The Florida Manatee

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By Victoria Brook Van Meter
Illustrated by
Laura Sartucci Weigert

The information in this booklet came from many sources and represents the work of many researchers. Many of the books and scientific papers used in writing this booklet are referenced in the section titled Citations. Anyone wishing to learn more about manatees will find a wealth of information in these sources.

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Contents

Introduction

The Florida manatee, or sea cow, *(Trichechus manatus latirostris*), a subspecies of the West Indian manatee *(Trichechus manatus),* is a large, herbivorous, aquatic mammal that can be found in the shallow coastal waters, rivers, and springs of Florida and adjoining states. These gentle creatures are endangered throughout their range. High annual mortality, primarily associated with human activity, as well as a low reproductive rate and loss of habitat continue to keep the number of manatees low and threaten the species' future.

In response to an increased awareness of the plight of the manatee, governmental agencies, universities, private conservation groups, and concerned corporations have joined together to promote research and identify the actions needed to encourage the recovery of manatee populations. This work has increased our knowledge of this species as well as raised many questions that remain unanswered. The combined efforts have been so effective that the Florida manatee is one of the best known marine mammals in the world. The following presents a review of current knowledge concerning the biology, life history and status of the manatee in Florida.

Description

Manatees are large, somewhat seal-shaped mammals with flat, rounded tails. Adults range in color from gray to brown. Calves are darker at birth and change to a grayish color in about one month. Newborn, or very young calves, may also be distinguished by their so-called "fetal folds", which encircle the baby's body, near the fluke. Adults are typically about 9 to 10 feet long and weigh around 1,000 pounds. They can, however, grow as large as 13 feet, weighing more than 3,000 pounds (Reynolds and Odell 1991). Female manatees tend to reach greater lengths and weights than males (Odell 1982).

The skin of the manatee is finely wrinkled and the surface layer continually sloughs off, which reduces the build-up of surface algae and other growths. A layer of fat is located under the skin and fat deposits are found between certain muscle layers and around the intestines. Hair is distributed sparsely over the body and stiff whiskers grow around the face. The manatee has no hind limbs and its forelimbs, or flippers, are paddle-shaped. The bones are massive and heavy and lack marrow cavities in the ribs and long bones of the forelimbs (Odell 1982). The Florida manatee has three or four nails at the tip of each flipper.

The face of a manatee is bulbous; the small, wide-set eyes give the animal a peaceful expression. The nostrils, located on the upper surface of the snout, are tightly closed by valves when underwater, and the eyes have inner membranes that can be drawn across the eyeballs for protection. The ear openings, located just behind the eyes, are small and lack external lobes. The brain of the manatee is small for a mammal of its size (O'Shea and Reep 1985).

About six to eight hours a day are spent feeding on seagrasses, freshwater plants and even plants growing along the shoreline.

Manatees have a flexible upper lip that is used to draw food into the mouth. Manatees are extremely unusual among mammals in that their teeth are continually replaced. Grinding molars form at the back of the jaw, wear down as they move forward, and eventually fall out. Tooth replacement is an adaption to the manatee's diet of abrasive plants that often are mixed with sand. The "wrinkles", or cusps in the surface enamel of the molars also may help reduce wear (Domning and Hayek 1986). The extreme wear of the front teeth noted in Florida's manatees appears to be unusual relative to manatees in some other locations and may be caused by the quartz-sand substrates of the Atlantic and Gulf coasts (Domning 1982).

The digestive system of the manatee is generally similar to that of some other herbivores such as horses, with bacterial digestion of cellulose occurring primarily in the hind part of the gut (i.e. the large intestine). This digestive system is adapted to processing large amounts of high-fiber, low-protein food. The

intestines of adults can measure up to 130 feet in length (Reynolds and Odell 1991). Because of these factors, manatees are highly efficient herbivores capable of extracting up to 80% of the digestible materials in the plants that they eat (Lomolino and Ewel 1984). A large glandular structure called the cardiac gland protrudes from the curvature of the stomach. This structure produces enzymes and hydrochloric acid as well as mucus that coats swallowed food and protects the lining of the digestive system from abrasion. Digestion is accompanied by the formation of large amounts of gas (Snipes 1984). Oddly enough, the manatee diaphragm may compress gas in the intestines to permit manatees to control their buoyancy without apparent muscular movement (Rommel and Reynolds 2000).

The lungs of the manatee may exceed three feet in length in adults. Manatees and other aquatic mammals replace about 90% of the air in their lungs with each breath. Humans at rest replace about 10% of the air in their lungs with each breath. Both the lungs and the uniquely-positioned diaphragm extend the length of the body cavity and are oriented in the same horizontal plane as the manatee. This arrangement is important for buoyancy control, (Rommel and Reynolds 2000) but it makes manatees extremely susceptible to serious injury or death when collisions occur with watercraft (Reynolds 2000).

The main external difference between male and female manatees is the location of the urinary and reproductive opening. In the female, this opening is located just in front of the anus; in the male, it is located further forward, just below the navel. Females also have a prominent teat located against the body under each flipper (Reynolds and Odell 1991).

Evolution

Manatees belong to the order Sirenia, which also includes the manatee's relative in the Pacific, the dugong, (*Dugong dugon*). Sirenians evolved from four-footed land mammals more than 60 million years ago (Hoenstine 1980). The presence of tiny pelvic bones in manatees, shaped differently in males and

females, is evidence of their terrestrial ancestry (Fagone, et al. 2000). The closest modern relatives of the Sirenia are elephants, aardvarks, and hyraxes, small furry mammals that resemble rodents. More than a dozen sirenian genera are known from the fossil record, so this order was once much more diverse and widespread than it is today (Dawson 1967).

The fossil record shows that both manatees and dugongs were once found in the Caribbean and western Atlantic, but that manatees eventually replaced the dugongs in this area. These manatees evolved into West Indian and West African manatees. Manatees may have prevailed because they evolved more wear-resistant teeth and so were better able to exploit gritty vegetation as a food source (Domning 1982).

Sirenian fossils 45 million years old have been discovered in Florida (Domning, et al. 1982). Researchers have documented fossil dugong ribs in shallow-water marine and estuarine sedimentary deposits throughout the state, (Hoenstine 1980) as well as manatee bones in pre-Columbian Indian refuse mounds in southeastern Florida (Larson 1969).

Related Species

The Florida manatee belongs to one of only four living species in the order Sirenia. A fifth species discovered in 1741 in the Bering Sea by Georg Wilhelm Steller, the Steller's sea cow *(Hydrodamalis gigas),* was hunted to extinction within 27 years of its discovery. Besides its extraordinary size, this species was unique because it inhabited cold water, fed exclusively on marine algae, lacked teeth and finger bones, and apparently could not dive (Reynolds and Odell 1991).

All living sirenians are found in warm tropical and subtropical waters and consist of one species of dugong and three species of manatees. The dugong is found in coastal regions of 43 countries in the Indian and

Pacific oceans. It is still the most abundant and widespread living sirenian. The largest surviving populations are found in northern Australian waters (Marsh 1994).

Manatees are found along the tropical coasts of both the eastern and western Atlantic. The West African manatee *(Trichechus senegalensis)* is found in the coastal waters and rivers of western Africa. Very little is known about this species, and its numbers have been greatly reduced by hunting, netting, and habitat changes. The Amazonian manatee *(Trichechus inunguis)* is found only in freshwater areas of the Amazon basin. Subjected to intensive hunting over the past few centuries, the Amazonian manatee is now protected by law. Due to ineffective enforcement, the remaining populations are subject to illegal hunting (Domning 1981). Currently the biggest threat to the Amazonian manatee is habitat destruction, which could cause the species to go extinct (Reynolds and Powell in press).

The third species of manatee is the West Indian manatee (*Trichechus manatus*), which is found from the southern United States to the northeastern coast of Brazil. There are two distinct subspecies, the Florida manatee (*Trichechus manatus latirostris*) and the Antillean manatee (*Trichechus manatus manatus*). The Florida manatee is found in the southeastern U.S. and the Antillean manatee is found throughout the Caribbean and northeastern South America. The cool winters of the northern Gulf coast and the deep water and strong currents of the Straits of Florida appear to keep the two subspecies separate (Domning and Hayek 1986). Recently, however, movements of manatees from Florida to the Bahamas have been documented and mixing between the two subspecies may occur in Texas (Reynolds and Odell 1991).

Habitat

Florida manatees live in freshwater, brackish, and marine habitats and can move freely between salinity extremes. They can be found in both clear and muddy water. Water depths of at least three to seven feet are preferred and flats and shallows are avoided unless adjacent to deeper water. Along the coast

manatees tend to travel in water that is 10-16 feet deep and are rarely seen in areas over 20 feet deep (Reynolds and Odell 1991).

High tides are used to reach feeding grounds and shoreline vegetation that are inaccessible at low tide, especially in northeastern Florida (Zoodsma 1991). Currents over three miles per hour are usually avoided. If the water is deep enough and the currents are not too strong, these animals may travel great distances up coastal rivers. Manatees living in the upper St. Johns River are more than 124 miles from the ocean. Along the west coast of Florida, principal summer habitats are grassbeds in estuaries rivers (Powell and Rathbun 1984).

Distribution

The West Indian manatee's range is from the southern United States throughout the Caribbean Islands, in northeastern Central America, Colombia, Venezuela, and south to Brazil's northeastern coast. As mentioned earlier, the Florida subspecies is distinct from other West Indian manatee subspecies in the Caribbean and South America. Researchers generally believe that there are four regional subpopulations of the Florida subspecies. They occupy the following parts of the state: Northwestern Florida, Southwestern Florida, Atlantic Coast (including the northern St. Johns River) and the St. Johns River south of Palatka. Manatees do occasionally move between subpopulations, including between the east and west coasts (Manatee Population Status Working Group 2000). Based on data collected during statewide aerial surveys, it appears that there are similar numbers of manatees using the Atlantic and Gulf coasts (U.S. Fish and Wildlife Service 1995).

Manatees can be found in freshwater, brackish and marine habitats throughout Florida.

Florida manatees are sub-tropical animals at the northern limit of their range, dependent upon sources of warm water in times of cold weather (Reynolds and Odell 1991). In the summer, finding warm water is not a problem, but as winter approaches, manatees living in areas north of Florida Bay, Biscayne Bay, and the Everglades often travel to sources of warm water. Those that roam outside Florida's borders in the summer and fail to return by winter may not survive. During extreme drops in temperature, manatees usually remain close to a warm-water source and, during breaks in the weather, travel to nearby feeding areas. Sometimes when the weather remains very cold, manatees may not feed for days at a time (Reynolds 2000).

Northwestern Florida manatees typically range from the Apalachicola River south to Tampa Bay. The number of manatees seen in the panhandle section of Florida, as well as in Louisiana and Mississippi, has increased as the Northwest Florida manatee population has expanded (Powell and Rathbun 1984). During the summer months, manatees are regularly observed throughout most of the west coast, from the Everglades to Citrus County and the rest of the Big Bend area (Reynolds 1999). Several natural springs are used on the west coast during the winter. The most important springs are at the headwaters of the Crystal and Homosassa Rivers in Citrus County (Reynolds and Odell 1991). Natural springs on the west coast provide sources of warmth and an abundance of food (Powell and Rathbun 1984). Over three hundred manatees regularly use the Crystal and Homosassa River area as winter aggregation sites.

Hundreds of southwestern manatees also rely on warm-water sources in Lee County. The largest manatee aggregations occur at industrial sites near Ft. Myers and in various manmade canal systems, such as those at Matlacha Isles and Port of the Islands.

Manatee usage of the upper St. Johns River has increased substantially over time. The number of manatees gathering at Blue Spring has increased at a rate of 8% per year over the last 28 years due largely to reproduction, a high rate of adult survival, and immigration from outside the St. Johns River (including the release of captive manatees). Well over one hundred manatees have been documented using the spring during the winter and most of these animals are believed to stay in the upper St. Johns

River area during the warmer months (Deutsch 2000). During the winter, many manatees congregate at Blue Spring State Park on the St. Johns River and at artificial warm water sources farther south (Reynolds and Odell 1991).

Atlantic coast manatees can range from the St. Johns River south to Miami and the Florida Keys, (Reynolds and Odell 1991) but some have been known to travel up the eastern seaboard. One animal, nicknamed "Chessie", traveled as far as Rhode Island. Most travel occurs seasonally as manatees move between summer dispersal areas and winter gathering sites, but manatees may also shift wintering locations during a season (National Biological Service 1993).

Manatees are also found abundantly on the east coast in Florida's Intracoastal Waterway and are occasionally sighted offshore in coastal waters. The Indian River Lagoon, which stretches from Brevard County to northern Martin County, is known to be important to manatees for a variety of reasons, including for feeding and traveling. Brevard County seems to be preferred year-round manatee habitat (Reynolds 1999). During the winter months, hundreds of manatees aggregate near industrial warm-water discharges on the Indian River and farther south in Palm Beach and Broward counties. During the spring and summer months, manatee use seems to be heaviest in the Banana River. The upper Banana River is used extensively by manatees; more than 360 have been observed in the area during surveys conducted in the spring (Provancha and Provancha 1988). This area provides manatees with abundant foraging habitat; it is also a protected area for manatees and is designated by the federal government as an area in which motorboats are prohibited.

It is believed that the historical winter range of the manatee was once centered in southern Florida, with small groups spending the winter at a few natural springs in northern Florida. For more than 50 years, industrial sites that discharge warm water, perhaps coupled with the loss of natural habitats, have caused a shift in manatee winter distribution (Reynolds and Odell 1991). Today, manatees congregate at about a dozen warm-water sources during the winter. The number of manatees observed daily at each of these sites ranges from 30 to 500 depending on the severity of the winter.

Manatees form temporary "mating herds" consisting of a female in heat pursued by several males.

Population Status

There is no evidence that manatees were once much more abundant in Florida than they are now. During the past couple decades manatees have become more widespread, and, possibly even more numerous in Florida, as a result of protection, the increase in winter refuges and the introduction of exotic vegetation (O'Shea 1988).

The exact number of manatees in Florida is unknown. Manatees are difficult to count because they are often in areas with poor water clarity, and their behavior, such as resting on the bottom of a deep canal, may make them invisible. As a result, the size of the total population is difficult to determine. Good counts are possible at two important manatee wintering areas in north Florida: the natural springs found in the headwaters of the Crystal and Homosassa rivers in northwestern Florida, and Blue Spring in the upper St. Johns River. Water clarity in these areas is generally good, and the manatee populations using these sites remain relatively stable throughout the winter.

A coordinated series of aerial surveys, known as the statewide synoptic survey, has been conducted in most years since 1991. The survey results are highly variable, and do not reflect actual population trend. For example, statewide counts on 16 and 27 January 2000 differed by 36% (1,629 and 2,222, respectively). The synoptic survey in January 2001 resulted in a count of 3,276, the highest count to date. The 2001 count was 47% higher than the highest count in 2000 because of favorable environmental conditions preceding and during the survey, and an unusually high degree of manatee aggregation at wintering sites.

Manatee populations in northwestern Florida and the upper St. Johns River, which make up less than 20% of Florida's minimum known manatee population, have increased over the last 25 years (Manatee Population Status Working Group 2000). This population growth is consistent with high estimates of adult survival and good manatee habitat in these regions (Langtimm, et al. 1998). During the same period, the population on the Atlantic coast appears to have been growing slowly in the 1980s, but may have leveled off or even declined in more recent years. This finding is consistent with the high level of human-related and, in some years, cold-related mortality in this region. Status of the southwestern coast population is still being assessed.

Scientists agree that adult survival is critical to the manatee's recovery, and that the number of human-related deaths needs to be reduced. Survival and population growth rates are currently being estimated through the 1990s for all regions (Manatee Population Status Working Group 2000).

Historic Importance

Past

As early as 8500 BC, the manatee has been hunted for meat, bone, hides and fat. Archaeological evidence shows Paleo-Indians, the earliest known inhabitants of Florida, hunted manatees. The arrival of the Europeans in the 1500s caused the elimination of many aboriginal people in Florida. After that, members from several Native American tribes from the north, known collectively as the Seminoles, moved to Florida. The Seminoles hunted manatees for meat, oil, and bones. Excess meat was sold to the Spanish (Husar 1977).

In the seventeenth century, dried manatee meat was shipped from the Guianas to feed sugar plantation laborers in the Caribbean (Bertram and Bertram 1968). Pioneers arriving in the nineteenth century shot

manatees for meat, oil and hides, and poaching was common in parts of Florida during the Depression and World War II.

Despite many centuries of hunting by Paleo-Indians, Native Americans, and Europeans, manatees in Florida never experienced the intense commercial exploitation that the South American manatee populations faced (Domning 1982). This hunting, which continues today in many countries, eliminated manatees from many parts of their former range (Lefebvre, et al. in press).

Present

The manatee has been an integral part of Florida's ecology for millions of years. The sight of one of these animals in its natural habitat is a memorable experience, for both residents and visitors enjoying Florida's waterways. Although the inherent value of manatees is difficult to determine, manatees bring millions of dollars to Florida's economy through the eco-tourism industry (Valade 2000).

Physiology

Our understanding of manatee physiology is somewhat limited because of the risks associated with working with endangered animals. The manatee's metabolic rate is unusually low - about 15-20% of what one would expect for a mammal their size (Reynolds and Odell 1991). This may in part account for its susceptibility to cold and a slow healing rate. A low metabolic rate is an adaptation for a large tropical animal that must keep cool and live on a relatively poor quality diet. This adaption can be a liability for populations at the northern edge of the species' range, where metabolic heat is needed to maintain body temperature. The manatee's body temperature is reported to be 97.5^{o}F, but this may vary seasonally or with water temperature (Irvine 1983).

Manatees at rest have relatively low heart rates compared to those of terrestrial mammals. A large, resting manatee can stay submerged for 20 minutes (Scholander and Irving 1941). Smaller and active

manatees cannot stay under for that long and need to breathe every two to three minutes (Reynolds 1981).

Studies of the manatee's ear bones, conducted in the 1990s at the University of Florida and later at the Florida Marine Research Institute (FMRI), indicate that the bones have growth layers that may persist throughout the animal's life and can therefore be used as an indicator of age. Using this technique, ages of over 50 years have been documented (Marmontel, et al. 1996). Another indicator of manatee longevity is the length of time they are maintained in captivity. One individual named Snooty has lived at the South Florida Museum in Bradenton for over 50 years.

Reproduction

Female manatees mature sexually when they are 3 years old (Marmontel 1995). They may produce calves as early as four to five years of age but at such an early age may be unsuccessful at raising calves. Most females breed successfully by six to ten years of age (Reynolds and Odell 1991). Males may produce sperm at two years of age, and at body lengths less than 7 feet (Reynolds 2000).

Manatee calves nurse underwater and may remain with their mothers for more than two years.

Manatees need to maintain a high adult survival rate because they reproduce so slowly (Marmontel, et al. 1996). The gestation period of the manatee is at least 12 and possibly 13 months and females usually produce one calf with each pregnancy. Twins are rare but do occur occasionally. The interval between births is generally 2 to 5 years, although a female losing her calf soon after birth could have another calf within two years. Calving occurs throughout the year. Newborn calves range in length from 4 to 4.5 feet and weigh about 66 pounds (Odell 1982).

Calves may remain dependent on their mothers for up to two years. The young calves nurse underwater for about three minutes at a time from teats located at the junction of the forelimbs and the body. Manatee milk contains more fats, proteins, and salt than cow's milk and does not contain lactose (Bachman and Irvine 1979). Manatees are born with premolars and molars, and as a calf begins to eat plants, the mechanical stimulation of chewing causes the teeth to move forward at a rate of about 0.03 inches a month. The front teeth wear down and eventually fall out to be replaced by hind teeth moving forward (Domning and Hayek 1984). Calves begin nibbling on plants within a few weeks of birth.

Research suggests that mothers and their young recognize each other beyond weaning and that some offspring spend at least their subadult lives within the range of their mother. This may enhance survival by enabling manatees to learn migration routes and the location of winter refuges and feeding grounds (O'Shea and Shane 1985). It should be noted that the number of calves dying each year is high and rising for reasons that are poorly understood (Reynolds 1999).

Behavior

The behavior of manatees is simple and well suited to the needs of these animals. Manatees evolved in regions with plentiful food supplies, fairly constant temperatures, and no natural predators. Because of this they have never needed to develop complex social behaviors to obtain food or protect themselves (Hartman 1979).

Activity Cycles

Generally, manatees do not have any set daily routines and feed, rest, and perform other activities throughout the day and night. However, during winter cold spells, activities such as feeding trips may be regulated by daily temperature cycles. Extensive studies at Blue Spring revealed that manatees leave the constant-temperature spring run in late afternoon to feed in the St. John's River and return in the early morning, thus conserving energy by leaving the spring run when the river was at its warmest. This routine

ceased with warm spring weather (Bengtson 1981). Manatees have also been observed to time their activities to avoid harassment by boats or divers (Powell 1981).

Locomotion

The manatee swims with up-and-down (dorso-ventral) motions of its body and tail (fluke), similar to dolphins and whales. Steering is done with their tail and flippers (Hartman 1979). They are neutrally buoyant in the water and can move vertically in the water, apparently by changing the volume of air in the lungs or intestines by contraction or relaxation of the diaphragm and abdominal muscles (Rommel and Reynolds 2000).

Manatees are surprisingly agile underwater and can perform maneuvers such as somersaults, barrel rolls, head and tail stands and upside-down gliding. Although clocked at speeds of up to 15 miles per hour for short bursts, manatees generally cruise at speeds of 2-6 miles per hour (Hartman 1979).

Feeding

Manatees spend about six to eight hours a day feeding (Reynolds and Odell 1991) and in that time may consume about four to nine percent of their body weight in wet vegetation (Etheridge, et al. 1985). Vegetation is grasped and torn by the lips, which are strengthened with lateral, horny pads, and then passed back to the grinding molars. Stomach content analyses show that food is well chewed (Marsh, et al. 1999). Manatees feeding in seagrass beds either crop the seagrass leaves or dig into the sediment with their flippers to eat the entire plant (Packard 1981). Much of the biomass and carbohydrates in seagrass are concentrated in the underground portion of the plant. In areas where manatees congregate, digging up seagrass roots can result in the temporary disruption of seagrass beds (Lefebvre, et al. in press). There is no evidence that suggests that manatees have a damaging effect on grass beds. On the contrary, studies of dugong behavior suggest that they may actually enhance productivity (Preen 1995).

Manatees are often seen feeding at the edge of seagrass beds, possibly because nearby deeper areas offer an escape route if disturbed (Lefebvre and Frohlich 1986). Protection from wind and currents seems to be preferred, so manatees often choose feeding sites behind barrier islands. Birds, such as little blue herons, sometimes feed on the fish and invertebrates flushed out of vegetation by browsing manatees (Scott and Powell 1982).

Wild and captive manatees are opportunistic feeders and have been known to eat over 60 species of plants. Some researchers have suggested that manatees will eat any plant soft enough to be torn by the muscular upper lip, and a varied diet is probably necessary to meet nutritional requirements. Some plants, such as blue-green algae are clearly avoided, because they contain natural toxins (Reynolds and Odell 1991). Submerged, emergent and floating vegetation, in that order, appear to be the preferred food of manatees. The manatee's mouth is well adapted to feeding on bottom vegetation (Domning 1980).

Manatees can crawl partway onto a bank to reach shoreline vegetation and have been observed eating over-hanging branches and acorns that fall in the water (O'Shea 1986). Acorns can be a nutritious source of food in early winter when aquatic vegetation is sparse (O'Shea 1986). Manatees may unintentionally eat invertebrates, which supply needed protein (Best 1981). Captive manatees readily accept fish. In Jamaica, they have been observed eating fish captured in gill nets (Powell 1978).

The freshwater requirements of manatees are not well known, but they are frequently spotted drinking freshwater from outfalls and culverts in salt and brackish water areas. Research on the structure of the manatee kidney suggests that the animals may survive for extended periods without freshwater (Oritz 1994).

Resting and Maintenance Behavior

Manatees rest from 2 to 12 hours a day either suspended near the surface or lying on the bottom, usually for several hours at a time. People have suggested that manatees resting on the bottom surface to breathe in an almost hypnotic state. On cold days when surface waters are warmer, manatees tend to rest and bask at the surface (Lefebvre and Frohlich 1986).

Manatees often clean their mouths with their flippers. They also rub themselves against logs, rocks, ropes, and the hulls of boats. Females tend to rub more than males. The parts of the body rubbed most often are places where glandular secretions are produced and include the genitals, around the eyes, under the flippers, and the chin. This scratching may just be to relieve itching, but it has been speculated that it might serve to leave a scent message as to the presence and reproductive condition of resident females. Males traveling over large areas could check traditional rubbing posts to assess the receptivity of local females (Rathbun and O'Shea 1984).

Manatees rest at the surface or on the bottom for many hours each day, surfacing only to breathe. While resting on the bottom, some manatees lie on their backs.

Communication

Manatees communicate through sound, sight, taste, and touch (Reynolds and Odell 1991). Despite the absence of external ear lobes and the small size of the auditory openings, manatees hear very well. Some studies suggest that manatees may even be able to hear sounds that are too low for humans to detect (Bullock, et al. 1982). Manatee cows respond to the squeals of their calves from almost 200 feet away, and adult manatees have been reported to respond to sounds 160 feet away (Hartman 1979).

Manatees emit a range of sounds underwater that are within human auditory range. These sounds are believed to be used for communication and not for echolocation or navigation (Reynolds and Odell 1991). Indeed, manatees may bump into objects in murky water (Packard, et al. 1984). Manatees make sounds when they are frightened, sexually aroused or playing. Vocalization plays a role in

maintaining contact between adults and between a cow and her calf (Reynolds 1981). Calls are used to maintain contact while feeding and traveling, particularly in turbid water. Rapid calling has been noted when a group is startled and flees an area, or when greeting new arrivals (Bengtson and Fitzgerald 1985). Information is conveyed by varying the pitch, loudness, and duration of calls (Rathbun and O'Shea 1984).

Manatees visually investigate objects. In very clear water, manatees respond to visual cues from distances of up to 115 feet away, although depth perception seems poor at close range (Hartman 1979). The presence of two types of cone cells in the retina suggests that manatees can see in color (Cohen, et al. 1982).

Social Behavior

The manatee has been described as "a mildly social, essentially solitary animal"(Hartman 1979). Except for the relationship between a cow and her calf, most associations appear temporary. Recent work in Sarasota Bay suggests that the social structure of manatees is non-random and fluid. Strong associations are formed between a few individuals, while most individuals weakly bond. The strongest associations appear to be between individuals of the same gender. Generally, males are more social than females (Koelsch 1997).

"Kissing" may be a form of communication between manatees.

Although individuals within a group do not exhibit dominance, an individual may initiate an activity that others follow. Manatees in Miami's Blue Lagoon Lake were seen bodysurfing together in flumes created by a salinity intrusion barrier. Four adults, following the lead of a fifth manatee, bodysurfed for over an hour, with frequent vocalizations and nuzzling between rides (Reynolds 1981).

Other forms of social interaction include "kissing", mouthing, bumping and chasing. Juvenile males sometimes instigate play with juvenile or adult females that suggests sexual activity. If they have fed and are not harassed, manatees may play for hours (Hartman 1979).

Sexual Behavior

A female manatee in heat, or estrus, is pursued by courting males. They form a "mating herd" that may remain together from a week to a month, or as long as the female is receptive to the courting males. Juvenile males may join and leave the herd but a group of mature, persistent males will remain (Hartman 1979). The males may establish a dominance order for mating rights, (Rathbun and O'Shea 1984) but factors leading to successful paternity are not understood (Reynolds 2000). Females have a long estrus period that allows time for many males to gather, thus increasing the number of potential mates (Rathbun and O'Shea 1984). During most of the cycle, however, females attempt to flee and avoid the persistent males. When the female is receptive, she copulates with one or more males in succession. Copulation is brief and occurs in an abdomen-to-abdomen position with the male below. In shallow water, a side-to-side position may be used. Females and males do not form permanent associations (Hartman 1979).

Radio transmitters were used in studies to track the summer movements of individual manatees using the St. Johns River system (Bengtson 1981). Adult males were found to systematically patrol and search sections of the river system in "circuits" that lasted several days. Adult females, unless in estrus, stayed within relatively small home ranges along well-traveled routes. These contrasting travel patterns may serve a reproductive function. The behavior of the males allows them to maintain contact with many females and increases the chances of locating a female in estrus. Likewise, the female's behavior increases the likelihood of contact with males. As the female in estrus travels with males in pursuit, additional males may be attracted for mating.

Cold-Related Aggregations

Warm-water refuges are essential to manatee survival due to the limited thermoregulatory capabilities of this species. Movement to these warm-water refuges is a learned response. The air and water temperatures associated with the arrival of manatees at warm-water refuges seem to vary with the location of the refuge and possibly the time of year. Air temperatures below 50°F and water temperatures below 70-72°F are correlated with the arrival of manatees at Crystal River and Blue Spring (Bengtson 1981). Industrial sites with warm-water discharges attract large numbers of manatees when water temperatures fall below 59°F (Packard 1981).

Mortality

During the past centuries, the principal causes of Florida manatee mortality were opportunistic hunting by humans and deaths associated with unusually cold winters. Today, hunting is illegal and poaching is rare in the U.S., but high and rising mortality from human-related sources, combined with natural causes of death and loss of valuable habitat, threaten the future of the species (Reynolds 1999).

Manatee mortality research in Florida got underway in the early 1970s. At that time, members of the U.S. Fish and Wildlife Service and personnel of the University of Miami salvaged manatee carcasses and conducted examinations to determine cause of death, understand functional anatomy, and interpret important life history attributes. The operation of the Manatee Salvage Program was taken over by the State of Florida in 1985. The primary focus of the examinations of carcasses is to determine the causes of death. A full examination of every collected carcass is performed and data such as morphometrics, organ system assessments, and age at death, just to name a few, are recorded in a mortality database. Since 1974, more than 4,000 dead manatees have been collected and examined through this program. Currently, biologists of the Florida Fish and Wildlife Conservation Commission collect and examine over 250 manatee carcasses annually. The most direct method for stabilizing or increasing Florida manatee

populations is to reduce the very high annual mortality, especially those deaths caused by human activities (Reynolds 1999).

Human-Related Causes

Information gathered through the Manatee Salvage Program has led to the identification of some of the causes of manatee mortality. Over 30% of all 4,000 manatee deaths have been attributed to human activities (Bolen 2000).

Watercraft

The largest single known cause of mortality is collision with watercraft. Early research suggested that the primary culprits were large boats over 24 feet long with inboard motors and propellers over 15 inches in diameter. However, we now know that in addition to large boats, small, fast-moving boats also kill manatees. Not all manatees die from an interaction with a boat, but the effects of these wounds on reproduction or long-term survival are unknown. Many manatees bear scars or deformities from being hit by propellers and some may have as many as 50 individual propeller patterns. Researchers use the scars to recognize individuals. To date, over 2,000 live manatees have been catalogued by their distinctive scars (Beck and Reid 1995).

Propeller cuts are not the sole culprit for manatee deaths from watercraft. According to the Florida Marine Research Institute, about 45% of all manatee deaths caused by encounters with boats are due solely to propeller cuts, whereas approximately 50% of these deaths are due to blunt trauma associated with boat hulls running into these animals. The remaining 5% of manatee watercraft-related deaths are caused by a combination of propeller impacts and blunt trauma (Bolen 2000). For this reason, propeller guards may help reduce the number of injuries and deaths from propellers, but would not resolve the problems related to boat hulls. Manatees move slowly, inhabit shallow coastal regions, and must come to the surface to breathe. These factors may make it difficult for manatees to avoid fast moving boats or boats traveling in shallow water.

Large-scale efforts by the Florida Fish and Wildlife Conservation Commission (FWC), the U.S. Fish and Wildlife Service (USFWS) and many private organizations are underway to educate the boating public. Regulations that restrict boat speeds and limit access to designated areas have been created in many parts of Florida to reduce boat-related threats and harassment. Many waterways are still not regulated for manatee protection. Manatees regularly travel through the Intracoastal Waterway, the St. Johns River, and other coastal areas, and must constantly contend with heavy boat traffic, both inside and out of channels. Boaters can help reduce the risk of injuring or killing a manatee by staying within marked channels, obeying speed zones, wearing polarized glasses, and traveling cautiously in shallow water.

Boat-related mortality is probably the greatest single threat to the manatee. Efforts by the USFWS, the FWC, and the U.S. Army Corps of Engineers to limit dredge and fill permits and control the size and location of marinas are directed toward this problem (Reynolds 1999).

Flood-Control Structures

Flood gates and canal structures can kill manatees by trapping them underwater until they drown or by crushing them. This problem is particularly acute in Dade County, where automatic flood-control structures kill more manatees than boat traffic. To resolve this problem, flood control structures and navigation locks are being equipped with manatee protection devices that detect a manatee's presence. While this technology is promising, additional testing and fine-tuning is needed to make structures completely manatee-safe (Frohlich 2000).

Watercraft collisions are responsible for many manatee deaths each year. Almost all manatees in Florida bear scars or deformities from being hit by watercraft.

Fishing Gear

Entanglement in monofilament fishing line, crab pot float lines, as well as ingestion of monofilament line and fishing tackle, are also problems manatees face. Lines may wrap so tightly around their flippers that severe infections, amputation, or death may result. Several manatees are rescued each year due to

entanglements. The number of entanglement-related rescues appears to be increasing each year. This may be due, in part, to a 1995 ban on the use of nets greater than 500 square feet of mesh area in Florida waters. This appears to have resulted in an increase in the number of crab pots being fished each year (Nill 1998).

Poaching and Vandalism

Poaching and vandalism account for very few manatee deaths per year in the U.S. This number continues to decline due to public awareness and law enforcement efforts.

Loss of Habitat

Loss of habitat is one of the most serious threats to the manatee, as it is for all of Florida's wildlife. Many freshwater and marine grass beds have been reduced or eliminated by water pollution, herbicides, dredge and fill projects and surface runoff. Formerly productive areas, including north Biscayne Bay and parts of Tampa Bay, have been extensively modified by human activity and many natural warm-water areas have been affected by loss or reduction of artesian flows (Sucsy, et al. 1998).

Unprecedented human population growth and associated boat traffic along Florida's coasts and waterways have degraded and eliminated manatee habitat. Today, there are very few places where the manatee is free from the danger and harassment posed by boats and other human activities.

Pollution

Pesticides, herbicides, and industrial chemicals are found in manatee habitat where they contaminate the water and vegetation ingested by manatees. These substances can accumulate in manatee tissue. Some studies have shown that pesticide residues in manatee tissues are below levels of pathologic significance and that manatees are relatively uncontaminated by organochlorines, lead, or mercury (O'Shea, et al. 1984).

Other analyses, however, have revealed that some manatees have high concentrations of copper in their tissues, probably as a result of feeding on vegetation treated with copper-based herbicides. The level of copper in the diet of manatees normally is very low so there may be no physiological regulating mechanism to prevent the accumulation of copper in the liver. Copper-based herbicides were once widely used in areas where manatees gather. In one year alone, six tons of elemental copper were applied to the Crystal River system (O'Shea, et al. 1984). Herbicide spraying is now restricted by state rule Chapter 62C-20, FAC, which prohibits the application of herbicides in areas where manatees are sighted and limits the application of copper-based herbicides to waters not associated with manatee gathering areas (Smith 2000). Policies within the FDEP also promote the use of alternate aquatic plant control measures such as mechanical harvesting when such activities are performed in manatee gathering areas. The effects of these contaminants are poorly understood. Researchers are concerned that they may act as stressors that may impair the manatees' ability to ward off naturally occurring illnesses (Florida Today 1997).

Harassment

Manatees are frequently disturbed by skin divers, boaters, and fishermen. The noise pollution from boats may disrupt vocal communication between manatees and boat traffic can interrupt mating activity (Rathbun and O'Shea 1984). Although some manatees seek the attention of divers, most avoid humans (Buckingham, et al. 1999). Nocturnal behavior at Crystal River and in certain parts of the Caribbean seems to be an avoidance technique. Harassment, particularly in some natural warm-water refuges, can drive manatees away and force them to use less suitable habitat, increasing the potential for cold-related illnesses (Buckingham, et al. 1999).

Manatees cannot escape fast boats, and there may not be enough clearance to get out of the way even when a boat is moving slowly. Regulation of boat speeds and boat exclusionary areas are being enforced to reduce boat-related injuries and harassment.

Natural Factors

Cold Weather

One of the leading non-human causes of death for Florida manatees is exposure to cold. In reports of large numbers of manatee deaths following the unusually cold winters of 1976-77, 1980-81, 1983-84, and 1989-90, hypothermia was the main cause of death. Tragedies like this occurred due to the fact that Florida is the northern-most extreme of the manatee's range. Although Florida has a mostly tropical climate, periods of cold do occur (Worthy 2000).

The reasons for cold-associated deaths are still not clear, but it is thought that death from exposure to cold may occur in two general ways. Manatees exposed to long-term moderate cold do not eat properly. These animals lose weight and become malnourished. The second way manatees can die from cold is from hypothermia, or other cold-related illnesses (Worthy 2000).

Two other factors are involved in the survival rate during the winter: size and experience using warm water sites. As water temperatures drop below 68^{o}F, manatees exhibit the typical mammalian response to cold of increasing metabolic rates. Studies of captive manatees show that adults greater than 660 pounds can survive the cold better than manatees that weigh less. Smaller manatees seem incapable of raising their metabolic rates. This makes them extremely susceptible to hypothermia and death. Size of the animal is a critical factor of survival during cold snaps (Worthy 1998).

Traveling to winter sites is a learned response. Since larger manatees are usually older, they have much more experience using the warm water refuges during the winter. Smaller younger manatees may not realize when they need to move to warm water and may not know where these sites are located. Getting to warm water is an important determinant as to whether or not they survive the winter (Worthy 1998).

Irregular feeding of manatees is noted at 64-66^{o}F and feeding may cease completely as the temperature approaches 50^{o}F.

Red Tide

During the spring of 1982, at least 37 manatees died in Lee County in the lower Caloosahatchee River and San Carlos Bay in association with an outbreak of red-tide. Many of the dead manatees had ingested large numbers of small marine animals, known as ascidians or sea squirts, which may have accumulated toxins from the red-tide organisms. The sea squirts were probably ingested incidentally as the manatees fed in seagrass beds. These manatees may also have been exposed to airborne toxins from red tide (Buergelt, et al. 1984). An even larger red-tide related manatee die-off occurred in 1996 in Southwest Florida. Inhalation of brevetoxin was suspected in the deaths of nearly 150 manatees that died during the spring (Bossart 1998).

Legal Protection and Conservation Efforts

Efforts to protect manatees date back to the 18th century when the English established Florida as a manatee sanctuary. In 1893, a Florida law was established to protect manatees, and since 1907 there has been a fine of $500 for a person who kills or molests a manatee. Legislation such as the Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973 have also helped the manatee. In July 1978, protection was increased significantly when the "Florida Manatee Sanctuary Act" was passed by the state. This act established the entire state of Florida as a "refuge and sanctuary for the manatees" and allowed for enforcement of boat speed regulations in designated areas.

State responsibility for manatee protection is vested with the Florida Fish and Wildlife Conservation Commission (FWC), the Department of Community Affairs (DCA), and the Florida Department of Environmental Protection (DEP). Through the FWC, the Florida Marine Research Institute performs research, rescues, and carcass salvage; the Bureau of Protected Species Management develops regulations and other management activities, and the Division of Marine Enforcement enforces regulations and assists in the recovery and rescue of dead, sick, and injured manatees. A few sites throughout

Florida provide care for injured, orphaned, or diseased manatees. Homosassa Springs State Wildlife Park, operated by the Florida DEP, is one of these areas.

The Marine Mammal Commission, the United States Fish and Wildlife Service (USFWS), and the Biological Resources Division of the United States Geological Survey (USGS) handle federal responsibilities. The Marine Mammal Commission was created by Title II of the Marine Mammal Protection Act (MMPA) of 1972 as an independent agency to oversee the research and conservation of marine mammals in the United States. The MMPA makes it illegal to harass, hunt, capture or kill any marine mammal. The USFWS enforces the Endangered Species Act (ESA) of 1973, as amended, and implements the Florida Manatee Recovery Plan, written to ensure that the goals of the previously mentioned legislation would be met. The ESA makes it a violation to "harass, harm, pursue, hunt, shoot, wound, kill, capture, or collect endangered species." Violations can result in fines of up to $50,000 and/or up to one year in prison. The law also prohibits the importation or exportation of endangered species or their parts or products. Many state law enforcement officers have been federally deputized so that they can enforce the federal as well as state laws. The Biological Resources Division of the USGS conducts long-term research on manatee life history, population dynamics, and ecology to support the development of effective conservation strategies. Other federal agencies such as the U.S. Army Corps of Engineers (COE), the U.S. Coast Guard (USCG), the U.S. Navy, the National Aeronautics and Space Administration (NASA), and the National Marine Fisheries Service (NMFS) are involved with protecting manatees and their habitat (Reynolds 1999).

Many private groups have joined in the effort to protect the manatee as well. Private aquariums and zoos such as the Miami Seaquarium, Sea World of Florida, and Lowry Park Zoo, provide care for injured, orphaned, or diseased manatees, and are sites of important research. The Save the Manatee Club (SMC), created by Governor Bob Graham and singer Jimmy Buffet in 1981, currently has over 40,000 members. The SMC educates the public about manatees, extensively lobbies legislators and agencies for manatee conservation, and supports numerous research initiatives.

All of the major manatee wintering sites are currently protected by state or federal regulations. The FWC currently has 19 limited entry (e.g., No Entry or Motorboats Prohibited) zones designated throughout Florida. These appear in Chapter 68C-22 of the Florida Administrative Code. The primary importance of 15 of these areas is as a manatee wintering site. Several of the other areas are also used during the winter but their primary importance is for feeding or some other purpose. The Kings Bay area of Citrus County has several federal sanctuaries but no state ones. Many other areas that are used to varying degrees by manatees during the winter also have protection zones in the vicinity (e.g., speed zones) but none has state (or federal) limited entry zones.

Most of the areas where manatees are frequently found in Florida are protected to some degree. In addition to the limited entry areas discussed above, the FWC has established rules that restrict boat speeds in many areas. The primary purpose of these rules is to protect manatees from being injured or killed by watercraft and, to a lesser degree, to protect them from harassment and to protect habitat. The FWC has countywide protection rules in all of the Atlantic Coast counties except Nassau, St. Johns, and Flagler. Countywide protection rules also exist for the Gulf Coast counties of Citrus, Sarasota, Lee, and Collier. Site-specific state or local zones exist in other areas, such as in Tampa Bay.

Manatee protection must also be addressed at the regional, county and local levels. The FWC, in cooperation with the USFWS, works closely with regional planning councils, county planners and city officials to include manatee protection in long-term planning. Marine industry representatives and boating interests have also been enlisted to determine ways to balance the needs of boaters with manatee safety.

The best of plans are ineffective if the public is not sufficiently informed to support conservation efforts. In response to this, the FWC and conservation organizations conduct a variety of public awareness programs on manatee conservation. The FWC operates a Resource Alert number to receive reports of manatee injuries, deaths, tag sightings or harassment. The number, for the state of Florida only, is 1-800-404-FWCC.

Florida Power & Light Company (FPL) is an important contributor to manatee research and conservation efforts. FPL has funded researchers, including biologists at Eckerd College and FMRI, to conduct aerial surveys and to identify essential manatee habitat. Other studies have included investigations into winter use of power plants in Brevard County, photo-identification studies and tracking projects. FPL sponsors public-awareness and educational programs, and distributes booklets, brochures, and "I Slow for Manatees" bumper stickers.

Many manatees take refuge during cold weather at industrial sites with warm-water discharges.

Outlook for the Future

The extinction of all sirenians is a distinct possibility. The tragedy of this is that the conservation of the manatee, particularly in Florida, poses such a tough challenge. Factors that contribute to this challenge are the manatee's slow breeding rate, degradation of habitat, and increased collisions with boats.

Wildlife management is really people management. In Florida, the problem is one of preserving habitat in the face of an ever-increasing number of people, marinas, boats, divers and waterfront developments. Research and conservation efforts by many cooperating public and private groups raise hopes that a way may be found to ensure the survival of the manatee. The establishment of refuges and sanctuaries, enforcement of boat speed limits, public education campaigns, and the reduction of mortality from specific causes such as flood-control structures and fishing gear are all positive steps. However, the loss of over 150 manatees in southwest Florida in the spring of 1996 shows how tenuous any progress can be.

In the near future, many of the artificial sources of warm water, which manatees have come to depend on, may be approaching the end of their normal operating life spans. The USFWS has convened a Warm-water Task Force to formulate recommendations that will compensate or cope with these losses. The challenge to protect manatees will continue for many years.

A wide variety of solutions are necessary. These must include public education and awareness, environmental regulations and law enforcement, corporate funding, and land-use planning that considers the needs of manatees. Attention must also be directed at cooperative efforts with other nations to develop research and conservation plans for manatee populations outside of the United States. Much still needs to be done if future generations are to know these unique animals.

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Florida Power & Light Company (FPL), in its concern for the environment, has funded a series of educational booklets, including this one, as well as many other educational and research projects. These booklets can be accessed on the company's Web site at http://www.fpl.com.

Manatee Protection Zones in Florida

The numbers refer to counties that are targeted by the Florida Fish and Wildlife Conservation Commission for protection zones. Areas in the following counties have boat speed limits already in effect or under revision:

1. Citrus County
2. Sarasota County
3. Lee County
4. Collier County
5. Dade County
6. Broward County
7. Palm Beach County
8. Martin County
9. St. Lucie County
10. Indian River County
11. Brevard County
12. Volusia County
13. Duval County

For site-specific details, consult the local Florida Fish and Wildlife Conservation Commission Division of Marine Enforcement in the appropriate county.

Blue indicates general distribution of the West Indian manatee in the Caribbean.

Boating Speed Zones

To alert the boater and protect the manatee, the law provides a number of cautionary and regulatory speed zones. Following are some illustrations and a brief explanation of the various signs:

Safe Operation Zone – a sign indicating that you may resume safe boating speed; visible as you leave a protected area.

Caution Area – an area frequently inhabited by manatees, requiring caution on the part of boaters to avoid disturbing or injuring the animals.

Slow Speed Zone – a minimum-wake zone where boats must not be on a plane and must be level in the water; generally these signs are posted on the fringe of protected areas to warn you that you are approaching an area frequented by manatees; in some areas the channel is exempt.

Idle Speed Zone – a zone where boats are not permitted to go any faster than necessary to be steered; generally these signs appear near the center of a protected manatee zone.

No Entry Zone – a protected zone that prohibits boating, swimming and diving for the protection of manatees.

For information on obtaining "Caution, Manatee Area" and "Manatee Basics for Boaters" display signs for your area and boat ramps, please contact the Florida Fish and Wildlife Conservation Commission's Bureau of Protected Species Management at 850-922-4330 or visit their Web site at http://floridaconservation.org/psm/signs/signs.htm

Help Save the Manatee

You can help save the manatee. You can make a donation of $1 or more to the Florida Fish and Wildlife Conservation Commission to help protect the manatee. When filing your boat registration at the county tax office, simply note the amount you would like to contribute in the box marked "manatee donation." Manatee decals are given out for donations of $5 or more to the manatee recovery program.

When renewing or purchasing new auto tags, request a "manatee tag." The additional fee you pay will fund manatee research and conservation activities as well as provide educational materials about manatees to Florida schools, libraries, and environmental centers. Call your local auto tag agency for additional information.

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Additional Manatee Information

The following Web sites may be helpful in obtaining additional manatee information:

U.S. Fish & Wildlife Service's Endangered Manatee Page
http://endangered.fws.gov/i/A0C.html

Florida Fish and Wildlife Conservation Commission's
Bureau of Protected Species Management
http://floridaconservation.org/psm/signs/signs.htm

Florida Fish and Wildlife Conservation Commission's
Florida Marine Research Institute
http://www.fmri.usf.edu

Save the Manatee Club
http://www.savethemanatee.org

Sea World's Manatee Page
http://www.seaworld.org/manatee/manatees.html

U.S. Geological Survey's Sirenia Project
http://www.fcsc.usgs.gov/Manatees/manatees.html

Homosassa Springs State Wildlife Park
http://www.nccentral.com/hswildlife.htm

Crystal River National Wildlife Refuge
http://www.gorp.com/gorp/resource/us_nwr/fl_cryst.htm