOPEX and ERS-2 altimeter data.

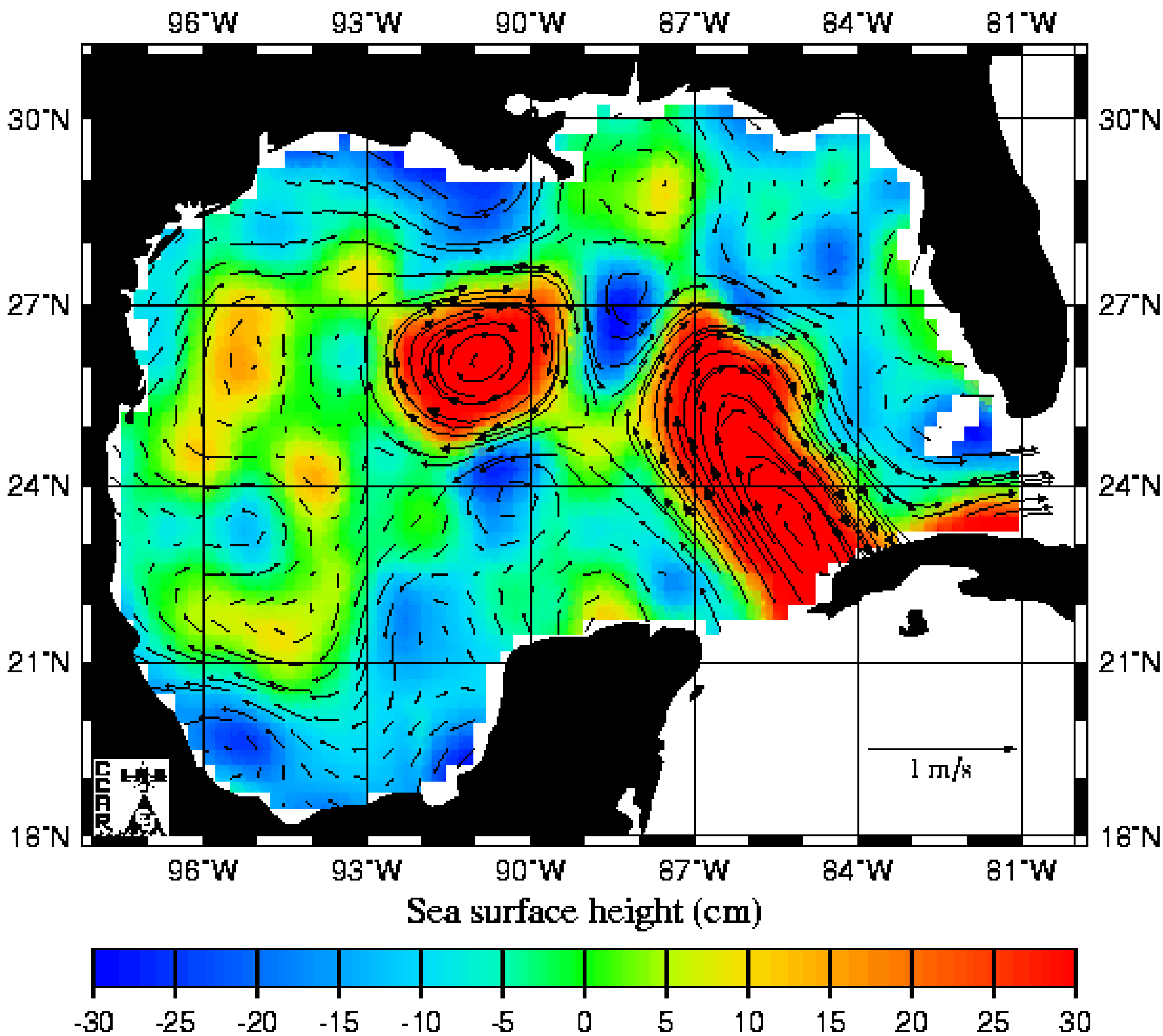

Figure 5.8. Sea surface height and current velocity, December 20, 1997, showing a Loop Current eddy and intrusion of the Loop Current into the Gulf of Mexico. Developed by Colorado Center for Astrodynamics Research (CCAR) from TOPEX and ERS-2 altimeter data.

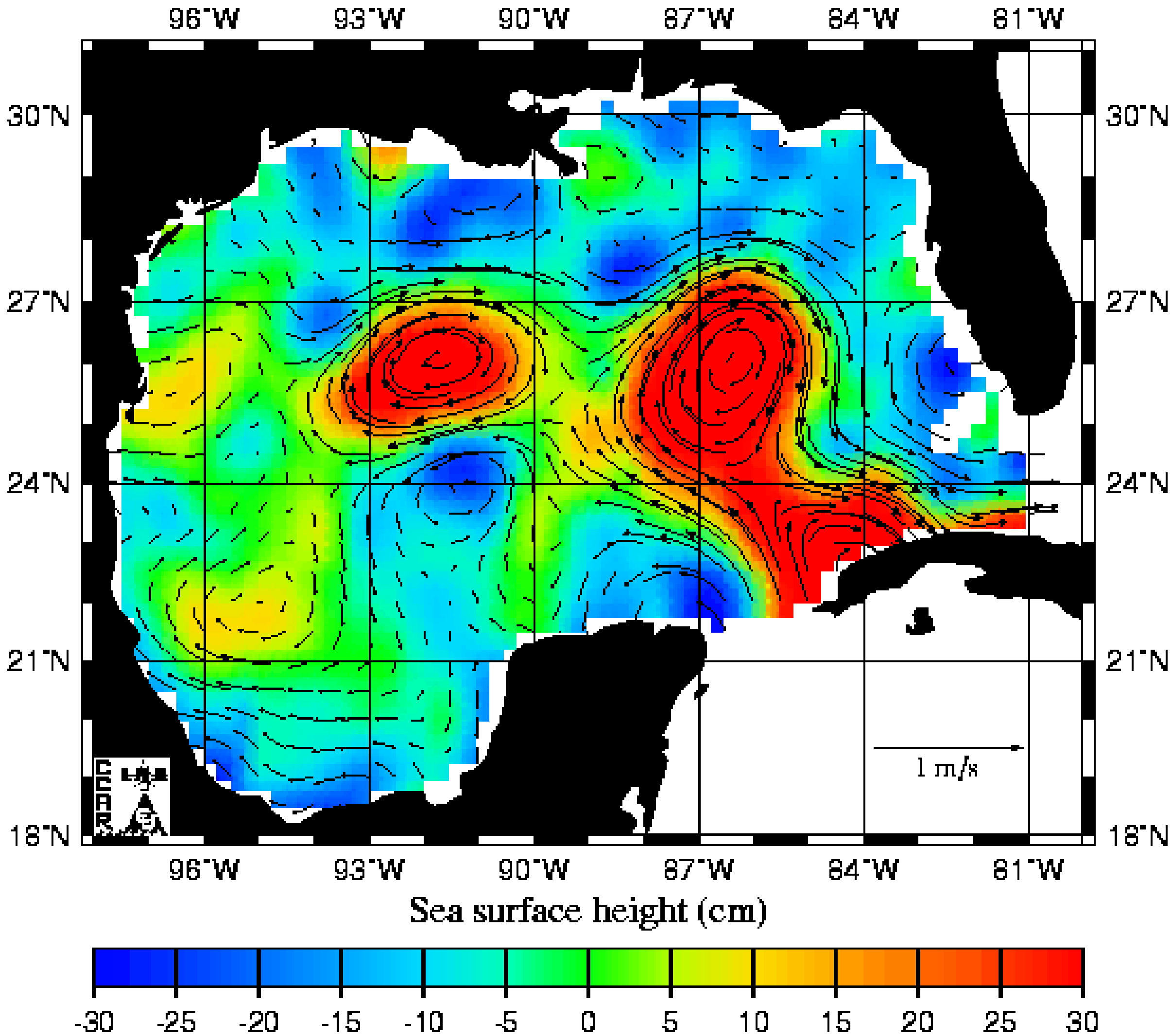

Figure 5.9. Sea surface height and current velocity, January 17, 1998, showing Loop Current eddy and "pinching" of the Loop Current intrusion in the Gulf of Mexico. Developed by Colorado Center for Astrodynamics Research (CCAR) from TOPEX and ERS-2 altimeter data.

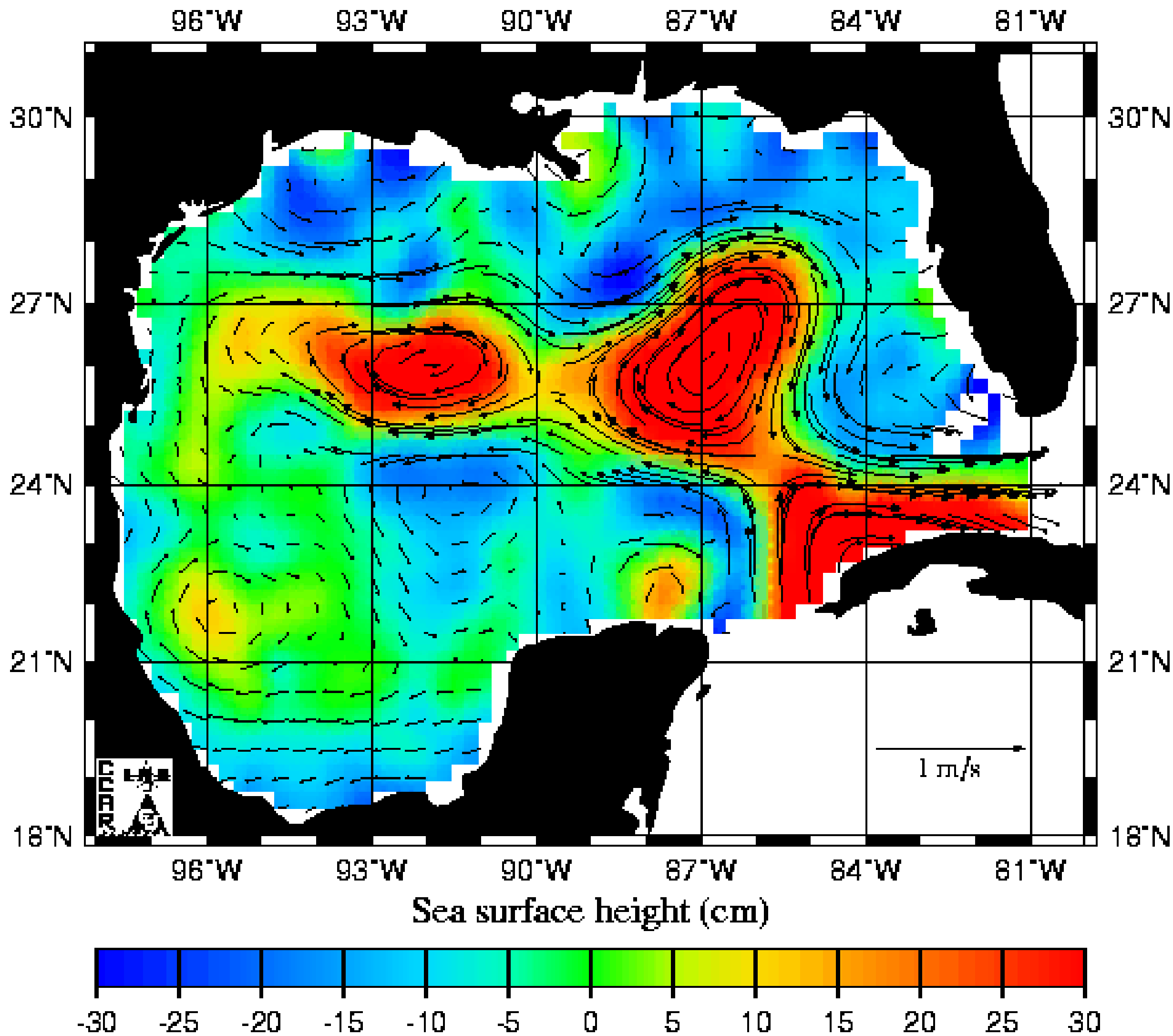

Figure 5.10. Sea surface height and current velocity, February 20, 1998, showing two LoopCurrent eddies in the Gulf of Mexico. Developed by Colorado Center for Astrodynamics Research (CCAR) from TOPEX and ERS-2 altimeter data.

West Florida Shelf

Circulation on the west Florida shelf is driven by winds, density differences, tides, and interactions with the Loop Current. The Loop Current, however, is not typically a primary forcing function inshore of the outer shelf, although intrusion may occur in the northern portion of the west Florida shelf (Gilbes et al., 1996). From the mid-shelf (50-m isobath) to the coast, comparison of model results to measured data suggests that wind is the dominant forcing mechanism for circulation (Yang and Weisberg, 1999). Winds from the northeast in winter (October-March) typically result in southeastward flow along the coast from the Big Bend region to south of Tampa Bay, while winds from the southeast in summer (April-September) result in northwestward flow along the coast.

Offshore of the 50-m isobath, however, model studies suggest that horizontal density differences may also be important determinants of circulation. These density differences may result from differential solar heating effects, with quicker heating of shallow water than of deeper water. Horizontal density differences may also result from transport of fresher water, as from the Mississippi River, along the outer shelf (He and Weisberg, 2001).

Tidal circulation on the west Florida shelf results in primarily cross-shelf movement of water parcels in an ellipse with a radius of about 1 km, with no net displacement over a tidal cycle (Weisberg et al., 1996). Simulations of tidal circulation (He and Weisberg, 2002) suggest that residual tidal circulation is small in the region of the Anclote Anchorage, with residual circulation directed to the southwest north and south of the Anchorage. During summer, when winds are typically from the southeast, tidal levels are higher than during winter, when winds are typically from the northeast.

Anclote Anchorage

Wind and tidal action, in concert with density effects related to freshwater inflow, are the primary forcing mechanisms for circulation in the Anclote Anchorage. Predicted tidal ranges for 2002 vary according to location in the area. For example, the difference between predicted highest and lowest tides at the north end of Anclote Key is 1.5 m, at the south end of the Key is 1.4 m, and at Tarpon Springs in the Anclote River is 1.4 m (Pentcheff, 2002). The mean diurnal tidal range, 0.8 m as measured at two nearby sites (Clearwater and Indian Rocks beaches), is approximately half the annual range. Observations of particle movement suggest that near the coast in the Anclote area, flooding tides transport water to the northeast, while ebbing tides transport water to the southwest (He and Weisberg, 2002). Early modeling studies of the Anclote area (Baird et al., 1972) support these observations. Observed and modeled currents during ebb and flood flows are presented in Figures 5.11 through 5.14.

Wind-induced circulation in the nearshore environment has been examined as part of a larger circulation study of the west Florida shelf (Yang and Weisberg, 1999). The model suggests that winter (October-March) winds from the northeast result in southward flowing nearshore currents from Tampa Bay to the Big Bend area, while summer (April-September) winds from the southeast result in northward flowing nearshore currents along the entire west Florida coast. The model results agree with observed transport off the coast of Clearwater.

Fresh water enters the Anchorage from the Anclote River, via discharge from the river mouth and through the Progress Energy facility discharge canal. Fresh water inflow to the coastal areas north of the Anchorage, from sources including the Pithlachascotee, Weeki Wachee, and Chassahowitzka rivers, may also be transported into the Anchorage. Transport of fresh water southward along the coast is dependent on wind-induced circulation, and is most likely when winds are from the north, as is typical during the winter. The main channel for the Anclote River extends into the Anchorage westward and then west-southwest in the direction of the southern end of Anclote Key. The Anclote Station discharge canal discharges to the Anchorage north of the river mouth, in the direction of the northern end of the Key. Salinity near the mouth of the river is typically 1-3 ppt less than in the middle of the Anchorage, based on data collected by the SWFWMD in 2000 and 2001. The effects of the fresh water input offshore of the mouth of the river are not evident, however. Likewise, input of fresh water from the Anclote Power Station discharge canal does not typically result in a recognizable low salinity signal near the mouth of the canal.

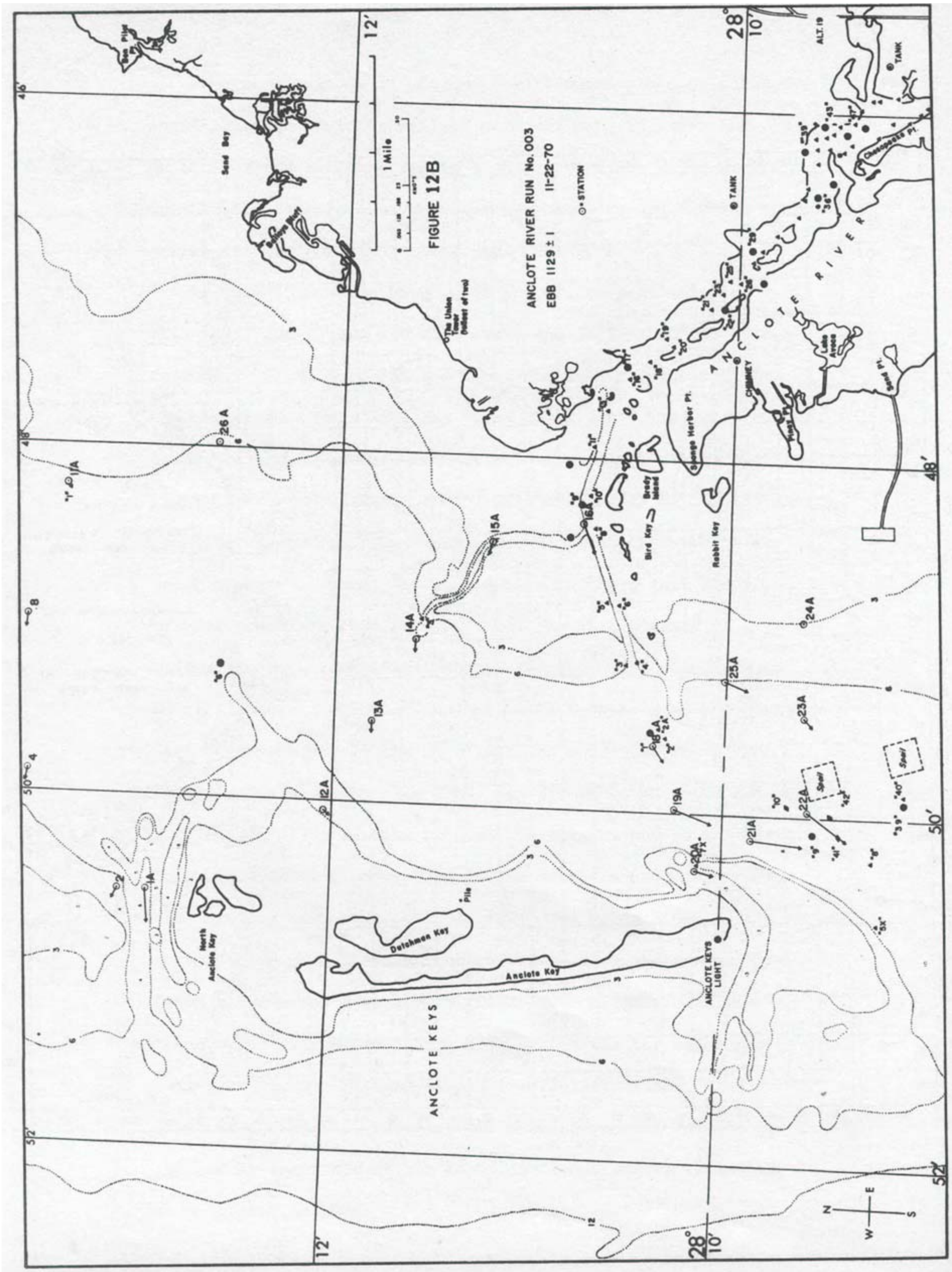

Figure 5.11. Observed current velocities at ebb flow under light wind conditions, Anclote Anchorage, November 22, 1970 (from Baird et al., 1972).

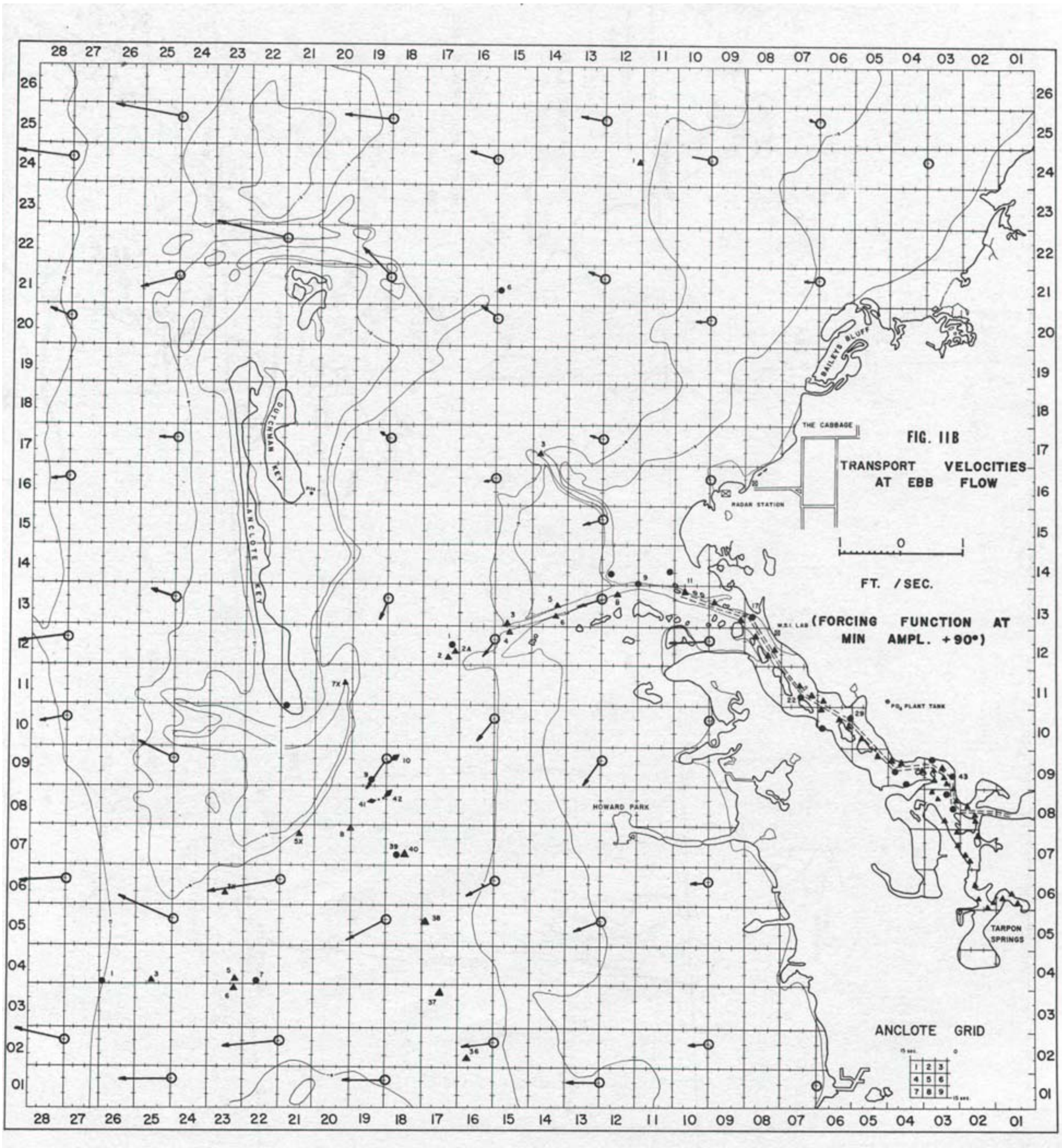

Figure 5.12. Modeled transport velocities at ebb flow, Anclote Anchorage (from Baird et al., 1972).

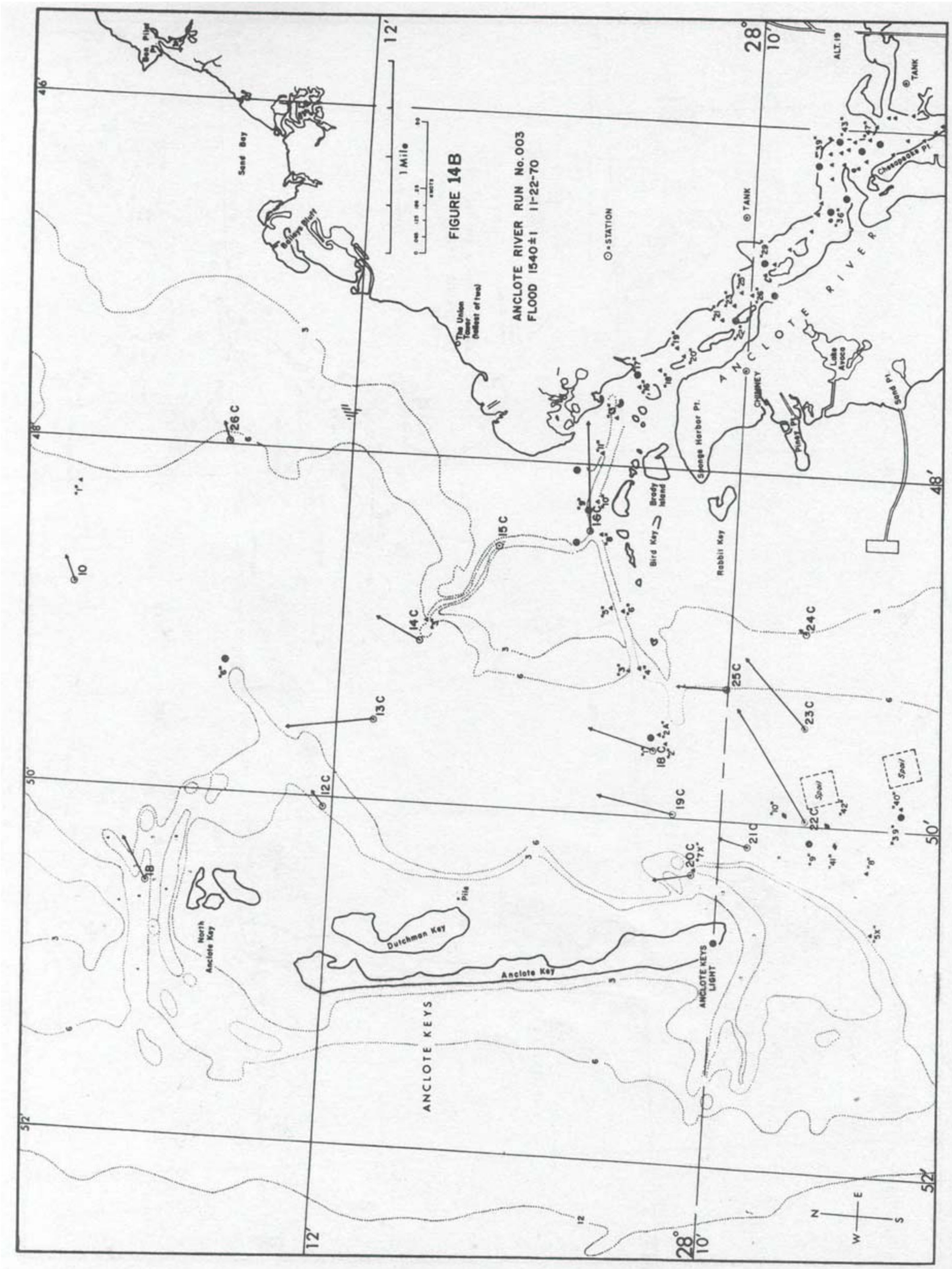

Figure 5.13. Observed current velocities at flood flow under light wind conditions, Anclote Anchorage, November 22, 1970 (from Baird et al., 1972).

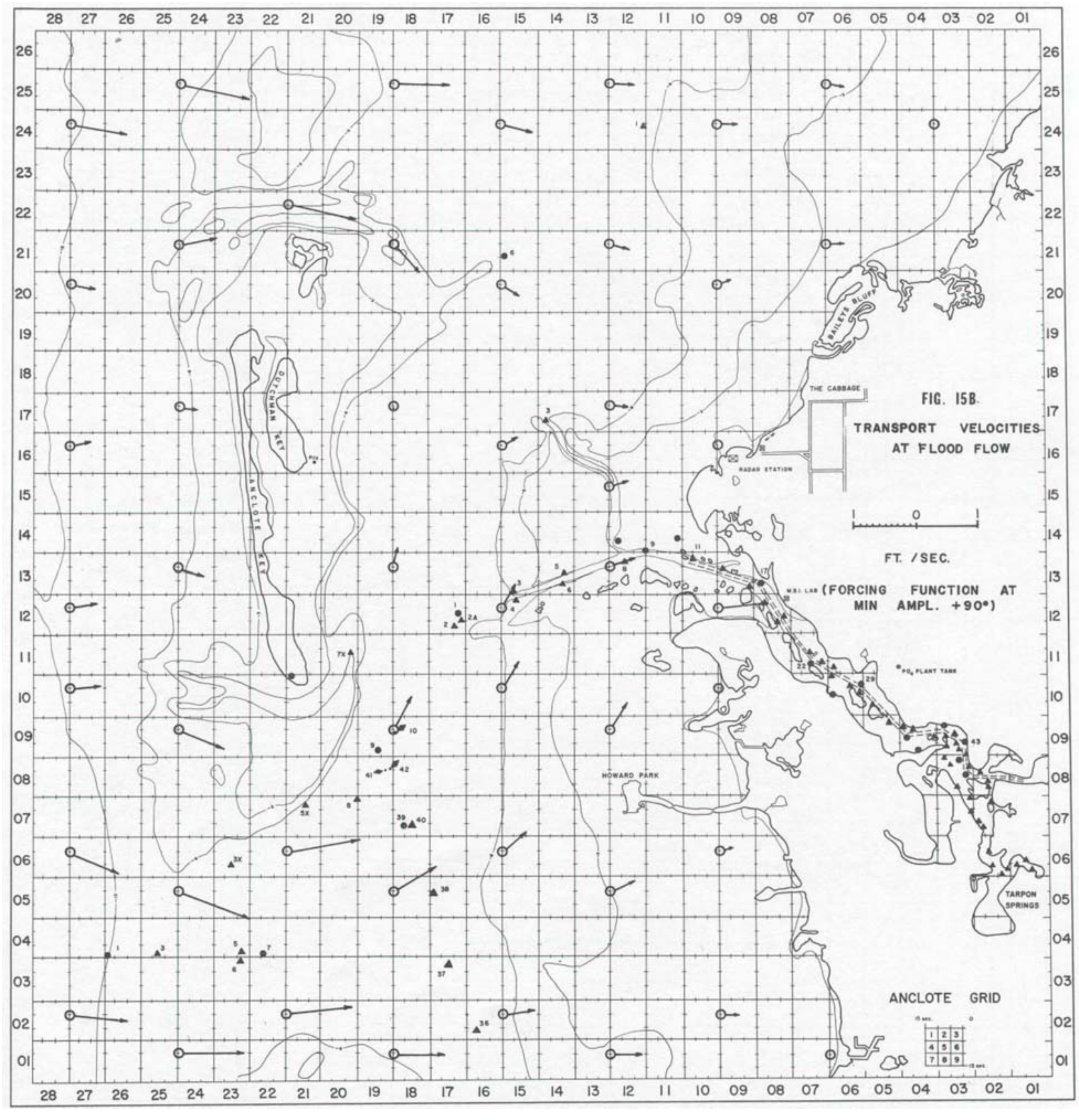

Figure 5.14. Modeled transport velocities at flood flow, Anclote Anchorage (from Baird et al., 1972).

6. WATER QUALITY

Water quality conditions in the Anclote Anchorage were summarized recently by Frazer et al. (2001), who conducted monthly monitoring at 10 stations (Figure 6.1.) in the Anchorage during 2000 and 2001. This work was done as part of "Project COAST," a cooperative monitoring effort carried out by SWFWMD and the University of Florida in the coastal waters of Pasco, Hernando, and Citrus counties (Frazer et al., 2001). Additional information on temperature and salinity patterns in the Anchorage is available from the early 1970s and early 1990s, from a series of reports prepared for the Florida Power Corporation. The University of South Florida College of Marine Science monitored temperature and salinity patterns in the area during the years 1970-1974 as part of broader effort to characterize physical and biological conditions prior to the construction of the Anclote Power Plant. Similarly, Mote Marine Laboratory (1991) monitored temperature and salinity as part of an evaluation of organisms associated with seagrasses along thermal gradients in the vicinity of the power station's outfall canal. Due to a lack of information on water quality conditions in the offshore waters of the Gulf of Mexico, the following summary covers only the inshore portion of the project area (i.e., the Anclote River, Anclote Anchorage, and nearshore Gulf waters in the immediate vicinity of Anclote Key).

6.1. Water Temperature

Contour maps of monthly surface water temperature during the years 2000 and 2001, based on data reported by Frazer et al. (2001), are shown in Appendix A. Surface temperatures show a clear pattern of seasonal fluctuation, with lowest values observed in the winter months (November through January) and highest values in late spring through fall (May through September). Spatial temperature variations are much smaller in magnitude, and in many months (e.g., March, April, November and December 2000; March, April, June, August, September and December 2001) no substantial spatial differences are apparent in the contour diagrams.

The range of water temperatures measured at the 10 Anclote Anchorage stations during the years 2000-2001 ranged between 10.0°C and 32.7°C (50-91°F). The highest median temperatures (24.8°C and 24.7°C, respectively) were observed at stations 2 and 3, reflecting the discharge of cooling water from the Anclote Power Plant, which is located just inshore from station 2. The lowest median temperatures (24.2°C and 24.0°C, respectively) were observed at stations 5 and 6, which are located on the western side of the Anchorage immediately east of Anclote Key. Effects of Anclote Power Plant operations on temperature regimes in the Anclote Anchorage have been investigated by the Florida Power Corporation. Thermal effects observed in a continuous monitoring program conducted between May 18, 1990 and January 3, 1991 were summarized as follows (FPC, 1991):

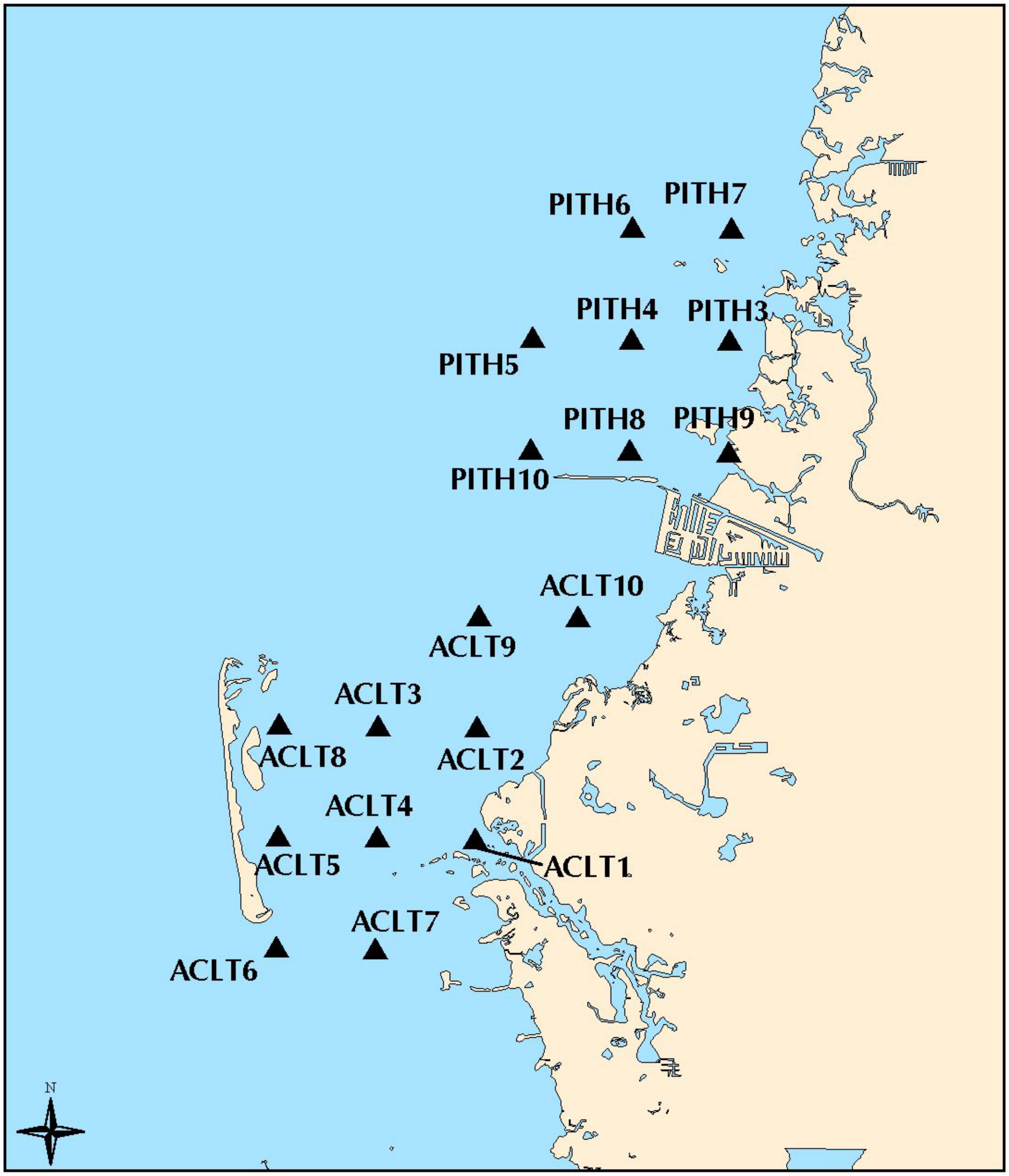

Figure 6.1. Project COAST water quality sampling stations used by Frazer et al. (2001).

"The heat content contributed by the Anclote Power Plant evidenced substantial seasonal variations as the result of planned operational practices... During the warmest summer period, heat content was increased on average by only 2.6%. The largest temperature increases across the plant took place during the fall and winter months (October to January) when the heat content of the intake waters was increased by up to 25%. On a daily basis, two periods of maximum discharge were typically observed and were presumably associated with periods of peak demand (0600-0800 hours and 1500-1800 hours). Diurnal cycles of temperature at the point of discharge produced maxima in later afternoon-early evening. These cyclical processes, coupled with tidal controls on the area and orientation of the plume, produce extremely variable thermal regimes within the study area."

6.2. Salinity

Near-surface salinities measured by Frazer et al. (2001) during 2000-2001 ranged between 23.0 and 38.5 part per thousand (ppt). The lowest median salinity (31.0 ppt) was observed at station 10, which is located immediately north of Bailey's Bluff. Station 1, located at the mouth of the Anclote River, exhibited a slightly higher median value of 31.6 ppt. The highest median salinities were observed at stations 6, 7, and 8, located near the passes at the northern and southern ends of Anclote Key, which connect the Anclote Anchorage to the Gulf of Mexico. The median values observed at all sites, which ranged between 31 and 33 ppt, were indicative of a "polyhaline" (high salinity) estuarine salinity regime (Day et al., 1989). Contour plots of wet-season and dry-season salinities measured by Frazer et al. (2001) are shown in Figure 6.2 through Figure 6.5.

Ambient salinity levels in the immediate vicinity of the Anclote Power Station discharge canal have probably been lowered somewhat by the construction and operation of the power plant, due to the diversion of river water to the plant and its subsequent discharge via the canal (Mote Marine Laboratory, 1991). During a normal rainy season, under conditions of high natural discharge in the river, the presence of the power plant's intake and discharge canals may actually reduce the likelihood of salinity shock in the area around the river mouth by diffusing the total discharge of the river over a broader area (Mote Marine Laboratory, 1991).

6.3. Dissolved Oxygen

Dissolved oxygen (DO) concentrations reported by Frazer et al. (2001) from stations in the Anclote Anchorage were characterized by a strong seasonal influence with highest DO concentrations occurring during the winter months and lowest concentrations during summer and fall. This pattern presumably reflects the inverse relationship that exists between water temperature and oxygen solubility, with higher solubility levels occurring at lower water temperatures.

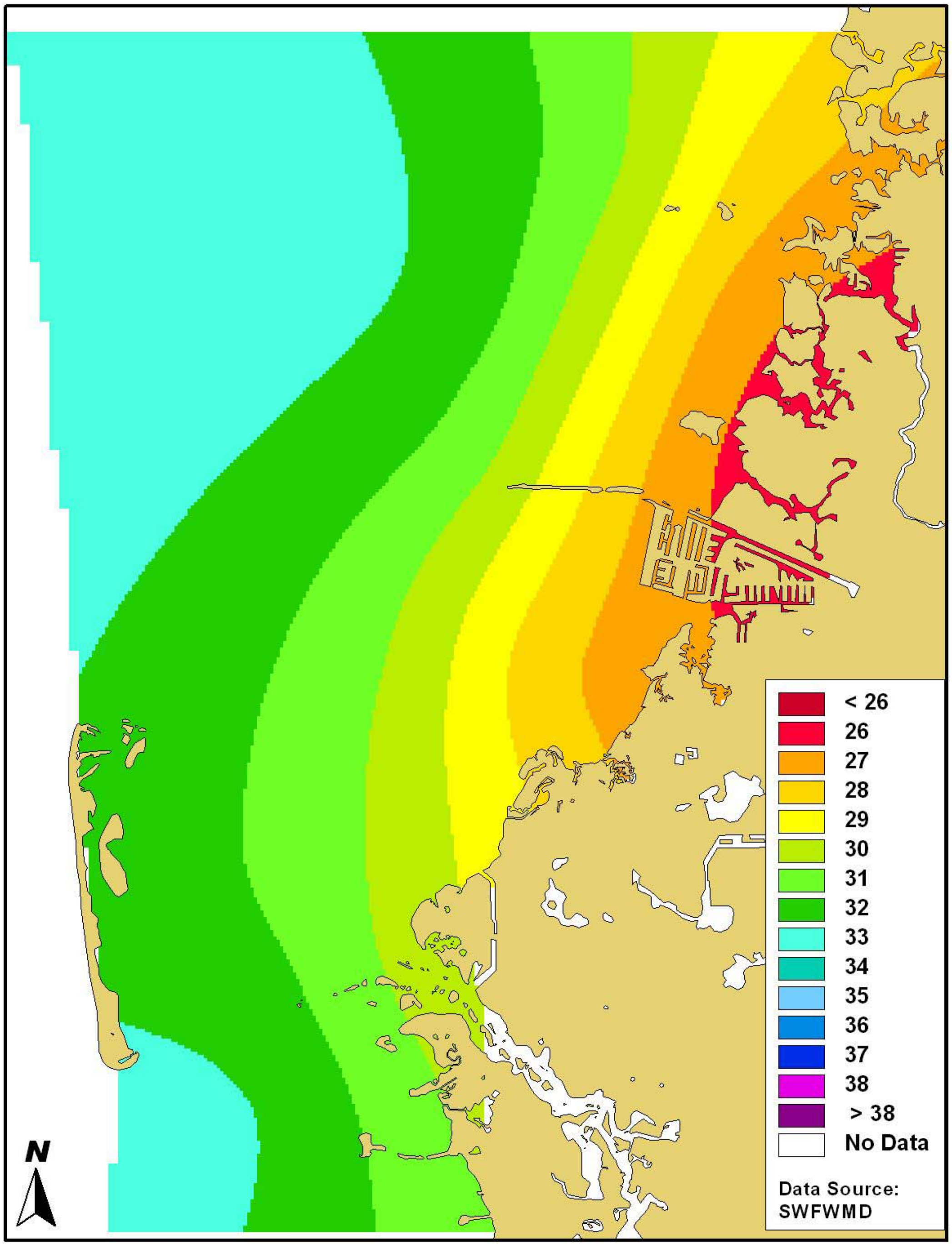

Figure 6.2. Contours of wet season salinities (ppt), July-October 2000.

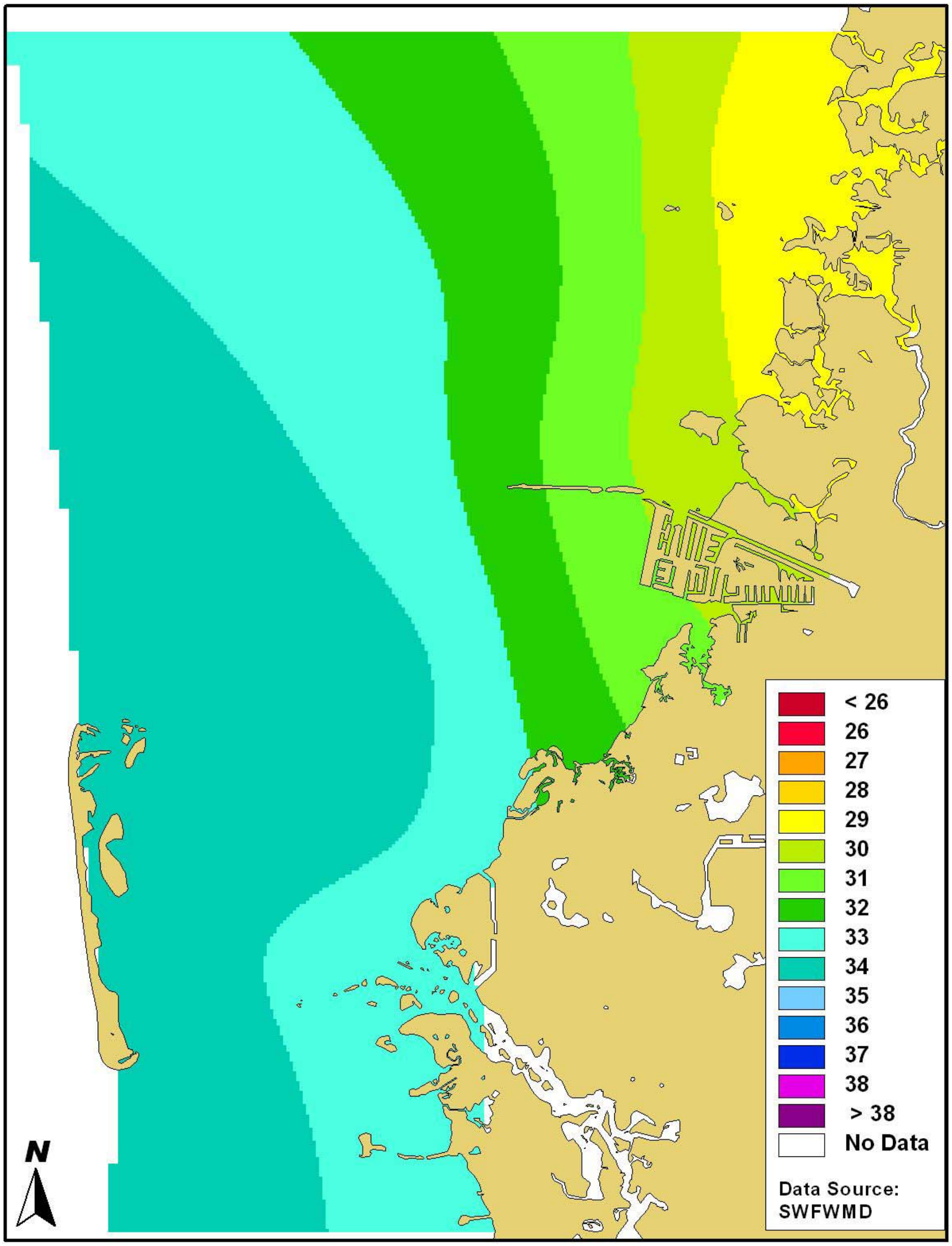

Figure 6.3. Contours of dry season salinities (ppt), January-June and November-December 2000.

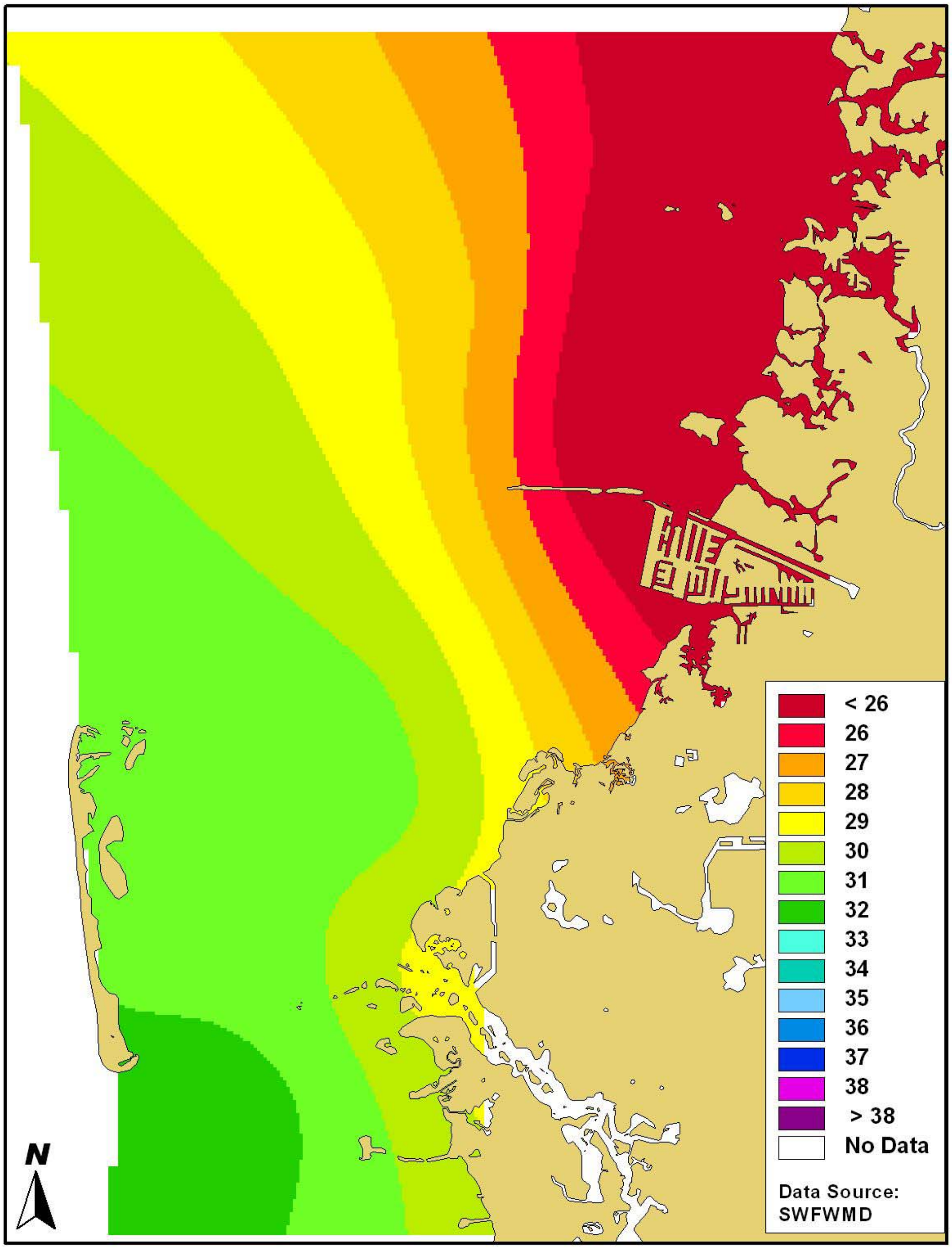

Figure 6.4. Contours of wet season salinities (ppt) July-October 2001.

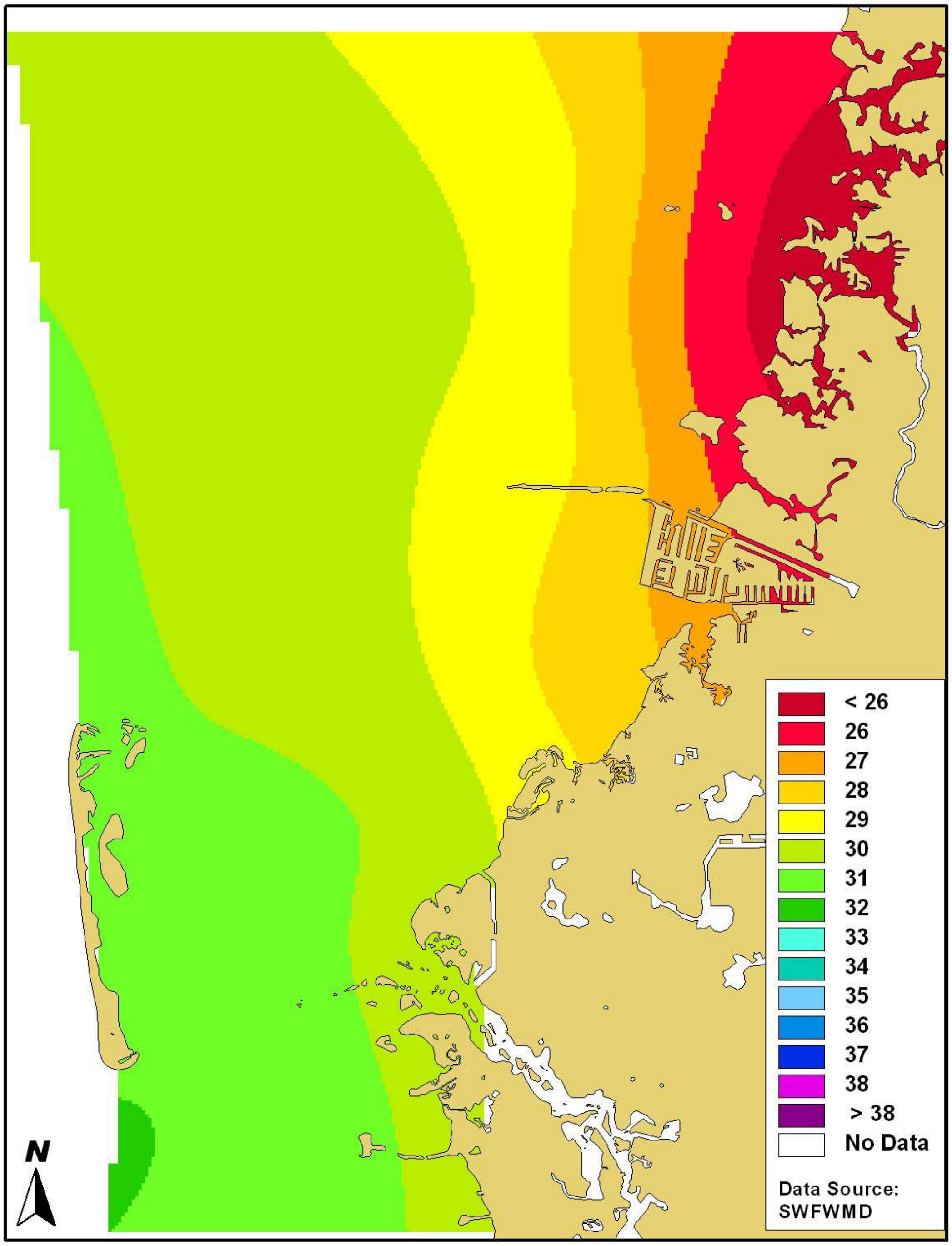

Figure 6.5. Contours of dry season salinities (ppt) January-June and November-December 2001.

Station 1, located in the mouth of the Anclote River, exhibited the lowest minimum (3.4 mg/L), highest maximum (10.4 mg/L), and lowest median (5.6 mg/L) DO concentrations observed at the Anclote Anchorage stations during 2000-2001. Station 1 also exhibited the highest median chlorophyll concentration (5.4 µg/L) during the period. The range of DO concentrations observed at the station may reflect, in part, the effects of phytoplankton photosynthesis and respiration on oxygen dynamics in the near-surface portion of the water column in that portion of the river.

6.4. Color

Water color, a measure of the level of dissolved organic materials that are naturally present in many freshwater rivers and streams, exhibited its highest values at stations 1, 2 and 10, three nearshore stations where the lowest median salinities were also recorded. The lowest median color levels occurred at stations 5, 6 and 7, presumably reflecting the influence of low-color marine water masses entering the Anchorage from the Gulf of Mexico through the pass located at the southern end of Anclote Key.

6.5. Nutrients and Chlorophyll

Macronutrients (nitrogen and phosphorus) and chlorophyll concentrations in the Anclote Anchorage during 2000-2001 were low, both in absolute terms and in comparison to other west-central Florida estuaries. At the Anclote Anchorage stations, median total nitrogen (TN) concentrations ranged from lows of 0.37 to 0.4 mg N/L (stations 5 and 6) to highs of 0.52 to 0.55 mg N/L (stations 1 and 10). These values are roughly comparable to the TN concentrations found near the mouth of Tampa Bay, and are substantially lower than the concentrations typically observed in more impacted estuarine areas such as Hillsborough Bay and Old Tampa Bay. Median total phosphorus (TP) ranged between 0.01 and 0.02 mg P/L at each of the Anclote Anchorage stations. These values are an order of magnitude lower than the TP concentrations typically observed in Tampa Bay.

Median chlorophyll concentrations at the Anclote Anchorage stations ranged between 1.1 and 4.6 µg/L, well below the 11 µg/L value that has been proposed as an indicator of "impaired" water quality by the State of Florida (Ch. 62-303 Florida Administrative Code). As was the case with TN, these concentrations are roughly comparable to the average chlorophyll concentrations observed near the mouth of Tampa Bay, and are substantially lower than the concentrations typically observed in more impacted areas such as Hillsborough Bay and Old Tampa Bay. Within the Anclote Anchorage the highest median concentrations of TN and TP were observed at station 1, presumably reflecting nutrient discharges from the Anclote River watershed. Station 4, located immediately west of the river mouth, exhibited the second-highest median TP concentration and the third-highest median TN concentration during the sampling period.

The second-highest median TN concentration was observed at Station 10, which is located immediately north of Bailey's Bluff. This station also showed relatively low salinity and high color values, suggesting that it may have been influenced by freshwater runoff from the nearby mainland. Chlorophyll concentrations exhibited their lowest median values at stations 8, 9 and 10, along the northern margin of the Anchorage. Highest median values occurred at stations 1, 4 and 7, in the south-central portion of the sampling area near the Anclote River mouth.

7. MAJOR HABITAT TYPES

Livingston (1990) provided the following description of the coastal area that extends northward from the Anclote Anchorage:

> "The region from the Anclote Keys north to the Ochlockonee River drainage can be viewed as one massive estuary. This open estuarine system is supplied by freshwater from the Anclote, Pithlachascotee, Weeki Wachee, Homosassa, Chassahowitzka, Crystal, Withlacoochee, Waccasassa, Suwanee, Steinhatchee, Spring Warrior, Fenholloway, Econfina, Aucilla, St. Marks, and Ochlockonee rivers. This combined drainage system of springs and streams contributes approximately 1 billion gallons of fresh water per day to…the northeastern Gulf of Mexico. This massive drainage is associated with relatively intact wetlands. The associated estuarine area, still undisturbed by human activities, is one of the least polluted coastal regions in the continental United States."

The following sections describe some of the more significant habitat types that are present in the Anclote Anchorage portion of this coastal region.

7.1. Inshore Habitats

Marshes and Mangrove Forests

Marshes and mangrove forests are intertidal wetlands that play an important role in estuarine and marine ecosystems. A number of studies have shown that these areas are among the most productive plant communities in the world (Day et al., 1989). In addition they play three critical ecological roles:

- providing food sources that support many estuarine and marine food webs,
- providing habitats for large number of juvenile and adult organisms, and
- regulating important components of estuarine chemical cycles.

A large number of recreationally and commercially important fish and shellfish species inhabit these areas during one or more stages of their life cycles (Haddad, 1989). Because of this ecological importance, coastal resource management programs place a high priority on marsh and mangrove habitats, focusing their efforts on protecting and maintaining existing areas and restoring sites that have been impacted by development or other human activities (e.g., TBNEP, 1996).

The plants that occur in these coastal wetlands inhabit a highly stressful physical environment. Natural tidal cycles cause alternate flooding and draining of their habitats. During extended periods of flooding soils become saturated with waters of varying salinities, oxygen levels become depleted, and natural toxins (such as sulfides) can develop that inhibit plant growth. During extended dry periods salt levels in soils can become elevated, and levels of sunlight and soil temperatures can become stressfully high.

The locations of salt marshes in the study area, based on 1999 land cover maps obtained from SWFWMD, are shown in Figure 7.1. The largest marshes occur in the northern portion of the area, along the coast immediately north of Bailey's Bluff, and in the upstream portion of the Anclote River. Smaller marshes are present on the coastal shoreline immediately north and south of the Anclote River mouth, and in scattered patches on the Anclote Key and Dutchman Key. Salt marshes on the Gulf coast of Florida often intermingle with mangroves, and are usually dominated by black needlerush (*Juncus roemerianus*), with several other herbaceous species such as cordgrass (*Spartina patens*), saltgrass (*Distichlis spicata*) and saltwort (*Batis maritima*) as secondary components (TBNEP, 1996).

The locations of existing mangrove forests in the study area, based on 1999 land cover maps obtained from SWFWMD, are also shown in Figure 7.1. The largest contiguous stands occur at the mouth of the Anclote River, on the eastern shorelines of Anclote Key and Dutchman Key, and throughout the smaller islands nearby. Smaller fringes of mangrove forest occur along the mainland coast north and south of the Anclote River mouth. Scattered pockets occur in the upstream portion of the Anclote River.

Three tree species dominate these forests: red mangrove (*Rhizophora mangle*); black mangrove (*Avicennia germinans*); and white mangrove (*Laguncularia racemosa*). These species usually occur on slightly different elevations within the intertidal zone, with white mangrove occurring most frequently at the highest elevation and red mangrove at the lowest (TBNEP, 1996). The number of species present and their vertical distributions can be quite variable among sites, however, in response to factors such as local topography, variations in freshwater inflow and salinity, and the frequency of disturbance from freezes, storms and lightning strikes (TBNEP, 1996).

Mangroves are tropical plants that can be stressed or killed by cold temperatures and usually do not occur in regions where the annual average temperature is below 19^{o}C (66 ^{o}F) (Odum and McIvor, 1990). Among the species found in the Anclote area white mangrove is the most cold-sensitive, reaching its northern limit on the Gulf coast in Hernando County. Red mangrove is intermediate in sensitivity, extending as far north as Levy County. Black mangrove is relatively cold-hardy and is found throughout the Florida Gulf coast (Wolfe, 1990). It survives in the northern portion of its range in a semi-permanent shrub form, through regeneration from the roots following severe freeze damage (Odum and McIvor, 1990).

Mangroves tolerate a wide range of salinities, from fresh water to hypersaline (elevated salinity) conditions. While Florida mangroves can be grown in fresh water, the mangrove ecosystem does not usually exist in freshwater environments, apparently

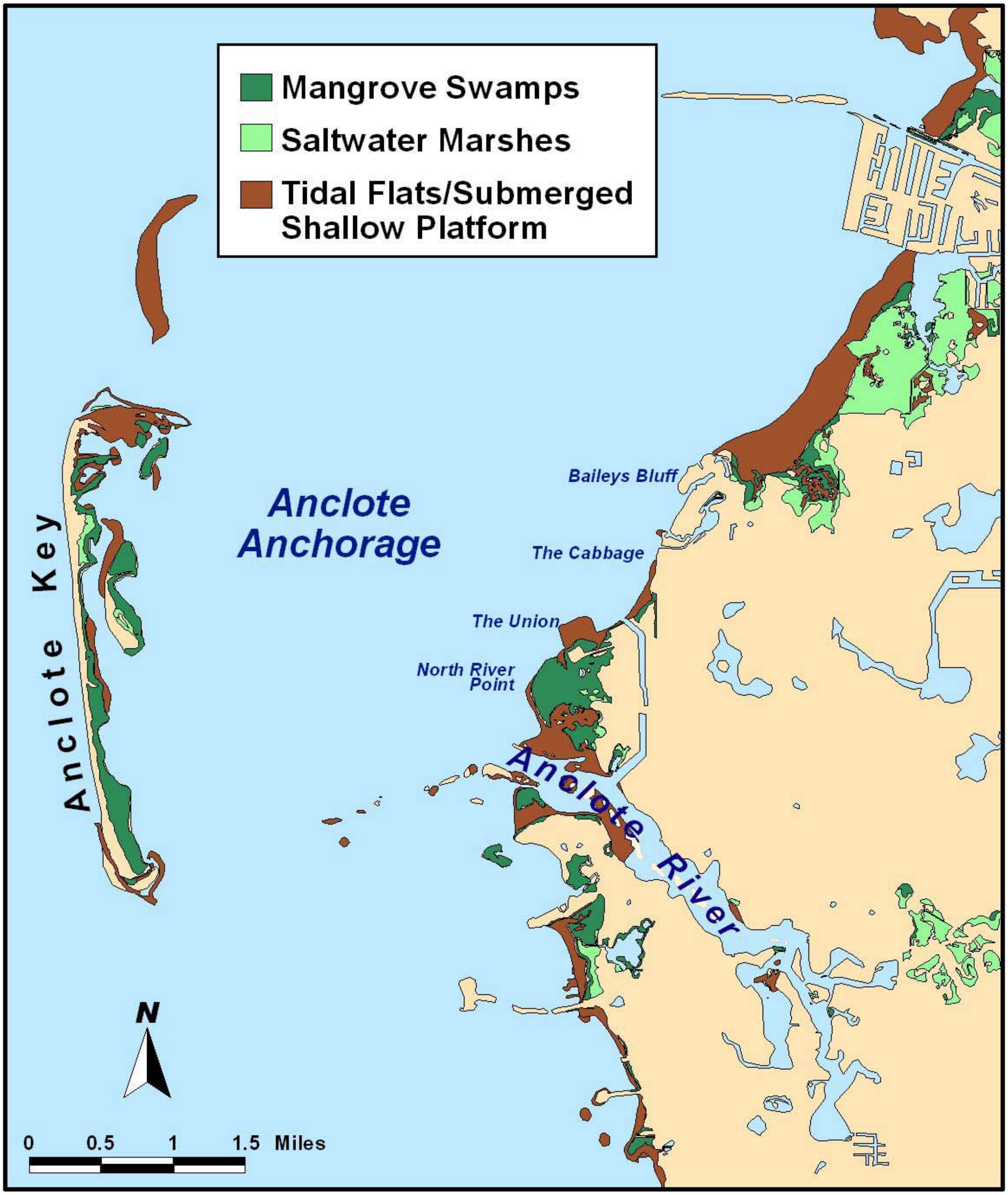

Figure 7.1. Map showing the locations of salt marshes, mangroves, and tidal flats.

because of ecological competition from freshwater plant species in those areas (Odum and McIvor, 1990). The physiological responses of mangroves to saline and hypersaline conditions include salt exclusion and salt secretion (Odum et al., 1982). Salt exclusion, a mechanism used by red mangroves, relies on the ability of the plant's roots to absorb only freshwater in a saltwater environment. The root cell membranes are able to exclude salt ions, and negative pressure in the xylem (produced as a result of transpiration by the plant's leaves) draws water into the root through the membrane in a "reverse osmosis" process (Odum and McIvor, 1990). Salt secretion, a mechanism used by black and white mangroves, is carried out by salt-secreting glands on the leaves that pump excess salts from the plant tissue. In practice most species of mangroves probably use a combination of salt exclusion and salt excretion together with other biochemical mechanisms of salt tolerance, including stomatal responses, enzyme activation, protein synthesis, and other ways to manage osmotic relationships across cell membranes (Odum and McIvor, 1990).

Mangroves occupy the intertidal zone, which is an area of transition between land and brackish or saline water, and the trees' growth forms often differ in different portions of this zone. The "fringe mangrove" growth form, which is relatively tall, is usually found in the lower intertidal zone where the trees are inundated by tides on a nearly daily basis. In areas where the lower intertidal zone is influenced more by river flows than tides, a "riverine mangrove" growth form is common. These trees develop in an environment characterized by higher nutrient levels and lower salinities than the "fringe" form, and are larger and more robust. Trees growing at slightly higher elevations, in the mid and upper intertidal zone, vary in size depending on local climatic conditions and levels of freshwater discharge. Higher still, at the lower edge of the supratidal zone, "scrub mangroves" occur which are nearing the limits of their physiological tolerances and experiencing competition from upland vegetation (Twilley 2001).

Intertidal Flats

The unvegetated bottoms of estuaries, bays and river mouths that lie between the extreme high and low tide lines are commonly referred to as "intertidal flats" (Wolfe, 1990). Bottom sediments in these areas range from coarse sand to fine mud, depending on the characteristic wave energy of the local environment. Coarse sediments normally predominate in high-energy areas where frequent scouring is a factor, while fine sediments normally predominate in low-energy depositional areas. Wolfe (1990) provided the following summary of the ecology of these areas:

> "Intertidal flats appear barren and unproductive because of the absence of macrophytes such as marshgrass or seagrass. Benthic microalgae, while very abundant and productive, do not accumulate the great biomass that marshgrasses do. Microalgae are nutritious and highly palatable to many herbivores; they are therefore rapidly used and maintain a low standing stock. Benthic microalgae generally do not go through the intermediate bacterial or fungal food chains but are consumed directly by benthic invertebrates. For these reasons,

> intertidal flats contribute to an estuarine system a substantial amount of primary production which is, in turn, converted into consumer biomass. The benthic invertebrates are preyed upon by larger predators such as shorebirds, crabs, and bottom-feeding fishes. Intertidal flats play a critical role in the functioning of the entire estuarine system."

The estimated locations of existing intertidal flats in the study area, based on maps obtained from the National Oceanographic and Atmospheric Administration (NOAA), are also shown in Figure 7.1.

Oyster Bars

In the "Springs Coast" region that lies immediately north of Anclote Anchorage, oysters have built immense reefs that extend up to 5.5 km (3.4 miles) from shore into the open Gulf of Mexico (Wolfe, 1990). This level of reef-building has not occurred in the Anclote Anchorage, where oysters are distributed in small bars and scattered clumps. These bars are intertidal structures that consist of a matrix of living oysters, shell and shell rubble, and a variety (up to several hundred species) of associated organisms (Wolfe, 1990).

The primary bar-building oyster in the Anclote Anchorage is the American oyster, *Crassostrea virginica*. The crested oyster (*Ostreola equestirs*) is also present in the region (Wolfe, 1990). These genera are particularly well-suited for estuarine existence because they can tolerate a wide range of temperatures 0-40°C (32–104°F), salinity (4–45 ppt), turbidity, and dissolved oxygen concentration (Day et al., 1989).

The American oyster typically lives in estuaries and behind barrier islands, and is abundant along the Gulf coast from Florida to Texas. Its range also extends from the Yucatan Peninsula to Venezuela in the Caribbean Sea, and along the east coast of North America from Key Biscayne to the Gulf of St. Lawrence (Stanley, 1988). In Florida its predominant habitats include estuaries (particularly near the mouths of rivers) in areas less than 10 m (33 ft) deep with firm substrates such as mud/shell bottom that provide suitable attachment sites for larvae. Adult oysters are sedentary filter-feeders, depending on phytoplankton, other particulate organic matter, and possibly dissolved organic substances for survival and growth (Livingston, 1990). Oyster bars have several important ecological effects, including:

- modification of current patterns and wave energy regimes,
- filtration of phytoplankton, bacteria and other small particles from the water column through oyster feeding activity,
- transformation of organic matter and nutrients through oyster digestion and excretion activity, and

- provision of habitat for other bar-dwelling organisms, and feeding sites for higher predators.

Oysters spawn in response to changes in water temperature, and the preferred spawning temperature varies among populations. In the Gulf of Mexico, the temperature must be constantly above 20ºC (68 ºF) for spawning, and above 25ºC (77ºF) for mass spawning. Oyster larvae are planktonic and remain in the water column for two to three weeks after hatching. Older larvae are often found in the lower portion of the water column during flood tides, rising nearer the surface during the ebb. This behavior apparently allows larvae to be transported up-estuary despite the presence of net downstream water flows. Oyster larvae settle preferentially in established oyster beds and in other habitats with hard substrate and appropriate salinities. Settling is affected by pheromones and other chemical cues associated with oyster shells and by physical factors such as currents, temperature, and light and silt levels. Following settling, oyster growth rates are influenced by temperature, salinity, levels of intertidal exposure, turbidity, and food supply (Stanley, 1988).

Optimum water temperatures for growth, reproduction and survival of American oysters range from about 20^{oC} to 30ºC (68-86ºF), and the response of oysters to temperature changes and extremes depend on a variety of other environmental and life-history conditions. Adult oysters in the Gulf of Mexico normally are found at salinities between 10 and 30 ppt, but tolerate a salinity range of 2 to 40 ppt. Outside this range they discontinue feeding and reproduction and may die. Prolonged exposure to low salinities (<10 ppt) during flood events is frequently fatal. Oysters in some areas can tolerate hypersaline conditions, and populations in the Laguna Madre area of Texas grow and spawn in salinities greater than 40 ppt. Mass mortality has also been observed in some locations at these salinity levels, however, perhaps exacerbated by water temperatures that exceeded 98 ºF during the same time periods. Conversely, heavy freshwater inflows can benefit oyster populations under some conditions, by killing relatively sedentary predators, such as oyster drills and welks, which cannot tolerate low salinities (Stanley, 1988).

An appropriate range of current velocities is particularly important for oyster survival, because currents play important roles in facilitating feeding, removing feces, and preventing burial by sediments. For maximum feeding the volume of water immediately above a reef must be renewed 72 times every 24 hours. Excessively strong currents that transport sand and pebbles, however, can damage oysters by eroding their shell surfaces (Stanley, 1988).

<u>Seagrass Meadows</u>

Seagrass meadows represent one of Florida's most important estuarine and marine habitats. Their ecological importance rests on a series of factors (Zieman and Zieman, 1989):

- *high productivity and growth*: seagrass plants are capable of very rapid growth (e.g., typical leaf growth rates 5 mm per day) and high levels of primary productivity,

- *food and feeding pathways*: the organic matter produced by seagrasses can follow either of two pathways through estuarine and marine food webs: direct grazing by herbivorous animals; or consumption of the detritus formed by decaying seagrass material,

- *shelter*: seagrass meadows serve as an important "nursery area" for the juvenile stages of many commercially and recreationally important fish and shellfish species,

- *habitat stabilization*: seagrasses stabilize sediments in two ways —the leaves and plants reduce current velocities near the sediment-water interface, allowing sedimentation of suspended particles and inhibiting sediment resuspension; and roots and rhizomes form an interlocking matrix that helps to retard scouring and erosion, and

- *nutrient effects:* the production of detritus and promotion of sedimentation provide organic material to the sediments, helping provide a conducive environment for nutrient recycling.

Seagrasses are a relatively small group of flowering plants that have adapted to survive and reproduce in the marine environment. The three dominant species of the Anclote Anchorage area are *Thalassia testudinum*, *Syringodium filiforme*, and *Halodule wrightii* (Zieman and Zieman, 1989).

Turtle grass (*Thalassia*) is the largest of the local seagrass species, with long strap-shaped leaves and robust rhizomes. Together with manatee grass (*Syringodium)*, this species dominates the densest meadows in the region. Manatee grass can be distinguished by its cylindrical leaves which, because they are brittle and buoyant, are frequently broken off from the parent plant and dispersed widely by winds and currents 1989. Shoal grass (*Halodule*) has flat, narrow leaves and a shallow root system, and is considered to be an early successional species in the development of seagrass beds in the Gulf and Caribbean. Shoal grass is able to survive more frequent and prolonged exposure during periods of low tide, and is often the predominant species at the shallow-water fringe of meadows in the Anclote region. Shoal grass also dominates the deep-water edge of many of these meadows, and exhibits different growth forms in the two depth zones (Zieman and Zieman, 1989).

The seagrass species found on the west coast of Florida are adapted to survive in a wide range of salinity and temperature regimes, but can be stressed or killed by extreme conditions. The three most common seagrasses in the Anclote region are all relatively euryhaline (tolerant of a wide range of salinities). However, turtle grass and manatee grass show reduced photosynthesis rates when salinity drops below full-strength seawater, and surveys in the Florida Big Bend region did not find either species in salinities less than 17 ppt, while shoal grass is more tolerant of low salinities (Zieman and Zieman, 1989). Temperature tolerances have been most widely studied for turtle grass, which exhibits maximum photosynthesis rates at temperatures of 28–30°C (82-86.0°F) and can tolerate temperatures of 20–36°C (68–97°F). Growth of manatee grass and shoal grass are reported to increase with temperature to a maximum near 30°C (86.0°F) (Mote Marine Laboratory, 1991).

Through its diversions of low-salinity Anclote River water and discharges of heated effluent, the Anclote Power Station causes small but measurable changes in salinity and temperature regimes in the portion of the Anclote Anchorage immediately adjacent to the station's discharge canal. Mote Marine Laboratory (1991) and Vanasse Hangen Brustlin, Inc. (2002) performed studies for Florida Power Corporation (now Progress Energy) to assess the potential impacts of these changes on seagrass meadows within the Anchorage. Mote Marine Laboratory (1991) compared seagrass acreage within the Anchorage in March 1981, November 1988, and April1990. In all three periods seagrass coverage was "generally limited to above the 6' contour below mean lower low water (MLLW) and most areas were classified as 'dense.'" No consistent pattern of loss, gain or net change in acreage as a function of temperature was apparent. Net increases in coverage or density predominated in both thermally-affected and non-affected areas. Substantial gains in seagrass acreage were observed in deeper sections of the Anchorage, a pattern that Mote Marine Laboratory (1991) attributed to regional improvements in water quality. Vanasse Hangen Brustlin, Inc. (2002) analyzed seagrass acreage trends for the years 1990 through 2000 and found a 19% (1,142 acre) increase over that period. The most notable areas of expansion were in northern, deeper portions of the Anchorage, a pattern also attributed to regional water quality improvements (Vanasse Hangen Brustlin, Inc., 2002). Figure 7.2 illustrates the distribution of seagrasses in the Anclote Anchorage area based on SWFWMD 1999 data.

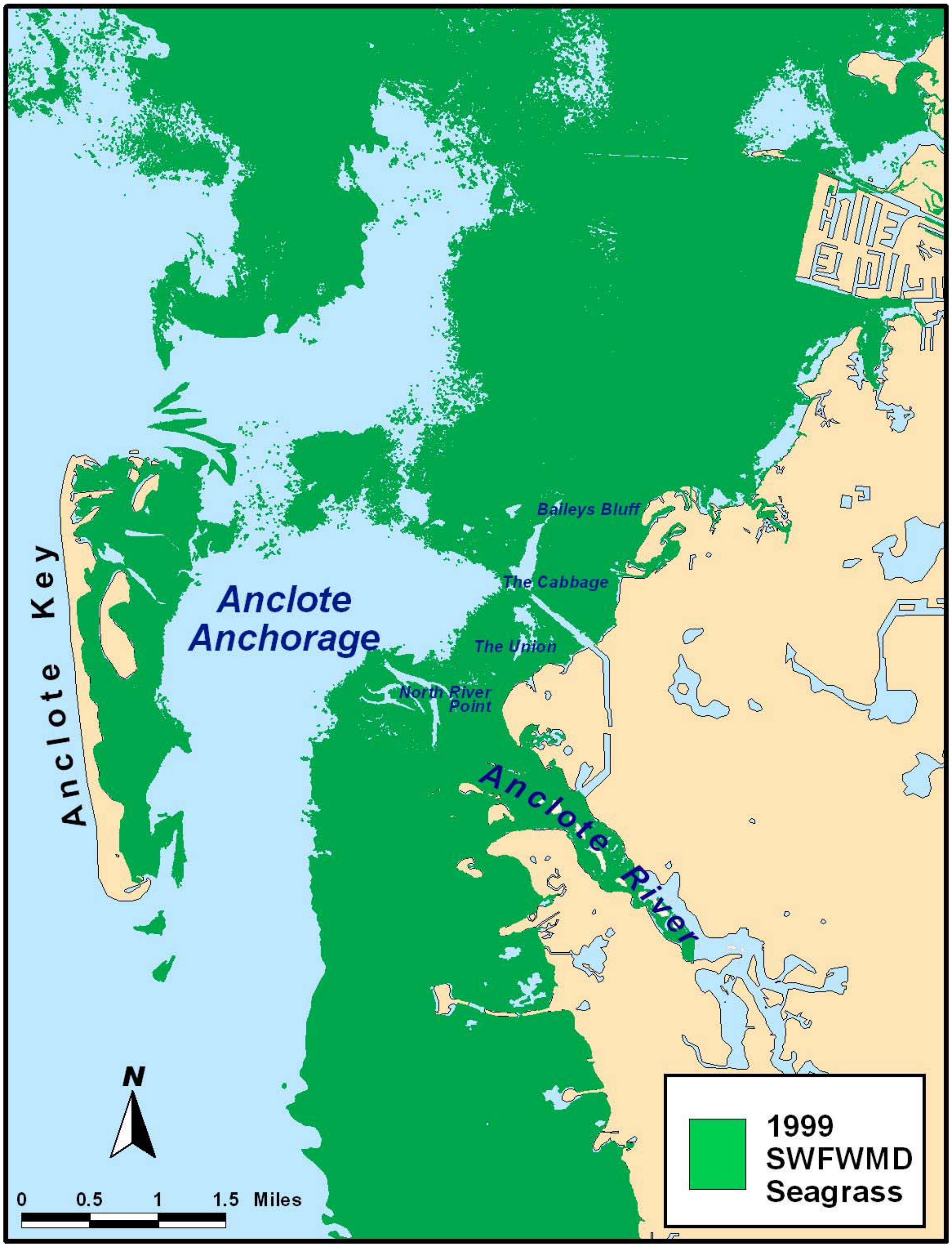

Figure 7.2. Distribution of seagrasses in the Anclote Anchorage.

Unvegetated Soft Bottom

Unvegetated soft-bottom areas are not widespread in the nearshore portion of the Anclote region, because the shallow depths and relatively high clarity of the water encourage the development of extensive seagrass meadows. Unvegetated areas are typically found near the mouths of rivers and other high-turbidity areas, where low salinities and light limitation may inhibit seagrass growth, and in areas of high wave energy near beaches and other exposed shorelines.

The distribution and abundance of benthic organisms in soft-bottom areas are strongly affected by sediment characteristics, such as grain size and organic content, and by physical factors such as temperature, salinity, and DO availability. Wolfe (1990) provides the following summary:

> "Grain size appears to be the single most critical factor, because many [benthic] organisms have specific requirements for feeding and tube building. Deposit feeders (i.e., animals that ingest sediment particles) usually dominate in fine-grained muddy sediments because of the increased availability of detrital material and microorganisms as food. Suspension feeders require contact with the sediment-water interface to feed and are usually present in more stable sedimentary environments where there is less sediment movement and suspended material to clog their feeding structures."

The distributions of coarse (sand) and fine (mud) particle sizes along transects within the Anclote Anchorage, based upon data from a study conducted by Mote Marine Laboratory (1991), is shown in Figure 7.3.

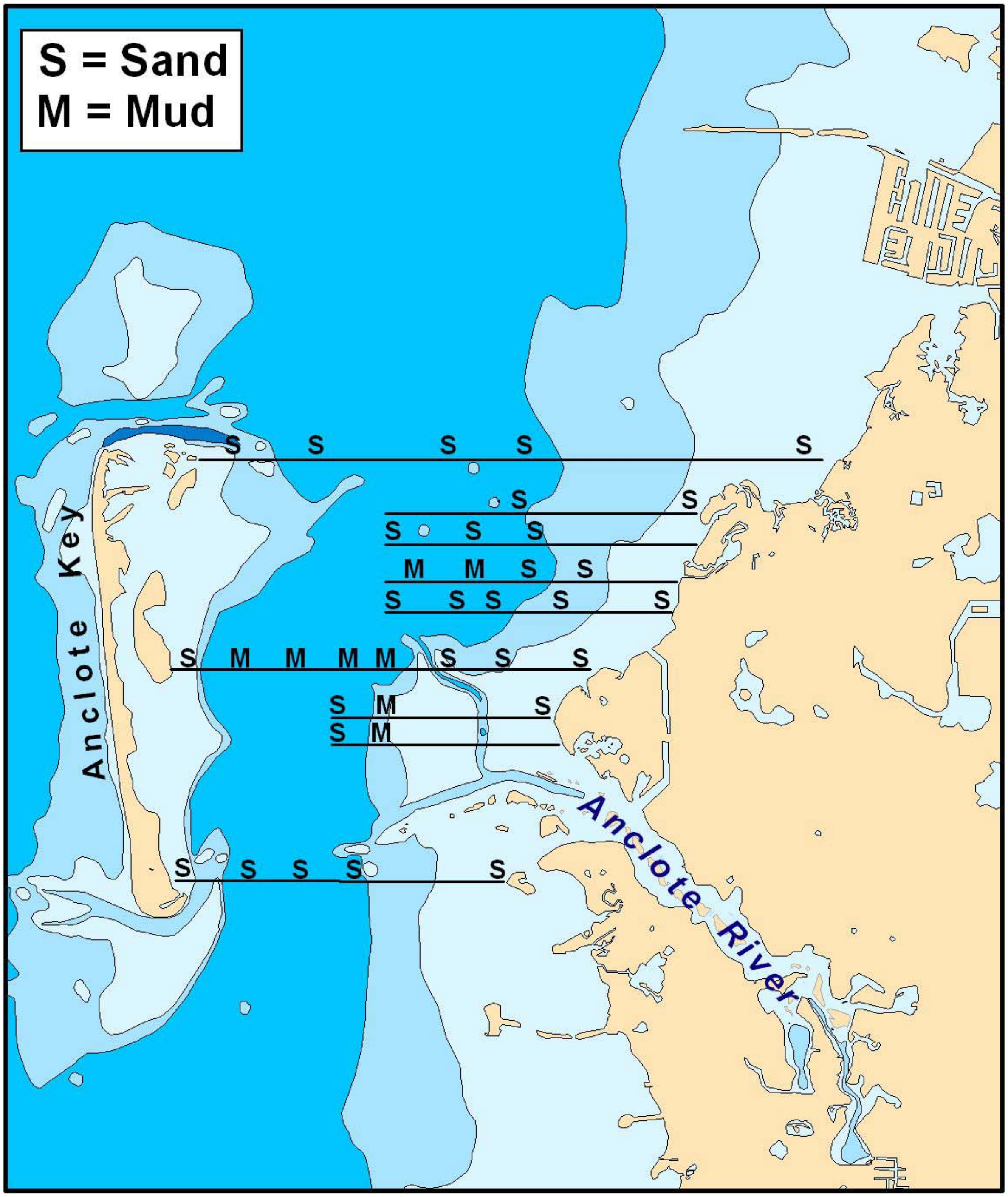

Figure 7.3. Distribution of sand and mud in the Anclote Anchorage.

Soft-bottom benthic habitats are ecologically important because the animals that inhabit them are directly or indirectly involved in most physical and chemical processes that occur in estuaries (Day et al., 1989). Some of these processes are complementary and others are contradictory. For example, some benthic animals increase water clarity by filtering particulate matter, while others increase turbidity by stirring up sediments. All benthic animals regenerate nutrients that can stimulate primary production, and nearly all serve as food for birds and for the larger numbers of fish and macroinvertebrate predators that characterize these shallow water systems (Day et al., 1989).

Unvegetated Hard Bottom

The terms "hard bottom" and "live bottom" are used interchangeably to describe estuarine and marine habitats that contain an emergent rock substrate colonized by sponges, hydroids, corals and sea whips, which attract and support dense fish populations (Thompson et al., 1999). The following definition of hard bottom habitats is used by the U.S. Minerals Management Service, a branch of the Interior Department:

> "…areas which contain biological assemblages consisting of such sessile invertebrates as sea fans, sea whips, hydroids, anemones, ascidians, sponges, bryozoans, or corals living upon or attached to naturally occurring hard or rocky formations with rough, broken, or smooth topography; or areas whose lithotope favors the accumulation of turtles, fishes, and other fauna."

Hard bottom habitats of this type have been documented within the Anclote Anchorage (CSA, 2000a, b) although their distribution and areal extent in the area have not yet been quantified. Within the Anchorage, CSA (2000a) identified hard bottom areas where rock outcrops were either exposed or covered by a thin veneer of sediment. In some instances the sediment veneer completely covered the rock bottom, and the presence of the rock was inferred from the presence of a characteristic hard bottom fauna of sponges or octocorals. These hard bottom outcrops rose to heights of 0 – 1.6 feet above the surrounding substrate (CSA, 2000a). Somewhat taller outcrops were noted southwest of Anclote Key, the inner edge of a more extensive offshore hard bottom habitat area (CSA, 2000a).

7.2. Offshore Habitats

Seagrasses

Seagrasses have a unique distribution along the west coast of Florida, occurring not only in protected coastal bays (such as Tampa Bay and Charlotte Harbor) but also in extensive offshore meadows that extend along the coast between the St. Marks River and Tarpon Springs. Dense beds, covering 80% or more of the bottom, occur in a band that extends from 11 to 35 km (7 to 22 miles) offshore in this region. Sparser beds are estimated to occur as far as 113 km (70 miles) offshore in some areas. The area of dense (80% or more) bottom coverage has been termed the "Big Bend seagrass bed," whose size has been

estimated at approximately 3,100 km^2 (1,200 $mile^2$) (Zieman and Zieman, 1989). The Anclote Anchorage lies at the extreme southern edge of this bed.
The offshore seagrass meadows in this area are dominated by turtle grass, manatee grass, and shoal grass, with turtle grass and manatee grass providing the majority of the biomass in the densest beds. Shoal grass occasionally forms both the innermost and outermost bands of these beds, exhibiting a short, narrow-leaf growth form when growing on shallow shoals that are frequently exposed at low tide and a taller, wider-leaf form when growing in deep water (Zieman and Zieman 1989). A fourth seagrass species, *Halophila engelmanni (*star grass), is also common in these grassbeds, and forms monotypic stands in deeper areas outside the major beds, in water depths up to 20 m (65 feet) (Zieman and Zieman, 1989).

Unvegetated Soft Bottom

Limited information on soft bottom habitats in the area offshore from Anclote Key are available from a recent survey by Continental Shelf Associates (CSA 2000a,b), which was performed along the proposed route of a natural gas pipeline between June 1999 and February 2000. Sediments along the route varied from medium grain-size sands in the shallows near Anclote Key to finer sand mixed with shell fragments at depths of about 6 m (20 ft). From that depth out to depths of about 9 m (30 ft), sediments ranged from fine sand and silt to coarse sand with shell fragments, varying with no apparent spatial pattern. At depths from 9 m to 40 m (30 ft to 130 ft) sediments were primarily fine sand, intermixed with areas of shell rubble and rock rubble from adjacent hard bottom habitats. Between depths of 40 m and 50 m (130 ft and 160 ft), small pieces of coralline algae were observed intermixed with or overlying the soft bottom sediments. Sediments became finer with higher amounts of silt at water depths greater than 80 m (260 ft).

Unvegetated Hard Bottom

On the west Florida shelf, at depths of 12 to 30 m (40 to 100 ft), numerous limestone ledges occur that are covered with abundant plant and animal life. Rock-boring organisms, including clionid sponges and *Lithophaga* clams, undermine the ledges producing caverns that are used by a variety of fish and inverterbrate species. Large basket sponges, octocorals and stony corals contribute further to habitat structure and complexity (Jaap and Hallock, 1990).

The surveys performed during 1999-2000 by Continental Shelf Associates (2000a,b), noted above, provide the bulk of the available quantitative data regarding the ecology of live bottom habitats in the northeastern Gulf of Mexico. In general, the hard bottom communities observed by CSA (2000a,b) at depths less than 20 m (65 ft) consisted of an algal/sponge/coral dominated community. At depths greater than 20 m (65 ft) the shallow water octocoral component of the community disappeared, and at depths between about 30 and 40 m (100 and 130 ft) there was a large decline in hard coral species. At water depths greater than 50 m (160 ft) there was a shift to a deeper water octocoral and antipatharian community with a few sponge and bryozoan species (CSA, 2000a).

8. BIOTA

The west-central Florida coast lies in a transition zone between a more temperate "Carolinian" fauna to the north and a more tropical ("West Indian" or "Caribbean") zone to the south (Zieman and Zieman, 1989). Based on the distributions of species in a number of taxonomic groups, biologists have suggested a variety of potential demarcation points for this temperate/tropical transition, ranging from the Cedar Keys to Tampa Bay to Cape Romano (McCoy and Bell, 1985). In general, however, the faunal transitions that occur along the west-central coast are gradual and show no clear-cut boundaries or demarcation points (McCoy and Bell, 1985; Zieman and Zieman, 1989). Because the Anclote Anchorage lies at an intermediate point in the transition between the more tropical and temperate marine faunas, it includes elements of both and is an area of relatively high biological diversity.

A variety of physical, geological and biological factors also show transitions along this section of the coast, perhaps contributing to the faunal diversity. As noted earlier the Anclote River mouth and Anclote Anchorage lie in a transition zone of coastal morphology, with a sand-rich coastline dominated by beaches and barrier islands extending southward from the area, and the sand-starved low-energy coastline of the Springs Coast extending to the north. The area also marks a transition between the mangrove-dominated shorelines to the south and marsh-dominated shorelines to the north. In terms of water temperature and salinity regimes the coastal region appears to represent the southern boundary of an area characterized by relatively simple dynamics that extends northward to Cape San Blas, and contrasts with an area of more complex salinity and temperature patterns (indicating possible interactions between the Loop Current and shelf water) that extends to the south (McCoy and Bell, 1985).

8.1. Phytoplankton, Benthic Algae and Macroalgae

Johansson (1975) assessed phytoplankton taxonomic composition and productivity in the Anclote Anchorage between March 1973 and February 1974. Phytoplankton cells were most numerous between June and November, with maximum numbers occurring in September. Planktonic diatoms were the most abundant taxa, averaging 84.5% of total cell numbers. The principal diatom genera observed during the summer season were *Skeletonema, Chaetoceros*, and *Nitzschia*. During the winter *Rhizosolenia, Leptocylindrus*, and *Chaetoceros* were most common. Dinoflagellates were occasionally abundant; a bloom of *Ceratium hircus* constituted the major portion of the phytoplankton biomass at two stations in January 1974.

During the period January 1 through September 30, 1971, Hamm (1975) assessed the distribution of macroalgae in the following 11 microhabitats within the Anchorage:

- seagrass (turtle, manatee, shoal and star grass) leaves,
- unconsolidated bottom sediments,
- *Spartina* stems,
- scattered shell,
- intertidal mud and sand,
- limestone rock,
- oyster bars,
- mangrove roots,
- pilings and other submerged solid structures,
- other artificial substrates, and
- drift algae.

The largest group of macroalgae (66 species) was found growing on seagrass leaves (epiphytes). Drift algae (64 species) made up the second largest group. Twenty-four species were found only in the drift, which at times made up a significant portion of the total biomass of benthic algae in the area. The drift algae were primarily marine rather than estuarine species, and were presumably transported into the Anchorage from the Gulf of Mexico. There were 124 identified taxa of benthic algae in the Anclote river estuary and information on seasonality, distribution, relative abundance, and substrate preferences was provided.

Florida Power Corporation (1991) provides an assessment of the species composition and biomass of drift and attached macroalgae at 21 sampling stations and along 5 transects within the Anchorage during spring (May), summer (August) and fall (November-December) of 1990. The dominant species of attached algae (on a biomass basis) were *Caulerpa prolifera*, *C. ashmeadii*, *Halimeda incrassata*, *Penicilllus capitatus*, and *Udotea conglutinata*. Biomass of drift algae was dominated by *Jania adherens*, *Acanthophera spicifera*, *Agardiella tenera*, and *Laurencia* spp. Four trends were noted in the monitoring data (FPC, 1991):

- both drift and attached algal biomass showed large between-station variation,

- *Caulerpa* biomass appeared reduced at stations affected by thermal discharges from the Anclote Station plant,

- *Halimeda incrassata* showed a similar, but less pronounced, biomass at the thermally impacted stations, and

- percent cover by drift algae was greater at stations with higher annual mean temperatures, but this may have been related to current patterns in the area rather than temperature.

8.2. Zooplankton

Weiss and Hopkins (1972) monitored monthly changes in the abundance and taxonomic composition of the zooplankton community at four stations located in the Anclote River (one station), Anclote Anchorage (two stations) and Gulf of Mexico (one station) from September 1970 through August 1971. Maximum biomass levels were observed in the warmer months of June, August and October.

The holoplankton (permanent plankton) were dominated by the copepods *Acartia tonsa, Oithona brevicornis*, *O. nana*, and *Paracalanus crassirostris*, representative of taxa that are characteristically prevalent in estuaries of the southeastern U.S. The most abundant species were *Acartia tonsa* and *Oithona brevicornis*, which made up 35% and 34% (respectively) of the adult copepods sampled. Copepod larval forms (nauplii) were the most abundant form of holoplankton, making up 48% of the total number sampled. Meroplankton (the larvae of benthic invertebrates) were also abundant, making up 19% of the total zooplankton sampled at the four stations. The most common forms were pelecypod, gastropod, polychaete, and cirriped larvae, in that order. Total zooplankton diversity varied seasonally, reaching its maximum in June and its minimum in December. Diversity was highest at the stations with the highest average salinities, located in the Anchorage and the Gulf of Mexico (Weiss and Hopkins, 1972).

8.3. Benthic Invertebrates

The benthic invertebrate fauna of the Anclote region includes *epibenthic* forms, which live above the substrate, and *infauna,* which live within the upper sediment layers. Providing a simple characterization of this fauna is difficult because of the large number of species involved and the complexity of their distribution patterns in time and space (Zieman and Zieman, 1989). Lists of the benthic species collected in the Anclote Anchorage and mouth of the Anclote River have been documented by a series of reports generated in the early and middle 1970s by the University of South Florida for the Florida Power Corporation (now Progress Energy). The study was called the Anclote Environmental Study and included lists of several hundred species of crustaceans, molluscs, echinoderms, and other taxa found in the area (Humm et al., 1970; Baird et al., 1971; Baird et al., 1973). These lists are provided in Appendix B. The following summary does not include extensive species lists of this type, focusing instead on a broader overview emphasizing taxa of ecological or economic importance. It is organized on the basis of the following three major habitat types:

- seagrass meadows,
- soft-bottom, and
- hard-bottom habitats.

Benthic invertebrates of seagrass meadows

A large number of economically important species inhabit estuarine seagrass beds during some portion of their life cycles. Juveniles of the pink shrimp (*Penaeus duorarum*) use shallow seagrass areas as nurseries, while adults favor higher salinities and a mix of shell, sand, and coral substrates. The stone crab (*Menippe mercenaria*), another important commercial species, also spends its juvenile stages in estuarine areas with seagrass, shell or rock substrates. Maturing individuals move to deeper waters, where they live in seagrass areas or burrow into soft substrates. Blue crabs (*Callinectes sapidus*) prefer sandy or muddy bottoms in shallow estuarine areas, and are often associated with seagrass meadows and oyster bars. Adult blue crabs migrate northward along the Gulf Coast to spawn in the general region of Apalachicola Bay (Livingston, 1990).

FPC (1991) characterized the benthic infauna of seagrass meadows in the Anclote Anchorage, evaluating the potential thermal impacts of power plant operations on the resident benthic community. Core samples were collected at 21 monitoring stations in the Anchorage (Figure 8.3.1.) during the spring (May), summer (August), and fall (November) of 1990. A total of 79,241 benthic organisms representing 414 taxa were collected, with the largest number of taxa occurring in the August sampling events. The taxonomic list and percentage composition from this study is provided in Appendix C.

The most abundant organisms collected in the FPC (1991) sampling program were polychaete worms (e.g., *Prionospio heterobranchia*, *Syllis gracilis*, *Brania clavata,* and *Aricidea philbinae*), tubificid worms (*Limnodriloides rubicundus, Techtidrilus squalidus, Thalassodrilides belli*), and several species of molluscs (*Caecum pulchellum, Caecum nitidum, Crepidula maculosa, Acteocina canaliculata, Diastoma varium*) and small crustaceans (*Cymadusa compta, Elasmopus levis, Podocopa sp.*).

The bay scallop (*Argopecten irradians*) is the predominant epifaunal bivalve mollusc in the Anclote area (Studt and Blake, 1975). Here, as in other parts of the scallop's range, population densities exhibit marked year-to-year fluctuations. In addition to variations in the physical environment, scallop population dynamics are affected by natural predation (primarily by stone crabs and blue crabs) and recreational harvesting by humans. Studt and Blake (1975) noted that the bay scallop is highly sensitive to biological changes, making the species suitable as an indicator of changes in environmental quality. They performed field experiments in the Anclote Anchorage during the fall and winter of 1974-1975 to examine the survival and reproductive health of scallops exposed to discharges of cooling water from the Anclote Power Station. One ambient and two thermally-affected stations were selected in the vicinity of the power plant. Temperatures at the ambient station (station I) ranged from 10°C to 24°C (50-75°F) during the study. Station II was almost always affected by the plant's thermal plume, and was 1-2°C (2-3.5°F) above ambient. Station III was exposed to the thermal plume occasionally, during unusual wind and current conditions.

Two hundred scallops (100 in two cages) were placed at each of the three Anclote stations. Once per week, from October 15, 1974 through February 18, 1975, 20 scallops were collected from each station, and the number of dead scallops at each station was recorded. Fourteen of the 20 scallops collected from each station were dissected to examine internal condition. Tissues from the remaining six were fixed and stained for histological examination.

During the five months of exposure greater mortality was observed at thermally-affected station II than at ambient station I. Mortality at station III was intermediate. Gonadal tissues reached their highest development levels at station I, significantly higher than the levels reached at stations II and III.

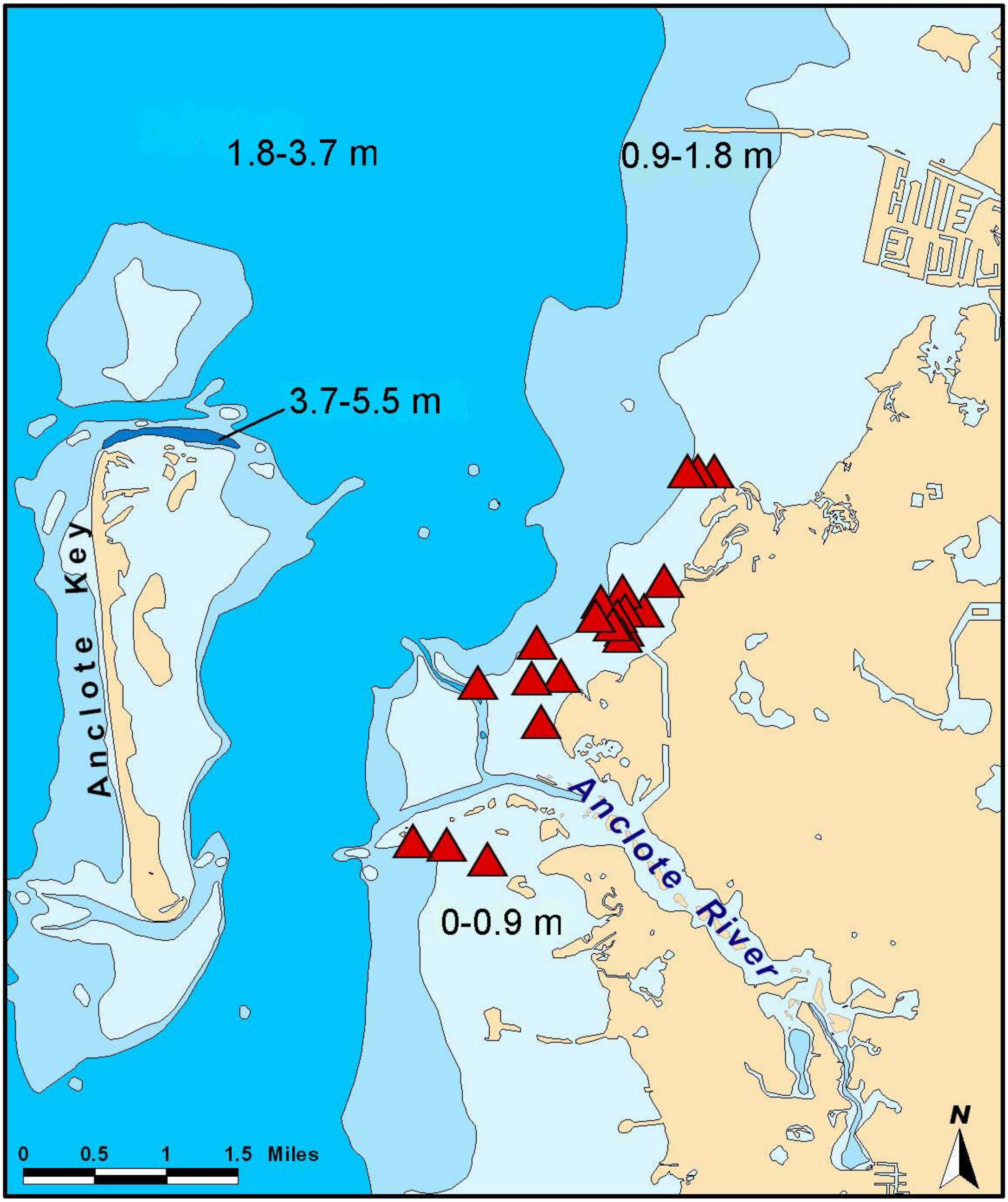

Figure 8.1. Benthic sampling sites (from FPC, 1991).

Concentrations of total suspended solids in the water column were also highest at the thermally-affected station (station II), complicating the interpretation of these experimental results. Studt and Blake (1975) gave the following summary:

> "Increased total suspended load can adversely affect a suspension feeder in two basic ways: it may clog the feeding apparatus...or it may increase metabolic demand by increasing sorting activity of the palps. One or both of these factors could have been operating in conjunction with elevated temperature at the Anclote site to produce elevated mortality. The effects of slight temperature elevation may have been insignificant, had the organisms not also been subjected to an increase in total suspended load."

The bay scallop is in the southern portion of its geographic range in the Anclote region, a factor that may also affect mortality rates and reproductive success in the area from year to year. Studt and Blake (1975) noted that more northern bay scallop populations usually spawn at or near the summer water temperature maximum, while southern populations often spawn during the fall as water temperatures are declining. In the Anclote area spawning had previously been observed during fall, while Studt and Blake (1975) found it occurring well into winter. Studt and Blake (1975) recommended additional study of reproductive timing and success of the bay scallop in the Anclote Anchorage, as an ecological case study examining the interactive effects of natural and manmade stresses on the population dynamics of the species.

<u>Benthic invertebrates of soft bottom habitats</u>
The invertebrate fauna of soft bottom habitats are usually categorized by size class (Day et al., 1989; Livingston, 1990):

- microorganisms ($<52\ \mu$m), which are primarily protozoans,
- meiobenthic organisms (between 62 and 250 μm), including nematodes, copepods, tubellaria and several minor phyla, and
- macrobenthos ($>250\ \mu$m), including polychaete worms, nemerteans, molluscs, and decapod and other crustaceans.

The macrobenthos is dominated by polychaete, crustaceans, and molluscs. Many of these species can tolerate wide ranges of salinity and temperature, with the distributions of individual species depending largely on life history characteristics such as dispersal and feeding habits (Livingston, 1990). These organisms are primarily detritivores, deposit feeders, filter feeders or predators. Ecologically, they play important roles in the food web that supports the mobile invertebrates and fishes that inhabit the overlying water column (Livingston, 1990).

Along transects performed southwest of Anclote Key, at water depths of <1 to about 30 ft, CSA (2000a,b) observed a soft-bottom epibenthic community that included urchins (*Mellita* sp. and *Lytechinus variegatus*), Florida fighting conch (*Strombus alatus*), and sea star

(*Astropecten articulatus*). At depths of 30 ft to 160 ft various species of green algae, including *Caulerpa* spp., *Codium* spp., *Halimeda* spp., and *Udotea* spp. were observed distributed irregularly across the bottom. Scattered patches of the seagrass *Halophila decipiens* were observed at depths of 12 to 30 m (40 to 100 ft). Epifauna observed in these areas included an unidentified sea pen (Pennatulacea), the box crab *Calappa flammea*, the sea stars *Astropecten articulatus*, *Luidia clathrata*, and *Oreaster reticulatus*, and the echinoid *Encope michelini*.

Hard bottom habitats

In general the fauna of shallow-water hard bottom habitats in Florida show temperate ("Carolinian") affinities, with tropical ("West Indian") taxa becoming increasingly important in deeper waters and in the southern portion of the state. Jaap and Hallock (1990) provide the following summary:

> "Live-bottom habitats are among the most widely distributed marine communities in Florida waters. They are found virtually anywhere, from subtidal areas to the continental shelf. The main criterion is solid substratum upon which members of this epibiotic community attach. Attached biotas occupy everything from reef limestones to rocky outcrops on the sea floor to artifical reefs, seawalls, buoys, bridge pilings, and boat bottoms. Flora and fauna naturally vary throughout this range of depths and substrata, but algae, sponges, octocorals, hardy stony corals, and bryozoans are often visually dominant."
>
> "On the west Florida shelf...numerous limestone outcrops jut upwards 0.5 m to 2 m, often forming table-like structures above surrounding sediments. Ledges are covered with abundant plant and animal life. Stony corals are common on these outcrops, though they seldom construct significant three-dimensional structures. Cavernous vertical faces provide refuges for crabs, lobsters, and fish. Octocorals dominate upper surfaces. Brittlestars often seek shelter in the branches of flexible octocorals and feed on plankton or suspended particles in the water. Limestone outcrops provide oases of vertical relief in the vast expanses of sands that cover most of the west Florida shelf. Snapper (*Lutjanus* spp.), grouper (*Epinephelus* spp.), and sea bass (*Centropristis* spp.) are frequently found in these habitats..."

CSA (2000b) performed a quantitative photographic survey of a site where rock outcrops were either exposed or covered by a thin veneer of sediment. An octocoral (*Leptogoria virgulata*) and several sponge species were the most abundant animals at the site in terms of spatial coverage, occupying 32.8% and 11.9% (respectively) of the surface area. Hard corals (*Solenastrea* sp. and an unidentified species) occupied less than 1% of the area. More than half of the hard corals present at the site remained unidentified due to a combination of poor underwater visibility and small colony size (CSA ,2000b).

CSA (2000a) also performed qualitative surveys within the Anchorage, noting that much of the hard bottom substrate was sediment-covered and not colonized by epibiota. Exposed rock surfaces supported an assemblage of animals that included a sponge (*Cliona celata*), octocorals (*Leptogorgia* sp. and *Lophogorgia* sp.) and small hard coral colonies (*Astrangia poculata, Phyllangia Americana, Siderastrea radians*, and *Solenastra hyades*).

Nearshore hard bottom habitats are also present near the mouth of Tampa Bay south of the Anclote Anchorage. Derrenbacker et al. (1985) provided a list of common invertebrate species found in those areas, which is summarized in Table 8.1 below.

Table 8.1. Common invertebrates from the mouth of Tampa Bay.

Taxon	Species	Common name
Porifera	*Cliona celata* *Spheciospongia vesparia*	boring sponge loggerhead sponge
Cnidaria	*Leptogorgia virgulata* *Cerianthopsis americanus* *Haloplenella sp.* *Siderastrea radians*	sea whip tube anemone rock anemone starlet coral
Mollusca	*Thais haemostoma floridana*	Florida rock snail
Polychaeta	*Dodecacaria concharum*	boring polychaete
Crustacea	*Alpheus sp.* *Dardanus sp.*	snapping shrimp hermit crab

The offshore surveys conducted by CSA (2000a,b) documented the presence of hard bottom communities, which were similar in structure and faunal composition to the hard bottom areas observed within the Anclote Anchorage. In terms of diversity and percent cover, sponges were the dominant epifaunal group, making up more than 30% of the taxa identified. Other abundant groups included macroalgae (at least 15 species), echinoderms (at least 15 species), octocorals (at least 12 species), and hard corals (at least 9 species).

The epifaunal density of these communities was reported to be associated with water depth, and with the vertical relief of the available hard surfaces above the sand. The highest densities of attached fauna were observed on higher-relief rock structures in water depths of 9 to 21 m (30 to 70 ft) (CSA, 2000a).

In water depths of less than 20 m (65 ft), zooxanthellate octocorals including *Eunicea* spp., *Muricea* sp., *Pseudoplexaura* sp., *Pseudopterogorgia* sp, and *Pterogorgia* sp were observed in hard bottom areas. This shallow-water octocoral component tended to diminish in deeper water, with only *Muricea* sp. observed at depths greater than 21 m (70 ft). Hard coral species observed along the transects included *Astrangia poculata*, *Cladocora arbuscula*, *Manicina areolata*, *Oculina* sp., *Phyllangia americana*, *Scolymia ?lacera*, *Siderastrea radians*, *Solenastrea hyades*, and *Stephanocoenia michelini*. As with the shallow water octocorals, hard coral density declined with increasing water depth, although several species were observed as deep as 35 m (115 ft) (CSA, 2000a).

Sponges were observed along much of the transect in areas with exposed rock or a thin veneer of sediment over a rock surface. They ranged in size from small species a few centimeters in height to large loggerhead and vase sponges more than 0.5 m (1.5 ft) in diameter. In general sponge density was reported to decrease at greater water depths, although some of the largest loggerhead sponges were observed at depths of 41 m (135 ft) (CSA, 2000a).

Fishes

Most research on the estuarine and marine fishes of west-central Florida has focused on species of commercial or recreational importance, such as snook, red drum, spotted seatrout, and striped mullet (Killam et al., 1992). Several members of the family Sciaenidae are of particular importance for commercial and recreational fisheries on the Gulf coast (Livingston, 1990). The sand seatrout (*Cynoscion arenarius*), which is fished commercially, is most common over sandy and muddy bottoms in coastal and shelf waters. The spotted seatrout (*C. nebulosus*), which is harvested both commercially and recreationally, is most common in shallow coastal areas associated with salt marshes, tidal flats, and seagrass beds. The spot (*Leiostomus xanthurus*), a highly abundant and commercially important species, is euryhaline, eurythermal, and shows little preference for specific habitats, although juveniles are typically associated with areas of structure such as seagrass, rocks, or seawalls (Killam et al., 1992). The red drum (*Sciaenops ocellatus*) inhabits a wide range of inshore and offshore habitats in different stages of its life cycle. Non-vegetated low-salinity areas adjacent to marshes and mangroves appear to be important nursery areas for this species (Killam et al., 1992).

Several estuarine dependent “forage” or “baitfish” species are particularly abundant in inshore waters on the west-central Gulf coast. The Gulf menhaden (*Brevoortia patronus*) is commercially harvested. Others, including the bay anchovy (*Anchoa mitchilli*), Atlantic thread herring (*Opisthonema oglinum*), Spanish sardine (*Sardinella aurita*), silver perch (*Bairdiella chrysoura*) and pinfish (*Lagodon rhomboides*) lack commercial importance but are ecologically significant because of their high abundance. The striped mullet (*Mugil cephalus*), an historically important food fish in Florida, is abundant in the inshore area, apparently using tidal rivers as nursery habitat and foraging as adults in areas with mud or mud-sand substrates with little or no submerged aquatic vegetation. The common snook (*Centropomus undecimalis*) is a recreationally important estuarine dependent species that is near the northern limit of its range in the Anclote Anchorage. Snook spend the majority of their life cycle in and near the mouths of estuaries. Their habitat preferences appear strongly oriented to factors such as water temperature, depth, current velocity, and physical structure.

Economically important fish that utilize offshore as well as inshore habitats include the king mackerel (*Scomberomerus cavalla*), Spanish mackerel (*S. maculatus*), several species of snapper (*Lutjanus* spp.), grouper (*Epinephelus* spp.) and sea bass (*Centropristis* spp.). As adults, the snapper, grouper and sea bass species are particularly common over offshore hard bottom habitats.

Fable (1973) carried out six quantitative collections of fishes, using fyke and seine nets, in an embayment near the mouth of the Anclote River between November 1970 and July 1972. Fifty species of finfish were collected at the site. Appendix D lists the scientific and common names of the taxa collected for the study. The most abundant species in these collections included the Atlantic stingray (*Dasyatis sabina*), ladyfish (*Elops saurus*), sheepshead minnow (*Cyprinodon variegatus*), Gulf killifish (*Fundulus grandis*) , longnose killifish (*Fundulus similis*), common snook (*Centropomus undecimalis*), sheepshead (*Archosargus probatocephalus*), pinfish (*Lagodon rhomboides*), silver perch (*Bairdiella chrysura*), spotted seatrout (*Cynoscion nebulosus*), spot (*Leiostomus xanthurus*), striped mullet (*Mugil cephalus*), fantail mullet (*Mugil trichodon*), and Gulf flounder (*Paralichthys albigutta*).

Szedlmayer (1982) used seine sweeps to examine the distribution of juvenile fishes along a salinity gradient in the lower Anclote River, in order to assess the relative abundance of ocean-spawned migrants within the juvenile fish population. The Anclote River was chosen for the study because of its relatively abrupt salinity gradient, with a change from low salinity to marine waters occurring in a distance of only 9 km and because no previous work had been done on the area's juvenile fish fauna (Szedlmayer, 1982). Three stations were established: station 1 in an "estuarine" (30 ppt salinity) area; station 2 in a "tidal salt marsh" (17 ppt salinity) area; and station 3 in and a "river" (7 ppt salinity) area. At each station juvenile fish fauna was dominated by a small number of highly abundant species. At station 1, three species, the tidewater silverside (*Menidia beryllina*), bay anchovy (*Anchoa mitchilli*) and pinfish (*Lagodon rhomboides*), made up 94% of the total catch. At stations 2 and 3, *A. mitchilli*, *M. beryllina*, and *Leiostomus xanthurus* (spot) made up 84% and 90% of all individuals sampled, respectively.

Five species (spot, pinfish, bay anchovy, silver jenny, and Gulf killifish) appeared to be ocean-spawned migrants that were using the Anclote River estuary as a nursery area. The youngest members of these species were found at the lowest-salinity station, and progressively older individuals were collected farther downstream (Szedlmayer, 1982). Gilmore (1987) (Table 8.2.) provided the following overview of the trophic relationships of fish communities associated with subtropical seagrass meadows in the southeastern U.S.

These species made up less than 23% of the individuals collected, however, and the juvenile fish faunas at each sampling station was generally dominated by species that were year-round residents rather than transient ocean-spawned migrants. As a working hypotheses, Szedlmayer (1982) suggested several potential explanations for the apparent dominance of the area by resident rather than transient species, including:

- sampling gear bias,
- alteration of the Anclote environment (e.g., through power station thermal discharges) with concomitant faunal change, and
- the possibility that seagrass areas farther offshore might have been serving as the primary nursery areas for most ocean-spawned fishes.

He recommended that additional studies be performed in the offshore seagrass beds to test the latter hypothesis.

Table 8.2. Overview of trophic relationships of fish communities associated with subtropical seagrass meadows (Gilmore, 1987).

Trophic Group	Species	Common Name
Herbivores	*Sparisoma spp.* *Acanthrus spp.*	Parrotfish Tang
Omnivores-Detritivores	*Brevoortia spp.* *Floridichtys carpio* *Mugil spp.* *Lagodon rhomboides*	Menhaden spp. Goldspotted killifish Mullet spp. Pinfish
Zooplanktivores and Epifaunal Invertebrates	*Anchoa spp.* *Harengula spp.* *Hyporhamphus unifasciatus* *Lucania parva* *Menidia spp.* *Allanetta harringtonensis* *Atherinomorus stipes* *Syngnathus scovelli* *Hippocampus zosterae* *Gobiosoma robustum* larvae and juveniles of various perciform fishes	Anchovy spp. Sardine spp. Halfbeak Rainwater killifish Silverside Reef silverside Hardhead silverside Gulf pipefish Dwarf seahorse Code goby
Carnivores on Invertebrates and Small Fishes	*Eucinostomus spp.* *Diapterus auratus* *Bairdiella chrysoura* *Strongylura spp.*	Mojarra Irish pompano Silver Perch needlefish
Carnivores on Fishes and Macrocrustaceans	Carcharhinid sharks *Dasyatus sabina* *Epinephelus spp.* *Mycteroperca spp.* *Centropomus undecimalis* *Cynoscion nebulosus* *Sciaenops ocellata* *Sphyraena barracuda*	 Atlantic stingray Grouper/hind Grouper Snook Spotted sea trout Red drum Great barracuda

Marine Reptiles

Several sea turtle species may occur in the Anclote area during some portion of their life cycles. The green sea turtle, *Chelonia mydas*, is an herbivore that feeds preferentially on seagrasses, particularly turtle grass (*Thalassia testudinum*). A commercial fishery for green turtles once existed on the Florida gulf coast, with the largest harvests occurring in the seagrass meadows near the mouths of the Withlacoochee River and Crystal River (Zieman and Zieman, 1989). The species is now listed as endangered under Federal and State protected-species laws, and all harvesting is prohibited. Green sea turtles occasionally nest on beaches in the northeastern Gulf of Mexico, but a majority of the Florida population nests on the Atlantic coast, as far north as Cape Canaveral (FERC, 2000).

The hawksbill sea turtle (*Eretmochelys imbricata*) is threatened or endangered throughout its range in tropical and subtropical regions of the Atlantic, Pacific, and Indian oceans. It is most commonly found in reef and other hard bottom habitats, where it feeds on sponges and other benthic invertebrates. Hawksbill turtle sightings in the northeastern Gulf of Mexico are relatively uncommon, and nesting is unusual in the area. The species is not uncommon in the Florida Middle Ground, a large area of hard bottom habitat located on the Florida shelf northwest from the Anclote Anchorage (FERC, 2000).

The Kemp's ridley sea turtle (*Lepidochelys kempi*) is found only in the Gulf of Mexico and North Atlantic Ocean, north of the Caribbean Sea. Nesting is apparently restricted to a small stretch of beach on the Gulf coast of Mexico. Crustaceans, particularly crabs, are reported to be its preferred food. Both juveniles and adults are found in estuaries and other nearshore waters throughout the northeastern Gulf of Mexico. Populations of this endangered species, once critically small, have increased in recent years, apparently in response to national and international management efforts (FERC, 2000).

The leatherback sea turtle (*Dermochelys coriacea*) nests on shores of the Atlantic, Pacific, and Indian Ocean. This is the largest of the sea turtles (up to nine feet in length, with a weight of nearly a ton), and is listed as endangered under the federal ESA. Although generally a deep-diving oceanic species, leatherbacks move seasonally into coastal waters, including estuaries, to feed on large jellyfish associated with river and other frontal boundaries. Small numbers of leatherback sea turtles nest on barrier islands and mainland beaches in the northeastern Gulf of Mexico, as well as on the east coast of Florida (FERC, 2000).

The loggerhead sea turtle (*Caretta caretta*), a threatened species, is found in temperate and tropical waters worldwide. Following a one to two year pelagic phase, adults inhabit nearshore continental shelf and estuarine areas in the Atlantic, Pacific and Indian Ocean. Loggerhead nests are common on coasts around the northeastern Gulf of Mexico, and this species is the most common sea turtle along the Florida Gulf coast (FERC, 2000).

Marine Mammals

Approximately 29 species of marine mammals, including manatees, dolphins, and whales, are found in the Gulf of Mexico. Only two of these species, the Florida manatee and the bottlenose dolphin, occur on a regular basis in the Anclote Anchorage region (FERC, 2000).

The Florida manatee, *Trichechus manatus latirostris,* a subspecies of the West Indian manatee (*T. manatus*), is generally found from the Crystal River southward along Florida's Gulf coast, and from Titusville southward along the Atlantic coast. A closely related species, the Antillean manatee (*T. manatus manatus*), inhabits the coastal waters of Mexico and southern Texas. Capable of long-range offshore migration, manatees have been reported off the Florida Panhandle and the coastal waters of Alabama, Mississippi, Louisiana, and Texas during summer and early fall.

This large aquatic mammal can be found in coastal bays, canals, slow rivers, estuarine habitats and any water body greater than three feet in depth where there are no barriers to its movement. Individuals are sometimes encountered in the Gulf of Mexico several miles from the coast. The manatee's diet consists mainly of a wide variety of submerged vascular plants, but emergent and floating vegetation is sometimes eaten. Seagrass meadows are a common feeding area. The Florida manatee is currently listed as an endangered species. In addition to natural mortality, collisions with boats and entrapment in manmade locks and dams cause a number of manatee deaths each year.

The bottlenose dolphin is not listed under the endangered species act, but is protected under the Marine Mammal Protection Act (MMPA) of 1972, which prohibits harassing, hunting, capturing, or killing of any marine mammals. In the Gulf of Mexico bottlenose dolphins are found in the pelagic zone as well as in inshore bays, lagoons, and estuaries. Dolphins are vulnerable to pollution, habitat alteration, and human disturbance (e.g., boating), and have been impacted by loss of habitat, indirect take via fishing activities, and live capture for commercial and educational purposes (FERC, 2000).

Other Designated Species

In addition to sea turtles and marine mammals, several other species that occur in the Anclote Anchorage area are protected by the Federal Endangered Species Act or by the State of Florida. Appendix E describes species designations and specifically list designated species of the Anclote Key State Preserve. FDEP (1998) has provided the following summary for the Anclote Key State Preserve:

> "Designated species are those which are listed by the Florida Natural Areas Inventory (FNAI), U.S. Fish and Wildlife Service (USFWS), Florida Game and Fresh Water Fish Commission (FGFWFC), and the Florida Department of Agriculture and Consumer Services (FDACS) as endangered, threatened or of special concern. Designated species also include those which are under review for inclusion in one of the above categories, and those species which

are regulated by the Convention on International Trade in Endangered Species (CITES)."

"Three Rooker Bar is a very significant nesting site for shorebirds on a state-wide basis, ranking among the top five sites (Douglass, 1997). In addition to 5000 Laughing gull nests, American oystercatcher, black skimmer, least tern and snowy plover nests have been recorded on the island (Schnapf, 1997). Three Rooker Bar also serves as an important wintering site, and is used by Piping plovers and a myriad of other species."

"Atlantic loggerhead sea turtles are known to crawl up on the beach at Anclote Key during nesting season (Brewer, 1997), but nesting has not been adequately monitored. Raccoons, which are responsible for most sea turtle nest depredation on barrier islands to the south, are also present on Anclote Key. Finally, Southern bald eagle and osprey nests occur in slash pine trees and snags on Anclote Key."

9. SUMMARY AND CONCLUSIONS

A Master Water Plan, developed in response to continuing population growth within the Tampa Bay area, was adopted by the West Coast Regional Water Supply Authority (now Tampa Bay Water) in 1995. As part of the Agreement, Tampa Bay Water was required to submit a "New Water Plan" to the Southwest Florida Water Management District (SWFWMD) by July 1989. This Plan contains projects which must be permitted, constructed and operational for production of 85 MGD of new surface water supplies, other than groundwater, by the end of 2007. To help achieve the goal, seawater desalination has been selected as an additional source of regional water supply. Two locations for desalination plants have been proposed: the Big Bend Power Plant on Hillsborough Bay (where a desalination plant has been permitted and is currently operational) and the Anclote Power Station located near the mouth of the Anclote River (which is currently being assessed as a potential desalination plant site).

The Anclote River originates in south-central Pasco County and flows to the southwest, crossing a portion of Pinellas County before discharging into the Anclote Anchorage. As defined by the U.S. Geological Survey, the Anclote River watershed comprises approximately 112 square miles. Resource management areas in the study area include the Anclote Key State Preserve, the Pinellas County Aquatic Preserve, Outstanding Florida Waters, and Essential Fish Habitat.

An ecological characterization of aquatic (inshore and offshore) habitats of the Anclote River estuary and the Anclote Anchorage has been completed. This document presents details of the project area including climate and meteorology, wind patterns, hydrology and hydrodynamics, water quality, major habitat types, and biota. Historical data show that salinity in the offshore area, as expected, is relatively constant at 35-36 ppt. In the Anclote Anchorage area, the salinity is typically lower and more variable, ranging from 23 to 38 ppt during 2000-2001. Critical habitats in the offshore area include hard and soft bottoms. Hard bottom habitats contain sponges, clams, and corals. Seagrass beds represent critical habitat in the nearshore area.

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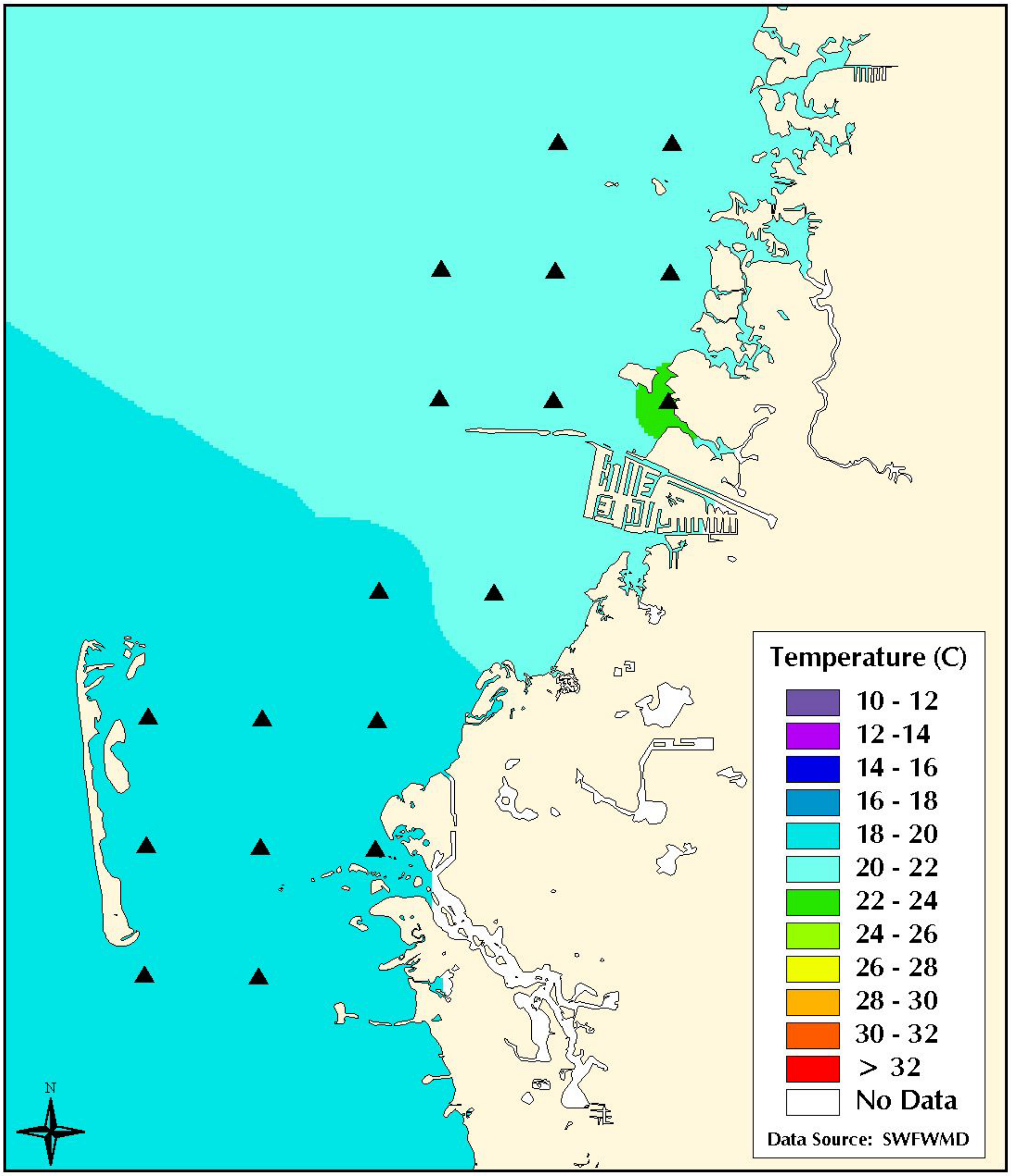
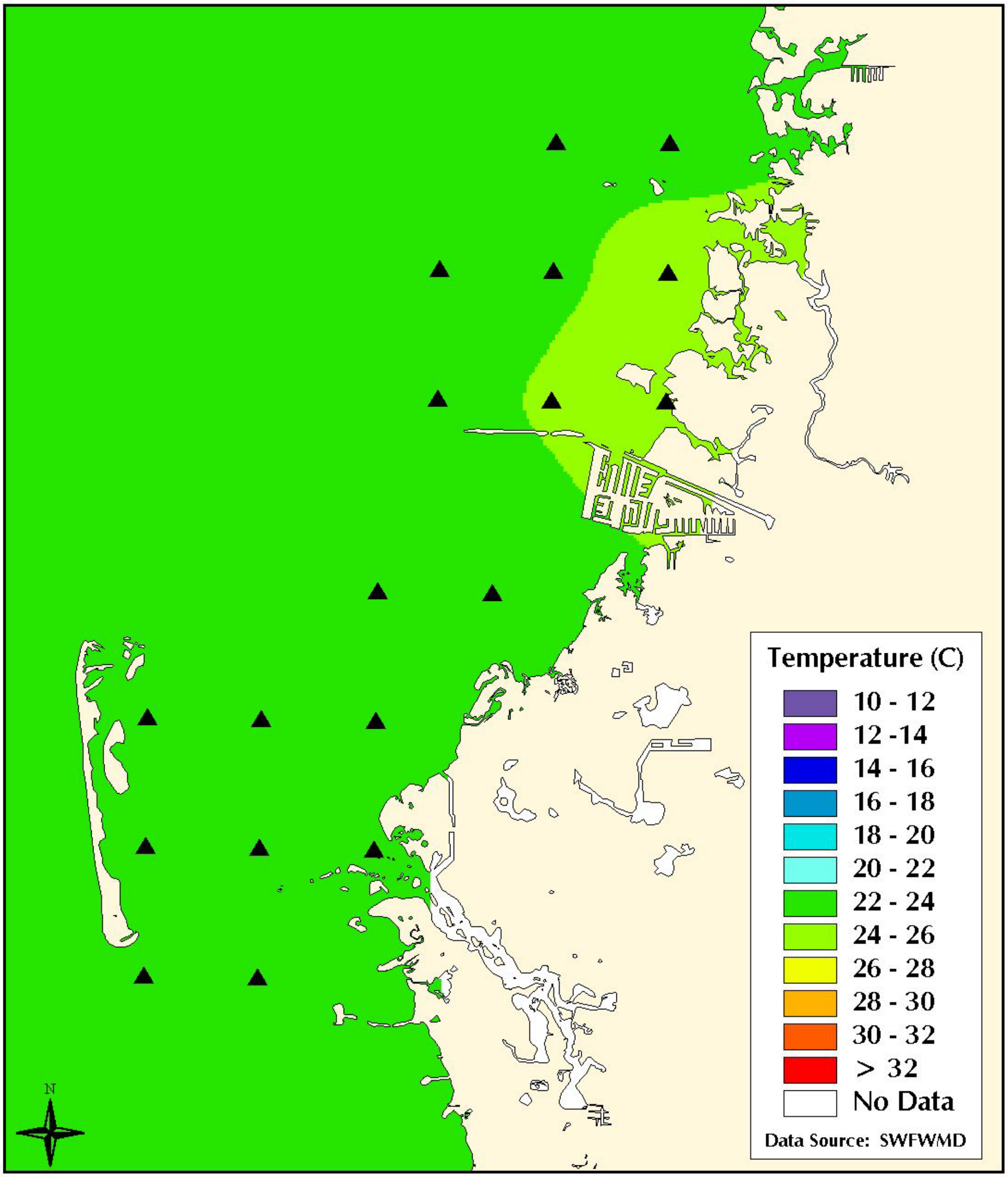
APPENDIX A

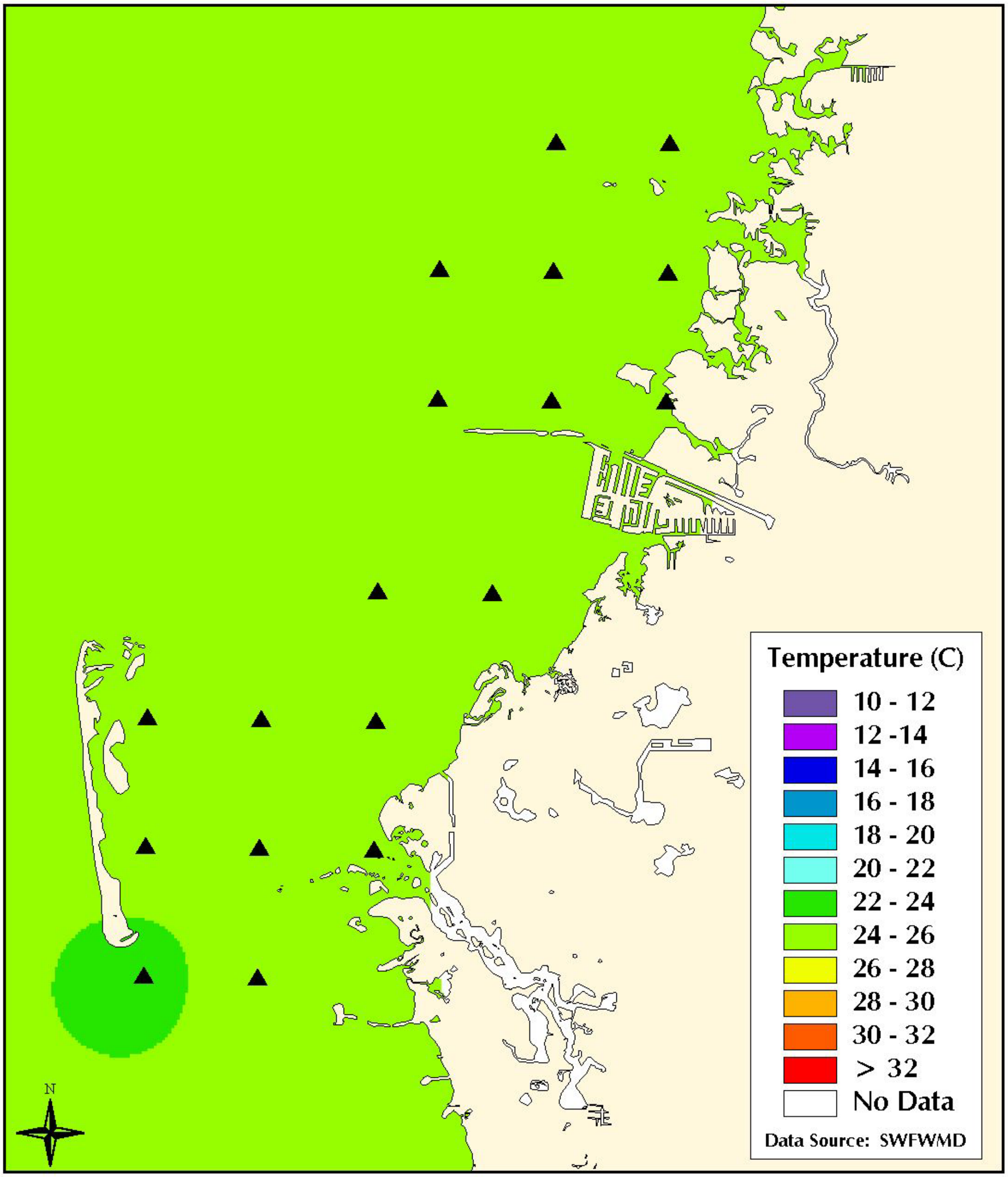
CONTOURS OF MONTHLY SURFACE WATER TEMPERATURE, 2000-2001, FROM DATA REPORTED BY FRAZER ET AL. (2001)



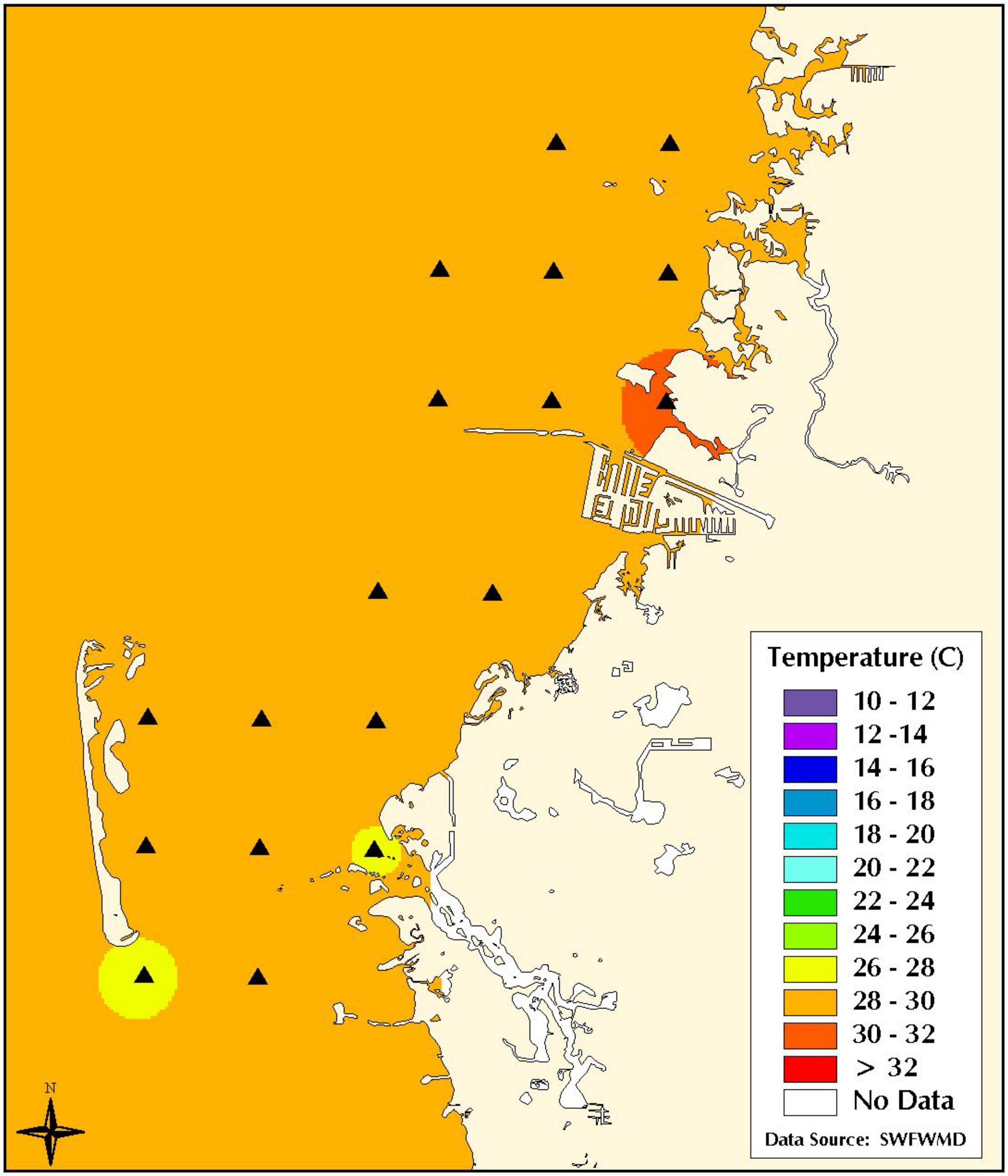
Contours of surface water temperature for February 2000.



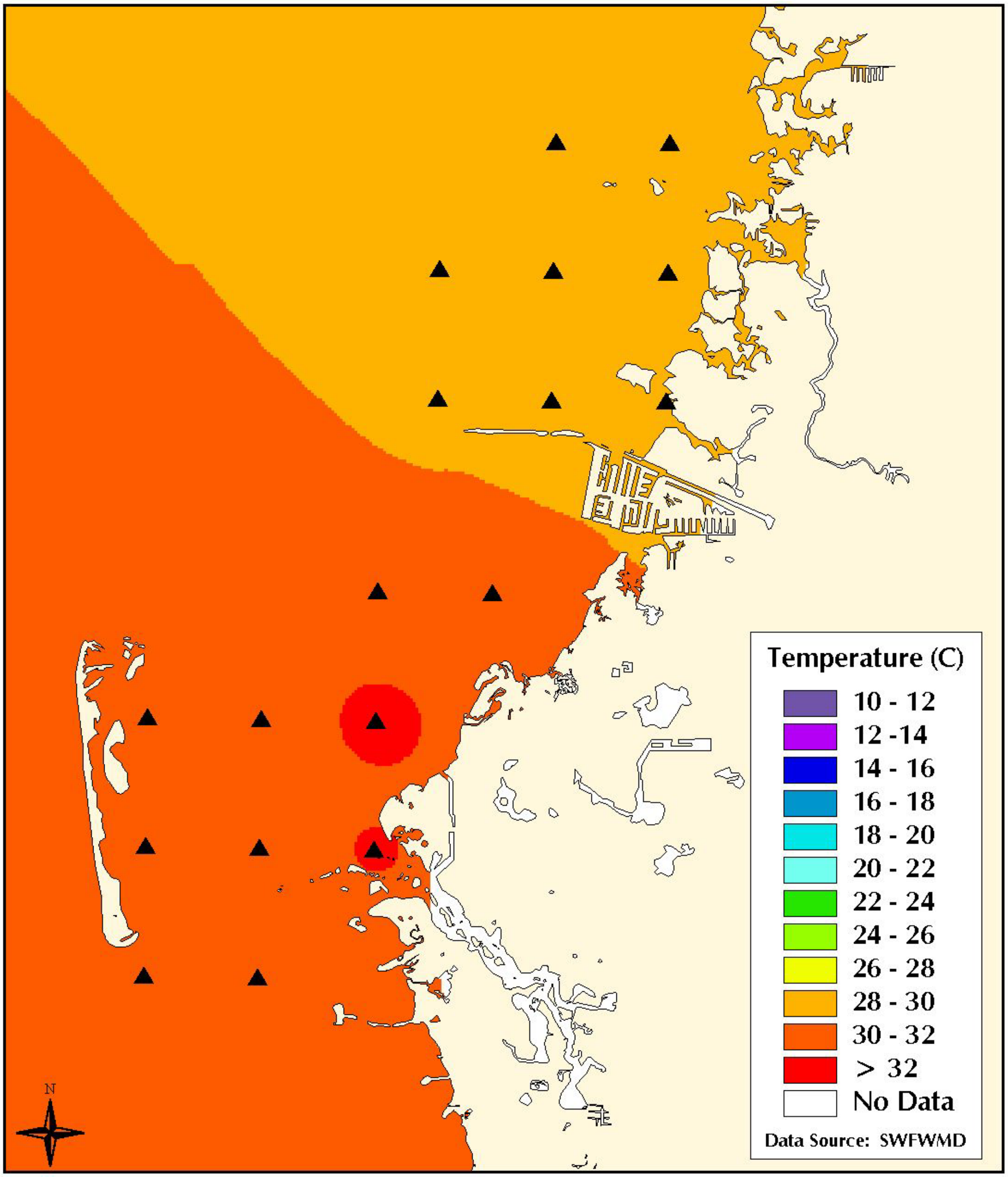
Contours of surface water temperature for March 2000.



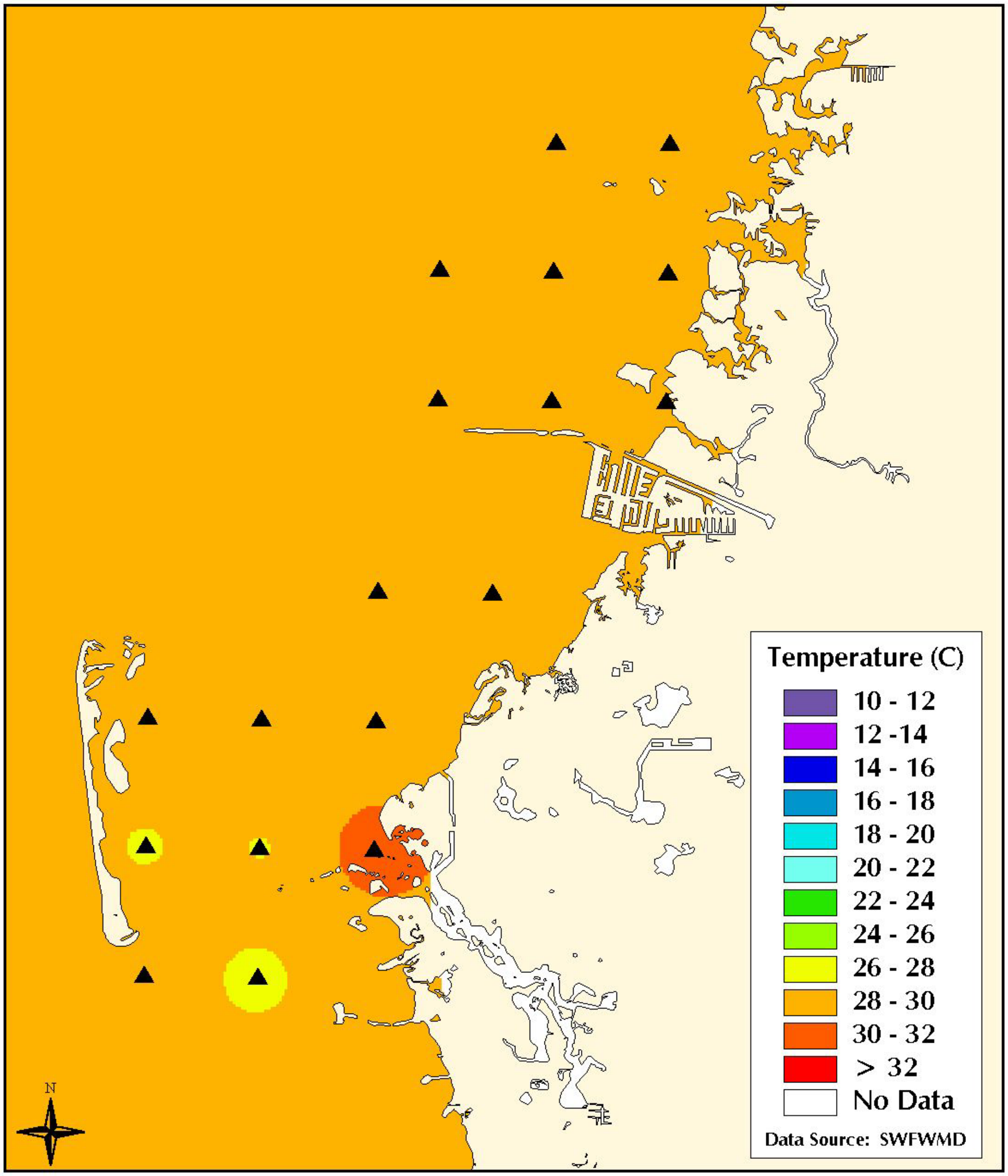
Contours of surface water temperature for April 2000.



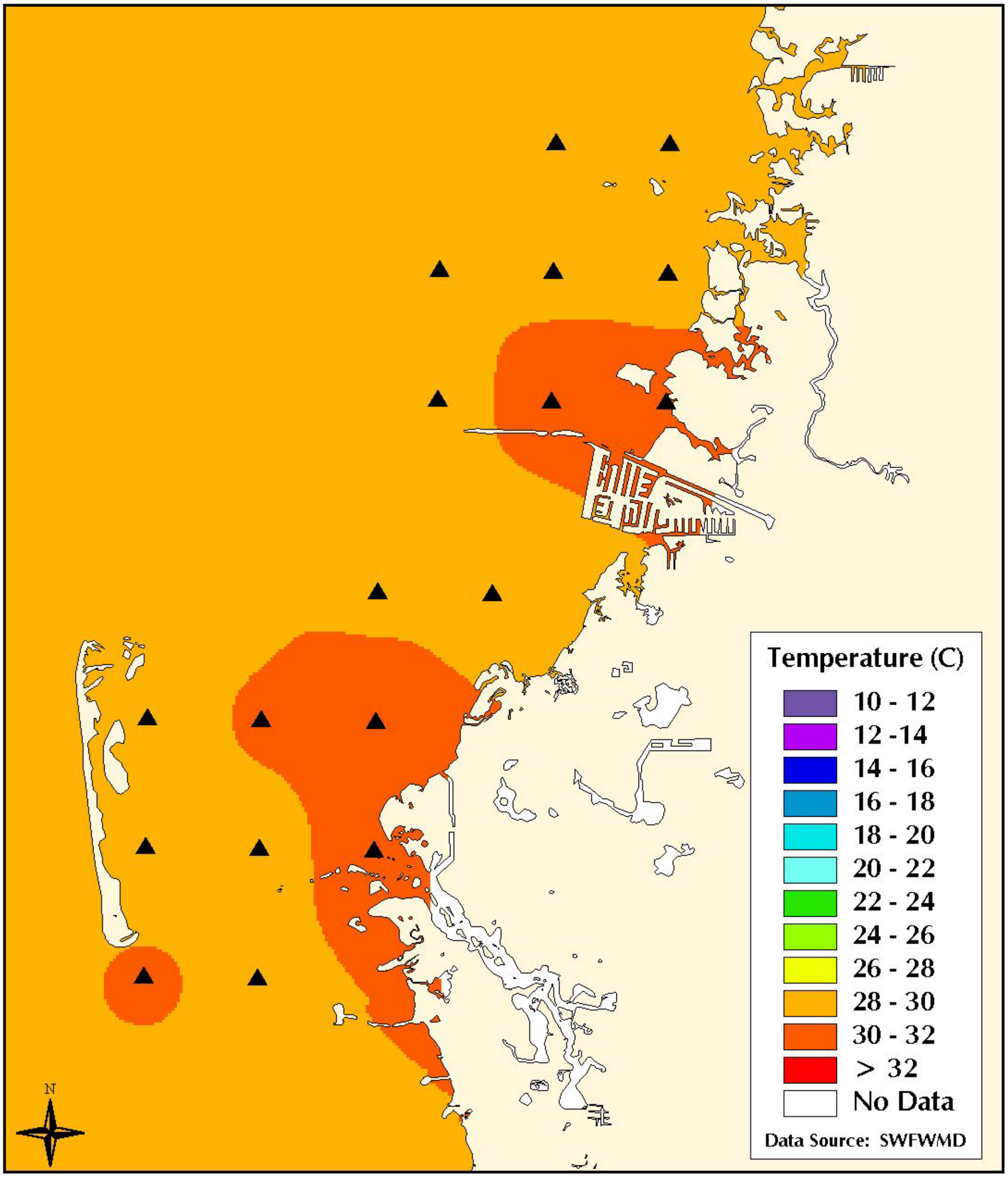
Contours of surface water temperature for May 2000.



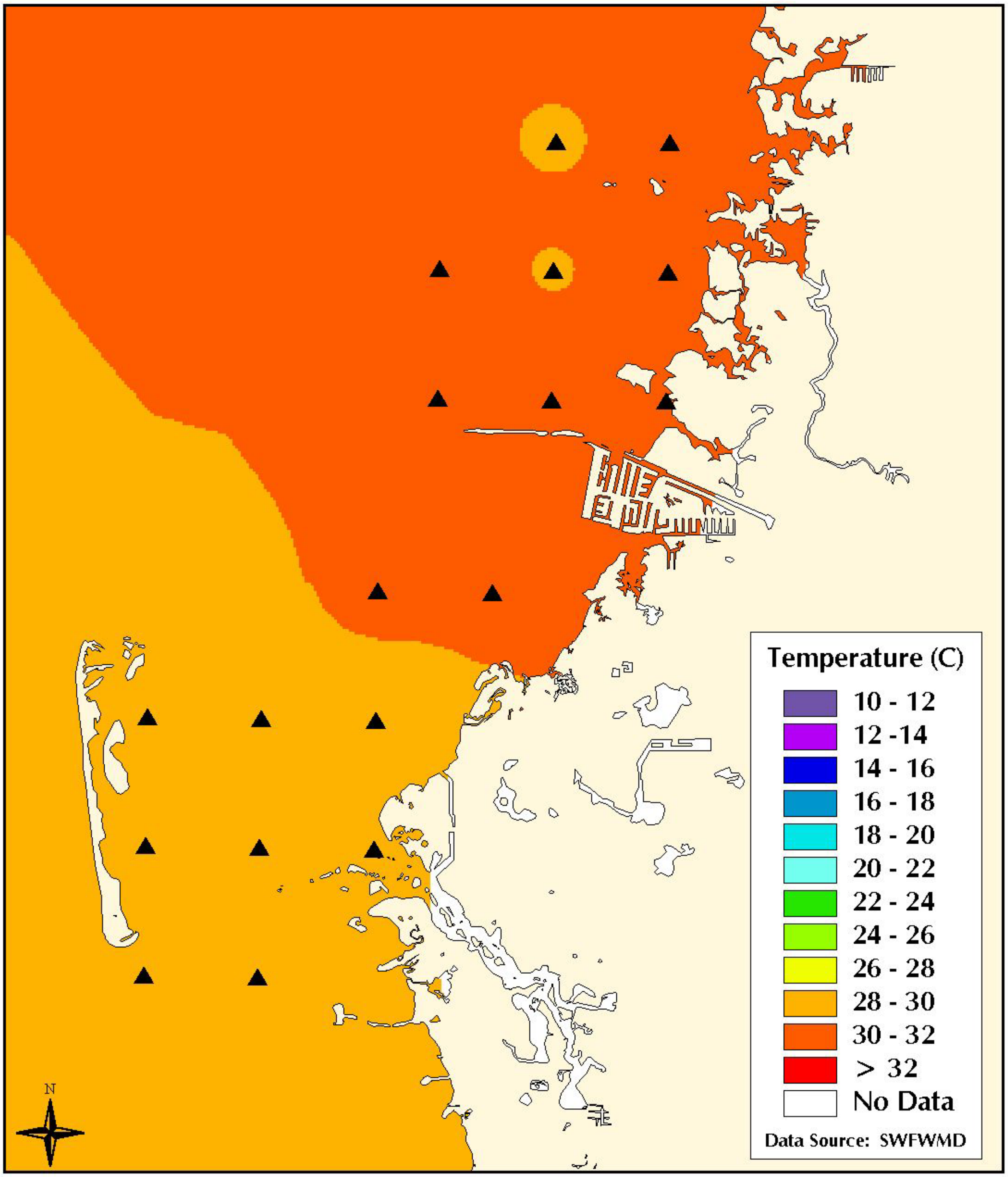
Contours of surface water temperature for June 2000.



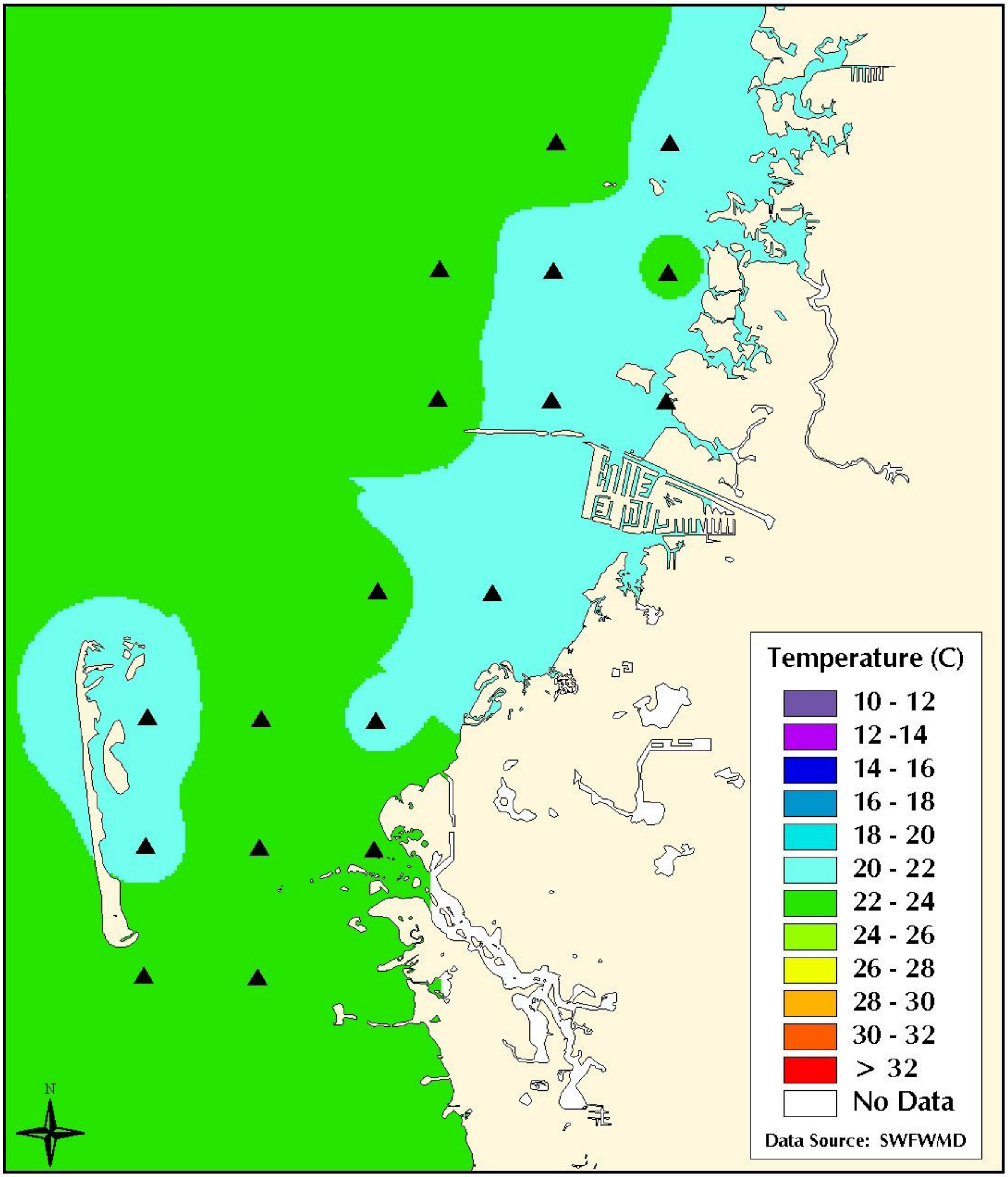
Contours of surface water temperature for July 2000.



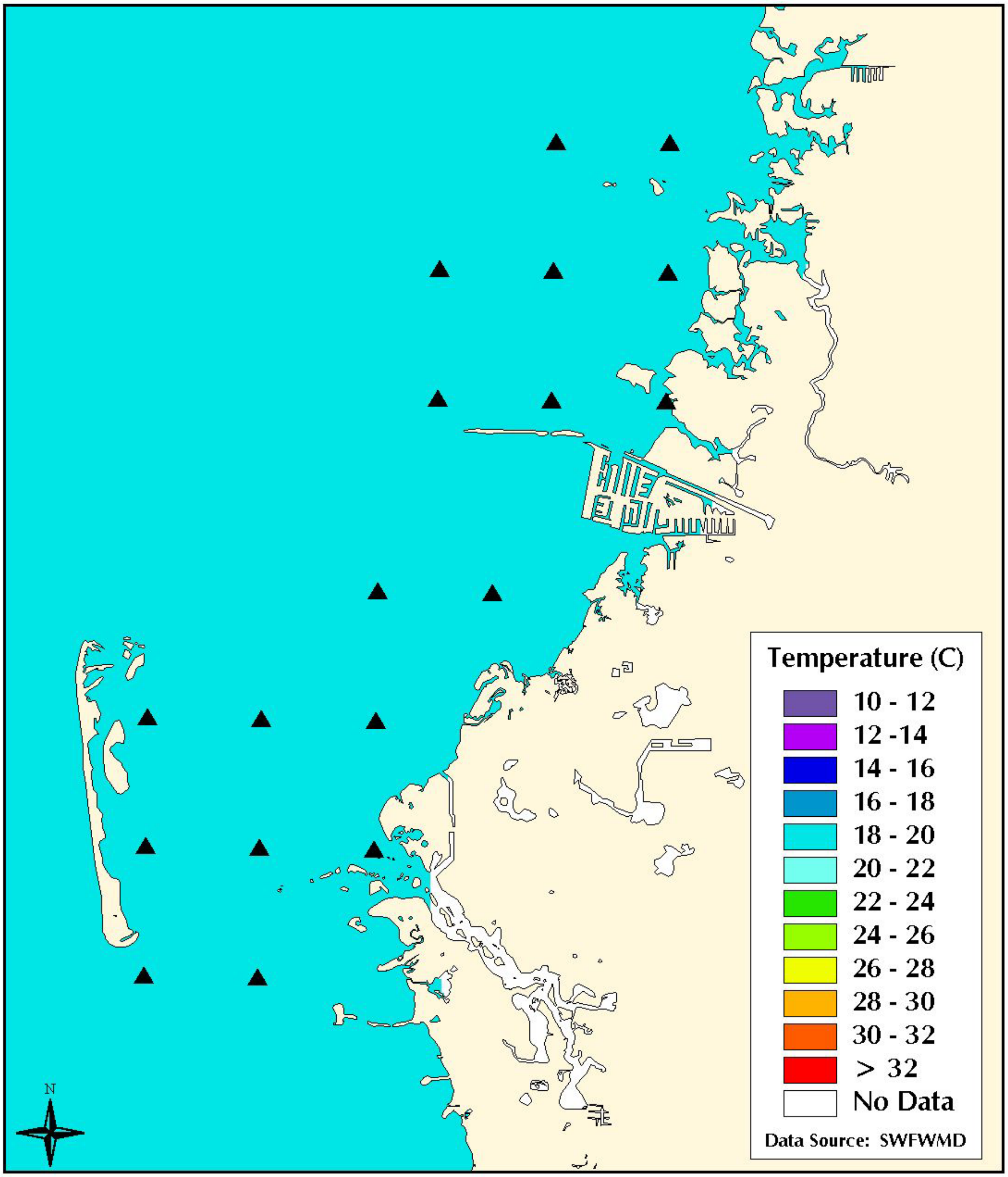
Contours of surface water temperature for August 2000.



Contours of surface water temperature for September 2000.



Contours of surface water temperature for October 2000.



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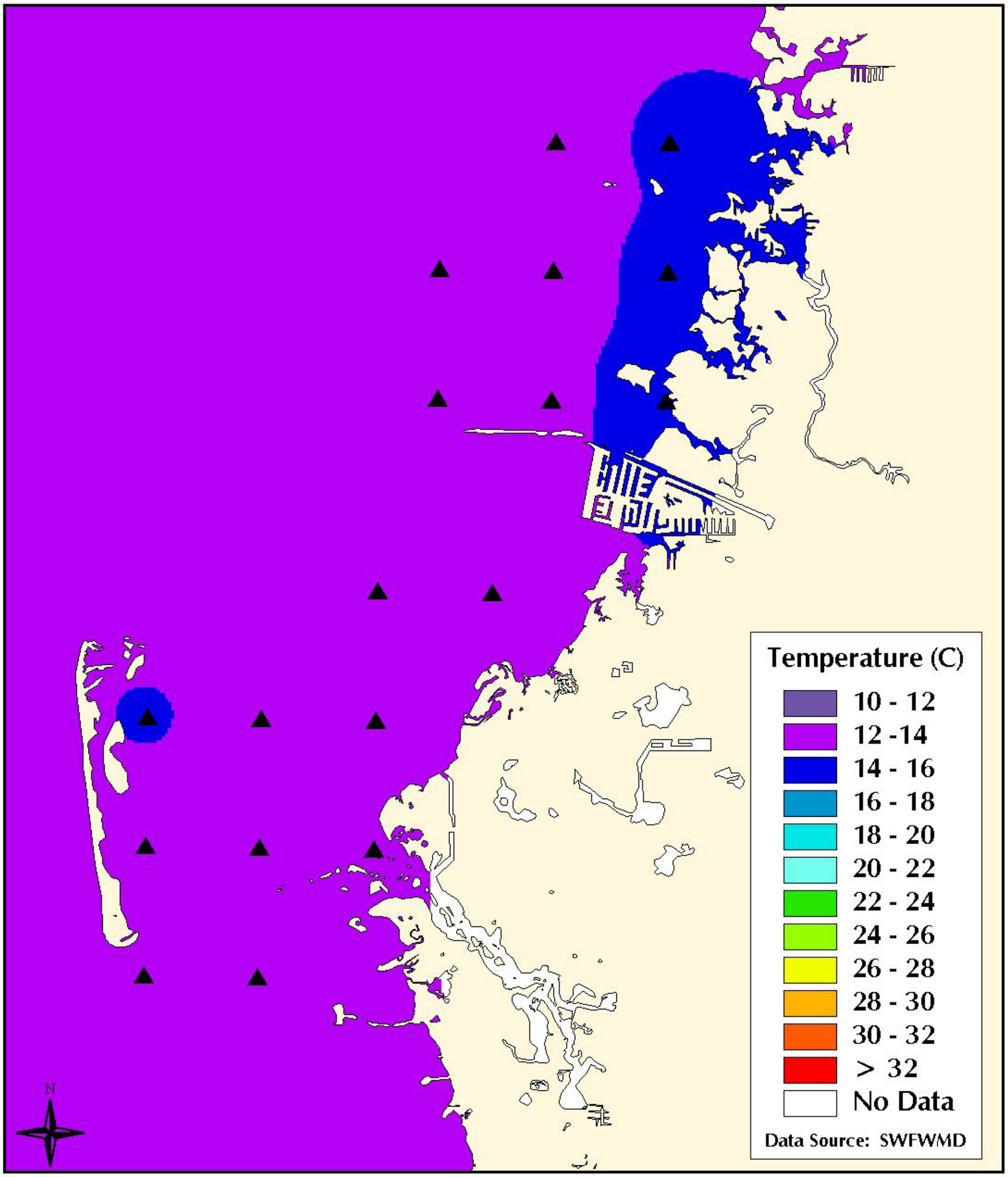
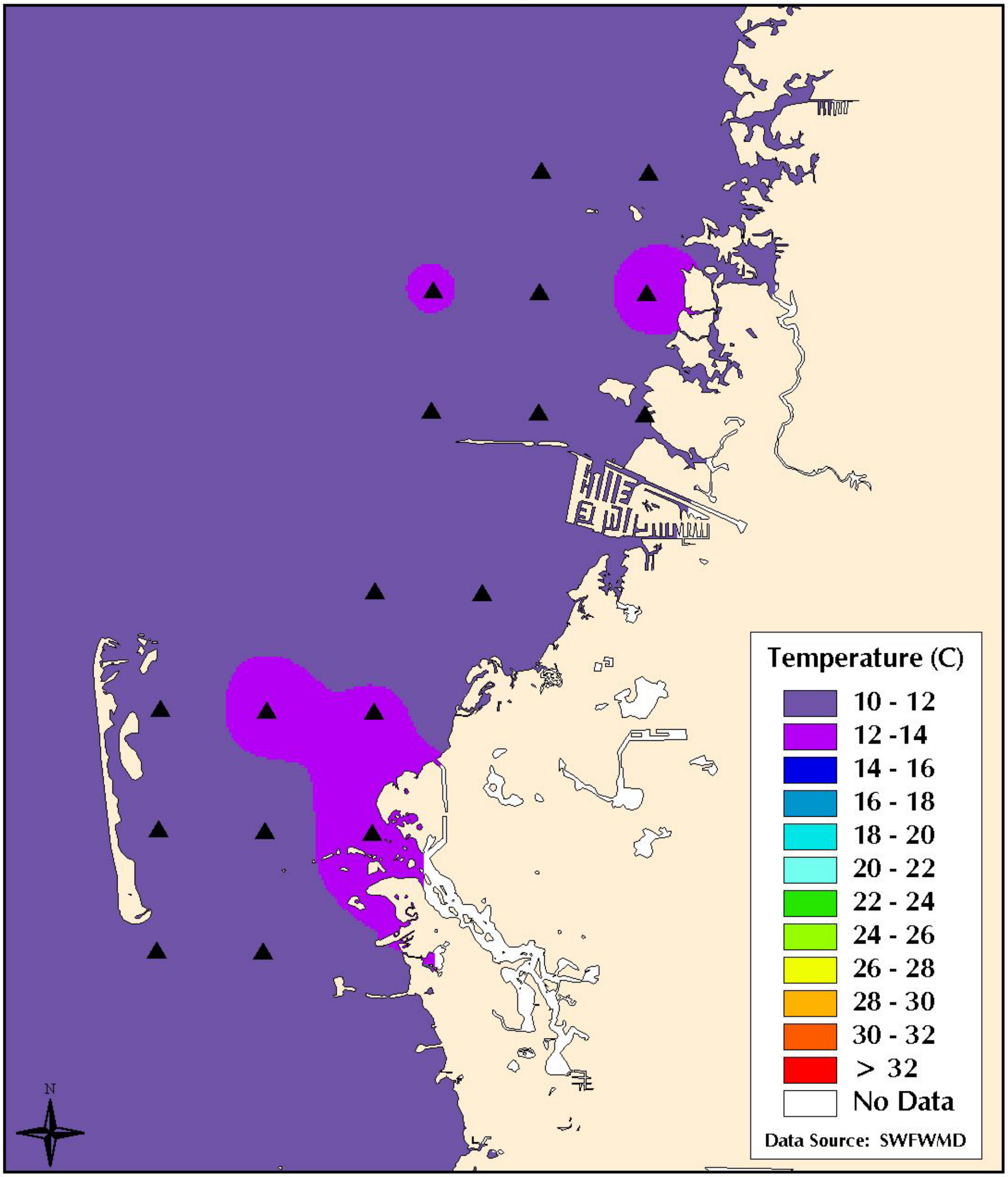
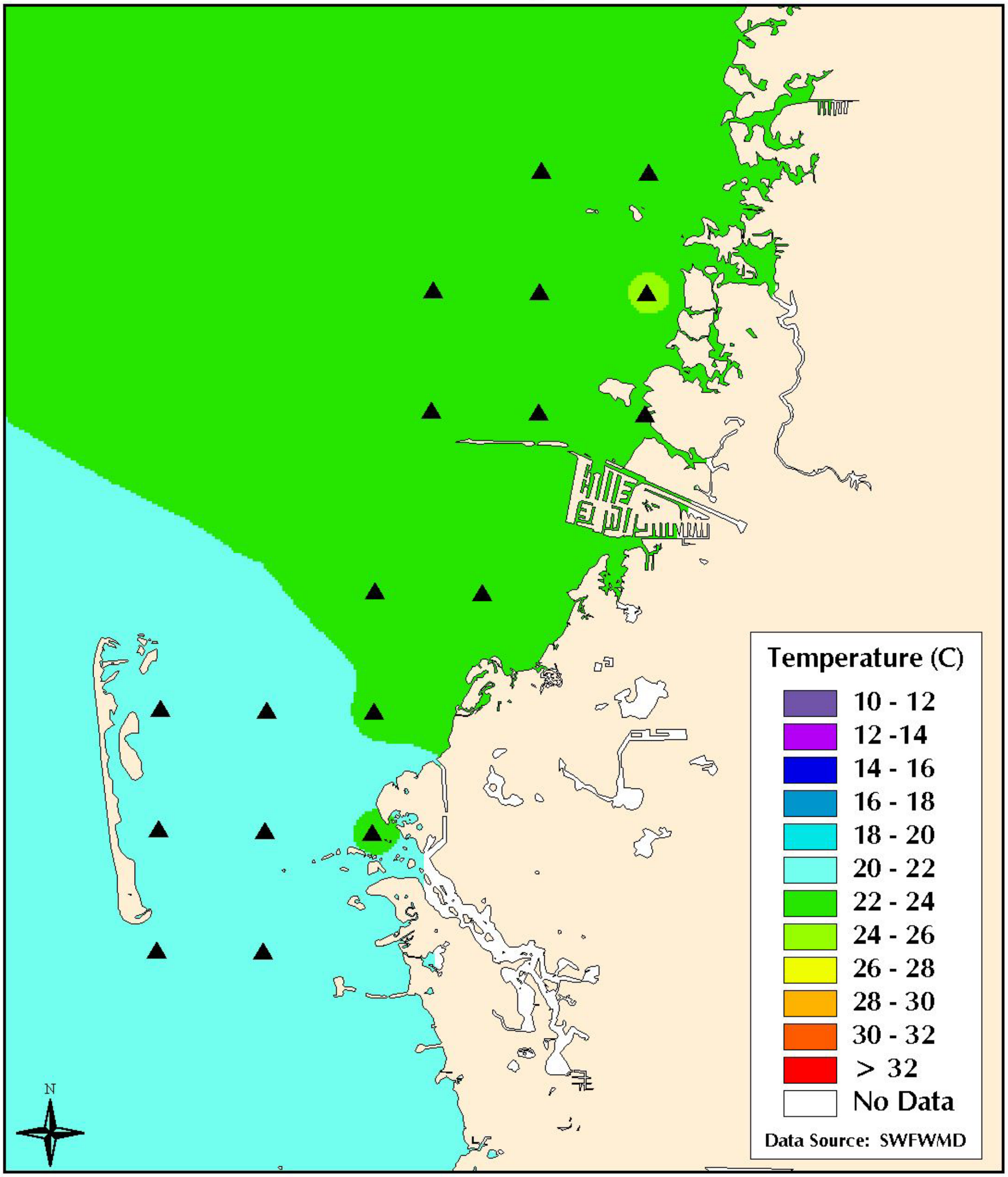


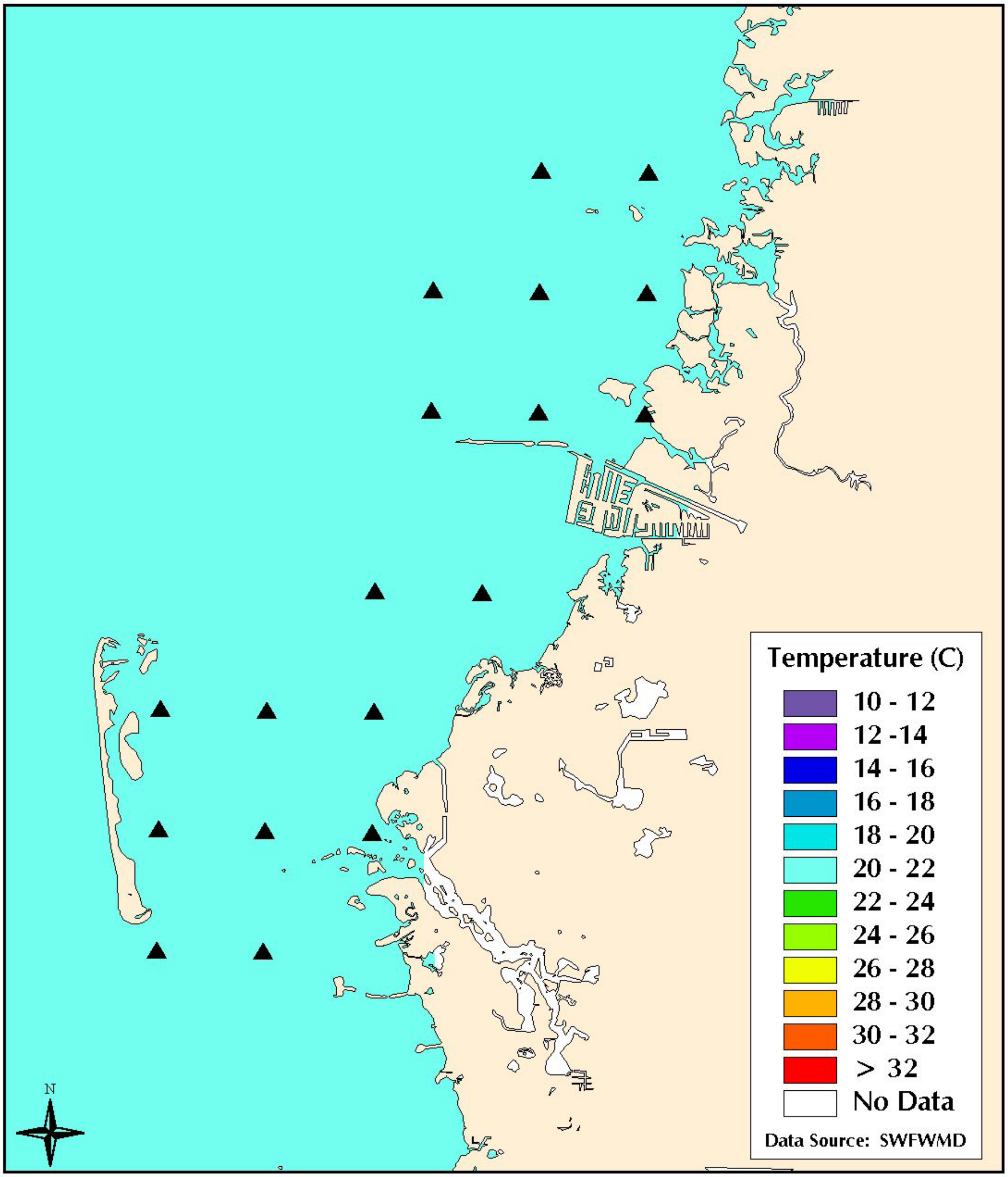
Contours of surface water temperature for December 2000.



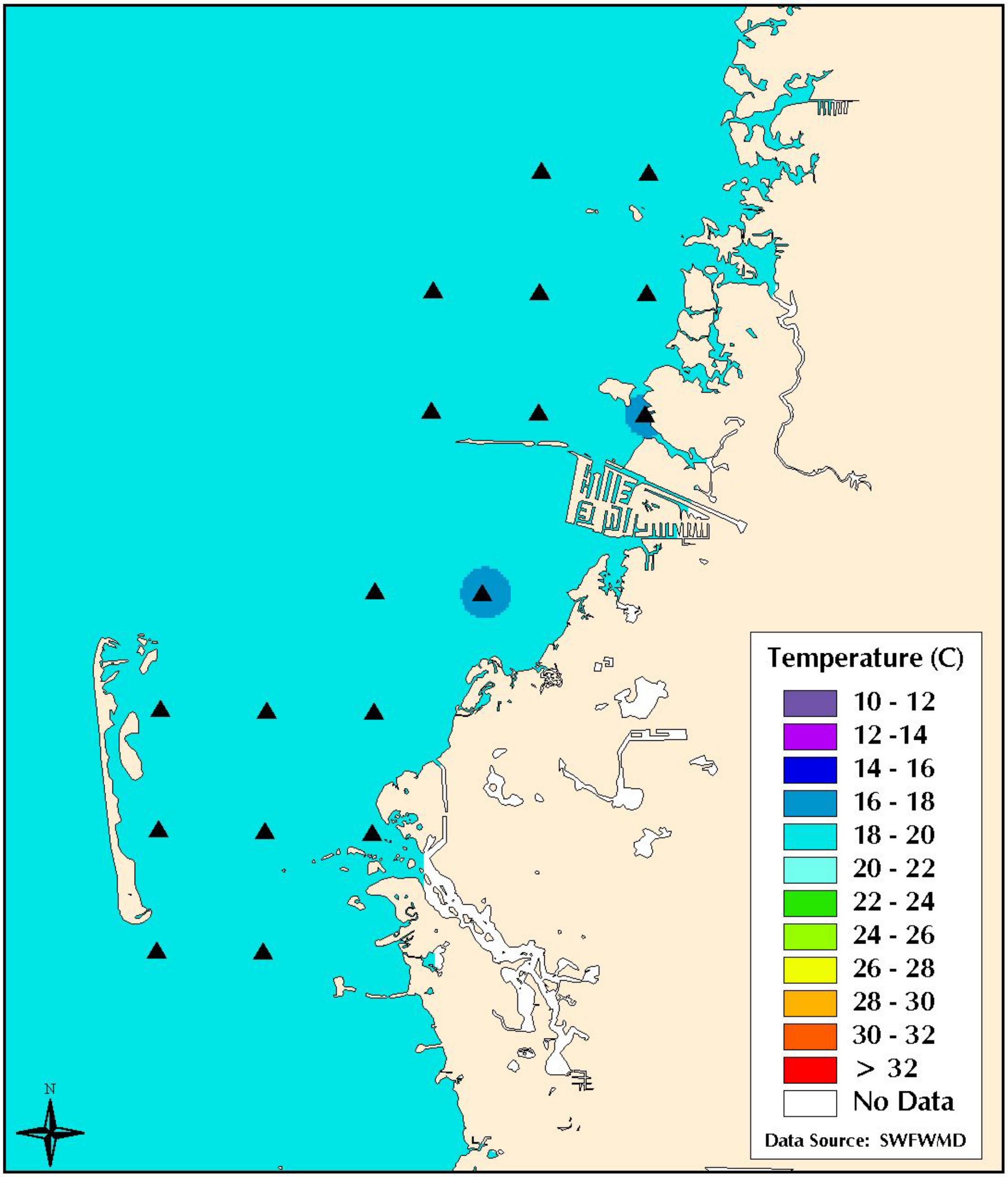
Contours of surface water temperature for January 2001.



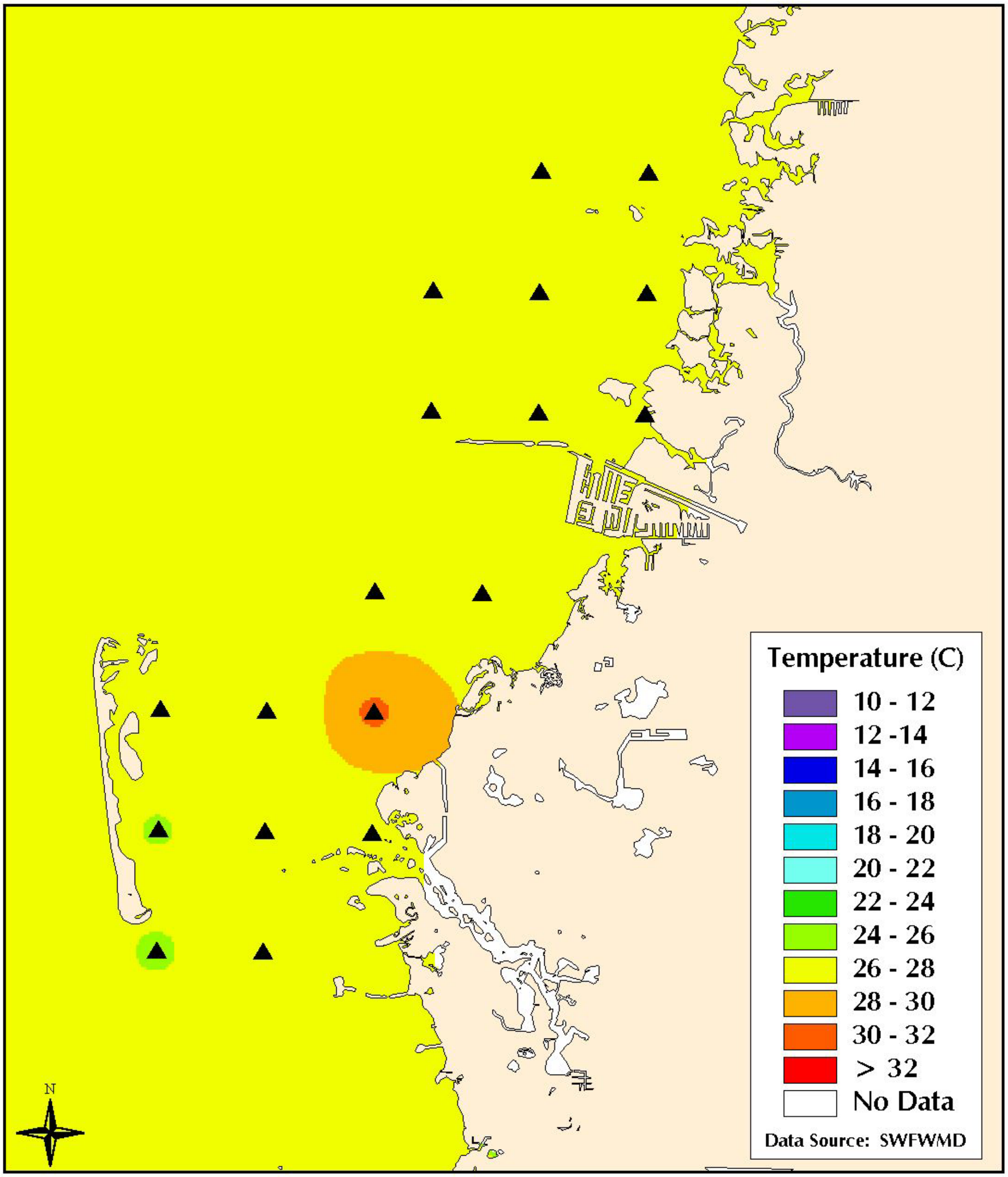
Contours of surface water temperature for February 2001



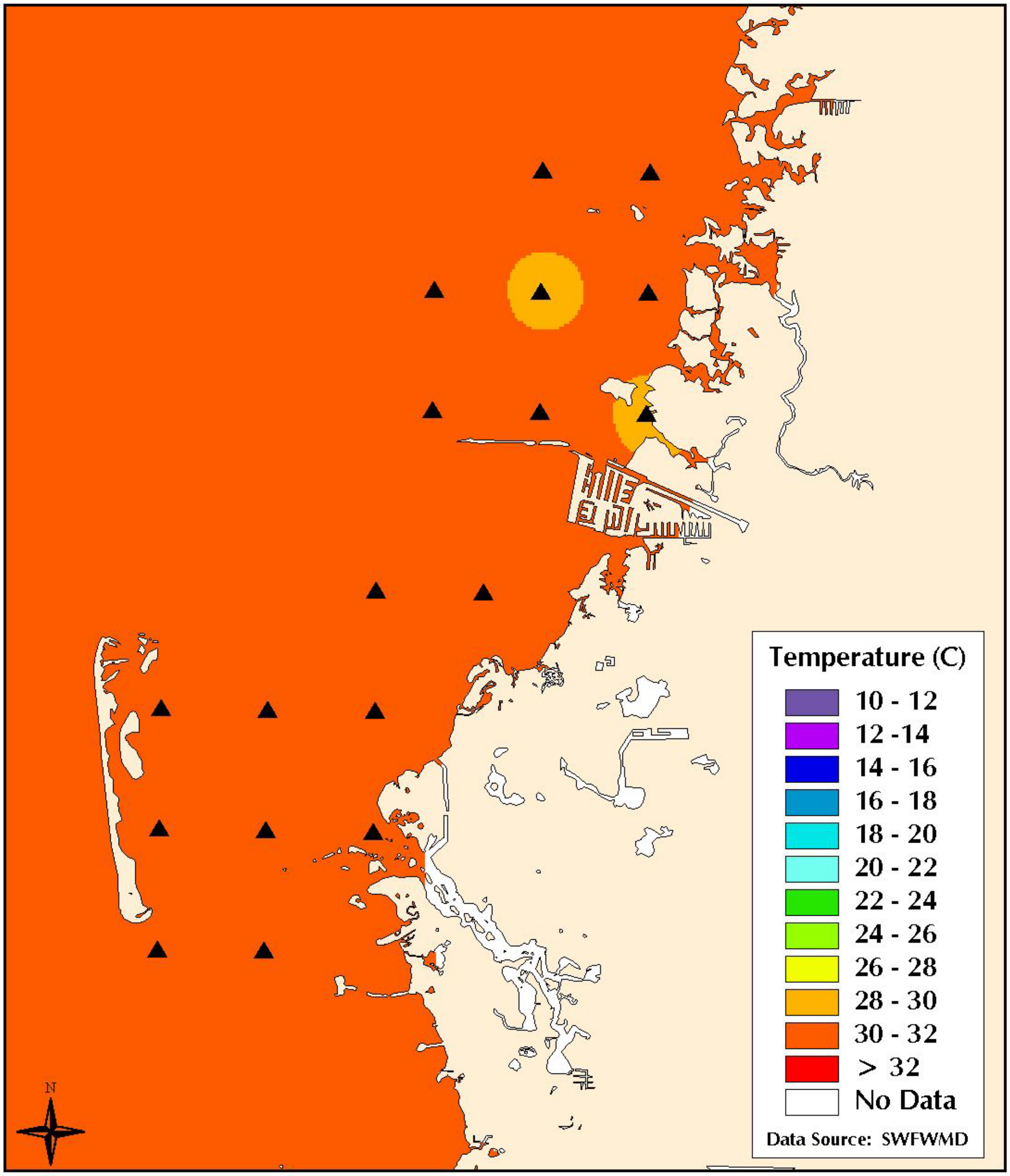
Contours of surface water temperature for March 2001.



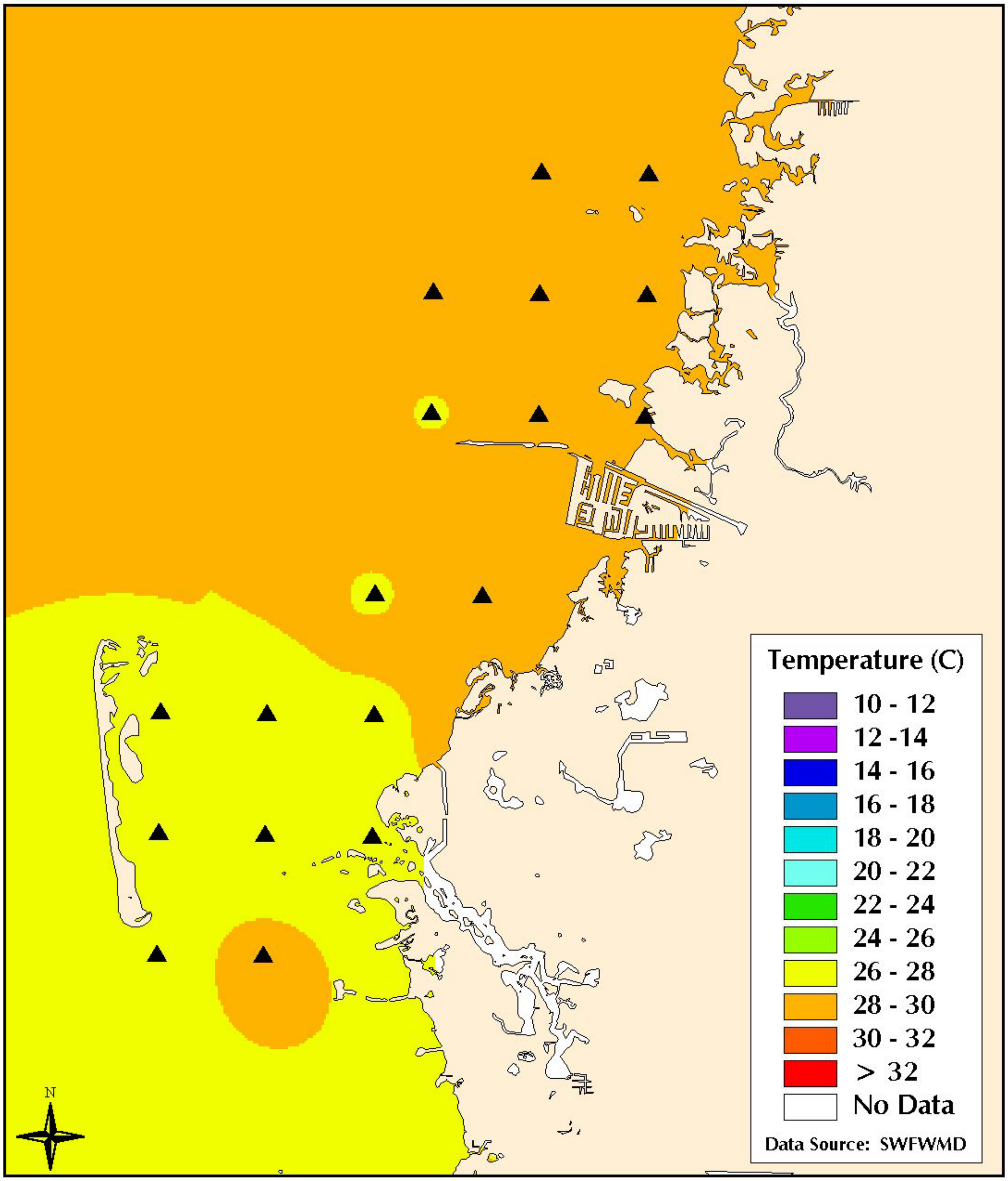
Contours of surface water temperature for April 2001.



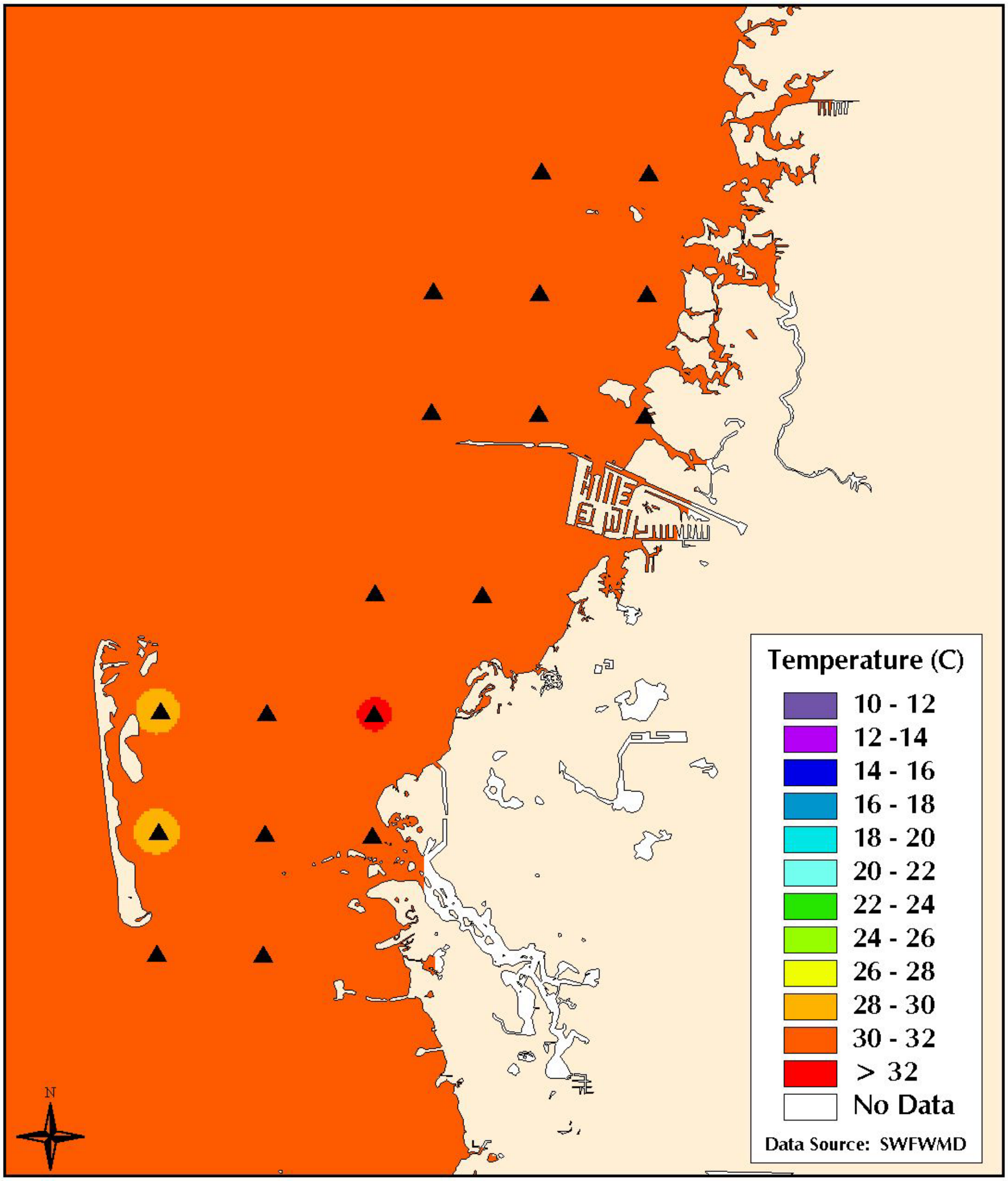
Contours of surface water temperature for May 2001.



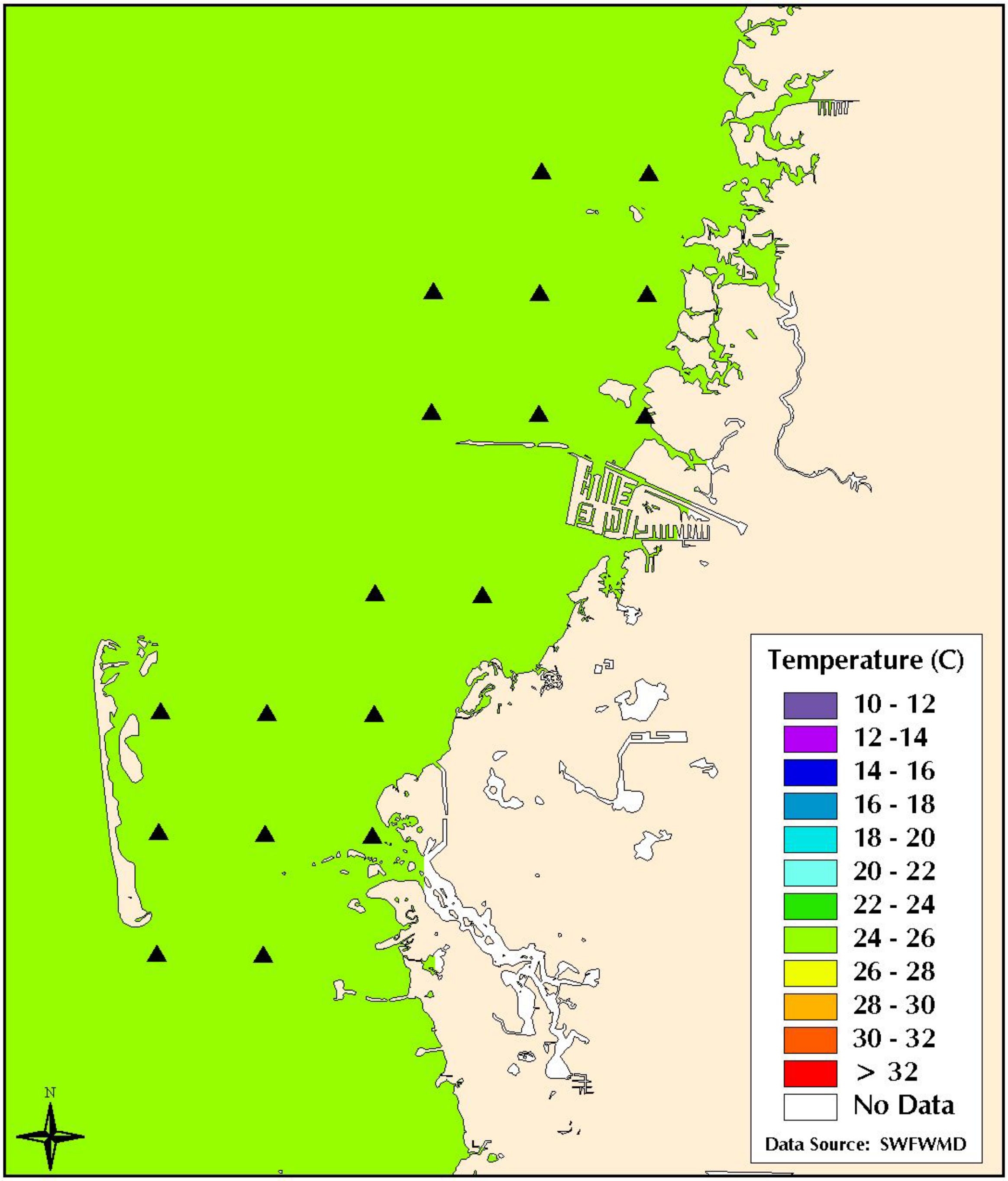
Contours of surface water temperature for June 2001.



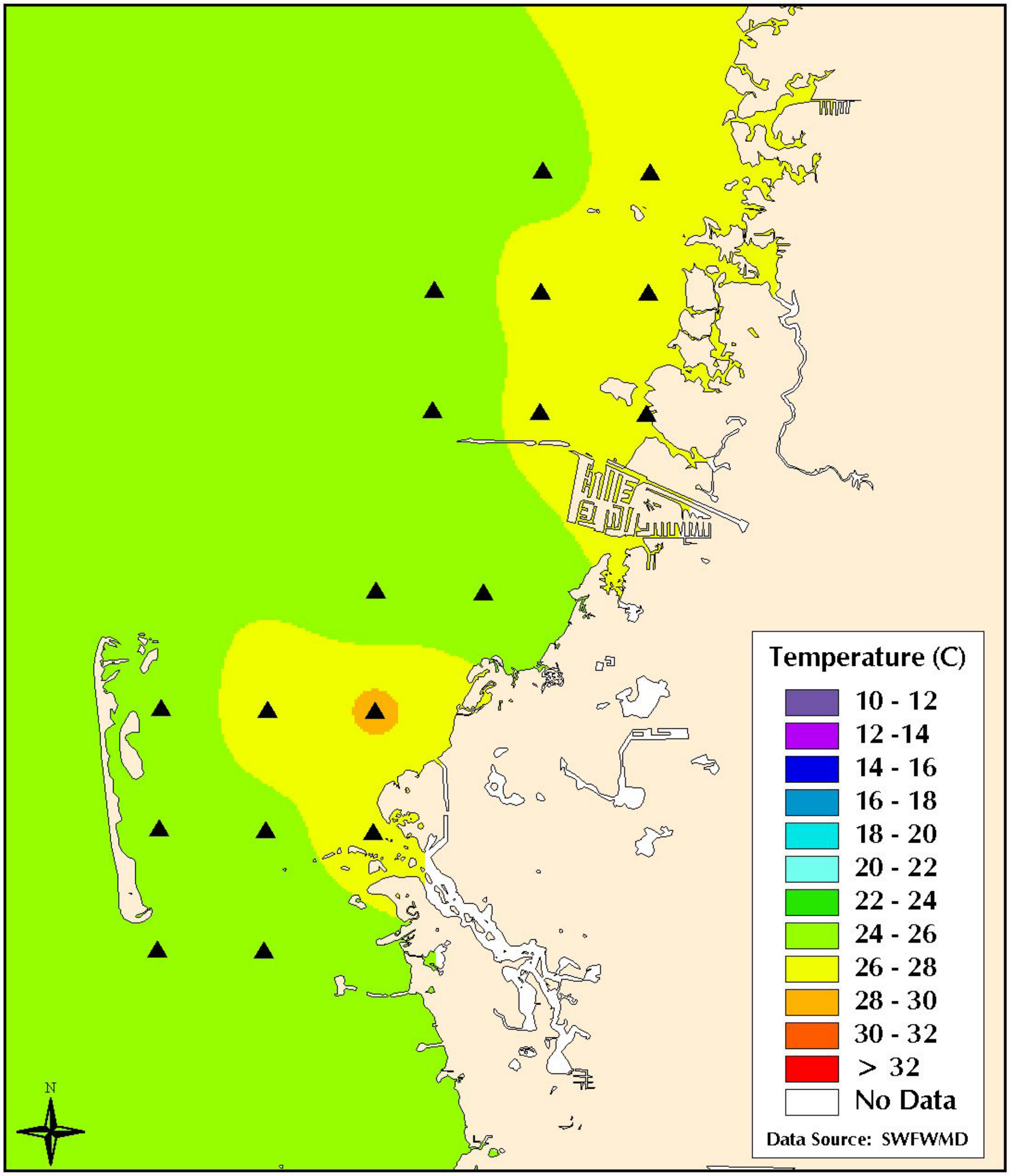
Contours of surface water temperature for July 2001.



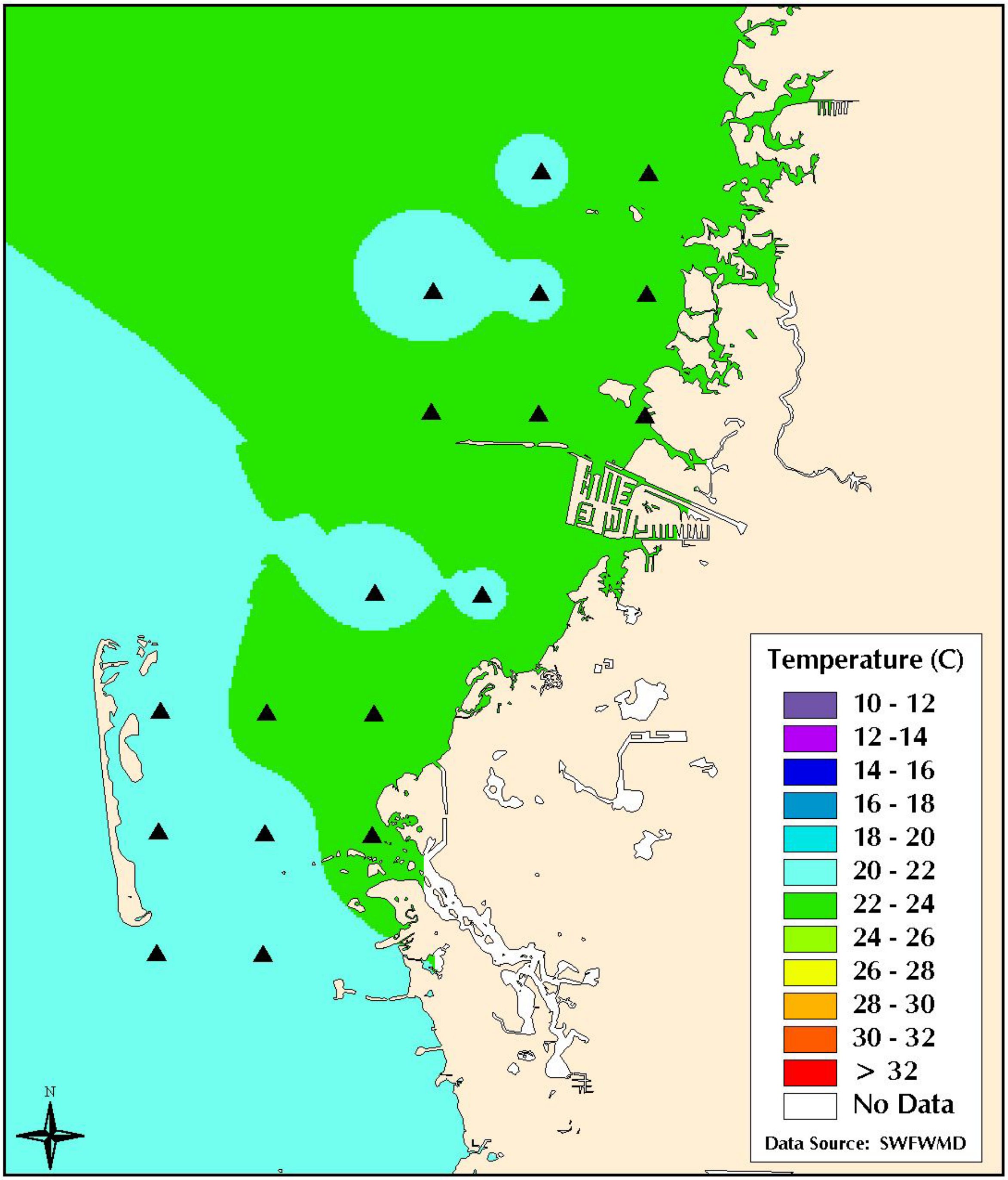
Contours of surface water temperature for August 2001.



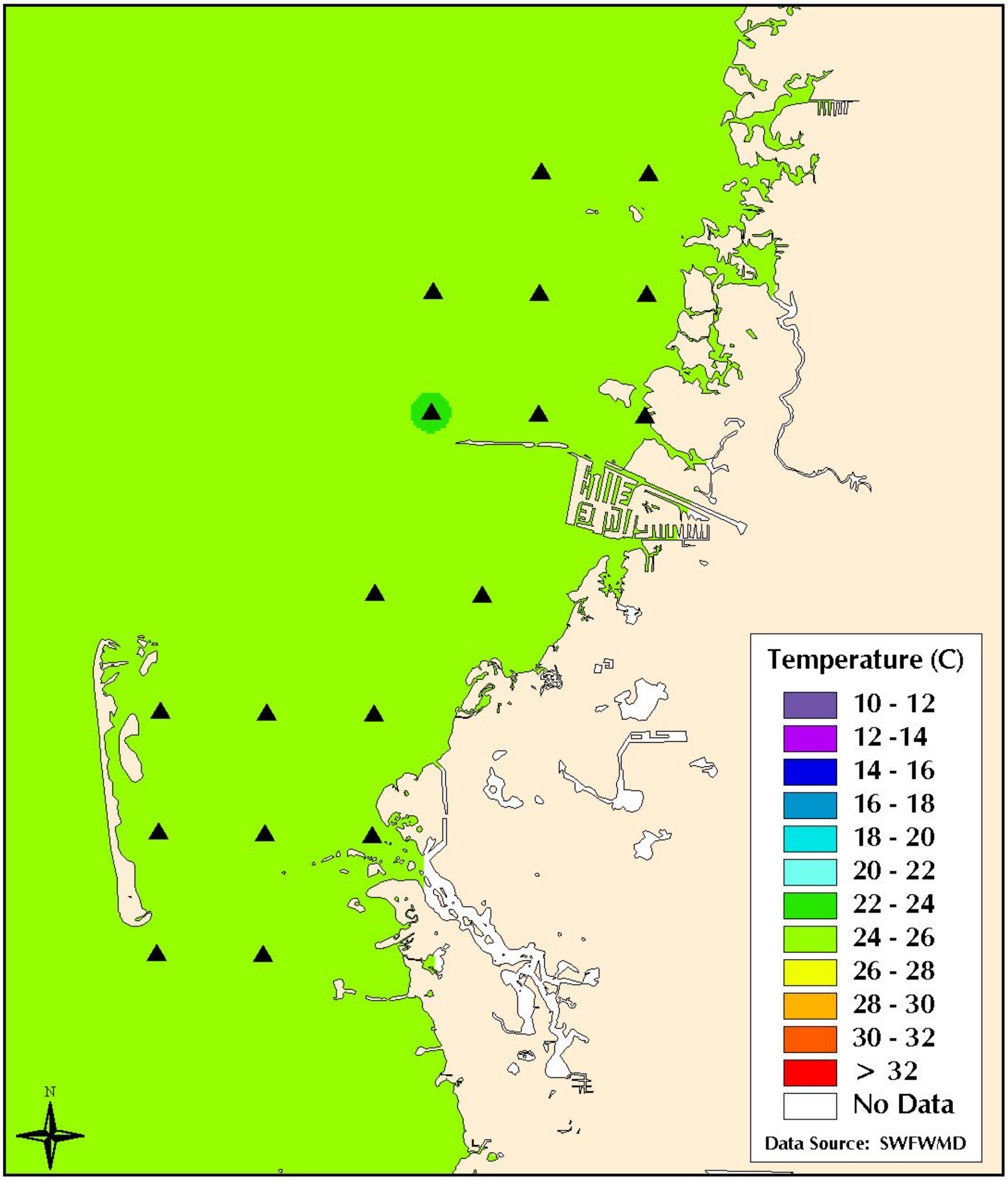
Contours of surface water temperature for September 2001.



Contours of surface water temperature for October 2001.



Contours of surface water temperature for November 2001.



Contours of surface water temperature for December 2001.

APPENDIX B

BENTHIC SPECIES COLLECTED FROM THE ANCLOTE ENVIRONMENTAL PROJECT (1970-1973)

Table B.1. Benthic species collected during the Anclote Environmental Study (1970-1973).

Taxonomic Group	Scientific Name	Common Name
Ascidians		
	Styela plicata	sea squirt
	Perophora viridis	sea squirt
Crustaceans		
	Alpheus heterochaelis	big claw snapping shrimp
	Ambidexter symmetricus	
	Callianassa sp.	ghost shrimp
	Callinectes sapidus	blue crab
	Clibanarius vittatus	thin stripe hermit crab
	Eurypanopeus depressus	mud crab
	Gastosaccus dissimilis	mysid shrimp
	Hepatus epheliticus	Dolly Varden crab
	Hippolysmata wurdemanni	veined shrimp
	Hippolyte pleuracantha	false zostera shrimp
	Hypochoncha arcuata	
	Latreutes fucorum	slender sargassum shrimp
	Latreutes sp.	
	Libinia dubia	longnose spider crab
	Libinia emarginata	
	Macrocoeloma camptocerum	decorator crab
	Menippe mercenaria	stone crab
	Metophorhapis calcarata	
	Mithrax hispidus	coral clinging crab
	Mysidopsis bigelowi	mysid shrimp
	Neopanope texana texana	mud crab
	Osachila tuberosa	
	Pagurus annulipes	hermit crab
	Pagurus bonairensis	hermit crab
	Pagurus impressus	hermit crab
	Pagurus longicarpus	hermit crab
	Pagurus pollicaris	hermit crab
	Palaemon floridanus	zebra shrimp
	Palaemonetes intermedius	grass shrimp
	Palaemonetes pugio	grass shrimp
	Palaemonetes vulgaris	grass shrimp
	Penaeus duorarum	pink shrimp
	Periclimenes americanus	grass shrimp
	Periclimenes longicaudatus	grass shrimp
	Persephona punctata aquilonaris	
	Petrochirus bahamensis	

Table B.1. Benthic species collected during the Anclote Environmental Study (1970-1973).

Taxonomic Group	Scientific Name	Common Name
	Petrolisthes armatus	porecelain crab
	Pilumnus sayi	hairy warf crab
Crustaceans	*Pinnixa chaetopterana*	pea crab
	Pinnixa sp.	pea crab
	Pinnotheres maculatus	pea crab
	Pitho sp.	
	Portunus gibbesii	
	Processa sp.	
	Sicyona sp.	
	Synalpheus sp.	fat handed snapping shrimp
	Taphromysis bowmani	
	Thor floridanus	grass shrimp
	Tozeuma carolinensis	arrow shrimp
	Trachypenaeus constrictus	spotted shrimp
	Trachypenaeus similis	roughback shrimp
	Uca pugilator	sand fiddler crab
	Upogebia affinis	mud shrimp
Echinoderms		
	Arbacia punctulata	purple spined sea urchin
	Astropecten duplicatus	spiney beaded sea star
	Echinaster spinulosus	orange ridged sea star
	Luidia alternata	limp sea star
	Luidia clathrata	netted sea star
	Lytechinus variegatus	green sea urchin
	Mellita quinquiesperforata	five-holed keyhole urchin
Mollusks		
	Acanthochitona sp.	chiton
	Amigdalum papyria	mussel
	Anachis avara	greedy dove shell
	Anachis iontha	dove shell
	Anachis obesa	fat dove shell
	Anachis semiplicata	dove shell
	Anadara ovalis	blood ark
	Anadara transversa	transverse ark
	Anomalocardia cuneimerius	pointed venus
	Anomia simplex	jingle shell
	Argopecten irradians concentricus	southern bay scallop
	Atrina rigida	stiff pen shell
	Batillaria minima	black horn shell
	Bursatella leachi plei	sea slug
	Bittium varium	variable bittium

Table B.1. Benthic species collected during the Anclote Environmental Study (1970-1973).

Taxonomic Group	Scientific Name	Common Name
	Brachiodontes exustus	scorched mussel
	Bulla occidentalis	common bubble
Mollusks	*Bullata ovuliformis*	teardrop marginella
	Busycon contrarium	lightning welk
	Busycon spiratum	pear welk
	Caecum pulchellum	beautiful caecum
	Caecum sp.	
	Cardiomya sp.	dipper shell
	Cardita floridana	broad ribbed cardita
	Cerithiopsis bicolor	horn shell
	Cerithiopsis greeni	Green's cerith
	Cerithium muscarum	dotted horn shell
	Cerodrillia perryae	drilla
	Chione cancellata	cross-barred chione
	Codakia orbicularis	little white lucine
	Conus jaspideus	jasper cone
	Crassostrea virginica	common oyster
	Crepidual fornicata	common slipper shell
	Crepiduala plana	flat slipper shell
	Crepidula maculosa	spotted slipper shell
	Cuspidaria sp.	dipper shell
	Cyclinella tenius	small ring clam
	Dentalium laqueatum	tusk shell
	Dinocardium robustum	great heart cockle
	Donax variabilis	coquina shell
	Dosinia discus	disk shell
	Ensis minor	dwarf razor clam
	Epitonium rupicola	lined wentletrap
	Eupleura sulcidentata	oyster drill
	Fasciolaria hunteria	banded tulip shell
	Fasciolaria tulipa	tulip shell
	Gemma gemma	gem shell
	Haminoea antillarum	antillean glassy bubble
	Haminoea succinea	amber glassy bubble
	Ischnochiton papillosus	chiton
	Laevicardium mortoni	morton's egg cockle
	Lima pellucida	inflated file shell
	Lioberus castaneus	chestnut mussel
	Littorina angulifera	southern periwinkle
	Littorina irrorata	gulf periwinkle
	Lolliguncula brevis	brief sqiud
	Lucina amiantus	decorated lucine
	Lucina floridana	Florida lucine

Table B.1. Benthic species collected during the Anclote Environmental Study (1970-1973).

Taxonomic Group	Scientific Name	Common Name
	Lucina sp.	
	Lyonsia hyalina floridana	glassy lyonsia
Mollusks	*Macoma sp.*	
	Macrocallista nimbosa	
	Marginella aureocincta	banded marginella
	Marginella eburneola	
	Marginella sp.	
	Meioceras nitidum	
	Melampus bidentatus	salt marsh snail
	Melampus coffeus	coffee bean snail
	Melongena corona	crown conch
	Mercenaria campechiensis	quahog
	Mercenaria mercenaria	quahog
	Mitrella lunata	crescent mitrella
	Modiolus americanus	tulip mussell
	Modiolus demissus	
	Modulus modulus	Atlantic modulus
	Monilispira leucocyma	knobby drilla
	Murex cellulosus	pitted murex
	Murex dilectus	
	Murex pomum	apple murex
	Musculus lateralis	lateral mussel
	Nassarius vibex	mottled dog welk
	Natica pusilla	miniature moon shell
	Natica sp.	moon shell
	Neritina reclivata	green nerite
	Neritina virginea	virgin nerite
	Noetia ponderosa	ponderous ark
	Nucula proxima	near nut shell
	Nuculana concentrica	concentric-lined nut shell
	Octopus joubini	
	Odostomia impressa	incised odostome
	Odostomia seminuda	half-smooth odostome
	Odostomia sp.	
	Oliva sayana	lettered olive
	Olivella mutica	dwarf olive
	Olivella sp.	
	Phacoides nassula	woven lucine
	Phacoides pectinatus	Jamaica lucine
	Polinices duplicata	lobed moon shell
	Prunum apicinum	common marginella
	Prunum minuta	
	Pyramidella creulata	crenate pyram

Table B.1. Benthic species collected during the Anclote Environmental Study (1970-1973).

Taxonomic Group	Scientific Name	Common Name
	Pyramidella sp.	
	Pyrgocythara plicosa	
	Retusa canaliculata	channeled barrel bubble
Mollusks	*Rissoina catesbyana*	
	Sinum perspectivum	ear shell
	Spisula solidissima	surf clam
	Strombus alatus	Florida stromb
	Tagelus divisus	piurple tagelus
	Tellidora cristata	crested tellin
	Tellina alternata	lined tellin
	Tellina tampaensis	Tampa tellin
	Terebra dislocata	common auger
	Terebra protexta	black auger
	Thais haemastoma haysae	Hays rock snail
	Trachycardium egmontianum	china cockle
	Triphora sp.	
	Turbo castaneus	knobby turbin
	Turbonilla dalli	Dall's turbonille
	Turbonilla sp.	
	Urosalpinx perrugata	Gulf oyster drill
	Urosalpinx tampaensis	Tampa oyster drill
	Venericardia tridentata	three-toothed cardita
	Vitrinella sp.	
Polychaetes		
	Arenicola cristata	
	Aricidea sp.	
	Aricidea fragilis	
	Brania sp.	
	Capitella capitata	
	Ceratonereis mirabilis	
	Chaetopterus variopedatus	
	Chone duneri	
	Chone infundibuliformis	
	Cirriformia filigera	
	Clymenella mucosa	
	Diopatra cuprea	
	Dispio sp.	
	Dodecaceria concharum	
	Eteone sp.	
	Eteone alba	
	Eteone heteropoda	
	Eucranta sp.	

Table B.1. Benthic species collected during the Anclote Environmental Study (1970-1973).

Taxonomic Group	Scientific Name	Common Name
	Eupomatus sp.	
	Exogone dispar	
	Fabricia sp.	
Polychaetes	*Harmothoe* sp.	
	Harmothoe aculeata	
	Heteromastus filiformis	
	Hypsicomus sp.	
	Hypsicomus torquatus	
	Glycera americana	
	Glycera dibranchiata	
	Goniadella sp.	
	Gyptis vittata	
	Laeonereis culveri	
	Loimia medusa	
	Lumbrineris sp.	
	Lumbrineris bassi	
	Lumbrineris branchiata	
	Marphysa sanguinea	
	Megalona pettiboneae	
	Melinna maculata	
	Naineris	
	Nereiphylla fragilis	
	Nereiphylla paretti	
	Nereis sp.	
	Nereis phylla paretti	
	Nereis succinea	
	Notomastus sp.	
	Notomastus latericeus	
	Onuphis eremita oculata	
	Onuphis magna	
	Pectinaria gouldii	
	Platynereis dumerilii	
	Polydora commensalis	
	Polydora ligni	
	Polydora websteri	
	Prionospio pinnata	
	Prionospio sp.	
	Prionospio heterobranchia	
	Prista palmata	
	Sabella microphthalma	
	Scoloplos fragilis	
	Scoloplos robustus	
	Scoloplos rubra	

Table B.1. Benthic species collected during the Anclote Environmental Study (1970-1973).

Taxonomic Group	Scientific Name	Common Name
	Sphaerosyllis sp.	
	Spiophanes bombyx	
	Spirobis sp.	
	Spirorbis sp.	
Polychaetes	*Spirorbis spirillum*	
	Tharyx dorsobranchialis	
	Typosyllis sp.	
Other benthos		
	Schizoporella unicornis	single horn bryzoan
	Limulus polyphemus	horseshoe crab

APPENDIX C

BENTHIC TAXA COLLECTED AT THE FLORIDA POWER BENTHIC SAMPLING SITES

Table C-1. Percent composition of taxa distributed among major groups for benthic infauna at Anclote seagrass stations for spring, 1990. Anclote Monitoring Studies.

Faunal Group	Station: 1.1	1.2	1.3	2.1	3.1	3.2	4.2	5.1	5.2	5.3	6.1	6.2	6.3	7.3	8.1	8.2	9.2	10.1	11.1	11.2	11.3
Annelida:																					
Polychaeta	41.4	35.3	34.5	38.4	45.7	46.4	44.2	50.8	45.7	40.9	44.9	44.2	52.9	41.9	51.9	39.3	42.3	40.2	39.8	43.9	40.0
Oligochaeta	8.1	7.8	6.9	8.1	9.6	8.7	7.7	11.9	10.0	6.5	6.7	8.1	5.9	9.7	6.3	6.0	6.2	7.2	8.4	7.1	6.7
SUB-TOTAL	49.5	43.1	41.4	46.5	55.3	55.1	51.9	62.7	55.7	47.3	51.7	52.3	58.8	51.6	58.2	45.2	48.5	47.4	48.2	51.0	46.7
Mollusca:																					
Gastropoda	14.1	13.7	17.2	16.2	13.8	15.9	15.4	6.8	11.4	14.0	13.5	16.3	2.9	9.7	12.7	11.9	11.3	17.5	9.6	16.3	16.2
Bivalvia	7.1	8.8	7.8	6.1	5.3	8.7	8.7	5.1	8.6	7.5	4.5	8.1	5.9	3.2	6.3	9.5	9.3	5.2	8.4	8.2	5.7
Misc.Mollusca	0.0	2.0	0.9	1.0	1.1	1.4	2.9	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	1.2	0.0	1.0	2.4	3.1	1.0
SUB-TOTAL:	21.2	24.5	25.9	23.2	20.2	26.1	26.9	11.9	20.0	22.6	18.0	24.4	8.8	12.9	19.0	22.6	20.6	23.7	20.5	27.6	22.9
Arthropoda:																					
Ostracoda	1.0	2.0	4.3	3.0	0.0	1.4	1.0	5.1	2.9	4.3	4.5	3.5	4.4	0.0	1.3	2.4	2.1	2.1	1.2	0.0	1.0
Cirripedia	0.0	0. 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mysidacea	1.0	1.0	0.9	1.0	1.1	0.0	0.0	1.7	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
Cumacea	1.0	2.0	1.7	1.0	1.1	0.0	0.0	0.0	1.4	0.0	4.5	0.0	1.5	0.0	0.0	1.2	1.0	1.0	2.4	1.0	1.9
Tanaidacea	2.0	1.0	0.9	2.0	1.1	0.0	0.0	1.7	1.4	1.1	1.1	2.3	1.5	3.2	1.3	1.2	1.0	1.0	1.2	1.0	1.0
Isopoda	2.0	3.9	4.3	4.0	3.2	1.4	1.4	0.0	0.0	2.2	2.2	0.0	2.9	0.0	2.5	2.4	2.1	3.1	3.6	2.0	1.9
Amphipoda	11.0	10.8	10.3	9.1	7.4	8.7	8.7	8.5	12.9	15.1	10.1	11.6	13.2	25.8	8.9	15.5	11.3	13.4	16.9	7.1	11.4
Decapoda	3.0	3.9	5.2	3.0	6.4	2.9	2.9	5.1	4.3	2.2	3.4	3.5	4.4	3.2	3.8	3.6	6.2	4.1	2.4	3.1	5.7
Insecta	0.0	1.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.1	0.0	0.0	0.0	1.0
M isc.																					
Arthropoda	1.0	1.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	1.2	0.0	0.0	0.0	1.2	1.0	1.0	1.2	1.0	1.0
SUB-TOTAL:	23.2	26.5	29.3	23.2	20.2	14.5	19.2	22.0	22.9	25.8	27.0	22.1	29.4	32.3	17.7	27.4	24.7	26.8	28.9	15.3	24.8
Echinodermata:																					
Echinodermata	2.0	2.0	0.9	2.0	0.0	1.4	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	1.3	1.2	2.1	2.1	1.2	1.0	1.9
Veterbrata:																					
Vertebrata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscellaneous	4.0	3.9	2.6	5.1	4.3	2.9	1.9	3.4	1.4	3.2	3.4	1.2	2.9	3.2	3.8	3.6	4.1	0.0	1.2	5.1	3.8
TOTAL:	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	

Table C-2. Percent composition of taxa distributed among major groups for benthic infauna at Anclote seagrass stations for summer, 1990. Anclote Monitoring Studies.

Faunal Group	Station: 1.1	1.2	1.3	2.1	3.1	3.2	4.2	5.1	5.2	5.3	6.1	6.2	6.3	7.3	8.1	8.2	9.2	10.1	11.1	11.2	11.3
Annelida:																					
Polychaeta	40.5	40.4	38.8	44.9	41.8	44.2	41.1	40.0	40.3	43.8	32.8	37.2	34.1	36.8	39.8	40.0	39.8	33.7	43.3	40.4	38.8
Oligochaeta	8.1	8.5	5.8	7.7	11.9	8.1	8.0	8.2	6.5	6.8	4.9	8.5	5.5	5.7	6.5	6.4	5.3	6.9	7.8	7.1	5,2
SUB-TOTAL	48.6	48,9	44.6	52.6	53.7	52.3	49.4	48.2	46.8	50.7	37.7	45.7	39.6	42.5	46.2	46.4	45.1	40.6	51.1	47.5	44.0
Mollusca:																					
Gastropoda	20.3	13.8	15.7	17.9	22.4	19.8	21.8	18.8	18.2	15.1	16.4	16.0	16.5	18.4	23.7	15.5	13.3	23.8	15.6	17.2	14.2
Bivalvia	9.5	5.3	9.9	11.5	10.4	10.5	10.3	4.7	11.7	4.1	6.6	6.4	9.9	10.3	10.8	7.3	11.5	11.9	4.4	4.0	9.0
Misc.Mollusca	1.4	2.1	0.8	0.0	0.0	1.2	2.3	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.9	0.0	0.0	1.1	1.0	1.5
SUB-TOTAL:	31.1	21.3	26.4	29.5	32.8	31.4	34.5	23.5	29.9	19.2	23.8	22.3	26.4	28.7	34.4	23.6	24.8	35.6	21.1	22.2	24.6
Arthropoda:																					
Ostracoda	1.4	2.1	3.3	1.3	0.0	1.2	0.0	1.2	1.3	1.4	2.5	5.3	5.5	6.9	1.1	2.7	2.7	1.0	0.0	1.0	3.0
Cirripedia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Mysidacea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Cumacea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	2.2	2.3	0.0	0.9	0.9	0.0	1.1	1.0	0.7
Tanaidacea	0.0	1.1	0.8	1.3	1.5	0.0	1.1	0.0	2.6	0.0	0.8	1.1	1.1	0.0	1.1	0.9	0.0	1.0	1.1	1.0	0.7
Isopoda	0.0	0.0	2.5	1.3	1.5	1.2	2.3	2.4	0.0	4.1	3.3	2.1	0.0	1.1	2.2	1.8	2.7	2.0	3.3	2.0	0.7
Amphipoda	8.1	8.5	8.3	3.8	1.5	4.7	1.1	8.2	5.2	2.3	12.3	11.7	8.8	4.6	4.3	10.9	8.0	4.0	8.9	7.1	9.7
Decapoda	4.1	7.4	5.0	3.8	3.0	4.7	8.0	2.8	6.5	9.6	10.7	5.3	8.8	5.7	5.4	6.4	10.6	10.9	6.7	9.1	7.5
Insecta	1.4	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
M isc. Arthropoda	0.0	1.1	0.8	1.3	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	1.1	0.0	0.9	0.9	0.0	0.0	1.0	0.7
SUB-TOTAL:	14.9	20.2	20.7	14.1	7.5	11.6	12.6	23.5	16.9	27.4	29.5	26.6	27.5	21.8	14.0	24.5	25.7	18.8	21.1	22.2	24.6
Echinodermata:																					
Echinodermata	1.4	1.1	1.7	0.0	1.5	0.0	1.1	1.2	1.3	1.4	2.5	1.1	2.2	2.3	2.2	1.8	0.9	1.0	0.0	3.0	2.2
Veterbrata:																					
Vertebrata	1.4	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscellaneous	2.7	8.5	5.8	3.8	4.5	4.7	2.3	3.5	5.2	1.4	6.6	4.3	4.4	4.6	3.2	3.6	3.5	4.0	6.7	5.1	4.5
TOTAL:	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table C-3. Percent composition of taxa distributed among major groups for benthic infauna at Anclote seagrass stations for fall, 1990. Anclote Monitoring Studies.

Faunal Group	Station: 1.1	1.2	1.3	2.1	3.1	3.2	4.2	5.1	5.2	5.3	6.1	6.2	6.3	7.3	8.1	8.2	9.2	10.1	11.1	11.2	11.3
Annelida:																					
Polychaeta	37.7	43.8	38.4	42.0	37.1	43.1	41.7	42.3	39.4	37.5	37.8	39.8	35.2	34.1	34.7	36.5	35.2	35.2	42.7	39.6	38.7
Oligochaeta	4.9	6.3	7.1	8.6	7.9	6.9	7.3	7.2	5.3	6.7	7.1	7.1	6.8	4.4	4.2	5.8	3.4	6.5	7.3	6.6	6.3
SUB-TOTAL	42.6	50.0	45.5	50.6	44.9	50.0	49.0	49.5	44.7	44.2	44.9	46.9	42.0	38.5	38.9	42.3	38.6	41.7	50.0	46.2	45.0
Mollusca:																					
Gastropoda	21.3	18.8	19.2	19.8	22.5	16.7	26.0	18.6	20.2	18.3	18.4	16.3	20.5	17.6	23.6	18.3	15.9	19.4	16.7	14.2	14.4
Bivalvia	8.2	4.5	9.1	6.2	9.0	9.8	4.2	5.2	5.3	6.7	9.2	13.3	9.1	11.0	4.2	8.7	11.4	9.3	6.3	8.5	9.0
Misc.Mollusca	2.5	2.7	3.0	2.5	4.5	2.9	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.1	0.9	4.2	4.7	2.7
SUB-TOTAL:	32.0	25.9	31.3	28.4	36.0	29.4	31.3	23.7	25.5	26.0	27.6	29.6	29.5	28.6	27.8	27.9	28.4	29.6	27.1	27.4	26.1
Arthropoda:																					
Ostracoda	0.8	0.9	2.0	0.0	0.0	1.0	0.0	2.1	3.2	2.9	2.0	2.0	4.5	3.3	2.8	1.9	2.3	0.0	0.0	0.0	0.9
Cirripedia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0
Mysidacea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cumacea	0.0	0.0	0.0	0.0	0.0	1.0	0.0	2.1	2.1	0.0	2.0	2.0	3.4	0.0	1.4	0.0	1.1	0.9	0.0	0.0	0.0
Tanaidacea	0.8	0.9	1.0	1.2	1.1	1.0	1.0	1.0	1.1	1.0	1.0	0.0	0.0	1.1	0.0	1.0	0.0	0.9	1.0	0.9	0.9
Isopoda	1.6	0.9	0.0	1.2	1.1	0.0	2.1	4.1	0.0	4.8	2.0	0.0	1.1	2.2	2.8	2.9	1.1	0.9	1.0	1.9	2.7
Amphipoda	10.7	9.8	6.1	6.2	6.7	7.8	7.3	9.3	12.8	12.5	9.2	9.2	10.2	13.2	13.9	10.6	13.6	8.3	10.4	10.4	9.0
Decapoda	4.9	4.5	5.1	6.2	3.4	2.0	4.2	3.1	6.4	5.8	6.1	6.1	5.7	6.6	8.3	4.8	6.8	6.5	5.2	3.8	7.2
Insecta	0.8	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
M isc. Arthropoda	0.8	0.9	1.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.1	0.9	1.0	0.9	0.9
SUB-TOTAL:	20.5	17.9	15.2	14.8	12.4	12.7	15.6	21.6	25.5	27.9	23.5	19.4	25.0	26.4	29.2	22.1	26.1	19.4	18.8	17.9	21.6
Echinodermata:																					
Echinodermata	2.5	0.9	3.0	0.0	2.2	2.0	1.0	1.0	1.1	1.0	2.0	1.0	2.3	3.3	1.4	3.8	3.4	4.6	1.0	1.9	1.8
Veterbrata:																					
Vertebrata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscellaneous	2.5	5.4	4.0	6.2	4.5	5.9	3.1	4.1	3.2	1.0	2.0	3.1	1.1	3.3	2.8	3.8	3.4	3.7	3.1	6.6	5.4
TOTAL:	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

APPENDIX D

FISH FAUNA FROM THE ANCLOTE ANCHORAGE AREA

Table D.1. List of fish fauna collected from the Anclote Anchorage area (Fable, 1973).

Scientific Name	Common Name
Achirus lineatus	lined soul
Adinia xenica	diamond killifish
Anchoa mitchilli	bay anchovy
Archosargus probatocephalus	sheepshead
Arius felis	hardhead catfish
Bairdiella chrysura	silver pearch
Brevoortia smithi	yellowfin mehaden
Caranx hippos	crevalle jack
Centropomus undecimalis	common snook
Chaetodipterus faber	Atlantic spadefish
Chilomycterus schoepfi	striped burrfish
Cynoscion nebulosus	speckled trout
Cyprinodon variegatus	sheepshead minnow
Dasyatis sabina	Atlantic stingray
Diapterus plumieri	striped mojarra
Echeneis naucrates	suckerfish
Elops saurus	ladyfish
Eucinostomus argenteus	spotfin mojarra
Eucinostomus gula	silver jenny
Floridichthys carpio	goldspotted killifish
Fundulus grandis	Gulf killifish
Fundulus similis	longnose killifish
Gymnura micrura	smooth butterfly ray
Harengula pensacola	scaled sardine
Hyporhamphus unifasciatus	common halfbeak
Lagodon rhomboides	pinfish
Leiostomus xanthurus	spot
Lucania parva	rainwater killifish
Lutjanis griseus	grey snapper
Menidia beryllina	inland silverside
Mugil cephalus	flathead mullet
Mugil curema	white mullet
Mugil trichodon	faintail mullet
Myrophis punctatus	worm eel
Oligoplites saurus	leatherjacket
Ophichthus gomesi	worm eel
Opisthonema oglinum	Atlantic thread herring
Orthopristis chrysoptera	pigfish
Paralichthys albigutta	Gulf flounder
Poecilia latipinna	sailfin molly
Pogonias cromis	black drum
Prionotus tribulus	bighead searobin

Table D.1. List of fish fauna collected from the Anclote Anchorage area (Fable, 1973).

Scientific Name	Common Name
Rachycentron canadum	cobia
Sciaenops ocellata	red drum
Sphoeroides nephelus	southern puffer
Strongylura marina	Atlantic needlefish
Strongylura notata	Atlantic needlefish
Strongylura timucu	Atlantic needlefish
Symphurus plagiusa	blackcheek tonguefish
Synodus foetens	lizzardfish

APPENDIX E

SPECIES DESIGNATIONS AND DESIGNATED SPECIES ANCLOTE KEY STATE PRESERVE

The Nature Conservancy and the Natural Heritage Program Network (of which FNAI is a part) define an “element” as “any exemplary or rare component of the natural environment, such as a species, natural community, bird rookery, spring, sinkhole, cave, or other ecological feature.” An element occurrence (EO) is a single extant habitat that sustains or otherwise contributes to the survival of a population or a distinct, self-sustaining example of a particular element.

Using a ranking system developed by The Nature Conservancy and the Natural Heritage Program Network, the Florida Natural Areas Inventory assigns two ranks to each element. The global rank is based on an element's worldwide status; the state rank is based on the status of the element in Florida. Element ranks are based on many factors, the most important ones being estimated number of Element occurrences, estimated abundance (number of individuals for species; area for natural communities), range, estimated adequately protected EOs, relative threat of destruction, and ecological fragility. Federal and State status information is from the U.S. Fish and Wildlife Service; and the Florida Game and Freshwater Fish Commission (animals), and the Florida Department of Agriculture and Consumer Services (plants), respectively.

Table E.1. Designated species of the Anclote Key State Preserve.

ORGANISM	DESIGNATED SPECIES STATUS			
REPTILES	**FFWCC**	**USFWS**	**CITES**	**FNAI**
Atlantic green turtle (*Chelonia mydas*)	E	E	I	
Atlantic hawksbill (*Eretmochelys imbricate*)	E	E	I	
Atlantic loggerhead (*Caretta caretta*)	T	T	I	
BIRDS				
Eastern brown pelican (*Pelecanus occidentalis*)	SSC			S3
Magnificent frigatebird *Fregata magnificens*				S1
Little blue heron (*Egretta caerulea*)	SSC			S4
Reddish egret (*Egretta rufescens*)	SSC			S2
Great egret (*Ardea alba*)				S4
Snowy egret (*Egretta thula*)	SSC			S4
Tricolored heron (*Egretta tricolor*)	SSC			S4
Black-crowned night heron *Nycticorax nycticorax*				S3?
Yellow-crowned night heron *Nycticorax violaceus*				S3?
White ibis *Eudocimus albus*	SSC			S4
Roseate spoonbill *Ajaia ajaja*	SSC			S2S3
Southern bald eagle *Haliaeetus leucocephalus*	T	T	I	S3
Osprey *Pandion haliaetus*			II	S3S4
American oystercatcher *Haematopus palliatus*	SSE			S3
Piping plover *Charadrius melodus*	T	T		S2
Southeastern snowy plover *Charardus alexandrinus*	T			
Least tern *Sterna antillarum*	T			S3
Royal tern *Sterna maxima*				S3
Sandwich tern *Sterna sandvicensis*				S2
Caspian tern *Sterna caspia*				S2?
Black Skimmer *Rynchops niger*	SSC			S3

FNAI Global Rank Definitions:

G1 = Critically imperiled globally because of extreme rarity (5 or fewer occurrences or less than 1000 individuals) or because of extreme vulnerability to extinction due to some natural or man-made factor.

G2 = Imperiled globally because of rarity (6 to 20 occurrences or less than 3000 individuals) or because of vulnerability to extinction due to some natural or man-made factor.

G3 = Either very rare and local throughout its range (21-100 occurrences or less than 10,000 individuals) or found locally in a restricted range or vulnerable to extinction of other factors.

G4 = apparently secure globally (may be rare in parts of range)

G5 = demonstrably secure globally

GH = of historical occurrence throughout its range, may be rediscovered (e.g., ivory-billed woodpecker)

GX = believed to be extinct throughout range

GXC = extirpated from the wild but still known from captivity or cultivation

G#? = tentative rank (e.g., G2?)

G#G# = range of rank; insufficient data to assign specific global rank (e.g., G2G3)

G#T# = rank of a taxonomic subgroup such as a subspecies or variety; the G portion of the rank refers to the entire species and the T portion refers to the specific subgroup; numbers have same definition as above (e.g., G3T1)

G#Q = rank of questionable species - ranked as species but questionable whether it is species or subspecies; numbers have same definition as above (e.g., G2Q)

G#T#Q = same as above, but validity as subspecies or variety is questioned.

GU = due to lack of information, no rank or range can be assigned (e.g., GUT2).

G? = not yet ranked (temporary)

FNAI State Rank Definitions

S1 = Critically imperiled in Florida because of extreme rarity (5 or fewer occurrences or less than 1000 individuals) or because of extreme vulnerability to extinction due to some natural or man-made factor.

S2 = Imperiled in Florida because of rarity (6 to 20 occurrences or less than 3000 individuals) or because of vulnerability to extinction due to some natural or man-made factor.

S3 = Either very rare and local throughout its range (21-100 occurrences or less than 10,000 individuals) or found locally in a restricted range or vulnerable to extinction of other factors.

S4 = apparently secure in Florida (may be rare in parts of range)

S5 = demonstrably secure in Florida

SH = of historical occurrence throughout its range, may be rediscovered (e.g., ivory-billed woodpecker)

SX = believed to be extinct throughout range

SA = accidental in Florida, i.e., not part of the established biota

SE = an exotic species established in Florida may be native elsewhere in North America
SN = regularly occurring, but widely and unreliably distributed; sites for conservation hard to determine
SU = due to lack of information, no rank or range can be assigned (e.g., SUT2).

S? = not yet ranked (temporary)

Legal Status

N = Not currently listed, nor currently being considered for listing, by state or federal agencies.

Federal (Listed by the U. S. Fish and Wildlife Service - USFWS)

LE = Listed as Endangered Species in the List of Endangered and Threatened Wildlife and Plants under the provisions of the Endangered Species Act. Defined as any species which is in danger of extinction throughout all or a significant portion of its range.

PE = Proposed for addition to the List of Endangered and Threatened Wildlife and Plants as Endangered Species.

LT = Listed as Threatened Species. Defined as any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

PT = Proposed for listing as Threatened Species.

C = Candidate Species for addition to the list of Endangered and Threatened Wildlife and Plants. Defined as those species for which the USFWS currently has on file sufficient information on biological vulnerability and threats to support proposing to list the species as endangered or threatened.

E(S/A) = Endangered due to similarity of appearance.

T(S/A) = Threatened due to similarity of appearance.

State (Listed by the Florida Fish and Wildlife Conservation Commission - FFWCC)

LE = Listed as Endangered Species by the FFWCC. Defined as a species, subspecies, or isolated population which is so rare or depleted in number or so restricted in range of habitat due to any man-made or natural factors that it is in immediate danger of extinction or extirpation from the state, or which may attain such a status within the immediate future.

LT = Listed as Threatened Species by the FFWCC. Defined as a species, subspecies, or isolated population which is acutely vulnerable to environmental alteration, declining in number at a rapid rate, or whose range or habitat is decreasing in area at a rapid rate and as a consequence is destined or very likely to become an endangered species within the foreseeable future.

LS = Listed as Species of Special Concern by the FFWCC. Defined as a population which warrants special protection, recognition, or consideration because it has an inherent significant vulnerability to habitat modification, environmental alteration, human disturbance, or substantial human exploitation which, in the foreseeable future, may result in its becoming a threatened species. Table D.1. lists the designated species of the Anclote Key State Preserve.