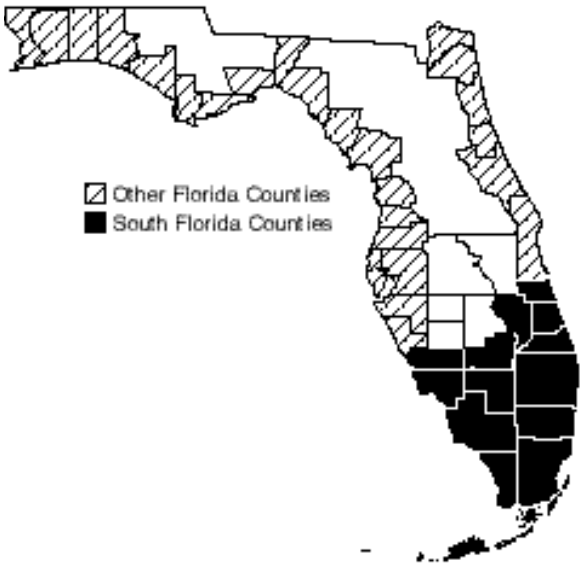
West Indian Manatee

Trichechus manatus

Federal Status:	**Endangered (March 11, 1967)**
Critical Habitat:	**Designated (1976)**
Florida Status:	**Endangered**
Recovery Plan Status:	**Contribution (May 1999)**
Geographic Coverage:	**South Florida**

Figure 1. Florida distribution of the West Indian manatee; inland counties include Lake Okeechobee and connecting rivers.



Once mistaken as a mermaid by sailors of the past, the West Indian manatee (*Trichechus manatus*) is one of the largest coastal mammals in North America. This unusual marine mammal with its massive, seal-like body, has been able to adapt well to its marine environment. Manatees migrate seasonally to adapt to changing water temperatures. West Indian manatees roam in fresh, brackish, and marine waters throughout Florida, the Greater Antilles, Central America, and South America. Intensive hunting pressures between the 1500s to 1800s reduced the number of manatees. The West Indian manatee is one of the most endangered marine mammals in coastal waters of the United States. This group includes a separate subspecies called the Florida manatee (*Trichechus manatus latirostris*) that appears to be divided into at least two somewhat isolated subpopulations-one along the Atlantic coast and the other on the Florida Gulf of Mexico coast.

This recovery plan represents South Florida's contribution to the recently published 1996 West Indian Manatee Recovery Plan (FWS 1996).

Description

The West Indian manatee is an aquatic mammal with a robust, fusiform body that is compressed dorsoventrally. Its grey to grey-brown, thick, tough skin is sparsely covered with small, thick hairs (3.0 to 4.5 mm) (Husar 1978) and is sometimes covered with barnacles and algae. The rounded body of the manatee has no hind limbs, but it has paddle-like forelimbs or flippers with three to four nails present on the dorsal surface of each flipper. The body tapers to a spatulate, dorsoventrally flattened tail. Females have a single prominent mamma or teat behind the axilla of each flipper and a relatively short anal-genital distance (Rathbun 1984). The urogenital opening in males is located just behind the navel.

The average adult manatee is 3.5 m long and weighs 1,000 kg. Male and female manatees are similar in size and appearance (Rathbun 1984). Newborn calves are, on average, 1.2 to 1.4 m long and weigh an average of 30 kg (Odell 1981).

Manatees have a dense skeleton. The massive skeletal bones lack marrow cavities in the ribs and forelimbs (Odell 1982). Similar to other marine mammals, manatees have large blubber stores.

The deeply-set, small eyes have no visible upper or lower lids, but instead have a nictating inner membrane capable of covering the eyeball for protection. Manatees can see for considerable distances, although their depth perception may be limited (Reynolds 1979). Manatees can hear well even though their inconspicuous ears have no external pinnae or earlobe flaps. Manatees communicate through different squeaks, chirps, grunts, and groans, that are within human audible range (Ketten *et al*. 1992). Two nostrils are located on the long upper snout that are capable of opening and closing by muscular valves. Manatees have an enlarged, lobed upper lip with short, stiff bristles and two muscular projections or prehensile pads that aid them in bottom feeding (Odell 1982).

To compensate for the excessive tooth wear caused by the tough vegetative matter they feed upon, manatees replace old, worn-down teeth with new ones. In a manner that is similar to a conveyor belt, their teeth move forward horizontally through their jawbones until worn-down teeth fall out and are replaced by new teeth in the back of their mouths. This replacement process occurs at a rate of about one mm per month. Manatees may use 30 or more molars in a lifetime (Domning and Hayek 1986).

Sea cows (*Protosiren*) first appeared during the Eocene period about 55 million years before the present when flowering plants first evolved. The family Trichechidae appeared in South America in the early Miocene (15 million years before present), about the same time as whales, apes and grazing animals (Domning 1982, Domning *et al.* 1982). During the Pliocene (12 million years before present), the time period when large carnivores evolved, members of Trichechidae first appeared in Atlantic North America (Reinhart 1951, 1959). Pleistocene *Trichechus* fossils have been recovered from the United States' east coast from Florida to Maryland (Simpson 1932).

Taxonomy

The mammalian Order Sirenia has two recent families, three recent genera and five recent species (Rathbun 1984). The two recent families: Dugongidae and Trichechidae have two genera with four living species and one extinct species. The Family Dugongidae contains two genera *Dugong* and *Hydrodamalis* and two species; of which *Dugong dugon* is the only living species of this family. The second species, Steller's sea cow (*Hydrodamalis giga),* was hunted to extinction by 1768 (Reeves *et al.* 1992). The family Trichechidae was described by Gill in 1872 (Rathbun 1984). The second living genus, *Trichechus,* includes three

West Indian manatee.
Original photograph courtesy of U.S. Fish and Wildlife Service.

allopatric species: the Amazonian manatee (*T. inunguis*), the West African manatee (*T. senegalensis*), and the West Indian manatee (*T. manatus*). The West Indian manatee is represented by two subspecies, the Florida manatee (*T. manatus latirostris*) and the Antillean manatee (*T. manatus manatus*) (Hatt 1934). *T. manatus* was described by Linneaus in 1758, and further distinguished as *T. m. latirostris* in 1924 (Harlan 1924). The four living sirenian species are geographically isolated, and listed as threatened or endangered (32 FR 4001, 35 FR 8495, 44 FR 42911). The closest, living terrestrial mammalian relative to the manatee is the elephant.

Distribution

The global distribution of sirenians, including dugongs and manatees, includes coastal waters, estuaries, and freshwater rivers. Dugongs can be found in marine habitats from eastern Africa to the Ryukyu Islands, Indo-Australian Archipelago, western Pacific and Indian oceans. Manatees can be found in tropical western Africa, including the Niger-Benue Basin, the tropical western Atlantic coast, the Caribbean Sea, and in the Amazon and Orinoco River basins (Rathbun 1984). The extinct Steller's sea cow range included the Bering Sea.

The present distribution of the West Indian manatee includes the coasts and rivers of Florida, the Greater Antilles, eastern Mexico and Central America and northern and eastern South America (Husar 1977, Lefebvre *et al.* 1989). *T. manatus latirostris* ranges from Texas to Rhode Island. The cooler winters along the U.S. coast of the Gulf of Mexico, in combination with the deep water and strong currents of the Straits of Florida, create a barrier between the Antillean and Florida manatee; the resulting isolation contributes to their status as subspecies (Domning and Hayek 1986).

The seasonal distribution of the manatee is affected by water temperatures. Waters colder than 20 degrees C increase the manatees' susceptibility to cold-stress and cold-induced mortality. Because of this temperature restriction, manatees seek out warm water refuges to help reduce energetic maintenance costs.

The manatee occurs throughout the southeastern United States. The only year-round populations of manatees occur throughout the coastal and inland waterways of peninsular Florida and Georgia (Hartman 1974). During the summer months, manatees may range as far north along the East Coast of the U.S. as Rhode Island, west to Texas, and, rarely, east to the Bahamas, FWS 1996, Lefebvre *et al.* 1989). There are reports of occasional manatee sightings from Louisiana, southeastern Texas, and the Rio Grande River mouth (Gunter 1941, Lowery 1974).

In Florida, manatees are commonly found from the Georgia/Florida border south to Biscayne Bay on the east coast and from Wakulla River south to Cape Sable on the west coast (Hartman 1974, Powell and Rathbun 1984) (Figure 1). Manatees are also found throughout the waterways in the Everglades and in the Florida Keys. Although temperatures are suitable for manatees in the Florida Keys, the low number of manatees has been attributed to the lack of fresh water (Beeler and O'Shea 1988). Manatees also occur in Lake Okeechobee.

In warmer months (April to November), the distribution of manatees along the east coast of Florida tends to be greater around the St. Johns River, the Banana and Indian rivers to Jupiter Inlet, and Biscayne Bay. On the west coast of Florida, larger numbers of manatees are found at the Suwannee, Crystal and Homosassa rivers, Tampa Bay, Charlotte Harbor/Matlacha Pass/San Carlos Bay area, the Caloosahatchee River and Estero Bay area, the Ten Thousand Islands, and the inland waterways of the Everglades.

On the west coast, manatees winter at Crystal River, Homosassa Springs, and other warm mineral springs (Powell and Rathbun 1984, Rathbun *et al.* 1990). In the winter, higher numbers of manatees are seen on the east coast at the natural warm waters of Blue Spring and near man-made warm water sources on or near the Indian River Lagoon, at Titusville, Vero Beach, Ft. Pierce, Riviera Beach, Port Everglades, Ft. Lauderdale, and throughout Biscayne Bay and nearby rivers and canals (FWS 1996). They also aggregate near industrial warm water outflows in Tampa Bay, the warmer waters of the Caloosahatchee and Orange rivers (from the Ft. Myers power plant), and in inland waters of the Everglades and Ten Thousand Islands.

Manatees frequently migrate throughout the waterways in South Florida. The South Florida Ecosystem region is home to the most resident manatee populations and transient migrants in Florida. In South Florida, manatees are most prominent year-round in the following areas: Indian River, Biscayne Bay, Everglades and Ten Thousand Island area, Estero Bay and Caloosahatchee River area, and Charlotte Harbor area. Some of the largest winter aggregations (50 or more manatees) occur in south and central Florida (FWS 1996).

Habitat

Manatees occur in both fresh- and saltwater habitats within tropical and subtropical regions. They depend on areas with access to natural springs or manmade warm water refugia and access to areas with vascular plants and freshwater sources (Humphrey 1992). Several factors contribute to the distribution of manatees in Florida. These factors are habitat-related and include proximity to warm water during cold weather, aquatic vegetation availability, proximity to channels of at least 2 m in depth, and location of fresh water sources (Hartman 1979).

Manatees are also dependent upon location of foraging sites. Normally, manatees feed on a variety of submergent, emergent, and natant (floating) vegetation. Manatees usually forage in shallow grass beds that are adjacent to deeper channels (Hartman 1979, Powell and Rathbun 1984). The proximity of these deeper channels may allow easy access to and from feeding areas.

Manatees often seek out quiet areas in canals, creeks, lagoons or rivers. These areas provide habitat not only for feeding, but also for resting, cavorting, mating, and calving. Deeper channels are often used as migratory routes (Kinnaird 1983). Natural or artificial freshwater sources are sought by manatees, especially manatees that spend time in estuarine and brackish waters (FWS 1996).

Critical Habitat

Critical habitat was designated for the manatee in the early 1970s, although no specific primary or secondary constituent elements were included in the designation (50 CFR 17.95). Critical habitat for the manatee identifies specific areas occupied by the manatee, which have those physical or biological features essential to the conservation of the manatee and/or may require special management considerations.

Behavior

Manatees have low metabolic rates indicating a possible adaptation to their large size and low nutrient food sources, or to permit long dives, since manatees have less advanced diving abilities than other marine mammals. Manatees can remain submerged for several minutes, with the longest submergence record lasting 24 minutes (Reynolds 1981). Manatees increase submergence times while feeding and resting. Female manatees coordinate their breathing and submergence times with their calves. Manatees do not appear to be fast swimmers, but they usually swim 4 to 10 km an hour and may attain faster speeds in short bursts (Husar 1977).

Manatees are not overly gregarious, but they do aggregate at warm-water refugia and during mating. Manatees have been observed displaying playful behaviors such as chasing, tumbling, and nuzzling (Hartman 1979, Bernier 1985).

Reproduction

The manatee population sex ratio is considered to be 1:1 for both adults and calves (Rathbun *et al*. 1992). Females reach sexual maturity at 3 to 5 years of age (Marmontel 1993) and males may reach sexual maturity at 3 to 4 years of age. Individuals at least 275 cm in length may be reproductively mature, although the modal female may not successfully rear young until 6 years or older (Marmontel 1993). Manatee longevity has been estimated at 50 years or more and they appear to be able to reproduce their entire adult life (Marmontel *et al*. 1992). Odell *et al*. (1995) reported a captive female manatee reproduced throughout its 34 years at the Miami Seaquarium.

The combination of suitable seagrass beds, nearby deeper water access, and minimal boat traffic may be indicative of important mating, calving, and nursery grounds for manatees (Smith 1993). Reproduction can occur throughout the year, although sperm production in male manatees is low during the winter (Hernandez *et al*. 1995). Most manatee calves are born in the spring or early summer (Irving and Campbell 1978). Breeding usually commences when one or more males are attracted to an estrous female, but permanent pair bonds are not formed (Marmontel *et al*. 1992). Manatees may form large breeding herds. Larger, presumably older males, dominate mating herds and may be responsible for most pregnancies (Rathbun *et al*. 1992).

The minimum interval between manatee birth is 2 years, but not all female manatees are this fecund. On average, 33 percent of mature, female manatees may be pregnant, which suggests a 3-year interval between calving (Marmontel 1993). If the interval between calving is 3 years and continues over a 36-year period, a female manatee could produce approximately 12 calves during her lifespan (Marmontel 1993). Calving intervals may be affected by the age and health of the female manatee. Although sexual activity may occur, female manatees may experience infertile estrous periods (Hartman 1979). Injuries caused by watercraft may also disrupt the manatee's estrous cycle (Marmontel 1993).

Gestation of the single calf takes 12 to 14 months (Reid *et al*. 1992). Age to weaning varies from 1 to 2 years. Calves usually stay close to their mothers during their first several years. Twin calves have been reported (D. O'Dell, Sea World, personal communication 1998).

Per capita reproductive rates in Florida manatees have been estimated from a low of 0.15 ($\pm$0.060) in the Blue Spring population to a high of 0.19 ($\pm$0.009) in the Atlantic coast population (Eberhardt and O'Shea 1995). The maximum potential rate of population increase has been estimated at 2.0 to 7.0 percent; this rate is most sensitive to changes in adult survival and, secondarily, subadult survival (Packard 1985, Marmontel 1993). For many years, the FWS (among others) has expressed concern about how the mortality rate will affect the survival and recovery of the manatee. These concerns were confirmed by the population viability analysis conducted by Marmontel (1993), which evaluated the probability of the manatee's persistence and the mean time to its extinction.

Foraging

Manatees feed with the help of their two muscular lips, which are flexible and move independently, in a fashion similar to an elephant's trunk or human

fingers. The lips are capable of manipulating food: grasping and moving food into the mouth. Manatees also use their forelimbs to dig into the sediment to remove seagrass rhizomes or roots (Hartman 1979, Provancha and Hall 1991, Lefebvre and Powell 1990). Manatees usually spend more time foraging in the late autumn (6.9 hours/day) than in early spring (3.2 hours/day)(Bengston 1983). Manatees must eat large amounts of aquatic vegetation to meet their metabolic requirements and may consume up to 20 percent of their body weight per day in aquatic plants (Zieman 1982).

These animals frequently forage at depths of 1 to 3 meters where aquatic vegetation is abundant. Manatees are opportunistic herbivores and feed on a variety of submerged, emergent, or floating aquatic plant species, including seagrasses, bank grasses, and overhanging mangroves (see Hurst and Beck 1988, and Smith 1993 for complete review). They may also feed on algal complexes attached to rocks, pilings, and dams (Reynolds 1981), and may occasionally eat fish or invertebrates while feeding on floating or submerged vegetation (Powell 1978, Smith 1993). In South Florida, manatees feed primarily on submerged vegetation such as turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme*), Cuban shoal grass (*Halodule wrightii*), and *Halophila* spp., although a variety of other emergent and floating vegetation is also eaten. Manatees may also forage on a variety of shoreline vegetation including red mangrove (*Rhizophora mangle*) leaves and cordgrass (*Spartina alterniflora*) (Longieliere 1994). In fresh water, manatees feed primarily on submerged aquatic macrophytes such as *Myriophyllum* spp. and hydrilla (*Hydrilla verticillata*).

Preferred manatee habitat in South Florida is characterized by the availability of submerged aquatic vegetation (SAV) (Smith 1993). Due to light limitations, most SAV, such as seagrass beds, are limited to shallow, nearshore waters. Seagrasses comprise the largest component of the manatee's diet, especially in South Florida (Hartman 1979, Zieman 1982, Smith 1993). Some manatees have been observed to return to the same seagrass beds to feed year after year and may show preferences for certain areas (USGS/BRD 1993, Smith 1993). Preference may also be shown for areas with healthy seagrass beds adjacent to relatively deeper waters with little boat traffic (Kadal and Patton 1991,USGS/BRD 1993). Manatees exhibit diel feeding patterns during the winter; they rest in warm waters during the day and head out in the late afternoon to feed in surrounding, sometimes, cooler areas (Bengston 1981).

Migration

Manatees normally migrate along shorelines and use deeper corridors to access shallow-water feeding and resting areas (Kinnaird 1983). Telemetry research suggests that calves learn migratory patterns from their mothers (USGS/BRD 1993). Migration patterns often vary between individuals. Some manatees may undertake extensive migrations along the coast and up rivers and canals (Reeves *et al*. 1992). Manatees may travel 40 km/day for several consecutive days, usually traveling directly and rapidly to a particular destination site, with males ranging longer distances than females (Bengston 1981, USGS/BRD 1993). On the east coast manatees migrate northward in the

springtime and southward in the fall and winter (Moore 1951). Manatees do not range far offshore, but may travel along the coast (Beeler and O'Shea 1988).

The increase in the number of manmade warm-water sources over the years has influenced manatee migratory patterns. Manatees frequent coastal, estuarine, and riverine habitats and are capable of extensive north-south migrations throughout the year (Reeves *et al*. 1992). Manatees have been observed migrating great distances northward in the springtime and southward in the fall and winter (Longieliere 1994); and as a result, abundances in regional populations change seasonally (Hartman 1974). There are 17 major aggregation sites in Florida (Garrott *et al.* 1994). These aggregation sites occur at or near manmade or natural warm-water refugia. Manatees will migrate to these warmer areas when water temperatures drop below 20 degrees C. Large aggregations of manatees occur at these warm-water areas. With the rise in water temperatures in the spring, some manatees may begin to migrate away from their winter refugia, while others remain relatively close. Manatees often return to the same winter refugia each year (Powell and Rathbun 1984, Reid *et al*. 1991). In the winter, manatees stay closer to warm-water during the day, then move to vegetated areas in the late afternoon or at dusk to feed.

Warm-water sources offer manatees refugia to escape the stresses of cold water temperatures. Most research has concentrated on developing methods to determine population trends at these sites, but little work has investigated manatee behavior in relation to man-made water sources.

Boat channels are often used by manatees to travel from one region to another (Curran 1989, USGS/BRD 1993). Although these channels may provide deeper waters for manatees to avoid or escape oncoming boats, for reasons not yet understood, they do not always move out of the way of approaching boats. Manatees are also vulnerable to collisions with boats in narrow waterways and shallow water areas. During high tide, manatees are able to access foraging habitat that is normally inaccessible during low tide (Smith 1993). Although watercraft may utilize deeper navigation channels, coastal shallow areas are used intensively for fishing and general sightseeing. The shallow depths of these areas increase the likelihood of manatee injury or death if a powerboat passes over them.

Relationship to Other Species

The manatee is an indicator species for aquatic habitats, including seagrasses and mangroves, in the South Florida Ecosystem. Because this species is dependent upon the health of its entire habitat, the status of the manatee acts as a signal for the condition of many of the other flora and fauna that rely upon aquatic systems. For example, seagrass beds and mangroves provide important areas for manatee foraging, calving, resting, and mating. They also provide important habitat resources for other aquatic species such as wading birds, crocodiles *(Crocodylus acutus)*, turtles, fish and invertebrates. The stability of these aquatic communities is essential for manatees and many other species.

Manatees have no known predators, except for humans. Manatees and their habitats are continually threatened by human activities, such as habitat loss for

residential and commercial purposes, increased turbidity levels from upland urbanization activities, pollution from sewage discharge and stormwater runoff, aquatic recreational and commercial activities, and alterations of natural hydrology. Several threatened and endangered sea turtles use the same seagrass beds as manatees for juvenile refugia and feeding. In addition, many migratory birds, and fish rely on the aquatic habitats manatees use. Habitat requirements of all of these species need to be considered and balanced in order to conserve and protect these resources.

Human interferences with natural water flows have affected the dynamics of vegetative communities in the South Florida Ecosystem. Changes in these flow regimes may affect not only manatees but other species as well, including the endangered American crocodile and pink shrimp (*Penaeus duorarum*), an important fishery species. Returning hydrologic flows to mimic more natural conditions will allow more fresh water into northeastern Florida Bay and may increase the amount of suitable crocodile nesting habitat. A decline in the pink shrimp fishery has been attributed to a lack of freshwater inflow into Florida Bay and a loss of seagrass habitat. The effects of hydrologic conditions on manatees is not well known; but effects on habitat have been observed.

Although reactions may be different, manatees are susceptible to the same natural and human disturbances other aquatic organisms experience, such as changes in water quality, loss of habitat, and susceptibility to diseases and natural catastrophes. Considering man is the only known predator of manatees, it is our responsibility to ensure our actions do not jeopardize the continued existence of this species nor those other species that share its home.

Status and Trends

The Federal government has recognized the threats to the continued existence of the Florida manatee for over 30 years. The West Indian manatee was first listed as an endangered species in 1967 under the Endangered Species Preservation Act of 1966 (16 U.S.C. 668aa(c)) (32 FR 48:4001). The Endangered Species Conservation Act of 1969 (16 U.S.C. 668aa(c)) continued to recognize the West Indian manatee as an endangered species (35 FR 16047), and the West Indian manatee was also among the original species listed as endangered pursuant to the Endangered Species Act of 1973. Critical habitat was designated for the manatee in 1976. The justification for listing as endangered included impacts to the population from harvesting for flesh, oil, and skins as well as for "sport," loss of coastal feeding grounds from siltation, and the volume of injuries and deaths resulting from collisions with the keels and propellers of powerboats. Manatees are also protected under the provisions of the Marine Mammal Protection Act of 1972, as amended (16 U.S.C. 1361 *et seq*.) and have been protected by Florida law since 1892.

Historic information on *T. manatus* distribution indicates manatees were once more common in pre-Colombian times. Manatees were highly utilized for their

meat, oil, bones, and hide; hence, their early decline has been attributed to overhunting (Lefebvre *et al.* 1989). Extirpation and range contraction is evident throughout the manatee's range; areas previously with abundant populations now contain few or none. For example, manatees have been extirpated from some coastal areas in Mexico, Virgin Islands, and Honduras.

Florida is at the northern limit of *T. manatus'* year-round range. Exact estimates of the historic manatee population are uncertain, but overhunting between the 1700s and 1900s is believed to be responsible for reducing the manatee population to only a few relict groups (Hartman 1979).

The geographic distribution of manatees within Florida has changed since the 1950s and 60s (Lefebvre *et al.* 1989) and prominent shifts in seasonal distribution are also evident. Before man introduced warm effluents from power plants to the natural environment in the early 1950s, the winter range of the manatee in Florida was most likely limited on its northern bounds by the Sebastian River on the east coast and Charlotte Harbor on the west coast (Moore 1951). Since that time, manatees altered their normal migration patterns and appreciable numbers of manatees began aggregating at new sites. As new powerplants became operational, more and more manatees began taking advantage of the sites by traveling great distances just to bask in the warm waters. The introduction of powerplants and paper mills in northern Florida, southern Georgia, Louisiana, and Texas has given manatees the opportunity to expand their winter range to areas not previously frequented (Hartman 1979).

As discussed earlier, determining exact population estimates or trends is difficult for this species. The best indicator of population trends is derived from mortality data and aerial surveys (Ackerman *et al.* 1992, Ackerman *et al.* 1995, Lefebvre *et al.* 1995). Aerial surveys conducted over the past 19 years have shown an increase in numbers, but this information is not an accurate account of trends since data has been obtained using different survey methods. O'Shea (1988) found no firm evidence of a decrease or increase between the 1970s and 1980s, even though aerial survey counts have increased. Increases in the number of recovered dead manatees have been interpreted as evidence of increasing mortality rates (Ackerman *et al.* 1992, Ackerman *et al.* 1995). Because manatees have low reproductive rates, these increases in mortality may lead to a decline in the population (O'Shea *et al.* 1988, 1992). Until better survey techniques are developed, efforts to reduce human-caused manatee deaths, like boat strikes, need to continue.

Although there are no accurate estimates of manatee population size, DEP's 1996 synoptic aerial surveys conducted between February 18-19, determined there were at least 2,639 manatees in Florida's waters. DEP conducted two synoptic surveys in 1997. The January survey determined that 2,229 manatees were present in Florida's waters: 900 on the east coast and 1,329 manatees on the west coast. The February survey determined that 1,709 manatees were present in Florida's waters: 791 manatees on the east coast and 918 on the west coast.

Surveys conducted by DEP in 1996 and 1997 determined that numbers of manatees on the east coast and west coasts of Florida are almost equal (Rathbun *et al.* 1992). These estimates represent the minimum number of manatees in Florida waters and may not represent the total population size (for discussions on bias in aerial surveys, see Garrott *et al.* 1995 and Lefebvre *et al.* 1994). Although this has been the highest estimate of manatees since the synoptic surveys were started, the results of these surveys may vary because of such factors as sampling methodology, manatee behavior, and weather conditions. Because of this variation and the high degree of uncertainty in surveying, it is difficult to correlate these manatee population estimates with overall manatee population trends (Ackerman *et al.* 1995).

Despite the lack of accurate estimates of the manatee population size, human activities have significantly affected manatees by eliminating or modifying suitable habitat, altering migratory access routes, increasing mortality, and decreasing abundance, all of which in turn, can affect manatee reproduction, recruitment, distribution, and behavior. To understand manatee mortality trends in Florida, Ackerman *et al.* (1995) evaluated the number of recovered carcasses between 1974 and 1992 and categorized the causes of death. During that time interval, the number of manatees killed in collisions with watercraft increased each year by 9.3 percent. The number of manatees killed in collisions with watercraft each year correlated with the total number of pleasure and commercial watercraft registered in Florida (Ackerman *et al.* 1995). Other human-related threats include manatee death or injury from flood-control structures and navigational locks, entanglement in fishing line, entrapment in culverts, and poaching. These other threats accounted for 162 known mortalities between 1974 and 1993.

Deaths from flood control structures and other human-related deaths did not change significantly but deaths due to these categories decreased more than deaths from other causes (Table 1). Of interest is the increase in the number of perinatal deaths of 11.9 percent/year. The frequency of perinatal deaths (stillborn and newborn calves) has been consistently high over the past 5 years and represented 24 percent of all manatee deaths in 1994. This estimate may not be a true representation of the actual number of perinatal deaths that occur because the carcasses of these young animals may not be recovered. The cause of the increase in perinatal deaths is uncertain, but may result from a combination of factors that includes pollution, disease, or environmental change (Marine Mammal Commission 1992). It may also result from the increase in collisions between manatees and watercraft because some newborn calves may die when their mothers are killed or seriously injured by boat collisions, when they become separated from their mothers while dodging boat traffic, or when stress from vessel noise or traffic induces premature births (Marine Mammal Commission 1992). As a result of the high perinatal death rate, there are fewer young age classes present in the population.

Of the 1,907 manatee carcasses that have been recovered in Florida between 1989 and 1997, (DEP 1998) nearly half were female. The reduction of mature females places an additional burden and pressure on younger, less-experienced females to be the foundation for population growth. Younger females may be more apt to abandon their calves and less successful in calf rearing (Marine Technical Advisory Council 1994). A loss of mature, experienced males may also reduce the likelihood of successful mating.

The greatest present threat to manatees is the high rate of manatee mortalities caused by watercraft collisions. O' Shea *et al.* (1985) recognized the dramatic increase in the rate of boat use in manatee habitat and, consequently, the increase in the potential of boat-related manatee injury or death. Between 1986 and 1992, watercraft collisions accounted for 37.3 percent of all manatee deaths, where the cause of death could be determined (Ackerman *et al.* 1995).

The significance of manatee mortalities related to watercraft appears to be the result of dramatic increases in vessel traffic. Ackerman *et al.* (1995) showed a strong correlation between the increase in recorded manatee mortality and increasing boat registrations. In 1960, there were approximately 100,000 registered boats in Florida; by 1990, there were more than 700,000 registered vessels in Florida (Marine Mammal Commission 1992, Wright *et al.* 1995). Approximately 97 percent of these boats are registered for recreational use. The most abundant number of registered boats are in the 16 foot to 26 foot size class. Between 1974 and 1997, there were 3,270 known manatee mortalities in Florida. Of these, 749 were watercraft-related. Since 1974, an average of 31 manatees have died from watercraft-related injuries each year; between 1983 and 1993, manatee mortalities resulting from collisions with watercraft reached record levels (DEP 1994). Approximately twice as many manatees died from impacts suffered during collisions with watercraft than from propeller cuts; this has been a consistent trend over the last several years. Most lethal propeller wounds are caused by medium or large-sized boats, while impact injuries are caused by fast, small to medium-sized boats (Wright *et al.* 1992). Watercraft-related mortalities were most significant in the southwest and northeast regions of Florida; deaths from watercraft increased from 11 to 25 percent in southwestern Florida. In all of the counties that had high watercraft-related manatee deaths, the number of watercraft and the seasonal abundance of manatees was high (Ackerman *et al.* 1995).

In addition to direct collisions with boats, secondary effects from boating activity include such stresses as disruption of normal breeding behavior, disruption of cow-calf bonding, interference with migration routes and patterns, and the loss of feeding areas. An increase in these effects is likely to increase the probability of unsuccessful mating, perinatal mortality, prevention of reaching freshwater resources and warm-water refugia, and decreasing the availability of food resources. In addition, these effects are likely to decrease the recruitment of young manatees into the breeding population and decrease the number of successful reproductions.

Table 1. Number of manatee (*Trichechus manatus*) deaths in Florida (1974-1997). Adapted from DEP (1998).

Year	Watercraft collision	Flood gate/canal lock	Other human-related	Perinatal	Other Natural	Undetermined	Total
1974	3	0	2	0	0	2	7
1975	6	1	1	7	1	13	29
1976	10	4	0	14	2	32	62
1977	13	6	5	9	1	80	114
1978	21	9	1	10	3	40	84
1979	24	8	9	9	4	23	77
1980	16	8	2	13	5	19	63
1981	24	2	4	13	9	64	116
1982	20	3	1	14	41	35	114
1983	15	7	5	18	6	30	81
1984	34	3	1	25	24	41	128
1985	33	3	3	23	19	38	119
1986	33	3	1	27	13	45	122
1987	39	5	2	30	16	22	114
1988	43	7	4	30	24	25	133
1989	50	3	5	38	32	40	168
1990	47	3	4	44	67	41	206
1991	53	9	6	53	14	39	174
1992	38	5	6	48	20	46	163
1993	35	5	6	39	24	36	145
1994	49	16	5	46	37	40	193
1995	42	8	5	56	35	55	201
1996	60	10	0	61	118	166	415
1997	54	8	8	61	46	65	242
Total	749	136	86	688	561	1,037	3,270

The second most significant threat to manatees is the loss and degradation of habitat, due primarily to direct damage by aquatic recreational and commercial boating activity, coastal construction, and pollution from sewage discharge and stormwater runoff (Marine Mammal Commission 1992, Smith 1993). Coastal land conversion accompanying the growth of Florida's human population has occurred largely along coastal waters and rivers used by manatees. Siltation, eutrophication, other forms of water pollution, and the destruction or degradation of wetlands to promote shoreline development degrade the coastal and riverine communities. This degradation reduces manatee food supplies and eliminates the secluded areas that are used by manatees to mate, calve, and nurse (Marine Mammal Commission 1992).

In Florida, manatees rely primarily on seagrass beds for foraging, mating, and calving. These seagrass beds incur most of their direct damage from boat propellers (Zieman 1982). Boat-induced turbidity results from propeller dredging of bottom habitats and propeller wash and wave wake disturbance. Sediments around seagrasses become unconsolidated and suspended, delaying recolonization for 2 to 5 years or longer, depending upon species type. Several bays in Florida formerly possessed extensive seagrass resources, but dredge and fill operations as well as other human disturbances have greatly reduced their extent (Zieman 1982).

Seagrasses along the coast of Florida have been declining since the 1950s. In Tampa Bay, about 16,188 ha of seagrass flourished along the shallow shelf of the bay. By 1982, only 8,741 ha remained baywide (Tampa Bay National Estuary Program 1995). In Sarasota Bay, seagrasses have declined by 30 percent (Sarasota Bay National Estuary Program 1994). From 1945 to 1982, seagrass acreage declined by 29 percent in Charlotte Harbor; with an additional 809 to 3,238 ha of seagrasses destroyed or damaged by boat propellers (Haddad and Sargent 1994). More than 100,000 acres of seagrasses have "died off" in Florida Bay since 1987 (FWS 1994). For the Indian River Lagoon, the total coverage of submerged aquatic vegetation (seagrasses and macroalgae) in the 1970s was 31,777 ha. In 1992, the total coverage decreased to 28,385 ha, an 11 percent reduction in seagrass distribution (Indian River Lagoon National Estuary Program 1994).

An unusual manatee mortality event was detected in southwest Florida in 1996. Between March 5 and April 29, 149 manatee deaths were attributed to this unusual die-off. Most of the manatee carcasses were recovered from Lee County followed by Collier, Charlotte, and Sarasota counties. After thorough investigations, red tide was indicated as the cause. Final reports on the 1996 manatee die-off concluded that brevetoxins from a bloom of dinoflagellates (*Gymnodinium brevii*), more commonly known as red tide, were responsible for the deaths of those manatees. Brevetoxins were found in the manatee carcasses in liver, kidney, and lung tissues and also in stomach contents. The majority of animals that died were large animals (greater than 275 cm long), although some smaller (younger) animals also died. The sex ratio of dead manatees was nearly one to one. High concentrations of red tide organisms

were also found in water samples taken in the geographic vicinity of the die-off. Researchers continue to look for the cause of the red tide outbreak, method of toxicity, organ selection of the toxin, and most importantly, ways to minimize the effects of another red tide event.

Other threats to the manatee include natural catastrophic events such as low temperatures, and hurricanes (Ackerman *et al.* 1995). Most catastrophic mortality, however, is due to low temperatures (O'Shea *et al.* 1985). Lethal temperatures and lethal exposure times are not well known, but manatees cannot survive indefinitely in water colder than 16 degrees C (Ackerman *et al.* 1995). Although deaths from natural weather events cannot be prevented by humans, these mortalities must be considered because they play an important factor in the overall status of the manatee.

The FWS has concentrated on controlling those factors that will respond to direct human intervention. The FWS has worked with the State to minimize the number of mortalities caused by watercraft collisions, and with the COE to reduce the number of manatees killed by floodgates and canal locks. The number of manatees killed by floodgates and canal locks has declined from a high of 8.8 percent (between 1976 and 1980) to 3.2 percent. The FWS is continuing to work with the COE to develop new technologies to further reduce the number of manatees killed in these water control structures. The FWS has also worked to reduce the number of manatees killed by other human causes. Since 1973, the number of manatees killed by poaching, net entanglement, and vandalism has declined from a high of 8.3 percent to 2.6 percent by 1992 (Ackerman *et al.* 1995).

Marmontel's (1993) population viability analysis (PVA) model discussed previously suggest that a 10 percent mortality rate is probably a critical threshold for the survival and recovery of manatees. Although the minimum population estimate reached a record high in 1996 with approximately 2,639 manatees, the number of manatees killed in the first quarter of 1996 almost equals 10 percent of that minimum population estimate. According to DEP, 415 manatees died in 1996.

Although Marmontel's (1993) PVA had limitations resulting from the lack of specific life history information on the manatee, her simulations represent the best information available regarding the consequences of human activities on the manatee. First, she noted that the small population size of the manatee lessens their probability of persistence and increases the chances that the populations will be adversely affected by environmental variation or additional mortalities. Second, her simulations projected that a 10 percent increase in overall manatee mortality would reduce the manatee below the critical threshold of 500 animals in about 100 years. Finally, her simulations projected that reducing the mortality of adult manatees by watercraft would be the most productive mechanism to increase the probability of manatee survival and recovery.

Management

Perhaps the first management action taken to conserve manatees was the 1892 prohibition on killing instituted by Florida law. The manatee was federally

listed as an endangered species in 1967. Some of the first research conducted on manatees began in the mid-1960s (Hartman 1979). Additional research continued in 1974 when the University of Miami and Gainesville Field Station of the FWS began focusing their efforts on manatee research. These efforts provided a foundation for later research and management activities. By 1978, Florida passed the Florida Manatee Sanctuary Act and by 1984, Florida Department of Natural Resources (now DEP) dedicated more resources to protect the manatee.

In 1980, the first manatee recovery plan was approved and a manatee coordinator was hired by the FWS to oversee the recovery of the manatee. The recovery plan was revised in 1989 and again in 1996. The primary goal for recovery of the manatee is to restore manatee populations to sustainable levels that will permit their reclassification from endangered to threatened. To progress with the recovery goals, the FWS's 1996 recovery plan for the manatee established four objectives: (1) identify and minimize causes of manatee disturbance, injury, and mortality, (2) protect essential manatee habitat, (3) determine and monitor the status of manatee populations and essential habitat, and (4) coordinate recovery activities, monitor and evaluate progress, and update and/or revise the recovery plan (FWS 1996).

Building upon efforts that began in the 1960s, an array of Federal, State, local, and private groups have contributed to the protection of the manatee. A considerable collaborative effort has been put forth and continues today to minimize human-induced effects on manatees and assist in its recovery. Current efforts include manatee salvage programs, population biology research, population surveys, habitat protection, public awareness programs, and growth management activities. Thirteen counties in Florida were designated in 1989 as "key" counties by the Governor of the State of Florida. This designation recognized the necessity of implementing protection measures in these counties, where 80 percent of the manatee mortalities occurred.

Accomplishments resulting from this collaboration include: (1) the protection of essential and critical manatee habitat, (2) implementation of speed zones in manatee-sensitive areas, (3) increased public awareness and support, (4) the initiation of a manatee rescue, rehabilitation and release network, and (5) advanced techniques for surveying and tracking manatees (FWS 1996).

Identify and Minimize Causes of Manatee Injury and Mortality

In response to the high number of manatee deaths due to floodgates and navigation locks, efforts began in the early 1980s to modify gate opening procedures to ensure manatees were not killed. A task force with representatives from the FWS, SFWMD, the COE, the DEP, and the Miami-Dade County DERM are overseeing ways to reduce these deaths. As a result of these efforts, the number of manatees killed by floodgates and canal locks declined between 1976 and 1980. The COE, SFWMD, and Harbor Branch Oceanographic Institution are developing and testing automatic reversal mechanisms to prevent manatee deaths. When these technologies become

available, the COE will retrofit the structures with the mechanisms, in accordance with section 1135 of the Water Resources Development Act of 1986, as amended.

The FWS, through section 7 of the ESA, reviews permit applications for various projects that may affect manatees. As part of these reviews, the FWS recommends ways to avoid, reduce, or minimize the effects of projects on manatees. In addition, the FWS has developed speed and access rules for motorboats within the boundaries of Merritt Island NWR, and similar guidelines are being recommended for other Federal facilities in manatee habitat. The DEP, through its manatee protection plan, is developing guidelines to reduce manatee watercraft injuries and deaths by implementing waterway speed and access (*e.g.*, no entry) zones in the 13 key counties.

Public education is an important management tool in protecting and recovering the manatee. Several groups, especially the Save the Manatee Club, have participated in the efforts to educate the public about manatee protection and habitat conservation, including ways to decrease the number of boat-caused manatee deaths, improve water quality, and reduce habitat degradation. The FWS is coordinating with the COE to develop manatee education and boating programs for proposed projects such as marinas, boating facilities, and boat ramps in an effort to reduce the number of manatees killed in collisions with watercraft.

Protect Essential Manatee Habitat

Through the NWR System, the FWS has acquired thousands of acres of land important to manatees in the Crystal, Homosassa, and Suwannee rivers. Three new manatee sanctuaries have been established in Florida, as well as a motorboat-prohibited area in the Merritt Island NWR and the Kennedy Space Center. The State of Florida has several programs to protect and acquire lands including the Conservation and Recreational Lands (CARL) Program which dedicates five percent of its program budget to habitat-related purchases for the manatee.

Determine and Monitor the Status of Manatee Populations

Several groups have contributed to the overall understanding and information available on the life history of the manatee, including the FWS, Sirenia, DEP, Georgia DNR, academic institutions, and marine zoological parks. Important components of past and ongoing research efforts include the carcass recovery and necropsy program, radio tracking and satellite telemetry studies on manatee movements and habitat use, the manatee individual photo-identification system (MIPS), aerial surveys to determine minimum population size and identify distribution patterns, a geographical information system (GIS) database to integrate available manatee information, and several additional studies on manatee biology and ecology.

Advance Techniques to Protect Manatees

The FWS established the Interagency/Oceanaria Working Group to coordinate captive manatee management and rehabilitation. An extensive program is now

in place to facilitate the rescue, rehabilitation, and release of manatees. Several long-term captive manatees have been direct-released in Everglades NP, and monitoring of these individuals continues.

Literature Cited

Ackerman, B.B., S.D. Wright, R.K. Bonde, C.A. Beck, and D.J. Banowetz. 1995. Analysis of watercraft-related mortality of manatees in Florida, 1979-1991. Pages 259-268 *in* T.J. O'Shea, B.B. Ackerman, and H.F. Percival, eds. Population biology of the Florida manatee: Information and technology report I. U.S. Department of the Interior, National Biological Service; Washington, D.C.

Ackerman, B.B, S.D. Wright, R.K. Bonde, D.K. Dell, and D. Banowetz. 1992. Trends and patterns in manatee mortality in Florida, 1974-1991. Page 22 *in* T.J. O'Shea, B.B. Ackerman, and H.F. Percival, eds. Interim report of the technical workshop on manatee population biology. Manatee population research report no. 10. Florida Cooperative Fish and Wildlife Research Unit, University of Florida; Gainesville, Florida.

Beeler, I.E. and T.J. O' Shea. 1988. Distribution and mortality of the West Indian manatee (*Trichechus manatus*) in the southeastern United States: a compilation and review of recent information. Report prepared by the U.S. Fish and Wildlife Service for the U.S. Army Corps of Engineers. PB 88-207 980/AS. National Technical Information Service; Springfield, Virginia.

Bengtson, J.L. 1983. Estimating food consumption of free-ranging manatees in Florida. Journal of Wildlife Management 47: 1186-1192.

Bengtson, J.L. 1981. Ecology of manatees in the St. Johns River, Florida. Ph.D. dissertation. University of Minnesota; Minneapolis, Minnesota.

Bernier, B.J. 1985. A comparison of differences in behaviors of captive-born and natural-born manatees (*Trichechus manatus*) as a measure of adjustment to a contained natural environment. Master's Thesis, Florida Institute of Technology; Melbourne, Florida.

Curran, A.P. 1989. Analysis of the effect of boat traffic on manatee (*Trichechus manatus*) densities in four selected study areas in Brevard County, Florida. Unpublished master's thesis, Florida Institute of Technology; Melbourne, Florida.

Domning, D.P. 1982. Evolution of manatees: a speculative history. Journal of Paleontology 56(3): 599-619.

Domning, D.P., G.S. Morgan, and C.E. Ray. 1982. North American Eocene sea cows (Mammalia: Sirenia). Smithsonian Contributions to Paleobiology; Washington, D.C.

Domning, D.P. and L.C. Hayek. 1986. Interspecific and intraspecific morphological variation in manatees (Sirenia: Trichechus). Marine Mammal. Science. 2:87-144.

Eberhardt, L.L. and T.J. O'Shea. 1995. Integration of manatee life-history data and population modeling. Pages 269-279 *in* T.J. O'Shea, B.B. Ackerman, and H.F. Percival, eds. Population biology of the Florida manatee: Information and technology report I. U.S. Department of the Interior, National Biological Service; Washington, D.C.

Florida Department of Environmental Protection. 1998. Manatee salvage data base: Summary report. Florida Marine Research Institute; St. Petersburg, Florida.

Florida Department of Natural Resources [DEP]. 1994. Manatee salvage data base: Summary report. Florida Department of Natural Resources, Florida Marine Research Institute; St. Petersburg, Florida.

Garrot, R. A., B.A. Ackerman, J.R. Cary, D.M. Heisey, J.E. Reynolds III, P.M. Rose, and J. R. Wilcox. 1994. Trends in counts of Florida manatees at winter aggregation sites. Journal of Wildlife Management 58(4): 642-654.

Garrott, R.A., B.A. Ackerman, J.R. Cary, D.M. Heisey, J.E Reynolds, III, and J.R. Wilcox. 1995. Assessment of trends in sizes of manatee populations at several Florida aggregation sites. Pages 34-55 *in* T.J. O'Shea, B.B. Ackerman, and H.F. Percival, eds. Population biology of the Florida manatee: Information and technology report I. U.S. Department of the Interior, National Biological Service; Washington, D.C.

Gerstein, E.R. 1994. Hearing abilities of the West Indian manatee (*Trichechus manatus*). Manatee hearing study, phase I: Experiments 1, 2, & 3. Technical report no. 119. Florida Atlantic University; Boca Raton, Florida.

Gunter, G. 1941. Occurrence of the manatee in the United States, with records from Texas. Journal of Mammalogy 22: 60-64.

Haddad, K. and F. Sargent. 1994. Scars under the water. The Florida Naturalist Winter: 9-11.

Harlan, R. 1824. On a species of lamantin (*Manatus latirostris* n.s.) resembling *Manatus senegalensis* (Cuvier) inhabiting the east coast of Florida. Journal of Academy of Natural Science Philadelphia 3: 390-394.

Hartman, D.S. 1979. Ecology and behavior of the manatee (*Trichechus manatus*) in Florida. Special publication: American Society of Mammologists special report no. 5: 1-153.

Hartman, D.S. 1974. Distribution, status and conservation of the manatee in the United States. National technical information service. PB81-140725; Springfield, Virginia.

Hatt, R. 1934. A manatee collected by the American Museum Congo Expedition, with observations on the recent manatees. Bulletin of American Museum of Natural History 66: 533-536.

Hernandez, P., J.E. Reynolds, III, H. Marsh, and M. Marmontel. 1995. Age and seasonality in spermatogenesis of Florida manatees. Pages 84-97 *in* T.J. O'Shea, B.B. Ackerman, and H.F. Percival, eds. Manatee population biology of the Florida manatee, information and technology report I. U.S. Department of the Interior; Washington, D.C.

Hurst, L.A. and C.A. Beck. 1988. Microhistological characteristics of selected aquatic plants of Florida with techniques for the study of manatee food habits. U.S. Department of Interior, Fish and Wildlife Service, Research and Development, biological report 88(18); Gainesville, Florida.

Husar, S.L. 1978. *Trichechus manatus*. Mammalian species no. 93: 1-5.

Husar, S.L. 1977. The West Indian manatee (*Trichechus manatus*). United States Department of Interior, Fish and Wildlife Service, Wildlife research report 7; Washington, D.C.

Irving, A.B. and H.W. Campbell. 1978. Aerial census of the West Indian manatee, *Trichechus manatus*, in the southeastern United States. Journal of Mammalogy 59: 613-617.

Kadel, J.J. and G.W. Patton. 1991. Aerial studies of the West Indian manatee (*Trichechus manatus*) on the west coast of Florida from 1985-1990: A comprehensive six year study. Mote Marine Laboratory technical report no. 246; Sarasota, Florida.

Ketten, D.R., D.K. Odell and D.P. Domning. 1992. Structure, function, and adaptation of the manatee ear. Pages 77-95 *in* J. Thomas, R.A. Kastelein, and A. Ya. Supin (eds.) Marine mammal sensory systems. Plenum Press, New York.

Kinnaird, M.F. 1983. Evaluation of potential management strategies for the reduction of boat-related mortality of manatees. Research report number 3, Florida Cooperative Fish and Wildlife Research Unit, U.S. Fish and Wildllife Service.

Lefebvre, L.W., B.B. Ackerman, K.M. Portier, and K.H. Pollock. 1995. Aerial survey as a technique for estimating trends in manatee population size-problems and prospects. Pages 63-74 *in* T.J. O'Shea, B.B. Ackerman, and H.F. Percival, eds. Population biology of the Florida manatee: Information and technology report I. U.S. Department of the Interior, National Biological Service; Washington, D.C.

Lefebvre, L.W., T.J. O'Shea, G.B. Rathbun, and R.C. Best. 1989. Distribution, status, and biogeography of the West Indian manatee. Pages 567-610 *in* C.A. Wood, ed. Biogeography of the West Indies. Sandhill Crane Press; Gainesville, Florida.

Lefebvre, L.W. and J.A. Powell. 1990. Manatee grazing impacts on seagrasses in Hobe Sound and Jupiter sounds in southeast Florida during the winter of 1988-89. Prepared for the U.S. Marine Mammal Commission; Washington, D.C.

Longieliere, T.J. 1994. Manatee spatial and temporal distribution between the Sebastian and St. Lucie inlets, Florida, during the winter and spring 1993-1994. Unpublished M.S. thesis. Florida Institute of Technology; Melbourne, Florida.

Lowery, J.H., Jr. 1974. The mammals of Louisiana and its adjacent waters. Louisiana University Press.

Manatee Technical Advisory Council [MTAC]. 1994. Update. Florida Department of Environmental Protection; Tallahassee, Florida.

Marine Mammal Commission [MMC]. 1992. Annual report to Congress, 1991. Marine Mammal Commission; Washington, D.C.

Marmontel, M. 1993. Age determination and population biology of the Florida manatee, *Trichechus manatus latirostris*. Unpublished Ph.D. dissertation. University of Florida; Gainesville, Florida.

Marmontel, M., D.K. Odell, and J.E. Reynolds III. 1992. Reproductive biology of South American manatees. Pages 293-312 *in* W.C. Hamlett, ed. Reproductive biology of South American vertebrates. Springer-Verlag; New York, New York.

Moore, J.C. 1951. The range of the Florida manatee. Quarterly Journal Florida Academy of Science 14: 1-19.

Odell, D.K. 1982. The West Indian manatee, *Trichechus manatus* Linnaeus. Pages 828-837 *in* J.A. Chapman and G.A. Feldhamer, eds. Wild mammals of North America. John Hopkins University Press; Baltimore, Maryland.

Odell, D.K. 1981. Growth of a West Indian manatee, *Trichechus manatus*, born in captivity. Pages 131-140 *in* R.L. Brownell, Jr. and K. Ralls, eds. The West Indian manatee in Florida. Proceedings of a workshop held in Orlando, Florida 27-29 March 1978. Florida Department of Natural Resources; Tallahassee, Florida.

Odell, D.K., G.D. Bossart, M.T. Lowe, and T.D. Hopkins. 1995. Reproduction of the West Indian manatee, *Trichechus manatus*, in captivity. Pages 192-193 *in* T.J. O'Shea, B.B. Ackerman, and H.F. Percival, eds. Population biology of the Florida manatee. National Biological Service Information and technology report 1.

O'Shea, T.J. 1995. Waterborne recreation and the Florida manatee. Pages 297-311 *in* R.L. Knight and K.J. Gutzwiller, eds. Wildlife and Recreationists: Coexistence through management and research. Island Press; Washington, D.C.

O'Shea, T.J. 1988. The past, present, and future of manatees in the southeastern United States: Realities, misunderstandings, and enigmas. Pages 184-204 *in* R.R. Odum, K.A. Riddleberger, and J.C. Ozier, eds. Proceedings of the third southeastern nongame and endangered wildlife symposium. Georgia Department of Natural Resources, Game and Fish Division; Atlanta, Georgia.

O'Shea, T.J., B.B. Ackerman, and H.F. Percival, eds. 1992. Interim report of the technical workshop on manatee population biology. Manatee population research report no. 10. Florida Cooperative Fish and Wildlife Research Unit, University of Florida; Gainesville, Florida.

O' Shea, T.J., C.A. Beck, R.K. Bonde, H.I. Kochman, and D.K. Odell. 1985. An analysis of manatee mortality patterns in Florida 1976-1981. Journal of Wildlife Management 49: 1-11.

O'Shea, T.J. and M.E. Ludlow. 1992. Florida manatee. Pages 190-200 *in* S.R. Humphrey, ed. Rare and endangered biota of Florida. Volume I. Mammals. University Press of Florida; Gainesville, Florida.

Packard, J.M. 1985. Preliminary assessment of uncertainty involved in modeling manatee populations. Manatee population research report no. 9. Technical report no. 8-9. Florida Cooperative Fish and Wildlife Research Unit. University of Florida; Gainesville, Florida.

Powell J.A., Jr. 1978. Evidence of carnivory in manatees (*Trichechus manatus*). Journal of Mammalogy 59(2): 442.

Powell, J.A. and G.B. Rathbun. 1984. Distribution and abundance of manatees along the northern coast of the Gulf of Mexico. Northeast Gulf Science 7(1): 1-28.

Provancha, J.A. and C.R. Hall. 1991. Observations of associations between seagrass beds and manatees in east central Florida. Florida Scientist 54(2): 87-98.

Rathbun, G.B. 1984. Sirenians. Pages 537-547 *in* S. Anderson and J.K. Jones, Jr., eds. Orders and families of recent mammals of the world. John Wiley and Sons, Inc.; New York, New York.

Rathbun, G.B., J.P. Reid, R.K. Bonde, and J.A. Powell. 1992. Reproduction in free-ranging West Indian manatees (*Trichechus manatus*). Pages 19-20 *in* T.J. O'Shea, B.B. Ackerman, and H.F. Percival, eds. Interim report of the technical workshop on manatee population biology. Manatee population research report no. 10. Florida Cooperative Fish and Wildlife Research Unit, University of Florida; Gainesville, Florida.

Rathbun, G. B., J. P Reid, and G. Carowan. 1990. Distribution and movement patterns of manatees (*Trichechus manatus*) in northwestern peninsular Florida. State of Florida, Department of Natural Resources, Florida Marine Research Institute, Florida Marine Research Publications, no. 48; St. Petersburg, Florida.

Reeves, R. R., B.S. Stewart, and S. Leatherwood. 1992. West Indian (Caribbean, Florida) manatee, *Trichechus manatus*. Pages 260-270 *in* The Sierra Club handbook of seals and sirenians. Sierra Club Books; San Francisco, California.

Reid, J.P., R.K. Bonde, and T.J. O'Shea. 1992. Reproduction, mortality, and tag loss of telemetered and recognizable individual manatees on the Atlantic Coast of Florida. Pages 20-21 *in* T.J. O'Shea, B.B. Ackerman, and H.F. Percival, eds. Interim report of the technical workshop on manatee population biology. Manatee population research report no. 10. Florida Cooperative Fish and Wildlife Research Unit, University of Florida; Gainesville, Florida.

Reid, J. P., G. B. Rathbun, and J. R. Wilcox. 1991. Distribution patterns of individually identifiable West Indian manatees (*Trichechus manatus*) in Florida. Marine Mammal Science 7(2): 180-190.

Reinhart, R.H. 1951. A new genus of sea cow from the Miocene of Columbia. University of California Department of Geological Science series B 28: 203-213.

Reinhart, R.H. 1959. A review of the Sirenia and Desmostylia. University of California Publications of Geological Science 36: 1-146.

Reynolds, J.E. 1979. Internal and external morphology of the manatee (sea cow). The Anatomical Record 193 (3): 663.

Reynolds, J.E., III. 1981. Behavior patterns in the West Indian manatee, with emphasis on feeding and diving. Florida Scientist 44(4): 233-241.

Simpson, G.G. 1932. Fossil Sirenia of Florida and the evolution of the Sirenia. Bulletin of the American Musuem of Natural History 59: 419-503.

Smith, K.N. 1993. Manatee habitat and human-related threats to seagrass in Florida: A review. Department of Environmental Protection, Division of Marine Resources; Tallahassee, Florida.

U.S. Geological Service Biological Resources Division.[USGS/BRD] 1993. Annual report on the radio telemetry of manatees in Puerto Rico. Sirenia Project; Gainesville, Florida.

U.S. Fish and Wildlife Service [FWS]. 1996. Florida manatee recovery plan. U.S. Fish and Wildlife Service; Atlanta, Georgia.

Wright, S.D., B.B. Ackerman, R.K. Bonde, C.A. Beck, and D.J. Banowetz. 1995. Analysis of watercraft-related mortality of manatees in Florida, 1979-1991. Pages 259-268 *in* T.J. O'Shea, B.B. Ackerman, and H.F. Percival, eds. Population biology of the Florida manatee: Information and technology report I. U.S. Department of the Interior, National Biological Service, Washington, D.C.

Wright, S.D., B.B. Ackerman, R.K. Bonde, C.A. Beck, and D.J. Banowetz. 1992. Analysis of watercraft-related mortality of manatees in Florida, 1979-1991. Page 23 *in* T.J. O'Shea, B.B. Ackerman, and H.F. Percival eds. Interim report of the technical workshop on manatee population biology. Manatee population research report no. 10. Florida Cooperative Fish and Wildlife Research Unit, University of Florida; Gainesville, Florida.

Zieman, J.C. 1982. The ecology of the seagrasses of south Florida: a community profile. U.S. Fish and Wildlife Service, Office of Biological Services; Washington, D.C. FWS/OBS-82/25.

Recovery for the West Indian Manatee

Trichechus manatus

Recovery Objective: RECLASSIFY to threatened, then delist.

South Florida Contribution: Reduce human-related mortality in South Florida; control or reduce threats to essential manatee habitat in South Florida.

Recovery Criteria

The statewide manatee recovery plan states that the West Indian manatee can be considered for reclassification to threatened when data and population models are available to assess population size and trends; when analyses indicate that the population is growing or stable; when mortality factors are controlled at acceptable levels or are decreasing; and when critical habitats are secure and threats to them are controlled or decreasing (FWS 1996).

Species-level Recovery Actions

S1. Support the investigation of the distribution and status of the manatee and its habitat in South Florida by continuing flying synoptic statewide aerial surveys. Aerial survey sighting data have provided and continue to provide useful data on manatee distribution and, in some situations, relative abundance. When combined with telemetry data, certain types of aerial sightings provide a sound basis for determining habitat use patterns. Aerial sightings also provide useful information on the proportion of calves. Because of uncertainty in the number of animals not seen in turbid water, uncertainty as to the proportion of the population within a survey area, and other problems, however, aerial sighting data generally do not permit scientists to estimate or detect trends in population size.

S1.1. Continue flying synoptic statewide aerial surveys. In 1991, the Florida Marine Research Institute began flying coordinated statewide aerial surveys of all known winter manatee habitat. The surveys are flown following cold fronts when manatees aggregate at warm water refuges in greatest numbers. They involve large numbers of observers flying simultaneously over different segments of known winter manatee habitat. Although problems limit the use of this sighting data to measure population size or trends, the surveys have provided high counts that improve the lower bound of the range of the estimated number of animals. If correction factors for uncertainties noted above can be developed, the resulting data also may be used in the future to determine population trends. As appropriate, such surveys should be continued. For South Florida, aerial surveys should emphasize both manmade and natural warmwater sites; particularly the waterways of Florida Bay and Everglades NP.

S1.2. Undertake regional or local aerial surveys. In some areas, aerial surveys are needed to improve information on local habitat use patterns. The information obtained through these surveys has been an important basis for developing and analyzing new speed zones and other management measures. As appropriate and possible, local aerial surveys should be undertaken or continued in the Indian, Miami, and Caloosahatchee rivers; Sarasota, Estero, and Rookery bays; Coral Gables Waterway, Ten Thousand Islands region, and Whitewater Bay as well as other areas to improve information on local habitat use patterns and trends in relative abundance.

S1.3. Continue aerial surveys of aggregation sites after cold fronts. Florida Power & Light Company has supported aerial surveys of manatees at warm-water powerplant outfalls each winter since 1977. In addition to data on the numbers of animals sighted at these warm-water refuges, this long-term data set includes calf counts that provide valuable information on reproduction. If correction factors can be developed to account for sighting uncertainties, the data may be useful in the future for assessing past population trends.

S1.4. Support a dedicated aerial survey specialist and convene an Aerial Survey Working Group. During a 1992 workshop on manatee population biology (O'Shea *et al.* 1992), participants reviewed aerial survey methodology and identified steps that might be taken to improve information generated by aerial surveys. Participants concluded that better interpretation of aerial data could help detect regional (though perhaps not statewide) trends in abundance. Improvements are needed in stratifying survey effort by type, refining information on diving behavior, defining acceptable sighting conditions, and testing strip transect methodology. A dedicated aerial survey specialist should be supported to monitor progress on aerial survey research, improve survey methodology, and develop correction factors for sighting uncertainties. In addition, an Aerial Survey Working Group chaired by the specialist should be convened at least annually to provide further advice and assistance.

S1.5. Analyze available aerial survey data. Re-evaluate the results of past aerial surveys to improve estimates of selected parameters and population trends. Aerial survey data sets should be evaluated regionally to determine whether they are sufficiently complete and up-to-date. Areas that need to be resurveyed should be identified. In addition, new methodologies and analytical techniques might be applied to ongoing aerial surveys. As possible, such analyses should be undertaken.

S2. Protect and enhance existing populations by identifying and minimizing causes of manatee injury, mortality, and disturbance. Manatees are killed and injured as a result of interactions with boats, floodgates, navigation locks, marine debris, and fishing gear. In rare cases, manatees are killed by vandals and poachers. Additional mortalities, from natural causes such as severe cold weather or red tide, may also significantly affect the status of the manatee population. To permit growth of the manatee population and reach an optimal sustainable population level, such causes of mortality must be reduced. This section of the recovery plan identifies activities needed to monitor and reduce such sources of mortality.

S2.1. Maintain and improve the salvage and necropsy program. The manatee salvage/necropsy program is fundamental to identifying causes of manatee mortality and injury. The program is responsible for collecting and examining virtually all manatee carcasses reported in the southeastern U.S., determining the causes of death, monitoring mortality trends, and disseminating mortality information. Program data

help identify, direct, and support essential management actions (*e.g.*, promulgating watercraft speed rules and reviewing permits for construction in manatee habitat). The program was begun by the Sirenia Project and the University of Miami in 1974. Procedures and protocols to standardize necropsies were developed in the early 1980s (Bonde *et al.* 1983) and expanded significantly early in the 1990s. Now part of the DEP's Florida Marine Research Institute, the major program duties include: receiving manatee carcass reports from the field; collecting and examining dead animals; maintaining accurate mortality records; and carrying out special studies to improve understanding of mortality causes, rates, and trends. Program staff also coordinate rescues of injured or distressed manatees.

S2.1.1. Ensure prompt and complete reporting of manatee carcasses. To obtain manatee carcasses for necropsy, the carcass recovery and necropsy program relies on reports of carcasses from members of the public. These reports are usually provided through the Florida Marine Patrol, officers in the GFC, or local officials. To provide the best possible understanding of manatee mortality causes and trends, it is important not only to obtain as many reports as possible, but also to assure that reports are received promptly so that carcasses are as fresh as possible when necropsied. The following tasks will facilitate reporting from the field.

S2.1.1.1. Provide training for law enforcement officials on carcass reporting procedures. Most manatee carcasses are found by the public and reported to the Florida Marine Patrol or local law enforcement officials. To ensure that program staff are notified of all reported carcasses, officials likely to receive such reports need to be advised and reminded of the data needs and procedures for reporting carcasses to the salvage and necropsy program staff and the importance of doing so promptly. Periodic presentations by program staff and/or mailings should be made to the Florida Marine Patrol Academy, to Florida Marine Patrol officers in the field, and to other law enforcement groups, such as the GFC, the U.S. Coast Guard, local police departments, and county sheriffs. To maintain interest and involvement, efforts to provide feedback to law enforcement officials on the results of necropsies and program findings should be undertaken routinely.

S2.1.1.2. Encourage public reporting of carcasses. Most manatee carcasses are found by boaters, shoreline residents, and other members of the public frequenting waterways and shorelines. To increase public reporting, information on procedures for reporting carcasses and the importance of doing so promptly should be included in posters and appropriate public education materials. Periodic mailings and/or presentations and public service announcements targeting appropriate groups such as homeowners associations, boating, diving, and fishing groups, and others should be prepared and sent.

S2.1.2. Maintain salvage and necropsy field stations and staff. The salvage and necropsy program includes a central necropsy facility operated by DEP at Eckerd College in St. Petersburg, three field stations on the east coast located at Jacksonville, Melbourne, and Tequesta, and one field station on the west coast at Port Charlotte. The stations collect, examine, and dispose of carcasses, and record, analyze, and distribute mortality data. Support must be provided to maintain an adequate program staff and provide the necessary equipment.

S2.1.2.1. Provide support for salvage and necropsy program staff and equipment. Salvage and necropsy program staff are part of DEP's Florida Marine Research Institute. Field station personnel are responsible for promptly collecting dead animals and related data in the field and transporting the carcasses to the central necropsy facility. The central facility's staff is responsible for conducting all necropsies; collecting, examining, and archiving tissue samples; distributing tissue samples to other researchers; photo-documenting wounds and scars on all salvaged carcasses; recording and analyzing data; performing special studies; preparing monthly and annual mortality summary reports; and administering and coordinating all salvage and necropsy program work. Staffing must be continued to properly conduct this program. In addition, annual funding is needed to repair, replace, upgrade, and otherwise maintain such equipment and supplies necessary to carry out necropsy work.

S2.1.2.2. Develop and coordinate out-of-state salvage efforts. During summer, some Florida manatees migrate north into Georgia, South Carolina, North Carolina, and Virginia or west into Alabama and Louisiana. To maintain accurate mortality data, arrangements are needed to collect carcasses and data from animals that die in these areas. This requires (1) alerting State and local officials in these areas of the importance of reporting dead manatees, and (2) supporting travel and other expenses associated with collecting carcasses and mortality data. The FWS and the salvage and necropsy program staff should cooperate in contacting appropriate officials outside of Florida to alert them as to reporting needs and procedures for manatee carcasses found in their respective areas, and ensuring funds are available for collecting manatee carcasses and mortality data promptly.

S.2.1.3. Undertake special studies and analyses to improve understanding of mortality causes and trends. Special studies are needed to better define and explain various factors, phenomena, or events influencing poorly understood mortality trends.

S2.1.3.1 Assess manatee carcass reporting rates. While it is believed that most dead manatees are found and reported, an unknown proportion go unreported, resulting in an under-representation of annual manatee mortality totals. To assess the number of manatee carcasses that go unreported, studies of carcass detection and reporting rates should be undertaken.

S2.1.3.2. Undertake a workshop and/or studies to identify the proximal cause(s) of perinatal mortality. In recent years, perinatal mortality has increased at a rate greater than any other mortality category and now constitutes approximately 25 percent of the total annual mortality. The causes of increased perinatal mortality are uncertain. It may be related to pollution, injuries and stress from increased vessel traffic and other human activities, changes in the age structure of mature breeding females, habitat changes, or some combination of these and other possible causes. It also may be due to a greater number of births. A workshop should be held to investigate available information on perinatal mortality, research needs, and mitigation measures. Possible contributing factors and any regional differences should be examined.

S2.1.3.3. Undertake routine and periodic tissue analyses. To obtain maximum information from carcasses and wild and rescued manatees, it is necessary to examine and analyze tissues for contaminant levels, reproductive status, age at death, *etc.* In addition, to improve understanding of disease and immunotoxicological processes, salvaged tissues, organs, and organ systems should be studied. Serum from wild and rescued manatees should also be screened to assess the incidence of exposure to various viral, bacterial, parasitic and other pathogenic organisms. A centralized serum bank should be established to analyze diseases.

S2.1.3.4. Investigate and respond to potential unusual mortality events. From time to time there are unusual mortality events in which large numbers of manatees die or become moribund. For example, over 45 animals died in association with a severe cold front in late December 1989, and at least 149 animals died in association with a red tide event that struck southwest Florida populations in 1996. A plan for responding to such an event has been prepared by the FWS as required by the Marine Mammal Stranding Act of 1992. If a large-scale mortality event occurs, the FWS and the salvage and necropsy program will need to coordinate response efforts using contingency plans and funding specifically designed for these events.

S2.2. Minimize collisions between manatees and watercraft. The largest source of human-related manatee mortality is collisions between manatees and watercraft. Known watercraft deaths now constitute at least 20 to 22 percent of the total known annual mortality. Watercraft may cause additional deaths or reduced population growth due to indirect effects of injuries and stress on the reproductive success of mature females (Marine Mammal Commission 1993). Actions to address specific needs are discussed below.

S2.2.1. Develop and refine State waterway speed and access rules. The State of Florida has begun promulgating waterway speed and access rules to

reduce the number of collisions between manatees and watercraft. The rules seek to create a system of speed and access zones tailored to local manatee habitat use-patterns and boating needs. Rulemaking is an intensive process that requires compiling and reviewing voluminous site-specific environmental data, particularly on manatee habitat-use patterns and boating activity; extensive coordination between county and DEP officials to develop rule provisions; public hearings and review; and approval by the Secretary of DEP. As directed by the Florida Governor and Cabinet in 1989, priority attention has been focused toward 13 key counties. Rules for 12 of the 13 key counties are complete. Over the next 5 years, the need for manatee protection measures in the remaining key county and some 20 other counties with important manatee habitat should be considered. Also, rule refinements likely will be needed to increase rule and sign uniformity and to reflect new information on manatee habitat-use patterns and boating activity.

S2.2.2. Develop and refine Federal waterway speed and access rules. For certain Florida waterways, particularly those in or adjacent to NWRs, the FWS has promulgated Federal rules regulating vessel speed and access. These rules, which complement State rules, are issued under authority of the ESA, the Marine Mammal Protection Act, and/or the NWR System Administration Act. Federal rules issued by the COE to control vessel speeds adjacent to navigation locks also may enhance manatee protection. Although the principal purpose of the latter rules is vessel safety around navigation locks, they also reduce the risk of manatee-vessel collisions and should be encouraged for both reasons at locks used by manatees along the Okeechobee Waterway, Cross Florida Barge Canal, and elsewhere. As necessary and appropriate, such Federal rules should be modified and new rules promulgated in cooperation with the State of Florida and other concerned parties.

S2.2.3. Post and maintain regulatory signs. To advise watercraft operators of speed and access restrictions, regulatory signs are posted strategically along waterways. As proper posting is a prerequisite for enforcing and prosecuting violations, signage is as important as the rules themselves. The extensive new rules necessitate posting thousands of new signs along thousands of miles of waterway. On the east coast, the Florida Inland Navigation District is responsible for sign posting and maintenance. Elsewhere the task is shared by the DEP, the West Coast Inland Navigation District, and the counties. Once county rules are adopted, the DEP's Office of Protected Species Management develops or reviews signage plans, the Florida Marine Patrol issues permits for sign placement, and the entity responsible for printing and posting then proceeds with actual posting. As rules are completed or modified, signs should be posted promptly by the responsible agency. Once posted, they should be inspected periodically and repaired or replaced as needed. Signage changes may be warranted based on enforcement or navigation needs or efforts to make sign messages clearer and more uniform.

S2.2.4. Enforce and encourage manatee protection regulations. The Florida Marine Patrol is the principal agency in Florida responsible for enforcing

speed and access rules as well as other manatee protection rules. Federal and State officers assigned to selected parks, refuges, and reserves, the GFC, and the U.S. Coast Guard also assist with enforcement. Effective enforcement requires training to ensure that officers are aware of the purposes and provisions of the rules and how to enforce them. It also requires cooperation among various Federal and State enforcement officials, and the judiciary.

S2.2.4.1. Focus and increase officer time dedicated to enforcing manatee protection rules. Manatee protection rules are but a few of the myriad of rules which law enforcement officers must enforce. To maximize the effectiveness of enforcing rules concerning manatees, steps should be taken to: (1) concentrate efforts at times and areas where boat and manatee densities are greatest; (2) increase the amount of time dedicated to enforcing manatee protection rules; and (3) provide speed guns and training to appropriate field officers. The Florida Marine Patrol, GFC, the Office of Protected Species Management, and the FWS should periodically review needs and strategies for concentrated enforcement efforts.

S2.2.4.2. Develop and implement a strategic plan to strengthen cooperative interagency enforcement. Enforcement of manatee protection rules involves field officers in various Federal, State, and local agencies as well as judicial, legislative, and regulatory support. Although waterway speed and access rules demand the greatest time and effort to administer, rules for poaching, incidental take in fisheries, harassment, *etc*., also require attention. A strategic enforcement plan should be developed and implemented to establish a cooperative interagency field enforcement network that is backed by a supportive judiciary and legislature. The strategic plan should address interagency agreements as may be needed for effectively cross-deputizing and coordinating Federal, State, and local field officers; develop and update officer training programs and explanatory materials on manatee protection rules and enforcement needs; conduct periodic training and refresher courses for enforcement units at all levels; coordinate interagency enforcement exercises; make regulations as clear and as uniform as possible; educate the judiciary and otherwise facilitate prosecutions of manatee-related rule violations; and work with the legislature to ensure fines, penalties, and other statutory provisions are clear and as effective as possible.

S2.2.4.3. Conduct surveys to assess compliance with rules. Field surveys should be done to monitor the extent to which watercraft comply with regulatory measures. Periodic surveys on selected waterways in each key county should be undertaken.

S2.2.4.4. Encourage and cooperate with efforts to develop unified statewide boating safety measures. Proposals for state-wide speed limits, boat operator licenses, and mandatory boater education have been considered in the past. Such measures would complement and enhance efforts to reduce watercraft-related manatee deaths by offering opportunities to educate boaters about manatees. Although such boating safety measures have been rejected to date, similar measures may be proposed and adopted in the future. To the extent possible, new proposals to establish statewide boating safety measures should be encouraged. Particular efforts should be made to integrate manatee protection concerns into any new boater education programs.

S2.2.5. Establish policies for authorizing boat races and other water sport events. Certain organized water sports events, such as boat races, water-ski contests, and fishing tournaments, involve boats traveling at high speed. In certain areas and times, these activities pose threats to manatees. Permits for such events typically are required from the U.S. Coast Guard. The U.S. Coast Guard considers advice from the FWS and DEP on whether a permit should be granted, denied, or granted conditionally given possible effects on manatees. To help planning for boat races, representatives from DEP, the FWS, and boat racing organizations developed guidelines on when, where, and under what conditions such events could be held consistent with manatee protection objectives. The guidelines are used by the FWS and DEP to review permit requests and by event organizers to plan events. The FWS and DEP should keep such guidelines under review and modify or expand them as needed to address other types of water sport events. The FWS, and the U.S. Coast Guard should continue to consult on the issuance of permits for sporting events that involve high speed boats in manatee habitat.

S2.2.6. Indicate speed and access zones on nautical charts. NOAA publishes nautical charts and a "Coast Pilot" to help vessel operators navigate in coastal waters. As new speed and access rules are adopted, NOAA and other organizations publishing navigation charts should update their publications.

S2.2.7. Assess and reduce mortality caused by large vessels. Large slow-moving ships (*e.g.*, tugs and cargo vessels) are known to kill manatees. Some animals appear to be pulled into propeller blades by the sheer power of generated water currents and others are crushed between the bottom and the hull of deep-draft ships. When moored, large vessels also can crush manatees between their hulls and adjacent wharves or ships. To prevent the latter problem, some ports (*e.g.*, the Mayport Naval Station) have begun using fenders to maintain minimum stand-off distances between moored vessels and wharves. To address the threat of propellers on large tugs operating at the Kings Bay Naval Base, the Navy recently designed and installed propeller shrouds on its C-tractor tugs. These approaches may be useful in other areas.

To consider applying such measures more widely, a study should review mortality data for evidence of deaths attributable to large vessels; examine barge, tug, and other large vessel traffic patterns relative to manatee distribution; assess the feasibility and cost of installing propeller guards or shrouds on large vessels or tugs routinely plying waterways used by manatees; consider rules to require fenders when mooring large vessels in manatee habitat; evaluate ways to educate harbor pilots about the threats large vessels pose for manatees; and identify other possible mitigation measures. Actions to implement appropriate measures should be taken based on study findings.

S2.2.8. Evaluate the feasibility of propeller guards or alternative propulsion technology for small watercraft. In the past, propeller guards have been examined as a possible solution to recreational watercraft-related manatee mortality. They also have been considered for improving human safety and protecting seagrass beds. While new designs are developed periodically, their effect on vessel speed and steerage have discouraged general use. Broad use of propeller guards should reduce propeller-caused manatee injuries; however, it may only marginally reduce overall injuries and deaths since the impact of a propeller guard on a fast-moving boat is as injurious to manatees as the wounds from propellers. Nevertheless, as new designs are developed, they should be tested and evaluated. Once efficient and effective guards are available, incentive-based programs should be explored to encourage greater use of propeller guards.

S2.2.9. Continue section 7 and State reviews of boating facilities and watersport events. Marinas, boat ramps and other boating facilities increase local boat traffic. They can therefore influence the frequency of watercraft collisions with manatees in areas where manatees are common. Facility construction and the resulting traffic also can degrade habitat features, such as seagrass beds, which are important to manatees. Such facilities require permits from the COE, environmental resource permits from the DEP, and submerged land leases from Florida's Board of Trustees. As noted above, watersport events also may affect manatees and require permits from the U.S. Coast Guard. Under section 7 of the ESA and other Federal regulations, the FWS reviews and comments on permit applications whenever they may affect endangered species and other natural resources. This formal review process is a fundamental part of the manatee recovery program and must be continued.

S2.3. Minimize manatee deaths in water control structures. Late in the 1970s, eight to nine manatees per year were killed in floodgates and navigation locks. To reduce this mortality, steps were taken to modify gate opening procedures. Annual mortality initially decreased in the early 1980s. The number of deaths subsequently increased and in 1994, 16 deaths were recorded. An ad hoc interagency task force was established with representatives from the SFWMD, the COE, the FWS, and DEP to examine other steps to prevent such deaths. Support the development, testing, and implementation of new alternative measures at water control structures to reduce the

number of manatee injuries and deaths. Coordinate with the South Florida Ecosystem Restoration Task Force to ensure alterations in the quantity or quality of water flow do not negatively affect the manatee and its habitat (*i.e.*, effects of alterations of water flow in the C & SF, Caloosahatchee River, St. Lucie Waterway, and Whitewater Bay).

S2.3.1. Develop, test, and implement new alternative measures. The interagency task force has identified several possible alternatives to reduce floodgate and navigation lock deaths. They include adjusting gate opening sequences, installing slotted gates or gates with new top-flow designed structures, adding detection devices to alert gate operators when manatees are present, and/or installing automatic door reversing mechanisms similar to safeguards on elevator doors. A pressure-sensitive unit has been designed and tested on two water control structures by the SFWMD with inconclusive results. The COE is preparing a Section 1135 Project Modification Report on Manatee Protection at Select Navigation and Water Control Structures. The devices and techniques that resulted from this study should be installed, tested for effectiveness, and implemented in a timely manner.

S2.3.2. Promptly investigate structure-related deaths. Gate-and lock-related manatee mortality should be kept under continual review by FWS, DEP, and the agencies directly responsible for the structures. Structures at which multiple deaths occur should be investigated immediately to identify and correct contributing factors.

S2.4. Assess and minimize manatee injuries and deaths caused by fisheries. In some years, as many as six manatees have been killed in commercial fishing gear. Most are caught and drowned in nets of inshore shrimp boats in northeast Florida; others are entangled in float lines for crab traps. Commercial fisheries in coastal Florida are managed cooperatively by the Florida Marine Fisheries Commission and the DEP. To minimize adverse interactions between fisheries and manatees, the following steps are needed.

S2.4.1. Minimize manatee drownings in shrimp nets. The Florida Marine Fisheries Commission has completed portions of a statewide shrimp fishery management plan. The Commission, DEP, and FWS should review and, as necessary, update measures to prevent manatees from being caught and drowned in shrimp nets. As an initial step, DEP has printed and distributed brochures to advise shrimp fishermen of the problem and the steps they can take to minimize drownings (*e.g.*, reducing tow times and immediately retrieving nets when heavy objects are encountered). If such education efforts do not resolve the problem, other measures (*e.g.*, gear, season, and/or area closures) should be considered, incorporated into the plan, and implemented.

S2.4.2. Minimize injuries and deaths in crab pot lines and other fishing gear. Manatees are entangled in crab pot float lines, various types of fishing nets, and monofilament line used by recreational fishermen. Information on interactions with such fishing gear should be kept under review by DEP and FWS. Steps should be taken to improve reporting of animals caught in fishing gear, particularly those that are released or escape alive.

Steps to identify and implement measures to reduce or avoid such interactions should be taken, if needed.

S2.4.3. Identify locations where fishing gear impacts manatees and implement measures to mitigate impacts. In certain areas where commercial and recreational fishing is particularly heavy and/or where manatees tend to aggregate, interactions with fishing gear may be particularly common. At some east coast aggregation sites, manatees are snagged by lines, lures, and treble hooks of recreational fishermen. These sites should be identified and, as warranted, steps should be taken to assess and implement actions to prevent potentially threatening interactions with fishing gear.

S2.5. Investigate and prosecute all incidents of poaching and malicious vandalism. Poaching, shooting, butchering, and other malicious vandalism against manatees are rare occurrences. All reports and evidence regarding such incidents should be turned over to the FWS's law enforcement agents for investigation and prosecution to the fullest extent of the law. As appropriate, a reward system should be established to help investigate and prosecute violations.

S2.6. Rescue, rehabilitate, and release distressed manatees. Reports of injured or distressed manatees are frequently received by officials in the manatee recovery program. While many prove false, some form of rescue action is deemed necessary in about 15 to 25 cases per year. In some cases, animals are treated and released immediately. In others, rehabilitation in captivity is needed and marine zoological parks make facilities, resources, and expertise available to transport and care for animals prior to their release back into the wild. Such actions help reduce manatee mortality but require extensive cooperation among Federal and State agencies, zoological parks, and other institutions and organizations. The FWS, with the assistance of an Interagency/Oceanaria working group, maintains oversight of work to rescue, rehabilitate, and release animals. The Florida Marine Research Institute's manatee salvage and necropsy program has agreed to coordinate rescue response work on a day-to-day basis. The FWS's Jacksonville field office coordinates captive program activities and manatee releases. In addition, under state law, DEP has been authorized and directed to provide partial reimbursement to cooperating parks and organizations to help defray rescue and rehabilitation costs. This program should continue.

S2.6.1. Authorize cooperative participation in the manatee rescue/ rehabilitation network. The FWS has overall responsibility for work to rescue, rehabilitate, and release injured or otherwise distressed manatees. To meet this obligation, the FWS's Office of Management Authority issued an endangered species/marine mammal enhancement permit to authorize related work by cooperating facilities and organizations. Letters of authorization under this permit are issued by the FWS to qualified groups interested in participating in the rescue/rehabilitation network. The letters set forth the scope of their respective involvement in (1) verifying, (2) rescuing and transporting, and/or (3) treating and maintaining distressed animals. Activities under letters of authorization need to be reviewed continually. Every effort should be made to provide training opportunities to members of authorized groups to ensure continuous improvement in

local rescue assessment and logistic capabilities. The FWS should update or modify the terms of existing letters and/or issue new authorization letters to additional qualified facilities or organizations as such needs are identified.

S2.6.2. Coordinate and oversee day-to-day rescue operations. To assure prompt, effective responses to distressed manatees, a rescue coordinator has been designated to receive initial reports of such animals and to mobilize and coordinate rescue network teams. The Director of the Florida Marines Research Institute's manatee salvage and necropsy program currently serves as the rescue coordinator. Reports of distressed animals should continue to be directed to the rescue coordinator who in turn contacts authorized rescue network teams to organize a response for verification, rescue, and transport to available treatment facilities as necessary, and notifies the FWS of ongoing rescue operations, and unusual or significant incidents as necessary.

S2.6.3. Ensure adequate rehabilitation facilities. In the past the number of captive manatees has ranged from about 40 to 50 animals. Three "Pre-Act" animals (animals brought into captivity prior to enactment of the ESA) have been in captivity for several decades. Some captives have been judged unreleasable due to the nature of their injuries or concern about their ability to adapt to the wild (*e.g.*, long-term captive animals that were born in captivity), and the remainder are animals in varying stages of rehabilitation.

Captive Florida manatees are held at eight marine facilities and zoological parks:

1. Sea World of Florida* - Orlando, Florida
2. Miami Seaquarium* - Miami, Florida
3. Lowry Park Zoo* - Tampa, Florida
4. Homosassa Springs State Wildlife Park - Homosassa Springs, Florida
5. Epcot's Living Seas - Lake Buena Vista, Florida
6. South Florida Museum -Bradenton, Florida
7. Sea World of California - San Diego, California
8. Mote Marine Laboratory - Sarasota, Florida

(* = Critical Care Treatment Facility)

Space for captive animals is limited and maintenance costs to feed and care for them are relatively high (at least $ 25-40,000 per animal per year). To assure space is available to maintain animals rescued in the future, steps are being taken to return rehabilitated animals to the wild as quickly as possible. To provide additional options for management, captive maintenance facilities at the Homosassa Springs State Wildlife Park and elsewhere should be expanded and improved, as needed.

S2.6.4. Convene periodic meetings of the Interagency/Oceanaria working group and the Captive Manatee Planning Committee. The FWS convenes periodic meetings of an Interagency/Oceanaria working group

to help coordinate rescue, rehabilitation, and release work and to manage captive maintenance activities in ways that will best meet manatee recovery objectives. Among other things, the working group reviews the status of manatee rescue and rehabilitation work; maintains records of captive manatees; charts the progress of animals towards their release; assists the FWS in developing and reviewing protocols and criteria for the rescue, transport, rehabilitation, maintenance, and release of animals; and exchanges information and expertise with respect to rescue, rehabilitation, maintenance, and release procedures.

Captive manatees also provide unique opportunities to study physiological processes and other aspects of manatee ecology that may add to the information base on habitat requirements and recovery needs. Such work, however, should not impede rehabilitation and release of captive animals. To help evaluate and direct research on captive animals the FWS has established a Captive Manatee Planning Committee. In part, the Committee is responsible for reviewing all research proposals and management options involving captive manatees and making recommendations to the FWS's manatee coordinator. At least two meetings per year of both the full working group and its planning committee should be held.

S2.6.5. Facilitate and evaluate animal releases. As soon as animals taken into captivity for rehabilitation or care are judged suitable for release back into the wild, steps should be taken to do so. Decisions on releases should be made by the FWS in coordination with the facility maintaining the animal and the Interagency/Oceanaria working group following established criteria.

S2.6.5.1. Develop protocols and criteria to govern releases and evaluate the manatee's readaptive success. To assure that released animals will readjust to the wild, criteria and protocols need to be developed and kept under review for assessing the physical health of animals in release pens and their fitness to be released. The guidance in these criteria and protocols should be modified as necessary based on the success or failure of animals with different histories and medical records to adapt to wild conditions. Veterinarians in the Interagency/Oceanaria working group, in coordination with the FWS, should develop and keep such protocols and criteria under review. Similar guidance also should be developed to help with decisions on whether and when to recapture animals not satisfactorily acclimating to the wild.

S2.6.5.2. Radio-tag and track released manatees. To help assess readjustment and survival of rehabilitated manatees returned to the wild, certain released animals should be followed by telemetry upon release and all released animals should be tagged with Passive Integrated Transponders (PIT) tags. This will aid in assessments of whether animals adopt normal habitat-use patterns, interact with other manatees, and readapt

successfully to the wild. If problems arise, it also may help in locating and recapturing animals. Over the next five years, 5 to 10 animals are expected to be released annually. Telemetry tags, staff, and other support needed to track about 5 to 7 released animals annually will be required.

S2.7. Minimize other human-related disturbances and harassment. Disturbance and harassment by boaters, divers, fishermen, and others can alter manatee behavior and reduce the suitability of some areas as manatee habitat. Waterway speed and access restrictions partially address causes of disturbance and harassment. However, general guidance and advice for certain user groups and the general public also are needed on ways to minimize or avoid interactions that alter natural behavior and movement of manatees. The following tasks are needed to develop regulations, guidelines, and/or practical principles that define proper conduct by divers, boaters, and others with respect to feeding, watering, approaching, viewing, or otherwise interacting with manatees.

S2.7.1. Prepare and adopt guidelines for the development of manatee viewing areas. Interest in developing facilities to allow members of the public to view wild manatees is increasing. While such facilities offer public education and awareness opportunities, they also increase the potential for harassment of animals and perhaps even malicious injuries. Proposals for such facilities need to be examined carefully. To respond to future proposals to create manatee viewing facilities, guidelines should be prepared for determining when such facilities would be consistent with manatee recovery objectives and what design features or other conditions should be required.

S2.7.2. Prepare and adopt guidelines or regulations on feeding and watering manatees. Even when well-intentioned, public feeding or watering of wild manatees may alter natural behavior in ways that ultimately change manatee distribution patterns or place individual animals at risk. It may condition animals to approach boats or areas that are hazardous, or encourage them to remain in areas during times that could expose them to thermal stress. The development of guidelines and public education programs and, if necessary, regulations to discourage such activities should be evaluated and implemented. Enforcement policies must be adopted by responsible agencies. Special attention is needed at areas where feeding or watering by the public is done routinely.

S2.7.3. Develop and keep under review guidelines governing close approaches to manatees. At times, manatees and people, particularly divers, come in close and even direct physical contact with one another. While manatees occasionally invite such contact, people often chase after manatees that are trying to avoid them. This constitutes harassment, which is a violation of Federal law and may cause animals to leave preferred habitats. The latter is an issue of particular concern at the Crystal River NWR. The FWS has prepared a brochure advising divers at Crystal River on proper conduct when encountering wild manatees. Current policies and provisions governing close encounters between

manatees and people in the wild should be kept under continuing review and their form and content modified if they are found to afford inadequate protection for manatees.

S2.7.4. Coordinate with the FWS' Contaminant Program and other entities to minimize contaminant effects on the manatee in South Florida. Investigate contaminant effects on the manatee, including red tide, nutrients, and heavy metals. Support the development and implementation of management actions to minimize negative effects from contaminants.

S3. Support research on the physiology, life history, and ecology of the manatee. Studies of physiology, life history, and ecology are needed for understanding population status and trends, and to help assess what habitats are most important to manatees and why. Collect additional biological information on number of individuals, age-class structure, habitat use, reproductive viability, food use and availability, and threats.

S3.1. Maintain and analyze manatee "scar catalog" data. Many manatees have scars from boat strikes or other sources. When carefully photographed, they provide a means of identifying individual animals. Photographs of distinctively marked animals collected by researchers in the field are compiled in a manatee scar catalog held by the Sirenia Project with support from the Florida Power & Light Company. The catalog has been expanded and improved and is now a computerized system of photos on compact-disc, the Manatee Individual Photo-identification System. The Florida Marine Research Institute now assists in maintaining portions of the catalog. The data provide valuable information on movements, site-fidelity, age at first reproduction, calving intervals, and other vital parameters. Recent analyses indicate resighting data can be used to derive survival rates. This database should continue to be maintained and analyzed.

S3.1.1. Continue to collect photographs of individually identifiable manatees in the field. Photographs of individually identifiable manatees should be routinely collected from the field. In particular, photographs should be obtained at winter aggregation sites. The routine collection of photographs from the field and their incorporation into the catalog will ensure that information on movement patterns, site-fidelity, reproductive histories, survival rates, and related databases remains current.

S3.1.2. Maintain staff support to collect, enter, check, retrieve, and analyze scar catalog data. Some 6,000 new photographs are submitted annually by field researchers for inclusion in the catalog. Comparison of photographs with previously identified animals, proper entry of new data, and retrieval of data for analyses requires a dedicated staff member who is proficient and familiar with both the classification system and the identified individuals. Continued support, including a dedicated scar catalog archivist, to maintain and upgrade the scar catalog for both the east and west coasts should be provided. Standardized protocols for describing and coding data collected by photographers have been distributed for use by all cooperators submitting photographs to the catalog. Distribution of photographs of carcasses must continue so that dead manatees can be removed from the active catalog files.

S3.1.3. Upgrade and maintain computer/camera equipment for the scar catalog. The scar catalog is presently maintained as a computer-based system that uses a CDROM. The catalog now includes over 1,000 animals

and nearly 15,000 sighting and resighting records (Beck and Reid 1995). Computer and camera equipment to store, sort, and retrieve photographs and sighting data must be purchased, maintained, and upgraded to facilitate and enhance use of the catalog's data.

Photographs of carcasses taken by the Florida Marine Research Institute should be shared with the Sirenia Project so that dead animals can be removed from the active scar catalog. It will also provide information on minimum ages of manatees in the system, permitting analysis of age-specific reproduction and survival. Carcass recovery data may also be combined with resighting data in some recently developed survival models to further enhance the accuracy and precision of survival estimates.

S3.1.4. Analyze scar catalog data to determine annual survival rates and other population parameters. One of the most important parameters for estimating trends in population status is age-specific survival. Scar catalog data on animals at Crystal River, Blue Spring, and along Florida's east coast are now sufficiently extensive to estimate survival rates in those areas (O'Shea and Langtimm 1995). Analyses of survival rates, as well as calving intervals, age of first reproduction, and other parameters should be undertaken and/or refined as new records are entered.

S3.2. Continue and expand long-term studies of individual animals. Long-term studies of the reproductive traits, behavior, and life history of individual females provide data on age-specific birth rates and success in calf rearing. Such data, in turn, are important for assessing potential population growth rates. Although long-term records on individual females are best from Crystal River and Blue Spring, useful data also have been collected at other locations. Relevant data are included in the scar catalog, in long-term telemetry results for individual females through routine monitoring programs at major warm-water refuges, by long-term telemetry studies on selected manatees, and through reports from various researchers. Efforts to gather and analyze data on the reproductive history and behavior of known females should be continued and expanded to other study areas. Research should address the behavioral/ environmental causes of perinatal mortality by focusing on cow-calf behavior and interaction with conspecifics, especially during the perinatal period.

S3.3. Analyze data on calf production. The total number of calves produced is uncertain and may vary regionally. Calf counts from research at Crystal River and Blue Spring and from aerial surveys and data on the reproductive status of females recovered in the salvage necropsy program should be analyzed to estimate and identify possible regional differences in reproductive rates.

S3.4. Continue aerial photogrammetry analyses. Aerial photographic techniques to estimate the size, and hence age class, of individual animals are being investigated as a way to determine the age-structure of manatee populations. If the results suggest that further work is needed, studies should be designed, and equipment and support should be provided to collect and analyze aerial photogrammetric data.

S3.5. Continue opportunistic deployment of passive integrated transponder (PIT) tags. PIT tags are small tags inserted under the skin of animals to identify them if they are recaptured or recovered in the salvage and necropsy program. By comparing data on an animal's size, reproductive status, and general condition between time of tagging and recovery, one can increase the amount of information obtained on life history

parameters. PIT tags are applied opportunistically by the Florida Marine Research Institute, the Sirenia Project, or an authorized veterinarian whenever animals are caught for radio tagging or rehabilitation or released from captivity. PIT tags should continue to be applied as opportunities arise and PIT tag readers should be purchased and made available to individuals and groups likely to handle manatees.

S3.6. Conduct additional physiological studies of thermal tolerances. Although it is known that manatees are sensitive to cold stress, precise information on thermal tolerances and the effects of cold on physiological processes of different manatee age and sex classes is not known. Such information may be useful for assessing the percentage of the manatee population likely to aggregate at warm-water refuges at different ambient water temperatures, when different age/sex groups are likely to arrive at and depart from refuges, when emergency situations are likely to arise from unexpected changes in thermal discharges, *etc*. Studies to assess thermal tolerances and physiological effects of cold stress should be designed and undertaken.

S3.7. Conduct additional studies to assess hearing capabilities. Manatees, particularly mothers and calves, communicate vocally. Noise from boats or other sources may interfere with such communications or be a source of stress. Hearing capabilities, however, have been poorly understood. Recent studies indicate that manatees may have a wider range of hearing than previous studies suggested (Gerstein 1994). There is a need for further research on hearing capabilities and the effects of noise on manatees.

S3.8. Complete and conduct additional studies of manatee food habits. Nutritional characteristics of manatee food plants and the importance of different food sources for different age and sex classes in various regions are poorly understood. Such information is needed to help assure that adequate food resources are protected in different portions of the population's range. Ongoing studies should be completed to identify manatee food habits and feeding patterns, the nutritional value of different aquatic plants important to manatees, and the regional food resources most in need of protection and management.

S3.9. Continue genetic analyses from manatee tissue samples. New molecular techniques to examine genetic material provide an opportunity to update information on the genetic sub-structure of manatee populations, male mating success, paternal contributions, and frequencies of kinship that vary within social groups. This genetic analysis also identifies regional homozygosity and possible effects due to localized matrilineages, *etc*. Such information could improve understanding of the structure and social interactions of populations, influencing management objectives for different groups of manatees.

These studies should also be interrelated to physiological findings; management efforts should reflect an accurate assessment of the influence that the existing gene pool may have on lowered reproductive potential, enhanced susceptibility to disease, and other factors. Research to examine a number of these points has already been initiated. In addition, a number of researchers are interested in conducting other analyses. For some questions, the genetic data alone will not yield insights into manatee biology without a simultaneous field effort to collect the appropriate behavioral data. To determine the role of kinship in social interactions it will be necessary to collect data on association patterns and interactions among known individuals. Likewise, assessment of paternity for a large number of males will

provide data on variance in male reproductive success but will not shed light on factors affecting male success. Associated data on male physical characteristics (*e.g.*, size, body condition, age) and behavioral traits (*e.g.*, movement patterns, "dominance" in a mating herd), as well as extended observations of mating herds will be important for understanding reproductive activity among males. Tasks that facilitate and coordinate research related to manatee genetics should be initiated.

S3.10. Conduct additional studies to identify requirements for fresh water. In estuarine and marine areas manatees are attracted to, and drink from, freshwater sources. While this attraction is well known, the physiological need for fresh water is not clear. Studies have been initiated to examine processes by which manatees regulate internal salt levels and the physiological role of drinking fresh water. The results of these studies should be reviewed and, if warranted, further research should be undertaken.

S3.11. Convene a population status working group to develop methodology, data and models to assess population size and trends. Information on trends in the size of Florida manatee populations is essential for assessing the effectiveness of manatee recovery actions. It also is needed to develop objective, measurable criteria required by the ESA for determining when manatee populations may be reclassified as threatened or removed from the endangered species list. Given the present difficulty in measuring population size and trends directly, assessments of these parameters in the foreseeable future will benefit from information derived from population models. Models should use estimates of mortality, reproduction, survivorship, age/sex structure that stem from various other research tasks. Models should be developed, evaluated, and improved as needed.

As more information on manatee life history parameters is obtained, population models will tend to become highly complex. It is important for those developing manatee population models to coordinate their activities, and interact directly with biologists who have collected manatee life history data or who are authorities on manatee ecology. Biologists will better understand how models were derived, and the modelers will obtain feedback on the validity of their assumptions and interpretation of their results. The working group should be convened at least once every 2 years chaired by the staff of the Sirenia Project.

S3.12. Conduct research to better understand manatee-boat interactions. More data is needed to assess how manatees respond to a variety of boat types and traffic patterns. Innovative research techniques such as remote observations using airships should be investigated. Research should be conducted to develop various devices, such as propeller guards, in an effort to minimize manatee injury or death caused by passing boats.

S4. Support the monitoring of manatee populations in South Florida. The success of efforts to develop and implement measures to minimize manatee injury and mortality and to protect manatee habitat will depend on the accuracy and completeness of data on manatee life history and ecology, population status, and habitat condition. Good data in these areas are needed to identify and define problems, make informed judgments on appropriate management alternatives, establish an information base to justify selected actions, and provide a basis for determining whether or not the actions taken are achieving the desired result**.**

S4.1. Maintain a manatee telemetry program. Telemetry programs are currently the only reliable means by which to generate detailed information on manatee movement and habitat-use patterns. Manatees are netted, belted, and tagged with transmitters for

remote and visual monitoring. These monitoring programs provide information used to identify key use areas and travel corridors, and to tabulate reproductive histories, monitor use of powerplant effluents, and trace the progress of re-introduced captive manatees. This information is used to develop specific recommendations for manatee protection and to support habitat management initiatives.

S4.1.1. Maintain adequate telemetry capabilities. Telemetry studies require personnel, tags, tag attachments, receivers, boats, vehicles, airplanes and other equipment to capture and tag animals and to retrieve or replace transmitting units. They also require computer hardware and software and personnel to process the data and funding for the cost of satellite data retrieval. Presently the Sirenia Project and the Florida Marine Research Institute can track up to 20 and 15 animals, respectively. This level of capability should be maintained exclusive of telemetry needs for tracking released rehabilitated animals, work in Puerto Rico (see the Puerto Rican manatee recovery plan), or cooperative studies in other countries.

S4.1.2. Enter telemetry locations into the manatee Geographic Information System (GIS) database. Accurate information on manatee habitat-use patterns provides a sound scientific basis for identifying and supporting management decisions on waterway speed and access rules, permits for facility construction in manatee habitat, *etc*. To assure access to new data by managers, telemetry data should be processed by researchers for entry into the Florida Marine Research Institute's GIS. A standardized methodology to interpret and display telemetry data should be developed with the results distributed to the appropriate management agencies and cooperating groups annually through the Manatee GIS Working Group.

S4.1.3. Prepare and distribute monthly updates, annual progress reports, and final summaries of telemetry results. To keep managers and researchers involved in the recovery program abreast of progress and new findings from manatee tagging and tracking studies, monthly updates on the status of tagged manatees should be compiled and distributed. Summary progress reports should be circulated annually and final research findings and conclusions should be made available as soon as possible following the completion of regional study elements.

S4.1.4. Develop regional atlases of telemetry location data. Telemetry research has proceeded as a series of regional studies with tracking work concentrated in different areas over time. To date, studies have been conducted or are underway in the upper St. Johns River, along the east coast of Florida and southeastern Georgia, in the Crystal River area, Lee County, Tampa Bay area, and along the southwest Florida coast. Upon the completion of a regional study, an atlas of telemetry results should be compiled to summarize habitat-use patterns of different age and sex classes by season.

S4.1.5. Develop a long-term strategy for telemetry studies. Presently, telemetry studies are being done on the east coast by the Sirenia Project and along the west-central Florida coast by the Florida Marine Research Institute. In the future, telemetry work may be needed in areas of the State not well studied (*i.e.*, Everglades, Okeechobee Waterway and Lake

Okeechobee) as well as in areas that have been previously studied. The latter is important to identify possible shifts in habitat use patterns over time. To ensure telemetry capabilities address recovery program data needs as effectively as possible, a set of goals with a long-term strategy for telemetry work in Florida should be developed. The goals and strategy should be reviewed by FWS, the Sirenia Project, and the Florida Marine Research Institute and updated as needed. A working group composed of FWS, Sirenia Project, and the Florida Marine Research Institute should be formed to develop the long-term strategies for telemetry studies.

S4.2. Maintain and improve the GIS for data on manatees and manatee habitat. The Florida Marine Research Institute has developed a GIS to store, synthesize, and retrieve large volumes of data on manatees and manatee habitat. This data management system can store, manipulate, analyze, and display site-specific data on manatee carcass recovery sites; manatee sighting data from aerial surveys, ground research, telemetry studies; water depths, vegetation coverage, waterway speed and access zones, shoreline characteristics and development patterns, etc. The hardware, software, and database are used by Federal, State, and local officials for scientific analyses, permit reviews, developing waterway speed and access rules, and preparing county manatee protection plans.

S4.2.1. Maintain the hardware, software, and expertise to operate the GIS. Hardware, software, personnel, and training to access the GIS should be provided and maintained by involved agencies. GIS work stations already exist at the DEP's Florida Marine Research Institute and Office of Protected Species Management, and the FWS's Jacksonville field office, and Sirenia Project. Other work stations should be established and maintained at appropriate agency offices (*e.g.*, COE District Office and other divisions of DEP). These agencies should assign trained staff to serve as GIS operators and analysts responsible for providing maps and data summaries needed by staff planners, managers, and scientists. DEP and/or FWS should provide sufficient staff support to respond to requests for needed information from cooperating agencies and organizations which lack the hardware, software, or expertise necessary to use the database (*e.g.*, some county planners).

S4.2.2. Convene regular meetings of the Manatee GIS Working Group. Optimum use of the GIS database requires that the staff of agencies, offices, laboratories, and organizations responsible for key research and management tasks have access to GIS databases pertinent to their analytical needs. To promote interactions between system users and system curators, a GIS Working Group composed of representatives from governmental agencies and interest groups wanting to use manatee GIS data should be convened on a regular basis. The Working Group should meet to review data processing needs, access procedures, and available data; encourage and organize cooperative efforts to acquire ancillary data sets that would contribute to the manatee GIS; and provide opportunities to instruct users in the use of available data and new technologies. Working Group members should be responsible for overseeing their agency's participation in manatee GIS-related work. Funding to convene this group should be provided as needed.

S5. Increase public awareness. Develop curricula and educational materials for schools and host public workshops to increase awareness about the manatee and instill a sense of stewardship for the protection of this endangered species. Increase the availability of manatee education services and materials in South Florida to provide better technical assistance to the public. Design and implement a program to evaluate the effectiveness of education in recovering the manatee. Initiate and implement a standard education program for marinas and develop standards for evaluating the effectiveness of this education program. It is essential that the public be made aware of the manatee and the efforts to protect and maintain the population.

S5.1. Develop curricula and materials for schools. Most manatee protection and conservation measures need to remain in place indefinitely. To provide a sound base of understanding and support for conservation measures by future generations of Floridians and Georgians, materials and curricula on manatees and manatee conservation should be updated periodically and made available for use at various academic levels from elementary to high school.

S5.2. Develop and update materials for target user groups. Information important to achieve manatee conservation objectives differs for different user groups (boaters, divers, fishermen, commercial ship operators, shoreline owners) and different areas (people using a particular protected area, residents of coastal areas in Florida, tourists). By the same token, appropriate media (films, posters, brochures, public service announcements, personal presentations) also differ according to user groups and areas. Agencies and organizations carrying out public education and outreach programs should cooperate in assuring that pertinent information in appropriate formats is made available to relevant sectors of the public.

S5.3. Maintain avenues to encourage and direct voluntary contributions in support of needed recovery work. A significant amount of the funding to support the State of Florida's manatee recovery work is obtained from voluntary contributions in the form of a special state license plate and an optional contribution on boat registration applications as authorized by the Florida Legislature. Some equipment and funding also are provided from donations to the Save the Manatee Club and other environmental organizations. These voluntary contributions form a significant part of the funding base for the recovery program and permit much work to be done that would not otherwise be possible. Innovative approaches to obtain and direct voluntary support to needed program work should be tested and maintained**.**

S6. Coordinate recovery activities, monitor and evaluate progress, and update/revise this narrative. The actions necessary to support and implement recovery are beyond the abilities or scope of any one agency. They require the participation and cooperation of many Federal, State, and local agencies, as well as public, private, and industry organizations. To ensure that the work of involved agencies and groups is carried out in a timely, cost-effective manner that addresses priority recovery needs, the following administrative and coordination tasks should be carried out.

S6.1. Maintain Federal and State manatee coordinator staff positions. Given the central role of the FWS and the DEP, each agency should designate a full-time manatee coordinator and provide basic support staff. The level of support must be adequate to carry out administrative functions for which each is responsible and to work directly with involved agency and organization officials on a day-to-day basis.

The primary responsibility of the **FWS' manatee coordinator** and support staff is to provide Federal oversight, guidance, and support for the overall manatee recovery

effort as outlined in the recovery plan. Additional responsibilities include preparing rules for Federal Manatee Sanctuaries; reviewing and providing guidance on development permits and section 7 consultations; assisting and monitoring recovery-related work by participating agencies and organizations; developing a die-off response plan; overseeing efforts to rescue, rehabilitate, and release distressed manatees; assisting and coordinating manatee land acquisitions; helping develop state waterway speed and access regulations and county manatee protection plans; assisting in the development of manatee-related provisions, programs and facilities at NWRs; updating the manatee recovery plan and preparing annual status reports; and chairing and convening meetings of the manatee recovery team.

Tasks for the **State manatee coordinator** and support staff include developing state waterway speed and access rules and overseeing efforts to post and enforce established zones; reviewing environmental resource permits and state submerged land leases; providing advice and assistance to responsible agencies on resolving mortality caused by flood gates and fishing gear; assisting and coordinating manatee-related land acquisition; assisting in the development of manatee-related provisions, programs, and facilities at state parks, reserves, and aquatic preserves, and other State lands; assisting counties in developing county manatee protection plans; serving as staff for the Manatee Technical Advisory Committee; and carrying out relevant public education and awareness work.

S6.2. **Convene periodic meetings of the Florida Manatee Recovery Team and Manatee Technical Advisory Council.** The FWS has constituted and periodically convenes meetings of a Manatee Recovery Team composed of the principal involved agencies and groups. Chaired by the FWS's manatee coordinator, the team reviews progress on the recovery program tasks; develops advice on program priorities and needs; and helps coordinate work and support on recovery tasks among involved agencies and groups. In addition, DEP has established a Manatee Technical Advisory Council. The Council provides advice to the Secretary of this agency on progress and priority needs with respect to DEP involvement in the manatee recovery program. Both groups complement each other. They meet at times when advice and assistance is most timely and have become an important means of reviewing, guiding, and coordinating ongoing activities. The FWS's manatee coordinator provides staff support for the recovery team and DEP's manatee coordinator serves as staff for the Advisory Council. Support to convene periodic meetings of both groups should be provided.

S6.3. **Develop an annual progress report.** As a means of documenting and monitoring progress on recovery tasks, the FWS, with the assistance of involved agencies and groups, prepares annual progress reports reviewing activities on all identified tasks. The annual reports provide a means of tracking ongoing work, identifying areas in need of further attention, and projecting priorities for the coming year. The preparation of annual status reports should continue.

S6.4. **Update the Florida Manatee Recovery Plan.** The Florida Manatee Recovery Plan identifies and interrelates fundamental recovery tasks. It also identifies task priorities, agency involvement, and funding needs for a 5-year period. Agency involvement and funding projections are included as guides rather than commitments and are provided solely for planning purposes. In this regard, it is used by the FWS and other agencies as a principal reference to develop annual budget requests for manatee-related work. Given progress on listed tasks, new information

on manatees, environmental changes, changes in agency administration, and other factors that are difficult or impossible to predict accurately more than a few years in advance, the plan is limited to a 5-year period and should be updated at least once every 5 years. Responsibility for doing so rests with the FWS, with assistance from the Florida Manatee Recovery Team.

S6.5. Convene a panel or workshop to evaluate the effectiveness of the manatee recovery program. The revised recovery plan assumes that more extensive boat speed regulations will minimize the major source of human-related mortality, and that local manatee protection plans, land acquisition, and development permit reviews will achieve adequate manatee habitat protection. While these assumptions seem reasonable and appropriate, it remains to be demonstrated that they will in fact be successful. A workshop or panel should be convened prior to the next revision of the recovery plan to identify and evaluate fundamental issues in the Florida Manatee Recovery Program, to evaluate whether present strategies and assumptions prove ineffective. To obtain a fresh, independent assessment of options, the panel or workshop should be heavily weighted toward expert scientists and wildlife managers not directly involved in the manatee recovery program.

S6.6. Share experience and expertise developed through the manatee recovery program. The Florida Manatee Recovery Program is a model for potential or evolving manatee recovery programs in other countries. The experience and expertise that has been gained in Florida should be applied to other southern states and U.S. territories with sirenian populations to encourage conservation efforts.

S6.6.1. Develop cooperative agreements with other states and countries. Manatees also occur in Georgia, occasionally in other southeastern states, and in Puerto Rico. Research and management techniques developed to protect manatees in Florida could be applied to protect manatees in those areas as well. Steps should be taken to establish working relationships with appropriate officials in other states or territories to transfer expertise and experience.

Similarly, other countries developing manatee conservation programs should be encouraged to enter into agreements with the FWS and the Sirenia Project to facilitate the transfer of information, experience, and expertise related to manatee research and management. Such agreements might involve the exchange of personnel for training purposes or cooperation in carrying out specific projects. Where opportunities arise to establish such agreements, they should be pursued and supported**.**

S6.6.2. Participate in and assist with manatee-related work under the Caribbean Environment Program. Under a regional SEAS program sponsored by the United Nations Environment Program, nations in the wider Caribbean region, including the U.S., cooperate in the Caribbean Environment Program. The program is guided by provisions set forth in an action plan and the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean (*i.e.*, the Cartagena Convention). In 1991, parties to the Convention signed a Protocol on

Specially Protected Areas and Wildlife. Convention members have an interest in the development of national or regional recovery plans for manatees. Participants in the Florida manatee recovery program should assist in recovery programs envisioned under this protocol and the Caribbean Environment Program.

S6.6.3. Participate in national and international manatee conservation and research activities. Results from the manatee recovery program are of interest not only to scientists and managers involved in manatee conservation, but also to other scientists and resource managers. In addition, the experience of other wildlife scientists and managers may provide insights of value to the manatee recovery program. Agencies should encourage individuals involved in the recovery program to present papers or otherwise participate in national and international activities involved in wildlife research and management, including conferences, training, and technical assistance.

Habitat-level Recovery Actions

H1. Prevent degradation of existing manatee habitat in South Florida. In addition to controlling direct sources of manatee injury and mortality, manatee recovery depends on maintaining the availability of habitat suitable to support a larger manatee population. Manatee habitat requirements include adequate sources of aquatic vegetation for food; sources of fresh water; secluded areas in which to mate, bear and nurse their young, and rest; warm-water refuges during cold periods; and safe travel corridors between these areas. Availability of these habitat features may be affected by coastal development and human activity patterns along waterways used by manatees. The challenge for managers is to provide for human needs while, at the same time, protecting the availability and quality of a network of essential habitat components. These essential habitat components reflect seasonal manatee movement patterns and maintain a full complement of habitat needs throughout the principal range of both the east and west coast manatee populations. This section of the recovery plan identifies the tasks needed to protect essential manatee habitat.

Ongoing dredge-and-fill and water quality permit review programs involving the FWS, the COE, the NMFS, and the EPA at the Federal level (section 10 of the Rivers and Harbors Act, section 404 of the Clean Water Act, and section 7 of the ESA), DEP and water management districts and Georgia Department of Natural Resources at the State level, and local environmental permitting agencies, should continue to review and comment on permit applications that have the potential to adversely impact manatees and/or their habitat.

H1.1. Support the acquisition of manatee habitat in South Florida. Federal and State systems of refuges, reserves, preserves and parks in Florida contain important manatee habitat. Management of those areas offers assurance that habitat will be maintained so as to protect the features (*e.g.*, grassbeds, quiet secluded waterways, warm-water springs, *etc*.) important to manatees. In the last 10 years, considerable cooperative effort has been devoted to acquiring essential manatee habitat and adding it to Federal and State protected area systems. These efforts are beginning to form regional protected area networks that contain many important habitat features essential for the long-term survival of manatee populations. These efforts need to continue as well as efforts to manage key protected areas in ways that enhance achievement of manatee recovery objectives.

H1.1.1. Support the acquisition and incorporation of essential manatee habitats to the NWR, park, and preserve system. Several NWRs managed by the FWS contain essential manatee habitat and are adjacent to other essential manatee habitat that is not similarly protected. Expanding refuges to add these areas would significantly improve protection not only for manatees, but also for many other species. Particularly important areas in this regard are along the Crystal River near the Crystal River NWR; Homosassa River near the Chassahowitzka NWR; and St. Johns River and associated waterways in and adjacent to the Lake Woodruff NWR. As possible, the FWS should pursue acquisitions, in cooperation with the State of Florida, to expand these and other refuges.

H1.1.2. Support the acquisition and incorporation of essential manatee habitats to state reserve, preserve, and park systems. Florida's Conservation and Recreation Lands (CARL) Program and the Save Our Rivers Programs administered by the five regional water management districts have acquired many areas that will further manatee habitat protection. They also have many important acquisition projects in varying stages of development. As possible, administrators of the two State programs, in cooperation with the FWS, should place special emphasis on completing acquisition projects important to manatees.

H1.1.3. Review and provide advice on priority habitat acquisitions relative to manatees. The CARL trust fund provides a significant source of funding for manatee habitat acquisition projects. In allocating these funds, the Office of Protected Species Management in the DEP provides comments and advice to the Division of State Lands and the Program's Land Acquisition Advisory Council on listed acquisition projects of particular importance to manatees. DEP and the FWS should continue to provide advice to this program and the Save Our Rivers program. Particular efforts should be made to solicit acquisition advice from manatee biologists with the DEP's Florida Marine Research Institute and field research biologists with the USGS/BRD's Sirenia Project.

H1.1.4. Identify and propose new land acquisition projects. As new information on manatee habitat-use patterns and essential habitat becomes available, new areas for acquisition may be identified. New land acquisitions can connect areas of essential manatee habitat to create regional protected systems. Periodic efforts should be undertaken to review manatee distribution and movement patterns to identify and propose new land acquisition projects. A task force to undertake this work should be created and convened as necessary.

H1.1.5. Encourage and coordinate Federal, State, and private land acquisition efforts. Manatee-related land acquisitions that help create regional networks of essential manatee habitat are particularly important. In this regard, identification of priority areas must include regional manatee habitat requirements and relationships among essential manatee habitats. To promote and guide complementary projects, the FWS and the

DEP should designate an individual to convene meetings, act as a clearinghouse on the status of manatee acquisition projects, and otherwise help coordinate relevant land acquisition by Federal and State agencies, The Nature Conservancy, and others.

H1.2. Protect and manage habitat in South Florida.

H1.2.1. Support the designation, management, and maintenance of Federal manatee sanctuaries and refuges in South Florida. Under authority of the Marine Mammal Protection Act and the ESA (50 CFR Part 17), the FWS may designate certain waters as manatee sanctuaries (areas in which all waterborne activities are prohibited) or manatee refuges (areas in which certain waterborne activities may be regulated). Six seasonal manatee sanctuaries have been designated by the FWS (FWS 1995). Established areas must be posted and enforced. As necessary, the FWS should modify existing rules and designate other sanctuaries or refuges.

H1.2.2. Support the maintenance of safe, reliable artificial warm-water refuges in South Florida. Many Florida manatees have come to rely on warm-water outfalls from certain power plants and other industrial facilities to avoid thermal stress during periods of extreme winter cold. If warm-water discharges used regularly by manatees are disrupted or otherwise fail to provide needed warmth during the winter, animals which have learned to use them may be exposed to cold stress and perhaps die before they can find or reach alternative heat sources. In addition, water intake canals, pipe openings, *etc*. could trap manatees attracted to these facilities. Management agencies should conduct a review of these artificial warm-water discharges and develop recommendations based on the importance of each outfall to the long-term survival of the manatee. For those discharges that are determined to be essential for the survival of the manatee, written agreements should be established between the FWS and relevant industries on appropriate courses of action.

To minimize discharge interruptions and other threats to artificial refugia, National Pollution Discharge Elimination System permits issued by the EPA or the DEP should be reviewed by the FWS pursuant to its authority under the ESA and the Clean Water Act. Manatee site protection plans should be developed by permittees as requirements of issued permits and should address such issues as: (1) disruptions to warm-water outflows during winter; (2) inadequate discharge temperatures to sustain manatees during extreme cold events; (3) precautions to minimize hazards to manatees at intake and outfall areas; and (4) timely communication to manatee recovery program personnel of any long-term changes in the availability of warm-water discharges and/or unanticipated problems that may affect manatees in outfall areas.

H1.2.3. Protect and promote regeneration of seagrass beds in South Florida. Implement new measures to protect and recover seagrasses. Particular attention should be given to establishing monitoring procedures and standards for water clarity in areas of existing or historic seagrass beds. In addition, guidelines should be established to assist in the review of applications for state environmental resource permits issued by the DEP

and requests for state submerged lands leases issued by the Florida Board of Trustees that may affect the quality of seagrass beds important as manatee feeding areas. Assess threats to seagrass habitats and develop protection strategies. Develop and implement alternative measures to mitigate threats to, and promote regeneration of, seagrasses. Primary areas in need of protection include Lee, Collier, and Miami-Dade counties.

H1.2.4. Support the review and implementation of aquatic plant control programs. Essential freshwater food supplies for manatees outside of protected areas may be damaged by dispersal of herbicides to control exotic aquatic plants. The FWS and the DEP Office of Protected Species Management should routinely review treatment plans developed by aquatic plant control programs to ensure that neither manatees nor their essential food sources are adversely affected by these herbicides. Mechanical or biological plant control alternatives should be considered, if possible. Such alternatives may not always be appropriate. For example, mechanical plant removal may be inadvisable in some areas when manatees are present in large numbers.

H1.2.5. Incorporate manatee protection measures into management systems for protected areas and State-owned submerged lands. Depending on local conditions and human activity patterns, management measures may be needed to ensure that activities and development projects within protected area boundaries or affecting state-owned submerged lands do not adversely affect manatees or their essential habitat.

H1.2.5.1. Include manatee protection and monitoring measures in management plans for Federal and State protected areas. As appropriate and possible, managers of Federal and State refuges, reserves, parks, *etc*. should adopt measures to develop and enforce waterway speed and access rules to avoid vessel traffic patterns that threaten manatees; manage aquatic plant control programs to avoid impacts to manatees or their food supplies; protect and monitor the quality and quantity of water flowing from natural warm-water springs used by manatees; and identify and avoid uses incompatible with protection of manatees and manatee habitat. They also should carry out programs to monitor and record manatee habitat-use patterns in and around unit boundaries. Such measures should be developed, reviewed, and modified periodically with the assistance of the FWS's manatee coordinator and the State's Office of Protected Species Management. Needed measures should be incorporated into unit management plans.

H1.2.5.2. Develop policies and provisions to guide decisions on leasing State-owned submerged lands. Most essential manatee habitat in Florida overlies publicly owned sovereignty submerged lands. Private use of these lands to construct marinas, docks or other facilities potentially

affecting manatees requires a lease from the Florida Board of Trustees. To ensure that the use of such areas is consistent with manatee recovery objectives, there is a need to develop policies, guidelines, and/or other provisions to help review lease requests involving activities or projects that may directly or indirectly affect manatees and manatee habitat.

H1.2.6. Develop, implement, and update county manatee protection plans. To develop effective, fair manatee protection schemes, site-specific conditions and information should be reviewed and protection measures should be integrated into local policies and ordinances. Comprehensive, multi-faceted county manatee protection plans are considered appropriate and vital. It is anticipated that such plans would be implemented as amendments to local government comprehensive plans required by the State's Comprehensive Growth Management Act of 1985 and reviewed for consistency by DCA. Steps to encourage manatee protection plans already have been taken for the 13 key counties where manatee mortality has been greatest and manatees occur most frequently. Two of the most important components of these plans are county waterway speed zones and measures to balance plans for new boating facilities with manatee protection needs. Regarding the latter point, the Governor and Cabinet have directed that limits be placed on the construction and expansion of boating facilities pending the implementation of more comprehensive plans. Eventually, such plans should be prepared for all counties with important manatee habitat.

H1.2.6.1. Assist counties to develop manatee protection plans. To develop and approve manatee protection plans, county planners and DCA need reliable information on local manatee habitats and habitat-use patterns. To varying degrees, counties also may need help to identify and evaluate appropriate planning provisions. Such information and assistance should be provided by DEP's Office of Protected Species Management, FWS's Jacksonville Field Office, and USGS's Sirenia Project. The staff of these agencies should cooperatively synthesize and provide accurate, up-to-date data on manatee distribution and habitat within county boundaries to county officials and work closely with them to develop appropriate planning measures. DEP and FWS should coordinate with DCA to draft local, county or State manatee protection programs. Once completed, the plan should be approved and implemented. DEP, FWS, and the Sirenia Project must allocate the staff and resources needed to provide such assistance.

H1.2.6.2. Assist in implementing manatee protection plans. Approved manatee protection plans should be provided to Federal and State agencies to aid in decision making with regard to permitting, leasing submerged lands, project review, or other activities that may have an affect on manatees. Of particular importance in this regard are DEP, the COE, and FWS.

H1.2.6.3. Periodically assess, review, and modify manatee protection plan provisions. As new information becomes available, there may be a need to modify manatee protection plans. One of the most critical needs in this regard is data on boating activity patterns. While efforts are underway to gather these data in the 13 key manatee counties, it should be collected state-wide. Accordingly, the Office of Waterway Management and the Office of Protected Species Management in DEP should cooperate in developing a state-wide database that includes data on: (1) boat traffic patterns; (2) areas of concern for boating safety; (3) the location of existing marine facilities; and (4) proposed sites of future marine facilities. Based on this and other relevant data, county officials and staff of DCA, the Office of Protected Species Management, and FWS should periodically review county manatee protection plans.

Modification of county plans may be called for in the future, based on changes in available information. Plans would need to be strengthened as needed should human-caused mortality increase. Similarly, modifications to accommodate boaters may be warranted where manatee use of speed zone areas is demonstrated to be significantly less than previously documented.

H2. Restore and create manatee habitat in South Florida.

H2.1. Support the maintenance and restoration of water quality in freshwater sources. Coordinate with the South Florida Restoration Task Force to restore natural tidal flow and hydrology in manatee habitat. Maintain minimum flows and levels in manatee use areas.

H2.2. Enhance manatee habitat in South Florida. Improve habitat by planting or encouraging native plant species, such as seagrasses and mangroves. Wetland restoration in the Indian River Lagoon area may significantly benefit the manatee. Coordinate with the FWS's Coastal Program and other pertinent groups to conduct manatee habitat restoration efforts.

H3. Support research on manatee habitat in South Florida and how it affects the manatee's persistence. Ongoing research on manatee-seagrass grazing interactions should be continued and completed. Investigations of manatee grazing effects and seagrass recovery, using both exclosures and enclosures, have been conducted in the Banana River in Brevard County. Results from these studies should provide information useful in design of monitoring studies, estimation of manatee carrying capacity of seagrass beds in key areas, and better understanding of the manatee's role in maintaining healthy, diverse seagrass communities.

H3.1. Investigate how manatees use different habitat components for survival. Investigate the effect of habitat change in South Florida on the manatee. Determine how manatee distribution and abundance is affected by increased mortality, habitat degradation, and hydrological changes.

H3.2. Determine an index of habitat fragmentation in South Florida.

H3.2.1. Investigate movement patterns and the spatial use of habitat to identify important core areas and corridors in South Florida.

H3.2.2. Determine if the amount and configuration of habitat is sufficient to support a stable or increasing population of manatees in South Florida.

H4. Develop and implement a manatee habitat monitoring program. In addition to efforts to monitor the status of manatee populations, work should be undertaken to monitor the condition and status of manatee habitat. Information from such a program could provide an early warning of future threats to manatee populations and help explain observed manatee population trends. Presently, there is no systematic approach to monitoring the condition of key manatee habitats.

H4.1. Develop methodology and expertise to monitor the condition of essential manatee habitats. While basic manatee habitat requirements have been identified and many, if not most, of the essential areas providing those requirements are known, there is no systematic approach for monitoring the condition of those habitat features. For example, the condition of essential grassbed feeding areas and the discharge rates and water quality at natural warm-water refuges are not routinely monitored. To provide a means of detecting potential problems in the capacity of such areas to support manatee populations, methodologies and expertise to monitor the condition of essential manatee habitat features should be identified and tested.

H4.2. Coordinate and implement a long-term habitat monitoring program. A long-term program should be initiated to monitor key parameters, such as the species composition and extent of aquatic plant species at vital feeding areas and the discharge rates and water quality at warm-water refuges. To the extent possible, such efforts should rely on habitat monitoring programs and research already undertaken by Federal and State agencies or academic institutions.

H5. Establish effective manatee management programs at Federal and State protected areas. After essential manatee habitats are acquired and added to Federal and State holdings, the agencies responsible for administering those areas should incorporate manatee protection and public awareness measures into unit administration programs.

H5.1. Develop and maintain public education programs at selected protected areas. Because Federal and State protected areas attract thousands of visitors each year, those containing essential manatee habitat offer valuable opportunities for interpretive programs on manatee conservation. Visitors to refuges, preserves, and parks with essential manatee habitat must be made aware of special measures to protect manatees within these areas.

H5.2. Develop public awareness/education programs at other parks and refuges. FWS and the State should develop and maintain displays and education programs explaining manatee conservation issues at other refuges, reserves, preserves, and parks that include essential manatee habitat. This should also be a priority at manatee aggregation sites where managed public viewing and education opportunities exist.