Manatee Awareness and Protection Resource (MAPR) Website

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1. HOME: Overview / Introduction

MAPR, Florida Sea Grant's Manatee Awareness and Protection Resource website, uses interactive maps and graphics to describe factors considered in the designation of manatee protection zones in Florida's coastal waters. We invite you to begin exploring the site by moving your cursor over the various features depicted in the graphic below. Text will appear and links to "more information" provides details. You can always return to this page by clicking the "HOME" link in the banner above. We welcome your comments on MAPR, which you provide on the contacts page.

2. GIS/MAP

Text and linked subpages are described below in Section 3.0 on "GIS / Spatial analysis Page"

3. Interactive map

This links directly to the map, there is no text associated with this button

4. Contacts

Text is given below in Section 4.0 on "Contacts Page."

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1.2 – Nine hot spots:

On the front page of the MAPR website is a graphic depiction of a profile of a coastal area showing a transition from an urban environment to an aquatic environment. It illustrates the paradigm that exists for many of Florida's coastal counties. In the profile are various activated objects that, when clicked on will provide some basic information. Scrolling to the bottom of the text box, the user can click on a "more information" link, where more detailed information is revealed. Altogether, there are nine objects in the diagram. The titles and accompanying text are given below:

1. Manatee (Manatee Facts)

Brief description
Modern Florida manatees have lived in the state's waters for about 12,000 years, while their ancestors were here for over one and a half million years. Manatees are a federally listed endangered species and are protected by the State of Florida. Human related impacts, including habitat destruction due to coastal development and lethal encounters with boats, are major threats to survival of Florida's manatee population (U.S. Fish and Wildlife Service, 2001).

Detailed description
The Florida Manatee, *Trichechus manatus latirostris*
The Florida manatee, *Trichechus manatus latirostris,* one of two subspecies of the West Indian manatee, is native to Florida's coastal waters. The other subspecies is the Antillean manatee, *Trichecus manatus manatus,* found in Mexico and the Caribbean. Manatees are semi-social herbivores and have no predators. Since 1991, statewide aerial surveys have been conducted during the winter to estimate the size of manatee populations. Recent estimates of the Florida manatee population ranges from 3300 to 4000 (Reep & Bonde, 2006).

Manatees are part of the mammalian order Sirenia, which includes three additional species: the West African manatee, *T. senegalensis*, the Amazonian manatee, *T. inunguis*, and the dugong, *Dugong dugon* (U.S. Fish and Wildlife Service, 2001). The fossil record of the Sirenian line dates back approximately 50 million years, with origins in the Amazonian region, prior to the uplift of the Andes Mountains. Ancestors of present day manatees have been living in Florida waters for millions of years, and their fossils are commonly found throughout Florida. While the family of present day West Indian manatees evolved in the Caribbean region about two million years ago, the modern Florida manatee appeared more recently, following the last glacial period, approximately 12,000 years ago (Reep & Bonde, 2006).

Figure. The Florida manatee (photo: USGS – Sirenia Project).

Extent of Florida Manatees

Today, Florida is at the northern extent of the range for manatees. However, in summer, manatees often roam northward along the Atlantic Coast to Georgia and the Carolinas. They have been observed as far north as the Chesapeake Bay and New York (Haubold *et al.*, 2006). In winter, manatees return to warmer waters. They retain a clear memory of resource patterns within their environment and will return to the same site year after year to seek refuge from cold winter temperatures (Reep & Bonde, 2006). Scientists have identified four distinct groupings of manatees in Florida that are based on the geographic configuration of resources: the Upper St. John's River, the Atlantic Coast, the Southwest, and the Northwest (Haubold *et al.*, 2006).

What is a Manatee?

Florida manatees are large, heavy-boned, "fusiform" shaped animals—their head and body comprise one streamlined form—about 10 feet in length, and weighing approximately 2200 lbs at maturity. They have thick, dark grey, rubbery skin with sparse hairs except around the snout, where the hairs form bristles (U.S. Fish and Wildlife Service, 2001). Their forelimbs and tail are flattened, paddle-like structures. They have no hind limbs. Their lungs are very large and aid the manatee in maintaining neutral buoyancy as they graze underwater. Their valve-like nostrils are located on the top of their snout, which is downturned, providing better control for feeding on aquatic vegetation. The snout itself is a muscular upper lip that, together with the bristles covering the lips, sense and manipulate vegetation for efficient feeding. Manatee teeth are specially designed to crush vegetation that may be covered with sand. As the sand wears away the molars, new teeth are continually produced in the back of the jaw, pushing the older teeth forward in a "conveyer belt" fashion (Reep & Bonde, 2006). The eyes of manatees are very small, are forward looking on the sides of the head, and can be closed or protected by a membrane. Manatee ears are tiny, and located on the sides of their head behind the eyes. Their hearing is not very acute, and extends over a narrow band of low frequency sounds (U.S. Fish and Wildlife Service, 2001).

Manatee Life Cycle

A manatee's life can span fifty to sixty years. They reach sexual maturity at two to five years of age and bear one calf after a gestational period of about 12 to 14 months. Calves stay with their mothers for one and a half to two and a half years, learning the patterns of the environment and nursing frequently. A female manatee gives birth about every two and a half to three years, if the calf survives to weaning age (Haubold *et al.*, 2006; Reep & Bonde, 2006). Manatee deaths in Florida have been reported and recorded since 1974. The FWC maintains statistics on the causes of death of all reported manatee carcasses. Causes of death are classified as: human-related, including "watercraft," "flood gate/canal lock," and "other human;" naturally occurring, including "perinatal," "cold stress," and other "natural;" and "undetermined." Another category for "unrecovered" counts the number of manatee carcasses that were sighted but not recovered for necropsy. The "other natural" category includes "manatee deaths resulting from infectious and non-infectious diseases, birth complications, natural accidents, and natural catastrophes (such

as red tide poisoning)" (Fish and Wildlife Research Institute, 2007a). Red tide dinoflagellettes (*Gymnodinium breve*) can cause sudden high numbers of manatee deaths. For example, in 1996 Lee County experienced a red tide event that killed numerous manatees, with 37 deaths reported in March and April alone, where normally between 1 and 5 deaths are reported in this category. Monthly and yearly counts of manatee mortality by county and cause of death since 1974 can be viewed and downloaded from the FWRI website (http://research.myfwc.com/manatees/). A summary of manatee mortality statistics between 1974 and 2000 is presented in the *Manatee Recovery Plan, 3rd Revision* (U.S. Fish and Wildlife Service, 2001)

Figure. Female manatee nursing a calf (photo: USGS – Sirenia Project).

Manatee Habitat

Manatees live in the shallow waters of estuaries and coastal areas, and are as commonly found in urban canals as in remote shoals and inlets. They are herbivores that feed on a wide variety of aquatic vegetation. While their diet consists mainly of seagrasses, they will eat other plants, including mangroves and salt marsh grasses. Therefore, manatees are considered generalists with respect to their diet and habitat (Reep & Bonde, 2006). In the summer months, from April through October, they disperse widely, in areas where aquatic vegetation is plentiful.

Despite their massive size and thick skin, manatees are very sensitive to cold water temperatures. During winter months, typically from November through March, when water temperatures drop below 68º F, they congregate at warm water aggregation sites. These sites include natural springs, power plants, other industrial discharges, dredged canals and basins, and areas at the southern end of the state. With the advent of power plants, industrial plants, and extensive canal development, manatees have become habituated to many artificial warm water sources—a significant issue in the overall status of manatees. They exhibit strong fidelity to these sites, remembering their locations and returning to them year after year. This behavior is not only exhibited with respect to warm water sources, but to other resources as well, including foraging areas and freshwater sources (Reep & Bonde, 2006)

Figure. Group of three manatees feeding on seagrass (photo: USGS – Sirenia Project).

Threats to Manatees

Manatees have no natural predators. Environmental threats to their survival include cold temperatures, extreme storms, and red tide events. Other threats stem from human interactions with their environment. When seagrass beds are scarred by boat propellers or water pollution diminishes seagrass production, manatees in turn feel the effects. Changes to power plant technology that reduce the availability of warm water in winter months could greatly influence manatee survival. Likewise, flow reductions in natural springs due to increased groundwater withdrawal could negatively affect manatees (Haubold *et al.*, 2006). Collision with boats, however, is the most significant human related threat to manatee survival (U.S. Fish and Wildlife Service, 2001). Accidents that do not result in the death of a manatee (sub-lethal) are also very significant. More than 1000 manatees have been photographed with scars from boat impacts, and 97% of these bear scars from more than one collision (Haubold *et al.*, 2006). Other human related causes of manatee mortality include being crushed in locks or between the hulls of boats and canal sides. Ingesting litter and entanglement in fishing nets and gear is also a serious problem for many marine animals, including manatees.

Figure. Two manatees under a boat propeller (photo: USGS – Sirenia Project).

Figure. Manatee with a rope embedded in its right flipper (photo: USGS – Sirenia Project).

2. Boat (Effects of Boating)

Brief description
An increasing number of boats use Florida waters inhabited by manatees. Inevitably, chance encounters occur. Usually they are benign and even enjoyable for boaters: seeing manatees in their natural environment heightens the satisfaction of a day on the water. Sometimes, however, accidents happen that may injure or even kill a manatee. Collision with boats is the most common human related cause of manatee mortality in Florida, accounting for approximately 24% of all deaths since 1976.

Detailed description

Water-Based Recreation
People are attracted to Florida's coasts due, in part, to an abundance of water-based recreational opportunities (Antonini *et al.*, 2002). Florida is the number one destination for marine recreation in the United States, including boating, with an estimated 22 million participants annually (Leeworthy & Wiley, 2001). With over one million, Florida ranks first in the nation in numbers of registered boats (National Marine Manufacturers Association, 2005). Since 1980, the number of watercraft registered in Florida has increased 120 percent (Bureau of Economic and Business Research, 1981; Florida Fish and Wildlife Conservation Commission, 2006).

Between 1974 and 2001, 1058 manatees have been killed in Florida by watercraft. As of 2003, an additional 1184 surviving manatees have been scarred from collisions with boats. As the number of registered vessels increases in the state of Florida, so does the number of manatees killed by watercraft. Of particular note is the rate of increase in manatee mortality, which for overall deaths was 5.8% between 1974 and 2000, but for watercraft collisions was 7.2% (U.S. Fish and Wildlife Service, 2003). Questions remain

as to what degree the increase in manatee mortality is due to increased boating in Florida, increased manatee populations, or a combination of both.

Figure. Whale Key in the Florida Keys, Monroe County.

Boating Patterns and Activities

Patterns and intensity of boating activities are considered when determining whether manatee protection zones are necessary within an area (68C-22.001 F.A.C.). To characterize boat use, local governments typically rely on counts of registered vessels—readily available from county tax departments—and on information characterizing the size and distribution of area boat facilities, such as marinas, boat ramps, and residential docks. Unfortunately, detailed spatial and temporal descriptions of recreational boat use are frequently unavailable. When such information is available, it likely has been collected using two primary methods: (1) map-based mail surveys and (2) aerial reconnaissance. The spatial boating data mapped on this website were compiled using these two methods.

Mail Surveys of Boaters

In 2001, the Florida Fish and Wildlife Conservation Commission partnered with Florida Sea Grant to develop scientific methods to map boating activities on the water and characterize boaters (Sidman & Flamm, 2001). A map-based mail survey was determined to be an appropriate method to capture both behavioral and spatial aspects of recreational boating. Since then, map-based mail surveys have been conducted for Tampa and Sarasota Bays (Sidman *et al.*, 2005), Greater Charlotte Harbor (Sidman *et al.*, 2005), and Sarasota County (Sidman *et al.*, 2006).

Recipients of the mail survey draw on a map the departure site, travel routes, favorite destinations, and congested areas associated with their last two pleasure boating trips. In addition, they characterize their trips according to vessel type, departure date and time, and duration on the water. They also identify activities they engage in while at particular destinations, and identify and rank reasons for selecting departure sites, travel routes, and favorite destinations. The mapped information on returned surveys is digitized into a geographic information system (GIS)—a computer application used to store, view, and

analyze geographical information, especially maps. Descriptive data about boaters including demographic and trip information is linked to the spatial data within the GIS.

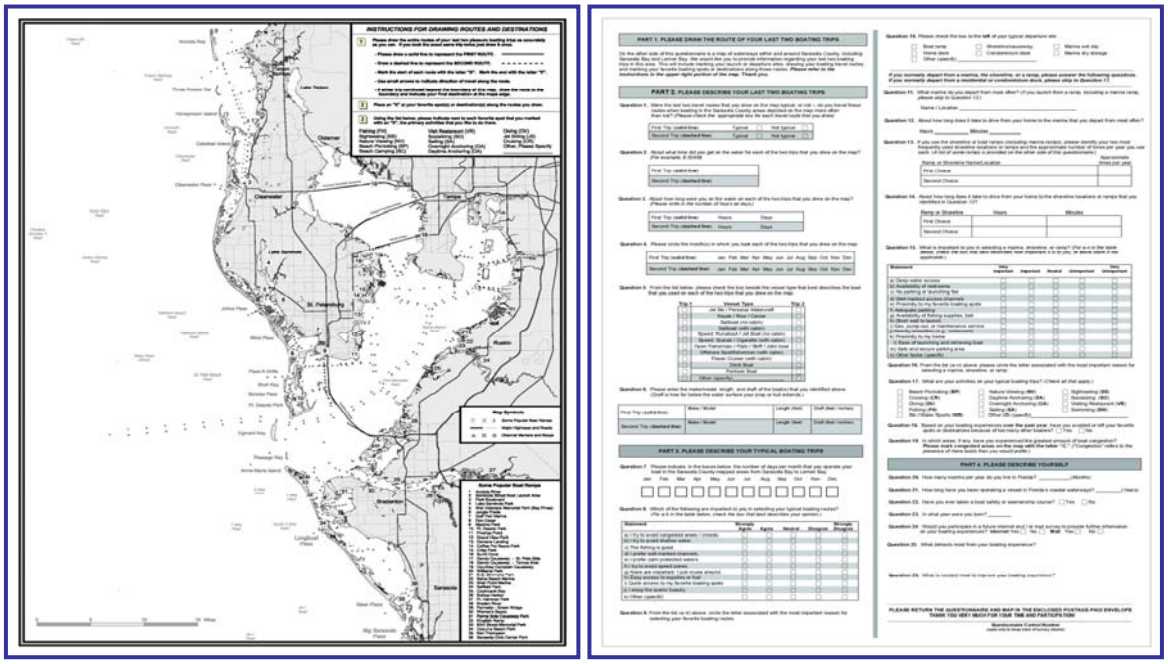
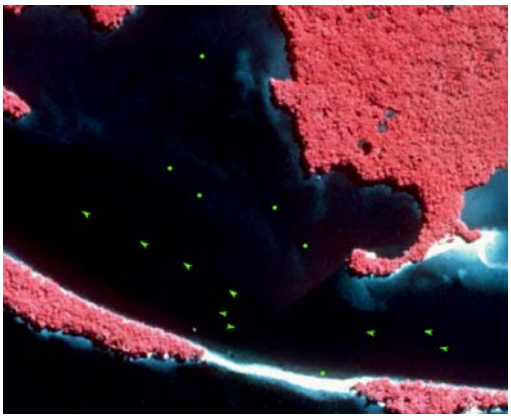


Figure. Example of a map-based survey distributed to boaters.

Aerial Surveys of Boating Patterns

Aerial surveys to document boating patterns have been implemented for the coastal waters of Brevard, Broward, Charlotte, Lee, and Sarasota counties. Surveys were conducted using fixed wing aircraft flying a standard flight path at altitudes ranging from 500 to 1000 feet (Gorzelany, 1998; Gorzelany, 2000; Gorzelany, 1999b; Gorzelany, 1999a; Gorzelany, 2002b; Gorzelany, 2002a). Multiple flights were conducted in each county and their starting and ending locations were varied. A single observer/videographer used an image-stabilizing, digital, hi-resolution camcorder with date and time imprint to record all vessels in use. The observer provided voice-over audio recording of vessel location and characteristics through a remote microphone attached to the aircraft headset. The start time for individual surveys was alternated between mornings and afternoons to capture daily variations in boating patterns.

Video footage was transferred to a Digital Video Disc (DVD) and, then, each vessel in use was digitized into a GIS. Digital Orthophoto Quarter Quadrangle (DOQQ) images were used to more accurately map vessels within the GIS. Quality control consisted of comparing mapped vessels with the original video footage. GIS spatial data were linked to attribute data, which included vessel type and length, direction of travel (if under way), and a unique alphanumeric code for each observed vessel. Environmental conditions including weather, wind speed and direction, and Beaufort scale were also recorded.



Figures. Snapshot of video footage taken from aerial reconnaissance and resulting GIS data file.

3. Water (Aquatic Habitat)

Brief description
Manatees generally prefer water depths between three to twelve feet (1 – 4 m), but may be in water as shallow as one foot. They are found in coastal and estuarine areas but will travel upstream to warm water or freshwater sources. They are found throughout Florida but occur in greater numbers in its southern regions (O'Shea, 1988; U.S. Fish and Wildlife Service, 2001; Reep & Bonde, 2006).

Detailed description
Manatees prefer water temperatures warmer than 68º F (18º C) and, during cold winter periods, they seek out warm water sites. In addition to migrating south during winter, manatees will aggregate where water temperatures are warmer than surrounding areas, such as at natural springs, outflows from power plants or industrial plants, and dredged canals and basins. While manatees live and breed in salt water, they search out fresh drinking water from time to time. Manatees do not require freshwater for survival, but they are attracted to water with salinity levels less than 25 ppt. Thus, places where freshwater is available are more attractive to manatees and will likely have higher numbers of manatees present. (U.S. Fish and Wildlife Service, 2001; Barnes, 2005)

4. Aquatic Vegetation

Brief description
Manatees are herbivores that graze on aquatic vegetation. Their diet is broad and they feed on many species of salt and freshwater vegetation. While they prefer to feed on seagrass, their grazing habits vary according to the time of the year and the nutritional qualities of the available vegetation.

Detailed description

Introduction

Manatees feed on aquatic vegetation at the bottom, the surface, and along the banks. They are generalist grazers, meaning that they are not restricted to a specific food source. Thus, while seagrasses are an important component of the manatee diet, they will also consume a wide variety of aquatic vegetation, even reaching out of the water to graze on overhanging leaves or grasses. The following is a general description of seagrass beds which are critical for manatee survival in Florida.

Figure. Manatee feeding on floating seagrass and mangrove leaves (photo: USGS – Sirenia Project).

Figure. Manatee feeding on seagrass (photo: USGS – Sirenia Project).

Seagrass Beds in Florida

Seagrasses are marine plants that are found in the soft intertidal sediments near shorelines. The plants are specially adapted to their aquatic environment. They occur worldwide and include between 50 to 60 species in two grass families, Hydrocharitaceae and Potamagetonaceae (Williams & Heck Jr., 2001). In Florida, a few species are found regularly in coastal areas (Dawes, 1987). These include *Thalassia testudinum* (Turtle Grass), *Syringodium filiforme* (Manatee Grass), and *Halodule wrightii* (Shoal Grass).

Vallisneria americana (Eel Grass) and *Ruppia maritime* (Ditch Grass) are also commonly found in the waters of southwest Florida. Seagrasses are clonal flowering plants that can form extensive beds that may be dominated by one species of grass, but which usually include several species. Seagrass plants have well-developed below ground mats of rhizomes and fibrous roots. Above ground, seagrass leaves are paddle-like or strap-like in shape. Seagrass beds may be large and extensive, covering many square kilometers.

Biological Diversity of Seagrass Beds

Seagrass beds are highly productive biological systems, producing as much as some intensive terrestrial agricultural systems (McRoy & McMillan, 1977). The richness and productivity of seagrass habitat has been well-documented since the early 1920s (Dawes *et al.*, 2004). Dawes et al. defined seagrass habitat as "a physical space containing seagrasses in sufficient quantity and pattern to produce the appropriate structural and physiological characteristics to support organisms typical of seagrass communities." The diversity of animals and plants associated with seagrass beds is impressive. Dozens of species of algae live as epiphytes on the leaf blades and within the root mass of the seagrass beds. A plethora of small marine animals, such as larval fish and crustaceans, feed on seagrass detritus, algae, and other tiny marine animals that use seagrass beds for cover and food. Larger predatory and carnivorous fish are attracted to seagrass beds for the supply of prey they harbor. Grazing marine animals, including sea turtles and manatees, feed on seagrasses. Wading birds frequent seagrass beds and raptors hunt over them (Williams & Heck Jr., 2001).

Ecological Function of Seagrass Beds

Seagrass ecosystems fulfill vital ecological functions in the maintenance of estuaries and coastal marine environments. Their structure affects the flow of water locally, dampening the effects of waves and thereby altering erosion and sedimentation rates, nutrient and microorganism fluxes, and recruitment of larval stages of marine animals. Seagrass beds provide refuge from predators for small fish and crustaceans, and act as nurseries for some species (Dawes, 1987; Dawes *et al.*, 2004; Williams & Heck Jr., 2001). They take up vast amounts of carbon (Zieman & Wetzel, 1990), acting as a "carbon sink," a valuable function considering the problems of increasing atmospheric CO_2 and its effects on global climate change.

Threats to Seagrass Beds

Threats to seagrass beds include eutrophication, changes in water salinity, and damage from boat propellers. Eutrophication has been linked to the effects of coastal development, including higher levels of sediment and nutrients in storm water runoff. These in turn raise water temperatures and attenuate light, stimulating the production of algae. Increased algae reduce light availability and dissolved oxygen in the water column and result in lower seagrass production rates.

Natural variations in water salinity influence the distribution and species composition of seagrass beds. Some seagrasses are found in more saline, marine environments, while others are found in estuarine salinity ranges, and yet others in brackish and freshwater. When water salinity concentrations change, the species composition and geographic

distribution of the seagrass beds change. For example, in the case of the Caloosahatchee River, the release of freshwater from the Franklin Lock and Dam structure may have affected the distribution of seagrass beds. Studies conducted between 1986 and 1997 sampled seagrass beds in the Caloosahatchee River. However, during a 1999 study, researchers were unable to find seagrass beds in the lower reaches of the river (Chamberlain & Doering, 1998; Florida Fish and Wildlife Conservation Commission, 2002).

Physical damage to seagrass beds is a concern where boat propellers leave scars in seagrass beds that take years to recover. Scars occur "when a boat's propeller tears and cuts up roots, stems, and leaves of seagrasses, producing a long narrow furrow devoid of seagrass" (Sargent *et al.*, 1995). In Florida, scarring is a serious problem affecting the productivity of seagrass beds. The extent of the damage caused by propellers is regularly monitored by resource managers in coastal areas.

Figure. Scarred seagrass bed.

5. Sign (Manatee Protection Zones)

Brief description
The purpose of manatee protection zones, as authorized by the Manatee Sanctuary Act and set forth in 68C-22, FAC, is "to protect manatees from harmful collisions with motorboats and from harassment; to protect manatee habitat, such as seagrass beds, from destruction by boats or other human activity; and to provide limited safe havens where manatees can rest, feed, reproduce, give birth or nurse undisturbed by human activity."

Detailed description
Manatee protection zones are areas in which the operation of vessels is subject to regulation beyond the usual rules of navigation. The Florida Fish and Wildlife Conservation Commission establishes regulatory zones in areas that manatees inhabit on a regular basis and where manatee sightings are frequent. Such zones include: "Idle Speed," "Slow Speed," "Motorboat Prohibited," "No Entry," "Maximum 25 MPH Zone," "Maximum 30 MPH Speed," and "Maximum 35 MPH Speed." The statutory requirement governing where zones may be established is "where manatees are frequently sighted and

the best available scientific information, as well as other available, relevant, and reliable information, which may include but is not limited to, manatee surveys, observations, available studies of food sources, and water depths, supports the conclusion that manatees inhabit such waters periodically [or on a regular basis]" (68C-22, FAC, State of Florida, 2007).

These zones may coincide with federal and local manatee protection measures. The intent is to prevent or reduce the number of vessel collisions with manatees or at least to minimize injury to the animals if a collision occurs. Factors considered in the design of manatee protection zones include water depth, presence of manatee forage (especially seagrass), seasonal counts of manatee populations, boat traffic characteristics, and other resources that may also need protection. Zones are marked by signs visible to boaters, usually in the form of buoys or of panels on pilings. The restrictions in some zones are seasonal; the appropriate regulations are indicated to boaters by varying sign messages. Municipal, county, state, and federal law enforcement officers enforce the posted restrictions.

Figure. State of Florida Officer enforcing manatee protection zone.

6. Effects of Coastal Development

Brief description
Population growth, residential and commercial development, and actions such as waterway dredge and fill projects and dock, marina, and boat ramp construction have altered Florida's coastal environment and greatly increased human activities in near-shore waters where manatees are typically found.

Detailed description
Population Growth
Florida is currently the fourth most populous state in the U.S., with an estimated 17.3 million residents (U.S. Department of Commerce, 2006). Between 1999 and 2003,

Florida led the nation with 607,000 building permits issued for residential single-family and multi-family dwelling units (National Oceanographic and Atmospheric Administration, 2004). More than three quarters of Florida's population growth and resulting development has occurred within its 35 coastal counties (Florida Department of Community Affairs, 1996; National Oceanic and Atmospheric Administration, 2004).

Figure. John's Pass area, Pinellas County, Florida.

Navigational Access

Florida's coastal population growth and urban development have been driven in part by the creation of the Intracoastal Waterway System (ICW) to facilitate vessel navigation. During the late 1800's to the 1960's, the channelization of Florida's shallow bays and estuaries attracted commerce and the development of waterfront communities upon what was once submerged land and tidal wetlands. Dredge material from access channels and canals were deemed the easiest way to create home sites from "worthless swampland" (Antonini *et al.*, 2002).

Residential Development

Canal systems, originally dredged to create land for homes, have become *de-facto* transportation systems linking tens of thousands of residential boat docks to the ICW and to deeper water in the Atlantic Ocean and Gulf of Mexico. Naturally occurring deeper channels, dredged waterways, and canal systems are also preferred by manatees as migratory routes and travel corridors to feeding areas and, in the case of residential canal systems, as "safe havens" and important sources of freshwater discharge (Lee County Division of Natural Resources, 2004). These natural and human created conditions contribute to a greater chance of collisions between manatees and boats—a significant cause of manatee deaths in Florida.


Figure. Redfish Point area, Lee county: Pre-development (1949) and post-development (1999).

Runoff and Pollution

Impacts to manatees from coastal development include degradation of habitat that sustains them (Sargent *et al.*, 1995). Nutrient- and pollution-rich effluent from mining and agricultural operations, roads, parking lots, and lawns has led to a deterioration of water quality and, subsequently, to a reduction in the extent and health of mangroves and seagrass beds (Livingston, 1990). In addition, the alteration of wetlands by dredge and fill operations, channelization of rivers and streams, and other changes to freshwater flow also threaten the habitat that manatees rely on for survival.

7. Power plant (Warm Water Aggregation Points)

Brief description

Manatees aggregate at natural and manmade warm water sites, such as natural springs, power plants and industrial discharges, and dredged canals and basins. Research indicates that manatees often return to the same warm water discharge site(s) year after year, and that calves may learn this routine from their mothers.

Detailed description

Manatees live in warm coastal waters and require water temperatures warmer than about 68ºF (18ºC) (Reep & Bonde, 2006). Their ability to regulate their internal body temperatures is limited and thus they seek warmer water refuges during periods of cold weather. In Florida, which is in the northernmost extent of the manatee's natural range, cold winter water limits their ability to survive year round in open water. The seasonal variability of water temperature is the most important factor driving manatee migration patterns (Haubold *et al.*, 2006). For centuries, prior to the extensive urbanization of Florida's coastal regions, manatees have sought refuge in naturally occurring sources of warm water. In winter, they migrate to warm water aggregation sites such as large natural springs, where the water maintains a constant temperature, and protected coves in the southerly parts of their range. Nowadays, warm water outflows from power plants also attract hundreds of manatees (Reynolds III, 1996; Shane, 1984). The fact that manatees

have become habituated to many artificial warm water sources is a significant issue in the overall status of manatees, but less so when establishing protection zones.

Figure. Biologist photographing manatee scar patterns at Fort Pierce power plant, Florida (photo: USGS – Sirenia Project).

With the development of coastal urban areas in Florida, a new source of warm water, the heated waste water discharged from power plants and industrial plants, became available for manatees to use in winter. The new source helped to expand the winter range for manatees in Florida by providing additional refuge sites during cold winter months. It is now common to see hundreds of manatees congregating around the discharge areas of power plants in winter. The difficulty for resource managers is the danger that any interruption in the operation of the power plant could cause harm to manatees that are habituated to these sites. Should a power plant close down during a cold snap, several dozens of manatees could be killed from the cold. Likewise, maintaining substantial flows of spring water during winter months is important for the manatee survival. Any changes to the configuration of this network of warm water refuges, to which manatees are now habituated, present a serious threat to the long-term survival of the Florida manatee (Haubold *et al.*, 2006; U.S. Fish and Wildlife Service, 2001).

8. Government building (Legislation for Manatee Protection)

Brief description
The Florida Manatee is listed as endangered under the guidelines of the Endangered Species Act and is protected by the Marine Mammal Protection Act and the Florida Manatee Sanctuary Act. The U.S. Fish and Wildlife Service (FWS) and the Florida Fish and Wildlife Conservation Commission (FWC) are the principal federal and state agencies responsible for planning and implementing activities designed to protect the manatee. The FWC has proposed reclassifying the state status to “threatened” (formal change could occur as soon as September 2007) and the FWS has also indicated a change in the federal status is possible. Internationally, the Florida Manatee is listed as

"threatened" by the World Conservation Union (IUCN) on the "Red List" of threatened species (IUCN, 2007)

Detailed description

Early Legal Protections of Manatees

Manatees were protected as early as 1764. British Colonial Records indicated "His Majesty (proposed) that an Instruction should be given to the Governor of the Provence of East Florida to restrain him from granting to any person whatsoever, without His Majesty's particular Orders and directions, those parts of the Coast of the said Province frequented by the Animals called the Manati or Sea Cow, where they have their Echouries [estuaries] or Landing Places." The edict was largely ignored and the hunting of manatees for food and other uses continued. The first state statute protecting the manatee was enacted in 1893 (Ch. 4208.94) and by 1907 a $500 fine and or 6 months imprisonment was assessed against anyone molesting a manatee (Florida Fish and Wildlife Conservation Commission, 2007).

Current Federal Protections of Manatees

More recent federal protections for the manatee primarily stem from the following Federal laws: the National Environmental Policy Act of 1969 (NEPA), the Marine Mammal Protection Act of 1972 (MMPA), and the Endangered Species Act of 1973 (ESA). Additional protections for the manatee are afforded by the Clean Water Act of 1977 (CWA).

Florida State Protections of Manatees

In addition to federal laws, the State of Florida has enacted its own set of concurrent protections to the manatee. The primary authority comes from the Florida Manatee Sanctuary Act, s. 370.12(2), Florida Statutes (2006). The process is described and further clarified in Chapter 68C-22, Florida Administrative Code (Antista, 2004; State of Florida, 2006; State of Florida, 2007). The state protects the manatee independently of the manatee's status as a "state or federal listed species." These laws require boaters to maintain their distance from manatees, and make it illegal to harass or feed a manatee.

Florida Manatee Regulations

The FWC establishes regulatory zones in areas that manatees inhabit on a regular basis and where manatee sightings are frequent. Such zones include: "Idle Speed Zone," "Slow Speed Zone," "Motorboat Prohibited Zone," "No Entry Zone," "Maximum 25 MPH Speed Zone," "Maximum 30 MPH Speed Zone," and "Maximum 35 MPH Speed Zone." These zones have been applied to waterways with frequent manatee sightings and can coincide with federal and local manatee protections. Permits are available for events and groups that allow for vessel operation outside the protected zone parameters. These include: Commercial Fishing and Professional Guiding Exemptions; Owners or Residents of Waterfront Property in Limited Entry Areas; Boat and Motor Manufacturing Testing Permits; Boat Races; and Research, Educational, Construction, Maintenance or Repairs (State of Florida, 2007).

9. Map

Brief description
The MAPR GIS interactive map integrates geographic information and educational modules, in an interactive format, that present human use, regulatory, and environmental factors that help to guide manatee protection in Florida. Lee County, Florida is the selected study area.

Lee County contains one of the largest open water estuaries in Florida and represents one of the state's most popular boating regions. Recreational boaters are attracted to this area by its many barrier islands and protected waters that provide excellent opportunities for small-craft fishing, nature viewing, and picnicking/socializing along barrier island beaches and exposed sand spits. An estimated 45,000 pleasure boats are currently registered in the county (Bureau of Economic and Business Research, 2006), which represents a 113% increase in vessel registrations over the past 20 years.

Lee County is also very important to manatees. Hundreds of manatees rely on county waterways during all or part of the year (Lee County Division of Natural Resources, 2004). The county has ranked first in Florida for watercraft related manatee mortality over the past five years.

Florida Sea Grant (FSG) and the FWC FWRI recently completed a recreational boating study for the Greater Charlotte Harbor region that can be used to characterize the preferences, activities, and seasonal use patterns of Lee County boater populations (Sidman *et al.*, 2005). In addition, a series of aerial surveys, covering the same time period, were conducted to identify observed seasonal boating patterns. The two complementary sources of boating information provide a comprehensive evaluation of seasonal spatial boating patterns in Lee County. These data provide important spatial information on boating patterns that can be used to help identify the most appropriate locations for manatee protection zones.

Detailed description
There is no detailed description. Clicking on the map, takes you there.

2.0 – Map page

2.1 – Map localities

On the map are six highlighted localities, displayed in a transparent orange rectangle with a pointer in an upper corner. Each of these places was chosen to illustrate important factors about manatee protection. When the user clicks on the pointer at a locality, a small box appears with a label and brief description. Users can then click on the option to get more information or view a zoomed-in map showing aerial photography for the locality. Any of the "clickable" map layers that have been selected can also be seen. In addition, users will be able to turn on or off any of the map layers while the map is zoomed.

1. Boca Grande Pass and Pelican Bay

Boca Grande Pass is a heavily traveled Gulf-to-bay passage that provides mariners immediate access to and from the Gulf Intracoastal Waterway, Charlotte Harbor, and Pine Island Sound. Its deep waters are the venue for an annual tarpon tournament, which draws hundreds of boats each spring. The south side of the pass is Cayo Costa Island, a largely undeveloped barrier island with a pristine Gulf beach. Off the beach just south of the pass is Johnson Shoal, a constantly-changing sand feature that usually offers a sheltered cove for small recreational boats. On a busy day, scores of vessels may be anchored in the cove or beached on the sand.

Just south of Boca Grande Pass along the Intracoastal Waterway is the entrance to Pelican Bay, an outstanding anchorage, one of the best and safest in Pine Island Sound. Its west shore is the bay side of Cayo Costa Island, and to the east is Punta Blanca Island. Both islands are bird sanctuaries. The secluded, sheltered bay and attractive surroundings are magnets to visiting boaters, many of whom anchor overnight. It is also attractive to manatees, particularly in the summer months. The entirety of Pelican Bay is designated by the FWC as a manatee protection zone where slow speed is indicated from April 1 to November 15. The zones displayed in this map are the FWC manatee protection zones. In some areas there are also local and/or federal zones. Boaters should abide by the regulations as posted on the water.

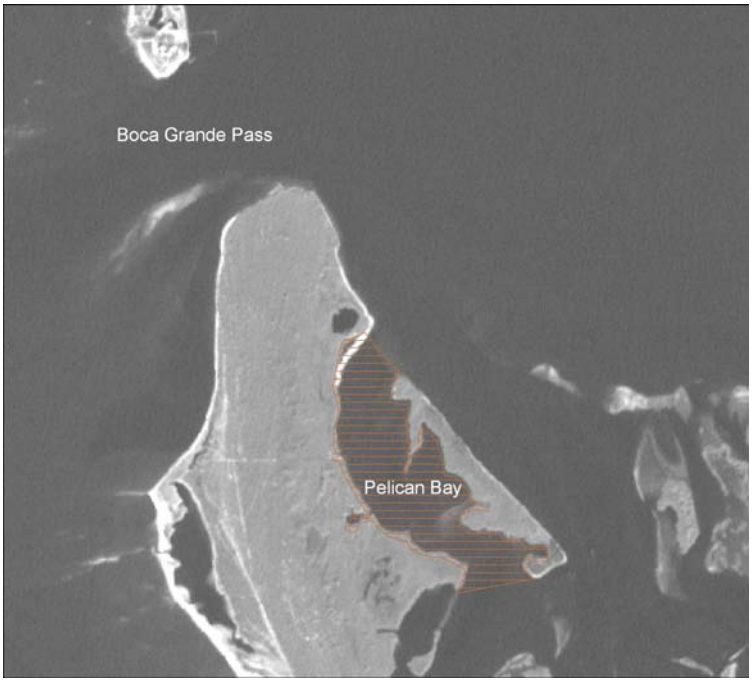


Figure. Satellite image showing Boca Grande Pass and the manatee protection zone in Pelican Bay.

2. Matlacha Pass

Matlacha Pass is a narrow waterway that connects Charlotte Harbor, to the north, and San Carlos Bay, to the south. Although called a pass, it is not an inlet from the Gulf of

Mexico, as are the other passes on Florida's Gulf coast. Rather, it is the remains of an estuary that separated an ancient coastal barrier island—today's Pine Island—from the mainland. The pass is relatively shallow, compared to the longer alternative route around the west side of Pine Island, and its waters hide numerous oyster reefs. Nevertheless, it is an attractive shortcut for smaller vessels. The pass is also a popular fishing destination. Approximately half-way through the pass is the town of Matlacha, where busy Pine Island Road joins the mainland to Little Pine Island via a causeway and bascule bridge.

The pass is rich with seagrass beds and lined with abundant mangrove forests, making it attractive manatee habitat. Just east of the Matlacha community is Matlacha Isles–Matlacha Shores, a Census Designated Place (CDP) with an access channel from the pass and a residential canal system. These waterways are important warm water refuges for manatees. A weir across the canal prevents manatees from swimming north into the immense canal network of northwest Cape Coral, but a boat–lift over the weir facilitates vessel traffic to and from the Cape Coral canals. All boats using this route must traverse part of the Matlacha Isles–Matlacha Shores canals and the access channel.

Reflecting the importance of this region for manatees, the FWC manatee protection zones implement slow speeds throughout the year for all areas except the main channel, where speeds of 25 miles per hour are permitted. The legend in the figure below can be used to interpret the manatee protection zones shown on the map layer. The zones displayed in this map are the FWC manatee protection zones. In some areas there are also local and/or federal zones. Boaters should abide by the regulations as posted on the water.

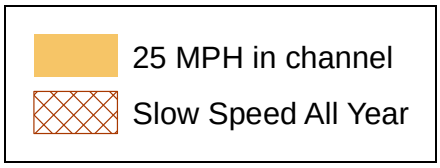


Figure. Manatee protection zones in Matlacha Pass region.

3. San Carlos Bay

San Carlos Bay is the confluence of Pine Island Sound, Matlacha Pass, the Caloosahatchee River, and a broad pass into the open Gulf of Mexico. At the mouth of the Caloosahatchee, the Gulf Intracoastal Waterway (ICW) connects to the Okeechobee Waterway. Pine Island defines the north shore of the bay. Most of the extensive residential canal systems in the Pine Island town of Saint James City open directly into San Carlos Bay. The Punta Rassa boat ramp, at the east end of the bay, is one of the busiest in Lee County. The long east/west reach of the ICW across San Carlos Bay is locally called "The Miserable Mile," because the open-water chop and swift tidal currents sometimes interact to create difficult conditions for navigating a waterway—much longer than a mile—where larger vessels must diligently stay in the dredged channel. Even so, San Carlos Bay is not only a busy thoroughfare, but also a very popular fair weather destination for recreational boaters. Good fishing abounds, and several islands—especially Picnic Island—host large collections of vessels on busy boating weekends.

Figure. Part of “The Miserable Mile” in San Carlos Bay.

Manatee protection zones in San Carlos Bay comprise two main areas: the entrance to Matlacha Pass and the Caloosahatchee River which is slow speed all year, and the southern end of Pine Island, including St. James City, which is slow speed from April 1 through November 15, but unregulated for the remainder of the year. The channels into Matlacha Pass are zoned as 25 miles per hour all year. The zones displayed in this map are the FWC manatee protection zones. In some areas there are also local and/or federal zones. Boaters should abide by the regulations as posted on the water.

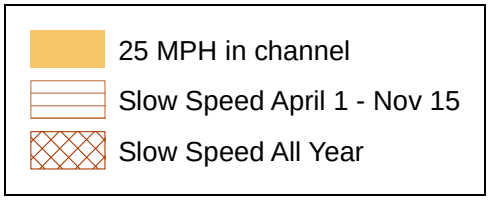


Figure. Manatee protection zones in San Carlos Bay region.

4. Caloosahatchee River

It is hard to recognize from today’s Okeechobee Waterway—with its abruptly-cut banks and straight-lined, flood-controlled, navigation-optimized, dredged channel—the once meandering, shifting, rope-bending, snag-laden course of the Caloosahatchee River. Today, the Caloosahatchee is the western portion of the Okeechobee Waterway, which stretches from Stuart, on the Atlantic Ocean, to San Carlos Bay and the Gulf of Mexico. The route crosses the state via the St. Lucie River and Canal, Lake Okeechobee, and the Caloosahatchee (Antonini *et al.*, 2002). In Lee County, the river is an essential waterway for significant boating traffic, much of which originates in major residential canal systems, the sole access of which is afforded by the Caloosahatchee (Swett *et al.*, 2002).

Manatees have been documented in the river throughout the year. Sitings during the colder months are centered around the power plant near the mouth of the Orange River (just upriver from the I-75 bridge), which is a significant source of warm water; however, the entire area is used during these times. The importance of the power plant area is highlighted by the following statistics from the *Lee County Manatee Protection Plan* (Lee County Division of Natural Resources, 2004): "An average of 63.9 manatees was seen per flight during the November through March period (average of 56.3 during the 1997-98 survey). The highest single day count for this period during these surveys was 247, recorded on January 20, 1997, 240 of which were in the power plant canal, the Orange River, or the section of the Caloosahatchee River nearest to its confluence with the Orange River. As many as 338 manatees have been seen in the power plant area on a single day during other surveys flown specifically to count manatee aggregations at Florida power plants. An average of 13.0 manatees was seen per flight during the April through October period (average of 7.8 during the 1997- 98 survey). The highest single day count for this period was 81, recorded on May 25, 1995."

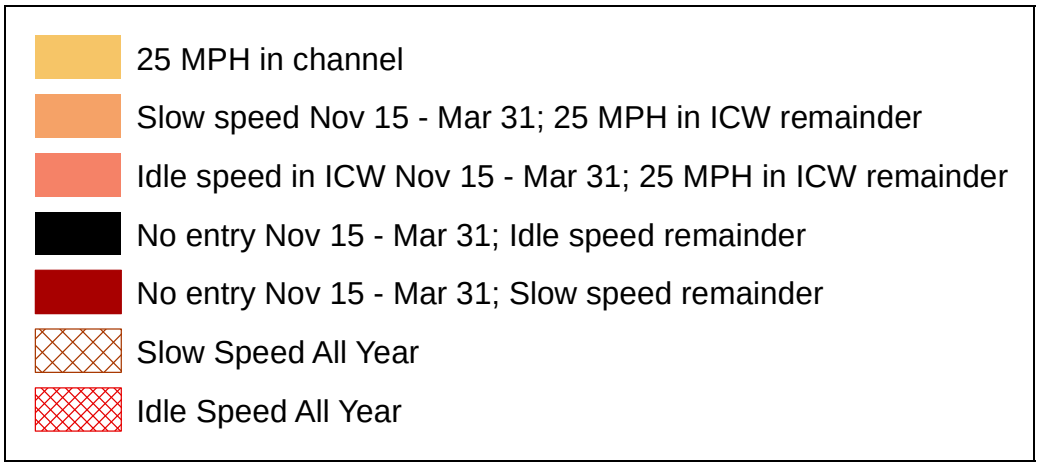


Figure. Manatee protection zones in Caloosahatchee River region.

The importance of this region to manatees is reflected in the complexity and nature of the manatee protections zones put in place by the FWC. Most of the area here is categorized as "Slow Speed" or "Idle Speed" for the entire year. The Intracoastal Waterway, which runs along the main channel of the Caloosahatchee, is also regulated into three distinct speed zones, two of which vary according to the time of year. The section of the channel that bisects the year round idle speed zone is restricted to idle speed from November 15 through March 31, when manatees aggregate in the Orange River. Finally, there are two zones where no entry is permitted during winter months, and either idle or slow speeds apply for the remainder of the year. The zones displayed in this map are the FWC manatee protection zones. In some areas there are also local and/or federal zones. Boaters should abide by the regulations as posted on the water.

5. Northern and Southern Estero Bay

Manatees have been observed in Estero Bay throughout the year. Use during the colder months is centered primarily on Ten-Mile Canal and Mullock Creek in the north and, to a

lesser extent, the Imperial River, which flows into the south end of the bay. Estero Bay has extensive seagrass beds and numerous islands that provide extensive mangrove shoreline. The bay accounts for 22.8 percent of all Lee County watercraft-related manatee deaths and 15.5 percent of deaths from all causes (Lee County Division of Natural Resources, 2004).

Compared with other open water bodies in Lee County, Estero Bay is a relatively shallow boating venue, used mostly by small, shoal draft craft. Big Carlos Pass, at the southeast end of San Carlos Island (and the city of Fort Myers Beach), is a popular recreational boating destination. Vessels traveling the bay side of the barrier islands can transit the length of Estero Bay—from Bowditch Point on the northwest end of San Carlos Island, through Matanzas Pass to Big Carlos Pass, and south to the Lee County line in Bonita Springs—via a sheltered inland waterway. Tributaries that feed boat traffic into the north and east bay from the mainland are Hendry Creek, Ten-Mile Canal, Mullock Creek, the Estero River, and Spring Creek. The Imperial River, at the south end of the bay, is the most significant boat source (Gorzelany, 1998).

The manatee protection zones in Estero Bay require boaters to travel 25 miles per hour in the channels. However, most of the Bay is regulated as a "Slow Speed" zone from April 1 through November 14. There are some areas in the northern and southern ends of Estero Bay that require slow speeds all year long. The zones displayed in this map are the FWC manatee protection zones. In some areas there are also local and/or federal zones. Boaters should abide by the regulations as posted on the water.

Figure. Manatee protection zones in Estero Bay region.

2.2 – Clickable map layers

The following spatial data layers are able to be turned on or off via a checkbox in the map's table of contents. Clicking on the "more information" tag in the table of contents will cause more information about the data layer in the context of Lee County to appear in a text box on the map page.

1. Boating Routes

Boaters drew on a mail-survey map the routes of their two most recent pleasure boating trips. Each route was then entered into a geographic information system (GIS) as a line feature, from origin to destination(s). Routes could be one-way or round trips that

returned to the original origin. A few either began or ended off the map, in which case only the portion on the survey map study area was entered into the GIS.

Data source: Map-based mail surveys of Charlotte and Lee County boaters conducted by Florida Sea Grant in 2005 and 2006.

2. Boating Destinations

Boaters drew on a mail-survey map the destinations of their last two pleasure boating trips and indicated the activity at each destination. A trip could have more than one destination. For instance, a trip with stops indicated for fishing, beachcombing, and visiting a restaurant would have three or more. The location for each destination was entered into a geographic information system (GIS) as a point feature, along with an activity code, date, and other information.

Data source: Map-based mail surveys of Charlotte and Lee County boaters conducted by Florida Sea Grant in 2005 and 2006.

3. Boat Sightings

Low-level aerial surveys of boat traffic used a video camera system to record all vessels *in use* (under way, drifting, or anchored outside a designated municipal anchorage). The surveys, flown with a fixed wing aircraft at an altitude of 500 to 1000 feet, alternated between mornings and afternoons in order to observe more complete boat use patterns. Each vessel was plotted as a point feature in a geographic information system (GIS). Also interpreted from the video were vessel type, length, and direction of travel (if under way).

Data source: Aerial video surveys flown by Mote Marine Laboratory over Charlotte and Lee County waters in 2005 and 2006.

4. Marinas and Ramps

Lee County is a microcosm of Florida's tremendous growth in waterway development and uses. Perhaps nowhere else in Florida are human alterations to the coastal landscape more visible than in Southwest Florida, which includes Lee County (Antonini *et al.*, 2002). The Lee County coastline is comprised of large estuaries such as Charlotte Harbor, Pine Island Sound, and Estero Bay, and hundreds of miles of man-made channels and canal systems linking the massive waterfront developments of Punta Gorda to the north (in Charlotte County), with Cape Coral and Ft. Myers to the south. The area also encompasses the Caloosahatchee, a riverine system that is part of the Okeechobee Waterway.

Lee County's 2006 population of 585,608 represents a growth rate of 185% since 1980, and 33% since 2000 (Bureau of Economic and Business Research, 2006). The tremendous population growth in Lee County has been driven, in part, by the

development of the Gulf Intracoastal Waterway system (ICW) and the dredging of hundreds of miles of canal systems to make land for waterfront residential developments.

Data source: "A Recreational Boating Characterization for the Greater Charlotte Harbor" (Sidman *et al.*, 2005)

5. Boating Channels

The boating channels shown were mapped during the Regional Waterway Management System (RWMS), conducted by Florida Sea Grant (FSG) in partnership with Lee County from 1999 through 2002. At the start of that project, the county's Division of Natural Resources personnel marked on large-scale topographic maps the channels used by recreational and commercial vessels to travel from their mooring or launch locations to "deep, open water" (the Intracoastal Waterway or the Gulf of Mexico). With these maps as a guide, FSG field crews measured depths along the waterways, searching out the deepest water. As they worked, the crews consulted shore residents and other boaters encountered, in order to ensure the routes being sounded were indeed those favored by local boaters. After being corrected for tides, the measured depth data points were converted to linear channel features and used in geographic information system (GIS) analyses that compared the drafts of boats moored in channel systems to water depths in the channels, a primary purpose of the RWMS. The channel data set has since found other uses, including manatee studies (Swett *et al.*, 2002)

Data source: "A Regional Waterway Management Plan for Lee County, Phase 1 and Phase 2" (Swett *et al.*, 2000; 2001)

6. Manatee Protection Zones

In Lee County, the Florida Fish and Wildlife Conservation Commission (FWC), and the county Division of Natural Resources participate in the investigative and legislative processes that lead to designation of manatee protection zones. The state adopts the regulations. The county plans, permits, installs, and maintains the official signs that demarcate the limits of each zone. County personnel also change the messages on seasonal zone signs (Lee County Division of Natural Resources, 2004).

To help protect manatees in Lee County and to counteract the trend of increasing numbers of boat strikes to manatees, the county provides technical and financial support to state, county, and local agencies responsible for speed zone enforcement and manatee education/awareness. A primary educational initiative by Lee County is creation and dissemination of boater guides; nearly 300,000 have been distributed. The guides map manatee zones and explain how boaters can obey the rules when navigating the zones. Other educational projects are also underway (Lee County Division of Natural Resources, 2004).

Both the FWC and Lee County make available maps of manatee zones, as PDF files that can be viewed online or downloaded for printing. The FWC website includes maps of

zones in Lee and other Florida counties (http://myfwc.com/manatee/data/mapref.htm). The zones displayed in this map are the FWC manatee protection zones. In some areas there are also local and/or federal zones. Boaters should abide by the regulations as posted on the water.

Data source: Florida Fish and Wildlife Conservation Commission

7. Manatee Sightings

Manatee locations in Lee County were mapped from aerial observations. The observations include numerous flights made between 1984 and 2004. Researchers fly in fixed wing aircraft recording the actual locations of manatees observed from the air during any given flight. The mapped points show general locations, not necessarily individual manatees. In cases where groups of manatees were observed, only one point was mapped. Locations of manatees shown on the map may represent one or more manatees in that location. They also represent manatee locations at one moment in time. Manatees are wide ranging, especially during the summer months. Radio telemetry data of manatees in Lee County show that they move regularly up and down the Caloosahatchee River and through Matlacha Pass (Florida Fish and Wildlife Conservation Commission, 2002).

Data sources: Florida Atlas of Marine Resources, Version 1.3, May 2000 (Florida Fish and Wildlife Conservation Commission, 2000); Mote Marine Laboratory.

8. Manatee Mortality Locations

The data shown here represent places where dead manatees were found from 1975 to 1999. The table below breaks down the mapped data according to cause of death. More recent statistics for Lee County are available from the FWRI website (http://research.myfwc.com/manatees/). One of the problems with these data is the difficulty in determining where the injury or death took place because an injured manatee may swim for days before dying or water currents may transport the carcass. Lee County has a significant manatee population, and a growing number of recreational boaters use its waterways. Manatee fatalities in the county—including those from encounters with boats—are among the highest in the state (Lee County Division of Natural Resources, 2004). Causes of death include human-related, naturally caused, and undetermined. Statewide, watercraft encounters are the leading known human-related cause of manatee deaths.

	Cause of Death	**# of deaths**	**% of deaths**
1	Watercraft	114	18.69
2	Floodgate/lock	1	0.16
3	Other human	11	1.80
	Total human related deaths		**20.65**
4	Perinatal	107	17.54
5	Cold stress*	11	1.80

6	Other natural**	150	24.59
	Total natural cause deaths		**43.93**
7	Not recovered	16	2.62
8	Undetermined (too decomposed)	144	23.61
9	Undetermined	56	9.18
	Total not recovered or undetermined		**35.41**
	Total mortality in Lee County (1975 – 1999)	**610**	

*Cold stress category did not exist prior to 1986
**Includes 1996 red tide event

Table. Manatee mortalities in Lee County from mapped data (1975 – 1999).

Since 1974, watercraft-related deaths in Lee County average 21% per year. Other common causes of death in Lee County are: perinatal (manatee carcass was less than 150 cm) with an average of 23% per year; other natural (which includes red tide), with an average of 19% per year; and undetermined, with an average of 28% per year. A closer look at the numbers provides a better picture of how things are changing in Lee County. Since 1997 watercraft-related mortality has ranged from a low of 11% of all manatee deaths in 2003 to a high of 45% of in 2001. The number of dead manatees recorded in Lee County has increased in recent years, with the five year running average going from 40 in 2001 to 69 in 2006. Of these, five year running averages of 12 to 14 deaths were due to watercraft collisions (statistics from data provided by the Marine Mammal Pathobiology Laboratory of the Florida Fish and Wildlife Conservation Commission) (Fish and Wildlife Research Institute, 2007b).

Data source: Florida Atlas of Marine Resources, Version 1.3, May 2000 (Florida Fish and Wildlife Conservation Commission, 2000)

9. Manatee Water Depth

Manatees prefer shallow water from 1 to 4 meters deep (approximately 3 to 12 feet) (Reep & Bonde, 2006). While manatees are found in shallower areas, biologists have observed that they tend to stay close to deeper water channels that provide easy accessibility to and from preferred grazing or aggregations sites. In Lee County, the extent of this preferred water depth covers all the major coastal areas including Pine Island Sound, Matlacha Pass, Estero Bay, San Carlos Bay, and up the Caloosahatchee River. The data shown in this map represent water depths relative to the North American Vertical Datum of 1988 (NAVD 1988). For this part of Florida, the Gulf shoreline corresponds to an NAVD elevation of approximately -1.15 feet (Liebermann, 2004). The depths shown on the map take this into account. Actual water depth can change by 2 to 3 feet depending on tidal state and weather conditions. Manatees are also frequently found in areas as shallow as one foot and are not restricted to any depth.

Data source: Derived from bathymetry supplied by South Florida Water Management District.

10. Warm Water Aggregation Points

There are five warm water aggregation sites in Lee County. They include the area near the Franklin Lock and Dam structure on the Caloosahatchee River; the Orange River, particularly surrounding the Florida Power and Light discharge area; the Cape Coral canals, including the Eight Lakes area; the Matlacha Isles canal system; and the Ten Mile Canal area (Lee County Division of Natural Resources, 2004).

Data source: Derived from manatee aerial survey locations provided by Florida Wildlife Research Institute and Mote Marine Laboratory.

11. Freshwater Sources

While manatees live and breed in salt water, they seek out fresh drinking water from time to time. Manatees do not require freshwater for survival, but they are attracted to water with salinity levels less than 25 ppt. According to the Lee County Manatee Protection Plan, freshwater in Lee County is found in most of the larger creeks and rivers, including the Caloosahatchee River, Trout Creek, Telegraph Creek, Orange River, Billy's Creek, Hancock Creek, Hendry Creek, Estero River, Spring Creek, and Imperial River. In addition to these natural sources, there are several sources of freshwater from human related sources such as treated wastewater and stormwater runoff in residential areas (Lee County Division of Natural Resources, 2004).

Data source: Digitized from description provided by Lee County Manatee Protection Plan (Lee County Division of Natural Resources, 2004).

12. Seagrass Beds

In Lee County, seagrass beds are composed of at least five different types of seagrass, including *Vallisneria Americana* (Eel Grass), *Ruppia maritime* (Ditch Grass), *Halodule wrightii* (Shoal Grass), *Syringodium filiforme* (Manatee Grass) and *Thalassia testudinum* (Turtle Grass). The majority of seagrass beds in the coastal areas were mapped from aerial photography taken in 2004. Seagrass beds in the Caloosahatchee River, while especially important for manatees during the winter season, are harder to map due to the turbidity of the water. The Caloosahatchee River seagrass beds shown here were mapped in 1993. Studies conducted between 1986 and 1997 sampled seagrass beds in the Caloosahatchee River. However, during a 1999 study, researchers were unable to find seagrass in the lower reaches of the river (Chamberlain & Doering, 1998; Florida Fish and Wildlife Conservation Commission, 2002).

Data source: South Florida Water Management District.

13. Mangrove Forests

Mangrove forests are found along shorelines throughout Lee County. Manatees are herbivores that consume many types of aquatic vegetation. While seagrass is preferred,

mangrove leaves also provide sustenance to manatees, particularly in the winter months when seagrass is less productive or farther from warm water aggregation sites.

Data source: Statewide Water Management District Land Use map supplied by the Florida Geographic Data Library (FGDL).

3.0 – GIS page

3.1 – MAPR Interactive Map

An important element of the Manatee Awareness and Protection Resource (MAPR) is the interactive map that displays and describes spatial data relevant to manatee protection. The map incorporates basic geographic information system (GIS) functionality that allows the user to display and overlay various environmental, manatee, and boating related data themes. Simply click on the data layer of your choice (e.g., mangrove forests) to display that feature on the map of Lee County. Clicking the "more info" link for each data theme in the legend (to the right of the map) provides further insights into that layer's origin and significance.

Additional functionality allows the user to zoom in to six locations (Boca Grande, Matlacha Pass, San Carlos Bay, Caloosahatchee River, and Estero Bay) in Lee County, Florida for a more detailed view. Each of the six locations is highlighted by an orange shaded box. Pause your cursor over the orange circles with white pointers to display options for "more information" and "zoomed in map." The "more information" option describes the local area and its relevance to manatees, and the "zoomed in map" opens a new, detailed view of the location. Explore the spatial relationships between various data themes or layers by clicking them "on" or "off" in the legend at the right.

3.2 – Description of a GIS

The MAPR interactive map incorporates basic geographic information system (GIS) concepts. A GIS is a computer-based tool to aid in the collection, storage, display, analysis, and distribution of *spatial* data, data for which place or location on the earth is important. A traditional paper map can show the size, shape, and location of a feature on the Earth's surface, but it can display little additional information. Books, database files, or other repositories may hold further insights, but the paper map is not a direct portal to them. A GIS map includes geographic content, too; but it may also contain or link to a nearly unlimited amount of additional information associated with each feature. The GIS allows immediate display, query, and analysis of all this information.

GIS tools help users identify and address environmental concerns by providing crucial information on where problems occur and who or what they affect. Users of GIS include scientists, resource managers, planners, and decision makers. Using a GIS, researchers can identify the sources, locations, and extent of environmental interactions and devise practical plans for monitoring, managing, and mitigating environmental issues.

The MAPR interactive map incorporates a number of data themes relevant to manatee protection. Over the years, researchers have collected much information on where and when manatees migrate, forage, rest, and use warm water refuges, as well as where encounters with boats have occurred. In many of these same areas, other studies have amassed data on boating populations and usage patterns from mail surveys (Sidman *et al.*, 2005) and airborne videography (Gorzelany, 1998). Although the study purposes were often unrelated to issues of manatee and boat interactions, all of these data are in GIS formats and ready for further analysis, and data collection continues.

One basic way that GIS facilitates the analysis of spatial data is by providing options for the visualization of information, typically using overlay analysis—as is illustrated by the MAPR interactive map. Specific categories of information are presented as "layers" such as channels or bathymetry. Users can easily change the way each layer appears and show or hide combinations of layers to best discover and display relationships among them. For instance, locations where manatees have been observed (point features) can be displayed over areas where seagrass beds exist (polygon features). If there is some correlation between where manatees are seen and where a potential food source occurs, it may be visually apparent. Then, in the same map view, the researcher can "turn on" a data layer containing routes (line features) used by boats revealing a new set of relationships. This method provides valuable insights to an investigator with adequate knowledge of the data sources and limitations.

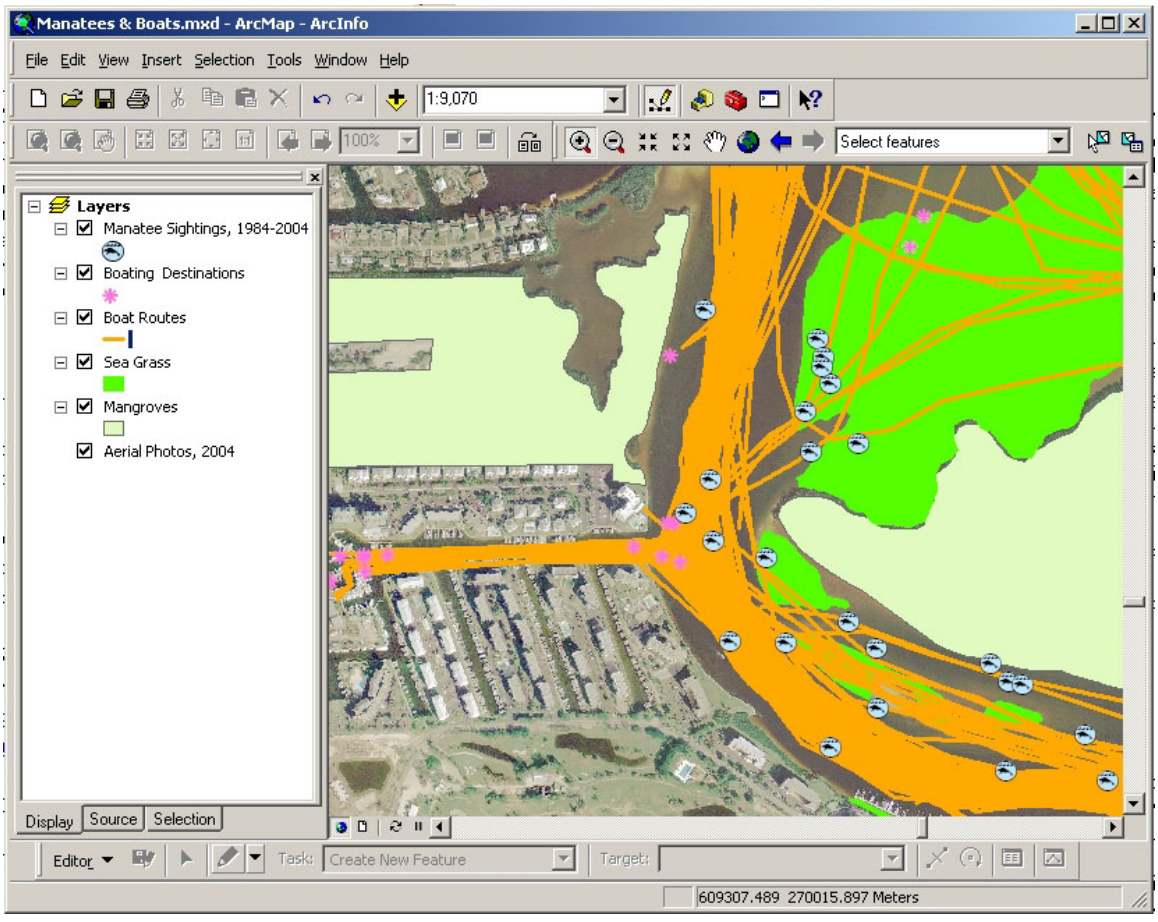


Figure. Screenshot of a GIS program showing spatial data related to manatees and boats.

However GIS can do much more than simply display map features. It allows researchers to query, make selections, and measure interactions of features by contiguity, proximity, similarity, and other spatial characteristics. Using a GIS, investigators can perform analyses on the attribute values of selected features. For example, for each manatee observation, attribute values may include: the number of animals at that location; the date or season; whether the animal was swimming, feeding, or at rest; and the observation method. These data can be queried and modeled just as in any database and, coupled with the locational information, can answer questions of not only what and how, but where phenomena are occurring.

As with any endeavor to provide decision makers with objective, sound, scientific information, valid GIS analysis depends upon careful data collection and processing as well as logical, appropriate, and robust procedures. GIS allows data collection, exploration, and analysis that would be inefficient or even impossible to accomplish by other means.

4.0 – Contacts page

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Charleston, SC 29405-2413
(843) 740-1200
www.csc.noaa.gov

Florida Sea Grant provides people, tools, and science to help protect and make wise use of our coastal and marine resources. The primary goal of Florida Sea Grant is a sustainable economy and environment, which it advances through a statewide, university-based research, education, and extension partnership of state and federal agencies, businesses, and citizens.

The **Coastal Services Center** is an office within the National Oceanic and Atmospheric Administration devoted to serving the nation's state and local coastal resource management programs. Many of the Center's efforts focus on helping state and local programs resolve site specific issues.

5.0 – Resources page

5.1 – Data Sources

The following organizations contributed spatial data which was used to derive information displayed in the MAPR interactive map:

- Florida Sea Grant
- Florida Fish and Wildlife Conservation Commission
- Fish and Wildlife Research Institute
- Mote Marine Laboratory
- Lee County Department of Natural Resources
- South Florida Water Management District

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