Chapter 2
Northwest Florida

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Description of the region

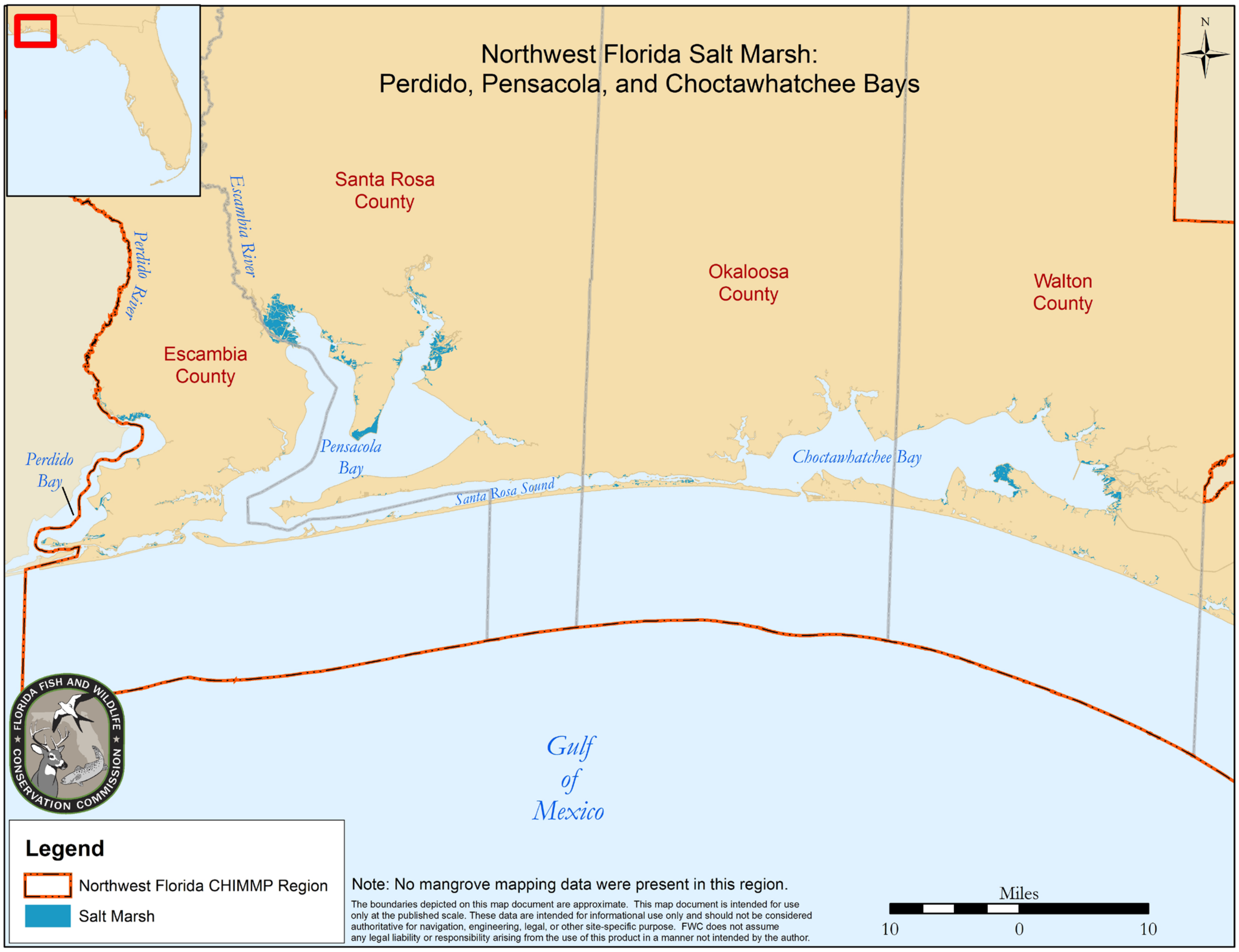
The numerous bays, peninsulas, barrier islands, and tidal creeks along the coast of northwest Florida create a circuitous coastline that provides extensive habitat for coastal wetlands (Figures 2.1 and 2.2). The region is characterized by low elevation and gentle topography. Variable past sea levels have left behind relict bars and dunes, and the predominantly sandy soils are moderately to poorly drained (FDEP 2008). The shoreline is dynamic; wave action, particularly that from tropical storms and hurricanes, continually reshapes the coastline and barrier islands. Salt marshes line the edges of bays and the shoreward side of barrier islands, where they are protected from Gulf of Mexico wave energy. In addition to providing habitat to a large array of animals, salt marshes also help stabilize the barrier islands and bay shorelines. The extensive seagrass beds found in many of the bays are made possible, in part, by the filtration of terrestrial runoff by salt marshes.

Marshes found in northwest Florida include freshwater, brackish, and salt marshes. Salt marsh vegetation is dominated by *Juncus roemerianus* (black needlerush), *Spartina alterniflora* (saltmarsh cordgrass), *Spartina patens* (saltmeadow hay or cordgrass), and *Distichlis spicata* (salt grass) (Livingston 1984, Handley et al. 2013, ANERR 2014). The transitional zone includes *S. patens*, *Sarcocornia ambigua* (perennial glasswort), *Scirpus pungens* (three-square bulrush), and *Baccharis* spp. (sea myrtle/groundsel shrubs) (Edmiston 2008, ANERR 2014). Inland oligohaline and freshwater marshes are dominated by *Scirpus* spp. (bulrushes), *Cladium jamaicense* (sawgrass), *Phragmites australis* (common reed), and *Typha* spp. (cattails) (FDEP 2012a, Handley et al. 2013, ANERR 2014).

Freezing temperatures in the winter limit the extensive proliferation of mangrove forests along the coast of northwest Florida. Mangrove trees, particularly the more cold-tolerant *Avicennia germinans* (black mangrove), do occur individually and in small clusters, but heavy freezes periodically cause massive diebacks. Cold winters in the 1980s led to 95–98% mortality of the mangroves in the northern Gulf, but more recently cold events have been less frequent, which has led to an expansion of mangroves in the area (Saintilan et al. 2014).

Northwest Florida has less urban development than southern Florida, but certain regions are growing rapidly in popularity as tourist destinations and retirement communities. Important economic components include fishing, shellfish harvesting, tourism, the military, agriculture, and forestry (Handley et al. 2013, ANERR 2014).

Subterranean water sources include the Floridan aquifer, the sand-and-gravel aquifer, and the surficial aquifer system. The watersheds of northwest Florida contain a high density of streams and extend north into portions of Georgia and Alabama. While the rivers have comparatively few flow-altering structures, the bays have been altered by shipping channels and by the opening and stabilization of tidal inlets to the Gulf. The U.S. Army Corps



Note: No mangrove mapping data were present in this region.

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Figure 2.1. Salt marsh extent in northwest Florida. Data source: NWFWMD 2009–2010 land use/land cover data, based on FLUCCS classifications (FDOT 1999, NWFWMD 2010).

of Engineers constructed the Gulf Intracoastal Waterway around 1950, creating inland connections between Choctawhatchee Bay, St. Andrew Bay, Lake Wimico, and Apalachicola Bay (Brin and Handley 2007).

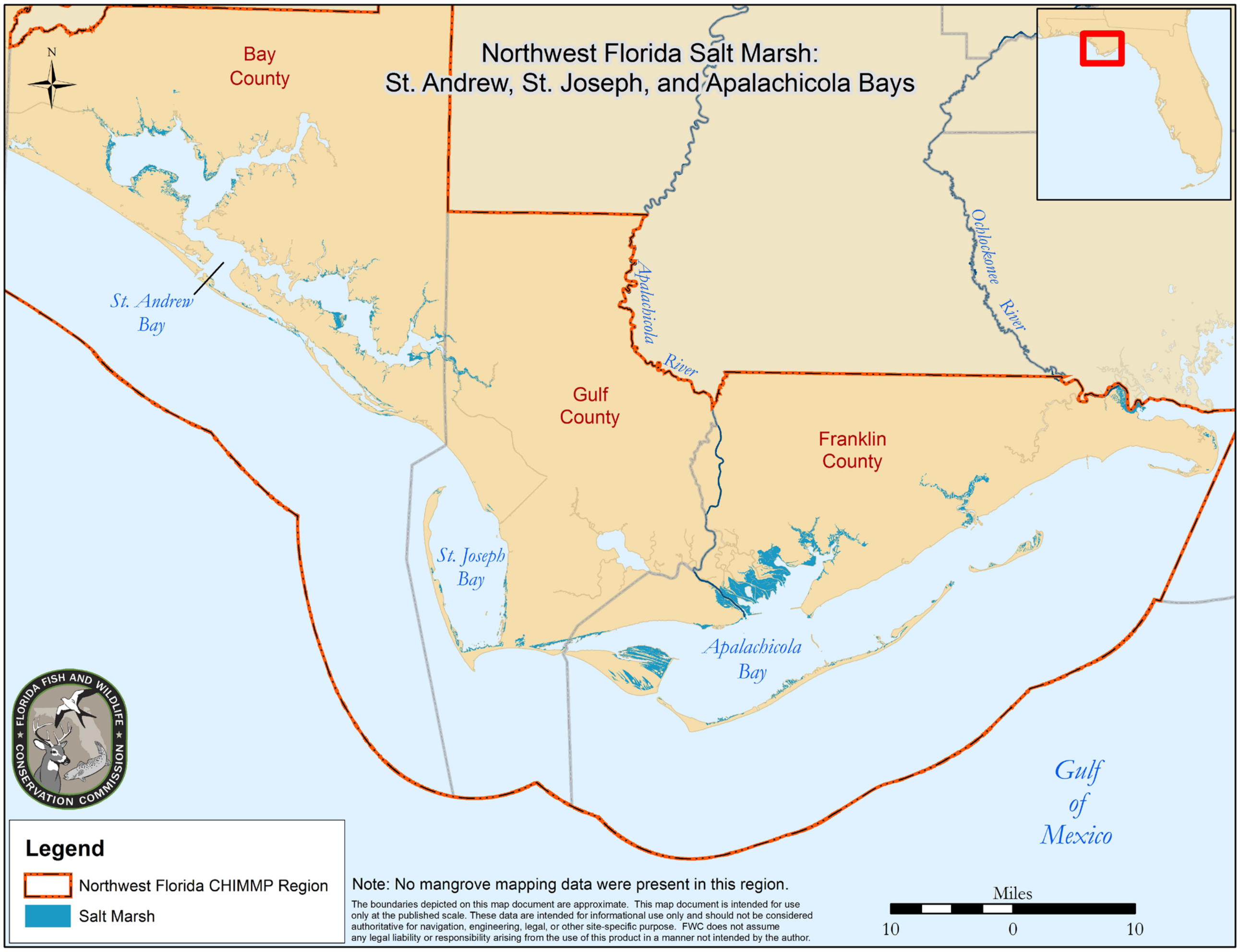
Perdido Bay

Perdido Bay lies on the border between Florida and Alabama and receives freshwater flow from the Perdido River (Figures 2.1 and 2.3). Extensive development lines the barrier islands and shorelines near the mouth of Perdido Bay. *J. roemerianus* salt marshes are found lining the shoreline of Tarkiln Bayou and along the mouth of the Perdido River. According to historical photos, Perdido Key once had a large area of salt marsh, much of which has been lost to erosion, leaving only an intermittent stretch of salt marsh just 1–4 ft (0.3–1.2 m) wide (FDEP 2006).

Overall, the watershed has fairly good water quality, with the exception of some point-source discharges into Elevenmile Creek and nonpoint-source discharges along development on the southern end (NWFWMD 2006a). High nutrient levels, biological oxygen demand, and coliform bacteria stemming from both point- and nonpoint-source pollution are the region's most common water quality problems (FDEP 2006).

Pensacola Bay System

The Pensacola Bay System includes Santa Rosa Sound, Pensacola, Blackwater, East, and Escambia Bays and several bayous (Figures 2.1 and 2.3). The bay receives freshwater flow from the Escambia, Conecuh, Blackwater, and Yellow rivers. More than 70% of the watershed is forested; the remainder contains agriculture and urban development (FDEP 2012a). The northern and eastern regions of Pensacola Bay are shallow (average depth 10 ft/3 m) and are often stratified (FDEP 2012a). *J. roemerianus* and *S. alterniflora* salt marshes proliferate in the lower reaches of the river flood plains. The bay opens to the Gulf of Mexico at the half-mile-wide Pensacola Pass.



Note: No mangrove mapping data were present in this region.

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Figure 2.2. Salt marsh extent in northwest Florida. Data source: NWFWMD 2009-2010 land use/land cover data, based on FLUCCS classifications (FDOT 1999, NWFWMD 2010).

Discharge of wastewater into Pensacola Bay was a large problem from the 1950s through the 1970s, but water quality has improved significantly since passage of the Clean Water Act and implementation of best land-use practices (USEPA 2004, FDEP 2012a). Water quality concerns continue regarding nutrients, chlorophyll, and clarity near Pensacola and other urban areas (USEPA 2004). Wetlands have been subject to fragmentation and conversion to other land-use types along with secondary impacts of neighboring development (NWFWMD 2006a). From 1979 through 1996, the Pensacola Bay System lost 7% (2000 acres/809 ha) of surrounding wetland habitat to coastal development, sea-level rise, coastal subsidence, and erosion (USEPA 2004).

Choctawhatchee Bay

The primary source of freshwater to Choctawhatchee Bay is the Choctawhatchee River, the watershed of which extends north into Alabama (Figures 2.1 and 2.4). Salinity fluctuates with input from the river, and the bay is generally stratified with a halocline (Ruth and Handley 2007). Choctawhatchee Bay connects to Santa Rosa Sound, the Gulf Intracoastal Waterway, and to the Gulf at the relatively small East Pass. Historically the pass only opened intermittently, but it was dredged in 1929 to provide relief from flooding and the Corps of Engineers has maintained the pass since then to keep it open (Ruth and Handley 2007). After the East Pass was opened, higher salinities, stratification, and altered erosion patterns resulted in the loss of salt marsh and seagrasses in the bay (Livingston 2014). These changes may help explain why the salt marsh fringe of Choctawhatchee Bay is less extensive than that in other bays in northwest Florida (Reyer et al. 1988, Livingston 2014).

The human population is growing rapidly around Choctawhatchee Bay, frequently outpacing statewide growth rates (Ruth and Handley 2007, U.S. Census 2015). Development is increasing in association with businesses supporting Eglin Air Force Base and with an increasingly

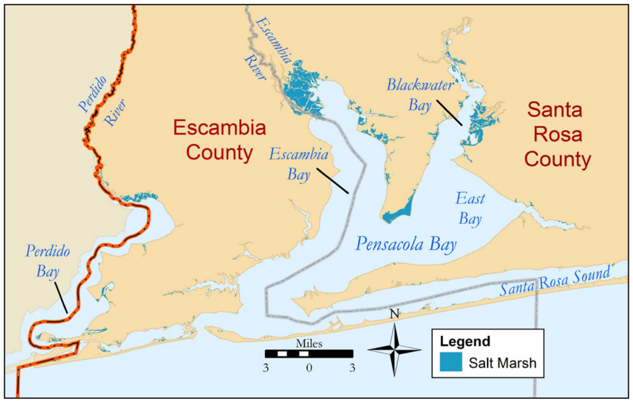

Figure 2.3. Salt marsh extent in Perdido and Pensacola Bays. Data source: NWFWMD 2009–2010 land use/land cover data (NWFWMD 2010).

popular retirement community (Ruth and Handley 2007). Development has caused habitat loss and has physically altered the bay through the construction of seawalls, jetties, bridges, and docks. Water quality is detrimentally impacted by increased pollutants and sedimentation in stormwater runoff and wastewater discharge (NWFWMD 2002, Ruth and Handley 2007). The low tidal energy and frequent stratification in the bay result in longer residence times for pollutants (NWFWMD 2002).

St. Andrew Bay

St. Andrew Bay (Figures 2.2 and 2.5) has three lobes (the West, North, and East Bays) that collect outflows from 10 major creeks (FDEP 2004). Narrow peninsulas protect the bay from Gulf waves and currents, resulting in little tidal flushing. Salt marshes dominated by *J. roemerianus* and *S. alterniflora* border the coastline of West Bay and East Bay (NWFWMD 2000). The natural filtration provided by the surrounding salt marshes contributes to the bay's characteristically clear water.

Historically, St. Andrew Bay was connected to the Gulf at the eastern end of Shell Island. After construction of a shipping channel through the center of the barrier peninsula in 1934, however, sediment slowly accreted in the East Pass until it closed in 1998. The East Pass was dredged in 2002 but closed again the following year due to sediment accretion (FDEP 2004). The coastline remains dynamic, and the shipping channel and surrounding beaches are dredged and renourished by the Corps of Engineers. Panama City and Tyndall Air Force Base are located on the eastern side of the bay. Tourism and the military are the dominant forces in the local economy, and much of the surrounding area is rural and under silviculture (Brin and Handley 2007).

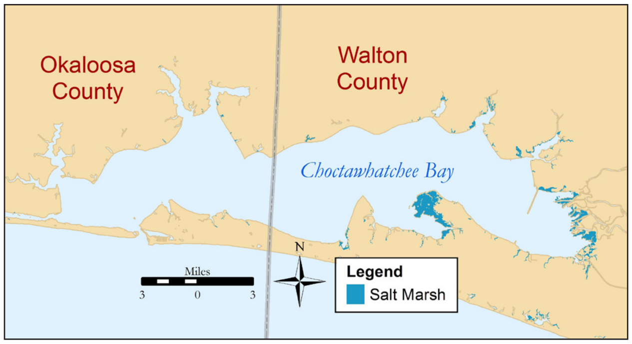

Figure 2.4. Salt marsh extent in Choctawhatchee Bay. Data source: NWFWMD 2009–2010 land use/land cover data (NWFWMD 2010).

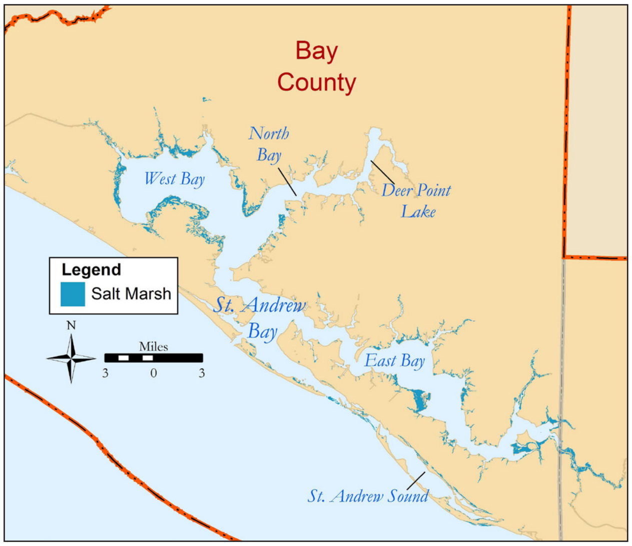

Figure 2.5. Salt marsh extent in St. Andrew Bay. Data source: NWFWMD 2009–2010 land use/land cover data (NWFWMD 2010).

St. Joseph Bay

St. Joseph Bay (Figures 2.2 and 2.6), located just west of Apalachicola Bay, is bordered by a spit extending out from St. Joseph Peninsula. Freshwater input into St. Joseph Bay is low; as a result, the average salinity in the bay reflects the salinity of the Gulf of Mexico. Small amounts of freshwater flow into St. Joseph Bay from the Gulf County Canal (which connects the bay to the Gulf Intracoastal Waterway), rainfall, small creeks, and groundwater seepage (SJBAP 2008). St. Joseph Bay is clear with a predominantly sandy bottom and supports extensive seagrass habitat.

Salt marshes dominated by *J. roemerianus* and *S. alterniflora* are found in fringes along the shoreline of the bay (SJBAP 2008). In the 1990s St. Joseph Bay salt marshes showed signs of stress (brown vegetation with

Figure 2.6. St. Joseph Bay salt marsh habitat and known mangrove locations. Data source: Apalachicola National Estuarine Research Reserve mapping (see text for details).

low above-ground biomass) and mortality (SJBAP 2008). Possible causes of this die-off include pathogens, pollution, drought-related factors, and lack of sediment (Flory and Alber 2002). Approximately 50% of the marsh grasses recovered naturally in the years after the die-off, and *S. alterniflora* was planted to aid repopulation of the remaining areas.

In 2009, Apalachicola National Estuarine Research Reserve (ANERR) staff began to map and document individual mangrove trees along the southeastern shoreline of St. Joseph Bay (Figure 2.6). Staff documented very few, small *Rhizophora mangle* (red mangrove) individuals that did not appear to survive the winter in 2010. *A. germinans* was far more abundant than *R. mangle* and better able to withstand the colder temperatures. Mapping efforts were discontinued in 2011 due to budget cuts, but reestablished in 2014.

Apalachicola Bay

The Chattahoochee and Flint rivers merge upstream of the Jim Woodruff Dam, forming the Apalachicola River, which then flows 106 mi (170 km) south to Apalachicola Bay (Figures 2.2 and 2.7). The large Apalachicola River watershed includes portions of Florida, Alabama, and Georgia, including Atlanta. Apalachicola Bay is therefore vulnerable to an array of upstream water quality and water quantity factors, and management of the watershed is complex due to different land- and water-use policies across three states (Edmiston 2008).

Apalachicola Bay is a broad, shallow estuary lined by barrier islands covering 220 mi^2 (570 km^2) (Edmiston 2008). The barrier islands provide protection from the waves of the Gulf, creating a low-energy environment in the bay. Oyster reefs are found throughout Apalachicola Bay, and shellfish harvesting is an important component of the local economy. The bay encompasses the ANERR, which also includes the lower 52 mi (84 km) of the Apalachicola River and several of its distributaries (ANERR 2014). A large amount of the land outside of ANERR is also publicly owned, including the Apalachicola National Forest and Tate's Hell State Forest, which limits human development and population growth. The region is one of the least populated coastal areas in the State, and current development is concentrated along the coast.

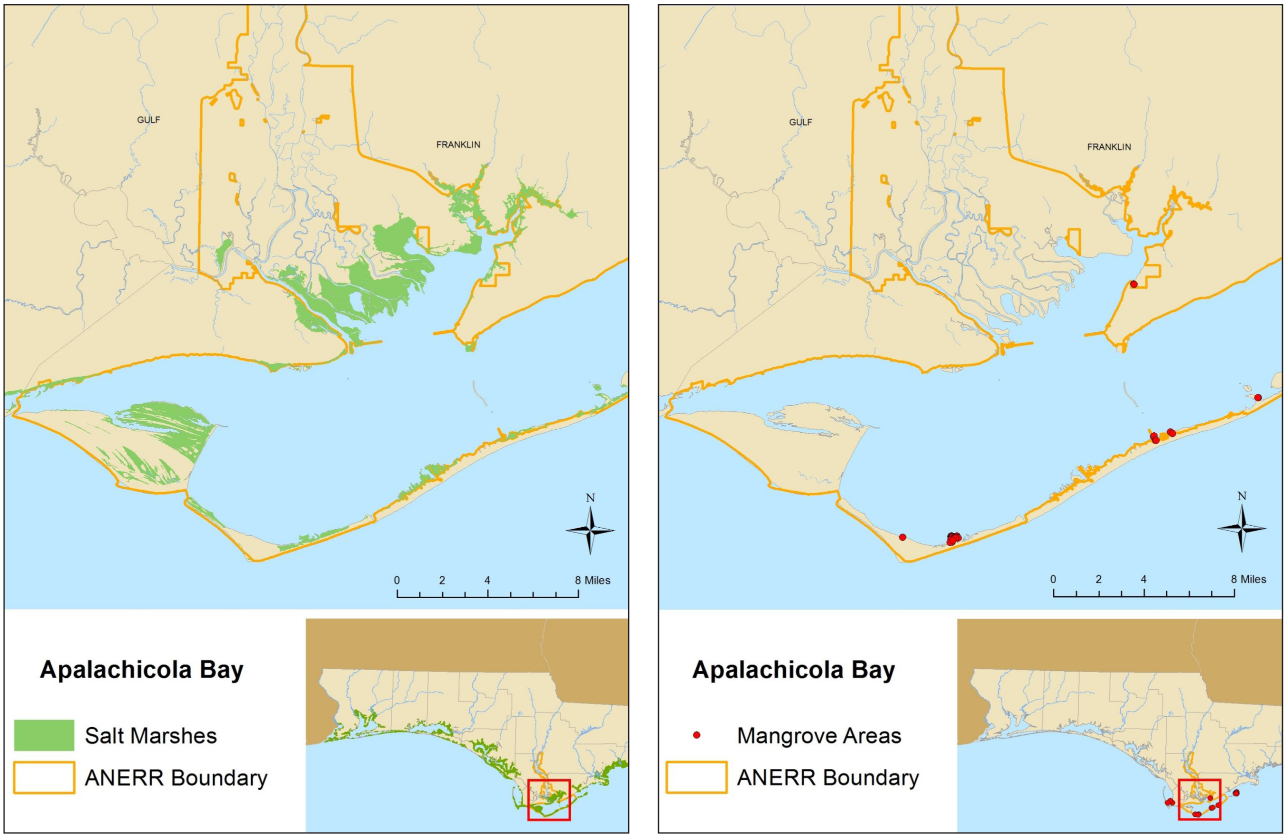

Figure 2.7. Apalachicola Bay salt marsh habitat and known mangrove locations. Data source: Apalachicola National Estuarine Research Reserve mapping.

Eastern Franklin County:
Dog Island/St. George Sound

Dog Island is located 3.5 mi (5.6 km) offshore of Franklin County, providing a barrier-island border to St. George Sound (Figures 2.2 and 2.8). Salt marshes are found on the island and at the mouths of the Carrabelle, Ochlockonee, and Sopchoppy rivers. Dog Island contains dune ridges along with a mixture of salt and freshwater wetlands (Anderson and Alexander 1985). The bay side of the island contains salt marshes dominated by *J. roemerianus* and *S. alterniflora*, while freshwater marshes are found toward the interior. *A. germinans* dieback due to cold winter temperatures has often been extreme (70% of mangroves died in the winter of 1983–84), but the community subsequently recovered (Anderson and Alexander 1985).

Threats to coastal wetlands

- **Human development:** While northwest Florida is relatively undeveloped compared with south Florida, the population in Santa Rosa, Okaloosa, and Walton counties is growing faster than statewide averages (U.S. Census 2015). Urban development is generally concentrated near the coastline, which has both direct effects (habitat loss and fragmentation) and indirect effects (poor water quality and altered hydrology) on surrounding wetlands (NWFWMD 2000, Ruth and Handley 2007, ANERR 2014). Increasing tourism and recreational use of the coast also impact wetlands through improper vehicle use, trampling, pesticide use, erosion from boat wakes, and dredging for boat access (Handley et al. 2013). While numerous public lands afford protection from development, much of the rural, undeveloped coastline remains in private ownership and is susceptible to future development.
- **Water quality and quantity:** Population growth and urban development have altered the quantity and quality of freshwater entering estuaries. Population growth in the upstream reaches of the Apalachicola watershed has led to increasing demand for freshwater, resulting in decreased flows to the Apalachicola River (ANERR 2014). Improperly treated wastewater and urban runoff are issues in several of the bays (NWFWMD 2006a, SJBAP 2008). Poorly functioning septic systems are of particular concern, especially for their possible impact on the quality of shellfish in oyster-harvesting regions

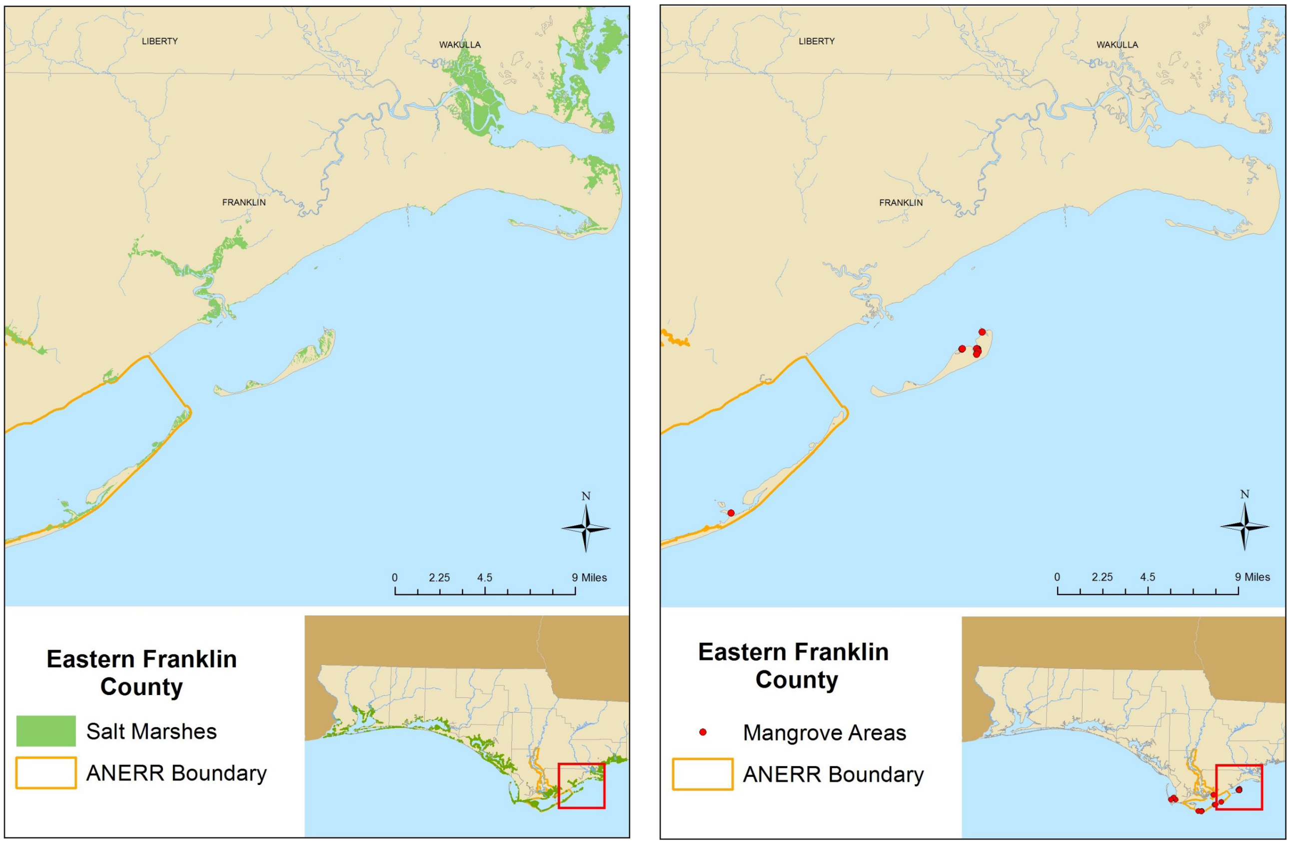

Figure 2.8. Eastern Franklin County (including Dog Island) salt marsh habitat and known mangrove locations. Data source: Apalachicola National Estuarine Research Reserve mapping.

(ANERR 2014). The impacts of chemical contamination and nutrient enrichment are worsened because many of these bays have small outlets into the Gulf; this causes stratification, limited tidal flushing, and a long residence time for contaminants (NWFWMD 2000, Brin and Handley 2007, FDEP 2012b).

- **Altered hydrology:** The hydrology of bays along the coast of northwest Florida have been altered by the construction of channels, the Intracoastal Waterway, and the opening or stabilization of tidal inlets to the Gulf. These alterations not only modify salinity and tidal flow in the bays, but they also alter patterns of accretion and erosion. Hydrology is also altered locally by hardened shorelines, bridges, and other coastal development. Stormwater runoff is diverted and concentrated by drainage systems collecting runoff from impervious surfaces. Even trenches designed to prevent the spread of forest fires alter surface water flow, compartmentalizing and channelizing runoff (FDEP 2008).

  Upstream alterations to rivers also change the delivery of freshwater to the estuaries. A dam was built in 1961 in the North Bay of St. Andrew Bay to create Deer Point Lake. The hydrology of the Apalachicola River has also been significantly modified by the Jim Woodruff Dam, channelization, and dredging. The straightening of the Apalachicola River has also resulted in increased flow rates and decreased river depth (ANERR 2014).

- **Erosion and accretion:** Patterns of erosion and accretion are altered by the construction and stabilization of shipping channels, sea-level rise, hardened shorelines, and subsidence (Handley et al. 2013). Erosion is particularly forceful during tropical storms and hurricanes. Cape San Blas on St. Joseph Bay is one of the most severely eroding locations in Florida and has eroded up to 40 ft (12 m) in one year (SJBAP 2008). Similarly, much of the salt marsh on Perdido Key has been lost to erosion (FDEP 2006).

- **Climate change and sea-level rise:** This area is susceptible to saltwater intrusion and the growing impact of tidal forces due to the low elevation and gentle topography. With higher sea level, tidal forces will reach farther upstream and storm surges will extend farther inland. Increasing salinity and inundation will likely result in salt marshes' displacing freshwater wetlands. Additionally, the proliferation of nonnative species may be aided by changes in abiotic factors, including temperature and salinity.

Even though cold events have historically restricted the proliferation of mangroves in northern Florida, *A. germinans* has been able to expand northward due to the reduced frequency of such events (Stevens et al. 2006). Mangroves in northwest Florida are still patchy and usually occur as solitary trees or in small clusters, but as their canopy coverage increases they can shade out and replace marsh vegetation (Stevens et al. 2006).

- **Natural events:** Naturally occurring events such as tropical storms, hurricanes, and droughts also threaten salt marsh habitat. For instance, when Hurricane Dennis made landfall on northwest Florida in 2005, an 8- to 10-ft (2.4–3 m) storm surge crossed the barrier islands in ANERR, depositing sediment and smothering aquatic vegetation. Many of the low-salinity marsh species were killed by inundation by sea water (ANERR 2014). Vegetation that survives the initial inundation from storm events may be ultimately displaced by invasive vegetation that thrives after a disturbance (Handley et al. 2013). Natural droughts, such as that in 1999–2001, also affect freshwater input, salinity regimes, nutrient delivery, and sedimentation (Ruth and Handley 2007).
- **Invasive species:** Invasive vegetation in and around wetlands in northwest Florida include *Triadica sebifera* (Chinese tallow), *Cinnamomum camphora* (camphor tree), *Arundo donax* (giant cane), *Lygodium japonicum* (Japanese climbing fern), *Schinus terebenthifolius* (Brazilian pepper), and an invasive strain of *Phragmites australis* (common reed) (NWFWMD 2006a, ANERR 2014). Otherwise, federally listed invasive species are currently not considered a serious threat to coastal wetlands in this region.

Mapping and monitoring efforts

Water management district mapping

The Northwest Florida Water Management District (NWFWMD) conducts periodic land use/land cover (LULC) mapping at regular intervals in its jurisdiction (Figure 2.9, Table 2.1). The features delineated in LULC maps are categorized according to the Florida Land Use and Cover Classification System (FLUCCS; FDOT 1999). NWFWMD LULC data sets are based on aerial orthoimagery and published at the 1:24,000 (1 in. = 2,000 ft) scale. The data files were created by Florida Department of Environmental Protection's Bureau of Watershed Restoration (NWFWMD 2010).

According to NWFWMD LULC data, salt marsh extent in northwest Florida has increased by more than 2,000 acres (809 ha) from 1994 to 2010 (Figure 2.9, Table 2.1).

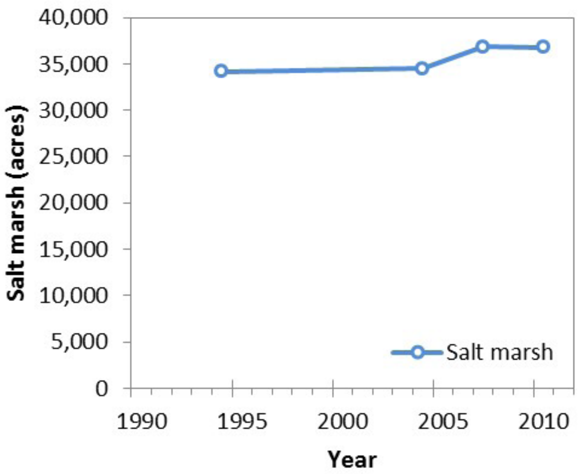

Figure 2.9. Recent acreages of salt marshes in northwest Florida, as derived from NWFWMD land use/land cover data (NWFWMD 2010).

Table 2.1. Recent acreages of salt marshes (FLUCCS 6420) in northwest Florida. Data sources: FDOT 1999, NWFWMD 2010.

Year	Salt marsh
1994–95	34,152
2004	34,483
2006–07	36,843
2009–10	36,804

The largest gain occurred when several wet prairies, nonvegetated wetlands, tidal flats, and mixed scrub–shrub wetlands from the 2004 LULC data set were reclassified as salt marsh in 2006–2007. Some of this variability may be due to refinement of mapping methods and classification rather than change in land cover. For example, one 75-acre (30 ha) region was recorded as a mangrove swamp (FLUCCS 6120) in NWFWMD's 1994–95 land use/land cover (LULC) data. This location, along western St. Andrew Bay, is classified as mixed scrub–shrub wetland (FLUCCS 6460) in later LULC data sets. The mixed scrub–shrub wetland classification (FLUCCS 6460) was not used in the 1994–95 LULC data yet proliferated in LULC data thereafter.

USGS and EPA emergent wetlands status and trend

Scientists with the U.S. Geological Survey (USGS) and the U.S. Environmental Protection Agency (EPA) partnered to map and analyze the status of coastal wetlands along the Gulf of Mexico. As part of that study, wetland extent in

Pensacola Bay and Choctawhatchee Bay was mapped from 1979 and 1996 data using stereoscopic photointerpretation and ground truthing (Handley et al. 2013). Vegetation was classified using Cowardin et al.'s (1979) classification system. Palustrine wetlands were found to have had a much greater decline from 1979 to 1996 (18,267 acre/7,390 ha lost, or 55.89%) than estuarine wetlands (436 acres/176 ha lost, or 4%). While several other estimates of marsh extent were also made in northwest Florida in the 1970s and 1980s, the methods used were so different that the data were difficult to compare (Reyer et al. 1988, FDEP 2012b, Handley et al. 2013).

Mapping of the Apalachicola National Estuarine Research Reserve

Using ArcGIS, ANERR staff isolated salt marsh layers from each of the following five regional land-cover data sets and merged them into one layer to provide a rough estimate of salt marsh habitat in this area overall (Figures 2.6–2.8):

- U.S. Fish and Wildlife Service National Wetlands Inventory (years of available data vary)
- Northwest Florida Water Management District (2009–11)
- Florida Fish and Wildlife Conservation Commission (FWC) compilation of Florida Water Management District data (1999–2011)
- Florida Natural Areas Inventory/FWC Cooperative Land Cover (2003–10)
- ANERR Habitat Mapping and Change Plan (NOAA/FDEP) (2012)

Mangrove habitat is not documented in any of the large regional data sets for northwest Florida, but ANERR staff have been monitoring individual mangrove trees in salt marsh habitats in the Apalachicola Bay area since 2009. Staff will continue to document this habitat annually, because observations indicate that these species are increasing in abundance, a trend that is expected to continue as a result of changing climate.

Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative mapping assessment

The Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative (GCPO LCC) is conducting a rapid ecological assessment of nine priority habitat systems defined in its draft Integrated Science Agenda, available at lccnetwork.org/resource/gcpo-lcc-draft-integrated-science-agenda. Estuarine tidal marsh along the Gulf Coast portion of the GCPO LCC region has been identified as one of the LCC's priority systems. As part of the assessment, the LCC is using land cover overlays from the National Wetlands Inventory, Cooperative Land Cover 3.0 and the Coastal Change Analysis Program in Florida to assess the extent of estuarine tidal marsh in the Gulf Coast portion of the western Florida panhandle. Overlays of multiple data sets are available at gcpolcc.databasin.org/.

National Estuarine Research Reserve monitoring

As part of the National Estuarine Research Reserve System's System Wide Monitoring Program (SWMP) bio-monitoring protocol, in 2014 ANERR staff began long-term monitoring of the freshwater and brackish emergent vegetation in the marshes of the lower Apalachicola River and the salt marshes of Little St. George Island. Monitoring locations are intended to represent natural estuarine communities that have not been significantly altered by natural causes or human activity (Moore 2009). Three transects at each location are monitored annually at the peak of biomass following Moore (2009). Two wells for monitoring pore water were installed adjacent to each transect.

Elevation and sediment accretion has also been studied in the Apalachicola region. In 1996 two sediment elevation tables (SETs) were installed by the Florida Geological Survey in a distributary of the Apalachicola River that drains into East Bay. Data from these SETs showed that the marshes did have high rates of accretion (as much as 0.5–0.75 in./14–19 mm per year). Nevertheless, overall elevation changes were negative due to compaction and subsidence in the river delta (Hendrickson 1997, Edmiston 2008).

Additionally, 20 SETs were installed in 2011–12 to monitor erosion and accretion rates in the lower-river marshes of the Apalachicola floodplain and in the salt marshes of the barrier islands. These monitoring efforts are part of the National Oceanic and Atmospheric Administration's Sentinel Site Program designed to track ecosystem integrity and socioeconomic health indicators for specific management initiatives. The data will be provided to researchers for modeling biological feedback to sea-level rise. These models will allow stakeholders and decision makers to understand how sea-level rise will affect freshwater and saltwater marsh habitats in the Apalachicola area.

Sea Level Affecting Marshes Model

As revealed by the Sea Level Affecting Marshes Model (SLAMM) developed in 2012 by The Nature Conservancy, the lands surrounding Apalachicola Bay are highly vulnerable to sea-level rise even under modest scenarios (Freeman et al. 2012). Forested wetlands would be replaced by salt-tolerant vegetation, reducing habitat extend for organisms that depend on forested wetland habitats. These changes would be exacerbated if freshwater inflow was reduced by drought or upstream demand.

Choctawhatchee Bay Live Oak Point shoreline erosion

Live Oak Point contains approximately 1,000 acres (404 ha) of salt marsh, the largest extent on Choctawhatchee Bay. The NWFWMD commissioned a study on shoreline changes in the salt marsh from 1941 to 2004 (NWFWMD 2006b). The study found that the salt marsh was eroding at a pace of 0.6 acre (0.24 ha) per year, which was likely to increase to 0.7 acre (0.28 ha) per year by 2020. It was noted that waves were carving into the marsh platform, undercutting the exposed peat and creating small ledges that ultimately broke off and were carried away by higher tides. Recommendations include the installation of permanent breakwaters to divert wave energy and the planting of salt marsh species in regions of accretion to compensate for erosional salt marsh loss (NWFWMD 2006b).

Independent research

Randall Hughes with the Florida State University Coastal and Marine Laboratory and Northeastern University began taking a closer look at *A. germinans* in the salt marshes of St. Joseph Bay in 2011. The less cold-tolerant *R. mangle* was found in the marshes as well. Over a five-year period she did not see any significant dieback, even during hard freezes. These trends are expected to continue, and it is anticipated that these species will become more abundant as the climate continues to change. Brief descriptions of the ongoing mangrove monitoring project and other salt marsh studies can be found at blog.wfsu.org/blog-coastal-health/.

Recommendations for protection, management, and monitoring

- Monitoring changes in habitat, water quality, and ecosystem health is a key component of management. Monitoring data should be used in conjunction with results of other scientific studies to aid in implementing best management practices for ecosystem management. The die-offs and stress signs demonstrated by St. Joseph Bay salt marshes point to the need for further study to identify specific stressors, restore affected areas, and implement long-term monitoring for areas of concern (SJBAP 2008). Studies of shoreline accretion and erosion would also help in prioritizing restoration and protection efforts for salt marshes (Handley et al. 2013).
- Mangrove range expands northward in Florida in the form of single trees or clusters of trees surrounded by salt marsh. Current land classification techniques are generally based on predominant vegetation types rather than on individual plants and so overlook individual trees. Presence/absence techniques, such as those shown in Figures 2.6–2.8, provide a better method of tracking mangrove proliferation.
- Engage communities and citizens in improving the stewardship of coastal resources. Encourage the planting of living shorelines along residential property and public parks. Shoreline vegetation provides stabilization, valuable ecosystem services, and is useful in educating the public.
- Identify and prioritize acquisition of lands and restoration of habitats that act as buffers and that will allow coastal wetlands to move inland as habitat is lost due to sea-level rise and erosion. Buffer zones of undisturbed native vegetation around wetlands and other sensitive habitats also help trap sediment and nutrients, stabilize the shoreline, lessen flooding, and provide habitat for other native species (SRC 2002).
- Thoughtful urban planning can decrease the impacts of development on surrounding natural areas. The use of porous pavement decreases concentration of stormwater runoff, and open, vegetated, curved stormwater paths mimic more natural drainage patterns (SRC 2002). When possible, construction of septic tank systems near wetlands and shorelines should be discouraged. The cumulative impact of urban development on coastal habitats should be considered, even though development permits are issued for individual projects (NWFWMD 2000). When combined together, multiple developments can fragment habitat and alter the hydrology of wetlands.

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