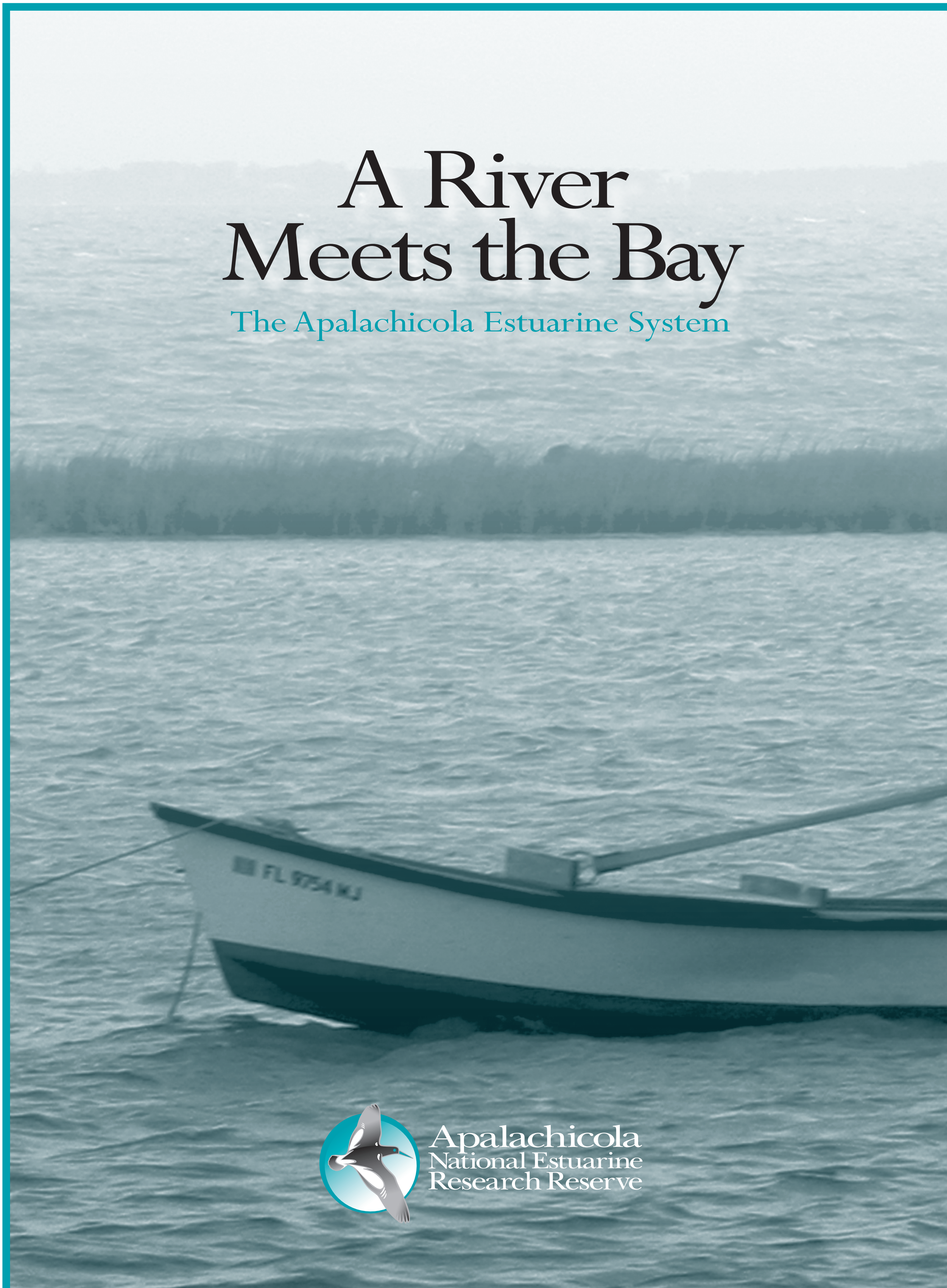
# A River Meets the Bay

## The Apalachicola Estuarine System




Apalachicola National Estuarine Research Reserve

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Apalachicola National Estuarine Research Reserve

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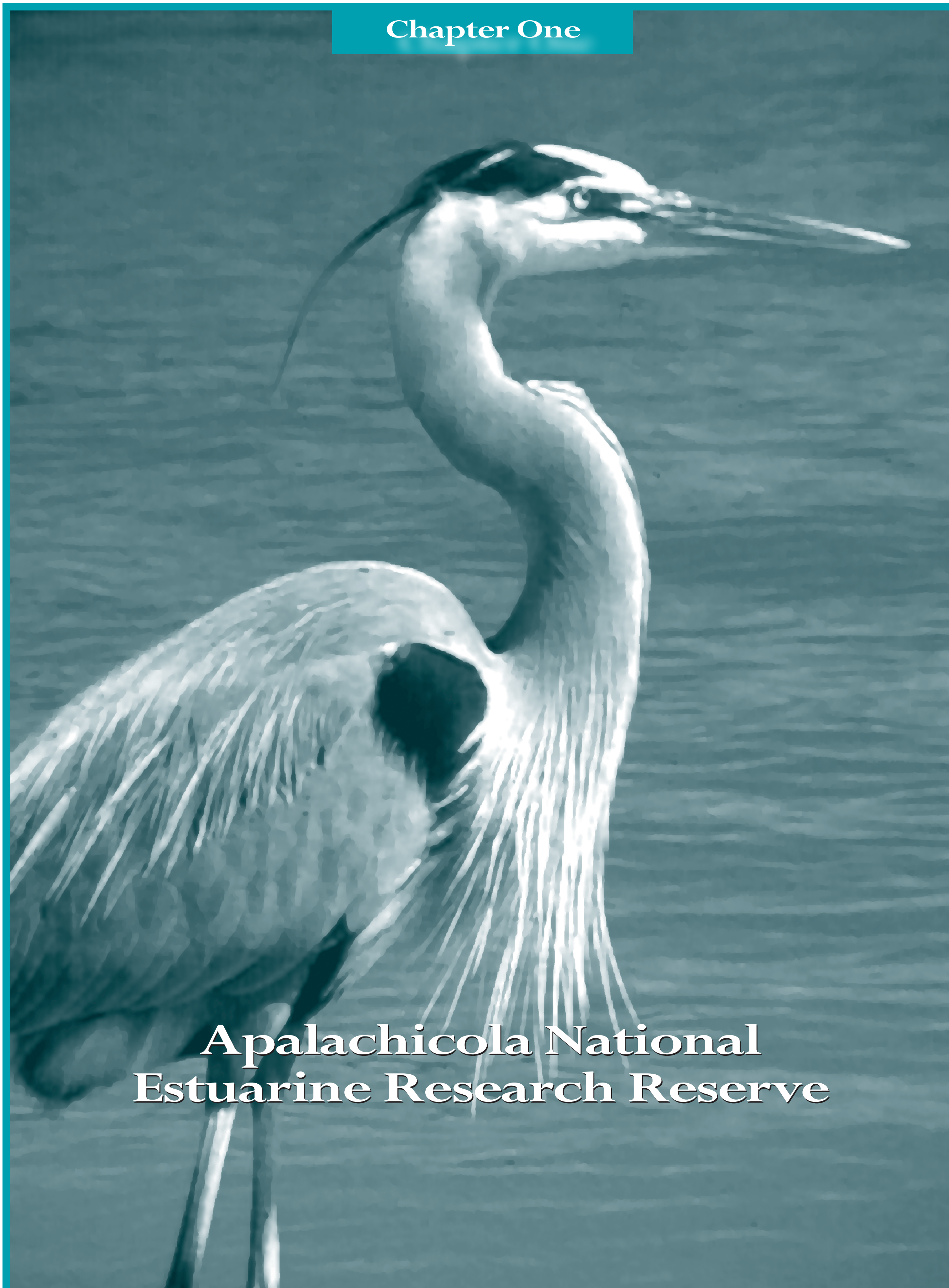

# Apalachicola National Estuarine Research Reserve

Apalachicola Bay and most of its drainage basin encompass what can be considered one of the least polluted, most undeveloped, resource rich systems left in the United States. The Apalachicola drainage basin includes upland, floodplain, riverine, estuarine, and barrier island environments which are closely interrelated and influenced by each other.

This document is an attempt to characterize the physical and ecological aspects of the Apalachicola River and Bay system, especially the components within the boundaries of Apalachicola National Estuarine Research Reserve. It is by no means all inclusive of scientific information known, but is rather a summary of knowledge of some of the more important factors that have been found through research and monitoring activities and to identify gaps that need to be studied in the future.

Because of its uniqueness, numerous protective designations have been granted to note the importance of and help protect the Apalachicola system. Not only have state and federal agencies been involved, but local participation has also been a key ingredient. In 1969, the State of Florida designated Apalachicola Bay one of eighteen Aquatic Preserves. In 1979, the lower river and bay system was designated a National Estuarine Research Reserve by the National Oceanic and Atmospheric Administration (NOAA). One of 27 reserves in the country (Figure 1), the designation confers protection and management benefits to help ensure the long-term endurance of the system. The State of Florida designated the lower Apalachicola River an Outstanding Florida Water in 1979 and included the upper river in 1983. Thus, the ambient water quality of the river, at the time of designation, is used as the standard which cannot be lowered, instead of allowing degradation to prescribed statewide values.

In 1984, the United Nations Education, Scientific, and Cultural Organization (UNESCO) designated the Reserve a Biosphere Reserve under the International Man and the Biosphere (MAB) program. Due to the developmental pressures being exerted, in 1985 the State of Florida declared Franklin County an Area of Critical State Concern in order to help protect the bay system. Since that time, most of the County has been de-designated due to improved ordinance development and planning. All these designations, from state, national, and international agencies, recognize the Apalachicola River and Bay system as a unique and environmentally sensitive resource which deserves protection.

## The National Estuarine Research Reserve System (NERRS)

The concept of the National Estuarine Research Reserve System (formerly called the National Estuarine Sanctuary Program) has its roots in the Commission on Marine Science, Engineering and Resources' final

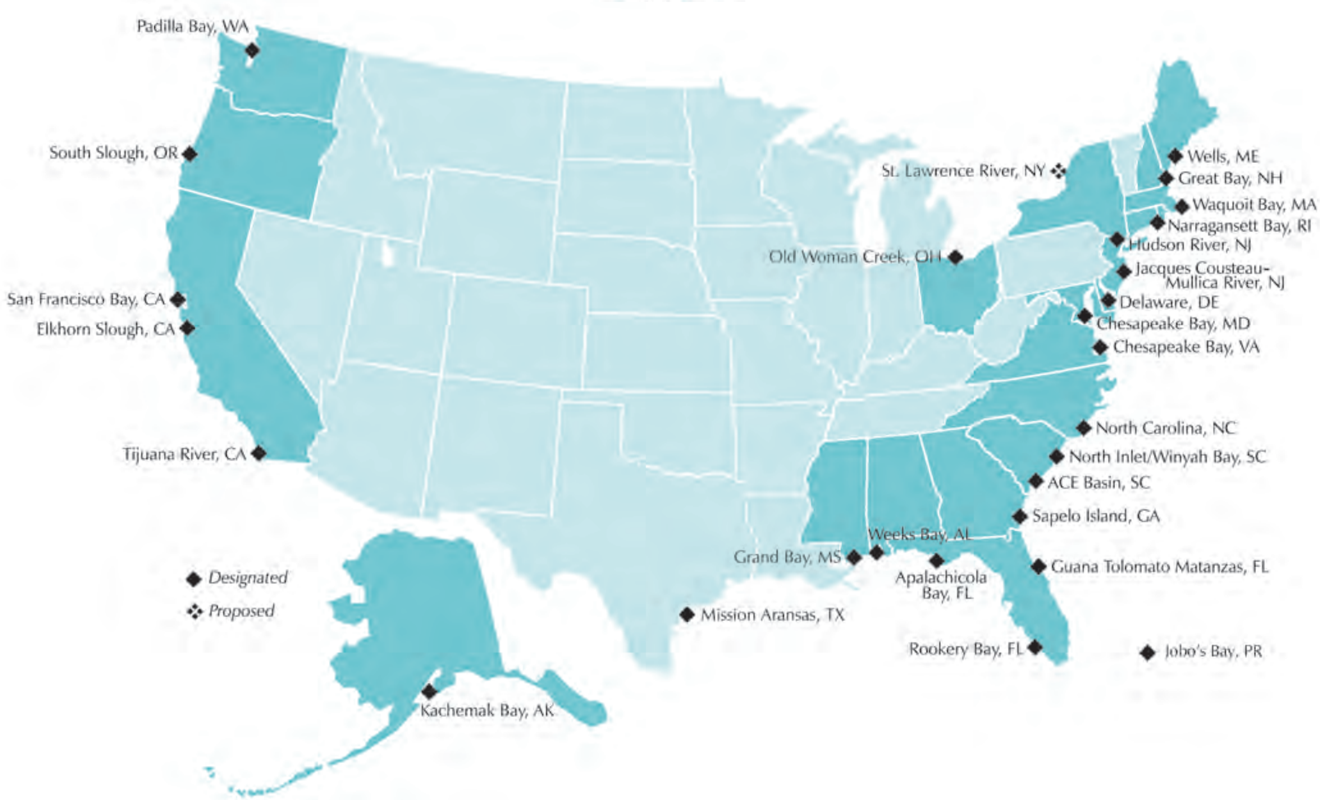


***Figure 1.*** *National Estuarine Research Reserve System*

report (1969), Our Nation and the Sea, and the Department of the Interior's National Estuarine Study. These reports, initiated in the late 1960's, describe the status of estuaries and the problems faced by these areas as a result of man's activities.

The National Estuarine Research Reserves System is a network of 27 areas representing different biogeographic regions of the United States that are protected for long-term research, water-quality monitoring, education and coastal stewardship. Established by the Coastal Zone Management Act of 1972, as amended, the reserve system is a partnership program between the National Oceanic and Atmospheric Administration and the coastal states. NOAA provides funding, national guidance and technical assistance. Each reserve is managed on a daily basis by a lead state agency or university, with input from local partners (NOAA, 2007).

The purpose of designating an area as a Reserve is to confer protection and management on special estuarine areas for the long term benefit and enjoyment of the public. Estuarine reserves are intended to allow multiple uses of the resources by public and commercial interests so long as these activities do not threaten the basic integrity of the site's resource value. National Estuarine Research Reserves have been established to provide opportunities for long-term estuarine research and monitoring, estuarine education and interpretation, resource management, and to provide a basis for more informed coastal management decisions. The Reserve designation is not intended to be used as a means to block or unduly restrict human use and development of estuarine resources; rather, it can be viewed as a tool in a broader, national interest approach to wise estuarine resource development, conservation, and utilization.

The Coastal Zone Management Act (P.L. 96-583) was passed by Congress in 1972 and amended several times. Section 315 calls for the establishment of a National Estuarine Research Reserve Program. Designation as a NERR is done by the National Oceanic and Atmospheric Administration, Office of Ocean and Coastal Resource Management. As stated in the rules and regulations governing estuarine research reserves: "The purpose of the program is to create natural field laboratories in which to gather data and make studies of the natural and human processes occurring within the reserves of the coastal zone. This shall be accomplished by the establishment of a series of estuarine reserves which will be designated so that at least one representative of each type of estuarine ecosystem will endure into the future for scientific and educational purposes, especially to provide some of the management information essential to the coastal management decision making process."

The goals of the NERR system as established by Federal Regulation, 15 C.F.R. Part 921.1 (b), are:

- Ensure a stable environment for research through long-term protection of National Estuarine Research Reserve resources;
- Address coastal management issues identified as significant through coordinated estuarine research within the System;
- Enhance public awareness and understanding of estuarine areas and provide suitable opportunities for public education and interpretation;
- Promote federal, state, public and private use of one or more Reserves within the System when such entities conduct estuarine research; and
- Conduct and coordinate estuarine research within the System, gathering and making available information necessary for improved understanding and management of estuarine areas (15 CFR 921, 2003).

## Apalachicola National Estuarine Research Reserve (ANERR)

The Apalachicola National Estuarine Research Reserve (ANERR) (Figure 2), designated in 1979, is located in Franklin, Gulf, and Liberty counties in the Florida panhandle in one of the least populated coastal areas in the state. The Reserve has two facilities in Franklin County. The education/visitor center is located near Scipio Creek on 7th Street in the city of Apalachicola. This 3,300 square foot facility, named the Robert L. Howell Building, includes a 100-person auditorium, marine habitat displays, and office space. The second facility, housing research, resource management, and maintenance staff, is located on the east side of Apalachicola Bay at 350 Carroll Street in the town of Eastpoint. This facility has 4,000 square feet of office space, a 900-square foot laboratory and a 3,000-square foot maintenance area.


***Figure 2.*** *Apalachicola National Estuarine Research Reserve Boundaries*

The second largest of the 27 existing National Estuarine Research Reserves, the Reserve encompasses 246,766 acres, most (135,680 acres) of which are state-owned submerged lands. There is the possibility of future expansion to include adjacent public lands as they are acquired by the state. The Reserve includes the bay with its associated tidal creeks, marshes and bayous, portions of the lower 52 miles of the Apalachicola River and its floodplain, and portions of the offshore barrier islands.

The Apalachicola National Estuarine Research Reserve is one of the more complex reserves in the national system, with reference to management and protection activities. The Reserve consists of several independently managed subunits, supports a variety of recreational and commercial activities, and is affected by land and water use policies in three states.

One of the unique features of this Reserve is the extensive multiple agency involvement in the area. Various upland regions within the Reserve boundaries have been previously acquired by federal and state agencies for a variety of different purposes. St. Vincent Island (12,358 acres) is a National Wildlife Refuge managed by the US Fish and Wildlife Service, the eastern tip of St. George Island (1,883 acres) is a state park managed by the Florida Park Service, the Apalachicola River Wildlife and Environmental Area (41,754 acres) is managed by the Florida Fish and Wildlife Conservation Commission, and the Apalachicola River Water Management Area (35,506 acres) is managed by the Northwest Florida Water Management District. Some privately owned land is also within the boundaries of the Reserve. Uses within the Reserve include recreational pursuits such as camping, fishing, hunting, and nature appreciation as well as commercial activities such as fishing, waterborne navigation and bee-keeping (ANERR, 1998).

One of the most productive estuarine systems in North America, Apalachicola Bay receives waters from a drainage basin which extends into Alabama and Georgia. Thus, the Bay is susceptible to factors affecting the Chattahoochee and the Flint River systems as well as those affecting Florida's Apalachicola River.

The Estuarine Reserve designation enhances resource-oriented research and monitoring, education and outreach, and resource management activities. It also promotes the integration of research and education programs, the integration of education and resource-oriented outdoor recreation, and the integration of scientific information into resource management decisions.

The overall goal of the Reserve is resource protection through research, education, and resource management. The objectives are to promote research and education programs and coordinate management activities among all involved agencies and groups to ensure that the Apalachicola estuary sustains or improves its current pristine nature and productivity.

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# General Characteristics of the Apalachicola River and Bay System

The Apalachicola River basin is only one component of the larger Apalachicola-Chattahoochee-Flint River system (ACF). The ACF basin covers the central and southwestern part of Georgia (14,454 mi$^2$), the southeastern part of Alabama (2,772 mi$^2$), and the central part of the Florida panhandle (2,574 mi$^2$) (U.S. Army Corps of Engineers, 1980). It drains an area covering approximately 19,800 square miles and contains parts of the Blue Ridge, Piedmont, and Coastal Plain physiographic provinces (Figure 3). The Chattahoochee River flows 430 miles from its source in the Blue Ridge Mountains of northern Georgia, drains a land area of 8,770 square miles, and has 13 dams located on the river. The Flint River flows 350 miles from its source south of Atlanta, drains a land area of 8,460 square miles, and has 2 dams affecting streamflow. The Apalachicola River is formed by the confluence of the Chattahoochee and Flint rivers, begins below the Jim Woodruff Dam, flows 106 miles to Apalachicola Bay (Figure 4), and drains a land area of approximately 2,600 square miles (Couch et al., 1996).

The ANERR encompasses the lower half of the Apalachicola River (52 miles) and its floodplain, the Apalachicola Bay estuary and its associated marshes, forested uplands, and parts of three offshore barrier islands (ANERR, 1998).

## Climate

The ANERR experiences a warm and humid, subtropical climate (Table 1) due to its latitude (29 degrees) and the stabilizing effects of adjacent Gulf of Mexico waters (Bradley, 1972). Mean daily temperatures range from the 40's Fahrenheit in January to the 80's in July (Fernald, 1981). Seasonal and annual temperatures vary greatly, ranging from the upper 90's in the summer to the lower 20's in the winter.

Average annual rainfall ranges from 52 to 60 inches within the Reserve boundaries (Jordan, 1984). Peak rainfall periods occur primarily during the summer with a secondary peak in early spring. Apalachicola experiences approximately 73 days of thunderstorms annually, three-quarters of these occurring between June and September (Jordan, 1973). Low rainfall periods occur primarily in the fall and mid-spring. Evapotranspiration averages approximately 42 inches per year and average annual runoff ranges from 20 to 30 inches within Reserve boundaries (Gebert et al., 1987).

Prevailing winds are typically from a southerly direction during the spring and summer and from a northerly direction during the fall and winter months. Local winds, however, may change abruptly due to thunderstorms and the movement of fronts through the area.

Hurricanes can also affect the local climate during the summer and fall months. Of 273 hurricanes that impacted the United States between 1851 and 2004, 92 of these had direct hits on Mississippi, Alabama, and the northwest Florida panhandle (Blake et al., 2005).


***Figure 3.*** *Apalachicola/Chattahoochee/Flint River basin*

## Physiography and Geology

The Reserve lies completely within the Gulf Coastal Lowlands physiographic province (Figure 4), which is characterized by low elevations and poor drainage. Numerous relict bars and dunes are associated with this province, remnants of quaternary and earlier fluctuations in sea level (USACOE, 1978; Clewell, 1986; Donoghue and Tanner, 1992).

The Apalachicola Embayment is the major structural feature that dominates the geology of the Reserve and river system. This feature represents a structurally downwarped segment of the limestone basement rocks of Florida, lying between the Ocala and Chattahoochee uplifts (Schmidt, 1984).

The Gulf Coastal Lowlands are characterized by Pleistocene marine sands near the river mouth and possibly Pliocene or older sands to the north (Alt and Brooks, 1965; Donoghue and Tanner, 1992). The cuspate foreland shape of the Apalachicola coast is believed to have been formed by the Apalachicola River during the late Tertiary and Quaternary periods and has subsequently been modified by waves and longshore drift. The present position of the bay system is considered to be less than 6,000 years old (Donoghue and White, 1995) and the general outline of the bay has been generally stable during that period, except for the southward migration of the delta into the estuary. Shallow seismic data from Apalachicola Bay indicates the river front, in addition to migrating southward over the long term, has also migrated eastward during the mid-to late Holocene (Donoghue, 1993). The present position of the Apalachicola delta is only its most recent locale. Ample sedimentologic and geomorphologic evidence exists throughout the region for older delta positions in late Quaternary time (Schnable, 1966; Stapor, 1973). The present barrier island chain formation is thought to have occurred approximately 5,000 years ago when sea level reached its modern position (Tanner, 1983).

At this time, little quartz sand is being supplied to the bay by the river system (Kofoed, 1961; Stapor, 1973), which is probably a result of dams on the upper river systems as well as a long-term trend toward dryer climate in the Southeast over the past 3,000 years (Kutzbach et al., 1998). The majority of the sand-sized sediment load that is supplied is being deposited in the delta, which has been prograding approximately 2 meters per year since 1892 (Bedosky, 1987). In-filling rates for the bay system have been estimated to range from less than 1 mm/year to over 17 mm/year depending on location (Isphording, 1985; Bedosky, 1987; Hendrickson, 1997).

## Soils

The major soil order that dominates the Apalachicola Reserve area is spodosols, which are characterized by a thin sandy subhorizon underlaying the A-horizon (Caldwell and Johnson, 1982). Franklin County and much of the Gulf of Mexico coastal region soils are derived from beach deposits, river alluvium, or marine terrace deposits. Twelve soil associations have been identified in Franklin County that range from deep, excessively drained soils to very poorly drained soils with water tables above the surface (Sasser et al., 1994). Approximately 90 percent of the land area is dominated by soil associations that are poorly suited or unsuitable for development and septic tank use (Table 2). These soil conditions pose major limitations for development in much of Franklin County (Franklin County, 1991).


***Figure 4.*** *Physiography of the Apalachicola River system*

Throughout the county soil is generally uniform with the color patterns reflecting drainage conditions: dark soils for poor drainage and light colors for areas of good drainage (Mooney and Patrick, 1915). The Scranton-Rutlege Association (USDA, 1975) is the predominant general soil type in the county, comprising approximately 26 percent of the land area. The Apalachicola floodplain and coastal

**TABLE 1**

**Temperature and Precipitation Apalachicola, Florida**

| Month | Monthly Mean Temperature ($^{0}$F) | Monthly Precipitation (in) |
|---|---|---|
| *January* | *55.1* | *3.14* |
| *February* | *56.8* | *3.91* |
| *March* | *61.0* | *4.52* |
| *April* | *67.5* | *4.30* |
| *May* | *74.8* | *2.88* |
| *June* | *80.2* | *5.30* |
| *July* | *81.5* | *7.93* |
| *August* | *81.5* | *7.74* |
| *September* | *78.9* | *8.53* |
| *October* | *71.2* | *2.44* |
| *November* | *61.3* | *2.58* |
| *December* | *55.8* | *2.96* |
| **Yearly** | | |
| **Average** | **68.8** | |
| **Total** | | **56.23** |

and delta marshes are predominantly comprised of the Chowan-Brickyard-Wehadkee and Bohicket-Tisonia-Dirego associations (Table 2). St. Lucie-Kureb-Riminini and Lakeland associations are found predominantly along the coastal areas while Plummer-Rutledge and Leon-Chipley-Plummer associations (Table 2) are found in the interior of the county (Sasser et al., 1994).

## Surface Water Classification

All surface waters of the State have been classified by the Florida Department of Environmental Protection (DEP) according to their designated use (F.A.C., 2006). Five classes have been designated with water quality criteria designed to maintain the minimum conditions necessary to assure the suitability of water for its designated use. In the Apalachicola drainage basin, three of the five classes of water are present and include:

**Class I:** Potable Water Supplies
**Class II:** Shellfish Propagation or Harvesting
**Class III:** Recreation, Propagation and Maintenance of a Healthy, Well-balanced Population of Fish and Wildlife.

Each of these classes have specific water quality standards for parameters such as bacterial levels, metals, pesticides, herbicides, dissolved oxygen, etc., designed to protect and maintain the use of the water body. The degree of protection is variable with Class I waters having the most stringent standards and Class V waters the least. All surface waters of the State are classified as Class III waters except those specifically described in Chapter 62-302 (F.A.C., 2006).

There is only one Class I water located within the entire Apalachicola River and Bay drainage basin. Mosquito Creek in northwestern Gadsden County is used by the City of Chattahoochee as a drinking water source and therefore is classified as a Class I water from U.S. Highway 90 north to the State line (Figure 5). As mentioned earlier, Class I waters, those used as potable water supplies, are afforded the most protection of any waters in the State due to their designated use.

Class II waters, those used for shellfish propagation or harvesting, include the majority of the brackish water areas in the estuary. The entire bay system from Alligator Harbor through St. George Sound, Apalachicola Bay, East Bay and its tributaries, St. Vincent Sound, and Indian Lagoon are Class II waters (Figure 5) with the exception of an area within a two-mile radius of the City of Apalachicola (F.A.C., 2006). This area has been closed to shellfish harvesting for years due to pollution from the City of Apalachicola. Class II water standards are more stringent concerning bacteriological quality than any class due to the fact that shellfish, oysters and clams, are consumed uncooked by humans and can concentrate pathogens in quantities significantly higher than the surrounding waters. The Florida Department of Agriculture and Consumer Services maintains a lab in


***Figure 5.*** *Florida surface water classification in Apalachicola Basin*

**TABLE 2**

### Soil Associations of Franklin County

| Soil Association | % of County | Suitability for Development | Suitability for Agriculture |
|---|---|---|---|
| *Albany/Blanton /Stilson* | *2* | *Mod. to Well* | *Moderate* |
| *Kershaw/Ortega /Ridgewood* | *3* | *Moderate* | *Poor* |
| *Plummer/Surrency /Pelham* | *15* | *Poor* | *Moderate* |
| *Mandarin/Resota /Leon* | *5* | *Moderate* | *Moderate* |
| *Leon/Scranton /Lynnhaven* | *17* | *Poor* | *Moderate* |
| *Scranton/Rutledge* | *26* | *Poor* | *Poor* |
| *Pamlico/Pickney /Maurepas* | *3* | *Poor to Unsuit* | *Poor* |
| *Bohicket/Tinsonia /Dirego* | *5* | *Unsuitable* | *Unsuitable* |
| *Medowbrook/Tooles /Harbeson* | *9* | *Poor* | *Mod. to Poor* |
| *Pickney/Pamlico /Dorovan* | *4* | *Poor* | *Poor* |
| *Chowan/Brickyard /Wehadkee* | *6* | *Unsuitable* | *Unsuitable* |
| *Corolla/Duckston /Newhan* | *5* | *Poor* | *Poor* |

*(Modified from Sasser et al., 1994).*

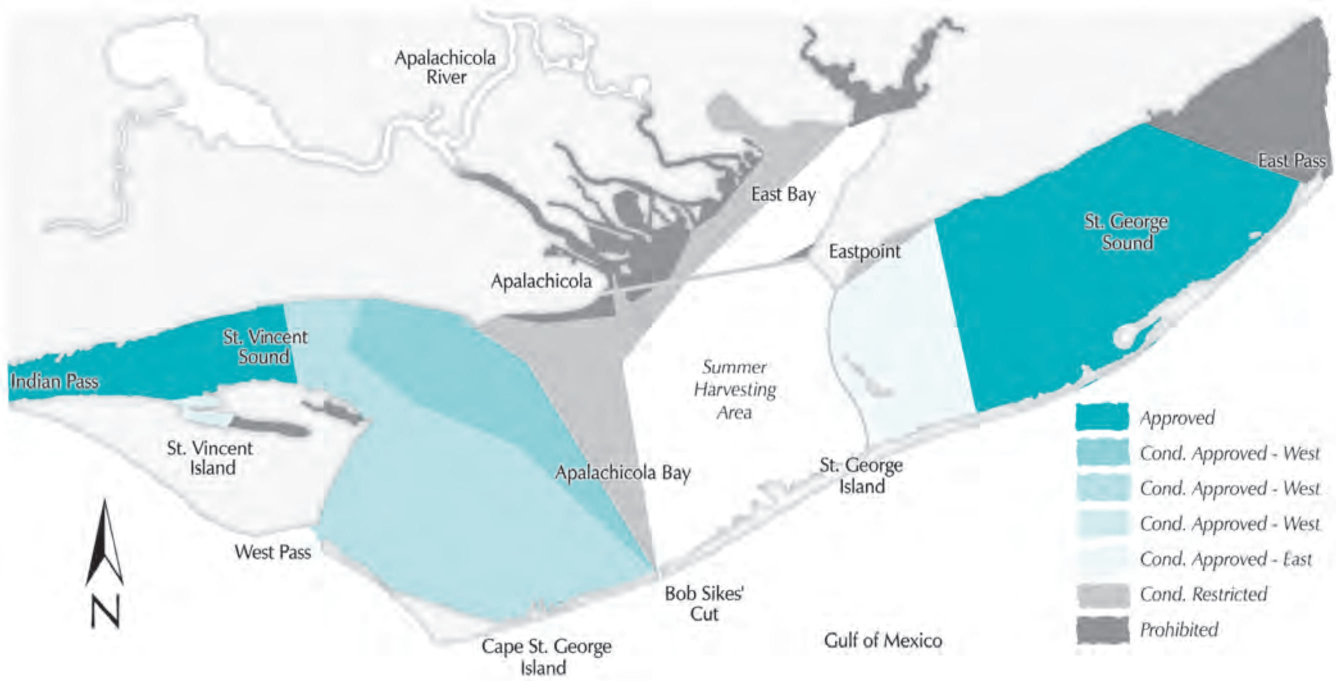


***Figure 6.*** *Shellfish harvesting area classification map (2005) Winter Harvest Areas: September - May*

Apalachicola and conducts surveys to determine water quality in shellfish harvesting waters. Waters classified for the harvest of shellfish are additionally classified as Approved, Conditionally Approved, Restricted, Conditionally Restricted, Prohibited and Unclassified (= Unapproved) (F.A.C., 2006) based upon these surveys (Shields and Pierce, 1997). As conditions and seasons change, areas are closed or opened based on bacterial surveys and river flow and major rainfall events which increase bacterial levels due to runoff (Figure 6).

All other waters in the Apalachicola River and Bay drainage basin are Class III waters. This includes the Apalachicola and Chipola Rivers, Dead Lake, Lake Wimico, Lake Seminole, and all other creeks, ponds, or surface waters (Figure 5). Class III water standards are less stringent than the other two classes but are intended to protect recreation and the propagation and maintenance of a healthy well-balanced population of fish and wildlife (F.A.C., 2006).

Another important designation used by FDEP is that of Outstanding Florida Water (OFW) (F.A.C., 2006) There are fifteen designated OFWs located within the Apalachicola River and Bay drainage system and the entire Reserve area, including both the lower river and bay. These waters are afforded special protection by the State due to their high quality, recreational or ecological significance, or their location within state or federally owned lands. This designation is intended to preserve the ambient water quality at the time of designation from future point source discharges and to prevent future degradation.

## Riverine Hydrology

The Apalachicola River is the largest in Florida and ranks 21st in the United States, in terms of volume of flow. It is also one of the last remaining undammed large rivers in the country, although its tributaries contain numerous dams and locks. The Apalachicola River is formed by the confluence of the Chattahoochee and Flint Rivers at the Jim Woodruff Dam and flows 106 miles to Apalachicola Bay. Lake Seminole, its headwaters, a 37,500 acre manmade reservoir, borders the three states of Alabama, Georgia, and Florida. Of the 19,800 square miles in the entire ACF drainage basin, approximately 2,400 square miles (12 percent) are located within Florida. The main tributary of the Apalachicola River, the Chipola River, accounts for approximately half of this draining an area 1,237 square miles (Figure 3), of which 1,020 square miles are in Florida (USACOE, 1980).

The Apalachicola River can be classified as a large, alluvial river. It is the only river in Florida which has its origins in the Piedmont and Southern Appalachians. Characteristics of alluvial rivers include a heavy sediment load, turbid water, large watersheds, sustained periods of high flow, and substantial annual flooding. The majority of its runoff is from distant precipitation and runoff from numerous tributaries (Clewell, 1986; Wharton et al., 1982).

Upstream rainfall has a much greater influence on river flows than Florida rainfall because the majority of the ACF basin is in Georgia and Alabama (Meeter et al., 1979; Leitman et al., 1983). Over eighty percent of Apalachicola riverflow comes from the upstream Chattahoochee and Flint Rivers. The Chattahoochee

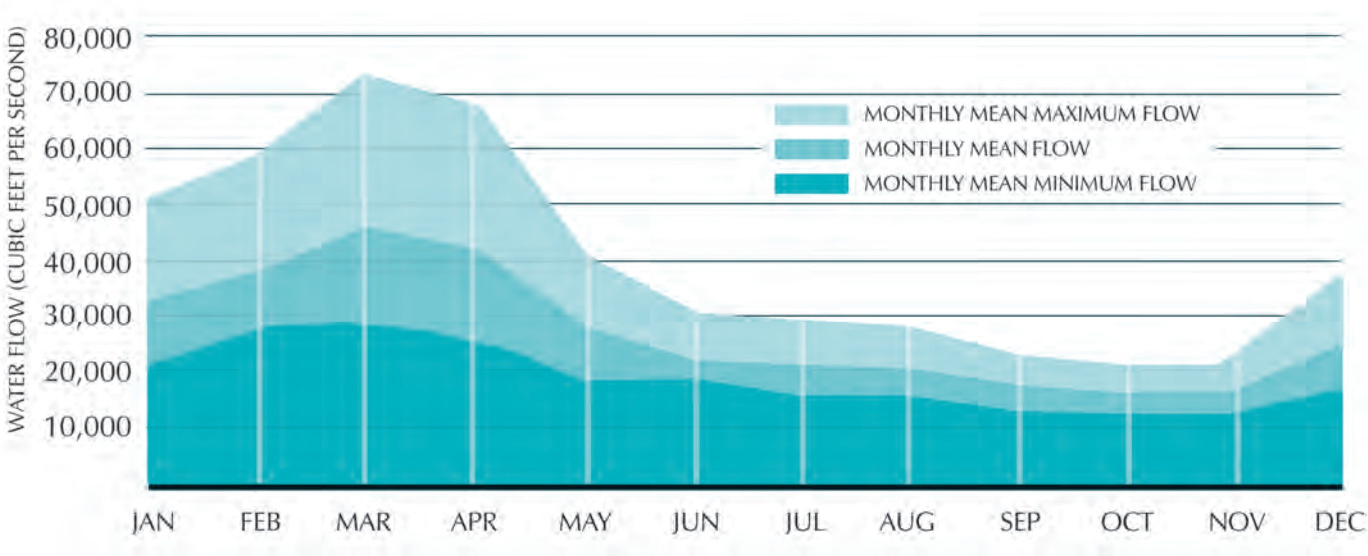


***Figure 7.*** *Mean seasonal water flow of the Apalachicola River at Sumatra (1939 - 1993)*

River has twice the flow of the Flint River and makes a greater contribution to peak flows in the Apalachicola River. However, the Flint River makes a higher contribution to flow in the Apalachicola River during extremely dry periods because its baseflow is sustained by groundwater discharges. Flows in the lower river can be substantially increased by Florida rainfall during periods of low flow and by inflow from the Chipola River, a spring fed river with baseflow derived mainly from aquifers, and the Apalachicola's major tributary (Elder et al., 1988).

Flow is an important factor not only to the bay but also to the river itself. The mean annual discharge of the river at Chattahoochee from 1922 to 1995 was 22,300 cubic feet per second ($ft^3$/sec) (Frick et al., 1998). Minimum and maximum flows at Chattahoochee, including all presently constructed dams, range from approximately 5,000 to 290,000 $ft^3$/sec, respectively. The mean annual discharge at Sumatra, within ANERR boundaries, is approximately 25,000 $ft^3$/sec, which also includes the discharge from the Chipola River. The Chipola River's annual flow is estimated at 3,500 $ft^3$/sec, much of which is groundwater discharge (Mattraw and Elder, 1984). Seasonally, summer and early fall are characterized by low flows and highest flows occur in late winter and early spring (Figure 7).

The Apalachicola River can be divided into three sections based upon its physiography: lower, middle, and upper. The lower river (RM 0-35), from below Wewahitchka to Apalachicola, is tidally influenced up to approximately river mile (RM) 25 (Leitman et al., 1983). The Chipola River joins the Apalachicola at RM 28. The lower river flows through lowlands with a maximum land elevation less than 50 feet, and is characterized by a wide floodplain. The river itself is characterized by long straight reaches with few bends in this section. Near the lower end, numerous distributaries are formed which empty into East Bay (Figure 8).

The middle river section (RM 35-78) runs from below Wewahitchka to below Blountstown. Land elevations in this section range from 150 feet in the upper reaches to 50 feet in the lower reaches. The floodplain is not as wide as the lower river section but is still much wider than the floodplain in the upper section. The river meanders considerably in this section forming large loops and numerous small acute bends. These acute bends are the cause of navigational problems in this area and some require frequent dredging by the U. S. Army Corps of Engineers (USACOE). At RM 41 a natural cutoff, the Chipola Cutoff, which has been modified by man, diverts approximately 25 percent of the Apalachicola River flow to the Chipola River below.

The upper river section (RM 78-106) runs from the Blountstown area to Jim Woodruff Dam. Land elevations in this section are among the highest in Florida and range up to 325 feet. A unique area of steep bluffs and ravines is located on the east side of the river below the dam, while the west side is characterized by gentle rolling hills. The river is characterized by long, straight reaches with a few wide gentle bends (Leitman et al., 1983). The entire river falls at a fairly uniform rate of 0.4 feet per mile with the greatest slope upriver.

## Groundwater Hydrology

The ACF basin is underlain by six major aquifers, but only two, the Surficial and Floridan, are within the Florida portion of the basin and affect the Reserve. The Surficial aquifer system is a shallow, unconfined water-table aquifer that is primarily used by isolated domestic wells within the lower ACF basin. The Floridan aquifer is one of the most productive aquifers in the world and underlies Florida and parts of Georgia, Alabama, and South Carolina. The regional direction of ground flow is from north to south; however, local variations in flow direction can occur, especially near major streams which are commonly incised into underlying aquifers (Couch et al., 1996; Frick et al., 1996).

The Surficial Aquifer system is primarily fed by rainwater and is therefore susceptible to contamination. The Floridan Aquifer is associated with limestones, ranges in thickness from 100 to 1,000 feet, and provides over 90 percent of the public and private water needs of the lower basin. Outcrops and recharge areas both occur in the upper portion of the Apalachicola drainage basin. Discharges occur through springs in the river and along the west bank, as seeps along the steep east bank, as streamflow in various small tributaries, and eventually into the Gulf of Mexico, through offshore outcroppings (Kwader and Schmidt, 1978; Wagner, 1988). The limestones of the Floridan aquifer become exposed above Blountstown, in the river channel and on the bluffs near the east bank, and dip southward until they are approximately 46 meters below sea level at Apalachicola (Kwader and Schmidt, 1978).

Data collected by U.S. Geological Survey personnel between 1957 and 1980 estimates groundwater discharge into the Apalachicola River of from 448 to 671 cfs. Since steep water gradients exist in the upper Apalachicola River and flat gradients exist in the lower river, the annual groundwater discharge probably varies from 671 cfs in the upper basin to 112 cfs in the middle basin, and is negligible in the lower Apalachicola basin (Mattraw and Elder, 1984). Very little work has been done on groundwater resources, either quantity, quality, or contaminants, within the lower Apalachicola drainage basin, including the Reserve boundaries.

## Estuarine Hydrology

The Apalachicola Bay system is a wide, shallow estuary located along the northwest Florida Gulf Coast that covers an area of approximately 210 square miles behind a chain of barrier islands (Gorsline, 1963). Its primary source of fresh water is the Apalachicola River. The bay system may be divided into four sections based on both natural bathymetry and man-made structural alterations: East Bay, St. Vincent Sound, Apalachicola Bay, and St. George Sound (Figure 9).

East Bay, north and east of the Apalachicola River delta, is a shallow water body surrounded by extensive marshes and swamps (Dawson, 1955). The bay receives fresh water from the numerous distributaries of the Apalachicola River and Tate's Hell Swamp. The John Gorrie Memorial Bridge is considered its southern limit. A causeway, extending west from Eastpoint, and a causeway island near the river mouth form partial barriers between East Bay and Apalachicola Bay. To the west is St. Vincent Sound, which is also shallow and contains numerous oyster bars and reefs (Gorsline, 1963). It separates St. Vincent Island from the mainland and is linked to the Gulf by Indian Pass.

Apalachicola Bay is the central and widest portion of the estuarine system. It is separated from St. Vincent Sound by shoal areas


**Figure 8.** *Apalachicola River drainage basin encompasses 2400 square miles in Florida.*

and oyster bars. To the north, the Bay is separated from the river mouth, delta, and East Bay by the John Gorrie Memorial Bridge. The western and southern land boundaries of Apalachicola Bay are St. Vincent Island, Cape St. George Island, and St. George Island. The bay is connected to the Gulf of Mexico through West Pass, a deep tidal inlet, and Sikes Cut, a man-made navigation channel which cuts through St. George Island and divides it into Cape St. George (also called Little St. George Island) to the west and St. George Island to the east. Depths in Apalachicola Bay average six to nine feet at mean low tide. The bay floor slopes toward the barrier islands where depths increase to 10 to 12 feet (Gorsline, 1963). Oyster reefs are scattered throughout the central bay area and near the Gorrie bridge. There is a major submerged oyster reef, St. Vincent Bar or Dry Bar, which extends in a north-south direction from St. Vincent Island's eastern edge towards Cape St. George. To the east Apalachicola Bay is bounded by Bulkhead Shoal, a natural submerged bar that extends from Cat Point on the mainland to East Hole on St. George Island. Construction of a causeway island in the center of the bar and a causeway extension at St. George Island raised two portions of this barrier above water level in 1968.

St. George Sound extends from Bulkhead Shoal to the Carrabelle River and East Pass. Numerous oyster bars, lumps, shoal areas, and channels fill St. George Sound. Its average depth is about nine feet and like Apalachicola Bay gets deeper toward the barrier islands with a maximum depth of 20 feet. East Pass, a broad opening between St. George Island and Dog Island, connects St. George Sound with the Gulf of Mexico (Gorsline, 1963). Dog Island Sound and Alligator Harbor, to the east of the Reserve, are included in the geographical boundaries of the estuary, yet are influenced


***Figure 9.*** *Apalachicola Bay and area features*

minimally by the Apalachicola River due to distance, current direction, and submerged shoals. Areas, volumes, and average depths of the major water bodies in the Apalachicola Bay system are given in Table 3. Overall bathymetry for the bay system is generally flat except for areas of oyster bars, navigation channels, or passes to the Gulf (Figure 10).

Apalachicola Bay is in an area of transition between the semi-diurnal tides of southwestern Florida and the diurnal tides of northwestern Florida. Its tides are, therefore, classified as mixed, which accounts for the number of tides ranging from 1 to 5 daily. The normal tidal range in the bay is one to two feet with a normal maximum range of three feet (Dawson, 1955; Gorsline, 1963). Larger tidal variability is generally found in the eastern bay with a smaller range and less variability in the western part of the bay due to a stronger diurnal signal. Because the bay is oriented in an east-west configuration, riverflow enters the bay at a right angle to the general flow direction of the tidal currents. This has been suggested to cause a greater degree of turbulence and mixing than most other bays in the panhandle that are oriented in a north-south direction (Huang and Jones, 1997). Because of the number of openings (5 passes) to the Gulf, a wide variety of tidal currents are found in the system. Tidal currents from 3.3 ft/sec to 8.2 ft/sec are routinely found in the passes with values up to 11.5 ft/sec occurring in Sikes Cut in extreme cases (Huang and Jones, 1997)

Water currents in the bay system are due primarily to the astronomical tides, but are strongly affected by the direction and speed of prevailing winds, riverflow, and the physical structure of the bay (Dawson, 1955). Strong winds can modify water movement to the point of obscuring tidal effects. Typical monthly water levels, fluctuations, with tidal, wind, and riverflow effects included are shown in Figure 11. Strong winds may also thoroughly mix the shallow water of the bay, but winds of lesser velocity affect only the surface layer, resulting in stratification of the water column (Estabrook, 1973). Net movement of water is from the east to the west. The more saline gulf water enters through St. George Sound and moves west mixing with the fresher water in East Bay and Apalachicola Bay and eventually moves back out to the Gulf through Sikes Cut, West Pass, and Indian Pass (Ingle and Dawson, 1953; Conner et al., 1982). In the bay, water velocities rarely exceed 1.5 ft/sec. Roughly 700,000 cubic feet of water per second leaves the bay system at maximum velocity during ebb flow (Gorsline, 1963).

**TABLE 3**

**Physical characteristics of major water bodies in the Apalachicola Bay System**

| Water Body | Area (acres) | Volume (acre-ft) | Average depth (ft) |
|---|---|---|---|
| Apalachicola Bay | 52,993 | 365,652 | 6.9 |
| St. George Sound (within the Reserve) | 32,974 | 270,387 | 8.2 |
| St. Vincent Sound | 13,172 | 43,468 | 3.3 |
| East Bay | 11,089 | 25,505 | 2.3 |
| TOTAL | 110,228 | 705,012 | 6.2 |

(modified from Huang and Jones, 1997).


***Figure 10.*** *Bathymetry of Apalachicola Bay*

Several two-dimensional models have been set up to determine changes in the bay caused by specific structural modifications that have occurred over the years such as the dredging of Sikes Cut (Mehta and Zeh, 1980; Raney et al., 1985; 1988), a man-made pass, or the construction of the St. George Island bridge and causeway (Conner et al., 1982). Others have investigated estuarine structure and specific transport processes (Clarke, 1976) and tidal currents (Vansant, 1980) affecting specific parts of the bay or the bay as a whole. These studies have primarily used barotrophic, depth averaged models. Unfortunately, some of the basic assumptions in these studies varied from assuming that wind-induced mixing created a homogenous water column which resulted in negligible density affects, to assuming that riverflow only slightly affected the salinity structure, to neglecting riverflow altogether. Better simulations have been acquired when the water column is divided into two vertical layers and horizontal salinity gradients are added (Jin and Raney, 1991). Many of these models ran in real-time and all of them concluded that the bay was more complex than could be accounted for by the models available at the time.

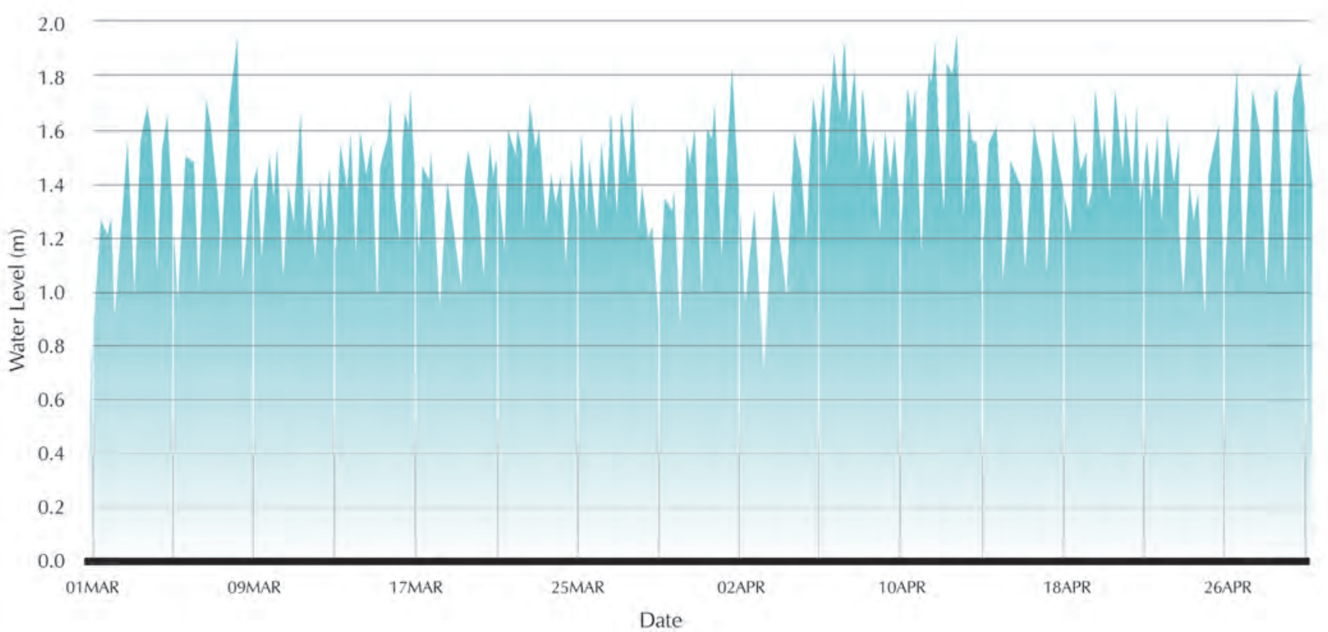


***Figure 11.*** *Water level fluctuations at Dry Bar, March - April 2005*

Due to proposed upstream water diversions a three dimensional hydrodynamic model (Huang and Jones, 1997; Huang et al., 2002 a&b; Huang and Spaulding, 2002) was utilized to help determine freshwater needs and possible impacts of modified flows on the bay. Preliminary simulations using an older dataset showed the important role that vertical and horizontal stratification play in the motion of water in the bay. The model also confirmed the generally accepted fact of a westward flow pattern for freshwater exiting at West Pass and a net inflow at Sikes Cut (Jones et al., 1994). A more detailed 3-D model was developed utilizing a six-month dataset collected in the summer and fall of 1993 during low river flow conditions. Findings from the model simulations demonstrate (Huang and Jones, 1997):

- the importance of the wind field on long-term motions
- riverine effects on the salinity of the mid-bay area and its effect on East Bay salinity
- high vertical stratification near the mouth of the river and significant horizontal stratification with little vertical stratification as distance from the mouth increases
- significantly different tidally induced water level ranges from the east to the west side of the bay
- a convergence zone east of the river mouth caused by the interaction of the flood tide from the west and east
- salt water from East Pass cannot be transported into the mid-bay area by tidal forces alone, easterly winds are also required.
- wind masks a large portion of riverine effects, but this does not mean riverine effects can be ignored, since bay-wide salinity is in a direct relationship with freshwater inputs.

The model also pointed out that average conditions cannot necessarily be considered "normal" conditions when examining circulation and salinity structure. Three distinct patterns were noted during the model simulations. First, during periods when average conditions prevailed, salinity contours radiated out from the river mouth symmetrically and salinity at Dry Bar (western bay) and Cat Point (eastern bay) were similar. This occurred the least amount of time. Second, during periods when the freshwater plume is directed west towards Dry Bar/West Pass, then Cat Point and East Bay exhibit higher salinity water due to the influence of East Pass and St. George Sound. And third, during periods when freshwater is transported eastward into the mid-bay region, then fresher water is tidally introduced to the East Bay and Cat Point areas resulting in high horizontal salinity gradients and high salinity variability in these regions. This third condition also coincides with increased saltwater intrusion at West Pass and higher salinities at Dry Bar (Huang and Jones, 1997).

Additional work on this model and the introduction of management scenarios to determine potential impacts on salinity and transport in the bay and, therefore, possible effects on the biota of the system are currently underway.


***Figure 12.*** *Freshwater discharge into the Gulf of Mexico (darker shades represent higher chlorophyll a concentrations)*

## Gulf of Mexico Hydrology

As mentioned previously the Apalachicola River has the largest freshwater discharge of any river in the State of Florida. To get an idea of the amount and importance of the river flow, McNulty et al., (1972) estimates that the Apalachicola River discharge accounts for 35 percent of the total freshwater runoff on the west coast of Florida. Recent work suggests that this fresh water discharge, referred to as the "green river plume" is an important component affecting offshore productivity, both primary and secondary, and may even affect fish production on some of the Marine Protected Areas in the northeast Gulf (Figure 12) (Gilbes, et al., 1996).

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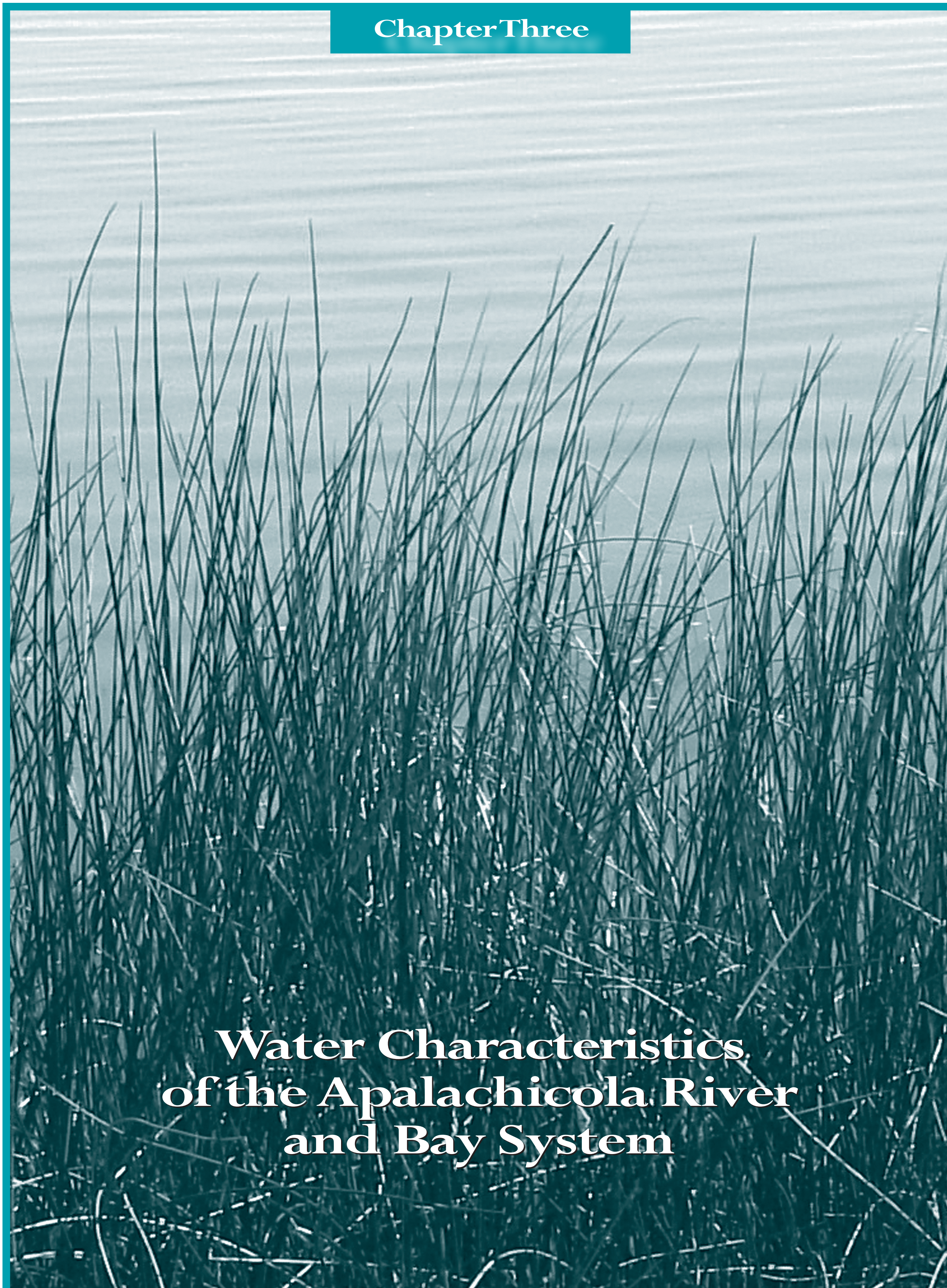
Chapter Three



# Water Characteristics of the Apalachicola River and Bay System

Apalachicola Bay water characteristics are primarily determined by a combination of flow from the Apalachicola River, local runoff, and Gulf of Mexico coastal water brought into the system by tidal and meteorological influences. Riverine water characteristics are determined by upland habitats and soil types, land use, and municipal and industrial discharges into the river and tributaries which extend into Georgia and Alabama. Because of the dynamic nature of the system and upstream water diversion threats, the Reserve instituted a monitoring program to define short-term variability and long-term changes in the water characteristics and chemistry that define and control the distribution of habitats and biological populations within the bay system. This monitoring program is part of the NERRS System-Wide Monitoring Program (SWMP), started nation-wide in 1995, as part of a NOAA funded long-term monitoring effort. A comparison between historical information and the temporally detailed "continuous monitoring" accomplished by the Reserve's SWMP, during the last eleven years, is included for illustrative purposes.

## Temperature

Water temperature in the Apalachicola River primarily follows meteorological and climatic conditions. From STORET (EPA's STOrage and RETrieval database) data collected from the late 1950's to the present, water temperatures in the Chipola River generally vary from 10 to 26 °C throughout the year while water temperatures within the lower Apalachicola River (River Mile 10-20) vary from 6 to 31 °C (Roaza, 1991). The Flint and Chipola rivers, which drain into the Apalachicola River system, are both spring-fed, which tends to moderate their temperatures and eliminate extreme values on the higher and lower ends.

Historical data illustrate that water temperatures in Apalachicola Bay are highly correlated with air temperature due to the shallowness of the bay and wind-mixing of the water column. Very little thermal stratification has been found because of rapid mixing in the bay (Livingston, 1983). Temperature ranges of from 5 to 33 °C have been recorded within a year with peak temperatures generally occurring in July and August and lowest temperatures occurring from December through February (Livingston, 1984).

Since the advent of the Reserve's system-wide monitoring program (SWMP), using in-situ dataloggers, a much more detailed picture of water temperature variability over daily and annual cycles has been noted (Figure 13). Dataloggers placed one-half meter above the sediment (at numerous locations), in water depths from 1.5 to 2.5 meters of water, show rapid changes in bottom water temperatures with the arrival of fronts and winter storms. Looking at temporally detailed data also demonstrates how quickly temperatures can rebound after these meteorological events. Bottom water temperatures can vary as much as 10°C over a 48 to 72 hour period (Figure 14). Surface temperatures can exhibit even wider fluctuations than bottom temperatures, making it difficult for some organisms to adjust to these rapidly changing conditions.

Ancillary information, noticed by Reserve personnel during this time period, seems to show increased barnacle sets during periods of rapid temperature change. However, those data are too preliminary at this time and further investigation

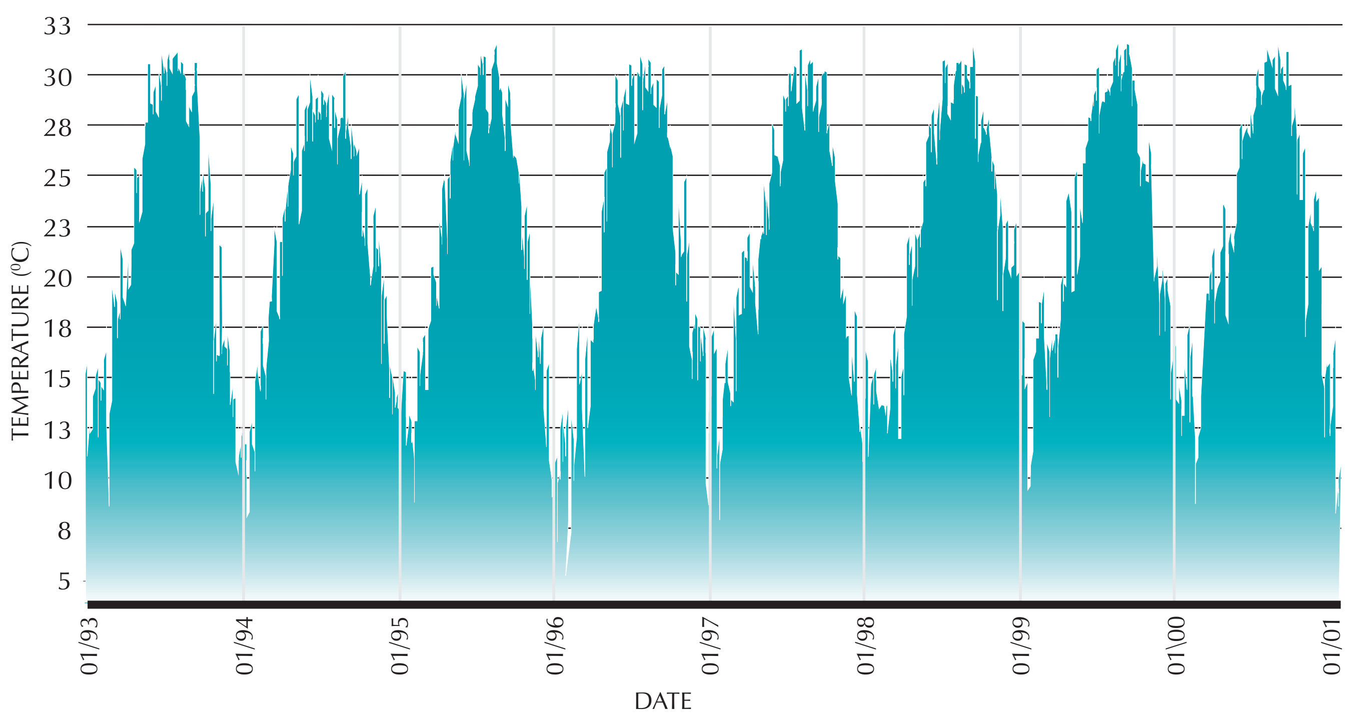



***Figure 13.*** *Water temperature at Dry Bar (daily average)*

is needed. The Reserve is also using this detailed information to correlate the beginning of the sea turtle nesting season with local water temperature.

## Salinity

Although tidal influence in the Apalachicola River extends up past Sumatra (River Mile 21) (Light et al., 1998), salinity is not thought to affect the lower river past RM 6.6 (Ager et al., 1987), locally called the Pinhook. However, since very little work has been done on the salt wedge in the lower river system, its extent is currently not certain.

Salinity distribution in the bay has been studied for years because of its effect on the distribution of important ecological, commercial, and recreational species. River flow, local rainfall, wind speed and direction, tidal currents, and basin configuration all affect and influence salinity in the bay (Dawson, 1955; Gorsline, 1963; Livingston et al., 1974; Livingston, 1984; Isphording, 1985; Niu et al., 1998). River flow, however, is the primary factor that influences the salinity structure of the system (Meeter and Livingston, 1978; Livingston, 1984), although other factors can play a large role within the bay depending on location (Niu et al., 1998).

As expected salinity values generally increase from north to south or as the distance from the river mouth increases. Because of the dynamic nature of the bay however, salinity values ranging from 0 parts per thousand (ppt) to 33 ppt can usually be found in the bay throughout the year. Salinity values also generally increase from west to east with higher values found in eastern St. George Sound and lower values found near the river mouth, St. Vincent Sound, and in East Bay (Figure 15 - modified from Livingston, 1983). Salinity values are generally lower in the late fall and early winter when annual floods occur on the river and highest during the summer and early fall when river flow is at a minimum (Figure 16 - modified from Livingston, 1983). Of course salinity is heavily influenced by riverflow so these figures are generalizations of conditions in the bay at a particular time related to a particular river discharge.

Data collected by the Reserve's monitoring programs, as well as the NERR SWMP, in place since 1993, have shown that salinity varies significantly not only within seasons and by location in the bay (Figure 17), but can also vary greatly within the water column itself (Figure 18). Strong winds can mix the water column quite rapidly in the shallow bay, but the bay can also exhibit vertical stratification during periods of low to moderate winds (Livingston et al., 1974; Livingston, 1983; Livingston, 1984). Temporal changes in salinity can also occur quickly, as thirty minute measurements from dataloggers deployed in the bay have shown (Figure 19). Salinity changes of greater than 15 ppt have been seen over a one-hour time period, especially at stations affected by tidal fronts in the bay (ANERR, unpublished data).

Although river flow plays a major role in determining salinity variability and distribution throughout the bay, it is not the only factor. Time series analysis, utilizing transfer function models and daily measurements of a wide variety of factors over a four year time period at two locations (Figure 20), has demonstrated that the importance of these factors vary depending upon location in the bay. For example, salinity on Cat Point, in the eastern part of the bay, is influenced more by water level fluctuations (tides) than river flow. Local rainfall plays a larger role in reducing salinity here than in the western part of the bay at Dry Bar. Winds with a westerly component tend to reduce the salinity in the eastern bay by shifting the river water to this side of the bay. At Dry Bar, the opposite occurs with river flow being the dominant factor,

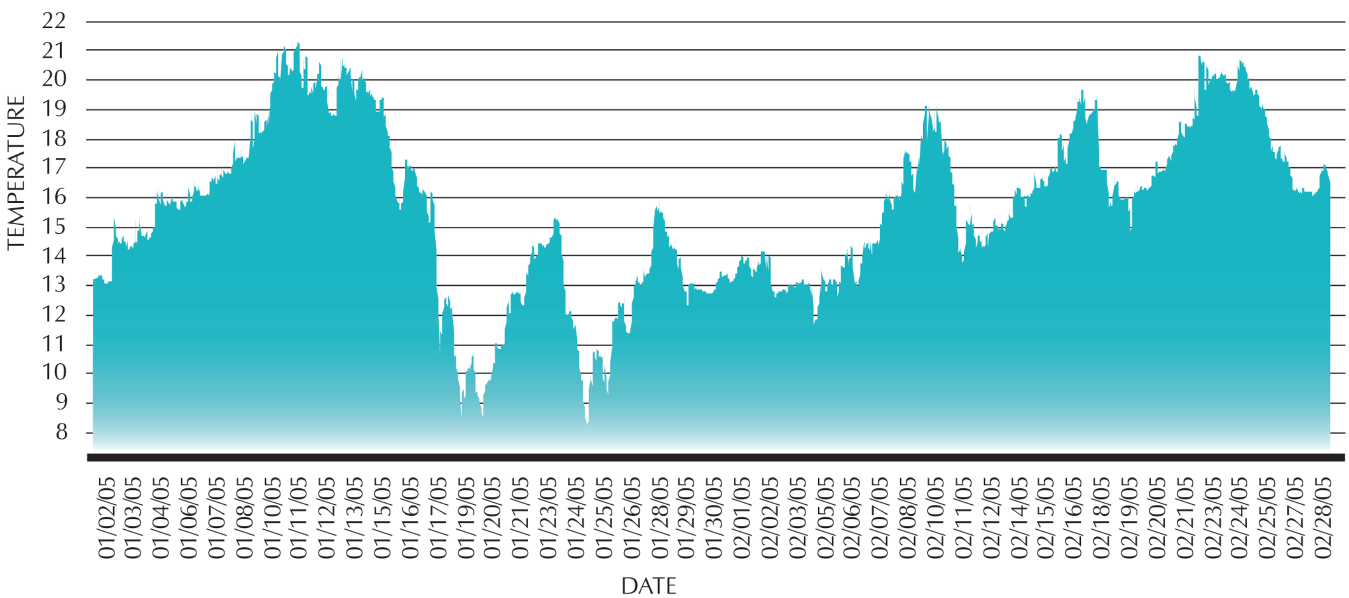



***Figure 14.*** *Water temperature at East Bay (30 min. data, Jan.- Feb. 2005)*

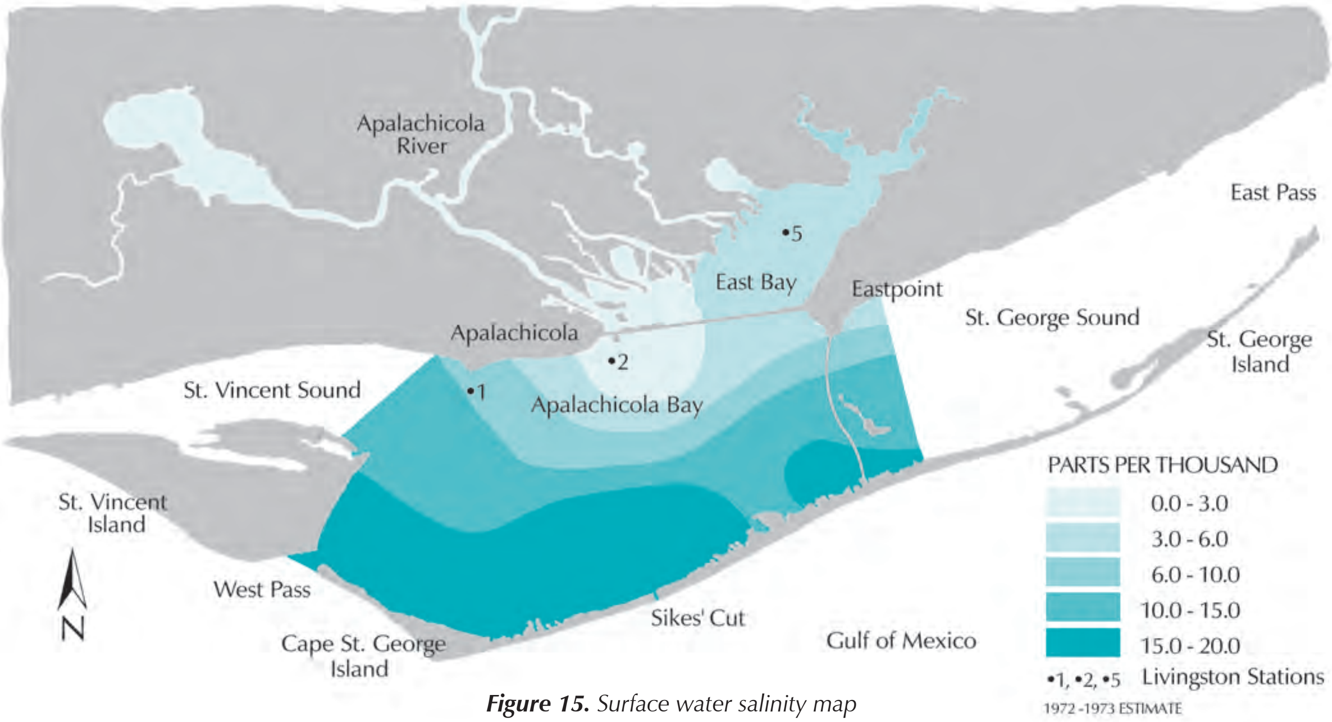



***Figure 15.*** *Surface water salinity map*

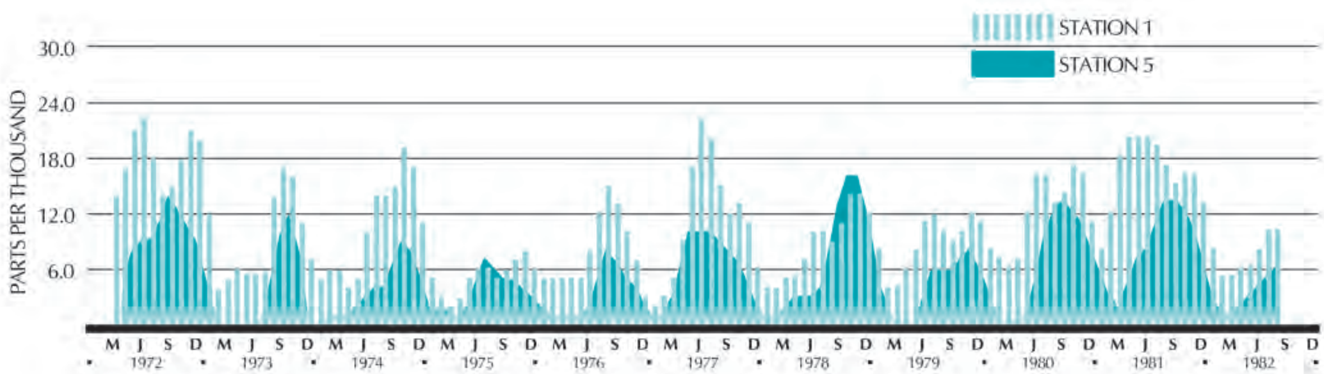



***Figure 16.*** *Surface water salinity (five month moving average - see Figure 15 for station locations)*

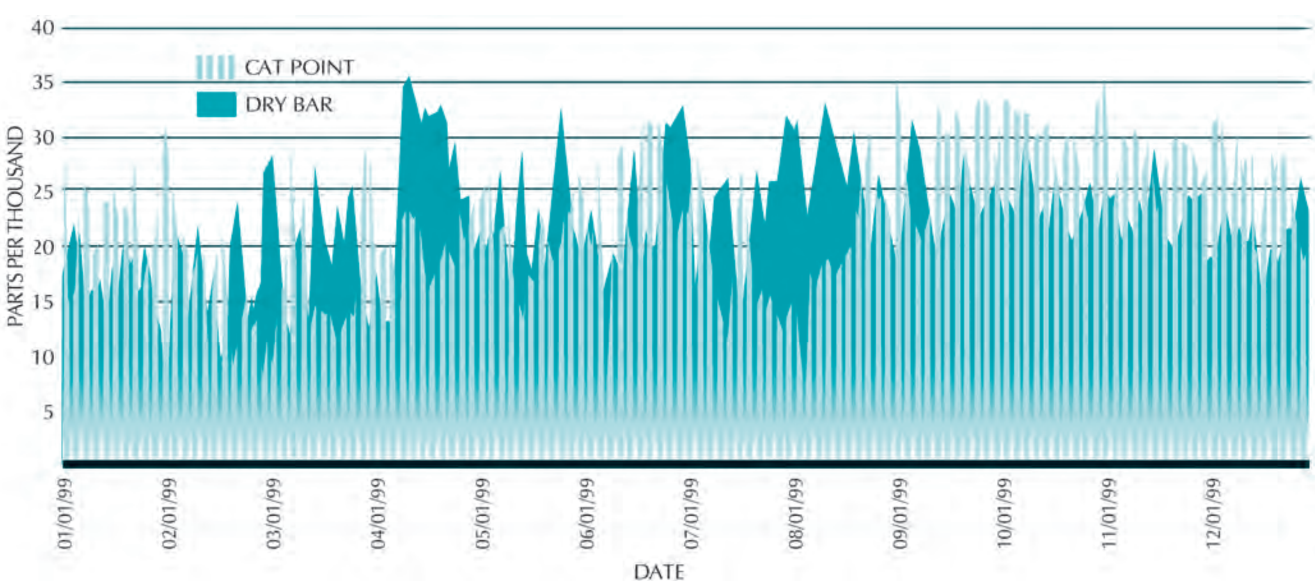



***Figure 17.*** *Average salinity of Cat Point and Dry Bar, 1999*

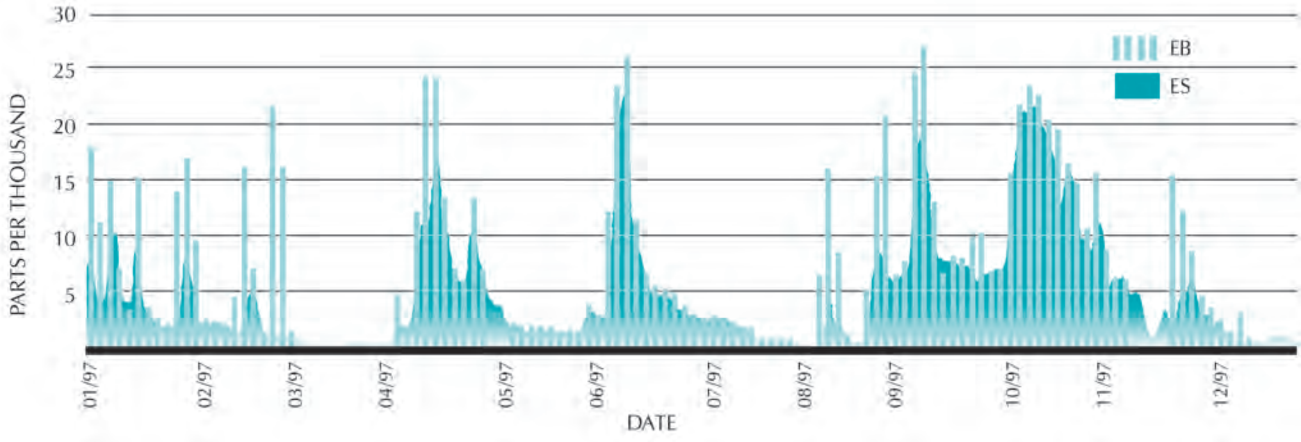



***Figure 18.*** *Average salinity in East Bay (EB - bottom, ES - surface), 1997*

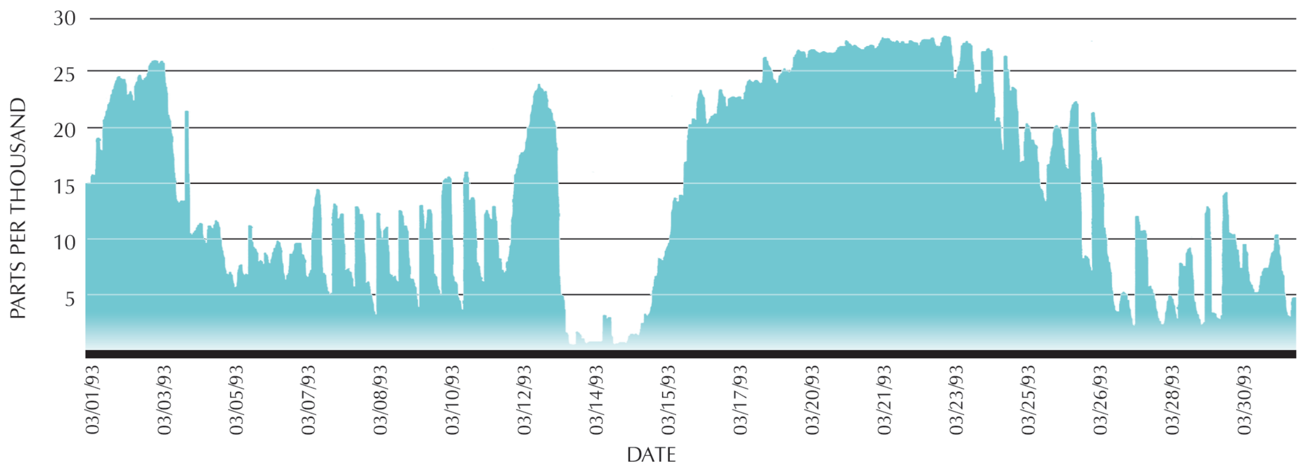



***Figure 19.*** *Salinity at Cat Point, March, 1993*

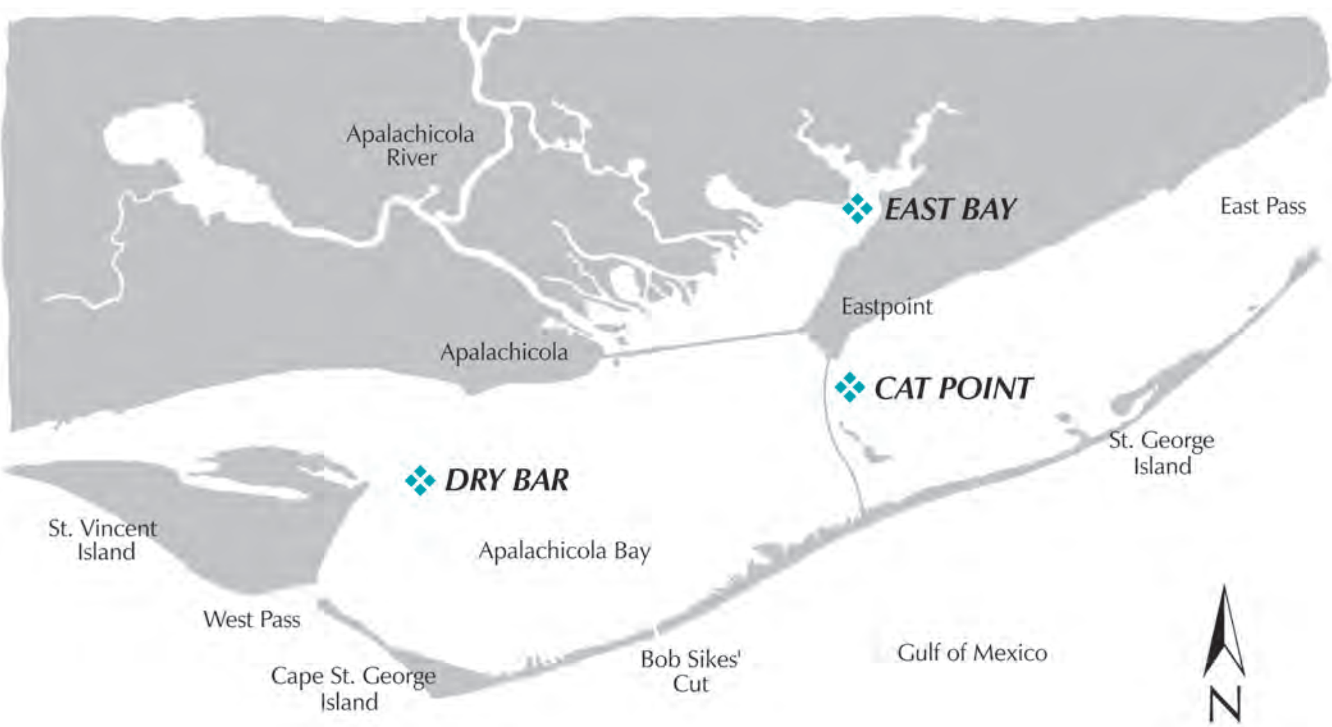



***Figure 20.*** *Datalogger stations in Apalachicola Bay*

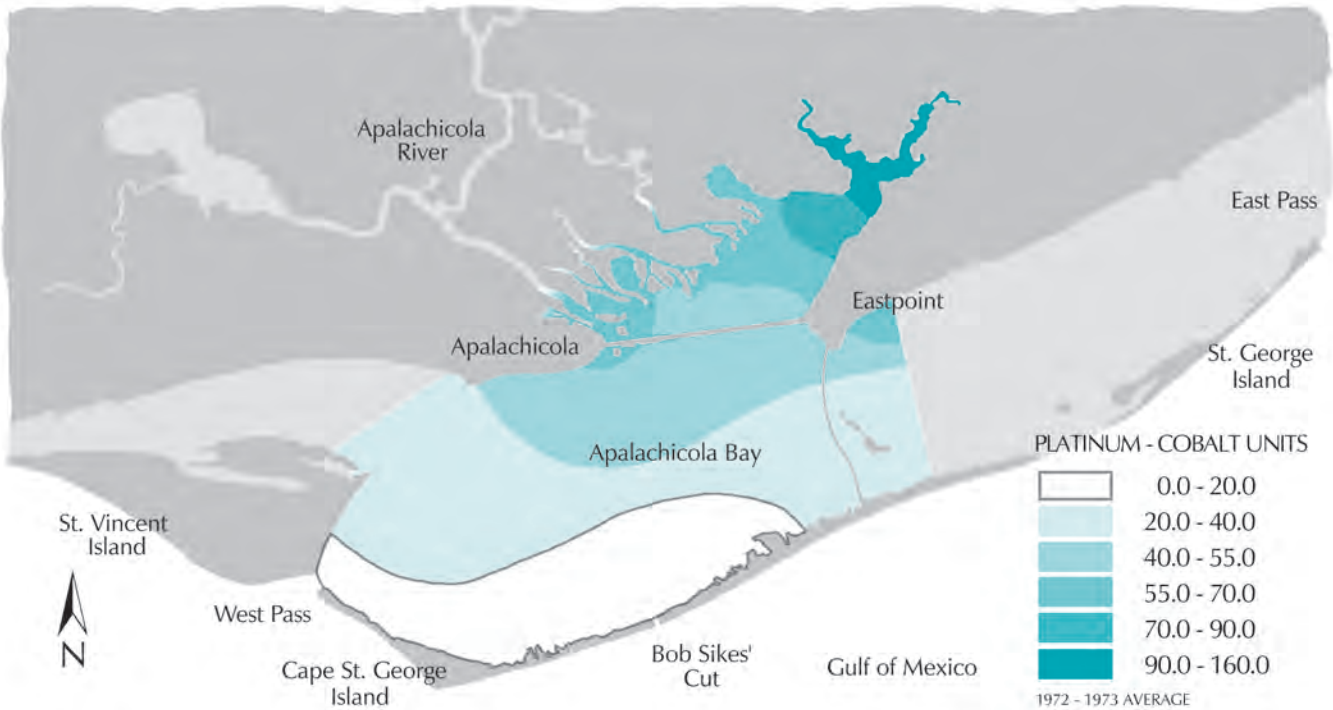



***Figure 21.*** *Surface water color*

and local rainfall and water level playing minor roles. Westerly winds also tend to increase the salinity at Dry Bar, illustrating that the two stations act as mirror images to each other. When the salinity is low at Cat Point it is usually high at Dry Bar due the varying importance of river flow, wind speed and direction, local rainfall, and water level that influence salinity at these stations (Niu et al., 1998).

## Water Color and Turbidity

Water color was routinely measured for a period of ten years from 1972 to 1982; however, few if any measurements have occurred since. As expected, water color values are directly related to river flow and local rainfall/runoff patterns. Values range from 0 to over 300 platinum-cobalt units at individual stations but are generally in the 20 to 160 range with lower values near the gulf (Figure 21). High color levels generally occur at the river mouth, during periods of high river flow (Figure 22) and in the upper areas of East Bay, when runoff is high due to local rainfall events. The high values in upper East Bay are probably caused by its proximity to the large swamps in Tates Hell, which drains into East Bay, and forestry management practices back in the seventies and early eighties (Livingston et al.,1974; Livingston and Duncan, 1979; Livingston, 1983; 1984).

Turbidity, like water color, mimics freshwater inflow regimes into the bay with similar patterns (Figure 23). Turbidity, however, is also affected by wind events, which tend to resuspend bottom sediments. Turbidity values collected in the 1970's and early 1980's were measured in Jackson Turbidity Units (JTU's). Turbidity values over 250 JTU's were found during periods of high river flow and storm events but usually ranged from 0 to 30 JTU's (Livingston et al., 1974; Livingston, 1978; 1983; 1984) (Figure 24).

Data collected since 1983, although infrequent, have been reported in Nephelometric Turbidity Units (NTU's). Turbidity values in the Apalachicola River typically range from 1 to 50 NTU's (FDER, 1984) while values in the bay typically range from 1 to 70 NTU's (ANERR, unpublished data), with most of the higher values associated with high river flow or storm events (Figure 25). High turbidity values, up to almost 800 NTU's, have been documented due to storm surges from Hurricane Dennis (Figure 26) in July 2005 (ANERR, unpublished data). Low turbidity values are typically found in the outer reaches of the bay, near the barrier islands, and in the eastern end of the bay in St. George Sound, probably due to the lack of fine sediment sources and depositional patterns (Isphording, 1985).

## pH

Hydrogen ion concentrations (pH) in the Apalachicola River fall within the normal range expected for this type of system ranging from 5.0 to about 8.6 and averaging 7.1 over the long-term (FDER, 1984; Roaza, 1991). Likewise bay pH's normally range from 6 to 9 (Livingston, 1984; Isphording, 1985). Low levels, especially for estuarine areas, have historically been found in the upper reaches of East Bay. These levels, in the 4 to 5 range, and as low as 4.0 were found in the mid 1970's and were related to local rainfall events and runoff from areas cleared in silvicultural operations in the Tates Hell drainage, which drains into East Bay. These

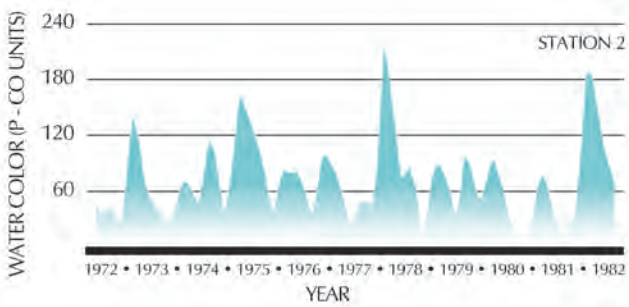



***Figure 22.*** *Color (5 month moving averages) at Station 2 (see Figure 15) in the Apalachicola Bay from 1972 through 1982*

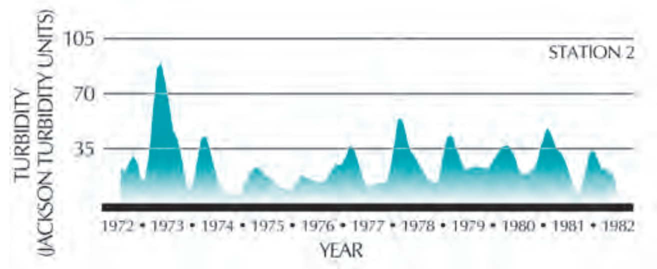



***Figure 24.*** *Turbidity (5 month moving averages) at Station 2 (see Figure 15) in the Apalachicola Bay from 1972 through 1982*

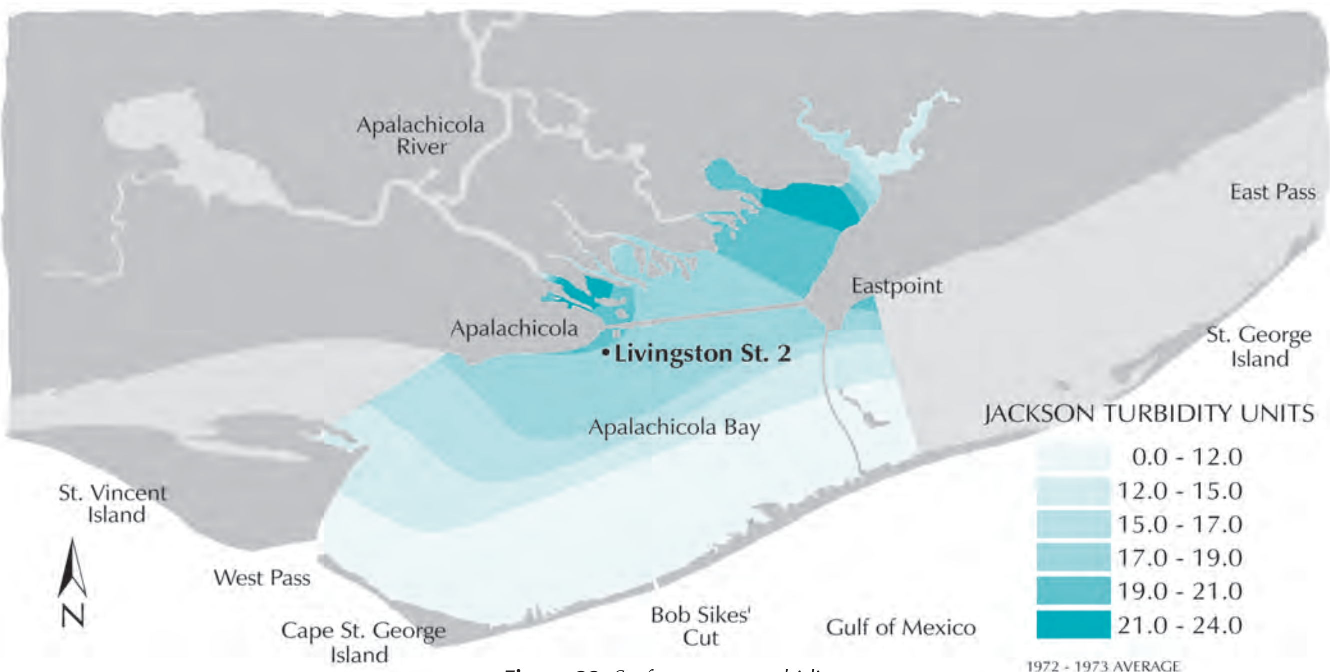



***Figure 23.*** *Surface water turbidity*

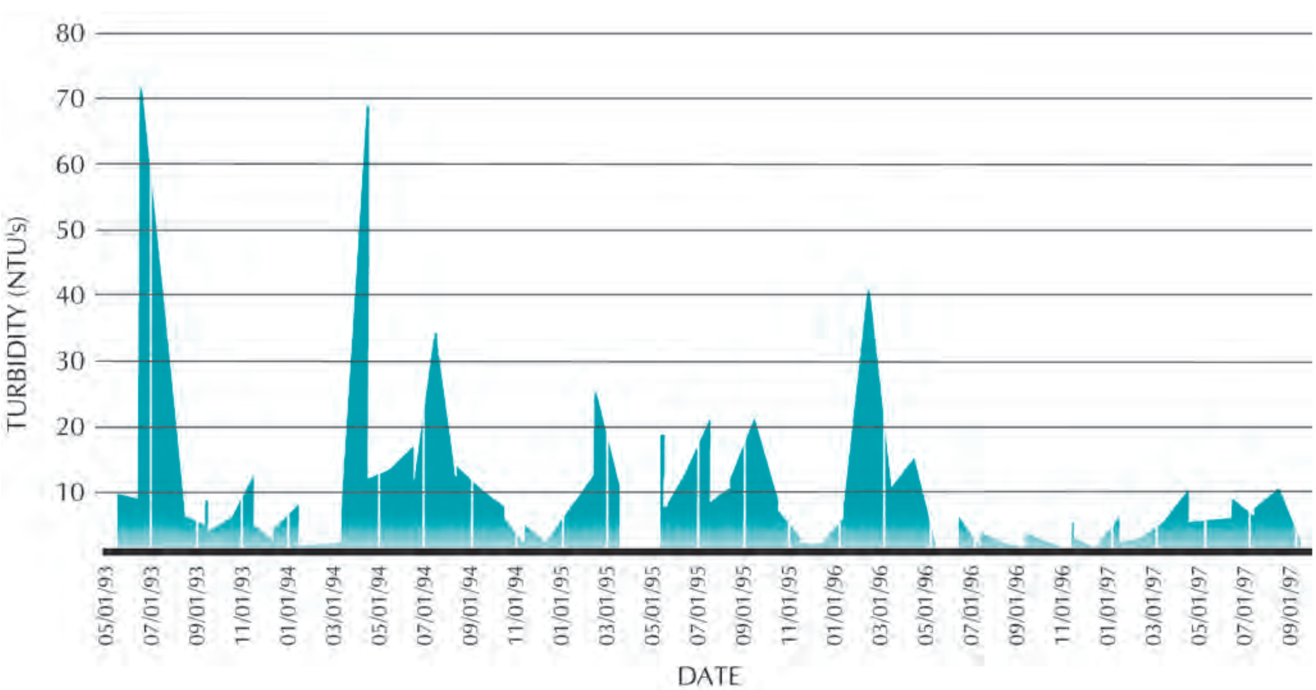



***Figure 25.*** *Bottom turbidity at Cat Point (1993 - 1997)*

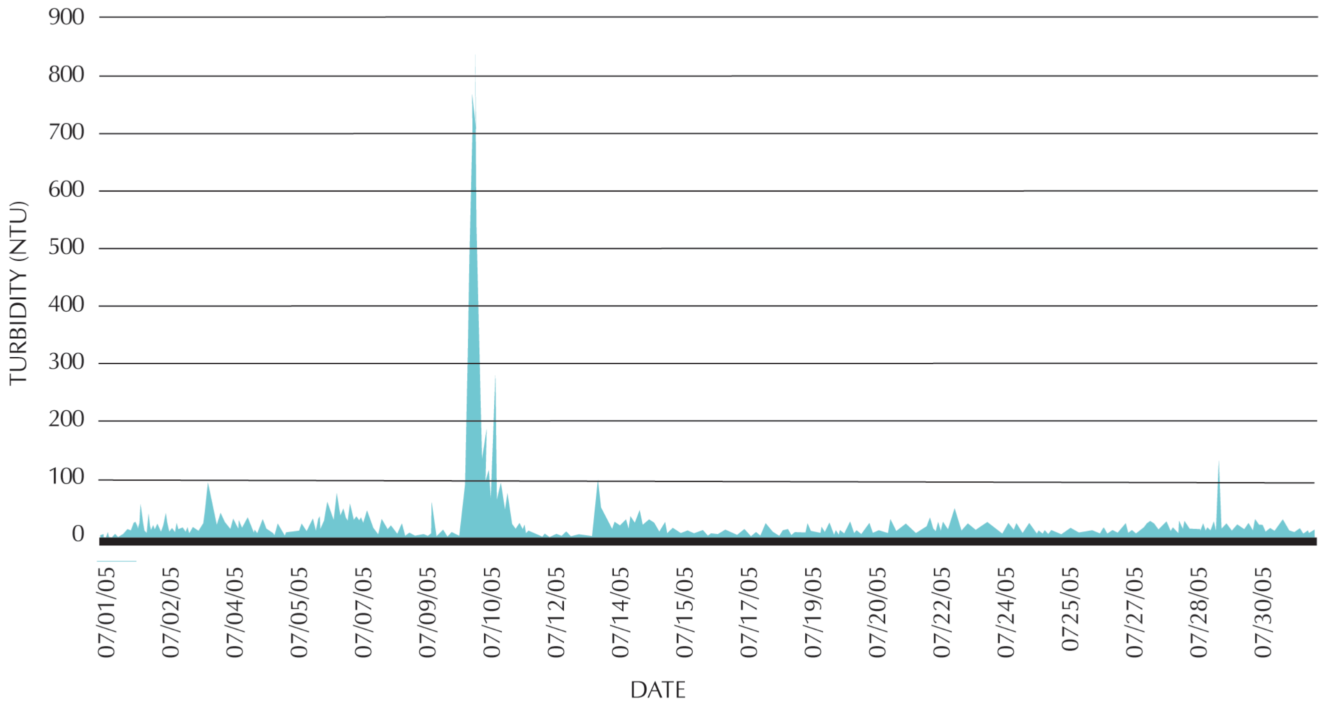



***Figure 26.*** *East Bay surface turbidity during Hurricane Dennis (July, 2005)*

operations were part of a project to drain this forested wetland area by massive ditching and diking in order to create a better environment for silvicultural activities (Livingston, 1978).

Data collected by the ANERR monitoring program, in place since 1993, show similar pH values for 2005 data. Lower pH values are found in East Bay during high river flow, local rainfall, and storm events (Figure 27); whereas Cat Point generally exhibits higher pH values showing the influence of the Gulf of Mexico and higher salinity water. Low pH values, in the range of 4 to 5, in August 1994, August 1997, and October 1998 are related to tropical storm and hurricane events that dumped large amounts of rain on the area in a few days (ANERR, 1999).

## Dissolved Oxygen

Dissolved oxygen (DO) in the lower Apalachicola River typically varies from about 5 to 10 mg/l (70-100% saturation) throughout the year (Roaza,1991) and is related more to seasonal (temperature) variations than river flow. Peak levels of DO normally occur in the winter and spring and lower levels occur in the summer and fall when temperatures are higher (Figure 28) (Livingston, 1984). Dissolved oxygen levels in the bay typically range from 4 mg/l to 14 mg/l, although most values fall between 5 and 12 mg/l (Livingston, 1978). Hypoxia in the bay is normally not evident, however, low DO levels (< 4 mg/l) have been noted in some areas affected by runoff from the City of Apalachicola and in local marinas.

The Reserve has been monitoring DO since 1993 at selected locations utilizing in-situ dataloggers deployed for two-to three-week periods. Biofouling of membranes, which used to be a major problem after 4-5 days has been mostly eliminated due to a new Extended Deployment System with wiper system that has been installed on the dataloggers. Seasonal and diurnal variations in DO can be pronounced in the upper reaches of the bay, especially during the summer months (Figure 29), due to increased temperature (June water temperature = 31$^{0}$C), light and primary productivity. In East Bay most hypoxic events that occur last less than 4 hours (Sanger, et al, 2002). During periods of relative calm the bay exhibits vertical stratification and dissolved oxygen differences do appear, although they do not appear to be significant at this time (ANERR, 1999).

## Nutrients

Seasonal flow related inputs, as well as the type and fluxes of nutrients in Apalachicola Bay have been shown to have a much larger impact on the productivity of the bay than was previously thought (Mortazavi et al., 1998; Mortazavi et al., 2000a; Pennock et al., 1999; Twilley et al., 1999). In order to understand these relationships, it is critical to understand the sources, contributions, and fluxes of nutrients into the estuarine system. Point sources of nutrients in the ACF system include municipal and industrial wastewater effluent and sanitary and combined sewer overflows. Nonpoint sources include animal manure, primarily chicken litter; fertilizer; runoff from agricultural, urban, and suburban areas; septic systems; atmospheric deposition; and decomposition of organic matter (Frick et al., 1996). However, contributions of

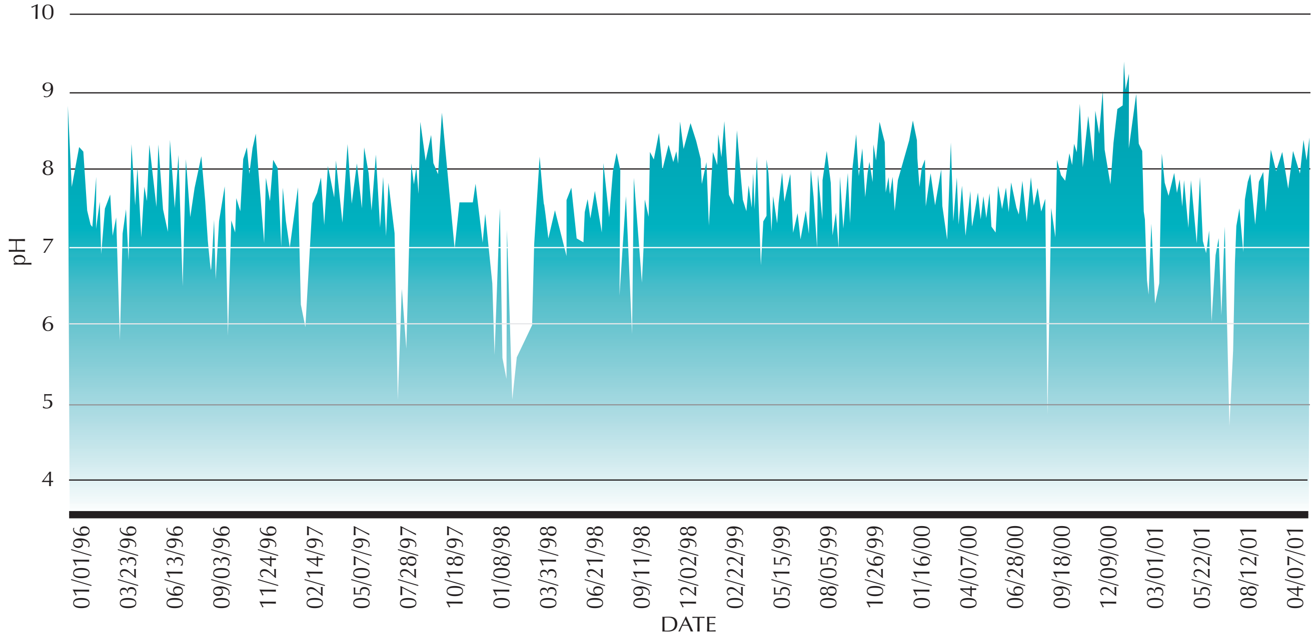



***Figure 27.*** *East Bay Surface pH Values (1996 - 2001)*

nutrients from natural sources such as groundwater are less clear. Most details on nutrient loading for the ACF system are found in an extensive USGS National Water-Quality Assessment (NAWQA) Program that was undertaken in the early 1990's and will be discussed in later chapters.

**Atmospheric Contribution**

Atmospheric deposition of nitrogen to the ACF basin has been estimated to range from 385 to 630 Kg/Km$^2$ annually (1.996x10$^7$ to 3.266x10$^7$ Kg annually in the basin from 1985 to 1991) and account for approximately 10 percent of estimated nitrogen

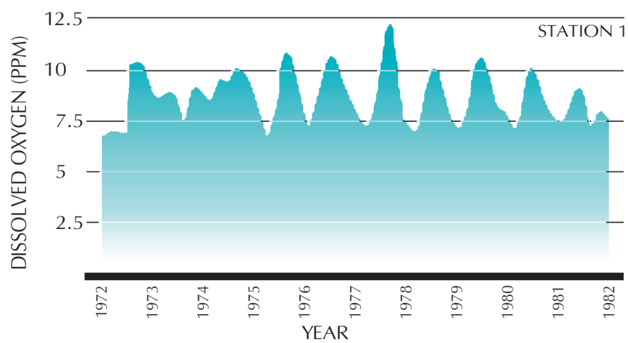



***Figure 28.*** *Surface Dissolved Oxygen (5 month moving averages) at Station 1 (see Figure 15) in the Apalachicola Bay, 1972 - 1982*

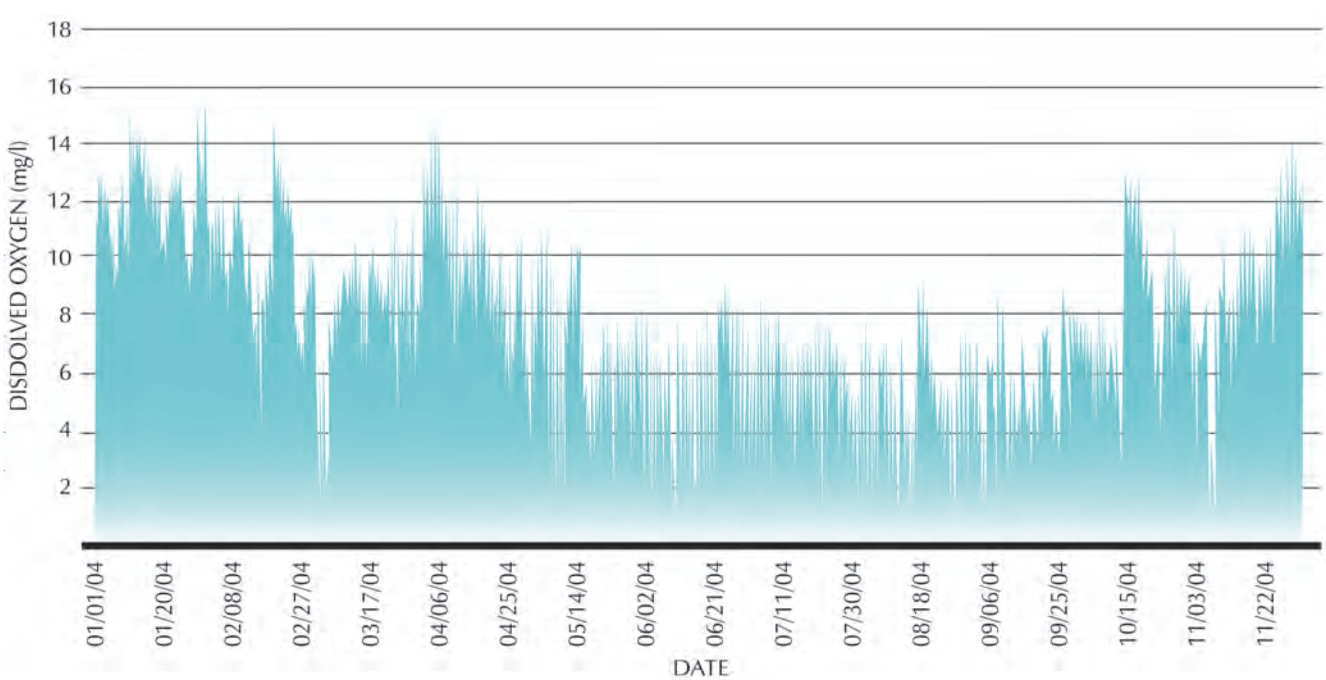



***Figure 29.*** *Dissolved Oxygen in East Bay (2004)*

inputs to the system (Frick et al., 1996). The primary source of this nitrogen is nitrogen oxide emissions from the combustion of fossil fuels, although the rate of deposition is a function of topography, nutrient sources, and spatial and temporal variations in climactic conditions (Frick et al., 1996). Atmospheric deposition of phosphorus is thought to be minor, although no estimate of phosphorus deposition is currently available. Additional information on the importance of atmospheric deposition of nitrate, and its transformation in the river and transport into the bay can be found in Winchester and Fu (1992).

**Ground Water Contribution**

Because of the paucity of data concerning ground water and the fact that only nitrate is considered to pose a human health risk, nitrate concentrations are the most available component from aquifers and wells in the area. Contributions of nitrate in ground water are higher and more varied than in surface water, however concentrations of organic nitrogen, ammonia, and orthophosphate in ground water are very low. Preliminary data on the distribution of nitrate concentrations in ground water throughout the ACF basin for 1972-1990 show that 38% of wells and 60% of springs tested had concentrations less than 0.2 mg/l (natural background). Additionally 51% of wells and 33% of springs had concentrations between 0.2 and 3.0 mg/l (may or may not be influenced by humans), 10% of wells and 6% of springs had concentrations between 3.1 and 10 mg/l (elevated concentrations), and 1% of wells had concentrations exceeding 10 mg/l (USEPA maximum contaminant level) (Frick et al., 1996).

**Riverine Contribution**

Because of the variability in nutrient parameters measured, methods of analysis, and types of estimates made (concentrations vs loadings) it is sometimes difficult to compare nutrient values from different studies. In the river nutrients can vary with season, river flow, and location. The most comprehensive study of nutrients in the ACF River system was undertaken by the USGS as part of their NAWQA program. Existing data from 1972-1990 was analyzed first to look at trends and the validity of the data (Frick et al., 1996). The NAQWA study, which focused on the entire ACF basin, was principally concerned with the Chattahoochee and Flint systems and impacts on nutrients from point sources as well as nutrient loadings from various land uses.

Results from this study that are important to the Apalachicola Reserve include the following:

- The large municipal discharges from Atlanta, Columbus, Albany, and Phenix City contributed to significant increases in concentrations of total inorganic nitrogen, dissolved ammonia, dissolved nitrate, and total phosphorus in the river downstream of these cities.
- Reservoirs affect the transport of nutrients through them, normally reducing the concentrations of total phosphorus and most nitrogen values significantly.
- Total phosphorus concentrations increased throughout most of the Chattahoochee River even though point source loads decreased significantly from wastewater treatment plants.
- Non-point source loadings of nitrogen and phosphorus from fertilizers and intensely farmed areas in the middle basin, especially the Flint River, may be significant.
- Estimated outflow of nutrients into Apalachicola Bay from the Apalachicola River are about 13% of estimated nitrogen sources and 3% of phosphorus sources for 1990 in the ACF basin.
- Seasonal changes in nutrient concentrations in the Chattahoochee River are strongly influenced by the 13 reservoirs on the river, especially the middle and lower reservoirs.
- Seasonal patterns of nutrient concentrations in the Apalachicola River are less noticeable than in the Chattahoochee River.

Nutrient concentrations measured at River Mile 11 in the lower Apalachicola River illustrate the relationship between concentration and river flow (Table 4). Analysis of seasonal data shows a wide range of values in both dissolved nitrate and total phosphorus concentrations throughout the year, probably related to river flow differences (Figures 30 & 31). Further trend analysis showed little change in most nutrients over time in the lower river except an increase in dissolved nitrate and a decrease in total phosphorus (Frick et al., 1996). Not enough samples were available, however, to put much faith in these trends. These values also compare favorably

**TABLE 4**

**Nutrient Concentrations in the Apalachicola River**

*at River Mile 11 from 1972-1990 (modified from Frick et al., 1996).*

| Parameter | Sample# | Min. | Max. | Med. |
|---|---|---|---|---|
| River flow | 101 | 11,000 | 50,000 | 24,000 |
| Total nitrogen (N) | 63 | 0.47 | 0.98 | 0.71 |
| Tot. inorganic N | 83 | 0.22 | 0.47 | 0.32 |
| Tot. organic N | 55 | 0.17 | 0.68 | 0.35 |
| Dissolved ammonia | 84 | 0.02 | 0.09 | 0.03 |
| Dissolved nitrate | 98 | 0.17 | 0.42 | 0.27 |
| Total Phosphorus | 101 | 0.02 | 0.09 | 0.05 |

*All parameters are in mg/l except River flow which is in cubic feet/second (cfs)*

*Minimum and maximum values are actually 10 and 90 percentile values based on the number of samples for each parameter.*

*Values estimated from graphs.*

with another study that looked at long-term surface water quality in the river (Roaza, 1991).

Earlier studies looked at sources of nutrients to the river and bay and found similar concentrations. However, these studies also found that while nutrient concentrations in the river varied little, the annual winter/spring flood could account for up to 50% of the annual flux of total nitrogen and phosphorus into the bay (Elder and Mattraw, 1982). The importance of the floodplain as a source of nutrients has also been shown with yields of phosphorus per unit area up to 15 times greater than the basin as a whole (Mattraw and Elder, 1984). Over the long term annual floods and a healthy floodplain, of bottom-land hardwood forest, were found to be critical in maintaining nutrient and detritus flow to the bay.

Studies that looked into nutrient concentrations in the bay and river from 1994 to 1997 found nitrate values in the lower river ranging from 180 to 480 ug N/l and phosphate (soluble reactive phosphorus, SRP) values ranging from 1 to 16 ug P/l (Fulmer, 1997; Mortazavi et al., 2000a, 2000b, 2001). Concentrations of these two nutrients in surface waters in the river were at their highest when river flow was high and appeared to decrease with decreased river flow. Therefore, nutrient inputs from the river followed a seasonal pattern with higher inputs during late winter and early spring and minimum concentrations during the summer months (Figure 32). High loading values for nutrients in the summer of 1994 were related to two tropical storms that resulted in extremely high river flows due to record precipitation in the drainage basin. A more specialized look at nitrogen shows that river nitrogen input to the bay increased with increasing river flow and that dissolved inorganic nitrogen (DIN) concentrations in the river were normally much higher than dissolved organic nitrogen (DON) concentrations. Mean DIN concentrations in the river averaged 350 ug N/l and mean DON averaged 183 ug N/l during the period from 1993-1995 (Figure 33) (Mortazavi et al., 2000a, 2000b, 2001). While SRP concentrations do not generally show seasonal trends monthly average values were 5.7 ± 4.1 ug P/l during 1994-1995 (Mortazavi et al., 2000b). Nutrient speciation, annual flooding, retention time, zooplankton grazing, and

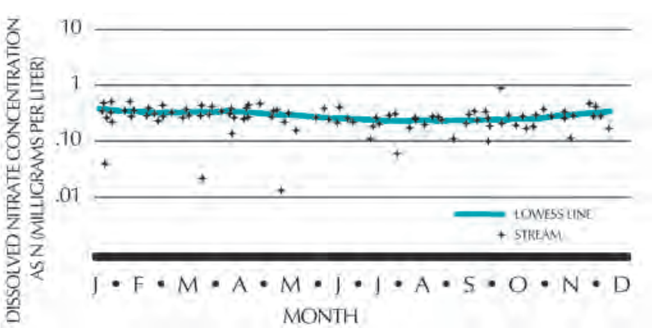



***Figure 30.*** *Seasonal variation in Nitrate concentration for the Apalachicalo River at river mile 11*

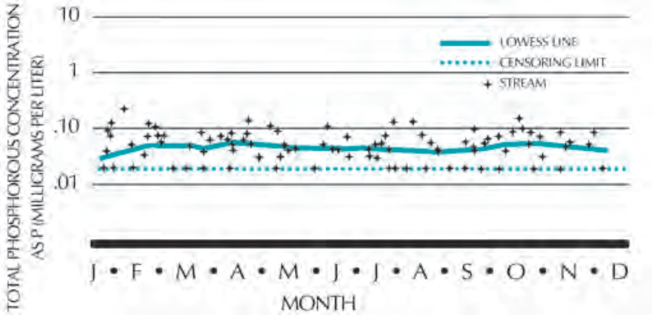



***Figure 31.*** *Seasonal variation in total Phosphorous concentration for the Apalachicola River at river mile 11*

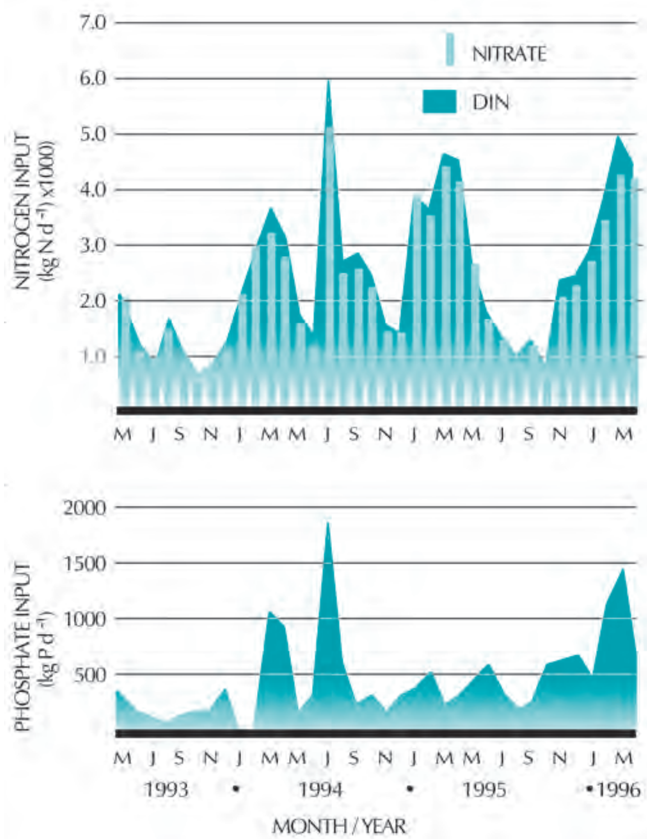



***Figure 32.*** *Top - Apalachicola River Nitrate and DIN input. Bottom - Apalachicola Soluable Reactive Phosphate input*

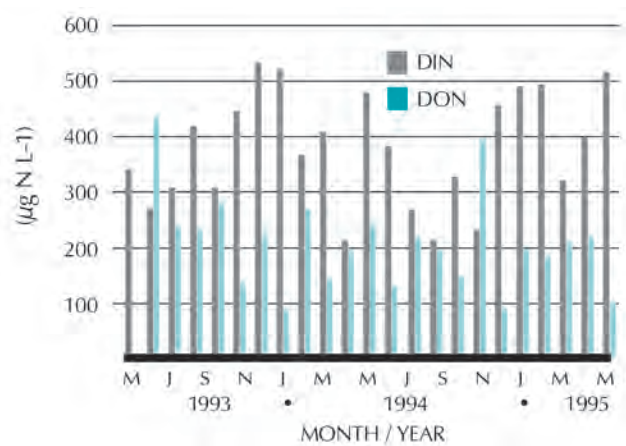



***Figure 33.*** *Monthly Apalachicola River nitrogen concentrations*

seasonal loading of nutrients have all been shown to be important factors in the productivity of the bay and will be the focus of a more detailed discussion in later chapters in this document.

**Estuarine Nutrients**

The Apalachicola River supplies most of the DIN, DON, particulate nitrogen, and phosphorus to the bay (Mortazavi et al., 2000a, 2000b, 2001). Nutrient concentrations in the bay are influenced by river flow, local runoff, tidal interactions, residence time, fluxes from benthic sediments, and the resuspension of sediments. The most important nutrients for phytoplankton productivity and the only two that have been found to be limiting in Apalachicola Bay are nitrate and phosphate. Nitrate concentrations have been found to vary from 3 to 400 ug N/l and to vary inversely with salinity. Phosphate concentrations range from less than 1 to 16 ug P/l (Estabrook, 1973; Fulmer, 1997, Mortazavi et al., 2000b) and appear to show little relationship with salinity. Nitrate and phosphate concentrations in Apalachicola Bay for high flow and low flow river conditions in 1996 are shown in Figures 34 and 35 (Mortazavi et al., 2000a, 2000b, 2001) .

Putland (2005) compared dissolved inorganic nitrogen (DIN) and SRP concentrations with salinity both seasonally and during high and low river flow years (Figure 36). Higher values of both DIN and SRP were documented during 2003, a high river flow year compared to 2004, and especially during winter, typically the flood season for the Apalachicola River. DIN values ranged up to 1400 $\mu$g N/l, at lower salinities, while SRP values were in the 0 to 15 $\mu$g P/l. DIN values were inversely related to salinity. During 2004, a low river flow year, SRP bay values averaged approximately half of those found in 2003. An inverse relationship between salinity and SRP was noted, although this correlation was much weaker than that between DIN and salinity. (Putland, 2005).

The Apalachicola River supplies 83% of the total nitrogen to the bay, while the rest comes into the bay from St. George Sound, the eastern boundary area (Figure 37). Nitrogen input to the bay is 2.5

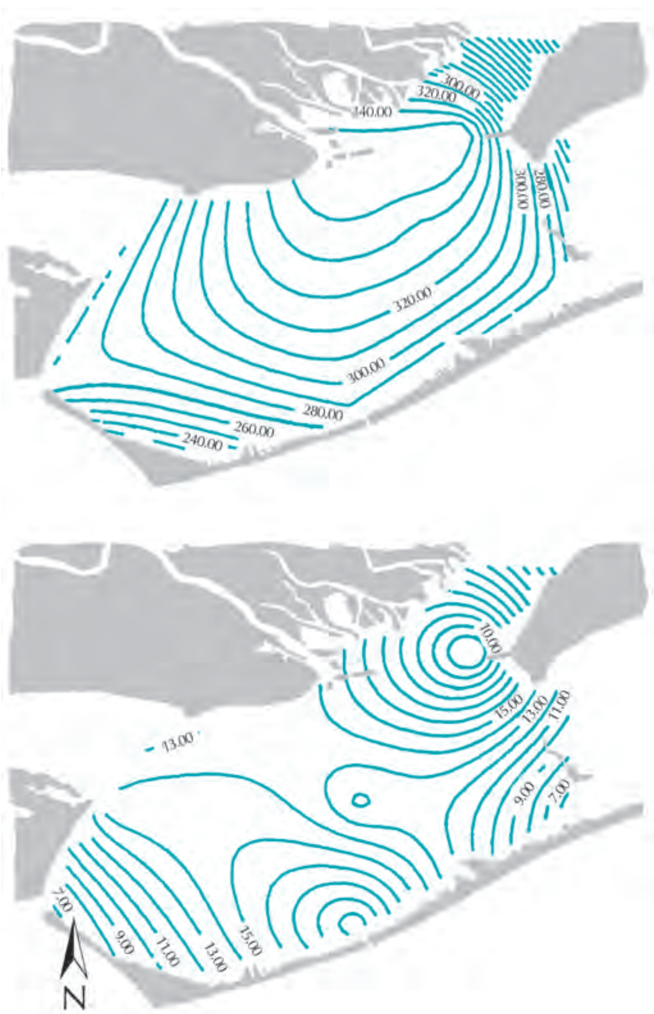



***Figure 34.*** *(top) $\mu$g $NO_3^-$-N - $L^{-1}$ (bottom) $\mu$g $PO_4^{3+}$-P - $L^{-1}$ Contours for Apalachicola Bay Surface Water, March 11, 1996 (high flow)*

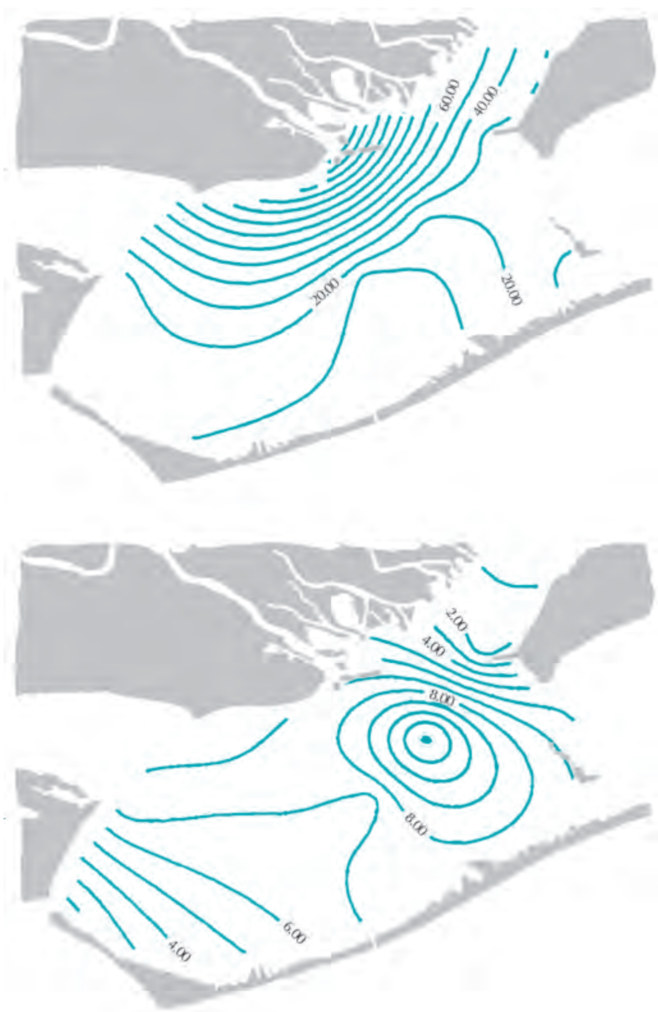



***Figure 35.*** *(top) $\mu$g $NO_3^-$-N - $L^{-1}$ (bottom) $\mu$g $PO_4^{3+}$-P - $L^{-1}$ Contours for Apalachicola Bay Surface Water, July 22, 1996 (low flow)*

times greater in the winter than the summer. A detailed analysis of the annual nitrogen budget of Apalachicola Bay indicates that it is balanced, with 64% of DIN input to the bay exported offshore, 20% buried in the sediments, and approximately 18% is denitrified. Export of DIN from the bay was related directly to the residence time of the bay water, which typically ranges from 2 to 12 days depending on river flow. On an annual basis approximately 98% of the dissolved organic nitrogen input to the bay is exported to the Gulf of Mexico (Mortazavi et al., 2000a, 2001). Annual (Figure 38A) and seasonal (Figure 38B&C) nitrogen box models illustrates changes in input and export throughout the year (Figures from Mortazavi et al., 2000a, 2001).

Average SRP concentrations in Apalachicola Bay generally increase with increasing river flow (Fulmer, 1997; Pennock et al., 1999). The lack of correlation of SRP concentration in the bay to riverine concentration shows it is not only related to fresh water residence times (Fulmer, 1997). A positive correlation has also been found between wind speed and increased phosphate con-

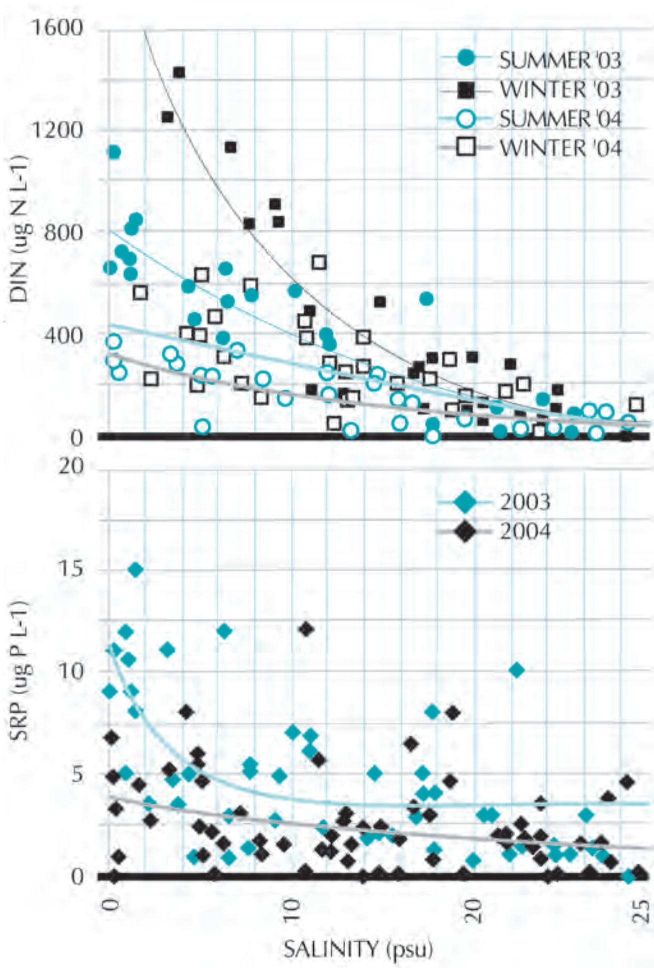



***Figure 36.*** *DIN & SRP concentrations with salinity seasonally & high / low river flow years*

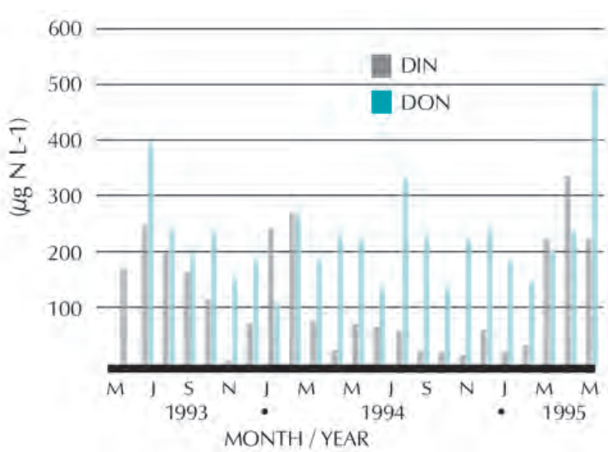



***Figure 37.*** *Nitrogen Concentration in St. George Sound*

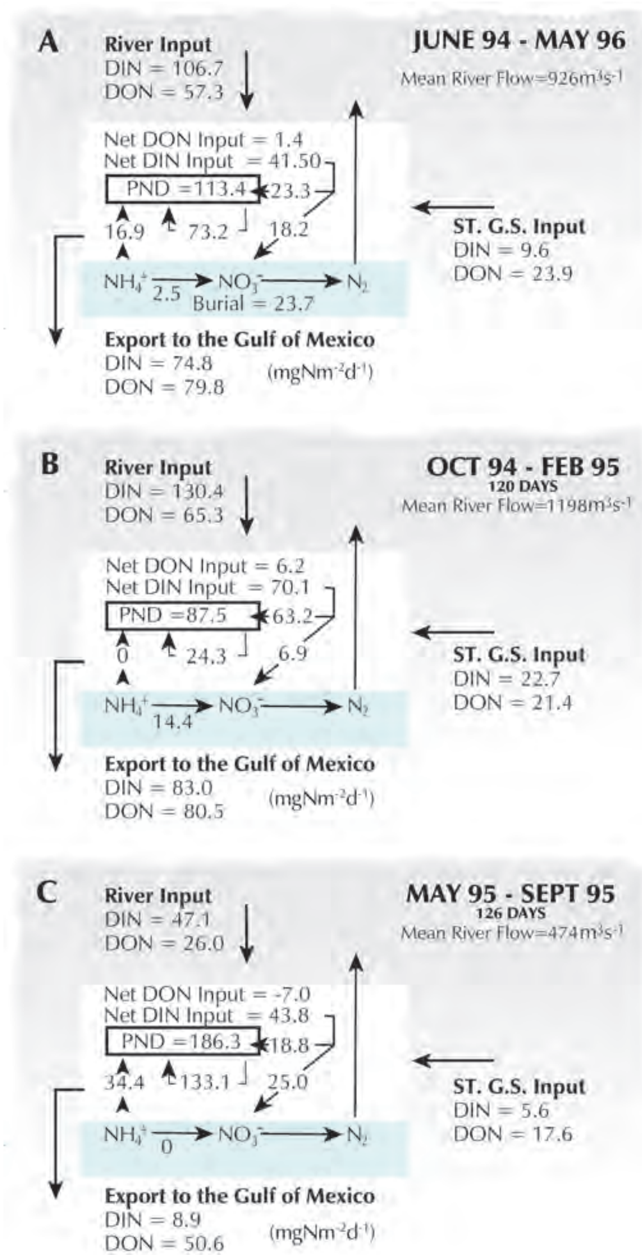



***Figure 38.*** *Changes in Nitrogen input & export throughout the year*

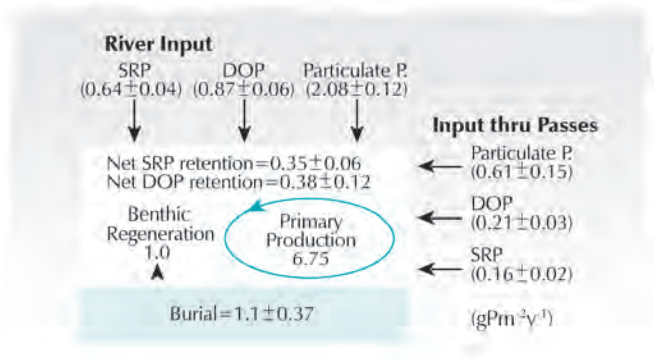



***Figure 39.*** *Annual Phosphorus input into Apalachicola Bay*

centrations and suspended sediments in this shallow bay during summer and fall (Myers, 1977). Therefore, resuspension of bottom sediments, that can contain between 0.04 and 0.18 percent reactive phosphate during wind events is the probable mechanism responsible for increased phosphate concentrations in bay water found away from the river mouth (Fulmer, 1997).

An annual phosphorus budget (Figure 39) shows that the river provides approximately 78% of the total phosphorus input to the bay with the rest coming in through the passes from the Gulf of Mexico. Most of the phosphorus input to the bay is also in particulate form (59%), while SRP represented only about 17%. Approximately 87% of the phosphorus input to Apalachicola Bay is exported, which is comparable to some northeastern estuaries with much higher residence times (Mortazavi et al., 2000b).

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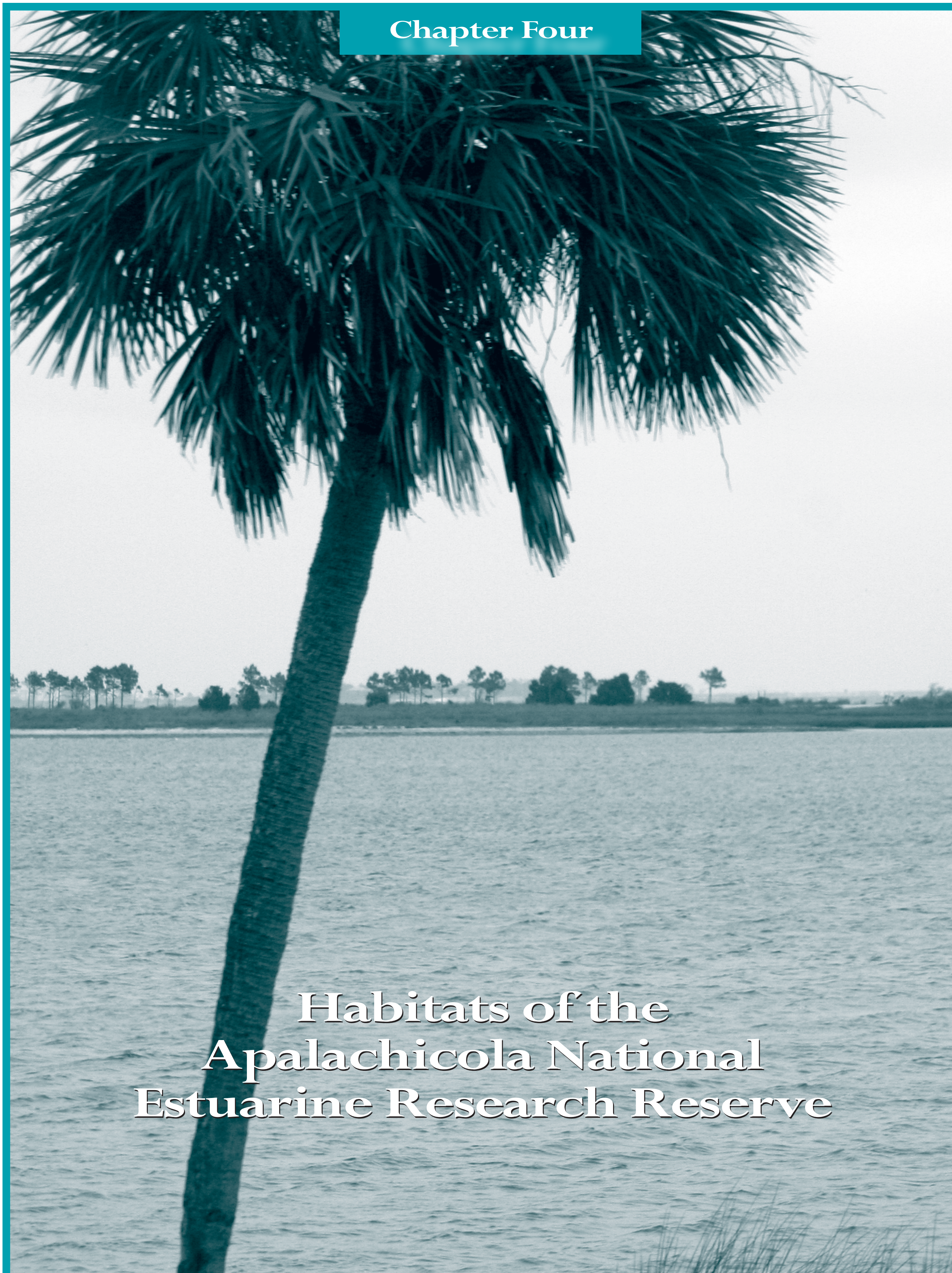
Chapter Four



# Habitats of the Apalachicola National Estuarine Research Reserve

The Apalachicola National Estuarine Research Reserve (ANERR) encompasses 246,766 acres of land and water (ANERR, 1998). Included within the Reserve's boundaries are two barrier islands and a portion of a third, the lower 52 miles of the Apalachicola River and its associated floodplain, portions of adjoining uplands, and the Apalachicola Bay estuarine system (Figure 2, Chapter 1, page 3).

## Barrier Island System

A well-developed barrier island system encompasses the outer bay. This barrier island complex lies roughly parallel to the mainland and is composed of four islands, three of which, St. George, Cape St. George, and St. Vincent Islands (Figure 9, Chapter 2, page 12) are included within Reserve boundaries. In their natural state, barrier islands play a crucial role in the formation of estuaries, lagoons, bays, and sounds. Barrier islands also provide protection to the coastal mainland, which they border, by providing a "first line of defense" to destructive hurricanes.

The various plant communities of barrier islands are dependent on geological formations and soil moisture gradients. Each barrier island has a unique plant community profile and structure. Typical profiles of the barrier islands are illustrated in the barrier island section.

The terrestrial (vertebrate) fauna (excluding birds) is often relatively depauperate on most barrier islands. The species are associated in site-specific assemblages in the terrestrial, freshwater, and saltmarsh habitats present. Most terrestrial vertebrates are effective colonizers and are tolerant of a variety of habitat types, but they are dependent on enough native terrestrial vegetation to maintain a given population. The importance of barrier islands to various bird species should not be underestimated. Non-migratory species such as woodpeckers, chickadees, and titmice are not usually found but various trans-Gulf migratory species on spring flights use the islands during unfavorable weather conditions. Birds are also associated with different habitats, with some species being restricted to one particular habitat (Livingston and Thompson, 1975).

### Physiography

St. George Island lies southeast of the mouth of the Apalachicola River and is connected to the mainland by the Bryan Patton Bridge (Figure 40). The island is 21 miles long and is quite narrow, averaging less than one-third mile in width. It contains approximately 7,340 acres of land and 1,200 acres of marshes. On the Gulf side, there is a narrow band of beaches and low-lying sand dunes that grade into mixed woodland grass, palmetto, and bayside marshes (Livingston et al., 1975). St. George Island State Park is located on the east end of the island and consists of approximately 1,750 acres. Sikes Cut separates the west end of the island from Cape or Little St. George Island. This channel was constructed in 1957.

St. George Island appears to have formed in its present location between 4,000 and 4,500 years ago. The ridges on the island tend to have an east-west trend and are predominately parallel, indicating a transverse or offshore drift system. According to Stapor (1973), St. George Island has been accreting sediment at its northeastern tip at about 64 ft/yr. The beach face in the same area has been retreating 4 ft/yr. for the interval 1934 - 1970. Of all the islands, St. George is the most accessible and has been modified the most by road building and development pressures.

Cape St. George Island, or Little St. George Island is approximately seven miles south of Apalachicola. The island is nine miles long and varies in width from 1/4 mile to a maximum width of one mile (Figure 41). The island was acquired by the State of Florida in 1977, and incorporated into ANERR in 1979. The island consists of approximately 2,300 acres at mean high tide. An additional 400 acres of perimeter tidal marshlands and lower beach areas, which are inundated by high tidal waters, are also present. Elevations range from sea level to 26 feet, but the bulk of the island lies between 3 and 12 feet above mean sea level (FDNR, 1983). Cape St. George is separated from St. George by Sikes Cut, about 500 feet wide, and St. Vincent Island by West Pass, a natural inlet averaging slightly more than 1/2 mile wide. The only access to Cape St. George is by boat.

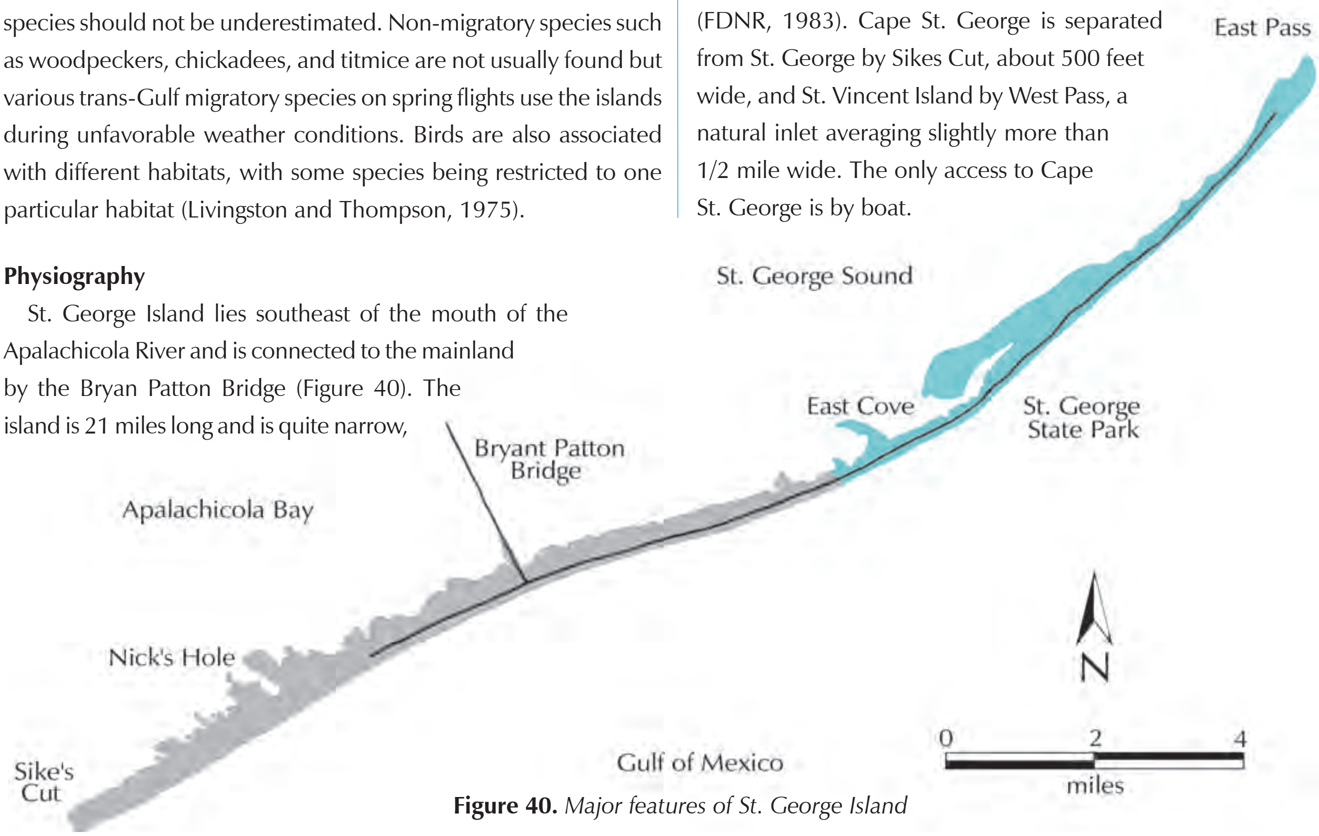



**Figure 40.** *Major features of St. George Island*

Cape St. George Island is a coastal dune/dune flat/washover barrier formation of recent geologic origin (FDNR, 1983). The western and eastern sections of the island are narrow terraces, subject to occasional overwash by storm surges. The western section is also a drift spit, the westernmost portion of which is known as "Sand Island." Nautical charts of 1858 show the presence of two natural passes through the island. These passes, New Inlet (east section of island), and Sand Island Pass (west section of island), were probably opened by hurricane overwash in the 1840s. By 1930, these were closed by gradual coastal deposition, thus forming one island. The ephemeral inlets are characteristic of powerful overwash events. Relic inlets become protected coves (Godfrey and Godfrey, 1976) and new bayshore marshes are formed on the substrate created by overwash sediments and relic inlet shoals. An example of this is the relic New Inlet where prominent marshes and Pilot's cove exist today (FDNR, 1983).

The dune ridges are oriented from northwest to southeast, paralleling the present shoreline west of the Cape. The shoreline east of the Cape runs northeastward. A dune strand truncates the relic dune ridges of the interior, creating and blocking swales between the dune ridges. Major plant communities of Cape St. George Island are illustrated in Figure 41. Cross sectional profiles of the island at representative points are shown in Figure 42.

St. Vincent Island, acquired by the federal government in 1968, is managed as a National Wildlife Refuge by the U.S. Fish and Wildlife Service. The island is triangular in shape, approximately 9 miles

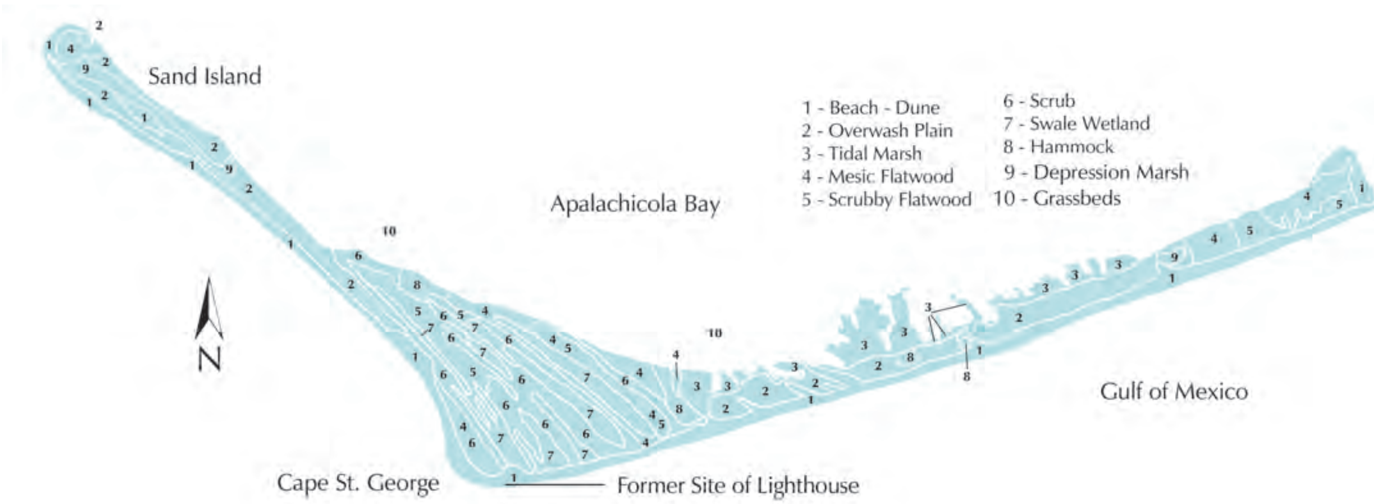



***Figure 41.*** *Major plant communities of Cape St. George Island (FDNR, 1983)*

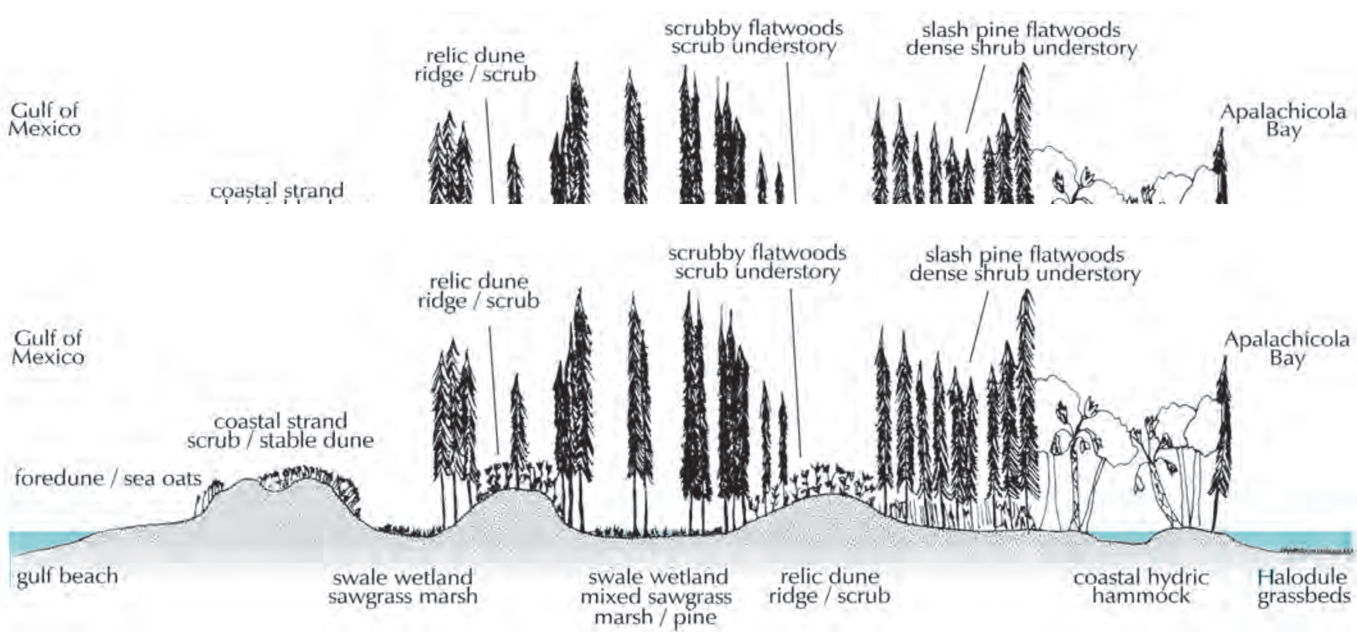



***Figure 42.*** *Typical profiles of habitats on Cape St. George Island (FDNR, 1983)*

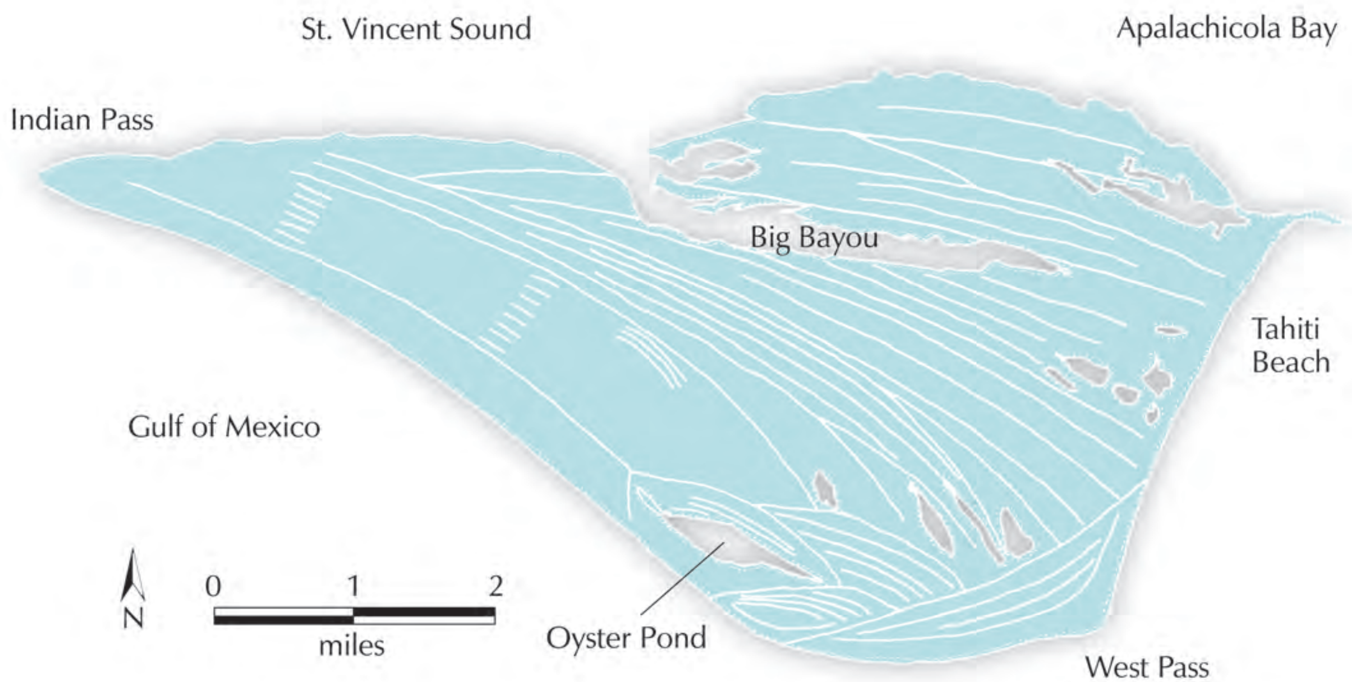



***Figure 43.*** *Major features and beach ridges of St. Vincent Island (modified from Spicola,1983)*

long and 4 miles wide (Spicola, 1983). It consists of approximately 12,358 acres. West Pass separates the island from Cape St. George and Indian Pass (approximately 400 yards wide) separates the island from Indian Pass Peninsula.

St. Vincent is somewhat atypical of the barrier islands found along North Florida, Alabama, and Mississippi. Instead of a simple beach and dune structure, it exhibits a highly complex topographic and physiographic makeup (Thompson, 1970). Beach ridges run east to west and are predominately parallel, indicating a transverse or offshore drift system. In the southeastern corner of the island, there are at least four beach ridge sets that are believed to have been formed by a westerly longshore drift system (Figure 43). The island is thought to have formed slightly more than 3,500 years ago and exhibits a complex ridge and swale topography. Typical ridges range three to seven feet high and measure 100 feet or more from crest to crest (Miller et al., 1980). Generally, dunes are highest on the south side and the very west end of the island. Interdune areas are lowest near the center and east end of the island (Thompson, 1970). Sets of ridges are frequently truncated by new deposition leaving a complicated pattern of ponds and sloughs. Most of the island has been stable up until a few decades ago. Since 1970, erosion has been quite spectacular at certain localities. Many trees have been left standing in the surf zone, but erosion rates have not been determined for this time interval (Tanner, 1975).

The vegetation from the Gulf side to the interior consists of scrub oak ridges, slash pine timberlands, sawgrass marshes and tidal marshes. The vegetative composition grades from west to east where, for example, live oak replaces the scrub oak complex and open water replaces sawgrass marshes (Thompson, 1970). A file report entitled "Vegetative Cover Types of St. Vincent National Wildlife Refuge" prepared by the Refuge Biologist, delineates and describes 17 major plant communities on St. Vincent Island as determined by a field survey, a published report (McAtee, 1913), and planimetric analysis of 1:10,000 aerial photography. These 17 communities have been combined into five landscape categories (Table 5). Typical island profiles, from north to south, show the general distribution of plant communities and their relation to topography (Figure 44). One favorable aspect of the islands' rolling dunes is the interspersion of pinelands with hardwoods. This provides a diversity of habitat favorable for wildlife.

A variety of mostly xeric communities can be found on the island ridges. Interspersed with these ridges are xeric to hydric communities consisting of pine flatwoods, hammocks, marshes, ponds, and sloughs (Edmiston and Tuck, 1987). A general description of barrier island plant communities, wildlife importance, and utilization follows.

**Beach and Berm**

Beaches are semi-terrestrial habitats that are subject to constant high-energy forces of wind and wave action. It is a detrital based community in which primary productivity in the intertidal zone is limited to unicellular algae. Animals consist of burrowers and interstitial amphipods and isopods. Many shorebirds, gulls, and terns use the beach for feeding, nesting, and loafing throughout the year.

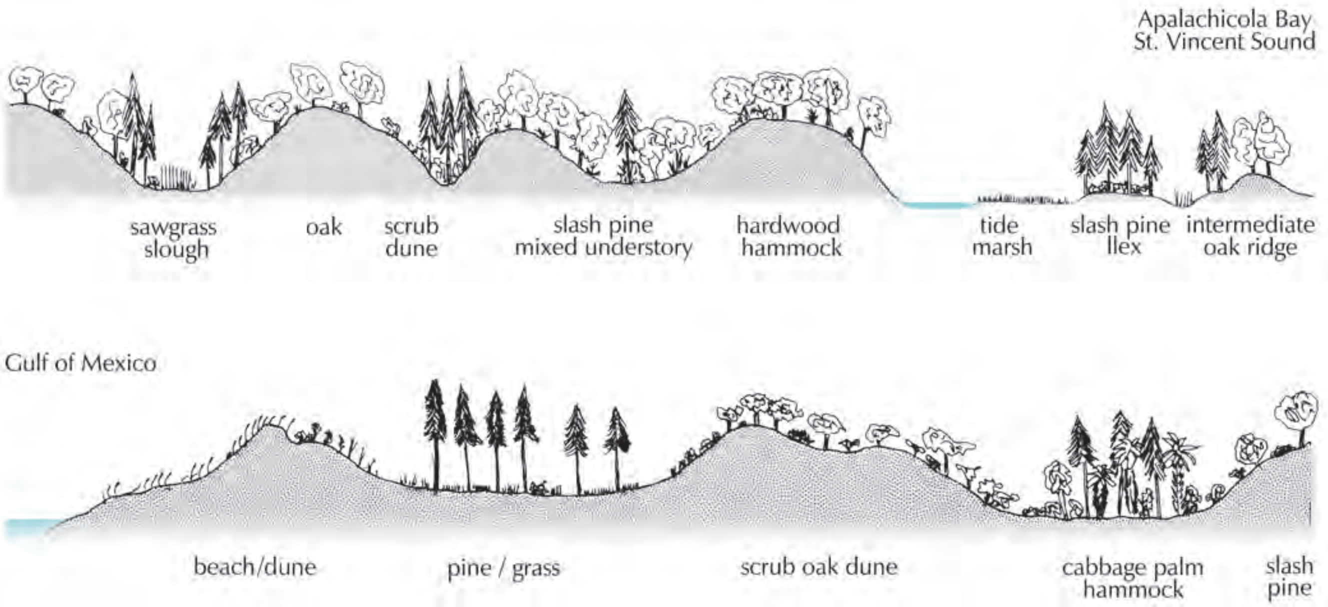



***Figure 44.*** *Typical profiles of habitats on St. Vincent Island (Thompson, 1970)*

**TABLE 5**

## Basic Vegetative Cover Types of St. Vincent Island

*(modified from Thompson, 1970)*

| *Community Type* | *Vegetative Type* | *Acreage Island* | *% of Dominant* | *Species* |
|---|---|---|---|---|
| **DUNES** | Scrub Oak Dune | 1,202 | 9.7 | Rosemary, myrtle oak, dwarf live oak, Chapman's oak, live oak |
| | Mixed Live Oak/ Scrub Oak Dune | 201 | 1.6 | As above with less Rosemary, more live oak |
| | Live Oak Dune | 505 | 4.1 | Live oak, laurel oak, cabbage palm |
| | Live Oak/Grass | 155 | 1.3 | As above with grass rather than saw palmetto |
| | Sand Pine /Scrub | 7 | 0.5 | Like scrub oak with addition of sand pine |
| | Hardwood Hammock | 185 | 1.5 | Water oak, live oak, hickory, cabbage palm, magnolia, cedar |
| **CABBAGE PALM** | Cabbage Palm | 221 | 1.8 | Cabbage palm alone or mixed with hardwood hammock |
| **PINELANDS** | Slash Pine/Mixed Understory | 2,332 | 18.8 | Slash pine, magnolia, gallberry, *Lyonia* sp. |
| | Slash Pine/Cabbage Palm Hammock | 1.234 | 10.0 | Slash pine, magnolia, saw palmetto, grape |
| | Slash Pine/Saw Palmetto/*Ilex* sp. | 1,040 | 8.4 | Slash pine, yaupon, grasses |
| | Slash Pine/Grass | 145 | 1.2 | Slash pine, grasses |
| **FRESH WATER** | Sawgrass/ Emergent Marsh | 792 | 6.4 | Sawgrass, St. John's-wort, buttonbush, willow |
| | Cattail Marsh | 660 | 5.3 | Cattail |
| | Fresh Water Pond | 269 | 2.2 | *Sagittaria, Nymphaea* |
| **TIDAL AREAS** | Tidal Marsh | 2,899 | 23.4 | *Spartina, Juncus, Distichlis* |
| | Salt Water Pond | 148 | 1.2 | Chara, widgeon grass |
| | Beach | 377 | 3.0 | Sea oats |

Plovers, turnstones, and sandpipers are constantly present at the surf line. Raccoons and ghost crabs, along with other nocturnal visitors, scavenge along the beach drift lines (FDNR, 1983).

Berms exist slightly above the elevations of the normal tide range and are constantly being altered by storms and wave action. Storms wash deposited shell fragments onto the landward slope of the berm. Vegetation is sparse. Annual plants commonly found in this zone include sea-rocket, sea purslane, Russian thistle, and the seaside spurge.

The relatively undisturbed miles of Gulf beach and berm of the barrier islands provide essential habitats for a number of endangered and rare birds. Beaches provide nesting sites for such species as the threatened least tern, royal tern, sandwich tern, black skimmer, and American oystercatcher, a species of special concern (a State of Florida designation less protective than threatened). All of these plus the Caspian tern, and the Eastern brown pelican, a species of special concern, use sand spits and beach bars for loafing and roosting (FDNR, 1983; Livingston et al., 1975). The threatened Southeastern snowy plover, piping plover and least tern are present on St. George and Cape St. George (ANERR, 2004). Snowy plovers require expansive open, dry, sandy beaches for breeding, and both dry and tidal sand flats for foraging. On Cape St. George they are primarily found on the western end of the island, near West Pass (Lamonte et, 2006). They are the only Florida bird species which feed and breed on open, dry sandy beaches. Least terns also nest here but feed in nearby waters. The numbers occurring on Franklin County beaches have declined sharply with human exploitation of the area (Livingston et al., 1975). The beaches and berms of the barrier islands are also used in the summer as some of the most important nesting areas in the panhandle of Florida for the threatened Atlantic loggerhead turtle (FDNR, 1983, ANERR, 2004).

**Dune Fields**

Primary dunes, or foredunes, are the first dunes on the seaward side of the islands. They provide protection for the other dune ridges and plant communities that lie behind them. Because dunes are subject to daily exposure of salt spray and sand blast, and the major shifts and wash down of storm surges, they are considered to be harsh environments. This dune system is unstable and constantly being altered, and therefore does not provide a permanent or continuous barrier to storm surges (FDNR, 1983).

The predominant plant found in the dune community is sea oats. They are very effective in building and stabilizing dunes. Sea oats also provide food for the red-winged blackbird and other species of birds. Other plants of the dune community include railroad vine, beach morning glory, evening primrose, bluestem, and sand coco-grass (FDNR, 1983; White, 1977; Livingston et al, 1975). The roots and rhizomes of dune vegetation also help to bind the sand and thereby stabilize the land.

In areas where water has ceased to wash through, a stabilized coastal dune strand has developed (for example, some areas of Cape St. George). Overwash in this stabilized strand is restricted to the foredune zone, although all of the other stresses (salt spray, etc.) still exist. Dunes of the stabilized strand are larger than those of the overwash dune field and tend to align in a continuous ridge form. With the stabilizing of the seaward ridge, succession is allowed to proceed behind the dune with scrub thickets replacing grasslands (FDNR, 1983).

Behind the primary dune is usually a wide, relatively flat sandy plain, containing some small windblown dunes. This interdunal zone is mostly devoid of larger woody plants found in more established scrub areas towards the interior of the island. Plant species of this zone include saw palmetto, yaupon, wax-myrtle, salt-myrtle, goldenrod, marsh elder, and marshhay cordgrass (White, 1977).

Only a few rare faunal species are known to utilize coastal strand habitat. The Southeastern snowy plover forages on dry, interdune flats of the overwash dune field and the endangered peregrine falcon migrates through the islands in the fall and spring. The Southeastern American kestrel is also an open habitat bird (FDNR, 1983) found in coastal strand habitats.

**Scrub**

Behind this dune system, a zone of more dense vegetation can be found. The understory vegetation of this zone includes mostly scrub species with a few scattered slash pines occurring. This scrub community is generally found on higher, well-drained sites corresponding to old dune ridges (White, 1977) and is excellent for stabilizing dunes. Dominant plant species found in this zone are saw palmetto, rosemary, buckthorn, staggerbush, Chapman oak, myrtle oak, sand live oak, and live oak. Various herbs, lichens and grasses often cover the open areas (Livingston et al., 1975).

Slash pine scrub grades into a broad vegetation zone with a more dense cover of slash pine and an understory consisting of scrub species. This slash pine-scrub community generally occupies flat ground on drier sites. Saw palmetto tends to form much broader patches (Livingston et al., 1975). Myrtle oak and sand live oak also form large patches as they do in the scrub on dunes. Chapman oak and rosemary are also present. The open areas located in the slash pine-scrub communities are also covered with herbs, grasses, lichens or low, semi-woody species such as *Aristida spiciformis, Rhynchospora megalacarpa, Polygonella polygama,* and *Hypericum reductum*.

Few sand pines have been found on Cape St. George and a few exist on St. George Island. Sand pine scrub exists in one area of St. Vincent Island and is limited to only 6.8 acres (Table 5). Understory species are similar to the scrub oak type. Sand pine is limited on these barrier islands but is common in the older dune ridges located on the mainland between Lanark Village and Eastpoint. Why they are not very extensive or even occur on these islands is uncertain (Thompson, 1970).

**Pine Flatwoods**

Slash pine also dominates pine flatwoods. The slash pine-scrub community usually grades into pine flatwoods which tend to occur on poorly drained or wet sites. The major associates include a dense understory of fetterbush, saw palmetto, gallberry, *Lyonia ligustrina*, and *Lyonia mariana* (Cape St. George). Saw palmettos form a more dense cover than in the scrub communities. Minor associates include sundew, St. John's-wort, mint, blueberry, and huckleberry. Pine flatwoods bordering salt marshes take on a tall understory of live oaks and occasional cedars and cabbage palms (FDNR, 1983).

Flatwood species are fire adapted. This community is susceptible to frequent and often intense fires because of the dense vegetation and heavy accumulation of litter (particularly during the dry season). However, on barrier islands managed for turpentine operations or by land management agencies, such as Cape St. George Island, this frequent fire regime has been altered. Typical natural fire regimes with fire intervals of 4 to 5 years can be doubled due to active fire suppression. Prior to re-establishing this natural fire regime fuel loads must be reduced through the use of prescribed fires (Huffman, et al., 2004). The integral role fire plays in arresting succession in flatwoods is widely recognized in the Southeast today.

Flatwoods provide food, as well as nesting and escape cover for a variety of wildlife species. The brown-headed nuthatch and pine warbler are restricted to pines during the breeding season and the red-breasted nuthatch is restricted to such areas in the winter. Mature slash pines are important nesting and perching sites for a few rare and endangered species (Livingston et al., 1975). The Southern bald eagle and osprey nest in pines close to the bayshore because of nearby feeding habitats. The Southern bald eagle prefers trees that provide a large expansive view of the surroundings while the migrating Cooper's hawk prefers more densely wooded areas such as scrubby flatwoods as well as open habitat for hunting prey. The Southeastern kestrel nests in cavities of live pines or snags which are also present in the woodland communities (FDNR, 1983).

**Salt Marshes**

Salt marshes are found on the bay side where they are protected by the barrier islands and are associated with the shallow, low-energy (wave, tide, etc.) areas (Livingston et al., 1975). Salt marshes act as filters for land runoff, removing sediments and pollutants. They transfer nutrients from upland areas to adjoining aquatic systems. Marshes are also important in their relationship to land surfaces in the overall system of water movement involving runoff, tidal currents, and wind and storm activities (White, 1977). Overwash sediments and inlet shoals have been shown to be excellent substrates for tidal marsh development (FDNR, 1983).

Sloughs gradually merge with the salt marshes on the bay side of St. George Island. Livingston and Thompson (1975) attribute plant zonation of such marshes to salinity gradients due to differential evaporation. Brackish or landward areas of marshes are dominated by black needlerush. Needlerush is joined by saltmeadow cordgrass, perennial glasswort, three-square bullrush, sand sedge, and the shrubs, sea myrtle and groundsel, in the high brackish or transitional zone. Waterward of the transitional zone, needlerush dominates exclusively to an elevation near mean high water (FDNR, 1983). Waterward of the mean high water line and the brackish zone lies an area dominated exclusively by smooth cordgrass. This community requires regular tidal inundation and attains its best development on Cape St. George Island behind protective sand/oyster bar barriers which have been deposited by bay wave action offshore in the Pilot's Cove area (FDNR, 1983). The most landward extent of smooth cordgrass is the margins of small tidal creeks meandering into the needlerush marsh. The smooth cordgrass of Cape St. George marshes is short and lacks vigor. Mesohaline estuarine waters of Apalachicola Bay account for this contrast in community vigor, as smooth cordgrass prefers tidal environments approaching sea water salinity (FDNR, 1983).

Barrens also exist in some salt marshes. These barrens are devoid of vegetation and are covered by tides. As the water evaporates from these areas the salinity rises several times greater than that of the open sea. Peat deposits, which have built up after several thousand years of occupation by marsh plants, slow the percolation rate of water and thus help to increase salinity in these habitats. These deposits may become several feet deep (Livingston et al, 1975).

Tidal marshes (2,899 acres) and associated ponds make up the largest vegetative type on St. Vincent Island (Table 5). There are also eight or nine saltwater ponds on the island. They consist of approximately 147.9 acres. *Chara* and widgeon grass are present in varying quantities in these ponds (Thompson, 1970). Salt marshes are breeding and nursery grounds for many organisms. Omnivores and detritivores have been sampled in nearby marshes of Cape St. George and include *Gammarus mucronatus, Neritina reclivata, Melitta spp., Corophium louisianum, Munna reynoldsi,* and *Gitanopsis* sp. (Livingston, 1983). The more common larval and juvenile fishes that seek out tidal marshes for shelter and feed on the litter fauna are the bay anchovy, spot, redfish, croaker, silver-sides, gobies, sea trout, and menhaden (FDNR, 1983). This habitat is also important to mammals, reptiles, and wading birds of the islands. The rare Florida mink and the common raccoon are aggressive predators of the marshes, although the mink has not been seen in many years. The rare Gulf salt marsh snake occurs exclusively in this habitat, as does the Wakulla seaside sparrow, a species of special concern.

Several species of special concern frequent the tidal marshes, including the little blue heron, great egret, snowy egret, tricolored heron, black-crowned and yellow-crowned night herons, and the least bittern. The American oystercatcher feeds around the mud flats and bars associated with tidal marshes (FDNR, 1983). Other species of birds associated with salt marshes include the clapper rail, seaside sparrow, long billed marsh wren, and the sharp-tailed sparrow (Livingston, 1976). The diamondback terrapin is also adapted to life in salt marshes (White, 1977). The American alligator, Eastern glass lizard and the cottonmouth are also found in salt marshes but their main populations occur elsewhere (White, 1977).

**Sloughs, Freshwater Marshes and Ponds**

Sloughs, freshwater marshes, and ponds are freshwater unless overwash or extreme high tides occur, which then turn them brackish temporarily. Sloughs on the barrier islands transport runoff from the dune system northward into the salt marshes. In low areas, sloughs may contain standing water even during the drier seasons. The areas with standing water support various freshwater marsh vegetation types including saw grass, water lilies and *Fuirena scirpoides* (Livingston et al., 1975).

Sloughs on St. George Island tend to be flanked by pine flatwoods and delimited by a dense zone of medium-sized oaks. Laurel oak and live oak occur most often. Sand live oak may also be present. Tall slash pines are also scattered about. Woody plants making up the understory include gallberry, wax-myrtle, greenbriar, bamboo vine, poison oak, muscadine grape, wild olive, yaupon, buttonwood, royal fern, and sawgrass.

Freshwater sloughs of hydric hammocks on Cape St. George Island have become freshwater lagoons. Sawgrass and seashore marsh-mallow line the margins of these duckweed-covered sloughs where sunlight penetrates the hammock canopy (FDNR, 1983).

St. Vincent National Wildlife Refuge has sawgrass/emergent marsh which occupies the lower elevations of the interdune area. Species composition varies from area to area but the dominant species found is generally sawgrass. An association of *Hypericum* sp. occupies some low sites, while willow, baccharis, and buttonbush may occupy other sites. Occasional remnants of more salt tolerant plants such as *Spartina* and *Juncus* are also scattered throughout (Thompson, 1970). Cattail marshes cover another 660 acres of St. Vincent Island (Table 5). Cattails generally occupy a zone of deeper, more permanent water than that tolerated by sawgrass. These marshes are situated around freshwater ponds and connecting waterways.

Freshwater ponds comprise approximately 269 acres on St. Vincent Island. They occupy the lowest elevation into which most drainage of the sawgrass sloughs terminate. Plant species found in these ponds include *Scirpus californicus, Sagittaria latifolia, Nelumbo lutea, Nymphaea odorata, Ceratophyllum demersum,* and *Vallisneria americana* (Thompson, 1970).

Sloughs, freshwater marshes, and ponds support a wide variety of fish, birds, reptiles, and amphibians. Cape St. George has one man-made pond and several other natural freshwater marsh systems in which fish fauna is sparse and dominated by top minnows. Top minnows are well adapted for the stress of low dissolved oxygen and extreme (periodic) fluctuations in the physico-chemical environment (White, 1977). Species normally present include mosquito fish, least killifish, sailfin molly, largemouth bass, warmouth and bluegill. Freshwater marshes and ponds are important habitats for the feeding and breeding habits of many species of birds. They include species such as the green heron and rails (White, 1977).

The existence of many vertebrate species is threatened by development on barrier islands. Vertebrates on St. George Island are more vulnerable than those found elsewhere because:

- freshwater communities are minimal in areal extent;
- small changes in physical parameters can cause rapid and widespread species compositional changes ultimately affecting vertebrates occupying upper positions in the food web; and
- the perched, highly localized water tables forming ponds and other freshwater sites can be easily drained and are abnormally lowered by nearby wells (Livingston et al., 1975).

Wildlife on St. George Island; many of whose existence is dependent upon the continued existence of freshwater bodies; include the Southern toad, cricket frog, green tree frog, squirrel tree frog, leopard frog, narrow-mouthed toad, American alligator, mud turtle, Eastern glass lizard, green snake, banded water snake, ribbon snake, garter snake, and cottonmouth (Livingston et al., 1975).

**Hammocks**

Cabbage palm hammocks make up approximately 221 acres of St. Vincent Island. It occupies some of the relatively higher sites such as the Tahiti beach area where it is associated with live oak and cedar or as a pure stand. Elsewhere cabbage palm occurs in lower sites. Understory species in the hammocks on St. Vincent Island are nearly absent. This could be due to hog rooting or the dense canopy that is formed by the palms (Thompson, 1970).

Hardwood hammocks are also present on St. Vincent Island. This community consists of approximately 185 acres and is located along one ridge (dune) on the north edge of the island (Table 5). This community generally occupies sites that are quite high and contains a significant amount of litter. The overstory includes water oak, live oak, pignut hickory, magnolia, cabbage palm, mulberry, laurel oak, and myrtle oak. The understory includes Yucca, American beautyberry, *Vitus* sp., poison ivy, trumpet vine, Virginia creeper, Hercules club, smilax and wax-myrtle (Thompson, 1970).

Most of the hammocks of Cape St. George Island are localized hydric environments. These small communities are dominated by live oak and cabbage palm, with conspicuous slash pine and an occasional southern red cedar and southern magnolia as associates. Shrubs consist of yaupon, wax-myrtle, and Spanish bayonet. Epiphytes, except for the resurrection fern, are conspicuously absent on the Cape. Lichens are common, especially the crustose wedding ring. The southern red cedar becomes increasingly dominant on calcareous substrates such as in midden hammocks. Xeric hammocks on the island are dominated by scrub live oak (FDNR, 1983).

**Overwash Zones and Grasslands**

Storm surges inundate berms, destroying those dunes closest to the Gulf and then flow between the remaining dunes into the almost-level grasslands behind. Sand and shell are deposited in these areas called overwash zones by the surge. The overwash energy rapidly dissipates as it crosses the barrier island. Changes in elevation from the dune field to the rear of the barrier island reveals the lateral extent of overwash deposition. Much of the eastern and western sections of Cape St. George Island consist of low terraces subject to storm overwash. These sections support grassland communities which are adapted to various environmental stresses such as salt spray, shifting sand, lack of nutrients, excessive evapotranspiration, overwash flooding, and burial by sediments (FDNR, 1983). The salt and sand deposition on the grasslands creates a stress that often results in the destruction of invading trees and shrubs. Only those species adapted to such conditions survive.

Barrier flat grasslands are savannah-like communities that occur on the flats behind the strand dune field and usually extend to the bayshore and salt marshes at the rear of the barrier. Vegetative cover is rapidly reestablished after overwash burial, primarily through the upward growth of rhizomes (particularly saltmeadow cordgrass), and re-rooting near the surface (Godfrey and Godfrey, 1976). The barrier flat grassland community consists of grasses, forbs, and sedges that persist as long as the overwash area is active. The grassland is more sparse closer to the dune field where overwash is more frequent and becomes denser towards the backshore (FDNR, 1983). The dominant species found is saltmeadow cordgrass. Important associates include needlerush, *Solidago sempervirens var. mexicana,* love grass, Gulf muhly, broomsedge, *Fimbristylis castanea,* three-square bullrush, foxtail, sea pink, white-top sedge, finger grass, and nodding ladies' tresses.

When enough sand is deposited to raise the stabilized dune strand above flood level the dune may become covered by lush grass or by a thicket. Trees and shrubs which begin invading the barrier flat grassland include Southern red cedar, cabbage palm, slash pine, yaupon, wax-myrtle, groundsel, marsh elder, and Spanish bayonet. Frequent overwash and die back must occur on Cape St. George Island grasslands because with the exception of cabbage palm, only young forms of these invading species are found (FDNR, 1983).

## Apalachicola Bay System

Apalachicola Bay, a bar-built river dominated system, is one of the most productive and undeveloped estuarine systems remaining in the United States (Livingston, 1984; Edmiston and Tuck, 1987; ANERR, 1998; Pennock, et al., 1999). The estuarine drainage area surrounding the bay has also been identified as having the tenth highest amount of total coastal wetlands (592,000 acres) in the continental United States (Field et al., 1991). Commercial and recreational fisheries in the area have historically been critical to the local economy. Approximately 90 percent of Florida's oyster harvest and 10 percent of that in the United States comes from the Apalachicola Bay system (Wilber, 1992). The annual shrimp harvest is worth even more in terms of dollar value than the oyster harvest. The bay also serves as a vital nursery area for a myriad of commercially and ecologically important invertebrates and finfish.

Besides the bridges, causeways, and cuts, several navigation projects in the Apalachicola estuary have resulted in alterations to the natural environment. These include the Gulf Intracoastal Waterway Channel, the Two-Mile Breakwater and Extension Channel, the Eastpoint Breakwater and Channel, and the Scipio Creek Boat Basin Channel. All these alterations contribute to the present configuration of the Apalachicola Bay system. Their effects on bathymetry have primarily been increased depth in areas of channels, decreased depth in areas of open-water spoil placement, and removal of bay bottom area with the creation of the Two Mile and Eastpoint Breakwater and spoil islands. Other man-made changes in bay topography include the creation of oyster reefs by the planting of cultch in many areas of the bay (Leitman et al., 1986).

The entire estuarine system is currently under pressure due to upstream water diversion, increasing local development, and an increasing potential for both point and nonpoint pollution. The following section is an attempt to describe the system by dividing it into its component habitats. These individual habitats are all interrelated and form the complex system known as the Apalachicola Bay system.

**Oyster Bars**

Oysters are important and common inhabitants in Apalachicola Bay. Aggregations of live oysters and empty shells are called oyster bottoms, beds, banks, reefs, or bars although these expressions are not well-defined biologically and are used interchangeably. Oyster bars referred to in this system are subtidal and form raised aggregations covering thousands of acres of bay bottom (Table 6). Coon oysters, small intertidal oysters not suitable for harvest, are not included in this discussion of subtidal oyster bars. The American oyster, *Crassostrea virginica*, is the dominant component on the bars. Growth occurs both horizontally and vertically because of surfaces


***Figure 45.*** *Major oyster bars of the Apalachicola estuary (Livingston, 1983)*

provided by dead shells for larval settlement. This new recruitment guarantees the survival of the bar as long as environmental conditions remain favorable.

Recent information (Twichell et al., 2006) relates the distribution of oyster bars in Apalachicola Bay to subsurface geological deposits. Most bars appear to be have developed on late Holocene delta deposits, flood tidal delta deposits, or modern deposits of dredge material. In St. George Sound the oyster bars are found on underlying flood tidal deltas, ridges of uncertain origin on top of Pleistocene sands, as well as modern dredge material.

Environmental conditions or factors can be divided into positive and negative categories based upon whether they are favorable or unfavorable to the growth and productivity of the oyster community (Galtsoff, 1964). The principal positive factors are bottom substrate, water movements, salinity, temperature, and food availability. Negative factors include sedimentation, pollution, competition, disease, and predation. The interaction of these factors determines the productivity of the oyster community. St. Vincent Sound, Apalachicola Bay, and the western portion of St. George Sound (Figure 45) apparently provide the best habitat for oysters in the system since the main concentrations of commercially important bars are located in these areas. The entire Apalachicola Bay system provides many of the necessary requirements, as evidenced by the fact that approximately ten percent of the entire aquatic area in the estuary is covered by oyster bars (Livingston, 1984). Approximately forty percent of the aquatic area has been estimated as suitable for oyster bar development with substrate type being the limiting factor (Whitfield and Beaumariage, 1977).

Production on the commercial bars has been estimated at between 400 and 1,200 bushels/acre/year (Ednoff, 1984; FDEP, personal communication). Because of the relatively mild temperatures in the area, oyster growth is continuous throughout the year and has been estimated to be among the fastest in the United States. Har-

**TABLE 6**

**Area (in acres) of major water bodies, oysters, submerged aquatic vegetation (SAV), and contiguous marshes within ANERR boundaries**

*(modified from Livingston, 1984).*

| Water Body | Water Area | Oysters | SAV | Marshes |
|---|---|---|---|---|
| St. Vincent Sound | 13,683 | 2,708 | —— | 4,463 |
| Apalachicola Bay | 51,771 | 4,096 | 2,778 | 1,737 |
| East Bay | 9,832 | 165 | 3,541 | 11,377 |
| St. George Sound (West) | 36,425 | 3,677 | 1,542 | 1,857 |
| Total | 111,711 | 10,646 | 7,861 | 19,434 |
| Percent of total water area | 100 | 10 | 7 | 17 |

vestable oysters, those larger than three inches, have been known to be produced from spat in as little as 39 weeks (Ingle and Dawson, 1952). The spawning season is also one of the longest in the United States, generally lasting from April through October with peaks from May to June and August to September (Ray and Livingston, 1987). The usual pattern in the bay requires approximately 18 months from planting cultch, clean shell, to commercial harvest (Ingle and Dawson, 1952). The Department of Agriculture and Consumers Services (DACS) has been planting cultch in Apalachicola Bay since 1949 and estimates over 750 acres of bars have been constructed since then (Futch, 1983). Relaying programs, moving oysters from closed and polluted areas to unpolluted areas, have also been in effect since 1982.

Because of the abundance of cavities and food and the optimal conditions on oyster bars, they provide a significant habitat for a variety of organisms. The oyster-associated community varies somewhat due to the salinity regime, which is the most important limiting factor on the bar itself (Menzel et al., 1966). Prolonged high salinity (due to droughts) allows predators associated with higher salinities to infiltrate the bars. Decreased river flow is indicative of lower food supplies. Prolonged low salinities (due to floods) eliminate many of the predators but can also stress the oyster and cause mortality (Menzel and Cake, 1969). Significant predators associated with Apalachicola Bay oyster bars include the boring sponge, southern oyster drill, flatworm (oyster leech), mudworm, stone crab, blue crab, crown conch, snail, and the boring clam (Pearse and Wharton, 1938; Menzel et al., 1966). The pathogen, *Perkinsus marinus* also causes significant mortality to adult oysters during times of stress (Menzel, 1983). Other organisms inhabiting the bars include mussel, mud crab, flat crab, horse oyster, gastropods, blennies, and toadfish. This is only a partial list and does not include commercially important temporary residents or transitory organisms such as shrimp, crabs, and fish.

While predators and environmental changes can alter the productivity of the oysters and the composition of the associated community, these effects are often slow and variable. Swift (1897) listed three natural conditions that can significantly harm Apalachicola Bay oyster bars: severe freezes, prolonged freshets (floods), and hurricanes. He also mentioned overharvesting of oysters by man as a potential cause. Over 100 years later two of these conditions, hurricanes and floods, continue to cause problems for the oyster bars of Apalachicola Bay. The 1985 season saw an unusual number of hurricanes (three) impact this system. Some of the most productive commercial bars in the eastern bay were not able to support commercial harvesting and oyster bars in the western bay, while not as severely impacted, would not be able to support sustained harvest pressure for long (Berrigan, 1988). This caused the bay to be closed for six months while research and replanting efforts continued. The bars recovered relatively rapidly, due in part to a highly successful spatfall and adequate habitat to allow for high survivability (Livingston et al., 1999).

The 1994 hurricane season caused a record flood on the river systems in the panhandle. The entire bay experienced extremely low salinity for almost two weeks, causing oyster mortality ranging from 10 to 100%, depending on the location of the oyster bar in the bay (Edmiston et al., 2008). The 1995 hurricane season brought three hurricanes to the area, one of which may have contributed to an outbreak of red tide resulting in the oyster bars being closed for approximately six weeks. Hurricane Katrina, in the summer of 2005, while not affecting the bay directly also brought in a red tide event from offshore which closed oyster bars in the bay for a period of over two months.

A new threat to the oyster bars is related to upstream water diversion from the tributaries of the Apalachicola River. Preliminary modeling efforts have demonstrated that decreased freshwater inflow, especially during low flow conditions, could cause a significant increase in oyster mortality due to predation (Christensen, et al., 1998). A drought in the ACF system that stretched from 1999 to 2002 caused the loss of oysters on various bars due to increased predation from higher salinities (DACS, 2004).

**Submerged Aquatic Vegetation**

The submerged aquatic vegetation (SAV) found in the Apalachicola Bay system includes fresh water, brackish water, and marine species. Their distribution is confined to the shallow perimeters of the system (Livingston, 1980; Continental Shelf Associates, 1985; Fahrny et al., 2006) because of high turbidity and color values, which limit the depth of the photic zone (Figure 46). Salinity is also an important variable and determines the type of vegetation present throughout the estuary. High sedimentation rates may also affect distribution (Livingston, 1984), although the continued resuspension of silt and clay particles from the sediment layer may be a more important factor due to the associated decrease in the depth of light penetration. Submerged vegetation covers approximately seven percent of the submerged bottom of the Apalachicola Bay system (Table 6).

The shallow bayside regions of Cape St. George Island, St. George Island and the mainland areas of St. George Sound support the largest assemblages of submerged vegetation in the estuarine system (Figure 46). Shoal grass (*Halodule wrightii*), manatee grass (*Syringodium filiforme*), and turtle grass (*Thalassia testudinum*) are the only true seagrasses in the Apalachicola Bay system and are limited to these areas. Manatee grass appears to be the least represented having been found by Livingston (1980) but not by CSA (1985), although they did not sample the eastern St. George Sound area. Turtle grass has only been located in small patches in St. George Sound associated with shoal grass. By far the most dominant species is shoal grass, occurring in narrow bands on the bayside of the barrier islands in shallow waters. The densest grass beds are located along the northeast shoreline of St. George Island and consist primarily of shoal grass.

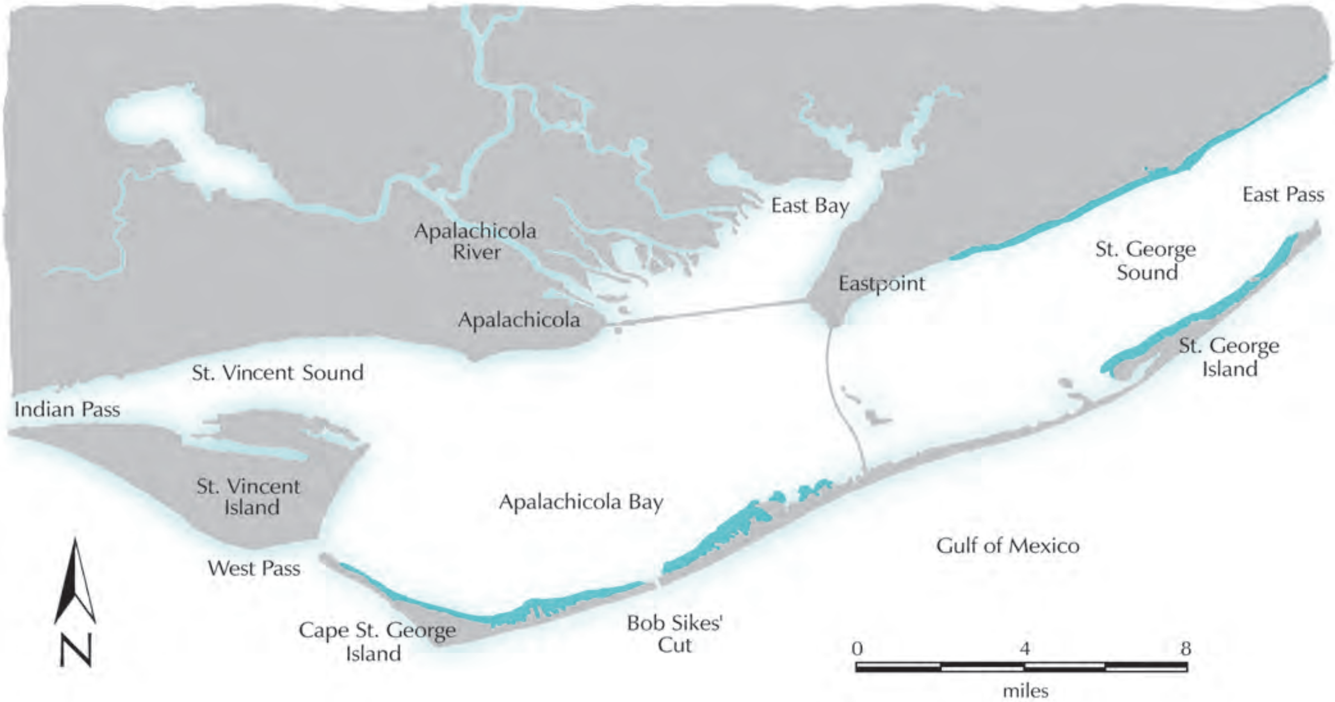



***Figure 46.*** *Submerged vegetation of the Apalachicola estuary (Livingston, 1983)*

Seagrass beds are important habitats in the marine environment not only for their high primary productivity but also for the role they play in sediment accretion, substrate stabilization, and as a nursery, feeding ground, and permanent home to numerous associated organisms (Phillips, 1980). Shoal grass is not only the most tolerant seagrass to variations in temperature and salinity but also is known as the early colonizer, or pioneer, of disturbed or unvegetated areas (Zieman, 1982). It can also survive in shallower water than turtle or manatee grass because its shallow, surficial root system can colonize the sediments within areas of minimal hydraulic stability such as shorelines. The flexibility of shoal grass leaves also allows it to conform to the damp sediment thereby allowing it to survive during times of exposure (Fonseca et al; 1981). These factors, combined with the limited availability of suitable areas where seagrasses can develop in this dynamic system, explain the distribution and dominance of shoal grass in the Apalachicola Bay system (Table 7). The benthic red algae *Gracilaria*, locally called June grass, has also been found in significant abundance associated with the shoal grass beds. No grass beds or submerged vegetation have been found in St. Vincent Sound (Livingston, 1984; CSA, 1985), although small patches may exist along the shoreline.

**TABLE 7**

**Submerged vegetation assemblages in the Apalachicola Bay system**
*(Continental Shelf Associates, 1985).*

| *Water Body* | *Species/Assemblages* | *Area (Acres)* |
|---|---|---|
| Apalachicola Bay | *Halodule wrightii* | 1,145 |
| | *Ruppia maritima / Vallisneria americana* | 282 |
| | *Ruppia maritima* | 50 |
| St. Vincent Sound | | 0 |
| St. George Sound | *H. wrightii* | 711 |
| | *H. wrightii / Thalassia testudinum* | 277 |
| East Bay | *R. maritima / V. americana* | 166 |
| | *Myriophyllum spicatum / Potamogeton pectinatus / V. americana / R. maritima* | 1,179 |
| | *Najas guadalupensis* | 187 |
| | *R. maritima* | 25 |
| | *R. maritima / P. pectinatus* | 55 |

Seagrass ecosystems create a diversity of structured habitats composed of diverse and interrelated groups of benthic and epiphytic micro- and macro- algae, sessile and motile epifauna, benthic infauna, and transient motile fauna (Phillips, 1980). Sheridan and Livingston (l983) measured one of the highest infaunal densities recorded in the literature, 104,338 organisms per square meter, working in a shoal grass bed in Apalachicola Bay. The dominant infaunal organisms found are tanaids, polychaetes, amphipods, and oligochaetes. Major biomass contributors of the community are bivalves, gastropods, and polychaetes. Blue crabs, pink shrimp, and grass shrimp are the dominant macro-invertebrates in the grass bed community and vary in numbers significantly during the year. Sheridan and Livingston (1983) also found that the arrival of juvenile fish and macro-invertebrates on the grass bed in summer corresponds to the rapid decline in infaunal densities, thereby showing the importance of the grassbeds as a nursery and food source. The dominant fishes utilizing the grass bed are silver perch, pigfish, pinfish, and spotted seatrout in the summer, and spot in the late winter and spring.

The John Gorrie Bridge and causeway generally acts as a barrier to the true seagrasses and none are found in East Bay because of low salinities. The only SAV found south of the bridge besides the seagrasses already mentioned are *Ruppia maritima* and *Vallisneria americana*. *Ruppia* and *Vallisneria* are found together only in dense beds near the mouth of the river in Apalachicola Bay (Figure 46).

The area to the north of the causeway, East Bay, supports extensive beds of fresh and brackish water species of submerged macrophytes. There appears to have been a significant species change within East Bay from 1980 to 1984. Livingston (1980) found the exotic pest *Myriophyllum spicatum* covering approximately 30 percent of the bays on the west side of East Bay. In 1984, CSA (1985) found *Myriophyllum* covering 90 percent of these bays and extending along the river channels into East Bay itself. This species, in particular, has been seen to vary considerably over the years. Its spatial distribution appears to be mostly affected by hurricanes, which tend to push high salinity waters into the upper reaches of the bay and bayous. After the hurricanes of 1995 and 1997, no *Myriophyllum* was found in any of the bays in East Bay (Van Dyke, personal communication). Other macrophytes that are found associated with *Myriophyllum* include *Vallisneria, Ruppia,* and *Potamogeton pectinatus*. The other macrophyte associates that occur in East Bay are *Ruppia* and *Vallisneria*, on the eastern side, and *Najas guadalupensis*, in East and West bayous.

The surveys of submerged vegetation listed by Livingston (1980) and CSA (1985) show significant differences in acreages between them (Table 8). These differences are probably caused by mapping methods, calculation techniques, change in species (*Myriophyllum*), the absence of data from eastern St. George Sound, or the actual loss of SAV (CSA 1985). Surveys by the Reserve has shown that the central eastern side of East Bay contains more submerged vegetation than previously reported, primarily *Ruppia* and *Vallisneria* (Fahrny et al., 2006). The Apalachicola River and Bay watershed went through an extended drought during the 1999-2002 period that resulted in record low flows for much of that time period, including the absence of normal winter floods for several years. During this period unusually high salinities were noted in upper East Bay from the Reserve's System-Wide Monitoring Program (SWMP) dataloggers (Figure 20). At the same time staff began to detect, qualitatively, the disappearance of the fresh/brackish SAV normally seen in East Bay and the lower river.

New studies (Fahrny et al., 2006) have documented a much wider distribution of SAV in East Bay that had been previously reported (Figure 47). In addition more species have been documented than have been found in the past (Table 9), either due to a more detailed survey or a change in the SAV community over time. Unfortunately after the most detailed SAV map for East Bay was created in Summer 2005 Hurricane Dennis, with a storm surge of 2.5 meters impacted the area. All the SAV in East Bay was eliminated and did not reappear that summer. The Reserve is documenting its recovery since the storm.

The fresh and brackish water submerged species also provide habitat and nursery areas for numerous organisms. Dominant organisms associated with these beds include polychaetes, amphipods, chironomid larvae, snails, amphipods, mysids, crabs and shrimp, rainwater killifish, pipefish, silversides, and gobies (Livingston, 1984).

Because of its position located between upland and unvegetated bay bottom habitats, submerged vegetation links dissimilar ecosystems. It tends to act similarly to salt marshes in this respect, and is

**TABLE 8**

**Comparison of submerged vegetation in the Apalachicola Bay system (1980/1984)**
*(Continental Shelf Associates, 1985).*

| Water Body | Summer, 1980 | Summer, 1984 |
|---|---|---|
| Apalachicola Bay | 2,778 | 1,477 |
| St. Vincent Sound | 0 | 0 |
| St. George Sound | 1,542 | 988 |
| East Bay | 3,541 | 2,153 |
| Total | 7,861 | 4,618 |

**TABLE 9**

**East Bay Submerged Aquatic Vegetation Species List**
*(Fahrny et al., 2006)*

| Species name | Common name | Native/Invasive |
|---|---|---|
| *Ceratophyllum demersum* | Coontail | Native |
| *Chara spp* | Muskgrass | Native |
| *Hydrilla verticillata* | Hydrilla | Invasive |
| *Myriophyllum aquaticum* | Parrot feather | Invasive |
| *Myriophyllum spicatum* | Eurasian watermilfoil | Invasive |
| *Najas guadalupensis* | Southern naiad | Native |
| *Najas minor* | Spiny naiad | Native |
| *Potamogeton pusillus* | Slender pondweed | Native |
| *Ruppia maritima* | Widgeon grass | Native |
| *Stuckenia pectinata* | Sago pondweed | Native |
| *Vallisneria americana* | Tapegrass | Native |
| *Zannichellia palustris* | Horned pondweed | Native |

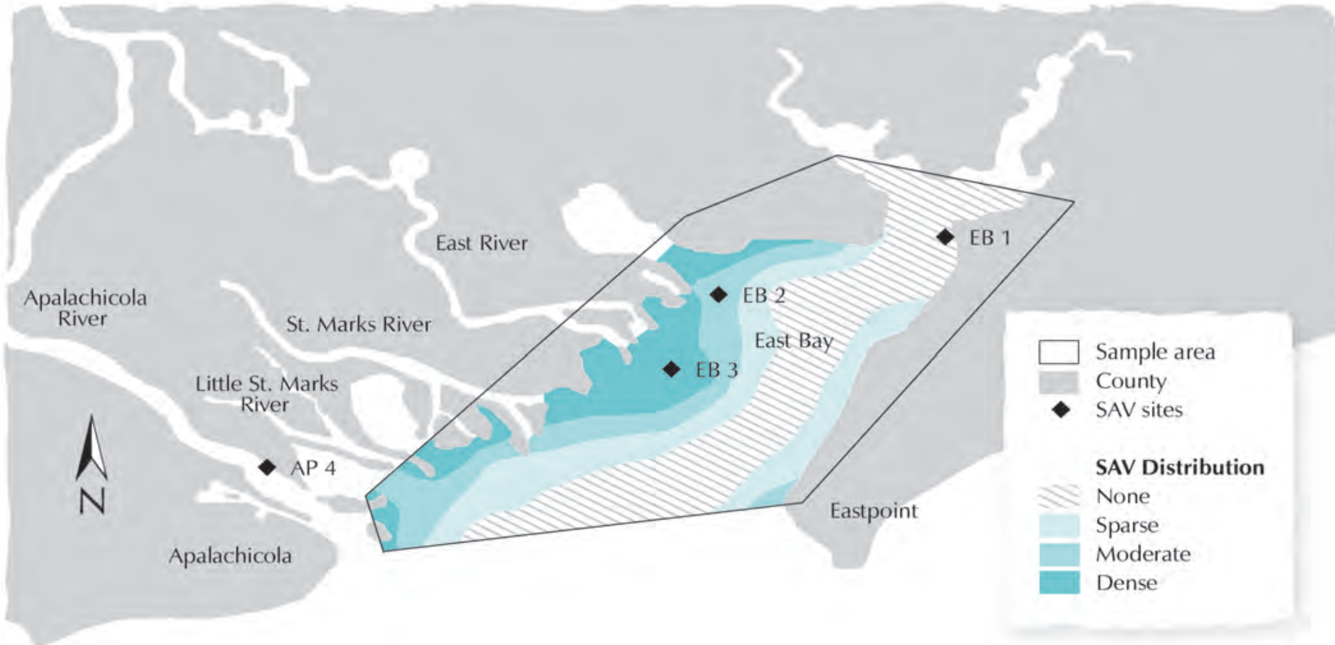



**Figure 47.** *SAV percent coverage in East Bay and ANERR SAV monitoring sites (June 2005)*

important to the productivity of estuarine systems because of its function as nursery areas by providing food and reducing predation pressure through habitat complexity.

### Tidal Flats

On the bayward sides of the barrier islands, along the mainland, and in shallow water areas associated with salt and freshwater marshes are located tidal flats, of which little is known in Apalachicola Bay. These unvegetated expanses of mud or sand are exposed at low tide and submerged at high tide. Tidal flats or mud flats are often unappreciated or ignored because their values are not visible (Clark, 1974). As habitats, they are subjected to one of the most variable environments in the aquatic system. Organisms inhabiting tidal flats must not only cope with extremes of salinity and temperature (heating and freezing) but also with exposure and desiccation.

The Apalachicola Bay system experiences normal tidal fluctuations of 1.5 to 2 feet, with a maximum normal range of approximately 3 feet (Livingston et al., 1974). The extent of tidal flats includes many nearshore areas shallower than 2 feet at mean high water that are unvegetated. It has been estimated that there are approximately 7,500 acres of tidal flats in the Apalachicola Bay estuarine drainage area (Field et al., 1991). If this is accurate then there is approximately the same area of tidal flats in the bay as grass beds. These tidal flats can be subdivided into two categories: the higher salinity areas in St. George Sound and bayward of the barrier islands, and the low salinity areas near the mouth of the river and in East Bay. Along the length and width of the estuary, all gradations and mixtures of bottom sediments are found which further differentiate the flats and the organisms able to live on them. St. George Sound tidal flats are primarily sand while areas bayward of the barrier islands in Apalachicola Bay range from sand to clay as the dominant sediment type. Areas of tidal flats in East Bay are primarily clay sediments while St. Vincent Sound flats contain more clay than sand (Isphording, 1985).

Organisms associated with tidal flats vary with the salinity regime and the type of substrate, as well as depth of water and time of exposure. The most visible organisms associated with tidal flats behind the barrier islands are oysters. Because of the increased stress in the "flat" environment, these oysters remain small and do not reach the large size of those growing sub-tidally on bars. They are commonly called "coon oysters" and have been used in replanting programs on the subtidal bars. Tidal flats provide important feeding grounds for finfish at high tide, as well as habitat for a wide variety of crabs, snails, worms, and algae. They also provide important feeding and loafing areas for plovers, sandpipers, gulls, ducks, and other birds (Taylor et al., 1973). Only recently has the potential importance of tidal flats with respect to primary production by benthic diatoms and algal mats been investigated (Eisma, 1998). Nothing is known concerning the importance or productivity of tidal flats in Apalachicola Bay.

### Soft Sediment

The largest benthic habitat type found in the Apalachicola Bay system is soft sediment, comprising approximately 70 percent of the estuarine area (Livingston, 1984). This habitat is essentially devoid of vegetation, except for some algal species, due to high turbidity and color values that limit light penetration. Its composi-

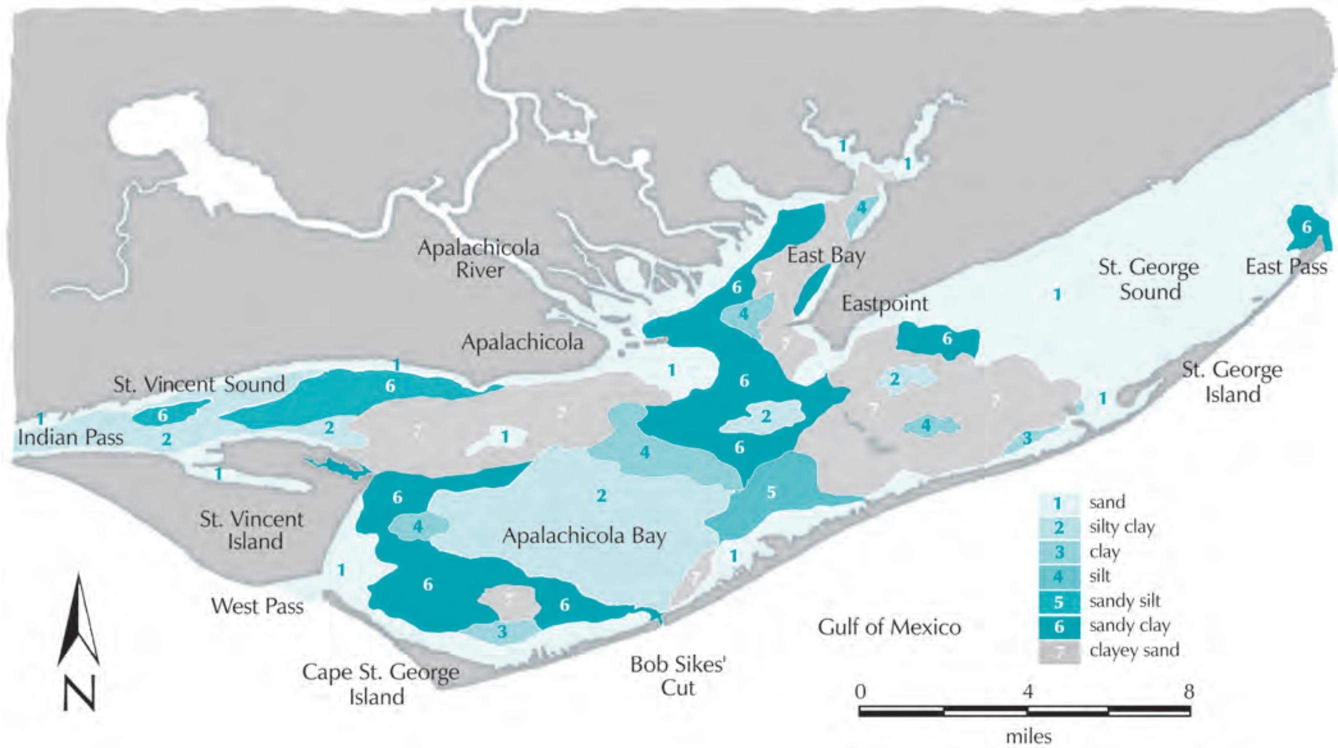



***Figure 48.*** *Bottom sediments of the Apalachicola estuary (Isphording, 1985)*

tion varies considerably depending on location in the bay (Figure 48). The sediments in East Bay are primarily sandy clay and clayey sand while Apalachicola Bay sediment ranges from clay and silty clay to clayey sand. St. George Sound sediment is primarily sand with some clayey sand found in the western regions. St. Vincent Sound sediment is primarily composed of silty clay in the west and sandy clay in the east. The entire habitat is sub-tidal with the majority of the silt and clay component being river borne and from adjacent upland areas. Many areas also have up to two percent shell fragments associated with the bottom sediment (Isphording, 1985).

The soft sediment habitat provides an important source of food for some of the more dominant fish in the system. Many benthic invertebrates also use this habitat as a burrowing and feeding substrate. The associated community is determined by sediment composition, organic content, physical factors such as salinity, pH and dissolved oxygen. Biological activity can also affect the sediment composition and animal community. Polychaetes and amphipods are the numerically dominant organisms of this community. The number and diversity of organisms present varies considerably, both seasonally and spatially throughout the estuary. Low salinity areas are typically characterized by high dominance of a few species, low species diversity, and variable numerical abundance. High salinity areas usually are characterized by low numerical abundance, few dominant species, and a high species diversity (Livingston, 1984).

Many of the commercially important benthic macro-invertebrates are harvested from this habitat. Shrimp and blue crabs are not restricted to this environment but feed and burrow extensively here when they leave the protection of the marshes as they mature. The soft sediments contain nutrients and detritus brought in from the river as well as providing an ideal substrate for bacteria. Atlantic croaker and spot feed extensively in this habitat. Most of the other important benthic invertebrates and epibenthic fishes are also associated with this habitat at one time during their life cycle.

**Marshes**

Marsh systems are among the most productive in the world and are vital habitats for important ecological and economic species. Marshes found in the Apalachicola Bay system include fresh, brackish, and salt marshes and cover approximately 17 percent (Table 6) of the total aquatic area (Livingston, 1980). Their distribution is mainly limited to the inter-tidal areas along the perimeter of the bay and the delta area of the lower river and East Bay (Figure 49). Since the amount of organic material exported or imported between the marsh and the estuary is still unknown (de la Cruz, 1980), the most important function of marshes may be as a nursery habitat. Marshes fulfill the three general criteria that characterize a nursery ground: 1) an area must provide some protection from predators; 2) it must provide an abundant food supply; and 3) it must be physiologically suitable in terms of physical and chemical features (Joseph, 1973).

The most developed marsh systems are found in East Bay and along the lower reaches of the Apalachicola River (Table 6, Figure 49). An extensive system of tidal creeks and bayous extends


***Figure 49***. *Major marshes of the Apalachicola estuary (Livingston, 1983)*

northward, increasing shoreline area and suitable regions for marsh development. The marshes here support predominantly fresh to brackish water vegetation consisting primarily of bullrushes, cattails, and sawgrass. Black needlerush and cordgrasses are also present in the more brackish areas of East Bay (Livingston, 1983). St. Vincent Sound also supports a large brackish and salt-marsh system, primarily located along the northeastern areas of St. Vincent Island and the western shoreline on the mainland. The dominant species are black needlerush, smooth cordgrass, and saltgrass. Marshes also occur on St. Vincent Island with sawgrass being the dominant feature (Thompson, 1970). A survey conducted by Miller et al. (1980) on St. Vincent Island found a shift in the composition of the freshwater marshes from mostly sawgrass to a sawgrass and cattail-dominated system. Fish and Wildlfe Service Refuge personnel have seen an increase in cattail coverage with a subsequent decrease in other species more beneficial to wildlife (Terry Peacock, personal communication). The lagoon and tidal creeks of Cape St. George and St. George Islands also support narrow bands of brackish and salt marshes. These are generally dominated by black needlerush with lesser amounts of smooth cordgrass and saltgrass (Livingston, 1984).

Plants associated with marshes must contend with rapid changes in environmental conditions, which restrict the number of species found in these habitats. Because of stressful conditions, salt marshes typically exhibit low plant diversity and in many instances consist of one or two species, with black needlerush and smooth cordgrass dominating in this area. Occupying a vertical gradient of approximately 3-5 feet, the vegetation is not organized into integrated communities but, instead, the species occur in zones defined by salinity, tides, and the soil moisture regime. Brackish marsh habitats are usually not as stressful as salt marshes and, therefore, the number of species found is usually greater (Clewell, 1986). The paucity of species is usually offset by the extremely dense concentrations of those present. Brackish marsh vegetation is also more variable spatially than salt marshes due to the differing salinity regimes encountered as the distance from the estuary increases. Eventually the brackish marsh vegetation is replaced by less tolerant species and becomes a freshwater marsh when salinities average less than 0.5 ppt. The freshwater marsh system will be further discussed in the river floodplain section.

Animals associated with marsh systems must also withstand the rapid changes in environmental conditions. Since only about 10 percent of vascular plant material produced in the marsh is consumed directly by herbivores (Heard, 1982), most organisms found in the marsh are predators and detritivores. Because of the importance of this habitat as a nursery area, organisms are typically grouped into permanent and transitory categories. Permanent residents include invertebrates such as insects, polychaete worms, amphipods, mollusks, larger crustaceans, and other omnivorous groups, which play an important role in the breakdown of organic matter. Year-round residents also include mammals such as muskrats, and birds such as the clapper rail and great blue heron. Transitory residents include such species as blue crabs, penaeid shrimp, anchovies, largemouth bass, striped mullet, spotted and sand seatrout, and lepomids (Livingston, 1984). These and other important estuarine organisms use the marsh habitat as a nursery ground, breeding area, or feeding zone. The summer and fall in Apalachicola Bay is the most critical period when the marsh is used as a nursery area. The marsh is also important to wildlife such as river otters, raccoons, alligators, and turtles. Transitory birds in marshes comprise one of the larger herbivorous groups and are also significant top carnivores in the system. Northeastern Gulf of Mexico marshes support summer nesting species, migrants, casual feeders, and summer visitors (Stout, 1984). Birds of prey that utilize the marsh system include hawks, owls, ospreys, and bald eagles that feed on fish and small rodents found in the marsh.

Marshes are unique, multifaceted natural systems that are valuable as food and nutrient sources, faunal habitats, water purification, shoreline stabilization, storm buffers, flood storage, and recreation. These systems have been viewed as having little value or use until recent times; therefore, many thousands of acres have been "enhanced" over the years to more "productive" uses by dredging and filling to convert them to open water or upland areas. The Apalachicola Bay system has escaped major alteration of the marsh system so far, although threats from pollution, watershed modification, increasing development, and dredge and fill activities continue to destroy small parcels of wetlands. Many small isolated marshes on St. George Island, in particular, have been and continue to be filled for development reasons. These barrier island wetlands are extremely important as stopover areas for migrating birds and as the primary habitats for many of the remaining amphibians and reptiles left on the islands. The continued expansion of the common reed, *Phragmites australis*, in the East Bay area and distributary marshes is also becoming an increasing area of concern for the Reserve.

**Open Water**

The simplest habitat to physically define and one of the hardest to measure is open water. This habitat is simply the water area that occupies the estuarine basin and is in contact with the Gulf and the river. Depths in Apalachicola Bay average six to nine feet, and all major water bodies in the Reserve combined cover an area of approximately 111,000 acres (Table 6). This makes the open water the largest habitat in the bay system. All the habitats previously described are similar in that type of substrate is an important component of the habitat, influencing its character and associated community. Since there is no substrate associated with the open water habitat, it is mainly influenced by depth, salinity, temperature, currents, and other parameters such as turbidity and color. Turbidity and color limit light penetration; therefore, the upper layer of this habitat is in the photic zone while the remainder is below it.

Organisms associated with the open water habitat include planktonic forms (weak swimmers at the mercy of currents) and nektonic forms (strong swimmers). Most planktonic forms are microscopic and are important in the pelagic food chain. Numerous studies have been conducted on phytoplankton (Estabrook, 1973; Myers and Iverson, 1977; Putland, 2005), zooplankton (Edmiston, 1979), and ichthyoplankton (Blanchet, 1979), and these will be discussed in a later chapter. In the Apalachicola Bay system, a large number of organisms that comprise the recreational and commercial fisheries are nektonic (Livingston, 1984). Important commercial species such as shrimp and crabs have limited swimming ability and also utilize the water column. The larval forms of shrimp, crab, oysters, and fish are also planktonic and utilize the water column for food, protection, and distribution purposes.

The nekton in Apalachicola Bay are primarily dominated by estuarine-dependent fish and up to three-fourths of the commercial seafood catch in Franklin County is dependent on the estuarine habitat and condition of Apalachicola Bay (Menzel and Cake, 1969). These species include true estuarine forms, those that use the estuary all or part of their life cycle for feeding and as a nursery ground; migratory forms (anadromous and catadromous species), that must pass through the system to fresh water; and fresh and salt water forms that enter the estuary when conditions are appropriate.

The four most numerous fish in the Apalachicola Bay system are bay anchovy, Atlantic croaker, sand seatrout, and spot (Livingston 1980, 1983, 1984; Livingston et al., 1974, 1976, 1977). While croaker and spot were once commercially fished, neither contributed significantly to total landings. They are important, however, in the estuarine food chain. The numerical abundance of fish in the estuary is highly seasonal (Table 10). Low temperatures and salinities may force many species offshore during winter while others migrate for spawning or nursery reasons.

## Apalachicola River System

The Apalachicola River flows 106 miles from Lake Seminole, a 37,500 acre man-made lake along the Florida, Georgia, Alabama border to Apalachicola Bay and drains 2,400 square miles (Figure 7). As it flows through the Gulf Coastal Lowlands it falls approximately 40 feet. Surrounding land elevations range from 325 feet, in the upper river, to sea level, in the lower river (Leitman et al., 1983). Being a large alluvial river, the Apalachicola River's width varies from several hundred feet, during low flow, to nearly 4.5 miles during high flow. The influence of the tide extends approximately 25 miles upstream from the river's mouth (Couch et al., 1996).

The largest tributary to the Apalachicola River, the Chipola River is an entirely different type of river. The Chipola River is classified as a spring fed or calcareous spring run. Its waters come principally from underground aquifers (Jue, 1989). Originating in southeast Alabama it flows 125 miles and enters the Apalachicola River below Wewahitchka. Characteristics of spring fed rivers include a small sediment load, very little water level fluctuation, stable environmental conditions, and nominal flooding. The geology, water supply, habitat, and faunal assemblages between the two rivers differ greatly (Couch et al., 1996; Edmiston and Tuck, 1987; Clewell, 1986; Bass, 1983). Very little is known about the habitats or fish assemblages on the Chipola River (Seaman, 1985).

The Apalachicola River has been recognized by The Nature Conservancy as one of the Nation's biodiversity hotspots (Stein et al., 2000). The importance of the Apalachicola River to the productivity of Apalachicola Bay cannot be overemphasized. Numerous studies relating the bay's functions to river nutrient inputs (Mattraw and Elder, 1980, 1983; Livingston et al., 1997; Putland, 2005), floodplain litter and detritus (Livingston, 1981; Elder and Cairns, 1982; Mattraw and Elder, 1983), and flow (Maristany, 1981; Alabama et al., 1984; Elder et al., 1988) have been published and are discussed in other chapters.

### Riverine Habitats

Riverine habitats can generally be sub-divided based upon the physical cover provided for organisms. This physical cover is dependent not only on the substrate composition, but also on the shoreline features associated with the substrate (Bass, 1983). These two factors combine to help determine the amount and type of food available, the type of species that will use the habitat, and its adequacy as a spawning and nursery area. Six distinctive habitat types have been located within the Apalachicola River along its 215 miles of shoreline (Ager et al., 1984). These have been catalogued and divided into steep natural bank, gently sloping natural bank, dike field, sandbar, rock, and submersed vegetation (Table 11). The distribution of these habitats in the lower river is shown in Figure 50. Surveys of fish populations of each habitat based upon electro-fishing samples have also been investigated.

The studies by Ager et al. (1984) deal specifically with the main river's shoreline habitats. Mid-river habitat, which accounts for a significant portion of the riverine habitat, is less well known. Observations by USFWS personnel using SCUBA and observations of dredged spoil material indicate that the bottom substrate consists of smooth rock, rock rubble, gravel, clam shells, clay, detritus, or sand depending on river location (USFWS, 1986; Ager et al., 1987). There are also numerous important tributaries to the Apalachicola River (Table 12) that provide riverine and stream habitat important for fish and other species.

Most of the river's bed sediments are sand except on channel margins, where low velocities occur, resulting in finer sediments and in areas in the upper river where high velocities make gravel, rock, and limestone the dominant habitat (USACOE, 2001).

### Steep Natural Bank

The steep natural bank habitat comprises the largest percentage of any riverine habitat on the Apalachicola River, accounting for 90 miles of shoreline or approximately 42 percent of the total length (Table 11). This habitat is characterized by a clay substrate with snags, roots, and submerged logs. The slope is greater than 45 degrees, which also accounts for a water depth usually greater than six feet.

**TABLE 10**

**Seasonality of Important Apalachicola Bay Fish**
*(modified from Leitman et al., 1986)*

| | |
|---|---|
| **Anchovy** | Year-round resident. Spawn from spring through fall with a peak in May. Highest population in summer and fall, lowest in winter. |
| **Mullet** | Migrate and spawn offshore October through February. Highest population in bay in summer and fall. Many young over winter in deep holes. |
| **Southern Flounder** | Present year-round. Many migrate offshore to spawn in winter. Juveniles arrive in bay in spring and summer. |
| **Gulf Flounder** | Migrate offshore in winter. Juveniles return February through April. |
| **Croaker** | Adults migrate offshore summer through fall. Juveniles return in October. Juveniles remain in bay their first summer and migrate offshore in winter. |
| **Spot** | Juveniles and adults migrate offshore from late summer through winter and return in later winter, early spring. Post-larvae return in January. |
| **Spotted Seatrout** | Generally, year-round residents but may migrate offshore during low salinity or temperature. Most abundant in spring. Spawn in spring and summer, sometimes even until October. Also spawn offshore of barrier islands. |
| **Sand Seatrout** | Migrate to spawn just offshore of barrier islands from October through March. Most abundant in summer and early fall. |
| **Redfish** | Spawn offshore from September through February. Post-larvae arrive in bay September through December. Remain in or near estuary for two years then spend more time at sea. |

This habitat is typically found on the outside of river bends where stream bank cutting occurs; therefore, currents are usually swift and erosional activities are apparent. The steep bank habitat is located throughout the river but predominates in the upper and middle sections (Figure 50) (Ager et al., 1984).

As with other habitats that are located throughout the river, the steep bank habitat exhibits higher catch rates for fish in the upper river than middle and lower river sections. Reasons for this include recruitment of individuals such as threadfin shad, bluegill, and others from Lake Seminole, abundance of good habitats, and blockage of upstream migration by the Jim Woodruff Dam (Ager et al., 1984).

**Gentle Sloping Natural Bank**

The gently sloping natural bank habitat currently comprises the second largest habitat type in the Apalachicola River (Table 11). The substrate in this habitat is a mixture of clay, mud, and fine sand, and typically contains overhanging trees with many snags and submerged logs. Water depth is generally less than four feet with a slope less than 45 degrees. This habitat is typically found in the coastal lowlands (Figure 50) and on either side of point sandbars; therefore, currents are generally slow. The gently sloping bank habitat is found throughout the river, accounting for 58 miles of shoreline but predominates in the lower river comprising 60 percent of the shoreline in this section (Ager et al., 1984; 1985).

In the upper Apalachicola River, this habitat is one of the major types used for spoil disposal by the USACOE maintenance dredging activity. As a result, gently sloping natural bank habitat is scarce in the upper river, which accounts for low catch rates. Disposal of dredged material on this habitat type has been shown to reduce the total number of fish and gamefish in the upper river by 50 percent at these sites. Similar disposal on other riverine habitats has reduced gamefish catches by 75 percent the year after this disturbance. These reductions appear to persist 5-10 years after disposal on gently sloping natural bank habitats (Ager et al., 1984; 1985).

**TABLE 12**

**Important tributaries to the Apalachicola River**

*(modified from COE, 1986)*

| *Tributary* [1] | *River* [2] *Mile* | *Length (miles)* | *Source Elev. (ft)* | *Mouth Elev. (ft)* |
|---|---|---|---|---|
| **Mosquito Creek** | 105.1 | 19.4 | 290 | 45 |
| **Flat Creek** | 100.4 | 11.0 | 250 | 45 |
| **Florida River** | 43.1 | 19.6 | 25 | 15 |
| **Chipola River** (Florida portion) | 27.9 | 95.8 | 85 | 5 |
| **Kennedy Creek** | 26.0 | 15.8 | 55 | 5 |
| **Brothers River** | 12.2 | 13.7 | 0 | 0 |

[1] *At least ten miles long*

[2] *Distance from the mouth that it empties into the Apalachicola River*

**TABLE 11**

**Linear miles of shoreline habitat for the Apalachicola River by section and habitat type, 1982-83**

*(Ager et al., 1984)*

| | *Steep Natural Bank>45°* | *Gently Sloped Bank<45°* | *Dike Field* | *Sandbar* | *Rock* | *Submersed Vegetation* | *Total* |
|---|---|---|---|---|---|---|---|
| **Lower River (35.0-00.0)** | | | | | | | |
| Shoreline Length (mi) | 14.2 | 42.3 | 0.93 | 6.6 | 0 | 6.7 | 70.73 |
| Percent of Shoreline | 20.0 | 59.8 | 1.3 | 9.3 | 0 | 9.4 | |
| **Middle River (78.0-35.0)** | | | | | | | |
| Shoreline Length (mi) | 47.16 | 10.85 | 0.34 | 29.98 | 0 | 0 | 88.33 |
| Percent of Shoreline | 53.3 | 12.2 | 0.3 | 33.9 | | | |
| **Upper River (106.3-78.0)** | | | | | | | |
| Shoreline Length (mi) | 28.6 | 5.11 | 3.64 | 14.99 | 4.47 | 0 | 56.82 |
| Percent of Shoreline | 50.3 | 8.9 | 6.4 | 26.3 | 7.8 | | |
| **Total Shoreline** | | | | | | | |
| **Length of Habitat for Entire River** | 89.96 | 58.26 | 4.92 | 51.57 | 4.47 | 6.7 | 215.88 |
| **Percent of Habitat type for Entire River** | 41.6 | 27.0 | 2.3 | 23.9 | 2.1 | 3.1 | 100 |

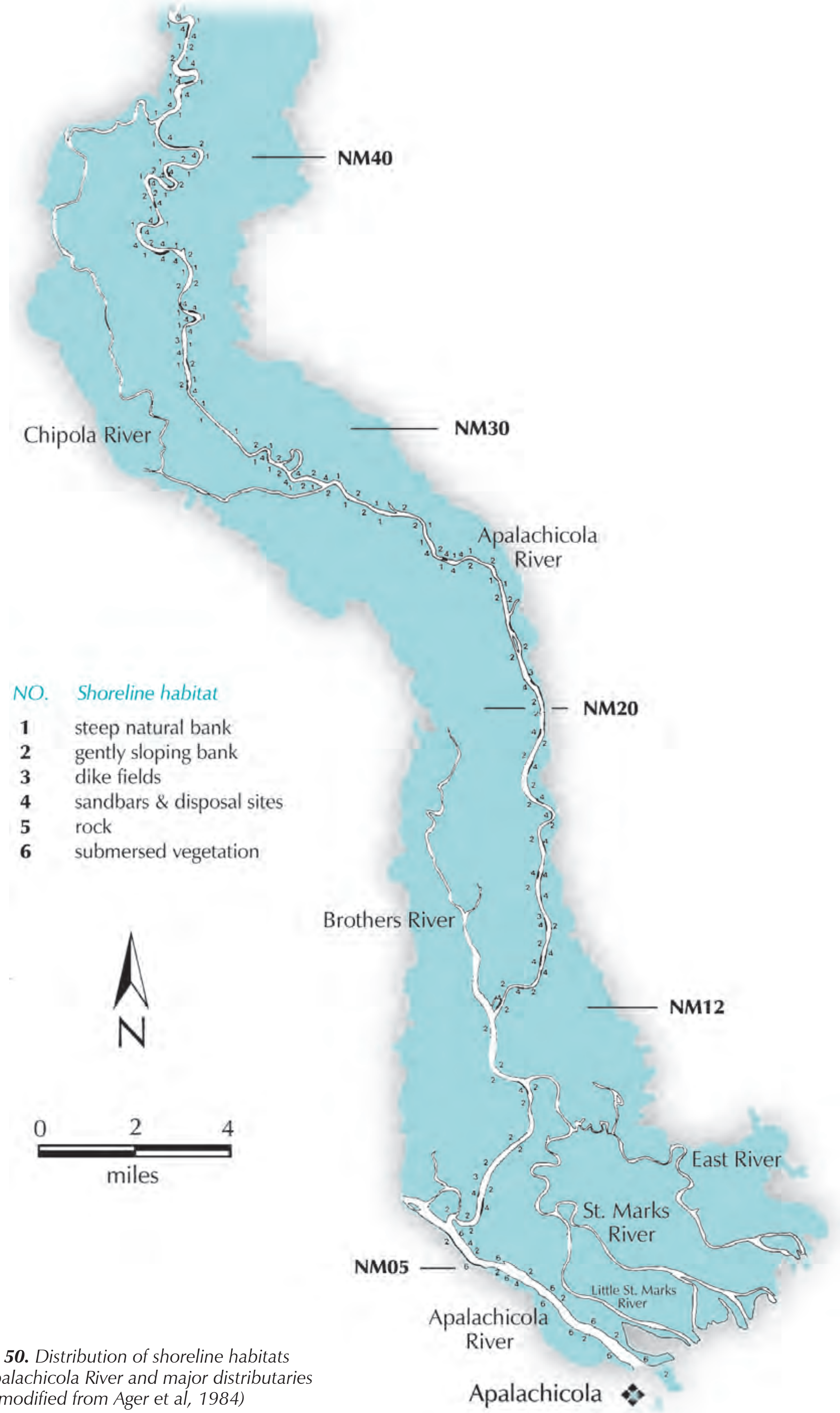



***Figure 50.*** *Distribution of shoreline habitats on the Apalachicola River and major distributaries (modified from Ager et al, 1984)*

**Dike Fields**

The dike field habitat found in the river is an artificial habitat, constructed by the USACOE for navigation purposes. Each field usually consists of three to five individual dikes. These dikes are constructed perpendicular to the shoreline and are made of wood pilings or rock. Dike field habitats are characterized by slow to swift water velocities, depending on river stage and location on the dike, and usually have large numbers of snags associated with them. The majority of the dike field habitat is located in the upper river where most of the navigation problems historically occurred (Figure 50). River-wide, dike fields account for approximately five miles of shoreline (Table 11) and are, therefore, a larger habitat type than the natural rock habitat (Ager et al., 1984; 1985).

Dike field habitat, although man-made, provides cover and food for fish in much the same manner as the naturally occurring rock habitat. The benefits to fish and the diversity of the habitat itself make dike fields very productive areas in the river. Unfortunately, they have also been used extensively for spoil disposal, especially in the upper river where they are most numerous. Disposal on these sites eliminates the cover and food which attracts fish to these habitats in the first place. A 50 percent reduction in catch rates of fish and gamefish has been observed by Ager et al. (1985) on dike fields which have been disturbed by spoil disposal.

**Submerged Aquatic Vegetation**

Submerged aquatic vegetation (SAV) habitat is uncommon in the Apalachicola River and is only found in the lower river section near the bay (Figure 50). The dominant vegetation of this habitat is typically *Vallisneria americana*, and is usually found in bands 10 to 100 feet wide parallel to the shoreline. Other species present includes *Najas guadalupensis, Chara spp, Myriophyllum spicatum, Salvinia spp, Hydrilla verticillata, Ceratophyllum demersum* (Fahrny et al., 2006). Water depth is shallow, and few snags or overhanging vegetation are present. Water velocity is slow, again a characteristic of submersed vegetation habitats. This habitat is only found in the lower six miles of the river and accounts for approximately three percent of the total shoreline available (Table 11). The SAV in the lower river has been impacted in the past due to saltwater intrusion caused by the 1995 hurricanes. Although the vegetation reappears naturally, the population of fish normally found in these regions is probably impacted in the short term. However, the same thing happened in 1985, due to hurricanes, and the vegetation reappeared within a couple of years.

The SAV habitat ranks last in catch rate in numbers and fifth for weight of fish compared with other riverine habitats. Part of this is due to the fact that this habitat is limited to the lower river and is generally less productive than the upper and middle sections. Common species found in this habitat include both fresh and estuarine species (Ager et al., 1984). The presence of so many estuarine species can be explained by the salinity variations in the lower river. Habitat preferences may be indicated by the fact that these species have not been collected from gently sloping natural bank habitats or sand bars and disposal site habitats in the same areas.

**Sandbar**

The sandbar habitat found in the Apalachicola River consists of two types, the natural sandbar of which few probably still exist, and the dredged material disposal sites which are already numerous. The sandbar habitat is found throughout the river with approximately 50 percent of the total in the middle section alone (Figure 50). This habitat is characterized by shallow water less than four feet deep, slow to moderate water velocities, the absence of snags, and an unstable, shifting, sand substrate (Ager et al., 1984). Natural sandbars traditionally form on the inside of river bends (point bars); however, on the Apalachicola River, dredge material has been disposed of upriver, on, and downriver of many of these natural sandbars. Not only have the natural sandbars decreased, but considerable gently sloping natural bank habitat has also been converted to a sandbar type habitat.

The sandbar habitat in the Apalachicola River that does not occur on point bars, is mostly man-made, created by the disposal of dredge material from the navigation channel maintained by the USACOE. Approximately 52 miles of shoreline, 25 percent of the total, are currently approved for within-bank disposal. At least 35 miles of this have been disposed on since 1977, with the majority of the rest utilized prior to that (Leitman, 1984). The river also currently has approximately 52 miles of sandbar (disposal site) habitat, much of which is disposal sites (Table 11). A large portion of this has been changed from the more productive gently sloping natural bank habitat to the less productive sandbar habitat. This change continues a shift from gamefish species, found on natural habitats, to forage and rough fish species, found on sandbar habitat (Ager et al., 1984). Studies by Ager et al., (1985) also show reductions of gamefish by 75 percent within the first year after disposal of material on natural habitats and an overall 50 percent loss of gamefish 5-10 years after disposal. Due to recent 2006 decisions by the Florida Department of Environmental Protection denying the dredge and spoil permit in the river, many of these non-productive sand bar habitats should begin to recover if not spoiled on in the future.

## Apalachicola River Floodplain System

The floodplain of the Apalachicola River is the largest in Florida and one of the larger floodplains on the Gulf Coast. Almost half of the nation's forested and scrub-shrub coastal wetlands are contained within the Gulf of Mexico. The Apalachicola drainage area, in Florida, has been identified as having over 550,000 acres of this habitat, ranking it the eighth largest in the continental United States


***Figure 51.*** *Apalachicola and Chipola River flood plains (Wharton et al, 1977)*

(Field et al., 1991). Floodplains in the Southeastern United States are, in many instances, the last refuge for rare and endangered plants and animals. Although floodplain land, like swamp land or marsh land, is usually considered the least desirable in terms of real estate value, it is probably some of the most valuable land from an ecological point of view.

**Physiography**

The Apalachicola River floodplain encompasses approximately 15 percent of its drainage area in Florida, about 144,000 acres. The Chipola River, about which less is known, drains the same area as the Apalachicola itself, but its floodplain encompasses only 27,000 acres (Wharton et al., 1977; Elder and Cairns, 1982). Alluvial river floodplains, like the Apalachicola, have broad flat floodplains due to their annual high water levels (Figure 51). In order to better describe the floodplain, it has been divided into three sections (upper, middle, and lower) in a manner similar to the riverine section to take advantage of the naturally occurring divisions. However, only the lower half of the floodplain, approximately 52 river miles, is within the boundaries of the Reserve.

The upper river floodplain, from Chattahoochee to Blountstown, is the narrowest part, ranging from one to two miles wide. It is limited on the eastern side by the steep bluffs of the Tallahassee Hills where elevations up to 325 feet occur. The western side of the floodplain is bounded by the Grand Ridge province, a gently rolling region which gradually rises to elevations as high as 125 feet (Figure 4). Natural riverbank levees are higher and wider here than the rest of the river ranging up to 15 feet above the surrounding floodplain and from 400 to 600 feet wide. Since the river is more "contained" in this section than in others, the fluctuation in water level is also greater, ranging from 19 to 24 feet.

The middle river floodplain from Blountstown to Wewahitchka varies from two to three miles wide. The Gulf Coastal Lowlands bound both sides of the floodplain in this section except for the upper reaches, which are bordered by the Beacon Slope and Grand Ridge (Figure 4). Generally upland elevations are less than 100 feet throughout this section. The natural riverbank levees are smaller than in the upper river, ranging from eight to 12 feet higher than the surrounding floodplain and from 200 to 400 feet wide. Water level fluctuations are also less, ranging from 11 to 19 feet above low stage during flood events.

The lower river floodplain from Wewahitchka to Apalachicola, all of which is located within the Reserve, exhibits the greatest width ranging from 2.5 to 4.5 miles across. It is completely within the Gulf Coastal Lowlands, and surrounding uplands do not exceed 50 feet in elevation. The natural riverbank levees vary from 2 to 8 feet higher than the surrounding floodplain and are 50 to 150 feet wide on the average. Water level fluctuations throughout the year range from 7 feet at Sumatra to 11 feet at Wewahitchka (Leitman et al., 1983; Leitman, 1983).

Very little seems to be known concerning the floodplain of the Chipola River. Spring fed streams, like the Chipola, typically have narrow floodplains due to less flow variability and low sediment loads. The upper Chipola River water level only fluctuates approximately 1 to 2 feet, caused mainly by heavy rainfall that keeps the width of the floodplain small. Lower river water level fluctuation normally ranges from 4 to 6 feet and again is mainly dependent on runoff for this variation (FFWCC, l959). Part of the floodplain in the river was permanently inundated and became the Dead Lakes when high floodplain deposits of the Apalachicola River blocked off the Chipola River north of Wewahitchka (Vernon, 1942). The water level in this natural lake was maintained by an artificial weir until the late 1980's when it was removed to improve fish habitat and fishing in the lake and restore natural riverine conditions. The dead stumps of cypress and gum attest to the fact that this area was once part of the floodplain.

**Floodplain Dynamics**

Floodplains represent a zone of transition between upland and aquatic systems and, therefore, have characteristics of both. In order to understand the biota of floodplains, an understanding of how floodplains are formed, their features, and how they are maintained is necessary. The two most important parameters responsible for floodplain characteristics are river flow and sediment load carried by the river. The type of river and its characteristics determines the type of floodplain that will develop. As mentioned previously, the Apalachicola is an alluvial river originating in the Piedmont and, therefore, its floodplain is typical of alluvial river floodplains that are continually reworked by the river.

Alluvial rivers characteristically have a variable seasonal flow (Figure 8), substantial annual flooding, and a heavy sediment load. The continuing erosion and depositional processes acting within the river causes the river channel to be in a constant state of change, even during low flow. The deposition and erosion of material in the river eventually creates meanders, which widen the river valley, decrease slope, slow down water velocity, and allow more sediments to be deposited, thereby continuing the movement of the river channel laterally. During high flow, rivers not only erode and deposit sediments on the floodplain, but they are also capable of creating new channels by cutting off meanders or blocking the mouths of tributaries forcing them to create new channels (i.e. Dead Lakes and Chipola Cutoff). As the river adjusts and stabilizes, floodplain features are formed which can be discerned by topography and soil characteristics.

The river channel is the most prominent floodplain feature (Figure 52) and its morphology is dependent on long-term flow patterns (Blench, 1972). The river channel moves laterally within the floodplain by eroding the concave bank (outside bank) of a meander and depositing material on the convex bank (inside bank). The Corley Slough reach, river mile 36, of the river has moved approximately 300 feet from 1959 to 1982 by meandering. It is estimated that the west bank has been eroding at a rate of 16 feet per year since 1982. Some of this has been caused by maintenance of the navigational channel; however, this area has historically been an area of active meandering. Streambed degradation due to the Jim Woodruff Dam has been documented by the USACOE, especially in the upper reaches. Since 1957, the channel bed has been degraded from three feet at Chattahoochee to 1.4 feet at Blountstown (USCOE, 1986). This degradation was thought to have stopped years ago but continues today at a slower rate (Light et al., 2006). As the bed degrades, the flow of water needed to inundate the floodplain increases and the exchange of water between the river and backwaters through sloughs and streams is also affected. Any change in the channel characteristics has the potential to impact the floodplain and alter habitats that have developed in response to the channel over long periods of time.

The natural levees of the Apalachicola River play an important role in determining the amount of time the floodplain is inundated by maintaining the river within its channel until overbank or flood stage is reached. Natural levees are formed on the banks of rivers as water spreads out over the floodplain during periods of overbank flow. As the water spreads out, the velocity decreases and the

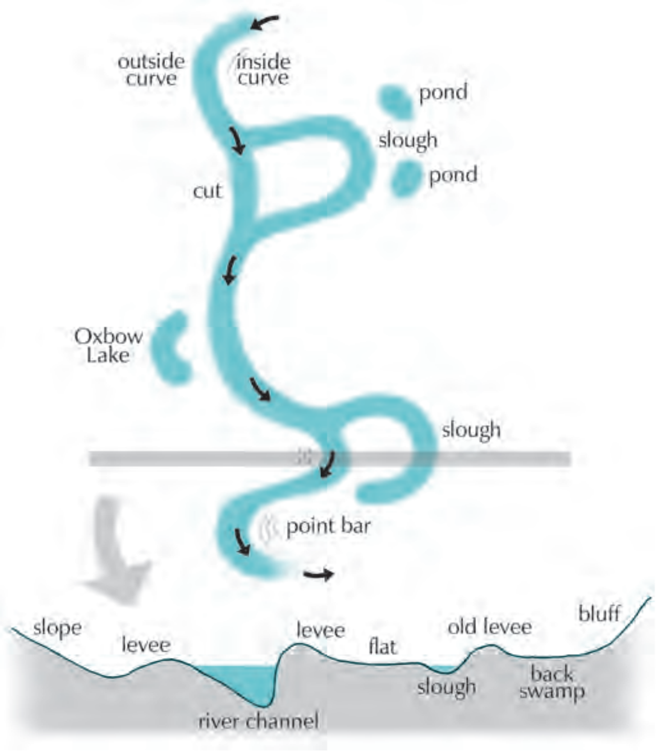



***Figure 52.*** *Major features of the Apalachicola River floodplain (modified from Clewell, 1986)*

larger suspended sediments are deposited parallel to the channel. These natural levees create a diversified habitat due to their height above the surrounding floodplain. Old levees can be seen scattered throughout the floodplain denoting previous river channel locations and meanders (Figure 52). Levees on the Apalachicola range from 2 to 15 feet in elevation and from 50 to 600 feet wide, depending on location. Levees not only keep water in the channel during rising water, but they also keep the floodplain inundated longer during decreasing water levels. During periods of low flow, levees are important features which help keep the backswamps of the Apalachicola floodplain wet by preventing local rainfall from draining into the river immediately (Leitman et al., 1983).

Backswamps or flats refer to those areas between the valley wall and the natural levee which are low in elevation (Figure 52). Small changes in elevation in these areas, especially in the lower river, create different soil conditions and help increase the diversity of the floodplain. Backswamp soils stay wet, saturated, or inundated most of the year and are almost impermeable, due to their high percentage of fine silts and clays. Backswamps are also known as peat-forming environments.

Point bars form on the convex (inside) bank of bends by the aggregation of sediments (Figure 52). During floods, small ridges are formed which act as temporary levees. As aggregation continues, interspersed with periodic flooding, a series of ridges with swales in between are formed. Because material eroded from one bend (meander) is usually deposited on the next point bar downstream, the floodplain is continually reworked (Wharton et al., 1982). Because of elevation differences, which cause velocity changes, sand is usually deposited on the ridges and silts and clays in the swales. These sediment differences influence not only water retention but also vegetation diversity. Due to the disposal of dredge material on these sites, few natural point bars remain unaffected by spoil on the Apalachicola River (Ager et al., 1984).

Other features such as scour channels, hummocks, and minibasins, although not as prominent topographically, have a pronounced effect on plant distribution due to their slight elevation differences. Scour channels are small waterways that connect tributaries and depressions to the main channel and create shortcuts for water during high flows. Hummocks are areas of higher elevation left between scour channels or elevated areas left around the bases of trees. The small change in elevation of hummocks is enough that some tree species, which cannot withstand 100 percent water inundation, can sometimes take root. Minibasins are small depressions that trap detritus and rainwater and are responsible for much of the nutrient recycling accomplished on floodplains (Wharton et al., 1982). All these features together create a diversity of soil conditions and inundation characteristics, which accounts for the wide range of plant associations occurring on the Apalachicola floodplain.

**Forested Floodplain**

Because floodplains occupy the transitional zone between aquatic and upland areas and are constantly changing, they are difficult to classify into distinctive habitats besides forested and non-forested. Of the 144,000 acres of floodplain on the Apalachicola River, approximately 85 percent is forested. The 121,000 acres of forested floodplain is the largest in the state with almost twice the area of the next largest floodplain. The term normally applied to forested floodplains in the Southeastern United States is bottomland hardwoods and generally includes wooded swamps, shrub swamps, and seasonally flooded basins and flats (which are forested). Florida ranked second in the nation behind Louisiana in area of bottomland hardwoods with almost 16 percent of the state in bottomland hardwoods as of 1970 (Turner et al., 1981).

Attempts to classify bottomland hardwoods and floodplains themselves are numerous and usually include soil characteristics, degree and duration of flooding, floodplain features, and floristic characteristics (Cowardin et al., 1979; Larson et al., 1981). Several early studies of the Apalachicola floodplain identified general features as well as important vegetational relationships (Harper, 1911; Kurz 1938; Hubbell et al., 1956). The most detailed studies of the floodplain to date, however, are those of Leitman (1978, 1983, et al., 1983), Clewell (1971, 1977, 1986), and Light et al. (1993, 1997, 1998). According to Clewell (1977), the major land use of the floodplain since the civil war has been forestry with most areas timbered between 1870 and 1925. Since that time, these same areas have been logged once or twice. Prior to the civil war, much of the upper river floodplain was used for growing cotton due to the fertile soils (Leitman, 1985). Therefore, some of the floodplain vegetation has been modified by man for over 100 years.

Over 70 species of trees have been identified in the Apalachicola river floodplain (Reed, 1988). Clewell (1977, 1986) has identified at least six different vegetation types in the Apalachicola floodplain, which as he says "... are not always sharply differentiated from each other." He relates these forest types to floodplain features with the more water-tolerant species occurring in low areas and less tolerant species occupying higher elevations (Figure 53). The relationship between species distribution and elevation is not an accident. In floodplains, the most important determinant in the distribution of forest type is the presence of anaerobic soil conditions. Anaerobic conditions are related to the hydroperiod characteristics of the river and the elevation of floodplain features. The height, length of time, and seasonality of flooding affects plant distribution in the floodplain by creating anaerobic conditions which some species can tolerate and others cannot. Depletion of available oxygen can occur in saturated soils in as little as three days. Areas which are inundated less often and for shorter periods support species which are intolerant of prolonged flooding (anaerobic conditions). Some species such as bald cypress and water tupelo have modified root structures which allow them


| NO. | Forest types | Associated Features |
|---|---|---|
| **1** | black willow, cottonwood, sycamore | aggrading sand bars |
| **2** | river birch, ogeechee-tupelo, alder | steep river banks |
| **3** | swamp chestnut oak, spruce pine, ironwood, water oak, sweetgum (mixed hardwoods) | natural levees |
| **4** | bald cypress, water tupelo | sloughs, oxbow lakes |
| **5** | overcup oak, water hickory, diamond-leaf oak, ash | low terraces |
| **6** | loblolly pine, sweetgum | slopes toward uplands |

***Figure 53.*** *Forest types and their association with floodplain features (modified from Clewell, 1977; 1986)*

**TABLE 13**

**Tree Species of the Apalachicola River Floodplain**
*(Leitman et al. 1983)*

| | *Relative Basal Area (%)* | *Relative Density Species (%)* |
|---|---|---|
| **Water tupelo** | 29.9 | 12.8 |
| **Ogeechee tupelo** | 11.0 | 6.6 |
| **Bald cypress** | 10.6 | 5.5 |
| **Carolina ash** | 5.4 | 11.5 |
| **Swamp tupelo/blackgum** | 5.0 | 2.0 |
| **Sweetgum** | 4.8 | 3.2 |
| **Overcup oak** | 3.2 | 2.0 |
| **Planer tree** | 2.9 | 9.4 |
| **Green ash** | 2.9 | 2.7 |
| **Water hickory** | 2.9 | 0.8 |
| **Sugarberry/hackberry** | 2.8 | 2.1 |
| **Diamond-leaf oak** | 2.5 | 1.4 |
| **American elm** | 2.4 | 1.2 |
| **American hornbeam** | 2.0 | 4.7 |
| **Pumpkin ash** | 1.9 | 4.4 |
| **Water oak** | 1.8 | 0.5 |
| **Red maple** | 1.5 | 4.8 |
| **Sweetbay** | 1.0 | 0.5 |
| **River birch** | 0.8 | 0.7 |
| **Possumhaw** | 0.8 | 10.5 |
| **American sycamore** | 0.6 | 0.3 |
| **Swamp cottonwood** | 0.4 | 0.4 |
| **Black willow** | 0.4 | 0.4 |
| **Swamp chestnut oak** | 0.3 | 0.1 |
| **Box elder** | 0.3 | 0.8 |
| **Other** (22 species) | 2.0 | 10.7 |

to survive and prosper in low areas which are subject to lengthy flooding (Wharton et al., 1982).

Leitman et al. (1983) has done the most detailed study on the Apalachicola floodplain forest types to date. Forty-seven species of trees were identified and density and basal areas were measured at various transects throughout the river (Table 13). The three most predominant trees in terms of density are water tupelo, Carolina ash, and possumhaw. Based on basal area, the three most predominant trees are water tupelo, ogeechee tupelo, and bald cypress. The floodplain is dominated by six wet-site species, water tupelo, ogeechee tupelo, bald cypress, Carolina ash, swamp tupelo, and planer tree, which account for approximately 48 percent of the number and 65 percent of the basal area of trees found. The upper river floodplain exhibits the highest diversity with 35 species, while 27 species have been found in the lower river floodplain.

Six forest types have been identified on the Apalachicola River floodplain using color infrared photographs and cruise transect data (Leitman, 1983; Leitman et al., 1983). The dominant and associated species, found with them, are the distinguishing characteristics used to separate the forest types from each other. Species, acreage, and distribution of these six forest types from the lower 42 miles of the river are shown in Table 14 and Figure 54.

The pine forest association is found on some of the highest elevations in the floodplain, near uplands or "islands" of higher elevation than the surrounding floodplain. This association, consisting primarily of loblolly and other pines, occurs mostly in the middle

**TABLE 14**

**Forest Types and Acreage of the Lower Apalachicola River Floodplain** *(modified from Leitman, 1983)*

| *Name* | *Predominant Species* | *Associated Species* | *Lower River - Wewahitchka to Mouth/42 miles) (acres)* |
|---|---|---|---|
| **Pine** | Loblolly pine & other pines | Sweetgum, sugarberry, American hornbeam, water oak, possumhaw, | 204 |
| **Pine & mixed hardwoods** | Sweetgum, sugarberry, water oak, loblolly pine | American hornbeam, possumhaw, diamond leaf oak, green ash | 628 |
| **Mixed hardwoods** | Water hickory, sweetgum, overcup oak, green ash, sugarberry | Diamond-leaf oak, water oak, American elm, possumhaw, red maple | 17,618 |
| **Tupelo-Cypress with mixed hardwoods** | Water tupelo, ogeechee tupelo, bald cypress, swamp tupelo, Carolina ash, planer tree | Overcup oak, pumpkin ash, red maple, water hickory, American elm, green ash, diamond-leaf oak, sweetbay | 31,030 |
| **Tupelo-cypress** | Water tupelo, bald cypress, ogeechee tupelo, swamp tupelo | Carolina ash, planer tree, pumpkin ash, sweetbay | 16,996 |
| **Pioneer** | Black willow | American sycamore, swamp cottonwood, river birch, green ash | 19 |
| **Marsh** | Sawgrass, bullrush, cattail giant cutgrass | Big cordgrass, softrush, | 9,030 |
| **Open Water** | | | 4,810 |
| **Unidentified** | | | 176 |
| **Total** | | | **80,400** |

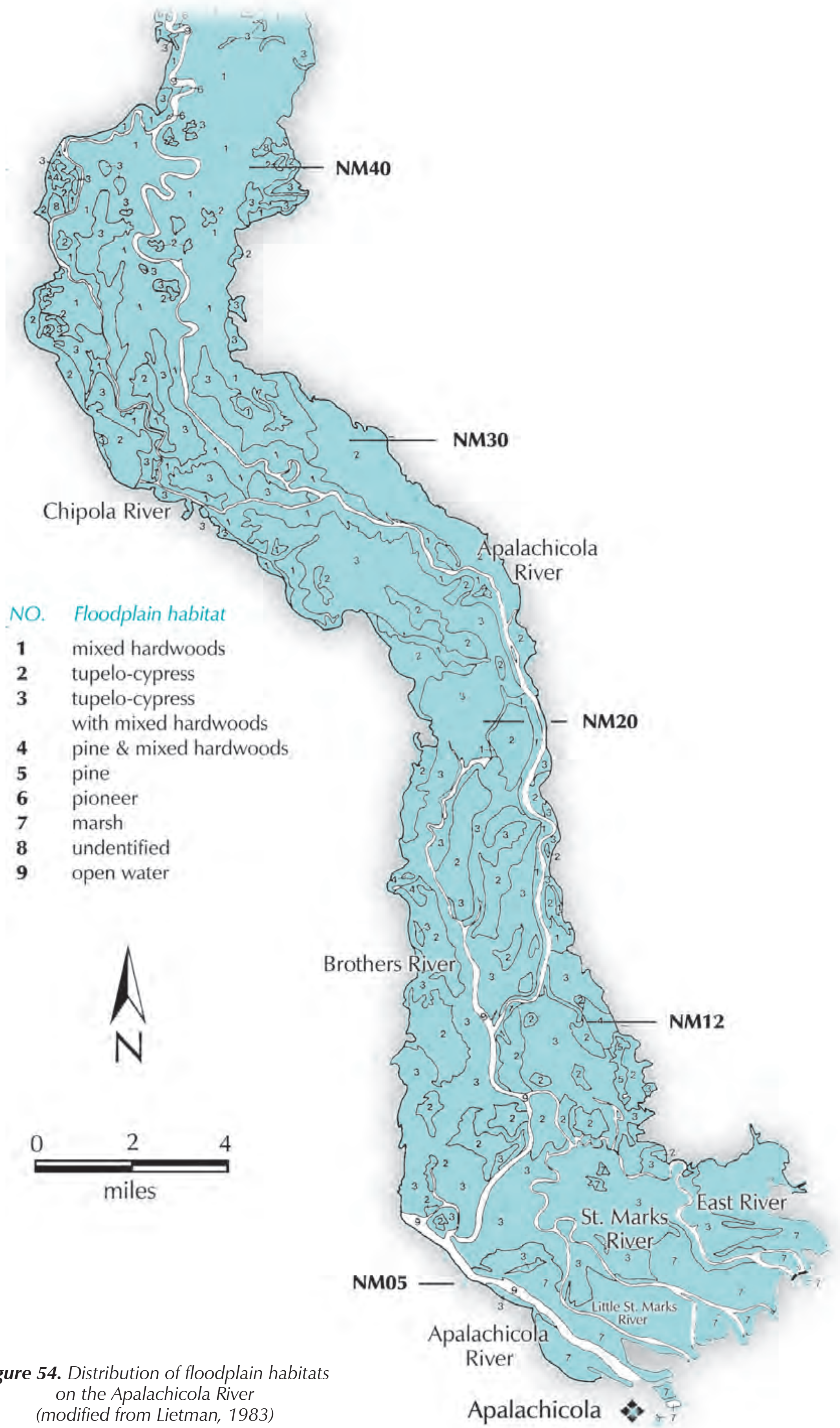



***Figure 54.*** *Distribution of floodplain habitats on the Apalachicola River (modified from Lietman, 1983)*

river stretches but is found in all three sections of the floodplain. Because this association needs drier soil conditions, it represents less than 1 percent of the floodplain area (Table 14). Areas in which the pine forest type is found are inundated less than 10 percent of the year.

The pine and mixed hardwoods forest is found in areas with conditions similar to the pine association. Predominant species of this forest type are sweetgum, sugarberry, water oak, and loblolly pine. It is found throughout the river but has been found chiefly in the middle river sections and covers approximately 2 percent of the entire floodplain area and less than 1 percent of the lower floodplain (Table 14).

The mixed hardwood forest type is the largest association found in the Apalachicola floodplain, covering 43 percent of the area. In the upper and middle river sections, it is found across the entire floodplain covering 78 percent of the area, but is restricted to the natural levees in the lower, tidally influenced section of the river (Figure 54). In the lower 42 miles of the river it accounts for less than 22 percent of the coverage (Table 14). Predominant species are water hickory, sweetgum, overcup oak, green ash, and sugarberry. There appears to be a shift in species importance from the upper to lower floodplain with sweetgum and sugarberry becoming less numerous in the lower river. This forest type is the association usually found on levees, terraces, and areas that are inundated from 5 to 30 percent of the year.

The second largest forest type found on the Apalachicola floodplain is the tupelo-cypress with mixed hardwoods association. Covering 24 percent of the entire floodplain, it is most often found in the lower river where it covers 39 percent of the area (Table 14, Figure 54). Dominant species of this forest type are water tupelo, ogeechee tupelo, bald cypress, swamp tupelo, Carolina ash, and planer tree. Occupying low flats, sloughs, and hummocky areas that provide small variations in elevations, this is mostly a wet-site forest. Areas occupied by this forest type are inundated or saturated from 50 percent (hummocks) to 100 percent (sloughs and pools) of the year.

The tupelo-cypress association is found in areas where the soil is poorly drained, such as backswamps and low flats. This is also a wet-site forest and is found mostly in the lower river floodplain. It accounts for 15 percent of the entire floodplain area but almost 22 percent of the lower floodplain (Table 14, Figure 54). Dominant species are water tupelo, bald cypress, ogeechee tupelo, and swamp tupelo. All four species have modified root systems which are capable of surviving anaerobic conditions characteristic of long periods of inundation. Areas in which this forest type are found usually have heavy clay soils which are inundated more than 50 percent of the year and saturated continuously.

The pioneer forest type is the smallest association on the floodplain covering only about 169 acres throughout and less than 19 acres in the lower floodplain (Table 14, Figure 54). Black willow is the dominant species and in many cases is the only species present. Found in narrow zones on "newly" formed point bars where sand is the predominant soil type, it occupies a somewhat dry area. Most of this type forest is located in the middle river where the majority of the meanders occur. As the age of the point bar increases, other species such as sycamore, swamp cottonwood, and river birch appear. Areas in which this forest type is found are usually inundated at least 25 percent of the year (Leitman, 1983; Leitman et al., 1983).

On the whole, the forested floodplain of the Apalachicola River appears to be split almost evenly between the wet-site species, dominated by tupelo and cypress, and the less water-tolerant bottomland hardwood species. Bottomland hardwood species dominate the upper and middle river floodplain while tupelo-cypress dominates the lower river forested floodplain. The absence of elevation differences in the lower river, along with tidal influences, is probably an important factor in this change. Elevation differences in the upper river floodplain vary up to 15 feet, while in the lower river floodplain, relief is limited to 2 feet (Leitman et al., 1983; Leitman, 1983). As mentioned previously, the distribution of plants on floodplains is directly related to hydrologic characteristics that cause anaerobic soil conditions. This relationship is demonstrated quite clearly on the Apalachicola River floodplain by the forest types present and the location where they are found.

**Non-forested Floodplain**

The non-forested area accounts for approximately 15 percent of the total area of the Apalachicola floodplain and over 17 percent of the lower 42 miles within the Reserve (Table 14). This component includes open water, marsh, and unidentified categories. The open water category includes ponds, lakes, streams, rivers, and excludes the bay area. Open water covers approximately 7 percent of the floodplain area mapped by Leitman (1983) and also includes the distributaries of the river which empty into East Bay. The unidentified areas cover less than 2 percent of the floodplain and include areas altered by man. These alterations include clearing, timbering, agricultural endeavors, construction, or spoil disposal. Most of these areas occur on the edge of the floodplain where access is easy and flooding is minimal.

The last category of non-forested floodplain is marsh, which covers approximately 11 percent of the lower floodplain or approximately 9,030 acres (Table 14, Figure 54). Most of this is tidal fresh marsh, located in areas where water movement is influenced by tidal fluctuations, and salinity levels are lower than 0.5 ppt. The lower marsh, closer to the bay, is a mixture of fresh and brackish water species. All of the marsh area is restricted to the lower 10 miles of the floodplain where it accounts for 51 percent of the floodplain area. Tidal fresh marsh provides a very diverse wetland community compared to salt marsh areas (Field et al., 1991). Sawgrass is the predominant species although bullrushes, cattails, big cordgrass, softrush, and giant cutgrass are also present in the freshwater areas of the river and distributaries. In the lower reaches of the river and East Bay, brackish water species such as *Spartina* and *Juncus* appear and mix with freshwater species (Leitman, 1983; Livingston, 1984; Clewell, 1986). Approximately 1,500 acres of this marsh, located on the west side of the Apalachicola River and north of the Jackson River, was altered in the 1970s and was undergoing a vegetation shift due to ditching and draining activities. Shrubs and wet-site trees had begun to appear until this property was purchased by the State and restoration activities were undertaken by the Florida Fish and Wildlife Conservation Commission. Dike breaching, ditch plugging, and controlled burning have been used to partially restore part of the marsh to its former function (FFWCC, 1982).

Very little work has been done in the fresh and brackish marsh areas in the lower river and upper bay. However, since coastal wetlands help to reduce erosion and act as filters for sediments two Sediment Elevation Tables (SET's) were installed by the Florida Geological Survey. These were put in the tidal marshes of the St. Mark's River, a distributary of the Apalachicola River that drains into East Bay, in 1996. Preliminary data from these instruments show that although the marshes are exhibiting accretion rates, up to 14 and 19 mm/yr, significantly above sea level rise rates, elevation changes are negative. This indicates that compaction/subsidence in the river delta is the dominant geological process controlling elevation in the marsh (Hendrickson, 1997). In comparison with other marshes in the Florida Big Bend however, the lower Apalachicola River marshes may be the only ones able to maintain or increase themselves in size in response to sea level rise (Ladner et al., 1999).

### Fish and Wildlife Values of Floodplains

Floodplains in the southeastern United States are in many instances the last refuge for rare and endangered flora and fauna (Gatewood and Hartman, 1977). The Apalachicola River floodplain is rich in both plant and animal species. Gholson (1985) in his study of disposal sites within the floodplain listed over 1,000 species of plants that includes canopy, understory, and ground cover types. Clewell (1977) listed 16 species of plants only found in Florida within the Apalachicola floodplain. Preliminary data indicates that at least 22 species of threatened or endangered plants have been found in the Apalachicola River floodplain.

The diversity of the plant species to wildlife is important. It has been estimated that approximately 361,000 metric tons of litter falls on the Apalachicola floodplain annually. Of this, 211,000 metric tons is strictly leaf fall with the remainder including berries, fruits, woody debris, etc. (Elder and Cairns, 1982). An important aspect of litter fall is not only the amount, which is high in the Apalachicola floodplain compared with other similar systems, but also the timing. Maximum litter accumulation occurs in the floodplain in late fall due mainly to leaf fall. Additionally non-leaf fall is high and consistent throughout the year. The length of the growing season, which ranges from 256 to 281 days throughout the length of the floodplain, is also a factor. The high diversity of species and variations in their patterns and seasons of litter fall is responsible for this sustained input of detritus and nutrients, and is an important energy source in the floodplain food web.

Since the floodplain is a "fluctuating water level ecosystem," it is characterized by pulses of productivity (Odum, 1969). These pulses are based not only on photosynthesis, but also on the decomposition of organic material. A typical floodplain food web is shown in Figure 55, which illustrates the importance of both the detrital food chain and the photosynthetic food chain to floodplain organisms and man.

The floodplain forest has been cited as being the most important wildlife habitat in northwest Florida (Gatewood and Hartman, 1977). Because of fluctuating water levels, the interface between the aquatic and terrestrial systems moves and organisms adapted to these systems must also move. Important macroinvertebrates found in alluvial floodplains include aquatic, terrestrial, and species adapted to varying stages in between. They include amphipods, isopods, a myriad of insects and insect larvae, clams, snails, worms, freshwater shrimp, and crawfish. Heard (1977) listed 60 species of snails and clams from the river and floodplain, seven of which are endemic. Clams are found not only in the river but also in sloughs and pools in the floodplain. Clams are fed upon by some catfish


***Figure 55.*** *Generalized food web of the Apalachicola floodplain (modified from Wharton et al., 1977)*

species, bream, birds, muskrat, raccoon, otters, salamanders, and turtles (Pennak, 1978).

Crawfish are important food items of mammals, birds, and fish and their numerous chimneys provide visible evidence of high water tables. Seven species have been identified from the Apalachicola (Wharton et al., 1982). Holder (1971) estimates that crawfish account for over one-third of the floodplain invertebrate biomass on the Suwannee River. Largemouth bass, bullheads, eels, bowfin, amphiuma, turtles, otter, raccoon, ibis and other birds, and water snakes utilize crawfish for food extensively. Alligators are also known to consume them as part of their diet. Crawfish burrows are used by small fish and other aquatic animals as refuges during dry periods when the floodplain dries out (Neill, 1951).

Crawfish and other floodplain invertebrates are an especially important food for fish when the floodplain is inundated. Studies have shown that many fish move out into the sloughs and onto the floodplain when it is inundated. The floodplain provides shelter from predators, food, and more habitat for reproduction and growth (Holder et al., 1970; Baker et al., 1991; Kilgore and Baker, 1996). As the waters recede the fish concentrate in the sloughs before returning to the main channel. Small fish are known to survive low-water periods on the Apalachicola floodplain by remaining in minibasins formed by the root systems of trees (Wharton et al., 1977). Receding waters also wash large quantities of invertebrates into the river channel where they become an important food source. Studies on other rivers have related the standing stock of gamefish, the size of the year class of largemouth bass, and the type of fish found to the duration and extent of flooding (Lambou, 1962; Bryan and Sabins, 1979).

Recently studies have focused on the aquatic habitats of the floodplain, their connectivity to the river, and their relationship to flow on the Apalachicola River. Eighty percent of the non-tidal fish species, 73 out of 91 species, collected in the Apalachicola River are known to occur in floodplains of the eastern United States. Fifty-one of these have been found in the Apalachicola floodplain (Light et al., 1998). The relationship between the acreage of aquatic habitat connected to the main river and the amount of non-aquatic habitat versus river flow illustrates the importance of flow on available habitat for fish (Figure 56). As aquatic habitat is reduced in the river the amount of food, protective cover, and spawning sites for many fish species is reduced. Some areas are drained of all standing water and are eliminated as aquatic habitat. Other areas remain wet but are not connected to the main channel and are inaccessible to the movement of fishes. These isolated areas may become crowded and exhibit poor water quality conditions such as low dissolved oxygen, which may further impact fish species. Low flow not only affects the quantity of aquatic habitat available to fish, but rapidly declining water levels can leave many species trapped in the floodplain that would normally be able to escape back into the river channel (Light et al., 1998).

The moist, shaded environment of the floodplain with the large accumulation of detrital material provides an ideal habitat for amphibians and reptiles. Means (1976, 1977) listed 44 species of amphibians and 64 species of reptiles found in the Apalachicola River basin. Although not all of these are found specifically within the floodplain, a significant number are transitory or permanent residents. The Barbour's map turtle is endemic to the Apalachicola. Because of the diversity of physical habitats, the mild climate, and the strategic location near four bio-geographical areas (Atlantic Coastal Plain, Gulf Coastal Plain, peninsular Florida, and northern area via the Piedmont and Appalachian regions), the Apalachicola basin supports the highest species density of amphibians and reptiles in North America, north of Mexico (Kiester, 1971; Means, 1977). The distribution of amphibians and reptiles within the floodplain is controlled by the hydrologic conditions of the varied environments. Aquatic or wet species are found in the tupelo-cypress and tupelo-cypress with mixed hardwood areas while species less tolerant to water range from the pine to mixed hardwood associations.

The Apalachicola floodplain provides not only an abundance of food, but also a myriad of environments that support a large and diverse population of birds year-round. Bottomland hardwoods, in particular, offer preferred habitat for migratory and over-wintering species from the north (Figure 57). The floodplains are utilized by waterfowl and terrestrial and arboreal species, with their distribution dependent upon hydrological conditions. Among the more prominent forested floodplain species observed by Stevenson (1977) are the swallow-tailed kite, Mississippi kite, red-shouldered hawk, barred owl, pileated woodpecker, hairy woodpecker, acadian flycatcher, red-eyed vireo, prothonotary warbler, Swainson's warbler, northern parula warbler, yellow-throated warbler, and hooded warbler. In his comparison of bird abundance below Jim Woodruff Dam in the forested floodplain and above the dam in the altered and flooded floodplain, he noted significant decreases or absence of these species in the altered habitat. Eichholz (1980) found what is believed to be the largest concentration of nesting

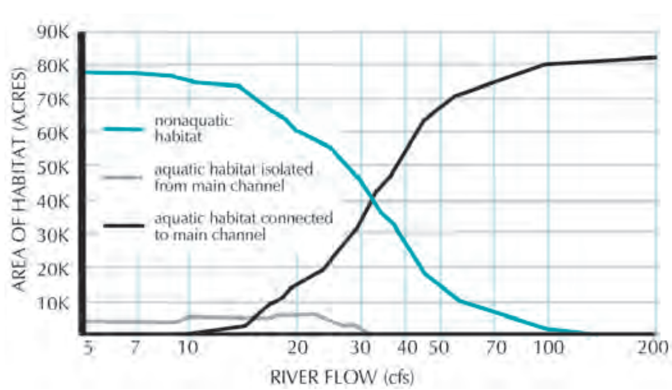



***Figure 56.*** *Flow of Apalachicola River at Chattahoochee in thousands of cubic feet per second (Light et al., 1998)*

ospreys, 45 active nests, in northwest Florida in the lower Apalachicola River floodplain. The ospreys, along with bald eagles forage extensively in the floodplain marshes and in the nearby Apalachicola Bay system. Forested floodplains support wild turkey populations two to three times higher than uplands (FFWCC, 1978) and are also important breeding areas to the wood duck (Gatewood and Hartman, 1977).

Mammals have probably been the least studied group, not only in the floodplain, but in the entire Apalachicola drainage basin. Means (1977) listed 52 species of mammals found in the drainage basin, which includes caves, uplands, floodplain, and barrier islands. While many of these species are found in the Apalachicola basin, not all are found on the floodplain. The American beaver and river otter probably utilize the river and tributaries of the floodplain more than any other mammal. Other significant mammals expected in the wetter portions of the floodplain, such as the tupelo-cypress association and marshes include the raccoon, round-tailed muskrat, mink, and the rice rat (Wharton et al., 1982).

Mammals that prefer the drier areas of the floodplain, characterized by the mixed hardwood association and the tupelo-cypress

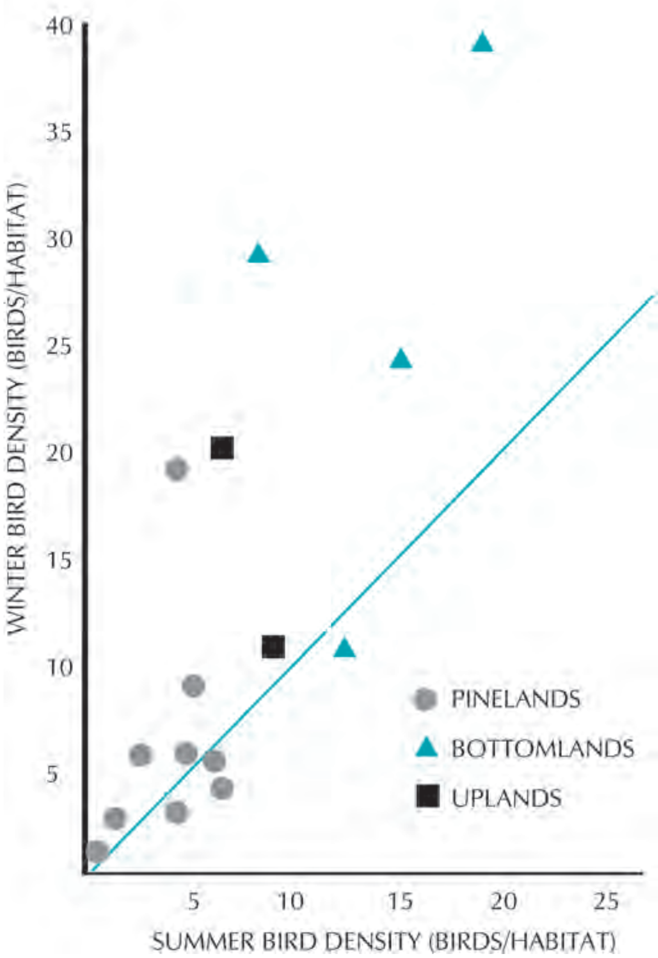



***Figure 57.*** *Distribution of birds in coastal plain habitats (modified from Harris & Gosselink, 1986)*

with mixed hardwood association, include the cotton mouse, southeastern shrew, marsh rabbit, and bobcat. Many species nest in the less inundated areas and forage throughout the floodplain. Important game mammals found in the Apalachicola floodplain include the white-tailed deer, feral hog, grey squirrel, and Florida black bear. Glasgow and Noble (1971) estimated that bottomland hardwoods have two to three times the carrying capacity of white-tailed deer than upland pine forests and almost two times that of upland hardwood forests. The grey squirrel also is known to reach its highest densities in the bottomland hardwoods (Gatewood and Hartman, 1977).

Perhaps the most important wildlife function floodplains serve today is that of providing large tracts of relatively undisturbed habitat and travel corridors that are used extensively by many species.

## Uplands

The panhandle is comprised of three principal provinces, the Northern Highlands, Gulf Coastal Lowlands, and the Marianna Lowlands (Figure 4). The entire Apalachicola Reserve is located within the Gulf Coastal Lowlands. The Gulf Coastal Lowlands are typified by flatwoods of longleaf pine, saw palmetto, wiregrass, runner oak, and gallberry, interrupted frequently by poorly drained depressions and stringers of pond cypress, blackgum, sweetbay, and titi (Clewell, 1977). This area is also noted for numerous, small but botanically interesting savannahs (Clewell, 1977; Means, 1977).

The distribution of seven generalized plant communities has been mapped by Davis (1967) and is shown in Figure 58. This map does not give accurate locations and distributions of these communities, but demonstrates their general occurrence and distribution in the Apalachicola drainage basin. Various inter-gradations between these communities may exist in a given area or at a particular point in time. Because of the diversity of the physical environment, the biota is high in species richness.

### ANERR Upland Habitats

The Florida portion of the Apalachicola drainage basin covers approximately 2,400 square miles. The boundaries of the Apalachicola Reserve cover 246,766 acres, more than half of which is open water (ANERR, 1998). Besides the barrier island uplands, which have already been described, very few uplands are within Reserve boundaries. The two primary upland habitats on the mainland within Reserve boundaries are sand pine scrub and pine flatwoods, both of which are located in the northern and eastern portions of East Bay in the Magnolia Bluff Addition (Figure 2).

### Scrub

Scrub habitat may be characterized by a dense shrub forest or dense shrub-pine forest. It is probably the least fertile and one of the most xeric plant communities in Florida. Scrub is almost entirely confined to Florida, with a few examples occurring in Alabama (Laessle, 1958). In the panhandle, scrub is common near the coast, west of the Ochlockonee River (Figure 58). Within the Apalachicola Drainage Basin, scrub occurs on dunes and beach ridges near the coast, with small isolated stands existing inland on relic shoreline features (Clewell, 1986). Kurz (1942) correlated scrubs and other vegetation types with coastal landforms throughout Florida, including in Franklin County.

Scrub contains fewer species than some of the more mesic and hydric communities. There are between 15-30 species in a given stand, not including invading species in disturbed areas or transition zones between adjacent communities (Clewell, 1986). Sand pine and slash pine are the overstory species of scrub; however, they will generally not occur together. Sand pine dominates the most xeric sites, and slash pine may be found on these dry sites or may be found in the more mesic areas (Clewell, 1986). Sand pines grow in very dense stands forming a closed overstory. Slash pines, however, tend to grow in open stands with an open canopy.

Clewell (1986) recognized three scrub communities: the coastal scrub community, the sand pine community, and the slash pine

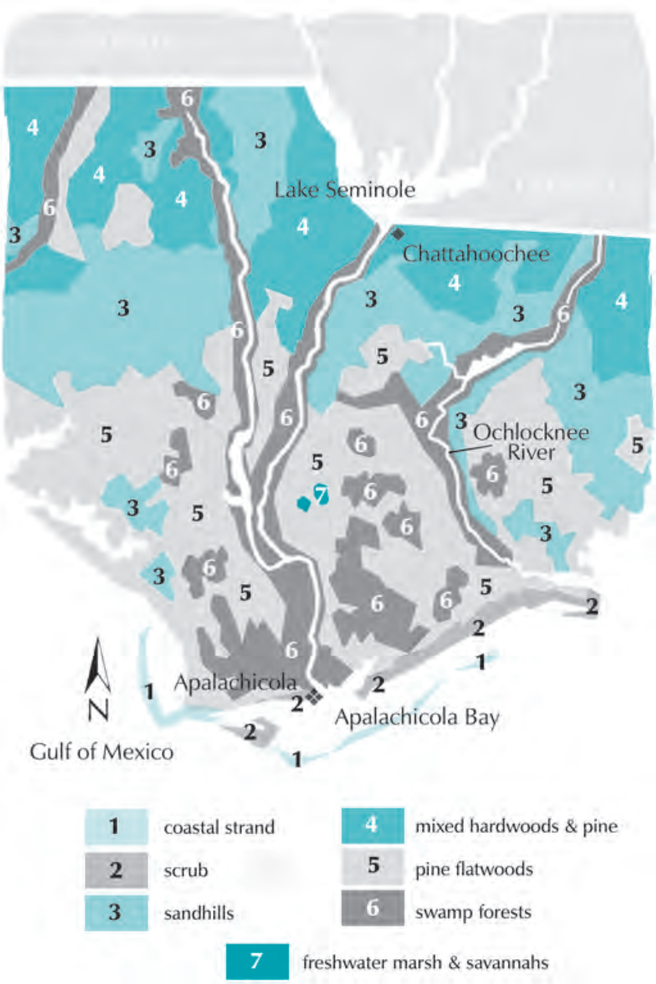



***Figure 58.*** *Natural vegetation of the Apalachicola basin (Davis, 1967)*

scrub community. An overstory is lacking in the coastal scrub community, although sand pines or slash pines may be widely scattered. The understory is usually 3-5 feet tall although some species may attain a greater height. The coastal scrub community contains fewer species than other scrub communities. Myrtle oak and sand live oak are the dominant species with rosemary also being commonly observed.

Approximately 400 acres of sand pine scrub exist on the eastern side of East Bay (Figure 2). Within Franklin County, sand pine scrub occurs on dune and beach ridges near the coast with small isolated stands existing inland on relic shorelines. A dense stand of sand pine forms the overstory while the understory is usually limited to myrtle oak, sand live oak, and rosemary. There is usually little or no herbaceous ground cover and little or no organic matter in the upper soils (Clewell, 1986).

The slash pine scrub communities often occupy interdunal swales between beach ridges. In many instances, slash pine communities are referred to as slash pine flatwoods. Scrub occurring along the coast is constantly subjected to salt spray and wind. Along the Gulf Coast, sand live oak and other woody plants of scrub appear as if wind-sheared. Along portions of US Highway 98, the coast road, this is quite noticeable. The crowns are sloping with the tallest part of the crown away from the bay. The vegetation is also somewhat stunted in growth and the crowns of the oaks and pines are brown, appearing dead. This is especially apparent after hurricanes.

Scrub is a fire dependent and a fire maintained community. However, scrub burns infrequently and has been labeled a “fire fighting association” because fires burning in adjacent vegetation rarely penetrate the scrub (Myers, 1985). When sand pine scrub does burn, it is usually during severe burning conditions and high fuel loads (Myers, 1985). Sand pines are intolerant of fire and are generally killed by the intense heat; however, they have serotinous cones and depend on fire for reseeding the stand.

Because scrub occurs almost exclusively in Florida, it often contains endemic animals, many of which are rare and endangered. However, many of the Florida scrub endemics occur in peninsular Florida. The scrub fauna of the panhandle is fairly depauperate. Wildlife species of scrub communities include the Eastern diamondback rattlesnake, coachwhip, black racer, six-lined racerunner, broadhead skink, Eastern glass lizard, slender glass lizard, Eastern mud turtle, Eastern box turtle, gopher tortoise, southern toad, oak toad, spotted skunk, loggerhead shrike, yellow-rumped warbler, and ground dove (FNAI, 1986; Means, personal communication).

## Pine Flatwoods

Pine flatwoods dominate the narrow band of uplands north of East Bay (Figure 58). Pine flatwoods are mesophytic communities characterized by one or more species of pine as the dominant tree species. Mesic flatwoods are the most widespread community in

Florida comprising 30-50 percent of the uplands (FNAI, 1986), and occurs most frequently in areas with flat topography (marine terraces) (Monk, 1968). Flatwoods are abundant and widespread throughout the panhandle and are particularly common in the Coastal Lowlands (Clewell, 1986). Wet flatwoods or boggy flatwoods are particularly characteristic of the Tates Hell region of Franklin County (Clewell, 1986).

Slash pine usually dominates pine flatwoods in this area. The slash pine-scrub community usually grades into pine flatwoods that tend to occur on poorly drained or wet sites. The major associates include a dense understory of fetterbush, saw palmetto, gallberry, maleberry, and large-flowered staggerbush (Cape St. George). Palmettos form a more dense cover than in the scrub communities. Minor associates include sundew, St. John's-wort, mint, blueberry, and huckleberry. Pine flatwoods bordering salt marshes take on a tall understory of live oaks and occasional cedars and cabbage palms (FDNR, 1983).

Slash pine flatwoods dominate poorly drained sites and occur in low spots surrounded by longleaf pine flatwoods, around flatwoods ponds, in narrow belts around the edges of bayheads or swamps, and over rather extensive areas of wet soils marked by the presence of pitcher plants or crayfish burrows (Hubbell et al., 1956). The more acidic, poorly drained sites are dominated by pond pine flatwoods. They occur in extremely flat areas, always at a slightly lower level than bordering areas of longleaf pine flatwoods. Pond pine flatwoods are stressed by an excess of water and tend to have the lowest diversity of the three flatwoods communities (McDiarmid, 1978). Pond pines are usually scattered, with large areas of fetterbush. Herbaceous vegetation is scarce (Hubbell et al., 1956).

The soils of flatwoods are moderately to poorly drained. They consist of acidic sands, with a moderate amount of organic matter in the upper few centimeters, and generally overlying an organic hardpan at depths of 1-3 feet (Harper, 1914; Hubbell et al., 1956; Snedaker and Lugo, 1972). This hardpan reduces the percolation of water below and above its surface. During the rainy season, water may stand in these areas, and in the dry season plant roots may have trouble penetrating the hardpan layer. Pine flatwoods are associated with and grade into wet flatwoods, scrubby flatwoods, dry prairies, titi swamps, bayheads, and sandhills.

The frequency and intensity of fire is one of the major controlling agents in terms of flatwood succession toward some other community type. Nearly all plants and animals inhabiting these communities are adapted to frequent fires and are dependent on them for their continued existence. The elimination of fire in slash pine flatwood communities allows succession to proceed towards mesophytic mixed hardwood communities. In the absence of fire, wetter slash pine flatwoods and pond pine flatwoods succeed towards bayhead communities (Monk, 1968; Snedaker and Lugo, 1972).

Flatwoods, depending on successional stage and management activities, generally have a high diversity of wildlife populations. Not only are flatwood communities important for wildlife, but the ecotones, or boundaries between flatwoods and associated communities, are used extensively by various animals. Flatwoods and ecotones surrounding them provide an extensive source of wildlife food, nesting, and escape cover. Animals characteristic of flatwood communities include black bear, white-tailed deer, raccoon, bobcat, fox, opossum, striped skunk, cotton rat, cotton mouse, black racer, pine warbler, red-shouldered hawk, southeastern kestrel, oak toad, and chorus frog.

**Adjacent Upland Habitats**

Although few uplands are within the boundaries of the Reserve, large tracts of uplands and isolated wetlands surround the aquatic and wetland areas within the Reserve. Many of these habitats are sensitive or unique environments found in few other areas of the United States. These private tracts are also where land use changes that could affect the natural resources of the river and bay are occurring. Therefore, it is important to be aware of and knowledgeable about these habitats, their characteristics, and the wildlife associated with them.

**Mixed Hardwoods**

Mixed hardwood forests range from being nearly xerophytic to nearly hydrophytic communities containing a variety of mixed deciduous and evergreen upland hardwoods. These forests are well developed and generally have closed canopies. In the panhandle, hardwood forests originally were restricted to riverine habitats and occasionally to protected habitats along the coast and around some lakes and sinks (Clewell, 1986). However, with fire protection and other human disturbances, hardwood forests have spread into other areas and habitats (pine communities).

Moisture, fire frequency, and the availability of nutrients account for the variations in species composition between communities. Broad-leaved hardwoods are usually the dominant species of hardwood forest; however, conifers (pines, cedar) or cabbage palms may dominate some stands. Evergreen and tardily deciduous species are usually present and sometimes more abundant than deciduous hardwoods (Clewell, 1986). Xeric sites tend to be dominated by evergreens, and the mesic and hydric sites tend to be dominated by deciduous species. Southern mixed hardwood forests may contain a minimum of 71 tree species from 30 families. A few of these range throughout the community type, lending floristic continuity, whereas others are restricted to specific environmental situations (Monk, 1968).

The wildlife present in mixed hardwood forests varies with the successional stage of the forest. Animals characteristic of early succession forests include broadly adapted generalists such as cottontail rabbit, quail, and bobcat. More narrowly adapted species like the pileated woodpecker, turkey, and grey squirrel are typical of later successional stages (Gatewood and Hartman, 1977). Other animals characteristic of hardwood forests include the grey rat snake, coral snake, rough green snake, red-bellied snake, box turtle, Eastern glass lizard, broadhead skink, ground skink, slimy salamander, green anole, grey tree frog, bronze frog, wood rat, cotton mouse, grey fox, shrew, moles, white-tailed deer, barred owl, red-bellied woodpecker, and woodcock (FNAI, 1986).

**Titi Swamps, Bayheads, Shrub Bogs**

Titi swamps, bayheads, and shrub bogs share similar community characteristics and are classified as acid swamp communities by Clewell (1986). These communities are widespread throughout the drainage basin, occupying depressions within pine flatwoods and grass-sedge bogs. Moisture, fire frequency, and disturbances affect the abundance and distribution of these three communities. Titi swamps, bayheads, and shrub bogs are usually but not always distinct from one another. They differ somewhat in their distribution, soil moisture, and species composition.

Titi swamps occur as strands or depressions in flatwoods or along the borders of some alluvial swamps in north Florida. Broadleaved shrubs and small trees comprise the principal element of the vegetation. The vegetation is usually very dense. At least one of the three species of titi (black titi, swamp cyrilla, little-leaf cyrilla) will be present and dominant. Their presence, dominance, and distribution varies between stands. The water table of titi swamps is generally near the surface except during droughts. Therefore, the soils are generally saturated but are not inundated for long periods of time after rains. Fire frequency is variable but usually does not exceed 20 years. Fires generally do not occur except under extreme burning conditions (drought, high winds, and low humidity).

Bayheads or bay swamps occur in shallow depressions, particularly in pine flatwoods and are usually dominated by broad-leaved evergreen trees. Typical species include sweetbay, swamp bay, and loblolly bay. Sweetbay is usually present and is the dominant overstory species except when slash pine is present. Slash pine may be dominant and sometimes forms a semiclosed canopy. The water table of bayheads is within about four feet of the soil surface at all times (Clewell, 1971). The soil is moist and generally wetter than those soils supporting titi swamps. Bayheads have a fire frequency of about 15 to 50 years (Clewell, 1986).

Shrub bogs usually do not have a well-defined understory or overstory. The trees and shrubs may be dense or they may form rather open canopies. The vegetation of shrub bogs may consist of various combinations of species found in titi swamps and bayheads. Open stands contain a distinct ground cover, often with sedges dominating. They probably burn more frequently than most acid swamps. The soils of shrub bogs are often saturated but are usually not saturated for long periods of time. However, they may be inundated for longer periods of time where they occur in shallow sloughs or stringers. The fire frequency of shrub bogs is about 5 to 20 years (Clewell, 1986).

Titi swamps, bayheads, and shrub bogs support various wildlife populations. Animals use these communities for refuge and cover, but other than reptiles and amphibians few are permanent residents. Transient animals include raccoon, deer, hog, bear, wood ducks, and others.

**Cypress Swamps**

Cypress swamps are characterized as shallow, forested wetlands, which have water at or just below the surface of the ground, and are dominated by either pond cypress or bald cypress. These swamps may be located along stream or lake margins. They may also be interspersed throughout other habitats, such as flatwoods and savannahs, where they may be represented as circular depressions called domes or heads. Cypress swamps located along shallow drainage systems are referred to as strands or sloughs.

Pond cypress and bald cypress are the dominant overstory species present in cypress swamp communities; however, they generally do not occur together. Soils of cypress swamps are composed of peat that is usually thicker towards the center of the dome. Clay pans or lens are present in some cypress swamps, which help to retain water levels. They also prevent these swamps from serving as recharge areas for the aquifer. Water in cypress domes and ponds is usually from surface runoff. Water levels fluctuate above and below the soil surface. High water marks may reach four feet, and during dry periods, the soil may be so dry that it cracks (Clewell, 1977).

Fire is important in maintaining cypress swamps. Hardwood invasion and peat accumulation would result without periodic fires and cypress domes could succeed to bottomland forests or bogs. Fire frequency is dependent on hydroperiods and the frequency of fire of surrounding habitats. It is greatest at the periphery of the dome and least in the interior where longer hydroperiods and deep peat accumulations occur. The fire cycle may be as short as three to five years along the outer edge and as long as 100 to 150 years towards the center (FNAI, 1986). Cypress is tolerant of light surface fires but will be killed by peat fires.

The fauna of cypress swamps is not well studied; however, they are important habitats for a variety of species. Species found will vary between those ponds with permanent standing water and those that are seasonally inundated. Bullfrogs and newts tend to utilize permanent bodies of water for breeding, while toads and most salamanders tend to utilize temporary bodies of water. Fish such as the mosquitofish, killifish, pygmy sunfish, and other small minnows, are commonly found in those ponds with permanent bodies of water (Wharton et al., 1977). Many insects also use cypress ponds for various stages of development. There are very few permanent residents of cypress swamps; however, large aggregations of salamanders, frogs, insects, and birds may be observed during their breeding seasons. Many of these species are common residents of surrounding flatwood communities. Cypress swamps also provide valuable nesting and feeding habitats for ospreys, eagles, and wading birds. During drought periods, cypress strands may be the only source of water for many animals. Typical animals found in cypress swamps include the wood duck, swallow-tailed kite, Mississippi kite, great-crested flycatcher, woodstork, alligator, snapping turtle, mud turtle, stinkpot, Eastern mud snake, cottonmouth, barred owl, prothonotary warbler, and pileated woodpecker.

**Savannahs**

Savannahs are low energy wetlands consisting mainly of grasses, sedges, orchids, insectivorous plants, and an abundance of wildflowers. Savannahs are found in areas with little relief. They have a limited distribution in the Apalachicola River basin in Liberty, Calhoun, and Franklin counties. It may be that the community is restricted largely or entirely to the lower Apalachicola River watershed (Clewell, 1986).

The soils of these habitats tend to be wetter than surrounding pine flatwoods and some bays and are also poorly aerated. Fires are frequent and eliminate litter that accumulates. Nutrient cycling is dependent on the organisms present and on the frequent release of nutrients by fire (Folkerts, 1982). With fire suppression, succession is towards mixed-pine hardwood forest communities.

Savannahs have very little defined overstory and understory. An occasional isolated slash pine may occur on sandy knolls within the savannah. Other trees and shrubs, if present, will be widely scattered. Pond cypress, blackgum, sweetbay, and titi of bays and shrub bogs, may be found along the edges of savannahs. St. John's-wort is the only shrub of significance. The ground cover usually consists of wiregrass, sedges, and other herbs. Wild flowers such as colic-root, grass-pink, coreopsis, white-tops, leopard lily, snowy orchid, rose pogonia, milkworts, meadow-beauty, coneflower, marsh pink, pitcher plants, yellow-eyed grass, and crow poison can also be found.

Except for the insect species associated with pitcher plants of the genus *Sarracenia*, the fauna of the bogs is poorly known. Pitcher plants have special adaptations that allow them to entrap, detain, and digest prey. The plants contain a decomposing mass of entrapped prey that is a potential food source for other organisms (Folkerts, 1982). The pools of water within bog Savannah communities are important habitats for the larvae of the pine barrens tree frog (Means and Moler, 1979). Ants and earthworms are common in those communities with normal cycles of moisture and fire. Burrowing crayfish are common and are important in redistributing leached nutrients to the surface.

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# Chapter Five

# Biological Components of the Apalachicola NERR

The uniqueness and productivity of the biological resources of the Apalachicola River and Bay System as well as its surrounding uplands are difficult to describe fully in a document such as this. Chapter 4 addresses the dominant habitats found within and adjacent to the Reserve and briefly describes the primary plant and animal communities associated with those habitats. This chapter is intended to provide information on some of the more important groups or components that make up the biological resources of the area. It is not intended to be all-inclusive, but rather a description of the more important groups and what is known about them. Information about some of these groups has already been presented in Chapter 4 and will not be repeated here.

## Microbial Community

Various species of microorganisms (bacteria, fungi, microalgae, and protozoans) are found in the habitats of the Reserve and play a key role at the base of the food chain by initiating the breakdown of detritus. Some of this detritus is autochthonous (originates within the bay and estuary), however the majority is allochthonous (primarily plant debris swept downstream by the river from uplands and floodplain forests upstream). The colonization and subsequent decomposition of leaf litter detritus by microorganisms produces particulate organic matter that is digestible by many complex organisms. Typically the detritus is colonized initially by simple bacterial populations followed within weeks by a more complex mix of detrital microflora such as bacteria, fungi, and algae (Morrison et al., 1977; Bobbie et al., 1978). The effect of light on the biomass and community structure of the microbiota, especially on the presence of diatoms has been documented (Bobbie et al., 1981). Examples of consumers of decomposing leaf litter as well as consumers of the microorganisms found on plant detritus include crabs, amphipods, isopods, decapods, shrimp, polychaetes and oligochaete worms, and oysters (Livingston et al., 1976; Smith et al.,1982; Livingston, 1983). Controlled experiments with oysters from Chesapeake Bay have demonstrated an increase in the amount and efficiency of nutrient uptake by oysters when they are in the presence of both bacteria and detrital matter taken from Chesapeake Bay waters (Crosby et al., 1990). The profound effects of epibenthic predators on the microbiota of estuarine mud-flat communities has also been demonstrated in Apalachicola Bay (Federle et al., 1983).

Studies have been performed on the microorganism colonization rates and preferences for the more common leaf litter found in the bay (Morrison, et al., 1977; Bobbie et al., 1978; White et al., 1979). The types of litter studied include pine needles (*Pinus elliottii*), oak leaves (*Quercus virginiana*) and sweet gum leaves (*Liquidamber styraciflua*). Sweet gum leaves have the most rapid decomposition time of the three leaf types and are preferentially colonized by microorganisms. Oak leaves rank second in decomposition rate and colonization preference. Pine needles exhibit a decomposition rate comparable to oak leaves. Oak leaves have been studied with electron microscopy to determine stages of microbial colonization. Bacteria are the early colonizers of oak leaves, followed by fungi at about four weeks. At five and six weeks microalgae, diatoms, and spirochetes are present on the oak leaf litter (Morrison et al., 1977). Complete leaf decomposition may take six months or longer depending upon species. Nitrogen and phosphorus are released completely from the leaf during the first month of decomposition while carbon release occurs throughout decomposition. Dry conditions significantly increase the time required for leaf decomposition, thereby slowing available nutrient release to the rest of the estuarine system (Elder and Cairns, 1982).

*Vibrio* species are naturally occurring microorganisms in Apalachicola Bay and estuarine systems as well as marine waters worldwide. Some of these species, particularly *Vibrio cholera* and *Vibrio vulnificus* are capable of causing wound infections, gastrointestinal ailments (gastroenteritis), and blood stream infections (septicemia) in humans. *Vibrio*-induced gastroenteritis and septicemia are more common in individuals with certain predisposing health conditions and may affect these persons after consumption of raw oysters (Motes et al.,1983; Hackney and Dicharry, 1988). Oysters accumulate *Vibrio* species, as well as other bacterial and viral species, in their tissues while filtering the bay water for nutrients. Icing of oysters at time of harvest (Cook, 1994) in addition to refrigeration or icing during transport and shucking help limit additional growth of *Vibrio* that may be present in the oyster meat.

*Vibrio cholera* is found throughout Apalachicola estuarine waters and sediments. *V. cholera* has also been detected in oyster meat sampled from Apalachicola Bay (Williams and LaRock, 1985; Motes et al., 1983; DePaola et al., 1984; Hood et al., 1981). Samples of oyster meat from which *V. cholera* was detected were collected from sites with no prior history of fecal contamination and from areas of the bay where coliform levels were within National Shellfish Sanitation Program shellfish harvesting limits (Hood et al., 1981; Williams and LaRock, 1985). However, the greatest concentrations of oyster meat with associated *V. cholera* were obtained from prohibited shellfish harvesting waters. Approved shellfish harvesting waters exhibit the lowest number of oyster meat samples with associated *V. cholera*. It has been speculated that *V. cholera* may attach to chitinous plankton ingested by oysters. *Vibrio cholera* has been isolated from plankton in Chesapeake Bay, but not from Apalachicola Bay (Hood et al. 1983).

Concentrations of *V. cholera* in the bay waters and sediments tend to peak during late summer and fall. Temporal correlation has been noted linking high concentrations of *V. cholera* in sediment samples collected from East Hole and public health reports documenting peak incidences of *V. cholera* induced gastroenteritis during October, November, and December (Williams and LaRock, 1985). It should be noted that a more virulent strain of *V. cholera* known as *V. cholera* serotype O1 has been found in greater concentrations in river and bay water samples collected adjacent to the city of Apalachicola, from the Apalachicola sewage treatment plant, and the East Hole area north of St. George Island (DePaola et al., 1984). The illness most commonly associated with ingestion of *V. cholera* contaminated oysters is gastroenteritis.

*Vibrio vulnificus* is found naturally occurring in estuaries on the U.S. East and West coasts as well as the Gulf of Mexico (Williams, 1990). *V. vulnificus* is the causative agent of wound infections and an invasive septicemia that may have a 40-60% fatality rate. Almost all documented cases of *V. vulnificus* septicemia infection have occurred in at-risk individuals who consumed raw oysters (Hackney and Dicharry, 1988). In all cases where the harvest location of oysters implicated in fatal septicemia could be determined, the oysters were harvested from Gulf of Mexico waters. *V. vulnificus* has been recovered in the past from East Hole area waters and sediments during summer and fall months (Williams, 1990).

Benthic microbial activity, including nitrogen fixation activity and $CO_2$ production, has been investigated at two sites in Apalachicola Bay. Differences in microbial activity levels can be attributed, in part, to differences in sediment composition between the two study sites. Microbial abundance and activity levels were found to be higher at Dry Bar, a silty-clay site with 11% organic carbon content, than at Nicks Hole, a sandy site with 0.7 % organic carbon content (DeSouza, 2001). Nitrogen fixation rates during a study conducted in March and April of 2001 were found to be 10 times greater at Dry Bar than at Nicks Hole. (Harvey, 2001).

Benthic microbial $CO_2$ production was found to be higher at Dry Bar than at Nicks Hole during the period of the DeSouza study, September 2000 through April 2001. Relationships between temperature, chlorophyll content and $CO_2$ production varied between the two sites. Dry Bar microbial $CO_2$ production rates correlated directly with temperature. No relationship between microbial $CO_2$ production and chlorophyll level at Dry Bar was found, indicating that microbes at Dry Bar utilize carbon from sources other than those indicated by chlorophyll level. A direct correlation was found at Nicks Hole between microbial $CO_2$ production rate and both temperature and chlorophyll levels. It was not possible in this study to separate the effects of temperature and chlorophyll level on $CO_2$ production at Nicks Hole. Sulfate-reducing bacteria, which are anaerobic, were also found in the top centimeter of sediment at both Dry Bar and Nicks Hole (DeSouza, 2001).

## Phytoplankton

Phytoplankton, generally considered the base of the marine food web, is one of the driving forces behind the productivity of Apalachicola Bay. Apalachicola Bay receives a steady supply of dissolved and particulate organic matter, mainly from the river but also from freshwater wetlands, coastal marshes, seagrass beds and phytoplankton. Although annual phytoplankton productivity in Apalachicola Bay is comparable to that of other estuaries in the Gulf of Mexico (Pennock et al., 1999), phytoplankton is the main source of carbon in the bay (Livingston 1984). The entire bay system produces about 230,000 tons of phytoplankton carbon per year (Livingston, 1984). Many estuarine food webs are primarily supported by organic matter derived from benthic algae, epiphytic algae, and phytoplankton (Sullivan & Moncreiff, 1990; Deegan & Garritt, 1997; Moncreiff & Sullivan, 2001). In Apalachicola Bay, secondary production is primarily supported by estuarine phytoplankton productivity (Chanton & Lewis, 2002).

Phytoplankton productivity varies considerably annually and peaks during the summer (Figure 59a) (Mortazavi et al., 2000) and in lower salinity waters (Putland, 2005) (Figure 59b). This temporal and spatial pattern in phytoplankton productivity is thought to be the result of temporal and spatial patterns in growth and biomass. Phytoplankton growth peaks during summer (Figure 60a) and in lower (5 to 20 ppt) salinity waters (Figure 60b). Temperature (Eppley, 1972), light energy, and nutrient concentration limit phytoplankton growth in estuaries (Boynton et al., 1982; Grobbelaar, 1985; Monbet, 1992; Cloern, 1999). Low temperature and/or low light energy (Figure 61a) can explain the low growth rates observed during winter. Higher temperature, higher light energy, and adequate nutrient concentrations (Figure 61a, Figure 61b) can explain the peak growth rates at 26° C. The low growth rates at high temperature (>26° C), however, are thought to be the result of limiting nutrient concentrations (Figure 61b) as temperature and light energy are relatively high. Phytoplankton growth rates are highest between about 5 and 20 ppt during summer (Figure 60b) probably because average mixed layer light energy levels (Figure 61c) and nutrient concentrations (Figure 61d) are sub-optimal in low and high salinity waters, respectively, yet adequate to support higher growth rates between about 5 and 20 ppt.

The concentration of chlorophyll is typically used as a proxy for phytoplankton biomass. In Apalachicola Bay, there are no strong seasonal patterns in chlorophyll concentration (Figure 62a). Additionally, if the data are separated into winter (corresponding to November, December, January, February, March, and April) and summer (corresponding to May, June, July, August, September, and October), there are no strong patterns between chlorophyll concentration and salinity (Figure 62b, Figure 62c). In contrast, there are strong seasonal and spatial patterns for phytoplankton carbon, determined with carbon:chlorophyll ratios for Apala-

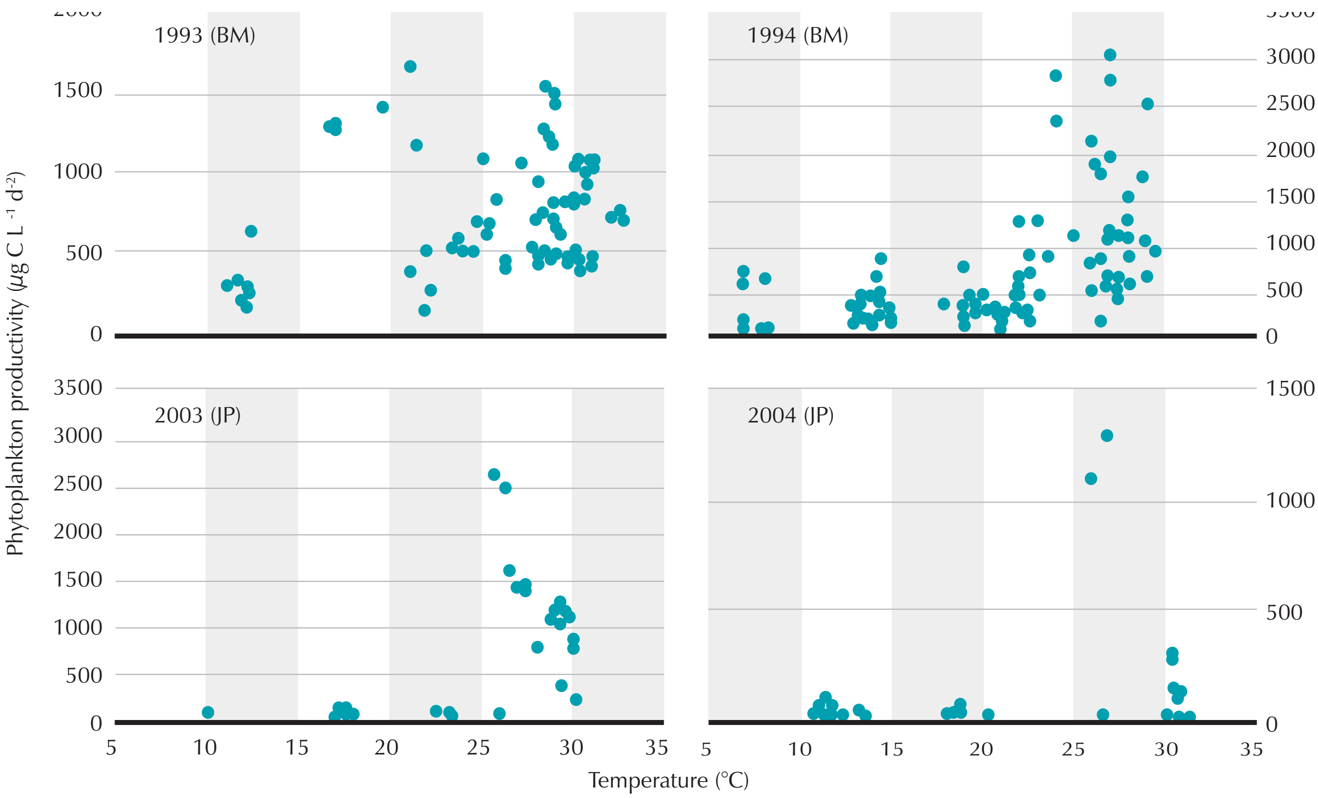



***Figure 59a.*** *Phytoplankton productivity related to surface temperature. Sources are Mortazavi (1998) (BM), and Putland (2005) (JP). Data from Mortazavi (1998) converted to daily rates assuming 9 and 12 hours of daylight during winter and summer, respectively.*

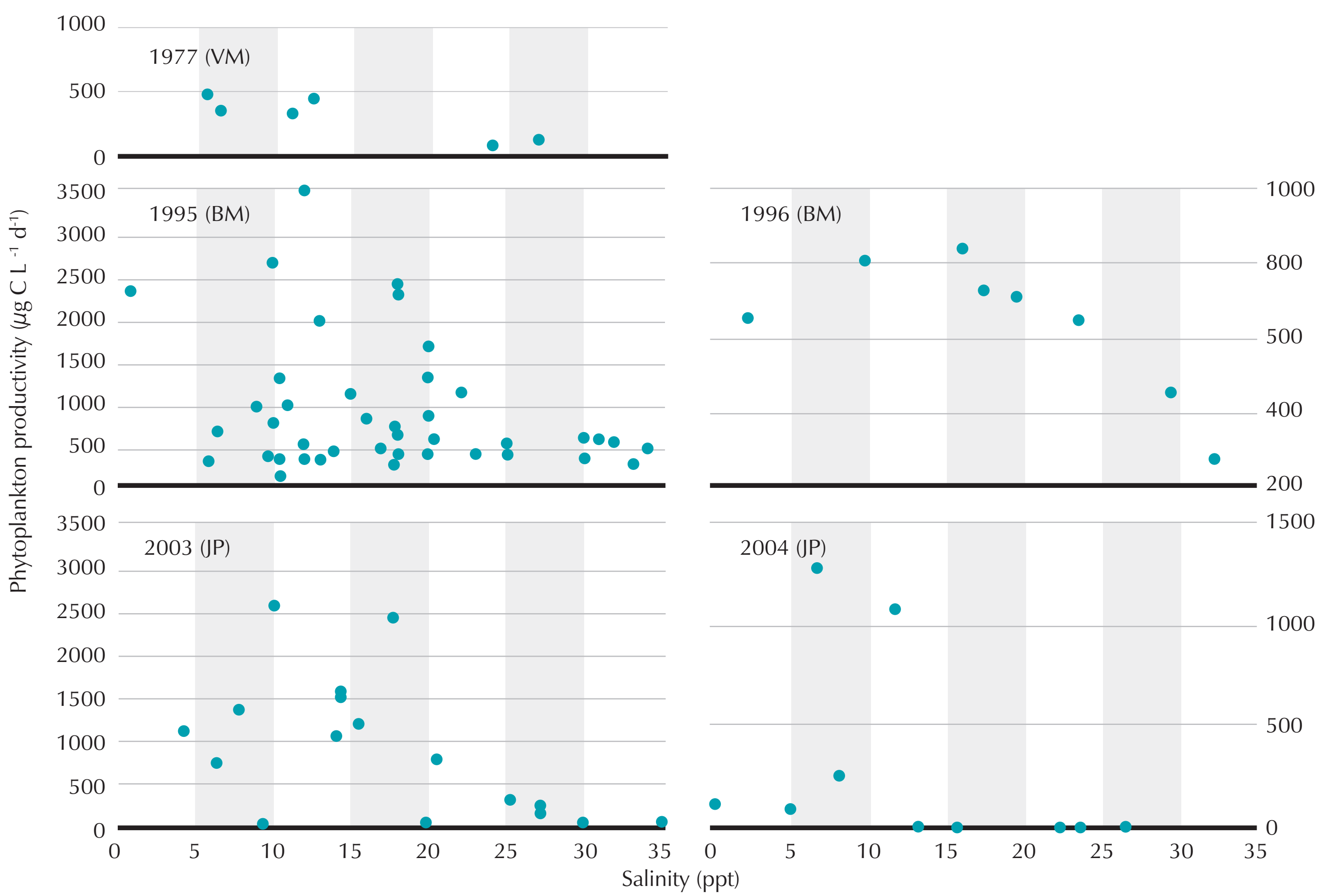



***Figure 59b.*** *Summer phytoplankton productivity related to surface salinity. Sources: Myers (1977) (VM), Mortazavi (1998) (BM), & Putland (2005) (JP).*

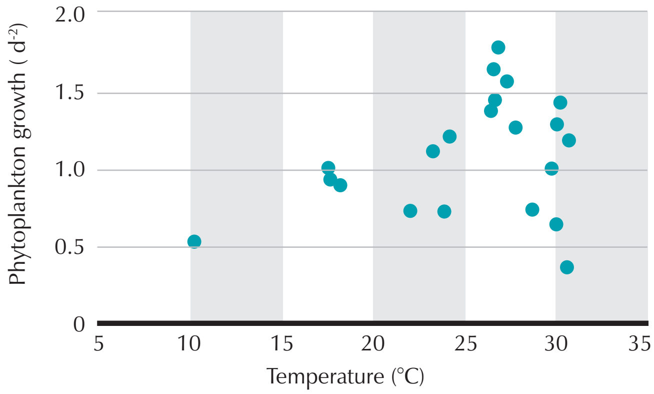



***Figure 60a.*** *Phytoplankton growth rate related to surface temperature (Putland, 2005).*

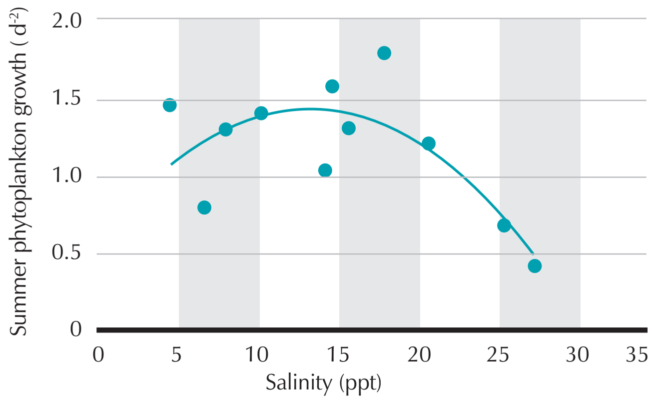



***Figure 60b.*** *Summer phytoplankton growth related to surface salinity (Putland, 2005).*

**TABLE 15**

## Dominant (*) Phytoplankton species collected in Apalachicola Bay in 1972-1973

*(modified from Estabrook, 1973)*

| | |
|---|---|
| *Chaetoceros lorenzianum* | *Thalassiothrix frauenfeldii* |
| *Bacteriasurum delicatulum* | *Biddulphia sinensis* |
| *Thalassionema nitzschioides* | *Cercaria tripos* |
| *Rhizosolenia alata* | *Lithodesmium undulatum* |
| *Nitzschia pungens* | *Bacteriastrum delicatulum* |
| *Peridinium furca* | *Pediastrum duplex* |
| *Skeletonema costatum* | *Pediastrum simplex* |
| *Melosira granulata* | *Peridinium fusus* |
| *Melosira dubia* | *Chaetoceros glandazi* |
| *Rhabdonema adriaticum* | *Guinardia flaccida* |
| *Chaetoceros decipiens* | *Rhizosolenia setigera* |
| *Coscinodiscus radiatus* | *Rhizosolenia calcar-avis* |
| *Fragilaria spp* | |

* Account for at least 10% of total numbers in any one sample.

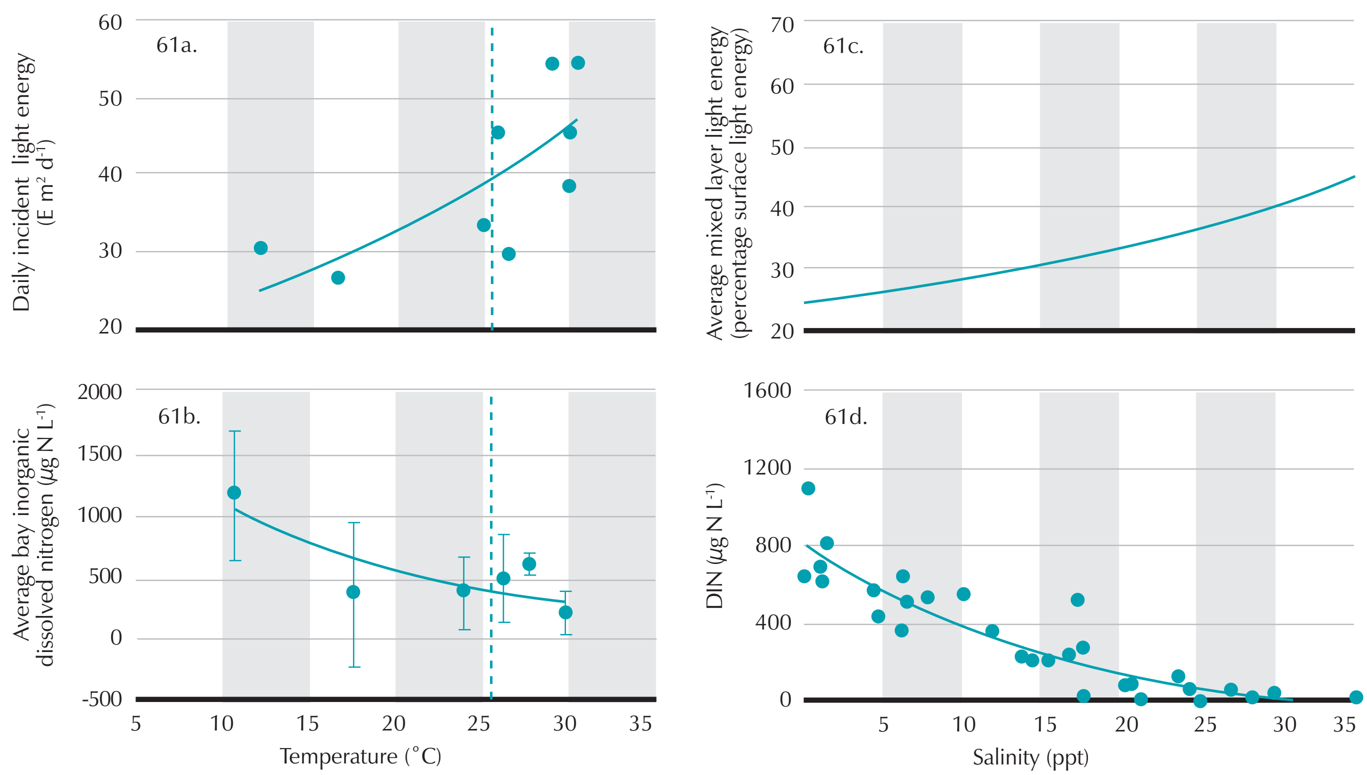



***Figure 61a.*** *Daily light energy related to surface temperature.* ***Figure 61b.*** *Average (+ S.D.) bay DIN concentration related to surface temperature.* ***Figure 61c.*** *Average mixed layer light energy related to surface salinity.* ***Figure 61d.*** *DIN concentration related to surface salinity (Putland, 2005). Dashed line demarcates winter from summer.*

chicola Bay (Putland, 2005). Like phytoplankton growth, phytoplankton carbon peaks during summer (Figure 63a) and in lower (5 to 20 ppt) salinity waters (Figure 63b). Of the carbon fixed by phytoplankton, more is allocated to the synthesis of proteins and lipids in lower salinity waters than in higher salinity waters (Putland & Iverson, 2007c). Therefore, in Apalachicola Bay the highest quantity and quality of phytoplankton occurs during summer in lower salinity waters.

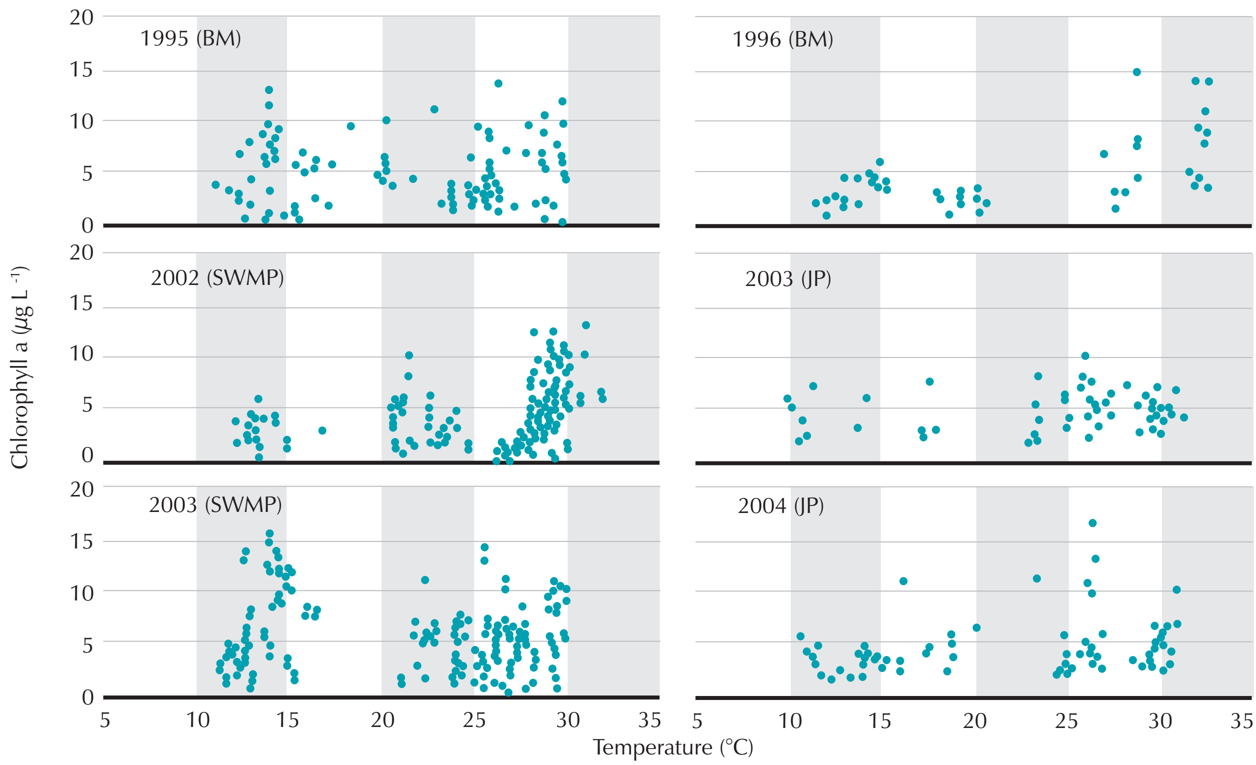



***Figure 62a.*** *Chlorophyll a concentration related to surface temperature.*
*Sources are Mortazavi (1998) (BM), Apalachicola NERR (SWMP), and Putland (2005) (JP).*

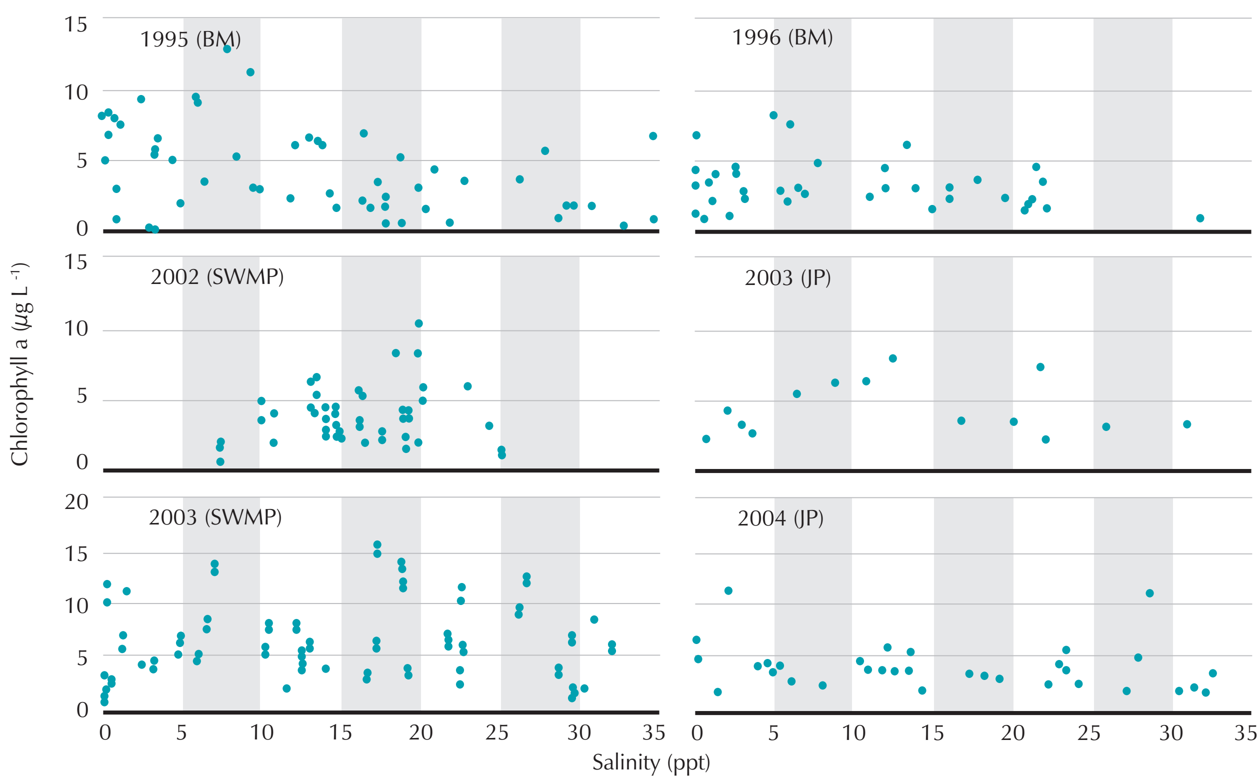



***Figure 62b****. Chlorophyll a concentration related to surface salinity during winter.*
*Sources are Mortazavi (1998) (BM), Apalachicola Bay NERR (SWMP), and Putland (2005) (JP).*

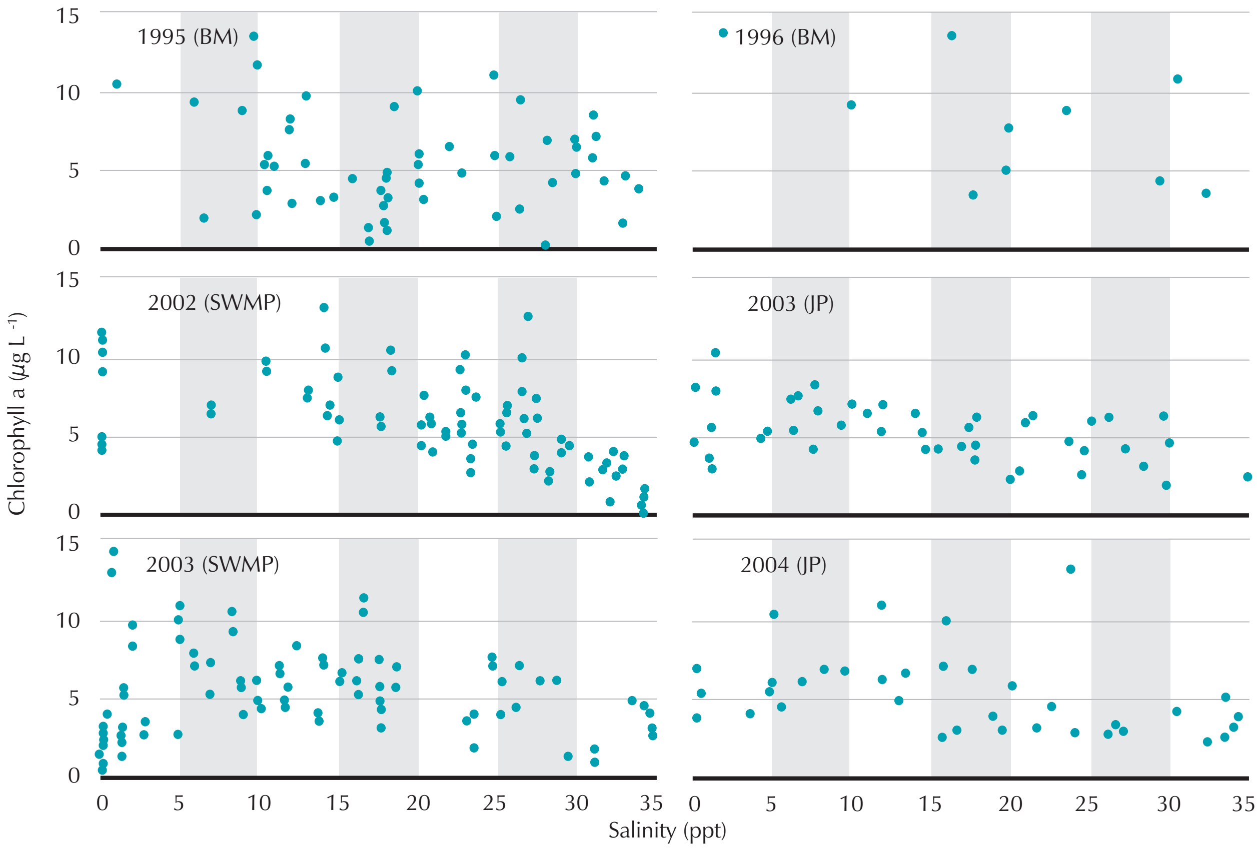



***Figure 62c.*** *Chlorophyll a concentration related to surface salinity during summer. Sources are Mortazavi (1998) (BM), Apalachicola Bay NERR (SWMP), and Putland (2005) (JP).*

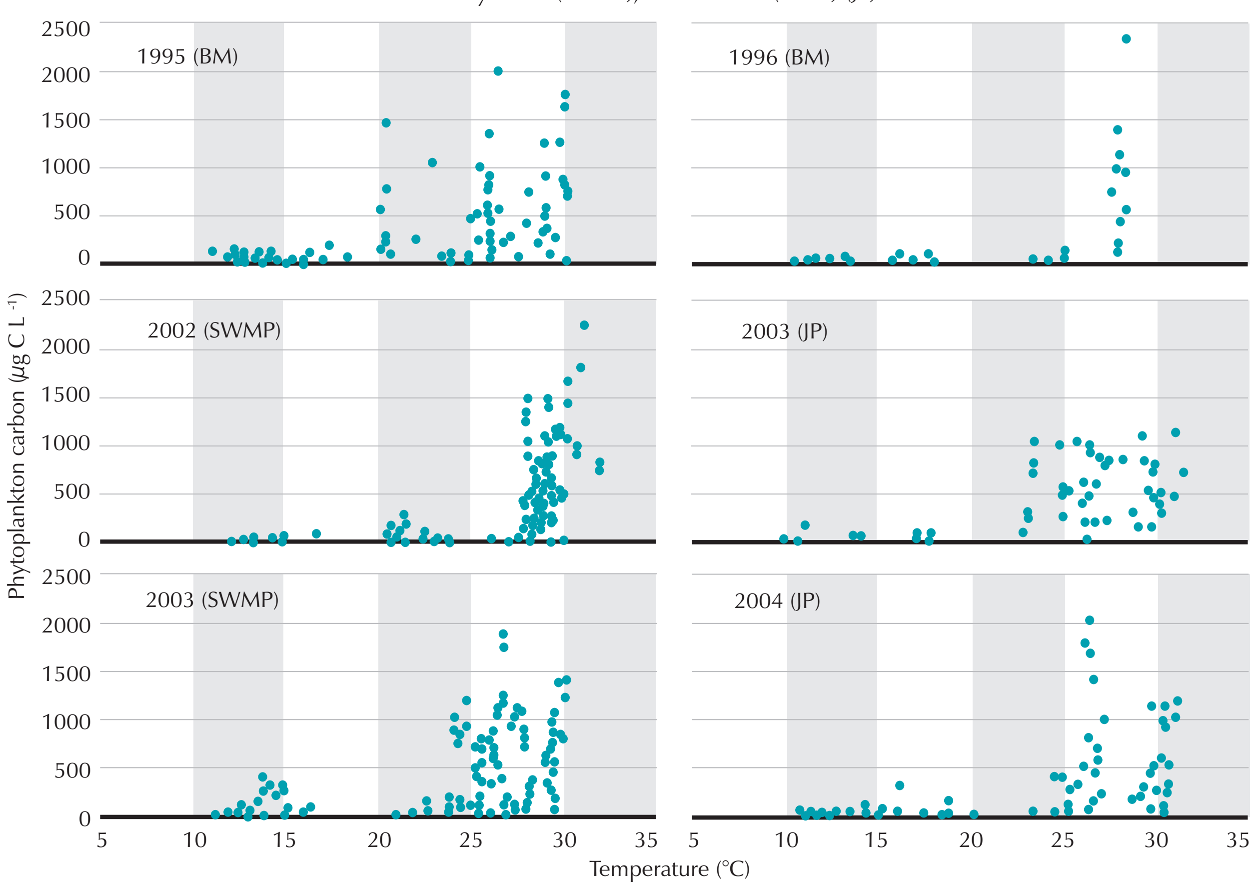



***Figure 63a.*** *Phytoplankton carbon related to surface temperature. Chlorophyll data were converted to carbon with carbon:chlorophyll ratios from Putland (2005). Sources for chlorophyll data are Mortazavi (1998) (BM), Apalachicola NERR (SWMP), and Putland (2005) (JP).*

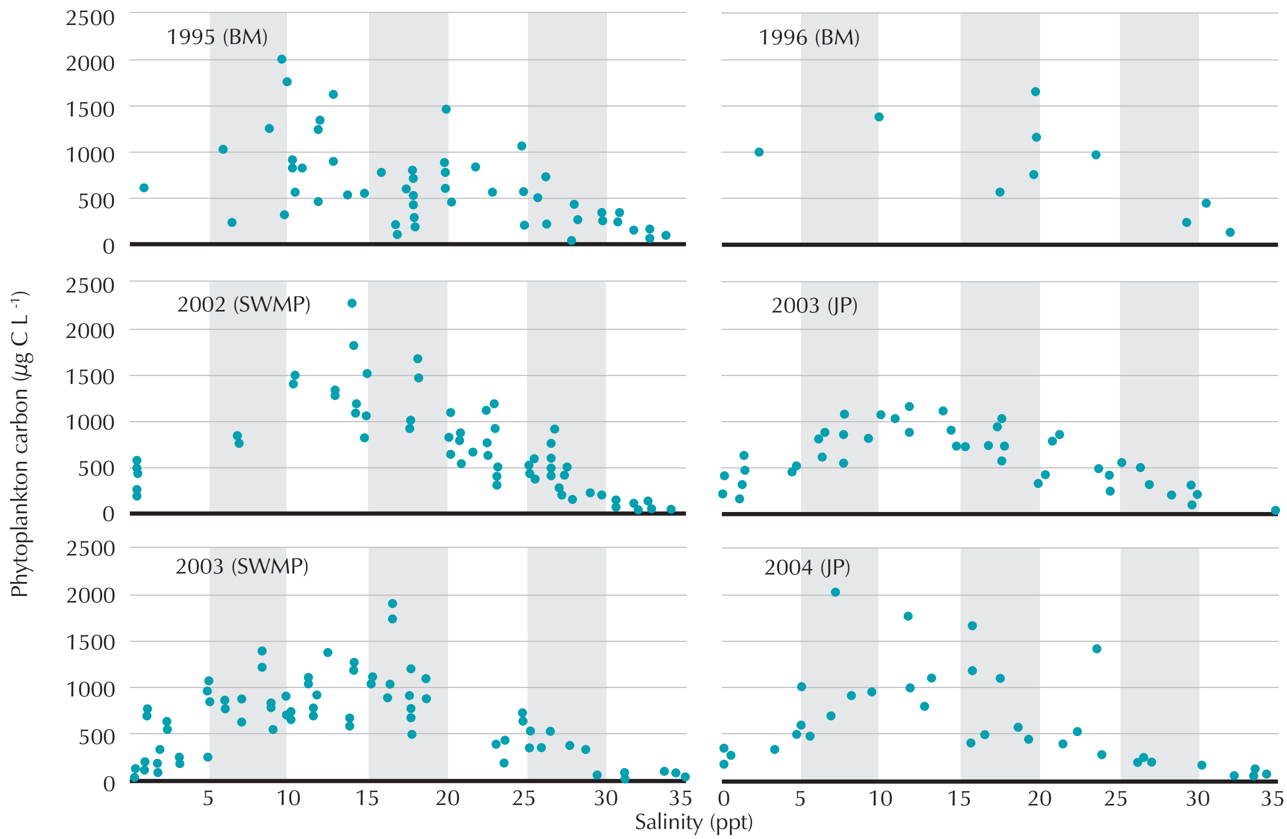



***Figure 63b.*** *Phytoplankton carbon related to surface salinity during summer. Chlorophyll data were converted to carbon with carbon:chlorophyll ratios from Putland (2005). Sources for chlorophyll data are Mortazavi (1998) (BM), Apalachicola NERR (SWMP), and Putland (2005) (JP).*

The magnitude of the phytoplankton standing stocks are the net result of growth and loss processes. In Apalachicola Bay, export and zooplankton grazing are the main loss processes influencing phytoplankton biomass (Mortazavi et al., 2000). However, zooplankton grazing is generally a more significant loss process than export (Mortazavi et al., 2000). Microzooplankton are the main planktonic herbivores in Apalachicola Bay (Figure 64a) (Putland & Iverson, 2007b). During winter, the relatively low stocks of phytoplankton are the result of low rates of phytoplankton growth coupled with microzooplankton grazing and export. Phytoplankton stocks increase during spring because phytoplankton growth peaks and is not balanced by microzooplankton grazing or export. Phytoplankton stocks decline at temperatures above 27 °C because of declining phytoplankton growth rates and microzooplankton grazing exceeding phytoplankton growth. Phytoplankton growth and microzooplankton grazing also control the spatial patterns of phytoplankton carbon during summer in Apalachicola Bay. The peak in phytoplankton carbon in lower (5 to 20 ppt) salinity waters during summer is not only the result of low export (Mortazavi et al., 2000), but also because phytoplankton growth peaks in lower (5 to 20 ppt) salinity waters and because microzooplankton consume relatively less phytoplankton in lower salinity waters than in higher salinity waters (Figure 64b).

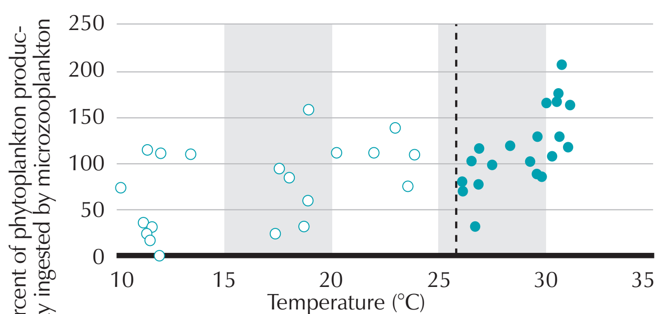



***Figure 64a.*** *Percent of phytoplankton productivity ingested by microzooplankton with respect to surface temperature (Putland, 2005). Dashed line demarcates winter from summer. Above 26°C, the percent of phytoplankton productivity ingested by microzooplankton is significantly correlated to temperature.*

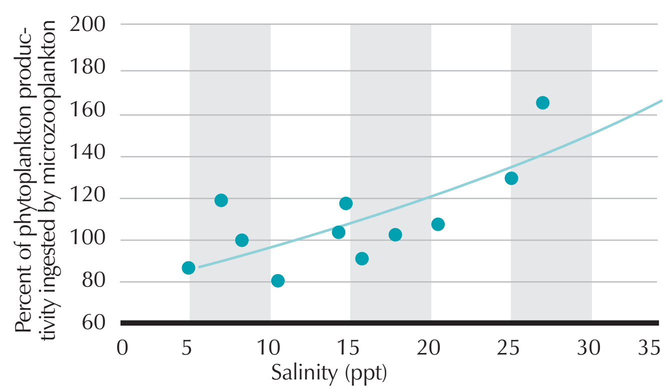



***Figure 64b.*** *Summer percent of phytoplankton productivity ingested by microzooplankton with respect to surface salinity (Putland, 2005).*

The community structure of net (>80 $\mu$m) phytoplankton in Apalachicola Bay has been studied qualitatively by Estabrook (1973). This work found that diatoms are abundant year round. Diatoms that represent a large fraction of net phytoplankton include *Coscinodiscus radiatus, Chaetoceros lorenzianum, Bacteriastrum delicatulum, Melosira granulata, Fragilaria spp., Thalassiothrix spp., Skeletonema costatum, and Rhizosolenia alata* (Table 15). More recent qualitative and quantitative work has shown that phytoplankton biomass, as carbon, is primarily composed of picophytoplankton (autotrophs between 0.2 to 2 $\mu$m in size) during the summer productive period (Putland, 2005) (Figure 65). Peak abundances of diatoms and dinoflagellates >20 $\mu$m in size occur in high (>30 ppt) salinity waters during summer. In contrast, abundances of picocyanobacteria peak between 10 and 26 ppt during summer and are about 1000 times more abundant than diatoms and dinoflagellates >20 $\mu$m in size (Figure 66).

Similar to other estuaries, phytoplankton are nitrogen-limited in higher (>20 ppt) salinity waters and phosphorus-limited in lower (<20 ppt) salinity waters (Myers, 1977; Fulmer, 1997; Putland & Iverson, 2007b; 2007c). Because of winds, tides, and the shallowness of the estuary, Apalachicola Bay is generally well mixed (Livingston, 1984). Wind mixing can alleviate phosphorus limitation (Myers, 1977; Putland and Iverson, 2007c) and therefore the estuary tends to be more frequently nitrogen-limited (Estabrook, 1973). Phosphorus limitation is most pronounced in low salinity water during summer when winds are minimal (Fulmer, 1997; Iverson et al., 1997). In other estuaries phytoplankton is often light limited in lower salinity waters (Putland & Iverson, 2007b). No studies, to date have determined whether phytoplankton are light limited in Apalachicola Bay.

Diversion of water from the watershed that feeds the Apalachicola River and increasing nutrient inputs can be expected to significantly alter phytoplankton productivity in Apalachicola Bay. The impact of nutrient pollution on phytoplankton productivity will be most pronounced during the summer. During winter, temperature and light levels are relatively low and residence time is, in general, relatively short in the estuary. Therefore, increases in nutrient input during winter are not likely to be utilized by the phytoplankton community (Mortazavi et al., 2000). In contrast, during summer, temperature and light levels are higher, residence time in the estuary is relatively longer, and phytoplankton are typically phosphorus and nitrogen limited in low and high salinity waters, respectively. Therefore, an increase in nutrient concentrations during summer months is more likely to lead to an increase in primary productivity.

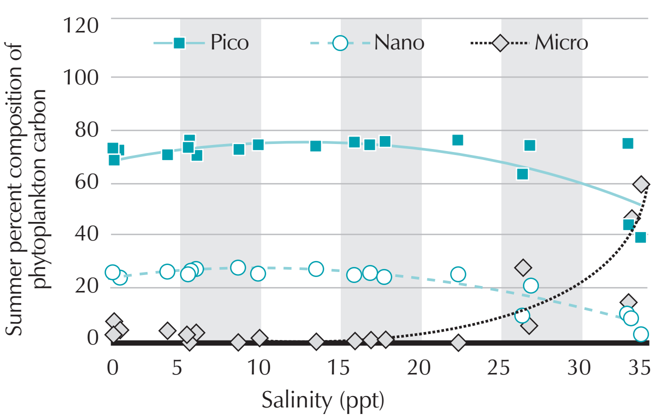



***Figure 65.*** *Percent composition of phytoplankton carbon related to size during summer (Putland, 2005).*

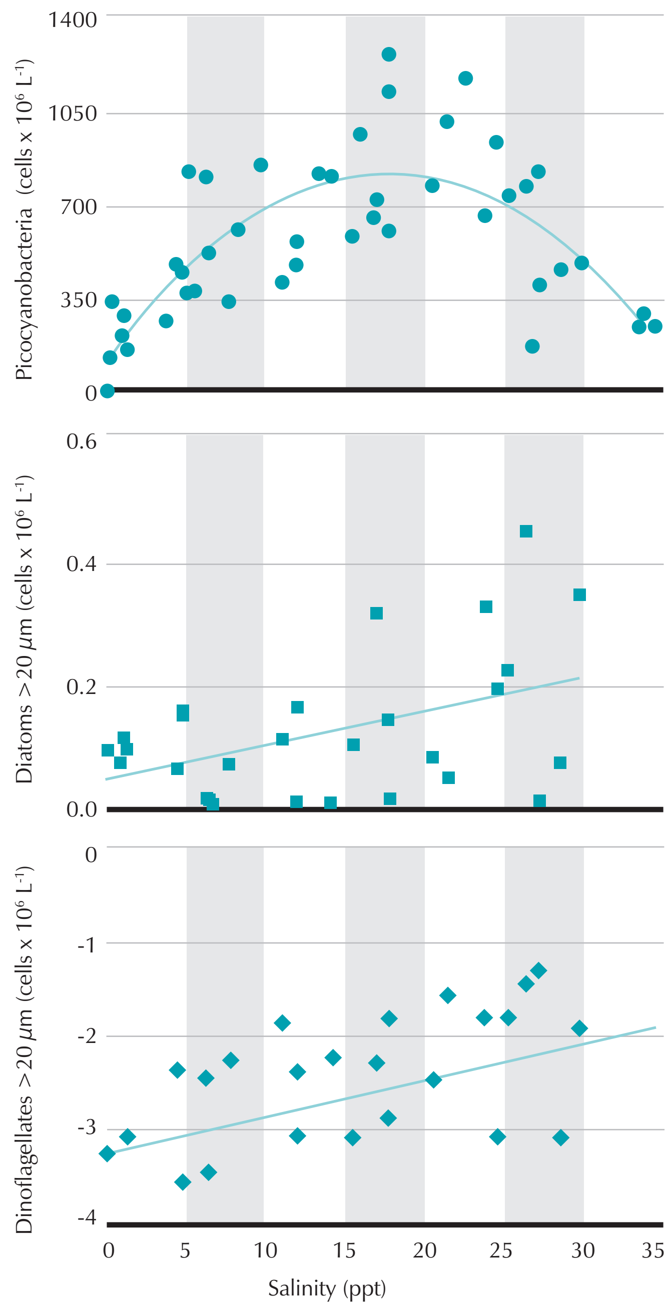



***Figure 66.*** *Abundance of picophytoplankton, diatoms >20 μm in size, and dinoflagellates >20 μm in size during summer with respect to surface salinity (Putland, 2005).*

Upstream diversion of water from the Apalachicola River during summer would reduce nutrient input (concentration) and can be expected to reduce phytoplankton productivity in Apalachicola Bay (Putland & Iverson, 2007c). Reduced river discharge will increase the areal extent of higher salinity water where phytoplankton growth, biomass, and productivity are lowest. In addition, reduced river discharge will reduce nutrient concentrations at a specific salinity and therefore reduce phytoplankton growth and productivity at a specific salinity. Phytoplankton support the food web in Apalachicola Bay (Chanton & Lewis, 2002). Significant changes in phytoplankton productivity, resulting from increasing nutrient loads or upstream water diversion, will inevitably impact higher trophic level productivity (Livingston et al., 1997).

Research in other systems also indicates the importance of benthic microalgae, in addition to other pelagic sources, to overall productivity within estuarine boundaries. These benthic colonies may not be visible or may appear as brownish or greenish films or mats on the surface of the substrate, with depth being a factor for local light penetration (Whitlatch, 1982). Organisms that probably contribute significantly to the photosynthetic input of the system are benthic diatoms, often overlooked in terms of nutritional importance within an estuarine ecosystem. Due to the minimal amount of information currently available on benthic diatoms in the Apalachicola area, this topic represents one of the research areas that warrants study.

## Zooplankton

The fate of phytoplankton in Apalachicola Bay is export to the Gulf of Mexico, burial in bay sediments, and as food for herbivores such as microzooplankton and mesozooplankton. Export and burial are generally negligible relative to zooplankton grazing (Mortazavi et al., 2000). Historically, mesozooplankton, such as copepods, have been considered the main herbivores of phytoplankton in productive waters, such as estuaries. Recent research, however, suggests that microzooplankton are the main herbivores in estuaries (Calbet, 2001; Calbet & Landry, 2004), including Apalachicola Bay. In Apalachicola Bay, *Acartia tonsa*, the main constituent of the mesozooplankton community, graze less than 10% of phytoplankton productivity. In contrast, microzooplankton graze >75% of phytoplankton productivity (Putland, 2005). Therefore, microzooplankton are not only the main sink for phytoplankton, but because phytoplankton support the food web in Apalachicola Bay (Chanton & Lewis, 2002), microzooplankton are also the main link to secondary producers.

A two-year study found significant temporal and spatial variability in microzooplankton ingestion and microzooplankton production in Apalachicola Bay (Putland, 2005). Total ingestion rates represented the consumption of phytoplankton plus bacterioplankton by the microzooplankton community. The study found that the diet of microzooplankton is primarily composed of phytoplankton, with bacterioplankton representing a significant fraction of their diet during winter in low salinity waters. Total ingestion (Figure 67) and microzooplankton production (Figure 68) peak during summer in low salinity waters. Relative to the twenty-four year average Apalachicola River discharge, the study was conducted during years with relatively high (2003) and low (2004) river discharge. The temporal and spatial patterns of ingestion and production during 2004 were the same as those during 2003. In contrast, rates of ingestion and production at a specific salinity were significantly lower during 2004 than during 2003.

A two-year study examined the temporal and spatial variability of ingestion and egg production of *Acartia tonsa* (Putland, 2005 ; Putland and Iverson, 2007a), the most abundant copepod and the main constituent of the mesozooplankton community in the Bay (Edmiston, 1979; Marcus, 1991). Total ingestion rates represented the consumption of phytoplankton plus microzooplankton by adult *A. tonsa*. Marcus (1991) found that adult *A. tonsa* have a mixed diet of phytoplankton and microzooplankton. On average, 53% and 47% of the carbon ingested was composed of phytoplankton and microzooplankton, respectively. The per capita rates of total ingestion (Figure 69) and egg production (Figure 70) were highest during summer and in lower salinity waters. The peak egg production rates during summer are thought to be the result of warmer temperatures and higher ingestion rates; whereas, the peak egg production rates in lower salinity waters are thought to be the result of higher ingestion rates and higher egg production efficiency. Peak egg production efficiency is thought to be related to the optimal salinity range of *A. tonsa* and/or improved quality of food ingested by *A. tonsa*. Marcus (1991) also studied the seasonal abundance of copepod (primarily *A. tonsa*) eggs in the bottom sediments of Apalachicola Bay, East Bay, and St. George Sound. In general, the number of eggs in sediments and the number of nauplii that emerge from sediments is greatest at lower (<26°C) temperatures and in lower (5 to 20 ppt) salinity waters. These eggs are a potentially important source of new recruits to the *A. tonsa* population.

The abundance and composition of mesozooplankton in Apalachicola Bay has also been studied (Edmiston, 1979). This work compared species distribution, diversity, and biomass between fresh water areas (East Bay), more typical estuarine salinity regimes (Apalachicola Bay), and coastal areas (offshore of the barrier islands).

As expected, salinity and temperature appear to play a major role in the population dynamics and distribution of species. Peak numbers and biomass generally follow high salinity and temperature occurrences in East Bay in spring, summer, and fall. East Bay exhibits the lowest populations as well as the widest fluctuation in numbers. Maximum riverflow, and therefore low salinities, occurs in winter and corresponds with low zooplankton numbers. In Apalachicola Bay itself, which exhibits the highest values of the three areas sampled, peak numbers and biomass usually occur when salinities

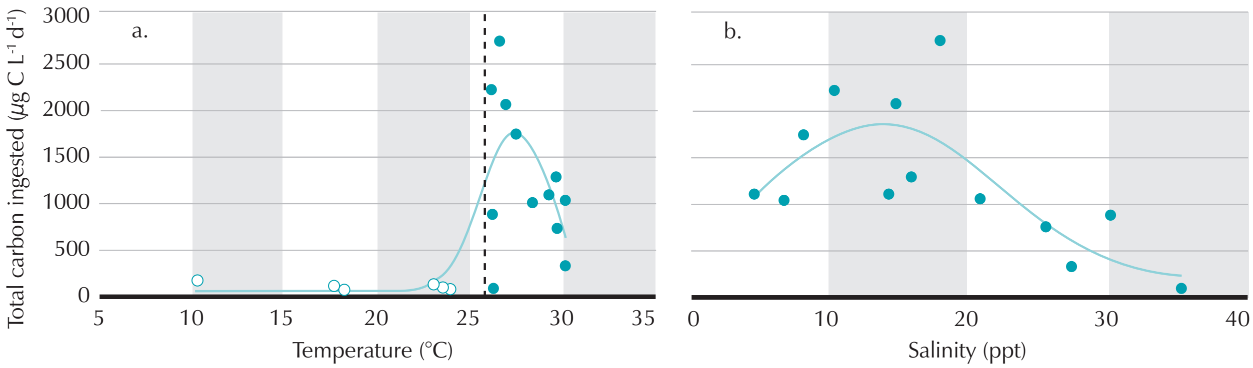



***Figure 67a.*** *Total carbon ingested by microzooplankton with respect to temperature. Dashed line demarcates winter from summer. Open symbols are winter, blue symbols are summer. Data from Putland (2005).* ***b.*** *Total carbon ingested, during summer, by microzooplankton with respect to salinity. Data from Putland (2005).*

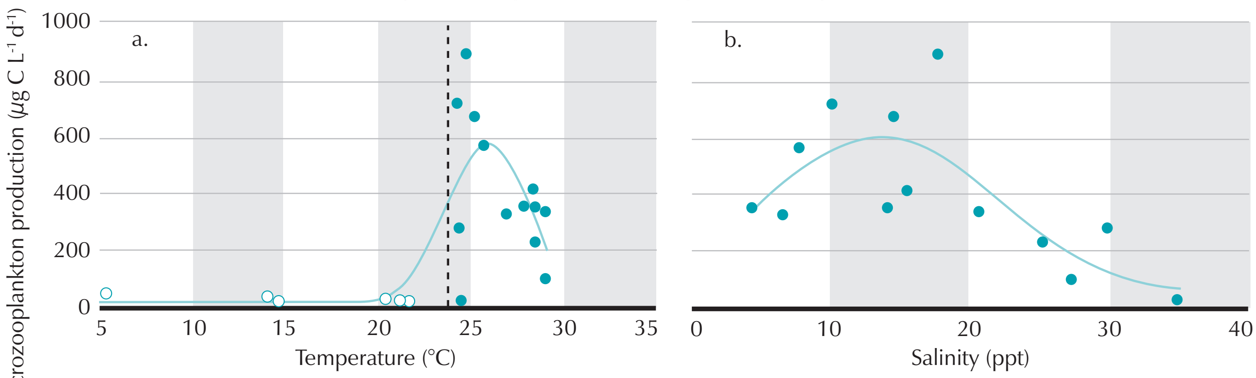



***Figure 68a.*** *Microzooplankton production with respect to temperature. Dashed line demarcates winter from summer. Open symbols are winter, blue symbols are summer. Data from Putland (2005).* ***b.*** *Microzooplankton production, during summer, with respect to salinity. Data from Putland (2005).*

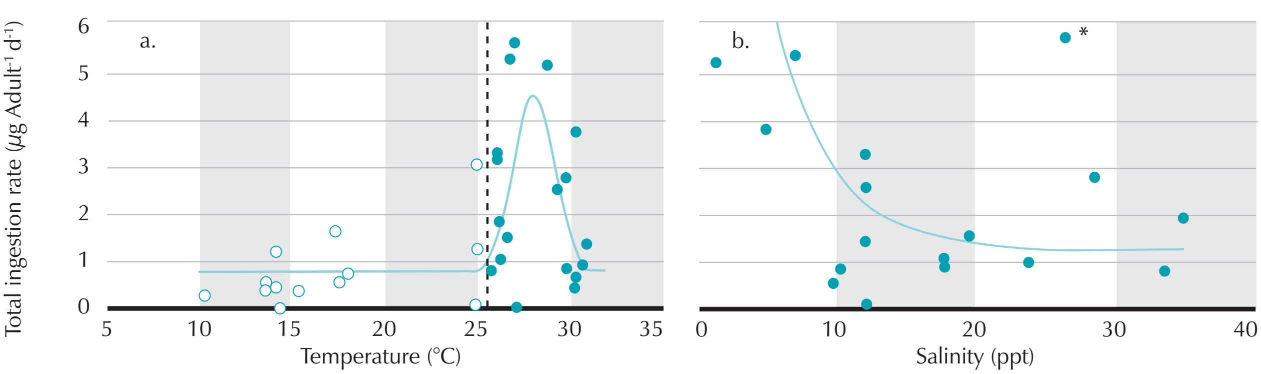



***Figure 69a.*** *Per capita total ingestion rate of adult Acartia tonsa with respect to temperature. Dashed line demarcates winter from summer. Open symbols are winter, blue symbols are summer. Data from Putland (2005).* ***b.*** *Per capita total ingestion rate of adult Acartia tonsa, during summer, with respect to salinity. Asterisk denotes data point not included in regression. Data from Putland (2005).*

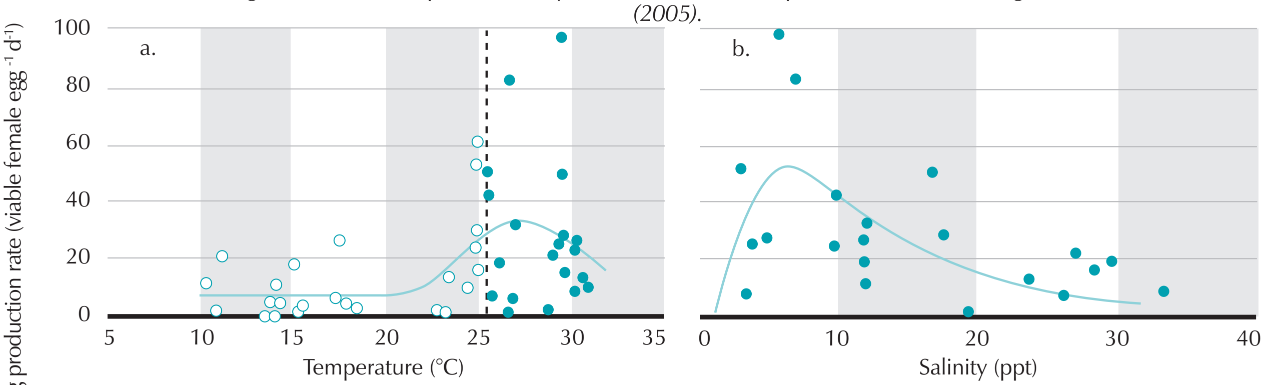



***Figure 70a.*** *Per capita egg production rate of Acartia tonsa with respect to temperature. Dashed line demarcates winter from summer. Open symbols are winter, blue symbols are summer. Data from Putland (2005).* ***b.*** *Per capita egg production rate of Acartia tonsa, during summer, with respect to salinity. Data from Putland (2005).*

are above 14 ppt and temperature is above 18°C. Low salinity, associated with flood conditions in the river, helps keep zooplankton numbers low during winter's colder temperatures. Coastal water zooplankton biomass is consistently less than Apalachicola Bay, but greater than East Bay, with highest values occurring in the warmer months (Figure 71).

As with most other estuarine studies, copepods are the main constituents of the plankton population accounting for 94%, 80%, and 71%, of total zooplankton numbers at the three areas, respectively (Table 16). The dominance of copepods generally decreases with increasing salinity, although this is not reflected when total numbers are compared. After copepods, holoplankton abundances are respresented primarily by cladocerans.

Thirty-six species of copepods have been identified from the Apalachicola Bay system with *Acartia tonsa* being the dominant species in every area. *Acartia tonsa* densities averaged over 5,500 numbers per cubic meter throughout the study and ranged from less than 100 to approximately 13,000/m$^3$. This dominance tends to decrease, however, with increasing salinity. As salinity increases the copepod population becomes more evenly distributed among the species that are present (Table 17). All copepod species tend to reach maximum abundance during the warmer months (March through October) with the exception of *Centropages hamatus*, which is a cooler water species and reaches maximum abundance in late fall and winter. Species minimums generally occur during January and February when temperature and salinity are also at their lowest values (Edmiston, 1979).

More detailed analysis of the copepod *Acartia tonsa* reveals that the density of copepod naupliar stages found are generally six to 16 times greater than the number of copepodite and adult stages. The abundance of copepod eggs in the sediments, most of which are assumed to be from *Acartia,* ranged from 77,000 to over 320,000 eggs/m$^2$. The number of naupliar stages that hatch from the sediments incubated in the laboratory for two days varied from 24,000 to over 480,000/m$^2$. This large pool of copepod eggs found in the sediments suggests that these "resting stages" may not only play a large role as a source of nauplii to the plankton population, but may also be an important source of prey items for larval fish and other species (Marcus, 1991).

Cladocerans (*Evadne* and *Podon* species), larvaceans (*Oikopleura* species), and chaetognaths are found throughout the year in Apalachicola Bay and coastal waters but are generally not found in East Bay due to the low salinities. These three groups were also more prevalent in coastal waters throughout the year than inside the bay, further illustrating their preference for higher salinity water (Edmiston, 1979).

Meroplankton generally comprised less than 10% of total zooplankton numbers, although Apalachicola Bay averaged 16% overall, except during the spawning seasons of organisms such as cirripeds (2.7-11.7%), decapods (0.8-2.8%), and molluscs (0.1-2.1%). Barnacle larvae, primarily the naupliar stage, are the most abundant group found in the meroplankton, and are found within Apalachicola Bay in the greatest numbers. Decapod larvae, primarily crab zoea, are the second most abundant group with maximum

**TABLE 16**

### Composition of the zooplankton community (in percent) by area

*(modified from Edmiston, 1979).*

| | East Bay | Apalachicola Bay | Coastal Waters |
|---|---|---|---|
| **Holoplankton** | | | |
| Copepods | 94.1 | 80.2 | 71.4 |
| Cladocerans | 0.1 | 2.1 | 14.4 |
| Larvaceans | + | 0.9 | 3.0 |
| Chaetognaths | – | 0.3 | 1.6 |
| **Meroplankton** | | | |
| Cirripedia larvae | 2.7 | 11.7 | 5.6 |
| Decapod larvae | 2.8 | 1.0 | 0.8 |
| Molluscan larvae | + | 2.1 | 1.8 |
| Polychaete larvae | + | 0.3 | 0.5 |
| Fish eggs and larvae | + | 1.1 | 0.3 |
| Other zooplankton | 0.1 | 0.4 | 0.5 |

+ < 0.1%, – Not Collected

**TABLE 17**

### Distribution of dominant copepod species in the Apalachicola Bay system (percent of total zooplankton)

*(modified from Edmiston, 1979).*

| | East Bay | Apalachicola Bay | Coastal Waters |
|---|---|---|---|
| *Acartia tonsa* | 92.5 | 68.2 | 19.8 |
| *Paracalanus crassisrostris* | + | 4.3 | 7.6 |
| *Paracalanus parvus* | – | 0.6 | 10.7 |
| *Temora turbinata* | + | 1.2 | 17.7 |
| *Oithona nana* | + | 0.4 | 6.0 |
| *Oithona colcarva* | 0.5 | 0.7 | 0.4 |
| *Psuedodiaptomus coronatus* | 0.5 | 2.7 | 0.5 |
| *Centropages velficatus* | – | 0.3 | 1.1 |
| *Centropages hamatus* | – | 0.2 | 2.0 |
| *Euterpina acutifroms* | 0.2 | 0.3 | 1.4 |
| *Corycaeus americanus* | – | 0.1 | 0.8 |
| *Corycaeus amazonicus* | – | 0.2 | 0.5 |
| *Labidocera aestiva* | – | 0.7 | 0.8 |
| *Other copepods* | 0.2 (9) | 0.3 (21) | 1.9 (10) |

+ < 0.1%, – Not Collected, (x) number of species numbers found in the spring and summer and being absent in the fall and winter. Molluscan larvae, primarily gastropod and bivalve (oyster) larvae, are found in greatest numbers in Apalachicola Bay during the summer months, although they are present throughout the year in all areas except East Bay (Edmiston, 1979).

The only other group accounting for a significant portion of the zooplankton population is ctenophorans. Ctenophores, represented primarily by *Nmemiopsis* species with some *Beroe*, are generally present throughout the year except during the fall. Maximum densities occur in Apalachicola Bay in the spring and summer (Figure 72), when their populations become so large that they interfere with accurate sampling of the plankton population (Edmiston, 1979).

Forty-two species of fish larvae and 13 species of planktonic fish eggs have been identified in ichthyoplankton surveys (Blanchet, 1979). The most abundant species found was the bay anchovy, accounting for over 75% of all larvae identified and 92% of all fish eggs collected. Bay anchovy larvae are generally found throughout the year but peak during the spring and summer, which is typical of warm water spawners (spawning at water temperature above 20$^0$C). Other warm season spawners found in abundance include silversides, skilletfish, and goby larvae. Croaker, menhaden, and spot larvae are found in abundance during cold-water periods, primarily in late fall and winter (Blanchet, 1979).

Very few studies have examined the community structure of microzooplankton in Apalachicola Bay. Protists, primarily ciliates, heterotrophic nanoflagellates, and dinoflagellates, are the most abundant constituents of the microzooplankton assemblage. Ciliates are primarily <20 $\mu$m in size and compared to other estuaries, are particularly abundant in Apalachicola Bay (Putland, 2005). Considering that microzooplankton are the main secondary producers in Apalachicola Bay, studies designed to examine the abundance and composition of the microzooplankton community and to identify the main herbivores within the microzooplankton community are needed.

## Submerged Aquatic Vegetation

Submerged aquatic vegetation (SAV) found in the Apalachicola Bay system includes fresh water, brackish water, and marine species. Seagrasses are a vital component of estuarine systems, occurring between uplands and oceanic ecosystems (Phillips, 1980) and rivaling cultivated terrestrial crops in terms of productivity per unit area (McRoy and McMillan, 1977). Seagrass communities are highly productive systems that can produce up to 300 g C m$^{-2}$ annually and host a diverse faunal assemblage (Duke and Kruczynski, 1992; Livingston, 1987; Zieman, 1982; Zieman and Zieman, 1989).

Seagrass communities are of critical importance to the survival of many organisms, some of which are important commercial and recreational species. They can be a major component of the total primary production in the bay. Seagrass functions in structural habitat complexity, in the reduction of contaminants, as nursery habitat for many organisms, in maintaining high water quality, and in sediment stabilization (Phillips, 1980; Sargent et al., 1995; Smith, 1998). Similar to that of marsh, seagrass beds can act as a filter for chemicals and nutrients, thus preventing the dissemination of these contaminants throughout the bay system. The role of the seagrass canopy as a nursery ground is vital to the continued existence of many economically important species including penaeid shrimp, crabs, and fishes (Livingston et al., 1998; Orth and van Montfrans, 1990; Strawn, 1961).

Grass beds effectively reduce turbidity in the water column by reducing wave action and dissipating current strength. Their role in sediment stabilization has positive effects on estuarine water quality. Water quality can also be positively affected when nutrients, such as nitrogen and phosphorus, are utilized by SAV. This tends to decrease the quantity of nutrients available to noxious algae and thus inhibit the occurrence of algal blooms (Stevenson et al., 1979). The distribution, productivity, and biomass of seagrass beds can be affected by climatological factors, such as river flooding, and man-induced alterations, both upland and aquatic (Livingston, 1984a).

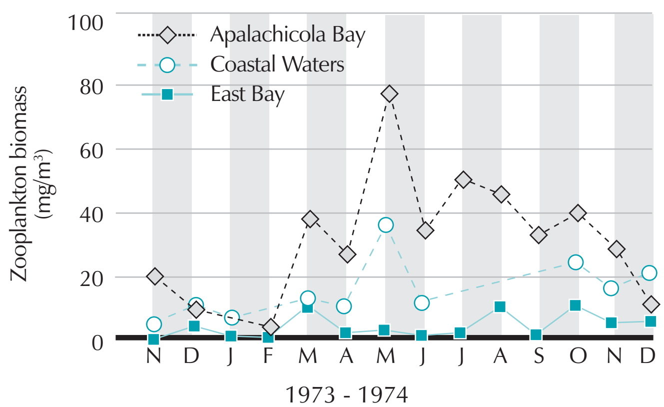



***Figure 71.*** *Seasonal distribution of zooplankton biomass (dry weight).*

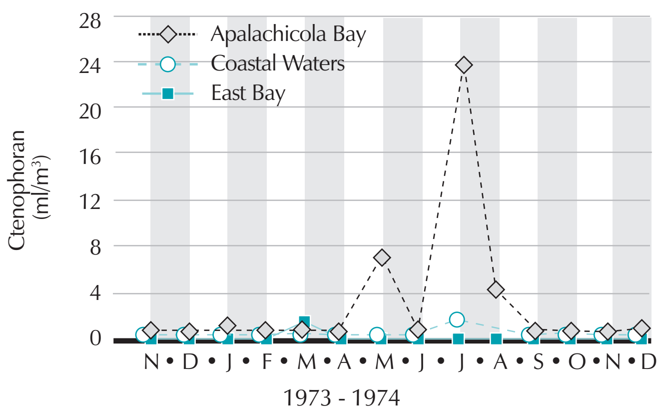



***Figure 72.*** *Seasonal distribution of ctenophoran biomass (displacement volume).*

Seagrass beds function as primary producers and, in particular, their role as a nursery area, feeding ground, and permanent home to numerous associated organisms (Phillips, 1980) is important to the health and biodiversity associated with the Apalachicola system. Major factors affecting the growth and composition of seagrass beds include the depth of the photic zone, availability of nutrients, water temperature, sediment characteristics, turbidity, salinity, wave action, and the degree of intertidal exposure (Fonseca et al., 1983; Fonseca, 1994; Fonseca and Fisher, 1986; Kenworthy and Haunert, 1990; Smith, 1998; Zieman, 1982; Zieman and Zieman, 1989).

*Halodule wrightii* is not only the most tolerant seagrass to variations in temperature and salinity (10-60 ppt) but is also known as an early colonizer, or pioneer species associated with disturbed or unvegetated areas (Phillips, 1980; Zieman, 1982). It can survive in shallower water than *Thalassia* or *Syringodium* because its shallow, surficial root system can colonize the sediments in areas of minimal hydraulic stability, such as shorelines. The flexibility of *Halodule* leaves also enables it to conform to the damp sediment, thereby allowing it to survive during times of exposure (Fonseca et al., 1981). The benthic red algae, *Gracillaria sp*., has been found in significant quantities associated with *Halodule* grassbeds (Edmiston and Tuck, 1987). These factors, combined with the limited availability of suitable areas where seagrass can develop explain the distribution and dominance of *Halodule* in Apalachicola Bay (See Chapter 4, SAV section).

*Syringodium* appears to be the least represented having been found by Livingston (1980) but not by CSA (1985), although they did not sample the eastern St. George Sound area. *Thalassia* has only been located in small areas of St. George Sound associated with *Halodule*. The optimum salinity range for *Thalassia* is more restrictive than *Halodule*, ranging from 20 to 35 ppt. The characteristic turbidity of Apalachicola Bay certainly restricts the extent and species of seagrass communities found in the bay. (Livingston, 1977; Livingston et al., 1998).

Seagrass ecosystems create structured habitats composed of diverse and interrelated groups of benthic and epiphytic micro- and macro-algae, sessile and motile epifauna, benthic infauna, and transient motile fauna (Phillips, 1980). Seagrasses, in particular *Thalassia* with its wide blades, serve as attractants for a variety of epiphytes (Harlin, 1980). Sheridan and Livingston (1983) measured one of the highest infaunal densities recorded in the literature, 104,338 organisms per square meter, working in a *Halodule* grassbed in Apalachicola Bay. The dominant infaunal organisms found are tanaids, polychaetes, amphipods, and oligochaetes. Major biomass contributors of the community are bivalves, gastropods, and polychaetes. Blue crabs, pink shrimp, and grass shrimp are the dominant macro-invertebrates in the grassbed community and vary in numbers significantly during the year (Edmiston and Tuck, 1987). Blue crabs from other estuaries have been hypothesized to gather in seagrass meadows just prior to ecdysis to escape predation in this structurally complex habitat (Ryer et al., 1990). These crabs may utilize the seagrass habitat during this molting phase, characterized by soft shells and low activity, to reduce their vulnerability to predation (Stevenson et al., 1979). The arrival of juvenile fish and macro-invertebrates on grassbeds in summer corresponds to the rapid decline in infaunal densities (Sheridan and Livingston, 1983), thereby showing the importance of the grassbeds as a nursery and food source.

The dominant fishes utilizing the grassbed are silver perch, pigfish, pinfish, and spotted seatrout in the summer, and spot in the late winter and spring. For these organisms, the benthic plant community hosts complex predator-prey interactions as well as interspecies and intraspecies competition (Livingston, 1984c). Settlement of red drum in seagrass habitat occurs regularly primarily due to the structure and protection provided by the seagrass canopy (Holt et al., 1983; Rooker and Holt, 1997; Rooker et al., 1998). In seagrass beds, red drum have been found to have 3-4 times lower mortality rates than in unvegetated substrates (Rooker et al., 1998). This habitat preference of early red drum and the preservation of the seagrass beds are important to the existence of this recreationally important species in the bay.

SAV is uncommon in the Apalachicola River and is only found in the lower river section near the bay. The vegetation characteristic of this community is *Vallisneria*, and is usually found in bands 10 to 100 feet wide parallel to the shoreline. SAV communities are fairly diverse, being represented by 50 species of fish, ten of which are gamefish species. Fish commonly collected from SAV habitat in the Apalachicola River include chain pickerel, spotted sunfish, spotted gar, bowfin, common carp, and golden shiner (Ager et al., 1984). SAV also appears to be important to the largemouth bass in the lower river, especially by young-of-the-year or subadult bass which use it as a nursery area.

This community is important to herbivorous marine animals such as marine turtles and manatees as a major food source (Smith, 1998) although the importance of seagrass to these organisms in the Apalachicola system has not yet been determined. Manatees, which utilize Apalachicola Bay in the warmer months of the year, have been documented feeding on seagrass on the bayside of St. George Island and along St. George Sound in the vicinity of Yent's Bayou. Other submerged aquatic vegetation such as *Myriophyllum spicatum, Potamogeton pectinatus*, and *Vallisneria americana* also appear important to manatees, which are routinely observed feeding in these areas during aerial surveys conducted in the East Bay area (Calleson, 1998; CSA, 1985).

Although propeller scarring is not overly abundant within the Reserve at this time, it does pose a threat as development and population increases continue in Franklin County. The acreage of scarred seagrass in Franklin County has been estimated as 810 acres (4.1%) with 440 acres listed as light and 370 acres listed as moderate (Sargent et al., 1995). These scars are typically inflicted when the propeller, engine, and/or steering structures of a boat in shallow water contact the submerged vegetation and the supporting sediments below. Under favorable conditions, the seagrass can recover within three to seven years (Sargent et al., 1995; Smith, 1998). Seagrass communities in Apalachicola Bay support a vast assemblage of marine organisms ranging from polychaetes to marine mammals. Although grassbeds in the area may be characterized as patchy with limited distribution, this habitat helps add to the primary production within the Reserve.

### Benthic Invertebrates

Due to increasing damage to fisheries stocks caused by habitat loss and alteration in the Apalachicola River from dredge and spoil activities by the U.S. Army Corps of Engineers in the 1980's, the Florida Fish and Wildlife Conservation Commission instituted numerous studies to determine the damages and long-range impacts of within-bank disposal of dredged material (Ager, et al., 1983). One of these studies was related to benthic invertebrate populations and distributions (both macro and infauna) throughout the river due to their importance as food items for fish. Transects were located in four sections of the river with the lower river transect being within the boundaries of the Reserve and only 3.3 miles north of the river mouth.

The lower river transect site exhibited four different substrate types including detritus, gytta, coarse sand, and fine sand. This area of the river, strongly affected by tidal action and exhibiting some salinity variation, is bordered by *Juncus* and *Phragmites* marsh and also thick beds of *Vallisneria*. The lower river site was the most diverse region of the river with 36 taxa identified and was the second most productive region averaging over 3,162 organisms per square meter, just below that of the tailrace transect below the dam at river mile 106. The dominant taxa for this area are listed in Table 18. This region is ranked third in biomass production, probably due to the low numbers of *Corbicula* shells, a larger macro-invertebrate. Of course the greatest numbers of amphipods, isopods, and mysid shrimp were also found here due to the proximity to the estuary (Ager, et al., 1983).

**TABLE 18**

**Number and percent composition of the dominant taxa found at the lower river site (river mile 3.3)**

*(modified from Ager et al., 1983).*

| Taxon | Percent Composition | Mean Num/m² |
|---|---|---|
| Oligochaeta | 25.1 | 795 |
| Talitridae | 19.0 | 599 |
| Chironomidae | 16.7 | 533 |
| Asellidae | 11.1 | 351 |
| Gammaridae | 7.2 | 226 |
| Nematoda | 6.0 | 191 |
| Neritidae | 3.7 | 117 |
| Corbiculidae | 2.0 | 64 |
| Heleidae | 1.8 | 56 |
| Mactridae | 1.6 | 51 |

Sediment is one of the largest habitat types found in the Apalachicola Bay system. This sediment substrate supports many species of macro-invertebrates including both epifaunal and infaunal species. Epifaunal species include organisms that live at the mud and water interface. In other words they live on the bottom, but do not submerge themselves in the muddy bottom. Epifaunal invertebrates include a variety of decapod crustaceans, molluscs and echinoderms. Infaunal species are those that burrow into and live in the bottom substrate. Infaunal species tend to be less mobile organisms and include organisms such as polychaetes, oligochaetes, amphipod and isopod crustaceans, and molluscs.

Six freshwater mussels found in the Apalachicola River or its main tributary, the Chipola River, have been listed by the US Fish and Wildlife Service as threatened or endangered species in March 1998 (USFWS, 1998). Four of the mussels, the fat threeridge (*Amblema neislerii*), shinyrayed pocketbook (*Lampsilis subangulata*), Gulf moccasinshell (*Medionidus peniccillatus*), and oval pigtoe (*Pleurobema pyriforme*) are listed as endangered. Two mussels, the Chipola slabshell (*Elliptio chipolaensis*) and purple bankclimber (*Elliptoideus sloatianus*) are threatened species. While not all of these species are found within the boundaries of the Reserve their designated critical habitat does include parts of the reserve's upper boundaries in the Apalachicola and Chipola rivers.

These species have been listed due to a serious decline in their range and abundance caused by dams, dredging, mining, channelization, pollution, sedimentation, and water withdrawals that degraded their riverine habitats. Three species in the Apalachicola region have already been declared extinct.

The muddy substrate of the Apalachicola Bay provides a suitable habitat for a diverse group of infaunal invertebrates. However, relatively little is known about the life histories of these species. Distribution is most likely due to factors such as temperature, salinity, substrate, and biological factors. Although abundance varies from year-to-year and from season to season, certain patterns are evident. Infaunal abundance usually reaches a peak during the winter and early spring periods of increasing temperatures and low salinity (Livingston, 1984). The species composition of collections depends primarily upon sampling gear. In Apalachicola Bay infaunal macro-invertebrates have been collected using leaf litter baskets (Livingston et al., 1977), dredge-nets (Purcell, 1977), and cores and ponar grabs (McLane, 1980; Mahoney and Livingston, 1982; Livingston et al., 1997).

Organic leaf litter baskets collect species utilizing detritus as a substrate for shelter or food. Collections include both omnivores and detritivores, primarily species of isopods, amphipods, and decapods. Dominant species collected in Apalachicola and East Bay include *Melita* spp., *Gammarus mucronatus*, *Grandidierella bonnieroides*, *Gitanopsis* spp., *Neritina reclivata*, *Munna reynoldsi*, *Palaemonetes spp.*, and *Corophium louisianium* (Livingston, 1977; Livingston, 1984a). Abundance of these species tends to vary according to season, and the numbers of individuals and species tend to increase with increased salinity.

Monthly cores taken over two years to determine spatial and temporal distribution of benthic infaunal species in Apalachicola and East Bay (Livingston et al., 1977) showed *Hargeria rapax* (Tamaidacea) to be the most abundant. This crustacean builds tubes attached to the substrate or to blades of seagrass and has been collected almost exclusively in *Halodule wrightii* beds on the bay side of St. George Island. *Hargeria* were shown to be most abundant in February and April, and least abundant in September.

The amphipod, *Grandidierella bonnieroides* was the second most abundant species from samples. This amphipod crustacean was collected in *Halodule* beds on the bay side of St. George Island as well as areas within East Bay. Preferring low salinities, it was most abundant in the freshwater areas of East Bay and had highest densities during the months of March and August with lowest numbers in May. Third in abundance was *Heteromastus filiformis* (Polychaeta). This polychaete was restricted to the *Halodule* beds located on the bay side of St. George Island. Abundance peaked in April and decreased significantly in October and November.

The polychaete, *Mediomastus ambiseta* was ranked fourth in overall abundance. *Mediomastus* was collected in lengths of 20-40 mm in soft muddy bottoms throughout Apalachicola Bay. Peak abundance was noted in March with lowest abundance in the summer months of July-August. Another highly abundant organism, *Ampelisca vadorum* (Amphipoda), was restricted to the bay side of St. George Island. Highest numbers were collected in February and early spring with secondary peaks around the month of October (Livingston, 1977: Livingston, 1984a). Other dominant species and their location can be viewed in Table 19.

Another study utilizing sediment cores to five cm, involving five stations in the East Bay area, found 47 species over a 20-month period (McLane, 1980). The average density in this study was similar to the lower river study with approximately 3,259 organisms per square meter but the species found were somewhat different. Dominant species included an amphipod *Grandidierella bonneroides*, an insect larvae *Dicronteendipes spp.*, a polychaete *Mediomastus ambiseta*, two mollusks *Mactra fragilis* and *Littoridina spictostoma*, and a polychaete *Amphicteis gunneri*. The number of individuals were generally higher during winter and spring months with lower numbers during the summer. At most sites there was also a positive relationship with riverflow, both seasonally and annually (McLane, 1980).

The most spatially detailed survey of infauna in Apalachicola Bay occurred as part of a benthic mapping project co-sponsored by the NOAA Coastal Service Center and the Apalachicola NERR. Over 430 stations, on one-kilometer centers throughout the bay, were sampled over a two-week period utilizing a sediment-profile imaging (SPI) camera (Figure 73). In addition, grab samples were taken at 136 of these stations and analyzed for organic carbon, sediment texture, and number and type of benthic infauna (Iocco, et al., 2000). Over 302 taxa were identified, averaging 100 individuals per grab, and ranging from 4 to 1010 individuals per grab. Dominant species from each region of the bay sampled can be found in Table 20.

Only three taxa were found at more than half the stations including *Mediomastus spp.*, a polychaete; Rhynchocoela, ribbon worms; and *Paraprionospio pinnata*, a polychaete. The river region stations had the highest abundance of individuals (Figure 74) mainly due to two amphipod species, *Ceraphus benthophilus* and *Corophium louisianum* (Valente, 2007). The diversity (H') of the community appeared to increase with increasing salinity, with the exception of the river region, which although fairly fresh exhibited a higher diversity than the East Bay region (Figure 75).

**TABLE 19**

**Ten most abundant infauna and epifauna taken by cores in Apalachicola and East Bay** (Livingston, 1984)

| Rank | Classification | Location |
|---|---|---|
| 1 | *Hargeria rapax* (Crustacea, Tanaidacea) | *Halodule wrightii* beds, inner side of SGI |
| 2 | *Grandidierella bonnieroide* (Crustacea,Amphipoda) | East Bay *Halodule wrightii* beds, inner side of SGI |
| 3 | *Heteromastus filiformis* (Polychaeta, Sedentaria) | *Halodule wrightii* beds, inner side of SGI |
| 4 | *Mediomastus ambiseta* (Polychaeta, Sedentaria) | Throughout the Bay |
| 5 | *Ampelisca vadorum* (Crustacea, Amphipoda) | *Halodule wrightii* beds, inner side of SGI |
| 6 | *Streblospio benedicti* (Polychaeta, Sedentaria) | Throughout the Bay |
| 7 | *Amphicteis gunneri floridus* (Polychaeta, Sedentaria) | Throughout the Bay |
| 8 | Oligochaete sp. | *Halodule wrightii* beds, inner side of SGI |
| 9 | *Aricidea fragilis* (Polychaeta, Sedentaria) | *Halodule wrightii* beds, inner side of SGI |
| 10 | *Dicrontendipes* sp. (Insecta, Diptera) | East Bay |

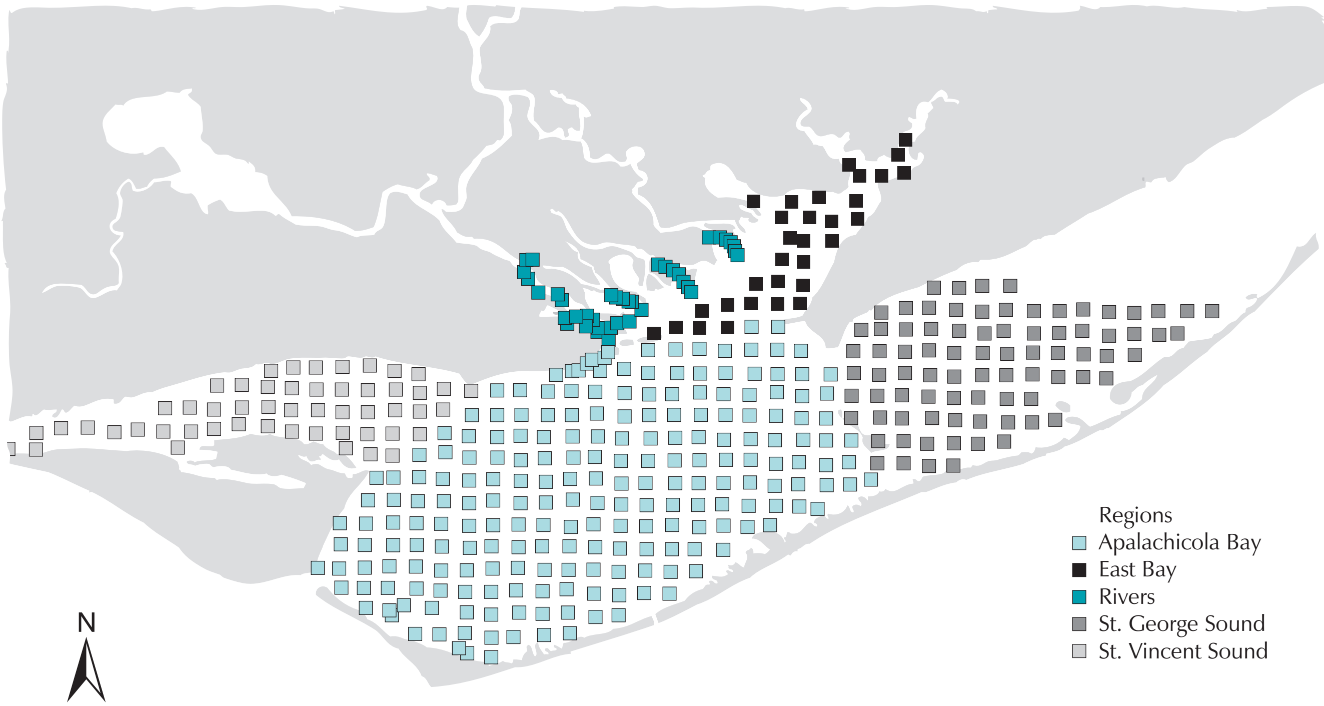



***Figure 73.*** *Distribution of SPI camera stations in the Apalachicola NERR.*

When the stations are grouped by salinity there is a positive and statistically significant relationship between diversity and salinity at the highest and lowest zones (Figure 76). Total abundance of individuals generally showed the opposite with lower salinity areas having the highest abundance with low to moderate diversity (Figure 77). This emphasizes how these areas are dominated by few species with large populations (Valente, 2007).

A comparison of infauna with sediment type also showed differences. Of four bottom types compared (shellbeds, silt, SAV, and sand) the silty areas exhibited the lowest diversity, abundance, and biomass and had significantly fewer species than other types (Valente, 2007). While SAV beds had higher abundance than shellbed types, the biomass found in shellbeds far outweighed that of SAV bottom type (Figure 78 and 79).

Information on abundance, seasonality, distribution, and species richness of macro-invertebrates in Apalachicola Bay has been mainly derived from a long-term monitoring program carried out in the 1970's and 1980's (Lewis, 1997; Livingston, 1976; 1983; 1984a; Livingston et al., 1976; 1977; 1997). Otter trawl collections have revealed epibenthic macro-invertebrate populations to be primarily composed of a few dominant species (Livingston et al. 1977). These species constituted approximately 70-80% of the total number of individuals collected (Livingston et al., 1976; Livingston, 1984). They included three species of shrimps (white, pink, and brown), as well as grass shrimp and blue crabs (Figure 80). All but the grass shrimp are commercially important and harvested in Apalachicola Bay.

Spatial and temporal patterns were evident in macro-invertebrate distribution. The abundance of dominant macro-invertebrate abundance generally reached peak levels during the summer and fall seasons. Numbers of invertebrates were greatly reduced in months of low salinity and temperatures. Thus, abundance was most likely due to seasonal variations in environmental parameters including salinity, turbidity, color, and river detritus levels (Livingston et al., 1977). Distribution can also be associated with species-specific reproduction and recruitment as well as feeding preference and habitat suitability (Livingston et al., 1976).

Dominant invertebrates rotated throughout the seasons with blue crabs dominant in the winter, grass shrimp most abundant in the spring months, and commercial shrimp species occurring in higher numbers in summer and fall months. The blue crabs and commercially important shrimp were generally evenly distributed throughout the bay system, while grass shrimps and squid were localized. Grass shrimp was most abundant in the grass beds of East Bay, and squid was found primarily in Apalachicola Bay (Livingston et al., 1976).

The most abundant invertebrate species in Livingston's study 1972-1975 (et al. 1976) was white shrimp (*Litopenaeus setiferus*) comprising 40% of the total catch (Figure 80). White shrimp were found to be highly abundant in late summer and fall in the Gulf of Mexico. In Apalachicola Bay, peaks in abundance were noted from August to November with few individuals collected from April to June. White shrimp are believed to spawn from spring to summer, producing large numbers of new recruits in the summer and fall. After spawning,

**TABLE 20**

### Ten most common benthic species within each region of the Apalachicola Bay basin. (Iocco et al., 2002)

*Percentages indicate the percent of total infauna represented by these ten taxa.*

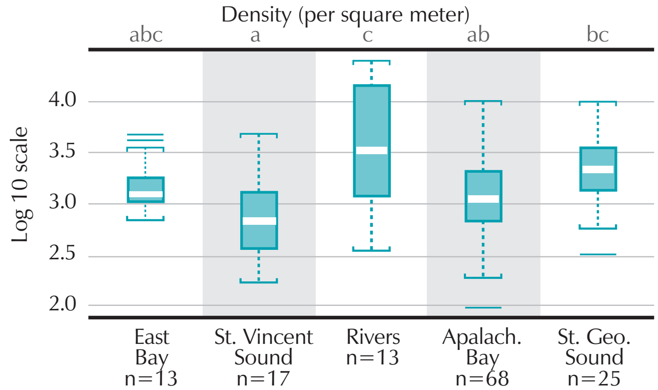
| Taxa | Function Group | Abundance ($m^2$) |
|---|---|---|
| **Apalachicola Bay** (68 stations) | | |
| *Mediomastus* (LPIL) | polychaete | 208 |
| *Crepidula* (LPIL) | gastropod | 74 |
| *Paraprionospio pinnata* | polychaete | 73 |
| *Ampelisca cristata microdentata* | amphipod | 65 |
| *Tubificidae* (LPIL) | oligochaete | 61 |
| *Onuphidae* (LPIL) | polychaete | 57 |
| *Dipolydora socialis* | polychaete | 51 |
| *Laeonereis culveri* | polychaete | 50 |
| *Kalliapseudes sp. C* | tanaid | 50 |
| *Ischadium recurvum* | bivalve | 46 |
| | **Total** (40%) | **734** |
| **East Bay** (13 stations) | | |
| *Mediomastus* (LPIL) | polychaete | 981 |
| *Streblospio benedicti* | polychaete | 385 |
| *Parandalia tricuspis* | polychaete | 194 |
| *Xenanthura brevitelson* | isopod | 73 |
| Rhynchocoela (LPIL) | rhynchocoel | 46 |
| *Ogyrides alphaerostris* | decapod | 27 |
| *Glycinde solitaria* | polychaete | 17 |
| *Cyclaspis varians* | cumacean | 12 |
| *Americamysis bahia* | mysid | 10 |
| *Ampelisca vadorum* | amphipod | 10 |
| | **Total** (93%) | **1754** |
| **Rivers** (13 stations) | | |
| *Cerapus benthophilus* | amphipod | 4713 |
| *Corophium louisanum* | amphipod | 1438 |
| *Mediomastus* (LPIL) | polychaete | 292 |
| *Parandalia tricuspis* | polychaete | 192 |
| *Cyathura polita* | isopod | 181 |
| *Tubificidae* (LPIL) | oligochaete | 154 |
| *Laeonereis culveri* | polychaete | 150 |
| Rhynchocoela (LPIL) | rhynchocoel | 121 |
| Spionidae (LPIL) | polychaete | 119 |
| *Hobsonia florida* | polychaete | 110 |
| | **Total** (93%) | **7471** |
| **St. George Sound** (25 stations) | | |
| *Mediomastus* (LPIL) | polychaete | 371 |
| *Diplodonta semiaspera* | bivalve | 127 |
| *Nereis succinea* | polychaete | 101 |
| *Melita* (LPIL) | amphipod | 88 |
| *Odostomia impressa* | gastropod | 81 |
| *Tubificidae* (LPIL) | oligochaete | 79 |
| *Tellina* (LPIL) | bivalve | 74 |
| *Melita elongata* | amphipod | 64 |
| *Ampelisca cristata microdentata* | amphipod | 61 |
| *Dipolydora socialis* | polychaete | 59 |
| | **Total** (38%) | **1105** |
| **St. Vincent Sound** (17 stations) | | |
| *Mediomastus* (LPIL) | polychaete | 215 |
| *Paraprionospio pinnata* | polychaete | 81 |
| *Streblospio benedicti* | polychaete | 79 |
| *Glycinde solitaria* | polychaete | 62 |
| *Corophium simile* | amphipod | 49 |
| *Crepidula* (LPIL) | gastropod | 49 |
| *Grandidierella bonnieroides* | amphipod | 37 |
| *Melita* (LPIL) | amphipod | 32 |
| *Tubulanus sp. A* | rhynchocoel | 32 |
| *Cyclaspis varians* | cumacean | 31 |
| | **Total** (64%) | **666** |

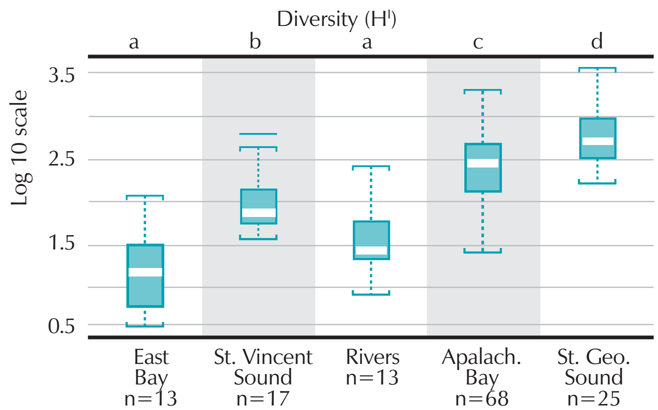
juveniles and post larvae migrate into the bay, accounting for peaks in abundance. They migrate to areas of low salinities such as in East Bay. Other factors besides salinity, such as habitat and possible food preferences, may also determine local distribution (Livingston, 1983). As fall approaches and temperatures decrease, a general offshore migration occurs. Some shrimp do not migrate and will over-winter in deep channels (Livingston et al., 1977).

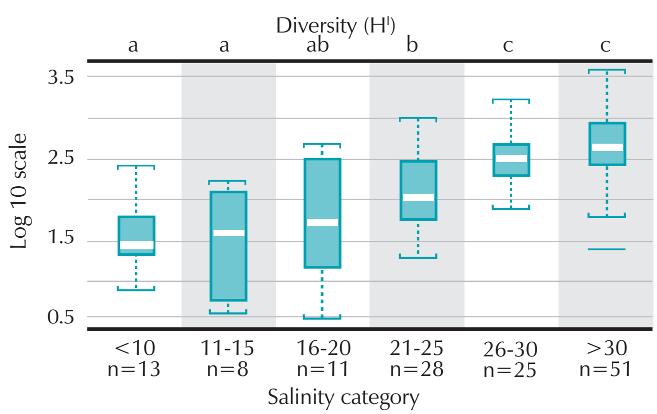
The second most abundant macro-invertebrate in Apalachicola Bay was the grass shrimp (*Palaemonetes sp*). Grass shrimp, unlike the commercial shrimps were found more commonly in shallow marshes and grass meadows along the coast. Grass shrimps made up 20% of the total trawl catch (Figure 80). This shrimp had been collected over a wide range of temperatures and salinities; however, they tend to prefer the low salinity grass beds in East Bay. Grass shrimp abundance in the Apalachicola Bay system peaks during winter and early spring, during which time gravid females have been observed (Livingston et al., 1977).

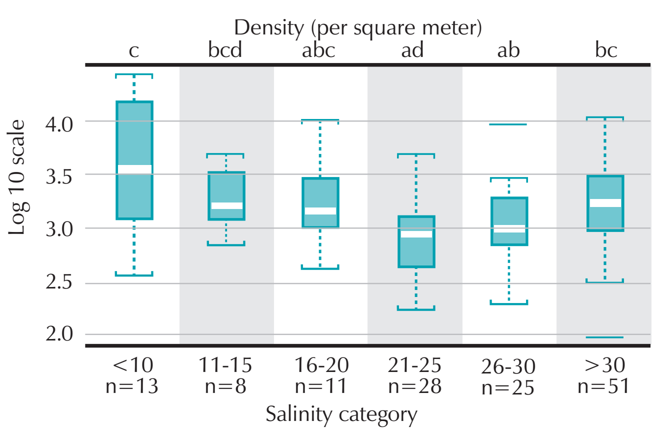
Blue crabs (*Callinectes sapidus*) were very abundant in the Apalachicola estuary. Blue crabs comprised 20% of the total abundance (Figure 80) and peaks have been noted in the summer, fall and winter. Highest abundances were observed in the fall-winter due to new recruits; however, secondary peaks also occurred in summer and fall months, mainly concentrated in East Bay. Spawning occurs in the spring and summer, with smaller individuals abundant during the winter seasons. These young blue crabs migrate to areas of lower salinity like East Bay and Nicks Hole, bayside of St. George Island (Livingston et al., 1977). There is a possible correlation between individual size and salinity preference; however, distribution could also be due to other factors including food availability.

Blue crabs do not spend their entire life cycle in the protection of the Apalachicola Bay. Adults migrate offshore annually to spawn, with their larval and juvenile stages returning back to the estuary in spring. When these young mature in the estuary they will migrate back to the Gulf of Mexico to spawn and complete the cycle. The Apalachicola Bay region is believed to be a major spawning area for blue crabs. An investigation of the spawning, migration, and distribution of blue crabs along Florida's Gulf coast indicated that larger concentrations of egg bearing blue crabs can be found near Apalachicola Bay than along other areas of the Gulf Coast (Oesterling and Evink, 1977). Female blue crabs were observed to migrate farther than males to spawn, some even as far as 310 miles from where they were tagged. Individuals were found to migrate not only to offshore areas of higher salinity, but also showed along shore movements between estuaries. Other studies on blue crab populations in the Apalachicola region include determination of size and sex of blue crabs collected by commercial operations (Meyer et al., 1981), feeding habits and population distributions (Laughlin, 1979), and avoidance of responses of blue crabs to storm water runoff (Laughlin, 1976).



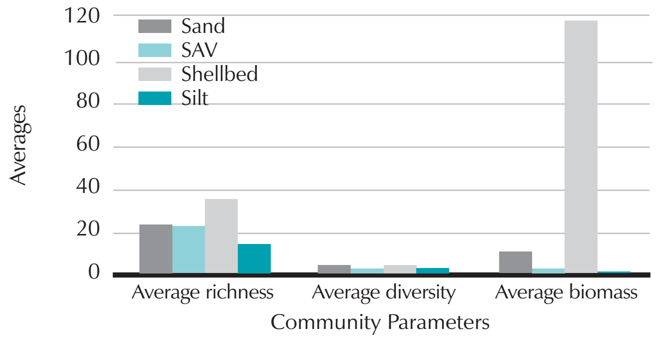




***Figure 78***. *Average species richness, diversity, and biomass in Apalachicola Bay bottom types.*

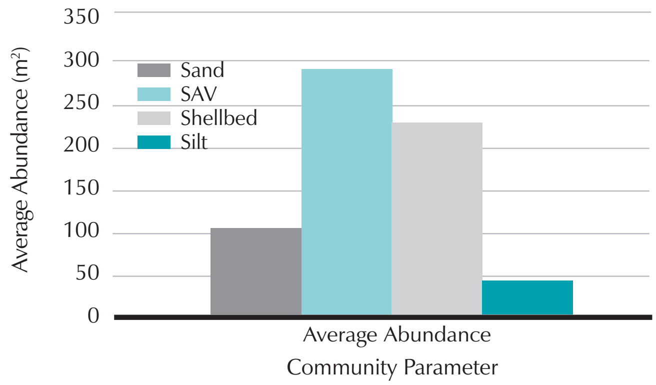



***Figure 79***. *Average infaunal abundance in Apalachicola Bay bottom types*

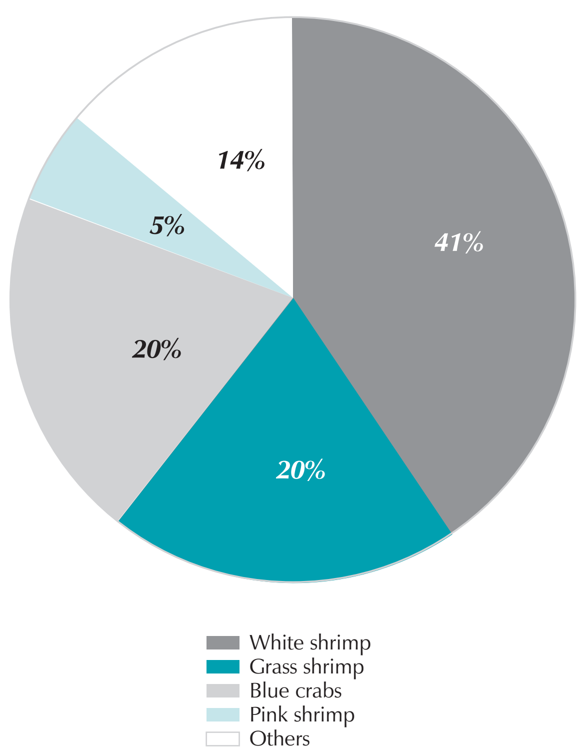



***Figure 80.*** *Percent composition of dominant macro-invertebrates in trawls (modified from Livingston, 1984).*

Pink shrimp (*Farfantepenaeus duorarum*) comprised 5% of the total catch in Apalachicola Bay. This species was most abundant from spring to fall, with peaks in abundance in March, April and October as well as from July to November. Abundance varied from year to year, with little to no individuals collected in June. It has been assumed that in Apalachicola Bay pink shrimp spawn in the late spring to early summer and juveniles recruit into the bay during summer and early fall. Unlike other species, pink shrimp were abundant in the bay during summer months and prefer high salinity conditions.

Brown shrimp (*Farfantepenaeus aztecus*) was the least abundant of the commercial shrimp, comprising only 2% of the total catch. In the first two years of the study abundance peaked in May, with a peak in July the following year (Livingston et al., 1977). Highest numbers were found in the late spring (Livingston et al., 1976). It is believed that brown shrimp in the Apalachicola Bay spawn in the winter and early spring, with recruitment occurring in the early spring and continuing throughout summer (Livingston et al., 1977). Brown shrimp were collected in a wide range of temperatures and salinities.

## Fish

The Apalachicola River and Bay form a dynamic system that supports a diversity of freshwater, estuarine, and marine fishes. The river itself supports a large recreational fishery and is home to several endemic as well as endangered and threatened species. The Apalachicola River is believed to contain the richest assemblage of primarily freshwater fish species in Florida (Bass, 1983; Seaman, 1985). A total of 131 species of freshwater and estuarine fishes have been found in the Apalachicola and lower Chipola Rivers. Of these, 91 species inhabit the nontidal portions of the two rivers, while the other 40 species (mostly estuarine) are found only in the tidal portion of the lower Apalachicola River (Livingston, 1977; Yerger, 1977; Bass, 1983; Ager et al. 1984b; Ager et al., 1985; Edmiston and Tuck, 1987; Hill et al., 1990; Light et al., 1998, Walsh et al., 2006).

The first checklist of riverine fish species was complied utilizing data collected through a variety of sampling methods including gill nets, rotenone, trammel nets, minnow traps, and wire traps (Brown, 1964). Additional stream investigations were conducted in the upper areas of the Apalachicola River from 1967-1975 to fill in missing baseline data (Cox et al., 1975). There is typically a higher gamefish abundance during the summer versus the fall/winter sampling period. These data, however, may have been biased due to limited sampling gear, variable sampling dates, and the lack of habitat variety. Many fish studies conducted in the Apalachicola River have primarily focused on habitat relationships.

Electrofishing in connected streams with sluggish flow has been the primary collection method of these early projects. Studies conducted in this habitat and with this gear mainly collect species such as bluegill, brook silversides, bowfin, largemouth bass, spotted gar, redear sunfish, spotted sucker, warmouth, American eel, and redbreast sunfish (Light et al., 1998). Many of these studies are primarily related to recreational fishery populations. Swifter flowing streams most likely support many more species.

The most prevalent families of fishes in the river, are the minnows (Cyprinidae) and the sunfishes (Centrachidae), with 20 and 17 species respectively occurring in the Apalachicola River. The dominant species occurring in the upper river and the flood plain are the weed shiner (*Notropis texanus*), the bluegill (*Lepomis macrochirus*), the blacktail shiner (*Cyprinella venusta*), and the warmouth (*Lepomis gulosus*). Four fish families common in the Apalachicola River and floodplain areas include the suckers (Catastomidae), darters (Percidae), catfishes (Ictaluridae), and the livebearers (Poecilidae). Another well-represented family, common in the lower Apalachicola River, is the drums (Sciaenidae), an estuarine-dependent, marine fish family. (Walsh et al., 2006).

Among the species found in the Apalachicola River system are four endemic species, eight diadromous species, and thirteen introduced species (Hoehn. 1998; Walsh et al., 2006). Most of the endemic species (Table 21), as might be expected, have specific habitat preferences. The bluestripe shiner is typically found in the main stem of the river and its major tributaries. The bluestripe shiner inhabits the sandy bottoms of large rivers and is rarely found in smaller soft bottom creeks. This species has experienced a loss of spawning habitat due to rock removal, siltation, and changes in river flow, caused by river management practices (Hoehn, 1998).

The bandfin shiner was believed to be endemic to tributaries of the Chattahoochee River and in the Flint and Apalachicola rivers but it has now also been found in areas of Georgia. It is often found in pools below riffles rather than in the swiftest water. In the Apalachicola River the bandfin shiner is only found in small tributaries. The greyfin redhorse occurs in a wide range of stream types in the Apalachicola River system but seems to prefer larger tributaries (Gilbert, 1992). The shoal bass is endemic throughout the lower Chattahoochee and Flint Rivers, as well as the Chipola and upper Apalachicola Rivers. The Chipola River, with large amounts of rock habitat in the upper reaches, supports the largest population of shoal bass in the State of Florida (Bass, 1983). The shoal bass prefer moderate to swift currents usually found over rocky or bedrock bottoms in large shoals along the main river channel and large creeks.

Over the years, there have been numerous species introduced to the Apalachicola River (Table 21). The common carp was probably the first introduction to the Apalachicola and is now widely distributed throughout the river (Yerger, 1977). Several species such as the white bass, yellow perch, orange-spotted sunfish, green sunfish, flathead catfish, and sauger (known from one specimen) were likely introduced in Georgia and made their way to the Apalachicola via Lake Seminole. Others, including the grass carp, blue catfish, Atlantic striped bass, and the sunshine bass, have been introduced for stock/fishing enhancement.

The eight diadromous species (Table 21) found in the Apalachicola River system include five anadromous species and three catadromous species. The five anadromous species, which migrate upriver from marine environments to spawn, include the Alabama shad, Atlantic needlefish, Gulf sturgeon, skipjack herring, and striped bass (Yerger, 1977). The most abundant anadromous fish is the Alabama shad. Catadromous species, which migrate downriver to spawn in marine environments, include the American eel, mountain mullet, and hogchoker (Yerger, 1977). The most abundant catadromous species, the American eel is known for its long migration to the Sargasso Sea to spawn. The eel is also a commercially targeted species.

The two most notable diadromous species occurring in the Apalachicola River are the striped bass and the Gulf sturgeon. The Apalachicola River system supports the only viable striped bass fishery along the Gulf of Mexico. The range of the Gulf-race striped bass once extended from Texas to the Suwannee River, FL (Reynolds, 1991; USFWS, 1991; Barkuloo, 1961). The Apalachicola River now has the only existing remnant population of Gulf-race striped bass (Wooley, 1982; Wooley and Createau, 1983). Since 1979, the U.S. Fish and Wildlife has monitored striped bass in the Apalachicola River to determine life history characteristics, distribution, population size, age and growth as well as length-weight relationships, food habits, spawning sites, and spawning conditions in order to make decisions about stock enhancement (Crateau et al., 1981).

**TABLE 21**

**Specialized groups of fishes from the Apalachicola River.**

| Common Name | Scientific name |
|---|---|
| **Diadromous Fishes** | |
| Gulf sturgeon | *Acipenser desotoi oxyrhynchus* |
| Mountain mullet | *Agonostomus monticola* |
| Alabama shad | *Alosa alabamae* |
| American eel | *Anguilla rostrata* |
| Striped bass | *Morone saxatilis* |
| Atlantic needlefish | *Strongylura marina* |
| Hogchoker | *Trinectes maculatus* |
| Skipjack herring | *Alosa chrysochloris* |
| **Introduced Fishes** | |
| Common carp | *Cyprinus carpio* |
| Grass carp | *Ctenopharyngodon idella* |
| Flathead catfish | *Pylodictis olivaris* |
| Blue catfish | *Ictalurus furcatus* |
| White bass | *Morone chrysops* |
| Green sunfish | *Lepomis cyanellus* |
| Orange-spotted sunfish | *Lepomis humilis* |
| Paddlefish | *Polyodon spathula* |
| Spotted bass | *Micropterus punctulatus* |
| White crappie | *Pomoxis annularis* |
| Yellow perch | *Perca flavescens* |
| Sauger | *Strizostedion canadense* |
| Sunshine bass | *Morone saxatilis x chrysops* |
| **Endemic fishes** | |
| Bluestripe shiner | *Cyprinella callitaenia* |
| Bandfin shiner | *Notropis zonistius* |
| Shoal bass | *Micropterus cataractae* |
| Grayfin redhorse | *Moxostoma n. sp. cf poecilurum* |

Important habitats for the striped bass in the Apalachicola River appear to be rock habitat, in the tailrace of the Jim Woodruff Dam (due to upstream blockage of migratory movement), submerged springs (present in the upper Apalachicola River), and the cool water plumes of spring runs which flow into the river via tributaries (USFWS, 1987; Wooley and Crateau, 1983). The presence of the dams, reduction of cool water refuges, increased sedimentation, and decreased water quality have adversely affected native populations of striped bass (Reynolds, 1991; USFWS, 1981). Cool water from springs or ground-water seepage creates thermal refuges that are critical to the survival of adult striped bass during the summer, when waters of the main channel are exceedingly warm (GSMFC, 1989; Van Den Avyle and Evans, 1990; Light et al., 1998). Genetic dilution of Gulf race striped bass has also occurred from introduction of the Atlantic race of striped bass. Alabama, Georgia, and Florida have actively stocked the striped bass and its hybrid (the sunshine bass) in the ACF system because of its desirability as a sport and food fish.

Gulf sturgeon (Figure 81) once supported a thriving commercial fishery in the Apalachicola River. However, overfishing and more recently, water quality and habitat reduction, have eliminated the fishery. The Gulf sturgeon is now listed as a threatened species. The range of the Gulf sturgeon once extended throughout the Northeastern Gulf of Mexico from the Mississippi River to Tampa Bay, Florida (Wooley and Crateau, 1985). Its range has been greatly reduced in recent years, extending only as far east as the Suwannee River. The Gulf sturgeon population estimates are unknown throughout its range except for the Apalachicola and Suwannee Rivers (Gulf Sturgeon Recovery/Management Task Team, 1995). The Apalachicola River population of Gulf Sturgeon has been estimated to be under 400 individuals (USFWS, 2004). Important habitats for this species appear to be rocky areas, deep holes in the mid-river habitat, the tailrace of the Jim Woodruff Dam (due to upstream blockage), the confluence of the Brothers River and Apalachicola Rivers, and the still-waters of oxbow lakes (USFWS, 2004; Wooley and Crateau, 1985).

Gulf sturgeon are an anadromous species that complete migrations each year to spawning grounds up the Apalachicola River and other Gulf Coast rivers. Gulf sturgeons generally begin to migrate from the Gulf of Mexico when river temperatures increase to about

***Figure 81.*** *Gulf sturgeon from Apalachicola River*

16-23°C, and continue to migrate until temperatures reach close to 21°C (USFWS, 2004; Wooley and Crateau, 1985). The river usually reaches these temperatures in early May. Since upstream movement to their historical spawning grounds in the Chattahoochee River is blocked by the Jim Woodruff Dam, Gulf sturgeon congregate in the tailrace of the dam. Most radio-tracked Gulf sturgeon remain in the tailrace of the dam until the summer is over. Downstream migration usually begins in late September and October and adults generally return to the estuary by mid-November or early December.

The Apalachicola River supports an important commercial and recreational fishery. Recreational fishermen are primarily interested in many species of basses and sunfishes that inhabit the Apalachicola River (Table 22). Catfish have been commercially fished for decades, but landings have decreased since the mid-sixties. Decreases in catfish numbers as well as many gamefish species are believed to have been caused by dredging and the removal of snags and rocks in the river. Dredging has been shown to cause both short term and long-term losses in gamefish and commercial fish abundance (Ager et al., 1985).

The Apalachicola River and its many distributaries empty into East Bay and Apalachicola Bay creating a unique relatively unpolluted tidal marsh system. In East Bay, commercial fishing is restricted, which contributes to the natural abundance of organisms (Lewis et al., 1997). Fresh, brackish, and salt marshes cover a large portion of the river basin, East Bay and fringe Apalachicola Bay. These marshes function as critical nursery habitat for many juvenile fishes, including ecologically, commercially, and recreationally important species.

**TABLE 22**

**Important recreational fish in the Apalachicola River** (Ager et al., 1985)

| | |
|---|---|
| Redfin pickerel | Chain pickerel |
| White bass | Striped bass |
| Sunshine bass | Shadow bass |
| Largemouth bass | Spotted bass |
| Bluespotted sunfish | Redbreast sunfish |
| Green sunfish | Redear sunfish |
| Spotted sunfish | Warmouth |
| Bluegill | Black crappie |
| Yellow perch | Flathead catfish |

Apalachicola Bay is home to many species including inshore and offshore species, which migrate through East Pass, Sikes Cut, West Pass, and Indian Pass. The Bay habitats include open water soft sediment, submerged vegetation and oyster bottom that provide food and shelter for many organisms. It has been estimated that 90 percent of the fish species in the Gulf of Mexico spend part or all of their lifecycles in estuaries.

During the 1970's and 80's, studies on the fish fauna of Apalachicola Bay were undertaken by means of seines, dip nets, and otter trawls for approximately 12 years (Livingston, 1976; 1983; 1984a; Livingston et al. 1976; 1977; 1997). Data from these collections were used to characterize fish populations within the estuary, such as seasonal and temporal distribution, species richness and diversity, diurnal variations, trophic organization, and the response of estuarine fishes to variations in the flow of Apalachicola River (Lewis et al., 1997; Livingston, 1976; 1984a; 1997; Livingston et al. 1976; 1997; Sheridan, 1978; 1979; 1983).

Two other long-term monitoring projects currently characterizing the ichthyofauna assemblages in Apalachicola Bay include the Florida Fish and Wildlife Conservation Commission's Fisheries Independent Monitoring (FIM) (1998 to the present), and the Apalachicola National Estuarine Research Reserve's Trawling Program (July 2000 to the present). The FIM survey collects data from the distributaries of the Apalachicola River, nearshore marsh areas, submerged vegetation areas, oyster beds, and nearshore seagrass beds. The ANERR trawling program utilizes the sampling protocols of Livingston's work during the 1970's. The Reserve utilizes the same sampling methods and gear as Livingston with the intention of eventually comparing data from the two studies. The Reserve has expanded the program to include more sampling stations in St. Vincent Sound and St. George Sound. Additional seagrass stations adjacent to the barrier islands have also been included.

Over 140 species of fish have been collected within the boundaries of the bay (See Appendices). These species include residents that spend their entire life within the estuary, transients that utilize the habitat only part of their life cycle, as well as migratory forms that leave or enter the bay to spawn. Under normal conditions, the highest abundance of fishes tends to occur from February through April, most likely due to the presence of juvenile spot (*Leiostomous xanthurus*) and Atlantic croaker (*Micropogonias undulatus*) (Figure 82). Overall species numbers tend to be lowest during high river flow, winter, and highest during low flow, summer and fall (Figure 83) (Livingston, 1997; ANERR, unpublished).

In the study conducted in the 1970's and 1980's, four dominant species comprised over 80% of the total fishes collected, including anchovy, Atlantic croaker, sand seatrout, and spot (Lewis et al., 1997; Livingston, 1977; 1984; Livingston et al., 1976a). The numerical abundance of these fishes was seasonal with anchovy dominating in the late summer and fall months. Atlantic croaker and spot were the most abundant in late winter and spring months, and sand seatrout occurred most often in the late spring and summer (Livingston, 1976; 1983; 1984; Livingston et al., 1976; 1977). These differences in abundance appear to be largely due to spawning and recruitment patterns. It was observed that peak levels of monthly abundance of these dominant fish species did not overlap and are comparable to data gathered in other estuaries (Livingston, 1976; 1984a; Livingston et al., 1976; 1977). Spatial distribution of the fish fauna has also been monitored, and dominant species have been found to vary according to salinity and habitat (Livingston, 1983; 1984). In Apalachicola Bay, distribution is often related to seasonal fluctuations of temperature, salinity, and other factors related to river flow. Despite the seasonal change of dominant species, the community structure remains stable throughout the year.

The current ANERR study has eight dominant species that comprise over 90% of the total fish collected annually (Figure 84). Four of the eight species are listed in the earlier study, but this study also includes silver perch, menhaden, pinfish, and pigfish. The difference is probably due to the expansion of sampling sites to include more stations in St. Vincent Sound, St. George Sound, and additional seagrass stations adjacent to the barrier islands, as well as fewer stations in East Bay. However, over 70% of the fish caught during this study were caught in East Bay, St. Vincent Sound, and near the river station, where salinities are lowest, further emphasizing the importance of river flow to the productivity of the bay (ANERR, unpublished data).

Spatially, the dominant species are usually found distributed throughout the bay by salinity and habitat (Livingston, 1983; 1984a). In Apalachicola Bay, their distribution is often related to seasonal fluctuations of temperature, salinity, and other factors related to freshwater inflow. In late winter, anchovies are found throughout the estuary then concentrate in the upper areas of East Bay in the spring. As spring progresses to summer they aggregate in the eastern areas of East Bay then become distributed around the bay during the summer. During the fall season, when this species is most abundant, they dominate around the mouth of the Apalachicola River and throughout East Bay.

Atlantic croaker are primarily present at the mouth of the Apalachicola River and in the upper portions of East Bay during their peak abundance period, from winter to early spring. During late spring and early summer they are found in highest numbers in the bay proper, but are scarcely collected in the estuary from late summer through the fall. Young sand seatrout move into the estuary in May and inhabit the upper portions of East Bay and areas around the mouth of the Apalachicola River throughout the summer when they are most abundant. As numerical abundance decreases in the fall, individuals spread out throughout East Bay and northern areas of Apalachicola Bay and are mostly absent from the estuary in the winter/early spring.

Spot, like the Atlantic croaker, are most abundant in the late winter/early spring due to individuals recruiting into the estuary in January and congregating in the upper areas of East Bay and around Nick's Hole, located on the bayside of St. George Island. Numbers decline in late spring and summer until few are found during late summer or fall. In winter months individuals expand throughout eastern portions of East Bay and Apalachicola Bay in areas receiving the most upland runoff.

The responses of estuarine fishes to variations in Apalachicola River flow, including reactions to important events such as floods and prolonged droughts, have also been investigated (Lewis et al., 1997; Livingston, 1984; 1997; Livingston et al., 1976; 1977; 1997). River flow causes seasonal variations in salinity, turbidity, color, productivity, and detritus levels and is the major influence on physical and biological relationships in the estuary. However,

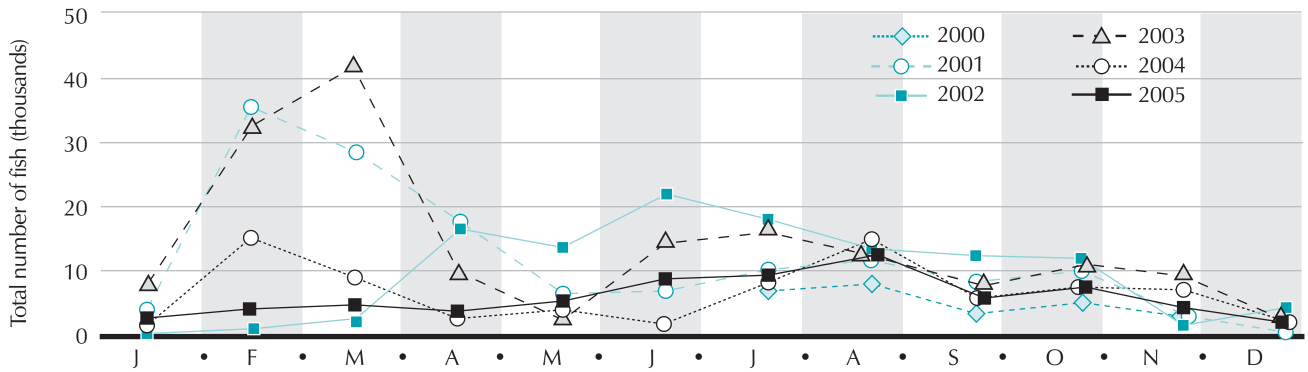



***Figure 82.*** *Total fish abundance annually (ANERR, unpublished).*

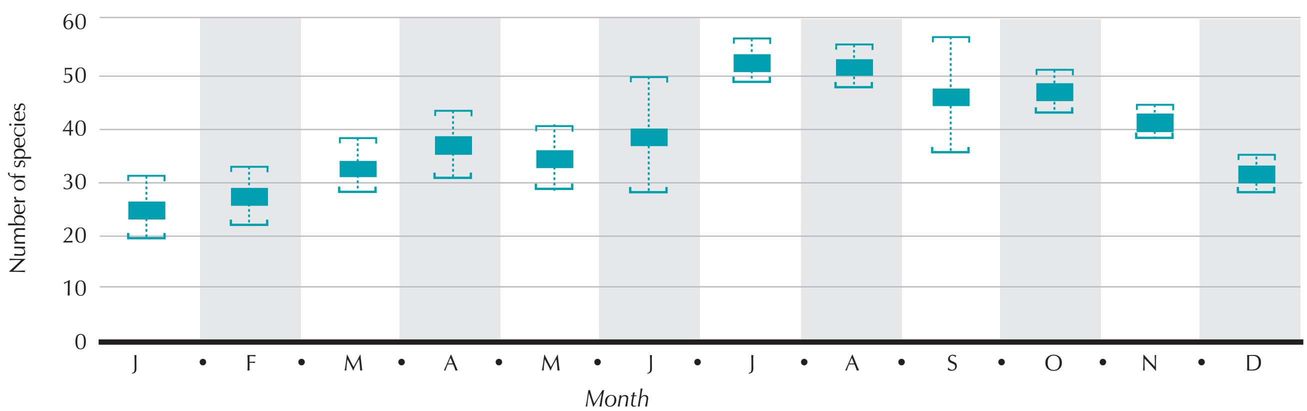



***Figure 83.*** *Number of species caught at all stations (Mean & SD) (ANERR, unpublished)*

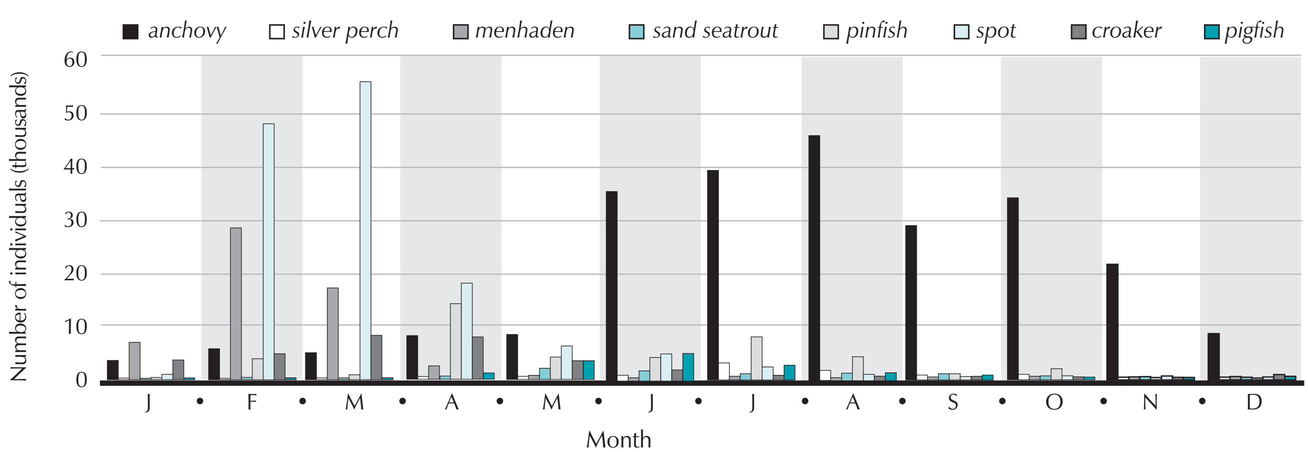



***Figure 84.*** *Seasonal abundance of eight dominant species over five years (ANERR, unpublished).*

correlations between species abundance and physical, chemical, and productivity variables have been difficult to determine. Many dominant species show great tolerance for short term changes in physical parameters, and occur in cyclic phase relationships without a single physical parameter driving the system, although salinity has been thought to cause some short term changes in distribution (Lewis et al., 1997; Livingston, 1984a). Increased salinities in East Bay may have caused the absence of several fish species during the 1980-1981 drought.

Species-specific biological data transformed into ontogenetic trophic units and dynamic regression models, have been used to examine the effects of physical and chemical factors. All organisms were divided into five trophic units: 1) herbivores that feed on phytoplankton and benthic algae, 2) ominivores that feed on detritus and plant and animal material, 3) primary carnivores whose main diet consists of herbivores and detritivores, 4) secondary carnivores that consume primary carnivores and omnivores, 5) and tertiary carnivores that feed on primary and secondary carnivores as well as omnivores (Livingston, 1997; Livingston et al. 1997). Herbivores and omnivores are primarily represented by invertebrates, while most carnivores are fish.

Primary carnivores, mainly anchovy and menhaden, dominate the trophic structure of the bay (Livingston et al., 1997). Each trophic level has individual patterns of population fluctuation due to changes in river flow. Research results have indicated that there are direct relationships between environmental factors and herbivores and omnivores but not with the carnivore group. However, there are direct relationships between the carnivore group and herbivores and omnivores. Therefore, river flow and primary production may directly affect the lower trophic levels, and indirectly affect higher trophic levels (Livingston et al. 1997). Primary carnivores tend to respond more to biological factors such as competition and predation, yet are indirectly affected by changes in river flow due to prey responses to productivity.

A drought from May 1980 through the end of 1981 caused major changes in primary production that affected the trophic structure of Apalachicola and East Bay. Several times during this drought river flow was reduced to less than 50% of the usual flow. This decreased flow resulted in increased abundance of herbivores and omnivores in the system, yet primary carnivores (primarily fishes) decreased in species richness and trophic diversity. Carnivores were associated more closely with biological factors, primarily the abundance of lower level consumers. Recovery of changes in productivity and river flow was considered to be long term.

Because the oyster bars in Apalachicola Bay cannot be adequately sampled for fish using trawls, the major bottom structure sampled is primarily soft sediment (mud and sand). The composition of dominant species within the bay, as mentioned previously, is driven by salinity via river flow. It is also affected by the presence/absence of submerged aquatic vegetation. Shoal grass, *Halodule wrightii*, is the dominant species of seagrass along the shore of the barrier islands. Habitat created by seagrass is important to many species for forage and cover. During drought conditions (2000-2002), water clarity in Apalachicola Bay improved due to decreased freshwater flow and turbidity from the river. Under these favorable conditions, the seagrass beds expanded, increasing their faunal carrying capacity.

The ANERR trawling program has shown that the number of individuals utilizing these seagrass areas increased during these drought conditions. The abundances of specific species including pinfish (*Lagodon rhomboides*), pigfish (*Orthopristis chrysoptera*), and silver perch (*Bairdiella chrysoura*) increased. Also, seagrass beds are located adjacent to the passes of the bay and provide habitat to transient marine species. During drought conditions the number of species increased in these areas as well (Figure 85)

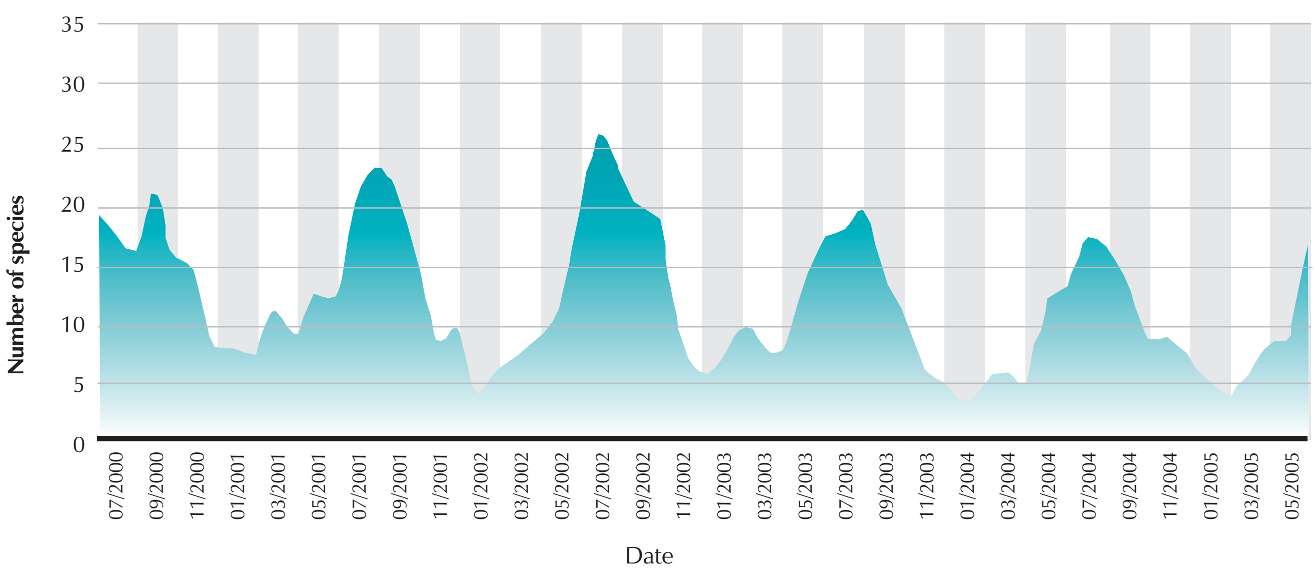



***Figure 85.*** *Average number of species per tow at 3 seagrass stations (ANERR, unpublished).*

probably due to the increased salinity and influence of Gulf waters (ANERR, unpublished data).

The number of species also increased slightly in East Bay, the area most influenced by freshwater from the river during this drought period. While the presence of higher-salinity species in East Bay positively influenced the total number of individuals, the four overall dominant species proliferated as well. While species presence/absence and abundance data cannot be directly related to shifts in environmental conditions, there appears to be a shift in the community composition at these stations during drought conditions. These shifts in community structure during high and low-flow periods continue to be investigated by the Reserve.

Numerous studies have examined prey items of the dominant fishes within Apalachicola Bay (Livingston, 1984a; Sheridan, 1978; 1979). From samples collected from 1973-1976, stomach contents were identified to determine prey items consumed (Sheridan, 1978). Small anchovies' diet consists mainly of calanoid copepods, while larger individuals consume more mysids, insect larvae, and juvenile fishes. Croaker feed on benthic organisms, primarily polychaetes, followed by detritus, fishes, insect larvae, mysids and infaunal shrimp. As croakers grow larger in size, diet specialization occurs, and fewer food types make up most of their diet. Spot, also considered benthic feeders, tend to consume mainly polychaetes and harpacticoid copepods. Their diet includes detritus, bivalves and nematodes. Sand seatrout, known to be piscivorous, feed mainly on juvenile fishes with mysids being a close second. This species shows a sequence of ontogenetic changes in feeding behavior in which small sized individuals consume mysids, while larger individuals are piscivorous (Sheridan, 1978). Little overlap in diet among the three most abundant Sciaenid species was observed (Sheridan, 1979). Identifying these interactions is important in understanding the relationships between food webs and habitat variables.

Other studies and thesis projects that have occurred in Apalachicola Bay over the years cover aspects such as evaluation of the red drum fishery in Apalachicola Bay (Murphy, 1988), abundance of infauna and epibenthic fishes and invertebrates in an Apalachicola Bay seagrass bed (Sheridan, 1983), and growth, movements, and mortality of spotted seatrout (Moffett, 1961; Murphy and Taylor, 1994). Graduate student projects also cover topics such as identification of trash fish from commercial shrimp hauls (Miles, 1951), trophic behavior of fishes (Sheridan, 1979), and overall occurrence, abundance, and diversity of biota in Apalachicola Bay (Buckley, 1973).

## Amphibians and Reptiles

The highest species density of amphibians and reptiles in North America north of Mexico occurs in the upper Apalachicola River basin. The warm climate, high humidity, and rainfall allow for the high numbers of turtles, frogs, salamanders and snakes, and low numbers of lizards (Means, 1977). The diversity of physical habitats and the strategic location near four biogeographical areas, the Atlantic Coastal Plain, the Gulf Coastal Plain, peninsular Florida, and the northern area via the Piedmont and Appalachian regions also plays a role in the high species density (Kiester, 1971; Means, 1977).

The moist, shaded environment of the floodplain with the large accumulation of detrital material provides an ideal habitat for amphibians and reptiles. Means (1976, 1977) lists 44 species of amphibians and 64 species of reptiles found in the Apalachicola River basin. Although not all of these reside specifically within the floodplain, a significant number are transitory or permanent residents. Four State of Florida Species of Special Concern (SSC), the American alligator, Suwannee cooter, Barbour's map turtle, and the alligator snapping turtle are found in the river and floodplain (Wood, 1996). The Barbour's map turtle is endemic to the Apalachicola Basin. In addition the flatwoods salamander, gopher frog, gopher tortoise, and Florida Pine Snake, found within the basin, are listed as SSC (FFWCC, 2006).

Spatial and temporal nesting of the alligator snapping turtle in the lower Apalachicola River is documented as well as nesting female characteristics, clutch size, egg properties (size, fertility, and viability), and hatchling characteristics. As in other reptilian populations, temperature is a critical factor in sex determination within the Apalachicola alligator snapping turtle population (Figure 86). Nest incubation temperatures below 24 °C and above 27 °C tend to yield female-biased sex ratios (Ewert and Jackson, 1994). Other important or unique species found in the Apalachicola floodplain include the one-toed amphiuma, the Florida red-bellied turtle, the four-toed salamander, the Southern coal skink, and the Georgia blind salamander (SSC) from the upper Chipola River floodplain (Means, 1977).

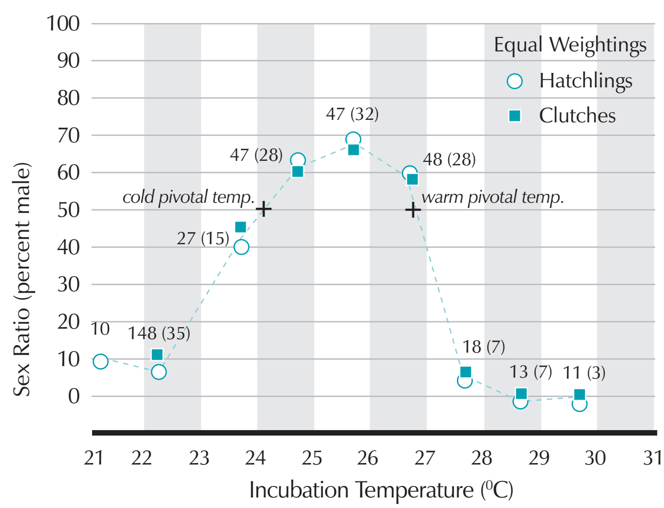



***Figure 86.*** *Hatchling sex ratios for alligator snapping turtles (Macroclemys temminckii) in the Apalachicola River floodplain (Ewert & Jackson, 1994).*

The distribution of amphibians and reptiles within the floodplain is controlled by the hydrologic conditions of the varied environments. Aquatic or wet species are found in the tupelo-cypress and tupelo-cypress with mixed hardwood areas, while species less tolerant to water range from the pine to mixed hardwood associations. Considerable overlap and movement through zones also exist and are dependent on environmental conditions, breeding requirements, and seasonal changes. The wildlife present in mixed hardwood forests varies with the successional stage of the forest. Amphibians and reptiles characteristic of hardwood forests include grey rat snake, coral snake, rough green snake, red-bellied snake, box turtle, Eastern glass lizard, broadhead skink, ground skink, slimy salamander, green anole, grey tree frog, and bronze frog (FNAI, 1986). The Eastern indigo snake, a threatened species, can also be found in uplands within the basin.

The fauna of cypress swamps is not well studied. However, they are important habitats for a variety of species. Species found will vary between those ponds with permanent standing water and those that are seasonally inundated. Bullfrogs and newts tend to utilize permanent bodies of water as habitat for breeding, while toads and most salamanders tend to occupy temporary bodies of water. The pools of water within bog and savannah communities are also important habitats for the larvae of the pine woods tree frog (Means and Moler, 1979).

Flatwood communities generally provide a high diversity of wildlife populations with an extensive source of food, nesting, and escape cover. The presence of the black racer, oak toad, and chorus frog is characteristic of this community type.

The scrub fauna of the panhandle is fairly depauperate. There are very few residents of scrub communities, but several species are temporary residents or transient species. Amphibian and reptile species associated with scrub communities include the Eastern diamondback rattlesnake, coachwhip, black racer, green anole, six-lined racerunner, broadhead skink, Eastern glass lizard, slender glass lizard, Eastern mud turtle, Eastern box turtle, gopher tortoise, southern toad, and oak toad (FNAI, 1986; Means, personal communication).

The minimal amphibian and reptile fauna documented in salt marshes is primarily restricted by high salinity regimes. The diamondback terrapin is adapted to life in salt marshes (White, 1977). The alligator, Eastern glass lizard, and the cottonmouth are found in salt marshes but their main populations occur elsewhere (White, 1977). The saltmarsh watersnake also frequents the salt marshes of the mainland and the local barrier islands (Means, 1977). However, the occurrence of the glass lizard on St. George Island is rather unusual since it is typically documented in peninsular Florida (Blaney, 1971).

Increasing coastal development on local barrier islands poses potential negative effects for several amphibian and reptile species. Local barrier island habitat has been and continues to be subjected to both habitat loss and alteration. Species whose existence depend on decreasing freshwater ponds on St. George Island include the Southern toad, cricket frog, green tree frog, squirrel tree frog, leopard frog, narrow-mouthed toad, American alligator, mud turtle, Eastern glass lizard, green snake, banded water snake, ribbon snake, garter snake, and cottonmouth (Livingston et al., 1975).

Coastal development also brings another threat, that of the spread of invasive species. Recently, the greenhouse frog, an invasive species from Cuba and the Caribbean, was documented in Franklin County (Irwin, 1999). The Cuban anole was documented on St. George Island in the late 1990's but has not been found since (Miley, pers.com.). These species were probably introduced with house or landscaping plants from South Florida.

The barrier island beaches in the Apalachicola area support some of the densest concentrations of nesting loggerhead sea turtles in northwest Florida. Although they are not as widely utilized as the beaches of southeast Florida, the beaches of northwest Florida provide excellent habitat for nesting sea turtles. During the late spring and summer months, female sea turtles migrate from the open Gulf to nest on the relatively undeveloped beaches of the Florida panhandle. The first nest of each season is generally documented in May with the last nest of the year noted in August or September (Figure 87). The hatching phase is typically completed in October or November (Wren et al., 2004.).

While four species of sea turtles frequent the northeast Gulf of Mexico, the Atlantic loggerhead (threatened) is the most common. Green sea turtle nests (endangered) are occasionally documented on northwest Florida beaches and occurrences of leatherback (endangered) nesting are even rarer (Calleson et al., 1998; Wren et al., 2004). The nests on the undeveloped barrier islands of Apalachicola Bay, St. Vincent, and Cape St. George, are exposed to heavy predation pressure by raccoons and feral hogs, whereas

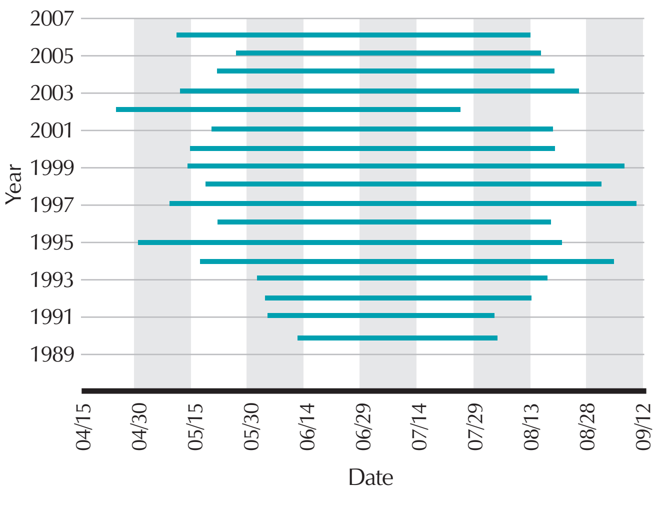



***Figure 87.*** *Duration of the sea turtle nesting season for Cape St. George and St. George Islands (ANERR, unpublished)*

clutches deposited on the developed islands, Dog Island and St. George Island, experience little if any threat from these mammalian predators (Lewis et al., 1994; Wren et al., 2004). Coyotes, which have increased in number and distribution throughout Florida in the last twenty years, have become a major predator on nesting beaches, especially in northwest Florida.

The gulf beaches of Franklin County are monitored for sea turtle nesting activity through the Florida Fish and Wildlife Conservation Commission's statewide monitoring program (Meylan et al., 1995). ANERR staff currently monitor nesting on parts of St. George Island, Cape St. George Island, and the mainland between Eastpoint and Carrabelle. Nesting data for 1998 indicate a record high 550 sea turtle nests on Franklin County beaches (Wren et al., 2004). However, since that time the number of nests in Franklin County and adjacent Gulf County have decreased (Figure 88).

Weather appears to be impacting the survival of sea turtle nests, with an increasing number of hurricanes and tropical storms destroying incubating nests recently. During 2004 and 2005 between 51 and 67 percent of nests on St. George Island and Cape St. George Island were lost due to tropical events. These losses are higher than those from hurricanes in 1995 and 1998 (Edmiston et al., 2008). The loss of nests from hurricanes can be caused both by coastal erosion as well as inundation of the nest by high water and storm surges. Increasing development on some of the barrier islands is also impacting nest survival and success.

## Birds

The floodplain of the Apalachicola system supports an extensive amount and diversity of avifauna. The bottomland hardwoods of the Apalachicola River floodplain supply migrating and over-wintering birds with an abundant food source and important pristine habitat (Edmiston and Tuck, 1987). The proximity of the Reserve to the Mississippi flyway also accounts for a large number of migrating birds (ANERR, 1998). Within the boundaries of the Reserve, as many as 282 avian species (See Appendices) are represented with 164 listed as migratory, 98 as breeding, and 20 as non-breeding summer residents (ANERR, 2003). Many of these species are encountered in relatively low numbers within the Reserve and are designated as threatened, endangered, or species of special concern (Table 23).

Throughout the year, the diversity of habitats associated with the Apalachicola system hosts an impressive assemblage of avian species. Plovers, sandpipers, gulls, and ducks are observed foraging on the tidal flats (Taylor et al., 1973), while green herons and a variety of rails feed and breed in the area's freshwater marshes and ponds (White, 1977). The marshes, mud flats, oyster bars, and shallow water habitats of the Apalachicola estuary provide rich food sources for foraging birds. These include bald eagle, osprey, northern harrier hawk, Forster's tern, black skimmer, brown pelican, wading birds, and also shorebirds such as willet, American oystercatcher, short-billed dowitcher, sanderling, ruddy turnstone, black-bellied plover, semi-palmated plover, and dunlin (DNR, 1983; Edmiston and Tuck, 1987).

Other species such as the endangered Arctic peregrine falcon and American kestrel are documented as they migrate through the area. The clapper rail, seaside sparrow, long-billed marsh wren, and the sharp-tailed sparrow are often associated with salt marsh habitat (Edmiston and Tuck, 1987; Livingston, 1976). The little blue heron, snowy egret, and tri-colored heron, all species of special concern, are fairly common inhabitants of the estuarine and freshwater habitats of the river and bay. The only known wading bird colonies or roost sites within Reserve boundaries occur on St. Vincent Island, near Lake Wimico, near the East River, and in a marsh area north of Highway 98 near Green Point (FGFWFC, 1991) although the lower Apalachicola River floodplain may support some undocumented sites. The tidal marshes support other species of special concern such as great egret, black-crowned night heron, yellow-crowned night heron, and the

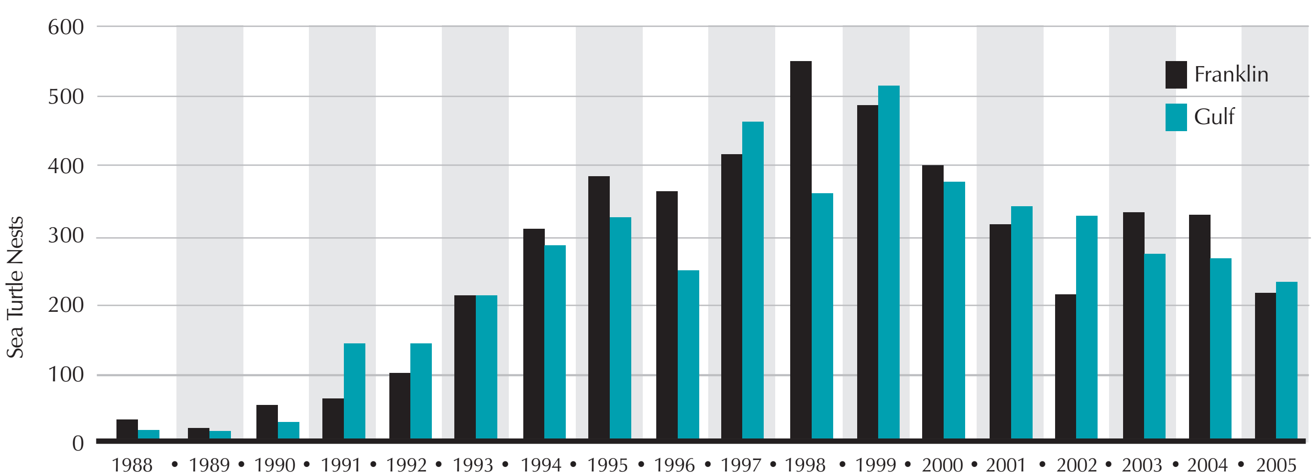



***Figure 88.*** *Sea turtle nests in Franklin and Gulf counties (ANERR, 2006).*

Eastern least bittern (Edmiston and Tuck, 1987). The freshwater habitats of the river and St. Vincent Island also host small numbers of wood stork during post-breeding dispersal in the late summer and fall with some over-wintering on the island. In addition to sporadic sightings on St. Vincent, white ibis are occasionally documented in the freshwater habitats of the river.

Common loons, horned grebes, American coots, and numerous ducks, including lesser scaup, greater scaup, common goldeneye, bufflehead, redhead, canvasbacks, red-breasted merganser, and hooded merganser utilize the open water areas of Apalachicola Bay during the winter. The freshwater ponds of St. Vincent Island provide winter habitat for gadwall, American widgeon, northern pintail, blue-winged teal, and green-winged teal. American black ducks have also been observed on the refuge (Cordray et al., 1994). Overall declines in duck populations are reflected in significantly reduced numbers of ducks which now winter in the area in comparison to past years. Winter surveys conducted in the early 1970's regularly documented between 10,000 and 20,000 redheads in the Pilot's Cove area on the bayside of Cape St. George Island, but by 1994, the Apalachicola Bay Christmas Bird Count reflected only 600 redheads in the entire western portion of the bay (Giddens, pers. comm.; National Audubon Society, 1995). While over a thousand were observed on Cape St. George island during the 2005 Count, only 12 were noted in 2006 around the St. Vincent Sound area (National Audubon Society, 2007).

**TABLE 23**

### State Listed species within and adjacent to ANERR

| Scientific Name | Common Name | Florida Listing |
|---|---|---|
| *Ammodramus maritimus juncicolus* | Wakulla seaside sparrow | SSC |
| *Aramus guaraun* | Limpkin | SSC |
| *Charadrius alexandrinus tenuirostris* | Southeastern snowy plover | T |
| *Charadrius melodus* | Piping plover | T |
| *Cistothorus palustris marianae* | Marian's marsh wren | SSC |
| *Egretta caerulea* | Little blue heron | SSC |
| *Egretta rufescens* | Reddish egret | SSC |
| *Egretta thula* | Snowy egret | SSC |
| *Egretta tricolor* | Tricolored (Louisiana) heron | SSC |
| *Eudocimus albus* | White Ibis | SSC |
| *Falco peregrinus tundrius* | Arctic peregrine falcon | E |
| *Falco sparverius paulus* | Southeastern American kestrel | T |
| *Grus canadensis pratensis* | Florida Sandhill Crane | T |
| *Haematopus palliatus* | American oystercatcher | SSC |
| *Haliaeetus leucocephalus* | Bald eagle | T |
| *Mycteria americana* | Wood stork | E |
| *Pelecanus occidentalis* | Brown pelican | SSC |
| *Picoides borealis* | Red cockaded woodpecker | T |
| *Rynchops niger* | Black skimmer | SSC |
| *Sterna antillarum* | Least tern | T |
| *Vermivora bachmanii* | Bachman's warbler | E |

Alteration of habitat within the Apalachicola system is a major detractor to continued avian abundance. Significant decreases in species density, or absence of species, in areas characterized by habitat alteration exist above the Jim Woodruff Dam as compared to the more pristine forested floodplain habitat below the dam (Stevenson, 1977). Some of the more dominant species of the forested floodplain include red-shouldered hawk, barred owl, Mississippi kite, swallow-tailed kite, hairy woodpecker, pileated woodpecker, red-eyed vireo, and acadian flycatcher. Several warbler species including hooded warbler, northern parula warbler, Swainson's warbler, yellow-throated warbler, and prothonotary warbler frequent the floodplain habitat (Edmiston and Tuck, 1987; Stevenson, 1977). The importance of the forested floodplain to game birds such as wild turkey and wood duck is well documented (Edmiston and Tuck, 1987; FGFWFC, 1978; Gatewood and Hartman, 1977). The Wakulla seaside sparrow and Marian's marsh wren, both designated species of special concern, are year-round residents of the cordgrass and needlerush marsh habitats.

Shorebird surveys conducted on Cape St. George gulfside beaches reveal high densities of common Panhandle shorebirds such as pelicans, terns, gulls, cormorants, plovers, sandpipers, oystercatchers, and black skimmers (ANERR, unpublished; Wolfe et al., 1988). These bird species utilize the beaches for resting, feeding, and loafing (Edmiston and Tuck, 1987). The Reserve sponsors or is directly involved in Audubon Christmas Bird Counts, the Florida Breeding Bird Atlas surveys, and numerous other bird surveys in the area.

One of the rare plovers, the threatened piping plover, is present in the Apalachicola area during winter months. The winter range of this plover encompasses the Atlantic and Gulf Coasts from North Carolina to Mexico (Federal Register, 1985: Hayman et al., 1986; Nicholls, 1989). The Reserve staff coordinate with USFWS on this species for the International Piping Plover Census conducted at 5-year intervals. Results of the winter portion of the 1991 survey revealed 93% of all sightings being made on the Gulf Coast of the United States, primarily on ocean beaches (Haig and Plissner, 1993). Franklin County was one of only three counties in Florida to document an overall increase in piping plovers from the 1991 (61) to the 1996 (75) census. In the past three years, only one piping plover was spotted during the Christmas Bird Survey, in 2005, (National Audubon Society, 2007).

The Cuban or Southeastern snowy plover, also listed as threatened, is unique because it is the only bird species in Florida which depends solely on sandy beach habitat for foraging and nesting (Kunneke and

Palik, 1984; Wolfe et al., 1988). Nesting by the snowy plover within Reserve boundaries occurs on the gulfside beaches of St. Vincent Island, on Cape St. George Island, and in the St. George Island State Park (Chase and Gore, 1989). The remainder of St. George Island tends to be devoid of snowy plover nesting, due most likely to the high volume of development and pedestrian traffic on the gulfside beaches. Between 1989 and 2002, snowy plover nesting on the beaches of Franklin County actually increased from 29 nesting pairs to 38 nesting pairs, although there was not consistent gain at all sites (Lamonte, et al., 2006). The success of the nests on Cape St. George and St. Vincent may be an indirect result of predator control efforts and lack of human disturbance. Between 2002 and 2006 the number of snowy plover nests increased on Cape St. George and on St. Vincent, from 8 to 16, and 3 to 11 nests, respectively. Numbers decreased on Dog Island (11 to 7) and at St. George Island State Park (16 to 13) (FWC unpublished data). Additionally, increased numbers of snowy plovers have been spotted during the Christmas bird count, increasing from just 1 in 2004 to 33 plovers in 2006 (National Audubon Society, 2007).

Aerial surveys conducted by FWC from the 1999-2006 nesting seasons reveal up to 34 active bald eagle nests in one year in Franklin County (Figure 89). These include three nests on Cape St. George Island, 4 on St. George Island, and two in the marshes west of East Bay (FFWCC, 2007). Bald eagles and ospreys tend to nest in pines along the bayshore due to its proximity to prime feeding habitat (Edmiston and Tuck, 1987). Both species forage extensively in the marshes of the Apalachicola River floodplain and nearby Apalachicola Bay. The area also supports a significant amount of osprey nests, most likely the largest concentration in northwest Florida, in the floodplain of the lower Apalachicola River (Eichholz, 1980).

Although considered extinct, the last known sightings of the ivory-billed woodpecker and the Bachman's sparrow are attributed to the Apalachicola area (Edmiston and Tuck, 1987; Livingston, 1984a). A pair, which nested near Scott's Ferry on the lower Chipola River until 1951, represents one of the last documented sightings of the ivory-billed woodpecker (Stevenson, 1977). Following the first sighting in nearly sixty years of this woodpecker in the Cache River National Wildlife Refuge in Arkansas in 2004, the Reserve assisted in surveys conducted throughout the river floodplain in winter 2007 by the Cornell University Lab of Ornithology. Though suitable habitat was found, there have been no sightings of the ivory-billed woodpecker to-date (Knothe, pers.com).

In contrast, one of the densest and most numerous populations of red-cockaded woodpeckers occurs in the Apalachicola National Forest, just outside of Reserve boundaries. This population, at one time estimated at 561 colonies, is one of the largest in the southeast United States (Bartush and Wood, 1983; Lennartz et al., 1983).

The Reserve concentrates most of its avian management efforts on several listed species, including least terns, black skimmers, and American oystercatchers, which utilize habitats within the ANERR for breeding and nesting. Monitoring within the Reserve is particularly important since nesting sites, especially new ground sites, for species such as least terns are at a premium as humans continue

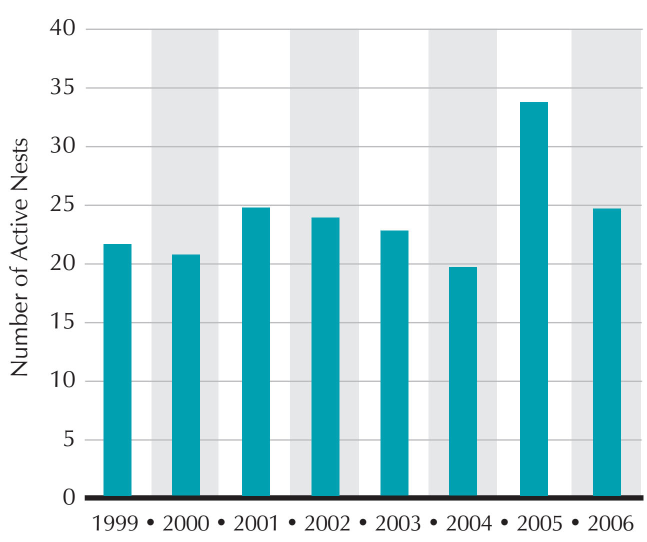



***Figure 89.*** *Active Bald Eagle Nests in Franklin County, 1999-2006.*

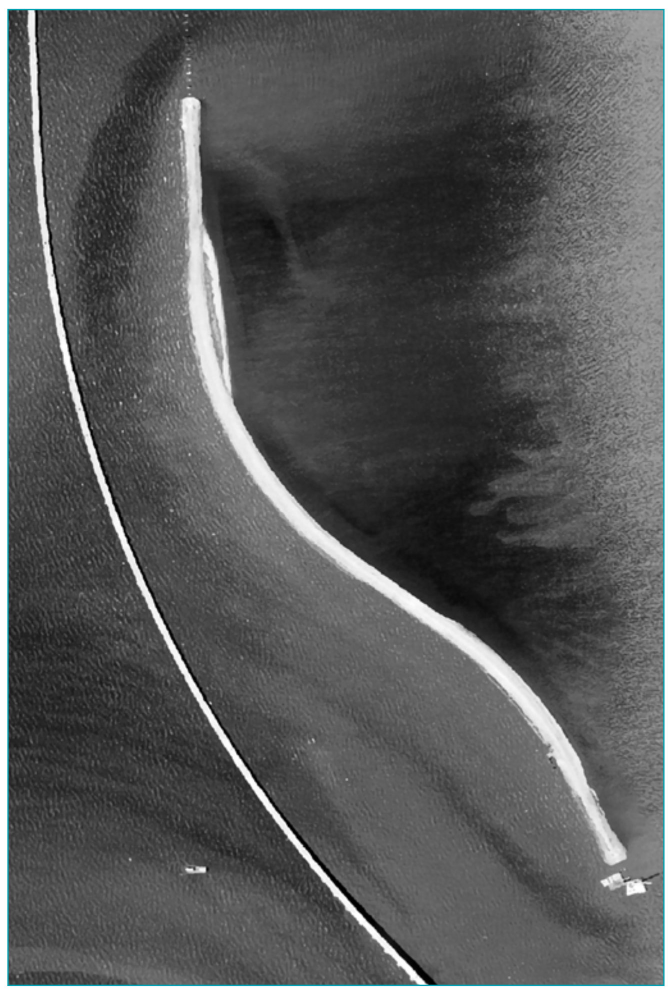


***Figure 90.*** *Aerial view of the St. George Island Causeway and the new St. George Island Bridge (at left).*

to develop many areas deemed suitable beach habitat for nesting activity (Gore and Kinnison, 1991). Colonial shorebirds such as least terns have been known to abandon unsuitable or consistently unproductive sites (Atwood and Massey, 1988; Burger, 1984; Gore and Kinnison, 1991; Kotliar and Burger, 1986).

Black skimmers exhibit reduced breeding success with human intrusion and are generally more sensitive during egg-laying, early incubation, and late in the breeding season (Safina and Burger, 1983). Vehicular traffic is a serious concern with least terns and black skimmers since they usually select flat, open areas of the upper portion of the beach (Rodgers and Burger, 1981). In addition, nesting on causeways can present serious dangers to colonial shorebirds in the form of adult mortality, chick mortality, and reduced reproductive success as a result of collisions with vehicles. Storm events are also detrimental to reproductive success by negatively affecting the egg and chick stages.

The St. George Island Causeway connected St. George Island with the mainland of Franklin County from 1964-2004. A new bridge, completed in 2004, now connects the island to the mainland. The causeway was disconnected from the mainland and island sides of the old bridge, creating an independent island (Figure 90). The causeway was designated a Florida Critical Wildlife Area by the FWC in the late 1980's and is closed to the public from April 1st through August 31st every year. Reserve staff conduct nesting surveys on the causeway in late May to early June, counting the number of nests, eggs, and chicks of each species (Table 24).

Least terns nested on St. George Island beaches until 1983 (ANERR, unpublished data) when increased beach traffic and predation by raccoons probably caused them to relocate to the causeway. Black skimmers were observed nesting at the old tern colony sites on St. George Island in 1984, but their nests were destroyed by vehicular and foot traffic on the beach. Some skimmers relocated to the causeway late in the summer of 1984 for the first time (Edmiston et al., unpubl.). Annual nesting by both least terns and black skimmers on the causeway shows marked differences in annual numbers with the highest number of nesting birds in the late 1980's and early 1990's (Figures 91 and 92).

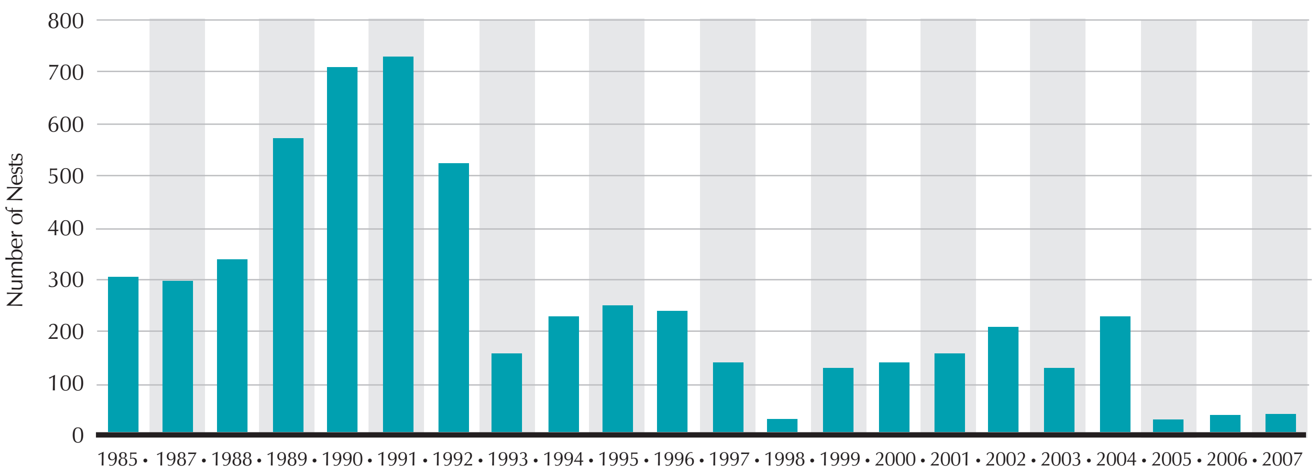



***Figure 91.*** *Least tern nests for the St. George Island Causeway site (1985-2007).*

**TABLE 24**

## Nesting species on the St. George Island Bridge Causeway 1995-2007

| Species | '95 | '96 | '97 | '98 | '99 | '00 | '01 | '02 | '03 | '04 | '05 | '06 | '07 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| American Oystercatcher | | | | | | | 1 | 0 | 1 pair | 1 pair | 2 pairs | pair /juvenile | 3 pairs |
| Black Skimmer | | | 79 | | | | | 28 | | 135 | 1 | 47 | 142 |
| Brown Pelican | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Caspian Tern | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| Gull-billed Tern | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16 | 0 | 1 | 48 |
| Laughing Gulls | | | | | 3443 | 2695 | 3308 | 1466 | 3747 | 3305 | 2554 | NA | NA |
| Least Tern | | | | 12 | 128 | 142 | 160 | 212 | 137 | 233 | 32 | 1 | 39* |
| Royal Tern | | | 305 | 358 | 1086 | 187 | 522 | ~600 * | 835 | 1350 | | 1111 | 1211 |
| Sandwich Tern | | | 18 | 7 | 39 | 3 | 28 | ~44 * | 128 | 195 | | 356 | 270 |
| Sooty Tern | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

*estimated number

As many as 3,300 laughing gull nests have been documented on the causeway during a single season. Laughing gulls are routinely observed entering the tern nesting area and preying on least tern chicks. Following the abandonment of traditional nesting sites, least terns are sometimes observed nesting or attempting to nest on Cape St. George, within the St. George Island State Park, and on the Eastpoint breakwater. Other species that benefit from management efforts and nest on the causeway include the American oystercatcher, gull-billed tern, royal tern, and sandwich tern.

An annual census has been conducted every year on "Bird Island" since it was created with dredged spoil material just south of the mouth of the river in 1995 (Table 25). Although the island was intended to target least terns and black skimmers, other species including American oystercatchers, gull-billed terns, Caspian terns, royal terns, sandwich terns, laughing gulls, and brown pelicans also utilize the island for nesting. As many as 42 species have been documented on the island, many utilizing the area for loafing and resting. Uncertainty exists concerning the success of nesting birds on the causeway and the Bird Island in 1995 since this area of the panhandle was impacted by three hurricanes (Allison, Erin, and Opal).

The Reserve staff routinely record the number of American oystercatchers on the beaches of Cape St. George Island while surveying for sea turtle nests (May - October). However, due to the population of raccoons and coyotes on the beaches during the nesting season, it is doubtful whether many of these birds successfully fledge young from the Cape. American oystercatchers on the St. George Island Causeway, Bird Island, and other sites on St. George Island are also monitored regularly during the summer months. Utilization of the causeway by oystercatchers is minimal, ranging from 0 to 2 nests documented per year between 1985 and 2007. Research staff has also documented nesting of this species on Bird Island (Table 25).

The nesting association of gull-billed terns with least terns and black skimmers is documented within Reserve boundaries and in other areas of Florida, although nesting of this species along the panhandle region of Florida has been considered relatively uncommon (Smith et al., 1993). The first record of nesting by a gull-billed tern on

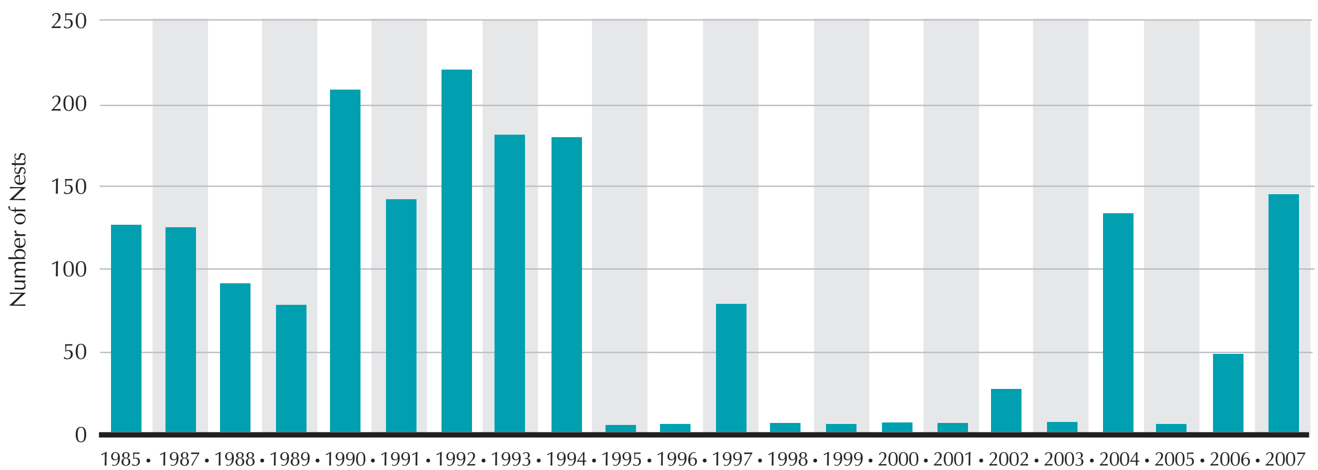



***Figure 92.*** *Black skimmer nests for the St. George Island Causeway site (1985-2007).*

**TABLE 25**

## Nesting species on Bird Island (1995-2007)

| Species | '95 | '96 | '97 | '98 | '99 | '00 | '01 | '02 | '03 | '04 | '05 | '06 | '07 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| American Oystercatcher | 1 | 3 | 1 | 0 | 0 | 0 | 0 | 1 | 2 pairs | 2 pairs | 5 pairs | 1 pair | 3 pairs |
| Black Skimmer | 150 | 181 | 9 | 129 | 142 | 119 | 172 | 0 | | 0 | 68 | 0 | 0 |
| Brown Pelican | 0 | 0 | 1 | 0 | 0 | 0 | 269 | 373 | 17 | 254 | 382 | 263 | 489 |
| Caspian Tern | 0 | 4 | 39 | 105 | 104 | 148 | 206 | 54 | 135 | 183 | 189 | 25 | 169 |
| Gull-billed Tern | 4 | 8 | 1 | 17 | 9 | 6 | 22 | 0 | | 0 | 13 | 2 | 0 |
| Laughing Gulls | | | | | | | | | | 0 | 3 | 69 | 0 |
| Least Tern | 35 | 0 | 0 | 0 | 20 | 0 | 6 | 0 | | 0 | 0 | 0 | 0 |
| Royal Tern | 0 | 0 | 0 | 14 | 42 | 718 | 958 | 100 | | 0 | 375 | 189 | 0 |
| Sandwich Tern | 0 | 0 | 0 | 7 | 0 | 30 | 285 | 20 | | 0 | 51 | 243 | 0 |

the causeway occurred in 1989, and nesting colonies return some years but not other. Notable years included 2004, with 16 nests found on the causeway, and 2007, with 48 nests. Smaller numbers of gull-billed tern nests have also been recorded on Bird Island since its creation (Tables 24 and 25) (ANERR, unpublished).

The 1996 census marked the first year royal terns and Caspian terns were documented nesting at the two primary sites in the area. Although the royal terns nest among the predatory laughing gulls, they appear to experience some success with immature royal terns visible throughout the nesting season. Sandwich tern nests have been noted within the royal tern colony since 1997. In recent years these species have been much more successful nesting on both the causeway and Bird Island (Tables 24 and 25). In 2007 a single sooty tern nest with one chick was found on the causeway. Sooty terns usually only breed in the Dry Tortugas or Bush Key, though nests have been documented in Franklin County previously (Loftin, 2007). Brown pelican nesting has been documented for the Lanark reef near Carrabelle (beginning in 1994) and Black's Island in St. Joseph Bay. Within Reserve boundaries, a growing number of brown pelicans have been nesting on Bird Island every year since 2001.

This area of the panhandle represents one of the last opportunities for these predominately ground nesting species to experience success as other suitable nesting areas in Florida succumb to developmental pressure and other negative human impacts. The tremendous amount of interagency coordination involved with the monitoring and protection of these colonial shorebirds in Franklin County will hopefully ensure their continued presence at local nesting sites. Reserve staff encourage avian work in the Reserve and assist with the monitoring of other species since the number of species and their future existence within the Apalachicola area is certainly a significant indicator of the overall health of the system.

### Mammals

Mammals have probably been one of the least studied groups, not only in the floodplain, but throughout the entire Apalachicola drainage basin. Means (1977) lists 52 species of mammals found in the drainage basin, which includes caves, uplands, floodplain, and barrier islands. This list was taken from a Hall and Kelson (1959) publication concerning the mammals of North America. While many of these species are found in the Apalachicola basin, not all are found within the boundaries of the ANERR (Edmiston and Tuck, 1987).

The American beaver and the river otter probably utilize the river and tributaries of the floodplain more than any other mammals. One of the unique aspects of the beaver is that it is one of the few animals with the ability to alter its own environment. By damming small sloughs and backwaters, the beaver can threaten floodplain vegetation by changing the hydrologic conditions in these areas (Edmiston and Tuck, 1987). The Florida otter is found from northern Florida to the Everglades. Although often targeted as a culprit for preying on gamefish, rough fish have been found to comprise the majority of the otter diet. Crayfish are also a common prey item. Breeding takes place from January through April (McDaniel, 1963). Otters are frequently observed in the Apalachicola waterfront and Scipio Creek areas as well as in the marshes of the Apalachicola River and upper Bay.

Although thirteen different species of bats are documented within the Florida portion of the drainage basin, little has been studied about their distribution or behavioral characteristics (See Appendices). The gray bat and the Indiana bat are both listed as endangered at both the state and federal levels (FFWCC, 2006). The gray bat is unique because its wing membrane attaches at the ankle. Although their diet consists predominately of insects, predation on mosquitoes commonly occurs only in Florida. The hoary bat exhibits the widest geographic range and is also one of the largest bats in the eastern U.S. In contrast, the smallest bat in the eastern U.S., the Eastern pipistrelle, is also found within the Reserve (Whitaker, 1996).

Small mammals such as the hispid cotton rat, cotton mouse, golden mouse, Eastern harvest mouse, house mouse, Southern flying squirrel, Southern short-tailed shrew, and least shrew abound within the Reserve. The hispid cotton rat is readily abundant, not only within the Reserve but generally throughout the southeastern United States. It is a popular prey species, being a primary component of the diets of snakes, owls, hawks, foxes, and bobcats (Landers and Crawford, 1995). The cotton mouse probably is the second most abundant small mammal in the area. Although habitat overlap exists between these two species, they are able to coexist through habitat specialization characterized by varying moisture gradients.

The wetter portions of the floodplain, including the tupelo-cypress association and marshes, probably host a high density of raccoon, round-tailed muskrat, mink, and rice rat (Wharton et al., 1982). The lower Apalachicola River encompasses the western-most distribution of the round-tailed muskrat (Schwartz, 1953). The floodplain habitat is vital to the existence of important game mammals such as white-tailed deer, feral hog, and gray squirrel. Although no longer hunted, Florida black bear are also common inhabitants of the floodplain and uplands. Mammals which prefer the drier areas of the floodplain include the cotton mouse, south-eastern shrew, marsh rabbit, and bobcat.

White-tailed deer, raccoon, bobcat, fox, opossum, striped skunk, cotton rat, and cotton mouse are dominant species of flatwood communities (Edmiston and Tuck, 1987). The hardwood communities of the area include a diverse assemblage of mammals including wood rat, cotton mouse, gray fox, shrews, moles, and white-tailed deer. The scrub communities of the Apalachicola area support few resident

***Figure 93.*** *Florida black bear near Apalachicola Bay*

mammals although the spotted skunk is commonly documented in this habitat type (FNAI, 1986; Edmiston and Tuck, 1987). Raccoons, white-tailed deer, and feral hogs are found in a variety of habitat types including flatwoods, titi swamps, bayheads, shrub bogs, and hardwood hammocks. They are quite numerous on St. Vincent NWR, primarily a function of the variety of habitat available.

Raccoons are common scavengers of the bayside and barrier island beaches. When they employ this foraging strategy in the summer months, it coincides with the sea turtle nesting season. As a result of their opportunistic nature, raccoons are vigorous predators of sea turtle eggs on barrier island beaches and depredate other species of turtle clutches in floodplain habitats. Feral hogs are known predators of sea turtle nests although their diet primarily consists of plant material. In recent years coyotes have become more numerous throughout Florida and also predate sea turtle nests along coastal counties.

Bobcat sightings in the area are fairly common, especially in flatwoods communities. They are typically small prey specialists frequently targeting rabbits, cotton rats, and birds but taking an occasional deer or hog when possible (Maehr and Brady, 1986). Their winter diet consists primarily of bobwhite quail and migratory passerines (Maehr and Brady, 1986).

The black bear (Figure 93) is the largest land mammal in Florida and is characterized by a relatively low population density and a large geographic home range. Most estimates of the Florida black bear population are between 500 and 1000 (Maehr and Wooding, 1992) with an 83% reduction in geographic range when contrasted with historical data (FGFWC, 1993). The black bear exists throughout Florida although its distribution has become reduced and fragmented (Maehr, 1984b; Maehr and Wooding, 1992). Due to negative impacts imposed by habitat destruction and poaching, the Florida Fish and Wildlife Conservation Commission designated the Florida black bear a threatened species in 1974. Besides loss of habitat, dangers are also imposed by encroaching silviculture, vehicle collisions (Wooding and Brady, 1987), and disgruntled landowners and beekeepers (Maehr and Brady, 1982; Maehr and Wooding, 1992; Williams, 1978). Management of black bear populations in the northeastern and northwestern portions of Florida is complicated by their ability to cross into neighboring states (Maehr, 1984b).

***Figure 94.*** *Sambar deer on St. Vincent Island National Wildlife Refuge*

A radio tracking study of black bears in the Apalachicola area in 1990 examined the extent of their home range while also looking at seasonal movements, habitat utilization, and denning. Home ranges for black bears in the Apalachicola area averaged 81 square miles for adult males and 25 square miles for adult females. Overall, the Apalachicola National Forest supports bears with larger home ranges than other parts of the country, and this characteristic is probably a factor of lower food availability. Black bears in the Apalachicola area typically exhibit denning for a period of 13 to 150 days (Siebert, 1997).

The Reserve hosts two species of deer, the white-tailed and the sambar (Figure 94). The exotic sambar deer is found only on St. Vincent Island. It is native to India and was introduced to the island for hunting purposes in 1908. The species seems to prefer the freshwater marshes and adjacent forested areas of St. Vincent (Newman, 1948; Lewis et al., 1990) with browse, grasses, sedges, forbs, and mast comprising the majority of their diet. Browse is also the primary component of the white-tailed deer diet, and some of the most abundant species include holly-wax myrtle-bay groups and oaks. Sambar deer also forage on a significant amount of aquatic vegetation such as water lilies (Shea et al., 1990). Although dietary and habitat overlap certainly occurs, sambar and white-tailed deer seem to coexist successfully on St. Vincent. Due to the exotic nature of the sambar, eradication was considered. However, current management strategies include estimating population density through track counts and monitoring the results of three special hunts on St. Vincent Island National Wildlife Refuge. The hunts are designed to maintain healthier herds of lower density (Flynn et al., 1990). The white-tailed deer is prevalent within the Reserve, especially in the floodplain and heavily forested areas.

The red wolf (Figure 95) is considered one of the most critically endangered mammals in North America. The red wolf was officially considered extinct in the wild in 1980. The U.S. Fish and Wildlife Service presently supervises red wolf reintroduction efforts. The species' gene pool has been significantly weakened through interbreeding with coyotes. Aggressive predator control programs and severe habitat losses continue to contribute to the decline of the species. Between 250 and 300 red wolves exist today, of which approximately 184 are housed at captive breeding facilities around the United States (USFWS, 2006). In a few instances, re-

***Figure 95.*** *Male red wolf on Cape St. George Island being released to the wild*

mote barrier islands are utilized to provide wolves with a place to gain wild experience prior to release at a mainland reintroduction site. Testing the theory that wolves raised on the islands are better adapted for life in the wild at a mainland reintroduction site than captive-reared wolves is the overall goal of these island propagation projects. Increasing survival rates and wild behavioral traits is a primary objective of this phase of the program. Secondary objectives include prey population control, public education, and public relations (Henry et al., 1995). These islands were not intended to serve as permanent homes for free-ranging wolves, but as temporary wild places to be used until a permanent re-introduction site could be made available.

In 1990, two red wolves were placed on St. Vincent National Wildlife Refuge as part of a breeding program. The project goal on the island is aimed at increasing the population of red wolves that can be used for reintroduction. Overall, the wolf project on the island has been successful with numerous litters being produced. On January 14, 1998, Cape St. George Island became the new temporary home for two red wolves in an interagency cooperative effort involving the Florida Department of Environmental Protection (ANERR) and the U.S. Fish and Wildlife Service. The island represents only the fourth island to house red wolves within the red wolf recovery program. The wolves' habitat use, prey selection, and overall behavior on the island was monitored closely by ANERR staff through radio-tracking efforts. It was hoped that placing the red wolves on the Cape would increase the success of sea turtle nests on the island which have suffered severe depredation from raccoons in the past. Raccoons were expected to be the main prey species consumed by the wolves on Cape St. George whereas prey species for the wolves are more diverse on St. Vincent. The program, which initially succeeded in reducing the number of raccoons on the island, was brought to a close approximately two years later when the wolves began preying on sea turtle nests.

## Marine Mammals

The majority of existing data on marine mammals from the Apalachicola area results from strandings, boat sightings, and aerial surveys (Mullin et al., 1991). This area harbors as many as three

***Figure 96.*** *Live rough-toothed dolphin stranded on area beach.*

endangered offshore cetacean species and one endangered sirenian on a seasonal basis. Of the fifteen species of cetaceans found in this region, one species is commonly sighted in the estuary. The bottlenose dolphin is widely distributed throughout the Gulf of Mexico, and is commonly found in Apalachicola Bay (Edmiston and Tuck, 1987; Wren et al., 2004).

The cetacean community generally exhibits increasing diversity with distance from the coast. Evidence of local offshore cetacean species is supported and documented by state stranding and sighting reports. Strandings of sperm whale, pygmy sperm whale, Sowerby's beaked whale, pygmy killer whale, and spinner dolphin are documented for this region and thus are assumed to be present in the surrounding offshore waters (Bonde and O'Shea, 1989; Schmidly, 1981). Three other species with documented strandings in this area include a sei whale (1994), a dwarf sperm whale (1997), and rough-toothed dolphins (1996 and 1997) (Wren et al., 2004). Other sighting data suggest the possible presence of the minke whale, Bryde's whale, fin whale, Risso's dolphin, Atlantic spotted dolphin, and short-finned pilot whale in the offshore areas (Mullin et al., 1991).

Bottlenose dolphins comprise the majority of marine mammal strandings for this area. The higher frequency of strandings by this species is most likely due to their coastal nature and wide geographic range, which usually extends to the continental shelf. The bottlenose dolphin utilizes the bay extensively for food, preying on smaller and medium-sized fish including mullet. While they may also socialize in estuarine habitats, breeding and calving are not restricted to these boundaries (Caldwell and Caldwell, 1973).

One hundred thirty-two strandings of cetaceans or sirenians are documented for Apalachicola and its surrounding areas between 1990 and 1998. Reserve staff has responded to 58 of these strandings, including 11 in 1995, 25 in 1996, 11 in 1997, and 5 in 1998. Although the majority of these strandings typically involve dead bottlenose dolphins, Reserve staff did have the opportunity to respond to three live strandings in Gulf County in 1997, including a dwarf sperm whale, a bottlenose dolphin, and a mass stranding of live rough-toothed dolphins (Figure 96). Although evidence of the interaction between marine mammals and the commercial fishing industry is minimal in this area, Reserve staff respond to animals entangled in fishing gear as was the case with a bottlenose dolphin calf entangled in a crab pot line and freed by Reserve staff in July 1998. A live juvenile sperm whale beached itself on St. George Island in the summer of 2001 and was transported to the Clearwater Marine Aquarium (Wren et al., 2004). The Reserve's participation in the marine mammal stranding network has decreased since 2001 due to other commitments and staff turnover.

Dolphin tooth samples collected by ANERR staff have historically been sent to Hubbs-Sea World Research Institute where they are evaluated for age. Through the end of 1998, lower jaw sections had been collected from 39 dolphins. Ages from 19 of these dolphins are currently available with ages ranging from 0.0 (no neonate line) to over 27 years of age (Wren et al., 2004). Stomach contents obtained from a stranded bottlenose dolphin in the Apalachicola area contained at least 23 different prey species (Barros, pers. comm.). Fish species comprised 90.4% of the individual's diet. Prey species represented in this sample included: sand seatrout, spotted seatrout, silver seatrout, Atlantic croaker, kingfish, hake, pinfish, searobin, star drum, striped anchovy, other *Anchoa* species, Atlantic cutlassfish, spot, bluefish, whiff, tonguefish, sardines, brief squid, arrow/long-finned squid, three to four unidentified teleosts, and shrimp. This diet is indicative of feeding strategies associated with local shrimping activity and is consistent with bottlenose dolphin from the Florida/Georgia border and the Texas coast (Barros, pers. comm.).

One species of sirenian, the Florida subspecies of the West Indian manatee (*Trichechus manatus latirostris*), is considered endangered throughout its range and is also found in the Reserve. In addition to the Marine Mammal Protection Act, these aquatic herbivores are protected by the Endangered Species Act of 1973 and the Florida Manatee Sanctuary Act of 1978. Manatees are frequently observed in the Apalachicola River and East Bay with the majority of sightings occurring in the summer months when water temperatures are high (Edmiston and Tuck, 1987). In terms of total sightings for 1996-2001, the months of June, July, August, and September reveal a higher number of manatees utilizing the Apalachicola area (Figure 97) (Wren et al., 2004). Although the sample size is small, this trend would be consistent with existing historical literature and aerial surveys conducted by ANERR staff in the Apalachicola area from May

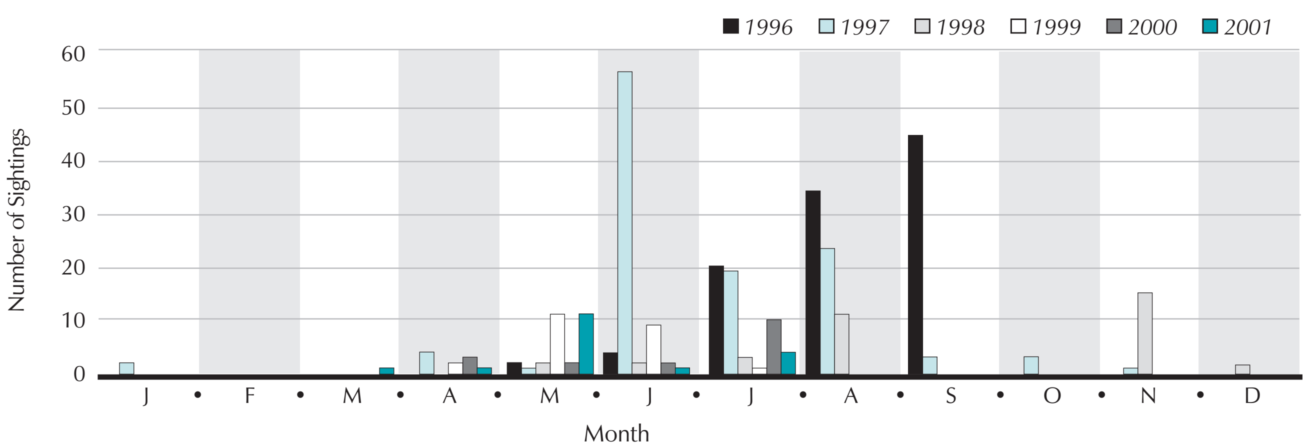



***Figure 97.*** *Manatee sightings documented in Franklin County, 1996-2001*

**TABLE 26**

## Apalachicola Bay aerial manatee survey results (1997-1998)

| Survey Date | Sightings | Adults | Calves | Location |
|---|---|---|---|---|
| 05/15/97 | 1 | 1 | 0 | Cape St. George Island bayside |
| 06/26/97 | 28 | 27 | 1 | Indian Pass, Thirteen Mile Point, St. George Island bayside, Yent's Bayou, East Bay, Round Bay |
| 07/16/97 | 15 | 15 | 0 | Yent's Bayou, between Yent's and Marsh Point, Cat Point, Round Bay, Little St. Mark's River mouth, Ten Foot Hole Marina and Boat Ramp, Two Mile Channel/Lafayette Park |
| 08/22/97 | 11 | 10 | 1 | St. Vincent Sound off Green Point, St. George Island bayside (east), Yent's Bayou, Round Bay, St. Mark's River mouth |
| 08/28/97 | 11 | 11 | 0 | Eastpoint breakwater area, Cash Bayou, Round Bay, East Bay, East River mouth |
| 09/30/97 | 0 | 0 | 0 | N/A |
| 10/23/97 | 0 | 0 | 0 | N/A |
| 11/25/97 | 0 | 0 | 0 | N/A |
| 12/17/97 | 0 | 0 | 0 | N/A |
| 01/27/98 | 0 | 0 | 0 | N/A |

1997 to August 1998 (Table 26). These surveys reveal primary usage of the area in the summer months and indicate a high frequency of sightings in the Blount's (Round) Bay area of East Bay (Calleson, unpublished).

Estuaries provide a variety of manatee habitat requirements including feeding areas, travel corridors, freshwater access, and protected areas for resting and calving. A large number of manatees on the Gulf Coast overwinter in the Big Bend region of Florida, particularly the Crystal and Homosassa Rivers, where natural springs produce water temperatures that are higher than surrounding ambient waters. The Apalachicola area may function as a stopover site for manatees during the warmer months of the year, providing sources of aquatic vegetation and freshwater access off the travel corridor between Florida and states to the west. In other areas of Florida, waterfront development and pollution are linked to the decline of suitable manatee habitat (Packard and Wetterqvist, 1986), including seagrass communities which are a critical nutritional source for manatees. Manatees consume as much as 4-9% of their body weight each day in wet vegetation (Etheridge et al., 1985), and several species commonly consumed by manatees are present within the ANERR. The manatee's known preference for consumption of freshwater vegetation may explain manatee sightings in the Apalachicola River and in East Bay, both of which have significant amounts of submerged vegetation.

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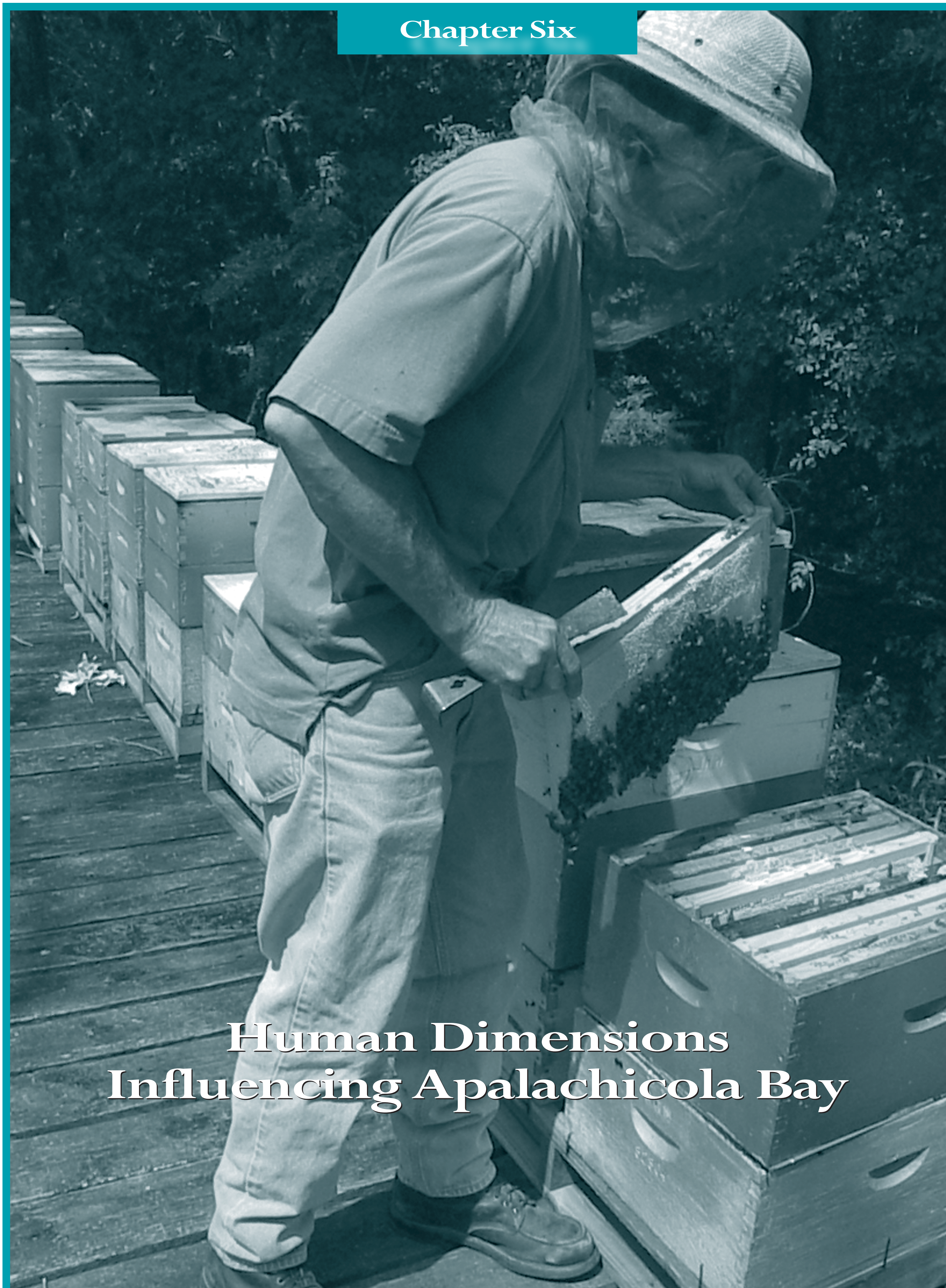

Chapter Six

# Human Dimensions Influencing Apalachicola Bay

The Apalachicola Bay area and Franklin County depend to a considerable degree on a rather narrow economic base that revolves around natural resources, especially the aquatic environment of the region. Both upland and aquatic resources of the Apalachicola National Estuarine Research Reserve provide a wide variety of uses. Areas adjacent to the Reserve, which impact the Reserve, also provide many diverse uses. Some of these uses are compatible with the goals of the Reserve while many are in direct conflict with the Reserve's goal of protecting the natural resources of the region. Understanding the activities that occur within the region is critical to defining the management issues with which the Reserve must deal. To better understand the issues associated with resource management, important information related to the cultural history, demographics, and land and water uses of the area within and adjacent to the Reserve is needed.

## Cultural History

The Apalachicola River Valley is believed to have been occupied by humans for over 10,000 years (Dunbar and Waller, 1983). Little is known of the early inhabitants, other than that they probably were small, seasonally wide-ranging groups of hunter-gatherers organized in family bands (White, 1986). The Apalachicola River Valley is believed to have been an ideal environment for small hunting groups; however no direct evidence of Paleo-indian occupation has been uncovered to date in the main valley (Henefield and White, 1986). Abundant Paleo-Indian remains are known from the Chipola Valley, the largest tributary, perhaps because the main river flowed through its channel 10,000 years ago (White and Trauner, 1987).

The Archaic cultural period (8000-1000 B.C.) is only slightly better known than the earlier period of habitation in the Apalachicola River Valley. Several middle to late Archaic sites, however, have been found in the region (Bullen, 1950; Kurjack, 1975; Huscher, 1964; and White, 1986). The type of tools used during this period indicates an increasing reliance on smaller game animals. Human populations became more sedentary by 1000 B.C., engaging in hunting and foraging as well as the beginnings of plant cultivation (White et al., 1992).

The next cultural period, known as the Woodland, lasted from 1000 B.C. to 1000 A.D. The hunter-gathering lifestyle was changing to more dependence on cultivated plants and settlements were becoming more permanent (White et al., 1992). In northwest Florida, the early Woodland adaptation is known as the Deptford period. Deptford pieces, normally associated with coastal swamps and estuaries (Milanich and Fairbanks, 1980), have been located at a number of inland sites in the region (Bullen, 1950; Huscher, 1964; White, 1986). One site in particular on the Apalachicola River suggests more than an occasional occupation with the Deptford component extending several hundred meters along the riverbank. Deptford components are also prevalent at estuarine shell mounds (White, 1986).

The Middle Woodland stage, known as the Swift Creek-early Weeden Island culture, spread to the basin by 200 A.D. and lasted until about 1000 A.D. Numerous Weeden Island sites, with multiple burial mounds and e-xtensive middens, have been investigated in the central river valley (Bullen, 1950; Kelly, 1950; Huscher, 1964, 1971; and White, 1981). In response to constant diffusion of culture traits from Mississippian peoples, the Weeden Island culture gave way to the Ft. Walton culture, which can be dated at A.D. 1000 to 1600. Fort Walton societies had evolved into true chiefdoms, complex political systems with temple mound - village settlements based on maize agriculture. These Ft. Walton populations were the first to have contact with Spanish explorers, who organized a chain of missions from 1670 to 1685 (Jones, 1973). By the mid-seventeenth century, native cultures were disrupted and populations had declined severely, mostly because of the introduction of European disease (Henefield and White, 1986).

The Apalachicola River and Bay Drainage Basin, which includes the Reserve, contains over 100 archaeological sites and numerous historic structures. Several systematic intensive surveys have been accomplished or are ongoing within the boundaries of the Reserve. An archaeological study funded by the Florida Department of State, Division of Historical Resources (DHR) investigated the impact of the 1994 record flood on 24 newly located and 67 previously located sites within the Apalachicola River Drainage Basin (White, 1996). Several sites exposed by flooding, hurricane-generated wave action, or coastal erosion were surveyed within the Reserve. The general locations of known cultural sites within the lower Apalachicola River basin can be seen in Figure 98. However, this probably represents only a small percentage of all the archaeological sites that may be present in the area (N. White, per comm.).

In more recent times the City of Apalachicola was established in 1831 and was once the third largest port in the Gulf of Mexico. By the 1850's, the city waterfront was lined with brick warehouses and broad streets to handle the loading and unloading of cotton. Steamboats laden with cotton came down the River, were unloaded, and the cotton reloaded onto small shallow draft schooners that shuttled the cargo to larger ships moored offshore. In the late 1800's, railroads expanded throughout the United States and a new industry took shape in the city. Because of the large cypress forests in the river floodplain and adjacent areas, numerous lumber mills sprang up in Franklin County. Lumber magnates, many from up north, built many magnificent historic homes that still line the city streets. Over 200 historic homes and buildings, listed on the National Register, remain today (ABCC, 2007). By the end of the 19th century, oysters and other local seafood became an important industry that is still the lifeblood of the County today.

## Demographics

Franklin County, which surrounds most of Apalachicola Bay, is a rural county in northwest Florida, encompassing 348,800 acres (544.3 square miles) of land, which ranks it 56th in size out of the 67 counties in the state (Rand McNally, 1993). The population also ranks as one of the lowest in the state with only 10,264 people county-wide and less than half of them living in the two incorporated areas of Apalachicola and Carrabelle (U.S. Census Bureau, 2007). The population has actually decreased from 11,057 since 2000, the only county in the Florida portion of the drainage basin to experience a decline. The per capita income in the County in 1999 was $16,140 with over 17% of the individuals below the poverty level (U.S. Census Bureau, 2007).

Employment in the area has been primarily dependent on products from the natural resource base: timber production, seafood harvesting, and tourist expenditures (Colberg et al., 1968). Historically over 65 percent of the Franklin County work force has been employed by the commercial fishing industry, although this has been changing with the increasing importance of tourism to the area. Because fishing is primarily an "export" industry, practically all sales are outside the region (Prochaska and Mulkey, 1983).

Population and residential development in Franklin and Gulf counties is relatively sparse. The only municipalities within these counties near the Reserve include Apalachicola, Carrabelle, Port St. Joe, and Wewahitchka. The combined population of these four cities is approximately 9,000. The rest of the Florida portion of the Apalachicola-Chattahoochee-Flint River drainage Basin is also sparsely settled. The eight counties that are part of the drainage basin in Florida (Table 27) had a 2007 Census population of 327,670 individuals (U.S. Census Bureau, 2007). However, the population within the actual drainage basin in Florida is probably less than 100,000 individuals. The economic base of these eight counties is primarily agriculture, forestry, commercial fishing, and recreational fishing and hunting (Starnes-Smith et al., 1991).

## Land Use/Land Cover

Land use characteristics influence runoff patterns, types of pollutants, water quality and quantity, and virtually all aspects of riverine and river-dominated estuarine systems. Of the approximately 19,800 square miles within the Apalachicola-Chattahoochee-Flint River drainage basin only about 2,800 square miles are within Florida (Figure 99). This Florida portion includes parts of eight counties encompassing over 1,820,000 acres, with most of this acreage contributed by the 6 counties that border the river (Table 28). The upper portion of the river basin is dominated by forestry and agriculture while the lower portion is predominantly natural areas with large tracts of managed forests and forested and non-forested wetlands (Rains, 1993). To get a better idea of the surrounding landscape, both the Apalachicola River and Franklin County drainage areas need to be understood since much of Franklin County drains primarily into the bay instead of the river.

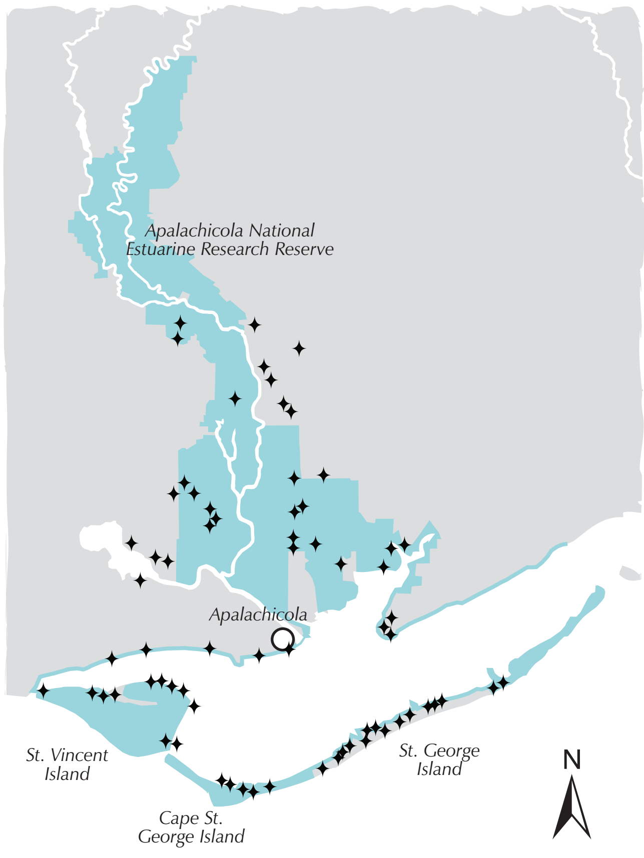


***Figure 98.*** *Archaeological sites in the lower Apalachicola Basin*

Franklin County is predominantly rural with 96 percent of the total county area of 348,800 acres zoned either agriculture (primarily forestry) or conservation lands (Franklin County Comprehensive Plan, 2004). There is actually a significant shift from agricultural lands to conservation lands since 1989, mostly due to the large land purchases

**TABLE 27**

### Population of Florida Counties within the Apalachicola Watershed

*(modified from U.S. Census Bureau, 2007)*

| County | 2006 population | 2000 population | Percent of County Area Within Watershed |
|---|---|---|---|
| Bay | 163,505 | 148,217 | 1.5 |
| Calhoun | 13,410 | 13,017 | 94.0 |
| Franklin | 10,264 | 11,057 | 89.0 |
| Gadsden | 46,658 | 45,087 | 21.1 |
| Gulf | 14,043 | 13,332 | 59.1 |
| Jackson | 49,288 | 46,755 | 87.3 |
| Liberty | 7,782 | 7,021 | 64.8 |
| Washington | 22,720 | 20,973 | 1.9 |
| **Total** | **327,670** | **305,459** | |


***Figure 99.*** *Apalachicola-Chattahoochee-Flint River Drainage Basin*

by the State of Florida as part of its efforts to protect Apalachicola Bay (Table 29). The Tate's Hell State Forest, created in 1994, is the largest in the State of Florida at 202,414 acres (FDOF, 2007) and accounts for most of this change. Much of the agriculture and conservation lands are also wetlands. The northern and interior portion of the county remains mostly uninhabited. Most new development in the county is concentrated along the coast. Although the county and basin are relatively undeveloped, there is considerable development pressure in the area, especially in the coastal zone. The major land use on most of the land surrounding the Reserve has historically been forestry operations, predominantly pine plantations. Most of the land away from the coast and outside Reserve boundaries is owned and managed by the state or federal government.

Agricultural/Silvicultural land dominates in all eight counties within the drainage basin, however, only a small percentage of persons are specifically employed in farming or forestry. Forest product quantities range from 5.2 million cubic feet in Gulf County to 17.2 million cubic feet in Bay County (Shoemyn et al., 1992). Forested uplands comprise almost half of the total drainage basin in Florida (Table 30). Approximately 78 percent is evergreen forests, much of which is slash pine plantations used in silviculture operations. Most of the actual cropland is found in the upper basin while silviculture dominates the middle and lower basin. Forested wetlands comprise the next largest land cover category, with most of this habitat found in the middle and lower basin, associated with the Apalachicola River floodplain (Rains, 1993).

Large areas have been drained, ditched, and diked and wetter species such as cypress replaced by slash pine. The Apalachicola River floodplain was first harvested between 1870 and 1925 and has been logged once or twice since that time. Regrowth has been rapid, however, and much of the floodplain has the general appearance of a mature forest, although the percent of cypress has been reduced (Clewell, 1977).

## Recreation

Resource-based recreational opportunities within the Reserve are varied and abundant. Included within the boundaries of the Reserve are the St. Vincent Island National Wildlife Refuge, Cape St. George Island (managed by ANERR), Dr. Julian G. Bruce St. George Island State Park, Apalachicola Bay Aquatic Preserve, Fort Gadsden Special Feature Site, the Apalachicola Wildlife and Environmental Area, and the Apalachicola River Water Management Area. Adjacent or near the Reserve are the Tate's Hell State Forest, Apalachicola National Forest, Edward Ball Wildlife Management Area, G.U. Parker Wildlife Management Area, St. Joe Bay Aquatic Preserve, Alligator Harbor Aquatic Preserve, and the St. Joe Buffer Preserve (Figure 100). Access to many areas within the Reserve is only by boat, as much of the acreage that is not estuarine habitat is forested floodplain and wetlands and few roads exist in these areas.

Although the Reserve does not coordinate recreation, it is an important activity within and adjacent to the Reserve. Currently the Reserve has restricted vehicle traffic and provides parking lots and gazebo's at some of the more popular sites within its boundaries; however, no sanitary facilities have been planned for these areas as yet. Recreation contributes to the social well-being

**TABLE 28**

## Land Area of Florida Portion of Apalachicola Watershed by County

*(modified from Rains, 1993)*

| County | County Area (sq.mi) | Area within Watershed (sq.mi.) | Area within Watershed (acres) | Percent of Watershed | Percent of County area | Percent Urban within Watershed |
|---|---|---|---|---|---|---|
| Bay | 758 | 11.1 | 7,129 | 0.4 | 1.5 | 2.4 |
| Calhoun | 568 | 532.4 | 340,731 | 18.7 | 94.0 | 2.0 |
| Gadsden | 518 | 109.1 | 69,822 | 3.8 | 21.1 | 5.1 |
| Gulf | 559 | 330.2 | 211,315 | 11.6 | 59.1 | 3.5 |
| Franklin | 545 | 486.3 | 311,210 | 17.1 | 89.0 | 3.1 |
| Jackson | 942 | 822.8 | 526,562 | 28.9 | 87.3 | 4.0 |
| Liberty | 837 | 542.0 | 346,898 | 19.1 | 64.8 | 3.1 |
| Washington | 590 | 11.3 | 7,235 | 0.4 | 1.9 | 1.4 |
| Total | | 2845.2 | 1,820,902 | 100 | | |

of the local residents and also to the local economy through tourism. Recreational activities within the Reserve include boating, fresh and saltwater fishing, camping, nature study and birding, canoeing, kayaking, hiking, picnicking, shelling and other beach activities, swimming, sailing, and hunting. Fresh and salt water fishing are primary activities of many visitors. Hunting opportunities during winter and spring are available on all Reserve uplands, State Wildlife Management Areas, in the National Forest, and on St. Vincent Wildlife Refuge, to a limited degree. For most of these recreational activities the Reserve has no regulatory or enforcement capabilities and must rely on other agencies, mostly state and federal entities.

Recreational fishing, both fresh and saltwater are probably the largest recreational activities in the area. As the commercial finfish fisheries have changed over the last 20 years, a growing number of charter boats have become active in Apalachicola Bay, specializing in taking recreational fishermen out for a day of fishing. The number of charter boats operating in the area is currently unknown,

**TABLE 29**

## Franklin County Land Use

*(Franklin County Comprehensive Plan, 2004)*

| Land Use | Total Acres | Percentage of County (2004) | Percentage of County (1989) |
|---|---|---|---|
| Agricultural | 32,142 | 9.2 | 76.0 |
| Commercial & Services | 408 | 0.1 | 0.2 |
| Conservation | 304,027 | 87.2 | 11.6 |
| Incorporated | 3,933 | 1.1 | 0.5 |
| Industrial | 560 | 0.2 | 0.4 |
| Institutional | 716 | 0.2 | 0.2 |
| Recreational | 112 | 0.03 | 0.5 |
| Residential | 6,399 | 1.8 | 4.7 |
| Trans., Comm, & Utilities | 458 | 0.1 | NA |
| **Total** | **348,755** | **100** | |

**TABLE 30**

## Dominant categories of Land use/Land cover within the Apalachicola Watershed area

*(modified from Rains, 1993)*

| FLUCCS Code | Land use /Land cover class | Total Acres | Percent Total | Percent Subtotals |
|---|---|---|---|---|
| 110.130 | Residential (low-high density | 24,254 | 1.33 | |
| 140.190 | Commercial, industrial, institutional, etc. | 6,937 | 0.38 | |
| | Subtotal | | | 1.71 |
| 210 | Cropland and Pasture | 303,264 | 16.65 | |
| 220.260 | Other Agriculture | 1,328 | 0.08 | |
| | Subtotal | | | 16.73 |
| 320 | Shrub and Brushland | 3,927 | 0.22 | 0.22 |
| | Subtotal | | | 0.22 |
| 410 | Coniferous Forests | 88,507 | 4.86 | |
| 420 | Hardwood Forests | 11,829 | 0.65 | |
| 430 | Hardwood/Coniferous Mixed | 49.478 | 2.72 | |
| 440 | Tree Plantations and Regeneration Areas | 720,688 | 39.58 | |
| | Subtotal | | | 47.81 |
| 510 | Streams and Waterways | 16,348 | 0.90 | |
| 520 | Lakes | 18,205 | 1.00 | |
| | Subtotal | | | 1.90 |
| 610 | Wetland Hardwood Forests | 352,581 | 19.36 | |
| 620 | Wetland Coniferous Forests | 42,577 | 2.34 | |
| 630 | Wetland Forested Mixed | 113,130 | 6.21 | |
| 640 | Vegetated Non-forested Wetland | 30,395 | 1.67 | |
| | Subtotal | | | 29.58 |
| 710 | Beaches | 2,205 | 0.12 | |
| 720.743 | Other bare or disturbed areas | 1,974 | 0.11 | |
| | Subtotal | | | 0.23 |
| 810 | Transportation | 31,687 | 1.74 | |
| 820 | Utilities | 1,591 | | |
| | Subtotal | | 0.09 | 1.83 |
| | **Grand Total** | 1,820,905 | 100 | 100 |

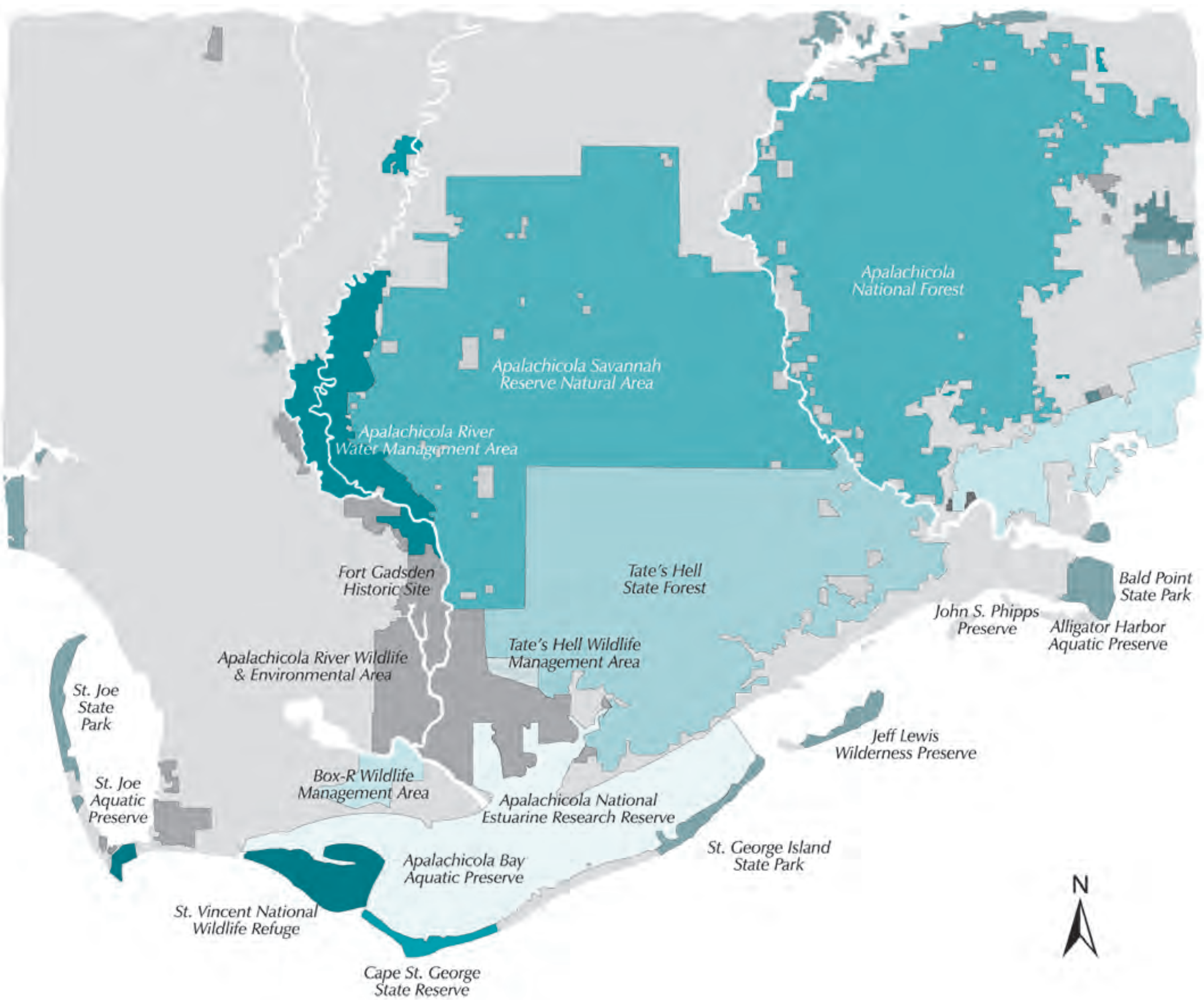


***Figure 100.*** *Publicly owned property within and adjacent to the Apalachicola NERR*

however, their numbers have grown significantly. This activity appears to fall somewhere in the middle of the recreational and commercial fishing industry. The State of Florida led the nation in the number of recreational marine fishing trips with over 29 million trips in 2006, approximately one-third of all recreational marine fishing trips taken in the United States (NMFS, 2007).

As with many other coastal and aquatic based areas, increased use leads to additional pressures on the resource, which normally leads to degradation of the resource. Non-impact, public recreation on Reserve lands is encouraged. Staff, through the Stewardship program, works to reduce or eliminate impacts of recreational activities on lands managed by the Reserve. More information on recreational opportunities, impacts and how the Reserve manages land under its authority can be found in the most recent copy of the ANERR Management Plan (ANERR, 1998).

## Commercial and Recreational Fishing

The Apalachicola Bay system is a highly productive lagoon/barrier island complex. It is estimated that the total commercial fishing industry in Apalachicola Bay is responsible for $134 million in economic output annually and an additional $71 million in value added benefits (Crist, 2007). Of this total the oyster industry supplies $30 million worth of economic benefits annually. In 2006 alone Franklin County reported oyster catches totaling 2,123,585 pounds, finfish catches totaling 1,813,240 pounds, and shrimp landings totaling 1,272,660 pounds (FFWCC, 2006). Commercial fishing has been the most important economic activity occurring within the bay, dating back to the early 1900's. Historically between 60 and 85 percent of the local people make a living either directly or indirectly from the fishing industry (Rockwood and Leitman, 1977). Species commercially harvested in the Apalachicola estuary are both diverse and substantial with considerable annual variation in landings like most natural resource based industries.

Economically, the American oyster is the most important invertebrate harvested in the estuary. The number of oyster harvesters working the bay typically varies from 600 to 1,100 over the last 17 years (Figure 101 ) (FDACS, Unpublished data). Approximately 10% of the oysters harvested nationally and 80-90% of the oysters harvested in Florida come from Apalachicola Bay. Historically, revenue from this industry has accounted for nearly half of Franklin County's income (Whitfield and Beaumariage, 1977). Production on commercial oyster bars has been estimated at between 400 to 1,200 bushels/acre/year (Ednoff, 1984; Berrigan, pers. comm.). Oyster landings vary considerably on an annual basis based on market demand, climactic variables such as rainfall and river flooding. Events such as hurricanes and red tides also play a role. Dockside oyster landings over the last 30 years have ranged from a low of less than 500,000 pounds in 1986, (due to impacts from three hurricanes in 1985 which devastated the oyster bars) to a high of over six million pounds during the early to mid nineteen eighties (Figure 102) (FFWCC, 2007). Since the middle nineteen eighties however, production has typically ranged from 1.5 to 2 million pounds annually, although the value of the harvest continues to increase. Some of these landings (historical vs. recent) are difficult to compare due to changes in the way the data were collected and the fact that harvests were reported as gallons and then changed to pounds landed. Lower demand, public health scares, increased regulations, harvest closures, red tide events, and the difficulty of "making a living on the bay" have all contributed to decreased harvests.

There are approximately 112,000 acres of classified shellfish growing waters within the Reserve but less than 9% of this area is covered by natural and constructed oyster bars. Commercially valuable bars cover an even smaller percentage of this area (Berrigan, 1989), so this economically important resource actually is concentrated in a very small area within the bay. However, because of relatively mild temperatures in the area, oyster growth is continuous throughout the year and has been estimated to be among the

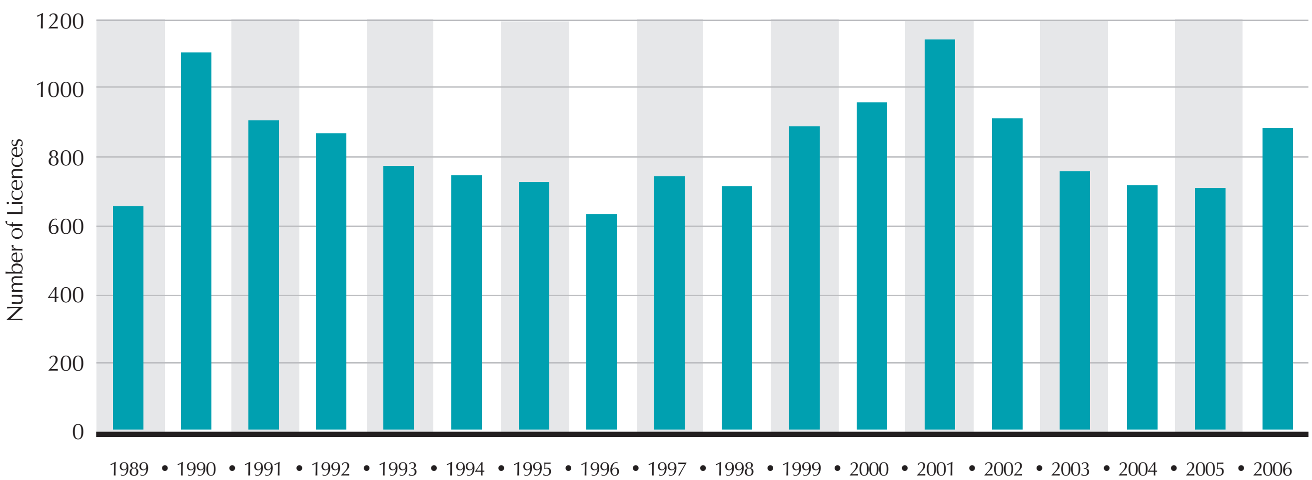


***Figure 101.*** *Franklin County oyster licenses issued*

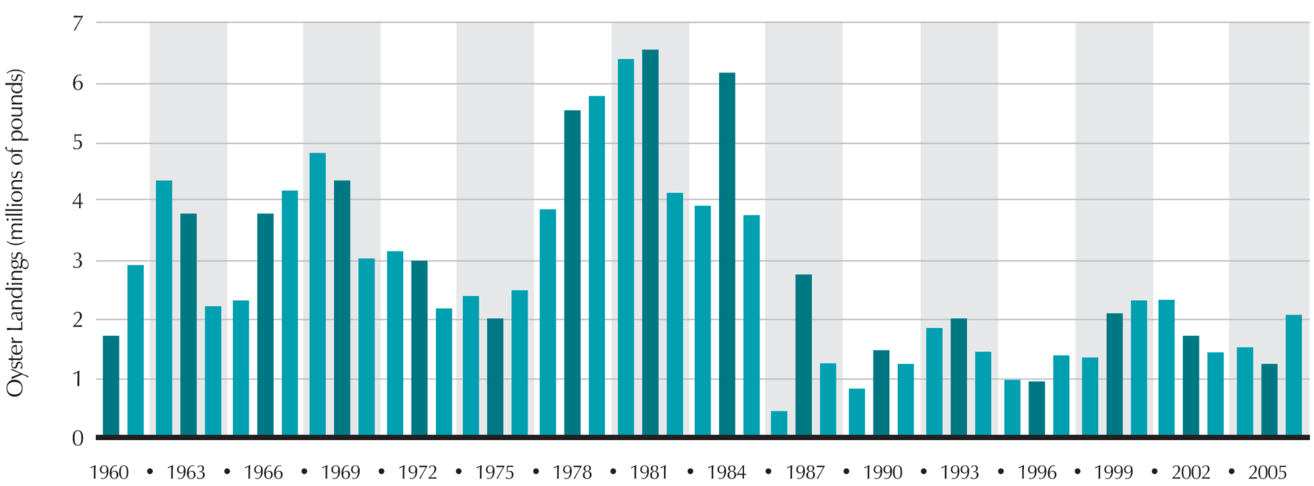


***Figure 102.*** *Franklin County oyster landings (lbs)*

fastest in the United States. Harvestable oysters, those larger than 3 inches, have been produced from spat in as little as 39 weeks. The spawning season is also one of the longest in the United States (Ingle and Dawson, 1952).

While the oyster industry employs more people, the shrimp fishery is worth more in terms of dockside value. Three species of shrimp (white shrimp, pink shrimp, and brown shrimp) are ecologically and economically important to the area. These three species combined represent one-third to one-half of the dollar value of all seafood landings in Franklin County (Cato and Prochaska, 1977). Shrimp landings typically average between two and five million pounds annually and include both bay and offshore harvests (Figure 103). These harvests may be underestimated due to boats from other areas or local offshore boats unloading local shrimp elsewhere.

The blue crab fishery, although substantially smaller than oysters or shrimp, is the third most abundant invertebrate species harvested (Figure 104). Historically more than one million pounds were commercially harvested annually; however, the catch for the last 15 years is down to approximately one-half million pounds or less. Blue crabs are also part of an important local sport fishery. Residents may fish up to five crab pots for their own personal consumption, and this catch is unreported.

Estuarine-dependent fish historically dominated the commercial finfish fishery in Apalachicola Bay. Menzel and Cake (1969) estimated that three-fourths of the commercial catch in Franklin County was dependent on the estuarine habitats and condition of Apalachicola Bay. These species included true estuarine forms, those that use the estuary during part of their life cycle for feeding and nursery grounds, migratory forms, and fresh and saltwater forms which enter the estuary when conditions are appropriate. Historical data indicates that mullet, flounder, and spotted seatrout (speckled trout) were the three most important commercial species of fish, both in terms of poundage and dollar value (NMFS, 2007). Other historically important commercial species caught offshore and landed in Franklin County or caught in Apalachicola Bay include menhaden, spanish mackerel, shark, redfish, pompano, grouper, amberjack, and snapper.

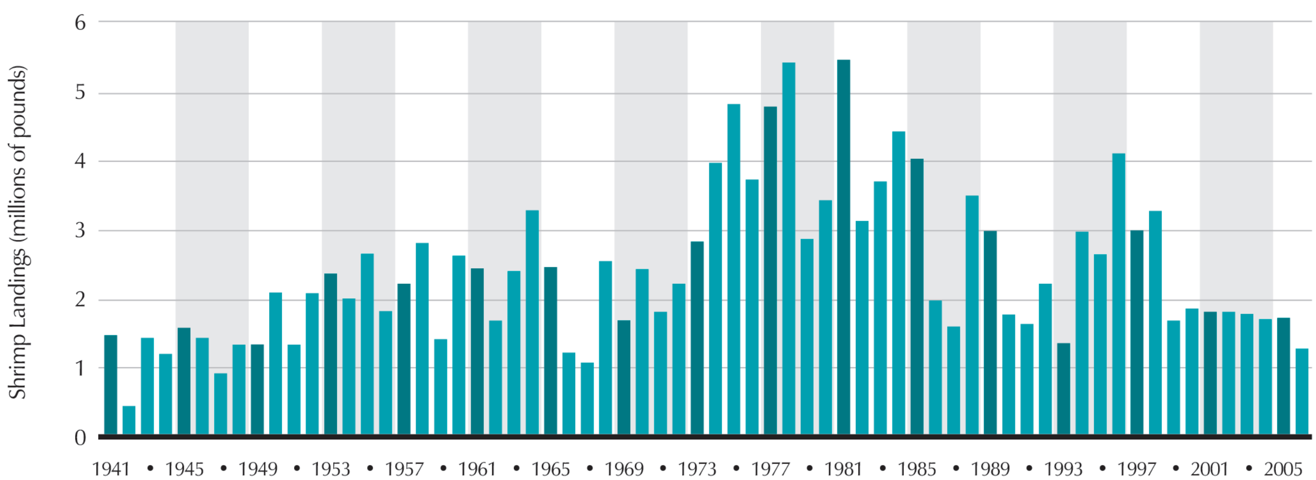


***Figure 103.*** *Franklin County shrimp landings*

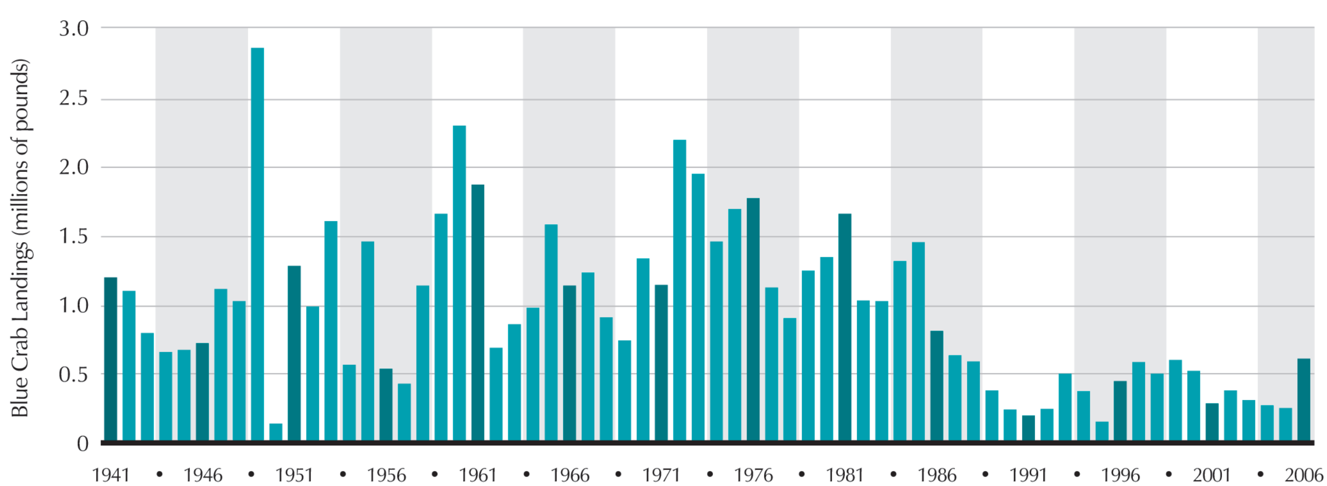


***Figure 104.*** *Franklin County blue crab landings*

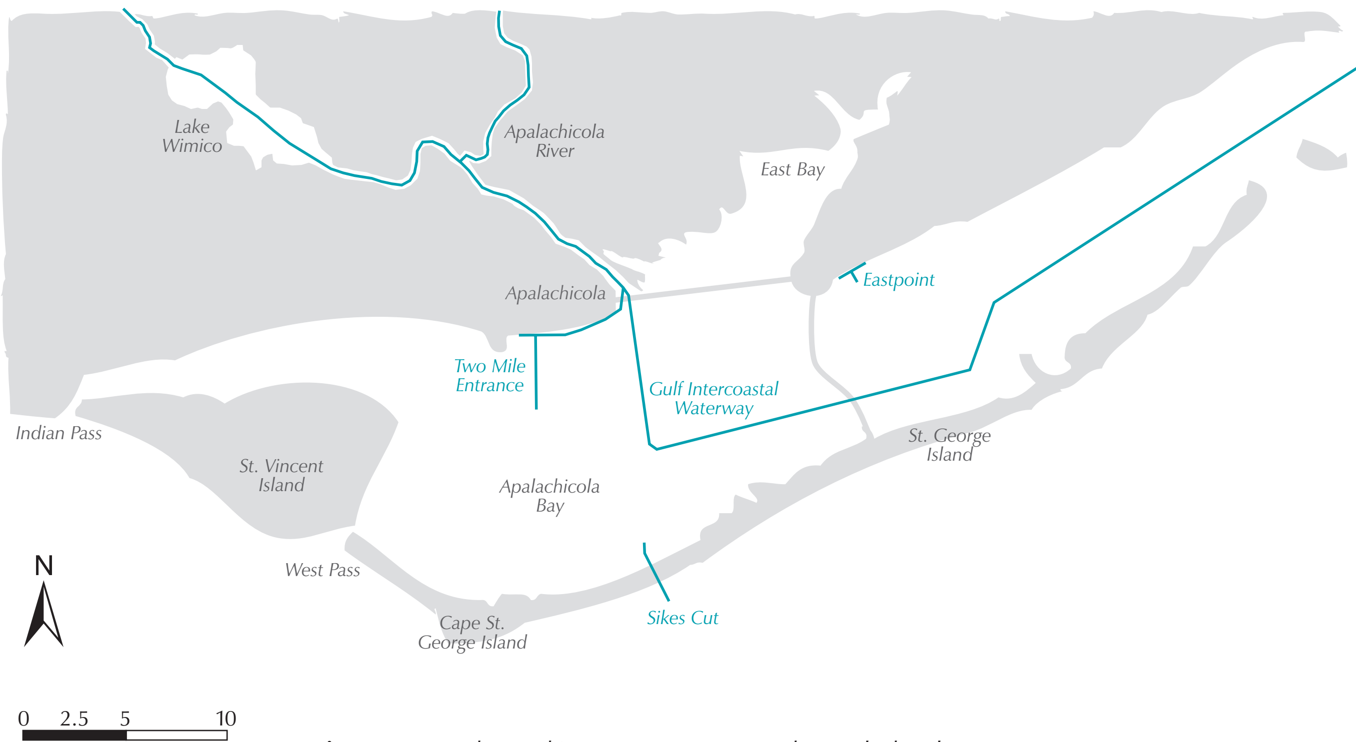


***Figure 105.*** *Authorized Navigation Projects in the Apalachicola Reserve*

Due to changes in regulations in the 1990's, banning gill nets and changing the status of speckled trout and redfish from commercial to recreational harvest only, the commercial fishery is primarily limited to offshore species such as amberjack, grouper, and snapper or species such as mullet and flounder caught in the bay. However, as recent as the late 1990's the commercial finfish harvest landed in Franklin County averaged over two million dollars dockside value (FWC, 2007).

The Apalachicola River historically supported several commercial freshwater fisheries. In the first half of this century, a sturgeon fishery prospered; however, greatly reduced catches occurred in the late 1950's. The State of Florida prohibited the taking of sturgeon in 1984 due to drastic reductions in population (Ager et al., 1985). Gulf sturgeon are now listed as an endangered species and cannot be caught. The largest commercial freshwater fishery has historically been the catfish fishery. Channel catfish was the predominant species, but white catfish and several species of bullheads were also taken. The typical catfish fisherman's harvest ranged from less than 100 pounds to more than 500 pounds with 80% of the fisherman catching less than 500 pounds annually (FGFWFC, 1983). This fishery is also much reduced recently. A small commercial fishery for American eels was active in the late 1980's and early 1990's but has since ended.

Recreational fishing has become more important in the area with the advent of increasing development and the tourism industry. Recreational fishing along the Apalachicola River annually contributes $35,280,000 to the surrounding six counties' economy and provides 655 jobs. This translates to about 4% of the total retail sales in the surrounding counties. (Calhoun-5%; Gadsden-1%; Gulf-11%; Franklin-4%; Jackson-3%; Liberty-14%) Recreational freshwater and saltwater fishermen contribute an estimated 14% of the total retail sales in the six county region. As the charter boat industry has grown over the years its importance to the local economy has also increased. Recreational saltwater fishing in Apalachicola Bay annually contributes approximately $155,924,000 to the local economy with a corresponding 1,960 jobs. This translates to about 11% of the total retail sales in the surrounding counties (Ted Hoehn, FFWCC-pers.comm.).

## Navigation

Several federal navigation projects pass through Reserve boundaries (Figure 105). The Apalachicola-Chattahoochee-Flint (ACF) River navigation project begins at the confluence of the Apalachicola and Jackson Rivers, approximately six miles north of Apalachicola and extends up the Apalachicola River through Lake Seminole, up the Chattahoochee River to Columbus, Georgia and up the Flint River to Bainbridge, Georgia. The project must be dredged annually in order to maintain the authorized depth. The ACF is authorized to have a 9-foot deep x 100 foot-wide channel and the principal commodities shipped on the river include fertilizers, petroleum products, basic chemical products, and agricultural products. Annual traffic on the river in the 1970's and 1980's was approximately one million tons with large variations due to periodic low water conditions (USACOE, 1986). However in the last 10 years the river has been used very little by shipping interests upstream. The ACF includes a series of upstream dams and a considerable amount of annual dredging in the Apalachicola

River portion of the project. This dredging has been controversial for years due to the impacts of spoil sites on fish and the floodplain of the river. The navigation project is one of the more expensive projects to maintain in the United States and its cost-benefit ratio is far above the average for Corps activities. The State of Florida denied the latest federal permit application in 2006 to maintain the project due to its environmental impacts to the system. The state and federal agencies are currently at an impasse with regard to continuing this navigation project.

The Gulf Intracoastal Waterway (GIWW) navigation project also traverses the Reserve, beginning at the Reserve's eastern boundary in St. George Sound, extending west through Apalachicola Bay, turning north near the center of the bay and running through the lower Apalachicola and Jackson rivers (Figure 105). The GIWW enables traffic on the ACF and eastern Gulf of Mexico to travel all the way to Texas. However, since the ACF project is a spur off the GIWW and their intersection is at the Jackson River, north of the bay, most traffic down from the ACF does not traverse the bay but heads westward through Lake Wimico. The GIWW is a 12 foot-deep x 125 foot-wide channel that primarily provides access across the bay to the open Gulf for a variety of commercial and recreational interests. Principal commodities shipped on this project across Apalachicola Bay include petroleum products, phosphate rock, asphalt, tar and pitches, and sodium hydroxide (USACOE, 1986). Dredge spoil from this project is deposited in within-bank sites along the river and in open-water sites and one island creation project in Apalachicola Bay.

Fifteen years ago, during a permitting phase for the GIWW, there was considerable controversy over a plan to create a spoil island near the mouth of the river at a pre-existing open-water site. After extended negotiations, all parties compromised on a reduced area for an island creation site. The Reserve and several other agencies developed a plan for the design and use of the island as a nesting site for listed migratory bird species. The Reserve staff continue to monitor this site, its usage by birds (See Chapter 5, Bird section), and work well with the U.S. Army Corps of Engineers to maintain this area as an important nesting site.

Several other smaller federally authorized projects are also located within Apalachicola Bay including Two Mile channel, Sike's Cut channel, Eastpoint channel, and the Scipio Creek channel (Figure 105). Two Mile and Eastpoint channels are used predominantly by oyster boats and small shrimp boats and require maintenance dredging every 10-15 years. The Sike's Cut channel is used predominantly as an access channel to the Gulf of Mexico by larger shrimp boats and pleasure craft and requires maintenance dredging every 2-5 years. Scipio Creek channel is used as an access channel to the Scipio Creek boat basin, a commercial marina for shrimp boats and offshore fishing boats. Scipio Creek requires maintenance dredging every 10-15 years. Most of the battles between the state and federal government related to the maintenance of these channels has been related to spoil placement and impacts from the material.

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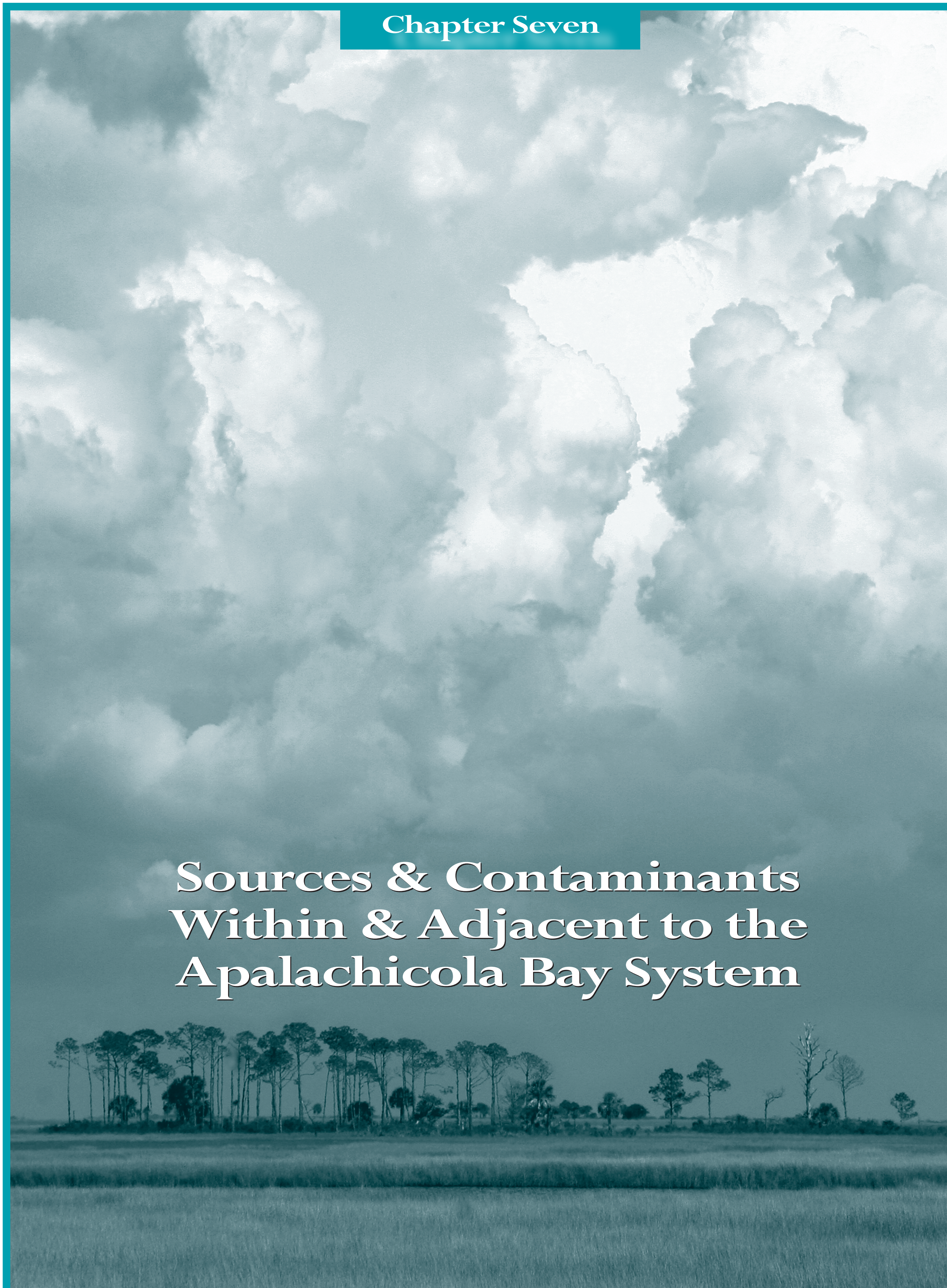
Chapter Seven

# Sources & Contaminants Within & Adjacent to the Apalachicola Bay System



Apalachicola Bay lies at the terminus of the Apalachicola River, which originates at the northern border of Florida at the confluence of the Chattahoochee and the Flint Rivers. The Florida portion of the basin encompasses only approximately 12% of the entire drainage basin (2,400 square miles), has a limited population, and is mostly undeveloped. However, because of its large watershed (19,600 square miles), proximity to a major metropolitan area (Atlanta), multiple adjacent land uses, including agricultural and urban, and somewhat modified hydrology, the system has the potential to carry contaminants and cause water quality degradation downstream.

To protect and manage any system, the probable sources of pollution must be identified and addressed. While the types of pollutants are numerous, their origin can be separated into two categories: point-source and nonpoint-source. Point-source pollutants are those associated with a specific source or location. These are typically industrial or municipal sources and produce specific contaminants such as metals, volatile organic compounds or sewage. Nonpoint-source pollutants, as the name implies, do not have an exact point of origin. These wastes are generally related to specific land uses including urbanization, agriculture, and resource extraction, such as silviculture. This category also includes atmospheric deposition.

In general, as anthropogenic changes are made within a system there is typically degradation in the amount and quality of resources and habitats as well as increase in pollution. There is also typically an increase in the amount of nutrients, pesticides, trace elements, and organic compounds entering the waters within the system. With any urban and suburban development, there is increased degradation in the surrounding waters due to increased sewage and garbage production, runoff from impervious surfaces, and increased chemical waste (Frick et al., 1998).

The development of the local area surrounding the Reserve could have the most direct effect on the water quality within the bay. The effects of clearing, ditching, and draining of land surrounding the bay may result in increases in pH and decreases in detrital influx. Other physical alterations such as damming and dredging directly affect water habitats as well as augment flow regimes and water quality. Industrialization and residential development typically result in an increase in the number of septic systems and may affect the quality of the nonpoint runoff going into the bay (Livingston, 1975).

## Contaminant Sources

Contaminant sources include point sources; primarily wastewater effluent, industrial effluent, storm drains, sanitary and combined sewer overflows, and untreated wastes from illegal outfall pipes. Nonpoint sources include stormwater runoff, animal wastes, fertilizer, atmospheric deposition, and natural sources (Frick et al., 1996).

The largest numbers of contaminant sources in the ACF basin come from the Chattahoochee and Flint rivers due to the large population concentrated in these regions and the amount of urban and agricultural land-uses associated with this population. Urban and suburban areas account for only about five percent of the entire ACF watershed, less than two percent within the Florida portion of the basin, however, they can have a large impact on stream quality (Table 31). Approximately 29% of the watershed, primarily in Georgia and Alabama, is agricultural lands and can also impact stream quality (Frick et al., 1996).

Ninety-seven percent of the population within the drainage basin lives in these two upper watersheds and approximately ninety percent of the municipal wastewater discharges are located in these areas. Upstream (Georgia and Alabama) municipal wastewater facilities contribute over ninety-eight percent of the nitrogen and phosphorus loadings in the ACF basin. Agricultural land uses in these watersheds also contribute ninety-five percent of the nonpoint nutrient loadings to the entire drainage basin (Table 32). Industrial effluents, stormwater runoff, groundwater inputs, and other sources of contaminants including natural inputs are not included in these estimates.

Within the Florida portion of the drainage basin, the Apalachicola River and Bay watersheds, only the City of Marianna wastewater facility discharges more than one million gal/d into the surface waters of the Chipola River. All wastewater facilities in Franklin County, with the exception of the City of Apalachicola, use on-site disposal, either extended aeration, sand filters, or spray irrigation. The Apalachicola wastewater facility uses extended aeration, a polishing pond, and final discharge into a wetland which generally flows toward the Jackson River, north of Apalachicola Bay. There are no sources of industrial waste with the potential to impact the bay (Shields and Pierce, 1997).

Although many residents of Apalachicola, Carrabelle, and Eastpoint are hooked up to municipal wastewater facilities in their area, there are still large numbers of residences in the County that are utilizing on-site disposal systems, primarily aerobic and anaerobic septic systems. In 1978, there were an estimated 587 households on septic systems in Franklin County. Between 1978 and 1995 over 1,600 permits were issued for septic system construction, with an additional 545 permits issued for repairs to systems. In 1995 approximately 478 septic systems were documented that had the potential to directly impact the bay's shellfish harvesting areas (Shields and Pierce, 1997). Septic systems in particular can be a source of fecal coliforms, due to the inadequate treatment, poor installation, and improper siting. Since 1995 additional permits have been issued (Franklin County Health Department, pers.com). There are currently no agricultural land use activities in the County, with the exception of silvicultural and beekeeping activities.

## Water Quality

Although the potential for pollution from upstream anthropogenic activities is high, there does not appear to be a problem with most contaminant levels in streams and rivers in the lower ACF basin. This is not necessarily the case in the upper river basin and tributaries. Between 1992 and 1995 the United States Geological Survey (USGS) undertook a major water quality assessment of the ACF as part of the National Water Quality Assessment (NAWQA) Program (Frick et al., 1998). Although the study did not include Apalachicola Bay or the tidally influenced portion of the lower river, it did include everything else within the drainage basin to characterize potential inputs and threats to the bay.

Excessive nutrients can be considered a pollutant because they can adversely affect water quality through eutrophication. They can also be toxic to aquatic life, as well as regulating or limiting productivity. Analysis of 18 years of data from 1972-1990 for the entire ACF basin showed nitrate concentrations typically low and never exceeding the USEPA drinking water standard of 10 mg/l. However, forty percent of the time the total phosphorus of 0.1 mg/l (USEPA recommendation to control eutrophication) was exceeded. Spatially the high values for both parameters occurred in the upper basin, primarily the Chattahoochee River, near Atlanta. Concentrations in the lower Apalachicola river were typically much lower and ranked within the lower 25th percent quartile of all NAWQA streams sampled nation-wide (Frick et al., 1996; 1998).

In the ACF basin, nutrient concentrations typically decrease as surface water flows downstream due to settling of sediments and detritus, dilution from tributaries, and uptake by phytoplankton and SAV in reservoirs. In the Florida portion of the drainage basin, only the Chipola River showed somewhat high values of nitrate, probably due to the predominantly agricultural land use in the basin or inflow of ground water with high nitrate concentrations (Frick et al., 1996). Over the 18 year time period, the trend in the Apalachicola River was generally toward decreasing loads of nutrients, and the estimated nitrogen and phosphorus loads into the bay from the river were relatively small compared to estimated sources upstream. Nutrient

**TABLE 31**

### Potential contaminant factors for the Apalachicola-Chattahoochee-Flint River basin

*(modified from Frick et al., 1996)*

| | *Population* | | | *Land-use and Land-cover* | | | |
|---|---|---|---|---|---|---|---|
| **River Basin** | **1990** | **% Pop.** | **Pop. Density (persons/mi²)** | **Urban/built-up (mi²)** | **Agricultural (mi²)** | **Forest (mi²)** | **Water/wetland (mi²)** |
| Chattahoochee | 1,920,000 | 73 | 230 | 780 | 1,700 | 5,900 | 272 |
| Flint | 634,000 | 24 | 76 | 250 | 3,600 | 4,100 | 505 |
| Apalachicola | 85,200 | 3 | 29 | 45 | 570 | 1,700 | 840 |
| ***Total*** | ***2,640,000*** | ***100*** | ***130*** | ***1,100*** | ***5,800*** | ***11,700*** | ***1,640*** |

*Apalachicola River Basin also includes the New River drainage and local (non-river) drainage into Apalachicola Bay.*

**TABLE 32**

### Point and nonpoint sources in the Apalachicola-Chattahoochee-Flint River basin

*(modified from Frick et al., 1996)*

| | *Point Sources* | | | *Nonpoint Sources* | | | |
|---|---|---|---|---|---|---|---|
| | *Municipal Wastewater* | | | *Agricultural Sources* | | *Atmospheric Deposition* | |
| **River Basin** | **(Sfc Dis) (Mgal/d)** | **(NH4 as N) (tons)** | **(TP) (tons)** | **(TN) (tons)** | **(TP) (tons)** | **(NO3+NH4) (tons)** | **(TP) (tons)** |
| Chattahoochee | 301 | 2,200 | 970 | 120,000 | 27,500 | 10,000 | --- |
| Flint | 35 | 180 | 120 | 73,000 | 17,500 | 10,000 | --- |
| Apalachicola | 4 | 46 | 14 | 9,600 | 2,950 | 3,500 | --- |
| ***Total*** | ***340*** | ***2,500*** | ***1,100*** | ***202,000*** | ***48,000*** | ***24,000*** | ***---*** |

*Apalachicola River Basin also includes the New River drainage and local (non-river) drainage into Apalachicola Bay.*
*(Sfc Dis) Effluent discharged to surface waters only, land application not included.*
*(Mgal/d) – million gallons per day, NH4 – ammonia, TN – total nitrogen, TP – total phosphorus, NO3 – nitrate.*
*Agricultural Sources include animal manure and fertilizer only.*

*---, no available data.*

outflow into the bay, although related to flow, was estimated to be approximately 13 percent of upstream source for nitrogen and only three percent for phosphorus (Frick et al., 1996).

Compared to other areas of the nation characterized by the USGS NAWQA program, the coastal plain portion of the ACF basin had lower pesticide concentrations, fewer pesticides detected and less disturbance to aquatic communities during and after floods. The NAWQA study included a synopsis of 15200 individual analyses: 55 percent groundwater, 23 percent sediment, 14 percent aquatic biota and eight percent surface water samples. Of these, less than four percent of the samples had concentrations above minimum reporting levels. Only four of the most commonly used pesticides (2,4-D, lindane, chlorpyrifos, and malathion) were detectable "at or above the minimum reporting levels" (Frick et al., 1996).

Most of the pesticides found at levels above the minimum reporting levels were organochlorine insecticides, those that have been found to be environmentally persistent and are now banned in the United States (Stell et al., 1995; Frick et al., 1998). Of the twenty-five pesticides studied, none exceeded or approached the standards that have been set for drinking water. Organophosphate insecticides (which replaced organochlorine) were found in surface waters of urban and agricultural areas around Atlanta, Chipola River, and Spring Creek. Compared with other NAWQA sites, degraded sites near Atlanta were similar to other sites evaluated, but Apalachicola River was one of the least degraded sites measured throughout the nation (Frick et al, 1998).

High levels of total and fecal coliforms, fecal streptococci, magnesium, zinc, and nutrients were characteristic of base flow in a stormwater runoff study of the City of Apalachicola Battery park marina site. The dissolved oxygen concentration was also periodically reduced. During storm events turbidity, total suspended solids, and nitrate/nitrite were elevated. Phosphorous, aluminum, and lead were also elevated but to a lesser degree. At other Apalachicola sites, samples taken during base flow showed consistently low dissolved oxygen and high total coliform, fecal coliform, and fecal streptococci. Nutrient concentration levels were also significantly high. High water flow associated with a storm event carried elevated amounts of total suspended solids, nitrate/nitrite, phosphorous, aluminum, copper, and zinc. The study concluded that "this combination of results could be indicative of sewage contamination, through cross connections, illicit connections, or through contamination by combined sewer overflows" (Marchman and Wooten, 2000).

Fecal coliform bacteria are typically used as an indicator of possible human pathogens. The standards for safe limits of fecal coliform bacteria in shellfish harvesting areas is a median MPN (most probable number) of 14/100 ml of water and should not exceed 43MPN/100 ml more than 10 percent of the time. In Apalachicola Bay there are 112,000 total acres of Class II Shellfish Harvesting Waters. Of those, 101,000 acres are conditionally approved and 10,000 acres are prohibited (Broutman and Leonard, 1988). Because the bay is typically affected only by non-point sources of pollution, much of the acreage has the conditionally approved classification. Often there are closures related to rainfall events that lead to flooding and high river flow. With higher flow there is greater transport of the fecal coliform bacteria off lands (Broutman and Leonard, 1988).

In an attempt to characterize the spatial distribution of fecal coliform bacteria in the bay, twenty-eight sites in the estuary were sampled. Counts from sites near the mouth of the river were four to five times higher than estuarine sites indicating the influence that freshwater flow from the river has on bacteria counts in the bay (Elder and Mattraw, 1984).

The Florida Department of Agriculture and Consumer Services regulates shellfish harvesting through their Shellfish Environmental Assessment Section. They maintain an array of bacteriological sampling stations in the bay (Figure 106) and monitor frequently to open or close harvesting waters based on fecal coliform counts, riverflow, rainfall, and other events such as red tide, or the presence of disease producing organisms (Shields and Pierce, 1997). Fecal coliform concentrations vary considerably due to seasonality, riverflow, rainfall, and local runoff and are difficult to characterize on a yearly basis.

**TABLE 33**

## Priority Pollutants Screened for in Apalachicola Bay

*(Donoghue and Cooper, 1993)*

| | |
|---|---|
| Acenaphthene | Bis(2-chloroethoxy)methane |
| Acenaphthylene | Bis(2-chloroethyl)ether |
| Anthracene | Bis(2-chloroisopropyl)ether |
| Benzo(a)anthracene | 1,2-Dichlorobenzene |
| Benzo(b)fluoranthene | 1,3-Dichlorobenzene |
| Benzo(k)fluoranthene | 1,4-Dichlorobenzene |
| Benzo(ghi)perylene | 4-Bromophenylphenyl ether |
| Benzo(a)pyrene | 4-Chlorophenylphenyl ether |
| Chrysene | 2-chloronaphthalene |
| Dibenzo(ah)anthracene | 2,4-dinitrotoluene |
| Fluoranthene | 2,6-dinitrotoluene |
| Fluorene | Hexachlorobenzene |
| Indeno(123cd)pyrene | Hexachlorobutadiene |
| Naphthalene | Hexachlorocyclopentadiene |
| Phenanthrene | Hexachloroethane |
| Pyrene | Isophorone |
| Benzidine | Nitrobenzene |
| 3,3-Dicholorbenzidine | N-nitroso-di-n-propylamine |
| Butylbenzylphthalate | N-nitrosodiphenylamine |
| Bis(2-ethylhexyl)phthalate | 1,2,4-trichlorobenzene |
| Di-n-butylphthalate | N-nitrosodimethylamine |
| Diethylphthalate | Dioxin(2378-TCDD) |
| Dimethylphthalate | Bis(2-ethylhexyl)adipate |
| Di-n-octylphthalate | |

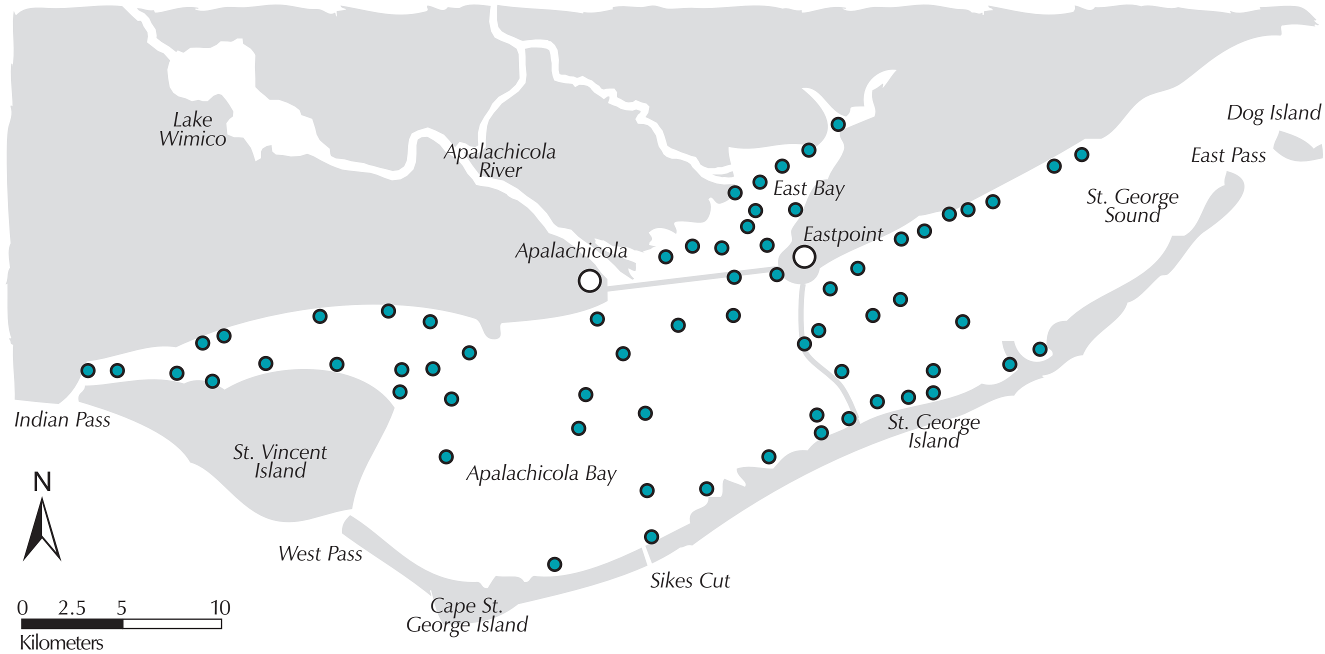



***Figure 106.*** *Bacteriological water quality sampling stations in Apalachicola Bay (Shields and Pierce, 1997).*

## Sediment Quality

A better indicator of possible contamination in natural systems is sediment quality, since many pollutants adsorb or adhere to fine silt and clay particles and can become concentrated in the sediments. Organochlorine pesticides, PCB's, semivolatile organic compounds, and trace elements such as zinc, cadmium, copper, and mercury have been found to be elevated above natural background levels in bottom sediments in much of the Chattahoochee and Flint River systems. However, these concentrations generally decrease in the Apalachicola River and the concentrations upstream appear to be from stormwater runoff from impervious surfaces in urban and suburban as well as regional industrial emissions (Frick et al., 1998).

A study, contracted by the Reserve, was carried out in 1993 to determine the history of contaminants in the bay, including pesticides, herbicides, polyaromatic hydrocarbons, and excess nutrients in the sediments. Sediments from eight stations in Apalachicola Bay (Figure 107) were tested for forty-seven USEPA priority pollutants (Table 33). In all cases little anthropogenic influence was detected

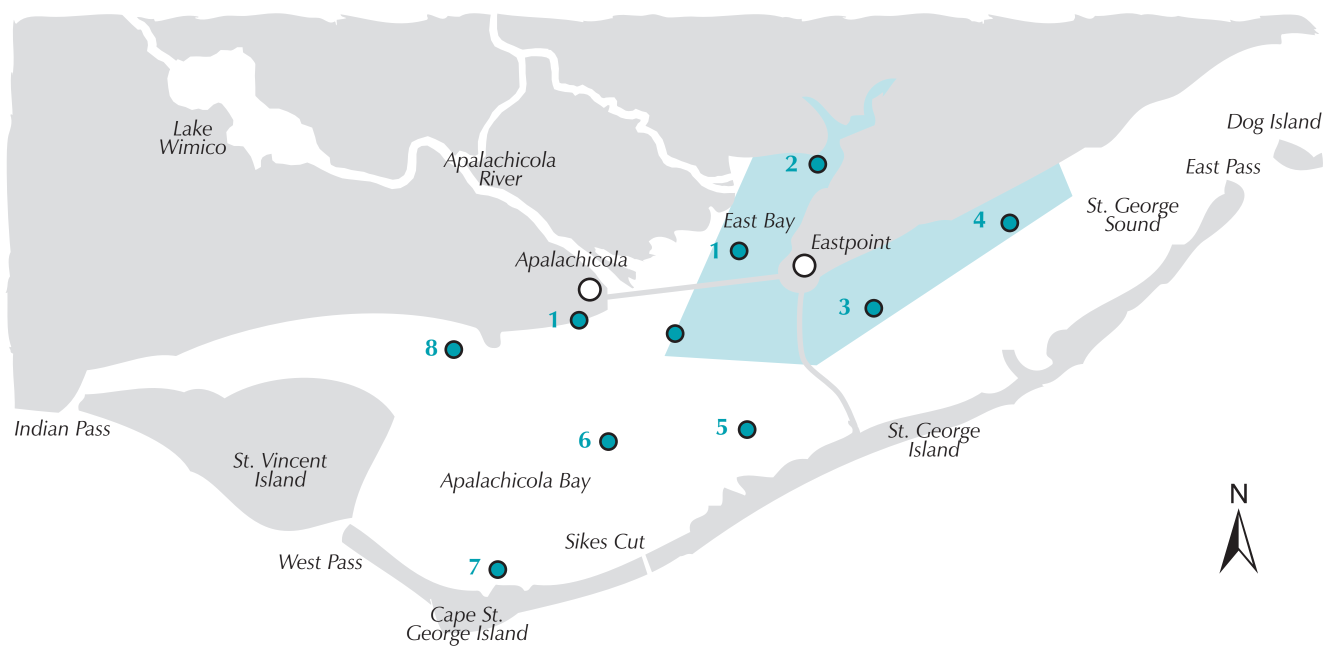



***Figure 107.*** *Apalachicola Bay core sampling locations - shaded area near Eastpoint is estuarine area adjacent to a proposed development*

with the values of all parameters below detectable limits. Organic contaminant levels were minimal, and overall sediment quality was good. Small amounts of inorganic nitrogen and total phosphorus were found, indicating that the source of these nutrients is natural (Donoghue and Cooper, 1993)

The U.S. Fish and Wildlife Service aggregated sediment samples collected over the past 10 years and over the length of the Panhandle to evaluate concentrations of dioxins. Apalachicola Bay had the lowest measured toxicity equivalent of all the sites sampled across the study area (Hemming et al., 2002). Another study looked at records of sediment data throughout the Gulf of Mexico collected over a period from 1980 to 1992. Contaminants were ranked by three criteria: an Exceedance Index (ratio of mean detected concentration of a chemical to a specific effect level), Exceedance/ Sampling Ratios, and sampling frequencies for each contaminant. Areas of concern were based on the percent and types of contaminants present and the effects index. Apalachicola Bay was second to last of the areas of concern. However, only one sample was taken within the bay, so it may not be representative of the entire bay (Brecken-Folse et al., 1989).

**TABLE 34**

**Contaminants monitored by National Status and Trends program.**

| | | |
|---|---|---|
| ***DDT and its metabolites*** | ***Polycyclic aromatic hydrocarbons*** | ***Major elements*** |
| 2,4′-DDD | *2-ring* | aluminum |
| 4,4′-DDD | Biphenyl | iron |
| 2,4′-DDE | Naphthalene | manganese |
| 4,4′-DDE | Methylnaphthalene | silicon |
| 2,4′-DDT | 2-Methylnaphthalene | |
| 4,4′-DDT | 2, 6-Dimethylnaphthalene | |
| | 1,6,7-Trimethylnaphthalene | |
| ***Tetra, tri-, di-, and monobutyltins*** | *3-ring* | ***Trace Elements*** |
| | Fluorene | |
| | Phenanthrene | antimony |
| | 1-Methylphenanthrene | arsenic |
| ***Chlorinated pesticides other than DDT*** | Anthracene | cadmium |
| | Acenapthene | chromium |
| | Acenaphthylene | copper |
| Aldrin | | lead |
| cis-Chlordane | *4-ring* | mercury |
| trans-Nonachlor | Fluoranthene | nickel |
| Dieldrin | Pyrene | selenium |
| Heptachlor | Benz[a]anthracene | silver |
| Heptachlor epoxide | Chrysene | tin |
| Hexachlorobenzene zinc | | |
| Lindane (gamma-HCH) | *5-ring* | |
| Mirex | Benzo[a]pyrene | |
| | Benzo[e]pyre | |
| | Perylene | |
| ***Polychlorinated biphenyls*** | Dibenz[ah]anthracene | |
| PCB congeners 8, 18, 28, 44, 52, 66, 77, 101, 105, 118, 126, 128, 138, 153, 179, 180, 187, 195, 206, 209 | Benzo[b]fluoranthene | |
| | Benzo[k]fluoranthene | |
| | *6-ring* | |
| | Benzo[ghi]perylene | |
| | Indeno[1,2,3-cd]pyrene | |
| ***Toxaphene at some sites*** | ***Related parameters*** | |
| | Grain Size | |
| | Total Organic Carbon (TOC) | |
| | Clostridium perfringens spores | |

Several studies by NOAA, looking at contaminant levels in sediments in National Estuarine Research Reserves have been undertaken as part of the National Status and Trends Program (NS&T). Two sites, Cat Point and Dry Bar, in Apalachicola Bay are part of the NS&T program and have been monitored since 1986 for over 60 chemical contaminants indicative of possible alteration by human activities (Table 34). The NS&T program ranks the concentrations of contaminants found at each site as either below the national geometric mean, above the mean, or high (one standard deviation above the mean). Of the contaminants measured, eight were found above the national mean, but none were rated high according to NS&T methods (Table 35) (Gottholm and Robertson, 1996). Dry Bar, in particular, which is more influenced by the river, had seven contaminants above average, while Cat Point, less influenced by the river, only had two contaminants above the mean. Having contaminant levels above the NS&T mean does not indicate that the levels are above EPA standards or harmful to aquatic life.

The NS&T program also compared sediment contaminant levels and toxicity in four bays in the Florida panhandle; Pensacola Bay, Choctawhatchee Bay, St. Andrew Bay, and Apalachicola Bay. Concentrations of organic compounds and metals found in Apalachicola Bay showed that the highest values were generally found in the western part of the bay at Dry Bar, an area more heavily influenced by riverflow (Figure 108). However, a comparison of the data from the four estuaries shows that Apalachicola Bay exhibited the lowest concentrations of organic compounds (Figure 109) and metals such as mercury found in the sediments (Figure 110). Of the four bays sampled, all of the data suggests that Apalachicola Bay exhibited the least contamination of all. In fact when metal contaminant concentrations were normalized to aluminum content, Apalachicola Bay was the only estuary of the four that was not anthropogenically enriched with trace metals (Long et al., 1997).

## Biota Quality and Sediment Toxicity

Effects of contaminants on biological organisms are difficult to determine. Concentrations can be measured within the biota directly, tests for toxicity of various parameters can be determined in laboratory experiments, or indices of various biological communities or habitats can be developed. In the ACF basin, primarily in urban, agricultural, and mixed land-use watersheds (not main channels areas), high levels of organochlorine pesticides and PCB’s have been found in clam and fish tissue. In addition stream habitat and fish community degradation has been documented. In particular, the fish community at the urban site below the City of Atlanta was the most degraded of all NAWQA sites nation-wide. However, these levels and degradation rankings generally decrease as you move downstream in the ACF watershed (Frick et al., 1998).

Another study in the Apalachicola River analyzed trace elements that were comprised of predominantly heavy metals. Three kinds of materials were surveyed: fine-grained sediments, whole-body tissue of the Asiatic clam, *Corbicula manilensis*, and bottom-load organic detritus. No hazardous levels of any of the substances were found. In both the fine-grained sediments and clams, the amounts found were at least ten times lower than the standard set as being hazardous to aquatic life (Elder and Mattraw, 1984).

An area of Tate's Hell Swamp, adjacent to East Bay (Figure 111), was used for silviculture until the 1970's. Lands were ditched and drained to grow trees during the 1960's and 1970's, which significantly increased the runoff volume and frequency, impacting pH, color, salinity, and dissolved oxygen for a time. There were indications that various clear-cutting activities may cause aquatic habitat alterations and water quality changes such as reductions in pH and salinity (Livingston, 1978). State regulators required the land owners to eventually fill in and block off some of the ditches to correct the problem. Concern over the effects of runoff from the modified land led to various studies.

It was determined that within a laboratory setting, juvenile and adult blue crabs (*Callinectes sapidus*) avoided run-off water from a clear-cut area. They also avoided waters with pH lower than 6.0. However, independent sampling of the distribution of the crabs in the bay environment did not correspond with the laboratory findings. Stations within East Bay were sampled following a 3-year period during the mid-seventies when the adjacent land was clear-cut. Adult blue crabs were not found in areas of high run-off and low pH, but juvenile blue crabs were actually found in higher numbers within these areas. (Livingston et al., 1976).

There were also significant changes in abundance and biomass of some species when water quality stress occurred. Fish (*Anchoa mitchilli* and *Cynoscion arenarius*), and shrimp *(Litopenaeus setiferus)* appeared to avoid areas of dark water that were characterized by low pH, high color, reduced DO, and lower salinity during normal high salinity months. It appeared that other species might be attracted to the darker water (Duncan, 1977). There also may be other environmental factors affecting their distribution such as predation or feeding pressures.

**TABLE 35**

**Reserves with NS&T site(s) having sediment contaminant concentrations above the national geometric mean [ ● ] and/or one standard deviation above the national mean [ ■ ].**

| Reserve & NS&T Site | As | Cd | Cu | Hg | Ni | Pb | Se | Zn | tCdane | tDOT | tPAH | tPCB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Wells, ME*** | | | | | | | | | | | | |
| *CAKP - sandy* | | | | | | | | | | | | |
| ***Waquoit Bay, MA*** | | | | | | | | | | | | |
| BBNI | ● | | | | | ● | | | ■ | | | ● |
| ***Narragansett Bay, RI*** | | | | | | | | | | | | |
| *NBPI - sandy* | | | | | | | | | | | | |
| ***Delaware, DE*** | | | | | | | | | | | | |
| *DBHC* | ● | ● | | | ■ | ● | ● | ■ | ● | ● | ● | ● |
| ***Chesapeake Bay, VA*** | | | | | | | | | | | | |
| *CBDP* | | | | | | | | | ● | ● | | |
| ***North Carolina, NC*** | | | | | | | | | | | | |
| *BIPI* | ■ | | | | ● | | | | ■ | ● | ■ | ● |
| *CFBI* | ■ | | | | | ● | ● | | | | | |
| ***North Inlet/Winyah Bay, SC*** | | | | | | | | | | | | |
| *WBLB* | ■ | | ● | ● | ■ | ● | ■ | ■ | ■ | ● | ● | ● |
| ***Sapelo Island, GA*** | | | | | | | | | | | | |
| *SSSI* | ● | | | | | | ● | | | | ● | |
| ***Jobos Bay, PR*** | | | | | | | | | | | | |
| *PRBJ* | ● | | ● | ■ | | | ● | | | | | |
| ***Rookery Bay, FL*** | | | | | | | | | | | | |
| *RBHC* | | | | | | | | | ● | | | |
| ***Apalachicola Bay, FL*** | | | | | | | | | | | | |
| *APDB (Dry Bar station)* | ● | | | | | ● | ● | | ● | ● | ● | ● |
| *APCP (Cat Point station)* | ● | | | | ● | | | | | | | |
| ***Tijuana River, CA*** | | | | | | | | | | | | |
| *IBNJ - sandy* | | | | | | | | | | | | |
| ***Elkhorn Slough, CA*** | | | | | | | | | | | | |
| *MBML - sandy* | | | | | | | | | | | | |
| ***South Slough, OR*** | | | | | | | | | | | | |
| CBCH | ■ | ■ | | | ■ | ● | ● | ● | *below detection* | *below detection* | *below detection* | *below detection* |

Two oyster bar sites, Cat Point and Dry Bar (See Figure 20 on page 21 for locations), in Apalachicola Bay are part of the NS&T Mussel Watch Program and have also been monitored since 1986 for over 60 chemical contaminants that indicate possible alteration by human activities (Table 34). Oysters (*Crassostrea virginica*) were sampled and analyzed for contaminants. Of the contaminants measured, eight were found above the national mean, but none were rated high according to NS&T methods (Table 36) (O'Connor, 2002). Dry Bar oysters, in particular, which are more influenced by the river, had seven contaminants above average, while Cat Point oysters, to the east of the river mouth only had three contaminants above the mean (Gottholm and Robertson, 1996). Having contaminant levels above the NS&T mean does not indicate that the levels are above EPA standards or harmful to aquatic life.

A more detailed study, utilizing more data, looked at oysters from the same two stations, but also analyzed temporal trends over 13 years. Trace element concentrations in oysters at both Cat Point and Dry Bar were similar and exhibited very little trend over the 13 year period (Figure 112 and 114). Most metals, with the exception of arsenic, mercury, and lead, were below or slightly above the national median. These three metals were at or above the 85th percentile

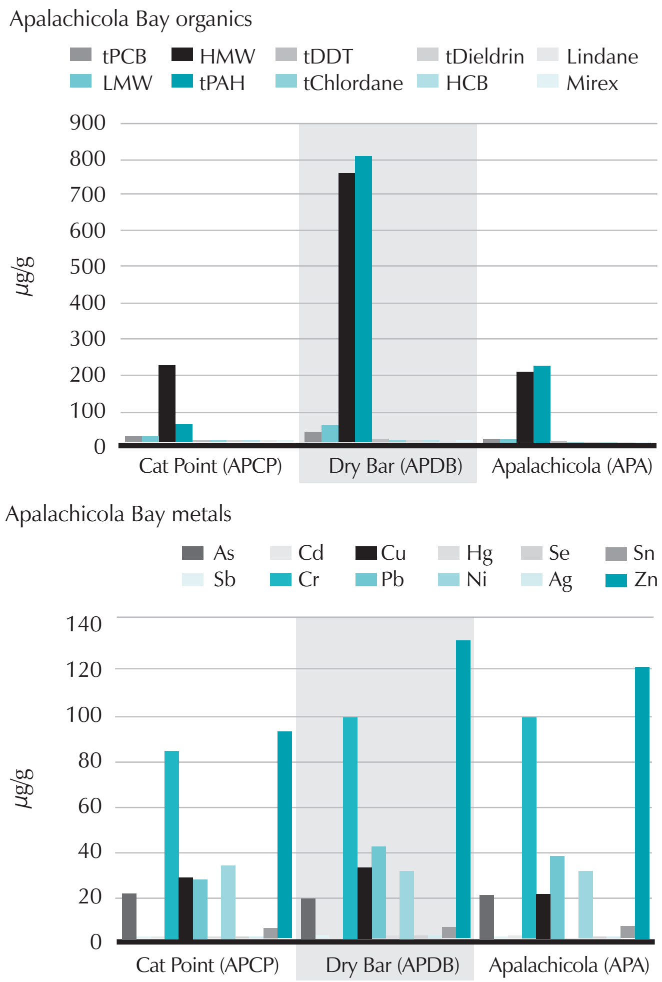



***Fig. 108***. *Concentrations of organics and trace metal in sediments from NS&T program sites in Apalachicola Bay in 1991.*

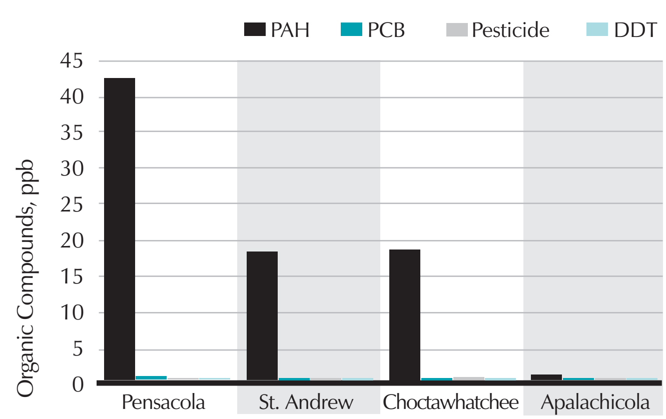



***Fig. 109***. *Maximum concentrations of major classes of organic compounds (total PAHs, total PCBs, total pesticides and total DDTs) in sediments from four western Florida bays.*

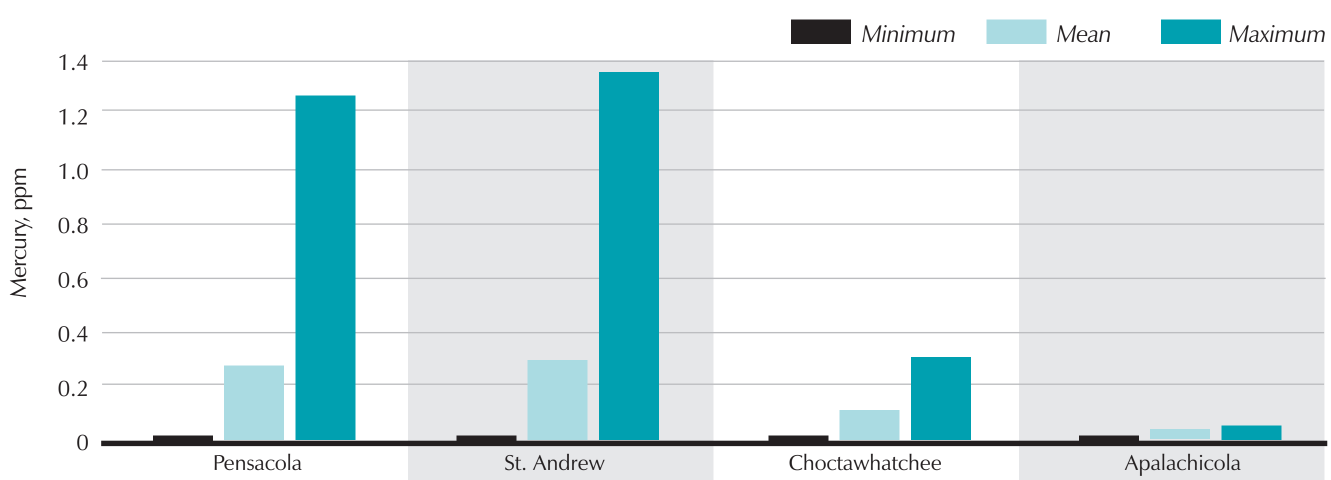



***Fig. 110.*** *Minimum, mean, and maximum mercury concentrations in western Florida bays.*

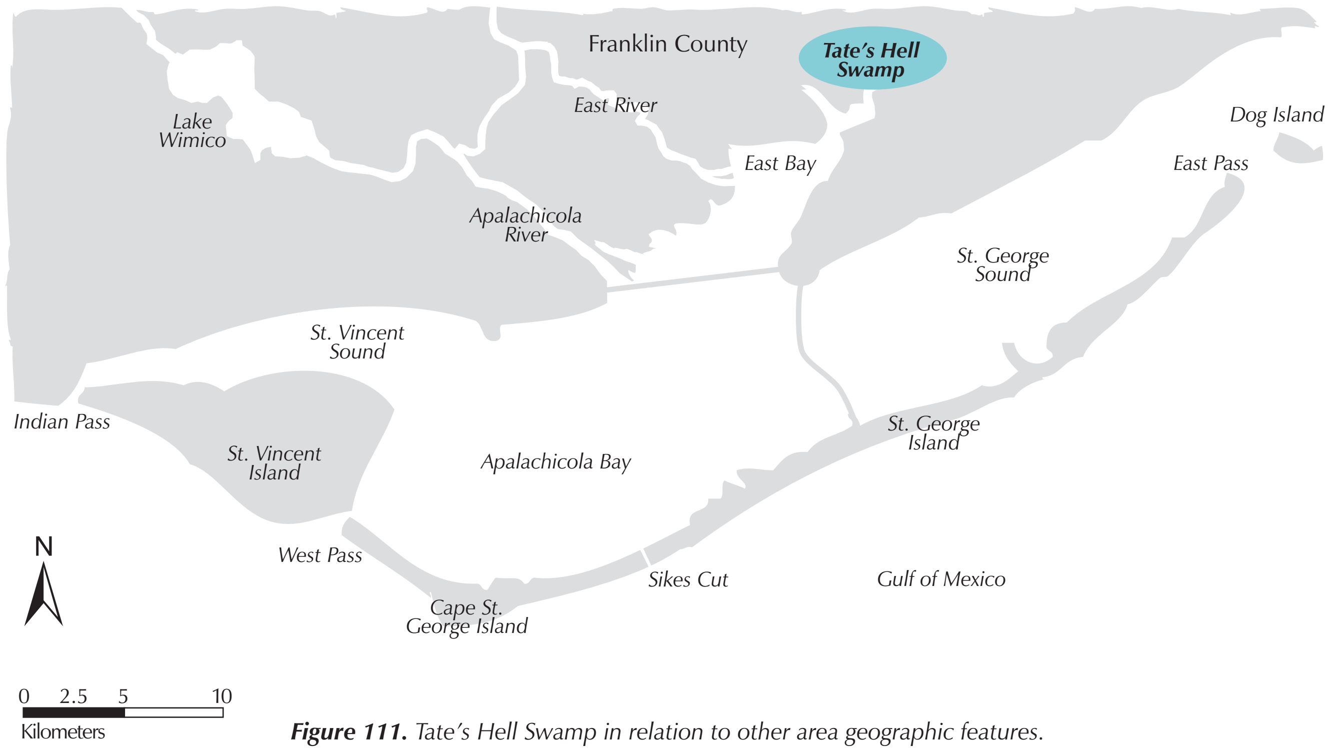



***Figure 111.*** *Tate's Hell Swamp in relation to other area geographic features.*

**TABLE 36**

## Reserves with NS&T site(s) having bivalve contaminant concentrations above the national geometric mean [ ● ] and/or one standard deviation above the national mean [ ■ ].

| Reserve & NS&T Site | As | Cd | Cu | Hg | Ni | Pb | Se | Zn | tCdane | tDOT | tPAH | tPCB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Wells, ME*** | | | | | | | | | | | | |
| CAKP - sandy | ● | | | ● | | | | | | | | |
| ***Waquoit Bay, MA*** | | | | | | | | | | | | |
| BBNI | ■ | | | ● | | | ● | | | | | |
| ***Narragansett Bay, RI*** | | | | | | | | | | | | |
| NBPI - sandy | ● | | ■ | | ● | ● | ● | | ● | ● | ● | ● |
| ***Delaware, DE*** | | | | | | | | | | | | |
| DBHC | | ■ | ■ | ● | ■ | ■ | ● | ■ | ● | ■ | | ● |
| ***Chesapeake Bay, VA*** | | | | | | | | | | | | |
| CBDP | ● | | | ● | ● | ● | | ● | ● | ● | ● | ● |
| ***North Carolina, NC*** | | | | | | | | | | | | |
| BIPI | ■ | | | | | | | ● | | ● | ■ | |
| CFBI | ■ | | | ● | | | | | | | | |
| ***North Inlet/Winyah Bay, SC*** | | | | | | | | | | | | |
| WBLB | ■ | | | | ● | | ● | | | | | |
| ***Sapelo Island, GA*** | | | | | | | | | | | | |
| SSSI | ■ | | | | ● | | ● | | | | | |
| ***Jobos Bay, PR*** | | | | | | | | | | | | |
| PRBJ | ● | | ● | | | | | | | | | |
| ***Rookery Bay, FL*** | | | | | | | | | | | | |
| RBHC | ■ | | | | ● | | | | | | | |
| ***Apalachicola Bay, FL*** | | | | | | | | | | | | |
| APDB (Dry Bar station) | | ● | | ● | | ● | | | ● | ● | ● | ● |
| APCP (Cat Point station) | ● | | | ● | | | | | | | ● | |
| ***Tijuana River, CA*** | | | | | | | | | | | | |
| IBNJ - sandy | ● | | | | | | ● | ● | ● | ■ | | |
| ***Elkhorn Slough, CA*** | | | | | | | | | | | | |
| MBML - sandy | ● | ● | ● | | ■ | ● | ● | ● | ● | ■ | | |
| ***South Slough, OR*** | | | | | | | | | | | | |
| CBCH | | | ● | | ● | | | | | ● | | |

of samples nation-wide. Trace organic contaminant concentrations generally showed a decreasing trend from 1986 through 1999 at both Cat Point and Dry Bar (Figure 113 and 115). At Cat Point only polyaromatic hydrocarbon were at the high 85th percentile concentration level. Dry Bar, on the other hand, had five of the organic contaminants above the high level during at least one of the thirteen years. Most other years the concentrations were at or below median values (Lauenstein and Cantillo, 2002). It is unknown whether this is an anomaly or bad data.

## Miscellaneous Contaminant Threats

Soils of barrier islands such as St. George Island are typically sandy. Sandy soils are poor for trapping bacteria and other pathogens. This, coupled with a high water table, makes septic systems on the island possibly ineffective in the treatment of coliforms and pathogens, although this is still undetermined. The distance between the bottom of the drainfield and the top of the water table is also a consideration. The Apalachicola Bay Protection Act requires that septic systems be setback 100 to 150 feet from


***Figure 112.*** *Trace element trends in American oysters (Crassostrea virginica) collected at NS&T Mussel Watch site Cat Point Bar (Apalachicola Bay) (APCP) (µg/g dry wt.) .*

the shoreline depending on the size of the lot where the house is located (Porter, 1985).

When the flow velocity, hydraulic conductivity and dispersivity of groundwater at different sites on St. George Island were measured, it was found that the movement of water within the aquifer was dependent on rainfall. When rainfall was low, there was some tidal influence on the direction and magnitude of groundwater flow. Concentrations of nutrients decreased rapidly with distance from each system indicating that there was only a small amounts of effluent transported into surface waters. The horizontal transfer rate, according to dye tracers, was somewhere between 0.02 and 0.42 meters per day (Corbett, 1999). Another study found the groundwater movement within a simulated drainfield moved between 0.69 and 1.05 meters per day during normal rainfall (Porter and Thompson, 1986). Homes and businesses on the island typically have systems with shallow drainfields and in soils inappropriate for proper absorption. In general, nutrient levels coincided with rainfall events. These systems appear to be effective in removing nutrients as the samples taken from the near-field wells showed levels only five percent of the concentrations flowing into the system; numbers resembling background numbers.

Evidence indicates there might be nutrient loading within the island canals and boat basins due to stormwater runoff and leachates from septic systems. However, it is not clear septic systems are contaminating to the bay, although there is certainly a potential for problems as septic systems increase in density on the island. Sixty-eight percent of the tanks located on the island as of 1986 were documented to be located within soils rated to have severe limitations for septic tank use or are in soils where the development is limited by the state (Lewis, 1986). Two major considerations to make when evaluating the potential effect of septic systems on the immediate environment are the type of soil and the density of tanks in the area. According to standards at the time of the study, it was estimated that when the island is completely developed there could be a total of 2,765 septic tanks. At that point, approximately 87.5% of the tanks on the island would be within soils rated severely limited for septic tank use (Lewis, 1986).

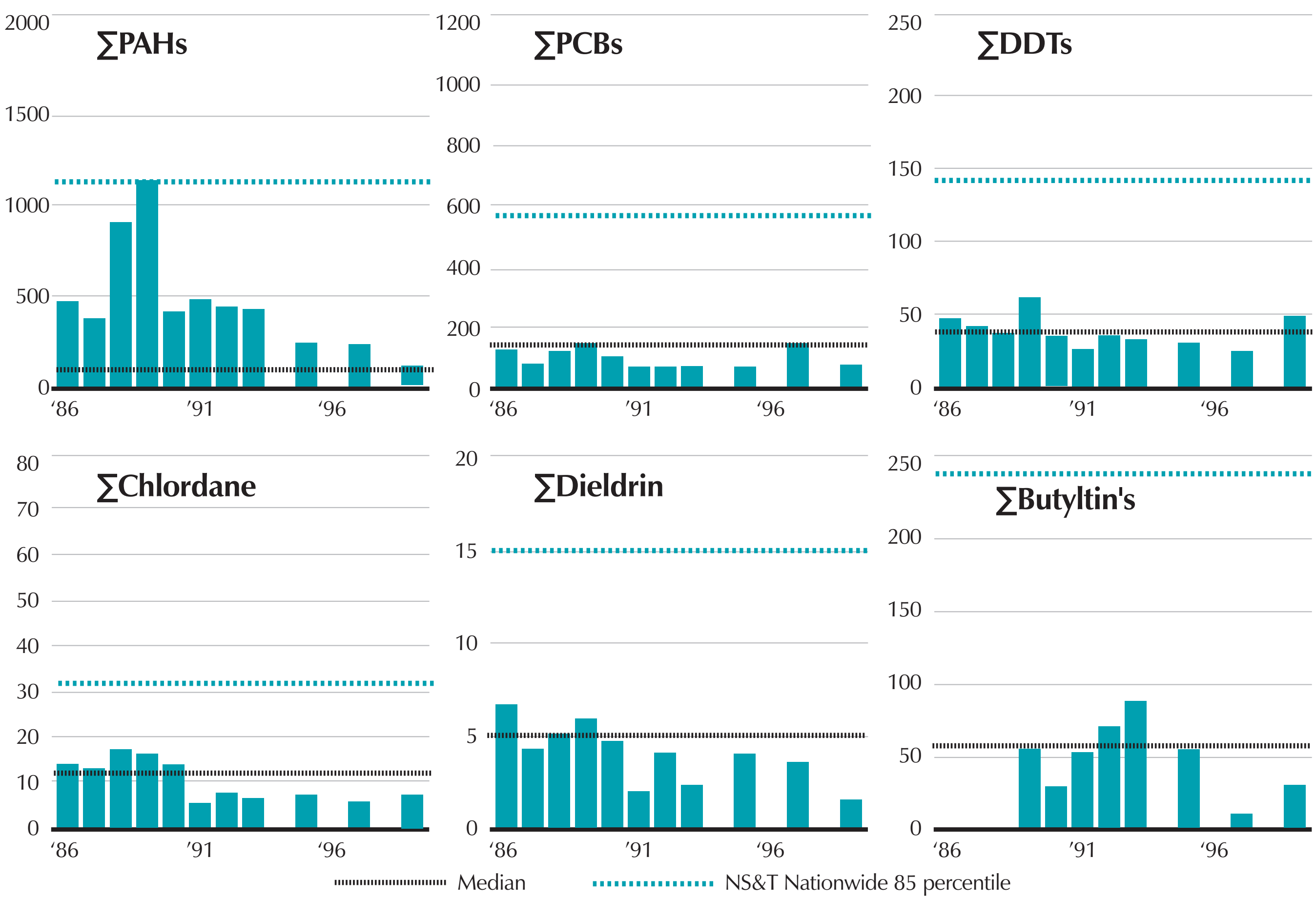



***Figure 113.*** *Trace organic contaminant and total butyltin trends in American oysters (Crassostrea virginica) collected at NS&T Mussel Watch site Cat Point Bar (Apalachicola Bay) (APCP) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.) .*


***Figure 114.*** *Trace element trends in American oysters (Crassostrea virginica) collected at NS&T Mussel Watch site Dry Bar (Apalachicola Bay) (APDB) (µg/g dry wt.) .*

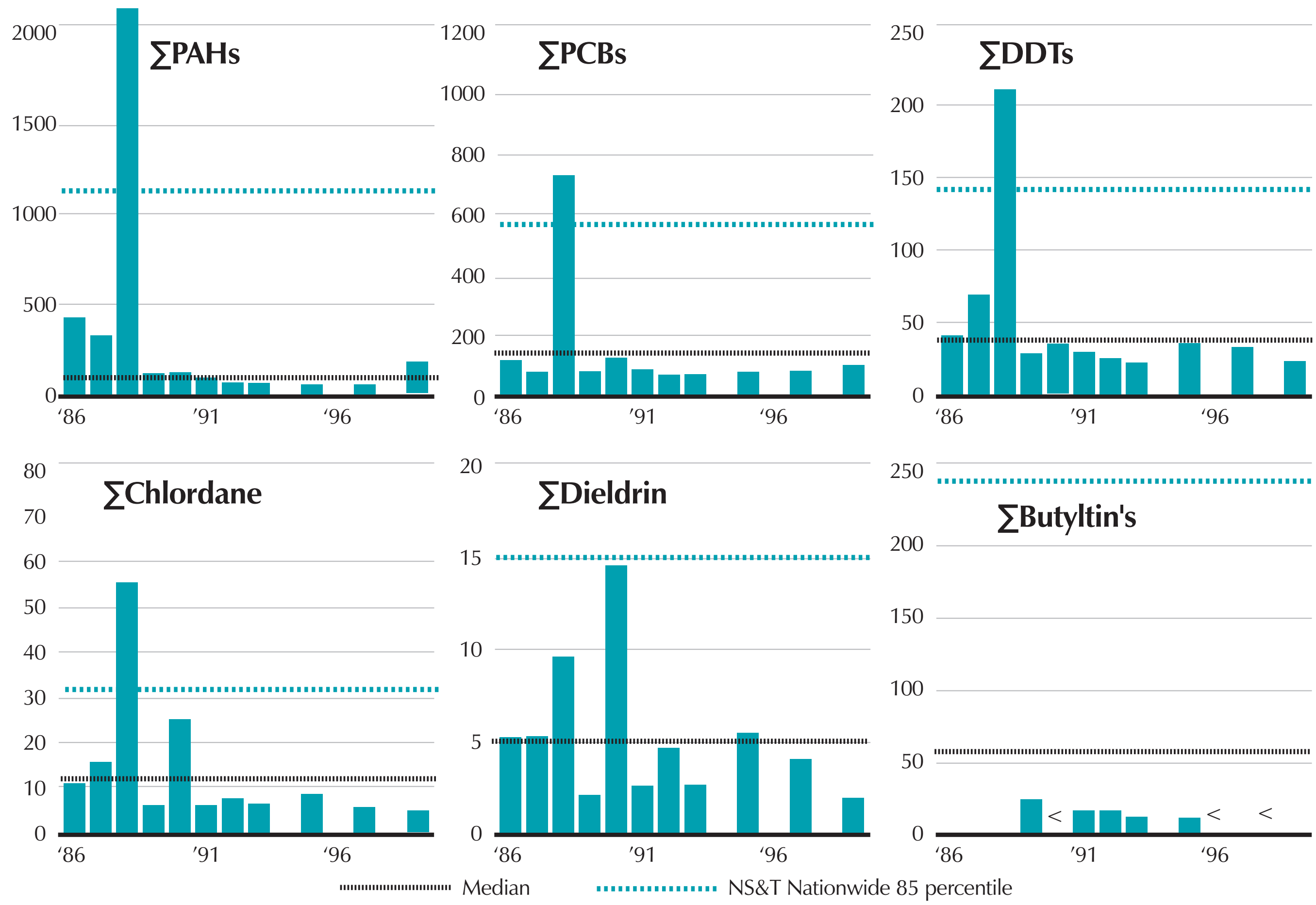



***Figure 115.*** *Trace organic contaminant and total butyltin trends in American oysters (Crassostrea virginica) collected at NS&T Mussel Watch site Dry Bar (Apalachicola Bay) (APDB) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.) .*

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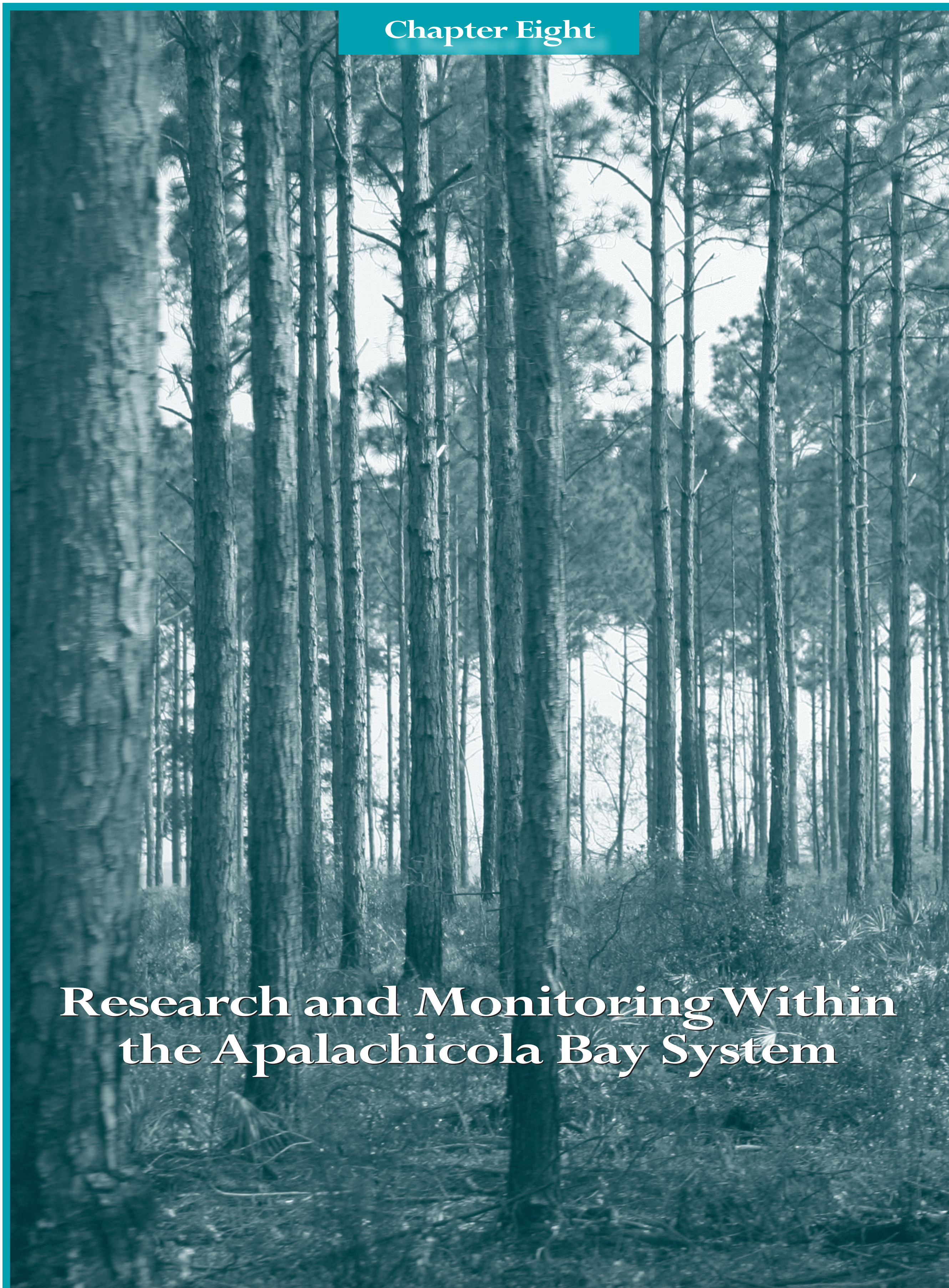
## Chapter Eight

# Research and Monitoring Within the Apalachicola Bay System



A research and monitoring program is an essential element in any successful effort to manage and protect complex environments such as estuarine ecosystems. Because of its size, the diversity of species and habitats present, and its ownership patterns, the Apalachicola River and Bay system poses an especially complex management undertaking. Therefore, it is especially important to have a research and monitoring program that can provide a base of support for in-house monitoring as well as visiting researchers. The program must provide clear, concise scientific information and expertise to other programs, both within and outside the Reserve. Research and monitoring should provide information to help in coastal decision-making, including local, state, regional, and national entities, and provide information to address important management issues and threats that may affect the resources not only of the Reserve but estuarine and coastal areas nation-wide.

The mission of the NERRS, as stated in the current strategic plan, is "To practice and promote coastal and estuarine stewardship through innovative research and education, using a system of protected areas." (NERRS, 2007)

## Goals

Research at Apalachicola NERR is designed to fulfill part of the NERR System goals as defined in the NERR program regulations (15CFR921,2003) as well as local and state needs. The three national goals, out of five, that relate directly to the research and monitoring program include:

- Address coastal management issues identified as significant through coordinated estuarine research within the System;
- Promote federal, state, public and private use of one or more Reserves within the System when such entities conduct estuarine research; and
- Conduct and coordinate estuarine research within the System, gathering and making available information necessary for improved understanding and management of estuarine areas.

Although all three goals of the current NERRS strategic plan developed by the Estuarine Reserve Division (ERD) are related to research and monitoring activities within the Reserves, two in particular directly address these topics. Goal 1 is *"Strengthen the protection and management of representative estuarine ecosystems to advance estuarine conservation, research and education."* The objective under this goal that relates to research and monitoring is:

- Biological, chemical, physical, and community conditions of Reserves are characterized and monitored to describe reference conditions and to quantify change.

Goal 2 is *"Increase the use of Reserve science and sites to address priority coastal management issues."* The three objectives under this goal all relate to research and monitoring and include:

- Scientists conduct estuarine research at Reserves that is relevant to coastal management needs.
- Scientists have access to NERRS datasets, science products and results.
- The scientific community uses data, tools and techniques generated at the NERRS (NERRS, 2007).

The overall goals of the ANERR research and monitoring program, working within the national goals are:

- To promote, engage in, and coordinate research and monitoring to provide information that promotes understanding, protection, and enhancement of the natural resources of the Apalachicola River and Bay system, as well as other estuaries nationwide.
- To provide assistance to and help other sections at the Reserve coordinate the distribution and use of this information to citizens, educators, and resource stewards as well as local, state, and federal agencies involved in coastal management decision-making that affects estuaries and adjacent natural resources.

The Apalachicola Reserve has developed objectives that address research, monitoring, and resource management issues and facilitate the accomplishment of all the above goals (Table 37).

**TABLE 37**

### Objectives utilized to fulfill the goals of the ANERR Research and Monitoring Program

- Maintenance of an easily accessible on-site library of scientific materials relevant to the Apalachicola system as well as natural resource management issues;
- Maintenance of a computerized database of pertinent information collected within and adjacent to the Reserve for use in long-term interdisciplinary research and monitoring efforts;
- Maintenance of field and laboratory facilities that provide a basic level of scientific and sampling equipment necessary to attract and support in-house and outside researchers;
- Maintenance of a comprehensive monitoring program that enables the Reserve to determine baseline changes in the health and status of the lower Apalachicola River and Bay system;
- Promotion of research and monitoring efforts within the Reserve through the development of agreements with other entities within FDEP, other research organizations and universities, and other state and federal agencies;
- Establishment of priority topics for research, actively solicit researchers to develop projects to address these topics, and conduct in-house research that address these topics;
- Acquisition of alternative funding for research and monitoring programs, especially those that deal with high priority management related issues that are of critical interest to the Reserve;
- Promotion of research and monitoring information necessary for sound natural resource management to federal, state, and local decision-makers that enable them to make informed planning decisions based on current scientific information.

## Research Facilities and Equipment

The Apalachicola Reserve provides two office facilities, a main laboratory, and a field station for researchers wishing to study in the Apalachicola Bay system. The main lab consists of approximately 500 square feet at the Eastpoint facility, which serves as the Reserve's headquarters, housing the research and resource management sections. The lab is outfitted with standard equipment such as a fume hood, lab benches, emergency eyewash/shower station, and assorted glassware. Other equipment currently available includes a digital balance, pH meter, centrifuge, drying oven, muffle furnace, turbidity meter, dissolved oxygen meter, multi-parameter programmable dataloggers, Olympus dissecting microscopes, and a Reichert Microstar IV compound microscope.

The Marshall House Field Station, located on Cape St. George Island, is a rustic facility available to researchers studying the many unique aspects of barrier islands. The house, built in the mid-1940's and somewhat primitive, can accommodate up to twelve people for research field trips. The house is equipped with solar power, which provides adequate lighting, well water supply and gas stove. For transportation on the island, four-wheel all terrain vehicles are available when accompanied by Reserve staff.

Because of the size and inaccessibility of many areas, research in the Reserve usually requires the use of boats. The Reserve currently has four vessels available for research a 22-foot C-Hawk powered by a 200 hp outboard, a 25-foot C-Hawk powered by a 225 hp outboard, a 29-foot C-Hawk with cabin powered by twin 225 hp outboards, and a 34-foot landing craft for transporting vehicles and heavy equipment. All vessels are outfitted with VHF marine radios and complete safety equipment. A depth machine, GPS navigational unit, and marine radar are also available and can be used on most boats.

Field sampling gear available at the Reserve includes water sampling bottles, benthic ponar grab, dissolved oxygen and salinity meters, plankton nets, otter trawls, dip nets, seines, and an underwater video camera.

Another valuable tool available for researchers and the general public at the Reserve is the research library located at the Eastpoint facility. The ANERR library consists of over 6,000 publications pertaining to research and monitoring studies conducted within the Reserve and other related topics, which are organized using a computerized bibliographic indexing system.

A variety of computers are available for data storage and management and a functioning Geographic Information System (GIS) with over 1,500 pertinent data layers of the bay and eight surrounding counties is also available (Table 38).

## Research and Monitoring

In order to establish an efficient research and monitoring program, thereby providing the information necessary for natural resource protection, it is essential to have a good understanding of the resources that made reserve designation important and the issues and problems that affect these resources. ANERR has utilized both national and state regulations and guidelines as well as local needs, issues, and budget restraints to develop an ambitious program designed to address issues, data gaps, and threats to the system.

**Table 38**

### Examples of Data Layers in ANERR GIS

| *Category* | *Layer* | *Year* |
|---|---|---|
| **Boundaries** | Florida Aquatic Preserves | 1997 |
| | Florida Managed Areas | 2005 |
| | Fl. Surface Water Classifications | 1993 |
| | Coastal Construction Control Line | 2002 |
| | Public Land Survey | 2006 |
| | Outstanding Florida Waters | 1996 |
| | FEMA Flood Zones | 2001 |
| **Images** | Old Referenced Aerials | 1942, 1987 |
| | Digital Ortho-Quadrats | 2004, 1999, 1994 |
| | Land Satellite | 2003 |
| | Beaches and Coastal | 2004 |
| **Habitat** | Florida Natural Areas Inventory | 2001 |
| | Fish & Wildlife Cons. Comm. | 2003 |
| | Oyster Bar Maps | 1980's, 2006 |
| | SURGO soil maps (NWFWMD) | 2006 |
| | Seagrass Maps(FWC) | 1990's |
| **Land Use** | Northwest FL. WMD | 1995 |
| | University of Florida | 1974, 1995 |
| **Water Quality** | ANERR nutrient sites | 2007 |
| | ANERR datalogger sites | 2007 |
| | ANERR turbidity | 1997 |
| **Listed Species** | Bald Eagle | 1994 |
| | Black Bear Roadkill | 2004 |
| | American Alligator | 1994 |
| | Sea Turtle Nests | 1995-2007 |
| **Man-made Features** | Apalachicola Bay Docks | 2007 |
| | Florida Marinas | 2003 |
| | Florida State Parks | 1999 |
| | Navigation Aids | 2007 |
| | TIGER road File | 2005 |

**NERR Program Components**

To assist sites in the establishment of on-site resource monitoring programs, which include at least some elements comparable throughout the national system, the ERD established a Phased Monitoring Program for the NERRS in 1989. This program, outlined within NERRS regulations (Sec. 921.60) (15CFR921, 2003), provides a systematic basis for developing a high quality estuarine resource and ecosystem information base for National Estuarine Research Reserves (http://nerrs.noaa.gov/Background_Regulations.html). NOAA may provide financial support for basic monitoring programs as part of operations and management under Sec. 921.32 (15CFR921, 2003). Monitoring funds are used to support three major phases of a monitoring program:

1. Studies necessary to collect data for a comprehensive site description/ characterization;
2. Development of a site profile; and
3. Formulation and implementation of a monitoring program.

In support of the third phase of this program, the NERRS and NOAA developed the System-Wide Monitoring Program (SWMP) in 1994 (Trueblood et al., 1996). A phased monitoring approach was instituted to focus on three different ecosystem characteristics that affect estuarine habitats and communities (http://nerrs.noaa.gov/Monitoring/welcome.html). This program includes:

**Phase 1** - Abiotic Parameters, including atmospheric conditions and water quality (salinity, nutrients, contaminants, etc.);

**Phase 2** - Biological Monitoring, including biodiversity, habitat, and population characteristics;

**Phase 3** - Watershed and Land Use Classifications, including changes in human use and land cover types.

As part of the implementation of the SWMP a Central Data Management Office (CDMO) was created to assist in storage, quality assurance and quality control, and dissemination of the data. All information generated by the SWMP from all sites is compiled electronically at the CDMO, located at the Belle Baruch Marine Laboratory in South Carolina (http://cdmo.baruch.sc.edu/), and is available to all Reserves, CZM programs, OCRM and other users. Each Reserve has constant electronic access to all system-wide data and summary statistics on environmental trends at the national, regional or site-specific levels.

In addition, to help support the SWMP program and increase research in each Reserve, the Graduate Research Fellowship (GRF) program was established in 1997. The GRF program funds two graduate students at each site to accomplish their research within Reserve boundaries. The fellowships are provided "to support management-related research projects that will enhance scientific understanding of Reserve ecosystems, provide information needed by Reserve management and coastal management decision-makers, and improve public awareness and understanding of estuarine ecosystems and estuarine management issues (15CFR921, 2003)."

To-date eight students have been funded at the Apalachicola NERR; seven Ph.D. candidates and one Master's student (Table 39). Their projects have had a management-oriented side to their work and have benefitted the Reserve's efforts to protect this system. The implementation of this program has had a positive impact on the amount of research accomplished in the Bay and also attracted many more researchers, especially professors supervising the students funded. The fellowships also offer hands-on training in ecological monitoring and coastal zone management (http://nerrs.noaa.gov/Fellowship/ApplicationI.html).

The Protected Areas Geographic Information System (PAGIS) Project was an initiative to develop fully integrated geographic information systems (GIS), spatial data management, and Internet capabilities within the National Estuarine Research Reserves (NERR). A tribute to the success of this project is each Reserve's current use of GIS in their management, stewardship, research and education programs. PAGIS enabled each site to set up a GIS with equipment, basic data layers, and the ability to substantially increase their capabilities to utilize this important management tool. PAGIS was initiated in 2000 by a partnership between ERD, the Cooperative Institute for Coastal and Estuarine Environmental Technology and the Coastal Services Center. Although funding for PAGIS has ceased, most sites have continued their GIS programs with NOAA operational funds due to the importance of this data collection effort and its use in resource management protection.

The newest component at the national level which will further strengthen the viability and visibility of the NERR research and monitoring program is the Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET) established at the University of New Hampshire in partnership with NOAA. This institute directly funds "the scientific development of innovative technologies for understanding and reversing the impacts of coastal and estuarine contamination and degradation" within reserves (http://ciceet.unh.edu/). To-date six projects have been funded by CICEET to accomplish research in Apalachicola Bay (Table 40).

**ANERR Program Components**

The Reserve has developed research priorities based on specific threats that currently confront the Apalachicola Reserve and the Apalachicola River and Bay system. The two main threats to the bay system and their potential impacts in particular include:

- The upstream diversion of fresh water (ACF Water Wars) with the potential for
  - Productivity impacts
  - Biodiversity impacts (river, floodplain, bay)
  - Habitat/Species loss
  - Economic impacts; and
- Increasing local coastal development and land use changes with the potential for

- Nutrient enrichment
- Coliform bacteria density and distribution (oysters)
- Habitat/Species loss
- Contaminant increase

Research priorities are developed based on the above threats, and utilized by the Reserve to help guide the research and monitoring program and also focus outside researchers on appropriate and applicable project ideas (Table 41).

One of the primary objectives of the Reserve's research and monitoring program is to promote research within and adjacent to the Reserve by outside investigators from universities, government agencies, and private institutions. The benefits of encouraging outside investigators include high quality research, broad and varied levels of expertise, an interdisciplinary approach, potential use of graduate students from universities, and a wide range of funding sources that are not available through NOAA or DEP sources.

The research staff is also involved in their own research and monitoring including oil spill planning, land development regulations, resource inventories, as well as judging local science fairs, advisory committees, and planning committees. These entities include but are not limited to many of the regulatory programs within the FDEP, Northwest Florida Water Management District, Florida Department of Transportation, Florida Coastal Management Program, Apalachee Regional Planning Council, Florida Department of Community Affairs, U.S. Coast Guard, U.S. Army Corps of Engineers (USACOE), The Nature Conservancy, Florida State University, University of Florida, Auburn University, and the University of South Florida.

All ten of these research priorities (Table 41) are related to and depend upon the development of a comprehensive monitoring program. This monitoring program, combined with a successful outside researcher program, allows the Reserve to address many of the resource management issues currently confronting it.

**Table 39**

## Graduate Research Fellowships at the Apalachicola NERR.

| Project Title | Fellow | Institution | Date |
|---|---|---|---|
| Metals contamination in the Apalachicola River and estuary | Debra Harrington | Florida State University | 1997-1999 |
| Use of artificial tracers to determine the impact of small-scale domestic sewage systems on Apalachicola Bay | D. Reide Corbett | Florida State University | 1997-2000 |
| A hydrogeologic framework for modeling nutrient-bearing groundwater flow and submarine groundwater discharge, St. George Island, FL | James Schneider | University of South Florida | 1999-2002 |
| A spatial and temporal assessment of factors affecting denitrification in Apalachicola Bay | Carl Childs | Florida State University | 2000-2003 |
| Planktonic food web variations related to salinity and nutrient patterns in Apalachicola Bay | Jennifer Putland | Florida State University | 2002-2005 |
| Evaluation of flushing rates of estuaries and embayments via natural geochemical tracers | Henrietta Dulaiova | Florida State University | 2003-2005 |
| The role of oligohaline marshes as a source or sink of nitrogen to the Apalachicola Bay | Thomas Gihring | Florida State University | 2005-2008 |
| Origin and fate of suspended particulates in the Apalachicola River: Impact on Apalachicola Bay | Richard Peterson | Florida State University | 2005-2008 |

**Table 40**

## CICEET Funded Projects within the Apalachicola NERR

| Project Title | Fellow | Institution | Date |
|---|---|---|---|
| Identification and Assessment of Anthropogenic Eutrophication in Shallow Estuaries | Dr. Ivan Valiela | Boston University, MBL | 1998-2002 |
| Development and Implementation of a Wide Area Real-Time Data Collection Network for the National Estuarine Research Reserve System | Dr. Steve W. Ross | University of North Carolina, Wilmington | 2000-2003 |
| Automated Radon-222 Mapping in the Coastal Zone for Assessment of Submarine Groundwater Discharge | Dr. William Burnett | Florida State University | 2001-2004 |
| F + RNA Coliphages as Source Tracking Viral Indicators of Fecal Contamination | Dr. Mark Sobsey | University of North Carolina | 2003-2006 |
| Implementation and Enhancement of Satellite Telemetry System for Real Time Water Monitoring throughout the NERRS Network | Dr. M. Blake Henke | North Star Technologies | 2004-2005 |
| Multichannel Handheld Sensor for Microbial Contaminants | Dr. John Paul | University of South Florida | 2005-2008 |

All Reports are online at http://ciceet.unh.edu/

Table 41

## ANERR Research Program Priorities

- Environmental effects on habitats and populations, abundance, distribution, recruitment, predation, and mortality of ecologically, recreational and commercially important species of the Apalachicola River and Bay system;
- Examination of the morphology and hydrology of the river and bay system and identification of the variables that are important forcing functions in the system;
- Effects of historic, current and proposed upstream water reductions and uses on the hydrodynamics and natural resources of the Apalachicola River and Bay system;
- Assessment of the effects of man-made alterations such as Sike's Cut, dredge and fill activities, shoreline stabilization, dock construction and development activities on the hydrodynamics, sediment regime, and natural resources of the Apalachicola River and Bay system;
- Assessment of the role of marshes and seagrass beds in nutrient cycling, estuarine productivity, and as nursery areas for important commercial and noncommercial species of the Apalachicola Basin;
- Ecology, development, and effectiveness of management strategies for threatened and endangered species found within the boundaries of ANERR;
- Assessment of the importance of upstream activities, local development and land use changes, and marine activities on the nutrients and contaminant loading of the bay system;
- Continued identification and cataloging of plants and animals as well as habitat delineation in the Apalachicola River and Bay Basin;
- Cultural and economic implications of past, present, and future uses of the natural resources of the system;
- Assessment of the effects of research and monitoring information on resource management decisions that impact the natural resources of the Apalachicola Bay system.

## ANERR Monitoring Program

Because estuarine ecosystems are naturally highly variable and complex systems with variations occurring over many spatial and temporal scales, distinguishing variability due to natural events from those due to anthropogenic factors has proven to be difficult. In addition to the need for more research to show cause and effect relationships, long-term monitoring programs are essential to identify the temporal and spatial scales of natural variability that characterize estuaries. Despite the importance of the coastal region to the Nation's economy and well-being, and the high potential for human use and for natural events to adversely impact the resources and coastal ecosystems, little is known about the status and trends of critical environmental variables in coastal regions.

Research and monitoring projects typically complement each other and are sometimes difficult to separate. The Reserve has set up an extensive long-term monitoring program designed to determine the health and status of the bay, detect changes in the system, identify the causes, and address these issues through management and coordination with other local, state, and federal agencies. While many short-term or limited scope programs are also undertaken, these long-term programs continue indefinitely and require a commitment of manpower and expendable supplies as well as periodic upgrades and maintenance of equipment.

**Long-term Monitoring Studies**

*System-Wide Monitoring Program (SWMP)*

The SWMP, funded by NOAA, entails the largest effort on the part of the research staff of any monitoring program at the Reserve. Staff maintains four multi-parameter programmable dataloggers in the bay on a continuous basis and has since 1995. The dataloggers measure temperature, specific conductivity, salinity, dissolved oxygen, pH, water level, and turbidity every fifteen minutes. The dataloggers are located at three separate locations (Figure 116), East Bay, Cat Point, and Dry Bar. One datalogger at each location is deployed approximately 0.3 meters of the bottom. At the East Bay site a second datalogger is deployed at the same location but at the surface. The dataloggers are deployed/retrieved every two weeks due to fouling concerns. Pre-calibration, programming, post-calibration, and cleaning and maintenance of the instrument also occurs at these intervals.

The Cat Point and Dry Bar sites are located on two of the most productive oyster bars in the bay and have been monitored since May, 1992. These sites were originally chosen to study the effects of changing river flow on environmental variables over these commercially important oyster bars. The East Bay site was chosen to look at potential changes in water quality in the upper bay related to a large-scale restoration effort planned within the Tate's Hell State Forest. The data from all these sites is also being used in most of the Reserve's research and monitoring studies.

Weather conditions can have a strong influence on water quality. Part of SWMP requires monitoring meteorological conditions and the Reserve maintains a weather station in the upper East Bay marshes (Figure 116). This weather station measures air temperature, relative humidity, wind speed and direction, barometric pressure, rainfall, and photosynthetically active radiation (PAR). Data is stored every fifteen minutes and downloaded monthly. The weather station has been in operation since late 1999.

Nutrient and chlorophyll a monitoring has been an integral part of SWMP since 2002. Duplicate samples for nitrate, nitrite, am-

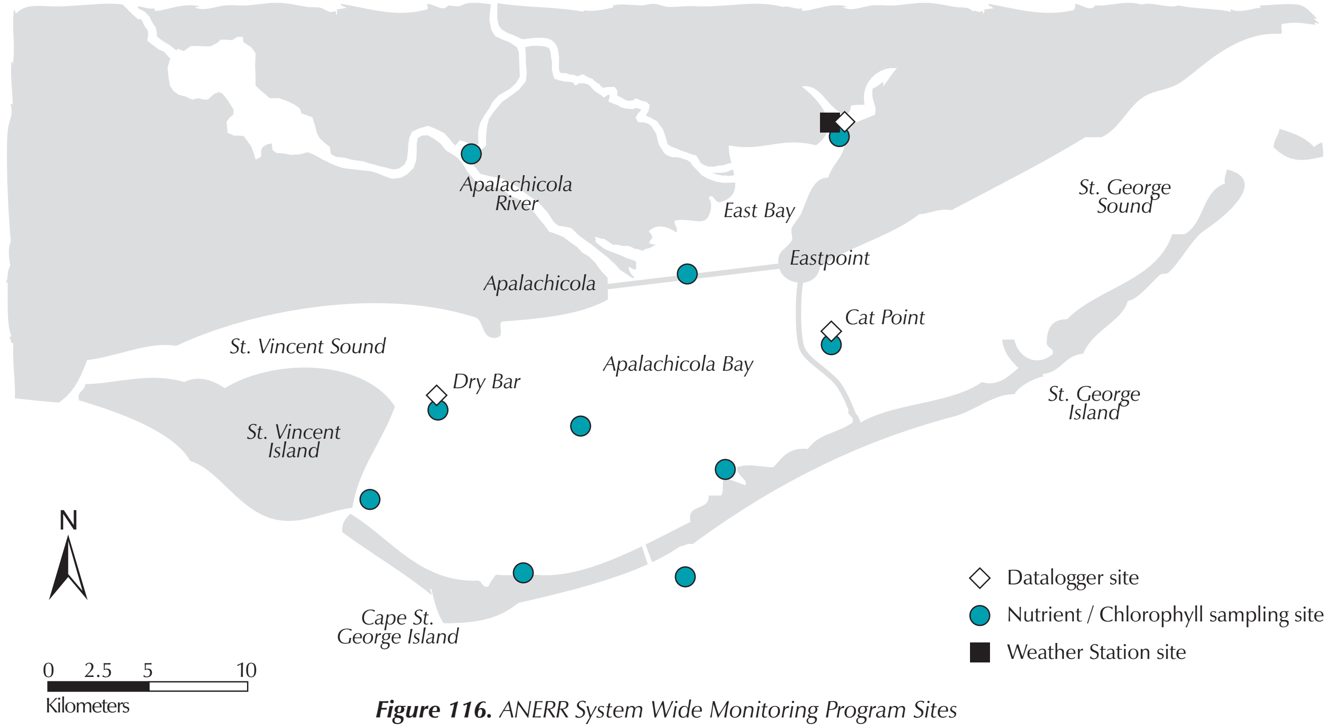



***Figure 116.*** *ANERR System Wide Monitoring Program Sites*

monium, ortho-phosphate, and chlorophyll a are collected monthly at the four datalogger sites and seven additional stations to get better spatial coverage of the bay (Figure 116). In 2007 total dissolved nitrogen and total dissolved phosphorus were added to the parameters measured monthly. Two of these stations are situated in the lower river and outside Sikes Cut in order to provide input data from river flow and tidal action. At the same time diel samples are taken over a complete tidal cycle (25 hours) every 2.5 hours.

All SWMP data is collected and processed utilizing NERR Standard Operating Protocols , and quality assured and quality checked (QA/QC). Federal Geographic Data Committee (FGCD) content compliant metadata is created to describe it and it is submitted to the CDMO annually. Telemetry units have been installed at several of the SWMP sites and real-time data as well as archived historic data is available over the web (http://cdmo.baruch.sc.edu/).

The data goes through another QA/QC review and is then posted to the web where it is available to any researcher, agency, or private citizen that requests it.

*Other Long-term Monitoring Programs*

In addition to SWMP, the Reserve has set up numerous other monitoring programs to monitor the health and status of the bay and relate this to changes occurring both locally and in the watershed far upstream.

A monitoring and management program for listed and non-listed species has been in effect since the early 1990's (Figure 117). Sea turtle nests are monitored and protected on beaches within and adjacent to the Reserve by staff, volunteers, and other agencies, most of which is coordinated by the Reserve. Management of the nests includes predator control, fencing nests, working with the County on a lighting ordinance, monitoring lighting violations, and working with a local NGO on correcting lighting problems. The Reserve also monitors and manages colonial migratory bird species including least terns, black skimmers, Caspian terns, Royal terns, brown pelicans, gull-billed terns, and sandwich terns on various man-made causeways and islands (both natural and man-made) within the Reserve in association with the FFWCC, Franklin County and the USACOE (Figure 117).

After Hurricane Opal impacted this area in 1995, a shoreline erosion and dune recovery study was instituted to monitor changes in local shorelines, dune and vegetation loss and recovery, as well as impacts from natural events such as hurricanes. The research section monitors beach and bay shorelines on Cape St. George Island quarterly at six locations to determine shoreline changes (Figure 117). Other monitoring trips are planned during hurricane season to monitor specific changes due to hurricane events.

The Reserve began a trawling program in 2000 and now has seven years of monthly fish and benthic macro-invertebrate data at twelve sites (Figure 117). The sampling program mimics the gear and procedures of a long-term study done in the bay by an Florida State University researcher from 1972-1984 as well as having many of the same sampling locations incorporated into the project. Trawls are performed monthly at twelve stations (five replicates at each site) that exhibit various habitat and salinity regimes associated with them. Species, size, and number, are determined from each site, along with baseline water quality measurements.

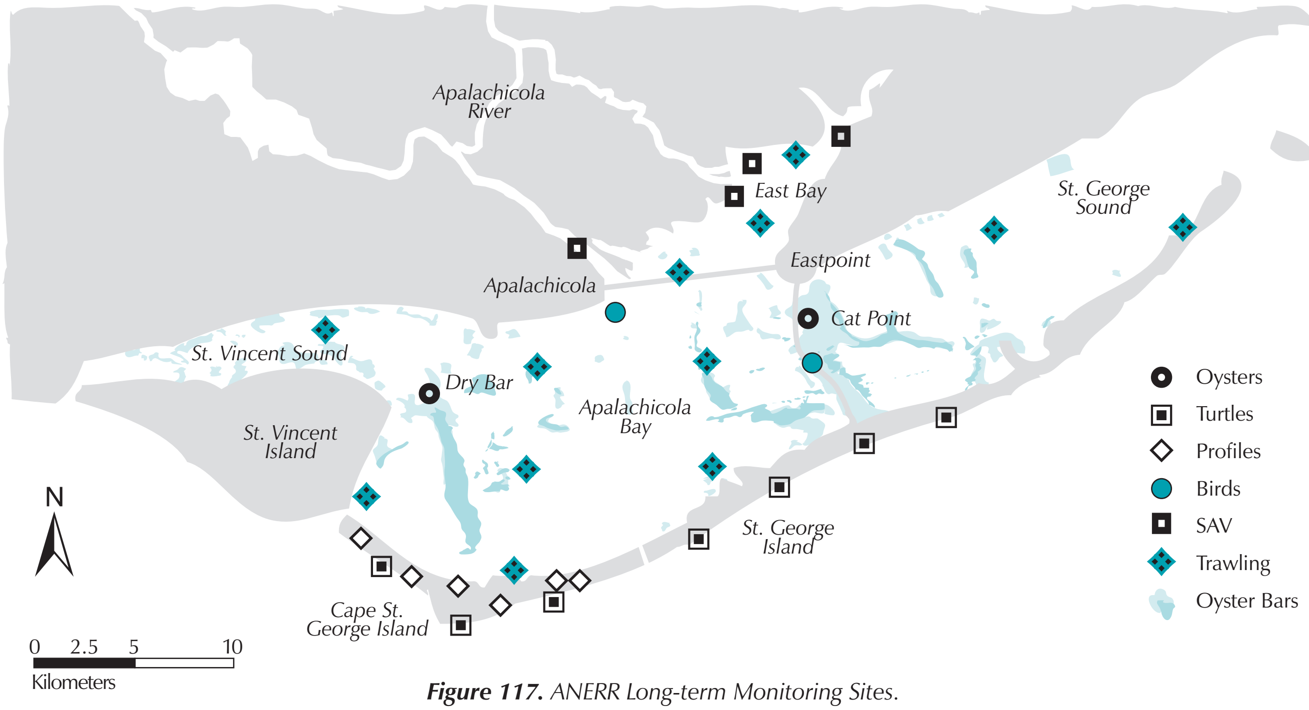



***Figure 117.*** *ANERR Long-term Monitoring Sites.*

The research section maintains a GIS containing over 1,500 data layers covering natural resource information (habitats, estuarine species, listed species), research information, land use and cover maps, storm surge and flood maps, etc. of areas both within and adjacent to the Reserve. This information, developed under an earlier grant, has been updated and maintained for use by other sections, programs, and agencies. In particular the research section works closely with the resource management section on GIS information and projects.

An oyster growth and spatfall monitoring study, begun in March 2004, has become another long-term project. Oyster growth and spatfall are monitored monthly at two of the most productive oyster bars in the bay, Cat Point and Dry Bar (Figure 117). Mesh bags containing three size classes of oysters are deployed at two of the SWMP datalogger locations. Differences in growth and spatfall can then be compared to environmental conditions on either side of the bay and their effects on oyster populations determined.

Started as a SWMP bio-monitoring project and continued after the nine-month funding ended, the submerged aquatic vegetation (SAV) study continues. This project is designed to detect changes in fresh and brackish SAV species and their distribution in East Bay caused by changes in the salinity regime (Figure 117). These changes could be due to natural events such as droughts or floods or man-made alterations to the historic flow regime caused by proposed upstream water diversions or changing reservoir operations.

**Short-term Monitoring Programs**

Numerous other studies occur over shorter time periods ranging from 6-months to several years but have defined ending dates. These are generally associated with visiting researchers, grant funded research, graduate student projects, partnerships with other agencies, or state required studies and projects. Examples of a few of these projects over the last several years include:

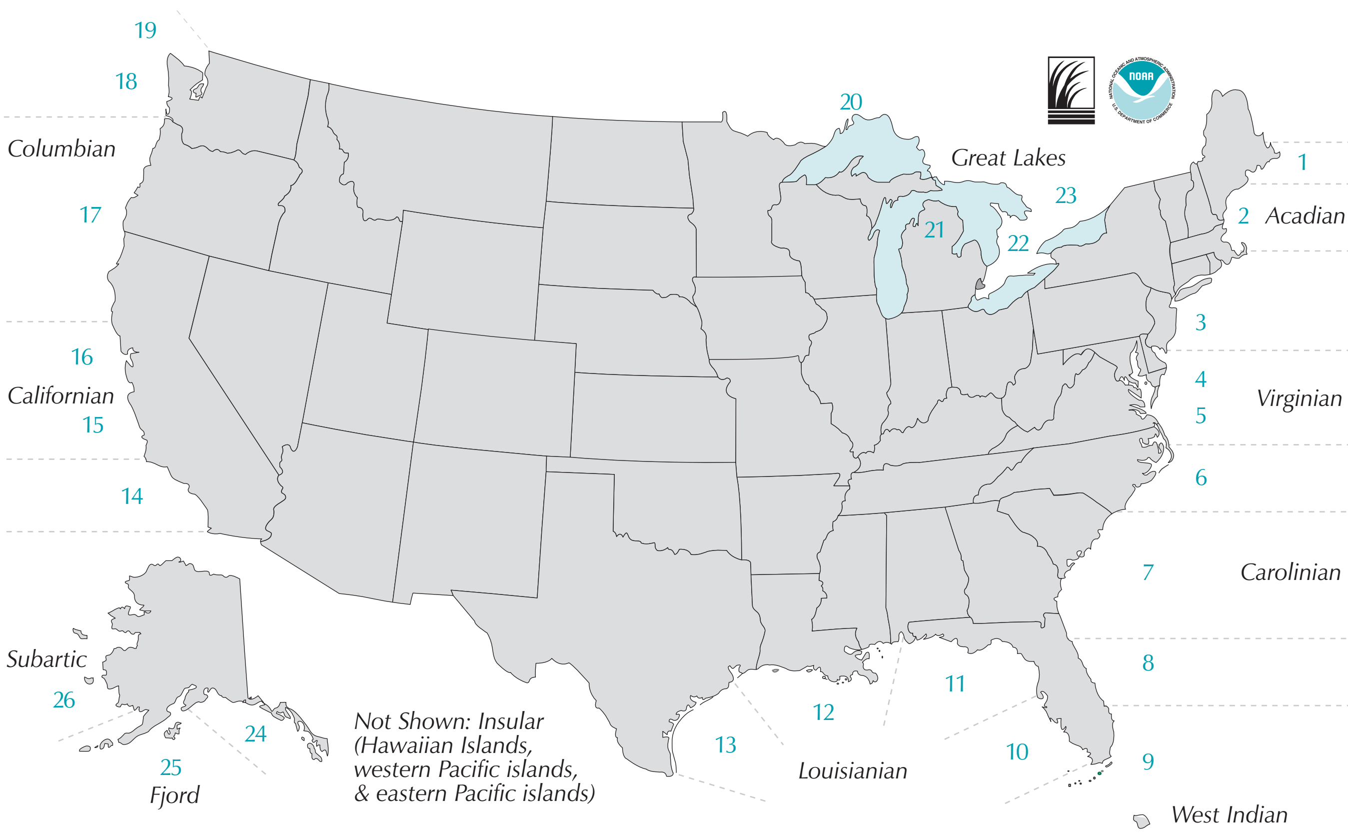
- a one-year benthic habitat mapping project with NOAA's Coastal Service Center (CSC);
- a two-year oyster bar mapping and detailed bathymetric survey project with NOAA's CSC and USGS Coastal and Marine Geology Program;
- a six-year continuing project with Florida A&M University's (FAMU) Environmental Sciences Institute as part of the Environmental Cooperative Science Center (ECSC) established there to help train under-represented minorities in marine science, develop a conceptual model of Apalachicola Bay to help in management decisions, and fill in data gaps about the system;
- a two-year project to develop a Geographic Information System project that includes natural resource data layers as well as county permitting and zoning data and train Franklin County planners in its applicability for land-use planning and permitting decisions;
- Sediment Elevation Tables (SET) deployed in the upper bay marshes in association with the FSU Bureau of Geology and the Florida Geologic Survey.

All information collected and analyzed by the ANERR's federal research and monitoring programs, including long- and short-term data, is available to researchers and the public for their use. Data are kept in easily retrievable database files. Monthly, seasonal, and annual analyses of the data are made available to researchers, decision-makers, school groups, and the general public as they are finalized. Additional stations, parameters, and projects will be added as new management concerns arise and as staff time and equipment become available.

**Research Gaps and Needs**

In the last ten years much of the monitoring and research undertaken has been to look at the potential effects of reduced water flows into the bay system from the river. Several research projects have been process-oriented studies on trophic relationships using stable isotopes (Chanton and Lewis, 2002) or salinity effects on phytoplankton productivity (Putland, 2005). In the late 1980's a large amount of research was done on the food web, source of food in the bay, and gut analysis to determine what nektonic and benthic macro-invertebrates fed on at different stages of their life cycle (Livingston, 1984; Livingston, 1997; Livingston et al.,1997). More of these types of studies relating how the biological components of the bay are affected by and respond to physical and chemical changes in the bay are needed. Studies related to reduced riverflow, changes in nutrient loads to the bay (from development and upstream water-diversion), and possible alterations to the bay's overall productivity are espcially needed.

In addition, very little is known about benthic macro-algae distribution, sediment chlorophyll productivity, upper bay marsh (fresh-brackish species) productivity, and benthic respiration and production. Additional research on oyster productivity, the




***Biographic Provinces (subregions)***

1. Northern Gulf of Maine
2. Southern Gulf of Maine
3. Southern New England
4. Middle Atlantic
5. Chesapeake Bay
6. North Carolina
7. South Atlantic
8. East Florida
9. Caribbean
10. West Florida
11. Panhandle Coast
12. Mississippi Delta
13. Western Gulf
14. Southern California
15. Central California
16. San Francisco Bay
17. Middle Pacific
18. Washington Coast
19. Puget Sound
20. Lake Superior
21. Lakes Michigan & Huron
22. Lake Erie
23. Lake Ontario
24. Southern Alaska
25. Aleutian Islands
26. Northern Alaska
27. Hawaiian Islands
28. Western Pacific Island
29. Eastern Pacific Island

***Figure 118.*** *Biographic Regions of the NERRS*

controlling mechanisms for growth and reproduction and effects of environmental change on the seafood industry needs to be accomplished. In the 1990's several studies relating oyster and blue crab commercial landing data to riverflow were accomplished (Wilber, 1992: Wilber,1994). These types of studies in particular need to be redone utilizing newer data and statistical techniques. There is a need for social and economic studies to determine the impacts of resource management, regulatory, and development decisions on cultural and generational issues related to the long-standing seafood industry in Apalachicola Bay. The Reserve's ability to address or attract researchers willing to undertake these projects will continue to be related to staff, facilities, and funding.

Finally, the Apalachicola NERR is in the Louisianian Biogeographic Region, sub-region Panhandle Coast, of the NERRS (Figure 118). Two other reserves, Weeks Bay and Grand Bay are within this region, but different sub-regions. More joint or comparative research and monitoring needs to be accomplished to not only determine the similarities and differences between these sites but other NERR sites across the country, particularly within the southeastern United States. Many of the NERR's are threatened by similar issues as ANERR. Information on how these areas are affected and cope with these difficulties can be utilized not only by the NERRS but also coastal zone managers across the United States.

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# Appendices



***Key to Appendices***

**FT** - Federally Threatened

**FE** - Federally Endangered

**ST** - Threatened (State of Florida)

**SE** - Endangered (State of Florida)

**SSC** - Species of Special Concern (State of Florida)

**N** - Non-native (Includes Introduced & Exotic)

**E** - Endemic

**A** - Accidental (Documented 7 times or less in the past 20 years)

**D** - Diadromous

## Appendix I

# Plants of the Apalachicola River and Bay Basin

| Scientific Name | Common Name |
|---|---|
| *Abelia grandiflora* | Glossy abelia |
| *Acacia farnesiana* | Sweet acacia |
| *Acalypha gracilens* | Three-seeded mercury |
| *Acalypha rhomboidea* | Three-seeded mercury |
| *Acanthospermum hispidum* | |
| *Acer negundo* | Box-elder |
| *Acer rubrum* | Red maple |
| *Acer saccharinum* | Silver maple |
| *Acer saccharum* | Sugar maple |
| *Acer saccharum ssp. floridanum* | Florida maple |
| *Achillea millefolium* | Common yarrow |
| *Achyranthes aspera* | Devil's horsewhip |
| *Acmella pusilla* | Dwarf spotflower |
| *Acmella repens* | Oppositeleaf spotflower |
| *Acnida cannabinus* | Water-hemp |
| *Actaea pachypoda* **(SE)** | Baneberry |
| *Adiantum capillus-veneris* | Southern maidenhair fern |
| *Aeschynomene americana* | Shyleaf |
| *Aeschynomene indica* | |
| *Aeschynomene viscidula* | |
| *Aesculus pavia* | Red buckeye |
| *Agalinis aphylla* | Gerardia |
| *Agalinis divaricata* | Gerardia |
| *Agalinis fasciculata* | Gerardia |
| *Agalinis filifolia* | Gerardia |
| *Agalinis maritima* | Gerardia |
| *Agalinis pinetorum* | Gerardia |
| *Agalinis purpurea* | Gerardia, purple false foxglove |
| *Agalinis setacea* | Gerardia |
| *Agrostis perennans* | Autumn bentgrass |
| *Ailanthus altissima* | Tree of heaven |
| *Albizia julibrissin* | Mimosa, silktree |
| *Aletris lutea* | Yellow colic-root |
| *Aletris obovata* | White colic-root |
| *Allium canadense* | Wild onion |
| *Allium canadense var. mobilense* | Meadow garlic |
| *Allium inodorum* | |
| *Allium neapolitanum* | White garlic |
| *Alnus serrulata* | Hazel alder |
| *Alternanthera philoxeroides* | Alligator-weed |
| *Alternanthera sessilis* | Chaff-flower |

| Scientific Name | Common Name |
|---|---|
| *Alysicarpus ovalifolius* | Alyce clover |
| *Alysicarpus vaginalis* | White moneywort |
| *Amaranthus australis* | Southern water hemp |
| *Amaranthus blitum* | Purple amaranth |
| *Amaranthus blitum var. emarginatus* | |
| *Amaranthus tuberculatus* | |
| *Amaranthus viridis* | |
| *Ambrosia artemisiifolia* | Common ragweed |
| *Ambrosia trifida* | Great ragweed |
| *Ambrosia trifida var. trifida* | Great ragweed |
| *Ammannia coccinea* | Scarlet ammannia |
| *Ammannia latifolia* | Toothcups, pink redstem |
| *Amorpha fruticosa* | False-indigo |
| *Amorpha herbacea* | |
| *Ampelaster carolinianus* | Climbing aster |
| *Ampelopsis arborea* | Pepper-vine |
| *Ampelopsis cordata* | |
| *Amphicarpum muhlenbergianum* | |
| *Amsonia tabernaemontana* | Texas-star |
| *Anagallis minima* | Chaffweed |
| *Andropogon arctatus* **(ST)** | Chapman pinewoods bluestem, pinewoods bluestem |
| *Andropogon elliottii* | Broomstraw |
| *Andropogon floridanus* | Florida bluestem |
| *Andropogon glomeratus* | Bushy beardgrass |
| *Andropogon glomeratus var. glaucopsis* | Bushy beardgrass |
| *Andropogon glomeratus var. pumilus* | Bushy beardgrass |
| *Andropogon gyrans* | Beardgrass |
| *Andropogon gyrans var. stenophylla* | Beardgrass |
| *Andropogon longiberbis* | Beardgrass, hairy bluestem |
| *Andropogon virginicus* | Broomsedge |
| *Andropogon virginicus var. glaucus* | Broomsedge |
| *Anemonella thalictroides* | Rue anemone |
| *Angelica dentata* | |
| *Anthaenantia rufa* | Purple silkyscale |
| *Anthaenantia villosa* | Green silkyscale |
| *Antigonon leptopus* | Coral vine |
| *Apios americana* | Ground nut |
| *Apium graveolens* | Wild celery |
| *Apium graveolens var. dulce* | Wild celery |
| *Apium leptophyllum* | Marsh parsley |
| *Apocynum cannabinum* | Dogbane, indian hemp |
| *Aquilegia canadensis* **(SE)** | Columbine |

| Scientific Name | Common Name |
|---|---|
| *Arabis canadensis* **(SE)** | Sickelpod |
| *Aralia spinosa* | Devils-walkingstick |
| *Ardisia crenata* | Hen's eyes |
| *Arenaria lanuginosa* | Sandwort |
| *Arenaria serpyllifolia* | Thyme-leaved sandwort |
| *Argemone albiflora* | Carolina poppy |
| *Argemone mexicana* | Mexican pricklypoppy |
| *Arisaema dracontium* | Green dragon |
| *Aristida condensata* | Big threeawn, piedmont threeawn |
| *Aristida gyrans* | |
| *Aristida mohrii* | Mohr's threeawn |
| *Aristida patula* | Tall threeawn |
| *Aristida purpurescens* | Arrowfeather |
| *Aristida spiciformis* | Bottlebrush threeawn |
| *Aristida stricta* | Wiregrass, pineland threeawn |
| *Aristida tuberculosa* | Seaside threeawn |
| *Aristolochia serpentaria* | Snake root |
| *Aristolochia tomentosa* **(SE)** | Pipevine, wooly dutchman's pipe |
| *Arnica acaulis* **(SE)** | Leopard's-bane |
| *Arnoglossum atriplicifolium* | Indian plantain |
| *Arnoglossum diversifolium* **(ST)** | Indian plantain, variable leaved indian plantain |
| *Arnoglossum ovatum* | Indian plantain |
| *Aronia arbutifolia* | Red chokeberry |
| *Arundinaria gigantea* | Cane |
| *Arundinaria tecta* | |
| *Arundo donax* | Giant reed |
| *Asclepias cinerea* | Milkweed |
| *Asclepias lanceolata* | Milkweed |
| *Asclepias pedicellata* | Milkweed |
| *Asclepias perennis* | Milkweed |
| *Asclepias viridiflora* **(SE)** | Milkweed, green flowered milkweed, green milkweed |
| *Asclepias viridula* **(ST)** | Southern milkweed, green milkweed |
| *Asimina longifolia var. spathulata* | |
| *Asimina parviflora* | Small-fruited pawpaw |
| *Asplenium platyneuron* | Ebony spleenwort |
| *Asplenium resiliens* | Blackstem spleenwort |
| *Aster adnatus* | |
| *Aster carolinianus* | Climbing aster |
| *Aster chapmanii* | |
| *Aster concolor* | |
| *Aster dumosus* | |
| *Aster eryngiifolius* | |
| *Aster lateriflorus* | Starved aster |

| Scientific Name | Common Name |
|---|---|
| *Aster puniceus ssp. elliottii* | |
| *Aster shortii* | |
| *Aster spinulosus* **(SE)** | Pinewoods aster, Apalachicola aster |
| *Aster subulatus* | |
| *Aster tenuifolius* | Perennial salt marsh aster |
| *Aster tortifolius* | White-topped aster |
| *Aster vimineus* | |
| *Atriplex cristata* | Crested saltbush |
| *Atriplex pentandra* | Seabeach orach |
| *Aureolaria flava* | Yellow foxglove |
| *Aureolaria pedicularia* | |
| *Avena sativa* | Common oat |
| *Avicennia germinans* | Black mangrove |
| *Axonopus affinis* | Common carpetgrass |
| *Axonopus furcatus* | Big carpetgrass |
| *Azolla caroliniana* | Mosquitofern, waterfern, Carolina mosquitofern |
| *Baccharis angustifolia* | False willow |
| *Baccharis glomeruliflora* | Groundsel tree |
| *Baccharis halimifolia* | Groundsel tree, sea myrtle |
| *Bacopa caroliniana* | Blue hyssop |
| *Bacopa monnieri* | Water hyssop |
| *Balduina uniflora* | |
| *Bambusa multiplex* | Bamboo, hedge bamboo |
| *Baptisia lactea* | White wild indigo |
| *Baptisia lecontei* | Wild indigo, pineland wild indigo |
| *Baptisia megacarpa* **(SE)** | Apalachicola wild indigo |
| *Baptisia simplicifolia* **(ST)** | Scare-weed |
| *Bartonia verna* | |
| *Batis maritima* | Saltwort, turtleweed |
| *Berchemia scandens* | Rattan vine |
| *Betula nigra* | River birch |
| *Bidens alba var. radiata* | Beggar-ticks |
| *Bidens bipinnata* | Spanish needles |
| *Bidens cernua* | |
| *Bidens discoidea* | Beggar-ticks |
| *Bidens frondosa* | Beggar-ticks |
| *Bidens laevis* | Wild goldenglow, smooth beggartick |
| *Bidens mitis* | Beggar-ticks |
| *Bigelowia nudata* | Rayless goldenrod |
| *Bignonia capreolata* | Cross-vine |
| *Boehmeria cylindrica* | False nettle, bog hemp |
| *Boerhavia erecta* | Erect spiderling |
| *Boltonia apalachicolensis* | Apalachicola daisy |
| *Boltonia asteroides* | |

| Scientific Name | Common Name |
|---|---|
| *Boltonia diffusa* | Doll's daisy, false aster |
| *Borreria laevis* | Borreria |
| *Borrichia frutescens* | Sea oxeye, sea daisies, bushy seaside tansy |
| *Botrychium biternatum* | Southern grapefern |
| *Bowlesia incana* | Hoary bowlesia |
| *Brasenia schreberi* | Watershield |
| *Brassica oleracea var. capitata* D | |
| *Briza minor* | Little quaking grass |
| *Bromus unioloides* | Rescuegrass, bromegrass |
| *Brunnichia ovata* | Buckwheat vine |
| *Buchnera floridana* | Bluehart |
| *Bulbostylis barbata* | Watergrass |
| *Bulbostylis capillaris* | Densetuft hairsedge |
| *Bulbostylis capillaris ssp. capillaris* | Densetuft hairsedge |
| *Bulbostylis ciliatifolia* | |
| *Bulbostylis ciliatifolia var. coarctata* | |
| *Bulbostylis stenophylla* | Sandy field hairsedge |
| *Bumelia lanuginosa* | Black-haw, gum bumelia |
| *Bumelia lycioides* | Buckthorn, gopherwood buckthorn |
| *Burmannia capitata* | |
| *Cakile constricta* | Sea rocket |
| *Cakile edentula* | Sea rocket, northern sea rocket |
| *Calamintha dentata* **(ST)** | Florida calamint, toothed savory |
| *Calibrachoa parviflora* | Seaside petunia |
| *Callicarpa americana* | American beautyberry |
| *Callirhoe papaver* **(SE)** | Poppy mallow , woodland poppy mallow |
| *Callisia graminea* | Grassleaf roseling |
| *Callisia repens* | Creeping inchplant |
| *Callitriche heterophylla* | Twoheaded water-starwort |
| *Callitriche heterophylla ssp. heterophylla* | Twoheaded water-starwort |
| *Calopogon barbatus* | Bearded grass-pink |
| *Calopogon multiflorus* **(SE)** | Many-flowered grass pink |
| *Calopogon pallidus* | Pale grass-pink |
| *Calopogon tuberosus* | Grass-pink |
| *Calycanthus floridus* **(SE)** | Sweet-shrub, Carolina-allspice, bubby-shrub |
| *Calycocarpum lyonii* | Cup-seed |
| *Calyptocarpus vialis* | Straggler daisy |
| *Calystegia sepium* | Hedge bindweed |
| *Campanula floridana* | Florida bellflower |
| *Campsis radicans* | Trumpet-vine, scarlet creeper |
| *Canavalia maritima* | |

| Scientific Name | Common Name |
|---|---|
| *Canna flaccida* | Yellow canna, bandanna of the Everglades |
| *Cannabis sativa* | Marijuana |
| *Cardamine hirsuta* | Butter cress |
| *Cardamine laciniata* | Pepper root |
| *Cardamine pensylvanica* | |
| *Cardamine pensylvanica var. brittoniana* | |
| *Carex abscondita* | |
| *Carex albolutescens* | |
| *Carex baltzellii* **(ST)** | Baltzell's sedge |
| *Carex caroliniana* | Carolina sedge |
| *Carex cephalophora* | |
| *Carex cherokeensis* | Cherokee sedge |
| *Carex corrugata* | Prune-fruit sedge |
| *Carex crebriflora* | |
| *Carex crus-corvi* | |
| *Carex debilis* | |
| *Carex fissa* | Hammock sedge |
| *Carex fissa var. aristata* | Hammock sedge |
| *Carex folliculata* | |
| *Carex frankii* | |
| *Carex glaucescens* | |
| *Carex gracilescens* | |
| *Carex howei* | |
| *Carex hyalinolepis* | |
| *Carex intumescens* | |
| *Carex joorii* | |
| *Carex laevivaginata* | Smoothsheath sedge |
| *Carex louisianica* | |
| *Carex lupulina* | |
| *Carex lurida* | |
| *Carex physorhyncha* | |
| *Carex reniformis* | |
| *Carex stipata* | |
| *Carex styloflexa* | |
| *Carex tribuloides* | |
| *Carex turgescens* | |
| *Carex verrucosa* | |
| *Carex vexans* | Florida hammock sedge |
| *Carphephorus odoratissimus* | Deer's tongue, vanilla plant |
| *Carphephorus paniculatus* | |
| *Carphephorus pseudoliatris* | |
| *Carpinus caroliniana* | Ironwood, American horn beam, Blue-beech |
| *Carpobrotus edulis* | Hottentot fig |
| *Carya aquatica* | Water hickory |
| *Carya cordiformis* | Bitternut hickory |

| Scientific Name | Common Name |
|---|---|
| *Carya glabra* | Pignut hickory |
| *Carya illinoensis* | Pecan |
| *Carya ovata* | Shagbark hickory |
| *Carya tomentosa* | Mockernut hickory |
| *Cassia fasciculata* | Partridge-pea |
| *Cassia marilandica* | Wild senna |
| *Cassia nictitans* | Wild sensitive plant |
| *Cassia obtusifolia* | Coffee weed |
| *Catalpa bignonioides* | Catalpa |
| *Catapodium rigidum* | Ferngrass |
| *Catharanthus roseus* | Madagascar periwinkle |
| *Celtis laevigata* | Sugarberry, hackberry |
| *Cenchrus echinatus* | Southern sandspur |
| *Cenchrus incertus* | Coast sandspur |
| *Cenchrus tribuloides* | Dune sandspur |
| *Centella asiatica* | |
| *Centrosema virginianum* | Butterfly-pea |
| *Cephalanthus occidentalis* | Buttonbush |
| *Cerastium glomeratum* | Mouse-ear chickweed |
| *Ceratiola ericoides* | Rosemary, Florida rosemary |
| *Ceratophyllum demersum* | Hornwort, coon's tail |
| *Ceratophyllum muricatum* | Prickly hornwort |
| *Ceratophyllum muricatum ssp. australe* | Prickly hornwort |
| *Cercis canadensis* | Redbud |
| *Chaerophyllum procumbens* | Spreading chervil |
| *Chaerophyllum procumbens var. procumbens* | Spreading chervil |
| *Chaerophyllum tainturieri* | Wild chervil |
| *Chamaecyparis thyoides* | Atlantic white-cedar |
| *Chamaesyce ammannioides* | Sand-dune spurge |
| *Chamaesyce hirta* | Hairy spurge |
| *Chamaesyce humistrata* | |
| *Chamaesyce hyssopifolia* | Eyebane |
| *Chamaesyce maculata* | Milk purslane |
| *Chamaesyce nutans* | Eyebane |
| *Chamaesyce ophthalmica* | Florida hammock sandmat |
| *Chamaesyce polypgonifolia* | Seaside spurge |
| *Chamaesyce prostrata* | Prostrate sandmat |
| *Chamaesyce serpens* | Matted sandmat |
| *Chasmanthium latifolium* | Spikegrass |
| *Chasmanthium laxum* | Spikegrass |
| *Chasmanthium nitidum* | Spikegrass |
| *Chasmanthium ornithorhynchum* | Spikegrass |
| *Chasmanthium sessiliflorum* | Spikegrass |
| *Chenopodium album* | Lamb's quarters |
| *Chenopodium ambrosioides* | Mexican tea |
| *Chenopodium ambrosioides var. ambrosioides* | Mexican tea |
| *Chenopodium berlandieri* | Pitseed goosefoot |
| *Chenopodium berlandieri var. boscianum* | Pitseed goosefoot |
| *Chloris glauca* | Fingergrass |
| *Chloris petraea* | Fingergrass |
| *Chrysoma pauciflosculosa* | Bush goldenrod |
| *Chrysopsis gossypina ssp. gossypina f. decumbens* | |
| *Chrysopsis gossypina ssp. hyssopifolia* | |
| *Cicuta maculata* | Spotted water hemlock |
| *Cicuta maculata var. maculata* | Spotted water hemlock |
| *Cicuta mexicana* | Water hemlock |
| *Cinnamomum camphora* | Camphor tree |
| *Cirsium horridulum* | Yellow thistle |
| *Cirsium nuttallii* | |
| *Cissus incisa* | Marine-ivy |
| *Citrullus lanatus* | Watermelon |
| *Citrus medica* | Citron |
| *Cladium jamaicense* | Sawgrass |
| *Cladium mariscoides* | Smooth sawgrass |
| *Cladium mariscus* | Swamp sawgrass |
| *Cladium mariscus ssp. jamaicense* | Jamaica swamp sawgrass |
| *Cladonia evansii* | |
| *Cladonia leporina* | |
| *Cleistes divaricata* **(ST)** | Rosebud orchid, spreading pogonia, lady's ettercap, rose orchid |
| *Clematis crispa* | Leather-flower |
| *Clematis glaucophylla* | |
| *Clematis reticulata* | Netleaf leather flower |
| *Clematis viorna* | Leather flower |
| *Cleome gynandra* | Spiderwisp |
| *Clerodendrum indicum* | Turk's turbin |
| *Clethra alnifolia* | Sweet pepperbush |
| *Cliftonia monophylla* | Black titi |
| *Clitoria mariana* | Butterfly-pea |
| *Cnidoscolus stimulosus* | Tread softly |
| *Cocculus carolinus* | Coralbeads |
| *Coelorachis rugosa* | Wrinkled jointtail grass |
| *Colocasia esculenta* | Wild taro |
| *Commelina benghalensis* | Jio |
| *Commelina diffusa* | Common dayflower, climbing dayflower |
| *Commelina erecta* | Dayflower |

| Scientific Name | Common Name |
|---|---|
| *Commelina erecta var. angustifolia* | Dayflower |
| *Commelina virginica* | Dayflower |
| *Conoclinium coelestinum* | Mist flower |
| *Conradina canescens* | Scrub rosemary |
| *Conradina glabra* **(FE,SE)** | Apalachicola rosemary , Apalachicola false rosemary |
| *Conyza bonariensis* | |
| *Conyza canadensis* | Horseweed |
| *Conyza canadensis var. pusilla* | Horseweed |
| *Corchorus aestuans* | Jute |
| *Coreopsis falcata* | |
| *Coreopsis gladiata* | |
| *Coreopsis lanceolata* | |
| *Coreopsis leavenworthii* | Leavenworth's tickseed |
| *Coreopsis linifolia* | |
| *Cornus alterniflora* **(SE)** | Pagoda dogwood , alternate-leaf dogwood, pagoda cornel, umbrella cornel |
| *Cornus amomum* | Silky cornel |
| *Cornus florida* | Flowering dogwood |
| *Cornus foemina* | Stiff cornel |
| *Cornus stricta* | Swamp dogwood |
| *Corydalis flavula* | |
| *Corydalis micrantha var. australis* | Harlequin slender fumeroot |
| *Crataegus marshallii* | Parsley haw |
| *Crataegus spathulata* | |
| *Crataegus viridis* | Green haw |
| *Crinum americanum* | Swamp lily, seven sisters |
| *Crinum zeylanicum* | Ceylon swamplily |
| *Crocosmia crocosmiiflora* | Montbretia |
| *Croomia pauciflora* **(SE)** | Few-flowered croomia , croomia |
| *Crotalaria lanceolata* | Rattle-box |
| *Crotalaria ochroleuca* | Slender leaf rattlebox |
| *Crotalaria pallida* | Smooth rattlebox |
| *Crotalaria pallida var. obovata* | Smooth rattlebox |
| *Crotalaria purshii* | Rattle-box |
| *Crotalaria rotundifolia* | Rabbit-bells |
| *Crotalaria spectabilis* | Rabbit-bells |
| *Croton capitatus* | Wooly croton |
| *Croton elliottii* | |
| *Croton glandulosus var. septentrionalis* | |
| *Croton punctatus* | Silver-leaf croton, beach tea |
| *Cryptotaenia canadensis* **(SE)** | Honewort , wild chervil, Canadian honewort |

| Scientific Name | Common Name |
|---|---|
| *Ctenium aromaticum* | Toothache grass |
| *Cucumis sativus* | Cucumber, garden cucumber |
| *Cuphea aspera* **(SE)** | Florida waxweed, tropical waxweed, Chapman's waxweed |
| *Cuphea carthagenensis* | Waxweed |
| *Cuscuta campestris* | Field dodder |
| *Cuscuta compacta* | Compact dodder |
| *Cuscuta indecora* | Bigseed alfalfa dodder |
| *Cuscuta indecora var. indecora* | Bigseed alfalfa dodder |
| *Cuscuta pentagona* | Dodder, love vine, fiveangled dodder |
| *Cuscuta pentagona var. pentagona* | Fiveangled dodder |
| *Cymodocea filiformis* | Manatee grass |
| *Cynanchum angustifolium* | |
| *Cynanchum scoparium* | |
| *Cynodon dactylon* | Bermuda grass |
| *Cynoglossum virginianum* **(SE)** | Wild comfrey |
| *Cyperus articulatus* | Jointed flatsedge |
| *Cyperus brevifolius* | |
| *Cyperus compressus* | |
| *Cyperus croceus* | |
| *Cyperus distinctus* | Swamp flatsedge |
| *Cyperus esculentus* | Yellow nut grass, Chufas |
| *Cyperus esculentus var. macrostachyus* | Yellow nut grass, Chufas |
| *Cyperus filiculmis* | |
| *Cyperus haspan* | |
| *Cyperus iria* | |
| *Cyperus lanceolatus* | |
| *Cyperus lecontei* | |
| *Cyperus odoratus* | |
| *Cyperus polystachyos* | Manyspike flatsedge |
| *Cyperus polystachyos var. texensis* | Texan flatsedge |
| *Cyperus pseudovegetus* | |
| *Cyperus pumilus* | Low flatsedge |
| *Cyperus retrorsus* | |
| *Cyperus robustus* | |
| *Cyperus rotundus* | Nut grass, sand coco-grass |
| *Cyperus sesquiflorus* | |
| *Cyperus strigosus* | Strawcolored flatsedge |
| *Cyperus strigosus* | |
| *Cyperus surinamensis* | |
| *Cyperus tetragonus* | |
| *Cyperus virens* | |
| *Cyrilla racemiflora* | Titi, Leatherwood |

| Scientific Name | Common Name |
|---|---|
| *Cyrilla racemiflora var. parvifolia* | Titi, Leatherwood |
| *Dactylis glomerata* | Orchard grass |
| *Dactylis glomerata ssp. glomerata* | Orchard grass |
| *Dactyloctenium aegyptium* | Crowfoot grass |
| *Dalea feayi* | Feay's prairie clover |
| *Datura stramonium* | Jimsonweed |
| *Datura wrightii* | Sacred thorn-apple |
| *Daucus carota* | Queen Anne's lace |
| *Daucus pusillus* | Wild carrot |
| *Decumaria barbara* | Climbing hydrangea, wood vamp |
| *Delphinium carolinianum* **(SE)** | Larkspur, Carolina larkspur |
| *Descurainia pinnata* | Tansy mustard |
| *Desmodium ciliare* | Beggar's lice |
| *Desmodium incanum* | Beggar's lice, zarzabacoa comun |
| *Desmodium incanum var. incanum* | Zarzabacoa comun |
| *Desmodium lineatum* | Beggar's lice |
| *Desmodium obtusum* | Stiff ticktrefoil |
| *Desmodium paniculatum* | Beggar's lice |
| *Desmodium strictum* | Beggar's lice |
| *Desmodium viridiflorum* | Beggar's lice |
| *Deutzia scabra* | Fuzzy pride-of-Rochester |
| *Dichanthelium aciculare* | |
| *Dichanthelium acuminatum* | |
| *Dichanthelium commutatum* | |
| *Dichanthelium dichotomum* | |
| *Dichanthelium erectifolium* | |
| *Dichanthelium oligosanthes* | |
| *Dichanthelium ovale* | |
| *Dichanthelium sabulorum* | |
| *Dichanthelium sphaerocarpon* | |
| *Dichanthelium strigosum var. leucoblepharis* | Roughhair rosette grass |
| *Dichanthelium tenue* | |
| *Dichondra carolinensis* | Pony-foot |
| *Dichromena colorata* | Starrush |
| *Dichromena latifolia* | White-tops |
| *Dicliptera brachiata* | |
| *Dicliptera halei* | |
| *Dicranopteris flexuosa* | Drooping forkedfern |
| *Digitaria ciliaris* | Southern crabgrass |
| *Digitaria decumbens* | Pangola grass |
| *Digitaria eriantha* | Digitgrass |

| Scientific Name | Common Name |
|---|---|
| *Digitaria filiformis* | Slender crabgrass |
| *Digitaria serotina* | Blanket crabgrass, dwarf crabgrass |
| *Dioclea multiflora* | |
| *Diodia teres* | Poor joe, buttonweed |
| *Diodia virginiana* | Buttonweed |
| *Dioscorea bulbifera* | Air yam |
| *Dioscorea villosa* | Wild yam |
| *Diospyros virginiana* | Persimmon |
| *Dirca palustris* | Leatherwood |
| *Distichlis spicata* | Saltgrass |
| *Drosera brevifolia* | Dwarf sundew |
| *Drosera capillaris* | Pink sundew |
| *Drosera intermedia* **(ST)** | Spoon-leaved sundew, water sundew, narrowleaf sundew |
| *Drosera tracyi* | Dew-threads |
| *Duchesnea indica* | Mock strawberry |
| *Dulichium arundinaceum* | Sheathed galingale |
| *Dyschoriste humistrata* | Swamp snakeherb |
| *Echinacea purpurea* **(SE)** | Purple coneflower |
| *Echinochloa colona* | Jungle-rice |
| *Echinochloa crusgalli* | Barnyard grass |
| *Echinochloa crus-pavonis* | Gulf cockspur grass |
| *Echinochloa crus-pavonis var. crus-pavonis* | Gulf cockspur grass |
| *Echinochloa muricata* | Rough barnyard grass |
| *Echinochloa walteri* | Coast cockspur grass |
| *Echinodorus cordifolius* | Burhead |
| *Eclipta alba* | |
| *Eichhornia crassipes* | Common water hyacinth |
| *Elaeagnus pungens* | Silverthorn, thorny olive |
| *Eleocharis acicularis* | |
| *Eleocharis albida* | |
| *Eleocharis baldwinii* | Roadgrass |
| *Eleocharis cellulosa* | |
| *Eleocharis elongata* | |
| *Eleocharis equisetoides* | Knotted spikerush |
| *Eleocharis flavescens* | Pale spikerush, yellow spikerush |
| *Eleocharis flavescens var. flavescens* | Yellow spikerush |
| *Eleocharis geniculata* | |
| *Eleocharis interstincta* | Knotted spikerush |
| *Eleocharis melanocarpa* | Black spikerush |
| *Eleocharis minima* | |
| *Eleocharis montevidensis* | |
| *Eleocharis nana* | Hairlike spikerush |
| *Eleocharis nigrescens* | Black spikerush |
| *Eleocharis obtusa* | |

| Scientific Name | Common Name |
|---|---|
| *Eleocharis olivacea* | Bright green spikerush |
| *Eleocharis olivacea var. olivacea* | Bright green spikerush |
| *Eleocharis parvula* | |
| *Eleocharis quadrangulata* | Squarestem spikerush |
| *Eleocharis tortilis* | |
| *Eleocharis tuberculosa* | |
| *Eleocharis vivipara* | Viviparous spikerush |
| *Elephantopus carolinianus* | Elephant's-foot |
| *Elephantopus elatus* | Florida elephant's-foot |
| *Elephantopus nudatus* | Purple elephant's-foot |
| *Eleusine indica* | Goosegrass |
| *Elionurus tripsacoides* | Pan American balsamscale |
| *Elymus virginicus* | Virginia wild rye |
| *Elyonurus tripsacoides* | Pan-american balsamscale |
| *Epidendrum conopseum* | Green-fly orchid |
| *Epigaea repens* **(SE)** | Trailing arbutus |
| *Eragrostis atrovirens* | Thalia lovegrass |
| *Eragrostis bahiensis* | Bahia lovegrass |
| *Eragrostis elliottii* | Elliott lovegrass |
| *Eragrostis glomerata* | Pond lovegrass |
| *Eragrostis hirsuta* | Bigtop lovegrass |
| *Eragrostis hypnoides* | Teal lovegrass |
| *Eragrostis lugens* | Mourning lovegrass |
| *Eragrostis mexicana* | Mexican lovegrass |
| *Eragrostis mexicana ssp. virescens* | Mexican lovegrass |
| *Eragrostis pectinacea* | Tufted lovegrass, Carolina lovegrass |
| *Eragrostis pectinacea var. miserrima* | Desert lovegrass |
| *Eragrostis pilosa* | Indian lovegrass |
| *Eragrostis refracta* | Coastal lovegrass |
| *Eragrostis secundiflora ssp. oxylepis* | Red lovegrass |
| *Eragrostis spectabilis* | Purple lovegrass, tumble-grass |
| *Eragrostis tephrosanthos* | |
| *Erechtites hieracifolia* | Fireweed |
| *Eremochloa ophiuroides* | Centipede grass |
| *Erianthus brevibarbis* | Plumegrass |
| *Erianthus giganteus* | Sugarcane plumegrass |
| *Erianthus strictus* | Narrow plumegrass |
| *Erigeron annuus* | Eastern daisy fleabane |
| *Erigeron quercifolius* | Southern fleabane |
| *Erigeron strigosus* | White-tops |
| *Erigeron vernus* | |
| *Eriocaulon compressum* | Hat pins |
| *Eriocaulon decangulare* | Common pipewort |
| *Eriochloa michauxii* | Longleaf cupgrass |

| Scientific Name | Common Name |
|---|---|
| *Eryngium aromaticum* | Fragrant eryngo |
| *Eryngium baldwinii* | |
| *Eryngium prostratum* | |
| *Erythrina herbacea* | Coral bean, Cherokee bean |
| *Erythronium umbilicatum* **(SE)** | Dogtooth-violet, dimpled dogtooth-violet, trout lily, amberbell, dimpled troutlilly |
| *Euonymus americanus* | Strawberry bush |
| *Euonymus atropurpureus* **(SE)** | Burningbush, wahoo, spindle tree, strawberry bush, arrow wood, eastern wahoo |
| *Eupatorium capillifolium* | Dog fennel |
| *Eupatorium compositifolium* | Dog fennel |
| *Eupatorium cuneifolium* | |
| *Eupatorium leptophyllum* | Dog fennel |
| *Eupatorium mikanioides* | Semaphore eupatorium |
| *Eupatorium mohrii* | |
| *Eupatorium perfoliatum* | Boneset |
| *Eupatorium rotundifolium* | False hoarhound |
| *Eupatorium rugosum* | |
| *Eupatorium semiserratum* | |
| *Eupatorium serotinum* | |
| *Euphorbia cyathophora* | |
| *Euphorbia discoidalis* | |
| *Euphorbia exserta* | |
| *Euphorbia maculata* | |
| *Euphorbia telephioides* **(FT,SE)** | Telephus spurge |
| *Euthamia graminifolia var. hirtipes* | |
| *Euthamia leptocephala* | |
| *Euthamia minor* | |
| *Euthamia tenuifolia* | |
| *Fagopyrum esculentum* | Buckwheat |
| *Fagus grandifolia* | American beech |
| *Fatoua villosa* | Hairy crabweed |
| *Festuca arundinacea* | |
| *Fimbristylis autumnalis* | |
| *Fimbristylis caroliniana* | |
| *Fimbristylis castanea* | |
| *Fimbristylis miliacea* | |
| *Fimbristylis puberula* | |
| *Fimbristylis schoenoides* | |
| *Fimbristylis spadicea* | |
| *Fimbristylis tomentosa* | |
| *Fimbristylis vahlii* | |
| *Fleischmannia incarnata* | |
| *Forestiera acuminata* | Swamp privet |

| Scientific Name | Common Name |
|---|---|
| *Fraxinus americana* | White ash |
| *Fraxinus caroliniana* | Carolina ash, pop ash |
| *Fraxinus pennsylvanica* | Green ash |
| *Fraxinus profunda* | Pumpkin ash |
| *Freesia corymbosa* | Common freesia |
| *Froelichia floridana* | Cottonweed |
| *Fuirena breviseta* | Umbrellagrass |
| *Fuirena longa* | Umbrellagrass |
| *Fuirena scirpoidea* | Umbrellagrass |
| *Fuirena squarrosa* | Umbrellagrass |
| *Fumaria capreolata* | Ramping fumitory, white ramping fumitory |
| *Gaillardia pulchella* | Firewheel |
| *Gaillardia pulchella var. pulchella* | |
| *Galactia floridana* | Milk-pea |
| *Galactia macreei* | Milk-pea |
| *Galactia mollis* | Soft milkpea |
| *Galactia volubilis* | Milk pea |
| *Galium aparine* | Bedstraw, goosegrass |
| *Galium hispidulum* | Bedstraw, coastal bedstraw |
| *Galium pilosum var. laevicaule* | Bedstraw |
| *Galium tinctorium* | Bedstraw |
| *Gaura angustifolia* | Southern gaura |
| *Gaylussacia dumosa* | Dwarf huckleberry |
| *Gaylussacia frondosa* | Dangleberry |
| *Gaylussacia mosieri* | |
| *Gelsemium rankinii* | Yellow jessamine |
| *Gelsemium sempervirens* | |
| *Gentiana pennelliana* **(SE)** | Wiregrass gentian |
| *Gentiana saponaria* | Soapwort gentian |
| *Geranium carolinianum* | Cranesbill |
| *Gladiolus gandavensis* | |
| *Gleditsia aquatica* | Water locust |
| *Gleditsia tricanthos* | Honey locust |
| *Gnaphalium falcatum* | Cudweed |
| *Gnaphalium obtusifolium* | Sweet everlasting |
| *Gnaphalium pensilvanicum* | Rabbit tobacco |
| *Gnaphalium purpureum* | Purple cudweed |
| *Gnaphalium spicatum* | Rabbit tobacco |
| *Gomphrena serrata* | Arrasa con todo |
| *Goodyera pubescens* **(SE)** | Downy rattlesnake plantain, downy rattlesnake orchid |
| *Gratiola brevifolia* | Sticky hedgehyssop |
| *Gratiola floridana* | |
| *Gratiola hispida* | |
| *Gratiola pilosa* | |

| Scientific Name | Common Name |
|---|---|
| *Gratiola virginiana* | |
| *Gymnostyles anthemifolia* | Button burrweed |
| *Habenaria repens* | Water spider orchid |
| *Halesia carolina* | Silverbells |
| *Halesia diptera* | Silverbells |
| *Halodule wrightii* | Shoal grass |
| *Halophila engelmannii* | Engelmann's seagrass |
| *Hamamelis virginiana* | Witch hazel |
| *Haplopappus divaricatus* | Scratch daisy |
| *Harperocallis flava* **(FE,SE)** | Harper's beauty |
| *Hedychium coronarium* | White garland-lily |
| *Hedyotis boscii* | |
| *Hedyotis corymbosa* | |
| *Hedyotis procumbens* | Innocence |
| *Hedyotis uniflora* | |
| *Helenium amarum* | Bitterweed |
| *Helenium autumnale* | Sneezeweed |
| *Helianthemum arenicola* | Rockrose |
| *Helianthemum carolinianum* | Rockrose |
| *Helianthemum corymbosum* | Pine barren frostweed, rockrose |
| *Helianthemum georgianum* | Georgia frostweed |
| *Helianthus angustifolius* | Sunflower |
| *Helianthus annuus* | Common sunflower |
| *Helianthus argophyllus* | Silverleaf sunflower |
| *Helianthus debilis ssp. tardiflorus* | Cucumberleaf sunflower |
| *Helianthus heterophyllus* | Sunflower |
| *Helianthus strumosus* | Sunflower |
| *Heliopsis helianthoides* | Oxeye |
| *Heliotropium amplexicaule* | Clasping heliotrope |
| *Heliotropium curassavicum* | Salt heliotrope, seaside heliotrope |
| *Heliotropium curassavicum var. curassavicum* | Salt heliotrope |
| *Heliotropium indicum* | Turnsole |
| *Hemerocallis fulva* | Orange daylily |
| *Hemicarpha micrantha* | |
| *Hepatica nobilis* **(SE)** | Liverleaf, roundolobed liverleaf |
| *Heteranthera dubia* | Mud plantain, grassleaf mudplantain |
| *Heteranthera reniformis* | |
| *Heterotheca subaxillaris* | |
| *Hexastylis arifolia* **(ST)** | Wild ginger, Heartleaf, heartleaf wild ginger, little-brown-jug |
| *Hibiscus aculeatus* | |
| *Hibiscus coccineus* | Scarlet rosemallow |
| *Hibiscus grandiflorus* | Swamp hibiscus |
| *Hibiscus militaris* | Halberd-leaved marshmallow |

| Scientific Name | Common Name |
|---|---|
| *Hibiscus moscheutos* | Rose mallow |
| *Hibiscus moscheutos ssp. Incanus* | Rose mallow |
| *Hibiscus trionum* | Flower of an hour |
| *Hordeum pusillum* | Little barley |
| *Hybanthus concolor* **(SE)** | Green violet |
| *Hydrangea arborescens* **(SE)** | Smooth hydrangea, wild hydrangea, mountain hydrangea, seven-bark, American hydrangea |
| *Hydrangea arborescens ssp. discolor* | Smooth hydrangea |
| *Hydrilla verticillata* | Hydrilla, waterthyme |
| *Hydrochloa caroliniensis* | Watergrass |
| *Hydrocotyle bonariensis* | |
| *Hydrocotyle prolifera* | Whorled marsh pennywort |
| *Hydrocotyle ranunculoides* | |
| *Hydrocotyle umbellata* | Whorled pennywort, marsh pennywort, manyflower |
| *Hydrocotyle verticillata* | Swamp pennywort |
| *Hydrocotyle verticillata var. triradiata* | Swamp pennywort |
| *Hydrolea quadrivalvis* | |
| *Hygrophila lacustris* | |
| *Hymenocallis carolinensis* | Spider-lily |
| *Hymenocallis floridana* | |
| *Hymenocallis franklinensis* | Franklin spiderlily |
| *Hymenocallis henryae* **(SE)** | Panhandle spiderlily, Mrs. Henry's spiderlily, green pine lily, green spiderlily |
| *Hypericum brachyphyllum* | |
| *Hypericum cistifolium* | St. John's-wort, cluster-leaf St. John's-wort |
| *Hypericum fasciculatum* | Sandweed |
| *Hypericum frondosum* | St. John's-wort |
| *Hypericum galioides* | St. John's-wort, bedstraw St. John's-wort |
| *Hypericum gentianoides* | Pineweed |
| *Hypericum hypericoides* | St. Andrew's cross |
| *Hypericum lissophloeus* **(SE)** | Smooth-barked St. John's-wort, water-cedar |
| *Hypericum microsepalum* | St. John's-wort |
| *Hypericum mutilum* | Dwarf St. John's-wort |
| *Hypericum nitidum* | St. John's-wort |
| *Hypericum reductum* | Atlantic St. Johnswort, St. John's-wort |
| *Hypericum tetrapetalum* | St. John's-wort |
| *Hypochoeris brasiliensis* | Cat's-ears |
| *Hypoxis juncea* | Common stargrass |
| *Hypoxis leptocarpa* | Swamp stargrass |

| Scientific Name | Common Name |
|---|---|
| *Hypoxis rigida* | |
| *Hyptis alata* | Musky mint, Cluster bushmint |
| *Hyptis mutabilis* | |
| *Ilex ambigua* | Carolina holly, sand holly |
| *Ilex cassine* | Dahoon, dahoon holly |
| *Ilex coriacea* | Large gallberry, sweet gallberry |
| *Ilex decidua* | Possum haw |
| *Ilex glabra* | Gallberry |
| *Ilex myrtifolia* | Myrtle-leaf holly |
| *Ilex opaca* | American holly |
| *Ilex vomitoria* | Yaupon |
| *Illicium floridanum* | Purple anise, Florida anise-tree |
| *Impatiens capensis* | Jewel weed |
| *Imperata cylindrica* | Cogongrass |
| *Indigofera hirsuta* | Roughhairy indigo |
| *Ipomoea cairica* | Mile-a-minute vine |
| *Ipomoea hederacea* | Ivyleaf morning-glory |
| *Ipomoea hederifolia* | Red morning-glory |
| *Ipomoea imperati* | Beach morning-glory |
| *Ipomoea indica* | Oceanblue morning-glory |
| *Ipomoea lacunosa* | White morning-glory |
| *Ipomoea pandurata* | Manroot, wild potato vine |
| *Ipomoea pes-caprae* | Railroad vine |
| *Ipomoea quamoclit* | Cypress vine |
| *Ipomoea sagittata* | Saltmarsh morning-glory |
| *Ipomoea trichocarpa* | |
| *Iris hexagona* | Dixie iris, prairie iris |
| *Iris tridentata* | |
| *Iris virginica* | Blue-flag |
| *Isoetes appalachiana* | Appalachian quillwort |
| *Isoetes flaccida* | Florida quillwort, southern quillwort |
| *Isopyrum biternatum* **(SE)** | False rue-anemone |
| *Itea virginica* | Virginia willow |
| *Iva annua* | |
| *Iva frutescens* | Jesuit's bark, marsh elder |
| *Iva frutescens ssp. frutescens* | Jesuit's bark |
| *Iva imbricata* | Seacoast marsh elder |
| *Iva microcephala* | |
| *Jacquemontia tamnifolia* | |
| *Juglans nigra* | Black walnut |
| *Juncus acuminatus* | Rush, tapertip rush |
| *Juncus bufonius* | Toad rush |
| *Juncus coriaceus* | Rush |
| *Juncus dichotomus* | Rush |
| *Juncus diffusissimus* | Rush |
| *Juncus effusus* | Soft rush |

| Scientific Name | Common Name |
|---|---|
| *Juncus elliottii* | Bog rush |
| *Juncus marginatus* | Shore rush |
| *Juncus megacephalus* | Rush |
| *Juncus polycephalus* | Rush |
| *Juncus repens* | |
| *Juncus roemerianus* | Needlerush, Black rush |
| *Juncus scirpoides* | Rush |
| *Juncus scirpoides* | Rush |
| *Juncus tenuis* | Path rush |
| *Juncus trigonocarpus* | Rush |
| *Juncus validus* | Rush |
| *Juniperus communis var. depressa* | Ground juniper |
| *Juniperus silicicola* | Southern red cedar |
| *Juniperus virginiana* | Red cedar |
| *Justicia americana* | Water-willow |
| *Justicia angusta* | Pineland water-willow |
| *Justicia crassifolia* **(SE)** | Thick-leaved water willow |
| *Justicia ovata* | |
| *Justicia ovata var. lanceolata* | |
| *Kallstroemia* | Caltrop |
| *Kallstroemia pubescens* | Caribbean caltrop |
| *Kalmia hirsuta* | Wicky |
| *Kalmia latifolia* **(ST)** | Mountain laurel, ivy, calico bush, spoon wood |
| *Kosteletzkya virginica* | Seashore mallow |
| *Krigia cespitosa* | |
| *Krigia virginica* | Dwarf dandelion |
| *Kummerowia striata* | Common lespedeza |
| *Lachnanthes caroliniana* | Redroot |
| *Lactuca canadensis* | Wood-lettuce, wild lettuce |
| *Lactuca graminifolia* | Blue lettuce |
| *Lagascea mollis* | Silkleaf |
| *Lagerstroemia* | Lagerstroemia |
| *Lagerstroemia indica* | Crape myrtle |
| *Lamium amplexicaule* | Henbit, henbit deadnettle |
| *Lantana camara* | Shrub verbena, lantana |
| *Lantana montevidensis* | Trailing shrubverbena |
| *Laportea canadensis* | Wood-nettle |
| *Lechea deckertii* | Deckert's pinweed |
| *Lechea minor* | Pinweed |
| *Lechea mucronata* | Pinweed |
| *Lechea pulchella* | Pinweed |
| *Lechea sessiliflora* | Pinweed |
| *Lechea torreyi* | Pinweed |
| *Leersia hexandra* | Southern cutgrass, C clubhead cutgrass |
| *Leersia lenticularis* | Catchflygrass |

| Scientific Name | Common Name |
|---|---|
| *Leersia oryzoides* | Rice cutgrass |
| *Leersia virginica* | Whitegrass |
| *Leitneria floridana* **(ST)** | Florida corkwood, corkwood |
| *Lemna obscura* | Little duckweed |
| *Lemna valdiviana* | Duckweed, little duckweed |
| *Leonotis nepetifolia* | Lion's ear |
| *Lepidium virginicum* | Peppergrass |
| *Leptochloa fascicularis* | Bearded spangletop, saltgrass |
| *Lespedeza angustifolia* | |
| *Lespedeza capitata* | Dusty clover |
| *Lespedeza cuneata* | Sericea lespedeza |
| *Lespedeza hirta* | Bush clover |
| *Lespedeza hirta ssp. curtissii* | Bush clover |
| *Leucothoe racemosa* | Fetterbush |
| *Liatris chapmanii* | Blazing star |
| *Liatris gracilis* | Blazing star |
| *Liatris provincialis* **(SE)** | Godfrey's blazing star , Godfrey's gayfeather |
| *Liatris spicata* | Blazing star |
| *Liatris tenuifolia* | Blazing star |
| *Liatris tenuifolia var. quadriflora* | Shortleaf blazing star |
| *Licania michauxii* | Gopher apple |
| *Ligustrum japonicum* | Japanese privet |
| *Ligustrum lucidum* | Wax-leaf privet |
| *Lilaeopsis carolinensis* | |
| *Lilaeopsis chinensis* | |
| *Lilium catesbaei* **(ST)** | Pine lily, Catesby lily, leopard lily, southern red lily |
| *Lilium michauxii* **(SE)** | Carolina lily, turk's cap lily |
| *Limnobium spongia* | Frog's-bit |
| *Limnodea arkansana* | Ozark grass |
| *Limnophila sessiliflora* | |
| *Limonium carolinianum* | Sea lavender |
| *Linaria canadensis* | Blue toad-flax |
| *Linaria floridana* | |
| *Lindera benzoin* | Spicebush |
| *Lindernia anagallidea* | False pimpernel |
| *Lindernia dubia* | False pimpernel |
| *Lindernia grandiflora* | Savannah false pimpernel |
| *Linum macrocarpum* | Spring Hill flax, big seed flax |
| *Linum medium* | Yellow flax |
| *Linum medium var. texanum* | Yellow flax |
| *Linum sulcatum var. harperi* | Harper's grooved yellow flax |
| *Linum westii* **(SE)** | Orange-flowered flax, West's flax |
| *Lipocarpha micrantha* | Smallflower halfchaff sedge |
| *Liquidambar styraciflua* | Sweetgum |

| Scientific Name | Common Name |
|---|---|
| *Liriodendron tulipifera* | Yellow poplar |
| *Liriope muscari* | Lily-turf |
| *Liriope spicata* | Creeping liriope |
| *Lithospermum tuberosum* | Pucoons |
| *Lobelia amoena* | Lobelia |
| *Lobelia brevifolia* | Lobelia |
| *Lobelia cardinalis* **(ST)** | Cardinal flower |
| *Lobelia glandulosa* | Lobelia |
| *Lobelia paludosa* | Lobelia |
| *Lolium perenne* | English ryegrass |
| *Lonicera japonica* | Japanese honeysuckle |
| *Lonicera sempervirens* | Coral honeysuckle, Trumpet |
| *Lopadium leucoxanthum* | Wedding ring lichen |
| *Lophiola americana* | Goldcrest |
| *Ludwigia alata* | |
| *Ludwigia alternifolia* | Seedbox |
| *Ludwigia arcuata* | Piedmont primrose-willow |
| *Ludwigia curtissii* | Curtiss' primrose-willow |
| *Ludwigia decurrens* | Primrose willow |
| *Ludwigia erecta* | |
| *Ludwigia glandulosa* | Cylindric-fruited ludwigia |
| *Ludwigia lanceolata* | Lanceleaf primrose-willow |
| *Ludwigia leptocarpa* | |
| *Ludwigia linearis* | |
| *Ludwigia linifolia* | |
| *Ludwigia maritima* | |
| *Ludwigia microcarpa* | |
| *Ludwigia octovalvis* | |
| *Ludwigia palustris* | Marsh purslane |
| *Ludwigia peruviana* | Primrose willow, Peruvian primrose-willow |
| *Ludwigia pilosa* | |
| *Ludwigia repens* | Water primrose |
| *Ludwigia sphaerocarpa* | Globefruit primrose-willow |
| *Ludwigia suffruticosa* | Shrubby primrose-willow |
| *Ludwigia virgata* | |
| *Lupinus diffusus* | Sky-blue lupine |
| *Lupinus westianus* **(ST)** | Sanddune lupine, Gulfcoast lupine |
| *Luzula acuminata* | Knot-leaved rush |
| *Luzula echinata* | Woodrush |
| *Lycium carolinianum* | Christmas-berry |
| *Lycopersicon esculentum* | Tomato |
| *Lycopodium appressum* | Southern clubmoss |
| *Lycopus angustifolius* | Bugleweed |
| *Lycopus rubellus* | Water hoarhound |
| *Lycopus virginicus* | Water hoarhound |

| Scientific Name | Common Name |
|---|---|
| *Lycoris radiata* | Red spider lily |
| *Lygodium japonicum* | Climbing fern |
| *Lyonia ferruginea* | Staggerbush, rusty lyonia |
| *Lyonia fruticosa* | Staggerbush |
| *Lyonia ligustrina* | Maleberry |
| *Lyonia lucida* | Fetterbush, shiny Lyonia |
| *Lyonia mariana* | Staggerbush, large flowered staggerbush |
| *Lysimachia ciliata* | Fringed loosestrife |
| *Lythrum curtissii* **(SE)** | Loosestrife, Curtiss' loosestrife, Curtiss' lythrum |
| *Lythrum lineare* | Loosestrife |
| *Macbridea alba* **(FT,SE)** | White birds-in-a-nest |
| *Macranthera flammea* **(SE)** | Hummingbird flower, flameflower |
| *Magnolia ashei* **(SE)** | Ashe's magnolia |
| *Magnolia grandiflora* | Southern magnolia |
| *Magnolia pyramidata* **(SE)** | Pyramid magnolia, cucumber tree, wood-oread |
| *Magnolia virginiana* | Sweetbay |
| *Malaxis unifolia* **(SE)** | Green adder's-mouth, green addersmouth orchid |
| *Malus angustifolia* **(ST)** | Crab apple,flowering crabapple, southern crabapple |
| *Malva parviflora* | Cheeseweed mallow |
| *Malvastrum* | False mallow |
| *Malvastrum americanum* | Indian Valley false mallow |
| *Malvastrum coromandelianum* | Threelobe false mallow |
| *Malvaviscus arboreus* | Wax mallow |
| *Malvaviscus arboreus var. drummondii* | Wax mallow |
| *Malvaviscus penduliflorus* | Mazapan |
| *Manihot grahamii* | Graham's manihot |
| *Manisuris rugosa* | Wrinkled jointtail |
| *Manisuris tesselata* | Lattice jointtail |
| *Manisuris tuberculosa* | Florida jointtail |
| *Marshallia tenuifolia* | Barbara's-button |
| *Marsilea vestita* | Hairy waterclover |
| *Matelea alabamensis* **(SE)** | Alabama spiny-pod, Alabama milkvine |
| *Matelea baldwiniana* **(SE)** | Baldwin's spiny-pod, Baldwin's milkvine |
| *Matelea flavidula* **(SE)** | Yellow-flowered angelpod, yellow-flowered spiny-pod, yellow Carolina milkvine |
| *Matelea floridana* **(SE)** | Florida milkweed, Florida spinypod, Florida milkvine |
| *Matelea gonocarpa* **(ST)** | Angle-pod |

| Scientific Name | Common Name |
|---|---|
| *Mecardonia acuminata* | |
| *Medeola virginiana* **(SE)** | Indian cucumber-root, cushat lily |
| *Medicago lupulina* | Black medic |
| *Medicago polymorpha* | Bur clover |
| *Melanthera nivea* | |
| *Melia azedarach* | Chinaberry |
| *Melica mutica* | Twoflower melic |
| *Melilotus alba* | White sweet-clover |
| *Melilotus indica* | Sour clover |
| *Melilotus indicus* | Annual yellow sweetclover |
| *Melinis repens* | Rose natal grass |
| *Melochia corchorifolia* | Chocolate-weed |
| *Melothria pendula* | Creeping cucumber |
| *Mentha piperita* | Peppermint |
| *Mentha suaveolens* | Apple mint |
| *Merremia dissecta* | Noyau vine |
| *Micranthemum umbrosum* | |
| *Microstegium vimineum* | |
| *Mikania scandens* | Climbing hempweed |
| *Mimulus alatus* | Monkey flower |
| *Mitchella repens* | Twin berry, partridge berry |
| *Mitreola angustifolia* | |
| *Mitreola petiolata* | Miterwort |
| *Mitreola sessilifolia* | Miterwort |
| *Modiola caroliniana* | Carolina bristlemallow |
| *Mollugo verticillata* | Carpetweed, Indian chickweed |
| *Monanthochloe littoralis* | Keygrass, shoregrass |
| *Monarda punctata* | Horsemint, Spotted beebalm |
| *Morus alba* | White mulberry |
| *Morus rubra* | Red mulberry |
| *Muhlenbergia capillaris* | Hairgrass, hairawn muhly, Gulf muhly |
| *Muhlenbergia schreberi* | Nimblewill |
| *Murdannia nudiflora* | |
| *Myrica cerifera* | Wax myrtle, southern bayberry |
| *Myrica heterophylla* | Bayberry |
| *Myriophyllum aquaticum* | Parrot feather watermilfoil |
| *Myriophyllum heterophyllum* | Eurasian water milfoil |
| *Myriophyllum laxum* | Piedmont water milfoil |
| *Myriophyllum spicatum* | Water milfoil |
| *Najas flexilis* | |
| *Najas guadalupensis* | Southern naiad |
| *Nandina domestica* | |
| *Nelumbo lutea* | Duck acorn |
| *Nemophila aphylla* | |
| *Neptunia pubescens* | Tropical puff |
| *Neptunia pubescens var. pubescens* | Tropical puff |

| Scientific Name | Common Name |
|---|---|
| *Nerium oleander* | Oleander |
| *Nolina atopocarpa* **(ST)** | Florida beargrass |
| *Nothoscordum borbonicum* | Fragrant false garlic |
| *Nuphar luteum* | Spatterdock |
| *Nuttallanthus floridanus* | Apalachicola toadflax |
| *Nymphaea mexicana* | Yellow water-lily |
| *Nymphaea odorata* | Fragrant water-lily |
| *Nymphoides aquatica* | Floating hearts |
| *Nyssa aquatica* | Water tupelo |
| *Nyssa biflora* | Blackgum, swamp tupelo |
| *Nyssa ogeche* | Ogeechee-lime, Ogeechee tupelo |
| *Nyssa sylvatica* | Sour gum |
| *Nyssa ursina* | Bog tupelo, bear tupelo |
| *Oenothera biennis* | Weedy evening-primrose |
| *Oenothera fruticosa* | Narrowleaf evening-primrose |
| *Oenothera fruticosa ssp. fruticosa* | Narrowleaf evening-primrose |
| *Oenothera grandiflora* | Largeflower evening-primrose |
| *Oenothera humifusa* | Seaside evening-primrose |
| *Oenothera laciniata* | Cut-leaved evening-primrose |
| *Oenothera speciosa* | Pinkladies |
| *Onoclea sensibilis* | Sensitive fern |
| *Onosmodium virginianum* | False gromwell |
| *Ophioglossum nudicaule* | Least adderstongue |
| *Ophioglossum petiolatum* | Stalked adder's-tongue |
| *Oplismenus setarius* | Wood grass |
| *Opuntia humifusa* | Prickly pear |
| *Opuntia humifusa var. ammophila* | Prickly pear |
| *Opuntia pusilla* | Prickly pear |
| *Opuntia stricta* **(ST)** | Prickly pear, shell mound prickly pear, erect prickly pear, common prickly pear |
| *Opuntia stricta var. dillenii* | Prickly pear |
| *Orontium aquaticum* | Golden club |
| *Oryza sativa* | Rice |
| *Osmanthus americanus* | Wild olive |
| *Osmunda cinnamomea* | Cinnamon fern |
| *Osmunda regalis* | Royal fern |
| *Osmunda regalis var. spectabilis* | Royal fern |
| *Ostrya virginiana* | Hop-hornbeam |
| *Oxalis corniculata* | Lady's woodsorrel |
| *Oxalis debilis* | Pink woodsorrel |
| *Oxalis debilis var. corymbosa* | Pink woodsorrel |
| *Oxalis priceae ssp. colorea* | |
| *Oxalis rubra* | Windowbox woodsorrel |
| *Oxypolis filiformis* | Common water-dropwort |

| Scientific Name | Common Name |
|---|---|
| *Oxypolis greenmanii* **(SE)** | Giant water-dropwort, giant water cowbane |
| *Paederia foetida* | Stinkvine |
| *Panicum amarum* | Beachgrass, bitter panicum, bitter panicgrass |
| *Panicum amarum* var. *amarulum* | Beachgrass, bitter panicum |
| *Panicum anceps* | Beaked panicum |
| *Panicum dichotomiflorum* | Fall panicum |
| *Panicum gymnocarpon* | Savannah panicum |
| *Panicum hemitomon* | Maidencane |
| *Panicum hians* | Gaping panicum |
| *Panicum longifolium* | |
| *Panicum miliaceum* | Broomcorn millet, hog millet |
| *Panicum miliaceum ssp. miliaceum* | Broomcorn millet |
| *Panicum repens* | Torpedo grass |
| *Panicum rigidulum* | Redtop panicum |
| *Panicum tenerum* | Bluejoint panicum |
| *Panicum texanum* | Texas panicum |
| *Panicum verrucosum* | Warty panicum |
| *Panicum virgatum* | Switchgrass |
| *Parietaria praetermissa* | Clustered pellitory |
| *Parnassia caroliniana* **(SE)** | Coastal or Carolina grass-of-parnassus, brook parnassia |
| *Parnassia grandifolia* **(SE)** | Large -leaved grass-of-parnassus, undine |
| *Paronychia baldwinii* | Whitlow-wort |
| *Paronychia erecta* | |
| *Paronychia patula* | Whitlow-wort |
| *Paronychia rugelii* | Sand-squares |
| *Parthenium hysterophorus* | Santa Maria feverfew |
| *Parthenocissus quinquefolia* | Virginia creeper |
| *Paspalum boscianum* | Bull paspalum |
| *Paspalum dilatatum* | Dallisgrass |
| *Paspalum distichum* | Knotgrass |
| *Paspalum floridanum* | Florida paspalum |
| *Paspalum laeve* | Field paspalum |
| *Paspalum notatum* | Bahiagrass |
| *Paspalum plicatulum* | Brownseed paspalum |
| *Paspalum praecox* | Early paspalum |
| *Paspalum setaceum* | Thin paspalum |
| *Paspalum urvillei* | Vaseygrass |
| *Passiflora lutea* | Yellow passionflower |
| *Pediomelum canescens* | Buckroot |
| *Peltandra virginica* | Green arum |
| *Penthorum sedoides* | Ditch stonecrop |
| *Perilla frutescens* | Beefsteak-plant |

| Scientific Name | Common Name |
|---|---|
| *Persea borbonia* | Redbay |
| *Persea palustris* | Swamp bay |
| *Petunia parviflora* | |
| *Phalaris caroliniana* | Carolina canarygrass |
| *Philadelphus inodorus* | Mock-orange |
| *Phlebodium aureum* | Golden polypody |
| *Phlox carolina* | Thick-leaf phlox |
| *Phoebanthus tenuifolia* **(ST)** | Narrow leaved phoebanthus, pineland false sunflower |
| *Phoradendron serotinum* | Mistletoe |
| *Phragmites australis* | Common reed |
| *Phyla nodiflora* | Cape-weed |
| *Phyllanthus caroliniensis* | |
| *Phyllanthus tenellus* | Mascarene Island leaf-flower |
| *Phyllanthus urinaria* | |
| *Physalis angulata* | |
| *Physalis angustifolia* | Groundcherry |
| *Physalis pubescens* | Groundcherry |
| *Physalis viscosa var. elliottii* | Groundcherry |
| *Physalis walteri* | Walter's groundcherry |
| *Physostegia godfreyi* **(ST)** | Obedient plant, Apalachicola dragon-head, Apalachicola obedience plant, Godfrey's dragonhead |
| *Physostegia leptophylla* | Obedient plant |
| *Physostegia purpurea* | Obedient plant |
| *Phytolacca americana* | Pokeweed, Pokeberry |
| *Pieris phillyreifolia* | |
| *Pilea pumila* | Clearweed |
| *Pinckneya bracteata* **(ST)** | Fever tree, maiden's blushes, Georgia bark |
| *Pinguicula ionantha* **(FT,SE)** | Godfrey's or Panhandle butterwort, violet butterwort |
| *Pinguicula lutea* **(ST)** | Yellow butterwort |
| *Pinguicula planifolia* **(ST)** | Chapman's or swamp butterwort, flatleaf butterwort |
| *Pinguicula pumila* | Small butterwort |
| *Pinus clausa* | Sand pine |
| *Pinus echinata* | Shortleaf pine |
| *Pinus elliottii* | Slash pine |
| *Pinus glabra* | Spruce pine |
| *Pinus palustris* | Longleaf pine |
| *Pinus semolina* | Pond Pine |
| *Pinus taeda* | Loblolly pine |
| *Pityopsis flexuosa* **(SE)** | Panhandle golden aster, zigzag silkgrass, bent golden aster |
| *Pityopsis graminifolia* var. *latifolia* | |

| Scientific Name | Common Name |
|---|---|
| *Pityopsis graminifolia var. microcephala* | Golden aster |
| *Pityopsis graminifolia var. tenuifolia* | Golden aster |
| *Pityopsis oligantha* | Golden aster |
| *Planera aquatica* | Planer tree, Water elm |
| *Plantago lanceolata* | English plantain, narrowleaf plantain |
| *Plantago major* | Plantain |
| *Plantago virginica* | Hoary plantain |
| *Platanthera blephariglottis* **(ST)** | White fringed orchid , plume of Navarre, large white-fringed orchid |
| *Platanthera cristata* **(ST)** | Crested fringed orchid |
| *Platanthera flava* **(ST)** | Southern rein-orchid, Southern tubercled orchid, Gypsy-spikes, palegreen orchid |
| *Platanthera flava var. flava* | Palegreen orchid |
| *Platanthera integra* **(SE)** | Orange rein-orchid, Southern yellow fringeless orchid, frog arrow |
| *Platanthera nivea* **(ST)** | Snowy orchid, bog orchid , frog spear, white rein orchid |
| *Platanus occidentalis* | Sycamore, American sycamore |
| *Pluchea camphorata* | Marsh fleabane |
| *Pluchea foetida* | Marsh fleabane |
| *Pluchea odorata* | Salt marsh fleabane, sweetscent |
| *Pluchea odorata var. odorata* | sweetscent |
| *Pluchea rosea* | Marsh fleabane |
| *Poa annua* | Annual bluegrass |
| *Pogonia ophioglossoides* **(ST)** | Rose pogonia , ettercap, crested ettercap, rose crested orchid |
| *Polygala balduinii* | White bachelor's button |
| *Polygala brevifolia* | Milkwort |
| *Polygala cruciata* | Drumheads |
| *Polygala cymosa* | Milkwort |
| *Polygala hookeri* | Milkwort |
| *Polygala incarnata* | Procession flower |
| *Polygala lutea* | Bog bachelor's button |
| *Polygala nana* | Wild bachelor's button |
| *Polygala ramosa* | Milkwort |
| *Polygala setacea* | Milkwort |
| *Polygonella fimbriata* | Sandhill jointweed |
| *Polygonella fimbriata var. robusta* | Sandhill wireweed |
| *Polygonella gracilis* | Wireweed |
| *Polygonella macrophylla* **(ST)** | Large-leaved jointweed |
| *Polygonella polygama* | October-flower |
| *Polygonella polygama var. brachystachya* | |

| Scientific Name | Common Name |
|---|---|
| *Polygonella robusta* | Largeflower jointweed |
| *Polygonum aviculare* | Prostrate knotweed |
| *Polygonum caespitosum var. longisetum* | Smartweed |
| *Polygonum densiflorum* | Smartweed |
| *Polygonum hydropiperoides* | Wild water-pepper |
| *Polygonum lapathifolium* | Pale smartweed |
| *Polygonum pensylvanicum* | Pinkweed |
| *Polygonum persicaria* | Smartweed |
| *Polygonum punctatum* | Dotted smartweed |
| *Polygonum sagittatum* | Tearthumb |
| *Polygonum scandens* | False buckwheat |
| *Polygonum setaceum* | Bog smartweed |
| *Polygonum virginianum* | Jumpseed |
| *Polymnia uvedalia* | Bear's foot, yellow leafcup |
| *Polypodium polypodioides* | Resurrection fern |
| *Polypremum procumbens* | |
| *Polystichum acrostichoides* | Christmas fern |
| *Pontederia cordata* | Pickerelweed |
| *Pontederia cordata var. lancifolia* | Pickerelweed |
| *Pontederia lanceolata* | Pickerelweed |
| *Populus deltoides* | Cottonwood |
| *Populus heterophylla* | Swamp cottonwood |
| *Portulaca amilis* | Paraguayan purslane |
| *Portulaca oleracea* | |
| *Portulaca oleracea ssp. Nicaraguensis* | |
| *Portulaca pilosa* | Pink purslane |
| *Potamogeton illinoensis* | Illinois pondweed |
| *Potamogeton pectinatus* | Sago pondweed |
| *Potamogeton perfoliatus* | Pondweed |
| *Potamogeton pusillus* | Pondweed |
| *Proserpinaca palustris* | Mermaid-weed |
| *Proserpinaca pectinata* | |
| *Prunus americana* | Wild plum |
| *Prunus angustifolia* | Chickasaw plum |
| *Prunus angustifolia var. angustifolia* | Chickasaw plum |
| *Prunus caroliniana* | Laurel cherry |
| *Prunus serotina* | Black cherry |
| *Prunus umbellata* | Hog plum |
| *Psilocarya nitens* | Baldrush |
| *Ptelea trifoliata* | Wafer ash |
| *Pteridium aquilinum* | Bracken fern |
| *Pteridium aquilinum var. pseudocaudatum* | |
| *Pterocaulon pycnostachyum* | Blackroot |

| Scientific Name | Common Name |
|---|---|
| *Ptilimnium capillaceum* | Mock bishop's-weed |
| *Pueraria montana* | Kudzu |
| *Pueraria montana var. lobata* | Kudzu |
| *Pycnanthemum flexuosum* | Mountain-mint |
| *Pyrrhopappus carolinianus* | False dandelion |
| *Quercus ashei* | |
| *Quercus comptoniae* | |
| *Quercus alba* | White oak |
| *Quercus chapmanii* | Chapman oak |
| *Quercus falcata* | Southern red oak |
| *Quercus falcata var. pagodifolia* | Cherry bark oak |
| *Quercus geminata* | Sand-live oak, scrub oak |
| *Quercus hemisphaerica* | Laurel oak |
| *Quercus incana* | Blue-jack oak |
| *Quercus laevis* | Turkey oak |
| *Quercus laurifolia* | Diamond-leaf oak, laurel oak |
| *Quercus lyrata* | Overcup oak |
| *Quercus margaretta* | Sand-post oak |
| *Quercus marilandica* | Blackjack oak |
| *Quercus michauxii* | Swamp chestnut oak |
| *Quercus minima* | Dwarf-live oak |
| *Quercus muhlenbergii* | Chinquapin oak |
| *Quercus myrtifolia* | Myrtle oak |
| *Quercus nigra* | Water oak |
| *Quercus pagoda* | Cherrybark oak |
| *Quercus pumila* | Runner oak |
| *Quercus shumardii* | Shumard oak |
| *Quercus stellata* | Post oak |
| *Quercus velutina* | Black oak |
| *Quercus virginiana* | Live oak |
| *Raphanus raphanistrum* | Wild radish |
| *Ratibida pinnata* | |
| *Rhamnus caroliniana* | Buckthorn |
| *Rhapidophyllum hystrix* | Needle palm |
| *Rhexia alifanus* | Meadow beauty |
| *Rhexia cubensis* | Meadow beauty |
| *Rhexia lutea* | Meadow beauty |
| *Rhexia mariana* | Pale meadow beauty |
| *Rhexia nashii* | Meadow beauty |
| *Rhexia parviflora* **(SE)** | Small-flowered or Apalachicola meadow beauty |
| *Rhexia petiolata* | Meadow beauty |
| *Rhexia salicifolia* **(ST)** | Panhandle meadow beauty |
| *Rhexia virginica* | Meadow beauty |
| *Rhododendron austrinum* **(SE)** | Florida flame azalea , orange azalea |
| *Rhododendron canescens* | Sweet pinxter azalea, wild azalea |

| Scientific Name | Common Name |
|---|---|
| *Rhododendron chapmanii* **(FE,SE)** | Chapman's rhododendron, rose-bay |
| *Rhododendron serrulatum* | Swamp honeysuckle , swamp azalea |
| *Rhus copallina* | Winged sumac, shining sumac |
| *Rhus glabra* | Smooth sumac |
| *Rhynchosia difformis* | Doubleform snoutbean |
| *Rhynchosia minima* | Least snoutbean |
| *Rhynchospora caduca* | Beakrush |
| *Rhynchospora cephalantha* | Beakrush |
| *Rhynchospora corniculata* | Hornedrush |
| *Rhynchospora curtissii* | Beakrush |
| *Rhynchospora divergens* | Beakrush |
| *Rhynchospora fascicularis* | Beakrush |
| *Rhynchospora fernaldii* | Beakrush |
| *Rhynchospora gracilenta* | Beakrush |
| *Rhynchospora megalocarpa* | Beakrush |
| *Rhynchospora microcarpa* | Beakrush |
| *Rhynchospora miliacea* | Beakrush |
| *Rhynchospora mixta* | Beakrush |
| *Rhynchospora odorata* | Beakrush |
| *Rhynchospora pineticola* | Pine barren beaksedge |
| *Rhynchospora plumosa* | Beakrush |
| *Rhynchospora tracyi* | Beakrush |
| *Richardia scabra* | |
| *Ricinus communis* | Castorbean |
| *Robinia hispida* | Bristly locust |
| *Robinia hispida var. hispida* | Bristly locust |
| *Robinia pseudoacacia* | Black locust |
| *Rorippa sessiliflora* | Yellow cress |
| *Rosa palustris* | Swamp rose |
| *Rotala ramosior* | Toothcups |
| *Rubus argutus* | Highbush blackberry |
| *Rubus cuneifolius* | Sand blackberry |
| *Rubus trivialis* | Dewberry |
| *Rudbeckia graminifolia* | Coneflower |
| *Rudbeckia mohrii* | |
| *Ruellia caerulea* | Britton's wild petunia |
| *Ruellia caroliniensis* | Wild petunia |
| *Ruellia noctiflora* **(SE)** | Night-flowering ruellia, night-flowering petunia |
| *Rumex chrysocarpus* | Dock, amamastla |
| *Rumex crispus* | Curled dock |
| *Rumex crispus ssp. crispus* | Curly dock |
| *Rumex hastatulus* | Sourdock |
| *Rumex obovatus* | Tropical dock |
| *Rumex paraguayensis* | Paraguayan dock |
| *Rumex pulcher* | Fiddle dock |

| Scientific Name | Common Name |
|---|---|
| *Rumex verticillatus* | Swamp dock |
| *Ruppia maritima* | Widgeon-grass |
| *Sabal minor* | Bluestem, dwarf palmetto |
| *Sabal palmetto* | Cabbage palm |
| *Sabatia bartramii* | Marsh pink |
| *Sabatia brevifolia* | Marsh pink |
| *Sabatia calycina* | Marsh pink |
| *Sabatia campanulata* | Marsh pink |
| *Sabatia dodecandra* | Marsh pink, marsh rose gentian |
| *Sabatia grandiflora* | Marsh pink, largeflower rose gentian |
| *Sabatia stellaris* | |
| *Sacciolepis indica* | India cupscale |
| *Sacciolepis striata* | American cupscale |
| *Sacciolepis striata* | American cupscale |
| *Sageretia minutiflora* | Buckthorn |
| *Sagina decumbens* | Pearlwort |
| *Sagittaria australis* | Longbeak arrowhead |
| *Sagittaria graminea* | Arrowhead |
| *Sagittaria graminea var. chapmanii* | Arrowhead |
| *Sagittaria lancifolia* | Arrowhead |
| *Sagittaria latifolia* | Duck potato |
| *Sagittaria latifolia var. pubescens* | Duck potato |
| *Sagittaria platyphylla* | Delta arrowhead |
| *Sagotia triflora* | |
| *Salicornia virginica* | Perennial glasswort |
| *Salix caroliniana* | Coastal plain willow |
| *Salix nigra* | Black willow |
| *Salsola kali* | Russian thistle, saltwort |
| *Salvia lyrata* | Lyre-leaved sage |
| *Sambucus canadensis* | Elderberry |
| *Samolus ebracteatus* | Water pimpernel |
| *Samolus parviflorus* | Pineland pimpernel |
| *Sanicula canadensis* | Black snakeroot |
| *Sapindus marginatus* | Soapberry |
| *Sarcocornia perennis* | Chickenclaws |
| *Sarracenia formosa* | |
| *Sarracenia flava* | Trumpets |
| *Sarracenia leucophylla* **(SE)** | White-top pitcher-plant |
| *Sarracenia psittacina* **(ST)** | Parrot pitcher-plant |
| *Sassafras albidum* | Sassafras |
| *Saururus cernuus* | Lizard's tail |
| *Schedonorus* | |
| *Schedonorus phoenix* | Tall fescue |
| *Schisandra coccinea* **(SE)** | Bay star vine, wild sasparilla, schisandra |

| Scientific Name | Common Name |
|---|---|
| *Schizachyrium littorale* | Shore little bluestem |
| *Schizachyrium maritimum* | |
| *Schizachyrium scoparium* | Little bluestem |
| *Schoenoplectus americanus* | Chairmaker's bulrush |
| *Schoenoplectus deltarum* | Delta bulrush |
| *Schoenoplectus robustus* | Sturdy bulrush |
| *Scirpus americanus* | Bulrush |
| *Scirpus californicus* | Bulrush |
| *Scirpus cyperinus* | Wool-grass |
| *Scirpus divaricatus* | Spreading bulrush |
| *Scirpus pungens* | Three-square |
| *Scirpus robustus* | Saltmarsh bulrush |
| *Scirpus validus* | Great bulrush |
| *Scleria ciliata* | Nutrush |
| *Scleria ciliata var. glabra* | Nutrush |
| *Scleria georgiana* | Nutrush |
| *Scleria hirtella* | Nutrush |
| *Scleria oligantha* | Littlehead nutrush |
| *Scleria pauciflora* | Nutrush |
| *Scleria reticularis* | Nutrush |
| *Scleria reticularis var. pubescens* | Nutrush |
| *Scleria triglomerata* | Nutrush |
| *Scleria verticillata* | Nutrush |
| *Scoparia dulcis* | Sweet broom |
| *Scoparia montevidensis* | |
| *Scrophularia marilandica* | Figwort |
| *Scutellaria floridana* **(FT,SE)** | Florida skullcap, helmet flowers |
| *Scutellaria integrifolia* | Skullcap |
| *Scutellaria lateriflora* | Blue skullcap |
| *Scutellaria lateriflora var. lateriflora* | Blue skullcap |
| *Sebastiana fruticosa* | Sebastian bush |
| *Secale cereale* | Cereal rye |
| *Selaginella apoda* | Meadow spikemoss |
| *Selaginella arenicola* | Sand spikemoss |
| *Senecio aureus* | Golden ragwort |
| *Senecio glabellus* | Butterweed, golden ragwort |
| *Senna marilandica* | Maryland senna |
| *Senna obtusifolia* | Java-bean |
| *Serenoa repens* | Saw-palmetto |
| *Sesbania macrocarpa* | |
| *Sesbania punicea* | Purple sesban |
| *Sesbania vesicaria* | Bladderpod |
| *Sesuvium maritimum* | Sea purslane, slender seapurslane |
| *Sesuvium portulacastrum* | Sea purslane, shoreline seapurslane |

| Scientific Name | Common Name |
|---|---|
| *Setaria barbata* | East Indian bristlegrass |
| *Setaria corrugata* | Coastal bristlegrass |
| *Setaria geniculata* | Knotroot foxtail |
| *Setaria macrosperma* | Coral foxtail, coral bristlegrass |
| *Setaria magna* | Giant bristlegrass |
| *Setaria magna* | giant bristlegrass |
| *Setaria viridis* | Green foxtail, green bristlegrass |
| *Setaria viridis var. viridis* | Green bristlegrass |
| *Seymeria cassioides* | Senna symeria, Black senna |
| *Sicyos angulatus* | Bur cucumber |
| *Sida acuta* | Broomweed |
| *Sida acuta* | Common wireweed |
| *Sida rhombifolia* | Indian hemp |
| *Sida spinosa* | Prickly mallow |
| *Sideroxylon thornei* **(SE)** | Thorne's buckthorn, Georgia bully |
| *Silene antirrhina* | Sleepy catchfly |
| *Silene polypetala* **(FE,SE)** | Fringed campion, fringed catchfly, fringed pink, eastern fringed catchfly |
| *Silphium compositum var. ovatifolium* | |
| *Sisyrinchium atlanticum* | Blue-eyed grass |
| *Sisyrinchium nashii* | |
| *Sisyrinchium rosulatum* | Annual blue-eyed grass |
| *Sisyrinchium xerophyllum* | Scrub blue-eyed-grass |
| *Smilacina racemosa* | False solomon's-seal |
| *Smilax auriculata* | Greenbrier |
| *Smilax bona-nox* | Catbrier |
| *Smilax glauca* | Wild sarsaparilla |
| *Smilax laurifolia* | Bamboo-vine |
| *Smilax pumila* | Wild sarsaparilla |
| *Smilax rotundifolia* | Greenbriar |
| *Smilax smallii* | Jackson-brier |
| *Smilax tamnoides* | Hogbrier |
| *Smilax walteri* | Coral greenbrier |
| *Solanum americanum* | Nightshade |
| *Solanum capsicoides* | Cockroach berry |
| *Solanum carolinense* | Horse-nettle |
| *Solanum carolinense var. floridanum* | Horse-nettle |
| *Solanum lycopersicum* | Garden tomato |
| *Solanum lycopersicum var. lycopersicum* | Garden tomato |
| *Solanum nigrescens* | Black nightshade |
| *Solidago auriculata* | Eared goldenrod |
| *Solidago caesia* | Bluestem goldenrod |
| *Solidago canadensis* | Goldenrod, tall goldenrod |
| *Solidago chapmanii* | Goldenrod, Chapman's goldenrod |

| Scientific Name | Common Name |
|---|---|
| *Solidago fistulosa* | Goldenrod |
| *Solidago odora* | Sweet goldenrod |
| *Solidago odora var. chapmanii* | Chapman's goldenrod |
| *Solidago sempervirens* | Seaside goldenrod |
| *Solidago sempervirens var. mexicana* | Seaside goldenrod |
| *Solidago stricta* | |
| *Sonchus asper* | Spiny-leaved sow thistle |
| *Sonchus oleraceus* | Common sow thistle |
| *Sorghastrum elliottii* | Slender indiangrass |
| *Sorghastrum nutans* | Wood grass |
| *Sorghastrum secundum* | Lopside indiangrass |
| *Sorghum halepense* | Johnsongrass |
| *Spartina alterniflora* | Smooth cordgrass, salt marsh cordgrass |
| *Spartina alterniflora var. glabra* | Saltmarsh cordgrass |
| *Spartina bakeri* | Sand cordgrass |
| *Spartina cynosuroides* | Big cordgrass |
| *Spartina patens* | Saltmeadow cordgrass, marshhay |
| *Spartina spartinae* | Gulf cordgrass |
| *Spermacoce prostrata* | |
| *Spermolepis divaricata* | Scale-seed |
| *Spermolepis echinata* | Scale-seed |
| *Sphenoclea zeylanica* | Gooseweed |
| *Sphenopholis nitida* | Shiny wedgescale |
| *Sphenopholis obtusata* | Prairie wedgescale |
| *Spilanthes americana* | |
| *Spiranthes cernua var. odorata* | Nodding ladies' tresses |
| *Spiranthes lacera* | Northern slender lady's tresses |
| *Spiranthes lacera var. gracilis* | Northern slender lady's tresses |
| *Spiranthes odorata* | Marsh lady's tresses |
| *Spiranthes ovalis* **(SE)** | Lesser ladies'-tresses, oval ladies' tresses, October ladies' tresses |
| *Spiranthes praecox* | Grass-leaved ladies'-tresses |
| *Spiranthes vernalis* | Spring ladies'-tresses |
| *Spirodela polyrrhiza* | Common duckmeat |
| *Spirodela punctata* | Duckmeat |
| *Sporobolus floridanus* | Florida dropseed |
| *Sporobolus indicus* | Smutgrass |
| *Sporobolus virginicus* | Virginia dropseed |
| *Stachydeoma graveolens* **(SE)** | Mock pennyroyal |
| *Stachys crenata* **(SE)** | Shade betony |
| *Staphylea trifolia* **(SE)** | Bladdernut, American bladdernut |

| Scientific Name | Common Name |
|---|---|
| *Stellaria media* | Common chickweed |
| *Stellaria prostrata* | Prostrate starwort |
| *Stellaria pubera* | |
| *Stenotaphrum secundatum* | St. Augustine grass |
| *Stewartia malachodendron* **(SE)** | Silky camellia |
| *Stillingia aquatica* | Corkwood |
| *Stipa avenacea* | Blackseed needlegrass |
| *Stipulicida setacea* | |
| *Strophostyles helvola* | Sand beans |
| *Strophostyles leiosperma* | Sand beans |
| *Stuckenia pectinata* | Sago pondweed |
| *Stylisma humistrata* | |
| *Stylisma patens* | |
| *Stylosanthes biflora* | Pencil flower |
| *Styrax americana* | Storax |
| *Styrax americana var. pulverulenta* | Storax |
| *Styrax grandifolia* | Big-leaf snowbell |
| *Suaeda linearis* | Southern sea blite |
| *Symphyotrichum bracei* | Brace's aster |
| *Symphyotrichum elliotii* | Elliott's aster |
| *Symphyotrichum lanceolatum* | White panicle aster |
| *Symphyotrichum lanceolatum ssp. lanceolatum* | White panicle aster |
| *Symphyotrichum lanceolatum ssp. lanceolatum var. latifolium* | White panicle aster |
| *Symphyotrichum praealtum* | Willowleaf aster |
| *Symphyotrichum praealtum var. praealtum* | Willowleaf aster |
| *Symphyotrichum tenuifolium* | Perennial saltmarsh aster |
| *Symplocos tinctoria* | Horse sugar, sweetleaf |
| *Synedrella nodiflora* | Nodeweed |
| *Syngonanthus flavidulus* | Shoe buttons |
| *Syringodium filiforme* | Manatee-grass |
| *Tamarix parviflora* | Smallflower tamarisk |
| *Taxodium ascendens* | Pond cypress |
| *Taxodium distichum* | Bald cypress |
| *Taxus floridana* **(SE)** | Florida yew |
| *Tephrosia hispidula* | |
| *Teucrium canadense var. nashii* | Wood sage |
| *Thalassia testudinum* | Turtle grass |
| *Thalia geniculata* | Fireflag |
| *Thaspium trifoliatum* | Purple meadow parsnip |
| *Thelypteris dentata* | Downy shield fern |
| *Thelypteris hexagonoptera* | Beech fern |

| Scientific Name | Common Name |
|---|---|
| *Thelypteris interrupta* | Hottentot fern, willdenows fern |
| *Thelypteris kunthii* | Southern shield fern |
| *Thelypteris palustris* | Marsh fern |
| *Thelypteris quadrangularis var. versicolor* | Hairy maiden fern |
| *Tilia heterophylla* | Basswood |
| *Tillandsia bartramii* | Wild pine, Air plant |
| *Tillandsia usneoides* | Spanish moss |
| *Torreya taxifolia* **(FE,SE)** | Florida torreya, Stinking cedar, gopherwood |
| *Toxicodendron radicans* | Poison ivy |
| *Toxicodendron toxicarium* | Eastern poison oak |
| *Trachelospermum difforme* | Climbing dogbane |
| *Tradescantia fluminensis* | Wandering jew |
| *Tradescantia hirsutiflora* | Spiderwort |
| *Tradescantia ohiensis* | Common spiderwort, bluejacket |
| *Tradescantia virginiana* | |
| *Tragia smallii* | |
| *Trepocarpus aethusae* | |
| *Triadenum tubulosum* | |
| *Triadenum virginicum* | Marsh St. John's wort |
| *Triadenum walteri* | Marsh St. John's wort |
| *Trichostema dichotomum* | Blue curls, bastard pennyroyal |
| *Tridens ambiguus* | Pine barren tridens |
| *Tridens flavus* | Tall redtop |
| *Trifolium campestre* | Low hop clover |
| *Trifolium carolinianum* | Clover |
| *Trifolium dubium* | Clover |
| *Trifolium repens* | White clover |
| *Trifolium vesiculosum* | Arrowleaf clover |
| *Triglochin striata* | Arrowgrass |
| *Trillium lancifolium* **(SE)** | Wakerobins, lance-leaved wakerobin, narrow leaf trillium |
| *Triodanis biflora* | Clasping Venus' looking-glass |
| *Triodanus perfoliata* | Venus' looking-glass |
| *Triplasis americana* | Perennial sand grass |
| *Triplasis purpurea* | Purple sand grass |
| *Tripsacum dactyloides* | Eastern gamagrass |
| *Tritonia crocosmaeflora* | Montbretia |
| *Typha domingensis* | Southern cattail |
| *Typha latifolia* | Common cattail |
| *Ulmus alata* | Winged elm |
| *Ulmus americana* | American elm |
| *Ulmus rubra* | Slippery elm |
| *Uniola paniculata* | Sea oats |
| *Utricularia biflora* | Bladderwort |
| *Utricularia cornuta* | Horned bladderwort |

| Scientific Name | Common Name |
|---|---|
| *Utricularia floridana* | Florida yellow bladderwort |
| *Utricularia foliosa* | leafy bladderwort |
| *Utricularia juncea* | Bladderwort |
| *Utricularia olivacea* | Piedmont bladderwort |
| *Utricularia purpurea* | Purple bladderwort |
| *Utricularia radiata* | Bladderwort |
| *Utricularia resupinata* | Small purple-bladderwort |
| *Utricularia subulata* | Bladderwort |
| *Uvularia floridana* **(SE)** | Bellwort, Florida bellwort, Florida merrybells |
| *Uvularia perfoliata* | Bellwort |
| *Uvularia sessilifolia* | Bellwort |
| *Vaccinium arboreum* | Sparkleberry |
| *Vaccinium corymbosum* | Highbush blueberry |
| *Vaccinium darrowii* | Blueberry |
| *Vaccinium myrsinites* | Shiny blueberry |
| *Vaccinium stamineum* | Deerberry |
| *Vallisneria americana* | Tapegrass (eelgrass), water celery |
| *Veratrum woodii* **(SE)** | False hellebores, Wood's false hellebore |
| *Verbascum blattaria* | Moth mullein |
| *Verbascum thapsus* | Wooly mullein |
| *Verbena bonariensis* | Vervain |
| *Verbena bracteata* | Bigbract verbena |
| *Verbena brasiliensis* | Vervain |
| *Verbena halei* | Texas vervain |
| *Verbena rigida* | Vervain |
| *Verbena utricifolia* | White vervain |
| *Verbesina alternifolia* | |
| *Verbesina chapmanii* **(ST)** | Chapman's crownbeard |
| *Verbesina occidentalis* | |
| *Verbesina virginica* | Frost weed |
| *Vernicia fordii* | Tungoil tree |
| *Vernonia angustifolia var. mohrii* | Ironweed |
| *Vernonia gigantea* | Ironweed |
| *Veronica agrestis* | Green field speedwell |
| *Veronica arvensis* | Corn speedwell |
| *Veronica peregrina* | Neckweed |
| *Veronica peregrina var. xalapensis* | |
| *Viburnum dentatum* | Southern arrow-wood |
| *Viburnum dentatum var. scabrellum* | Southern arrow-wood |
| *Viburnum nudum* | Possum haw |
| *Viburnum obovatum* | Small viburnum |
| *Viburnum rufidulum* | Rusty-haw |
| *Vicia acutifolia* | Sand vetch, fourleaf vetch |

| Scientific Name | Common Name |
|---|---|
| *Vicia floridana* | Florida vetch |
| *Vicia sativa* | Common vetch |
| *Vicia tetrasperma* | Lentil-tare |
| *Vicia villosa* | Winter vetch |
| *Vigna luteola* | Hairypod cowpea |
| *Viola affinis* | |
| *Viola hastata* | Halberd-leaved yellow violet |
| *Viola lanceolata* | Bog-white violet |
| *Viola primulifolia* | Primrose-leaved violet |
| *Viola septemloba* | |
| *Viola tricolor* | johnny jumpup |
| *Vitex agnus-castus* | Lilac chastetree |
| *Vitis aestivalis* | Summer grape |
| *Vitis palmata* | Red grape |
| *Vitis rotundifolia* | Muscadine, scuppernong |
| *Vitis vulpina* | Frost grape |
| *Vulpia octoflora* | Common six-weeks grass |
| *Wahlenbergia marginata* | |
| *Warea sessilifolia* | |
| *Wisteria frutescens* | American wisteria |
| *Wisteria sinensis* | Chinese wisteria |
| *Woodsia obtusa* | Cliff fern |
| *Woodwardia areolata* | Netted chain-fern |
| *Woodwardia virginica* | Virginia chain-fern |
| *Xanthium strumarium* | Cocklebur |
| *Xanthorhiza simplicissima* **(SE)** | Yellow-root, brook feather |
| *Xyris ambigua* | Yellow-eyed grass |
| *Xyris brevifolia* | Yellow-eyed grass |
| *Xyris caroliniana* | Yellow-eyed grass |
| *Xyris drummondii* | Yellow-eyed grass |
| *Xyris elliottii* | Yellow-eyed grass |
| *Xyris flabelliformis* | Yellow-eyed grass |
| *Xyris iridifolia* | Yellow-eyed grass |
| *Xyris isoetifolia* **(SE)** | Yellow-eyed grass, quillwort yellow-eyed grass |
| *Xyris jupicai* | Common yellow-eyed grass |
| *Xyris longisepala* **(SE)** | Karst pond yellow-eyed grass, karst pond xyris, Kral's pond yellow-eyed grass |
| *Xyris scabrifolia* **(ST)** | Harper's yellow-eyed grass |
| *Xyris stricta* | |
| *Yucca aloifolia* | Aloe yucca, Spanish bayonet |
| *Yucca flaccida* | Weak-leaf yucca |
| *Yucca gloriosa* **(SE)** | Moundlily yucca, Spanish daggar, Roman candle, palm lily |
| *Zannichellia* | Horned pondweed |
| *Zannichellia palustris* | Horned pondweed |

| Scientific Name | Common Name |
|---|---|
| *Zanthoxylum americanum* **(SE)** | Toothache-tree, prickly ash |
| *Zanthoxylum clava-herculis* | Hercules'-club |
| *Zenobia pulverulenta* | Zenobia |
| *Zephyranthes candida* | Autumn zephyrlily |
| *Zephyranthes grandiflora* | Rosepink zephyrlily |
| *Zephyranthes treatiae* **(ST)** | Rain-lily, Treat's zephyr lily, easter lily, Treat's rainlily |
| *Zigadenus densus* | Crow-poison |
| *Zigadenus glaberrimus* | |
| *Zizania aquatica* | Indian rice, annual wildrice |
| *Zizania aquatica var. aquatica* | Annual wildrice |
| *Zizaniopsis miliacea* | Water millet, Southern wild rice, Giant cutgrass |
| *Zizia aurea* | Golden alexander |
| *Zostera marina* | Salt water eel-grass |

## Appendix II

# Common Aquatic Invertebrates of the Apalachicola River & Bay Basin

| Scientific Name | Common Name |
|---|---|
| **Crustaceans** | |
| *Acetes americanus* | Aviu shrimp |
| *Alpheus armillatus* | Banded snapping shrimp |
| *Alpheus normanni* | Green snapping shrimp |
| *Ambidexter symmetricus* | Shrimp |
| *Calappa ocellata* | Flame crab |
| *Callinectes sapidus* | Common blue crab |
| *Callinectes similis* | Lesser blue crab |
| *Cambarus diogenes* | Devil crawfish |
| *Cambarus spp.* | Crawfish |
| *Cambarus striatus* | Hay crawfish |
| *Clibanarius vittatus* | Thinstripe hermit crab |
| *Dyspanopeus texana* | Gulf grassflat crab |
| *Farfantepenaeus aztecus* | Brown shrimp |
| *Farfantepenaeus duorarum* | Pink shrimp |
| *Faxonella clypeata* | Ditch fencing crawfish |
| *Hexapanopeus angustifrons* | Smooth mud crab |
| *Hippolyte pleuracanthus* | False zostera shrimp |
| *Hippolyte zostericola* | Zostera shrimp |
| *Latreutes parvulus* | Sargassum shrimp |
| *Leander tenuicornis* | Brown grass shrimp |
| *Libinia dubia* | Decorator crab |
| *Libinia emarginata* | Portly spider crab |
| *Litopenaeus setiferus* | White shrimp |
| *Menippe mercenaria* | Florida stone crab |
| *Metaporhaphis calcarata* | False arrow crab |
| *Neopanope packardii* | Florida grassflat crab |
| *Neopanope texana* | Mud crab |
| *Ovalipes floridanus* | Florida lady crab |
| *Pagurus annulipes* | Hermit crab |
| *Pagurus bonairensis* | Right handed hermit crab |
| *Pagurus longicarpus* | Long-clawed hermit crab |
| *Pagurus maclaughlinae* | Right handed hermit crab |
| *Pagurus pollicaris* | Flatclaw hermit crab |
| *Pagurus spp.* | Right handed hermit crab |
| *Palaemon floridanus* | Florida grass shrimp |
| *Palaemonetes intermedius* | Brackish grass shrimp |
| *Palaemonetes pugio* | Daggerblade grass shrimp |
| *Palaemonetes vulgaris* | Common grass shrimp |
| *Periclimenes americanus* | American grass shrimp |
| *Periclimenes longicaudatus* | Longtail grass shrimp |
| *Persephona mediterranea* | Mottled purse crab |
| *Petrolisthes armatus* | Flat crab |
| *Petrolisthes armatus* | Green porcelain crab |
| *Portunus gibbesii* | Irridescent swimming crab |
| *Portunus spinimanus* | Blotched swimming crab |
| *Procambarus acutus* | White river crawfish |
| *Procambarus howellae* | Crawfish |
| *Procambarus paeninsulanus* | Crawfish |
| *Rhithropanopeus harrisii* | Estuarine mud crab |
| *Rimapenaeus constrictus* | Roughneck shrimp |
| *Rimapenaeus similis* | Roughback shrimp |
| *Rimapenaeus spp.* | Shrimp |
| *Sicyonia brevirostris* | Brown rock shrimp |
| *Sicyonia dorsalis* | Lesser rock shrimp |
| *Sicyonia laevigata* | Rock shrimp |
| *Sicyonia typica* | Kinglet rock shrimp |
| *Squilla empusa* | Mantis shrimp |
| *Tozeuma carolinense* | Arrow shrimp |
| *Xanthidae spp.* | Mud crabs |
| *Xiphopenaeus kroyeri* | Atlantic seabob |
| | |
| **Molluscs** | |
| *Amblema neislerii* (FE) | Fat threeridge mussel |
| *Brachidontes spp.* | Mussel |
| *Busycon contrarium* | Lightning whelk |
| *Busycon spiratus* | Pear whelk |
| *Corbicula manilensis* (N) | Asiatic clam |
| *Crassotrea virginica* | American oyster |
| *Elliptoideus sloatianus* (FT) | Purple bankclimber mussel |

| Scientific Name | Common Name |
|---|---|
| *Lolliguncula brevis* | Atlantic brief squid |
| *Martesia smithi* | Boring clam |
| *Melongena corona* | Crown conch |
| *Neritina reclivata* | Olive nerite |
| *Odostomia impressa* | Impressed odostome |
| *Ostrea equestris* | Crested oyster |
| *Polinices duplicatus* | Snail |
| *Rangia cuneata* | Atlantic rangia |
| *Thais haemastoma* | Southern oyster drill |
| | |
| **Echinoderms** | |
| *Astropecten articulatus* | Royal sea star |
| *Echinarachnius parma* | Sand dollar |
| *Echinaster sp.* | Sea star |
| *Hemipholis elongata* | Sea star |
| *Luidia alternata* | Limp starfish |
| *Mellita quinquiesperforata* | Five-holed keyhole urchin |
| *Ophiothrix angulata* | Angular brittle star |
| *Ophioderma species* | Brittle star |
| *Luidia clathrata* | Lined sea star |
| | |
| **Miscellaneous** | |
| *Aurelia aurita* | Moon jellyfish |
| *Chrysaora quinquecirrha* | Sea nettle |
| *Cliona spp.* | Boring sponge |
| *Mnemiopsis mccradyi* | Comb jellyfish |
| *Polydora Websteri* | Mud worm |
| *Renilla reniformis* | Sea pansy |
| *Stomolophus meleagris* | Cannonball jellyfish |
| *Stylochus Frontalis* | Flatworm (oyster leech) |

## Appendix II

# Amphibians & Reptiles of the Apalachicola River & Bay Basin

| Scientific Name | Common Name |
|---|---|
| **Amphibians** | |
| *Acris crepitans crepitans* | Northern cricket frog |
| *Acris gryllus dorsalis* | Florida cricket frog |
| *Acris gryllus gryllus* | Southern cricket frog |
| *Ambystoma bishopi* **(FT,SSC)** | Reticulated flatwoods salamander |
| *Ambystoma cingulatum* **(FT,SSC)** | Frosted flatwoods salamander |
| *Ambystoma opacum* | Marbled salamander |
| *Ambystoma talpoideum* | Mole salamander |
| *Ambystoma tigrinum tigrinum* | Eastern tiger salamander |
| *Amphiuma means* | Two-toed amphiuma |
| *Amphiuma pholeter* | One-toed ampiuma |
| *Bufo quercicus* | Oak toad |
| *Bufo terrestris* | Southern toad |
| *Desmognathus apalachicolae* | Apalachicola dusky salamander |
| *Desmognathus auriculatus* | Southern dusky salamander |
| *Desmognathus fuscus conanti* | Spotted dusky salamander |
| *Eleutherodactylus planirostris* **(N)** | Greenhouse frog |
| *Eurycea cirrigera* | Southern two-lined salamander |
| *Eurycea lonicuada guttolineata* | 3-Lined salamander |
| *Eurycea quadridigitata* | Dwarf salamander |
| *Gastrophryne carolinensis* | Eastern narrowmouth toad |
| *Haideotriton wallacei* **(SSC)** | Georgia blind salamander |
| *Hemidactylium scutatum* | Four-toed salamander |
| *Hyla avivoca* | Bird-voiced treefrog |
| *Hyla chrysocelis* | Cope's gray treefrog |
| *Hyla cinerea* | Green treefrog |
| *Hyla femoralis* | Pinewoods treefrog |
| *Hyla gratiosa* | Barking treefrog |
| *Hyla squirella* | Squirrel treefrog |
| *Necturus alabamensis* | Alabama waterdog |
| *Notophthalmus perstriatus* | Striped newt |
| *Notophthalmus viridescens* | Eastern newt |
| *Plethodon grobmani* | Slimy salamander |
| *Psedobranchus striatus* | Northern dwarf siren |
| *Pseudacris crucifer* | Spring peeper |
| *Pseudacris feriarum* | Upland chorus frog |
| *Pseudacris nigrita* | Southern chorus frog |
| *Pseudacris ocularis* | Little grass frog |
| *Pseudacris ornata* | Ornate shorus frog |
| *Pseudotriton montanus* | Mud salamander |
| *Pseudotriton ruber* | Southern red slamander |
| *Rana capito* **(SSC)** | Gopher frog |
| *Rana catesbeiana* | Bullfrog |
| *Rana clamitas clamitans* | Bronze frog |
| *Rana grylio* | Pig frog |
| *Rana heckscheri* | River frog |
| *Rana pipiens* | Northern leopard frog |
| *Rana sphenocephala* | Southern leopard frog |
| *Scaphiopus holbrookii holbrookii* | Eastern spadefoot toad |
| *Siren intermedia intermedia* | Eastern lesser siren |
| *Siren lacertina* | Greater siren |
| **Reptiles** | |
| *Agkistrodon contortrix contortrix* | Southern copperhead |
| *Agkistrodon piscivorus conanti* | Florida cottonmouth |

| Scientific Name | Common Name |
|---|---|
| *Alligator mississippiensis* **(SSC)** | American alligator |
| *Anolis carolinensis* | Green anole |
| *Anolis sagrei* **(N)** | Cuban brown anole |
| *Apalone ferox* | Florida softshell |
| *Caretta caretta* **(FT,ST)** | Loggerhead sea turtle |
| *Cemophora coccinea coccinea* | Scarlet snake |
| *Cemophora coccinea copei* | Northern scarlet snake |
| *Chelonia mydas* **(FE,SE)** | Green turtle |
| *Chelydra serpentina serpentina* | Common snapping turtle |
| *Clemmys guttata* | Spotted turtle |
| *Cnemidophorus sexlineatus* | Six-lined racerunner |
| *Coluber constrictor helvigularis* | Brownchin racer |
| *Coluber constrictor priapus* | Southern black racer |
| *Crotalus adamanteus* | Eastern diamondback rattlesnake |
| *Deirochelys reticularia* | Chicken turtle |
| *Dermochelys coriacea* **(FE,SE)** | Leatherback turtle |
| *Diadophis punctatus* | Ringneck snake |
| *Drymarchon couperi* **(FT,ST)** | Eastern indigo snake |
| *Elaphe guttata guttata* | Corn snake |
| *Elaphe obsoleta spiloides* | Gray rat snake |
| *Eumeces anthracinus pluvialis* | Southern coal skink |
| *Eumeces fasciatus* | Five-lined skink |
| *Eumeces inexpectatus* | Southeastern five-lined skink |
| *Eumeces laticeps* | Broadhead skink |
| *Eumerces egregius* | Mole skink |
| *Farancia abacura abacura* | Eastern mud snake |
| *Farancia erytrogramma* | Rainbow snake |
| *Gopherus polyphemus* **(SSC)** | Gopher tortoise |
| *Graptemys barbouri* **(SSC)** | Barbour's map turtle |
| *Heterodon platyrhinos* | Eastern hognose snake |
| *Heterodon simus* | Southern hognose snake |
| *Kinosternon subrubrum subrubrum* | Eastern mud turtle |
| *Lampropeltis calligaster rhombomaculata* | Mole kingsnake |
| *Lampropeltis getul n. subspecies* | Apalachicola kingsnake |
| *Lampropeltis getulus* | Common kingsnake |
| *Lampropeltis triangulum elapsoides* | Scarlet kingsnake |
| *Lepidochelys kempii* **(FE,SE)** | Kemp's ridley |
| *Macrochelys temmincki* **(SSC)** | Alligator snapping turtle |
| *Malaclemys terrapin* | Diamondback terrapin |
| *Masticophis flagellum flagellum* | Eastern coachwhip |
| *Micrurus fulvius fulvius* | Eastern coral snake |
| *Nerodia clarkii clarkii* | Gulf saltmarsh snake |
| *Nerodia cyclopion floridana* | Florida green watersnake |
| *Nerodia erythrogaster erythrogaster* | Redbelly watersnake |
| *Nerodia fasciata fasciata* | Banded watersnake |
| *Nerodia taxispilota* | Brown watersnake |
| *Opheodrys aestivus* | Rough green snake |
| *Ophisaurus attenuatus longicaudus* | Eastern slinder glass lizard |
| *Ophisaurus compressus* | Island glass lizard |
| *Ophisaurus ventralis* | Eastern glass lizard |
| *Pituophis melanoleucus mugitus* **(FT,SSC)** | Florida pine snake |
| *Pseudemys concinna suwanniensis* **(SSC)** | Suwannee cooter |
| *Pseudemys floridana floridana* | Florida cooter |
| *Pseudemys nelsoni* | Florida redbelly turtle |
| *Regina rigida* | Glossy water snake |
| *Regina septemvittata* | Queen snake |
| *Rhadinaea flavilata* | Pine woods snake |
| *Sceloporus undulatus undulatus* | Southern fence lizard |
| *Scincella lateralis* | Ground skink |
| *Seminatrix pygaea pygaea* | North florida swamp snake |
| *Sistrurus miliarius barbouri* | Dusky pigmy rattlesnake |
| *Sternotherus minor* | Loggerhead musk turtle |
| *Sternotherus odoratus* | Stinkpot |
| *Storeria dekayi wrightorum* | Midland brown snake |
| *Storeria occipitomaculata* | Redbelly snake |
| *Tantilla coronata* | Southeastern crowned snake |
| *Terrapene carolina major* | Gulf coast box turtle |
| *Thamnophis sauritus sauritus* | Eastern ribbon snake |
| *Thamnophis sirtalis sirtalis* | Eastern garter snake |
| *Trachemys scripta scripta* | Yellowbelly turtle |
| *Virginia striatula* | Rough earth snake |
| *Virginia valeria valerial* | Smooth earth snake |

## Appendix IV

# Fishes of the Apalachicola River & Bay Basin

| Scientific Name | Common Name |
|---|---|
| **Family: Achiridae** | |
| *Achirus lineatus* | Lined sole |
| *Trinectes maculatus* **(D)** | Hogchoker |
| **Family: Acipenseridae** | |
| *Acipenser oxyrynchus desotoi* **(FT,SSC;D)** | Gulf sturgeon |
| **Family: Amiidae** | |
| *Amia calva* | Bowfin |
| **Family: Anguilidae** | |
| *Anguilla rostrata* **(D)** | American eel |

| Scientific Name | Common Name |
|---|---|
| **Family: Antennariidae** | |
| *Antennarius radiosus* | Singlespot frogfish |
| **Family: Aphredoderidae** | |
| *Aphredoderus sayanus* | Pirate perch |
| **Family: Ariidae** | |
| *Ariopsis felis* | Hardhead catfish |
| *Bagre marinus* | Gaftopsail catfish |
| **Family: Atherinopsidae** | |
| *Labidesthes sicculus* | Brook silverside |
| *Membras martinica* | Rough silverside |
| *Menidia spp.* | Silverside |
| **Family: Balistidae** | |
| *Aluterus schoephi* | Orange filefish |
| *Aluterus scriptus* | Scrawled filefish |
| *Monocanthus ciliatus* | Fringed filefish |
| *Stephanolepis hispidus* | Planehead filefish |
| **Family: Batrachoididae** | |
| *Opsanus beta* | Gulf toadfish |
| *Porichthys plectrodon* | Atlantic midshipman |
| **Family: Belonidae** | |
| *Platybelone argalus* | Keeltail needlefish |
| *Strongylura marina* **(D)** | Atlantic needlefish |
| *Strongylura notata* | Redfin needlefish |
| *Strongylura timucu* | Timucu |
| *Tylosurus crocodilus* | Houndfish |
| **Family: Blenniidae** | |
| *Chasmodes sabarrae* | Florida blenny |
| *Hypeurochilus multifilis* | Crested blenny |
| *Hypsoblennius hentz* | Feather blenny |
| *Hypsoblennius ionthas* | Freckled blenny |
| *Paraclinus spp.* | Blenny |
| *Parablennius marmoreus* | Seaweed blenny |
| **Family: Bothidae** | |
| *Ancylopsetta quadrocellata* | Ocellated flounder |
| *Citharichthys macrops* | Spotted whiff |
| *Citharichthys spilopterus* | Bay whiff |
| *Etropus crossotus* | Fringed flounder |
| *Etropus cyclosquamus* | Shelf flounder |
| *Paralichthys albigutta* | Gulf flounder |
| *Paralichthys lethostigma* | Southern flounder |
| *Paralichthys squamilentus* | Broad flounder |
| **Family: Carangidae** | |
| *Caranx hippos* | Crevalle jack |
| *Caranx latus* | Horse-eye jack |
| *Chloroscombrus chrysurus* | Atlantic bumper |
| *Hemicaranx amblyrhynchus* | Bluntnose jack |
| *Oligoplites saurus* | Leather jacket |
| *Selene setapinnis* | Atlantic moonfish |
| *Selene vomer* | Lookdown |
| *Trachinotus carolinus* | Florida pompano |
| *Trachinotus falcatus* | Permit |
| **Family: Carcarhinidae** | |
| *Carcharhinus isodon* | Finetooth shark |
| *Carcharhinus leucas* | Bull shark |
| *Carcharhinus limbatus* | Blacktip shark |
| *Rhizoprionodon terraenovae* | Atlantic sharpnose shark |
| **Family: Catastomidae** | |
| *Carpoides cyprinus* | Quillback |
| *Erimyzon sucetta* | Lake chubsucker |
| *Minytrema melanops* | Spotted sucker |
| *Moxostoma spp.* **(E)** | Grayfin redhorse |
| **Family: Centrarchidae** | |
| *Ambloplites ariommus* | Shadow bass |
| *Centrarchus macropterus* | Flier |
| *Enneacanthus gloriosus* | Bluespotted sunfish |
| *Enneacanthus obesus* | Banded sunfish |
| *Lepomis auritus* | Redbreast sunfish |
| *Lepomis cyanellus* **(N)** | Green sunfish |
| *Lepomis gulosus* | Warmouth |
| *Lepomis humilus* **(N)** | Orange-spotted sunfish |
| *Lepomis macrochirus* | Bluegill |
| *Lepomis marginatus* | Dollar sunfish |
| *Lepomis microlophus* | Redear sunfish |
| *Lepomis punctatus* | Spotted sunfish |
| *Micropterus cataractae* **(SSC;E)** | Shoal bass |
| *Micropterus puntulatus* **(N)** | Spotted bass |
| *Micropterus salmoides* | Largemouth bass |
| *Pomoxis annularis* **(N)** | White crappie |
| *Pomoxis nigromaculatus* | Black crappie |
| **Family: Clupeidae** | |
| *Alosa alabamae* **(D)** | Alabama shad |
| *Alosa chrysochloris* **(D)** | Skipjack herring |
| *Brevoortia spp.* | Gulf menhaden |
| *Dorosoma cepedianum* | Gizzard shad |
| *Dorosoma petenense* | Threadfin shad |
| *Harangula jaguana* | Scaled sardine |
| *Opisthonema oglinum* | Atlantic thread herring |
| *Sardinella aurita* | Spanish sardine |
| **Family: Cynoglossidae** | |
| *Symphurus civitatium* | Offshore tonguefish |
| *Symphurus plagiusa* | Black cheeked tonguefish |
| **Family: Cyprinidae** | |
| *Ctenopharyngodon idella* **(N)** | Grass carp |
| *Cyprinella (Notropis) venustus* | Blacktail shiner |

| Scientific Name | Common Name |
|---|---|
| *Cyprinella callitaenia* **(E)** | Bluestripe shiner |
| *Cyprinella leedsi* | Bannerfin shiner |
| *Cyprinus carpio* **(N)** | Common carp |
| *Ericymba (Notropis) buccatus* | Silverjaw minnow |
| *Hybopsis (Notropis) winchelli* | Clear chub |
| *Luxilus zonistius* | Bandfin shiner |
| *Notemigonus crysoleucas* | Golden shiner |
| *Notropis chalybaeus* | Ironcolor shiner |
| *Notropis cummingsae* | Dusky shiner |
| *Notropis harperi* | Redeye chub |
| *Notropis hypselopterus* | Sailfin shiner |
| *Notropis hysilepis* | Highscale shiner |
| *Notropis longirostris* | Longnose shiner |
| *Notropis maculatus* | Taillight shiner |
| *Notropis petersoni* | Coastal shiner |
| *Notropis spp.* | Unidentified shiner |
| *Notropis texanus* | Weed shiner |
| *Notropis zonistius* **(E)** | Bandfin shiner |
| *Opsopoeodus (Notropis) emiliae* | Pugnose minnow |
| *Pteronotropis (Notropis) signipinnis* | Flagfin shiner |
| *Pteronotropis (Notropis) welaka* | Bluenose shiner |
| *Pteronotropis grandipinnis* | Apalachee shiner |
| *Semotilus atromaculatus* | Creek chub |
| *Semotilus thoreauianus* | Dixie chub |
| **Family: Cyprinodontidae** | |
| *Adina xenica* | Diamond killifish |
| *Cyprinodon variegatus* | Sheepshead minnow |
| **Family: Dasyatidae** | |
| *Dasyatis americana* | Southern stingray |
| *Dasyatis sabina* | Atlantic stingray |
| *Dasyatis say* | Bluntnose stingray |
| **Family: Diodontidae** | |
| *Chilomycterus schoepfi* | Striped burrfish |
| **Family: Echeneidae** | |
| *Echeneis naucrates* | Sharksucker |
| *Echeneis neucratoides* | Whitefin sharksucker |
| **Family: Elassomatidae** | |
| *Elassoma evergladei* | Everglades pygmy sunfish |
| *Elassoma okefenokee* | Okefenokee pygmy sunfish |
| *Elassoma zonatum* | Banded pygmy sunfish |
| **Family: Eleotridae** | |
| *Dormitator maculatus* | Fat sleeper |
| *Eleotris amblyopsis* | Large-scaled spinycheek sleeper |
| *Erotelis smaragdus* | Emerald sleeper |
| **Family: Elopidae** | |
| *Elops saurus* | Ladyfish |
| *Megalops atlanticus* | Tarpon |

| Scientific Name | Common Name |
|---|---|
| **Family: Engraulidae** | |
| *Anchoa cubana* | Cuban anchovy |
| *Anchoa hepsetus* | Bay anchovy |
| *Anchoa lyolepis* | Dusky anchovy |
| *Anchoa mitchilli* | Striped anchovy |
| **Family: Ephippidae** | |
| *Chaetodipterus faber* | Atlantic spadefish |
| **Family: Esocidae** | |
| *Esox americanus* | Redfin pickerel |
| *Esox niger* | Chain pickerel |
| **Family: Exocoetidae** | |
| *Hyporhamphus meeki* | American halfbeak |
| **Family: Fundulidae** | |
| *Fundulus chrysotus* | Golden topminnow |
| *Fundulus cingulatus* | Banded topminnow |
| *Fundulus confluentus* | Marsh killifish |
| *Fundulus disparotti* | Starhead topminnow |
| *Fundulus escambiae* | Russetfin topminnow |
| *Fundulus grandis* | Gulf killifish |
| *Fundulus lineolatus* | Lined topminnow |
| *Fundulus majalis* | Longnose killifish |
| *Fundulus olivaceus* | Blackspotted topminnow |
| *Fundulus similis* | Longnose killifish |
| *Leptolucania ommata* | Pygmy killifish |
| *Lucania goodei* | Bluefin killifish |
| *Lucania parva* | Rainwater killifish |
| **Family: Gerreidae** | |
| *Eucinostomus argenteus* | Spotfin mojarra |
| *Eucinostomus gula* | Silver jenny |
| *Eucinostomus harengulus* | Spotfin mojarra |
| **Family: Gobiesocidae** | |
| *Gobiesox strumosus* | Skilletfish |
| **Family: Gobiidae** | |
| *Bathygobius soporator* | Frillfin goby |
| *Ctenogobius schufeldti* | Freshwater goby |
| *Ctenogobius boleosoma* | Darter goby |
| *Gobioides broussonetii* | Violet goby |
| *Gobionellus oceanicus* | Sharptail goby |
| *Gobiosoma bosc* | Naked goby |
| *Gobiosoma longipala* | Twoscale goby |
| *Gobiosoma robustum* | Code goby |
| *Microgobius gulosus* | Clown goby |
| *Microgobius thallasinus* | Green goby |
| **Family: Gymnuridae** | |
| *Gymnura micrura* | Smooth butterfly ray |
| **Family: Haemulidae** | |
| *Haemulon plumierii* | White grunt |

| Scientific Name | Common Name |
|---|---|
| *Orthopristis chrysoptera* | Pigfish |
| **Family: Ictaluridae** | |
| *Ameiurus bruneus* | Snail bullhead |
| *Ameiurus catus* | White catfish |
| *Ameiurus natalis* | Yellow bullhead |
| *Ameiurus nebulosus* | Brown bullhead |
| *Ameiurus serracanthus* | Spotted bullhead |
| *Ictalurus catus* | White catfish |
| *Ictalurus furcatus* **(N)** | Blue catfish |
| *Ictalurus punctatus* | channel catfish |
| *Noturus funebris* | Black madtom |
| *Noturus gyrinus* | Tadpole madtom |
| *Noturus leptacanthus* | Speckled madtom |
| *Pylodictis olivaris* **(N)** | Flathead catfish |
| **Family: Labridae** | |
| *Halichoeres bivittatus* | Slippery dick |
| *Lachnolaimus maximus* | Hogfish |
| *Xyrichtys novacula* | Pearly razorfish |
| **Family: Lepisosteidae** | |
| *Lepisosteus oculatus* | Spotted gar |
| *Lepisosteus osseus* | Longnose gar |
| *Lepisosteus platyrhincus* | Florida gar |
| **Family: Lobotidae** | |
| *Lobotes surinamensis* | Tripletail |
| **Family: Lutjanidae** | |
| *Lutjanus campechanus* | Red snapper |
| *Lutjanus griseus* | Gray snapper |
| *Lutjanus synagris* | Lane snapper |
| **Family: Moronidae** | |
| *Morone chrysops* **(N)** | White bass |
| *Morone saxatalis* **(D)** | Striped bass |
| *Morone saxatalis x chrysops* | Sunshine bass |
| **Family: Mugilidae** | |
| *Agonostomus monticola* **(D)** | Mountain mullet |
| *Mugil cephalus* | Striped mullet |
| *Mugil curema* | White mullet |
| **Family: Myliobatidae** | |
| *Aetobatus narinari* | Spotted eagle ray |
| *Rhinoptera bonasus* | Cownosed ray |
| **Family: Narcinidae** | |
| *Narcine bancroftii* | Lesser electric ray |
| **Family: Orgocephalidae** | |
| *Ogcocephalus cubifrons* | Polka-dot batfish |
| *Ogcocephalus parvus* | Roughback batfish |
| **Family: Ophichthidae** | |
| *Myrophis punctatus* | Speckled worm eel |
| *Ophichthus gomesii* | Shrimp eel |

| Scientific Name | Common Name |
|---|---|
| **Family: Ophidiidae** | |
| *Ophidion holbrookii* | Bank cusk-eel |
| *Ophidion josephi* | Crested cusk-eel |
| **Family: Ostraciidae** | |
| *Acanthostracion quadricornis* | Scrawled cowfish |
| *Lactrophrys quadricornis* | Scrawled cowfish |
| *Lactrophrys trigonus* | Smooth trunkfish |
| **Family: Percidae** | |
| *Ammocrypta bifascia* | Florida sand darter |
| *Etheostoma edwini* | Brown darter |
| *Etheostoma fusiforme* | Swamp darter |
| *Etheostoma parvipinne* | Goldstripe darter |
| *Etheostoma swaini* | Gulf darter |
| *Perca flavescens* **(N)** | Yellow perch |
| *Percina nigrofasciata* | Black banded darter |
| *Sander canadense* **(N)** | Sauger |
| **Family: Petromyzontidae** | |
| *Ichthyomyzon gagei* | Southern brook lamprey |
| **Family: Phycidae** | |
| *Urophycis floridana* | Southern hake |
| *Urophycis regia* | Spotted hake |
| **Family: Poeciliidae** | |
| *Gambusia holbrooki* | Eastern mosquitofish |
| *Heterandria formosa* | Least killifish |
| *Poecilia lattipinna* | Sailfin molly |
| **Family: Polyodontidae** | |
| *Polydon spathula* **(N)** | Paddlefish |
| **Family: Pomatomidae** | |
| *Pomatomus saltatrix* | Bluefish |
| **Family: Priacanthidae** | |
| *Priacanthus arenatus* | Bigeye |
| **Family: Rachycentridae** | |
| *Rachycentron canadum* | Cobia |
| **Family: Rajidae** | |
| *Raja eglanteria* | Clearnose skate |
| **Family: Scaridae** | |
| *Nicholsina usta* | Emerald parrotfish |
| **Family: Sciaenidae** | |
| *Bairdiella chrysoura* | Silver perch |
| *Cynoscion arenarius* | Sand seatrout |
| *Cynoscion nebulosus* | Spotted seatrout |
| *Cynoscion nothus* | Trout |
| *Larimus fasciatus* | Banded drum |
| *Leiostomus xanthurus* | Spot |
| *Menticirrhus americanus* | Southern kingfish |
| *Menticirrhus littoralis* | Gulf kingfish |
| *Menticirrhus saxatilis* | Northern kingfish |

| Scientific Name | Common Name |
|---|---|
| *Micropogonias undulatus* | Atlantic croaker |
| *Pogonias cromis* | Black drum |
| *Sciaenops ocellatus* | Red drum |
| *Stellifer lanceolatus* | Star drum |
| **Family: Scombridae** | |
| *Scomberomorus maculatus* | Spanish mackerel |
| **Family: Scorpaenidae** | |
| *Scorpaena brasiliensis* | Barbfish |
| **Family: Serranidae** | |
| *Centropristis philadelphica* | Rock sea bass |
| *Centropristis striata* | Black sea bass |
| *Diplectrum bivittatum* | Dwarf sand perch |
| *Diplectrum formosum* | Sand perch |
| *Epinephelus morio* | Red grouper |
| *Mycteroperca microlepis* | Gag grouper |
| *Serraniculus pumilio* | Pygmy seabass |
| *Serranus subligarius* | Belted sandfish |
| **Family: Sparidae** | |
| *Archosargus probatocephalus* | Sheepshead |
| *Calamus arctifrons* | Grass porgy |
| *Diplodus holbrooki* | Spottail pinfish |
| *Lagodon rhomboides* | Pinfish |
| *Stenotomus caprinus* | Longspine porgy |
| **Family: Sphyraenidae** | |
| *Sphyraena barracuda* | Great barracuda |
| *Sphyraena borealis* | Northern sennet |
| *Sphyraena guachancho* | Guachancho |
| **Family: Sphyrnidae** | |
| *Sphyrna tiburo* | Bonnethead shark |
| **Family: Stromateidae** | |
| *Peprilus burti* | Gulf butterfish |
| *Peprilus paru* | Harvest fish |
| **Family: Syngnathidae** | |
| *Anarchopterus criniger* | Fringed pipefish |
| *Hippocampus erectus* | Lined seahorse |
| *Hippocampus zosterae* | Dwarf seahorse |
| *Syngnathus floridae* | Dusky pipefish |
| *Syngnathus louisianae* | Chain pipefish |
| *Syngnathus scovelli* | Gulf pipefish |
| **Family: Synodontidae** | |
| *Synodus foetens* | Inshore lizzardfish |
| **Family: Tetradontidae** | |
| *Sphoeroides nephelus* | Southern puffer |
| *Sphoeroides parvus* | Least puffer |
| **Family: Trichiuridae** | |
| *Trichiurus lepturus* | Atlantic cutlassfish |
| **Family: Triglidae** | |
| *Prionotus longispinosus* | Bigeye searobin |
| *Prionotus rubio* | Blackwing searobin |
| *Prionotus scitulus* | Leopard searobin |
| *Prionotus tribulus* | Bighead searobin |
| **Family: Uranoscopidae** | |
| *Astroscopus y-graecum* | Southern stargazer |

## Appendix V

# Birds of the Apalachicola River & Bay Basin

| Scientific Name | Common Name |
|---|---|
| **Family: Accipitridae** | |
| *Accipiter cooperii* | Cooper's hawk |
| *Accipiter striatus* | Sharp-shinned hawk |
| *Aquila chrysaetos* **(A)** | Golden eagle |
| *Buteo brachyurus* **(A)** | Short-tailed hawk |
| *Buteo jamaicensis* | Red-tailed hawk |
| *Buteo lagopus* **(A)** | Rough-legged hawk |
| *Buteo lineatus* | Red-shouldered hawk |
| *Buteo platypterus* | Broad-winged hawk |
| *Circus cyaneus* | Northern harrier |
| *Elanoides forficatus* | Swallow-tailed kite |
| *Falco columbarius* | Merlin |
| *Falco peregrinus* **(SE)** | Peregrine falcon |
| *Falco sparverius* | American kestrel |
| *Falco sparverius paulus* **(ST)** | Southeastern kestrel |
| *Haliaeetus leucocephalus* **(ST)** | Bald eagle |
| *Ictinia mississippiensis* | Mississippi kite |
| *Pandion haliaetus* | Osprey |
| **Family: Alcedinidae** | |
| *Ceryle alcyon* | Belted kingfisher |
| **Family: Anatidae** | |
| *Aix sponsa* | Wood duck |
| *Anas acuta* | Northern pintail |
| *Anas americana* | American wigeon |
| *Anas clypeata* | Northern shoveler |
| *Anas crecca* | Green-winged teal |
| *Anas discors* | Blue-winged teal |
| *Anas fulvigula* | Mottled duck |
| *Anas platyrhynchos* | Mallard |
| *Anas rubripes* | American black duck |
| *Anas strepera* | Gadwall |
| *Aythya affinis* | Lesser scaup |
| *Aythya americana* | Redhead |
| *Aythya collaris* | Ring-necked duck |
| *Aythya marila* | Greater scaup |

| Scientific Name | Common Name |
|---|---|
| *Aythya valisineria* | Canvasback |
| *Branta canadensis* | Canada goose |
| *Bucephala albeola* | Bufflehead |
| *Bucephala clangula* | Common goldeneye |
| *Chen caerulescens* | Snow goose |
| *Clangula hyemalis* | Long-tailed duck |
| *Dendrocygna bicolor* | Fulvous whistling-duck |
| *Lophodytes cucullatus* | Hooded merganser |
| *Melanitta fusca* | White-winged scoter |
| *Melanitta nigra* | Black scoter |
| *Melanitta perspicillata* | Surf scoter |
| *Mergus serrator* | Red-breasted merganser |
| *Oxyura jamaicensis* | Ruddy duck |
| **Family: Anhingidae** | |
| *Anhinga anhinga* | Anhinga |
| **Family: Apodidae** | |
| *Chaetura pelagica* | Chimmey swift |
| *Chaetura vauxi* **(A)** | Vaux's Swift |
| **Family: Aramidae** | |
| *Aramus guarauna* **(SSC)** | Limpkin |
| **Family: Ardeidae** | |
| *Ardea alba* | Great egret |
| *Ardea herodias* | Great blue heron |
| *Botaurus lentiginosus* | American bittern |
| *Bubulcus ibis* | Cattle egret |
| *Butorides striatus* | Green-backed heron |
| *Egretta caerulea* **(SSC)** | Little blue heron |
| *Egretta rufescens* **(SSC)** | Reddish egret |
| *Egretta thula* **(SSC)** | Snowy egret |
| *Egretta tricolor* **(SSC)** | Tricolored heron |
| *Ixobrychus exilis* | Least bittern |
| *Nycticorax nycticorax* | Black-crowned night-heron |
| *Nycticorax violaceus* | Yellow-crowned night-heron |
| **Family: Bombycillidae** | |
| *Bombycilla cedrorum* | Cedar waxwing |
| **Family: Caprimulgidae** | |
| *Caprimulgus carolinensis* | Chuck-will's widow |
| *Caprimulgus vociferus* | Whip-poor-will |
| *Chordeiles acutipennis* | Lesser nighthawk |
| *Chordeiles minor* | Common nighthawk |
| **Family: Cardinalidae** | |
| *Cardinalis cardinalis* | Northern cardinal |
| *Guiraca caerulea* | Blue grosbeak |
| *Passerina ciris* | Painted bunting |
| *Passerina cyanea* | Indigo bunting |
| *Pheucticus ludovicianus* | Rose-breasted grosbeak |
| *Pheucticus melanocephalus* **(A)** | Black-headed grosbeak |

| Scientific Name | Common Name |
|---|---|
| *Spiza americana* | Dickcissel |
| **Family: Catharticdae** | |
| *Cathartes aura* | Turkey vulture |
| *Coragyps atratus* | Black vulture |
| **Family: Certhiidae** | |
| *Certhia americana* | Brown creeper |
| **Family: Charadriidae** | |
| *Charadrius a.tenuirostris* **(ST)** | Southeastern snowy plover |
| *Charadrius alexandrinus* **(ST)** | Snowy plover |
| *Charadrius melodus* **(FT,ST)** | Piping plover |
| *Charadrius semiplamatus* | Semipalmated plover |
| *Charadrius vociferus* | Killdeer |
| *Charadrius wilsonia* | Wilson's plover |
| *Pluvialis dominica* | American golden-plover |
| *Pluvialis squatarola* | Black-bellied plover |
| **Family: Ciconiidae** | |
| *Mycteria americana* **(FE,SE)** | Wood stork |
| **Family: Columbidae** | |
| *Columbia livia* **(N)** | Rock pigeon |
| *Columbina passerina* | Common ground-dove |
| *Streptopelia decaocto* **(N)** | Eurasian collared-dove |
| *Zenaida asiatica* | White-winged dove |
| *Zenaida macroura* | Mourning dove |
| **Family: Corvidae** | |
| *Corvus brachyrhynchos* | American crow |
| *Corvus ossifragus* | Fish crow |
| *Cyanocitta cristata* | Blue jay |
| **Family: Cuculidae** | |
| *Coccyzus americanus* | Yellow-billed cuckoo |
| *Coccyzus erythropthalmus* | Black-billed cuckoo |
| *Coccyzus minor* **(A)** | Mangrove cuckoo |
| *Crotophaga sulcirostris* | Groove-billed ani |
| **Family: Emberizidae** | |
| *Aimophila aestivalis* | Bachman's sparrow |
| *Ammodramus caudacutus* | Saltmarsh sharp-tailed sparrow |
| *Ammodramus henslowii* | Henslow's sparrow |
| *Ammodramus leconteii* | LeConte's sparrow |
| *Ammodramus m. junciolus* **(SSC)** | Wakulla seaside sparrow |
| *Ammodramus maritimus* | Seaside sparrow |
| *Ammodramus nelsoni* | Nelson's sharp-tailed sparrow |
| *Ammodramus savannarum* | Grasshopper sparrow |
| *Chondestes grammacus* | Lark sparrow |
| *Junco hyemalis* | Dark-eyed junco |
| *Melospiza georgiana* | Swamp sparrow |
| *Melospiza lincolnii* | Lincoln's sparrow |
| *Melospiza melodia* | Song sparrow |

A

| Scientific Name | Common Name |
|---|---|
| *Passerculus sandwichensis* | Savannah sparrow |
| *Passerella iliaca* | Fox sparrow |
| *Pipilo erythrophthalmus* | Eastern towhee |
| *Plectrophenax nivalis* **(A)** | Snow bunting |
| *Pooecetes gramineus* | Vesper sparrow |
| *Spizella pallida* | Clay-colored sparrow |
| *Spizella passerina* | Chipping sparrow |
| *Spizella pusilla* | Field sparrow |
| *Zonotrichia albicollis* | White-throated sparrow |
| *Zonotrichia leucophrys* | White-crowned sparrow |
| **Family: Fregatidae** | |
| *Fregata magnificens* | Magnificent frigatebird |
| **Family: Fringillidae** | |
| *Carduelis pinus* | Pine siskin |
| *Carduelis tristis* | American goldfinch |
| *Carpodacus purpureus* | Purple finch |
| *Carpodacus purpureus* **(N)** | House finch |
| **Family: Gaviidae** | |
| *Gavia immer* | Common loon |
| *Gavia pacifica* | Pacific loon |
| *Gavia stellata* | Red-throated loon |
| **Family: Gruidae** | |
| *Grus canadensis* **(A)** | Sandhill crane |
| *Grus c. pratensis* **(ST; A)** | Florida sandhill crane |
| **Family: Haematopodidae** | |
| *Haematopus palliatus* **(SSC)** | American oystercatcher |
| **Family: Hirundinidae** | |
| *Hirundo rustica* | Barn swallow |
| *Petrochelidon fulva* | Cave swallow |
| *Petrochelidon pyrrhonota* | Cliff swallow |
| *Progne subis* | Purple martin |
| *Riparia riparia* | Bank swallow |
| *Stelgidopteryx serripennis* | Northern rough-winged swallow |
| *Tachycineta bicolor* | Tree swallow |
| **Family: Icteridae** | |
| *Agelaius phoeniceus* | Red-winged blackbird |
| *Dolichonyx oryzivorus* | Bobolink |
| *Euphagus carolinus* | Rusty blackbird |
| *Euphagus cyanocephalus* | Brewer's blackbird |
| *Icterus galbula* | Baltimore oriole |
| *Icterus spurius* | Orchard oriole |
| *Molothrus aeneus* **(A)** | Bronzed cowbird |
| *Molothrus ater* | Brown-headed cowbird |
| *Molothrus bonariensis* **(A)** | Shiny cowbird |
| *Quiscalus major* | Boat-tailed grackle |
| *Quiscalus quiscula* | Common grackle |

| Scientific Name | Common Name |
|---|---|
| *Sturnella magna* | Eastern meadowlark |
| *Xanthocephalus xanthocephalus* | Yellow-headed blackbird |
| **Family: Laniidae** | |
| *Lanius ludovicianus* | Loggerhead shrike |
| **Family: Laridae** | |
| *Chlidonias niger* | Black tern |
| *Gelochelidon nilotica* | Gull-billed tern |
| *Hydroprogne caspia* | Caspian tern |
| *Larus argentatus* | Herring gull |
| *Larus atricilla* | Laughing gull |
| *Larus delawarensis* | Ring-billed gull |
| *Larus fuscus* | Lesser black-backed gull |
| *Larus marinus* | Great black-backed gull |
| *Larus philadelphia* | Bonaparte's gull |
| *Larus pipixcan* | Franklin's gull |
| *Onychoprion fuscata* | Sooty tern |
| *Rynchops niger* **(SSC)** | Black skimmer |
| *Stercorarius parasiticus* | Parasitic jaeger |
| *Stercorarius pomarinus* | Pomarine jaeger |
| *Sterna antillarum* **(ST)** | Least tern |
| *Sterna forsteri* | Forster's tern |
| *Sterna hirundo* | Common tern |
| *Sterna paradisaea* **(A)** | Arctic tern |
| *Thalasseus maxima* | Royal tern |
| *Thalasseus sandvicensis* | Sandwich tern |
| **Family: Mimidae** | |
| *Dumetella carolinensis* | Gray catbird |
| *Mimus polyglottos* | Northern mockingbird |
| *Toxostoma rufum* | Brown thrasher |
| **Family: Motacillidae** | |
| *Anthus spargueii* | Sprague's pipit |
| *Anthus spinoletta* | American pipit |
| **Family: Paridae** | |
| *Baeolophus bicolor* | Tufted titmouse |
| *Peocile carolinensis* | Carolina chickadee |
| **Family: Parulidae** | |
| *Dendroica caerulescens* | Black-throated blue warbler |
| *Dendroica castanea* | Bay-breasted warbler |
| *Dendroica cerulea* | Cerulean warbler |
| *Dendroica coronata* | Yellow-rumped warbler |
| *Dendroica d. stoddardi* | Stoddard's yellow-throated warbler |
| *Dendroica discolor* | Prairie warbler |
| *Dendroica dominica* | Yellow-throated warbler |
| *Dendroica fusca* | Blackburnian warbler |
| *Dendroica magnolia* | Magnolia warbler |
| *Dendroica palmarum* | Palm warbler |

| Scientific Name | Common Name |
|---|---|
| *Dendroica pensylvanica* | Chestnut-sided warbler |
| *Dendroica petechia* | Yellow warbler |
| *Dendroica pinus* | Pine warbler |
| *Dendroica striata* | Blackpoll warbler |
| *Dendroica tigrina* | Cape May warbler |
| *Dendroica virens* | Black-throated green warbler |
| *Geothlypis trichas* | Common yellowthroat |
| *Helmitheros vermivorus* | Worm-eating warbler |
| *Icteria virens* | Yellow-breasted chat |
| *Limnothlypis swainsonii* | Swainson's warbler |
| *Mniotilta varia* | Black-and-white warbler |
| *Oporornis agilis* | Connecticut warbler |
| *Oporornis formosus* | Kentucky warbler |
| *Parula americana* | Northern parula |
| *Protonotaria citrea* | Prothonotary warbler |
| *Seiurus aurocapillus* | Ovenbird |
| *Seiurus motacilla* | Louisiana waterthrush |
| *Seiurus noveboracensis* | Northern waterthrush |
| *Setophaga ruticilla* | American redstart |
| *Vermivora celata* | Orange-crowned warbler |
| *Vermivora chrysoptera* | Golden-winged warbler |
| *Vermivora peregrina* | Tennessee warbler |
| *Vermivora pinus* | Blue-winged warbler |
| *Vermivora ruficapilla* | Nashville warbler |
| *Wilsonia canadensis* | Canada warbler |
| *Wilsonia citrina* | Hooded warbler |
| *Wilsonia pusilla* | Wilson's warbler |
| **Family: Passeridae** | |
| *Passer domesticus* | House sparrow |
| **Family: Pelecanidae** | |
| *Pelecanus erythrorhynchos* | American white pelican |
| *Pelecanus occidentalis* **(SSC)** | Brown pelican |
| **Family: Phalacrocoracidae** | |
| *Phalacrocorax auritus* | Double-crested cormorant |
| **Family: Phasianidae** | |
| *Colinus virginianus* | Northern bobwhite |
| *Meleagris gallopavo* | Wild turkey |
| **Family: Picidae** | |
| *Colaptes auratus* | Northern flicker |
| *Dryocopus pileatus* | Pileated woodpecker |
| *Melanerpes carolinus* | Red-bellied woodpecker |
| *Melanerpes erythrocephalus* | Red-headed woodpecker |
| *Picoides borealis* **(FE,SSC)** | Red-cockaded woodpecker |
| *Picoides pubescens* | Downy woodpecker |
| *Picoides villosus* | Hairy woodpecker |
| *Sphyrapicus varius* | Yellow-bellied sapsucker |
| **Family: Podicipedidae** | |

| Scientific Name | Common Name |
|---|---|
| *Podiceps auritus* | Horned grebe |
| *Podiceps nigricollis* | Eared grebe |
| *Podilymbus podiceps* | Pied-billed grebe |
| **Family: Rallidae** | |
| *Coturnicops noveboracensis* **(A)** | Yellow rail |
| *Fulica americana* | American coot |
| *Gallinula chloropus* | Common moorhen |
| *Laterallus jamaicensis* | Black rail |
| *Porphyrula martinica* | Purple gallinule |
| *Porzana carolina* | Sora |
| *Rallus elegans* | King rail |
| *Rallus l. scotti* | Florida clapper rail |
| *Rallus limicola* | Virginia rail |
| *Rallus longirostris* | Clapper rail |
| **Family: Recurvirostridae** | |
| *Himantopus mexicanus* | Black-necked stilt |
| *Recurvirostra americana* | American avocet |
| **Family: Regulidae** | |
| *Regulus calendula* | Ruby-crowned kinglet |
| *Regulus satrapa* | Golden-crowned kinglet |
| **Family: Scolopacidae** | |
| *Actitis macularia* | Spotted sandpiper |
| *Arenaria interpres* | Ruddy turnstone |
| *Bartramia longicauda* | Upland sandpiper |
| *Calidris alba* | Sanderling |
| *Calidris alpina* | Dunlin |
| *Calidris bairdii* | Baird's sandpiper |
| *Calidris canutus* | Red knot |
| *Calidris fuscicollis* | White-rumped sandpiper |
| *Calidris himantopus* | Stilt sandpiper |
| *Calidris mauri* | Western sandpiper |
| *Calidris melanotos* | Pectoral sandpiper |
| *Calidris minutilla* | Least sandpiper |
| *Calidris pusilla* | Semipalmated sandpiper |
| *Gallinago gallinago* | Common snipe |
| *Limnodromus griseus* | Short-billed dowitcher |
| *Limnodromus scolopaceus* | Long-billed dowitcher |
| *Limosa fedoa* | Marbled godwit |
| *Numenius americanus* | Long-billed curlew |
| *Numenius phaeopus* | Whimbrel |
| *Phalaropus tricolor* | Wilson's phalarope |
| *Scolopax minor* | American woodcock |
| *Tringa flavipes* | Lesser yellowlegs |
| *Tringa melanoleuca* | Greater yellowlegs |
| *Tringa semipalmata* | Willet |
| *Tringa solitaria* | Solitary sandpiper |

| Scientific Name | Common Name |
|---|---|
| *Tryngites subruficollis* | Buff-breasted sandpiper |
| **Family: Sittidae** | |
| *Sitta canadensis* | Red-breasted nuthatch |
| *Sitta carolinensis* | White-breasted nuthatch |
| *Sitta pusilla* | Brown-headed nuthatch |
| **Family: Sturnidae** | |
| *Sturnus vulgaris* **(N)** | European starling |
| **Family: Sulidae** | |
| *Morus bassanus* | Northern gannet |
| *Sula leucogaster* | Brown booby |
| **Family: Sylviidae** | |
| *Polioptila caerulea* | Blue-gray gnatcatcher |
| **Family: Thraupidae** | |
| *Piranga ludoviciana* | Western tanager |
| *Piranga olivacea* | Scarlet tanager |
| *Piranga rubra* | Summer tanager |
| **Family: Threskiornithidae** | |
| *Ajaia ajaja* | Roseate spoonbill |
| *Eudocimus albus* **(SSC)** | White ibis |
| *Plegadis falcinellus* | Glossy ibis |
| **Family: Trochilidae** | |
| *Archilochus alexandri* | Black-chinned hummingbird |
| *Archilochus colubris* | Ruby-throated hummingbird |
| *Amazilia yucatanensis* | Buff-bellied hummingbird |
| *Selasphorus rufus* | Rufous hummingbird |
| **Family: Troglogytidae** | |
| *Cistothorus p. marianae* **(SSC)** | Marian's marsh wren |
| *Cistothorus palustris* | Marsh wren |
| *Cistothorus platensis* | Sedge wren |
| *Thryothorus ludovicianus* | Carolina wren |
| *Troglodytes aedon* | House wren |
| *Troglodytes troglodytes* | Winter wren |
| **Family: Turdidae** | |
| *Catharus fuscescens* | Veery |
| *Catharus guttatus* | Hermit thrush |
| *Catharus minimus* | Gray-cheeked thrush |
| *Catharus ustulatus* | Swainson's thrush |
| *Hylocichla mustelina* | Wood thrush |
| *Sialia sialis* | Eastern bluebird |
| *Turdus migratorius* | American robin |
| **Family: Tyrannidae** | |
| *Contopus virens* | Eastern wood-pewee |
| *Empidonax flaviventris* | Yellow-bellied flycatcher |
| *Empidonax minimus* | Least flycatcher |
| *Empidonax traillii* | Willow flycatcher |
| *Empidonax virescens* | Acadian flycatcher |
| *Myiarchus cinerascens* | Ash-throated flycatcher |
| *Myiarchus crinitus* | Great crested flycatcher |
| *Pyrocephalus rubinus* | Vermilion flycatcher |
| *Sayornis phoebe* | Eastern phoebe |
| *Tyrannus dominicensis* | Gray kingbird |
| *Tyrannus forficatus* | Scissor-tailed flycatcher |
| *Tyrannus melancholicus* **(A)** | Tropical kingbird |
| *Tyrannus tyrannus* | Eastern kingbird |
| *Tyrannus verticalis* | Western kingbird |
| **Family: Tytonidae** | |
| *Asio flammeus* **(A)** | Short-eared owl |
| *Bubo scandiaca* **(A)** | Snowy owl |
| *Bubo virginianus* | Great horned owl |
| *Otus asio* | Eastern screech-owl |
| *Strix varia* | Barred owl |
| *Tyto alba* | Barn-owl |
| **Family: Vireonidae** | |
| *Vireo altiloquus* | Black-whiskered vireo |
| *Vireo bellii* | Bell's vireo |
| *Vireo flavifrons* | Yellow-throated vireo |
| *Vireo griseus* | White-eyed vireo |
| *Vireo olivaceus* | Red-eyed vireo |
| *Vireo philadelphicus* | Philadelphia vireo |
| *Vireo solitarius* | Blue-headed vireo |

## Appendix VI

# Mammals of the Apalachicola River & Bay Basin

| Scientific Name | Common Name |
|---|---|
| *Blarina carolinensis* | Southern short-tailed shrew |
| *Canis latrans* | Coyote |
| *Canis rufus* | Red wolf |
| *Castor canadensis* | American beaver |
| *Cervus unicolor* | Sambar deer |
| *Cryptotis parva* | Least shrew |
| *Dasypus novemcinctus* **(N)** | Nine-banded armadillo |
| *Didelphis virginiana* | Virginia opossum |
| *Eptesicus fuscus* | Big brown bat |
| *Geomys pinetus* | Southeastern pocket gopher |
| *Glaucomys volans* | Southern flying squirrel |
| *Lasirus intermedius* | Yellow bat |
| *Lasiurus borealis* | Eastern red bat |
| *Lasiurus cinereus* | Hoary bat |
| *Lasiurus seminolus* | Seminole bat |
| *Lontra canadensis* | Northern river otter |

| Scientific Name | Common Name |
|---|---|
| *Lynx rufus* | Bobcat |
| *Mephitis mephitis* | Striped skunk |
| *Microtus pinetorum* | Woodland pine vole |
| *Mus musculus* | House mouse |
| *Mustela frenata* | Long-tailed weasel |
| *Mustela vison* | Mink |
| *Myotis grisescens* **(FE,SE)** | Gray bat |
| *Myotis sodalis* **(FE,SE)** | Indiana bat |
| *Myotis austroriparius* | Southern bat myotis |
| *Myotis keeni* | Keen's myotis |
| *Neofiber alleni* | Round-tailed muskrat |
| *Neotoma floridana* | Florida woodrat |
| *Nycticeius humeralis* | Evening bat |
| *Ochrotomys nuttalli* | Golden mouse |
| *Odocoileus virginianus* | White-tailed deer |
| *Oryzomys palustris* | Marsh rice rat |
| *Peromyscus gossypinus* | Cotton mouse |
| *Peromyscus polionotus* | Oldfield mouse |
| *Pipistrellus subflavus* | Eastern pipistrelle |
| *Plecotus rafinesquii* | Rafinesque's big-eared bat |
| *Podomys floridanus* **(SSC)** | Florida mouse |

| Scientific Name | Common Name |
|---|---|
| *Procyon lotor* | Raccoon |
| *Rattus norvegicus* **(N)** | Brown Norway rat |
| *Rattus rattus* | Black rat |
| *Reithrodontomys humulis* | Eastern harvest mouse |
| *Scalopus aquaticus* | Eastern shrew |
| *Sciurus carolinensis* | Gray squirrel |
| *Sciurus niger* | Fox squirrel |
| *Sigmodon hispidus* | Hispid cotton rat |
| *Sorex longirostris* | Southeastern shrew |
| *Spilogale putorius* | Eastern spotted skunk |
| *Sus scrofa* | Feral pig |
| *Sylvilagus floridanus* | Eastern cottontail |
| *Sylvilagus palustris* | Marsh rabbit |
| *Tadarida brasiliensis* **(N)** | Mexican-Brazilian free-tailed bat |
| *Trichechus manatus latirostris* **(FE,SE)** | West Indian manatee |
| *Tursiops truncatus* | Atlantic bottle-nosed dolphin |
| *Urocyon cinereoargenteus* | Gray fox |
| *Ursus americanus floridanus* **(ST)** | Black bear |
| *Vulpes vulpes* | Red fox |

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