Florida Manatee Recovery Plan

(*Trichechus manatus latirostris*)
Third Revision

U.S. Fish and Wildlife Service
Southeast Region

FLORIDA MANATEE RECOVERY PLAN

(Trichechus manatus latirostris)

THIRD REVISION

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Southeast Region
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Sam D. Hamilton, Regional Director, Southeast Region,
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***Appointed Recovery Team members have an asterisk by their name.**

EXECUTIVE SUMMARY

CURRENT SPECIES STATUS

Endangered. The near and long term threats from human-related activities are the reasons for which the Florida manatee currently necessitates protection under the Endangered Species Act. The focus of recovery is not on how many manatees exist, but instead the focus is on implementing, monitoring and addressing the effectiveness of conservation measures to reduce or remove threats which will lead to a healthy and self-sustaining population. The Florida manatee could be considered for reclassification from endangered to threatened provided that threats can be reduced or removed, and that the population trend is stable or increasing for a sufficient time period.

HABITAT REQUIREMENTS AND LIMITING FACTORS

The Florida manatee lives in freshwater, brackish and marine habitats. Submerged, emergent, and floating vegetation are their preferred food. During the winter, cold temperatures keep the population concentrated in peninsular Florida and many manatees rely on the warm water from natural springs and power plant outfalls. During the summer they expand their range and on rare occasions are seen as far north as Rhode Island on the Atlantic coast and as far west as Texas on the Gulf coast.

The most significant problem presently faced by manatees in Florida is death or injury from boat strikes. The long-term availability of warm-water refuges for manatees is uncertain if minimum flows and levels are not established for the natural springs on which many manatees depend, and as deregulation of the power industry in Florida occurs. Their survival will depend on maintaining the integrity of ecosystems and habitat sufficient to support a viable manatee population.

RECOVERY GOAL

The goal of this revised recovery plan is to assure the long-term viability of the Florida manatee in the wild, allowing initially for reclassification to threatened status and, ultimately, removal from the List of Endangered and Threatened Wildlife.

RECOVERY CRITERIA

This plan sets forth criteria, which when met, will ensure a healthy, self-sustaining population of manatees in Florida by reducing or removing threats to the species' existence.

The following criteria must be met prior to **reclassification of the Florida manatee from endangered to threatened (downlisting)**:

1. Reduce threats to manatee habitat or range, as well as threats from natural and manmade factors by:
   - identifying minimum spring flows;
   - protecting selected warm-water refuge sites;
   - identifying for protection foraging habitat associated with the warm-water refuge sites;
   - identifying for protection other important manatee areas; and
   - reducing unauthorized human caused "take."

2. Achieve the following population benchmarks in each of the four regions over the most recent 10 year period of time:
   - statistical confidence that the average annual rate of adult survival is 90% or greater;
   - statistical confidence that the average annual percentage of adult female manatees accompanied by first or second year calves in winter is at least 40%; and
   - statistical confidence that the average annual rate of population growth is equal to or greater than zero.

The following criteria must be met prior to **removal of the Florida manatee from the List of Endangered and Threatened Wildlife (delisting)**:

1. Reduce or remove threats to manatee habitat or range, as well as threats from natural and manmade factors by enacting and implementing federal, state or local regulations that:
   - adopt and maintain minimum spring flows;
   - protect warm-water refuge sites;
   - protect foraging habitat associated with select warm-water refuge sites;
   - protect other important manatee areas; and
   - reduce or remove unauthorized human caused "take."

2. Achieve the following population benchmarks in each of the four regions for an additional 10 years after reclassification:
   - statistical confidence that the average annual rate of adult survival is 90% or greater;
   - statistical confidence that average annual percentage of adult female manatees accompanied by first or second year calves in winter is at least 40%; and
   - statistical confidence that average annual rate of population growth is equal to or greater than zero.

ACTIONS NEEDED

1. Minimize causes of manatee disturbance, harassment, injury and mortality.
2. Determine and monitor the status of the manatee population.
3. Protect, identify, evaluate, and monitor manatee habitats.
4. Facilitate manatee recovery through public awareness and education.

DATE OF RECOVERY

Currently, in some regions of the state, there are only reliable population data for the past 6 years. Therefore, full recovery may not be possible for at least another 14 years in order to meet the standard of assessing the population over the most recent 10 years of data for reclassification from endangered to threatened status and for an additional 10 years after reclassification for removal from the List of Endangered and Threatened Wildlife. Time is also needed to establish and implement management initiatives to reduce or remove the threats.

TOTAL ESTIMATED COST OF RECOVERY

Based on information provided by our recovery partners, current annual estimated budget expenditures for recovery approach $10,000,000.

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LIST OF ACRONYMS AND ABBREVIATIONS

The following standard abbreviations for units of measurements and other scientific/technical acronyms and terms are found throughout this document:

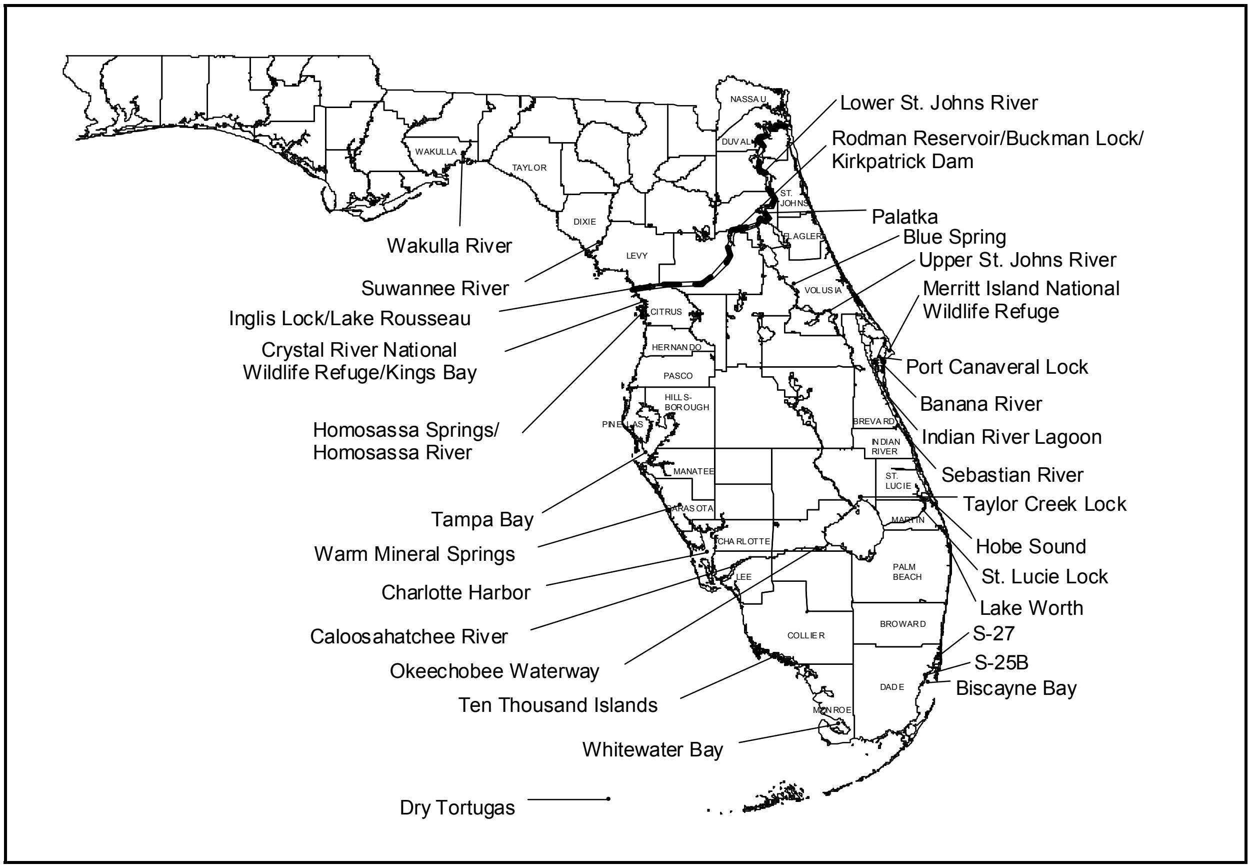
BPSM	Florida Fish and Wildlife Conservation Commission, Bureau of Protected Species Management
CERP	Comprehensive Everglades Restoration Plan
CFR	Code of Federal Regulations
COE	U.S. Army Corps of Engineers
CZS	Chicago Zoological Society
DERM	Miami-Dade Department of Environmental Resources Management
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act of 1973, as amended
FDEP	Florida Department of Environmental Protection
FDNR	Florida Department of Natural Resources
FIND	Florida Inland Navigation District
FMRI	Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute
FPL	Florida Power and Light Company
FR	Federal Register
FWC	Florida Fish and Wildlife Conservation Commission
FWC-DLE	Florida Fish and Wildlife Conservation Commission Division of Law Enforcement
FWS	U.S. Fish and Wildlife Service
GDNR	Georgia Department of Natural Resources
GIS	Geographic Information System
GPS	Global Positioning System
HBOI	Harbor Branch Oceanographic Institute
HWG	Habitat Working Group
IOWG	Interagency Oceanaria Working Group

LOA	Letter of Authorization
LE	Law Enforcement
MIPS	Manatee Individual Photo-Identification System
MML	Mote Marine Laboratory
MMPA	Marine Mammal Protection Act of 1972, as amended
MMPL	Marine Mammal Pathology Lab
MNPL	Maximum net productivity level
MPP	Manatee Protection Plan
MPS	Manatee protection system
MPSWG	Manatee Population Status Working Group
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
NPS	National Park Service
NSAV	Native submerged aquatic vegetation
NWR	National Wildlife Refuge
OC	The Ocean Conservancy (formerly the Center for Marine Conservation)
OSP	Optimum Sustainable Population
PIT	Passive Integrated Transponder
SAV	Submerged aquatic vegetation
SMC	Save the Manatee Club
USCG	U.S. Coast Guard
USGS-Sirenia	U.S. Geological Survey, Sirenia Project
USN	U.S. Navy
VHF	Very high frequency
WMD's	Water Management Districts

C Fish Industry	Commercial Fishing Industry
Local Gov'ts	Local Governments
M Industry	Marine Industries
Oceanaria	Cincinnati Zoo, Columbus Zoo, Homosassa Springs State Wildlife Park, Living Seas, Lowry Park Zoo, Miami Seaquarium, Mote Marine Laboratory, Sea World Florida and California, South Florida Museum
Photo-ID	Photo-identification
P Industry	Power Industries
R Fish Industry	Recreational Fishing Industry

C	Centigrade
cm	centimeters
ft	feet
hrs	hours
K	carrying capacity
kg	kilograms
km	kilometers
lbs	pounds
m	meters
mi	miles
min	minutes
ppm	parts per million
%	percent
≤	less than or equal to
°	degrees

Florida Coastal Counties and Other Sites Referenced in the Florida Manatee Recovery Plan



PREFACE

This Florida Manatee Recovery Plan revision adds new and refines existing recovery program activities for the next five years. The Recovery Plan is composed of four major sections:

1. Introduction: This section acquaints the reader with the Florida manatee, its status, the threats it faces, and past and ongoing conservation efforts. It also serves as a review of the biological literature for this subspecies.

2. Recovery: This section describes the goal of the plan; outlines an upcoming status review; presents reclassification and delisting criteria based upon the five listing/recovery factors and population benchmarks to assist in evaluating the status; objectives, strategy and actions or tasks needed to achieve recovery. These recovery tasks are presented in step-down outline format for quick reference and in a narrative outline, organized by four major objectives: (1) minimize causes of manatee disturbance, harassment, injury and mortality; (2) determine and monitor the status of the manatee population; (3) protect, identify, evaluate, and monitor manatee habitats; and (4) facilitate manatee recovery through public awareness and education.

3. Implementation Schedule: This section presents the recovery tasks from the step down outline in table format; assigns priorities to the tasks; estimates the time necessary to complete the tasks; identifies parties with authority, responsibility, or expressed interest in implementation of the tasks; and estimates the cost of the tasks and recovery program.

4. Appendices: This section presents additional information utilized by the FWS and Recovery Team to draft this revision.

PART I. INTRODUCTION

The Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq*.) (ESA), establishes policies and procedures for identifying, listing and protecting species of wildlife that are endangered or threatened with extinction. The ESA defines an "endangered species" as "any species which is in danger of extinction throughout all or a significant portion of its range." A "threatened species" is defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range."

The West Indian manatee, *Trichechus manatus*, was listed as endangered throughout its range for both the Florida and Antillean subspecies (*T. manatus latirostris* and *T. manatus manatus*) in 1967 (32 FR 4061) and received federal protection with the passage of the ESA in 1973. It should be noted that since the manatee was designated as an endangered species prior to enactment of the ESA, there was no formal listing package identifying threats to the species, as required by Section 4(a)(1) of the ESA. Critical habitat was designated in 1976 for the Florida subspecies, *Trichechus manatus latirostris* (50 CFR Part 17.95(a)). This was one of the first ESA designations of critical habitat for an endangered species and the first for an endangered marine mammal.

The Secretary of the Interior is responsible for administering the ESA's provisions as they apply to this species. Day-to-day management authority for endangered and threatened species under the Department's jurisdiction has been delegated to the U.S. Fish and Wildlife Service (FWS). To help identify and guide species recovery needs, section 4(f) of the ESA directs the Secretary to develop and implement recovery plans for listed species or populations. Such plans are to include: (1) a description of site-specific management actions necessary to conserve the species or population; (2) objective measurable criteria which, when met, will allow the species or populations to be removed from the List; and (3) estimates of the time and funding required to achieve the plan's goals and intermediate steps. Section 4 of the ESA and regulations (50 CFR Part 424) promulgated to implement its listing provisions, also set forth the procedures for reclassifying and delisting species on the federal lists. A species can be delisted if the Secretary of the Interior determines that the species no longer meets the endangered or threatened status based upon these five factors listed in Section 4(a)(1) of the ESA:

(1) the present or threatened destruction, modification, or curtailment of its habitat or range;
(2) overutilization for commercial, recreational, scientific, or educational purposes;
(3) disease or predation;
(4) the inadequacy of existing regulatory mechanisms; and
(5) other natural or manmade factors affecting its continued existence.

Further, a species may be delisted, according to 50 CFR Part 424.11(d), if the best scientific and commercial data available substantiate that the species or population is neither endangered nor threatened for one of the following reasons: (1) extinction; (2) recovery; or (3) original data for classification of the species were in error.

West Indian manatees also are protected under the Marine Mammal Protection Act (MMPA) of 1972, as amended (16 U.S.C. 1461 *et seq*.). The MMPA establishes, as national policy, maintenance of the health and stability of marine ecosystems, and whenever consistent with this primary objective, obtaining and maintaining optimum sustainable populations of marine mammals. It also establishes a moratorium on the taking of marine mammals, which includes harassing, hunting, capturing, killing, or attempting to harass, hunt, capture, or kill any marine mammal. Section 101(a)(5)(A) of the MMPA allows FWS, upon request, to authorize by specific regulation the incidental, unintentional take of marine mammals by persons engaged in identified activities within specific geographic areas, if FWS determines that such taking would have a negligible impact on the species or stock. Since the West Indian manatee, which is comprised of the Florida and Antillean manatee stocks, is currently listed as "endangered" under ESA, they are thus considered "depleted" under the MMPA. Section 115(b) of the MMPA requires that conservation plans be developed for marine mammals considered "depleted." Such plans are to be modeled after recovery plans required under section 4(f) of the ESA, as described above. The purpose of a conservation plan is to identify actions needed to restore species or stocks to optimum sustainable population levels as defined under the MMPA. Thus, in the case of the Florida manatee, this plan addresses conservation planning under MMPA and recovery planning under the ESA.

FWS developed the initial recovery plan for the West Indian manatee in 1980. This initial plan focused primarily on manatees in Florida, but included Antillean manatees in Puerto Rico and the United States Virgin Islands. In 1986, FWS adopted a separate recovery plan for manatees in Puerto Rico. To reflect new information and planning needs for manatees in Florida, FWS revised the original plan in 1989 and focused exclusively on the Florida manatee. This first revision covered a 5-year planning period ending in 1994. FWS revised and updated the plan again in 1996, which again covered a 5-year planning period ending in 2000. In 1999, FWS initiated the process to revise the plan for a third time. A 18-member recovery team (see Acknowledgment Section), consisting of representatives of the public, agencies, and groups that have an interest in manatee recovery and/or could be affected by proposed recovery actions, was established to draft this revision.

In the 20 years since approval of the original recovery plan, a tremendous amount of knowledge of manatee biology and ecology has been obtained, and significant protection programs have been implemented, through the guidance provided by the recovery planning process. This third revision of the Florida Manatee Recovery

Plan reflects many of those accomplishments, addresses current threats and needs, and specifically addresses the planning requirements of both the ESA and MMPA through 2006. This plan was developed with the assistance of the Florida Manatee Recovery Team. Henceforth in this document, unless otherwise specified, the term "manatee" refers to *Trichechus manatus latirostris*, the Florida manatee subspecies of the West Indian manatee.

OVERVIEW

In the southeastern United States, manatees occur primarily in Florida and southeastern Georgia, but individuals can range as far north as Rhode Island on the Atlantic coast (Reid 1996), and probably as far west as Texas on the Gulf coast. This population appears to be divided into at least two somewhat isolated areas, one on the Atlantic coast and the other on the Gulf of Mexico coast of Florida and into two regional groups on each coast: Northwest, Southwest, Atlantic, and Upper St. Johns River (Fig. 1).

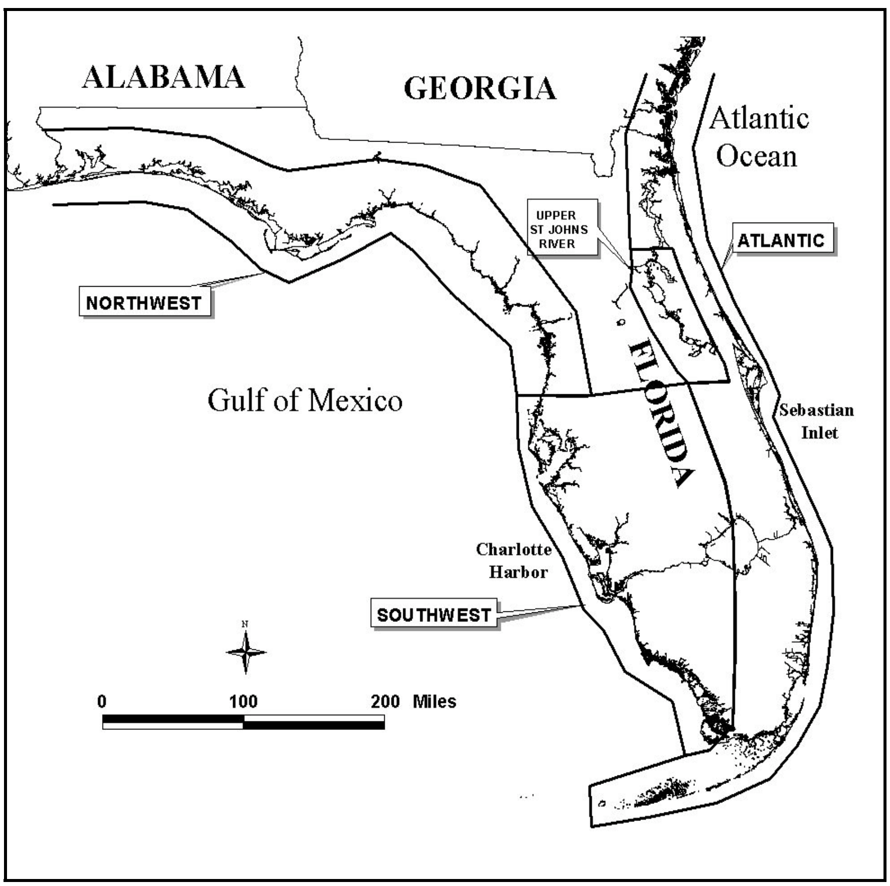


Figure 1. Florida manatee generalized regions: Northwest, Southwest, Upper St. Johns River and Atlantic coast.

Florida manatees have a low level of genetic diversity (Garcia-Rodriguez *et al*. 1998). Historical accounts and archeological evidence of manatees prior to the first half of the 20th century are poor and often contradictory (Domning *et al*. 1982; O'Shea 1988). The record indicates that manatees probably are almost as geographically widespread today as they were historically; however, they appear to be less abundant in many regions (Lefebvre et al. 2001). They were hunted by pre-Columbian societies, but the extent to which they were taken is unclear. After Spanish occupation, Florida's human population increased, and manatees probably were taken in greater numbers. Commercial and subsistence hunting, particularly in the 1800s, probably reduced the population significantly. In 1893, the State of Florida passed legislation prohibiting the killing of manatees.

The major threats faced by manatees today are many fold. Collisions with watercraft account for an average of 24 percent (%) of known manatee deaths in Florida annually (1976-2000), with 30% in 1999 and 29% in 2000. Deaths attributed to water control structures and navigational locks represents 4% of known deaths. The future of the current system of warm-water refuges for manatees is uncertain as deregulation of the power industry in Florida occurs, and if minimum flows and levels are not established and maintained for the natural springs on which many manatees depend. There are also threats to habitat caused by coastal development throughout much of the manatee's Florida range. Florida's human population has grown by 130% since 1970 (6.8 to 15.7 million) and is expected to exceed 18 million by 2010 and 20 million by the year 2015 (Florida Office of Economic and Demographic Research 2000). It is also projected that by 2010, 13.7 million people will reside in the 35 coastal counties (Florida Office of Economic and Demographic Research 2000). There are also threats from natural events such as red tide and cold events. The challenge for managers has increasingly become how to modify human, not manatee, behavior (Reynolds 1999). Yet, since the first Manatee Recovery Plan in 1980, well-coordinated interagency and non-governmental efforts to recover the Florida manatee have been extraordinary, making recovery an achievable goal (Domning 1999).

Based on the highest minimum count of the southeastern United States manatee population (Table 1), Florida manatees constitute the largest known group of West Indian manatees anywhere in the species' range. Outside the United States, manatees occur in the Greater Antilles, on the east coast of Mexico and Central America, along the North and Northeastern coast of South America, and in Trinidad (Lefebvre *et al*. 2001). In most of these areas, remaining populations are believed to be much smaller than the United States population and are subject to poaching for food, incidental take in gillnets, and habitat loss. Manatee protection programs in many countries are not well organized or supported and, in this context, protection of the Florida population takes on international significance.

Table 1. Estimates of manatee life history traits and related statistics. Except as noted, information was obtained from O'Shea *et al*. 1995.

Life-history trait		**Data**
Maximum determined age		59 years
Gestation		11-14 months
Litter size		1
% twins	Blue Spring	1.79%
	Crystal River	1.40%
Sex ratio at birth		1:1
Calf survival	Blue Spring	60%
	Crystal River	67%
Annual adult survival	Atlantic coast	90%
	Blue Spring	96%
	Crystal River	96%
Age of first pregnancy (female)		3-4 years
Mean age at first reproduction (female)		5 years
Age of spermatogenesis (male)		2-3 years
Proportion pregnant	Salvaged carcasses	33%
	Blue Spring (photo-ID)	41%
Proportion nursing - 1st-year calves during winter	Mean	36%
	Blue Spring	30%
	Crystal River	36%
	Atlantic coast	38%
Calf dependency		1.2 years
Interbirth interval		2.5 years
Highest number of births		May-September
Highest frequency in mating herds		February-July
No. verified carcasses in Florida[a]		4,043 (1974-2000)
No. documented in ID catalog		>1,200 (1975-2000)
Highest minimum count (aerial surveys)[a]		3,276 in Jan 5-6, 2001

[a] Data provided by the Florida Marine Research Institute, FWC.

A. TAXONOMY

The West Indian manatee, *Trichechus manatus* Linnaeus, 1758, is one of four living species of the mammalian Order Sirenia. The other three sirenians are the West African manatee (*T. senegalensis*), the Amazonian manatee (*T. inunguis*), and the dugong (*Dugong dugon*). All four species are aquatic herbivores listed as endangered or threatened throughout their ranges by FWS. A fifth species, Steller's sea cow (*Hydrodamalis gigas*), existed in sub-Arctic waters of the Bering Sea. Hunted to extinction within 27 years of its discovery in 1741, Steller's sea cow was a toothless sirenian that fed on kelp and reached lengths of up to 8 m (26 ft) (Reynolds and Odell 1991).

Two subspecies of West Indian manatee are now recognized: the Florida manatee, *T. manatus latirostris*, which occurs in the southeastern United States, and the Antillean manatee, *T. manatus manatus*, found throughout the remainder of the species' range. The Florida manatee was first described by Harlan (1824) as a separate species, *Manatus latirostris*. Later, Hatt (1934) recognized Florida manatees as a subspecies of *T. manatus* Linnaeus. Although subsequent researchers (Moore 1951; Lowery 1974) questioned the validity of the subspecies status, Domning and Hayek (1986) carefully examined morphological characteristics and concluded that the distinction was warranted. The historical ranges of the two subspecies may overlap on the coast of Texas, where the origin of occasional strays (from Florida or Mexico) is uncertain.

B. SPECIES DESCRIPTION

West Indian manatees are massive fusiform-shaped animals with skin that is uniformly dark grey, wrinkled, sparsely haired, and rubber-like. Manatees possess paddle-like forelimbs, no hind limbs, and a spatulate, horizontally flattened tail. Females have two axillary mammae, one at the posterior base of each forelimb (Fig. 2). Their bones are massive and heavy with no marrow cavities in the ribs or long bones of the forearms (Odell 1982). Adults average about 3.0 m (9.8 ft) in length and 1,000 kg (2,200 lbs) in weight, but may reach lengths of up to 4.6 m (15 ft) (Gunter 1941) and weigh as much as 1,620 kg (3,570 lbs) (Rathbun *et al*. 1990). Newborns average 1.2 to 1.4 m (4 to 4.5 ft) in length and about 30 kg (66 lbs) (Odell 1981). The nostrils, located on the upper snout, open and close by means of muscular valves as the animals surface and dive (Husar 1977; Hartman 1979). A muscular flexible upper lip is used with the forelimbs to manipulate food into the mouth (Odell 1982). Bristles are located on the upper and lower lip pads. Molars designed to crush vegetation form continuously at the back of the jaw and move forward as older ones wear down (Domning and Hayek 1986). The eyes are very small, close with sphincter action, and are equipped with inner membranes that can be drawn across the eyeball for protection. Externally, the ears are minute with no pinnae. Internally, the ear structure suggests that they can hear sound within a relatively narrow low frequency range, that their hearing is not acute, and that they have difficulty in localizing sound (Ketten *et al*. 1992). This indirect "structured" evidence is not entirely concordant with actual electro physiological measurements. Gerstein (1995) suggested that manatees may have a greater low-frequency sensitivity than the other marine mammal species that have been tested.

Figure 2. Mother manatee nursing a calf. (*Photograph by G. Rathbun*)

C. POPULATION BIOLOGY

Information on manatee population biology was reviewed during a technical workshop held in February 1992 (O'Shea *et al.* 1992). The objectives of the workshop were to synthesize existing information, evaluate the strengths and weaknesses of current data sets and research methods, and make recommendations for future research, particularly for constructing new population models (O'Shea *et al*. 1995). The population and life history information published in the workshop proceedings suggests that the potential long-term viability of the Florida manatee population is good, provided that strong efforts are continued to curtail mortality, ensure warm-water refuges are protected, maintain and improve habitat quality, and offset potential catastrophes (Lefebvre and O'Shea 1995).

The value of maintaining long-term databases was emphasized in the 1992 workshop. The collection of manatee reproduction, sighting history, life history, carcass salvage, and aerial survey data has continued, and improved techniques for estimating trends in important population characteristics have been developed.

Such measures include estimation of adult manatee survival (probabilities based on photo-identification) (Langtimm *et al*. 1998), determination of population trends from aerial survey data (Craig *et al*. 1997; Eberhardt *et al*. 1999), and development of population models (Eberhardt and O'Shea 1995). Population modeling will be an ongoing process that evolves as databases and modeling tools improve.

POPULATION SIZE Despite considerable effort in the early 1980s, scientists have been unable to develop a useful means of estimating or monitoring trends in the size of the overall manatee population in the southeastern United States (O'Shea 1988; O'Shea *et al*. 1992; Lefebvre *et al.* 1995). Even though many manatees aggregate at warm-water refuges in winter (Fig. 3) and most if not all such refuges are known, direct counting methods (i.e., by aerial and ground surveys) have been unable to account for uncertainty in the number of animals that may be away from these refuges at any given time, the number of animals which are not seen because of turbid water, and other factors. The use of mark-resighting techniques to estimate manatee population size based on known animals in the manatee photo identification database also has been impractical, as the proportion of unmarked manatees cannot be estimated.

Figure 3. Manatee aggregated during a winter cold front at a power plant warm-water outfall in Titusville, Florida. (*Photograph by B. Bonde*)

The only data on population size have been uncalibrated indices based on maximum counts of animals at winter refuges made within one or two days of each other. Based on such information in the late 1980s, the total number of manatees throughout Florida was known to be at least 1,200 animals (Reynolds and Wilcox 1987). Because aerial and ground counts at winter refuges are highly variable depending on the weather, water clarity, manatee behavior, and other factors (Packard *et al.* 1985; Lefebvre *et al*. 1995), interpretation of analyses for temporal trends is difficult (Packard and Mulholland 1983; Garrott *et al*. 1994). Strip-transect aerial surveys are used routinely to estimate dugong population size and trends (Marsh and Sinclair 1989); however, they are difficult to adapt to manatees because of the species' much more linear (coastal and riverine) distribution. This survey method was tested in the Banana River, Brevard County, and recommended for use in that area to monitor manatee population trends (Miller *et al*. 1998). This approach may also have utility in the Ten Thousand Islands-Everglades area.

Beginning in 1991, the former Florida Department of Natural Resources (FDNR) initiated a statewide aerial survey program to count manatees in potential winter habitat during periods of severe cold weather (Ackerman 1995). These surveys are much more comprehensive than those used to estimate a minimum population during the 1980s. The highest two-day minimum count of manatees from these winter synoptic aerial surveys and ground counts is 3,276 manatees in January 2001 (Fig. 4); the highest east coast of Florida count is 1,756 and highest on the west coast is 1,520, both in 2001. It remains unknown what proportions of the total manatee population were counted in these surveys. No statewide surveys were done during the winters of 1992-93 or 1993-94 because of the lack of strong mid-winter cold fronts. These uncorrected counts do not provide a basis for assessing population trends. However, trend analyses of temperature-adjusted aerial survey counts show promise for providing insight to general patterns of population growth in some regions (Garrott *et al*. 1994, 1995; Craig *et al.* 1997; Eberhardt *et al.* 1999).

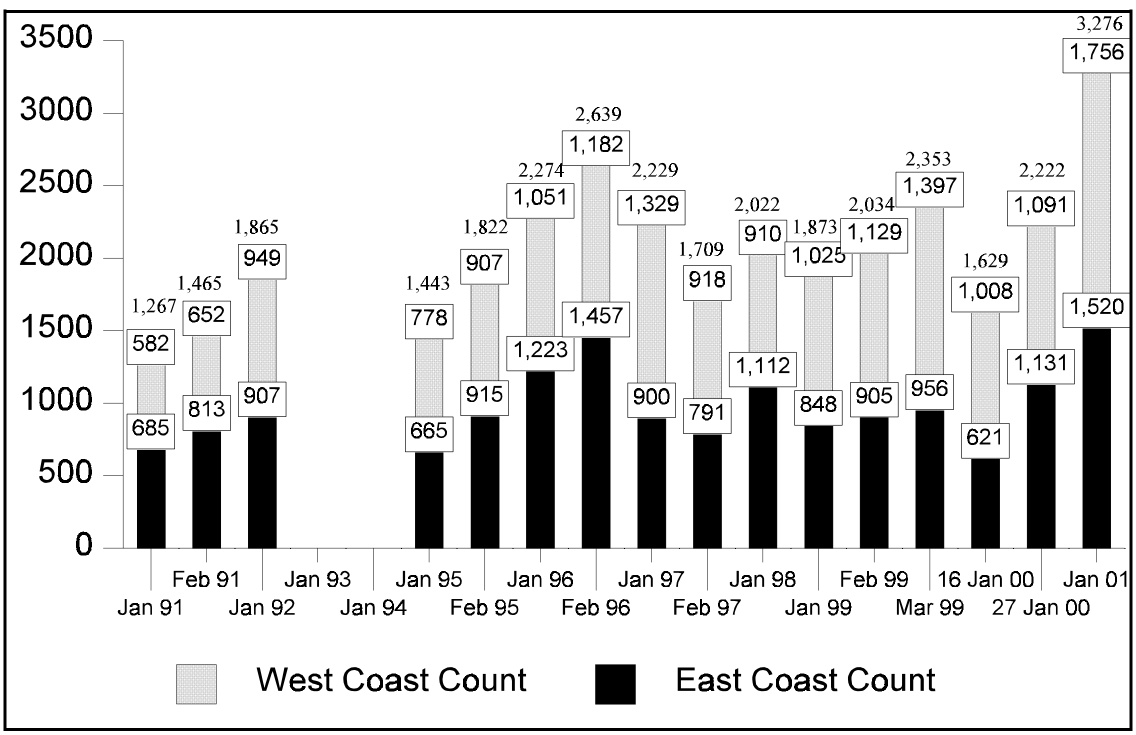


Figure 4. Manatee synoptic survey total, West coast, and East coast counts, 1991-2001 (FWC, unpublished data).

On a more limited basis, it has been possible to monitor the number of manatees using the Blue Spring and Crystal River warm-water refuges. At Blue Spring, with its unique combination of clear water and a confined spring area, it has been possible to count the number of resident animals by identifying individual manatees from scar patterns. The data indicate that this group of animals has increased steadily since the early 1970s when it was first studied. During the 1970s the number of manatees using the spring increased from 11 to 25 (Bengtson 1981). In the mid-1980s about 50 manatees used the spring (Beeler and O'Shea 1988), and in the winter of 1999-2000, the number increased to 147 (Hartley 2001).

On the west coast of Florida, the clear, shallow waters of Kings Bay have made it possible to monitor the number of manatees using the warm-water refuge in Kings Bay at the head of the Crystal River. Large aggregations of manatees apparently did not exist there until recent times (Beeler and O'Shea 1988). The first careful counts were made in the late 1960s. Since then manatee numbers have increased significantly. In 1967 to 1968, Hartman (1979) counted 38 animals in Kings Bay. By 1981 to 1982, the maximum winter count increased to 114 manatees (Powell and Rathbun 1984) and in December 1997, the maximum count was 284 (Buckingham *et al.* 1999). Both births and immigration of animals from other areas have contributed to the increases in manatee numbers at Crystal River and Blue Spring. Three manatee sanctuaries in Kings Bay were established in 1980, an additional three were added in 1994, and a seventh in 1998. The increases in counts at Blue Spring and Crystal River are accompanied by estimates of adult survival and population growth that are higher than those determined for the Atlantic coast (Eberhardt and O'Shea 1995; Langtimm *et al.* 1998; Eberhardt *et al.* 1999).

OPTIMUM SUSTAINABLE POPULATION The MMPA defines the term "optimum sustainable population" (OSP) for any population stock to mean "the number of animals which will result in the maximum productivity of the population or species, keeping in mind the carrying capacity of the habitat and the health of the ecosystem of which they form a constituent element." By regulation (50 CFR 216.3), the OSP is further defined as a range of population sizes between the maximum net productivity level (MNPL) and the carrying capacity (K) of the environment, under conditions of no harvest. The MNPL is defined as the population level producing "the greatest net annual increment in population numbers or biomass resulting from additions to the population due to reproduction and/or growth less losses due to natural mortality."

Pursuant to the MMPA, stocks are to be maintained within their OSP ranges. Just as we are uncertain of the Florida manatee's population size and trend, we are uncertain whether the population is currently below or within its OSP level. Even in the regions where population growth has been documented (Northwest and Upper St. Johns River), we do not know if maximum productivity has yet been achieved.

The MNPL has been estimated only for a few marine mammal species, and is generally treated as a percentage of carrying capacity. Carrying capacity varies over time and space, and is likely to be artificially reduced by a growing human population. Loss of artificial and natural warm-water refuges, for example, could greatly reduce the winter carrying capacity of habitats north of the Sebastian River on the Atlantic coast and the Caloosahatchee River on the Gulf coast. The Recovery Team recognizes the importance of conserving important manatee habitat, and emphasizes the need for sufficient quantity and quality of habitat within each region of the Florida manatee's range to permit sustained manatee population growth from current population levels. Key habitat types include those that are used for the following essential manatee activities: (1) thermoregulation at warm-water refuges; (2) feeding, reproduction and shelter; and (3) travel and migration.

DETERMINATION OF POPULATION STATUS The quality of the long-term database of scarred manatees "captured" by photography (Fig. 5) at winter-aggregation sites, combined with advances in mark-recapture (resighting) statistical models and computer programs, has allowed statistically valid estimates of adult manatee survival rates (Pollock *et al.* 1990; Lebreton *et al.* 1992; Pradel and Lebreton 1993, cited in Langtimm *et al*. 1998; Langtimm *et al.* 1998; White and Burnham 1999). Additional models have been developed that will allow estimation of the proportion of females with calves (Nichols *et al.* 1994). These statistical techniques allow the examination of vital rate variation over time or in association with specific environmental factors. They provide "Goodness-of-Fit" tests of the data to the models to assess bias in the estimates, and provide confidence intervals to assess the precision of the estimates. The application of these techniques to the manatee photo-identification (photo-ID) data provides statistical robustness (Langtimm *et al.* 1998) that has not yet been achieved with trend analyses of aerial survey data (Lefebvre *et al.* 1995; Eberhardt *et al.* 1999) or carcass recovery data (Ackerman *et al.* 1995). Furthermore, population size changes only after there has been a change in survival and/or reproductive rates (or emigration/immigration). Thus, directly monitoring survival and reproduction rates can provide immediate information on probable trends in abundance and gives managers specific information that can help them design realistic plans to achieve species recovery, reclassification, and eventual removal from the List of Endangered and Threatened Wildlife.

The previous recovery plan (FWS 1996) identified the need for a population status working group to assess manatee population size and trends. The first meeting of the Manatee Population Status Working Group (MPSWG), a subcommittee of the Recovery Team, was held in March 1998. The goals of the MPSWG are to: (1) assess the status of the Florida manatee population; (2) advise FWS on population recovery criteria for determining when recovery has been achieved (see Appendix A); (3) provide interpretation of available information on manatee population biology to managers; (4) make recommendations concerning needed research directions and methods; and (5) obtain rigorous external review of manatee population data, conclusions, and research methods by independent researchers with expertise in population biology. The Manatee Population Ecology and Management Workshop, scheduled for April 2002, is a forum that will address these goals and will specifically include a panel of independent experts to review research progress and to make recommendations on how to improve integration of population models with management.

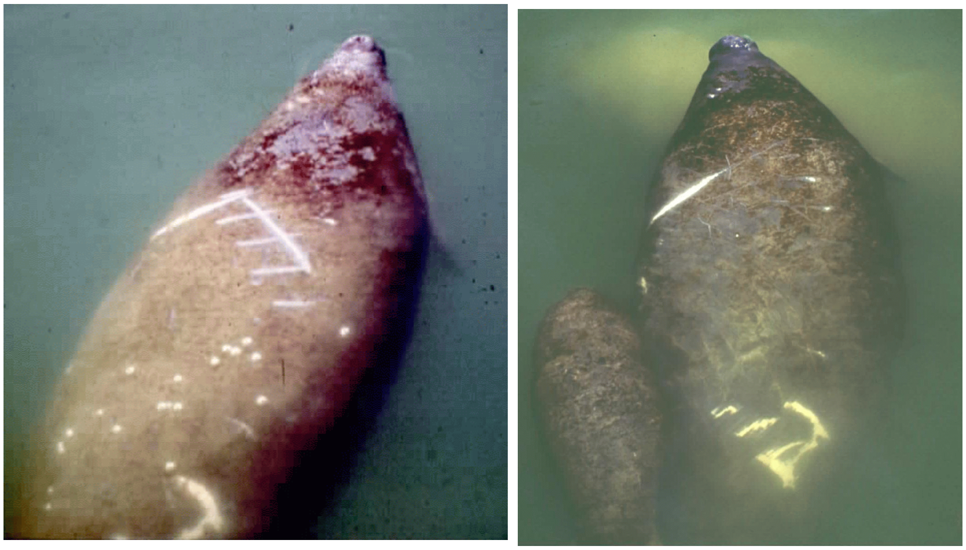


Figure 5. Catalogued female Florida manatee SB 79 was first documented on May 1, 1993 with a large calf (not shown on left). Documented with her third calf (right) on August 15, 1997. These photographs illustrate how injuries/scars appear to change as they heal or as they are altered by new features. This individual uses the Ft. Myers/Charlotte Harbor area during the winter and Sarasota Bay during the warmer months. Estimated to be at least 13 years old, she has given birth to calves in 1992, 1994, 1997, and 2000. (*Photographs by J. Koelsch*)

In order to develop quantitative recovery criteria, the MPSWG reviewed the best available published information on manatee population trends, and determined that analysis of status and trends by region would be appropriate. Based on the highest minimum winter counts for each region between 1996 and 1999 (Fig. 4 and Fig. 6), the number of manatees on the east and west coasts of Florida appears to be approximately equal. Within both the east and west coast segments of the Florida manatee population, documented movements suggest that at least some loosely formed subpopulations exist, which may constitute useful management units. Four subgroups were identified, which tend to return to the same warm-water refuge(s) each winter (Fig. 1) and have similar non-winter distribution patterns. For example, on the east coast, a core group of more than 100 manatees use the Blue Spring warm-water refuge in the upper St. Johns River. Radio-tracking studies (Bengtson 1981) and other information (Beeler and O'Shea 1988; Marine Mammal Commission 1988) suggest that most manatees wintering at Blue Spring tend to remain in the area identified as the **Upper St. Johns River Region** (Fig. 1). The lower St. Johns River, the east coast, and the Florida Keys are considered to represent the **Atlantic Region** (Fig. 1), based on the results of long-term radio tracking and photo-ID studies (Beck and Reid 1995; Reid *et al.* 1995; Deutsch *et al.* 1998).

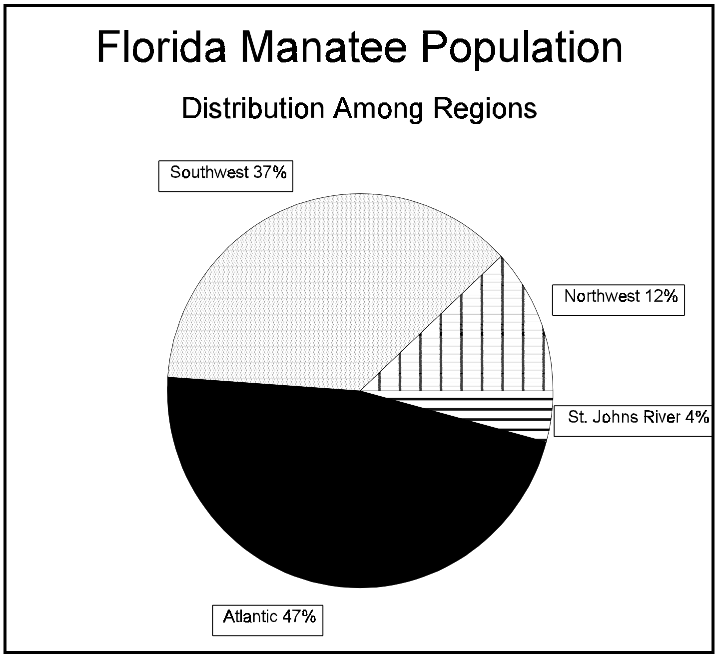


Figure 6. Florida manatee population distribution among regions. Percentage estimates are based upon highest minimum winter counts for each region between 1996 and 2000 (FWC, unpublished data).

On the west coast, Rathbun *et al.* (1995) reported that of 269 recognizable manatees identified at the Kings Bay and Homosassa River warm-water refuges in northwest Florida between 1978 and 1991, 93% of the females and 87% of the males returned to the same refuge each year. Radio-tracking results suggest that many animals wintering at Crystal River disperse north in warm seasons to rivers along the Big Bend coast, particularly the Suwannee River (Rathbun *et al.* 1990). This area is designated as the **Northwest Region** (Fig. 1). The existence of more or less distinct subgroups in the southwestern half of Florida (i.e., from Tampa Bay south) is debatable. It is possible that manatees using warm-water refuges in Tampa Bay, the Caloosahatchee River, and Collier County may be somewhat discrete groups; however, given available data, the Recovery Team chose to identify them as one group, the **Southwest Region** (Fig. 1).

Determination of manatee population status is based upon research described in Objective 2 and Appendix B. Table 2 provides regional status summaries and includes an overview of current status, habitat concerns, carcass recovery and cause of death data, and reproduction, survival, and population growth estimates for each region, if available. Cause of death data are summarized for each region in Appendix C to provide an overview on causes of death for: (1) all age classes; and (2) for adults only. Modeling has shown that manatee population trends are most sensitive to changes in adult survival rates (Eberhardt and O'Shea 1995; Marmontel *et al.* 1997; Langtimm *et al.* 1998).

Table 2. Florida manatee population status summaries by region. Data from the Northwest, Upper St. Johns River and Atlantic Regions were based upon survival rates from Langtimm et al. (1998) and population growth estimates from Eberhardt and O'Shea (1995).

		Northwest Primarily NW peninsular FL	**Southwest** Tampa Bay to Whitewater Bay	**Upper St. Johns** Upstream, South of Palatka	**Atlantic** GA - Miami & lower St. Johns
Photo-identification-based estimates	Adult Survival (% per year)	96.5 (95.1-97.5)	Survival, reproductive and population growth rate estimates based on resightings of known individuals are not currently available.	96.1 (90.0-98.5)	90.7 (88.7-92.6)
	Population Growth Rate (% per year)	7.4		5.7 (3-8)	1.0
	Reproduction: Percent adult females with calf	43% ± 9%		41%	42%
	Percent adult females with 1st year calf	36% ± 6%		30%	39%
	Mean interbirth interval	2.5 ± 0.77		2.6 ± 0.81 winter seasons	2.6 ± 0.64 winter seasons
	Mean calf dependency period	1.2 ± 0.42		1.3 ± 0.48 winter seasons	1.2 ± 0.42 winter seasons
	Mean age females at first reproduction	5.1 ± 1.21 years		5.4 ± 0.98 years	- - -
Causes of death based on carcass recovery	1980 - 1999 Overview	• Total of 153 carcasses • All causes, increasing 5.5% per year • Watercraft-related, increasing 10.8% per year	• Total of 1,358 carcasses • All causes increasing 4.8% per year • Watercraft-related, increasing 7.1% per year	• Total of 79 carcasses • All causes, increasing 2.6% per year • Watercraft-related, increasing 1.6% per year	• Total of 1,659 carcasses • All causes, increasing 6.9% per year • Watercraft-related, increasing 5.5% per year
	1989 - 1999 More recent trends	• Average of 8.9 per year (range = 6-12) • Human related cause of death 30% (adults 40%)	• Average of 85.5 per year (range = 57-134) • 281 in 1996 (including 145 red tide related deaths) • Human related cause of death 30% (adults 48%)	• Average of 4.5 per year (range = 2-7) • Human related cause of death 43% (adults 62%)	• Average of 107 per year (range = 70-135) • 206 in 1990 (46 cold-related) • Human related cause of death 34% (adults 57%)
Habitat Related Concerns		• Spring flow rates • Water quality and SAV • Storm-related salinity fluctuations, resulting in vegetation declines • Storm-related impacts on adult survival • Human disturbance at warm-water springs • Potential conflict between weed control and manatee food supply • Papilloma virus implications unknown	• Manatee dependence on power plants as thermal refuges • Increasing boat traffic • Periodic red tide-related deaths • Moderate level of water control structure deaths • Water quality and SAV • Salinity fluctuations, resulting in vegetation declines • Storm-related impacts on adult survival • Human disturbance	• Spring flow rates • Increasing boat traffic • Water quality and SAV • Low to moderate level of water control structure deaths • Potential conflict between weed control and manatee food supply	• Manatee dependence on power plants as thermal refuges • Increasing boat traffic • ICW shared manatee-human travel corridor • High level of water control structure deaths, especially in SE • Water quality and SAV • Salinity fluctuations, resulting in vegetation declines • Storm-related impacts on adult survival • Human disturbance
Current Status		• Exceeds survival, reproduction, and population growth criteria • Although overall deaths are relatively low, watercraft-related deaths are increasing rapidly	• Estimates of survival and population growth not yet available; reproduction criterion has been exceeded for group that summers in Sarasota Bay • Overall deaths are high, watercraft-related deaths are increasing rapidly	• Meets or exceeds survival, reproduction, and population growth criteria • Overall deaths are moderate, watercraft-related deaths increasing slowly	• Meets reproduction criterion; may meet survival and population growth criteria • Overall deaths are high, watercraft-related deaths increasing moderately

CURRENT STATUS Two goals of the MPSWG are to assess the status of the Florida manatee population and provide interpretation of available information on manatee population biology to managers. The MPSWG developed a status statement (Appendix D) for these purposes, and through Recovery Task 2.1 will update this statement annually.

The **Northwest** and **Upper St. Johns River Regions** have survival and reproduction rates that are adequate to sustain population growth (Eberhardt and O'Shea 1995). The adult survival rates are estimated at 96.5% and 96.1% respectively (Table 2). These two regions represent only 16% of the manatees documented in the last three years (Fig. 6). Collection of comparable life history data for the **Southwest Region** only began in 1995 and was not adequate for these survival estimates. This region represents 37% of the population. The health of the population in the **Atlantic Region**, which represents almost one-half of the entire population, is less certain, and the confidence interval surrounding a 90.7% adult survival rate suggests a cause for concern as it drops below 90.0% (Langtimm *et al*. 1998). These statements about the regions are based on data collected from 1977 to 1993 and thus may not reflect the current status of the population. Additionally, the recent increase in the percentage of watercraft-related deaths as a proportion of the total mortality and the effects this will have on adult survival rates is uncertain. Regional demographic estimates are currently being updated for the Manatee Population Ecology and Management Workshop in April 2002.

The near and long term threats from human-related activities are the reasons for which the Florida manatee currently necessitates protection under the ESA. The focus of recovery is not on how many manatees exist, but instead the focus is on implementing, monitoring and addressing the effectiveness of conservation measures to reduce or remove threats which will lead to a healthy and self-sustaining population. The Florida manatee could be considered for reclassification from endangered to threatened provided that threats can be reduced or removed, and that the population trend is stable or increasing for a sufficient time period.

D. DISTRIBUTION AND HABITAT USE PATTERNS

Based on telemetry, aerial surveys, photo identification sighting records, and other studies over the past 20 years, manatee distribution in the southeastern United States is now well known (Marine Mammal Commission 1984, 1986; Beeler and O'Shea 1988; O'Shea 1988; Lefebvre *et al.* 2001). In general, the data show that manatees exhibit opportunistic, as well as predictable patterns in their distribution and movement. They are able to undertake extensive north-south migrations with seasonal distribution determined by water temperature.

When ambient water temperatures drop below 20° C (68°F) in autumn and winter, manatees aggregate within the confines of natural and artificial warm-water refuges (Fig. 7, Lefebvre *et al.* 2001) or move to the southern tip of Florida (Snow 1991). Most artificial refuges are created by warm-water outfalls from power plants or paper mills. The largest winter aggregations (maximum count of 100 or more animals) are at refuges in Central and Southern Florida (Fig. 7). The northernmost natural warm-water refuge used regularly on the west coast is at Crystal River and at Blue Springs in the St. Johns River on the east coast. Most manatees return to the same warm-water refuges each year; however, some use different refuges in different years and others use two or more refuges in the same winter (Reid and Rathbun 1984, 1986; Rathbun *et al.* 1990; Reid *et al.* 1991; Reid *et al.* 1995). Many lesser known, minor aggregation sites are used as temporary thermal refuges. Most of these refuges are canals or boat basins where warmer water temperatures persist as temperatures in adjacent bays and rivers decline.

During mild winter periods, manatees at thermal refuges move to nearby grassbeds to feed, or even return to a more distant warm season range (Deutsch *et al.* 2000). For example, manatees using the Riviera Power Plant feed in adjacent Lake Worth and in Jupiter and Hobe Sounds, 19 to 24 km (12 to 15 mi) to the north (Packard 1981); animals using the Port Everglades power plant feed in grass beds in Biscayne Bay 24 to 32 km (15 to 20 mi) to the south (Marine Mammal Commission 1988); animals in Kings Bay feed on submerged aquatic vegetation along the mouth of the Crystal River (Rathbun *et al.* 1990); animals at Blue Spring leave the spring run to feed on freshwater aquatic plants along the St. Johns River and associated waters near the spring (Bengtson 1981; Marine Mammal Commission 1986).

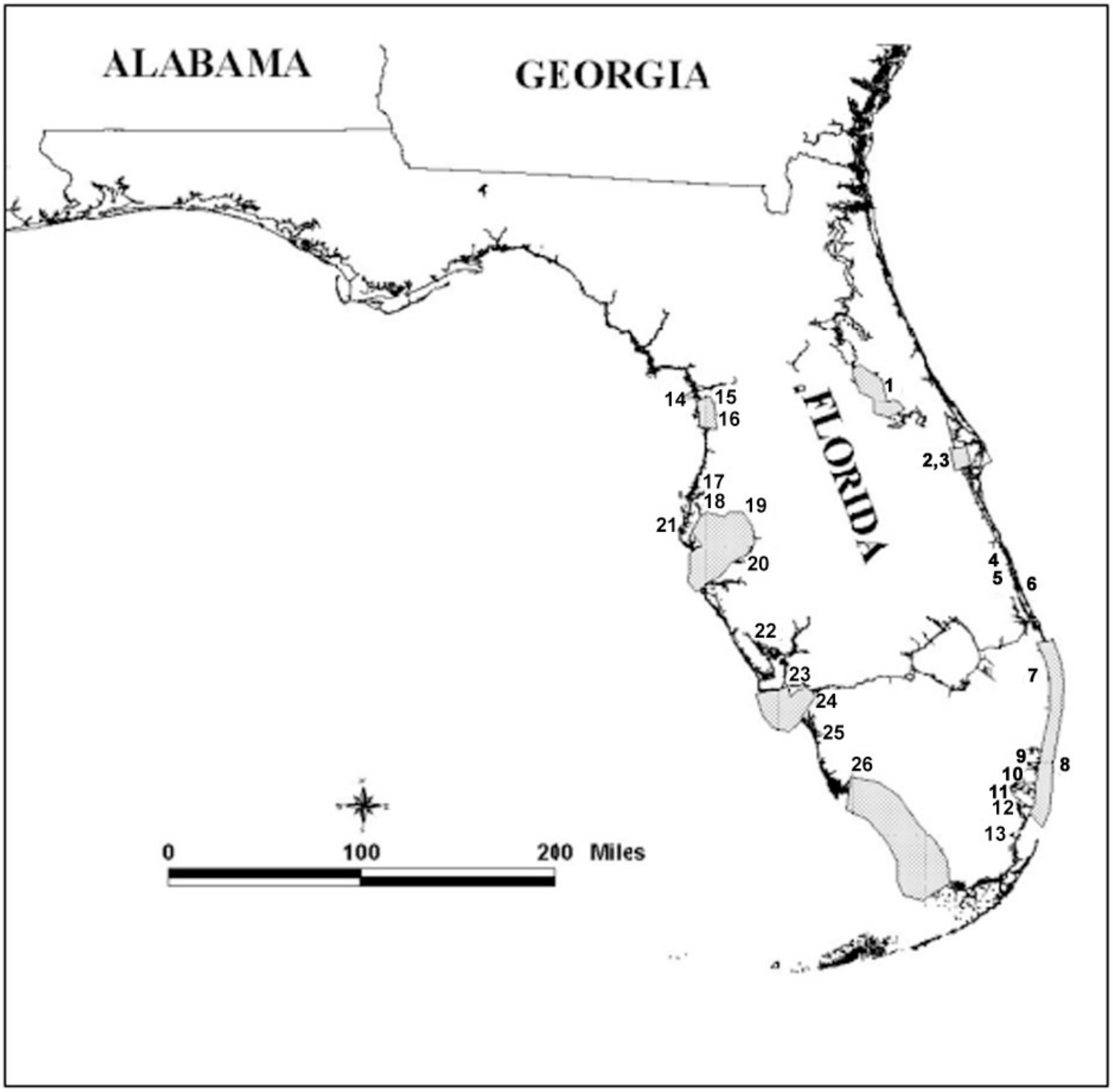


Figure 7. General winter distribution and warm-water manatee aggregation sites in the southeastern United States. Key with name of location and status of refuge is on the following page.

Key to Figure 7. Winter Aggregation Sites (based on Table 1, FWS 1996)

	❶ =	commonly have aggregations of 100 or more manatees
	❷ =	commonly have aggregations of 25 to 100 manatees
	❸ =	aggregations of less than 25 manatees
EAST COAST	(1)	❶Blue Spring (Volusia County, FL)
	(2)	❶Reliant Energy Power Plant (Brevard County, FL)
	(3)	❶FPL Canaveral Power Plant (Brevard County, FL)
	(4)	❷Sebastian River (Brevard County, FL)
	(5)	❷Vero Beach Power Plant (Indian River County, FL)
	(6)	❷Henry D. King Electric Station (St. Lucie County, FL)
	(7)	❶FPL Riviera Beach Power Plant (Palm Beach County, FL)
	(8)	❶FPL Port Everglades Power Plant (Broward County, FL)
	(9)	❶FPL Fort Lauderdale Power Plant (Broward County, FL)
	(10)	❷Little River (Dade County, FL)
	(11)	❷Coral Gables Waterway (Dade County, FL)
	(12)	❷ Palmer Lake (Dade County, FL)
	(13)	❸Black Creek Canal (Dade County, FL)
WEST COAST	(14)	❷FPC Crystal River Power Plant (Citrus County, FL)
	(15)	❶Crystal River (Citrus County, FL)
	(16)	❶Homosassa River (Citrus County, FL)
	(17)	❸Weeki Watchee/Mud/Jenkins Creek Springs (Hernando County, FL)
	(18)	❸FPC Anclote Plant (Pasco County, FL)
	(19)	❷TECO Port Sutton Plant (Hillsborough County, FL)
	(20)	❶TECO Big Bend Power Plant (Hillsborough County, FL)
	(21)	❷FPC Bartow Power Plant (Pinellas County, FL)
	(22)	❷Warm Mineral Springs (Sarasota County, FL)
	(23)	❷Matlacha Isles (Lee County, FL)
	(24)	❶FPL Fort Myers Power Plant (Lee County, FL)
	(25)	❷Ten Mile Canal Borrow Pit (Lee County, FL)
	(26)	❶Port of the Islands (Collier County, FL)
Abbreviations:	FPC	Florida Power Corporation
	FPL	Florida Power & Light Company
	TECO	Tampa Electric Company

As water temperatures rise manatees disperse from winter aggregation areas. While some remain near their winter refuges, others undertake extensive travels along the coast and far up rivers and canals. On the east coast, summer sightings drop off rapidly north of Georgia (Lefebvre *et al.* 2001) and are rare north of Cape Hatteras (Rathbun *et al.* 1982; Schwartz 1995); the northernmost sighting is from Rhode Island (Reid 1996). On the west coast, sightings drop off sharply west of the Suwannee River in Florida (Marine Mammal Commission 1986), although a small number of animals, about 12 to 15 manatees, are seen each summer in the Wakulla River at the base of the Florida Panhandle. Rare sightings also have been made in the Dry Tortugas (Reynolds and Ferguson 1984) and the Bahamas (Lefebvre *et al*. 2001; Odell *et al.* 1978).

In recent years, the most important spring habitat along the east coast of Florida has been the northern Banana River and Indian River Lagoon and their associated waters in Brevard County; more than 300 to 500 manatees have been counted in this area shortly before dispersing in late spring (Provancha and Provancha 1988; FWC, unpublished data). A comparable spring aggregation area does not appear to exist on the west coast, although Charlotte Harbor was visited in the spring by almost half of the 35 manatees radio-tagged at the Fort Myers power plant in Lee County (Lefebvre and Frohlich 1986). During summer, manatees may be commonly found almost anywhere in Florida where water depths and access channels are greater than 1 to 2 m (3.3 to 6.6 ft) (O'Shea 1988). Manatees can be found in very shallow water. Hartman (1979) observed manatees utilizing waters as shallow as 0.4 m with their backs out of the water. In warm seasons they usually occur alone or in pairs, although interacting groups of five to ten animals are not unusual.

Shallow grass beds with ready access to deep channels are preferred feeding areas in coastal and riverine habitats. Manatees often use secluded canals, creeks, embayments, and lagoons, particularly near the mouths of coastal rivers and sloughs, for feeding, resting, cavorting, mating, and calving (Marine Mammal Commission 1986, 1988). In estuarine and brackish areas, natural and artificial fresh water sources are sought by manatees. As in winter, manatees often use the same summer habitats year after year (Reid *et al.* 1991; Koelsch 1997).

E. BEHAVIOR AND PHYSIOLOGY

The first comprehensive study of manatee behavior was conducted in the late 1960s at Crystal River by Hartman (1979). This study attempted, among other things, to develop an ethogram for the species, and despite a number of additional studies that have been done since, Hartman's work stands today as the best source of information on certain aspects of manatee behavior, such as locomotion, breathing, resting, and socializing.

Other aspects of manatee behavioral ecology have been clarified during the last 20 years of manatee research. Migration corridors and responses by individual animals have been elaborated by long-term telemetry studies initiated by scientists at U.S. Geological Survey, Sirenia Lab (USGS-Sirenia) and the Florida Fish and Wildlife Conservation Commission (FWC) Florida Marine Research Institute (FMRI). Scientists have demonstrated site-fidelity in manatees, but have also noted that individual animals adjust their behaviors to take advantage of protected areas or changes in availability of resources. For example, Buckingham *et al.* (1999) confirmed increased manatee use of selected sanctuary areas during times when surrounding disturbance by boats was high. Reynolds and Wilcox (1994) continued to document the extent that manatees seek warm water at power plant discharges in winter (Fig. 8), taking advantage of the tendency by the manatees to aggregate around warm-water refuges in winter. Packard (1981, 1984), Lefebvre and Powell (1990), Rathbun *et al.* (1990) and Zoodsma (1991) described feeding and feeding ecology of manatees aggregated at natural or artificial warm-water refuges in winter, and additional studies further elaborated aspects of feeding behavior and ecological consequences thereof. Studies of foraging ecology were complemented by analyses of gut contents (e.g., Ledder 1986) and assessments of the functional morphology of the gastrointestinal tract (Reynolds and Rommel 1996).

Figure 8. Manatee aggregation at power plant warm-water outfall in Titusville, Florida. (*Photograph by T. O'Shea*)

Descriptions of behaviors have been followed or paralleled by studies that address how and why questions. Perhaps the most obvious questions center around why manatees need to seek warm-water refuges in winter. Gallivan and Best (1980) and Irvine (1983) documented the surprisingly low metabolism of manatees, and scientists suggested that water temperatures below 19° C triggered manatee behavioral changes, such as movements to warm-water sources. Recent research suggests that the temperature eliciting metabolic and behavioral changes in manatees is closer to 17° C, but upper and lower critical temperatures for manatees (the points at which they become metabolically stressed) remain unclear (Worthy *et al.* 1999). It is also unclear, but vital to understand, how manatees would react physiologically and behaviorally to reductions, cessations, or other changes in availability of warm water in winter.

Scientists have noted that manatees seek freshwater sources to drink. Hill and Reynolds (1989) suggested that the structure of the manatee kidney should permit the animals to survive well without regular access to freshwater. In other words, fresh water may be an attractant, without being required for survival, by manatees. Although manatees can tolerate a wide range of salinities (Ortiz *et al.* 1998), they prefer habitats where osmotic stress is minimal or where fresh water is periodically available (O'Shea and Kochman 1990). Ortiz *et al*. (1998) report that "manatees may be susceptible to dehydration after an extended period if freshwater is not available."

A number of research projects have considered manatee sensory capabilities, in part to attempt to comprehend how manatees perceive their environment, including aspects of the environment that are harmful to manatees, such as high-speed watercraft. Behavioral observation studies (e.g., Hartman 1979; Wells *et al*. 1999), and anatomical studies (e.g., Ketten *et al*. 1992) and psychoacoustic research that produced an audiogram for the manatee (Gerstein *et al.* 1999) have all addressed manatee hearing capabilities and the watercraft/manatee issue. These studies have not produced a complete understanding of manatee acoustics.

Other studies that have assessed other sensory capabilities, neuroanatomy, or fine motor coordination include: (1) Cohen *et al.* 1982 (photo receptors and retinal function); (2) Griebel and Schmid 1996 (color vision); (3) Griebel and Schmid 1997 (brightness discrimination); (4) Marshall *et al.*1998a (use of perioral bristles in feeding); (5) Marshall *et al.* 1998b (presence of a muscular hydrostat to facilitate bristle use); (6) Marshall and Reep 1995 (structure of the cerebral cortex); (7) Mass *et al.* 1997 (ganglion layer topography and retinal resolution); (8) O'Shea and Reep 1990 (extent of encephalization); (9) Reep *et al.* 1998 (distribution and innervation of facial bristles and hairs)and (10) Bowles *et al.* 2001(studies of response to novelty). Questions still remain regarding chemosensory ability of manatees, and clarification is needed regarding acoustics and the functional morphology of non-cerebral cortex regions of the brain.

The outcome of research into behavior, general physiology and sensory biology is that these aspects of manatee biology are better understood than is the case for most marine mammals. Due to long-term and diverse research efforts, scientists understand a great deal and continue to learn more about manatee habitat utilization, general behavior patterns, and life history attributes. Science and management would benefit from a carefully structured approach to answering, or providing higher resolution answers to questions associated with thermoregulation and thermal requirements of manatees and aspects of psychoacoustics and perceptual psychology (e.g., what they hear and how they respond to high levels of anthropogenic noise).

A comprehensive description of manatee behavior appears in Wells *et al.* (1999). This chapter provides synopses of the following topics: diving behavior, predation, foraging, thermoregulation and thermally-induced movements, resource aggregations, mating, rearing patterns, communication, and social organization. Sensory and general physiology of manatees are reviewed by Wartzok and Ketten (1999) and Elsner (1999), respectively. Reynolds and Powell (in press) provide a brief overview of manatee biology and conservation, including synopses of behavioral and physiological attributes.

F. FEEDING ECOLOGY

Manatees are herbivores that feed opportunistically on a wide variety of submerged, floating, and emergent vegetation. Because of their broad distribution and migratory patterns, Florida manatees utilize a wider diversity of food items and are possibly less specialized in their feeding strategies than manatees in tropical regions (Lefebvre *et al.* 2000).

Feeding rates and food preferences depend, in part, on the season and available plant species. Bengtson (1981, 1983) reported that the time manatees spent feeding in the upper St. Johns River was greatest (6 to 7 hrs/day) before winter (August to November), least (3 to 4 hrs/day) in spring and summer (April to July), and intermediate (about 5 hrs/day) in winter (January to March). He estimated annual mean consumption rates at 33.2 kg/day/manatee or about 4 to 9% of their body weight per day depending on season (Bengtson 1983). At Crystal River, Etheridge *et al.* (1985) reported cumulative daily winter feeding times from 0 to 6 hrs. 10 min. based on observations of three radio-tagged animals over seven 24-hour periods. The estimated daily consumption rates by adults, juveniles, and calves eating hydrilla (*Hydrilla verticillata*) were 7.1, 9.6, and 15.7% of body weight per day, respectively.

Seagrasses appear to be a staple of the manatee diet in coastal areas (Ledder 1986; Provancha and Hall 1991; Kadel and Patton 1992; Koelsch 1997; Lefebvre *et al.* 2000). Packard (1984) noted two feeding methods in coastal seagrass beds: (1) rooting, where virtually the entire plant is consumed; and (2) grazing, where exposed grass blades are eaten without disturbing the roots or sediment. Manatees may return to specific seagrass beds to graze on new growth (Koelsch 1997; Lefebvre *et al.* 2000).

In the upper Banana River, Provancha and Hall (1991) found spring concentrations of manatees grazing in beds dominated by manatee grass (*Syringodium filiforme*). They also reported an apparent preference for manatee grass and shoalgrass (*Halodule wrightii*) over the macroalga *Caulerpa* spp. Along the Florida-Georgia border, manatees feed in salt marshes on smooth cordgrass (*Spartina alterniflora*) by timing feeding periods with high tide (Baugh *et al*. 1989; Zoodsma 1991).

G. REPRODUCTION

Breeding takes place when one or more males (ranging from 5 to 22) are attracted to an estrous female to form an ephemeral mating herd (Rathbun *et al*. 1995). Mating herds can last up to 4 weeks, with different males joining and leaving the herd daily (Hartman 1979; Bengtson 1981; Rathbun *et al*. 1995. Cited in Rathbun 1999). Permanent bonds between males and females do not form. During peak activity, the males in mating herds compete intensely for access to the female (Fig. 9; Hartman 1979). Successive copulations involving different males have been reported. Some observations suggest that larger, presumably older, males dominate access to females early in the formation of mating herds and are responsible for most pregnancies (Rathbun *et al.* 1995), but males as young as three years old are spermatogenic (Hernandez *et al.* 1995). Although breeding has been reported in all seasons, Hernandez *et al.* (1995) reported that histological studies of reproductive organs from carcasses of males found evidence of sperm production in 94% of adult males recovered from March through November. Only 20% of adult males recovered from December through February showed similar production.

Figure 9. Mating herd in Plummers Cove, St. Johns River, Jacksonville, Florida. (*Photograph by B. Brooks*)

Females appear to reach sexual maturity by about age five but have given birth as early as four (Marmontel 1995; Odell *et al.* 1995; O'Shea and Hartley 1995; Rathbun *et al.* 1995), and males may reach sexual maturity at 3 to 4 years of age (Hernandez *et al.* 1995). Manatees may live in excess of 50 years (Marmontel 1995), and evidence for reproductive senescence is unclear (Marmontel 1995; Rathbun *et al.* 1995). Catalogued Florida manatee CR 28, a wild manatee that overwinters in Crystal River, was last documented with a calf in 1998, at which time she was estimated to be at least 34 years of age (USGS-Sirenia, unpublished data). A captive animal, MSTm-5801, gave birth to a calf in 1990, at which time she was estimated to be 43 to 48 years of age (FWS, unpublished data). The length of the gestation period is uncertain but is thought to be between 11 and 14 months (Odell *et al.* 1995; Rathbun *et al.* 1995; Reid *et al.* 1995). The normal litter size is one, with twins reported rarely (Marmontel 1995; Odell *et al.* 1995; O'Shea and Hartley 1995; Rathbun *et al.* 1995).

Calf dependency usually lasts one to two years after birth (Hartman 1979; O'Shea and Hartley 1995; Rathbun *et al.* 1995; Reid *et al.* 1995). Calving intervals vary greatly among individuals. They are probably often less than 2 to 2.5 years, but may be considerably longer depending on age and perhaps other factors (Marmontel 1995; Odell *et al.* 1995; Rathbun *et al.* 1995; Reid *et al.* 1995). Females that abort or lose a calf due to perinatal death may become pregnant again within a few months (Odell *et al.* 1995), or even weeks (Hartman 1979).

H. THREATS TO THE SPECIES

The most significant problem presently faced by manatees in Florida is death or serious injury from boat strikes. The availability of warm-water refuges for manatees is uncertain if minimum flows and levels are not established for the natural springs on which many manatees depend, and as deregulation of the power industry in Florida occurs. Consequences of an increasing human population and intensive coastal development are long-term threats to the Florida manatee. Their survival will depend on maintaining the integrity of ecosystems and habitat sufficient to support a viable manatee population.

CAUSES OF DEATH (A summary of Cause of Death by region can be found in Appendix C). Data on manatee deaths in the southeastern United States have been collected since 1974 (O'Shea *et al.* 1985; Ackerman *et al.* 1995; FWC, unpublished data). Data since 1976 were used in the following summary (Table 3), as carcass collection efforts were more consistent following that year. They indicate a clear increase in manatee deaths over the last 25 years (Fig. 10, 6.0 % per year exponential regression between 1976 and 2000; Ackerman *et al.* 1995; FWC, unpublished data). Most of the increase can be attributed to increases in watercraft-related and perinatal deaths (Marine Mammal Commission 1993). However, it is unclear whether this represents a proportional increase relative to the overall population of manatees.

Natural causes of death include disease, parasitism, reproductive complications, and other non-human-related injuries, as well as occasional exposure to cold and red tide (O'Shea *et al.* 1985; Ackerman *et al.* 1995). These natural causes of death accounted for 17% of all deaths between 1976 and 2000 (FWC, unpublished data). Perinatal deaths accounted for 21% of all deaths in the same period. Human-related causes of death include watercraft collisions, manatees crushed in water control structures and navigational locks, and a variety of less-common causes. Human-related causes of death accounted for at least 31% of deaths between 1976 and 2000. Cause of death of some carcasses could not be determined, because they were too decomposed, the cause was medically difficult to determine, or the carcass was verified but not recovered. The cause of death for these carcasses was classified as undetermined (30% of deaths between 1976 and 2000).

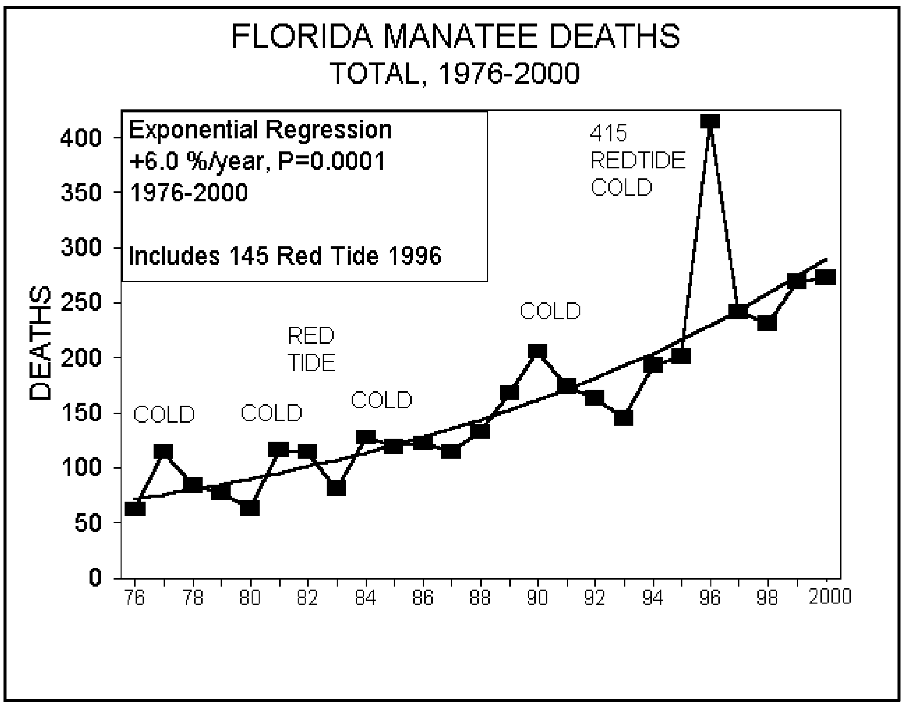


Figure 10. Florida manatee deaths from 1976 to 2000 with an exponential regression of +6.0% per year (FWC, unpublished data).

A prominent natural cause of death in some years is exposure to cold. Following a severe winter cold spell at the end of 1989, at least 46 manatee carcasses were recovered in 1990; cause of death for each was attributed to cold stress. Exposure to cold is believed to have caused many deaths in the winters of 1977, 1981, 1984, 1990, 1996, 2001 and have been documented as early as the 19th century (Ackerman *et al.* 1995; O'Shea *et al.* 1985; FWC, unpublished data).

In 1982, a large number of manatees also died coincidentally with a red tide dinoflagellate (*Gymnodinium breve*) outbreak between February and March in Lee County, Florida (O'Shea *et al.* 1991). At least 37 manatees died, perhaps in part due to incidental ingestion of filter-feeding tunicates that had accumulated the neurotoxin-producing dinoflagellates responsible for causing the red tide. In 1996, from March to May, at least 145 manatees died in a red tide epizootic over a larger area of southwest Florida (Fig. 11; Bossart *et al.* 1998; Landsberg and Steidinger 1998). Although the exact mechanism of manatee exposure to the red tide brevetoxin is unknown in the 1982 and 1996 outbreaks, ingestion, inhalation, or both are suspected (Bossart *et al.* 1998). The critical circumstances contributing to high red tide-related deaths are concentration and distribution of the red tide, timing and scale of manatee aggregations, salinity, and timing and persistence of the bloom (Landsberg and Steidinger 1998). It is difficult to manage for these rare but catastrophic causes of mortality.

Figure 11. Several of the 145 manatees that died during the red tide mortality event, Southwest Florida, 1996. (*Photographs by T. Pitchford*)

Perinatal deaths are carcasses of very small manatees (≤150 cm in length, O'Shea *et al.* 1995). Some are aborted fetuses; others are stillborn or die of natural causes within a few days of birth. Some may die from disease, reproductive complications, and/or congenital abnormalities. The cause of many perinatal deaths is difficult to determine, because these carcasses are generally in an advanced state of decomposition at the time they are retrieved. Most perinatal deaths appear to be due to natural causes; however, watercraft-related injuries or disturbance, or other human-related factors affecting pregnant and nursing mothers also may be responsible for a significant number of perinatal deaths. It has also been suggested that some may die from harassment by adult males (O'Shea and Hartley 1995). Between 1976 and 1999, perinatal deaths increased at an average of 8.8 % per year, increasing from 14% of all deaths between 1976 and 1980 to 22% between 1992 and 2000 (Ackerman *et al.* 1995; FWC, unpublished data).

The largest known cause of manatee deaths is collisions with the hulls and/or propellers of boats and ships. Between 1976 and 2000, watercraft-related deaths accounted for 24% of the total mortality and increased at an average of 7.2% per year: increasing from 21% of all deaths between 1976 and 1980; to 29% between 1986 and 1991; and 24% between 1992 and 2000 (Ackerman *et al.* 1995; FWC, unpublished data). Watercraft-related deaths were much lower in 1992 and 1993, but increased thereafter. From 1996 to 2000, the watercraft-related deaths have been the highest on record.

The next largest human-related cause of manatee deaths is entrapment or crushing in water control structures and navigational locks and accounts for 4% of the total mortality between 1976 and 2000 (Ackerman *et al.* 1995; FWC, unpublished data). These deaths were first recognized in the 1970s (Odell and Reynolds 1979), and steps have been taken to eliminate this source of death. Beginning in the early 1980s gate-opening procedures were modified; annual numbers of deaths initially decreased after this modification. However, the number of deaths subsequently increased, and in 1994, a record 16 deaths were documented. An ad hoc interagency task force was established in the early 1990s and now includes representatives from the South Florida Water Management District (WMD), U.S. Army Corps of Engineers (COE), FWS, Miami-Dade Department of Environmental Research Management (DERM), FWC and Florida Department of Environmental Protection (FDEP). This group meets several times a year to discuss recent manatee deaths and develop measures to protect manatees at water control structures and navigational locks. The overall goal is to eliminate completely structure-related deaths.

Other known causes of human-related manatee deaths include poaching and vandalism, entanglement in shrimp nets, monofilament line (and other fishing gear), entrapment in culverts and pipes, and ingestion of debris. These account for 3% of the total mortality from 1976 to 2000. Together, deaths attributable to these causes have remained constant and have accounted for a low percentage of total known deaths, i.e., about 4% between 1976 and 1980, 3% between 1981 and 1985, 2% between 1986 and 1991, and 2% between 1992 and 2000 (Ackerman *et al*. 1995; FWC, unpublished data). Entrapment in shrimp nets has been the largest component of this catch-all category. Eleven deaths were probably related to shrimping activities from 1976 to 1998 (7 in Florida, 4 in other states; Nill 1998). These deaths have become less common since regulations on inshore shrimping, the 1995 Florida Net Ban regulations, and education efforts about protecting manatees were implemented.

These data on causes of manatee deaths, and particularly the increasing number of watercraft-related deaths, should be viewed in the context of Florida's growing human population, which increased by 130% since 1970, 6.8 to 15.7 million (Florida Office of Economic and Demographic Research, 2001). The rise in manatee deaths during this period is attributable, in part, to the increasing number of people and boats sharing the same waterways. It should be noted that the increasing number of deaths could, in part, also be due to increasing numbers of manatees.

Table 3. Known manatee mortality in the southeastern United States reported through the manatee salvage and necropsy program, 1976 to 2000 (FWC, unpublished data).

Age Class	Adult/Subadult					Perinatal (≤150 cm)				Total
Cause / Year	Water-craft	Lock Gate	Other Human	Natural	Undeter-mined	Water-craft	Lock Gate	Other Human	Natural/ Undeter-mined	
1976	10	3	0	1	32	0	1	0	15	62
1977	13	6	5	1	79	0	0	1	10	115
1978	21	9	1	3	40	0	0	0	10	84
1979	22	8	8	4	24	2	0	1	9	78
1980	15	8	2	6	19	1	0	0	14	65
1981	23	2	4	9	65	1	0	0	13	117
1982	19	3	2	40	37	1	0	0	15	117
1983	15	7	5	6	30	0	0	0	18	81
1984	33	3	1	24	41	1	0	0	27	130
1985	35	3	3	20	39	0	0	0	23	123
1986	31	3	1	13	47	2	0	0	28	125
1987	37	5	3	15	23	2	0	1	31	117
1988	43	7	3	22	25	0	0	1	33	134
1989	50	3	4	32	45	1	0	1	40	176
1990	49	3	4	71	41	0	0	0	46	214
1991	52	9	6	15	39	1	0	0	53	175
1992	38	5	6	21	49	0	0	0	48	167
1993	35	5	7	24	36	1	0	0	39	147
1994	50	16	5	37	40	0	0	0	46	194
1995	43	8	5	35	55	0	0	0	57	203
1996	59	10	1	118	164	1	0	0	63	416
1997	52	8	8	46	67	3	0	1	61	246
1998	66	9	6	23	85	1	0	0	53	243
1999	83	15	7	43	69	0	0	1	56	274
2000	79	8	8	51	75	0	0	0	58	279
Total	973	166	105	680	1,266	18	1	7	866	4,082

THREATS TO HABITAT

WARM WATER One of the greatest threats to the continued existence of the Florida manatee is the stability and longevity of warm-water refuges. Historically, the sub-tropical manatee relied on the warm temperate waters of south Florida and on natural warm-water springs scattered throughout their range as buffers to the lethal effects of cold winter temperatures. With the advent of industrial plants and their associated warm-water discharges, manatees have expanded their winter range to include these sites as refuges from the cold. In the absence of these sources of warm water, manatees are vulnerable to cold temperatures and can die from both hypothermia and prolonged exposure to cold. Based upon recent synoptic survey data, just under two-thirds of the population of Florida manatees rely on industrial sites, which are now made up almost entirely of power plants (FWC unpublished data).

Overall, industrial warm-water refuges have been a benefit to manatees inasmuch as they have: (1) reduced the frequency of cold-related deaths by providing reliable sources of warm water during the winter; (2) reduced the incidence of juvenile, cold-weather related mortality in south Florida; and (3) provided additional winter refuges and foraging sites which supplant heavily-stressed wintering sites in south Florida. While these sites have clearly benefitted the species, they also pose a significant risk. During periods of extreme cold, some plants are unable to provide water warm enough to meet the manatees' physiological needs. Plants are also vulnerable to winter shutdowns due to equipment failures and needed maintenance and, in the long-term, have a limited life span. Older plants are less cost-effective to operate, and market economics will increasingly play a more significant role in the plants' operating schedules (FWS 2000).

In addition, natural wintering sites also have been affected by human activities (FWS 2000). Winter habitat in south Florida has been altered (e.g., shoreline areas have been rip-rapped and bulkheaded, sources of warm water have been diverted and/or capped, foraging and resting sites have been eliminated, etc.). Important springs in the northern area of the species' range have also been altered; demands for water for residential, industrial, and agricultural purposes from the aquifer have diminished spring flows, as have paving and water diversion projects in spring recharge areas. Nutrient loading (e.g., nitrates) from residential and agricultural sources has promoted the growth of alga and clouded water columns, thus reducing available winter forage in these refuges.

Alterations to both natural and industrial warm-water refuges will significantly affect the manatee's ability to tolerate and withstand the cold. In the absence of stable, long term sources of warm water and winter habitat, large numbers of manatees may succumb to the cold. Given the magnitude of the problem, the outright loss of these numbers of animals could significantly affect recovery efforts. The power industry and wildlife managers and researchers are currently working together to secure the manatee's winter habitat.

OTHER HABITAT As discussed earlier in this document, Florida manatees are found in fresh, brackish, and marine environments in the southeastern United States. These areas include many habitat types (including vegetated freshwater bottoms, salt marshes, sea grass meadows, and many others) where manatees ably exploit the many resources found in these areas. As herbivores, manatees feed on the wide range of forage that these habitats provide. In addition, manatees utilize many other resources found in these areas, including: (1) springs and deep water areas for warmth; (2) springs and freshwater runoff sites for drinking water; (3) quiet, secluded tributaries and feeder creeks for resting, calving, and nurturing their young, (4) open waterways and channels as travel corridors, etc.

These habitats are affected by human activities. Dredge and fill activities, polluted runoff, propeller scarring, and other actions have resulted in the loss of vegetated areas and springs. Quiet backwaters have been made more accessible to human activities, and increasing levels of vessel traffic have made manatees increasingly vulnerable to boat collisions in travel corridors. Manatees seem to have adapted to some of these changes. For example, industrial warm-water discharges and deep-dredged areas are now used as wintering sites, stormwater pipes and freshwater discharges in marinas provide manatees with drinking water, and the imported exotic plant, hydrilla (which has replaced native aquatic species), has become an important food source at wintering sites.

While manatees may adapt to some changes, some activities clearly can have an adverse effect on the species. The loss of industrial warm-water discharges can result in the deaths of individuals using these sites. Dozens of manatees die each year due to collisions with watercraft. Other activities may also affect manatees, albeit on a much more subtle level. Harassment by boats and swimmers may drive animals away from preferred sites; the loss of vegetation in certain areas (e.g., as seen in winter foraging areas) requires manatees to travel greater distances to feed. Adequate feeding habitat associated with warm-water refuge sites is important to the overall recovery of the Florida manatee, however, it does not appear that warm season foraging habitat is limiting.

Efforts are in place and are being made to protect, enhance, and restore the manatee's aquatic environment. There are many existing federal, state, and local government regulations in place to minimize the effect of human activities on manatees and their habitat (e.g., Clean Water Act, Rivers and Harbors Act, ESA, Fish and Wildlife Coordination Act, Coastal Zone Management Act, etc.), and significant efforts are being made to improve this environment and to maintain those resources that are vital to the manatee. Also refer to the discussion in section I, **HABITAT PROTECTION**.

CONTAMINANTS AND POLLUTION EFFECTS The reliance of manatees on inshore habitats and their attraction to industrial and municipal outfalls have the potential to expose them to relatively high levels of contaminants. Despite this relationship, there have been few studies of contaminant levels and their effects on manatees. Available information suggests that direct effects are not significant at a population level. O'Shea *et al.* (1984) investigated levels of pesticides, polychlorinated biphenyls, mercury, lead, cadmium, copper, iron, and selenium in manatee tissues collected in the late 1970s and early 1980s. Of these, only copper levels in the liver were found to be notably high. The highest copper levels (1,200 ppm dry weight) were found in animals from areas of high herbicidal copper usage and exceeded all previously reported concentrations in livers of wild mammals. Despite these findings, there were no field reports of copper poisoning and no evidence of deleterious effects to individual animals. Ames and Van Vleet (1996) analyzed a small number of tissue samples for chlorinated hydrocarbons and petroleum hydrocarbons. None of the latter were found; however, pesticides (o,p-DDT, o,p-DDD, hexachlorobenzene, and lindane) were found in some of the liver, kidney, and blubber samples, but at very low concentrations and at a lower frequency of occurrence than in earlier studies. Contaminants, siltation and modified deliveries of fresh water to the estuary can indirectly impact manatees by causing a decline in submerged aquatic vegetation on which manatees depend.

Manatees ingest various debris incidental to feeding. Beck and Barros (1991) found monofilament fishing line, plastic bags, string, rope, fish hooks, wire, rubber bands, and other debris in the stomachs of 14.4% of 439 manatees recovered between 1978 and 1986. Monofilament line was the most common item found. In most cases, ingested items do not appear to affect animals. However, ingested monofilament line has resulted in death due to blockage of the digestive system (Forrester *et al.* 1975; Buergelt *et al.* 1984). A few deaths were caused by ingesting wire, which perforated the stomach lining, and plastic sheeting, which blocked the digestive tract (Laist 1987). Discarded monofilament line and rope were found wrapped around flippers, sometimes leading to serious injury or death (Beck and Barros 1991). Records of scarred or mutilated flippers on free-ranging manatees known from the photo-ID catalog and rescue events suggest that female manatees are more vulnerable than males to entanglement in fishing gear (Beck and Lefebvre 1995).

I. PAST AND ONGOING CONSERVATION EFFORTS

Under the guidance of previous manatee recovery plans, federal agencies, state agencies, local agencies and private organizations have initiated cooperative actions to address the important conservation needs, which this plan builds upon. Some of the major initiatives are reviewed below.

EFFORTS TO REDUCE WATERCRAFT-RELATED INJURIES AND DEATHS The largest identified cause of manatee death is collisions with watercraft. Many living manatees also bear scars or wounds from vessel strikes. An analysis of injuries to 406 manatees killed by watercraft and recovered between 1979 and 1991 found that 55% were killed by impact, 39% were killed by propeller cuts, 4% had both types of injuries, either of which could have been fatal, and 2% with unidentified specifics (Wright *et al.* 1995). Between 1976 and 2000, the total number of carcasses (i.e., deaths due to all causes) collected has increased at a rate of 6.0 percent per year, while deaths caused by watercraft strikes increased by 7.2 percent per year (Fig. 12). Because watercraft operators cannot reliably detect and avoid hitting manatees, federal and state managers have sought to limit watercraft speed in areas where manatees are most likely to occur to afford both manatees and boaters time to avoid collisions.

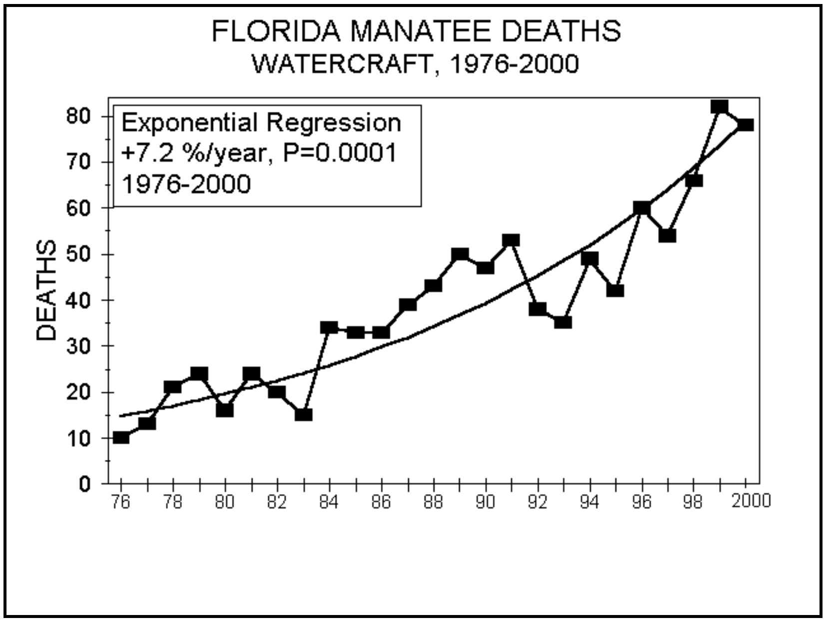


Figure 12. Florida manatee watercraft deaths from 1976 to 2000 with an exponential regression increase of 7.2% per year (FWC, unpublished data).

In 1989, the Florida Governor and Cabinet approved a series of recommendations by the former FDNR to improve protection of manatees in 13 key counties. For the next ten years, state and local governments cooperated in the creation and implementation of four county Manatee Protection Plans and 12 county-wide manatee protection speed zone rules. In 1999, Florida's manatee research and management programs were transferred to the newly created FWC. FWC approved comprehensive manatee protection rules in Lee County, completing the speed zone component of the initiative started in 1989. As the State of Florida's initiative to establish manatee protection zones in the 13 key counties is completed, attention is now focused on the development and approval of key county manatee protection plans.

Two types of manatee protection areas also have been developed by FWS: (1) manatee sanctuaries; and (2) manatee refuges. Manatee sanctuaries are areas in which all waterborne activities are prohibited, and manatee refuges are areas where certain waterborne activities are restricted or prohibited (designation of refuges or sanctuaries, however, will not eliminate waterway property owner access rights). To date, FWS has established seven winter sanctuaries to protect manatees in association with the Crystal River National Wildlife Refuge (NWR). The most recent was a one-quarter-acre sanctuary established in 1997 at Three Sisters Spring run (Fig. 13).

Figure 13. Three Sisters Spring Manatee Sanctuary, Crystal River, Florida. Manatees within the sanctuary and tour boats (left) and snorklers (right) along the outer sanctuary boundary edge. (*Photographs by J. Kleen and C. Shaw*)

FWS and FWC continue to evaluate needs for additional protection areas that may be necessary to achieve recovery. The goal is to consider the needs of the manatee at an ecosystem level and to establish regulations to ensure that adequate protected areas are available throughout Florida to satisfy habitat requirements of the Florida manatee population with a view toward recovery. In addition, through the NWR System Administration Act, access rules for boats have been established by FWS to protect manatees within Merritt Island NWR.

In recent years, both the FWS and FWC have been using targeted enforcement strategies in an attempt to increase boater compliance with speed zones and ultimately reduce manatee injuries and death. FWS strategy has been to allocate significant enforcement manpower to specific areas on designated weekends. These enforcement teams travel to various locations around the state, with particular emphasis given to those zones within counties where there is a history of high watercraft-caused manatee deaths. FWC has increased its emphasis on enforcement and compliance with manatee speed zones by adding new officers, conducting law enforcement task force initiatives, increasing overtime, and increasing the proportion of law enforcement time devoted to manatee conservation.

In addition to manatee protection plans, manatee protection areas, and other efforts, managers, researchers, and the boating industry have investigated the use of various devices to aid in the reduction of watercraft-related manatee deaths. For example, the State of Florida funded an evaluation of propeller guards (Milligan and Tennant 1998). The state's evaluation concluded that these devices would reduce cutting damage associated with propellers when boats were operating at low speeds. However, when boats (including boats equipped with propeller guards) operate at high speeds, guards would be of little benefit because animals would continue to be killed by blunt trauma associated with impacts from boat hulls, lower units, and other gear. The U.S. Coast Guard (USCG) identified additional concerns, stating that propeller guards on small recreational vessels "may create more problems than they solve" and does not support their use on recreational vessels at this time (Carmichael 2001). There are propeller guard applications, however, that appear to work for certain large, commercial vessels; for example, the use of guards on C-tractor tugs has eliminated this specific source of manatee mortality at the Kings Bay Naval Submarine Base in St. Marys, Georgia. To prevent injuries to manatees, propeller guards are used on some rental and sight-seeing boats at Blue Spring and Crystal River.

Researchers have also begun to investigate the manatees' acoustic environment to better evaluate the animal's response to vessel traffic. This line of research needs to be thoroughly assessed for its potential as another management tool to minimize collisions between manatees and boats. Results from Gerstein (1999) indicate that manatees hear in the range from 500 Hz to 38 kHz and that inadequate hearing sensitivity at low frequencies may be a contributing factor to the manatees' ability to effectively detect boat noise to avoid collisions. One technology often discussed is an acoustic deterrence device mounted on a boat. Conceptually, this technological approach may sound like an answer to the manatee/watercraft issue. A number of problems have been defined with the use of acoustic deterrents. No alarm/warning device has yet been demonstrated to adequately protect wildlife or marine mammals. Additionally, concern has also been stated regarding the increase in background noise that these deterrents would add to an already noisy marine environment. It has not been determined what negative impacts this device would have on marine life and what effects it would have on animals that use acoustic cues for a variety of purposes. For these reasons, this technology needs to be thoroughly researched and assessed and managers need to evaluate the MMPA and ESA "take" issues related to implementing such technology.

Current research into the sensory capabilities of manatees is being supported at both the state and federal levels. The FWC contracted Mote Marine Laboratory to further test manatee sensory capabilities. One contract assessed the effects of boat noise in a more controlled environment. This study recorded the physical and acoustic reaction of a manatee to a pre-determined acoustical level. This study design will allow the development of a relationship between acoustic dosage and behavioral responses (vocal and visual displays; movements). Another contract study looked at acoustical propagation over various types of marine topography. In cooperation with Mote Marine Laboratory and the Woods Hole Oceanographic Institution, the FWC is also examining manatee behavioral response to watercraft using new technology, the DTAG, a digital acoustic tag which records acoustic attributes of the environment and detailed manatee movement simultaneously. A FWS contracted study to assess manatee behaviors in the presence of fishing gear and their response to novelty and the potential for reducing gear interactions has an acoustic component. The FWC also received funding to support the development and implementation of technological solutions for reducing the risks that watercraft pose to manatees. They recently issued a Request for Proposals (RFP) to specifically address manatee avoidance technology.

Currently, priority actions in manatee conservation and protection include boater education, enforcement, maintenance of signs and buoys, compliance assessment, and periodic re-evaluation of the effectiveness of the rules. Such work requires close cooperation between FWC Bureau of Protected Species Management (BPSM), FWC's Division of Law Enforcement (DLE), county officials, the Inland Navigation Districts, FWS, USCG, and, of course, boaters.

EFFORTS TO REDUCE FLOOD GATE AND NAVIGATION LOCK DEATHS Entrapment in water-control structures and navigational locks is the second largest cause of human-related manatee deaths. In some cases, manatees appear to have been crushed in closing gates; in others, they may have been drowned after being pinned against narrow gate openings by water currents rushing through openings. Water-control structures implicated in manatee deaths in Dade and Broward counties are operated by the South Florida WMD. From 1976 through 2000, 166 manatees have been killed in water control structures in Dade County alone, accounting for 33% of all manatee deaths in this county.

The COE operates five water-control structures in conjunction with navigational locks along the Okeechobee Waterway and also operates the Port Canaveral Lock, located in Brevard County. FDEP operates locks and water-control structures associated with the Cross Florida Greenway.

In the early 1980s, steps were taken to modify gate-opening procedures to ensure openings were wide enough to allow a manatee to pass through unharmed. Steps were also initiated to fence off openings and cavities in gate structures where manatees might become trapped. Manatee deaths subsequently declined and remained low for much of the 1980s (Table 2). Since the 1996 Recovery Plan, much progress has been made toward identifying, testing, and installing manatee protection devices at water control structures. The COE Section 1135 Study, "Project Modification on Manatee Protection at Select Navigation and Water Control Structures, Part I," has been completed and the technology developed and successfully tested. Consequently, since 1996, pressure sensor devices have been installed at the five water control structures. Three recent deaths at two of the modified South Florida Water Management District water control structures suggests that these type of protective measures will continue to need on-going maintenance, review and refinement. The COE has also installed removable barriers on the upstream side of the Ortona and St. Lucie Lock spillway structures. The large difference in the up and downstream water levels at these structures compromises the effectiveness and use of pressure sensor devices. Such barriers will be considered for other structures where appropriate. A task force, established in 1991, comprised of representatives from the South Florida WMD, COE, FWC, FDEP, DERM, and FWS, continues to monitor, examine and make recommendations to protect manatees at water control structures and navigational locks.

The COE completed the "Section 1135 Project Modification Report on Manatee Protection at Select Navigation and Water Control Structures, Part II," which investigated several alternatives to protect manatees at locks. The COE contracted with the Harbor Branch Oceanographic Institute (HBOI) to develop and install a prototype acoustic array for manatee protection at lock gates. HBOI completed system design, and during 1999 the St. Lucie Lock was equipped with this manatee protection system (Fig. 14). This system consists of a device that is installed on the lock gates and detects the presence of manatees through acoustic signals. When a manatee is detected near the gate during the last 52 inches of closure, an alarm sounds; the gate stops closing and is then re-opened back to 52 inches. An upgraded version of this same type of system also has been installed at Port Canaveral Lock. Future plans are to install protective systems at the following locks: Moore Haven, Ortona, and Port Mayaca.

Figure 14. Water control structure retrofitted with pressure sensitive technology (left). Retrofitting of St. Lucie Lock with acoustic sensors (right) to protect manatees from being crushed as the gates close. (*Photographs by FWS and B. Brooks*)

FDEP currently is designing and preparing to install barriers at the Kirkpatrick Dam (Putnam County), and on the tainter valve culvert pipes at Buckman Lock (Putnam County) and downstream side of Inglis Lock (Levy County); work is anticipated to be completed during 2001. FDEP also has contracted with HBOI to install an acoustic array system at Buckman Lock, similar to arrays installed at the COE's Port Canaveral and St. Lucie Locks. Upon completion of the manatee protection systems at the Rodman Reservoir (Putnam County), FDEP plans to reopen Buckman Lock for operation. Currently the FDEP's Inglis Lock at Lake Rouseau/Withlacoochee River is not operating; long-term plans are to replace Inglis Lock with a smaller one with a manatee protection system installed.

HABITAT PROTECTION Intensive coastal development throughout Florida poses a long-term threat to the Florida manatee. There are three major approaches to address this problem. First, FWS, FWC, Georgia Department of Natural Resources (GDNR), and other recovery partners review and comment on applications for federal and state permits for construction projects in manatee habitat areas and to minimize their impacts. Under section 7 of the ESA, FWS annually reviews hundreds of permit applications to the COE for construction projects in waters and wetlands that include or are adjacent to important manatee habitat. FWC and GDNR provide similar reviews to their respective state's environmental permitting programs.

A second approach is the development of county manatee protection plans. The provisions of these plans are anticipated to be implemented through amendments to local growth management plans under the Florida's Local Government Comprehensive Planning and Land Development Regulation Act of 1985. In addition to boat speed rules, manatee protection plans are to include boat facility siting policies and other measures to protect manatees and their habitat. To date, five counties (Citrus, Collier, Dade, Duval, and Indian River counties) have completed manatee protection plans, which the State of Florida has approved, and other counties' plans are in varying stages of development. Of the five completed plans, FWS has approved only two, those of Citrus and Dade.

A third approach to habitat protection is land acquisition. Both FWS and the State of Florida have taken steps to acquire and add new areas containing important manatee habitat to federal and state protected area systems. The State of Florida has acquired important areas through several programs, most notably the Florida Forever Program (formerly the Conservation and Recreational Lands Program). In Florida, the Governor and Cabinet have included special consideration for purchase of lands that can be of benefit to manatees and their habitat. Over $500 million has been spent to acquire 250,000 acres, whose importance included, but was by no means limited to, protection of manatee habitat. Particularly important purchases have been made along and near the Crystal River, at Rookery Bay, the Sebastian River, and near Blue Spring. FWS has also acquired and now manages thousands of acres of land important to manatees and many other species in the NWR System. In addition to these efforts, FWS's initiative to propose new manatee refuges and sanctuaries factors into habitat protection. Both the State of Florida and FWS are continuing cooperative efforts with a view towards establishing a network of important manatee habitats throughout Florida.

Manatee Rescue, Rehabilitation and Release Thousands of reports of distressed manatees purportedly in need of assistance have been made to the state wildlife enforcement offices and other resource protection agencies by a concerned public. While most of the manatees do not require assistance, dozens of manatees are rescued and treated each year. A network of state and local agencies and private organizations (Fig. 15), coordinated by FWS, has been rescuing and treating these animals for well over twenty years.

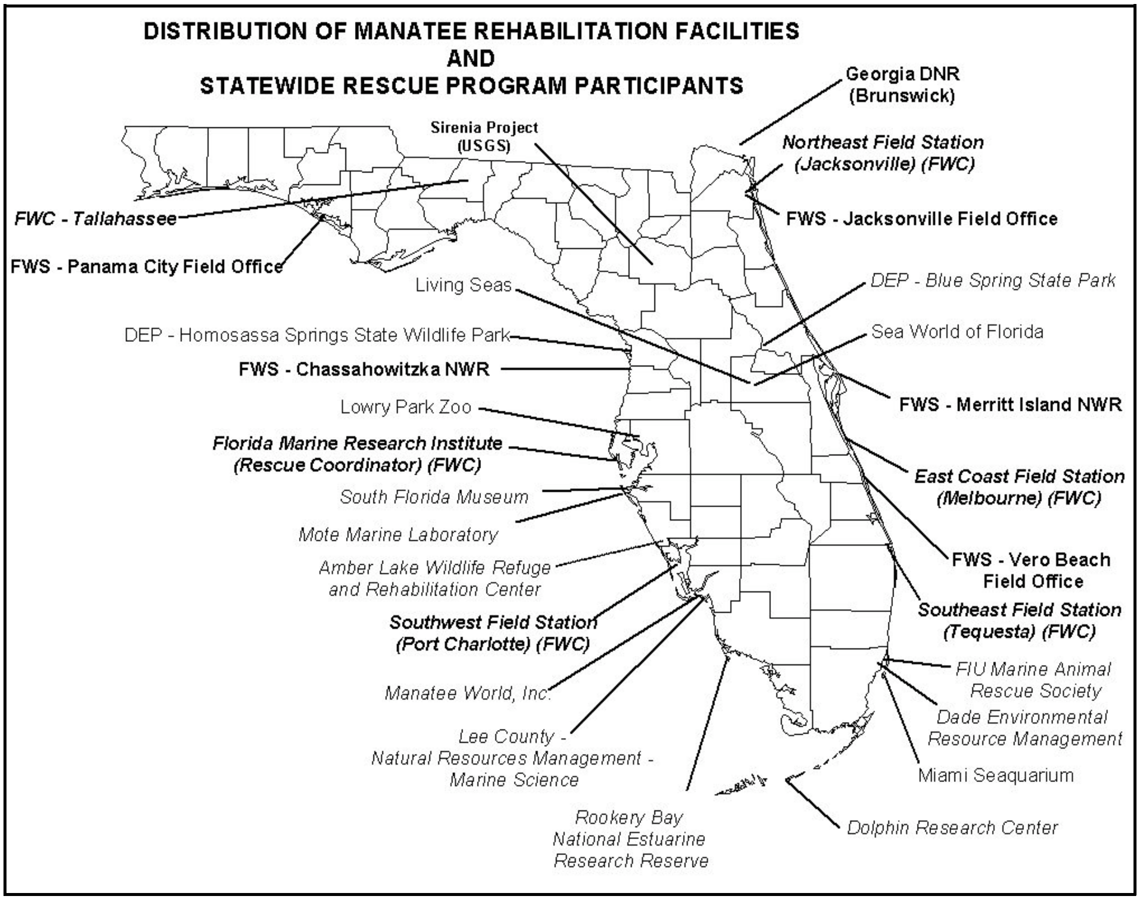


Figure 15. Locations of participants in the manatee rescue, rehabilitation, and release program.

Manatees are brought into captivity when stressed by cold weather, when struck and injured by watercraft, when injured because of entanglements in crab traps and monofilament fishing line, when orphaned, and when compromised by other natural and man-made factors. Program veterinarians and staff have developed treatments and protocols for these animals and have been remarkably successful in their efforts to rehabilitate compromised individuals (Fig. 16). Since 1973, over 180 manatees have been treated and returned to the wild (FWS unpublished data).

Treatments and protocols developed for these distressed animals have provided notable insights into the physiology and behavior of manatees. In certain settings, captive manatees are used in research; captive studies have provided a wealth of information on sensory capacities, digestion, reproduction, etc. Information obtained through treatments and research, in addition to the number of animals released back into the wild each year, contributes significantly to efforts to reduce mortality and further the recovery of the species.

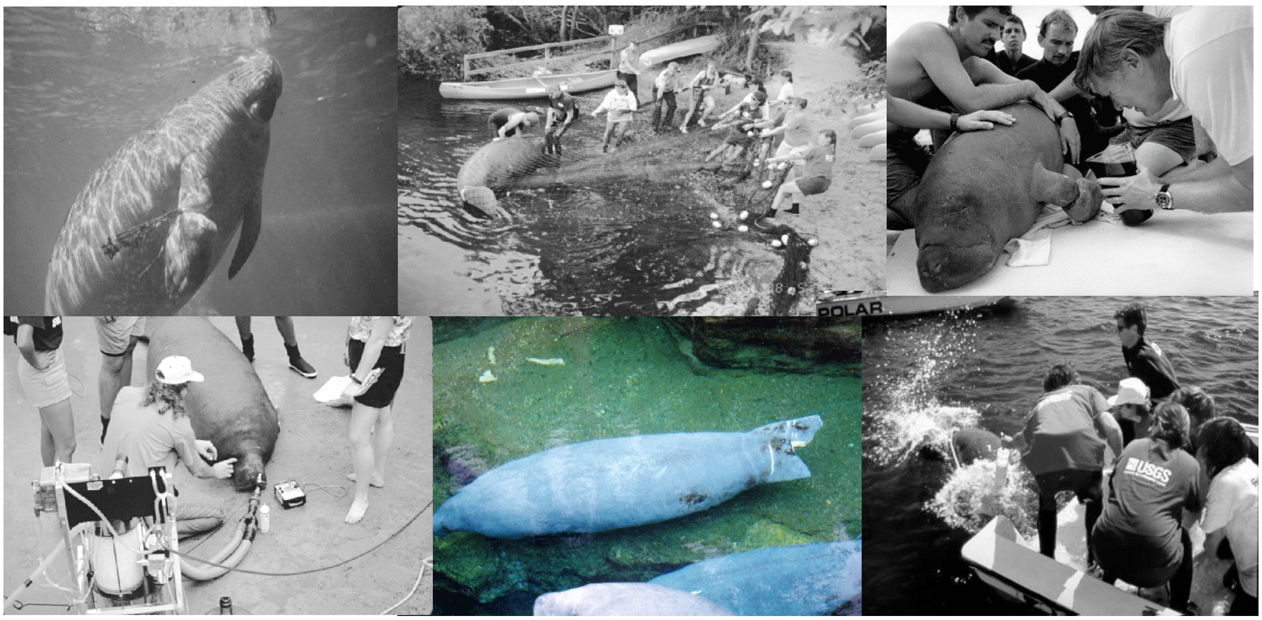


Figure 16. Manatee rescue, rehabilitation, and release program. (*Photographs by G. Rathbun, C. Shaw, J. Reid, Miami Seaquarium, J. Pennington, and J. Reid*)

Media coverage of manatee rescues, treatments, and releases helps to educate millions of people about manatees, the life-threatening problems that they face, and actions that can be taken to minimize the effect of anthropogenic activities on this species. In addition, more than eighteen million visitors a year see manatees at rehabilitation facilities and participate in manatee education programs sponsored by several parks. The publicity and outreach inherent in this program provide significant support to efforts to recover the manatee.

PUBLIC EDUCATION, AWARENESS, AND SUPPORT Government agencies, industries, oceanaria and environmental groups have all contributed to manatee public awareness and education efforts that were initiated in the 1970s. These efforts have expanded in scope and increased in quantity since that time. Some key counties in Florida also have started the education component of their manatee protection plans.

These public awareness and education efforts encourage informed public participation in regulatory and other management decision-making processes and provide constructive avenues for private funding of state manatee recovery programs, research, and land acquisition efforts through programs such as the specialty automobile license tag for manatees. This particular funding source has resulted in substantial savings in federal and state tax revenues and has permitted important work to proceed which likely would not have been possible in their absence.

The public has been made aware of new information on the biology and status of manatees, urgent conservation issues, and the regulations and measures required to assure their protection through the production of brochures, posters, films and videos, press releases, public service announcements and advertisements, and other media-oriented materials. Outdoor signs have been produced that provide general manatee information and highlight the problems associated with feeding manatees.

Manatee viewing opportunities have also been made available to the public. In addition, volunteers from several organizations annually give presentations to schools and other groups and distribute educational materials at festivals and events. Such efforts are essential for obtaining public compliance with conservation measures to protect manatees and their habitats.

Many public awareness materials have been developed specifically focusing on boater education. Public awareness waterway signs are produced and distributed alerting boaters to the presence of manatees. Brochures, boat decals, boater's guides, and other materials with manatee protection tips and boating safety information have been produced and are distributed by law enforcement groups, through marinas, and boating safety classes. Educational kiosks have been designed and installed at marinas, boat ramps, and other waterfront locations. Fishing line collection sites and cleanup efforts are being established. In addition, the Manatee Awareness Coalition of Tampa Bay and Crystal River NWR have initiated programs for on-water manatee public awareness.

Several agencies and organizations provide educator's guides, posters, and coloring and activity books to teachers in Florida and across the United States. In addition, Save The Manatee Club (SMC) and FWC Advisory Council on Environmental Education have produced a video for distribution to schools throughout Florida and the United States. SMC and FWC also provide free manatee education packets to students and staff interviews for students. Agencies and organizations help to educate law enforcement personnel about manatees and inform them about available outreach materials that can be distributed to user groups.

Public interest in manatee conservation also has grown internationally. Manatee education and public awareness materials are distributed in Central and South America and the wider Caribbean, as well as to numerous other countries around the world.

PART II. RECOVERY

The goal of this revised recovery plan is to assure the long-term viability of the Florida manatee in the wild, allowing initially for reclassification from endangered to threatened status (downlisting) and ultimately removal from the List of Endangered and Threatened Wildlife (delisting).

This section of the Recovery Plan presents: (A) details on an upcoming status review; (B) objective and measurable recovery criteria; (C and D) site-specific management actions to monitor and reduce or remove threats to the Florida manatee; and (E) Literature Cited. The steps for reclassification and removal from the list are consistent with provisions specified under sections 4(a)(1), 4(b), 4(c)(2)(B), and 4(f)(1) of the ESA. The FWS must, to the maximum extent practicable, incorporate into each recovery plan objective, measurable recovery criteria which, when met, would result in a determination that the species be removed from the List of Endangered and Threatened Wildlife. In designing these criteria, the FWS has addressed the five statutory listing/recovery factors (section 4(a)(1) of the ESA, (see page 1) to the current extent practicable.

A. STATUS REVIEW

The 1967 Federal Register Notice (32FR406) designating the West Indian manatee and several other species as “endangered” did not provide a detailed explanation for the listing. Since the manatee was designated as an endangered species prior to enactment of the ESA (1973), there was no formal listing package identifying threats to the species, as required by Section 4(a)(1). Under section 4(c)(2) of the ESA, the FWS is charged with periodically reviewing the the status of species included in the List of Endangered and Threatened Wildlife to determine whether any species should change in status from a threatened species to an endangered species, change in status from an endangered species to a threatened species, or be removed from the List.

During the 20 years since approval of the first manatee recovery plan, a tremendous amount of knowledge has been gained about manatee biology and ecology and significant protection programs have been implemented. The knowledge and the results of these protection programs are reflected in this recovery plan. The Manatee Population Ecology and Management Workshop scheduled for April 2002 will update and review the science and population ecology of manatees, including an assessment of the recovery criteria presented in this plan. The FWS has determined that the year following this workshop is an appropriate time to conduct a thorough status review of the Florida manatee and anticipates this review to take place in 2003.

The review will include:

(1) a detailed evaluation of the population status using the most up to date demographic data and other biological indices available (The FWS anticipates that much of this data will come from the April 2002 Manatee Population Ecology and Management Workshop);
(2) an evaluation of the status of manatee habitat as it relates to recovery;
(3) an evaluation of the existing threats to the species and the effectiveness of existing mechanisms to reduce or remove those threats (e.g., adequate protection areas, signage, enforcement, education and compliance have resulted in a reduction or minimization of watercraft deaths) as prescribed in this recovery plan;
(4) recommendations, if any, regarding reclassification of the Florida manatee; and
(5) if necessary, recommendations to update or modify recovery criteria.

B. RECOVERY CRITERIA

RECLASSIFICATION FROM ENDANGERED TO THREATENED (DOWNLISTING)

The near and long term threats from human-related activities are the reasons for which the Florida manatee currently necessitates protection under the ESA. The focus of recovery is not on how many manatees exist, but instead the focus is on implementing, monitoring and addressing the effectiveness of conservation measures to reduce or remove threats which will lead to a healthy and self-sustaining population. The Florida manatee could be considered for reclassification from endangered to threatened status if the following listing/recovery and demographic criteria are met:

LISTING/RECOVERY FACTOR CRITERIA: Tasks listed with each criterion are examples of actions that may reduce or remove the identified threats and were developed from recovery team discussions.

Listing/Recovery Factor A: The Present or Threatened Destruction, Modification, or Curtailment of a Species Habitat or Range (Habitat Working Group and Warm-water Task Force identified in other portions of this plan are tasked to further refine and improve these criteria.) In order to ensure the long-term recovery needs of the manatee and provide adequate assurance of population stability (i.e., achieving the demographic criteria), threats to the manatee's habitat or range must be reduced or removed. This can be accomplished through federal, state or local regulations (identified in Factor D below) to establish minimum spring flows and protect the following areas of important manatee habitat:

a. Minimum flow levels to support manatees at the Crystal River Spring Complex, Homosassa Springs, Blue Springs, Warm Mineral Spring, and other spring systems as appropriate, in terms of quality (including thermal) and quantity have been identified by the WMDs or other organizations.(Task 3.2.4.3)
b. A network of the level 1 and 2 warm-water refuge sites identified in Figure 7 are protected as either manatee sanctuaries, refuges or safe havens. (Task 1.2.3, 1.3, 3.2.2, 3.2.3, 3.2.4, 3.3.1)
c. Feeding habitat sites (extent, quantity and quality) associated with the network of warm-water refuge sites above in (b) have been identified by the HWG for protection. (Task 3.1(3), 3.3.8).
d. A network of migratory corridors, feeding areas, calving and nursing areas are identified by the HWG to be protected as manatee sanctuaries, refuges and/or safe havens in the following Florida counties: Duval (including portions of Clay and St. Johns in the St. Johns River), Volusia, Brevard, Indian River, Martin, Palm Beach, Broward, Dade and Monroe on the Florida Atlantic Coast; Citrus, Pinellas, Hillsborough, Manatee, Sarasota, Charlotte, Lee and Collier on the Florida Gulf Coast; and Glades County on the Okeechobee Waterway. (Task 1.3, 3.3.1)

Listing/Recovery Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes "Take" in the form of harassment, is currently occurring at some of the winter refuge sites and other locations. This "take" is presently not authorized under the MMPA or ESA. However, there are no data at this time to indicate that this issue is limiting the recovery of the Florida manatee. The actions in this plan that address harassment are recommended in order to achieve compliance with the MMPA and ESA and as a conservation benefit to the species. Statutory mechanisms outlined in Factor D to protect and enact protection regulations for important manatee habitats identified in Factor A and enact regulations to address unauthorized "take" identified in Factor E, will also assist to reduce or remove these threats.

Recovery actions and their subtasks specifically addressing this issue are 1.1, 1.11, 4.4 and those tasks identified in Factors A, D and E.

Listing/Recovery Factor C: Disease or Predation At this time, there are no data indicating that this is a limiting factor, thus no reclassification (downlisting) criteria are necessary.

Listing/Recovery Factor D: The Inadequacy of Existing Regulatory Mechanisms The current legal framework outlined below allows federal and state government agencies to take both broad scale and highly protective action for the conservation of the manatee and its habitat. The FWS believes these regulatory mechanisms are adequate for recovery. However, additional specific actions under these laws such as those listed pursuant to Factor A and E must be accomplished (as well as meeting the demographic criteria) before the FWS will consider this species for reclassification.

Factor A (a) Establish Minimum Flows (Task 3.2.4.3)

STATE Florida Water Resources Act of 1972, Chapter 373, F.S. (specifically Minimum Flows and Levels, Sect. 370.42, F.S. and Establishment and Implementation of Minimum Flows and Levels, Sect. 370.421, F.S.)

Factor A (b)(c) and (d) Protect Important Manatee Habitats (Task 1.2, 1.3.1, 1.3.2, 1.4, 3.2.2, 3.2.3, 3.2.4, 3.3.1, 3.3.8)

FEDERAL Endangered Species Act; Marine Mammal Protection Act; Clean Water Act, Sect. 401, 402 and 404; Rivers and Harbors Act, Sect. 10; National Environmental Policy Act; and Coastal Zone Management Act;

STATE Florida Manatee Sanctuary Act, Sect. 370.12(2), F.S.; Florida Water Resources Act of 1972, Chapter 373, F.S.; Florida Air and Water Pollution Control Act, Chapter 403, F.S.; State Lands, Chapter 253, F.S.; and State Parks and Preserves, Chapter 258, F.S.; and

LOCAL Florida Manatee Sanctuary Act, Sect. 370.12(o), F.S. which allows local governments to regulate by ordinance, motorboat speed and operations to protect manatees.

Factor E (a)(b)(c) Reduce or Remove Unauthorized "take" (Task 1.1, 1.2, 1.3.1, 1.3.2, 1.4, 1.6, 1.7, 3.3.1)

FEDERAL Marine Mammal Protection Act; and Endangered Species Act; and

STATE Florida Manatee Sanctuary Act, 370.12(2), F.S.

Listing/Recovery Factor E: Other Natural or Manmade Factors Affecting Its Continued Existence The most predictable and controllable threat to manatee recovery remains human-related mortality. In order to ensure the long-term recovery needs of the manatee and provide adequate assurance of population stability (i.e., achieving the demographic criteria), natural and manmade threats to manatees need to be reduced or removed. This can be accomplished through establishing the following federal, state or local regulations, tasks and guidelines to reduce or remove human caused "take" of manatees:

a. State safe havens and/or federal manatee refuges have been established by regulation and are being adequately enforced to reduce unauthorized watercraft-related “take” in the following Florida counties: Duval (including portions of Clay and St. Johns in the St. Johns River), Volusia, Brevard, Indian River, Martin, Palm Beach, Broward, Dade and Monroe on the Florida Atlantic Coast; Citrus, Pinellas, Hillsborough, Manatee, Sarasota, Charlotte, Lee and Collier on the Florida Gulf Coast; and Glades County on the Okeechobee Waterway. (Task 1.3, 1.4, 1.5, 3.3.1)
b. One half of the water control structures and navigational locks listed as needing devices to prevent mortality have been retrofitted. (Task 1.6)
c. Guidelines have been drafted to reduce or remove threats of injury or mortality from fishery entanglements and entrapment in storm water pipes and structures. (Task 1.7, 1.6.3)

DEMOGRAPHIC CRITERIA: The annual synoptic surveys have too many weaknesses to reliably guage the health of the population (see discussion of Population Size in the Introduction and in Appendix D). Therefore, the FWS has established population related benchmarks for certain aspects of manatee demographics (based upon mark/recapture studies and population modeling) that it will use to help determine the success of manatee conservation efforts. These are derived from the MPSWG’s Recommendation for Population Benchmarks To Help Measure Recovery (Appendix A). While these benchmarks are dependent on the amount and statistical reliability of the data available, we believe these “vital signs” are currently the best scientific indicators of the overall health of the manatee population. If future scientific studies indicate that other survival, reproduction, or population growth rates or other population indices are more appropriate for demographic recovery criteria, the FWS will modify these benchmarks.

The current benchmarks are as follows:

a. statistical confidence that the average annual rate of adult manatee survival is 90 % or greater;
b. statistical confidence that the average annual percentage of adult female manatees accompanied by first or second year calves in winter is 40% or greater; and
c. statistical confidence that the average annual rate of population growth is equal to or greater than zero.

These population benchmarks should be achieved with a 95% level of statistical confidence. When they are achieved in each of the four regions for the most recent ten year period of time (approximately one manatee generation), we may conclude that the manatee is not in danger of extinction throughout all or significant portion of its range and reclassify to threatened, provided the listing/recovery factor criteria (outlined above) are also met.

REMOVAL FROM THE LIST OF ENDANGERED AND THREATENED WILDLIFE (DELISTING)

The Florida manatee could be considered for removal from the List of Endangered and Threatened Wildlife if the following listing/recovery and demographic criteria are met:

LISTING/RECOVERY FACTOR CRITERIA: Tasks listed with each criterion are examples of actions that may reduce or remove the identified threats.

Listing/Recovery Factor A: The Present or Threatened Destruction, Modification, or Curtailment of a Species Habitat or Range (The Warm-water Task Force and Habitat Working Group identified in other portions of this plan are tasked to further refine and improve these criteria.) In order to ensure the long-term recovery needs of the manatee and provide adequate assurance of population stability (i.e., achieving the demographic criteria), threats to the manatee's habitat or range must be reduced or removed. This can be accomplished through federal, state or local regulations to establish and maintain minimum spring flows and protect the following areas of important manatee habitat:

a. Minimum flow levels to support manatees at the Crystal River Spring Complex, Homosassa Springs, Blue Springs, Warm Mineral Spring, and other spring systems as appropriate, in terms of quality (including thermal) and quantity have been adopted by regulation and are being maintained.(Task 3.2.4.3)
b. A network of level 1, 2 and 3 warm-water refuge sites identified in Figure 7 have been protected as either manatee sanctuaries, refuges or safe havens. (Task 1.2.3, 1.3, 3.2.2, 3.2.3, 3.2.4, 3.3.1)
c. Adequate feeding habitat sites (extent, quantity and quality) associated with the network warm-water refuge sites identified by the HWG and are protected. (Task 3.1(3), 3.3.8).
d. The network of migratory corridors, feeding areas, calving and nursing areas identified by the HWG are protected as manatee sanctuaries, refuges or safe havens. (Task 1.3, 3.3.1)

Listing/Recovery Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes "Take" in the form of harassment, is currently occurring at some of the winter refuge sites and other locations. This "take" is presently not authorized under the MMPA or ESA. However, there are no data at this time to indicate that this issue is limiting the recovery of the Florida manatee. The actions in this plan that address harassment are recommended in order to achieve compliance with the MMPA and ESA and as a conservation benefit to the species. Statutory mechanisms outlined in Factor D to protect and enact protection regulations for important manatee habitats identified in Factor A and enact regulations to address unauthorized "take" identified in Factor E, will also assist to reduce or remove these threats.

Recovery actions and their subtasks specifically addressing this issue are 1.1, 1.11, 4.4 and those tasks identified in Factors A, D and E.

Listing/Recovery Factor C: Disease or Predation At this time, there are no data indicating that this is a limiting factor, thus no delisting criteria are necessary.

Listing/Recovery Factor D: The Inadequacy of Existing Regulatory Mechanisms The current legal framework outlined below allows federal and state government agencies to take both broad scale and highly protective action for the conservation of the manatee and its habitat. The FWS believes these regulatory mechanisms are adequate for recovery. However, additional specific actions under these laws such as those listed pursuant to Factor A and E must be accomplished (as well as meeting the demographic criteria) before the FWS will consider this species for removal from the List of Endangered and Threatened Wildlife.

Factor A (a) Establish Minimum Flows (Task 3.2.4.3)

STATE Florida Water Resources Act of 1972, Chapter 373, F.S. (specifically Minimum Flows and Levels, Sect. 370.42, F.S. and Establishment and Implementation of Minimum Flows and Levels, Sect. 370.421, F.S.)

Factor A (b)(c) and (d) Protect Important Manatee Habitats (Task 1.2, 1.3.1, 1.3.2, 1.4, 3.2.2, 3.2.3, 3.2.4, 3.3.1, 3.3.8)

FEDERAL Marine Mammal Protection Act; Clean Water Act, Sect. 401, 402 and 404; Rivers and Harbors Act, Sect. 10; National Environmental Policy Act; and Coastal Zone Management Act;

STATE Florida Manatee Sanctuary Act, Sect. 370.12(2), F.S.; Florida Water Resources Act of 1972, Chapter 373, F.S.; Florida Air and Water Pollution Control Act, Chapter 403, F.S.; State Lands, Chapter 253, F.S.; and State Parks and Preserves, Chapter 258, F.S.; and

LOCAL Florida Manatee Sanctuary Act, Sect. 370.12(o), F.S. which allows local governments to regulate by ordinance, motorboat speed and operations to protect manatees.

Factor E (a)(b)(c) Reduce or Remove Unauthorized “take” (Task 1.1, 1.2, 1.3.1, 1.3.2, 1.4, 1.6, 1.7, 3.3.1)

FEDERAL Marine Mammal Protection Act; and

STATE Florida Manatee Sanctuary Act, 370.12(2), F.S.

Listing/Recovery Factor E: Other Natural or Manmade Factors Affecting Its Continued Existence The most predictable and controllable threat to manatee recovery remains human-related mortality. In order to ensure the long-term recovery needs of the manatee and provide adequate assurance of population stability (i.e., achieving the demographic criteria), natural and manmade threats to manatees need to be removed or removed. This can be accomplished through establishing the following federal, state or local regulations, tasks and guidelines to reduce or remove human caused "take" of manatees:

a. State, federal and local government manatee conservation measures (such as, but not limited to speed zones, refuges, sanctuaries, safe havens, enforcement, education programs, county MPPs etc.) have been adopted and implemented to reduce or remove unauthorized watercraft-related "take" in the following Florida counties: Duval (including portions of Clay and St. Johns in the St. Johns River), Volusia, Brevard, Indian River, Martin, Palm Beach, Broward, Dade and Monroe on the Florida Atlantic Coast; Citrus, Pinellas, Hillsborough, Manatee, Sarasota, Charlotte, Lee and Collier on the Florida Gulf Coast; and Glades County on the Okeechobee Waterway. These measures are not only necessary to achieve recovery, but may ultimately help to comply with the MMPA. (Task 1.3, 1.4, 1.5, 3.3.1).

   Stable or positive population benchmarks as outlined in the demographic criteria provide measurable population parameters that will assist in measuring the stabilization, reduction, or minimization of watercraft related "take." Two other indices (weight of evidence) will assist in measuring success include: (1) watercraft-related deaths as a proportion of the total known mortality; and (2) watercraft-related deaths as a proportion of a corrected estimated population. These and other indices should be monitored.

b. All water control structures and navigational locks listed as needing devices to prevent mortality have been retrofitted. (Task 1.6)
c. Guidelines have been established and are being implemented to reduce or remove threats of injury or mortality from fishery entanglements and entrapment in storm water pipes and structures. (Task 1.7, 1.6.3)

DEMOGRAPHIC CRITERIA: The ESA requires that the FWS, to the maximum extent practicable, incorporate into each recovery plan objective, measurable recovery criteria which, when met, would result in a determination that the species be removed from the List of Endangered and Threatened Wildlife. The MPSWG thus far has not proposed delisting criteria to the FWS "as specific, quantitative habitat criteria have yet to be developed" (Appendix A). In lieu of criteria from the MPSWG, the FWS will use the population benchmarks for reclassification (downlisting) to help determine the long-term success of manatee conservation efforts and recovery. While these benchmarks are dependent on the amount and statistical reliability of the data available, we believe these "vital signs" are currently the best scientific indicators of the overall health of the manatee population. If future scientific studies indicate that other survival, reproduction, or population growth rates or other population indices are more appropriate for demographic recovery criteria, the FWS will modify these benchmarks.

Those benchmarks are as follows:

a. statistical confidence that the average annual rate of adult manatee survival is 90 % or greater;
b. statistical confidence that the average annual percentage of adult female manatees accompanied by first or second year calves in winter is 40% or greater; and
c. statistical confidence that the average annual rate of population growth is equal to or greater than zero.

These benchmarks should be achieved with a 95% level of statistical confidence. When they are achieved in each of the four regions for an additional 10 years after reclassification (an additional manatee generation), we may conclude that the population is healthy and will sustain itself such that the Florida manatee could be removed from the List of Endangered and Threatened Wildlife provided the listing/recovery factor criteria (outlined above) are also met.

C. OUTLINE OF RECOVERY ACTIONS ADDRESSING THREATS

D. NARRATIVE OUTLINE OF RECOVERY ACTIONS

OBJECTIVE 1: Minimize causes of manatee disturbance, harassment, injury, and mortality. Manatees are killed and injured as a result of interactions with boats, water control structures, navigational locks, stormwater pipes, 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 maintenance and/or growth of the manatee population to attain recovery, such causes of mortality, injury, harassment and disturbance must be minimized. This section of the recovery plan identifies activities needed to minimize sources of disturbance, harassment, injury, and mortality.

1.1 **Promulgate special regulations for incidental take under the MMPA for specific activities.** FWS will evaluate its programs related to watercraft operation and watercraft access facilities and promulgate incidental take regulations under the MMPA for FWS activities (e.g., operation of vessels, managing surface waters and recreation on NWRs, and funding of boat ramps through Federal Aid). The process will lead to appropriate modification to FWS activities to ensure that such activities are minimized to the maximum extent practicable and ensure that these activities will have no more than a negligible impact on the manatee. FWS believes that programs of other federal and state agencies would benefit from a similar review and rule promulgation process.

1.2 **Continue state and federal review of permitted activities to minimize impacts to manatees and their habitat.** There are three separate processes where state and federal agencies provide biological review in order to minimize impacts to manatees and their habitat. These are: (1) review of permits for development activities (such as marinas, boat ramps, and other boat-related facilities) and dredge and fill activities; (2) review of permits for marine events (boat races and regattas); and (3) review of permits for power plants and other industrial outfalls (authorization to discharge warm water through the NPDES permit). FWS , FWC and GDNR should continue to participate in all of these review processes.

1.2.1 **Continue to review coastal construction permits to minimize impacts.** Dredge and fill activities and coastal construction of facilities such as marinas or large docks require permits from the COE, environmental resource permits from FDEP or the WMDs, and, in some cases, submerged land leases from Florida’s Board of Trustees, and in Georgia from the GDNR Coastal Resources Division. There are several aspects of these development projects that must be considered. First, the construction process itself should be conducted in a way to minimize the direct risk to manatees. Second, the permanent effect of the facility once it is built must be considered. For example, facilities should be designed to minimize shading of submerged aquatic plants. Third, the intended use or indirect effects of the project must also be considered. Marinas, boat ramps, and docking facilities can alter boat traffic patterns and increase boat traffic in specific areas, thus potentially increasing the possibility that manatees will be injured or killed. The effects of that traffic should be considered in the permit evaluation. Finally, the cumulative effect of multiple projects must be taken into account. While the impacts of a small single project may be negligible, multiple small projects may have a cumulative effect as great or greater than single large projects.

FWC will continue to provide assessments and recommendations on permit and submerged land lease applications to FDEP or appropriate WMD. GDNR Wildlife Resources Division will continue to provide assessments and recommendations on permit applications to the Coastal Resources Division. These permitting agencies have specific state statutory obligations to protect listed species and should use the recommendations provided by FWC and GDNR in meeting those obligations. In addition, FWC and GDNR will actively coordinate on an annual basis with the permitting agencies to ensure that the best data are available, that communication remains unimpeded, and that the review process is efficient and effective. FWS will continue to provide consultations, pursuant to section 7 of the ESA and other federal laws to the COE, USCG, and other federal agencies on permit applications where it has been determined that the activity may affect manatees or any other listed species and/or their habitat. This formal review process is a fundamental part of the manatee recovery program and must be continued. (Also refer to Task 3.3.5 regarding regulatory recommendations supporting habitat conservation.)

1.2.2 Minimize the effect of organized marine events on manatees. Marine sport events may also affect manatees, and many of these events require permits from the USCG. Under section 7 of the ESA and other federal laws, the FWS reviews and comments on permit applications where it has been determined that the activity may affect manatees or any other listed species. In order to provide guidance to the USCG regarding the types of events and the locations where manatee conditions are needed, standard draft guidelines were prepared. These are also intended to assist event planners involved in the planning process for boat races, fishing tournaments, water ski events, boat parades, and other organized boating events. The guidelines and standard conditions pertaining to when, where, and under what conditions such events could be held consistent with manatee protection objectives, should be updated and agreed upon by FWS and FWC. These guidelines should be distributed to the USCG groups in Florida. The USCG, in following those guidelines, should consult with FWS on appropriate events. FWC should provide technical expertise and data where needed to assist FWS in the review.

1.2.3 **Continue to review NPDES permits to minimize impacts.** The NPDES has been approved by the Environmental Protection Agency (EPA) to be implemented by FDEP and GDNR. Power plants and other industries that discharge into state waters are required to obtain a NPDES permit. In Florida, power plants that have the potential to affect manatees because of the attraction of a warm-water discharge are required to have a power plant manatee protection plan (MPP) as part of the permit. FWC works directly with the utilities in the development of the plan. FWC provides a recommendation to FDEP whether to accept, modify, or reject the MPP. FWS also reviews the plan and provides an assessment. This program ensures that issuance of the NPDES permit for discharge of warm water into ambient waters of the State of Florida by powerplants includes FWS- and FWC-approved plans. GDNR Nongame and Endangered Wildlife Program provides an assessment and recommendations to the GDNR Environmental Protection Division on NPDES permits in Georgia. This permit review process should be continued. (Task 3.2.2 provides further discussion of NPDES permits.)

1.2.4 **Pursue regulatory changes, if necessary, to address activities that are "exempt," generally authorized, or not covered by state or federal regulations.** FWS should look at non-regulated coastal construction projects or projects authorized under general permits to assess their cumulative impact on manatees. FWS should propose changes to existing regulatory programs as appropriate to minimize such impacts.

1.3 **Minimize collisions between manatees and watercraft.** Significant work is needed to monitor, review, assess needs to update existing protection zones (Task 2.7.2), develop new zones warranted in other areas, and make vessel operators aware of those zones. FWC has the responsibility for developing and amending state waterway speed and access rules to protect manatees. These rules aim to reduce the risk of collisions between manatees and watercraft by considering both manatee use patterns and the needs of the boating public. Further, under the authority of the ESA and MMPA and their implementing regulations at 50 CFR 17, FWS may designate certain waters as manatee protection areas, within which certain waterborne activities will be restricted or prohibited for the purpose of preventing the taking of manatees. Actions to address these needs are discussed below. In addition to these methods, alternative strategies minimizing collisions between manatees and watercraft should be investigated (Tasks 1.5.1, 1.5.2, 2.8.12, and 2.8.16).

1.3.1 **Develop and refine state waterway speed and access rules.** FWC is responsible for developing and amending state waterway speed and access rules to protect manatees under the State of Florida Manatee Sanctuary Act. FWC will monitor and review the effectiveness of existing zones and make appropriate modifications as needed. FWC will establish additional zones, as needed, to protect manatees throughout the state and implement where appropriate.

1.3.2 **Develop and refine federal waterway speed and access rules.** As necessary and appropriate, federal rules should be promulgated and existing rules should be modified in cooperation with the State of Florida and other concerned parties to protect the manatee. Particularly, waterways in or adjacent to NWRs, National Parks, and other federally-managed areas within manatee habitat should be protected as warranted. Under the authority of the ESA and MMPA and their implementing regulations at 50 CFR 17, FWS may establish boating speed and access rules in conjunction with efforts to designate certain waters as manatee sanctuaries (areas where all waterborne activities are prohibited), no entry areas or manatee refuges (areas where certain waterborne activities such as boat speeds may be regulated) (Task 3.3.1).

1.3.3 **Post and maintain regulatory signs.** The effective use of regulatory and informational signs is essential in providing the public with on-site information on manatee protection measures. Sign messages, to the greatest extent possible, should be uniform, understandable, and concise. Sign design and placement should provide for uniformity, rapid identification as a regulatory sign, and should be located at a site where it is readily observable to the target audience. Regulated areas should be posted by the appropriate agency. Of critical need is the continued effort to inspect and repair/replace signs as needed in an expedient manner. A task force, which includes the USCG, FWC, FWS, the navigation districts, and those counties with sign-posting responsibilities needs to be established. This task force should focus on improving the sign-posting and maintenance process and will explore innovative sign designs that would contribute to better compliance and enforcement.

1.4 **Enforce manatee protection regulations.** Enforcement is one the highest priorities for manatee recovery. Compliance with manatee protection regulations will reduce human-caused manatee mortality, particularly that caused by watercraft collisions. Effective enforcement of these regulations is needed to maximize protection efforts and to minimize manatee injuries and deaths.

(Also refer to Task 1.11 and its related tasks regarding enforcement of regulations prohibiting harassment).

1.4.1 Coordinate law enforcement efforts. Enforcement of manatee protection rules is provided by officers of FWS and FWC-DLE, USCG, and local law enforcement agencies, as well as the courts. To ensure compliance with the waterway speed and access rules and with manatee harassment provisions, enforcement capabilities must be expanded and coordinated. Although efforts have increased significantly during the past two years, manatee enforcement operations still must be expanded in both geographic scope and frequency. To meet these needs, federal and state enforcement agencies should take all possible steps to increase funding and heighten agency priority for manatee-related law enforcement activities. Those activities should be maintained at levels commensurate with those of vessel traffic, watercraft-related manatee deaths, and added enforcement responsibilities. To carry out enforcement activities as efficiently and cost-effectively as possible, involved agencies are encouraged to coordinate enforcement efforts. In addition, enforcement agencies should review and assist as possible with the development of new manatee protection statutes and regulations, the posting of manatee regulatory signs, enforcement training seminars, studies to monitor regulatory compliance, and actions by the judiciary to prosecute violations.

1.4.2 Provide law enforcement officer training. Law enforcement officers responsible for enforcing manatee regulations need to receive training in order to acquire knowledge and skills to enhance their abilities. Officers should be given training on manatee regulations during appropriate agency training courses. Refresher training should be conducted annually at appropriate opportunities.

1.4.3 Ensure judicial coordination. Designated personnel will meet periodically with members of the judiciary to ensure their knowledge of present manatee protection regulations or changes thereto, as well as to provide a forum for information exchange.

1.4.4 Evaluate compliance with manatee protection regulations. Compliance with manatee protection regulations is paramount to their subsequent success. FWS, FWC, and local governments should evaluate compliance with manatee protection regulations through research, surveys and other methods to ensure effectiveness and to identify needed improvements (Task 2.7.2.2.).

1.4.5 **Educate boaters about manatees and boater responsibility.** State-wide speed limits, boat operator licenses, and mandatory boater education will enhance efforts to reduce watercraft-related manatee deaths by offering opportunities to educate boaters about rules to protect manatees and to reduce boat speeds in other areas where manatees may occur. New proposals to establish state-wide boating safety measures should be encouraged. Particular efforts should be made to integrate manatee protection concerns into any new boater education programs (Tasks 4.1 through 4.3.). A website should be developed to allow the public and boating community easy access to manatee protection zone information (Task 4.2.2).

1.4.6 **Evaluate effectiveness of enforcement initiatives.** In recent years, both federal and state agencies have been using targeted enforcement strategies in an attempt to increase boater compliance with speed zones and ultimately reduce manatee injuries and death. FWS strategy has been to allocate significant enforcement manpower to specific areas on designated weekends. These enforcement teams travel to various locations around the state, with particular emphasis given to those zones within counties where there is a history of high watercraft-caused manatee deaths. FWC has increased its emphasis on enforcement and compliance with manatee speed zones by adding new officers, conducting law enforcement task force initiatives, increasing overtime, and increasing the proportion of law enforcement time devoted to manatee conservation. FWS and FWC should evaluate the effectiveness of these and other enforcement efforts and make adjustments, as appropriate. The research should evaluate if there are significant changes in boater compliance as a result of additional enforcement, and determine the residual effect of the enforcement efforts, if any.

1.4.7 **Provide updates of enforcement activities to managers.** It is important for managers to have a good understanding of enforcement activities and special initiatives in order to determine if the desired outcomes (reduction of manatee injury/death and enhanced public awareness and compliance) are achieved. In addition, up-to-date information on enforcement activities is needed for outreach and media contacts. As part of a new manatee enforcement initiative, FWC provides updates of manatee-related enforcement every other week to FWC managers. Such data summary and distribution should continue. Other law enforcement agencies also should provide similar updates of their special enforcement details. Information provided in the updates should be standardized across agencies so that a law enforcement database can be developed to provide information on effort, number of citations and/or other contacts, vessel registration, size, type, disposition of the case, and other pertinent information.

1.5 **Assess and minimize mortality caused by large vessels.** Large vessels (e.g., tugs and cargo vessels) and large displacement hull vessels are known to kill manatees. Some animals appear to be pulled into propeller blades by the sheer power of generated water currents, while 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.

1.5.1 **Determine means to minimize large vessel-related manatee deaths.** Studies should be undertaken to: (1) further review mortality data for evidence of deaths attributable to large vessels; (2) examine barge, tug, and other large vessel traffic patterns relative to manatee distribution; (3) assess the feasibility and cost of installing propeller guards or shrouds on large displacement hull vessels or tugs routinely plying waterways used by manatees; (4) evaluate ways to educate harbor pilots about threats large vessels pose to manatees; and (5) identify other possible mitigation measures to minimize these threats. Actions to implement appropriate measures should be taken based on study findings.

1.5.2 **Provide guidance to minimize large vessel-related manatee deaths.** FWS and FWC will promote use of devices such as fenders to maintain minimum stand-off distances of four feet at maximum compression between moored vessels and between vessels and wharves to minimize manatee deaths. If studies support actions to address the threat of large vessel propeller-related incidences to manatees, it is recommended that propellers of large displacement hull vessels, particularly tugs that tend to remain in harbors or rivers, be retrofitted with a propeller guard or shroud to reduce these types of mortalities.

1.6 **Eliminate manatee deaths in water control structures, navigational locks, and drainage structures.** The second largest source of human-related manatee death is due to entrapment in water control structures and navigational locks. These structures are owned and operated by the WMDs, COE, and FDEP and are primarily located in South Florida. They have been responsible for an average of 10 manatee deaths per year since 1995 and a total of 167 deaths since 1976. An ad hoc interagency task force was established in 1991 (current members include South Florida WMD, COE, FWS, DERM, FWC, and FDEP) to examine steps to prevent such deaths. This group meets at least twice a year to discuss recent manatee deaths and measures to protect manatees from structure-related mortality. The overall goal is to eliminate completely structure-related deaths.

In addition to causing crushing deaths, manatees may become trapped in the extensive canal systems of south Florida. Manatees passing through open structures become trapped once the structures close, due to changing water conditions. Manatees trapped in the shallow canal systems are vulnerable to cold stress during the winter. An evaluation and mapping of manatee-accessible canals is needed, and actions should be taken to prevent manatee entry into these areas.

FWS also should assess the need for manatee protection technology and help to update standard operating procedures at the lock systems at Lake Moultrie, South Carolina and Lake Seminole, Florida/Georgia.

Entrapment in drainage structures such as pipes, culverts and ditches also lead to injury and death of manatees. Installation of barriers or guards on such structures can prevent future entrapments.

1.6.1 Install and maintain protection technology at water control structures where manatees are at risk and monitor success. Pressure sensor devices have been installed at the five water control structures in south Florida through a South Florida WMD/COE cooperative project. Although the success of these devices generally has been encouraging, two structures equipped with the device have failed to eliminate all manatee deaths at them. An investigation at S-25B, after two deaths in December 1999, revealed that modifications to the sensitivity were required to provide the needed protection for manatees; after a manatee death at S-27 in January 2000, the South Florida WMD moved the manatee sensor strips in an attempt to get them closer to the actual gate. Thus, while it has been demonstrated that manatees can be successfully protected through the installation of pressure devices at water control structures, it is possible that as more devices are installed and operated, occasional failures will occur until all site-specific maintenance and installation needs are identified and resolved.

Twenty identified water control structures should be equipped with a manatee protection system (MPS) (pressure devices or removable barriers) by the year 2004. Removable barriers should be installed at structures where the pressure sensor devices are not feasible or appropriate. Standard operating procedures to protect manatees also have been developed for periods when the barriers are removed for high flow or cleaning the debris off the barriers. MPSs will be installed at additional water control structures in the Central and South Florida Project on a case-by-case basis as part of the Comprehensive Everglades Restoration Plan (CERP), and standard operating procedures and the need for a MPS should be assessed and installed as needed for other structures in manatee habitat.

The FDEP is designing and preparing to install barriers at the Kirkpatrick Dam, the tainter valve culvert pipes at Buckman Lock, and the downstream side of Inglis Lock. FDEP anticipates to complete this work during the summer of 2001.

1.6.2 **Install and maintain protection technology at navigational locks where manatees are at risk and monitor success.** Manatee protection devices have been installed at the St. Lucie, Port Canaveral, and Taylor Creek Locks. The long-term plan is to continue installing these protective devices on the remaining locks in order of their potential to harm manatees until all such structures are equipped with manatee protection devices. The COE should continue to partner with local sponsors to accomplish this retrofitting as quickly as possible. The COE should prepare an annual report assessing the performance of the manatee protection devices and evaluating the needs for modification and improvement.

FDEP has contracted with HBOI to install an acoustic array system at Buckman Lock similar to arrays installed at the COE's Canaveral and St. Lucie Locks. FDEP plans to reopen Buckman Lock for operation once the manatee protection systems are installed on both the Buckman Lock and Kirkpatrick Dam. It is anticipated that these projects will be completed during the summer of 2001 (the State of Florida has also budgeted $800,000 to begin restoring the Oklawaha River). Currently FDEP's Inglis Lock at Lake Rouseau/Withlacoochee River is not operating; long-term plans are to replace the existing lock with a smaller one which includes manatee protection equipment.

1.6.3 **Minimize injuries and deaths attributable to entrapment in drainage structures.** Sites where manatees have been rescued or died due to entrapment in drainage structures should be identified and, as warranted, steps taken to install barriers or guards which prevent such entrapment at these culverts or drainage structures. Additionally, stormwater outfalls or similar drainage structures in aggregation areas should be retrofitted with appropriate barriers to prevent manatee entrapment. Federal, state, and local permits should require that new drainage structures (greater than 18 but less than 84 inches in diameter) in manatee habitat be grated or otherwise made inaccessible to manatees.

1.6.4 **Assess risk at existing and future water control structures and canals in South Florida.** Using existing data bases and/or field inspections, categorize all structures as to whether manatees could pass through the structure, and what level of risk the structure poses. Similarly, characterize all canals (including minor irrigation ditches and storm water connector canals) as to whether manatees have access. Based on interagency recommendations, some canals may be designated as off-limits to manatees. The South Florida WMD should establish manatee-safe barriers to prevent access to designated areas. The CERP will dramatically alter the water delivery system in south Florida. New canals and water retention areas will be created, and existing canals will be modified or eliminated. It is critical that the COE and South Florida WMD coordinate closely with FWS and FWC and consider impacts to manatees from this long-range restoration project. Only manatee-safe structures should be installed, and manatee access to newly-created areas should be evaluated by the interagency task force.

1.7 **Minimize manatee injuries and deaths caused by fisheries and entanglement.** Due to the dynamic nature of commercial and recreational fishing and gear, information on interactions with fishing techniques and gear should be kept under review by FWS, GDNR, and FWC, and measures to reduce or avoid such interactions should be taken. This review should also assess the impacts of the mariculture industry and develop recommendations to minimize impacts to manatees and habitat. To minimize adverse entanglement interactions, the following steps are needed. A working group, which was established in 1999 to address fishery and marine debris and to make recommendations to minimize impacts, should continue to meet regularly.

1.7.1 **Minimize injuries and deaths attributed to crab pot fishery.** With the recent increasing trend of manatee rescues from crab trap buoy lines, information on interactions with buoy lines should be kept under review by FWC and FWS, and steps should be taken to improve reporting and documentation of such incidents. Steps to identify and implement measures which would reduce or avoid such interactions should be taken, including research regarding gear interactions and ways to avoid them, outreach, and promulgation of regulations (e.g., gear modification) if necessary.

1.7.2 **Minimize injuries and deaths attributed to commercial and recreational fisheries, gear, and marine debris.** Sites where interactions with recreational and/or commercial fishing gear occur should be identified and, as warranted, steps should be taken to assess and implement actions to prevent potentially threatening interactions with fishing gear. Strategies to reduce monofilament entanglements also need to focus on educating the fishing community on properly discarding monofilament and provide an avenue for recycling it. Strategies also should encourage underwater and drift line debris clean-up of monofilament and other debris in popular fishing areas used by manatees (Task 2.7.4).

1.8 **Investigate and prosecute all incidents of malicious vandalism and poaching.** Poaching, shooting, butchering, and other malicious vandalism against manatees are rare occurrences. All reports and evidence regarding such incidents should be turned over to FWS law enforcement agents for investigation and prosecution to the fullest extent of the law.

1.9 **Update and implement catastrophic plan.** FWS and FWC Contingency Plans for Catastrophic Rescue and Mortality Events for the Florida Manatee should be reviewed annually and updated as needed by those who would be involved in the response. Additionally, guidance and notification procedures between FWC and FWS should be developed and updated as needed for events that do not reach unusual or catastrophic levels in order for such events to be documented.

1.10 **Rescue and rehabilitate distressed manatees and release back into the wild.** Thousands of reports have been provided by the public regarding sick, injured, orphaned, entrapped, and wayward manatees that appear to be in need of assistance. While many clearly do not require intervention, 30 to 40 manatees are rescued every year. Some are assisted and immediately released, while others are taken to one of three critical-care facilities for supportive treatment. Animals successfully treated are released, and to the extent possible, their progress is monitored through tagging and tracking studies. Publicity surrounding distressed manatees, their rescues, treatment, and outcome help to educate millions of people every year about manatees and the problems that they face. The number of manatees successfully treated and released back into the wild provides an important safeguard to the wild population of manatees.

1.10.1 **Maintain rescue network.** FWS is responsible for the rescue and rehabilitation network and coordinates this program through an endangered species/marine mammal enhancement permit. Participants are authorized to participate in the program through Letters of Authorization (LOAs) under the permit held by FWS Jacksonville Field Office. Letter holders: (1) verify the status of manatees reportedly in distress; (2) rescue and/or transport rescued manatees; and (3) treat and maintain distressed manatees. The terms and conditions of the LOA describe the letter holders' level of participation and responsibilities in the program, based on their level of experience and resources. FWS must retain a current permit to authorize these activities and must maintain, update, and modify participant LOAs. As needs and circumstances dictate, letter holders may be added or removed from the program.

To ensure prompt, effective responses to distressed manatees, a rescue coordinator is needed to coordinate and mobilize rescue network teams. FWC 's FMRI maintains a network of field stations to conduct manatee research throughout the state. Field station activities are coordinated through the FMRI's Marine Mammal Pathobiology Laboratory's manager, who acts as the rescue coordinator. FMRI's existing network of staff, resources, and contacts with local law enforcement officials (and others likely to receive reports of distressed manatees) provides the necessary infrastructure for the program. Reports of distressed animals are directed to the rescue coordinator and his/her staff, who in turn contact authorized participants to respond. FWS is notified of ongoing rescues and unusual or significant events, as appropriate. GDNR maintains similar capabilities through its Nongame and Endangered Wildlife Program in their Brunswick, Georgia office.

1.10.2 Maintain rehabilitation capabilities. Adequate facilities are needed to place and treat injured animals. Every year, there are approximately 50 manatees in captivity at any given time, including manatees receiving critical and long-term care treatment. In 2000, there were three critical-care and six long-term care facilities treating manatees, including three out-of-state facilities. In order to maintain our ability to treat distressed manatees, critical care space must be available for these animals. While every effort is made to release treated manatees in a timely manner, some animals are not immediately releasable. Manatees that cannot be released quickly may be transferred to long-term care facilities to make room for critical-care cases. When necessary, existing facilities may expand their holding areas, or additional facilities may be authorized to create room for long-term care cases. Critical-care facilities provide the resources needed to conduct these activities; some costs are statutorily defrayed throughout the State of Florida.

1.10.3 Release captive manatees. As manatees complete the rehabilitation process, their medical status is reviewed by respective facility veterinarians in anticipation of their release. Following this review of physical and behavioral parameters, facility veterinarians recommend that the animal is either ready for release or should be retained for further supportive care. If an animal is deemed healthy, FWS (with input from the Interagency Oceanaria Working Group (IOWG)) evaluates the status of the animal in the context of captive release guidelines and determines whether or not the animal should be released. When an animal is deemed releasable, a release site and release date are identified, and appropriate follow-up monitoring plans are selected. The animals are then transported to the selected site and released. Follow-ups are then conducted, relying on either active monitoring (in which the animals are tagged with satellite, very high frequency (VHF), and/or sonic tags and tracked via satellite and in the field) or passive monitoring (which relies on marking the animals with PIT tags and freeze-brands or by their unique, distinctive markings). These animals are then monitored opportunistically in the field during field studies and/or through the carcass salvage program. Methods identified during a 1998 captive release workshop should be implemented to improve survival rates for released captives. Behavioral parameters need to be evaluated to assess their value in the captive release process.

1.10.4 Coordinate program activities. In addition to authorizing network participants, FWS coordinates many of the day-to-day needs of the program. All transfers and releases, research proposals, and follow-up monitoring plans, program concerns, etc., are evaluated and acted upon by FWS. Many of these are discussed and resolved through the IOWG, which meets twice a year to coordinate rescue, rehabilitation, and release activities and to manage captive program activities to meet manatee recovery objectives. Inherent in this are reviews on the status of rescue and rehabilitation activities, record keeping, development and review of rescue, transport, rehabilitation, maintenance, and release methods, informational exchanges, etc. A product of these meetings will include the development of an annual work plan describing projected releases and monitoring activities.

1.10.5 Provide assistance to international sirenian rehabilitators. Manatee rescue and rehabilitation activities in the United States and Puerto Rico are characterized by more than 30 years of experience and expertise. Rescue and transport techniques, medical practices, and release protocols have been successfully developed and are models for similar efforts. These experiences and expertise should be shared with other countries developing manatee and dugong rescue and rehabilitation programs.

1.10.6 Provide rescue report. An annual report summarizing each year's rescue and rehabilitation activities will be prepared consistent with the requirements of FWS's endangered species/marine mammal enhancement permit. In the interim, monthly updates will be made available to program participants through FWS's internet website.

1.11 Implement strategies to eliminate or minimize harassment due to other human activities. In some cases, human activities (e.g., fishing, swimming, snorkeling, scuba diving, manatee observation, and provisioning) may also disturb, alter behavior or harass manatees. Such disturbance could be life-threatening to manatees, for example, if it occurs in warm-water refuges and animals subsequently move into colder waters. Areas of such conflict should be identified and management actions implemented in order to reduce negative impacts on manatees. Harassment of manatees is considered a form of take as defined in both the ESA and MMPA. Any activity that results in a change of natural behavior which could create harm to the animal is considered take. Most waterborne activities, as well as some upland activities, have the potential to disturb and harass manatees. The following efforts are needed to minimize the impact of these activities.

1.11.1 Enforce regulations prohibiting harassment. Where clear and convincing evidence of harassment is occurring, enforcement of regulations controlling such activities is needed.

1.11.2 Improve the definition of "harassment" within the regulations promulgated under the ESA and MMPA. The current definition of harassment is very vague, making it difficult to enforce. Regulatory definitions need to be amended to specify, to the greatest extent practicable, what actions and activities constitute manatee harassment.

OBJECTIVE 2: Determine and monitor the status of manatee populations. The success of efforts to develop and implement measures to minimize manatee injury and mortality depends upon the accuracy and completeness of data on manatee life history and population status. Population data are needed to identify and define problems, make informed judgments on appropriate management alternatives, provide a sound basis for establishing and updating recovery criteria and management plans, and to determine whether or not actions taken are achieving management objectives. The tasks outlined below are essential to a complete understanding of manatee population status and trends. For all tasks, publication of peer-reviewed results is the preferred method of information dissemination. A detailed research plan is presented in Appendix D and includes informative background information and more detail than is presented here in the narratives.

2.1 Continue the MPSWG. The interagency MPSWG was established in March 1998 as a subcommittee of the recovery team. The group's primary tasks are to: (1) assess manatee population trends; (2) advise FWS on population criteria to determine when species recovery has been achieved; and (3) provide managers with interpretation of available information on manatee population biology. The group also has formulated strategies to seek peer review of their activities. The MPSWG should continue to hold regular meetings, refine recovery criteria, annually update regional and statewide manatee status statements, convene a population biology workshop early in 2002, analogous to the one held in 1992, and publish the results of the workshop.

2.2 Conduct status review. After the Population Status Workshop referenced in Task 2.1 is held, FWS will conduct a status review of the Florida manatee. The review will include: (1) a detailed evaluation of the population status using the benchmark data obtained from the 2002 Population Biology Workshop; (2) an evaluation of the status of manatee habitat as it relates to recovery-based information obtained from the HWG; (3) an evaluation of existing threats to the species and the effectiveness of existing mechanisms to control those threats; (4) recommendations, if any, regarding reclassification of the Florida manatee from endangered to threatened; and (5) objective, measurable criteria for delisting.

2.3 Determine life history parameters, population structure, distribution patterns, and population trends. Population research and data are needed to determine the status of the Florida manatee population. Data collection should be focused so that information on manatee sightings, movement patterns, site use and fidelity, and reproductive histories all can be utilized for further analyses of manatee survival and reproductive rates. Tools which should be continued as a means of gathering these data include: (1) the Manatee Individual Photo-identification System (MIPS); (2) the carcass salvage program; (3) PIT-tagging; (4) telemetry studies; and (5) aerial survey. It is particularly important to utilize these tools at important wintering sites, areas of high use, and poorly-studied regions.

2.3.1 Continue and increase efforts to collect and analyze mark/recapture data to determine survivorship, population structure, reproduction, and distribution patterns. Photographs using standardized protocols for data collection and coding should be collected annually and documented in the field, especially at the winter aggregation sites; these efforts should be expanded, particularly in Southwest Florida. In addition, PIT tags should be inserted under the skin of all manatees that are captured during the course of ongoing research or rescue/rehabilitation. All manatees captured, recaptured, rescued, or salvaged should be checked for PIT tags and other identifying information, because these data provide an additional source of life history information (changes in manatee size, reproductive status, and general condition between time of tagging and recovery). Methods for reliably checking for PIT tags on free-swimming manatees should be developed and tested, and plans should be developed for re-examining the utility of PIT-tagging manatees of certain age classes (juveniles and subadults) or in specific areas where photo-ID is not a feasible way to re-identify individuals.

Analyses using mark-recapture modeling procedures to estimate annual survival rates should be updated annually, utilizing data in MIPS and comparing results to analyses of PIT tag data. To enhance the accuracy and precision of survival estimates, dead manatees previously identified by photographic documentation must be noted in the MIPS database before mark-recapture analyses are undertaken. This research should include estimates of sample sizes required to determine population traits, such as survival and reproductive rates.

Additionally, emphasis should be placed on estimating variance and 95% confidence intervals.

Concurrently with data collection and monitoring, it is important to conduct long-term studies of reproductive traits and life histories of individual females. Such studies would provide information on: (1) age at first reproduction; (2) age-specific birth rates; (3) calving interval; (4) litter size; and (5) success in calf-rearing. The relative success of severely- and lightly-scarred females in bearing and rearing calves also should be determined.

2.3.2 **Continue collection and analysis of genetic samples to determine population structure and pedigree.** Collection of tissue samples from salvage specimens and from living manatees at winter aggregation sites, captured during research, or rescued for rehabilitation should continue. Continued genetic analysis through collaborations with state and federal genetics laboratories may reveal greater population structure than has been demonstrated thus far (i.e., a significant difference between east and west coasts, but not within coasts). Such research will improve our ability to define regional populations and management units. Stock and individual identity for forensic purposes ultimately will be possible. Analytical techniques recently developed for identifying the structure of other marine stocks should be investigated.

Paternity cannot be established in wild manatees without the ability to determine family pedigrees. This information is needed to determine if successful reproduction is limited to a small proportion of adult males, which has important implications for the genetic diversity of the Florida manatee population. By continuing the development of nuclear DNA markers, pedigree analysis can be applied to the growing collection of manatee tissue samples. Pedigree analysis also would improve greatly our knowledge of matrilineal relationships and female reproductive success. Identification of factors associated with successful breeding by males is important in assessing reproductive potential in the wild and in captivity.

2.3.3 **Continue carcass salvage data analysis to determine reproductive status and population structure.** Information and tissue samples collected from all carcasses recovered in the salvage program to determine reproductive status should be continued. Resulting estimates of reproductive parameters complement information obtained from long-term data on living manatees and will help to determine trends and possible regional differences in reproductive rates. The salvage program yields important information on the manatee population sex ratio and proportion of age classes (adult, subadult, juvenile, and perinatal) within each cause-of-death category. Annual changes in these proportions may indicate increases or decreases in certain types of mortality, and thus should be considered as part of the weight of evidence that supports (or rejects) a reclassification decision. Ear bone growth-layer-group analysis should be continued to determine more precise ages of dead manatees, particularly those that have a known history through the MIPS database, telemetry studies, or PIT tag data. Although the age structure of the carcass sample is biased toward younger animals, opportunities may occur to document better the natural age structure within specific regions because of age-independent mortality events.

2.3.4 **Continue and improve aerial surveys and analyze data to evaluate fecundity data and to determine distribution patterns, population trends, and population size.** Aerial surveys provide limited information on the proportion of calves to adults, which may provide insights on reproductive trends when a long time-series of surveys have been conducted by one or relatively few individuals in the same geographic regions. Calf counts from such surveys should be continued and should be compared to those obtained by photo-ID methods.

As appropriate and possible, local and regional aerial surveys should be undertaken or continued to improve information on habitat use patterns and changes in distribution. Documentation of changes in distribution at power plants will be particularly important when changes in warm water availability occur.

Methods to correct for various types of visibility bias in surveys should be developed. Standard procedures for survey teams involved in annual statewide surveys need to be developed and implemented. Where appropriate, strip transect aerial surveys should be used, as it is possible to use this type of survey data to detect regional population trends. Specifically, strip transect surveys should be continued on an annual basis in the Banana River, and their feasibility should be investigated in remote coastal areas of Southwest Florida. To the extent possible, all aerial surveys should be designed to estimate accurately a minimum population number.

2.3.5 **Continue collection and analysis of telemetry data to determine movements, distribution, habitat use patterns, and population structure.** Multi-year telemetry studies have been completed for the Atlantic coast and Southwest Florida from Tampa Bay through Lee County, and research findings have been summarized in manuscripts currently undergoing peer review. Radio-tracking has provided substantial documentation of seasonal migrations, other long-distance movements, and local movements that reveal patterns of site fidelity and habitat use. Such information is needed from each region, particularly Southwestern Florida and the Everglades and areas where anticipated changes are likely to impact manatees, in order to develop management strategies for all significant subgroups within the regional population, however transitory they may be.

Steps should be undertaken to incorporate geographic positioning system (GPS) technology into telemetry studies to improve the accuracy of manatee location data. Such improvements will be helpful in studying precise habitat-use patterns (e.g., the extent to which manatees use marked boat channels verses waterway margins for travel) and the location of preferred foraging sites, especially around warm-water refuge sites.

2.3.6 Continue to develop, evaluate, and improve population modeling efforts and parameter estimates and variances to determine population trend and link to habitat models and carrying capacity. Uncorrected aerial survey data do not permit statistically valid population estimation or trend analysis. Models to correct for the inherent bias and uncertainty have been developed, and these efforts need to be continued.

It also is important to utilize models such as that developed by Eberhart and O'Shea (1995). The underlying assumptions of a population model, the importance of parameters used in the model, the accuracy and uncertainty of the parameter estimates, the relationships of the parameters, and the appropriateness of the mathematics implemented in the model need to be critically evaluated and updated. Also, comparisons need to be made between predicted outcomes of a model and estimates or indices of population trend from other modeling efforts or other data sets. Steps should be taken to improve and to develop more complex models incorporating additional life history information and which better reflect our understanding of the processes involved in population dynamics.

Where estimates of model parameters need to be developed or improved, other relevant tasks should be modified or strengthened. Because parameters can vary over space and time and such variation affects population growth rates, emphasis should be placed on estimating variance and 95% confidence intervals along with developing best estimates of particular population parameters.

It is important for those developing manatee population models to coordinate their activities and to interact directly with research biologists who have collected manatee life history data or who are very familiar with manatee ecology. Interaction with management also is needed to help focus the questions addressed by present and future modeling efforts. Estimates of the number of manatee deaths that can be sustained per region, while still allowing population stability or growth to be achieved are needed. Coordination is needed to develop better models that meet the needs of manatee biologists, policy makers, and managers. The MPSWG is best positioned to track research developments, link important players, and provide one level of peer review and evaluation. Additional peer review from other internal and external sources also is essential.

As manatee habitat requirements are documented and recovery criteria are identified (based on habitat needs) (Task 3.1.1), it will become possible to link regional population and habitat models and estimate optimum sustainable populations for regions. Integration of population and habitat information is essential to understand the implications of habitat change before negative impacts on manatee population trends can occur. The MPSWG and Geographic Information System (GIS) Working Group should meet jointly on an annual basis to coordinate their activities and progress. Summary reports of these meetings should be distributed to all agencies and interested parties involved in manatee recovery efforts.

2.3.7 **Conduct a PVA to help assess population parameters as related to the ESA and MMPA.** The FWS should conduct a PVA and/or other modeling exercises to: determine minimum viable population(s); model effects of various scenarios of stochastic events; determine consequences of losses of industrial warm-water refuge sites; further test and refine demographic recovery criteria; and assist in determination of negligible impacts under the MMPA.

2.4 **Evaluate and monitor causes of mortality and injury.** The manatee salvage/necropsy program is fundamental to identifying causes of manatee mortality and injury and should be continued. The program is responsible for collecting and examining virtually all manatee carcasses reported in the Southeastern United States, determining the causes of death, monitoring mortality trends, and disseminating mortality information. Program data are used to identify, direct, and support essential management actions (e.g., promulgating watercraft speed rules, establishing sanctuaries, and reviewing permits for construction in manatee habitat).

The current manatee salvage and necropsy program components are: (1) receiving manatee carcass reports from the field; (2) coordinating the retrieval and transport of manatee carcasses and conducting gross and histological examinations to determine cause of death; (3) maintaining accurate mortality records; and (4) carrying out special studies to improve understanding of mortality causes, rates, and trends. The carcass salvage program should continue to: (1) describe functional morphology of manatees; (2) assess certain life history parameters of the population; and (3) collect data on survival of known individuals.

To improve the program, FWC should continue to hold manatee mortality workshops to review critically its salvage and necropsy procedures and methods. These workshops: (1) establish and improve “state-of-the-art” forensic techniques, specimen/data collection, and analyses; (2) identify and create projects focusing on death categories that are unresolved; (3) prepare for and assist with epizootics; (4) generate reference data on manatee health; and (5) generate suggestions for attainment of a “healthy” manatee population.

To implement the salvage and rescue program in Florida, FWC maintains a central necropsy facility called the Marine Mammal Pathobiology Laboratory (MMPL) which is located in St. Petersburg. FWC also has three field stations on the east coast situated in Jacksonville, Melbourne, and Tequesta, and one field station on the west coast at Port Charlotte. The GDNR, South Carolina Department of Natural Resources, Louisiana Department of Wildlife and Fisheries, Texas Marine Mammal Stranding Network, University of North Carolina at Wilmington, and others help to coordinate carcass salvages and rescues in other Atlantic and Gulf coast states. FWS and FWC should provide assistance to these manatee salvage and rescue programs through workshops, providing equipment and assistance when possible. The MMPL will maintain and curate the Southeast U.S. Manatee Mortality Database to facilitate management and enhance communication among state agencies and reinforce timely reporting.

2.4.1 Maintain and improve carcass detection, retrieval, and analysis. To the extent possible, the historic mortality database should be reviewed and updated to reflect the cause of death categories currently in used. To estimate the number of unreported manatee carcasses, studies should be done on carcass detection and reporting rates. Studies focusing on carcass drift, rate of decomposition, and how decomposition affects necropsy results should be conducted. Periodic peer reviews should be conducted of necropsy methods, data recording and analysis, and documentation of tissues collected. Selected representative samples should be archived with appropriate national tissue banks. Workshops such as FWC Manatee Mortality Workshop should continue to be conducted to strengthen collaborative research and information sharing. Partnerships with other agencies and process analysis of carcass retrieval protocols should be ongoing to improve efficiency.

2.4.2 Improve evaluation and understanding of injuries and deaths caused by watercraft. Longitudinal studies should be established to examine the effect of boats and boating activity on population growth and reproductive success. Investigations of the characteristics of lethal compared to non-lethal injuries and causes should be developed using data from carcasses and photo-ID records. Another important data set would be that characterizing healing in rescued injured animals; under-reporting of watercraft mortality may occur as individuals die from complications resulting from injuries sustained by boats. Lethal and non-lethal injuries should be investigated to characterize size of vessels, relative direction of movement of vessel, and propeller vs. blunt trauma statistics. Research on mechanical characteristics of skin and bones should be developed to obtain a better understanding of the effects of watercraft-related impacts. Regional studies are needed to characterize boating intensity, types of boats, boating behavior, and boating hot spots in relation to manatee watercraft-related mortality.

2.4.3 Improve the evaluation and understanding of injuries and deaths caused by other anthropogenic causes. Research is needed to continue to assess manatee behavior leading to vulnerability around the water control structures and navigational locks, as well as operational or structural changes that can prevent serious injury or death of manatees. MMPL should continue to associate forensic observations obtained at necropsy with specific characteristics of the particular structure that caused the death.

Commercial fishing is not a major culprit involved in manatee mortality, unlike the case with most other marine mammals. However, manatees have been killed by shrimp trawls and hoop nets, and in recent years injuries and death from monofilament entanglement, hook and line ingestion, and crab pot/rope entanglement have been more prevalent. There is a need to improve the evaluation and understanding of injuries and deaths of manatees caused by commercial and recreational fisheries. To reduce the increasing numbers of fishing gear entanglements, a multi-agency Manatee Entanglement Task Force has been established and should continue to focus on creating changes in data collection protocols, potential technique/gear modifications, innovative tag designs, entanglement research, gear recovery/clean-up, and education/outreach efforts. Research on rates of entanglement, types of gear, and geographical and temporal changes in rates and types of entanglements should be developed. Studies on behavioral characteristics of manatees contributing to entanglement should be pursued. Research on the amount of marine debris in inshore waters should be conducted, particularly where there are high levels of manatee entanglement. Programs to remove marine debris and recycle monofilament line also should be encouraged and continued (Task 1.7.2).

Although no known death or pathology has been associated with toxicants, some concentrations of contaminants have caused concern. Over time, concentrations of chemicals found in manatees from early studies have changed, possibly as a result of the regulation of chemical use. Such changes highlight the need to monitor tissues for chemical residue and also can provide insight into the presence of different or new compounds in the environment. While a broad range of tests have been conducted, there needs to be a greater focus on endocrine disruptor compounds. These compounds can alter reproductive success and have a dramatic effect on population growth.

2.4.4 Improve the evaluation and understanding of naturally-caused mortality and unusual mortality events. By definition, natural causes of mortality are not directly anthropogenic and thus not easily targeted by management strategies. However, some aspects of natural mortality may be influenced by human activities. These activities include but are not limited to: (1) sources of artificial warm water; (2) nutrient loading; and (3) habitat modification.

Cold stress can be a cause or contributing factor to manatee deaths during the winter. Acute cold-related mortality is related to hypothermia and metabolic changes which occur as a consequence to exposure to cold. Research should continue to focus on critical cold air and water temperatures affecting manatee physiology (particularly as it pertains to acute cold- and cold stress-related mortality). To provide important clues as to how manatees deal with cold temperature, future research should study behavioral adjustments to cold (e.g., directed movement to warm-water refuges, time budget during cold periods, and surface resting intervals during warm spells). Research identifying the manatee's anatomical and physiological mechanisms for heat exchange are an important step to understanding the biological limitation of the species. Ancillary research should include identification of natural warm-water sites, because a growing population of manatees may be seasonally-limited by overcrowding at the larger well-known warm-water refuges.

Research is needed to improve our ability to detect brevetoxin in manatee tissues, stomach contents, urine, and blood. At the same time, environmental detection of red tides, their strengths, and the development of retardants are necessary. More advanced immunological research utilizing manatee cell cultures may result in the development of better treatment of manatees exposed to brevetoxin.

Improved methods are needed to subdivide the perinatal category into categories of: (1) clearly fetal; (2) at or near the time of birth; and (3) clearly born. Once these categories are well-defined, analysis can ascertain the life stage subject to the greatest impact, thus allowing for the future development of appropriate management policies. Field research focusing on factors affecting calf survival should be conducted (e.g., age of mother at reproduction, behavior, characteristics of calving areas, and human disturbance).

The FWS and FWC have created complementary manatee die-off contingency plans (Geraci and Lounsbury 1997; FWS 1998) that have been merged into one comprehensive document (FDEP *et al.* 1998). The document contains information and guidance from the two plans together with advice and provisions outlined in the executive summary from Wilkinson (1996). Research and investigations should follow the protocols and recommendations found in the Contingency Plans. In addition, there should be ongoing collection and storage of tissues and samples from healthy and non-mortality event manatees to establish a baseline and to aid interpretation of test results obtained during a catastrophic event and for retrospective studies. Investigators should contact and work closely with other research projects monitoring and evaluating harmful algal blooms. FWC mortality workshops should continue and help to facilitate and develop cooperative arrangements among investigators and institutions.

2.5 **Define factors that affect health, well-being, physiology, and ecology.** Relatively little attention has been paid to the health and well-being of individual manatees, although factors affecting individuals ultimately influence the overall status of the population. There is a need to determine the relatively constant internal state in which factors such as temperature and chemical conditions remain stable and therefore within a range of values that permit the body to function well, despite changing environmental conditions. Stress is part of existence, and not all stress is bad for an individual. However, a stressor can affect homeostasis and health, and thereby precipitate a chain of events that can compromise the survival of an individual. There also is a need to understand the factors that underlie large-scale trends. For example, individual manatees compromised by severe injury or disease may not be able to reproduce successfully. Similarly, sublethal effects of toxicants and even the effects of nutritional, noise-related, and disturbance-related stresses can impair immune function and potentially reduce the ability of individuals to reproduce. Study plans and protocols should be developed, collaborators identified, and results published.

2.5.1 Develop a better understanding of manatee anatomy, physiology, and health factors. Efforts should be made to develop and publish a synthesis of: (1) current knowledge of manatee serology; (2) ranges of values associated with manatees in various demographic groups; (3) anomalies identified in manatees via serum analyses; and (4) any remaining unanswered questions. Major organs and organ systems have been examined by a variety of scientists over the years. Those systems or organs which have been ignored are important to assessing manatee health and should be studied; these include: (1) the lymphatic system; (2) most parts of the endocrine system; and (3) non-cerebral parts of the brain. In addition, potential changes in reproductive tracts routinely should be assessed as part of ongoing life history assessments. Manatee histology (microscopic anatomy) has been relatively unstudied, compared to gross anatomy. It is of no less importance in understanding normal organ or tissue functions, as well as abnormalities thereof; therefore, responsible agencies should respond to this important deficiency.

Anatomical and experimental studies have indicated that manatees osmoregulate well in either fresh or salt water; however, it is unclear whether or not manatees physiologically require fresh water to drink, and it is unknown what stresses may be created when fresh water is not available. Research should be continued, and managers attempting to protect resources sought by, if not required by, manatees should bear in mind that fresh water is a desirable and possibly necessary resource for healthy manatees.

Body indices research at FMRI has initiated certain measurements documenting the body condition of manatees. Maintenance of this work, and refinements/extensions thereof, should be continued to gain a better understanding of physiology and health of individuals and the population.

Continuous long-term monitoring of individual manatees allows for documentation of an animal's health. Information should be gathered on: (1) the acquisition and severity of new wounds to facilitate research on the length of time required for injuries to heal; and (2) any effects of injuries on behavior or reproduction. Natural factors affecting the health of the population also should be monitored during the course of photo-ID studies on wild individuals (e.g., cold-related skin damage, scars caused by fungal infections, and papilloma lesions).

As discussed earlier, brevetoxin has been implicated or suspected in major and minor mortality events for manatees for decades. Tests now exist to allow pathologists to assess, even retrospectively, manatee tissues for signs of brevetoxicosis. The important questions include: (1) how many manatee deaths can be truly attributed to exposure to brevetoxin over the years; (2) if red tides are a natural occurrence, how can effects of red tides on manatees be reduced or mitigated; (3) would changes in human activities (i.e., creation of warm-water refuges which lead to aggregations of manatees) appreciably change vulnerability of the animals; and (4) have human activities contributed to increased prevalence and virulence of red tides.

Inasmuch as a single epizootic event can cause 2 to 3 times as many manatee deaths as watercraft causes annually, gaining a better understanding of the issue is vital and urgent. Development of cell lines and testing of manatee tissues would represent an extremely useful approach. In particular, preliminary results indicate that exposure to brevetoxin reduces manatee immune system function. Further study of the immune system will define levels of concern and will help to identify when rehabilitated manatees are ready for release into the wild. Other natural toxins have affected marine mammals (e.g., saxitoxin) and may represent another potential problem for manatees. Exposure of cultured cells of manatees to saxitoxin and assessment of the responses of those cells, would be useful.

Toxicant studies demonstrate that a few metals occur in high concentrations in manatee tissues. Testing for toxicants can be extremely expensive, thus a carefully-constructed study plan should be developed first to address the most critical uncertainties and to make the assessments as cost-effective as possible. Sediment chemistry/toxicity testing could be used as an indicator to direct toxicant studies in important habitats known to contain sediments that are contaminated.

A disease involves an illness, sickness, an interruption, cessation, or disorder of body functions, systems, and organs. As noted at the outset of this section, scientists need to learn the boundaries of normal structure and function before they can diagnose what is normal or diseased. This process has occurred to some degree through the necropsy program, but it needs considerable refinement. Over the years, cause of death for about 1/3 of all manatee carcasses has been undetermined; this percentage would doubtless drop considerably with better information about and diagnosis of manatee disease states. Planned workshops by the FMRI will attempt to bring scientists conducting necropsies on manatees together with pathologists and forensic scientists working with humans and other species. This effort should be very useful as a first step in an ongoing process of refinement.

Nutritional characteristics of manatee food plants and the importance of different food sources for different manatee age and sex classes in various regions are needed to help assure that adequate food resources are protected in different areas of the population's range. Ongoing studies should be completed to identify manatee food habits and the nutritional value of different aquatic plants important to manatees. In addition, seasonal patterns of food availability in areas of high manatee use need to be documented. Research should also address manatee foraging behavior, emphasizing ways that manatees are able to locate and utilize optimal food resources.

Since degrees of parasitic infestation may be associated with the changes in the health of manatees, assessments of changes in prevalence of parasites over time should be undertaken. Inasmuch as parasite loads are assessed, at least qualitatively, during necropsies, this should be easy to accomplish, relatively speaking.

2.5.2 **Develop a better understanding of thermoregulation.** Although work has been ongoing to assess effects of environmental temperatures on metabolism of manatees, the relationship among temperature change, metabolic stress, onset of chronic or acute disease symptoms, and even mortality of manatees is not perfectly understood. As noted above, the relationships among manatee reproductive status, body condition, thermal stress levels, and metabolic responses to such stress remain unclear. Answers are needed as the specter of decreased availability of both natural and artificial warm-water sources looms. The research should focus not only on lower critical temperatures (the cold temperatures where metabolic stress occurs), but also on the upper critical temperature.

2.5.3 **Develop a better understanding of sensory systems.** Vision in manatees has been well studied and tactile ability and acoustics also have been assessed. Conclusions reached as a result of acoustic studies are somewhat inconsistent and controversial, especially in terms of the extent that manatees may hear approaching watercraft. Since the auditory sense of manatees appears to be vital to their ability to communicate and to avoid injury, further studies are warranted. In addition, although chemoreception has been suggested as a mechanism by which male manatees locate estrous females, chemosensory ability of manatees is virtually unknown and should be studied.

2.5.4 **Develop a better understanding of orientation and navigation.** It is clear from various lines of evidence that manatees show site fidelity, especially in terms of their seasonal use of warm-water refuges, but also in their use of summer habitat. To some extent, calves learn locations of resources from their mothers. However, the way that manatees perceive their environment, cues they use to navigate, and the hierarchy of factors they use to select a particular spot or travel corridor are all unknown. As humans continue to modify coastal environments (physically, acoustically, visually, and chemically), it would be useful to understand better how such changes may interfere with the manatee's ability to orient and to locate or select optimal habitat.

2.5.5 **Develop a better understanding of foraging behavior during winter.** Research should address manatee winter foraging behavior, emphasizing ways that manatees are able to locate and utilize optimal food resources. Research should address food availability near winter aggregation areas and determine if they are a limiting resource. Therefore, food resources near winter aggregation sites in each region need to be assessed to ensure that food resources are adequate and protected.

2.5.6 **Develop baseline behavior information.** Both field studies and controlled experiments at captive facilities are needed to document basic behaviors. This documentation will allow detection and understanding of changes in behavior that occur through changes in allocation of essential resources, such as vegetation and warm water. Telemetry, photo-ID, and aerial videography have been useful tools for behavioral research. New innovative approaches are needed, particularly in habitats where visibility is poor.

2.5.7 **Develop a better understanding of disturbance.** Stress caused by disturbance will be difficult to document, but if manatees move away from critically important resources (e.g., warm water in winter) to avoid being disturbed, this movement could place the animals in immediate and acute jeopardy. Sources and level of activities eliciting disturbance responses need to be characterized further.

2.5.7.1 **Continue to investigate how a vessel's sound affects manatees.** In order to understand the nature of watercraft/manatee interactions, the primary reasons for collisions must be identified. Manatees, particularly mothers and calves, communicate vocally. Often, while vessels are still outside of visual range, manatees initiate movements as boats approach, suggesting that they respond on the basis of hearing the boats. Noise from boats or other sources may interfere with communications or provide a source of stress. Hearing capabilities have been examined through studies involving two individuals in captivity (Gerstein 1995, 1999).

There is a need for further research on hearing capabilities and the effects of noise on manatees potentially to provide another management tool to minimize collisions between manatees and boats. In particular, it is important to determine: (1) the sensitivity of manatee hearing to the different kinds of vessels to which they are exposed; (2) the range of frequencies of importance to manatee communication; (3) the abilities of manatees to localize sound sources; and (4) the role that habitat features may play in altering sound characteristics. The levels and characteristics of vessel sounds leading to behavioral changes, including potentially vacating an area, need to be determined. Development of manatee avoidance technology needs to be thoroughly researched and assessed and managers need to evaluate the MMPA and ESA "take" issues related to implementing such technology.

2.5.7.2 **Investigate, determine, monitor, and evaluate how vessel presence, activity, and traffic patterns affect manatee behavior and distribution.** More effective diagnosis of watercraft-related injuries and mortalities is important for describing the extent and nature of the threat posed by watercraft. Mortality workshops are intended to improve our ability to diagnose watercraft-related mortalities more effectively on both fresh and decomposed carcasses. Prevention of such injuries and mortalities is the goal. Research is needed to address the causes of watercraft mortality and the effectiveness of management actions. Importantly, such research also should investigate the effects of sublethal injuries and stress occurring as a result of boating activity. Injuries and stress may: (1) lead to reductions in animal condition and reproductive success; (2) cause animals to abandon habitat important for foraging, reproduction, or thermal regulation; or (3) impair immune system function thereby increasing the vulnerability of animals to disease, pollutants, or toxins. Thus, indirect or secondary effects of boating activity also may impede population recovery in ways that have not yet been assessed.

MML, FWC, and others are investigating reactions of manatees to boats. Preliminary information indicates that manatees perceive boats, but may, under certain circumstances, react in ways that place the animals in the path of, rather than away from, the boats. Additional studies of manatee responses to boats and vessel acoustics are needed (Task 2.5.7.1). Indirect deleterious effects of shallow-draft or jet boats that can disturb manatees and cause them to move to boating channels or interrupt normal behaviors need to be studied. An evaluation of spatial and temporal factors associated with risk to manatees (i.e., proportion of time manatees are exposed to vessels relative to depth, habitat, and manatee activity) should be conducted. Additional factors to be investigated include: (1) types and frequency of approaches; (2) numbers of boats; (3) distance of nearest approach; (4) individual variations in manatee responses to boats; (5) influences on diurnal activity patterns and habitat use; and (6) effects on mothers and young.

2.5.7.3 **Assess boating activity and boater compliance.** Studies that characterize the intensity and types of boating activities should be conducted at selected locations around the state, with emphasis on areas where boat-related mortality of manatees is highest. Studies are underway and should be expanded to additional areas to identify and evaluate adherence to manatee speed zone restrictions through statewide boater compliance studies. The following studies should be continued and assessed: (1) the frequency of boater compliance with posted manatee speed zone restrictions; (2) the degree of boater compliance with posted manatee speed zone restrictions; (3) the levels of compliance among boat classes, seasonally, and temporally; (4) changes in compliance resulting from different enforcement regimes; and (5) changes in compliance resulting from different signage. Underlying sociological factors affecting compliance also should be investigated (Task 1.4.4). New methods for monitoring compliance, such as remote video systems, should be assessed.

2.5.7.4 **Evaluate the impacts of human swimmers and the effectiveness of sanctuaries.** Specific circumstances or characteristics of human swimming, snorkeling, or SCUBA diving that may result in changes in manatee behavior, including vacating an area, remain to be determined. Factors to be investigated include: (1) types and frequency of approaches; (2) numbers of swimmers; (3) distance of nearest acceptable approach; (4) occurrence of contact; (5) individual variations in manatee responses to humans; (6) influences on diurnal activity patterns and habitat use; and (7) effects on mothers and young.

2.5.7.5 **Evaluate the impacts of viewing by the public.** The relative benefits of burgeoning human attention as compared to potential adverse impacts on the animals have not been evaluated properly to determine the desirability of increasing or decreasing control over manatee viewing activities. Studies relating marketing and overall levels of human viewing activities to changes in manatee behavior, including vacating an area, need to be conducted. Conversely, benefits accrued to the manatees from increased viewing by the public also should be evaluated for comparison.

2.5.7.6 Evaluate the impacts of provisioning. In many parts of the species' range, people provide food or water to manatees, in spite of regulations prohibiting such activities. A systematic evaluation should be conducted to determine if these activities potentially adversely affect manatees in terms of changing their behavior, placing them at greater risk from other human activities, or encouraging them to use inappropriate habitat.

OBJECTIVE 3: Protect, identify, evaluate, and monitor manatee habitats. Manatee population recovery and growth depend on maintaining the availability of habitat suitable to support a larger manatee population. Manatee habitat needs include: (1) ample food sources (including submerged, floating, and emergent vegetation); (2) warm-water refuges during cold winter periods; (3) quiet, secluded areas for calving and nursing; (4) mating and resting areas; (5) safe travel corridors connecting such areas; and (6) possibly fresh drinking water. These resources are affected by development in coastal and riverine areas and by human activities in waterways used by manatees. Managers must protect the quality and quantity of essential manatee habitats and provide for human needs.

Many important manatee areas in Florida are protected through the state's Florida Manatee Sanctuary Act, which protects manatees and their habitat through designated manatee protection zones and sanctuaries; manatee areas also are protected under the ESA and MMPA manatee sanctuaries and refuges provisions. These Acts provide a means to minimize the direct and indirect effects of coastal development on manatees. Existing protection areas should be evaluated and properly-managed, and other important unprotected areas should be identified and afforded necessary protection. Resource agencies, through these authorities, are able to address and minimize the effects of development through comments to state and federal permitting agencies. County MPPs are important guidance documents for agencies and developers. Plans should be developed for those counties lacking state- and federally-approved plans. All plans should be reviewed periodically.

In order to protect adequate quantities of essential habitat in the quality necessary to recover the manatee, information is needed to identify habitats, assess their condition, and understand the factors affecting them.

Methods and means should be improved/developed to understand better and monitor the interactions that take place between manatees, manatee habitat, and humans. A HWG should be convened to assess needs and to identify the tools needed to identify, monitor, and evaluate manatee habitats and better define manatee ecology.

3.1 **Convene a Habitat Working Group.** A HWG (established as a subcommittee of the recovery team), that includes resource managers, manatee biologists, and experts familiar with the many features of the manatees' aquatic environment will meet on a regular basis. This group will: (1) assist managers responsible for protecting habitat; (2) help identify information needs; (3) ensure the implementation of tasks needed to identify, monitor, and evaluate habitat; and (4) refine and improve the recovery criteria that address threats to manatee habitat by October 2002.

3.2 **Protect, identify, evaluate, and monitor existing natural and industrial warm-water refuges and investigate alternatives.** One of the greatest threats to the continued existence of the Florida manatee is the stability and longevity of warm-water habitat. Manatees have learned to rely on natural and industrial warm-water refuges during periods of cold weather. This reliance has made it extremely important for managers and researchers to understand the role played by warm-water refuges in overall manatee survival. Protection, enhancement and/or replacement, identification, and characterization of these sites are essential to the continued recovery of the manatee population.

3.2.1 **Continue the Warm-Water Task Force**. A task force consisting of governmental agencies, power industry representatives, and non-government organizations has been convened to develop and implement strategies to ensure safe and dependable warm-water refuges for manatees. In developing these strategies, the task force should: (1) develop a conceptual plan for a long-term network of warm-water refuges; (2) determine the optimal northern extent of industrial warm-water refuges; (3) develop a plan to reduce the potential loss of manatees in the event that a power plant goes off-line, either permanently or for an extended period of time; (4) explore whether new sources of artificial warm water are an avenue that should be considered and, if so, identify potential new sources that could be exploited to produce consistent, dependable, and inexpensive warm water. The task force also should examine the potential effects of deregulation of the Florida power industry.

3.2.2 **Develop and implement an industrial warm-water strategy.** Short- and long-term strategies should be developed for industrial warm-water refuges. Efforts to address short-term concerns currently are accomplished through the state-adopted NPDES permitting program, which includes power plant-specific MPPs. These plans ensure a safe, consistent, and dependable network of warm-water refuges. A long-term plan, addressing concerns identified in Task 3.2.1, should be developed with the creation of an effective network of warm-water refuges as its goal. The development of this plan will require that all industrial sites used by wintering manatees be identified, described, and monitored. These assessments should contain the location and physical description of each plant, expected life span of each plant, and history of manatee use at each plant. Habitat attributes associated with each plant also should be addressed. These attributes should include: (1) availability and location of forage and freshwater; and (2) an assessment of human disturbance levels over the next 5, 10, and 20 years. As more information regarding each plant is collected, BPSM and FWS should recommend modifications to existing power plant-specific MPPs to insure protection of manatees at these facilities.

3.2.2.1 Obtain information necessary to manage industrial warm-water refuges. Research efforts should focus on collating and analyzing existing data related to manatees and industrial warm-water refuges. New research initiatives should focus on filling in data gaps concerning manatees, warm water requirements, and associated behaviors. These research efforts should include: (1) determining the tolerance of manatees to low ambient air and water temperatures; and (2) investigating manatee use of warm-water refuges and nearby habitats in relation to water temperature. Existing research efforts such as aerial monitoring of manatee use at power plants and identifying trends in the abundance of manatees at each plant should be continued. Carrying capacity and factors influencing the number of manatees which can and/or should be using each individual plant should be assessed for each facility. Building partnerships with the industry is imperative in finding resources and answers to a multitude of questions related to this issue.

3.2.2.2 Define manatee response to changes in industrial operations that affect warm-water discharges. Current power plant operations involve activities that affect their respective warm-water discharges. For example, in the absence of demand for electricity, power companies cut back on the amount of electricity produced by certain power plants. These cut-backs may result in temporary or long-term loss of warm water or diminished flows of warm water, thereby reducing their attractiveness to wintering manatees. These operational changes and the effects they have on wintering manatees should be monitored. Understanding the response of manatees to these changes will provide important information for managers seeking to improve short- and long-term management strategies.

3.2.3 Protect, enhance, and investigate other non-industrial warm-water refuges. Non-industrial warm-water refuges include areas such as dredged basins which provide warm water because of their configurations and other features. For example, deep dredged basins with few inputs from adjoining ambient waters may create solar-heated, manatee-accessible systems with water temperatures several degrees above ambient. Dredged areas accessible to manatees also may penetrate sources of groundwater. When tapped into, these warm-water seeps elevate ambient water temperatures and are attractive to manatees in need of refuge from the cold. Due to the uncertainty of some of the power plant discharges being available in the future for manatees, alternatives to these discharges should be identified and developed, if needed. New environmentally-sensitive, non-industry-dependent warm-water refuges should be considered. Sites should be identified and technologies tested while existing refuges remain available.

3.2.4 Protect and enhance natural warm-water refuges. The continued functioning of the natural springs, rivers, and creeks used by manatees is essential to their recovery. Of greatest immediate importance are the spring systems at Blue Spring, Kings Bay, Homosassa Springs, and Warm Mineral Springs. These springs are used as cold season warm-water refuges by at least 20% of the manatee population during winter cold fronts (FWC, unpublished data). Critical to the continued functioning of natural warm-water sites is the maintenance of minimum spring flows and levels, maintenance or improvement of water quality, and protection of adequate foraging habitat within and adjacent to these sites.

3.2.4.1 Develop and maintain a database of warm-water refuge sites. BPSM and FMRI staff should identify and maintain an active database of all natural and non-industrial warm-water refuge sites. When new sites are discovered, these should be added to the database. Manatee use and changes in system function these sites should be monitored over time. Sites should be prioritized based on extent of manatee use and regional importance to cold season populations. FWS and FWC staff also should identify potential natural refuge sites near industrial warm-water facilities used by manatees and assess whether enhancement of these sites should be pursued.

3.2.4.2 **Develop comprehensive plans for the enhancement of natural warm-water sites.** If the strategy for a site includes enhancement, then a comprehensive plan should be developed addressing: (1) agency responsibilities; (2) permitting requirements; (3) funding sources; and (4) physical modifications. Existing and additional needed protection measures for each site should be identified and assessed for effectiveness. To provide for maximum protection of these warm-water sites, protection strategies also should include land acquisition, use of regulatory mechanisms, and outreach.

3.2.4.3 **Establish and maintain minimum spring flows and levels at natural springs.** Water demands from the aquifer for residential and agricultural purposes have diminished spring flows at important manatee wintering areas. Additionally, paving and water diversion projects in spring recharge areas can reduce water levels at springs.

A database of priority springs and flowing systems accessible to manatees should be developed and maintained by FWC staff. The database should include baseline information on water availability and quality so that adverse changes can promptly be identified and impacts mitigated. FWC and FWS should coordinate with the WMDs to prioritize establishing minimum spring flows for high manatee use systems, such as King, Homosassa and Blue Springs. Agency staff should advocate maintaining spring flow rates above the minimum levels necessary to support manatees. FWS and FWC should develop a coordinated review program with FDEP and WMDs' permitting programs on applications requesting ground water withdrawal from applicable spring systems. In addition, FWC and FWS should participate in FDEP and/or WMD springs task force efforts where manatee warm-water refuge protection issues are involved. State legislation protecting spring flow should be sought. Other recovery partners should advocate the establishment of minimum flows and levels as appropriate.

3.2.5 **Assess changes in historical distribution due to habitat alteration.** Summarize what is known about historical distribution in order to clarify how and to what extent artificial warm-water refuge sites and flood control canals have altered distribution and habitat use patterns.

3.3 **Establish, acquire, manage, and monitor regional protected area networks and manatee habitat.** The establishment of manatee sanctuaries, refuges, and protected areas, along with the federal, state, local and private acquisition of coastal areas and essential manatee habitat has created regional networks of protected areas crucial for the long-term survival of the manatee population. Management of these refuges, sanctuaries, reserves, preserves, and parks in Florida offers assurance that habitat (e.g., warm-water springs, grassbeds, and quiet secluded waterways) important to manatees are protected. These efforts need to continue as well as efforts to manage key protected areas in ways that enhance achievement of the recovery objectives.

In addition, work should be undertaken to better understand and monitor the complex interactions among manatees, humans, and manatee habitat. Information from such a program will identify future threats to manatee populations and help to explain observed manatee population trends. Presently, there is no systematic approach to monitoring the condition of important manatee habitats. To provide a means of detecting potential problems in areas supporting manatee populations, essential manatee habitat features should be monitored and evaluated. This information also will assist in determining areas which may need some additional level of protection (i.e., sanctuaries or refuges).

3.3.1 **Establish manatee sanctuaries, refuges, and protected areas.** Under authority of the ESA and its implementing regulations at 50 CFR 17, FWS may designate certain waters as manatee sanctuaries (areas where all waterborne activities are prohibited) or manatee refuges (areas where certain waterborne activities may be regulated). In the 1980s and 1990s, FWS designated six manatee sanctuaries in Kings Bay, Citrus County. In addition, under the NWR System Administration Act, the FWS established a 24-square-km (15-square-mi) zone, in the upper Banana River south of the NASA Causeway, in which motorboats are prohibited. Any such established areas must be posted and enforced.

In 2000, FWS initiated an effort to assess and propose new manatee refuges and sanctuaries throughout peninsular Florida. The goal is to consider the needs of the manatee at an ecosystem level and to use this rule-making provision to ensure that adequately protected areas are available to satisfy the life requisites of the species, with a view toward recovery. The FWS will periodically assess the need for additional or fewer manatee refuges and sanctuaries.

The establishment of No Entry, Limited Entry and No Motorboat zones by state and local regulations function similarly to FWS manatee sanctuaries. These protection areas were established to prevent human disturbance. Examples of these types of zones include: (1) Winter No Entry Zones around power plant warm-water outfalls that attract manatees; (2) Winter No Entry Zone at Blue Spring in Volusia County; (3) Year-round No Entry at Pansy Bayou in Sarasota County; and (4) the Virginia Key and Black Creek Year-round No Entry Zones in Dade County.

3.3.2 **Identify and prioritize new land acquisition projects.** Manatee-related land acquisition, which helps to expand regional networks of essential manatee habitat, is particularly important. In this regard, identification of priority areas must consider regional manatee habitat requirements and relationships among essential manatee habitats. To promote and guide these efforts, the HWG will establish a subcommittee, to include individuals from FWS, FWC, USGS-Sirenia, and others, to convene an annual meeting regarding acquisition projects. The subcommittee will act as a clearinghouse on the status of manatee acquisition projects and otherwise help coordinate efforts for relevant land acquisition projects by federal and state agencies, The Nature Conservancy, and others. As new information on manatee habitat use patterns and essential habitats become available, new areas for acquisition should be identified as warranted. Recent examples of local, state and federal manatee-related acquisition efforts are at Weeki Wachi Spring, Blue Waters and Three Sisters Spring in Citrus County, Warm Mineral Spring Run in Charlotte County, and Munyon and Little Munyon Islands in Palm Beach County.

3.3.3 **Acquire land adjacent to important manatee habitats.** Several NWRs managed by FWS contain essential manatee habitat and are adjacent to other essential non-protected manatee habitat areas. Expanding these areas and establishing new refuges would significantly improve protection not only for manatees, but also for many other species. State land acquisition programs administered by the five regional WMDs, FDEP, FWC, and DCA have acquired many areas that will further manatee habitat protection and have many important acquisition projects in varying stages of development. Local and private land acquisition efforts also enhance manatee habitat protection. Particularly important areas utilized as warm-water refuges, such as Three Sisters Spring in Citrus County and Warm Mineral Spring in Sarasota County, should be considered. As possible, FWS and state land acquisition programs cooperatively should pursue expanding publically-owned lands to incorporate manatee habitat.

3.3.4 **Establish and evaluate manatee management programs at protected areas.** After essential manatee habitats are acquired as identified in Task 3.3.5, the agencies responsible for administering those areas should incorporate manatee protection and public awareness measures into these unit administration programs. Such management measures, depending on local conditions and human activity patterns, may be needed to ensure that activities and development projects within or adjacent to protected areas or affecting state-owned submerged lands do not adversely affect manatees or their habitat. Such measures should be updated as appropriate.

3.3.5 **Support and pursue other habitat conservation options.** Manatee habitat conservation can be achieved through existing regulatory means (Task 1.2 and its subtasks) and through coordination with private foundations with an interest in environmental protection. Federal and state regulatory programs can provide for additional protection of water quality and aquatic resource protection through establishment of conservation easements and mitigation. Private foundations should be approached to procure sensitive lands around important manatee habitat areas. Purchased lands can be managed with the purpose of maintaining water quality (and quantity in the case of springs) by existing local, state or federal programs or through the foundation itself. It is also possible to foster protection of privately held lands important to manatee habitat protection through government tax incentives and focused outreach efforts.

3.3.6 **Assist local governments in development of county MPPs.** Local governments in Florida are encouraged to develop comprehensive, multi-faceted MPPs with technical and financial assistance from FWS , FWC, FDEP, COE, special interest groups, and the general public. Each plan should be designed to ensure manatee protection by addressing a variety of recovery elements or components including: (1) regulating boat facility siting; (2) protecting manatee habitat; (3) providing for public outreach and education; and (4) ensuring appropriate levels of law enforcement. Each plan also should reflect manatee protection zones established by state and federal agencies (sanctuaries, refuges, boat speed zones) and consider if other locally-approved zones are needed. These comprehensive plans will assist in planning future development in a manner compatible with manatee protection, and will ensure local government involvement in manatee protection efforts. All efforts should be made to achieve concurrence among state and federal agencies regarding the approval of county plans.

If local governments are not willing or able to develop comprehensive plans, then FWS and FWC will offer assistance in the development of individual components which would aid in manatee recovery and form the basis for future comprehensive planning efforts. For example, such a component might outline local government's public outreach and education efforts and set forth funding needs and sources as well as an implementation schedule. While not as valuable as a comprehensive plan, these individual components would still be helpful in achieving recovery of the manatee.

In the absence of approved MPPs, or components thereof, case-by-case decision-making on permit applications by state and federal regulatory agencies will consider the best available scientific and commercial data in order to render their decisions. It is likely that some permits will be denied or required to undergo significant modifications because of uncertainties resulting in the absence of comprehensive planning. While plans or components do not have official status as state or federal laws, certain elements, such as boat facility-siting, can be adopted as local ordinances, and the implementation of these elements can strongly influence and streamline state and federal permitting systems.

Florida's Governor Jeb Bush convened a special manatee summit in October 2000, to examine improvements which might be made to achieve better manatee protection. A special panel, including representatives from marine-related industries, environmental organizations, local governments, and state and federal agencies, evaluated the elements of a MPP. After discussing boating speed limits, boater education, law enforcement, manatee refuges and sanctuaries, and marina siting, the panel unanimously agreed that improved law enforcement and improved boater education should be a priority. Additionally the panel agreed that speed zones and sanctuaries were both effective means of protecting manatees. Governor Bush envisioned that the results of the summit would be used to develop more detailed budget priorities, legislation, and local plans for the protection and conservation of manatees, while preserving Florida's traditional culture of recreational and commercial boating.

3.3.7 Implement approved MPPs. MPPs approved by FWC and FWS should be implemented with the assistance of the action agencies, as appropriate. Copies of these plans should be provided to federal and state agencies as reference documents for decision-making with regard to permitting, leasing submerged lands, project review, or other agency actions. To affirm federal support for the county MPP process, COE should incorporate county MPPs into their permit review process and consult with FWS regarding the adoption of MPPs for the purpose of permit review.

As new information becomes available on manatees and the effectiveness of measures to protect manatees and manatee habitat, there may be a need to modify MPPs. FWC and FWS shall take the lead in periodically reviewing MPPs and make recommendations regarding the need to modify and/or update them.

3.3.8 Protect existing SAV and promote re-establishment of NSAV. Manatees in most Florida waters depend upon the prolific growth of SAV (e.g., seagrass and freshwater submerged plant communities). Coastal construction activities (e.g., dock development, dredging, shoreline stabilization, and urbanization) have contributed to the destruction of SAV habitat. Water pollution contributing to reduced water transparency has reduced the abundance of SAV in most water bodies around the state. Introduction of exotic plant species has eliminated or threatened diverse assemblages of freshwater NSAV communities, providing manatees with restricted food resources in many accessible rivers, lakes, and springs. Nutrient pollution, through contamination of ground and surface waters at major manatee aggregation areas like Crystal and Homosassa Rivers, has contributed to a reduction of available food plants in these areas. Such pollution has caused dramatic increases in certain blue-green algae species (most notably *Lyngbia spp*.) that covers over SAV and prevents growth of manatee food plants.

All manatee research, resource protection, and conservation agencies/organizations should actively support the establishment of water quality standards that will protect the existing and promote the regeneration of SAV in all Florida waters. In particular, FDEP and WMDs actively should pursue changing water transparency and nutrient pollution standards to reflect the light requirements of seagrass and other NSAV species. Water transparency standards should be based on light regimes needed for native rooted aquatic plant species historically found in affected waters.

3.3.8.1 Develop and implement a NSAV protection strategy. Protection and restoration of NSAV communities can be accomplished by enforcing and augmenting existing regulatory programs. Prior to a permit being issued, an assessment of seagrass resources should be required, involving site sampling. This sampling should occur between May and October to coincide with the seagrass growing season and should be based on a standardized sampling methodology so that the assessments can be compared equitably. For seagrass communities, regulatory agencies should standardize monitoring of seagrass damage and alterations authorized through environmental resource permitting activities. The HWG should develop and implement standardized seagrass mitigation criteria for all projects proposing any activities resulting in damage to seagrass. Freshwater NSAV communities considered for state and federal permitting programs should be afforded the same level of protection as seagrass, because the destruction or alteration of such communities often leads to dominance of exotic species. FWS and FWC should participate actively in regional and local seagrass protection working groups (e.g., National Estuarine Program focus groups) to assist in directing protection efforts in areas important to manatees.

3.3.8.2 **Develop and implement a state-wide seagrass monitoring program.** FWS, NFS, FWC, and FDEP should develop and implement a regular statewide seagrass monitoring program based on a biennial remote sensing effort. Monitoring efforts should involve trend analysis and comparison to historical distribution of all areas supporting seagrass growth. The FMRI should continue to be the central repository for all collected seagrass monitoring information in Florida. FDEP and FWC should establish a task force to identify total state-wide losses of seagrass due to human activities including, but not limited to, dredge-and-fill projects, dock construction, propeller-scarring, vessel-groundings, freshwater diversion projects, and industrial/municipal pollution changing water transparency. This task force should use the best available scientific data to assess the magnitude of statewide seagrass loss and modify regulatory practices to allow for recovery of seagrass in areas where it has been lost and to protect it in areas where it currently exists.

3.3.8.3 **Ensure aquatic plant control programs are properly designed and implemented.** Aquatic plant control programs around the state are conducted mostly in freshwater systems and are designed to control the dominance of certain species of exotic or native nuisance plants. Introduced species quickly can displace native plant communities and cause a reduction of diversity, fluctuations in NSAV abundance, and nutritional value of the habitat for manatees. It should be noted, however, that manatees have come to rely on exotic vegetation in some areas. Therefore, while efforts should support NSAV restoration, care must be taken to ensure adequate supplies of winter forage, including both native and exotic species. Such programs are especially important in areas of large manatee aggregations, such as Crystal River, Homosassa River, Warm Mineral Spring, and Blue Spring.

FWC, FWS, FDEP, and COE should continue to coordinate aquatic plant control programs for these systems through established working groups that address the protection of manatee habitat. The focus of these groups should be to: (1) reduce the need for excessive aquatic herbicide use through a policy of maintenance control for nuisance species; (2) focus control efforts during periods of minimal manatee use; (3) remove infestations of new exotic plant species; and (4) maintain a historically diverse NSAV community accessible to manatees as much as possible. New working groups should be established for waterways where aquatic plant control programs may jeopardize the aquatic plant abundance and diversity needed to sustain recognized manatee aggregations. FWC, FDEP, and FWS should continue to coordinate state-wide aquatic plant control policies, such as the exclusion of the use of copper herbicides in manatee habitat and on areas where conflicts between manatees and aquatic herbicide use may develop.

3.3.9 Conduct research to understand manatee ecology. Habitat-oriented research is important in identifying key habitats and the factors that determine what features are important for manatees and their recovery. Research should focus on the interrelationships between humans, manatees and their environment. Researchers should continue to monitor free-ranging manatees throughout their habitat, observe behaviors, document habitat use, and define how these influence the status of the manatee. Such research will help to understand and protect the manatees' environment; therefore, efforts should be made to improve ongoing studies and methods and to develop new ones.

3.3.9.1 Conduct research and improve databases on manatee habitat. Habitat-related research should focus on: (1) evaluating food preferences, nutritional requirements, and freshwater requirements; (2) development of body condition indices as potential indicators of environmental conditions; (3) evaluation of and monitoring the extent and condition of seagrass beds; (4) the effects of manatee grazing on seagrass ecology and recovery; and (5) continuing current studies outside Florida on the relationships between manatee health and reproduction with habitat condition. Results from these studies should provide information useful in the design of monitoring studies, estimation of manatee carrying capacity of seagrass beds in key areas, and a better understanding of the manatee’s role in maintaining healthy, diverse seagrass communities.

3.3.9.2 **Continue and improve telemetry and other instrumentation research and methods.** Radio tracking provides an extremely valuable tool to determine and monitor manatee habitat use and behavior associated with environmental and habitat changes. Studies using telemetry should be designed to monitor a large number of manatees for short periods (cross-sectional studies) and individual animals (longitudinal studies) to better understand both population and individual responses to habitat change and habitat use. These studies should be coupled with health and reproductive assessments in order to make comparisons with habitat condition.

The use of conventional VHF and satellite telemetry should continue. Data generated from tracking studies should be entered into GIS databases and analyzed for correlations with habitat preferences and requirements. Verified point data should be provided to management as quickly as possible through technical reports and data transfer. Telemetry results should be published with appropriate analyses in refereed journals as frequently as the data allow.

Emerging technologies such as radio tags utilizing a Global Positioning System (GPS) and data loggersshould be further investigated and incorporated to provide better resolution of manatee movements and habitat use. Tags allowing the compilation and transfer of environmental, acoustical, and physiological data should be developed further and implemented to improve our ability to correlate with environmental and habitat parameters or disturbances.

3.3.9.3 **Determine manatee time and depth pattern budgets.** Time/depth recorders will allow evaluation of risks to manatees from vessel traffic in various habitat types by identifying the position of the animals in the water column. Such information can be related to vessel draft in the area, availability of waters deeper than vessel drafts, and time spent by manatees at specific depths. This information will contribute to a comprehensive risk assessment described in Task 3.3.11.4.

3.3.10 Define the response to environmental change. The Florida environment is not static. Future variation and change are anticipated and could impact survival, reproduction, and distribution of animals among regions, which in turn may affect population growth rates. In order to assess recovery, a need to understand how individual manatees, and consequently the population at large, respond to changes in the environment (e.g., changes in minimum flows at natural springs and elimination of industrial warm-water sources) on the redistribution of fresh water through the Everglades. Research to address such response should proceed at two levels: (1) test for correlation of changes in population parameters with known changes in the environment during long-term monitoring studies; and (2) test of hypothesized cause-effect relationships with behavioral and physiological studies and/or manipulative experimental trials.

3.3.10.1 Define response to changes in fresh water flow patterns in south Florida as a consequence of the Everglades' Restoration. Restoration of the Everglades to its historic water flow pattern is scheduled for the near future. This restoration will affect not only the distribution of fresh water leaving the Everglades, but also the estuarine ecosystem located off the south Florida coast. Studies should be structured to define how changes in sedimentation, bathymetry, seagrass beds, and fresh water input from restoration affects the distribution, survival, and reproduction of manatees.

3.3.10.2 Define response to degradation and rehabilitation of feeding areas. Marine seagrasses and fresh water aquatic vegetation are primary foods for manatees. Regionally, there have been documented declines in seagrass beds and freshwater aquatics resulting from pollution, hurricane-related die-offs, and scarring from boat propellers. Management is making attempts to reverse those declines and has been successful in areas such as Tampa Bay. Studies should be structured to define how changes in the distribution or abundance of feeding areas impact the distribution, survival, and reproduction of manatees.

3.3.11 Maintain, improve, and develop tools to monitor and evaluate manatee habitat. Protection of the manatee from human-related threats in part requires the determination of what constitutes optimal manatee habitats. Resource managers need to know what types of habitat are important to the species, including both natural and manmade features. Understanding manatee distribution in relation to the spatial arrangement of their habitat requires: (1) volumes of data; and (2) specialized computer software and appropriate techniques to analyze the data. GIS is used as an important geo-spatial tool and data-management system to store, synthesize, retrieve, and analyze these large volumes of data on manatees and manatee habitat. Site-specific data stored in GIS include: (1) manatee carcass recovery sites; (2) manatee sighting from aerial surveys; (3) ground research; (4) telemetry studies; (5) water depths; (6) vegetation coverage; (7) waterway speed and access zones; (8) shoreline characteristics and development patterns; etc. Computer hardware, software, and databases are used by researchers, resource managers, and conservationists for scientific analyses, permit reviews, developing waterway speed and access rules, and preparing county MPPs. Programs with theoretical and technical expertise need to focus on research and development of geo-spatial techniques to foster proactive manatee conservation strategies.

3.3.11.1 Maintain, improve, and develop tools to monitor and evaluate natural and human-related habitat influences on manatee ecology, abundance, and distribution. Utilize spatial models linked to a GIS to synthesize data and knowledge and to predict the most suitable habitats for manatees in Florida. GIS tools have the potential of evaluating human use impacts on manatees and their habitat. Analyses should be conducted to determine how human activities, such as coastal development and boating, affect manatee habitats and manatee distribution. These analyses will contribute to a comprehensive risk analysis.

3.3.11.2 Maintain, improve, and develop tools to evaluate the relationship between boating activities and watercraft-related mortality. Utilize GIS and manatee carcass information to create density models to spatially explore areas where manatees may be at higher risk. Evaluate the mortality density information in combination with human-use data, such as boating, to contribute to a comprehensive risk assessment.

3.3.11.3 Evaluate impact of changes in boat design and boater behavior. In recent years, changes in boat designs have resulted in changing threats to manatees. For example, the development of shallow draft vessels, such as flats boats and personal watercraft, along with high speed operation of these vessels over seagrass and other shallow water habitats used by manatees have created new threats to manatees in habitats where they were previously free of vessel interactions. The level of risk imposed by changing boating patterns needs to be evaluated. The boating industry, boating community, scientists, and wildlife managers should work to develop predictions of threats resulting from changes in boat designs and market-trend projections.

3.3.11.4 **Conduct a comprehensive risk assessment.** Utilize the results from the above Recovery Tasks and information from other databases to conduct a comprehensive risk assessment for the manatee.

3.4 **Ensure that minimum flows and levels are established for surface waters to protect resources of importance to manatees.** Minimum flows and levels are being established by state WMDs for surface waters throughout the state, including those used by manatees (*e.g.,* Biscayne Bay, Florida Bay and the Caloosahatchee River). Current and future withdrawals from surface waters have the potential to impact aquatic resources (e.g., SAV) important to manatees. Managers and researchers should participate in WMD efforts to set these limits to ensure that resources of importance to manatees are minimally affected.

3.5 **Assess the need to revise critical habitat.** Critical habitat for the Florida manatee was designated in 1976 (50CFR 17.95(a)). Much has been learned about manatee distribution in the decades since manatee critical habitat was originally defined. The FWS should assess the need to revise critical habitat for the Florida manatee.

Objective 4. Facilitate manatee recovery through public awareness and education. Compliance with regulations and management plans depends on broad public support for manatee recovery, which includes both manatee and habitat protection elements. Public support, in turn, depends on an informed public who understands manatee conservation issues and the rationale behind necessary regulatory and management actions. Knowledge of manatees, their habitat requirements, general biology, and protection measures can contribute toward the minimization of manatee disturbance, harassment, injury, and mortality. This information must be clear, consistent, concise, and readily available to the general public and target user groups. Many manatee and habitat education programs and materials are produced and made available to school systems as well as the general public and user groups; however, such efforts need to be continually evaluated and updated.

4.1 **Identify target audiences and key locations for outreach**. The success of a manatee/habitat conservation effort requires identification of target audiences and locations. Target audiences and key locations should be prioritized by need, i.e., areas where manatee mortality and injury are highest, areas where manatee/human interaction occurs frequently, and areas where habitat is most at risk. These areas include, but are not limited to, the thirteen key manatee counties, high watercraft use areas, boat ramps, manatee aggregation sites, manatee observation areas, fishing piers, seagrass areas, and other areas identified as having important habitat features (e.g., fresh water areas and areas used for resting and/or calving).

4.2 Develop, evaluate, and update public education and outreach programs and materials. There are many existing manatee and habitat awareness and education materials. Materials should be developed and updated for the general public, including students. As future stewards of our environment, it is important for students to learn about endangered species and their habitats and how to take positive actions to care for our fragile ecosystems. It is also important that some materials explicitly target specific user groups, such as: (1) boaters in areas of high watercraft mortality; (2) snorkelers/divers in areas where interaction and harassment occur; (3) recreational and/or commercial fishermen in areas where entanglements are prevalent; and (4) commercial/port facilities. Innovative ways to reach the public should be explored.

4.2.1 Develop consistent and up-to-date manatee boater education courses/programs. Boater education is critical to minimizing disturbance, harassment, injury, and mortality to manatees throughout Florida. Both resident and non-resident boat use in Florida continues to increase as water-related activities become more popular throughout the state. With the increasing traffic on our waterways, education becomes crucial for both manatee and public safety. Educating the boating public about the manatee will provide a better understanding of how the manatee lives and create a greater public appreciation toward the species. Efforts should continue to update and implement a consistent manatee education program for use in federal, state, and local boater education and training programs (e.g,. USCG Auxiliary Boating Safety Courses, U.S. Power Squadron Boat Safety Course, FWC On-Line Boating Safety Course).

4.2.2 Publish and post manatee protection zone information. To educate the boating community and public, organizations that produce materials (e.g., boater's guides, waterway guides, and fishing guides) should add or update the manatee protection zone information in forthcoming editions of their documents. A standardized format should be utilized to develop consistency throughout manatee habitat. Further, at all boat ramps, marinas, vessel rental operations and other access areas, efforts should be made to post signs containing information on manatee zones and "you are here" maps. Additionally, a website should be established allowing the public easy access to manatee protection zone information on the internet. This website could contain rules and regulations, detailed maps of the zones, sign locations within individual zones, examples of each type of sign, and definitions and explanations of manatee protection zones.

4.2.3 **Update nautical charts and Coast Pilot to reflect current manatee protection zone information.** FWS should request National Oceanic and Atmospheric Administration (NOAA) to update these documents to include: (1) a chart note referencing manatee protection zones for applicable nautical charts; and (2) information regarding the manatee protection zones for specific water bodies in Coast Pilot 4 and 5.

4.3 **Coordinate development of manatee awareness programs and materials in order to support recovery.** There are overlap and conflicting messages among existing materials produced by various agencies and conservation organizations. A Manatee Education Committee should be convened to review materials and programs with emphasis on reducing redundancy, providing consistent, standardized messages, and coordinating production of materials among participating organizations. All appropriate recovery plan tasks for education and public awareness materials and programs which have not been developed should be identified by the committee, and any unmet needs should be addressed.

4.4 **Develop consistent manatee viewing and approach guidelines.** Harassment is a violation of federal and state laws such as the MMPA, ESA, and Florida Manatee Sanctuary Act. While manatees may occasionally approach people on their own accord, people often chase after and pursue interactions with the animals. Human interference can disturb manatees and disrupt their natural behaviors (e.g., feeding, breeding, parenting, sheltering). Manatees which are harassed may leave preferred habitats or flee into areas with heavy vessel traffic. With increasing popularity of ecotourism, manatee harassment is an issue of growing concern statewide. Consistent viewing guidelines and education programs will be developed to teach responsible manatee viewing and approach practices, while ultimately serving to minimize disturbance. Coordination with agencies responsible for upholding marine mammal protection laws will allow for pooling of resources, thereby increasing the effectiveness of outreach materials and projects. A working group to address manatee harassment has been formed; the objective of this group is to develop easy-to-understand and comprehensive marine mammal and marine wildlife viewing education materials that promote responsible wildlife watching ethics.

4.5 **Develop and implement a coordinated media outreach program.** Public awareness and understanding is crucial to the recovery of the manatee in Florida. Whenever possible, when media opportunities occur, all recovery partners should make an effort to coordinate information prior to release. This coordination would serve to inform the general public with a consistent message on manatee biology, status, laws affecting them, how those laws benefit their quality of life, and why these laws are important to the recovery of the species. Such opportunities include, but are not limited to, annual mortality updates, synoptic survey results, manatee rescues and releases, and annual implementation of seasonal manatee protection zones and sanctuaries.

4.6 Utilize the rescue, rehabilitation, and release program to educate the public. The media heavily publicize rescues and releases and millions of visitors see and learn about manatees at critical- and long-term care facilities every year. Program participants should incorporate accurate, up-to-date information in their news releases, publications, presentations, displays, and other media to accurately portray the status of the manatee.

4.7 Educate state and federal legislators about manatees and manatee issues. Legislators in Tallahassee and Washington, D.C. can enact manatee protection regulations, or conversely, they can enact legislation that could result in harm to the species and/or its habitat. Holders of some legislative seats change as frequently as every two years, making the issue of educating legislators an ongoing one. To the greatest extent possible, at a frequency of at least every to years, recovery team partners should provide legislators with manatee awareness and education materials, as well as available status reports on the species and its management.

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PART III. IMPLEMENTATION SCHEDULE

The Implementation Schedule indicates task priorities, task numbers, task descriptions, duration of tasks, potential or participating parties, and lastly estimated costs (Table 6). These tasks, when accomplished, will bring about the recovery of the Florida manatee as discussed in Part II of this plan.

Parties with authority, responsibility, or expressed interest to implement a specific recovery task are identified in the Implementation Schedule. When more than one party has been identified the proposed lead party is indicated by an asterisk (*). The listing of a party in the Implementation Schedule does not imply a requirement or that prior approval has been given by that party to participate or expend funds. However, parties willing to participate will benefit by being able to show in their own budget submittals that their funding request is for a recovery task which has been identified in an approved recovery plan and is therefore part of the overall coordinated effort to recover the Florida manatee. Also, Section 7(a)(1) of the ESA directs all federal agencies to utilize their authorities in furtherance of the purposes of the ESA by carrying out programs for the conservation of threatened and endangered species.

Following are definitions to column headings and keys to abbreviations and acronyms used in the Implementation Schedule:

PRIORITY NUMBER

Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant impact short of extinction.

Priority 3 - All other actions necessary to provide for full recovery of the species.

TASK NUMBER AND TASK Recovery tasks as numbered in the Narrative Outline.

RESPONSIBLE OR PARTICIPATING PARTY

C Fish Industry	Commercial Fishing Industry
COE	U.S. Army Corps of Engineers
CZS	Chicago Zoological Society
DERM	Miami-Dade Department of Environmental Resources Management
EPA	U.S. Environmental Protection Agency
Ecotour Ind	Ecotourism Industry
FDEP	Florida Department of Environmental Protection
FIND	Florida Inland Navigation District
FPL	Florida Power and Light Company
FWC	Florida Fish and Wildlife Conservation Commission
	Bureau of Protected Species Management
	Florida Marine Research Institute
	Division of Law Enforcement
FWS	U.S. Fish and Wildlife Service
GDNR	Georgia Department of Natural Resources
LE	Law Enforcement
Local Gov'ts	Local Governments
M Industry	Marine Industries
MML	Mote Marine Laboratory
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
OC	The Ocean Conservancy (formerly the Center for Marine Conservation)
Oceanaria	Cincinnati Zoo, Columbus Zoo, Homosassa Springs State Wildlife Park, Living Seas, Lowry Park Zoo, Miami Seaquarium, Mote Marine Laboratory, Sea World Florida and California, South Florida Museum
P Industry	Power Industries
Port Auth	Port Authorities
R Fish Industry	Recreational Fishing Industry
Sirenia	U.S. Geologic Survey - Sirenia Project
SMC	Save the Manatee Club
USCG	U.S. Coast Guard
USN	U.S. Navy
WMD's	Water Management Districts

ESTIMATED ANNUAL BUDGETS AND OTHER PROJECTIONS OF RECOVERY PARTNERS

Based upon recovery partners' current or proposed FY2001 budgets, it is estimated that close to $10 million is being spent annually on manatee recovery. This estimate does not include several significant recovery initiatives. Costs for USCG and FWC-DLE's manatee law enforcement efforts are not included in this total, nor are estimates included for COE, FDEP, and WMD regulatory programs which work regularly on manatee issues. Additionally, the COE's and the South Florida WMD's multi-million dollar project to retrofit navigational locks and water control structures with manatee protection technology in South Florida and FDEP's plan to retrofit structures at the Rodman Reservoir are not included in this total. It is possible that these programs may total an additional $4 to 5 million annually.

FWS FY 2001-2002 budget proposal for $1.36 million includes staff salary, recovery implementation projects, and a $1 million congressional add-on for: (1) manatee law enforcement; (2) a new manatee sanctuary and refuges initiative; and (3) a warm-water refuge initiative. In addition, regulatory consultations pertaining to manatee issues cost approximately $350 thousand annually in Florida. There is a need for two additional full time employees to handle the projected increase in consultations at a cost of $150 thousand.

COE, USCG, FDEP, and WMD's regulatory programs work regularly on manatee issues; however it was not possible to project the annual costs of these programs.

COE and South Florida WMD have partnered through the Central and Southern Florida Project, including matching funds, over $6.3 million has been budgeted to retrofit navigational locks and water control structures in South Florida with manatee protection technology during the next five years. In designing and constructing critical projects for the Everglades Restoration Project, water control structures are being designed to be manatee-safe, and cost estimates are not available for these projects.

USCG No estimate regarding the cost of USCG enforcement efforts has been provided. When on patrol, the USCG enforces all applicable federal laws and regulations. Costs of enforcing specific regulations, such as manatee speed zones, are not determinable. However, the USCG spends a significant amount of time patrolling navigable waterways that have speed zone regulations, and enforcement of speed zones is a high priority.

Sirenia FY 2001-2002 projected budget is $683 thousand.

FWC **BPSM** FY July 2000 - June 2001 budget of $1.566 million.

FMRI FY July 2000 - June 2001 budget of $3.325 million. This includes: (1) FMRI's research budget for $1.9 million; (2) $1.1 million administered by FMRI and earmarked for the critical care Oceanaria facilities and to the University of Florida Veterinary School; and (3) an additional $325 thousand in research contracts with MML that are administered by FMRI.

DLE No estimates were made regarding manatee law enforcement efforts, but the effort probably exceeds $1.0 million.

FDEP is budgeting to retrofit the Buchman Lock and Kirkpatrick Dam with manatee protection technology. Costs are anticipated to exceed $600 thousand over the next several years, however, this total is not included in the annual estimate.

GDNR FY 2001 budget of $19 thousand.

SMC FY 2001 proposed budget of $1.535 million.

MML FY 2001 manatee budget is $366 thousand. This includes $325 thousand in research contracts administered by FMRI and $41 thousand from MML and CZS.

Oceanaria estimated costs of $1.5 million for 50 manatees annually at $30 thousand per animal for basic maintenance of captive and rehabilitating animals. The critical care facilities receive $400 thousand from the Florida's Save the Manatee Trust Fund, and these funds are administered through the FWC-FMRI budget.

FPL projects FY 2001 budget that includes $110 thousand for studying warm-water refuge issues and for education.

Implementation Schedule

Florida Manatee Recovery Plan | **U.S. Fish and Wildlife Service**

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
2	1.1	Promulgate special regulations for incidental take under the MMPA for specific activities.	5 yrs	**FWS** COE	95	95	95	50	50	
2	1.2	Continue state and federal review of permitted activities to minimize impacts to manatees and their habitat.	Continuous	**FWS** **FWC** COE FDEP **GDNR** M Industry SMC USCG WMDs	500 278 4	500 278 4	500 278 4	500 278 4	500 278 4	
2	1.2.1	Continue to review coastal construction permits to minimize impacts.	Continuous	FWS FWC COE GDNR SMC WMDs						
2	1.2.2	Minimize the effect of organized marine events on manatees.	Continuous	FWS FWC GDNR M Industry SMC USCG						

Implementation Schedule										
Florida Manatee Recovery Plan										**U.S. Fish and Wildlife Service**
Priority	**Task Number**	**Task Description**	**Task Duration**	**Participants**	**Estimated Fiscal Year Costs ($1000s)**					**Comments**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	
2	1.2.3	Continue to review NPDES permits to minimize impacts.	Continuous	FWS FWC EPA FDEP GDNR P Industry SMC						
2	1.2.4	Pursue regulatory changes, if necessary, to address activities that are "exempt," generally authorized, or not covered by state or federal regulations.	2 yrs	FWS COE M Industry SMC						
1	1.3	Minimize collisions between manatees and watercraft.	Continuous	**FWS** **FWC** FIND GDNR Local Gov'ts Local LE M Industry OC SMC USCG	25 439	25 439	25 439	25 439	25 439	

Implementation Schedule										
Florida Manatee Recovery Plan										U.S. Fish and Wildlife Service
Priority	**Task Number**	**Task Description**	**Task Duration**	**Participants**	**Estimated Fiscal Year Costs ($1000s)**					**Comments**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	
1	1.3.1	Develop and refine state waterway speed and access rules.	5 yrs to Develop Continuous to Refine	FWS FWC Local Gov'ts M Industry OC SMC						
1	1.3.2	Develop and refine federal waterway speed and access rules.	3 yrs to Develop Continuous to Refine	FWS FWC COE Local Gov'ts M Industry NPS OC SMC						
1	1.3.3	Post and maintain regulatory signs.	Continuous	FWS FWC FIND Local Gov'ts NPS USCG						

Implementation Schedule

Florida Manatee Recovery Plan | **U.S. Fish and Wildlife Service**

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
1	1.4	Enforce manatee protection regulations.	Continuous	**FWS** **FWC** Local LE MML NPS USCG	655 9	655 9	655 9	655 9	655 9	
2	1.4.1	Coordinate law enforcement efforts.	Continuous	FWS FWC Local LE NPS USCG						
2	1.4.2	Provide law enforcement officer training.	Continuous	FWS FWC Local LE NPS USCG						
2	1.4.3	Ensure judicial coordination.	Continuous	FWS						
2	1.4.4	Evaluate compliance with manatee protection regulations.	Periodic	FWS FWC MML SMC						

Implementation Schedule Florida Manatee Recovery Plan — U.S. Fish and Wildlife Service										
Priority	**Task Number**	**Task Description**	**Task Duration**	**Participants**	**Estimated Fiscal Year Costs ($1000s)**					**Comments**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	
1	1.4.5	Educate boaters about manatees and boater responsibility.	Continuous	FWS FWC Local Gov'ts Local LE M Industry MML OC SMC USCG						
2	1.4.6	Evaluate effectiveness of enforcement initiatives.	Periodic	FWS FWC Local Gov'ts MML						
2	1.4.7	Provide updates of enforcement activities to managers.	Continuous	FWS Local LE USCG						
1	1.5	Assess and minimize mortality caused by large vessels.	1 yr to Assess Continuous to Reduce	**FWS** FWC COE Port Auth. USCG USN	5	5	5	5	5	
2	1.5.1	Determine means to minimize large vessel-related manatee deaths.	2 yrs	FWS						

Implementation Schedule

Florida Manatee Recovery Plan | **U.S. Fish and Wildlife Service**

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
1	1.52	Provide guidance to minimize large vessel-related manatee deaths.	Continuous	FWS FWC COE FDEP USCG						
1	1.6	Eliminate manatee deaths in water control structures, navigational locks, and drainage structures.	Continuous	FWS FWC **COE** DERM FDEP **WMDs**	10 10	10 10	10 10	10 10	10 10	
1	1.6.1	Install and maintain protection technology at water control structures where manatees are at risk and monitor success.	5 yrs to Install Continuous to Maintain & Monitor	FWS FWC COE FDEP WMDs						
1	1.6.2	Install and maintain protection technology at navigational locks where manatees are at risk and monitor success.	5 yrs to Install Continuous to Maintain & Monitor	FWS FWC COE FDEP WMDs						

Implementation Schedule										
Florida Manatee Recovery Plan										**U.S. Fish and Wildlife Service**
Priority	**Task Number**	**Task Description**	**Task Duration**	**Participants**	**Estimated Fiscal Year Costs ($1000s)**					**Comments**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	
1	1.6.3	Minimize injuries and deaths attributable to entrapment in drainage structures.	Install or Retrofit as Needed	FWS COE FDEP FWC Local Gov'ts WMDs						
1	1.6.4	Assess risk at existing and future water control structures and canals in South Florida.	2 yrs to Assess Continuous Monitoring	FWS COE FDEP FWC Local Gov'ts WMDs						
2	1.7	Minimize manatee injuries and deaths caused by fisheries and entanglement.	Continuous	**FWS** FWC GDNR SMC C Fish Indus R Fish Indus	10 10 1	10 10 1	10 10 1	10 10 1	10 10 1	
2	1.7.1	Minimize injuries and deaths attributed to crab pot fishery.	Continuous	FWS FWC C Fish Indus R Fish Indus						

Implementation Schedule

Florida Manatee Recovery Plan **U.S. Fish and Wildlife Service**

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
2	1.7.2	Minimize injuries and deaths attributed to commercial and recreational fisheries, gear, and marine debris.	Continuous	FWS FWC Local Gov't C Fish Indus R Fish Indus OC SMC						
3	1.8	Investigate and prosecute all incidents of malicious vandalism and poaching.	As Needed	**FWS** **FWC** Local LE SMC USCG						
3	1.9	Update and implement catastrophic plan.	As Needed	**FWS** **FWC**	2	2	2	2	2	
2	1.10	Rescue and rehabilitate distressed manatees and release back into the wild.	Continuous	**FWS** Sirenia **FWC** GDNR MML **Oceanaria** SMC	50 1,130 1,000	50 1,130 1,000	50 1,130 1,000	50 1,130 1,000	50 1,130 1,000	
2	1.10.1	Maintain rescue network.	Continuous	FWS FWC MML						

Implementation Schedule

Florida Manatee Recovery Plan | **U.S. Fish and Wildlife Service**

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
2	1.10.2	Maintain rehabilitation capabilities.	Continuous	FWS Oceanaria						
2	1.10.3	Release captive manatees.	Continuous	FWS FWC Oceanaria						
3	1.10.4	Coordinate program activities.	Continuous	FWS						
3	1.10.5	Provide assistance to international Sirenian rehabilitators.	Continuous	FWS FWC Oceanaria SMC						
3	1.10.6	Provide rescue report.	Annually	FWS						
2	1.11	Implement strategies to eliminate or minimize harassment due to other human activities.	Continuous	**FWS** FWC Local Gov’t OC SMC	5	5	5	5	5	
2	1.11.1	Enforce regulations prohibiting harassment.	Continuous	FWS FWC USCG						
2	1.11.2	Improve the definition of “harassment” within the regulations promulgated under the ESA and MMPA.	2 yrs	FWS						
		Totals for Objective 1.			4,238	4,238	4,238	4,193	4,193	$21,100

Implementation Schedule Florida Manatee Recovery Plan										U.S. Fish and Wildlife Service
Priority	**Task Number**	**Task Description**	**Task Duration**	**Participants**	**Estimated Fiscal Year Costs ($1000s)**					**Comments**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	
2	2.1	Continue the MPSWG.	Continuous	**FWS** **Sirenia** FWC	5 20 12	5 20 12	5 20 12	5 20 12	5 20 12	
2	2.2	Conduct status review.	1 yr	**FWS**			25			
2	2.3	Determine life history parameters, population structure, distribution patterns, and population trends.	Continuous	FWS **Sirenia** Academia **FWC** GDNR MML	110 342 360 3	110 383 360 3	110 415 360 3	110 430 360 3	110 445 360 3	
2	2.3.1	Continue and increase efforts to collect and analyze mark/recapture data to determine survivorship, population structure, reproduction, and distribution patterns.	Continuous	Sirenia FWC MML SMC						
2	2.3.2	Continue collection and analysis of genetic samples to determine population structure and pedigree.	Continuous	Sirenia FWC MML						
2	2.3.3	Continue carcass salvage data analysis to determine reproductive status and population structure.	Continuous	FWC						

Implementation Schedule

Florida Manatee Recovery Plan | **U.S. Fish and Wildlife Service**

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
2	2.3.4	Continue and improve aerial surveys and analyze data to evaluate fecundity data and to determine distribution patterns, population trends, and population size.	Continuous	FWS Sirenia FWC MML						
2	2.3.5	Continue collection and analysis of telemetry data to determine movements, distribution, habitat use patterns, and population structure.	Continuous	Sirenia FWC						
2	2.3.6	Continue to develop, evaluate, and improve population modeling efforts and parameter estimates and variances to determine population trend and link to habitat models and carrying capacity.	Continuous	Sirenia FWC						
2	2.3.7	Conduct a PVA to help assess population parameters as related to the ESA and MMPA	2yrs	FWS						
2	2.4	Evaluate and monitor causes of mortality and injury.	Continuous	**FWS** **Sirenia** **FWC** CZS GDNR MML	15 12 1,102 5	15 12 1,022 5	15 12 1,022 5	15 12 1,022 5	15 12 1,022 5	

Implementation Schedule

Florida Manatee Recovery Plan **U.S. Fish and Wildlife Service**

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
2	2.4.1	Maintain and improve carcass detection, retrieval, and analysis.	Continuous	FWS FWC GDNR						
2	2.4.2	Improve evaluation and understanding of injuries and deaths caused by watercraft.	Continuous	FWS Sirenia FWC M Industry						
2	2.4.3	Improve the evaluation and understanding of injuries and deaths caused by other anthropogenic causes.	Continuous	FWS Sirenia FWC COE FDEP M Industry OC WMDs						
2	2.4.4	Improve the evaluation and understanding of naturally-caused mortality and unusual mortality events.	Continuous	FWS Sirenia Academia FWC MML						

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
2	2.5	Define factors that affect health, well-being, physiology, and ecology.	Continuous	FWS **Sirenia** Academia **FWC** MML Oceanaria	10 22 470	10 22 470	10 22 470	10 22 470	10 22 470	
2	2.5.1	Develop a better understanding of manatee anatomy, physiology, and health factors.	Continuous	Sirenia Academia FWC MML Oceanaria						
2	2.5.2	Develop a better understanding of thermoregulation.	Continuous	FWC Academia Oceanaria						
2	2.5.3	Develop a better understanding of sensory systems.	Continuous	FWS Sirenia Academia FWC MML Oceanaria						
2	2.5.4	Develop a better understanding of orientation and navigation.	Continuous	Sirenia Academia FWC Oceanaria						

Implementation Schedule

Florida Manatee Recovery Plan **U.S. Fish and Wildlife Service**

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
2	2.5.5	Develop a better understanding of foraging behaviors during winter.	Continuous	Sirenia FWC Academia Oceanaria						
2	2.5.6	Develop baseline behavior information.	Continuous	FWC Academia Oceanaria						
2	2.5.7	Develop a better understanding of disturbance.	Continuous	FWS Academia CZS FWC MML Oceanaria						
2	2.5.7.1	Continue to investigate how a vessel's sound affects manatees.	Continuous	FWS Academia FWC M Industry MML Oceanaria						

Implementation Schedule										
Florida Manatee Recovery Plan									**U.S. Fish and Wildlife Service**	
Priority	**Task Number**	**Task Description**	**Task Duration**	**Participants**	**Estimated Fiscal Year Costs ($1000s)**					**Comments**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	
2	2.5.7.2	Investigate, determine, monitor, and evaluate how vessel presence, activity, and traffic patterns affect manatee behavior and distribution.	Continuous	FWS Sirenia Academia FWC CZS M Industry MML Oceanaria						
2	2.5.7.3	Assess boating activity and boater compliance.	Periodic Assessment Continuous to Improve Compliance	FWS Sirenia FWC Local Gov'ts M Industry MML SMC						
2	2.5.7.4	Evaluate the impacts of human swimmers and effectiveness of sanctuaries.	2 yrs	FWS FWC						
2	2.5.7.5	Evaluate the impacts of viewing by the public.	2 yrs	FWS FWC						
2	2.5.7.6	Evaluate the impacts of provisioning.	2 yrs	FWS FWC						
		Totals for Objective 2.			2,488	2,449	2,506	2,496	2,511	$12,450

Implementation Schedule

Florida Manatee Recovery Plan — **U.S. Fish and Wildlife Service**

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
2	3.1	Convene a Habitat Working Group.	Continuous	**FWS** **Sirenia** **FWC** M Industry OC SMC	5 20 80	5 22 80	5 24 80	5 26 80	5 28 80	October 2002, HWG will make recommendations to refine and improve habitat criteria
1	3.2	Protect, identify, evaluate, and monitor existing natural and industrial warm-water refuges and investigate alternatives.	Continuous	**FWS** **Sirenia** **FWC** FPL MML P Industry SMC	10 120 50 80	10 126 50 20	10 132 50	10 160 50	10 160 50	
2	3.2.1	Continue the Warm- Water Task Force.	Continuous	FWS Sirenia FWC FPL P Industry SMC						
1	3.2.2	Develop and implement an industrial warm-water strategy.	2 yrs to Develop Continuous to Implement	FWS Sirenia FWC EPA FDEP P Industry						

Implementation Schedule

Florida Manatee Recovery Plan | **U.S. Fish and Wildlife Service**

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
1	3.2.2.1	Obtain information necessary to manage industrial warm-water refuges.	3 yrs	FWS FWC FPL P Industry						
2	3.2.2.2	Define manatee response to changes in industrial operations that affect warm-water discharges.	Continuous	FWS Sirenia FWC FPL						
1	3.2.3	Protect, enhance, and investigate other non-industrial warm-water refuges.	Continuous	FWS FWC FDEP SMC WMDs						
1	3.2.4	Protect and enhance natural warm-water refuges.	Continuous	FWS FWC FDEP SMC WMDs						
3	3.2.5	Assess changes in historical distribution due to habitat alteration.	1yr	FWS MMC Sirenia FWC						

Implementation Schedule

Florida Manatee Recovery Plan — **U.S. Fish and Wildlife Service**

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
2	3.2.4.1	Develop and maintain a database of warm-water refuge sites.	Continuous	FWS Sirenia FWC						
1	3.2.4.2	Develop comprehensive plans for the enhancement of natural warm-water sites.	Continuous	FWS FWC						
1	3.2.4.3	Establish and maintain minimum spring flows and levels at natural springs.	Continuous	FWS FWC EPA SMC WMDs						
1	3.3	Establish, acquire, manage, and monitor regional protected area networks and manatee habitat.	Continuous	**FWS** **Sirenia** **FWC** FDEP Local Gov'ts SMC WMDs	290 165 547	290 180 547	290 190 547	290 160 547	290 170 547	
1	3.3.1	Establish manatee sanctuaries, refuges, and protected areas.	2 yrs Periodic Update	FWS FWC						

Implementation Schedule

Florida Manatee Recovery Plan **U.S. Fish and Wildlife Service**

Priority	**Task Number**	**Task Description**	**Task Duration**	**Participants**	**Estimated Fiscal Year Costs ($1000s)**					**Comments**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	
	3.3.2	Identify and prioritize new land acquisition projects.	Annually	FWS Sirenia FWC FDEP FWC SMC WMDs						
2	3.3.3	Acquire land adjacent to important manatee habitats.	Continuous	FWS FDEP Land Trusts Local Gov'ts WMDs						
2	3.3.4	Establish and evaluate manatee management programs at protected areas.	Continuous	FWS FWC						
3	3.3.5	Support and pursue other habitat conservation options.	Continuous	FWS FWC SMC						
1	3.3.6	Assist local governments in development of county MPPs.	Continuous	FWS FWC Local Gov'ts M Industry R Fish Indus OC SMC						

Implementation Schedule

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
1	3.3.7	Implement approved MPPs.	Continuous	FWS FWC Local Gov'ts						
2	3.3.8	Protect existing SAV and promote re-establishment of NSAV.	Continuous	FWS FWC FDEP FWC WMDs Local Gov'ts						
2	3.3.8.1	Develop and implement a NSAV protection strategy.	2 yrs to Develop Continuous to Implement	FWS Sirenia FWC FDEP FWC WMDs Local Gov'ts						
2	3.3.8.2	Develop and implement a state-wide seagrass monitoring program.	Continuous	FWS Sirenia FWC FWC NMFS WMDs Local Gov'ts						

Implementation Schedule										
Florida Manatee Recovery Plan								**U.S. Fish and Wildlife Service**		
Priority	**Task Number**	**Task Description**	**Task Duration**	**Participants**	**Estimated Fiscal Year Costs ($1000s)**					**Comments**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	
21	3.3.8.3	Ensure aquatic plant control programs are properly designed and implemented.	Continuous	FWS Sirenia FWC COE FDEP FWC						
2	3.3.9	Conduct research to understand and define manatee ecology.	Continuous	Sirenia Academia FWC MML SMC						
2	3.3.9.1	Conduct research and improve databases on manatee habitat.	Continuous	Sirenia FWC						
2	3.3.9.2	Continue and improve telemetry and other instrumentation research and methods.	Continuous	Sirenia FWC						
2	3.3.9.3	Determine manatee time and depth pattern budgets.	Continuous	FWC MML						
2	3.3.10	Define the response to environmental change.	Continuous	FWS Sirenia FWC						

Implementation Schedule										
Florida Manatee Recovery Plan										**U.S. Fish and Wildlife Service**
Priority	**Task Number**	**Task Description**	**Task Duration**	**Participants**	**Estimated Fiscal Year Costs ($1000s)**					**Comments**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	
2	3.3.10.1	Define response to changes in fresh water flow patterns in south Florida as a consequence of the Everglades' Restoration.	Continuous	Sirenia Academia FWC						
2	3.3.10.2	Define response to degradation and rehabilitation of feeding areas.	Continuous	Sirenia FWC						
2	3.3.11	Maintain, improve, and develop tools to monitor and evaluate manatee habitat.	Continuous	FWS Sirenia FWC						
2	3.3.11.1	Maintain, improve, and develop tools to monitor and evaluate natural and human-related habitat influences on manatee ecology, abundance, and distributions.	Continuous	FWS Sirenia FWC						
1	3.3.11.2	Maintain, improve, and develop tools to evaluate the relationship between boating activities and watercraft-related mortality.	Continuous	FWS FWC M Industry MML						
3	3.3.11.3	Evaluate impact of changes in boat design and boater behavior.	Continuous	FWS M Industry MML						
2	3.3.11.4	Conduct a comprehensive risk assessment.	1 yr	FWS						

Implementation Schedule

Florida Manatee Recovery Plan | **U.S. Fish and Wildlife Service**

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
2	3.4	Ensure that minimum flows and levels are established for surface waters to protect resources of importance to manatees.	Continuous	**FWS** FWC SMC WMDs	3	3	3	3	3	
3	3.5	Assess the need to revise critical habitat.	1yr	**FWS**						
		Totals for Objective 3.			1,370	1,333	1,331	1,331	1,343	$6,708
3	4.1	Identify target audiences and key locations for outreach.	3 yrs Periodically Update	FWS FWC GDNR OC SMC	5 5 2	5 5 2	5 5 2	5 5 2	5 5 2	
2	4.2	Develop, evaluate, and update public education and outreach programs and materials.	3 yrs to Develop Periodically Update	FWS FWC FPL GDNR OC SMC	5 205 30 2	5 205 2	5 205 2	5 205 2	5 205 2	
1	4.2.1	Develop consistent and up-to-date manatee boater education courses/programs.	2 yrs to Develop Periodically Update	FWS FWC M Industry OC SMC USCG						

Implementation Schedule

Florida Manatee Recovery Plan | **U.S. Fish and Wildlife Service**

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
1	4.2.2	Publish and post manatee protection zone information.	Annually Publish Continuous	FWS FWC COE Local Gov'ts M Industry						
1	4.2.3	Update nautical charts and Coast Pilot to reflect current manatee protection zone information.	1 yr	FWS NOAA						
3	4.3	Coordinate development of manatee awareness programs and materials in order to support recovery.	Continuous	FWS FWC COE FDEP GDNR Local Gov'ts OC SMC USCG WMDs	5 14 2	5 14 2	5 14 2	5 14 2	5 14 2	
2	4.4	Develop consistent manatee viewing and approach guidelines.	2 yrs	**FWS** FWC OC SMC Ecotour Ind	3 1	3 1	3 1	3 1	3 1	

Implementation Schedule

Florida Manatee Recovery Plan — **U.S. Fish and Wildlife Service**

Priority	**Task Number**	**Task Description**	**Task Duration**	**Participants**	**Estimated Fiscal Year Costs ($1000s)**					**Comments**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	
3	4.5	Develop and implement a coordinated media outreach program.	1 yr to Develop Continuous to Implement	FWS FWC Local Gov'ts OC Oceanaria SMC	5	5	5	5	5	
3	4.6	Utilize the rescue, rehabilitation, and release program to educate the public.	Continuous	**FWS** FWC Oceanaria	3 1	3 1	3 1	3 1	3 1	
3	4.7	Educate state and federal legislators about manatees and manatee issues.	Continuous	FWS FWC M Industry OC P Industry SMC						
		Totals for Objective 4.			288	258	258	258	258	$1,320
		Total for Recovery.			8,384	8,278	8,333	8,278	8,305	$41,578

Manatee Population Status Working Group's (MPSWG) Recommendation of Population Benchmarks To Help Measure Recovery

RECOMMENDED POPULATION BENCHMARKS

The Manatee Population Status Working Group developed the following population benchmarks to assist in evaluating the status of the Florida manatee for reclassification to threatened status. In each of the four regions of the Florida manatee population (Northwest, Southwest, Atlantic, and Upper St. Johns River):

1. the average annual estimated rate of adult survival is at least 94%, with statistical confidence that the rate is not less than 90%;
2. the average annual percentage of adult females with calves during winter is at least 40%; and
3. the average annual rate of population growth is at least 4%, with statistical confidence that the rate is not less than 0 (no growth).

The MPSWG recommended that estimates of the benchmark statistics (survival, reproduction, and population growth rate) be determined over a minimum of a 10-year time period, and that no significant downward trend be detectable in these parameters, before FWS considers reclassification of the Florida manatee from endangered to threatened status. The MPSWG did not propose delisting criteria, as specific, quantitative habitat criteria have yet to be developed.

Table 4. Published population benchmark values for each region.

Region	Percent Survival	Proportion of Females with Calves	Percent Growth
Northwest	96.5 (95.1 - 97.5)[a] (1982 -1993)	.431 (1977 - 1991)	7.4 (1978 - 1991)
Southwest	unknown	unknown	unknown
Upper St. Johns River	96.1 (90.0 - 98.5)[a] (1978 - 1993)	.407 (1979 - 1993)	5.7 (3 - 8) (1978 - 1991)
Atlantic	90.7 (88.7 - 92.6)[a] (1985-1993)	.423 (1979 - 1992)	1.0 (1985 - 1991)

[a] 95% Confidence Interval

Data Sources: **Percent Survival** - Langtimm, O'Shea, Pradel, and Beck 1998. **Proportion of Females with Calves** - Rathbun, Reid, Bonde, and Powell, 1995 (Northwest); O'Shea and Hartley, 1995 (St. Johns River); and Reid, Bonde, and O'Shea, 1995 (Atlantic). **Percent Growth** - Eberhardt and O'Shea, 1995.

METHODS FOR DETERMINING THE POPULATION BENCHMARKS

Criterion A: average annual adult survival estimates, is based upon a mark-recapture approach, using resightings of distinctively marked individual manatees (Langtimm et al. 1998; see p. 11 for further details). Using open population models, adult survival probabilities were estimated for manatees in the Northwest, Upper St. Johns River, and Atlantic regions of Florida. After using goodness-of-fit tests in Program RELEASE to search for violations of the assumptions of mark-recapture analysis, survival and sighting probabilities were modeled with Program SURGE. Statistically robust population models with explicit assumptions will continue to be the basis for estimation of this benchmark.

Criterion B: average annual percentage of adult females with calves, is also based upon resightings of distinctively marked individual manatees. Ongoing development of multi-state models that account for misclassification of breeders and non-breeders will improve the accuracy of regional estimates of productivity. Efforts are also being made to develop a statistically valid method for estimation of a confidence interval for this benchmark.

Criterion C: average annual rate of population growth, is based upon a deterministic population model (Eberhardt and O'Shea 1995). Parameters in the model were primarily derived from life history information obtained through resightings of distinctively marked individual manatees in the Northwest, Upper St. Johns River, and Atlantic regions. It is a simple, 2-stage (calves and adults) model that does not incorporate stochasticity (variability in survival and fecundity rates caused by changes in environmental, demographic, and genetic factors). Future models of population growth rates will undoubtedly incorporate more stages (e.g., juvenile and subadult year classes) and stochasticity. New analyses of life history data (obtained through both carcass salvage data and resightings of known individuals), will undoubtedly improve parameter estimates and reduce uncertainty in modeling results.

BASIS FOR THE POPULATION BENCHMARKS

The benchmarks were based on published estimates of survival, reproduction, and population growth rate (Table 1). Adult survival is the most influential factor determining manatee population dynamics (Eberhardt and O'Shea 1995; Marmontel et al. 1997; Langtimm et al. 1998). Since there is currently no method for determining juvenile survival rates, the MPSWG included a reproduction benchmark. Manatee population growth is less sensitive to changes in reproductive rates than adult survival rates (Marmontel et. al. 1997); however, the average proportion of females with calves over long time spans (at least 10 years) is remarkably consistent across regions (O'Shea and Hartley 1995). The MPSWG concluded that changes in reproductive rates could be a useful indicator of manatee population status, but recognized that a relatively high level of variation in reproductive rates among years requires that a period of at least 10 years be used to estimate this parameter.

Survival rates are estimated from resightings of known individuals in the photo-identification catalog, using adults only (at least 5 years of age), resighted between December and February each year (Langtimm *et al.* 1998). Survival rates for three regions (the Northwest, Upper St. Johns, and Atlantic) were estimated using state-of-the-art statistical methods (Langtimm *et al.* 1998). The target is an adult survival rate of at least 94%, that is, at least 94 of each 100 adult manatees survive from one year to the next. This benchmark is less than the estimated survival rates (96%) in two regions (the Northwest, Upper St. Johns), and higher than the lowest estimated survival rate (91%) in the Atlantic region. The lower bound of the 95% confidence interval should be greater than 0.90 (95% certainty that survival rate is actually greater than 0.90).

Similarly, reproductive rates were estimated from resightings of known individuals in the photo-identification catalog, using adult females only (at least 5 years of age), resighted between December and February of each winter (O'Shea and Hartley 1995, Rathbun *et al.* 1995, Reid *et al.* 1995). The target is 40% of known adult females seen with calves in winter each year (1st or 2nd year calves). The target level has been reached in all three regions (the Northwest, Upper St. Johns, and Atlantic) for which adequate data exist to determine reproductive status of adult females (Table 2). The similarity across regions in the average proportion of adult females observed with calves in winter (43%, 41% and 42%, respectively) suggests that Florida manatees may have achieved a maximum level of reproduction (O'Shea and Hartley 1995).

The population growth rates for each region were calculated using a population model that incorporated estimated survival rates for adults, subadults, and calves, and reproductive rates (Eberhardt and O'Shea 1995). The target is a population growing at 4% per year, which is below the estimated growth rate for the Northwest and Upper St. Johns regions (Table 2). There is a one-to-one correspondence between adult survival above 90% and population growth rate (Eberhardt and O'Shea 1995). Thus, an adult survival rate of 94% corresponds to an annual population growth rate of 4%. In addition, 4% is mid-way between 0 and 8% growth, and 8% is likely to be the maximum manatee population growth rate through internal recruitment. Eberhardt and O'Shea (1995) estimated an annual growth rate of 7.4% for the Crystal River. Without any human-related deaths, this population could almost certainly attain a growth rate of 8%.

The proposed benchmark for population growth (4%) is based upon the results of the Eberhardt and O'Shea (1995) deterministic population model. These authors did not attempt to estimate confidence intervals for two of the three regions for which they estimated population growth rates (Northwest and

Atlantic), and used two different methods to estimate (relatively large) confidence intervals for the growth rate of the Upper St. Johns region. There is clearly uncertainty in their model results. Additionally, they did not attempt to account for the effect of environmental variability over time on population trend. It is essential either to be conservative in selecting a minimum growth rate benchmark, as in selecting 4%, or to require a high degree of statistical confidence that the average growth rate is not lower than 0 in all regions. The latter alternative will require development of new models that include statistically robust methods for estimating confidence intervals.

Research Plan to Determine and Monitor the Status of Manatee Populations

The success of efforts to develop and implement measures to minimize manatee injury and mortality depends upon the accuracy and completeness of data on manatee life history and population status. Population data are needed to identify and define problems, make informed judgments on appropriate management alternatives, provide a sound basis for establishing and updating management actions, and to determine whether or not actions taken are achieving management objectives.

MANATEE POPULATION STATUS WORKING GROUP

The interagency Manatee Population Status Working Group (MPSWG) was established in March 1998. The group's primary tasks are to: (1) assess manatee population trends; (2) advise the U.S. Fish and Wildlife Service (FWS) on population criteria to determine when species recovery has been achieved; and (3) provide managers with interpretation of available information on manatee population biology. The group also has formulated strategies to seek peer review of their activities. The working group should continue to hold regular meetings, refine recovery criteria, annually update regional and statewide manatee status statements, and convene a population biology workshop early in 2002, analogous to the one held in 1992.

STATUS REVIEW

Following the Population Status Workshop in 2002, FWS will conduct a status review of the Florida manatee. The review will include: (1) a detailed evaluation of the population status of the species; (2) an evaluation of existing threats to the species and the effectiveness of existing mechanisms to control those threats, particularly with respect to the five listing factors identified under the Endangered Species Act of 1973, as amended (ESA); and (3) recommendations, if any, regarding reclassification and additional and/or revised recovery objectives, criteria and tasks to deal with remaining threats.

LIFE HISTORY PARAMETERS AND POPULATION TREND

Many manatees have unique features, primarily scars caused by boat strikes. When carefully photographed, these features can provide a means of identifying individuals. **Photographs of distinctively-marked manatees** collected by researchers in the field are compiled in a database begun in 1981 by the U.S. Geological Service Sirenia Project (USGS-Sirenia) with support from the Florida Power and Light Company (FPL). Since its inception, the database has been expanded greatly and improved. It is now a photo CD-based computerized system, known as the Manatee Individual Photo-identification System (MIPS), that utilizes digitized images and PC-based search technologies. The Florida Fish and Wildlife Conservation Commission's (FWC) Marine Research Institute (FMRI) and Mote Marine Lab (MML) now assist in maintaining portions of the database.

It is essential to maintain the photography efforts of the USGS-Sirenia, FMRI, and MML to ensure that vital information on manatee sightings, movement patterns, site use and fidelity, reproductive histories, and related databases remain current for further analyses of survival and reproductive rates. Photos routinely should be collected in the field, especially at the winter aggregation sites, according to standardized protocols for data collection and coding by all cooperators. Annual collection of photographs is essential, as the loss of feature information for individuals in one season could result in an inability to recognize the individual in subsequent years, and potentially compromise the value of the database. Efforts to gather photographic documentation of known females should be continued and expanded to the Southwestern region (Naples through Ten Thousand Islands and the Everglades).

One of the most important parameters for estimating trends in population status is age-specific survival. Photographs documenting sightings of individually-identifiable manatees can be used to estimate minimum ages of manatees in the database and **annual survival rates**. Data on manatees overwintering at specific sites (e.g., Crystal River, Blue Spring, and the warm-water discharges on the Atlantic Coast) are extensive. Analyses using mark-resighting modeling procedures to estimate annual survival rates at these sites have been completed through 1993. Analyses to update these estimates and add additional survival estimates for sites in Southwest Florida (Tampa Bay to the Caloosahatchee River) are underway.

Dead manatees previously identified by photographic documentation must be noted in the database before sight-resighting analyses are undertaken. It is crucial that carcasses continue to be photographically documented and those images distributed to managers of the photo-ID databases, to enhance the accuracy and precision of survival estimates.

Concurrently with photography of individual manatees, information on the **reproductive status of each manatee** (e.g., calf associated with female) should continue to be collected whenever possible. Minimum ages of documented manatees and information such as age at first reproduction, calving interval, and litter size can be determined either during photo-documentation or by timely examination of the database. Long-term studies of reproductive traits and life histories of individual females provide data on age-specific birth rates and success in calf-rearing. The relative success of severely- and lightly-scarred females in bearing and rearing calves should be determined.

Information and tissue samples should continue to be collected from all carcasses recovered in the **salvage program** to determine reproductive status. Resulting estimates of reproductive parameters complement information obtained from long-term data on living manatees and will help to determine trends and possible regional differences in reproductive rates.

Paternity cannot be established in wild manatees without the ability to determine family pedigrees. This information is needed to determine if successful reproduction is limited to a small proportion of adult males, which has important implications for the **genetic diversity** of the Florida manatee population. By continuing the development of nuclear DNA markers, pedigree analysis can be applied to the growing collection of manatee tissue samples. Pedigree analysis also would greatly improve our knowledge of matrilineal relationships and female reproductive success. Identification of factors associated with successful breeding by males is important in assessing reproductive potential in the wild and in captivity.

Aerial surveys provide information on the proportion of calves which may provide insights on reproductive trends when a long time-series of surveys have been conducted by one or relatively few individuals in the same geographic regions. Calf counts from such surveys should be continued (particularly the state-wide surveys conducted by FMRI since 1991, the power plant surveys sponsored by FPL since 1977, and the Crystal/Homosassa River surveys conducted by FWS since 1983). The results should be compared to those obtained by photo-ID methods (particularly for the Crystal/Homosassa River wintering group).

Passive Integrated Transponder (PIT) tags should be inserted under the skin of all manatees captured during the course of ongoing research or rescues. All manatees that are recaptured, rescued, or salvaged should be checked for PIT tags, and identification information should be provided to FMRI. By comparing data on manatee size, reproductive status, and general condition between time of tagging and recovery, one can increase the amount of information obtained on life history parameters. This technique is particularly useful in identifying carcasses, which is very important in obtaining accurate survival estimates. Methods for checking for PIT tags reliably on free-swimming manatees should further be developed and tested. When the latter work shows promise, plans should be developed for re-examining the utility of PIT-tagging manatees of certain age classes (juveniles and subadults) or in specific areas where photo-ID is not a feasible way to re-identify individuals. This research should include estimates of sample sizes required to determine population traits, such as survival and reproductive rates.

POPULATION STRUCTURE

Information on population structure can be obtained through the carcass salvage program, the

MIPS database, and telemetry studies. This information is important for the development of realistic population models.

Collection of tissue samples from salvage specimens and from living manatees at winter aggregation sites, captured during research, or rescued for rehabilitation should continue. Continued genetic analysis through collaborations with state and federal genetics laboratories may reveal greater population structure than has been demonstrated thus far (i.e., a significant difference between east and west coasts, but not within coasts). Such research will improve our ability to define regional populations and management units. Stock and individual identity for forensic purposes ultimately will be possible. Analytical techniques recently developed for identifying the structure of other marine stocks also should be investigated.

To aid in characterizing population structure, life history information (e.g., sex and size class) should continue to be collected concurrent with photographs to augment similar information collected from other sources (e.g., carcasses and telemetry). Long-term patterns of fidelity to winter aggregation sites and summer ranges, as well as movement among sites, also can be documented.

Radio-tracking has provided substantial documentation of seasonal migrations, other long-distance movements, and local movements that reveal patterns of site fidelity and habitat use. In Brevard County, for example, a large group of manatees overwinters in the Indian River, using two power plants for thermal refuge, and another group travels south to Palm Beach and Dade counties, using several power plants for refuge along the way. While these two groups are not entirely mutually exclusive, many individuals consistently display the same pattern each year, in timing and distance of moves as well as destinations. Such information is needed from other regions, particularly Southwest Florida, in order to develop management strategies for all significant subgroups within the regional population, however transitory they may be.

The **salvage program** yields important information on the manatee population sex ratio and proportion of age classes (adult, subadult, juvenile, and perinatal) within each cause-of-death category. Annual changes in these proportions may indicate increases or decreases in certain types of mortality, and thus should be considered as part of the weight of evidence that supports (or rejects) a downlisting decision. Ear bone growth-layer-group analysis should be continued to determine more exact ages of dead manatees, particularly those that have a known history through the photo-ID or telemetry studies, or received PIT tags. Although the age structure of the carcass sample is biased toward younger animals, opportunities may occur to document better the natural age structure within specific regions because of age-independent mortality events.

DISTRIBUTION PATTERNS

Shifts in manatee distribution over time may interfere with our ability to assess accurately regional population trends. Changes may occur in response to human activities, such as modifications of warm-water discharges, enforcement of boat speed regulations, or restoration programs, and because of natural events, such as hurricanes or red tides. Efforts to document manatee distribution through aerial surveys, photo-ID, and telemetry should continue, particularly at important wintering sites, areas of high use, and poorly-studied regions. The validity of the four regional subpopulation designations should be periodically re-evaluated, as they may change over time.

As discussed above, **photographs documenting individual manatees** are important to provide information on life history parameters, population trends, and population structure. Such photographs are also important to provide information on fidelity to winter and summer sites, high-use of and seasonal movements among sites. These photos should continue to be taken at aggregation sites primarily in Florida, but also opportunistically at other sites in the Southeastern United States. Photo-ID efforts recently were initiated in the Ten Thousand Islands region, and should be continued and expanded to other sites in Southwestern Florida.

As appropriate and possible, local and regional **aerial surveys** should be undertaken or continued to improve information on habitat use patterns and changes in distribution. Documentation of changes in distribution at power plants will be particularly important when changes in warm water availability occur.

Telemetry research has proceeded as a series of regional studies with tracking efforts concentrated in different areas in different years. Multi-year studies have been completed for the Atlantic coast and Southwest Florida from Tampa Bay through Lee County, and research findings have been summarized in manuscripts currently undergoing peer review. Verified high quality satellite telemetry location information, with descriptive meta data, will be added to the Marine Resources CD-ROM produced by FMRI. Areas not well-studied, such as the Everglades or where anticipated changes are likely to impact manatees, will be targeted for future research.

POPULATION MODELING

Population models are mathematical representations of the underlying biological processes that control population dynamics. In order to be useful in describing the true behavior of population growth, existing models must be evaluated and improved continually. The underlying assumptions of models, the importance of parameters used in the models, the accuracy and uncertainty of the parameter estimates, the relationships of the parameters, and the appropriateness of the mathematics implemented in the models need to be evaluated critically. Comparisons also need to be made between predicted outcomes from the models and estimates or indices of population trend from other modeling efforts or other data sets.

Eberhardt and O'Shea (1995) developed a deterministic population model using estimates of mortality, reproduction, and survivorship to calculate estimates of population growth rates for three subpopulations of manatees. They considered this a provisional model requiring further development and modification. Steps should be taken to continue to improve this model and to develop more complex models incorporating additional life history information and which reflect better our understanding of the processes involved in population dynamics. Examples of additional population parameters that most likely will be needed in future models are stochastic variation in survival and reproduction rates, genetic population structure, and movement of individuals between regional subpopulations.

To construct valid models, accurate **estimates of population parameters** are required. Where estimates of model parameters need to be developed or improved, other relevant tasks should be modified or strengthened. Because parameters can vary over space and time and such variation affects population growth rates, emphasis should be placed on **estimating variance** and 95% confidence intervals along with developing best estimates of particular population parameters.

It is important for those **developing manatee population models** to coordinate their activities and to interact directly with research biologists who have collected manatee life history data or who are very familiar with manatee ecology. Biologists will understand better how models were derived, and the modelers will obtain feedback on the reasonableness of their assumptions and interpretation of their results. Interaction with management also is needed to help focus the questions addressed by present and future modeling efforts. For example, FWS wants to know if modelers can estimate the number of manatee deaths that can be sustained per region, while still allowing population stability or growth to be achieved. The coordination and interaction of all players will lead to the adaptive development of newer and better models that meet the needs of manatee biologists, policy makers, and managers. The multi-agency MPSWG is best positioned to track research developments, link important players, and provide one level of peer review and evaluation. Peer review from internal and external sources is essential to such evaluations.

Uncorrected aerial survey data do not permit statistically valid population estimation or trend analyses. However, models to correct for some of the inherent bias and uncertainty have been developed, and these efforts should be continued. Methods to correct for various types of visibility bias in surveys should be developed. Standard procedures for survey teams involved in annual statewide surveys need to be developed and implemented. Use of strip transect aerial surveys make it possible to use survey data to detect regional population trends, e.g., in the Banana River and perhaps in Southwest Florida between the Ten Thousand Islands and Whitewater Bay. Strip transect surveys should be continued on an annual basis in the Banana River, and their feasibility should be investigated in remote coastal areas of Southwest Florida. To the extent possible, surveys should be designed to estimate accurately a minimum population number.

As manatee habitat requirements are documented and recovery criteria are identified (based on habitat needs), it will become possible to **link regional population and habitat models and estimate optimum sustainable populations for regions and subregions**. Integration of population and habitat information is essential to understand the implications of habitat change before negative impacts on manatee population trends can occur. The Population Status and Geographic Information System (GIS) working groups should meet jointly on an annual basis to coordinate their activities and progress. Reports of these meetings should be distributed to all agencies and interested parties involved in manatee recovery efforts.

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 United States, determining the causes of death, monitoring mortality trends, and disseminating mortality information. Program data help to identify, direct, and support essential management actions (e.g., promulgating watercraft speed rules, establishing sanctuaries, and reviewing permits for construction in manatee habitat). The program was started by FWS and the University of Miami in 1974 and was transferred to the State of Florida in 1985.

The current manatee salvage and necropsy program is administered through FWC 's FMRI. The major program components are: (1) receiving manatee carcass reports from the field; (2) coordinating the retrieval and transport of manatee carcasses and conducting gross and histological examinations to determine cause of death; (3) maintaining accurate mortality records (including out-of-Florida records); and (4) carrying out special studies to improve understanding of mortality causes, rates, and trends. The carcass salvage program also has permitted scientists to: (1) describe functional morphology of manatees; (2) assess certain life history parameters of the population; and (3) collect data on survival of known individuals. Program staff also coordinate rescues of injured or distressed manatees. To implement the salvage program, FWC maintains a central necropsy facility called the Marine Mammal Pathobiology Laboratory (MMPL), located on the Eckerd College campus in St. Petersburg. FWC also has three field stations on the east coast situated in Jacksonville, Melbourne, and Tequesta, and one field station on the west coast at Port Charlotte.

To improve the program, FWC is hosting a series of manatee mortality workshops to review critically its salvage and necropsy procedures and methods. These workshops: (1) establish and improve "state-of-the-art" forensic techniques, specimen/data collection, and analyses; (2) identify and create projects focusing on unresolved death categories; (3) prepare for and assist with epizootics; (4) generate reference data on manatee health; and (5) generate suggestions for attainment of a "healthy" manatee population. In addition, FMRI personnel are urged to move forward with models based on life history and mortality data, and process improvement is being implemented to expedite data dissemination.

Georgia Department of Natural Resources, South Carolina Department of Natural Resources, Louisiana Department of Wildlife and Fisheries, Texas Marine Mammal Stranding Network, University of North Carolina at Wilmington, and others help to coordinate carcass salvages and rescues in other Atlantic and Gulf coast states. Mortality information collected from these efforts needs to be centralized and should be kept in the mortality database maintained by FWC. FWS and FWC should provide assistance to these manatee salvage and rescue programs through workshops, providing equipment and assistance when possible.

While it is believed that most dead manatees are found and reported to the salvage program, an unknown proportion are unreported. Annual manatee carcass totals, therefore, under-represent the actual number of deaths, indicating the need to **improve carcass detection, retrieval, and analysis**. Decomposition, increased in part by delayed carcass retrieval, reduces the ability to assign cause of death in some cases. To estimate the number of unreported manatee carcasses, studies should be done on carcass detection and reporting rates. Studies focusing on carcass drift, rate of decomposition, and how decomposition affects necropsy results should be conducted. Periodic peer reviews should take place on necropsy methods, data recording and analysis, and documentation of tissues collected. Representative samples should be archived with appropriate national tissue banks. Workshops such as the FWC Manatee Mortality Workshop should continue to be conducted to strengthen collaborative research and information sharing. Partnerships with other agencies and process analysis of carcass retrieval protocols should be ongoing in order to improve efficiency.

Collisions between manatees and boats is the largest known cause of manatee mortality, both human and non-human related; in the late 1990s, watercraft-related deaths constituted at least 25% of the total known annual mortality. Therefore, it is essential to **improve the assessment and understanding of manatee injuries and deaths caused by watercraft**. Under-reporting of watercraft mortality may occur because individuals may not die immediately but rather may develop complications resulting from injuries sustained by boats; such deaths are difficult to attribute to watercraft.

Benchmarks have been established for survival, reproduction, and population growth.

Longitudinal studies should be established to examine the effect of boats and boating activity on these parameters. Investigations of the characteristics of lethal compared to non-lethal injuries and causes should be developed using data from carcasses, photo-ID records, and characterizing healing in rescued injured animals. Investigations on lethal and non-lethal injuries also should attempt to characterize size of vessels, relative direction of movement of vessel, and propeller vs. blunt trauma statistics. Research on mechanical characteristics of skin and bones should be developed to obtain a better understanding of the effects of watercraft-related impacts. Regional studies are needed to characterize boating intensity, types of boats, boating behavior, and boating hot spots in relation to manatee watercraft-related mortality.

Increasing numbers of manatees in the Northwest region of Florida may lead to increasing numbers of animals killed by watercraft. However, such population increases would not explain the recent increase in the percent of mortalities related to watercraft. In addition, this explanation cannot be used for areas where the number of manatees is stable or decreasing. The available data suggest that on average in 2000, collisions with watercraft killed a manatee every 4.6 days. However, these data may underestimate the number of manatee mortalities. More effective diagnosis of watercraft-related injuries and mortalities is important for describing the extent and nature of the threat posed by watercraft. Mortality workshops are intended to improve our ability to diagnose watercraft-related mortalities more effectively on both fresh and decomposed carcasses.

Prevention of such injuries and mortalities is the goal. **Research is needed to address the causes of watercraft mortality and the effectiveness of management actions**. Importantly, such research also should investigate the effects of sublethal injuries and stress occurring as a result of boating activity. Injuries and stress may: (1) lead to reductions in animal condition and reproductive success; (2) cause animals to abandon habitat important for foraging, reproduction, or thermal regulation; or (3) impair immune system function thereby increasing the vulnerability of animals to disease, pollutants, or toxins. Thus, indirect or secondary effects of boating activity also may impede population recovery in ways that have not yet been assessed.

Studies are underway to **identify and evaluate adherence to manatee speed zone restrictions through statewide boater compliance studies**. The following should be continued and assessed: (1) the frequency of boater compliance with posted manatee speed zone restrictions; (2) the degree of boater compliance with posted manatee speed zone restrictions; (3) the levels of compliance among boat classes, seasonally, and temporally; (4) changes in compliance resulting from different enforcement regimes; and (5) changes in compliance resulting from different signage. Underlying sociological factors that affect compliance also should be investigated.

MML recently completed a **study that characterizes the intensity and types of boating**

activities in Southwest Florida. Similar studies should be conducted at selected locations around the state, with emphasis on areas where boat-related mortality of manatees is highest.

MML, FWC, and others are **investigating reactions of manatees to boats**. Preliminary information indicates that manatees perceive boats, but may, under certain circumstances, react in ways that place the animals in the path of, rather than away from, the boats. Additional studies of manatee responses to boats and vessel acoustics are needed. Indirect deleterious effects of shallow-draft or jet boats that can disturb manatees and cause them to move to boating channels or interrupt normal behaviors need to be studied. An evaluation of spatial and temporal factors associated with risk to manatees (i.e., proportion of time manatees are exposed to vessels relative to depth, habitat, and manatee activity) should be conducted.

In the 1970s, Odell and Reynolds described the extent to that flood control structures killed manatees in southeastern Florida. In response, the South Florida Water Management District modified the way that the structures operate, to determine if this change would mitigate the problem. The problem, however, continues to exist, and it involves flood control structures and navigational locks located throughout the state. The U.S. Army Corps of Engineers and various flood control agencies (among others) have devoted considerable time and money to possible solutions, but mortality in the structures was the second highest ever in 1999 (15 manatees died, accounting for approximately 5% of the total deaths during this year). **Research is needed to continue to assess manatee behavior leading to vulnerability around these structures**, as well as operational or structural changes that can prevent serious injury or death of manatees.

Presently, pressure-sensitive strips are being installed on vertical lift structures, and acoustic arrays are being installed on navigational locks. Efforts continue to understand better how and why manatees are killed by structures. The MMPL will associate forensic observations obtained at necropsy with specific characteristics of the structure that caused the death. Continued testing and improvement of manatee protection technology is encouraged.

Commercial fishing is not a major culprit involved in manatee mortality, unlike the case with most other marine mammals. Commercial fishing accounts for far fewer manatee deaths than do either collisions with boats or entrapment in water control structures. Nonetheless, manatees are killed by shrimp trawls, hoop nets, monofilament entanglement, hook and line ingestion, and crab pot/rope entanglement, indicating the need to **improve the evaluation and understanding of injuries and deaths of manatees caused by commercial and recreational fishing**.

Since the introduction of Florida's ban on the use of commercial nets in inshore waters in July

1995, manatees have been exposed to fewer opportunities to become entangled in nets. Because of the net ban, however, some former commercial net fishermen switched to crabbing using crab pots. Probably as a result of this increased number of crab pots, rescues of manatees entangled in crab pot lines have more than tripled since 1995. To reduce the increasing numbers of fishing gear entanglements by manatees, a multi-agency Manatee Entanglement Task Force has been established, focusing on creating changes in data collection protocols, potential technique/gear modifications, innovative tag designs, entanglement research, gear recovery/clean-up, and education/outreach efforts. Research on rates of entanglement, types of gear involved, and geographical and temporal changes in rates and types of entanglements should be developed. Studies on behavioral characteristics of manatees contributing to entanglement should be pursued. Hubbs-Sea World Research Institute currently is studying how manatees become entangled. Research on the amount of marine debris in inshore waters should be conducted, particularly where there are high levels of manatee entanglement. Programs to remove marine debris and recycle monofilament line also should be encouraged and continued.

Tests for several types of man-made compounds and elements have been conducted on manatee tissues. Although no known death or pathology has been associated with toxicants, some concentrations of contaminants have caused concern. Over time, concentrations of chemicals found in manatees from early studies have changed, possibly as a result of the regulation of chemical use. Such changes highlight the need to monitor tissues for chemical residues. In addition, survey studies provide insight into the presence of different or new compounds in the environment. While a broad range of tests have been conducted, there needs to be a greater focus on endocrine disruptor compounds. These compounds can alter reproductive success and have a dramatic effect on population growth.

By definition, **natural causes of mortality** are not directly anthropogenic and thus not easily targeted by management strategies. However, some aspects of natural mortality may be influenced by human activities. These activities include but are not limited to: (1) sources of artificial warm water; (2) nutrient loading; and (3) habitat modification.

Cold stress- and cold-related death are both factors contributing to manatee deaths. Acute cold-related mortality is related to hypothermia and metabolic changes which occur as a consequence to exposure to cold. Cold stress is related to the amount of cold exposure, nutritional debt, age and size of the animals, and time; cold stress can last as long as several months before the individual dies. The syndrome was originally described based upon the gross internal appearance of carcasses, combined with age of the animal (e.g., recently-weaned) and time of year (late winter to early spring). More recently, the appearance of skin lesions, not unlike frostbite, have been associated with cold stress, although the presence of these lesions is not considered to be a definitive indicator. Research continues to focus on critical cold air and water temperatures that affect manatee physiology (particularly as it pertains to acute cold- and cold stress-related mortality). To provide important clues as to how manatees deal with cold temperature, future research should study behavioral adjustments to cold (e.g., directed movement to warm-water refuges, time budget during cold periods, and surface resting intervals during warm spells). Research identifying the manatee's anatomical and physiological mechanisms for heat exchange are important to understanding the biological limitation of the species. Ancillary research should include identification of natural warm-water sites, because a growing population of manatees may be seasonally-limited by overcrowding at the larger well-known warm-water refuges.

In Florida, there are many species (approximately 20) of marine alga that can produce harmful **naturally-occurring biotoxins**. These toxins have the potential to cause massive deaths of fish, fish-eating predators (e.g., birds and dolphins), some species of sea turtles, and manatees. Many of the toxins also affect humans after they consume contaminated fish or shell fish (although human deaths are rare). One biotoxin (brevetoxin) has been the suggested cause of deaths of manatees. Brevetoxin is produced by the marine dinoflagellate, *Gymnodinium breve*, and is responsible for the red tides that occur along coastal Florida. The most recent epizootic of manatees in 1996 was attributed to brevetoxin and underscores the catastrophic effect such events can have on the population; in just 8 weeks, 145 manatees died in Southwestern Florida, representing a substantial loss to the population. Research is needed to improve our ability to detect brevetoxin in manatee tissues, stomach contents, urine, and blood. At the same time, environmental detection of red tides, their strengths, and the development of retardants are necessary. More advanced immunological research utilizing manatee cell cultures may result in the development of better treatment of manatees exposed to brevetoxin as well as the development of prophylactic vaccine.

Perinatal mortality has averaged approximately 24% of the total annual mortality for the last ten years; ranging from 11% in 1981 to 30% in 1991. The category termed "perinatal" is based on a size classification and is not a true cause of death; all manatees measuring 150 cm or less are grouped into this category regardless of developmental stage. Since the developmental stage of a young manatee may have important implications in the analysis of overall deaths, the MMPL initiated the generation of a protocol to identify characteristics of specific stages within this category. The protocol includes the documentation of changes in the circulatory system which occur around the time of birth. Improved methods are needed to subdivide the perinatal category into categories of: (1) clearly fetal; (2) at or near the time of birth; and (3) clearly born. Once these categories are well-defined, analysis can ascertain the life stage subject to the greatest impact, thus allowing for the future development of appropriate management policies. Field research focusing on factors affecting calf survival should be conducted (e.g., age of mother at reproduction, behavior, characteristics of calving areas, and human disturbance).

Periodically, **unusual mortality events** occur in which large numbers of manatees die or become moribund. In 1982 and again in 1996, manatees died or became ill from inhalation and ingestion of brevetoxin (see discussion above). Spikes in mortality also occur during periods of extreme or prolonged cold. Such events represent: (1) the potential for disastrous reductions in numbers of manatees occupying certain regions of the state; (2) the opportunity to learn about manatee response to disease agents or about manatee life history; and (3) a logistic ordeal if proper steps for coordination and communication have not been taken ahead of time. Consequently, FWS and FWC have created complementary manatee die-off contingency plans (Geraci and Lounsbury 1997; FWS 1998) that have been merged into one comprehensive document (FDEP *et al*. 1998). The document contains information and guidance from the two plans together with advice and provisions outlined in the executive summary from Wilkinson (1996). Research and investigations should follow the protocols and recommendations found in the Contingency Plans. In addition, there should be ongoing collection and storage of tissues and samples from healthy and non-mortality event manatees to establish a baseline and to aid interpretation of test results obtained during a catastrophic event and for retrospective studies. Investigators should contact and work closely with other research projects monitoring and evaluating harmful algal blooms. FWC mortality workshops should continue to facilitate and develop cooperative arrangements among investigators and institutions.

FACTORS AFFECTING MANATEE HEALTH, WELL-BEING, PHYSIOLOGY AND ECOLOGY

Relatively little attention has been paid to the health and well-being of individual manatees, although factors affecting individuals ultimately influence the overall status of the population. A variety of factors go into the making of a healthy individual, and health is defined by ranges of values rather than specific ones. Scientists discuss these ranges of values in terms of biological limits. Assessment of what is outside the range of normal values is important, and to make such assessments, baseline data are needed. This generally requires multiple samples from individuals representing a range of ages, different sexes, and a variety of reproductive stages.

There is a need to determine the relatively constant internal state in which factors such as temperature and chemical conditions remain stable and therefore within a range of values that permit the body to function well, despite changing environmental conditions. Stress is part of existence, and not all stress is bad for an individual. However, a stressor can affect homeostasis and health, and thereby precipitate a chain of events that can compromise the survival of an individual. There is also a need to understand the factors underlying large-scale trends. For example, individual manatees compromised by severe injury or disease may not be able to reproduce successfully. Similarly, sublethal effects of toxicants and even the effects of nutritional, noise-related, and disturbance-related stresses can impair immune function and potentially reduce the ability of individuals to reproduce. Study plans and protocols should be developed, collaborators identified, and results published.

Blood serum is the watery portion of the blood remaining after cells and fibrin are removed. Analysis of serum permits assessment of electrolyte levels, hormones, antibodies indicative of exposure to certain pathogens, and other factors important to the health of individual manatees. Serum can be banked for retrospective analyses. Efforts should be made to develop and publish a synthesis of: (1) current knowledge of **manatee serology**; (2) ranges of values associated with manatees in various demographic groups; (3) anomalies identified in manatees via serum analyses; and (4) any remaining unanswered questions.

Major organs and organ systems have been examined by a variety of scientists over the years. The compilation of anatomical observations by Bonde *et al*. (1983) reflects the fact that early in the evolution of manatee programs, efforts were made to understand **anatomy of manatees**. Such assessments have assisted scientists performing necropsies of dead manatees to determine morphologies and pathologies. Some systems or organs have been ignored but are important to assessing manatee health; these include: (1) the lymphatic system; (2) most parts of the endocrine system; and (3) non-cerebral parts of the brain. In addition, potential changes in reproductive tracts routinely should be assessed as part of ongoing life history assessments.

Manatee histology (microscopic anatomy) has been relatively unstudied, compared to gross anatomy. However, it is of no less importance in understanding normal organ or tissue functions, as well as abnormalities thereof. Responsible agencies should respond to this important deficiency.

Although work has been ongoing to assess effects of environmental temperatures on metabolism of manatees, the relationship among temperature change, metabolic stress, onset of chronic or acute disease symptoms, and even mortality of manatees is not perfectly understood. As noted above, the relationships among manatee reproductive status, body condition, thermal stress levels, and metabolic responses to such stress remain unclear. Answers to these **thermoregulation** questions are needed urgently as the specter of decreased availability of both natural and artificial warm-water sources looms. The research should focus not only on lower critical temperatures (the cold temperatures where metabolic stress occurs), but also on the upper critical temperature.

It is unclear whether or not manatees physiologically require fresh water to drink, and it is unknown what stresses may be created when fresh water is not available. Anatomical and experimental studies have indicated that manatees **osmoregulate** well in either fresh or salt water. The extent to which manatees seek fresh water suggests that the animals prefer it to drink, and they may be healthiest when they have at least occasional access to fresh water. Managers attempting to protect resources sought by, if not required by, manatees should bear in mind that fresh water is a desirable and possibly necessary resource for healthy manatees.

Stirling *et al*. (1999) provided an important assessment of polar bear **body condition indices** and related those values to changes in the environment and in consequent availability of polar bear food. They also related changes in reproductive performance and survival of offspring with changes in female body condition. This study exemplifies the importance of long-term data regarding animal health (as assessed by body condition), reproduction, and environmental quality. In Florida, where environmental quality varies considerably over time and space, the value of such a study is enormous. Body indices research at FMRI has initiated certain measurements documenting body condition of manatees. Maintenance of this work and refinements/extensions thereof, should be continued to gain a better understanding of physiology and health of individuals and the population.

Continuous long-term monitoring of the **health histories of individual manatees** allows for documentation of an animal's health. Information should be gathered on: (1) the acquisition and severity of new wounds to facilitate research on the length of time required for injuries to heal; and (2) any effects of injuries on behavior or reproduction. Natural factors affecting the health of the population also should be monitored during the course of photo-ID studies on wild individuals (e.g., cold-related skin damage, scars caused by fungal infections, and papilloma lesions).

As discussed earlier, brevetoxin, a **naturally-occurring toxin**, has been implicated or suspected in major and minor mortality events for manatees for decades. Tests now exist to allow pathologists to assess, even retrospectively, manatee tissues for signs of brevetoxicosis. The important questions include: (1) how many manatee deaths can be truly attributed to exposure to brevetoxin over the years; (2) if red tides are a natural occurrence, how can effects of red tides on manatees be reduced or mitigated; (3) would changes in human activities (i.e., creation of warm-water refuges which lead to aggregations of manatees) appreciably change vulnerability of the animals; and (4) have human activities contributed to increased prevalence and virulence of red tides.

Inasmuch as a single epizootic event can cause 2 to3 times as many manatee deaths as watercraft causes annually, gaining a better understanding of the issue is vital and urgent. Development of cell lines and testing of manatee tissues would represent an extremely useful approach. In particular, preliminary results indicate that exposure to brevetoxin reduces manatee immune system function. Further study of the immune system will define levels of concern and will help to identify when rehabilitated manatees are ready for release into the wild.

Other natural toxins have affected marine mammals (e.g., saxitoxin) and may represent another potential problem for manatees. Exposure of cultured cells of manatees to saxitoxin and assessment of the responses of those cells, would be useful.

To date, the only efforts to assess levels of **toxicants** in manatees have involved some organochlorines and a few metals. This situation is typical of toxicological work for marine mammals in general (O'Shea 1999; Marine Mammal Commission 1999). These studies demonstrate that a few metals occur in high concentrations in manatee tissues. Testing for toxicants can be extremely expensive; thus, a carefully-constructed study plan should be developed first to address the most critical uncertainties and to make the assessments as cost-effective as possible. Some important habitats in Dade County (e.g., Miami River and Black Creek) contain sediments contaminated with trace metals and/or synthetic organic chemicals to the extent that the sediments are considered to be toxic. Sediment chemistry/toxicity testing could be used as an indicator to direct toxicant studies in these types of areas.

A **disease** involves an illness, sickness, an interruption, cessation, or disorder of body functions, systems, and organs. In other words, disease represents the antithesis of homeostasis. As previously noted, scientists need to learn the boundaries of normal structure and function before they can diagnose what is normal or diseased. This process has occurred to some degree through the necropsy program, but it needs considerable refinement. Over the years, cause of death for about 1/3 of all manatee carcasses has been undetermined; this percentage probably would drop considerably with better information about and diagnosis of manatee disease states. Planned workshops by FMRI will attempt to bring scientists conducting necropsies on manatees together with pathologists and forensic scientists working with humans and other species. This effort should be very useful as a first step in an ongoing process of refinement.

Nutritional characteristics of manatee food plants and the importance of different food sources for different manatee age and sex classes in various regions are understood poorly. Such information is needed to help assure that adequate food resources are protected in different areas of the population's range. Ongoing studies should be completed to identify manatee food habits and the nutritional value of different aquatic plants important to manatees. In addition, seasonal patterns of food availability in areas of high manatee use need to be documented. Research also should address **manatee foraging behavior**, emphasizing ways that manatees are able to locate and utilize optimal food resources.

Catalogs of **manatee parasites** were prepared two decades ago (Forrester *et al*. 1979). A recent description of parasites for cetaceans (including manatees) in Puerto Rico also was published (Mignucci-Giannoni *et al*. 1998). Since degrees of parasitic infestation may be associated with the changes in the health of manatees, assessments of changes in prevalence of parasites over time should be undertaken. Inasmuch as parasite loads are assessed, at least qualitatively, during necropsies, this should be easy to accomplish, relatively speaking.

Vision in manatees has been well studied relatively. Tactile ability and acoustics also have been assessed. Conclusions reached as a result of acoustic studies are somewhat inconsistent and controversial, especially in terms of the extent that manatees may hear approaching watercraft. Since the auditory sense of manatees appears to be vital to their ability to communicate and to avoid injury, further studies are warranted. In addition, although chemoreception has been suggested as a mechanism by which male manatees locate estrous females, chemosensory ability of manatees is virtually unknown. Studies should continue on these topics to **develop a better understanding of manatee sensory systems**.

It is clear from various lines of evidence that manatees show site fidelity, especially in terms of their seasonal use of warm-water refuges, but also in their use of summer habitat. To some extent, calves learn locations of resources from their mothers. However, the way that manatees perceive their environment, cues they use to navigate, and the hierarchy of factors they use to select a particular spot or travel corridor are all unknown. As humans continue to modify coastal environments (physically, acoustically, visually, and chemically), it would be useful to understand better how such changes may interfere with the manatee's ability to **orient and to locate or select optimal habitat**.

Relatively few studies have been directed at **manatee behavior** since Hartman's work in the late 1970s. Rathbun (1999) summarized existing information on activity and diving, foraging, thermoregulation and movements, resource aggregations, mating, social organization, and communication. He concluded that, although the manatee's herbivorous diet is perhaps the most important factor in understanding their life history and behavior, it is the least studied aspect of manatee behavioral ecology. Both field studies and controlled experiments at captive facilities are needed to document basic behaviors. This documentation will allow detection and understanding of changes in behavior that occur through changes in allocation of essential resources, such as vegetation and warm water. To date, telemetry, photo-ID, and aerial videography have been useful tools for behavioral research. New innovative approaches are needed, particularly in habitats where visibility is poor.

Captive dolphins have developed ulcers and died when subjected to excessive human activity or excessive noise (i.e., from pumps) around their enclosures. Chronic levels of **disturbance** may create stresses to manatees; certainly, manatees change their behavior or actually leave certain areas to avoid disturbance. The stress involved would be difficult to document, but if manatees move away from critically important resources (e.g., warm water in winter) to avoid being disturbed, this movement could place the animals in immediate and acute jeopardy. Buckingham *et al*. (1999) provide an interesting case study for manatees, and data exist to support problems created by disturbance for a variety of marine mammals, including animals sympatric with Florida manatees (i.e., dolphins). Sources and level of activities eliciting disturbance responses need to be characterized further.

Manatees, particularly mothers and calves, communicate vocally. Often, while vessels are still outside of visual range, manatees initiate movements as boats approach, suggesting that they respond on the basis of hearing the boats. Noise from boats or other sources may interfere with communications or provide a source of stress. Hearing capabilities have been examined through studies involving two individuals in captivity (Gerstein 1995, 1999). There is a need for further research on hearing capabilities and the **effects of noise on manatees**. In particular, it is important to determine: (1) the sensitivity of manatee hearing to the different kinds of vessels to which they are exposed; (2) the range of frequencies of importance to manatee communication; (3) the abilities of manatees to localize sound sources; and (4) the role that habitat features may play in altering sound characteristics. The levels and characteristics of vessel sounds leading to behavioral changes, including potentially vacating an area, need to be determined.

Manatee distributions have been found to be **affected by boat traffic** in at least one study, with manatees moving into established sanctuary areas during periods of heavy boat traffic (Buckingham *et al*. 1999). Factors to be investigated include types and frequency of approaches, numbers of boats, distance of nearest approach, individual variations in manatee responses to boats, influences on diurnal activity patterns and habitat use, and effects on mothers and young.

Human swimming (and to a lesser extent diving) with manatees occurs in many parts of the species' range. In a few warm-water refuges, sanctuary areas have been established for manatees to escape from contact with human swimmers, but few data from systematic studies are available to evaluate the potential **impacts of human swimmers** or the effectiveness of the sanctuaries. The specific circumstances or characteristics of human swimming, snorkeling, or SCUBA-diving that may result in changes in manatee behavior, including vacating an area, remain to be determined. Factors to be investigated include types and frequency of approaches, numbers of swimmers, distance of nearest acceptable approach, occurrence of contact, individual variations in manatee responses to humans, influences on diurnal activity patterns and habitat use, and effects on mothers and young.

Public viewing of manatees has become increasingly popular in recent years and now occurs in many parts of the species' range. Commercial operations as well as private individuals are bringing increasing numbers of people to view manatees in areas where the animals can be found predictably. The opportunity for the public to move into close proximity to the animals typically is associated with other potentially disturbing activities such as swimming, diving, boating, or provisioning. The relative benefits of burgeoning human attention as compared to potential adverse impacts on the animals have not been evaluated properly to determine the desirability of increasing or decreasing control over manatee viewing activities. Studies relating marketing and overall levels of human viewing activities to changes in manatee behavior, including vacating an area, need to be conducted. Conversely, benefits accrued to the manatees from increased viewing by the public also should be evaluated for comparison.

In many parts of the species' range, people provide food or water to manatees, in spite of regulations prohibiting such activities. A systematic evaluation should be conducted to determine if these **provisioning** activities potentially adversely affect manatees in terms of changing their behavior, placing them at greater risk from other human activities, or encouraging them to use inappropriate habitat.

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FLORIDA MANATEE CAUSE OF DEATH BY REGION (1991-2000)
ATLANTIC, UPPER ST. JOHNS RIVER, NORTHWEST AND SOUTHWEST

Manatee carcasses reported in Florida from 1991 to 2000 (FWC, unpublished data) were assigned to four regions of the state: (1) Atlantic Coast (St. Johns River and tributaries downstream (north) of Palatka); (2) Upper St. Johns River (St. Johns River upstream (south) of Palatka); (3) Northwest (Homosassa/Crystal River and north); and (4) Southwest (Tampa Bay area). The percentage of carcasses by each cause of death was calculated for each region (Tables 5-6 and Figures 17-21).

Two regions contained most of the 2,306 carcasses located state-wide (Atlantic 50%, Upper St. Johns River 2%, Northwest 5%, Southwest 43%); however, the Atlantic and Southwest regions also have the highest numbers of living manatees. Therefore, results should be viewed cautiously because percentages among causes of death can seem contradictory. Large numbers of deaths in one region in one category can make another category seem less important. A mortality event in one region can make all the other causes seem less important (smaller percentages), when actually all of the causes take on even greater importance due to the high number of deaths in a short time period.

Carcasses (n=145) from the 1996 red tide epizootic in southwest Florida were omitted from the following analysis, because this was considered to be a non-typical situation; their inclusion here would make other human-related and natural causes of death seem less important.

Causes of death varied among regions. The percentage of watercraft-related deaths was highest in the St. Johns River region (15 carcasses, 34%) and lowest in the Atlantic (264 carcasses, 24%) region. The highest number of watercraft deaths occurred in the Atlantic and in the Southwest regions (252 carcasses, 27%).

The highest percentage of flood gate and lock deaths occurred in the Atlantic (69 carcasses, 6%) and St. Johns River regions (4 carcasses, 8%), and lowest percentage occurred in the Northwest region (1 carcasses, 1%). The highest number of gate/lock deaths occurred in the Atlantic and Southwest (19 carcasses, 2%) regions. Only a few water control structures and navigational locks are present on the west coast, and percentages were lower there.

All other human-related causes of deaths combined accounted for the highest percentage of deaths in the Atlantic (40 carcasses, 4%) and Northwest regions (4 carcasses, 4%), and accounted for the lowest in the St. Johns River (0 carcasses, 0%). The highest number of other human-related deaths occurred in the Atlantic and Southwest (14 carcasses, 2%) regions.

Perinatal deaths accounted for the highest percentage of deaths in the Northwest region (32 carcasses, 33%). The highest number of perinatal deaths occurred in the Atlantic (296 carcasses, 27%) and Southwest (190 carcasses, 20%) regions.

Cold-related deaths accounted for the highest percentage of deaths in the Atlantic region (29 carcasses, 3%). The only recent large cold mortality event primarily in Brevard County during the winter of 1989-1990. Cold-related deaths were lowest in the two regions with major natural springs, the St. Johns River (0 carcasses, 0%) and Northwest (3 carcasses, 3%) regions.

Other natural causes of death combined accounted for the highest percentage of deaths in the Southwest Region (154 carcasses, 17%), and accounted for the lowest percentage in the St. Johns River (2 carcasses, 5%). The highest number of other-natural deaths occurred in the Southwest and Atlantic (112 carcasses, 10%) regions. The high number of deaths from natural causes in the Southwest region may partly reflect occasional small red tide events.

Undetermined deaths (including verified but not recovered carcasses) accounted for the highest percentage in the Southwest Region (277 carcasses, 30%), and accounted for the lowest percentage in the Northwest (20 carcasses, 20%). The highest number of undetermined deaths occurred in the Southwest and Atlantic (279 carcasses, 26%) regions. The high number of undetermined deaths in the Southwest region may be related to the high levels of carcass decomposition because of the warm temperatures and remoteness of large parts of the region (i.e., few observers to find carcasses and long travel times required to retrieve carcasses). The high percentage of undetermined causes in the Southwest makes all the other categories proportionately smaller in that region.

Deaths of adult-sized animals (276 to 411 cm total length) were summarized separately. Analysis using only deaths of adult-sized animals eliminates all of the perinatal carcasses and most of the cold-related deaths, which are mostly sub-adult manatees. Percentages of deaths, by causes, were similar among the four regions. Regions with high percentages of perinatal and cold-related deaths showed the greatest differences when adults were considered separately.

Statewide, watercraft-related deaths accounted for 39% of adult deaths, and all human-related deaths combined comprised 53% of deaths. All human-related causes combined constituted the highest percentage of deaths in the St. Johns region (14 carcasses, 64%) and in the Atlantic region (181 carcasses, 58%). The Atlantic region has the largest coastal human population of the four regions. The health of a regional population is closely tied to the adult survival rate. Therefore, it is very important that the percentages of human-related deaths be kept as low as possible.

Table 5. Manatee deaths in Florida, 1991-2000, by 4 regions and statewide. **All size classes** (FWC, unpublished data).

CAUSE OF DEATH	ATLANTIC		ST. JOHNS		NORTHWEST		SOUTHWEST		STATEWIDE	
	Number	%	Number	%	Number	%	Number	%	Number	%
Watercraft	264	24.2	15	34.1	26	26.5	252	27.1	557	25.8
Gate/Lock	69	6.3	4	9.1	1	1.0	19	2.0	93	4.3
Other Human	40	3.7	0	0.0	4	4.1	14	1.5	58	2.7
Perinatal	296	27.2	11	25.0	32	32.7	190	20.4	529	24.5
Cold-Related	29	2.7	0	0.0	3	3.1	24	2.6	56	2.6
Other Natural	112	10.3	2	4.5	12	12.2	154*	16.6	280*	12.9
Undetermined	279	25.6	12	27.3	20	20.4	277*	29.8	588*	27.2
TOTAL	1089	100.0	44	100.0	98	100.0	930*	100.0	2161*	100.0

* Omit n=145 Red Tide deaths in Southwest Florida, 1996

Table 6. Manatee deaths in Florida, 1991-2000, by 4 regions and statewide. **Adult-only size class** (>275 cm total length). FWC unpublished data.

CAUSE OF DEATH	ATLANTIC		ST. JOHNS		NORTHWEST		SOUTHWEST		STATEWIDE	
	Number	%	Number	%	Number	%	Number	%	Number	%
Watercraft	122	39.0	11	50.0	8	33.3	103	39.3	244	39.3
Gate/Lock	37	11.8	3	13.6	0	0.0	13	4.9	53	8.5
Other Human	22	7.0	0	0.0	2	8.3	6	2.3	30	4.8
Perinatal	—	—	—	—	—	—	—	—	—	—
Cold-Related	1	0.3	0	0.0	2	8.3	0	00.0	3	0.5
Other Natural	35	11.2	1	4.6	5	20.9	51*	19.5	92*	14.8
Undetermined	96	30.7	7	31.8	7	29.2	89*	34.0	199*	32.1
TOTAL	313	100.0	22	100.0	24	100.0	262*	100.0	621*	100.0

* Omit n=145 Red Tide deaths in Southwest Florida, 1996

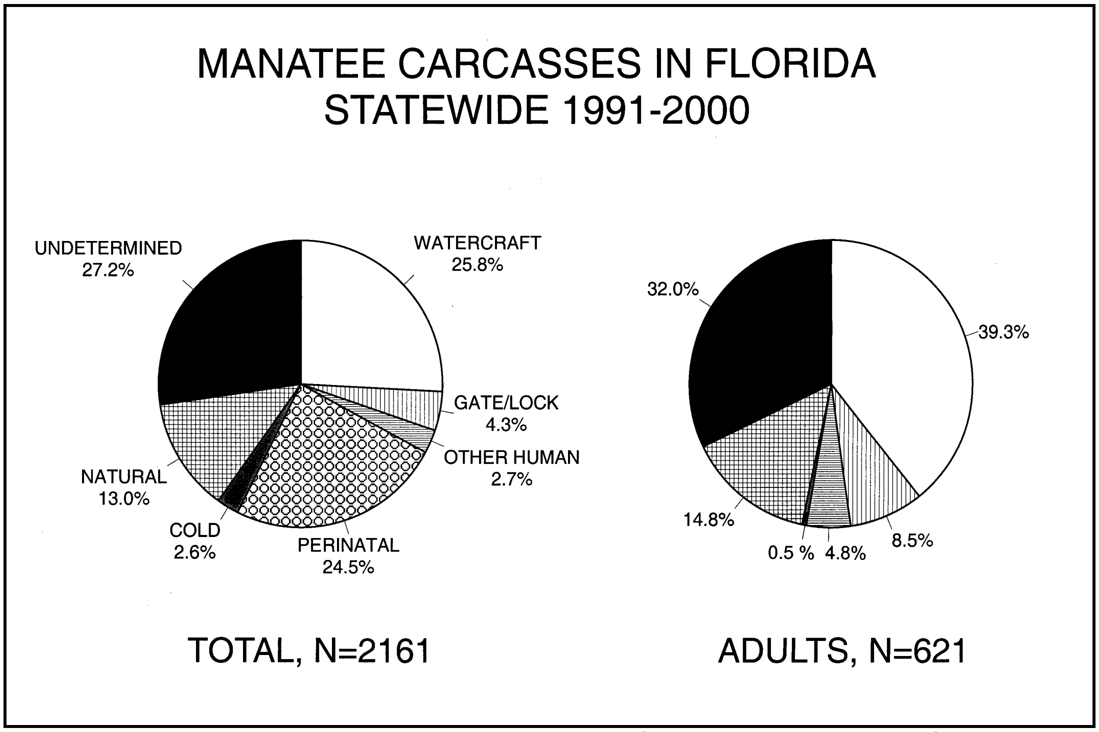

Figure 17. Manatee deaths in Florida by cause of death, 1991-2001. FWC unpublished data.

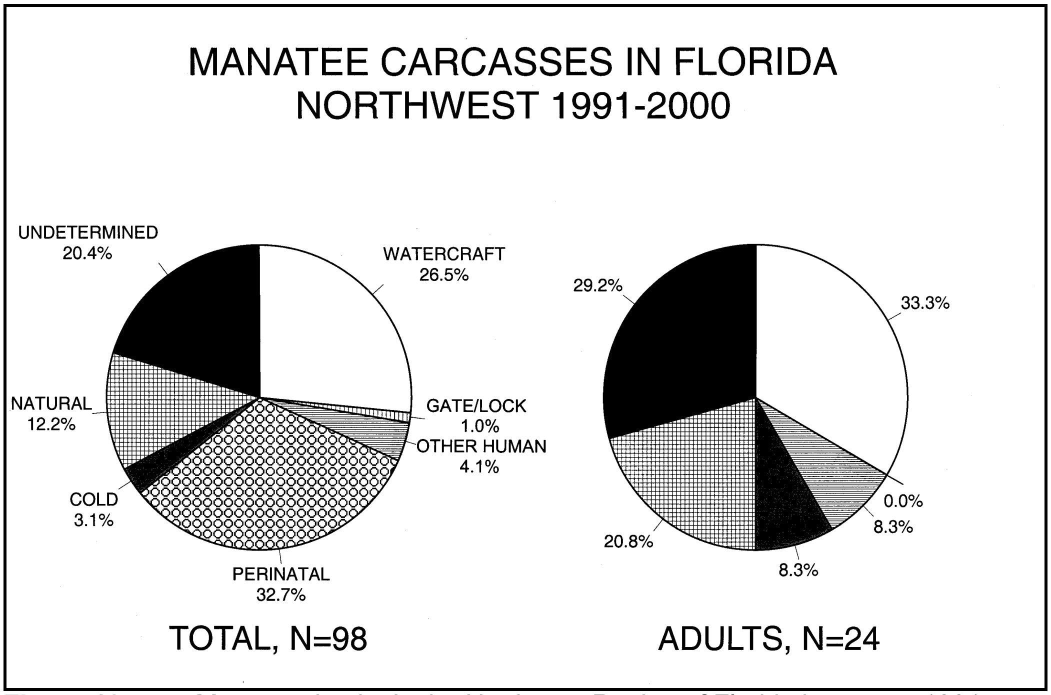

Figure 18. Manatee deaths in the Northwest Region of Florida by cause, 1991-2000. FWC unpublished data.

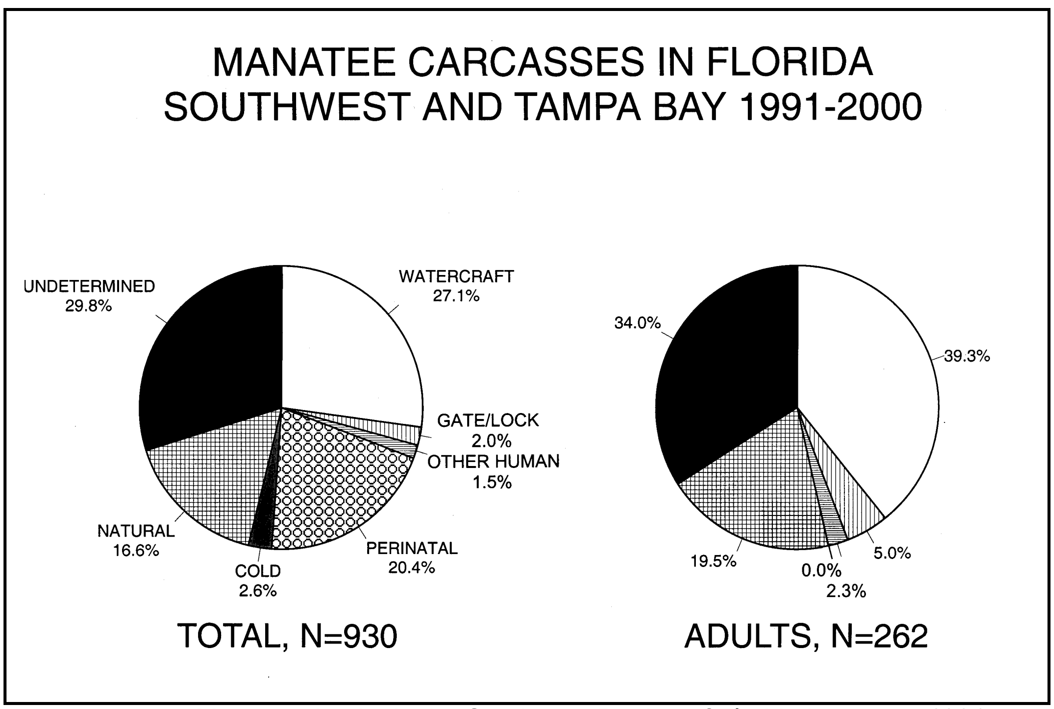

Figure 19. Manatee deaths in the Southwest Region of Florida by cause, 1991-2000. FWC unpublished data.

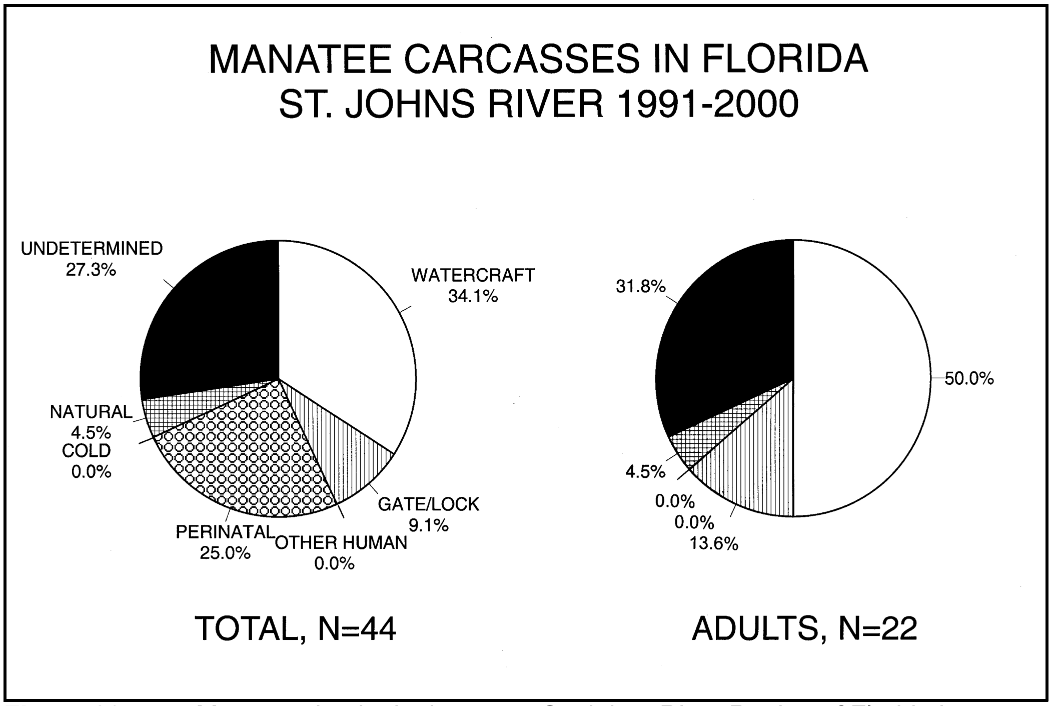

Figure 20. Manatee deaths in the upper St. Johns River Region of Florida by cause, 1991-2000. FWC unpublished data.

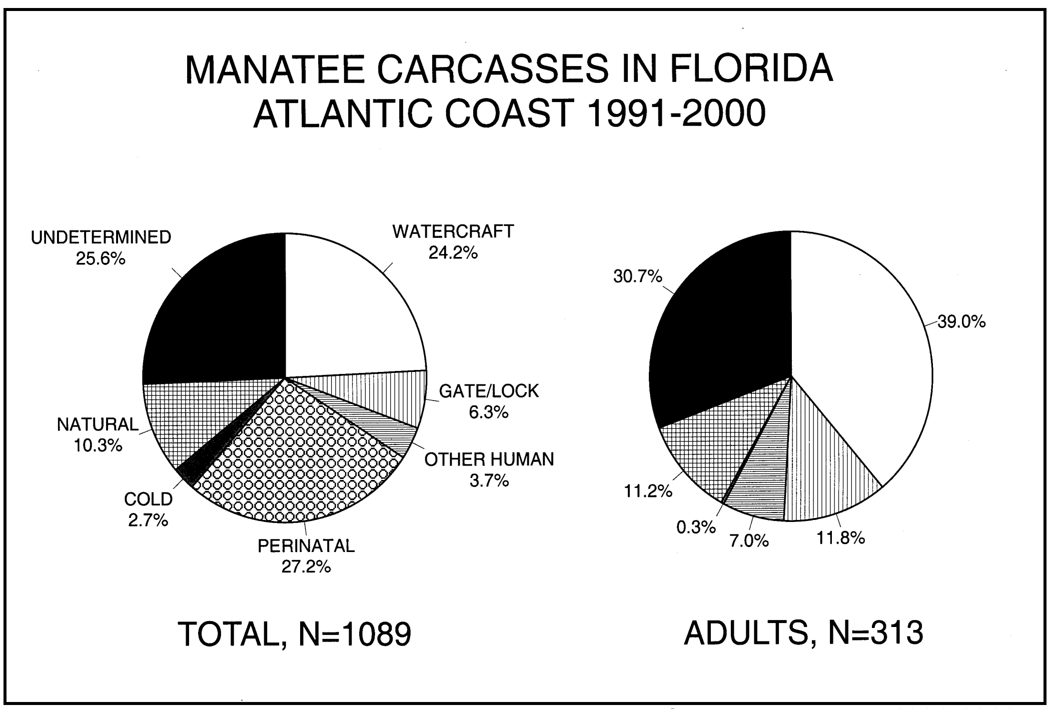

Figure 21. Manatee deaths in the Atlantic Region of Florida by cause, 1991-2000. FWC unpublished data.

FLORIDA MANATEE STATUS STATEMENT

Manatee Population Status Working Group

9 March 2001

Years of scientific study of the Florida manatee have revealed both good news and some cause for concern regarding the status of this endangered aquatic mammal, according to the interagency Manatee Population Status Working Group. The Manatee Population Status Working Group comprises biologists from the U.S. Geological Survey, U.S. Fish and Wildlife Service, Florida Fish and Wildlife Conservation Commission, Chicago Zoological Society, and Wildlife Trust. The group's primary tasks are to assess manatee population trends, to advise the U.S. Fish and Wildlife Service on population criteria to determine when species recovery has been achieved, and to provide managers with interpretation of available information on manatee population biology.

Long-term studies suggest four relatively distinct regional populations of the Florida manatee: Northwest, Southwest, Atlantic (including the St. Johns River north of Palatka), and St. Johns River (south of Palatka). These divisions are based primarily on documented manatee use of wintering sites and from radio-tracking studies of individuals' movements. Although some movement occurs among regional populations, researchers found that analysis of manatee status on a regional level provided insights into important factors related to manatee recovery.

The exact number of manatees in Florida is unknown. Manatees are difficult to count because they are often in areas with poor water clarity, and their behavior, such as resting on the bottom of a deep canal, may make them difficult to see. A coordinated series of aerial surveys and ground counts, known as the statewide synoptic survey, has been conducted in most years since 1991. The synoptic survey in January 2001 resulted in a count of 3,276, the highest count to date. The highest previous count was 2,639 in 1996. Survey results are highly variable, and do not reflect actual population trend. For example, statewide counts on 16 and 27 January 2000 differed by 36% (1,629 and 2,222, respectively). Excellent survey conditions and an unusually cold winter undoubtedly contributed to the high count in 2001.

Evidence indicates that the Northwest and Upper St. Johns River subpopulations have steadily increased over the last 25 years. This population growth is consistent with the lower number of human-related deaths, high estimates of adult survival, and good manatee habitat in these regions. Unfortunately, this good news is tempered by the fact that the manatees in these two regions probably account for less than 20% of the state's manatee population.

The picture is less optimistic for the Atlantic coast subpopulation. Scientists are concerned that the adult survival rate (the percentage of adults that survives from one year to the next) is lower than what is needed for sustained population growth. The population on this coast appears to have been growing slowly in the 1980s but now may have leveled off, or could even be declining. In other words, it's too close to call. This finding is consistent with the high level of human-related and, in some years, cold-related mortality in the region. Since 1978, management efforts to reduce human-related manatee deaths have included strategies focused on reducing manatee collisions with boats, reducing hazards such as entrapment in water control structures and entanglement in fishing gear, and protecting manatee winter aggregation sites to reduce cold-related mortality. Managers are continually challenged to develop innovative protection strategies, given the rapidly growing human population along Florida's coasts.

Estimates of survival and population growth rates are currently underway for the Southwest region. Preliminary estimates of adult survival are similar to those for the Atlantic region, i.e., substantially lower than those for the Northwest and Upper St. Johns River regions. This area has had high levels of watercraft-related deaths and injuries, as well as periodic natural mortality events caused by red tide and severe cold. However, pending further data collection and analysis, scientists are unable to provide an assessment of how manatees are doing in this part of the state.

Over the past ten years, approximately 30% of manatee deaths have been directly attributable to human-related causes, including watercraft collisions, accidental crushing and drowning in water control structures, and entanglements in fishing gear. In 2000, 34% (94 of 273) of manatee deaths were human-related. The continued high level of manatee deaths raises concern about the ability of the overall population to grow or at least remain stable. The Manatee Population Status Working Group is also concerned about the negative impacts of factors that are difficult to quantify, such as habitat loss and chronic effects of severe injuries.

The group agrees that the results of the analyses underscore an important fact: Adult survival is critical to the manatee's recovery. In the regions where adult survival rates are high, the population has grown at a healthy rate. In order to assure high adult survival the group emphasizes the urgent need to make significant headway in reducing the number of human-related manatee deaths.