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PRELIMINARY ASSESSMENT OF HABITAT PROTECTION NEEDS FOR WEST INDIAN MANATEES ON THE EAST COAST OF FLORIDA AND GEORGIA

Report of the
Marine Mammal Commission
in Consultation with its
Committee of Scientific Advisors on Marine Mammals

1625 I Street, N.W.
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EXECUTIVE SUMMARY

West Indian manatees occur from Florida and Georgia, in the southeastern United States, to northern Brazil. The species is endangered throughout its range. Remaining populations outside the United States are believed to be small and, in many areas, declining. Because the largest known concentration of animals is in Florida, the long-term survival of the species may depend on its continued existence in the southeastern United States. Survival in Florida, however, is in grave doubt. Each year, large numbers of dead animals are recovered, and human use and development further degrade remaining manatee habitat.

To provide a basis for better protecting habitats essential for the survival of the manatee population on the East Coast, the Marine Mammal Commission, in consultation with its Committee of Scientific Advisors on Marine Mammals, conducted a study to: 1) review information on the status and essential habitats of manatees on the east coast of Florida and Georgia; 2) assess potential threats to those manatee habitats; 3) evaluate the extent to which existing Federal and State Refuges, Reserves, boat speed regulatory zones, etc. protect the most important manatee habitats; and 4) identify further steps needed to protect essential habitats to make possible continued existence of the East Coast manatee population.

New information on manatee habitat use patterns is now being developed by the U.S. Fish and Wildlife Service and the Florida Department of Natural Resources. For that reason, this must be considered a preliminary study. Although ongoing research has not been completed, current information is adequate to identify many of the most important habitats. Valuable opportunities to protect those areas would be lost if actions are not begun immediately.

Available information suggests that East Coast manatees constitute a discrete population whose principal range extends from southern Georgia to southern Florida and up the St. Johns River to Lake Monroe. The East Coast population is estimated to number from 700 to 900 animals. In 1987, 73 manatee carcasses were recovered along the East Coast. Based on the estimated population size, the mortality rate that year was at least between 8.1% and 10.4%. Human-related causes accounted for 32 deaths on the East Coast in 1987, 27 of which were the result of collisions with boats. Given such mortality rates and the species' inherently low reproductive rate, it is likely that the population is stable or perhaps declining in size.

The most important winter habitats for East Coast manatees include six warm-water refuges and at least four major feeding areas. Five warm-water refuges are power plant outfalls in Brevard County (two plants south of Titusville), Palm Beach County (one plant in Riviera Beach), and Broward County (two plants in the southeast corner of the County). The sixth refuge is Blue Spring, a natural warm-water spring on the upper St. Johns River in Volusia County. Winter feeding areas are within 20 miles of warm-water refuges. The most important areas are along the Indian River near Titusville; Jupiter Sound in Martin and Palm Beach Counties; northern Biscayne Bay in Dade County, and the St. Johns River near Blue Spring.

In spring manatees begin traveling north up the Intracoastal Waterway toward summer feeding areas. The northern Banana River is the most important spring habitat, used by up to 300 animals. The most important summer feeding and resting areas identified to date are in the Banana River and the St. Johns River between Jacksonville and Green Cove Springs. Southern Georgia is also a non-winter habitat for manatees, but information is insufficient to assess its importance. The lower portions of small creeks and rivers along Florida's east coast are also used regularly during non-winter months.

The principal threats to manatees and their essential habitat are boat traffic, which makes areas hazardous to animals, and coastal development, which can reduce grassbeds preferred as feeding areas and eliminate secluded natural areas for resting, mating, calving, and nursing. Between April 1974 and June 1988, 208 manatees killed by boats were recovered on the East Coast of the United States, almost all of which were in Florida. Most carcasses were recovered from four areas: Duval County along a manatee travel corridor from Jacksonville to the mouth of the St. Johns River; Brevard County along a travel corridor through Sykes Creek and in non-winter feeding and resting areas in the central Banana River; Martin County along a manatee travel corridor between the lower St. Lucie River and northern Hobe Sound; and Broward County near the warm-water refuges in Port Everglades.

Presently, food supplies do not appear to be limiting population recovery; however, food resources near winter refuges could affect recovery if the productivity of remaining grassbeds declines significantly. Dredging, shoreline construction, and boat traffic are among threats to grassbeds.

An additional threat to manatee habitat is disruption of heated effluent at artificial warm-water refuges. Although these warm-water refuges may eventually be eliminated when and if plants are closed, a more immediate concern is possible interruptions in the availability of warm water during winter periods as a result of scheduled shutdowns for maintenance or reductions in operations. To date, at least one industry group, the Florida Power & Light Company, has gone to exceptional lengths to assure that changes in its operations have not adversely affected the availability of warm water for manatees.

More than 50 Federal and State refuges, reserves, preserves, and parks either containing or adjacent to manatee habitat exist in the principal range of the East Coast population. The areas containing the most important manatee habitat are the Merritt Island National Wildlife Refuge in Brevard County and the Blue Spring and Hontoon Island State Parks in Volusia and Lake Counties. The most important protected area systems for East Coast manatees are Florida's boat speed regulatory zones (13 areas covering approximately 70 miles of waterway) and Florida's State Aquatic Preserves (13 areas including approximately 564,000 acres of submerged estuarine lands).

Additional actions to protect essential manatee habitat are identified in four areas. First, recommendations are made for reducing the frequency of collisions between manatees and boats in essential manatee habitats. Because boaters are generally unable to spot or avoid manatees, it is recommended that a code of operations for boats be instituted to minimize the probability of collisions with manatees in areas where manatees are most likely to occur. The code would be implemented through a system of boat speed regulatory zones, education efforts targeted at boaters, and enforcement actions. The regulations would be based on efforts to: a) reduce boat speeds in certain areas where manatees are most likely to occur so as to give them a chance to avoid oncoming boats; and b) direct high speed boat traffic to areas where manatees are least likely to occur.

The existing system of State boat speed regulatory zones is based on these principles, however, the present system does not include many of the important manatee habitats used by boaters. To be effective, the present system must be expanded. For this purpose, it is recommended that the Florida Department of Natural Resources, the Fish and Wildlife Service, and agencies responsible for preparing Local Growth Management Plans review relevant data, including analyses in this report, with a view toward quadrupling the size of the existing boat speed regulatory system. New zones should seek to reduce the probability of boats hitting manatees, while minimizing inconvenience to boaters or infringing on other legitimate uses of State waters. In this regard, recommendations are made for 22 new boat speed zones covering approximately 195 additional miles of waterway. Funding to support posting of regulatory signs, public information, and enforcement is a critical part of efforts to expand the system.

Second, recommendations are made to strengthen protection of submerged grassbeds, which provide food for manatees. Grassbeds may be the most vulnerable habitat essential to manatees. Those used as feeding areas during winter months, when manatees are restricted to areas near warm-water refuges, are most important. To provide greater protection to submerged grassbeds and manatees that use them, it is recommended that management plans for Aquatic Preserves and Local Growth Management Plans: a) identify and map the location of grassbeds used by manatees; and b) prohibit new bulkheads, marinas, and other development, in or immediately

adjacent to those areas, that could reduce grassbed productivity or render areas hazardous to manatees.

Third, recommendations are made for acquiring additional undeveloped areas containing essential manatee habitat for addition to the existing system of Federal and State refuges, parks, preserves, reserves, etc. Two pending land acquisition projects currently listed under the State Conservation and Recreation Lands Program are particularly important: the St. Johns River Project, which is ranked number 48 on the State priority list and includes 8,290 acres along the St. Johns River south of Blue Spring Park; and the Goldy/Bellemead Project, which is ranked number 49 on the State list and includes 716 acres of undeveloped marshes adjacent to the Tomoka River State Park. The former project includes important feeding areas for manatees wintering at Blue Spring and the latter is one of the most important feeding and resting areas along the north-south coastal migratory corridor north of the Indian River.

In addition, it is recommended that undeveloped lands near both of the above projects be examined as potential new land acquisition projects. In the Blue Spring area, it is recommended that the Fish and Wildlife Service and the State of Florida consider cooperative efforts to consolidate holdings along a 30-mile stretch of the St. Johns River between Lake Dexter and Lake Monroe. In the Tomoka River area, it is recommended that the Florida Department of Natural Resources consider opportunities to develop a new land acquisition project including undeveloped lands on the north side of the Tomoka River opposite the Tomoka State Park and upstream of the park.

Fourth, recommendations are made for strengthening cooperative government-industry efforts to avoid, to the extent practicable, interruptions in the availability of heated effluent used by manatees as winter refuges. By innovative action, the Florida Power & Light Company was recently able to meet manatee requirements for warm water while reducing operations at certain power plants used by manatees in winter. The Company's responsible approach should be a standard for industries whose operations provide warm-water sources for manatees.

Therefore, to help continue and expand government-industry cooperation in this area, it is recommended that the Fish and Wildlife Service and the Florida Department of Natural Resources establish cooperative arrangements with relevant industries to encourage consultations between the parties if changes in plant operations are anticipated that would significantly reduce or interrupt the availability of warm water used by manatees. The objective of these consultations would be to consider what, if any, measures might be taken to avoid potential adverse affects on manatees. Such arrangements are being considered by the Fish and Wildlife Service as part of an updated Recovery Plan now being prepared for West Indian manatees in Florida and Georgia, and such provisions should be included in the final Plan.

In addition to habitat protection measures, recommendations are identified for restoring and enhancing manatee habitats. With respect to habitat restoration, a recommendation is made for consultations between the National Aeronautics and Space Administration and the Fish and Wildlife Service to identify alternative approaches for reconnecting Banana River and Banana Creek. These waterways were severed by construction of the solid-fill shuttle crawlerway connecting the Vehicle Assembly Building and launch pads at the Kennedy Space Center. The northern Banana River is a major feeding and resting area for manatees migrating along the coast, and the crawlerway now blocks direct access by manatees through Banana Creek back to the north-south migratory corridor in the Indian River. The shortest alternative route across Merritt Island to the Indian River lies about 12 miles south through the barge canal and Sykes Creek. This passageway, however, has been one of the most hazardous areas on the East Coast for collisions between manatees and boats. Two alternatives are recommended for consideration with respect to reconnecting Banana Creek and Banana River: 1) dredging a 1.5- to 2-mile canal around the west side of the Vehicle Assembly Building; and 2) installing a culvert beneath the shuttle crawlerway through which manatees could pass.

With respect to habitat enhancement, a recommendation is made for conducting a pilot study to explore the feasibility of creating "Manatee Habitat Enhancement Reserves." Much of the Indian River, Mosquito Lagoon, and perhaps other areas along the East Coast manatee migratory corridor contain grassbeds that could provide feeding and resting areas for animals. Most of these areas, however, are not available to animals because broad expanses of shallow water separate them from the manatee's travel route along the Intracoastal Waterway. If channels could be dredged into pockets containing grassbeds deep enough for manatees, new protected feeding and resting reserves might be created. This could draw animals away from channels carrying hazardous levels of boat traffic and open new habitat alternatives. Such reserves might be enhanced by installing a spigot or hose to provide a constant source of freshwater from a well or other nearby source.

Protected areas closed to boats at certain warm-water refuges and in the northern Banana River suggest that manatees will recognize and learn to use suitable protected areas such as the contemplated Manatee Habitat Enhancement Reserves. If creation of such areas proves feasible, a series of Reserves might be strategically located along the species' migratory corridor. Therefore, the objective of the recommended pilot study is to identify possible Reserve sites, assess critical factors and constraints concerning their development (particularly effects on other natural resources), and, if deemed possible, create a test Reserve within a protected area such as the Canaveral National Seashore or the Merritt Island National Wildlife Refuge.

I. INTRODUCTION

The West Indian manatee, Trichechus manatus, is one of the most endangered marine mammals in coastal waters of the United States. Although its range includes Florida, the east coast of Central America, the north coast of South America, and the Greater Antilles in the Caribbean Sea, populations are believed to be small and, in many areas, declining (Lefebvre et al. in press). The largest known concentration of animals is in Florida where the remaining populations are believed to include at least 1200 animals (Reynolds and Wilcox 1987 and in review). Programs outside of the United States to prevent poaching, protect remaining habitat, and otherwise ensure the survival of remaining populations are of questionable effectiveness. Thus, long-term survival of the species may well depend on the recovery and continued existence of the remaining populations in the southeast United States.

Because of the large number of dead manatees recovered in Florida, the relatively small number of animals in the State, and manatees' inherently low reproductive rate, long-term survival of the species in the southeast United States also is in doubt (O'Shea 1988). Known manatee mortality in Florida has averaged about 120 animals per year (10 percent of the minimum population estimate) between 1984 and 1987 (Marine Mammal Commission 1988). Boat collisions are the principal cause of known human-related manatee injury and deaths in Florida and represent one of the two greatest threats to the species' continued survival. More than 25% of the recovered carcasses displayed wounds, such as propeller slashes and crushed ribs, that clearly indicate collisions with boats as the cause of death. In addition, most living manatees bear propeller scars from non-lethal collisions (Reid and Rathbun 1984 and 1986).

The other principal threat to Florida manatees is destruction and alteration of essential habitat by coastal development and pollution. Manatees depend on warm-water refuges, feeding areas, freshwater sources, secluded areas for normal behavior (e.g., mating, calving, nursing, and resting), and travel corridors connecting these areas. Human development and use patterns, however, are destroying or degrading many of these areas. For example, dredging, bulkheading, and pollution of coastal waters have caused the loss or reduction of seagrass beds used by manatees for food. Similarly, increasing levels of boat traffic in essential habitats can increase manatee deaths from collisions

with boats or create disturbances which disrupt essential behavior patterns.

In recent years, Florida's human population has grown at an extraordinary rate and associated development is posing unprecedented threats to manatees and remaining manatee habitat. Based on comparisons of population estimates for 1987 and 1988 developed by the Bureau of Economics and Business Research at the University of Florida at Gainesville, Florida's human population is presently increasing at a net growth rate of more than 1,000 people per day (Scott Cody, Demographer, University of Florida, personal communication). Six of the State's ten most populous counties (Dade, Broward, Palm Beach, Duval, Brevard, and Volusia) are on the east coast and over 50% of the State's population lives in the Florida portion of the study area.

Approximately 90% of the residents in the Florida portion of the study area live within 15 miles of the coast or the St. Johns River. Most East Coast manatees occur within this area and, without proper planning, shoreline development and the increasing congestion of waterways by boats could, in the next few decades, eliminate or seriously damage many features, such as grassbeds or secluded areas, essential for the recovery and continued existence of manatees in Florida. With respect to boats, the number registered in Florida has increased from about 100,000 in the early 1960s to about 650,000 in 1987. Establishment of boat speed zones in some areas frequented by manatees has helped protect animals; however, unless further steps are taken immediately to protect essential manatee habitats and better insulate manatees from the increasing probability of collisions with boats caused by increasing boat traffic, the number of boat-killed manatees undoubtedly will increase.

As with most species of wildlife, the foundation for addressing critical manatee conservation problems rests in identifying and protecting essential habitat. Several recent developments offer hope that a requisite system of manatee habitat protection might be established in time to secure the species' recovery and long-term survival in Florida. For example, a number of Federal and State refuges and preserves have been established containing important manatee habitat and additional areas, particularly on Florida's west coast, are being acquired (Marine Mammal Commission 1988). In addition, a strong, cooperative manatee conservation program has been forged among Federal, State and local agencies, industry, and private organizations (Reynolds and Gluckman 1988). This coalition has supported studies to better identify manatee habitat use patterns and has taken a number of steps to improve habitat protection. Also, in 1985, the Florida legislature passed the Local Government Comprehensive Planning and Land Development Regulation Act (the "Growth Management Act") offering a vital opportunity to incorporate manatee protection provisions into local land use and development plans.

Although this progress is encouraging, accomplishments to date do not provide sufficient assurance that remaining manatee habitat will receive the necessary level of protection, given existing trends in development and use of coastal areas. To establish an effective approach for protecting manatees, the first step is to identify an optimum network of essential habitats that incorporates a full range of habitat requirements necessary to sustain populations of manatees throughout the year. Actions to protect that network should then be taken by building upon the existing network of protected areas. For example, existing refuges or reserves might be expanded to include adjacent habitat, manatee protection provisions in existing areas might be strengthened, and/or new protected areas might be established. Priority actions should be based, in part, on an assessment of trends in threats such as boat kills and development patterns.

To date, such a systematic approach to habitat protection has been developed for only one of Florida's more or less discrete manatee populations -- the Crystal River manatee population on Florida's northwest coast (Marine Mammal Commission 1984). The movement of manatees along Florida's east coast (Reid and Rathbun 1986) suggest that they constitute a single population unit. To help develop an effective habitat protection system for the east coast population, the purposes of this study are to: (1) identify areas of special biological significance to east coast manatees; (2) assess trends in potential threats to manatees and their habitats; (3) describe the existing system of refuges, reserves, and boat speed zones for protecting those areas; and (4) identify actions that should be taken to protect a network of essential habitats necessary to assure the recovery and continued existence of the East Coast manatee population.

To be effective, this approach requires detailed information on manatee movements and habitat use patterns. Although much relevant data has been gathered in recent years, the Fish and Wildlife Service and the Florida Department of Natural Resources are presently cooperating on radio-tracking studies of East Coast manatees that will significantly improve our understanding of habitat use patterns and habitat requirements. In addition, a series of aerial surveys of manatees along the East Coast is being undertaken by the Florida Department of Natural Resources and the Fish and Wildlife Service and the results of those surveys will be compiled and analyzed soon.

Therefore, this study is seen as a preliminary assessment, to be reviewed and updated as soon as results of these ongoing research projects become available. This study is being undertaken now for two reasons: 1) available information is adequate to identify at least some the most important habitats; and 2) we cannot afford to delay efforts that could and should be started now to ensure that these areas are well protected. Given current and planned development and use along the East Coast, vital opportunities to protect remaining habitat will be lost if action is not begun immediately.

II. METHODOLOGY

This study is based on published and unpublished data, consultations with manatee biologists involved in manatee research along the East Coast of the United States, and a series of overflights and site visits to manatee habitats. As a first step, information was reviewed to develop a synoptic description of manatee movement and habitat use patterns along the East Coast. Unlike manatees on Florida's west coast, which appear to be divided among more or less discrete management units with limited intermixing (e.g., the northwest Florida or Crystal River population and the southwest Florida or Fort Myers population), manatees on the East Coast often travel great distances and appear to constitute a single population whose range extends primarily from southern Georgia to southern Florida.

To facilitate analyses, the principal part of the East Coast population's range was divided into four Regions based on manatee movements and political boundaries (Figure 1). This study area covers a 420-mile length of coast from southern Georgia to southern Florida. The four Regions were defined as follows:

North Coast Region: (170 miles in length)	including the estuaries and coastal waters in Camden County, Georgia, and Nassau, Duval, St. Johns, Flagler, and Volusia Counties, Florida, including the lower St. Johns River below the Fuller Warren Bridge in Jacksonville;
St. Johns River Region: (110 miles in length)	including the St. Johns River and its tributaries south of the Fuller Warren Bridge at Jacksonville in Duval, Clay, St. Johns, Putnam, Flagler, Marion, Lake, and Volusia Counties;
Indian River Region: (135 miles in length)	including the coastal bays and rivers in Brevard, Indian River, St. Lucie, and Martin Counties;
South Coast Region: (115 miles in length)	including the coastal bays and canals in Palm Beach, Broward, and Dade Counties.

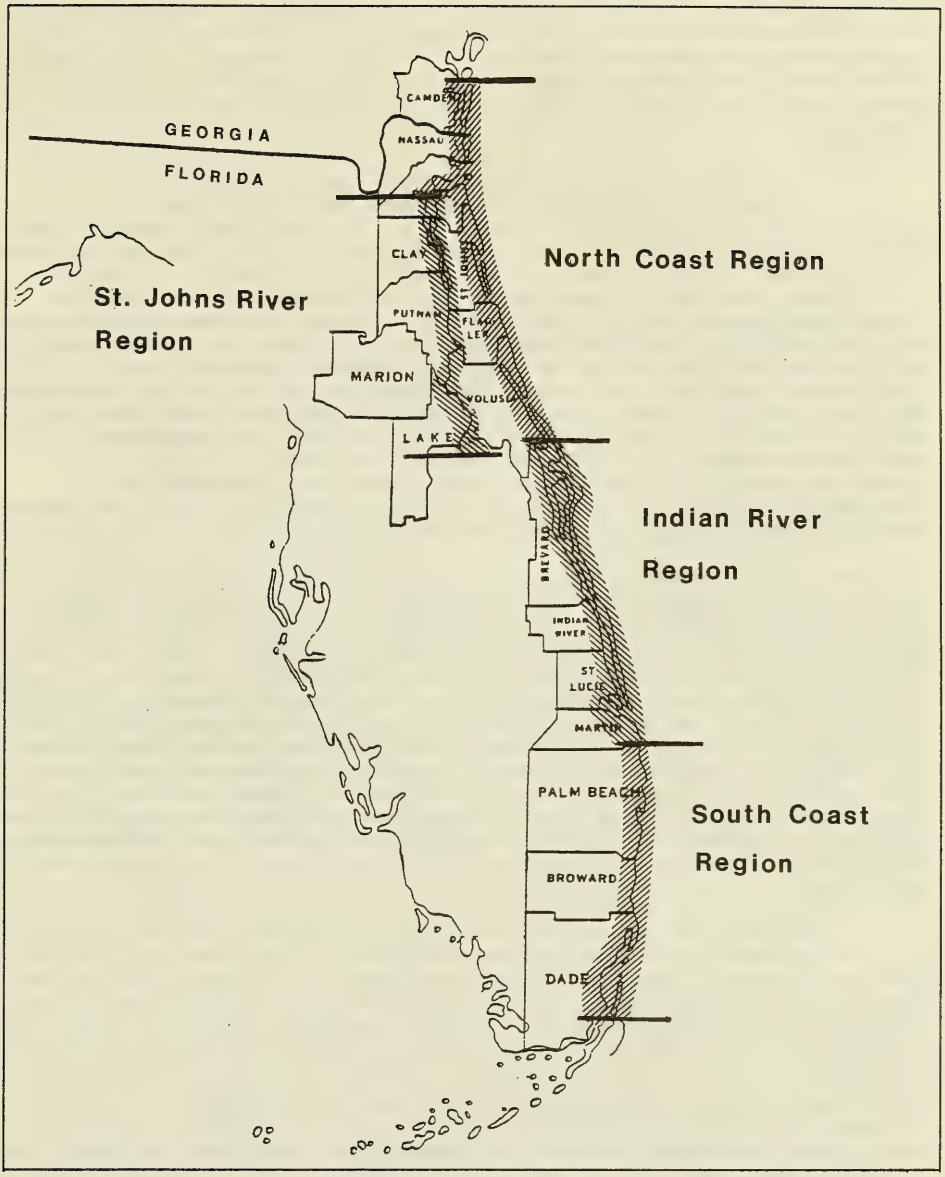

Figure 1. Coastal Counties in Study Area

For each Region, information was considered with respect to: (1) manatee habitat use patterns, with particular reference to essential manatee habitat requirements; (2) information on threats to manatees and manatee habitat; (3) the existence of protected areas, such as refuges, reserves, aquatic preserves, and boat speed regulatory zones, which bear on manatee protection; and (4) the extent to which essential manatee habitat is protected and the steps that could or should be taken to improve that protection.

To help identify essential manatee habitats in each Region, information was evaluated according to the approach used by the Marine Mammal Commission (1984) to assess habitat protection needs for manatees in the Crystal River area of northwest Florida. Under that approach, five categories of essential manatee habitat requirements are identified: (1) warm-water refuges for shelter during periods of cold winter weather; (2) feeding areas near warm-water refuges and other larger areas for summer use; (3) freshwater sources; (4) quiet sheltered areas for normal behaviors such as resting, cavorting (i.e., social interactions such as mating), calving, and nursing; and (5) travel and migratory corridors connecting the above habitat elements. Specific locations meeting these needs were identified through the literature and consultations with scientists currently conducting research on manatee distribution and movements.

To help identify threats to manatees and manatee habitats, published and unpublished literature was reviewed. Manatee mortality data developed through the manatee salvage program and boat registration data were particularly helpful. With respect to boat kills, the study relied on data presented by Beeler and O'Shea (1988) for the period April 1974 through December 1985, and on mortality files provided by the Florida Department of Natural Resources for the period January 1986 through June 1988. Data on the number of registered commercial and recreational boats by county for the years 1977/78 to 1986/87 were provided by the Florida Department of Natural Resources and the Georgia Department of Natural Resources. Information on protected area management was obtained through contacts with officials at the responsible agencies.

A preliminary assessment was then undertaken to identify habitat protection needs for each Region. This analysis was based on: (a) whether the most important manatee habitats, including areas meeting each of the above listed habitat requirements, were included within the overall system of refuges, reserves, and other protected areas; (b) the nature of the protective provisions available in those areas; and (c) whether protected areas were located such that manatees have convenient access from one to another in accord with their natural, annual pattern of habitat use. Overflights of the entire study area and selected site visits to particularly important habitats were then conducted to help assess the usefulness and, as necessary, modify preliminary recommendations.

III

OVERVIEW OF THE DISTRIBUTION, MOVEMENT, AND HABITAT USE PATTERNS OF EAST COAST MANATEES

The population of West Indian manatees living in coastal waters and rivers along the Atlantic coast of the southeastern United States (the "East Coast" manatee population) occupies the northern limit of the species' range and constitutes one of the largest remaining manatee populations anywhere. The number of manatees throughout Florida has been estimated to be at least 1200 animals (Reynolds and Wilcox 1987 and in review).

The best available data on the size of the East Coast population comes from two sources: a series of aerial surveys conducted each winter from 1977/78 to 1987/88 at the five principal warm-water refuges in central and south Florida (i.e., the Florida Power & Light Company's Canaveral, Riviera, Port Everglades, and Lauderdale plants and the Orlando Utility Commission plant at Delespine); and winter counts of known individuals over that same period at Blue Spring, the only other major warm-water refuge on the East Coast. During that 11-year period, the maximum one-day count at the five east coast power plants and along the Intracoastal Waterway between them was 613 animals recorded in February 1988 (Reynolds 1988). A count of 52 overwintering animals was recorded that year at Blue Spring (Sirenia Project, U.S. Fish and Wildlife Service, unpublished data). Together, these data suggest a minimum population estimate of at least 665 manatees. Assuming that 10% to 30% of the animals were either overlooked or absent from the surveyed areas during the exceptionally good counting conditions of that February survey, a reasonable estimate of the the number of East Coast manatees is 700 to 900 animals.

Although manatees have been reported as far north as the Potomac River in Virginia (Rathbun et al 1982), the range of the East Coast population appears to be limited primarily to coastal waters from south Georgia to Key Largo, Florida, the St. Johns River in north-central Florida, and the system of flood control canals criss-crossing southeast Florida (O'Shea 1988). There are no documented incidents of animals moving between the east and west coasts of Florida, suggesting that interchange of animals between the two coasts is uncommon. However, a recent study of genetic variability in Florida manatees suggests that there are no genetic differences between animals on the east and west coasts of

Florida and that some gene flow does occur across or around the peninsula (McClenaghan and O'Shea 1988).

Manatees are unable to survive prolonged exposure to water temperatures much below 20°C and, thus, seasonal fluctuation above and below this level is a dominant influence on manatee movements. Except at the southern tip of the Florida peninsula, water temperatures usually drop below this level for at least short periods during the winter. To survive winter cold spells, manatees have learned to find and use localized warm-water outfalls at industrial plants (e.g., electric generating stations and paper manufacturing plants) and discharges from natural warm-water springs.

Warm-water refuges in the United States known to support manatees throughout the winter occur almost exclusively in Florida (see Figure 2). Most of the population winters at warm-water refuges created by power plant outfalls along the Intracoastal Waterway south of Titusville, Florida. Aggregations of more than 200 animals have been observed during cold winter periods at some of these outfalls (Reynolds, 1988). The only other warm-water refuges occupied by manatees throughout the winter are at Blue Spring on the upper St. Johns River, presently used by about 50 animals each year; a group of industrial outfalls in the Jacksonville area used by perhaps a dozen manatees; and possibly a paper plant outfall at St. Mary's, Georgia, which may be used by a few animals. Other warm-water refuges available to manatees in Florida and Georgia appear to be used only by animals caught away from winter refuges by sudden spring or fall cold spells.

Although most animals appear to return to the same warm-water refuge each winter, others move to different refuges both within years or from one year to the next (Reid and Rathbun 1986). Because of the exchange of animals between winter refuges on the east coast, an intermixing of animals throughout the summer range, and the apparent absence of movements between the east and west coasts of Florida, manatees on the East Coast are believed to be a single population, rather than a number of separate populations.

Factors determining which warm-water refuges manatees use may include: the temperature and size of the warm-water discharge plume; the dependability of heated discharges throughout the winter and in previous years; unimpeded access to and from a discharge area and surrounding waters; the level of waterborne human activity in the discharge area; the availability of freshwater and feeding areas either at or near the refuge; and a temperature regime surrounding the refuge that allows animals to make periodic forays to nearby feeding areas and freshwater sources with sufficient regularity to meet metabolic needs.

In the warmer months, manatees disperse from the winter refuges, many moving northward (O'Shea 1988). Travel corridors are the inland waters along the Intracoastal Waterway and the St. Johns River. Manatees are seen most often moving along the

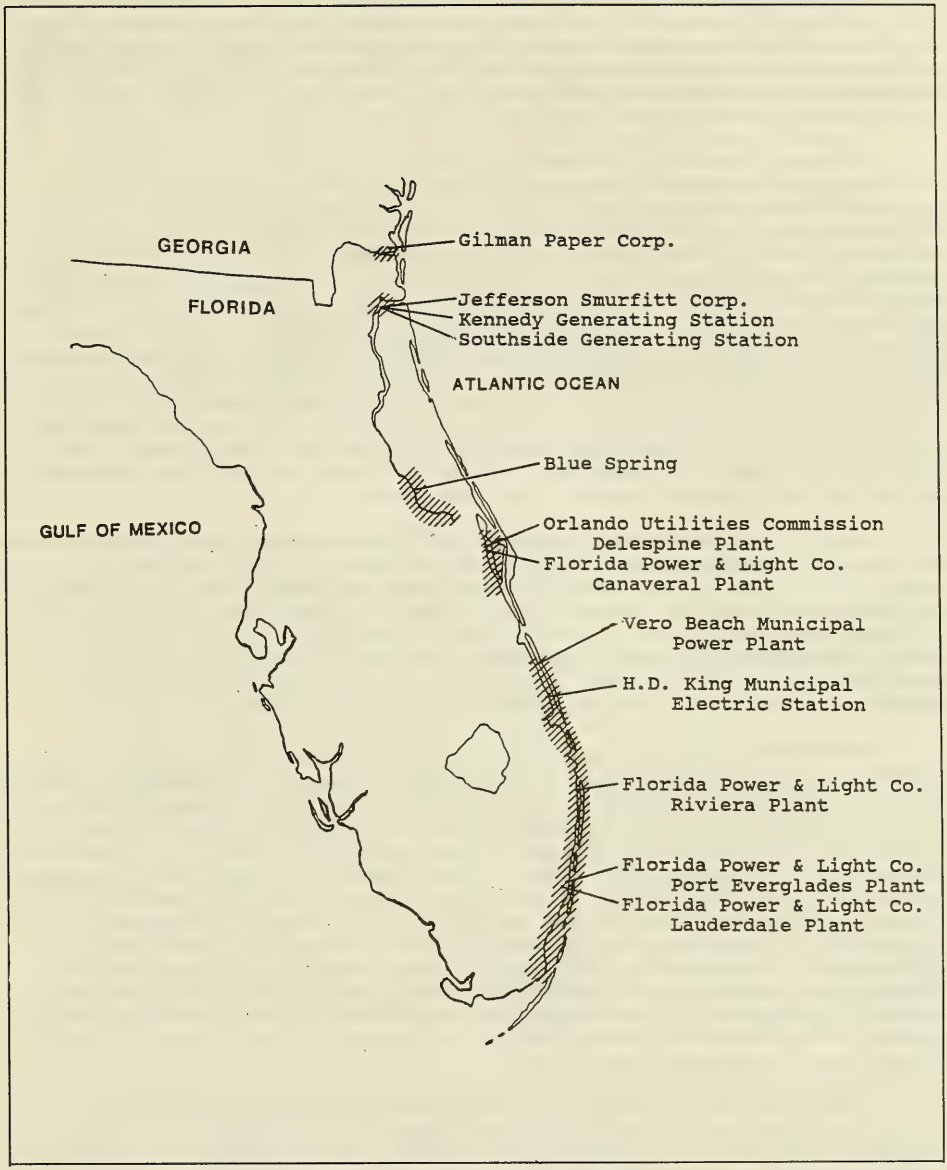

Figure 2. Location of mid-winter range and warm water refuges used by manatees in the study area (modified from O'Shea 1988).

margins of rivers and the Intracoastal Waterway, rather than in the center of channels, perhaps because of reduced levels of boat traffic along the channel margins. Along the coast, there is evidence of occasional movement through inlets and along the ocean side of coastal barrier beaches, but use of open ocean routes is not considered typical.

Between March and November, preferred feeding, resting, calving, and cavorting areas include certain tributaries, creeks, and shoreline embayments along inland waters from southern Georgia to southern Florida. These areas are most often along the mainland side of the Intracoastal Waterway in relatively secluded creeks, canals, and rivers. One major exception to this pattern is in the Banana River in east-central Florida. Preferred areas are most often along waterbody margins where relatively deep channels or basins (>3 meters) cut into shallow waters with ample submerged aquatic vegetation on surrounding flats, or extend up to banks with emergent vegetation (Provancha and Provancha 1988, Packard 1981, and Kinnaird 1983a and 1983b). The upper reaches of creeks and canals emptying into the Intracoastal Waterway are important freshwater sources; however, hoses at marinas, sewage outfalls, and storm drains also are used.

East coast manatees exhibit both opportunism and independence in their movements and habitat use patterns. This suggests a capacity to learn new behavior patterns and adapt to the creation of favorable habitat conditions. Their opportunism is illustrated by the consistent use of artificial warm-water refuges, which enable manatees to remain in areas otherwise too cold for them to survive during the winter, and by the use of sewage outfalls, hoses, and other artificial sources to meet freshwater needs.

Manatees also display opportunism with respect to their diet. Depending on availability, manatees will feed on submerged aquatic plants, intertidal marsh grasses, non-native floating plants such as water hyacinth, and various forms of algae growing on the bottom or on exposed surfaces in the water. In addition, manatees appear to recognize and prefer areas closed to boats or otherwise protected from sources of human disturbance and will avoid comparable unprotected areas nearby. The latter is suggested by preferential manatee use of small areas closed to boats and swimmers at warm-water refuges in the Crystal River and the Port Everglades power plant discharge canal (Reynolds 1988), and by recent increases in the number of manatees in restricted access areas at the Kennedy Space Center in the northern Banana River (Provancha and Provancha 1988).

The independent nature of manatees is illustrated by the often solitary and highly variable movement patterns of individual animals. Traveling manatees are usually seen alone or in pairs. In addition, as noted above, while most animals seem to return to the same warm-water refuge year after year, others use different refuges in succeeding years or move between refuges during a single winter (Reid and Rathbun 1986). Individualistic habitat

use patterns also occur during transitional and warm weather seasons. For example, some animals appear to remain near warm-water winter refuges throughout the summer while other more nomadic animals may travel well over a thousand kilometers to and from winter and summer habitat areas, sometimes making several round trips in a single summer (Reid and Rathbun 1986, and Sirenia Project, U.S. Fish and Wildlife Service, unpublished data).

Ongoing radio-tracking studies by the Fish and Wildlife Service and Florida Department of Natural Resources are beginning to provide new information on manatee movement patterns. For example, preliminary results document spring and summer movements of both males and females, including a female with a calf, between winter areas in central and south coastal Florida and areas along southern Georgia (Zoodsma and Valade 1987). One animal made three such trips in a single year and some individuals have now returned to southern Georgia two years in a row (Sirenia Project, U.S. Fish and Wildlife Service, unpublished data).

IV. NORTH COAST REGION

A. Manatee Distribution and Essential Habitat Areas

The North Coast Region includes the coastal waters and lower portions of rivers along approximately 170 miles of Atlantic Ocean coastline from Camden County, Georgia, south to Volusia County, Florida. Most manatee habitat in this Region occurs in the system of creeks, marshes, and waterways lying within about eight miles of the barrier islands fronting the Atlantic Ocean north of the St. Johns River mouth, along the coast within about three miles of the barrier beaches south of the St. Johns River, and along the lower 25 miles of the St. Johns River below the Route 95 Fuller Warren Bridge at Jacksonville, Florida. Important manatee habitat features in the North Coast Region are identified on Figure 3. The most complete overview of available information on manatees in the Region is found in Beeler and O'Shea (1988).

At least a few manatees are seen throughout the winter months at warm-water refuges created by the J. Dillon Kennedy Generating Station, the Southside Generating Station, and the Jefferson Smurfitt Corporation plant at Jacksonville on the St. Johns River (Kinnaird and Valade 1983 and Valade et al. 1987). The three refuges lie within four miles of each other. Combined winter counts for the three refuges suggest regular winter use by perhaps 10-12 animals. The refuges are not considered major overwintering sites. An even smaller number of manatees may winter at the Gilman Paper Corporation paper plant in St. Mary's, Georgia, on the North River (J.A. Valade, personal communication). If animals winter in the outfall created by this plant, it likely would represent the northernmost site where manatees occur regularly throughout the winter.

Other warm-water refuges also occur in the North Coast Region but are used more sporadically by manatees, primarily during the early spring and late fall. These include the Container Corporation of America pulp mill on Amelia Island (Nassau County) and the Northside Generating Station on the St. Johns River. An additional warm-water refuge used by manatees lies north of the study area at the Hercules organic gum and wood chemical processing plant on Terry Creek at Brunswick in Glynn County, Georgia (Rathbun et al. 1982).

Although warm-water refuges in the North Coast Region are not major overwintering sites, they are important features for manatees. In particular, they appear to reduce the risk of

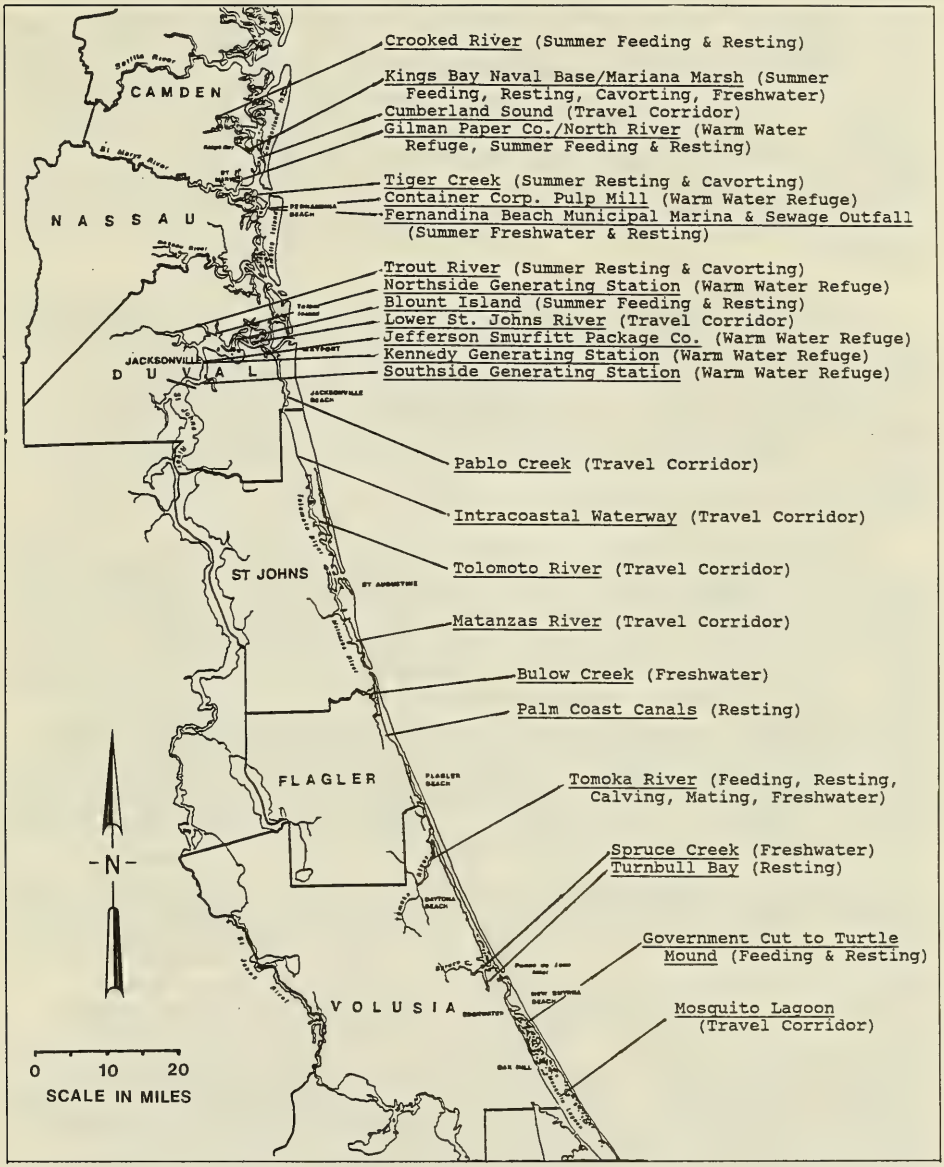

Figure 3. Important manatee habitats in the North Coast Region of the Study Area (Kinnaird 1983a, Zoodsma and Valade 1987, Valade et al. 1988, and Beeler and O'Shea 1988).

exposure to potentially fatal cold snaps in early spring and late fall, thereby helping extend seasonal use and travel periods beyond what they otherwise might be (Kinnaird 1983a). Manatee use of warm-water outfalls in the Region peaks during late winter and early fall (Rathbun et al. 1982, Kinnaird and Valade 1983, Valade et al. 1987, and Beeler and O'Shea 1987) suggesting that the refuges enable manatees to use surrounding feeding and resting habitats before the last cold winter periods give way to consistently warm weather in spring. Similarly, the refuges may enable manatees to survive early fall cold spells that occur before animals have returned to preferred overwintering sites to the south.

The North Coast Region appears to be of greatest importance as a travel corridor for manatees moving between winter habitat in the Indian River and South Coast Regions and summer feeding and resting areas in the St. Johns River Region (upstream of Jacksonville). However, some areas in the Region, particularly the northern portion in Camden and Nassau Counties and Volusia County, provide summer feeding, resting, and cavorting habitat. Preferred warm weather feeding and resting sites typically lie along quiet creeks, rivers, and embayments on the mainland side of the Intracoastal Waterway.

Recent aerial surveys and radio-tracking studies document the movement of manatees from overwintering sites in the Indian River and south Florida to and from south Georgia and northern Florida in early spring and summer (Zoodsma and Valade 1987 and Sirenia Project, U.S. Fish and Wildlife Service, unpublished data). Warm water, available food, freshwater sources, and secluded resting areas appear to offer suitable seasonal habitat for manatees. Intertidal marsh grasses (Spartina alterniflora) appear to be the most important food source for manatees in these northern areas. Feeding has been observed to coincide with high tides affording manatees access to marsh edges (Hardisky 1979 and Baugh et al. in review). Manatees sometimes pull themselves half out of the water to reach marsh grasses along creek banks.

Areas of repeated manatee sightings in southern Georgia and northern Florida (north of the St. Johns River) include: Terry Creek on the Brunswick River near Brunswick (north of the study area); White Oak Creek on the Satilla River; the Crooked River; Kings Bay (site of a Naval submarine base); the North River (location of a warm-water outfall created by the Gilman Paper Corporation plant); and the mouth of Tiger Creek just south of the Georgia-Florida border. The Nassau River, which forms part of the border between Nassau and Duval Counties, appears to provide similar habitat but, to date, there is little evidence of manatee occurrence in that River. Cumberland Sound is a major travel route for manatees moving around and through south Georgia. Artificial freshwater sources at the Burgess Seafood plant in Brunswick, the Kings Bay Naval Station, the Fernandina Beach municipal sewage outfall, and the Fernandina Beach municipal marina have been used by manatees seeking freshwater.

Several areas in Volusia County appear to offer preferred summer habitat for manatees, including Bulow Creek, the Tomoka River, and Spruce Creek. All three Creeks provide freshwater for manatees (Beeler and O'Shea, 1988) as well as secluded areas for resting, calving, and feeding. Kinnaird (1983a) reported numerous sightings of manatees, including some feeding on emergent bank vegetation, in the Tomoka River between April and June during the course of aerial surveys in 1982-83. She also reported low levels of boat traffic in the Tomoka River relative to adjacent waters along the Intracoastal Waterway and suggested that reduced levels of boat disturbance may attract manatees to the River. Aerial surveys of the Tomoka River between May and December 1985 produced counts ranging from zero to eight animals with highest counts in early spring and late summer (unpublished Florida Department of Natural Resources data cited in Beeler and O'Shea, 1988). The Tomoka River is one of the few locations where a manatee birth has been observed in the wild (McNerney 1982). Ponce de Leon Inlet and the nearby Spruce Creek and Turnbull Bay also are locations which manatees seem to prefer (Kinnaird 1983a and unpublished data from the Sirenia Project, U.S. Fish and Wildlife Service).

Inland waters between Nassau and Volusia Counties, including the lower St. Johns River, appear to be used primarily as travel corridors. There are few known resting or feeding areas along this portion of the Region and manatees are usually observed traveling alone or in pairs. Resting and feeding areas that do exist here include residential canal systems and boat basins along the coast, and the Blount Island area and Trout River on the lower St. Johns River. These areas may be used mostly by transiting animals.

Mosquito Lagoon at the southern end of Volusia County and northern Brevard County is, for the most part, too shallow for manatees (<1 m deep). The Intracoastal Waterway running the length of the Lagoon along its west side is a travel corridor for manatees moving north and south. A few animals occasionally use a channel across the northern end of the Lagoon to the headquarters of the Canaveral National Seashore at Turtle Mound on the eastern side of the Lagoon. Ongoing radio-tracking studies should provide additional information on habitat use patterns throughout the North Coast Region in the near future.

B. Regional Threats to Manatees and Manatee Habitat

The principal threat to manatee habitat in the North Coast Region is increasing levels of boat traffic in essential travel corridors and at feeding areas, resting areas, warm-water refuges, and freshwater sources. Increasing levels of boating traffic are a threat to manatee habitat because they increase the probability that animals will be killed or injured by collisions with boats and because they disrupt normal behavior patterns. While this is not a threat in the usual sense of so altering an area that it no

longer meets a species' needs, the hazards created by high speed boat traffic in areas preferred by manatees clearly reduce its suitability for the species.

Between April 1974 and June 1988, the manatee salvage/ necropsy program recovered 47 manatees killed as a result of collisions with boats in the North Coast Region. As shown in Figures 4 and 5, nearly three-quarters of these animals (34 of 47 animals) were recovered in Duval County. The histogram in Figure 6 shows that these carcasses have been recovered in all months of the year with no clear seasonal trend.

The number of boat kills along the lower St. Johns River in Duval County, particularly around the City of Jacksonville, is one of the highest for any area in Florida. Nine boat-killed manatees have been recovered since 1974 along a relatively narrow 3-mile stretch of the St. Johns River in Jacksonville upstream from the mouth of the Trout River. This section includes the warm-water refuges created by the Jefferson Smurfitt Corporation box plant and the Kennedy Generating Station. A study of boat traffic patterns along the lower St. Johns River indicates that barge, ocean liner, and other large vessel traffic is particularly heavy along this part of the river (Kinnaird 1983a). Elsewhere along the lower St. Johns River, carcass recovery locations have been distributed more evenly. Eight of 34 boat-barge-killed manatees from Duval County (24%) were recovered from January 1986 through June 1988, suggesting a recent increase in the number of boat kills in this area.

As indicated by boat registration data maintained by the Florida Department of Natural Resources for both commercial and recreational boats, the number of registered boats in northern Florida counties in the North Coast Region increased by 68% in the 10-year period from 1977 to 1987 (see Table 1). The greatest rate of increase over that period (151%) has been in Flagler County, but the greatest increase in actual numbers of boats has been in Volusia and Duval Counties (increases of 7,880 boats and 5,960 boats, respectively). Given continuing increases in the number of registered boats and a corresponding increase in boat traffic, the number of boat-killed manatees is likely to increase unless new steps are taken to reduce the probability of collisions between manatees and boats.

As noted above, emergent salt marsh grasses and perhaps benthic algae appear to be the principal source of food for manatees in the North Coast Region. This vegetation is very abundant and is in no imminent danger of depletion.

C. Regional Protected Areas

The system of existing and proposed protected areas in and adjacent to manatee habitat in the North Coast Region includes: two National Seashores and two National Monuments administered by

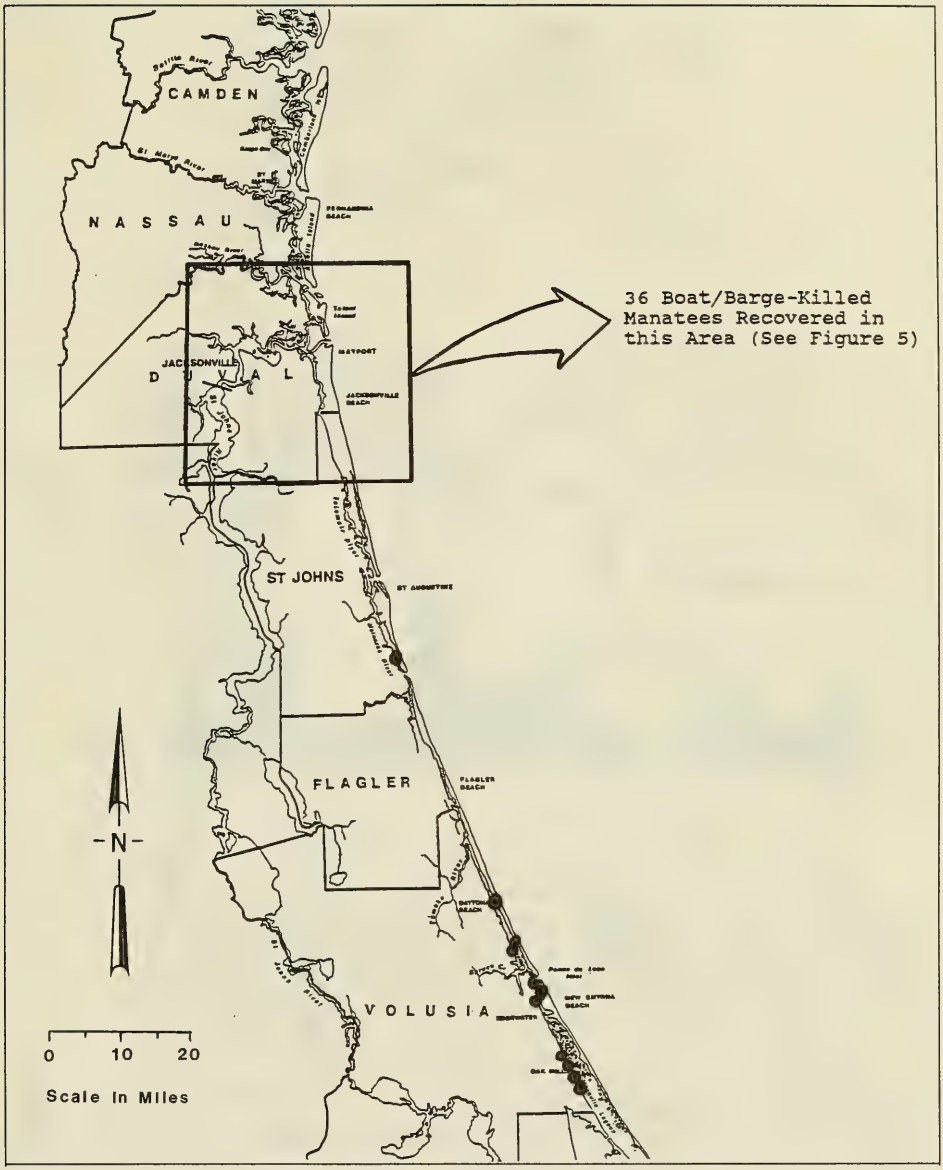

Figure 4. Recovery sites of boat-killed manatees recorded from April 1974 through June 1988 in the North Coast Region (Beeler and O'Shea 1988 and Bureau of Marine Research, Florida Dept. of Nat. Res., unpublished data).

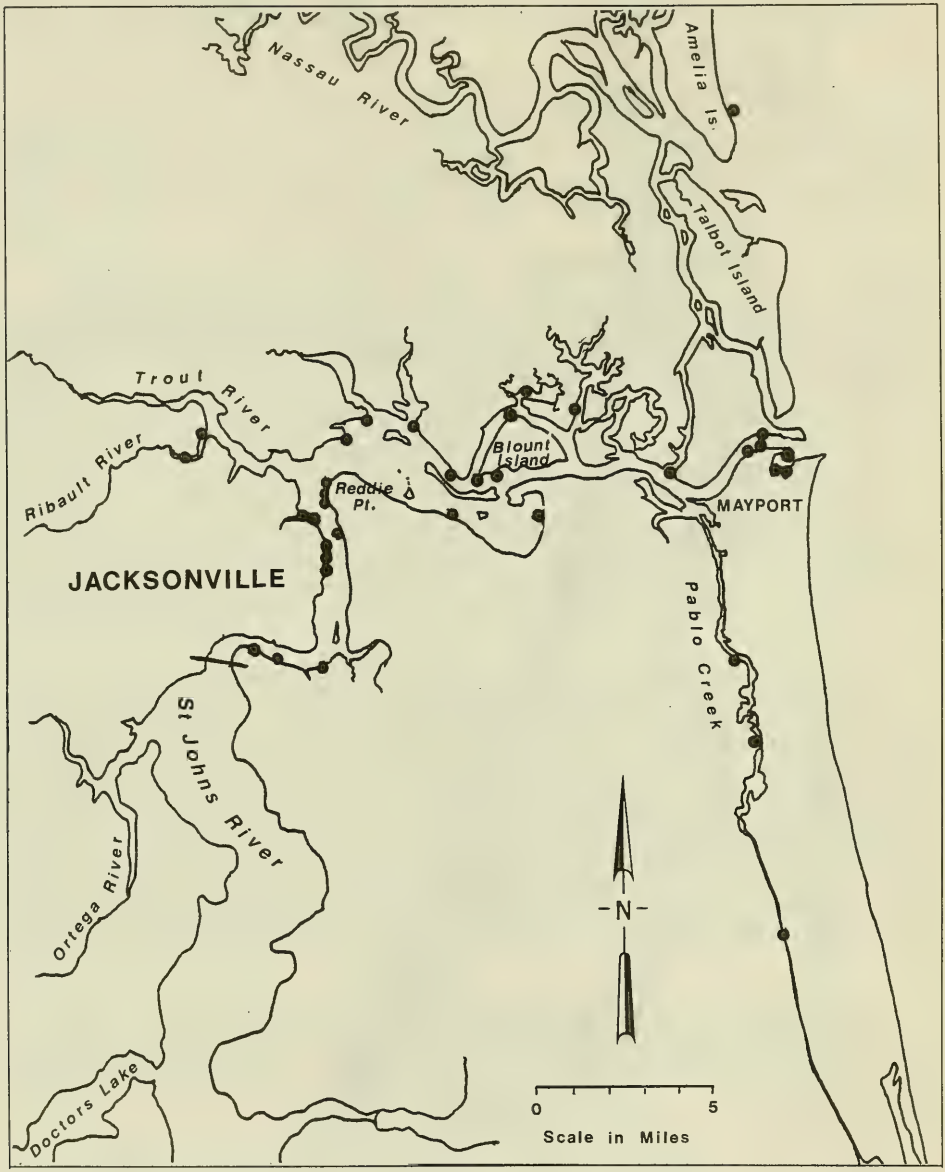

Figure 5. Recovery sites of boat-killed manatees recorded from April 1974 through June 1988 in the lower St. Johns River area of the North Coast Region (Beeler and O'Shea 1988 and Bureau of Marine Research,Fla. Dept. of Nat. Res., unpublished data).

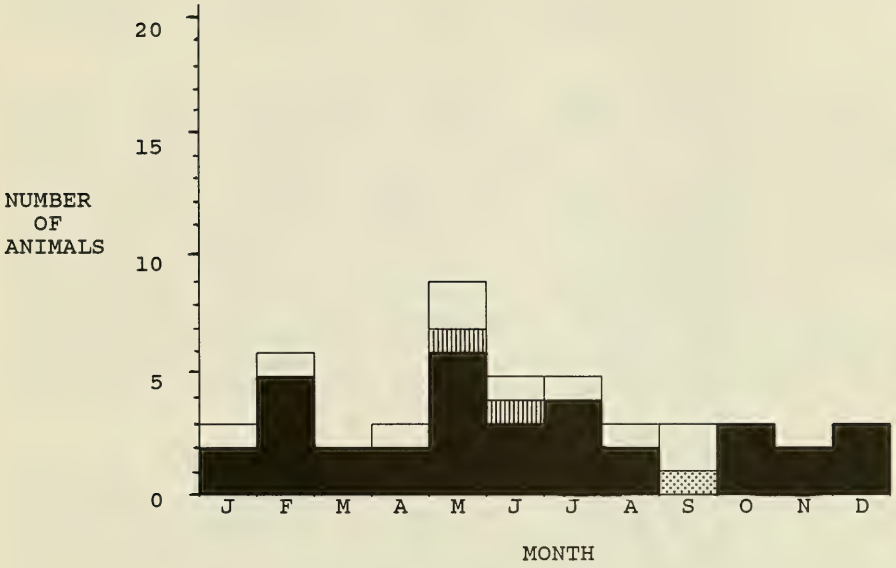

Figure 6. Number of known boat-killed manatees by month for Counties in the North Coast Region from April 1974 through June 1988. Duval = ; St. Johns = ; Nassau = ; and Volusia = . (Beeler and O'Shea 1988 and Bureau of Marine Research, Florida Department of Natural Resources, unpublished data)

Table 1. Total number of recreational and commercial boats registered by year for counties in the North Coast Region (Florida only) between 1977 and 1987 and the percent increase over that ten-year period (based on data from the Florida Department of Natural Resources).

County	Number of Registered Boats by Year (in thousands)										Increase Over Ten Year Prd.
	1977/ 1978	1978/ 1979	1979/ 1980	1980/ 1981	1981/ 1982	1982/ 1983	1983/ 1984	1984/ 1985	1985/ 1986	1986/ 1987	
North Coast Region											
Nassau	1.68	1.79	1.88	2.00	1.89	2.36	2.64	2.49	2.61	2.81	1.13(67%)
Duval*	23.29	25.67	25.30	25.61	25.08	25.68	26.94	28.04	29.00	29.25	5.96(26%)
St. Johns*	2.13	2.31	2.49	2.49	2.43	2.91	3.07	3.20	3.41	3.86	1.73(81%)
Flagler*	0.71	0.85	1.23	1.28	1.02	1.16	2.09	1.84	1.87	1.78	1.07(151%)
Volusia*	10.15	11.65	12.30	13.20	12.55	14.57	15.62	16.45	17.17	18.03	7.88(78%)
TOTALS	37.96	42.27	43.20	44.58	42.97	46.68	50.36	52.02	54.06	55.73	17.77(68%)

* = County includes major boating areas along the Atlantic Ocean coast and the St. Johns River.

the National Park Service; one National Wildlife Refuge managed by the U.S. Fish and Wildlife Service; one State Reserve, five State Aquatic Preserves, nine State Parks, and four State Recreation Areas managed by divisions of the Florida Department of Natural Resources; and five proposed land acquisition projects currently listed as recommended projects under the State Conservation and Recreation Lands Program (see Table 2 and Figure 7). In addition, the upper reaches of the North River within the Kings Bay Submarine Base owned by the Navy have been established as a restricted access area and are designated as a manatee reserve. No boat speed regulatory zones for manatees have been established in the North Coast Region by the Florida Department of Natural Resources. A description of some of the more important areas is provided below.

The two National Seashores are among the largest protected areas in the Region. The Cumberland Island National Seashore in Camden County, Georgia, was established by Congress in 1972 to preserve the island's scenic, scientific, and historical values. It is largely undeveloped and includes marshes, beaches, and uplands above mean high tide east of the Intracoastal Waterway. Manatees have been seen adjacent to the island, but the marshes and creeks within the park do not appear to be used as heavily for feeding and resting as those west of the Intracoastal Waterway. The Park has no rules or provisions specifically related to manatee protection, but it does offer educational materials and information programs on manatees to visitors. Park managers are also cooperating with the U.S. Fish and Wildlife Service, which is conducting aerial surveys of manatees in the Cumberland Sound area.

The Canaveral National Seashore in Volusia and Brevard Counties, established in 1975, includes most of the marshes, beaches, and water bottom in and along Mosquito Lagoon west of the Intracoastal Waterway. Portions of the Park are owned by the National Aeronautics and Space Administration and are within or adjacent to the Merritt Island National Wildlife Refuge (most of which is in Brevard County -- see discussion under Indian River Section) and the Mosquito Lagoon State Aquatic Preserve. A complex ownership and management arrangement exists between the National Park Service, NASA, the Fish and Wildlife Service, and the Florida Department of Natural Resources. Manatees are occasionally seen along the channel leading to Turtle Mound at the northern end of the Lagoon where the Park headquarters is located, but this and other areas adjacent to the Park in Mosquito Lagoon do not appear to be major feeding or resting areas (R. Bryant, Park Resource Specialist, personal communication). The Park has no special provisions for manatee protection, but information on the species is included in visitor education programs.

Five State Aquatic Preserves have been established in the North Coast Region by the Florida Department of Natural Resources. These areas include State-owned submerged lands below mean high water underlying creeks and inland waters in a substantial portion

Table 2. Federal and State protected areas containing or adjacent to manatee habitat in the North Coast Region.

Name	County	Size (in Acres)
NATIONAL SEASHORES, PARKS, AND MONUMENTS (NATIONAL PARK SERVICE)		
Cumberland Island National Seashore	Camden	36,876
Canaveral National Seashore	Volusia/Brevard	57,627
Castillo de San Marcos Nat. Mon.	St. Johns	20
Fort Matanzas Nat. Mon.	St. Johns	299
NATIONAL WILDLIFE REFUGES (FISH AND WILDLIFE SERVICE)		
Merritt Island Nat. Wildlife Ref.	Volusia/Brevard	140,293
STATE PRESERVES AND RESERVES (FLORIDA DEPT. OF NATURAL RESOURCES		
Nassau River State Reserve	Nassau/Duval	1,602
STATE AQUATIC PRESERVES (FLORIDA DEPT. OF NATURAL RESOURCES)		
Fort Clinch State Park Aq. Pres.	Nassau	9,000
Nassau River-St. Johns River Marshes Aq. Pres.	Nassau/Duval	85,000
Pellicer Creek Aq. Pres.	St. Johns/Flagler	505
Tomoka Marsh Aq. Pres.	Flagler/Volusia	7,000
Mosquito Lagoon Aq. Pres	Volusia/Brevard	36,000
STATE PARKS AND RECREATION AREAS (FLORIDA DEPT. OF NATURAL RESOURCES)		
Amelia Island St. Rec. Area	Nassau	215
Anastasia St. Rec. Area	St. Johns	1,835
Big Talbot Island State Park	Duval	1,344
Bulow Creek State Park	Flagler/Volusia	1,990
Crooked River State Park	Camden	81
DeLeon Springs St. Rec. Area	Volusia	71
Favor-Dykes State Park	St. Johns	752
Flagler Beach State Park	Flagler	145
Fort Clinch State Park	Nassau	1,085
Guana River State Park	St. Johns	2,398
Little Talbot Island State Park	Duval	2,500
North Peninsula St. Rec. Area	Flagler	1,460
Tomoka State Park	Volusia	915
WILDLIFE MANAGEMENT AREAS (FLORIDA GAME & FRESHWATER FISH COMMISSION)		
Guana River Wildlife Mgt. Area	St. Johns	8,700
PROPOSED LAND ACQUISITION PROJECTS (FLORIDA CONSERV. & REC. LANDS PROGRAM)		
Fort George Island	Duval	900
Princess Place	St. Johns/Flagler	1,849
North Peninsula	Volusia	135
Goldy/Bellemead	Volusia	716

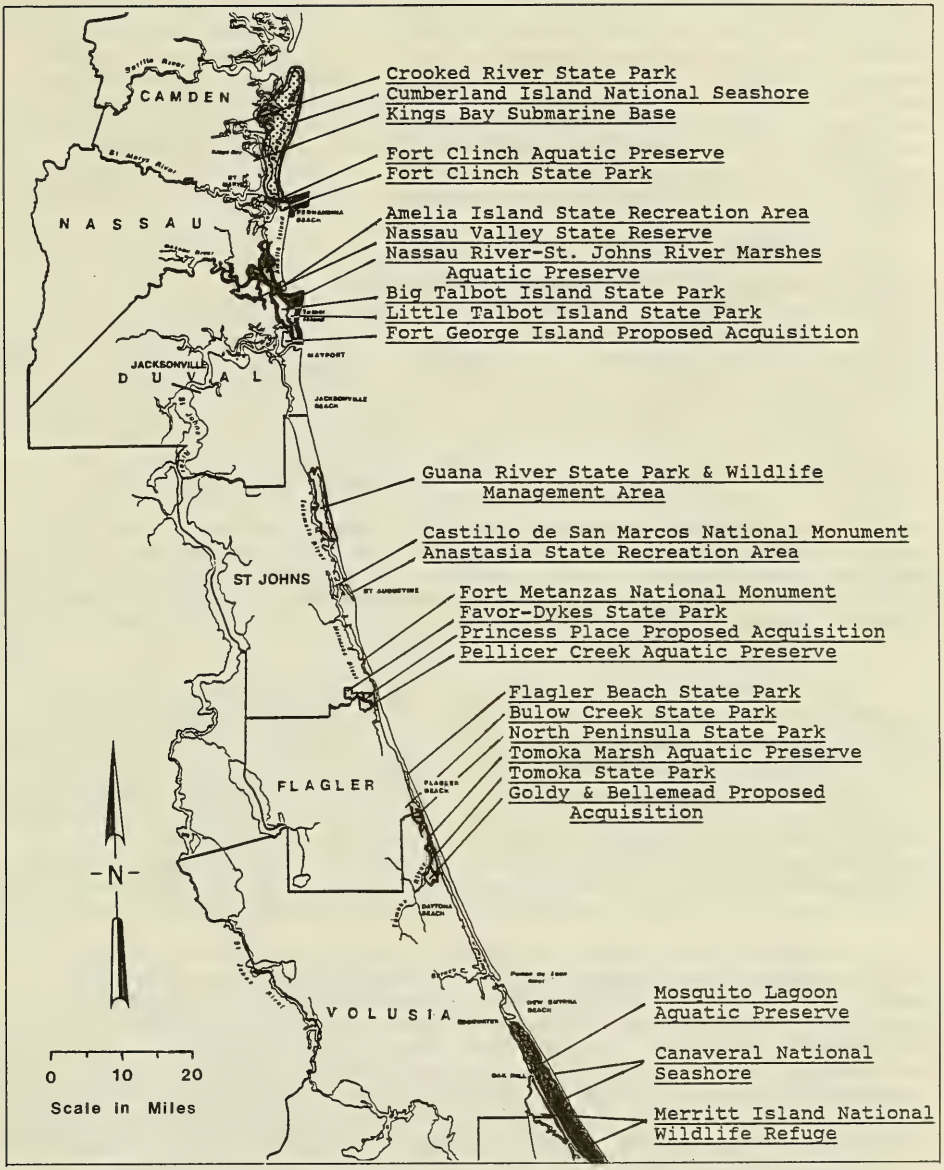

Figure 7. Location of Federal and State protected areas containing or adjacent to manatee habitat in the North Coast Region (Florida Department of Environmental Regulation, 1987).

of the study area. Rules pertaining to the management of all Aquatic Preserves specifically address manatee protection by prohibiting marina development in all state manatee sanctuaries established in Aquatic Preserves, and, in other areas of known manatee concentrations, requiring that warning signs and speed limit signs be posted as appropriate at access points to new marinas. Because of ambiguities and other problems that have arisen since the rules were adopted, the existing rules for Aquatic Preserves are presently being revised. It is uncertain whether or how provisions pertaining to manatees will be changed.

To provide more specific guidance for management decisions, management plans are also prepared for each Aquatic Preserve. To date, a management plan has been developed for two of the five Aquatic Preserves in the North Coast Region: the Fort Clinch Aquatic Preserve and the Nassau Valley River-St. Johns River Marshes Aquatic Preserve. A management plan for the Tomoka Marsh Aquatic Preserve is nearing completion and will be submitted to the Governor and Cabinet shortly. Provisions for manatees in the plans prepared to date are virtually identical for each Aquatic Preserve on the Florida east coast. Among other things, they provide for: consulting with the State Manatee Coordinator on the effect of submerged land leases for proposed developments, such as marinas and multi-slip docking facilities, on manatees and manatee habitat; compiling data on manatee habitat use patterns within Aquatic Preserve boundaries; mapping areas where boats are likely to be particularly hazardous to manatees; and identifying new areas that merit manatee sanctuary status, designation as a slow speed zone, or special channel marking.

Areas in Aquatic Preserves in the North Coast Region that appear to be particularly important to manatees include: the mouth of Tiger Creek (feeding and resting area) in the Fort Clinch State Park Aquatic Preserve; the Intracoastal Waterway (travel corridor) in the Nassau River-St. Johns River Marshes Aquatic Preserve; Bulow Creek (freshwater source), the Tomoka Basin/Tomoka River (freshwater source, feeding, resting, cavorting, and calving) and the Intracoastal Waterway (travel corridor) in the Tomoka Marsh Aquatic Preserve; and the Intracoastal Waterway (travel corridor) in the Mosquito Lagoon Aquatic Preserve.

Thirteen State Parks and State Recreation Areas (Table 2) exist in the North Coast Region of the study area. They are administered by the Florida Division of Recreation and Parks, in the Florida Department of Natural Resources. Many of these Parks and Recreation Areas include boat ramps affording public access to waterways. None of the Parks has special provisions pertaining to manatee protection; however, signs either are posted or are being posted at those parks with boat ramps to advise visitors of the occurrence of manatees in the area. The Tomoka State Park, which is strategically located at the mouth of the Tomoka River, is regularly used by manatees as a non-winter feeding, resting, and calving area and as a source of freshwater. The Park has more than two miles of riparian land along the southeast side of the

River and also includes the lower portion of Thompsons Creek, a secluded waterway used by manatees.

Five proposed State land acquisition projects that lie adjacent to the major north-south manatee travel corridor in the North Coast Region are presently under consideration through the State Conservation and Recreation Lands Program (Florida Department of Natural Resources 1988). Two projects, the Goldy/Bellemead Project and the Fort George Island Project, are particularly relevant to manatees. The Goldy/Bellemead Project, ranked number 49 on the State's 1988 recommended land acquisition priority list, includes 716 acres of marsh along the lower Tomoka River and is adjacent to the Tomoka State Park. It also includes about a mile of Thompsons Creek, which is used regularly by manatees. The Fort George Island Project, ranked number 7 on the State priority list, includes 900 acres and is located northeast of the junction of the Intracoastal Waterway and the lower St. Johns River. This area is a crossroads for manatees moving between south coastal Florida and feeding areas on the St. Johns River and in southern Georgia.

D. Analysis of Regional Habitat Protection Needs

Based on currently available information, the manatee habitats most in need of additional protection in the North Coast Region appear to be: (1) the lower St. Johns River around the warm-water refuges at Jacksonville and along the travel corridor downstream from Jacksonville to the river mouth where boat traffic poses a high risk to manatees; and (2) the Tomoka River area. Additional areas where further protection seems warranted are around Ponce de Leon Inlet near New Smyrna Beach, along the Intracoastal Waterway near Oak Hill, around Fernandina Beach, and along the Intracoastal Waterway just south of the St. Johns River in Pablo Creek. New information from ongoing radio-tracking studies also suggests that the certain coastal creeks, marshes, and waterways in southern Georgia may be more important as manatee habitat than previously suspected. Additional protection for some of these areas may be warranted; however, ongoing radio-tracking and aerial survey studies of manatees in that area should be completed before determining whether or what steps should be taken.

With respect to the lower St. Johns River from Jacksonville to its mouth, actions are needed to reduce the probability of boat kills. Fifty-seven percent of all boat-killed manatees recovered from the North Coast Region (27 of 47 animals) have been found along the lower 25 miles of the river. Boat speed regulatory zones, including channel-exempt speed zones and slow speed zones, would be appropriate measures for protecting essential travel corridors. Different provisions would be applied depending on channel configurations, widths, and vessel traffic characteristics. Seasonal idle speed and restricted access zones would be appropriate to protect manatees aggregating at warm-water refuges. Although boat speed regulatory zones for manatees have been

established elsewhere in Florida to protect manatees, no such areas presently exist along the lower St. Johns River, even though the concentration of boat-killed manatees is one of the greatest in the State.

Kinnaird and Valade (1983) and Kinnaird (1983a) have studied manatee distribution and vessel traffic patterns in the lower St. Johns River and northern Florida and recommended that: slow speed zones be established in the vicinity of the Kennedy Generating Station, the Alton Packaging Corporation (now the Jefferson Smurfitt Corporation), and the Southside Generating Station warm-water refuges; recreational boat access to discharge areas at these refuges be restricted during the winter months from November to March; and consideration be given to re-routing the dredged channel in the vicinity of the Jefferson Smurfitt Corporation plant and the Kennedy Generating Station to the opposite side of the river during the next maintenance dredging cycle.

These and alternative actions should be reviewed by the Florida Department of Natural Resources, the Corps of Engineers, local officials responsible for preparing Growth Management Plans, and other involved parties with a view toward adopting needed measures as quickly as possible. In this context, the following actions are recommended for consideration:

1. The nine-mile section of the St. Johns River from the the Fuller Warren Bridge (the upstream boundary of the North Coast Region in this report) downstream to the Trout River (e.g., a line across the St. Johns River from Reddie Point to the mouth of the Trout River on its northern shore) should be established as a year-round boat speed zone with some segments designated slow speed and others channel-exempt slow speed. Slow speed segments would include the 5.5-mile stretch from the Fuller Warren Bridge to the Mathew Bridge and a 2.5-mile segment from a point one mile north of the Jefferson Smurfitt Corporation plant to a point one mile south of the Kennedy Generating Station. This is one of the narrowest stretches along the lower St. Johns River and all manatees moving between the coast and summer feeding areas upstream from Jacksonville must transit this area. Twelve boat-killed manatees, more than any other comparable length of waterway in the North Coast Region, have been recovered from these narrows with no distinct seasonal trend in occurrence.

2. During cold weather months from November through April when manatees aggregate at warm-water sources, segments of the St. Johns River, including its channel, within one mile of the warm-water outfalls at the Jefferson Smurfitt Packaging Corporation plant, the Kennedy Generating Station, and the Southside Generating Station should be designated as idle speed zones and waters immediately surrounding the heated discharge plume at

each facility should be designated as a no entry zone for boats other than those servicing those facilities.

3. The lower 18 miles of the St. Johns River downstream from Jacksonville (i.e., from a line across the river from Reddie Point to the north shore of the Trout River at its mouth) should be designated as a slow speed channel-exempt area for reasons similar to those noted in 1 above. The river loop north of Blount Island should be established as a slow speed zone. Fifteen boat-killed manatees have been recovered along this stretch of the river. Carcasses have been recovered in all seasons, suggesting the zone should be effective on a year-round basis.

4. The Fort George Island State land acquisition project should be purchased and maintained in its natural state. This 900 acre acquisition project, which is currently ranked number 7 on the recommended acquisition list of the State Conservation and Recreation Lands Program, is located near the junction of the St. Johns River and the Intracoastal Waterway. This junction is a crossroads for manatees moving between summer feeding areas up the St. Johns River and in Georgia and winter warm-water refuges along the coast to the south. The site's potential contribution to protecting this strategic portion of the East Coast manatee travel corridor should be considered when evaluating acquisition priorities.

As noted above, the Tomoka River is a source of freshwater for manatees and is used during warm weather for feeding, resting, and calving. Kinnaird (1983a) recommends that the Tomoka State Park on the southeast shore of the river at its mouth be established as a summer sanctuary zone for manatees, with slow and idle boat speed areas and with vessel access to the Park restricted to boats less than 7.3 m in length. No action has been taken to implement these provisions and it is recommended that the Florida Department of Natural Resources review these and other actions to strengthen protection of this area. In this context, it is recommended that consideration be given to the following actions:

-- The Tomoka River downstream from the Route 95 bridge to its mouth on the Halifax River should be designated as a slow speed zone and Thompsons and Stricklands Creeks, which enters the Tomoka River near its mouth, should be designated as an idle speed zone. The Tomoka basin at the mouth of the Tomoka River should be established as a channel-exempt slow speed zone. Such measures would protect preferred feeding, resting, and calving areas from disturbance and hazards created by high speed boat traffic. Representatives of the Florida Department of Natural Resources should work with local officials responsible for preparing Growth Management Plans to establish such an area.

-- The Goldy/Bellemead State land acquisition proposal adjacent to the Tomoka State Park should be purchased and added to the Park. This 716-acre tract includes a half mile of River shoreline and almost a mile of Thompsons Creek. It is currently ranked number 49 on the recommended land acquisition list for the State Conservation and Recreation Lands Program. Efforts to identify, acquire, and protect additional undeveloped shoreline along both sides of the river adjacent to the State Park should be considered.

-- Management of the Tomoka Marsh Aquatic Preserve should reflect the importance of the Tomoka River as a non-winter feeding, resting, and calving habitat and as a freshwater source for transient manatees and manatees remaining in the river system for extended periods. To control levels of boat traffic along the river, the management plan for the Aquatic Preserve should establish a policy discouraging the leasing of submerged lands within the Tomoka River section of the Aquatic preserve for the purpose of large new marinas and multi-family docking facilities.

Manatees are sighted regularly in the vicinity of Ponce de Leon Inlet in Volusia County during non-winter months. To the south of this inlet, three boat-killed manatees have been recovered from the narrow four-mile stretch of Intracoastal Waterway near New Smyrna Beach and four animals have been recovered near the town of Oak Hill. Four of the seven animals have been recovered since 1986. Volusia County is one of the fastest growing counties in the North Coast Region with respect to the number of registered boats, and the recent increase in boat kills suggests that boat speed regulatory zones may be warranted at both areas. It is therefore suggested that representatives of the Florida Department of Natural Resources work with local officials responsible for preparing Growth Management Plans to establish such areas.

In this regard, it is suggested that the New Smyrna Beach zone be a non-winter (March to November) channel-exempt slow speed area extending from a point about three miles north of Ponce de Leon Inlet, including Turnbull Bay and lower Spruce Creek, south to Edgewater. A two-mile stretch north of the route A1A bridge including the channel should be designated as slow speed, while certain non-channel areas elsewhere in the zone used infrequently by manatees should be designated for water skiing, jet skis, etc. The Oak Hill boat speed zone should also be a non-winter, channel-exempt slow speed area and would extend about two miles north and south of town.

Two additional areas where non-winter boat speed zones may be warranted are at Fernandina Beach in Nassau County and Pablo Creek in Duval County. Manatees frequently occur along the developed shoreline at Fernandina Beach, attracted to freshwater sources

from the municipal marina and sewer outfall and warm-water discharged from the Container Corporation of America pulp mill. Northwest of Fernandina Beach, the mouth of Tiger Creek appears to be an important manatee feeding, resting, and cavorting area. To reduce the probability of collisions between manatees and boats in these areas, it is suggested that the three-mile stretch of the Amelia River along the Fernandina Beach waterfront be designated as a channel-exempt slow speed zone and that waters between the mouth of Tiger Creek and the Intracoastal Waterway also be designated as a slow speed area.

Pablo Creek is a 12 to 13 mile long creek immediately south of the St. Johns River upstream from its mouth at Mayport. It includes a section of the Intracoastal Waterway and is a narrow waterway that forms part of the north-south manatee travel corridor. A number of new boating facilities are being developed along the creek and, given associated increases in boat traffic, the narrow channel width, and use of the corridor by manatees, it is suggested that the Florida Department of Natural Resources and officials responsible for preparing local Growth Management Plans consider alternative vessel traffic approaches that could reduce risks to manatees. For example, linear traffic patterns that avoid channel margins may pose a low threat to manatees and establishment of a speed limit that minimizes the size of boat wakes (e.g., 20 miles per hour) with passing restrictions could promote linear traffic patterns that would reduce the probability of collisions with manatees as well as improve boating safety.

V. ST. JOHNS RIVER REGION

A. Manatee Distribution and Habitat Use Patterns

The St. Johns River Region includes the coves, lakes, and streams along the St. Johns River from the Fuller Warren Bridge at Jacksonville upstream through Duval, Clay, St. Johns, Putnam, Flagler, and Marion Counties to Lake and Volusia Counties approximately 110 miles to the south. Manatees occur in greatest numbers in the Region in non-winter months and generally appear to stay within or close to the river, rather than straying far up associated streams. Important manatee habitats are identified on Figure 8. The best review of available information on manatees in this Region is included in Beeler and O'Shea (1988).

The only major warm-water refuge in the Region is at Blue Spring in Volusia County approximately 140 miles upstream from the mouth of the St. Johns River at Mayport. The spring, which discharges 116 million gallons of water per day at a constant temperature of 22.5°C, forms the headwaters of Blue Spring Run, which flows approximately 0.4 mile west to the St. Johns River. The spring and spring run form the only natural warm-water refuge on the Florida east coast used by substantial numbers of manatees.

Between 1970 and 1980, the spring was used by between 11 and 25 manatees as an overwintering area. In the mid 1970s, the spring was purchased by the State and added to the State Park system. Shortly thereafter, a section of the spring run was closed to swimming when manatees were present and, during the winter of 1979-80, all boat access to Blue Spring Run was prohibited for the first time (Bengtson 1981). Since then, the number of overwintering manatees has increased to about 50 animals during the winter of 1986-87 (Beeler and O'Shea 1988). Manatees are most numerous at the Spring between December and March when water temperatures outside the spring run drop below 20°C (Bengtson 1981). Most manatees return repeatedly to Blue Spring winter after winter; however, some animals identified at Blue Spring one winter have been seen using warm-water refuges at Jacksonville and along the coast as far away as the Riviera power plant in the South Coast Region (Reid and Rathbun 1986).

Food resources in Blue Spring Run for overwintering manatees are negligible and, throughout the winter, manatees leave the spring run on feeding forays that appear to be timed with temperature changes (Bengtson 1981). Winter feeding areas, identified by radio-tracking individual animals, are located

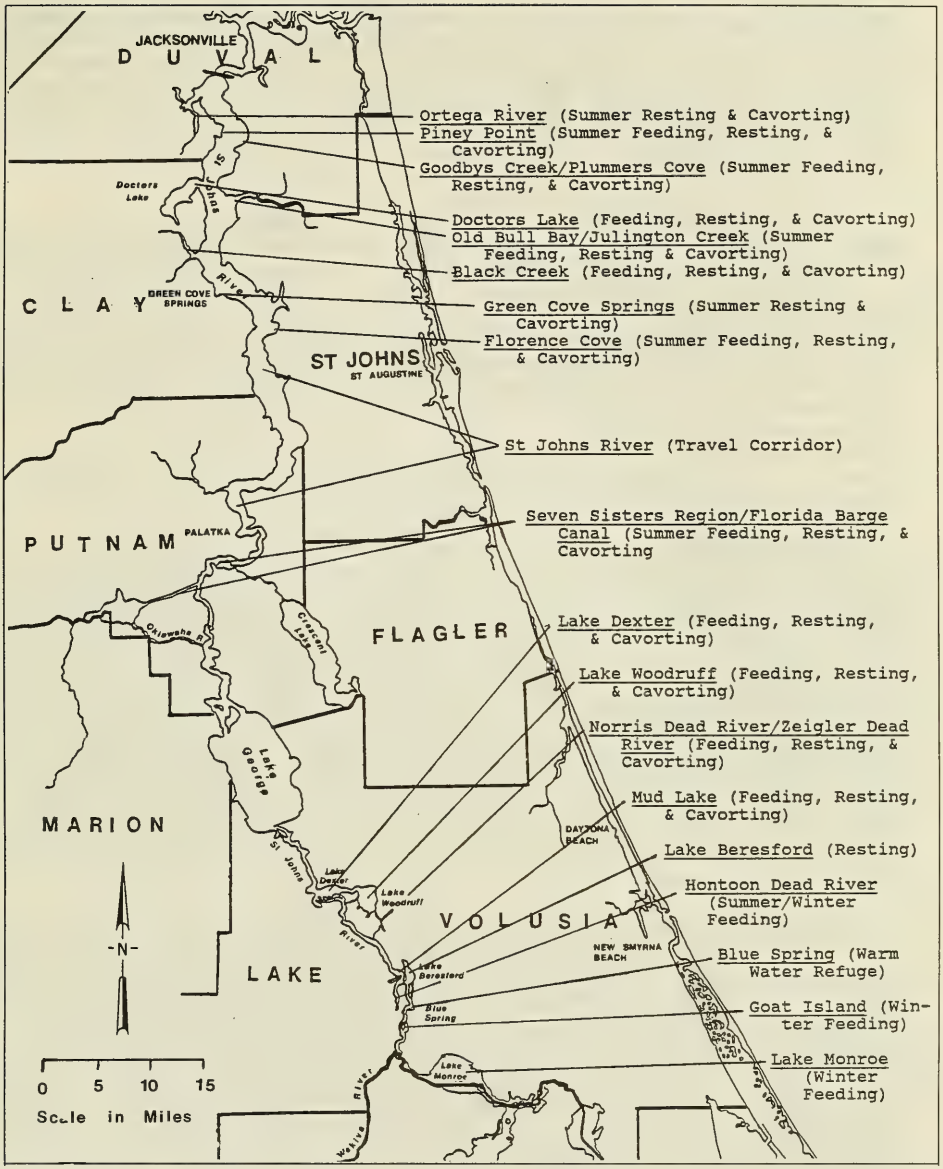

Figure 8. Important manatee habitats in the St. Johns River Region of the Study Area (Bengston 1981, Kinnaird 1983a, Beeler and O'Shea 1988, and Valade 1988).

principally within about 12 kilometers (8 miles) of the spring run at Beresford Lake, the Hontoon Dead River, and Mud Lake to the north and west, and along the St. Johns River both north and south of the Run (Bengtson 1981). Preferred winter feeding areas within this range may vary from year to year, perhaps depending on changes in the condition of plant stocks. Preferred food sources include water hyacinth (Eichhornia crassipes), southern naiad (Najas guadalupensis), water lettuce (Pistia stratiotes), and eelgrass (Vallisneria americana) (Bengtson 1981).

As noted in Chapter IV, manatees also occur throughout the winter in the St. Johns River at artificial warm-water refuges in Jacksonville in the North Coast Region. Feeding areas along the St. Johns River at the north end of the St. Johns River Region between the Fuller Warren Bridge and Green Cove Springs about 20 miles to the south may be used by those animals during winter warm spells. However, aerial surveys for manatees in this area during the winter of 1982-83 produced only a single sighting of one individual near the mouth of Doctors Lake (Kinnaird 1983a). Ongoing aerial surveys of this area presently supported by the Florida Department of Natural Resources through the City of Jacksonville will provide additional information on the extent to which this area is used during winter months.

In the spring, manatees disperse from warm-water refuges at Blue Spring and Jacksonville. In 1979 and 1980, the years for which the best data are available, many Blue Spring manatees traveled downriver about 55 miles to the Cross Florida Barge Canal (Bengtson 1981). A few animals, however, particularly older males, made it all the way down to the mouth of the St. Johns River (Bengtson 1981) from which point they may have moved some distance north or south along the coast. Other non-winter feeding, resting, and cavorting areas used by manatees tagged at Blue Spring in 1979 and 1980 (Bengtson 1981) include: Doctors Lake, Green Cove Springs, Lake Dexter, Lake Woodruff, the Norris Dead River, the Zeigler Dead River, Beresford Lake, the Hontoon Dead River, the St. Johns River near Blue Spring, and Lake Monroe. Traveling animals generally are seen moving along the margins of the St. Johns River.

Aerial surveys in 1982-83 and the summer of 1988 over the 25-mile stretch of the lower St. Johns River between the Fuller Warren Bridge and Green Cove Springs document regular use of the north end of the St. Johns River Region during non-winter periods between April and December (Kinnaird 1983a and Valade 1988). Manatees using this area may winter at warm-water refuges along the central and south Florida coast as well as at Jacksonville and Blue Spring. Counts of up to 48 animals were recorded during non-winter aerial surveys in 1982-83 (Kinnaird 1983a) and a count exceeding 90 animals was recorded in 1988 (Valade 1988). Almost all animals seen were either alone or in small groups feeding, resting, or cavorting along the margins of Doctors Lake and the Ortega River and along both sides of the St. Johns River. The St. Johns River varies from two to four miles in width in this area

and manatees are rarely seen far from shore. The largest single group of animals reported to date in this area is a group of 13 animals seen in the Ortega River (Valade 1988). The primary submerged aquatic plant in the Doctors Lake and Green Cove Springs areas is eelgrass (Kinnaird 1983a). Preliminary results from ongoing radio-tracking studies also suggest frequent use of these areas by manatees (Sirenia Project, U.S. Fish and Wildlife Service, unpublished data).

Areas along the St. Johns River from Green Cove Springs south to the Barge Canal have not been rigorously surveyed, but the area is not thought to be used as extensively as areas north of Green Cove Springs. Preliminary results of radio-tagging studies suggest light-to-moderate levels of use for certain areas (Sirenia Project, U.S. Fish and Wildlife Service, unpublished data). These include Florence Cove and Palmo Cove on the east bank of the St. Johns River and shoreline areas near the mouth of Dunn Creek connecting the St. Johns River and Crescent Lake.

B. Regional Threats to Manatees and Manatee Habitat

The principal threat to manatee habitat in the St. Johns River is the hazard created by boat traffic. Seventeen manatees killed by boats have been recovered along the St. Johns River from April 1974 through June 1988. Although this is by far the lowest number of any of the four Regions in the study area, it does not indicate that the threat is insignificant. Virtually all manatees observed at Blue Spring bear wounds and scars from encounters with boats and researchers recording these marks for the purpose of identifying individual animals have noted the constant need to add fresh wounds to their records in order to distinguish animals over time (Bengtson 1981). The comparatively low number of recovered boat kills in this Region may, in part, reflect a smaller number of animals in the Region, low levels of boat traffic, difficulty in locating dead animals along shaded river margins, and/or fewer people to find and report dead animals.

Nearly 60% of the boat kills recovered in the St. Johns River Region (10 of 17 animals) were from two stretches of the river covering a total of about 15 miles (see Figure 9). Four animals were recovered along a 6 to 7-mile stretch from about Lake Beresford south past Blue Spring. Six animals were recovered along an 8 to 9-mile section from a point just south of Doctors Lake north towards Jacksonville. Kinnaird (1983a) has studied boat traffic patterns in the northern end of the Region, including Doctors Lake and the adjacent St. Johns River, and found that boat traffic from the Ortega River south to Green Spring Cove is dominated by small recreational vessels less than 7.3 meters in length. The periods of peak boating activity occur between July and September when manatees are most abundant and when five of the six boat kills in the north end of the Region were recovered.

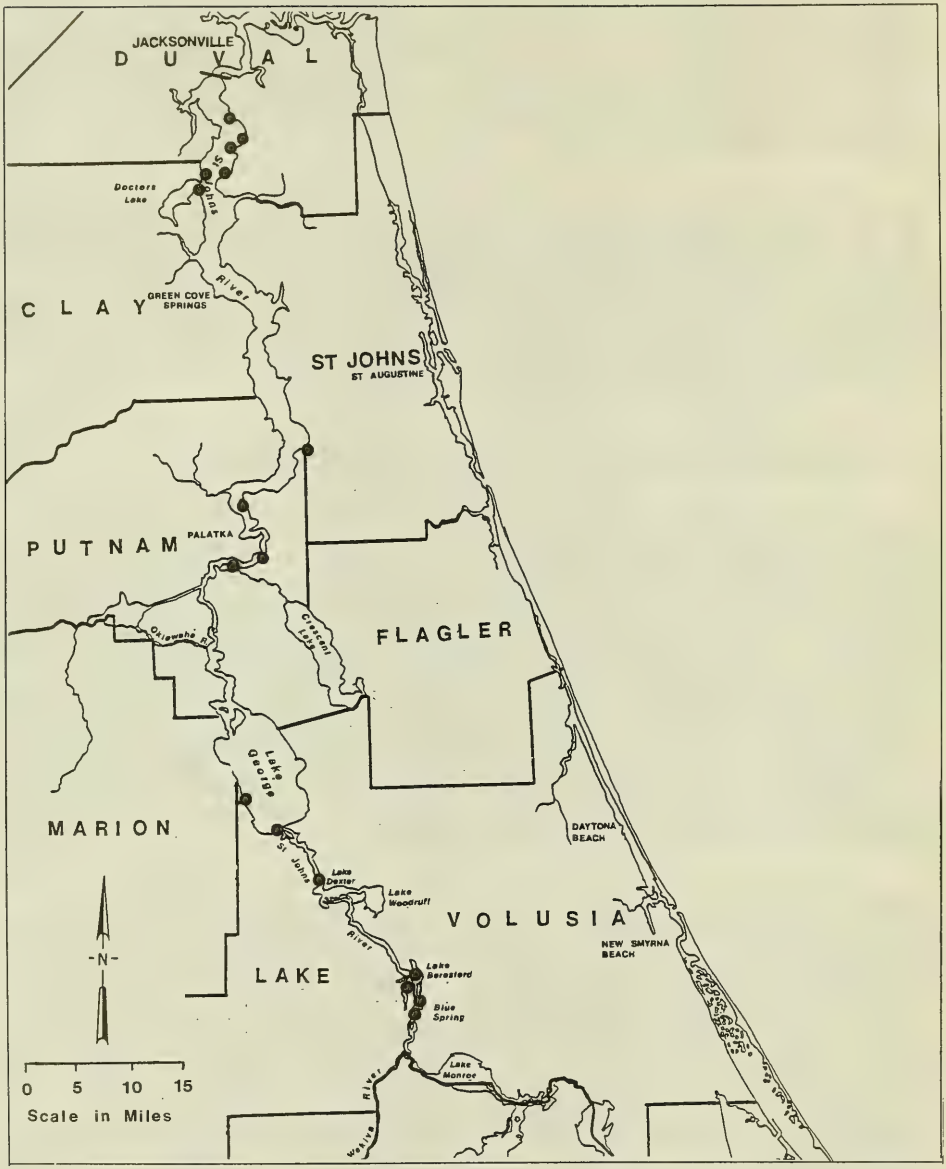

Figure 9. Recovery sites of boat-killed manatees recorded from April 1974 through June 1988 in the St. Johns River Region (Beeler and O'Shea 1988 and Bureau of Marine Research, Florida Department of Natural Resources, unpublished data).

All but one boat/barge kill in the Region were recovered during the non-winter period from May to November (Figure 10). Three of the 17 animals (18%) were recovered between January 1986 and June 1988, two of which were found in the Blue Spring area. Given the small number of animals that regularly use Blue Spring in the winter (about 50), even a low number of boat kills in this area is a significant cause for concern.

As indicated in Table 3, the number of registered commercial and recreational boats in counties along the St. Johns River Region increased by 49% in the ten-year period from 1977 to 1987. The greatest absolute increases in boat numbers occurred in Duval and Clay Counties at the north end of the Region and Lake and Volusia Counties at the south end. These two areas are where most of the Region's boat-killed manatees have been recovered and where the Region's most important manatee habitats occur. Clay County, which includes Doctors Lake, Black Creek, and Green Cove Springs, was the fastest growing county in the Region with respect to the number of registered boats during the ten-year period.

Submerged grassbeds important as feeding areas for manatees are among the habitat features most susceptible to degradation. When vegetation in preferred feeding areas is lost due to natural or human-related causes, manatees must find alternative food sources in other areas. Losses of submerged grasses near warm-water refuges pose particularly serious threats as alternative feeding areas may require animals to travel greater distances, thereby increasing the risk of exposure to potentially fatal cold snaps. At present, available winter and summer feeding areas and food resources in the St. Johns River Region do not appear to be limiting factors. However, the vulnerability of important feeding areas is illustrated by a die-off of aquatic vegetation in the early 1980s at Lake Beresford, located about 3 miles north of Blue Spring.

Between 1978 and 1981, Lake Beresford was a major winter feeding area for radio-tagged manatees overwintering at Blue Spring (Bengtson 1981). In the early 1980s, however, most of the lake's submerged aquatic vegetation died due to unidentified causes. Radio-tagged manatees did not use the lake for feeding during the winter of 1983-84 and, instead, increased use of feeding areas in Lake Monroe more than 10 miles south of Blue Spring. As of 1987, vegetation in Lake Beresford still had not recovered. While food in other areas has been sufficient to support an increase in the number of manatees overwintering at Blue Spring despite loss of the Lake Beresford feeding area, the loss of additional nearby feeding areas could slow or even reverse this trend. No information was found on the status of grassbeds used as feeding areas by manatees in the north end of the St. Johns River Region.

Another potential threat to manatees in this Region is entanglement in float lines for crab traps along portions of the St. Johns River. Certain nearshore areas used by manatees contain

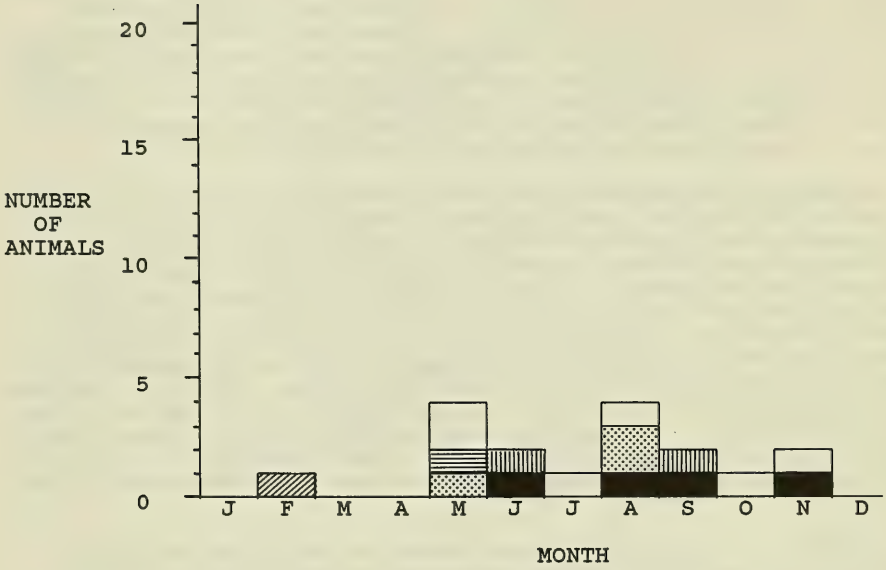

Figure 10. Number of known boat-killed manatees by month for Counties in the St. Johns River Region from April 1974 through June 1988. Duval = ; Clay = ; St. Johns = ; Putnam = ; Lake = ; and Volusia = . (Beeler and O'Shea 1988 and Bureau of Marine Research, Florida Department of Natural Resources, unpublished data).

Table 3. Total number of recreational and commercial boats registered by year for Counties in the St. Johns River Region between 1977 and 1987 and the percent increase during that ten-year period (based on data from the Florida Department of Natural Resources).

County	Number of Registered Boats by Year (in thousands)										Increase Over Ten Year Prd.
	1977/ 1978	1978/ 1979	1979/ 1980	1980/ 1981	1981/ 1982	1982/ 1983	1983/ 1984	1984/ 1985	1985/ 1986	1986/ 1987	
St. Johns River Region											
Duval*	23.29	25.67	25.30	25.61	25.08	25.68	26.94	28.04	29.00	29.25	5.96(26%)
Clay	2.80	3.25	3.66	3.92	3.81	4.57	4.76	5.11	5.36	6.00	3.20(114%)
St. Johns*	2.13	2.31	2.49	2.49	2.43	2.91	3.07	3.20	3.41	3.86	1.73(81%)
Putnam	4.07	4.52	4.75	4.68	4.11	5.22	5.36	5.54	5.82	6.06	1.99(49%)
Flagler*	0.71	0.85	1.23	1.28	1.02	1.16	2.09	1.84	1.87	1.78	1.07(151%)
Lake	8.96	9.65	10.26	10.67	10.07	10.86	11.16	11.45	11.90	12.91	3.95(44%)
Volusia*	10.15	11.65	12.30	13.20	12.55	14.57	15.62	16.45	17.17	18.03	7.88(78%)
TOTALS	52.11	57.90	59.99	61.85	59.07	64.97	69.00	71.63	74.53	77.89	25.78(49%)

* = County includes major boating areas along the St. Johns River and the Atlantic Ocean coast.

large numbers of traps. Entanglement of manatees in such fishing gear has, on occasion, caused death by drowning or injury by the abrasion and constriction of attached ropes.

C. Regional Protected Areas

Nine Federal and State protected areas were identified in the St. Johns River Region including: one National Wildlife Refuge managed by the Fish and Wildlife Service; one National Forest administered by the U.S. Forest Service (portions of the National Forest are also designated as a State Wildlife Management Area administered cooperatively by the Florida Game and Freshwater Fish Commission); and three State Reserves, one boat speed regulatory zone, one State Recreation Area, and two State Parks managed by the Florida Department of Natural Resources (Table 4 and Figure 11). In addition, there is one proposed project currently listed on the State Conservation and Recreation Lands Program recommended land acquisition list.

The Lake Woodruff National Wildlife Refuge, located about 10 miles north of Blue Spring, is an area used by manatees for feeding, resting, and cavorting during non-winter months. It includes all lands surrounding Lake Woodruff and a substantial portion of the shorelines along Lake Dexter and the Norris Dead River. Occasional sightings of up to 8 animals have been reported in the Refuge with many of the sightings made in the Norris Dead River connecting the St. Johns River and the south end of Lake Woodruff (L. Rhodes, Resource Manager, Lake Woodruff National Wildlife Refuge, Fish and Wildlife Service). Manatees also are seen in Lake Dexter and occasionally near the mouth of Spring Garden Creek, which enters Lake Woodruff from the northeast. The Refuge has no special provisions for protecting manatees.

The largest protected area in the study area is the Ocala National Forest, which is 382,337 acres. Much of the National Forest also is designated as a State Wildlife Management Area that the Florida Game and Freshwater Fish Commission manages in cooperation with the National Forest Service. For reasons of boating safety, some lakes and small creeks within the National Forest have restrictions on boats with large engines. For example, boats with motors larger than 10 horsepower are excluded from Hopkins Creek, which flows into Lake George from the southwest. Only a few lakes and small streams in the National Forest have such restrictions and none are known to be used regularly by manatees. Larger waterways in the National Forest that may be used occasionally by manatees, such as the Oklawaha River, have no such restrictions.

Two State Parks (Blue Spring State Park and Hontoon Island State Park) and a State Recreation Area (De Leon Springs State Recreation Area) are located on the upper St. Johns River. Blue Spring State Park completely surrounds the Blue Spring/Blue Spring

Table 4. Federal and State protected areas containing or adjacent to manatee habitat in the St. Johns River Region.

Name	County	Size
NATIONAL WILDLIFE REFUGES (FISH AND WILDLIFE SERVICE)		
Lake Woodruff Nat. Wildlife Refuge	Volusia	18,416 ac.
NATIONAL FORESTS (DEPARTMENT OF AGRICULTURE)		
Ocala National Forest	Putnam/Marion/ Lake	382,337 ac.
STATE PRESERVES AND RESERVES (FLORIDA DEPT. OF NATURAL RESOURCES)		
Haw Creek State Preserve	Flagler/Volusia	3,065 ac.
Lower Wekiva River State Reserve	Lake/Volusia/ Seminole	4,532 ac.
Rock Springs River State Reserve	Lake/Orange/ Seminole	8,723 ac.
STATE BOAT SPEED REGULATORY ZONES (FLORIDA DEPT. OF NATURAL RESOURCES)		
Blue Spring-St. Johns River Zone (no entry, idle, & slow speed zones)	Volusia	3.3 mi.*
STATE PARKS AND RECREATION AREAS (FLORIDA DEPT. OF NATURAL RESOURCES)		
DeLeon Springs St. Rec. Area	Volusia	71 ac.
Blue Spring State Park	Volusia	1,473 ac.
Hontoon Island State Park	Lake	1,650 ac.
PROPOSED LAND ACQUISITION PROJECTS (FLORIDA CONSERVATION AND RECREATION LANDS PROGRAM		
St. Johns River Project	Lake	8,290 ac.

* Size of boat speed regulatory zones is provided as approximate length of waterway along channel or shoreline subject to regulation.

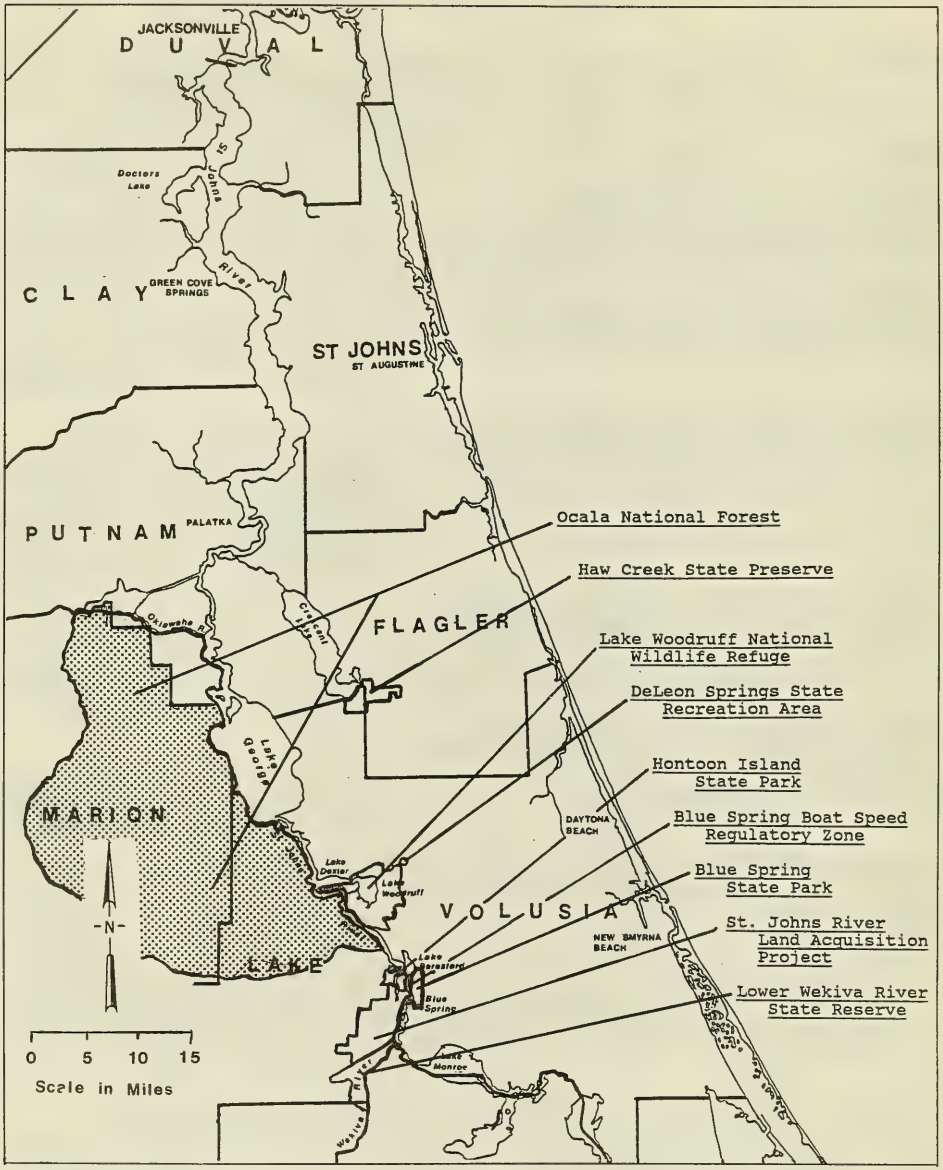

Figure 11. Location of Federal and State protected areas containing or adjacent to manatee habitat in the St. Johns River Region (Florida Department of Environmental Regulation 1987).

Run warm-water refuge which, as noted above, is the only significant warm-water refuge used by manatees in the Region. Swimming, diving, and boating are prohibited in the spring and spring run down to the St. Johns River between 15 November and 31 March to protect manatees. The Park also includes lands north and south of the spring run on both sides of the St. Johns River. Recently, Volusia County purchased a 719 acre tract of undeveloped shoreline on the east side of the St. Johns River from the the boundary of Blue Spring State Park north to Lake Beresford. The property has recently been sold to the State as an addition to the Blue Spring State Park.

Immediately to the north of Blue Spring State Park on the west bank of the St. Johns River is Hontoon Island State Park. The Park is managed in conjunction with Blue Spring State Park and includes much of the shoreline along the Hontoon Dead River, which is a feeding area used by manatees throughout the year. No special provisions have been established within this Park for manatee protection.

The De Leon Springs State Recreation Area is adjacent to the Lake Woodruff National Wildlife Refuge. It surrounds a natural warm-water spring which, with Spring Garden Lake, forms the headwaters of Spring Garden Creek that drains into Lake Woodruff. The Spring discharge (about 20 mgd) is low compared to Blue Spring and manatees do not use the spring as a warm-water refuge in winter.

One major State land acquisition project occurs in the St. Johns River Region -- the St. Johns River Project. This Project includes 8,290 acres land and more than 5 miles of undeveloped shoreline along the west bank of the St. Johns River from Hontoon Island State Park south to the Lower Wekiva River State Preserve. The Project is ranked number 48 on the recommended land acquisition priority list for the State Conservation and Recreation Lands Program (Florida Department of Natural Resources 1988). Much of the proposed Project has already been purchased and other parts are under option. Proposed use of the area is as a State Preserve or State Reserve.

One boat speed regulatory zone has been established in the Region by the Florida Department of Natural Resources. The zone, effective between 15 November and 31 March, extends 3.3 miles along the St. Johns River north and south of the mouth of Blue Spring Run. Approximately 0.9 mile of the St. Johns River at the mouth of the spring run is designated as an idle speed zone and the remainder of the regulatory zone is designated for slow speed. As noted above, the spring run is closed to all boats during this period.

D. Analysis of Regional Habitat Protection Needs

The areas of the St. Johns River Region in greatest need of additional protection are along a 20-mile stretch of the lower St. Johns River and Doctors Lake in northern Clay County and southern Duval County, and near Blue Spring Run in Volusia and Lake Counties. Both areas contain important non-winter feeding, resting, and cavorting areas and the latter also contains a vital warm-water refuge and winter feeding ground. More boat-killed manatees have been recovered in these two areas than any other parts of the Region. The principal habitat protection needs are to reduce hazards created by boat traffic in preferred habitats and to protect productivity of grass beds preferred as feeding areas.

With respect to the lower St. Johns River, Kinnaird (1983a) has studied seasonal patterns of manatee distribution and boat traffic. Based on her findings, she recommended that signs be posted advising boaters of the presence of manatees along the lower St. Johns River, particularly in Doctors Lake and at Green Cove Springs, and that efforts be made to limit development of new boating facilities in Doctors Lake pending the acquisition of additional information on manatee use patterns in the area. The Florida Department of Natural Resources has since begun to review permit applications for boating facilities with a view towards limiting developments that threaten manatees or manatee habitat. It is also supporting additional aerial surveys of manatees in the area to improve data for decision-making.

Recent information suggests that nearshore areas of the St. Johns River from the Fuller Warren Bridge at Jacksonville south to Green Cove Springs, including Doctors Lake and the Ortega River, are major non-winter feeding, resting, and cavorting areas for a substantial portion of the East Coast manatee population. The areas may well be used by manatees overwintering in all Regions of the Study Area. Between the spring and fall of 1988, aerial survey counts frequently exceeded 50 animals and were as high as 94 animals (Valade 1988). Because of its importance to manatees and the increasing numbers of registered boats in the area, it is recommended that representatives of the Florida Department of Natural Resources, the Fish and Wildlife Service, and local agencies responsible for developing Growth Management Plans cooperate in establishing a new non-winter (April through September) boat speed regulatory zone or zones.

In this regard, to protect preferred feeding, resting, cavorting and traveling areas close to shore, it is recommended that a shoreline slow speed zone be established within one-quarter mile of shore around the perimeter of Doctors Lake and along both banks of the St. Johns River between the Fuller Warren Bridge in Duval County and Green Cove Springs in Clay County. The river and lake are between two and four miles in width in this area and high speed boat travel outside this perimeter would not be affected. Certain segments within this zone that are used infrequently by

manatees might be exempted from speed restrictions to afford opportunities for water skiing or similar sports. At other areas where evidence suggests that manatee feeding and resting habitat extends further offshore (e.g., Old Bulls Bay at the mouth of Julington Creek) or part way up creeks (e.g., Black Creek), the designated area might be extended beyond one-quarter mile. A narrower shoreline zone, perhaps 200 feet, might be established within the Ortega River. Approval of any additional marinas, boat ramps, or multi-family dock facilities within this area should be contingent upon establishing such a zone.

A similar approach should be adopted for the non-winter season in the Blue Spring area. The 20-mile segment of the St. Johns River from Lake Dexter to the Wekiva River, particularly waters close to river and lake margins, is used consistently by feeding, resting, cavorting, and traveling manatees during non-winter periods. All boat kills south of Lake George have been recovered during this period (i.e., May to November). Therefore, to protect manatees using the shoreline areas on this portion of the river, it is recommended that the Florida Department of Natural Resources, the Fish and Wildlife Service, and local agencies responsible for preparing Growth Management Plans establish a non-winter (March to November) shoreline idle speed zone that applies to all waters within a specified distance of river or lake margins. For example, the idle speed zone might extend 100 feet from shore along the St. Johns River and associated lakes. On narrower waterways, such as the Norris Dead River and the Hontoon Dead River, the zone might extend 25 feet from shore. On very narrow waterways (e.g., <50 feet) known to be used by manatees, such as some river segments and logging canals, slow or idle speed limits should be considered.

In addition, steps should be taken to expand the winter boat speed regulatory zone that already exists in the Blue Spring area so that it covers a greater portion of the winter feeding range. Specifically, the slow speed zone should be extended north up to and including Lake Beresford and Mud Lake (approximately 4.5 miles north of Blue Spring Run) and south to the southern end of Goat Island in the St. Johns River (approximately 3 miles south of Blue Spring Run). The Hontoon Dead River should also be included within the winter slow speed zone. Waters south of Goat Island to Lake Monroe might be established as a shoreline idle speed zone under an approach similar to that suggested above for the non-winter period.

As indicated above, some of the most important manatee habitat in the southern end of the St. Johns River Region is contained in the Blue Spring and Hontoon Island State Parks and the Lake Woodruff National Wildlife Refuge. Efforts to maintain these areas in a natural state afford significant protection for wildlife habitat in general and for manatees and manatee habitat in particular. These areas form an outstanding nucleus of sites for protecting wildlife values along the upper St. Johns River; however, future development of surrounding areas could adversely

affect conditions or wildlife within established boundaries. Indeed, external threats from development and use of adjacent areas are the cause of many of the most difficult problems now facing many existing National Parks and Wildlife Refuges.

Therefore, to secure long-term protection of the ecosystem upon which manatees and other area wildlife depend, it is recommended that the State of Florida and the Fish and Wildlife Service cooperatively pursue efforts to purchase undeveloped areas along the St. Johns River between Lake Dexter in the Lake Woodruff National Wildlife Refuge and Lake Monroe. The objective of the effort should be to develop an integrated system of protected areas to be left in an essentially natural condition along the entire 20-mile stretch of the St. Johns River from Lake Dexter to Lake Monroe. In this regard, it is recommended that the State complete acquisition of the 8,290-acre St. Johns River Project in Lake County that is currently ranked number 48 on the recommended land acquisition priority list for the Conservation and Recreation Lands Program.

In addition, it is recommended that representatives of the Division of State Lands, the Bureau of Marine Research, the U.S. Fish and Wildlife Service, the National Forest Service, and other appropriate agencies meet to consider, and as possible, develop a cooperative strategy for identifying and purchasing additional undeveloped areas along this stretch of the river. In particular, consideration should be given by the State to developing a new land acquisition project or projects which encompass Goat Island and other islands in the St. Johns River and undeveloped shoreline areas on the east bank of the river south of Blue Spring State Park. Similarly, the Fish and Wildlife Service should assess opportunities for expanding the Lake Woodruff National Wildlife Refuge southward toward the Blue Spring and Hontoon Island State Parks. Lands along the western shore of the St. Johns River that are presently undeveloped and not already part of the Ocala National Forest should be studied as part of a possible addition to the Refuge.

Given the proximity of the existing protected areas along this part of the St. Johns River to one another and the remaining undeveloped shoreline between them, such a consolidation effort would provide an outstanding basis for protecting virtually all of the most important manatee habitat on the upper St. Johns River, which includes the only natural warm-water refuge for manatees on the East Coast. It also would create an integrated network of protected areas whose complementary management objectives would ensure substantial protection against external threats to the broader ecosystem that otherwise might arise if remaining undeveloped privately held land were developed.

VI. INDIAN RIVER REGION

A. Manatee Distribution and Habitat Use Patterns

The Indian River Region includes manatee habitat along a 135-mile stretch of coastline along Florida's east coast in Brevard, Indian River, St. Lucie, and Martin Counties. The dominant feature in the Region is the Indian River, which separates the mainland from a series of narrow barrier islands running approximately 115 miles along the coast from northern Brevard County south to St. Lucie Inlet in Martin County. South of St. Lucie Inlet, the most important manatee habitat is Hobe Sound and Jupiter Sound. The northern part of the Region around Cape Canaveral and Merritt Island is used by large numbers of manatees throughout the year, whereas the southern end of the Region at Hobe and Jupiter Sounds is used most heavily during winter months. Particularly important manatee habitat features in the Region are identified on Figures 12 and 13. The best overview of available information on manatees in the Region is found in Beeler and O'Shea (1988).

The Indian River Region includes four warm-water refuges for manatees, all of which are formed by power plant discharges: the Orlando Utility Commission's Indian River Plant and the Florida Power & Light Company's Canaveral Plant in northern Brevard County; the Vero Beach Municipal Power Plant in southern Indian River County; and the H.D. King Municipal Electric Station at Fort Pierce in St. Lucie County. The two power plants in northern Brevard County lie within two miles of each other and are the most extensively used warm-water refuges in the Region. Greatest use occurs between November and March. Although most manatees tend to return to the same warm-water refuge in successive years, some known individuals seen at the Brevard County refuges have been observed at other refuges outside of the Region, particularly to the south, in both the same and different winters (Reid and Rathbun 1986).

Regular manatee counts at Brevard County power plants have been conducted since 1977 as part of an aerial survey program supported by the Florida Power & Light Company. Peak winter counts at the two power plants ranged from 113 to 138 between 1977 and 1982, dropped to between 15 and 34 between 1983 and 1986, and increased to 129 and 185 in 1987 and 1988, respectively (Reynolds 1988). Changes in the counts are not believed to be reflections of changes in the overall population size. Rather, they are believed to be caused by a combination of shifts between years in the use of different warm-water refuges, changing patterns of cold

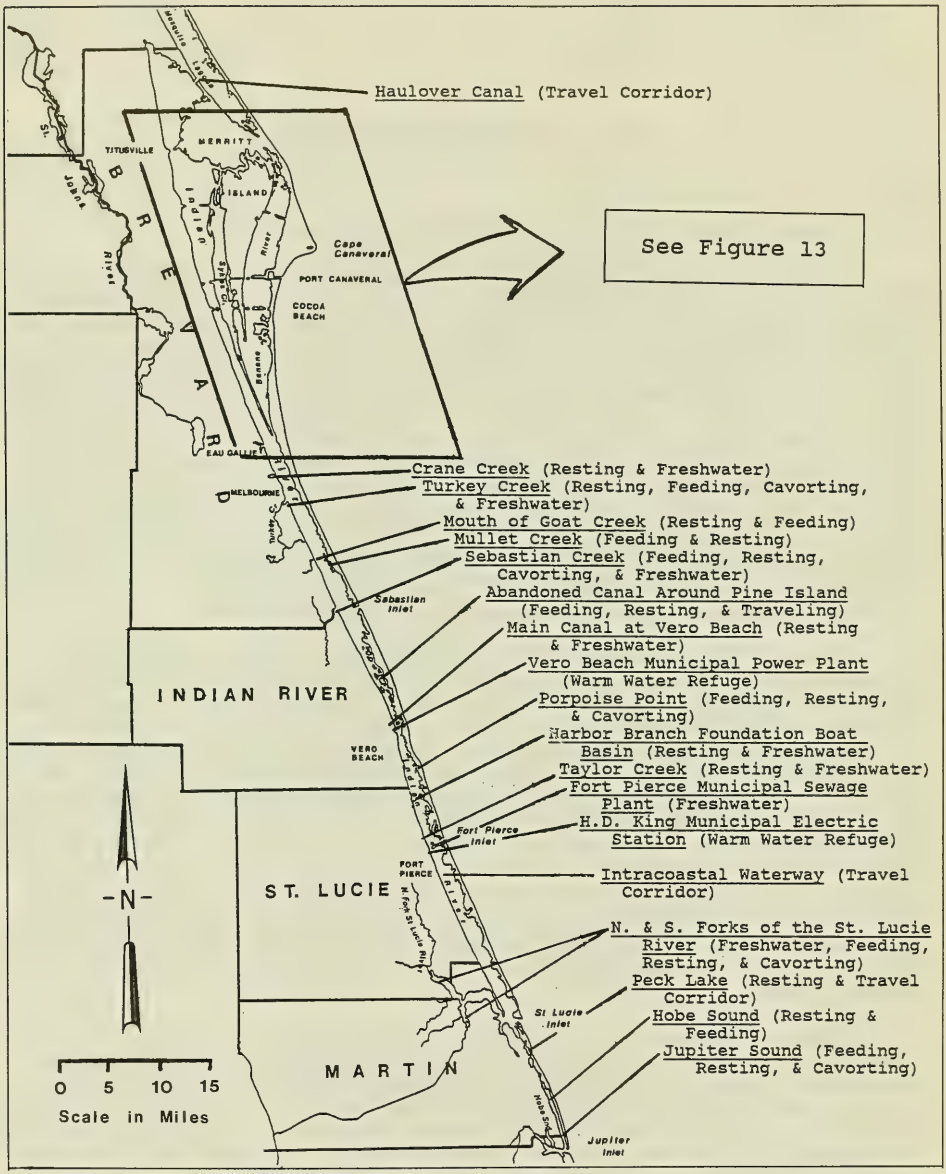

Figure 12. Important manatee habitats in the Indian River Region of the Study Area (Shane 1984, Beeler and O'Shea 1988, Provancha and Provancha 1988 and Reynolds 1988).

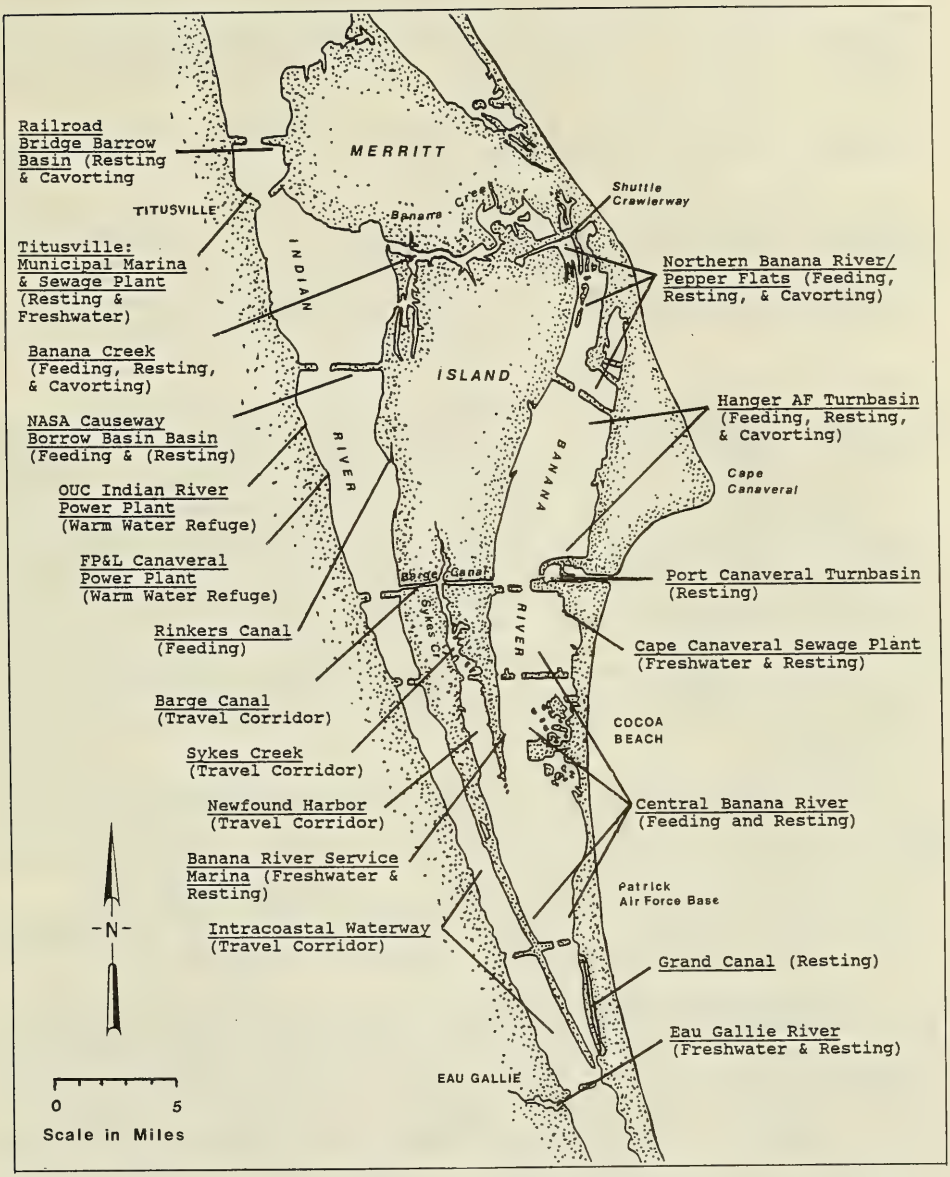

Figure 13. Important manatee habitats in the Merritt Island area of the Indian River Region (Shane 1984, Beeler and O'Shea 1988 and Provancha and Provancha 1988).

weather, and/or differences in survey methodologies in certain years. Although manatees graze on algae growing in the warm-water discharge area at the two power plants, food resources at the discharge sites are not adequate to support overwintering animals. Therefore, during winter warm spells, manatees leave the discharge sites and move across the Indian River to grassbeds along the opposite (east) bank of the Indian River (Shane 1984) at the mouth of Banana Creek and near Rinkers Canal.

In 1988, operation of the Orlando Utility Commission's Indian River Plant was reduced substantially as the utility's electricity generation shifted to a new plant located on the upper St. Johns River. With reduced amounts of warm water discharged from the Commission's Indian River Plant, counts increased at the nearby Florida Power & Light Company Canaveral Plant (Reynolds 1988).

The H.D. King Municipal Electric Station at Fort Pierce is used by a much smaller number of manatees during some winter periods. Often during the coldest days, very few or no manatees are seen, suggesting that manatees rely more heavily on the larger refuges to the north or south at these times. Winter counts since 1983 have rarely exceeded 15 to 20 animals (Rose and McCutcheon 1980 and Reynolds 1983 through 1988). Periods of peak use occur in late winter as the weather begins to warm, suggesting that the refuge is used as a way-station by animals beginning to move north from more heavily used warm-water refuges to the south. A similar pattern of use by a smaller number of animals occurs at the Vero Beach Municipal Power Plant. Both plants operate inconsistently throughout the winter, making them undependable warm-water sources for manatees. During warm winter periods, manatees also are seen at the Harbor Branch boat basin between the two plants. The number of animals observed there often exceeds that at the two power plants.

At the south end of the Region, grassbeds in Hobe Sound, and particularly Jupiter Sound, provide essential feeding habitat for manatees overwintering at the warm-water refuge created by the Florida Power & Light Company's plant at Riviera Beach in northern Palm Beach County (South Coast Region). Studies of manatee feeding habits and distribution by Packard (1981) show peak counts of manatees in February with highest counts occurring during warm winter periods when counts at the power plant are low.

As the weather turns consistently warm, manatees disperse from the warm-water refuges (O'Shea 1988). Some animals move north to Georgia (Sirenia Project, U.S. Fish and Wildlife Service, unpublished data) or into the St. Johns River (Valade 1988), while others remain in the Indian River area (Provancha and Provancha 1988). Animals also move into the Indian River Region from the south, with some remaining in the Indian River area throughout the summer and others moving on north. Animals moving north follow the Intracoastal Waterway up the Indian River through the Haulover Canal and then north through Mosquito Lagoon. Traveling manatees are observed most frequently moving along the margins of the

Intracoastal Waterway with some animals pausing to browse along the banks of spoil islands adjacent to the dredged channel. As animals move north, they often pause to rest, seek freshwater, and/or feed in rivers, canals, and boat basins along the western side of the Indian River.

The most important summer feeding and resting area in the Region and perhaps the entire study area is the Banana River and the Indian River in Brevard County. Although numbers peak in March with the influx of northward-moving animals from the south, numbers remain high throughout the summer. During aerial surveys between 1978 and 1980, Shane (1984) reported peak March counts of 148 in 1978 and 245 in 1979. Typical summer counts ranged between 75 and 150. In both summers, concentrations of manatees were consistently observed at the northernmost end of the Banana River, the Cape Canaveral Municipal Sewage Plant outfall, and the Banana River Service Marina on Merritt Island.

The portion of the Banana River north of the Barge Canal is especially important habitat that has been used increasingly by manatees in recent years (Provancha and Provancha 1985 and 1988). The area features dredged channels and basins (3-12 m deep) adjacent to shallow flats (<1-2 m deep) covered by submerged aquatic vegetation including algae (Caulerpa prolifera) and/or seagrasses (Halodule wrightii, Syringodium filiforme, and Ruppia maritima). Large numbers of animals are regularly seen feeding, resting, or cavorting in the various basins and adjacent flats. This part of the Banana River is within the Kennedy Space Center.

Year-round aerial surveys of the northern Banana River were conducted between 1978 and 1986. During that period, maximum counts always occurred in early spring and increased from 56 in 1978 to 297 in 1986 (Provancha and Provancha 1988). Counts of "resident" animals in the May-to-November periods were always lower than the spring counts but also increased over the study period. Average counts per survey during this period increased from 13-20 animals prior to 1981 to 60-70 animals between 1984 and 1986.

Rather than reflecting an increase in population size, the observed increase in numbers in the northern Banana River may, in part, reflect a learning process. That is, manatees may be learning that because of no-entry and slow speed zones established in this particular area, they are less frequently disturbed or injured by boats. Provancha and Provancha (1988) suggest that the increasing counts are caused by immigration and a shift in manatee distribution prompted by greatly increased development pressure over the past 10 years along the estuary outside of the Kennedy Space Center. The decrease in numbers after early spring may be due to the movement of some animals farther north. Channels through Sykes Creek and the Barge Canal across Merritt Island are major travel corridors for manatees moving between the Banana River and the Indian River.

Other warm weather feeding and resting habitats used consistently but by fewer numbers of manatees in the Indian River Region include the series of creeks and canals entering along the west bank of the Indian River (Florida Department of Natural Resources, unpublished data). From north to south, these include: the Eau Gallie River at Eau Gallie; Crane Creek in Melbourne; Turkey Creek in southern Brevard County; Sebastian Creek, which forms part of the southern boundary of Brevard County; the Harbor Branch boat basin in northern St. Lucie County; Taylor Creek at Fort Pierce in St. Lucie County; and the North and South Forks of the St. Lucie River in northern Martin County. Of these, Sebastian Creek appears to be the most intensively used.

These areas appear to be particularly important as stop-over sites for manatees migrating along the Intracoastal Waterway in the Indian River. For example, Turkey Creek offers a secluded refuge away from heavy boat traffic on the Intracoastal Waterway, grassbeds for feeding, and freshwater. During a one-year survey of manatees using the creek, 45 individuals were identified by distinctive scars or marks (Tiedemann 1980 and 1983). The average number of manatees sighted per week, however, ranged from zero in winter to a peak of 10 in early June. The greatest number of sightings occurred during the spring and fall migratory seasons.

Many areas in the Indian River itself are too shallow for manatees. Sightings usually occur in or immediately adjacent to the Intracoastal Waterway where animals are seen traveling or feeding on submerged vegetation growing on the banks of dredge spoil islands adjacent to the channel. An exception to this pattern is where side channels have been dredged into grassbeds or along marsh islands to provide boat access to the Intracoastal Waterway. These channels provide manatees with access to feeding and resting sites that otherwise would require travel across broad expanses of shallow water. One such area where substantial numbers of animals have been observed is at Porpoise Point on the east side of the Indian River south of Vero Beach (Florida Department of Natural Resources, unpublished data). Manatees also are seen frequently in channels adjacent to the Mullet Creek Islands approximately 5 miles north of Sebastian Inlet.

B. Regional Threats to Manatees and Manatee Habitat

The principal threats to manatee habitat in the Indian River Region are boat traffic, which renders essential travel routes and feeding and resting areas hazardous for manatees, and high levels of turbidity, which depress growth of submerged seagrasses essential for food. The latter problem is not entirely independent of boat traffic patterns. That is, propellor action and boat wakes in shallow water may contribute to increased turbidity levels.

Ninety boat-killed manatees have been recovered in the Indian River Region between April 1974 and June 1988, and this Region has the largest number of boat kills in the study area. Fifty-two of

the carcasses (58%) were recovered from the 40-mile stretch of coastal waters between Titusville and Eau Gallie on either side of Merritt Island in northern Brevard County. As indicated on Figures 14 and 15, the greatest concentrations of carcass recovery sites in the Region have been in the following areas: a four-mile stretch of the Indian River north of the Florida Power & Light Company's Canaveral power plant (9 boat kills); the four-mile stretch of Sykes Creek south of the Barge Canal on Merritt Island (12 boat kills); an eight-mile stretch of the Banana River between Port Canaveral and Cocoa Beach, including the Port Canaveral turning basin (15 boat kills); a four-mile stretch of the Indian River and the lower three miles of Sebastian Creek near Sebastian Inlet in southern Brevard and northern Indian River Counties (7 boat kills); and an eleven-mile stretch of the Intracoastal Waterway from the mouth of the St. Lucie River to the northern end of Hobe Sound (12 boat kills).

As shown by the histogram in Figure 16, there is a slight seasonal peak in boat/barge mortalities between May and August when 50% of the carcasses (45 of 90 animals) were recovered. This increase may reflect increasing summer boating activity. Regional trends in boat kills over the past 10 years show marked increases in recent years. Twenty-eight percent of the boat kills recovered in this Region (25 of 90 animals) were recovered from January 1986 through June 1988, with almost all of the recent recoveries from Brevard (14) and Martin (9) Counties.

The occurrence of boat-killed manatees and boating activity also has increased dramatically in the southern part of the Indian River in recent years. Prior to 1981, no boat kills had been recovered from the "interinlet" area between the Sebastian Inlet (Indian River County) and St. Lucie Inlet (Martin County). Between 1981 and 1985, however, 13 manatee carcasses were recovered. Between 1977 and 1988, boat registrations in Indian River, St. Lucie, and Martin Counties increased by about 100 percent (Table 5), and the number of boat slips in the interinlet area for which permit applications were reviewed by the Fish and Wildlife Service increased by 600% in 1985 over the previous two-year period (Pulliam 1985). These data suggest a direct correlation between boating activities and manatee mortality in this area.

In the late 1970s, there also was concern that vessel traffic in the Banana River north of Port Canaveral could become a problem. The concern focused on potential collisions between manatees and the hulls and propellers of barges used to retrieve the space shuttle's rocket boosters after shuttle launches from Kennedy Space Center. To address the problem, the National Aeronautics and Space Administration supported a study to identify possible solutions (United Space Boosters, Inc. 1980). The study indicated that the broad flat shape of the vessel's hull would minimize the risk of crushing manatees in the shallow inland channels of the northern Banana River, but that its propellers posed a significant threat. The study therefore recommended that the vessels be equipped with jet propulsion rather than propeller-driven engines.

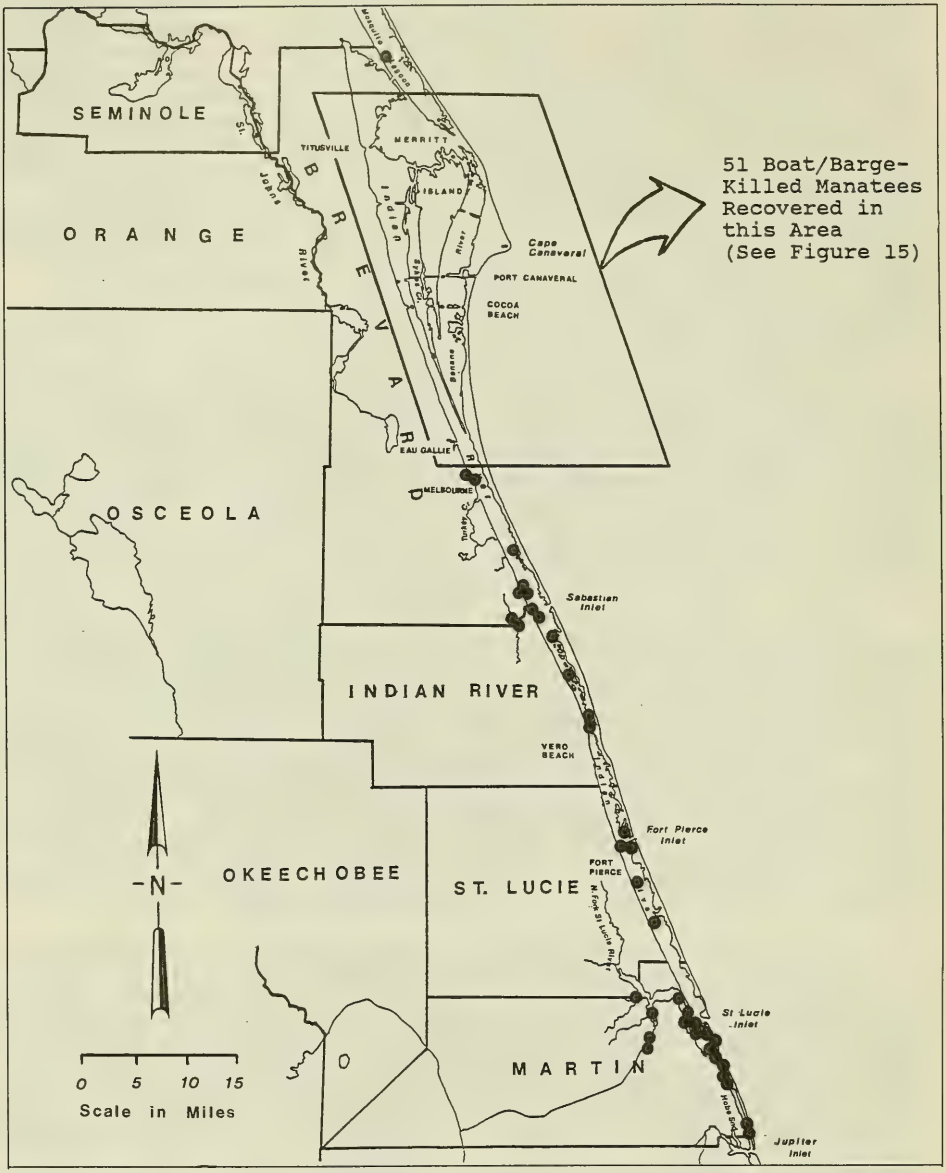

Figure 14. Recovery sites of boat-killed manatees recorded from April 1974 through June 1988 in the Indian River Region (Beeler and O'Shea 1988 and Bureau of Marine Research, Florida Dept. of Nat. Res., unpublished data).

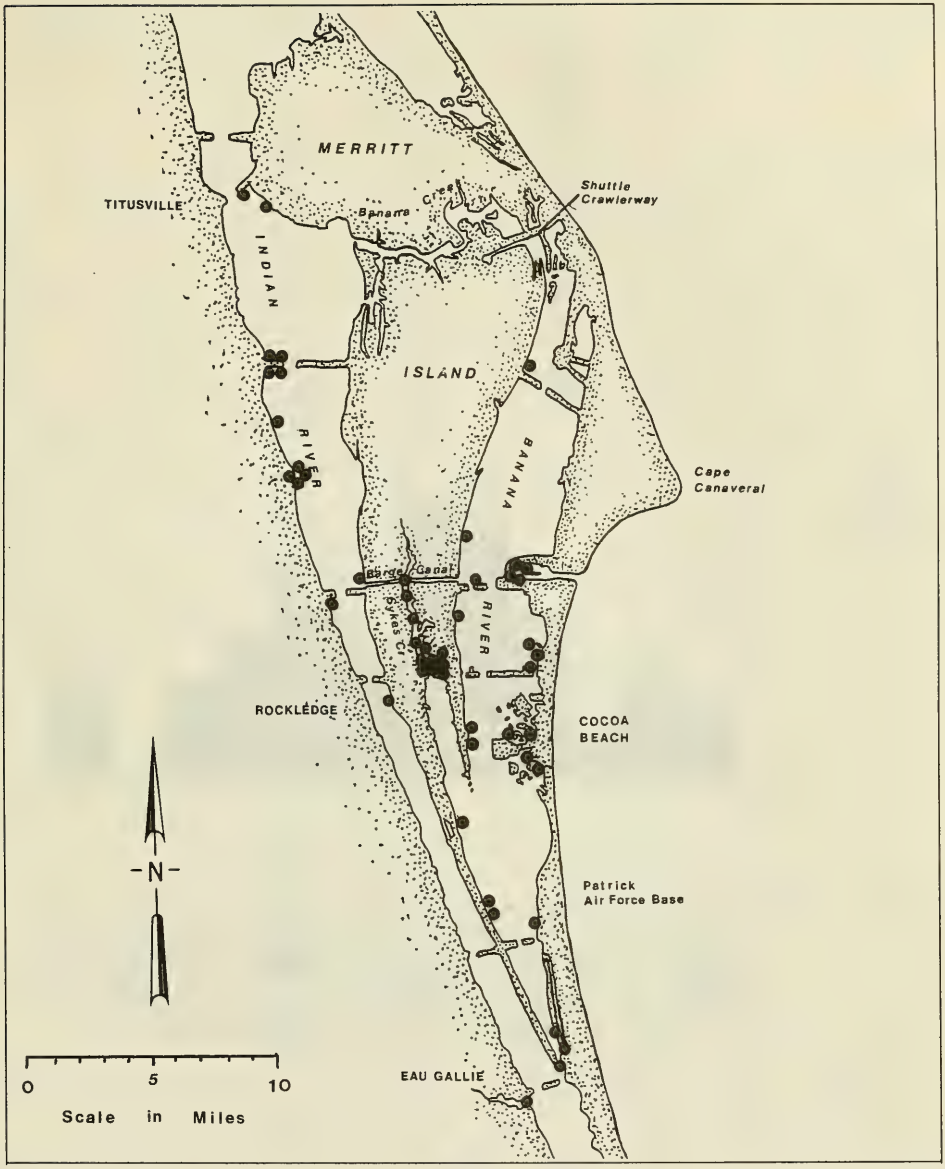

Figure 15. Recovery sites of boat-killed manatees recorded from April 1974 through June 1988 in the Merritt Island area of the Indian River Region (Beeler and O'Shea 1988 and Bureau of Marine Research, Florida Department of Natural Resources, unpublished data).

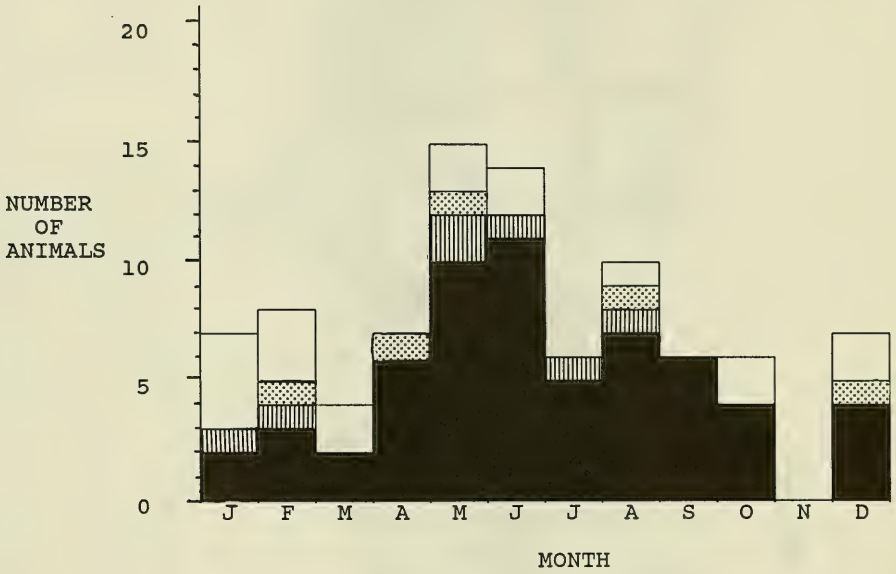

Figure 16. Number of known boat-killed manatees by month for Counties in the Indian River Region from April 1974 through June 1988. Brevard = ; Indian River = ; St Lucie = , and Martin = . (Beeler and O'Shea 1988 and Bureau of Marine Research, Florida Department of Natural Resources, unpublished data).

Table 5. Total number of recreational and commercial boats registered by year for Counties in the Indian River Region between 1977 and 1987 and the percent increase over that ten-year period (based on data from the Florida Department of Natural Resources).

County	Number of Registered Boats by Year (in thousands)										Increase Over Ten Year Prd.
	1977/ 1978	1978/ 1979	1979/ 1980	1980/ 1981	1981/ 1982	1982/ 1983	1983/ 1984	1984/ 1985	1985/ 1986	1986/ 1987	
Indian River Region											
Brevard	15.71	17.00	17.66	18.47	17.89	19.18	20.23	21.28	22.22	23.37	7.66(49%)
Indian River	3.33	3.84	4.29	4.52	4.50	5.28	5.71	6.02	6.38	6.71	3.38(102%)
St Lucie	3.32	3.68	3.95	4.20	4.31	4.75	5.15	5.46	5.97	6.69	3.37(102%)
Martin	4.81	5.48	6.20	6.65	6.74	7.00	7.53	8.22	8.76	9.53	4.72(98%)
TOTALS	27.17	30.00	32.10	33.84	33.44	36.21	38.72	40.98	43.33	46.30	19.13(70%)

The recommendation was adopted and new retrieval vessels were constructed with the recommended propulsion systems. Operations since that time have proven the solution to have been an effective mitigation measure.

A second major threat to manatee habitat in this Region is increasing turbidity levels in coastal waters. High levels of suspended material decrease light penetration in water, and thereby suppress growth of benthic seagrasses and limit seagrass distribution to areas shallower than otherwise might occur. An increase in turbidity at grassbed locations used by manatees for feeding is therefore a serious concern because of the importance of these plants as a food source for manatees and because the deep grassbeds accessible to manatees (over one meter) would be among the first to be affected by decreased light penetration.

Available information suggests that grassbeds in the Indian River have declined significantly in recent decades. For example, a recent assessment of grassbeds along a 12-mile stretch of the Indian River near Sebastian Inlet using old aerial photographs indicates that this area has experienced a 38% decrease in the size of grassbeds between 1951 and 1984, with a 16% decline occurring after 1970 (Haddad and Harris 1985a). Comparable declines have been reported for the Fort Pierce Inlet area. To the north, near the Ponce de Leon Inlet in Volusia County, 30 ha of grassbeds visible in a 1943 photograph had completely disappeared by 1984 (Haddad and Harris 1985b).

Although the cause of declines in grassbeds is attributed generally to changes in water quality associated with coastal development (Haddad and Harris 1985b), the precise cause is uncertain. However, it may be related, at least in part, to increased turbidity. Major sources of turbidity can include: particulate and nutrient material discharged through storm sewers; bulkheaded shorelines, which reflect wave energy normally absorbed by marsh or mangrove-lined shores; dredging; and boat traffic. The latter may increase turbidity directly when propellers of boats traveling across shallow flats drag through bottom sediment and indirectly when wakes from boats in channels move across shallow water and resuspend bottom sediment.

A manatee habitat of particular concern with respect to turbidity is Hobe Sound at the southern end of the Indian River Region in Martin County. Submerged grassbeds accessible to manatees in this area are used by animals wintering at the Riviera power plant (Packard 1981 and 1984). If the productivity of these grassbeds, particularly those in deep waters (>1 m) where manatees feed, is reduced due to increased turbidity, available food resources may be reduced to levels below that necessary to support the number of animals wintering at the power plant. Heavy boat traffic along the Intracoastal Waterway through Hobe Sound is thought to be contributing to high turbidity, which may be restricting the distribution of grassbeds. A cooperative study involving the National Marine Fisheries Service, the Fish and

Wildlife Service, the Florida Department of Natural Resources, the Save the Manatee Club, and the Marine Mammal Commission is currently underway to assess the potential effect of boats on turbidity and seagrass productivity in the Sound.

C. Regional Protected Areas

Twenty-four Federal and State protected areas have been identified in the Indian River Region (see Table 6 and Figure 17). These include: one National Seashore managed by the National Park Service; four National Wildlife Refuges managed by the Fish and Wildlife Service; and seven boat speed regulatory zones, seven Aquatic Preserves, two State Parks, two State Recreation Areas, and one State Reserve administered by the Florida Department of Natural Resources. The National Aeronautics and Space Administration owns a large tract of land in the Merritt Island area of Brevard County, which is the site of the John F. Kennedy Space Center. Public access to most of the Space Center is closed and its lands are managed in conjunction with the Fish and Wildlife Service and the National Park Service as part of the Merritt Island National Wildlife Refuge and the Canaveral National Seashore. In addition, there are four proposed land acquisition projects in the Region presently under consideration for purchase through the State Conservation and Recreation Lands Program.

The Canaveral National Seashore, administered by the National Park Service, encompasses most of Mosquito Lagoon east of and including the Intracoastal Waterway in northern Brevard County. The Lagoon's north end includes numerous marsh and mangrove islands but most of the Lagoon is too shallow for manatees and it is not considered an important feeding, resting, or cavorting habitat. The Intracoastal Waterway, however, is an essential travel route used by a substantial portion of the East Coast population as animals move between warm-water refuges along the southeast Florida coast and summer feeding areas in the North Coast Region. Information on manatees is made available to Park visitors. There are no special management provisions for manatees.

The Merritt Island National Wildlife Refuge and Kennedy Space Center, managed cooperatively by the Fish and Wildlife Service and the National Aeronautics and Space Administration, may be the most important protected area in the Region, and perhaps the study area, for manatees. It is probably used by more individual manatees than any other single location on the East Coast. Three areas of particular importance to manatees in this area are the northern Banana River, Banana Creek, and Haulover Canal. All three receive special protection.

The northern Banana River is protected by a restricted access area and a slow speed regulatory zone. The restricted area is located within the Kennedy Space Center at the northernmost end of the Banana River and is closed year-round to public boat access for security reasons. It extends from the NASA Causeway to the

Table 6. Federal and State protected areas containing or adjacent to manatee habitat in the Indian River Region.

Name	County	Size
NATIONAL SEASHORES (NATIONAL PARK SERIVCE)		
Canaveral National Seashore	Volusia/Brevard	57,627 ac.
NATIONAL WILDLIFE REFUGES (FISH AND WILDLIFE SERVICE)		
Merritt Island Nat. Wildlife Refuge	Volusia/Brevard	140,393 ac.
St. Johns Nat. Wildlife Refuge	Brevard	2,396 ac.
Pelican Island Nat. Wildlife Refuge	Indian River	4,359 ac.
Hobe Sound Nat. Wildlife Refuge	Martin	773 ac.
STATE PRESERVES AND RESERVES (FLORIDA DEPT. OF NATURAL RESOURCES)		
Savannas State Reserve	St. Lucie/Martin	3,491 ac.
STATE AQUATIC PRESERVES (FLORIDA DEPT. OF NATURAL RESOURCES)		
Banana River	Brevard	29,700 ac.
Indian River -- Malabar to Sebastian Inlet	Brevard & Indian River	27,800 ac.
Indian River -- Vero Beach to Fort Pierce	Indian River & St. Lucie	12,000 ac.
Intracoastal Waters -- Jensen Beach to Jupiter Inlet	St. Lucie/Martin	26,000 ac.
Loxahatchee River-Lake Worth Creek	Martin/Palm Beach	9,000 ac.
Mosquito Lagoon	Volusia/Brevard	36,000 ac.
North Fork, St. Lucie River	St. Lucie/Martin	6,100 ac.
STATE BOAT SPEED REGULATORY ZONES (FLORIDA DEPT. OF NATURAL RESOURCES)		
St. Lucie Inlet to Jupiter Inlet (Slow Speed/Channel-Exempt Area)	Martin/Palm Beach	16 mi.*
Fort Pierce Area (Slow and Idle Speed Areas)	St. Lucie	2 mi.*
Vero Beach Area (Slow and Idle Speed Areas)	Indian River	2 mi.*
Turkey Creek Area (Slow and Idle Speed Areas)	Brevard	3 mi.*
Indian River Area (Idle Speed Area)	Brevard	3 mi.*
Sykes Creek Area** (Slow Speed/Channel-Exempt Area)	Brevard	4 mi.*
Banana River Area (Idle Speed Area)	Brevard	0.1mi.*

Continued

Table 6. Continued - Protected areas in Indian River Region

Name	County	Size
STATE PARKS AND RECREATION AREAS (FLORIDA DEPT. OF NATURAL RESOURCES)		
Fort Pierce Inlet St. Rec. Area	St. Lucie	1,298 ac.
Jonathan Dickenson State Park	Martin	10,284 ac.
St. Lucie Inlet State Park	Martin	1,027 ac.
Sebastian Inlet St. Rec. Area	Brevard	578 ac.
PROPOSED LAND ACQUISITION PROJECTS (FLORIDA CONSERVATION AND RECREATION LANDS PROGRAM)		
Brevard Turtle Beaches	Brevard	12 ac.
Mullet Creek Islands	Brevard	200 ac.
Wabasso Beach	Indian River	110 ac.
North Fork of the St. Lucie River	St. Lucie	1,350 ac.

* Size of boat speed regulatory zones is provided as approximate length of waterway along channel or shoreline subject to regulation.

** The Sykes Creek boat speed regulatory zone is established under local, rather than State authority.

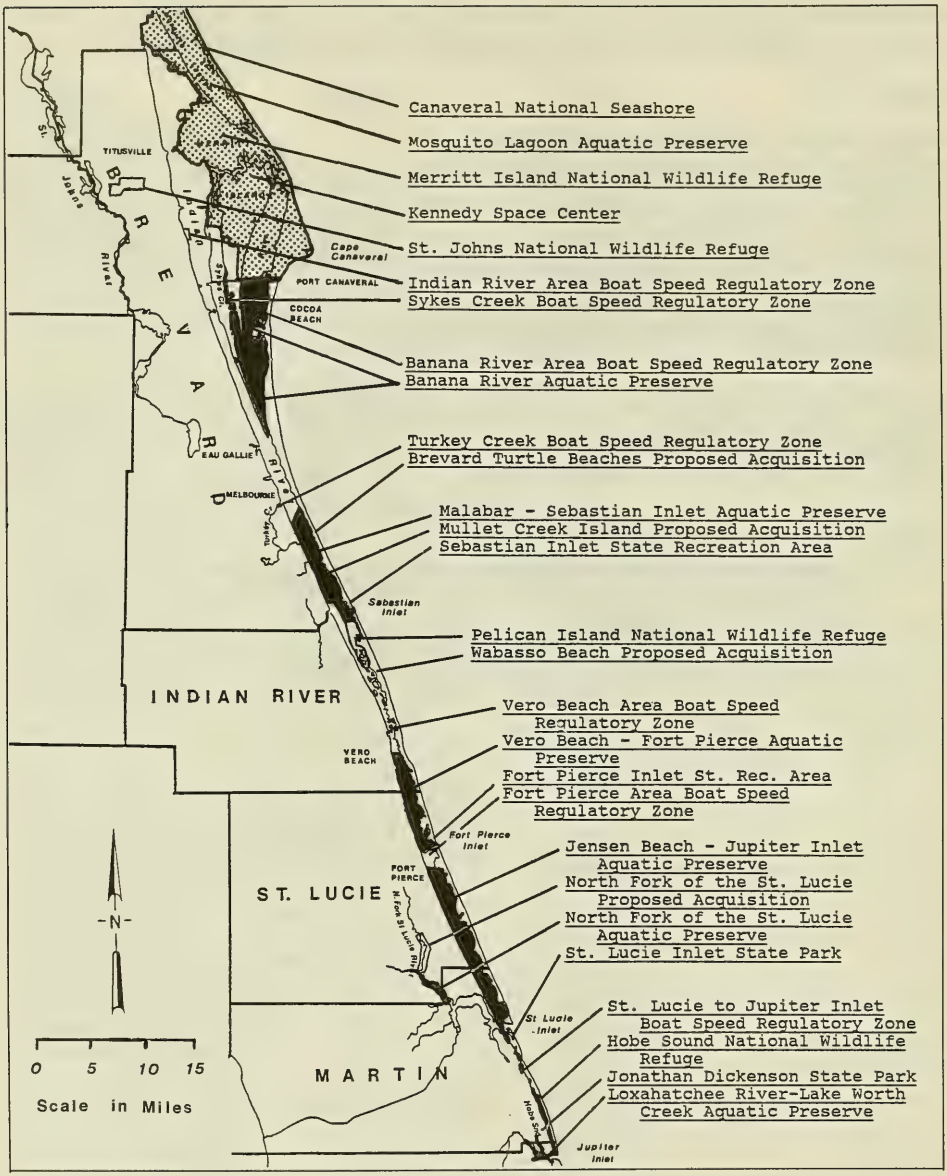

Figure 17. Location of Federal and State protected areas containing or adjacent to manatee habitat in the Indian River Region (Florida Department of Environmental Regulation 1987).

head of the river at the shuttle crawlerway, which is a solid fill causeway that severs its connection to Banana Creek. The area offers extensive beds of submerged aquatic vegetation, dredged channels and basins, and secluded habitat away from boat traffic. Perhaps because of this combination of features, it is used by manatees more extensively than any other area of the river. The next basin south (the Hanger AF Turnbasin between the NASA Causeway and the Barge Canal) is open to public boat access; however, non-channel areas and certain channel areas have been established as a year-round slow speed/minimum wake regulatory zone by the Fish and Wildlife Service to protect manatees. It too has extensive submerged aquatic vegetation and dredged basins used intensively by manatees.

Banana Creek, which cuts across Merritt Island from the Indian River to the shuttle crawlerway, also is closed to public boat access for security reasons. The area includes submerged aquatic vegetation and is used by manatees for feeding, resting, and cavorting. The third area of importance to manatees is Haulover Canal. The canal is a dredged connection for the Intracoastal Waterway across the sand spit separating the Indian River and Mosquito Lagoon. It is a strategic travel corridor through which all boats and manatees moving north or south must pass. By regulation in 1978, the Fish and Wildlife Service designated the nearly two-mile passageway as a slow speed/minimum wake zone to protect manatees. No boat kills have been reported from the Haulover Canal and, considering the high numbers of manatees and boats passing through the Canal, the measure appears to have been very effective.

The Fish and Wildlife Service also manages two other Wildlife Refuges adjacent to the Intracoastal Waterway in the Region. One of these, the Pelican Island Refuge, is located along the Indian River in Indian River County. Manatees are sighted infrequently within its boundaries, perhaps because water depths are too shallow to allow manatees access. The other Refuge is the Hobe Sound National Wildlife Refuge located at the southern end of the Region. This Refuge includes lands along approximately 9 miles of the Intracoastal Waterway between the St. Lucie and Jupiter Inlets. The Refuge includes a portion of the north-south travel corridor probably used by well over 50% of the East Coast manatee population. The southern half of the Refuge is adjacent to Hobe Sound and is a feeding area for manatees. The Sound ranges from less than a quarter-mile wide to about a half-mile across with the Intracoastal Waterway running its entire length.

No special protection provisions have been established for manatees at the Hobe Sound Refuge; however, Refuge staff help enforce a winter season channel-exempt slow speed zone established by the Florida Department of Natural Resources to protect manatees. The slow speed zone runs through the Refuge and extends from the St. Lucie Inlet to the Jupiter Inlet. In addition, the Service is cooperating on a a study with the State of Florida, the National Marine Fisheries Service, the Save the Manatee Club, and

the Marine Mammal Commission to assess the effects of boat wakes on submerged grassbeds. As part of that study, consideration is being given to designating a six-mile section of the Intracoastal Waterway running through the Hobe Sound National Wildlife Refuge as a channel inclusive slow speed zone.

By Act of the Florida Legislature, the Florida Department of Natural Resources has established seven idle and/or slow boat speed regulatory zones to protect manatees in the Indian River Region (see Table 6 and Figure 17). These zones cover about 30 linear miles of channel, over two-thirds of which either is designated as a channel-exempt slow speed zone or does not extend out to the Intracoastal Waterway. About 7.5 miles are designated as idle speed only. Enforcement of these zones is provided primarily by the Florida Marine Patrol, although Fish and Wildlife Service Refuge staff and the U.S. Coast Guard assist as possible.

The Florida Department of Natural Resources, Division of Recreation and Parks, administers seven Aquatic Preserves covering a total of about 147,000 acres of submerged bottom lands. The Banana River Aquatic Preserve and the Jensen Beach-Jupiter Inlet Aquatic Preserves contain particularly important manatee habitats. Management plans have been prepared for all but the Mosquito Lagoon Aquatic Preserve. As discussed in Chapter IV, the management plans include specific provisions for manatees that are essentially the same for each Aquatic Preserve. For example, the Banana River Aquatic Preserve Management Plan provides that "the creation of new marinas and multiple slip residential docking facilities should be prohibited in manatee sanctuaries and severely limited in identified manatee use areas" (Florida Department of Natural Resources 1985). Rules pertaining to Aquatic Preserve management are presently being revised.

Four proposed State land acquisition projects adjacent to or near manatee habitat are currently pending as part of the State Conservation and Recreation Lands Program (Florida Department of Natural Resources 1988). Of these, the Mullet Creek Island and North Fork of the St. Lucie River Projects are of greatest relevance. Mullet Creek Island is a series of small mangrove-lined islands on the eastern side of the Indian River five miles north of Sebastian Inlet. The area is proposed for acquisition, in part to protect the wildlife habitat associated with the river and Lagoon ecosystem. Manatees have been observed feeding and resting in dredged channels and basins near the Island. The Mullet Creek Island Project involves 200 acres of wetland and upland and is presently ranked number 62 on the State's Recommended Land Acquisition List.

The North Fork of the St. Lucie River Acquisition Project is located along the upper portions of this river and includes 1,350 acres of wetland and upland. In part, the project is intended to help protect water quality in the North Fork of the St. Lucie River Aquatic Preserve. Although manatees may not regularly move as far upriver as the Project area, they do occur in the Aquatic

Preserve and protection of water quality in that area would help protect grassbeds used by manatees. The area is threatened by development and the Project presently is ranked number 20 on the State's Recommended Land Acquisition List.

D. Analysis of Regional Habitat Protection Needs

The manatee habitats most in need of additional protection in the Indian River Region are the Banana River and Indian River between the towns of Titusville and Eau Gallie in central Brevard County (including Sykes Creek), and the travel corridor/feeding areas between the St. Lucie and Jupiter Inlets (including Hobe and Jupiter Sounds) in southern Martin County (and northern Palm Beach County). Other areas where additional protection is warranted include the series of small creeks and rivers emptying into the Indian River along its west bank from southern Brevard County to the St. Lucie Inlet in Martin County and the section of the Indian River near Sebastian Inlet.

The Banana River and the Indian River around Merritt Island in Brevard County are probably the most important areas for manatees on the East Coast. The area around the two power plants south of Titusville provides a warm-water refuge and feeding area used by one of the largest winter concentrations of manatees in Florida. Concentrations of manatees in the spring in the Banana River are the largest known in this season anywhere on the East Coast, suggesting the area is a major feeding and resting area for animals migrating along the coast. The Banana River also supports one of the largest concentrations of summer "resident" animals. The major objectives for protecting habitat in this area should be to: a) eliminate the disturbance, injury, and death of animals by boats; and b) protect the area's submerged aquatic vegetation.

Kinnaird (1983b) studied boat-related manatee mortality in relation to the location of grassbeds used for feeding and boat traffic patterns in the Banana River. She determined that the areas where most boat kills occur are around shallow grassbeds where small shallow-draft boats cut rapidly across shoal areas outside of channels in a non-linear traffic pattern. Based on her findings, she recommended, among other things, that: summer (April-November) slow speed sanctuary zones be established around important grassbed feeding areas in the central Banana River from the causeway to Cocoa Beach (Route 520) south to the causeway near Patrick Air Force Base (especially at grassbeds on the west bank of the river opposite Patrick AFB, and on the east bank north of the Cocoa Beach Recreational Complex); Sykes Creek between the Barge Canal and the bridge at Route 528 be established as a slow speed zone; marina and boat ramp development in the central Banana River and near the power plants on the Indian River be limited; and public boat access to the Hanger AF Turnbasin be restricted during summer shuttle launches to prevent the build-up of large numbers of boats in manatee feeding and resting areas.

With respect to these recommendations, local authorities established portions of Sykes Creek as an idle speed speed zone in late 1985. Between April and July 1986, however, three manatees killed by boats were recovered in Sykes Creek. Therefore, in 1986, the entire creek was established as a channel-exempt slow speed zone with three sections of the creek's channel designated as slow speed. As of the date of this report, no additional boat kills have been recovered from the creek; however, one boat-killed manatee was recovered near the west end of the Barge Canal which connects Sykes Creek and the Indian River. The State is currently considering action to establish the canal as a slow speed area.

Other speed zones have not been designated in the Merritt Island area. Fifteen boat-killed manatees have been recovered in in the central Banana River since 1974 (three between January 1986 and June 1988) suggesting that additional boat speed regulatory measures also are needed in that waterway. Management policies to limit development in the Banana River also have been incorporated into the Banana River Aquatic Preserve management plan, but manatee-related provisions for Aquatic Preserves are presently being revised.

To improve protection of manatee habitat in the Merritt Island area of Brevard County, the Florida Department of Natural Resources, the Fish and Wildlife Service, the National Aeronautics and Space Administration, and officials responsible for developing Local Growth Management Plans should reassess alternative actions to reduce boat-related manatee deaths and injuries and to protect grassbed feeding areas by: expanding the system of boat speed regulatory zones; clarifying provisions to limit shoreline development that could affect manatees or manatee feeding areas; and, where possible, restoring natural conditions. In this context, the following additional actions are recommended for the Merritt Island area:

-- Create a Manatee Sanctuary in the Hanger AF Turnbasin in the Banana River: The Fish and Wildlife Service should expand the restricted access area presently in place north of the NASA Causeway to the Hanger AF Turnbasin on a ten-year experimental basis. This basin is entirely within the Merritt Island National Wildlife Refuge and includes important manatee feeding areas. Available information suggests that closure of the Banana River north of the NASA Causeway has resulted in increased use by manatees. The Hanger AF Turnbasin is one of the few areas along the Indian River with suitable deep water access to feeding areas for manatees. Extending restricted access protection to this basin would be consistent with the objectives of National Wildlife Refuges to protect endangered species. The closure should be accompanied by a cooperative Fish and Wildlife Service-NASA study to determine whether and how the action affects the future distribution of manatees in the Banana River. If it does not result in increased

manatee use of the basin over the study period, the area should be reopened to slow speed boat traffic.

-- Establish boat speed regulatory zones in the central Banana River and Barge Canal: The barge canal across Merritt Island should be established as a year-round slow speed zone. The canal is a major travel route between the Banana River and Indian River and may be used by manatees overwintering at the power plants to reach feeding areas in the Banana River. It is used regularly during non-winter months. In the central Banana River itself, the area from the section from the barge canal south to Buck Point at the mouth of Newfound Harbor should be designated as a channel-exempt slow speed zone to protect feeding areas. All waters south of Buck Point within one-quarter mile of shore (including shorelines north of Buck Point in Newfound Harbor) should be designated as a shoreline idle speed zone. Certain areas used infrequently by manatees should be exempt from speed restrictions to provide opportunities for activities, such as water skiing and jet skis. The objective of these provisions would be to eliminate high-speed traffic by small boats across shallow areas where manatees are susceptible to boat strikes and to assure adequate opportunities for recreational water sports that involve high boat speeds.

-- Designate the Grand Canal as an idle speed zone: Those portions of the Grand Canal on the east bank of the Banana River south of State Route 404 that are not already designated as idle speed to protect private property should be so designated for the period March to November. Manatees frequently use the canal as a resting area during non-winter periods.

-- Control development near manatee feeding areas and warm-water refuges: The Banana River Aquatic Preserve management plan and Local Growth Management Plans should specify the location of feeding and resting areas around which boating facilities, bulkheads, or other structures that could damage grassbeds or create hazards for manatees using them would be permitted. Similar measures should be developed for areas within one mile of the two power plants on the Indian River.

-- Reconnect Banana River and Banana Creek: The Fish and Wildlife Service should initiate consultations with the National Aeronautics and Space Administration to identify alternative approaches for reconnecting the Banana River and Banana Creek, which were separated when the solid-fill shuttle crawlerway was built. The increasing number of manatees using the northern Banana River in spring on their northward migration must now travel down to Sykes Creek and the Barge Canal off the central

Banana River to return to the north/south travel corridor along the Indian River. These areas have been among the most hazardous waterways for manatees on the East Coast. An access route for manatees beneath or around the Mobile Service Structure to Banana Creek would provide a safe route to the Indian River. It could also help restore natural water circulation patterns and generally enhance access for manatees to the important feeding areas in the northern Banana River.

-- Expand boat speed regulatory zones along the Indian River: The existing winter idle speed zone around the power plants south of Titusville should be expanded by connecting the separate idle speed zones at each plant and extending the connected areas across to include the entire width of the Indian River, including the Intracoastal Waterway. Extension across the width of the Indian River would provide overwintering manatees safe access across the Intracoastal Waterway to feeding areas on the opposite bank during winter warm spells. In addition, a year-round shoreline idle speed zone should be established including all waters within one-quarter mile of shore from the railroad bridge north of Titusville south to the Route 528 Causeway at Rockledge. This 23-mile stretch of the Indian River is used year-round and includes important winter and summer feeding areas at the mouth of Banana Creek on Merritt Island as well as other areas used regularly by manatees. Certain areas used infrequently by manatees within the shoreline idle speed zone should be exempt from speed restrictions to provide opportunities for water skiing and other water sports involving high speeds.

6. Improve arrangements to maintain warm-water refuges: As discussed in the section on habitat protection needs for the South Coast Region, cooperative Federal-State-industry arrangements should be developed to identify foreseeable changes in power plant operations that could affect the availability of warm-water refuges for manatees and, as possible, to identify ways to reduce or avoid possible adverse effects to manatees.

The inland waters between St. Lucie Inlet and Jupiter Inlet contain one of the most important winter feeding areas for manatees on the East Coast (i.e., Jupiter Sound and Hobe Sound). In addition, the area includes a section of the East Coast manatee travel corridor that is probably used by more than half of the East Coast manatee population. Because of its narrow configuration, extensive boat traffic, and high use by manatees, the section also is particularly hazardous for manatees. Twelve boat-killed manatees have been recovered along an 11-mile stretch of Intracoastal Waterway between the lower St. Lucie River and northern Hobe Sound. Six of the 12 carcasses were recovered between January 1986 and June 1988. To improve protection of manatees and

manatee habitat, it is recommended that the Fish and Wildlife Service, the Florida Department of Natural Resources, and officials responsible for preparing Local Growth Management Plans consider alternative actions to strengthen control of boat traffic patterns and to limit development and activities that pose threats to essential manatee habitat In this regard, it is recommended that the following actions be considered:

-- Complete the Hobe Sound seagrass study: Cooperative ongoing studies involving the National Marine Fisheries Service, the Fish and Wildlife Service and the Florida Department of Natural Resources to assess the effect of boat speeds on turbidity levels and grassbeds in Hobe Sound should be continued. The next phase of the study involves establishing an experimental three-year slow speed zone along a 6-mile stretch of the Intracoastal Waterway within the Hobe Sound National Wildlife Refuge. Plans to establish and study the effect of this experimental slow speed zone should be implemented. As soon as the study is completed, the results should be reviewed to determine whether to retain, revise, or remove speed restrictions in the channel.

-- Establish additional boat traffic controls from the lower St. Lucie River to northern Hobe Sound: An experimental three-year, 20-mile-per-hour speed limit with no passing zones along particularly narrow stretches should be established along the inland waters from Snug Harbor just north of the A1A bridge across the lower St. Lucie River south to northern Hobe Sound. The zone should be effective year-round and the speed limit selected should be one that avoids large boat wakes. Twelve boat-killed manatees have been recovered along this 11-mile stretch of water, including 6 between January 1986 and June 1988. The concept to be tested by provisions for speed limits and no passing zones is to see if they might create a more regular linear pattern of boat traffic that poses a reduced threat to transiting manatees while minimizing inconvenience to boaters. No passing zones through narrow sections would reduce boat traffic along margins of channels where manatees may be more likely to be struck, and a more constant pattern of boat speeds may enable manatees to learn behaviors that would allow them to better avoid oncoming boats. Existing provisions for slow speeds in non-channel areas should be retained. If, after the study period, the number of boat-killed manatees recovered is not significantly reduced, channels in this area should be designated slow speed/minimum wake.

-- Strengthen manatee protection provisions in the Jensen Beach-Jupiter Inlet Aquatic Preserve: As discussed in the recommendations for the South Coast Region, the Jensen Beach-Jupiter Inlet Aquatic Preserve management

plan and Local Growth Management Plans should specify policies and provisions to prohibit development of new marinas and multi-family boat docks along Hobe Sound and Jupiter Sound because of the increased boat traffic they would prompt in shallow feeding and resting areas essential to overwintering manatees.

The series of small creeks and rivers along the west bank of the Indian River between Eau Gallie in Brevard County and the St. Lucie Inlet provide important warm weather stop-over points where traveling manatees frequently stop to feed, rest, and drink freshwater. The most important of these waterways for manatees are: the Eau Gallie River, Crane Creek (Melbourne), and Turkey Creek in Brevard County; Sebastian Creek at the Brevard County-Indian River County border; Taylor Creek in St. Lucie County; and the St. Lucie River, including both the North and South Forks in Martin County. Boat speed regulatory zones exist for manatees on two of these streams (Turkey Creek and the St. Lucie River). The Florida Department of Natural Resources and officials responsible for developing Local Growth Management Plans should consider establishing slow and/or idle speed zones along the other creeks and rivers, particularly along Sebastian Creek where manatees are more common and where three boat-killed carcasses have been recovered. In addition, development of additional marinas and multi-family docking facilities along these creeks should be discouraged in favor of sites along the Indian River. Deepening access channels to these streams to allow access by larger boats also should be prohibited.

The Indian River near Sebastian Inlet is an area of frequent manatee sightings. Sebastian Creek enters the Indian River at this point and several manatees killed by boats have been recovered from the area. The establishment of a channel-exempt slow speed zone in the summer months (March to November) is recommended to enhance protection of manatees entering or leaving Sebastian Creek and feeding or resting near Sebastian Inlet. The zone should extend along the Intracoastal Waterway five miles in either direction from Sebastian Inlet. As appropriate, non-channel areas infrequently used by manatees should be exempt from the slow speed restriction to provide opportunities for water skiing and other water sports involving high boat speeds.

Recent aerial surveys and radio-tracking studies suggest that manatees use the channels and waterways around Mullet Creek Island as a non-winter feeding and resting area (Sirenia Project, U.S. Fish and Wildlife Service, unpublished data). The undeveloped islands in this area have been placed on the recommended land acquisition list of the State's Conservation and Recreation Lands Program to help protect wildlife in the surrounding Lagoon and it is recommended that these islands be acquired. It is also recommended that the State Land Acquisition Selection Committee, which oversees the Acquisition Program, consider acquiring undeveloped shoreline areas across Mullet Creek on the Canaveral

peninsula to further advance the objectives of the proposed acquisition project.

In addition to the above habitat protection efforts, consideration should be given to creating new "Manatee Habitat Enhansement Reserves" that could provide new feeding and resting habitats for manatees and new freshwater sources. Specifically, consideration should be given to dredging new restricted access channels into naturally deep pockets containing grassbeds that presently are inaccessible to manatees due to surrounding shoals. Much of the Indian River and Mosquito Lagoon contains grassbeds that could be suitable feeding areas for manatees except that presently they are inaccessible because of the large distances of shallow water that must be crossed. If some of these areas could be made accessible to manatees, but not boats, by dredging narrow restricted access channels into them, it may be possible to create secluded Manatee Habitat Enhancement Reserves with sufficient food and resting space to draw animals away from channels congested with boat traffic. Such areas could be further improved for manatees by providing a constant source of freshwater for manatees. The freshwater might come from a well, nearby drainage ditches, or a water line and could flow from a spigot or hose directly into the water. The presence of a reliable freshwater source likely would attract regular manatee use.

Enhancement possibilities should be explored by developing a cooperative pilot project involving the Fish and Wildlife Service, the Florida Department of Natural Resources, the Corps of Engineers, and other appropriate Federal and State agencies. The pilot study should identify critical factors for selecting an optimal Manatee Habitat Enhancement Reserve site as well as specific candidate areas. Among the critical site selection factors that should be considered are: natural water depths, the type and condition of submerged aquatic vegetation, availability of freshwater sources, optimum channel depths and dimensions, availability of spoil disposal sites, proximity to developed areas, local boat traffic patterns, the effects of the project on the local and regional ecosystems, and consistency with protection objectives for other estuarine resources. The pilot study also should seek to develop and carry out plans to create a test Manatee Habitat Enhancement Reserve to evaluate the effectiveness of the concept and the feasibility of creating other reserves.

Initial testing might be undertaken at existing protected areas, such as the the Canaveral National Seashore, the Merritt Island National Wildlife Refuge, or the Pelican Island National Wildlife Refuge, where vessel traffic in the new channels could be strictly controlled during seasonal use periods. Alternatively, testing might be carried out elsewhere in the Indian River under authority of one of the Region's Aquatic Preserves. Ultimately, if the test proves successful, a series of strategically located Manatee Habitat Enhancement Reserves might be developed at 10 to 15-mile intervals along the Indian River Region from St. Lucie Inlet north to and including Mosquito Lagoon.

VII. SOUTH COAST REGION

A. Manatee Distribution and Habitat Use Patterns

The South Coast Region includes approximately 115 miles of coastline along Palm Beach, Broward, and Dade Counties in southeast Florida. The waterways that parallel the coast less than three miles inland along the northern two-thirds of the Region contain three important artificial warm-water refuges that provide winter habitat for perhaps three-fourths of the East Coast population. In the southern third of the Region, the most important manatee habitat is the eastern margin of Biscayne Bay and the network of creeks and canals that flow into the Bay from the west. Areas of particular importance to manatees in the South Coast Region are identified on Figure 18.

The three major warm-water refuges in the Region are all power plants operated by the Florida Power & Light Company. They include the Riviera Plant in northern Palm Beach County and the Port Everglades and Lauderdale Plants about 50 miles south in southern Broward County. The period of greatest use by manatees at all three plants is between December and March. Maximum winter counts of manatees at these plants based on aerial surveys supported by the Florida Power & Light Company over the past ten years have ranged from 60 to 277 at the Riviera Plant, from 56 to 276 at the Port Everglades Plant, and from 11 to 56 at the Lauderdale Plant (Reynolds 1988).

Manatees also move between warm-water refuges during the course of a single winter (Reid and Rathbun 1986) and there is some evidence that large numbers of animals may shift refuge sites. For example, on 14 February 1988, counts of 277 and 99 animals were made at the Riviera and Port Everglades plants, respectively. A survey of the two plants just three days later yielded counts of 96 animals at the Riviera Plant and and 276 animals at the Port Everglades plant (Reynolds 1988). Reciprocal counts at these two plants, which are about 50 miles apart, have been noted in the past, strongly suggesting that manatees move back and forth between the two sites over the course of a winter.

The warm-water discharge areas at the three refuges contain virtually no submerged aquatic vegetation and manatees must leave the refuges during winter warm spells to feed. The most important feeding areas for manatees at the Riviera Plant are grassbeds in Jupiter Sound and Hobe Sound 15 to 20 miles north. The comparatively sparse grassbeds in northern Lake Worth and the Loxahatchee

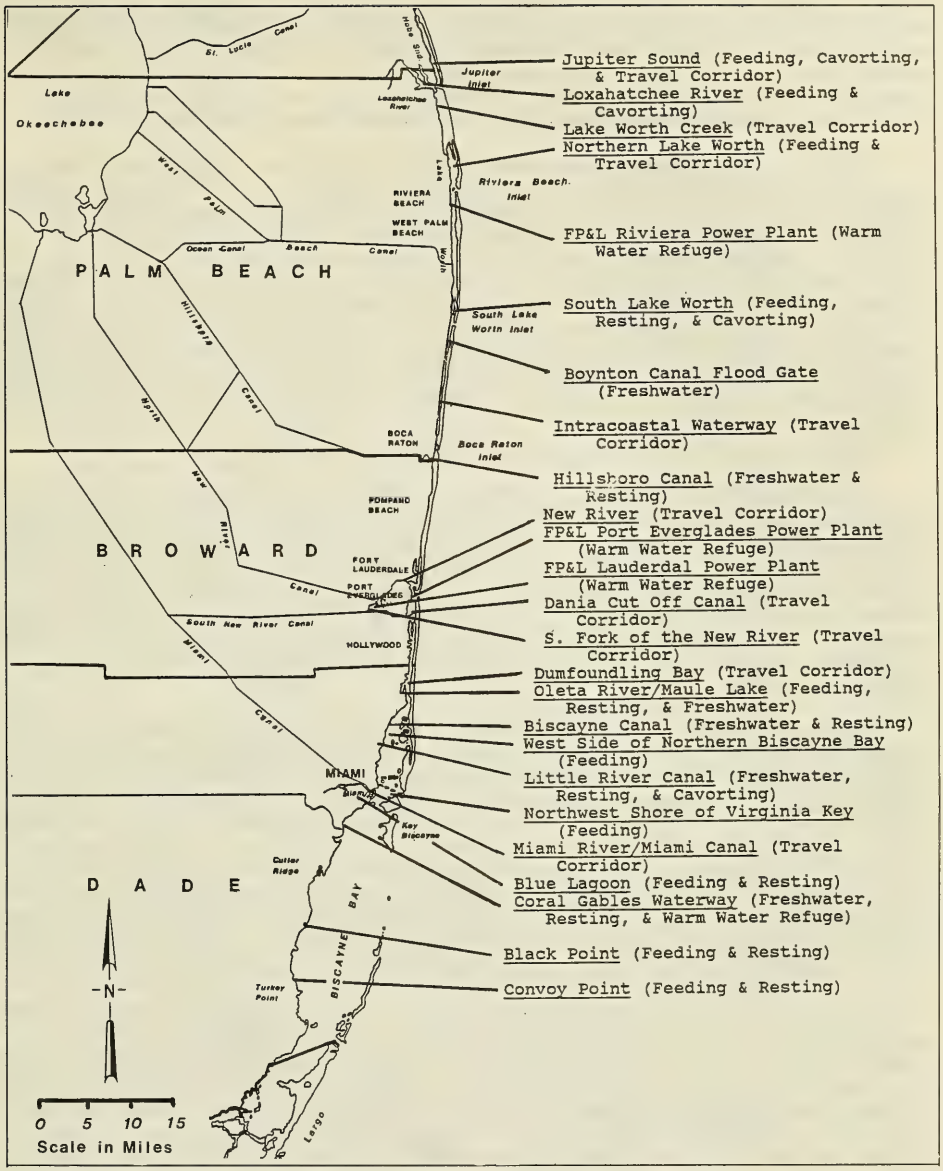

Figure 18. Important manatee habitats in the South Coast Region of the Study Area (Beeler and O'Shea 1988 and Reynolds 1988).

River, however, also are used (Packard 1981). Feeding areas for manatees at the Port Everglades and Lauderdale Plants are less well known. Some animals appear to feed along margins of the South New River, the North New River, and the Dania Cutoff Canal; however, feeding areas near the plants may not provide adequate food resources, given the large number of overwintering animals.

Recent information suggests that grassbeds along the eastern margin of northern Biscayne Bay, approximately 10-20 miles south of the power plants, may be used by substantial numbers of animals. Aerial surveys in Biscayne Bay during the winter of 1987-88 yielded counts of up to 54 manatees north of the Miami River, with most sightings at grassbeds within a half mile of the Bay's western shore (Bureau of Marine Research, Florida Department of Natural Resources, unpublished data). In addition, grassbeds off the northwest coast of Virginia Key in northern Biscayne Bay are used frequently. Recent radio-tracking studies also document movements of animals between the two power plants and grassbeds in northern Biscayne Bay during winter warm spells (Sirenia Project, U.S. Fish and Wildlife Service, unpublished data).

The lower portions of canals and rivers entering northern Biscayne Bay, particularly the Oleta River, the Little River, and the Miami River, are used regularly by manatees as resting areas and freshwater sources. For example, ground counts of more than 30 animals from the Little River Canal are not unusual during winter warm spells, with concentrations of animals often seen just below the flood gate about two miles upstream from the canal mouth (Sirenia Project, U.S. Fish and Wildlife Service, unpublished data).

No major warm-water refuges presently occur in Dade County; however, aggregations of between 10 and 50 manatees have been observed in the Coral Gables Waterway off Biscayne Bay in south Miami during occasional winter cold spells. Warm water seems to be retained in this area. Most manatees, however, are assumed to move north to the warm-water refuges at the power plants during the coldest winter periods. Freshwater sources for animals in the South Coast Region include rivers and canals flowing from the Everglades (manatees are frequently occur at the base of spillways and flood gates in canals and rivers), as well as storm sewers and other artificial sources along the Intracoastal Waterway.

Beginning in March, most overwintering manatees begin moving north toward the Indian River Region. Some animals, however, remain in the South Coast Region. Important winter habitats, such as Jupiter Sound, Lake Worth, and Biscayne Bay, are used during summer months by resident animals, while others move up into canal and river systems wherever sufficiently deep and unobstructed water access is available. Residential canal systems and boat basins along the mainland side of the Intracoastal Waterway are areas frequently used by manatees as resting areas and places to find freshwater. In southern Biscayne Bay, channels dredged through shallow grassbeds up to marinas at Black Point, Convoy

Point, and Turkey Point on the west side of the Bay are areas where small numbers of animals (up to 10) are sometimes seen (R. Currey, Biscayne Bay National Park, personal communication).

B. Regional Threats to Manatees and Manatee Habitat

Major threats to manatee habitat in the South Coast Region are: boat traffic in and/or adjacent to warm-water refuges, winter feeding areas, and travel corridors; and loss of seagrasses at winter feeding areas due to pollution and shoreline development. Over the long term, the loss of artificial warm-water refuges due to plant closings also poses a threat. At present, there is no indication that any of the plants now producing heated effluent used by substantial numbers of manatees are planning to shut down; however, industrial facilities are inherently impermanent structures and the loss of at least some existing artificial warm-water refuges over the course of coming decades seems almost certain.

The most immediate threat to manatees in the South Coast Region is boat traffic, which creates hazards for manatees in preferred habitats and may discourage use of otherwise suitable feeding and resting areas. Fifty-four boat-killed manatees were recovered in the South Coast Region from April 1974 through June 1988. As indicated in Figure 19, the greatest concentration of boat kills has been in the canals and coastal waters near the Port Everglades and Lauderdale Plants in southern Broward County. Eighteen carcasses have been recovered from areas within a few miles of the two plants. Other areas where boat kills have been concentrated include: waters along an eight-mile stretch of the Intracoastal Waterway through northern Biscayne Bay in northern Dade County (9 carcasses); a four-mile stretch of water along the Intracoastal Waterway extending two miles north and south of South Lake Worth Inlet (4 carcasses); and waters along the Intracoastal Waterway within one mile of the Riviera Plant.

Boat kills in Palm Beach and Broward Counties show a distinct seasonal peak in occurrence during the winter months between December and March (see Figure 20). More than 75% of the boat kills recovered in these two counties through June 1988 (28 of 37 animals) were found during this period. In contrast, boat kills in Dade County have been distributed more evenly throughout the year. These trends probably reflect, at least in part, the large winter influx of animals from the north to the power plants in Palm Beach and Broward Counties, and a small group of residents animals present in Biscayne Bay in Dade County year-round. Thirty-one percent of the boat kills in the three counties (17 of 54 animals) were recovered between January 1986 and June 1988, suggesting that collisions between manatees and boats are increasing in the South Coast Region.

As indicated by the number of registered commercial and recreational boats (see Table 7), the South Coast Region supports

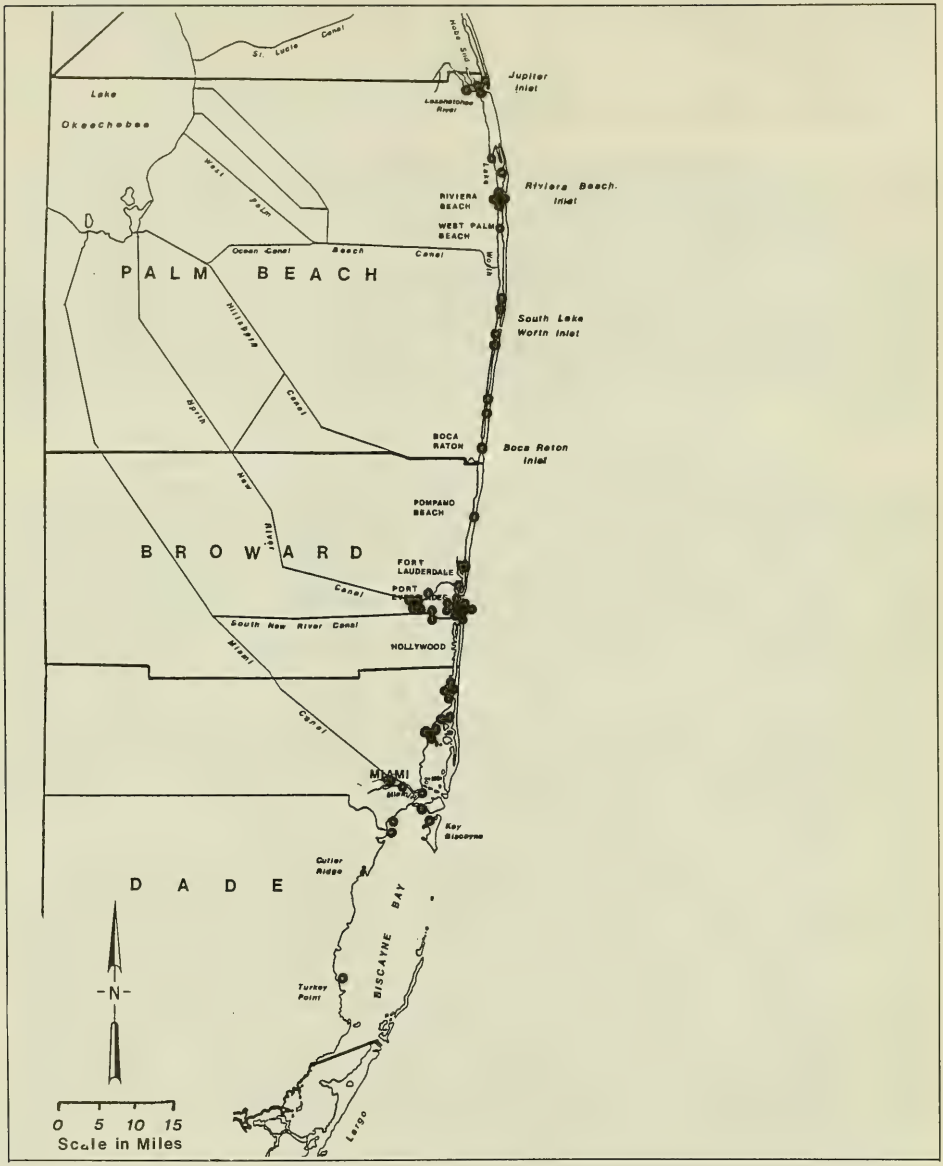

Figure 19. Recovery sites of boat-killed manatees recorded from April 1974 through June 1988 in the South Coast Region (Beeler and O'Shea 1988 and Bureau of Marine Research, Fla. Dept. of Nat. Res., unpublished data).

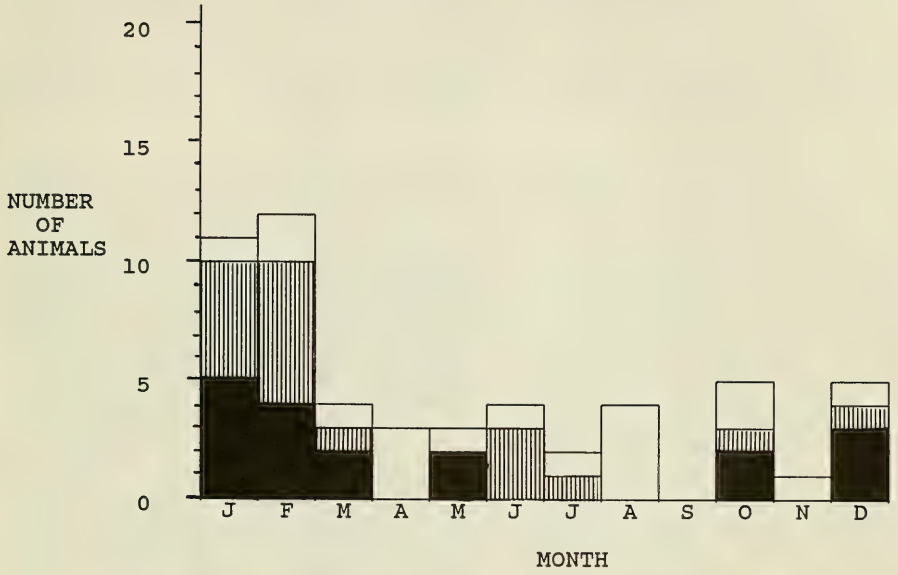

Figure 20. Number of known boat-killed manatees by month for Counties in the South Coast Region from April 1974 through June 1988. Palm Beach = ▓▓▓; Broward = ▒▒▒; Dade = □. (Beeler and O'Shea 1988 and Bureau of Marine Research, Florida Department of Natural Resources, unpublished data).

the greatest levels of coastal boat traffic in the study area. The 114,830 boats registered in Palm Beach, Broward, and Dade Counties in 1986-87 represented 48% of the 241,530 boats registered in the 15 county Florida portion of the study area. The number of boats registered in these three counties that year was 34,830 boats greater than the number ten years earlier (80,000 boats), a 43% increase over that period. In addition, the South Coast Region is a major destination for out-of-state boaters. In short, both boating activity and collisions between manatees and boats are increasing in the South Coast Region.

Loss of grassbeds used as feeding areas by manatees also is a threat to manatees in the South Coast Region. Available information indicates grassbeds in Biscayne Bay have declined dramatically in past decades. If, as recent information indicates, large numbers of manatees rely on these beds as feeding areas, additional losses could have serious adverse affects on animals wintering at the power plants in southern Broward County.

As noted above, loss of at least some artificial warm-water refuges in coming decades seems likely as power plants reach the end of their expected operational lives. If existing generating units are retired without being replaced by new ones or if alternative measures are not taken to continue to make warm water available to manatees, both the distribution and size of the East Coast population likely would be reduced significantly. Manatees probably would aggregate at remaining warm-water refuges and/or move to southern Biscayne Bay during the winter. If the entire population were to converge at one or two winter refuges, available food supplies surrounding those sites might be insufficient to support the current number of animals throughout the winter period. If plants gradually curtail operations, or if winter operations were disrupted temporarily for some reason, shifts in manatee distribution likely would occur. Abrupt changes in the availability of warm water in winter months could result in the death of some animals because of an inability to locate an alternative warm-water refuge and a consequent exposure to cold.

Prior to 1980, flood control gates also were a major threat to manatees and caused a number of deaths comparable to boat kills (Odell and Reynolds 1979). For example, in Dade County alone, 23 manatees were recovered crushed or drowned by opening or closing flood gates between 1974 and 1979. To address the problem, steps were taken in 1979 and 1980 by the South Florida Water Management District to alter the way in which problem gates opened and closed. Between 1980 and 1984, only four animals whose death could be attributed to flood gates were recovered in Dade County (Beeler and O'Shea 1988), suggesting that the adjustments had been quite successful in addressing this problem.

The modifications, however, have not completely eliminated this problem. In particular, seven and possibly eight manatees were crushed or drowned in a flood gate on the Little River Canal in Miami between November 1987 and September 1988. The South

Table 7. Total number of recreational and commercial boats registered by year for Counties in the South Coast Region between 1977 and 1987 and the percent increase during that ten-year period (based on data from the Florida Department of Natural Resources).

County	Number of Registered Boats by Year (in thousands)										Increase Over Ten Year Prd.
	1977/ 1978	1978/ 1979	1979/ 1980	1980/ 1981	1981/ 1982	1982/ 1983	1983/ 1984	1984/ 1985	1985/ 1986	1986/ 1987	
South Coast Region											
Palm Beach	18.56	20.05	20.39	20.00	19.27	21.04	22.40	23.81	25.00	27.58	9.02(49%)
Broward	26.04	29.40	30.11	30.37	29.64	29.88	32.12	33.97	35.89	38.51	12.47(48%)
Dade	35.40	40.32	40.64	39.64	38.03	40.35	42.41	44.03	46.00	48.74	13.34(38%)
TOTALS	80.00	89.77	91.14	90.01	86.94	91.27	96.93	101.81	106.89	114.83	34.83(44%)

Florida Water Management District, in coordination with the Fish and Wildlife Service and the Florida Department of Natural Resources, has since examined the problem and made further adjustments to the gate operations. It is believed that these changes will resolve this problem. The situation illustrates the need to continue to monitor the occurrence of flood gate-related deaths and to respond promptly when problems become apparent.

C. Regional Protected Areas

Eighteen Federal and State protected areas were identified along the South Coast Region containing or adjacent to manatee habitat (Table 8 and Figure 21). These include: one National Park managed by the National Park Service; one National Wildlife Refuge managed by the Fish and Wildlife Service; and three Aquatic Preserves, six boat speed regulatory zones, two State Parks, and three State Recreation Areas managed by the Florida Department of Natural Resources. In addition, there is one proposed and one recently completed acquisition project relevant to manatees under the State Conservation and Recreation Lands Program.

The Biscayne Bay National Park, managed by the National Park Service, is the largest Federally owned protected area in the South Coast Region. Its administrative boundary encompasses most of the shoreline and waters of southern Biscayne Bay. Manatees using the Park occur most often in dredged channels on the mainland side of the Bay, but only a few animals appear to use the area (R. Currey, Resource Manager, Biscayne Bay National Park, personal communication). Groups of up to 10 animals are seen occasionally in the boat channel to Convoy Point just north of Turkey Point on the mainland side of the Bay at the Park Headquarters. The Park has no special management provisions for manatees. However, concerns about both boater safety and manatee protection recently prompted the Park Service to approve an idle speed zone covering about a mile of the channel leading to Convoy Point. The area is now being posted. Another large Federal holding in the South Coast Region is the Loxahatchee National Wildlife Refuge managed by the Fish and Wildlife Service; however, this Refuge is located inland and is not accessible to manatees.

Six State boat speed regulatory areas covering approximately 41 miles of channel have been established in the South Coast Region to protect manatees. Five of the areas are in Broward and Palm Beach Counties and are effective only during the winter period from 15 November to 31 March when manatees are most abundant. Three of these are located in waters surrounding the warmwater refuges created by power plants. The Port Everglades Plant boat speed zone includes an idle speed zone about 0.5 mile in length along the Intracoastal Waterway and within the effluent discharge canal. In addition, two small areas of the discharge canal have been roped off to exclude boats during the winter months and thereby provide a sanctuary area for manatees. Since being established, use of these areas by manatees has increased

Table 8. Federal and State protected areas containing or adjacent to manatee habitat in the South Coast Region.

Name	County	Size
NATIONAL MONUMENTS (NATIONAL PARK SERVICE)		
Biscayne Bay National Park	Dade/Monroe	103,701 ac.
NATIONAL WILDLIFE REFUGES (FISH AND WILDLIFE SERVICE)		
Loxahatchee Nat. Wildlife Refuge	Palm Beach	145,635 ac.
AQUATIC PRESERVES (FLORIDA DEPT. OF NATURAL RESOURCES)		
Biscayne Bay-Card Sound	Dade/Monroe	227,000 ac.
Intracoastal Waters --	St. Lucie/Martin	Jensen
Beach to Jupiter Inlet	Palm Beach	26,000 ac.
Loxahatchee River-Lake Worth Creek	Martin/Palm Beach	9,000 ac.
STATE BOAT SPEED REGULATORY ZONES (FLORIDA DEPT. OF NATURAL RESOURCES)		
Loxahatchee River Area (Slow Speed/Channel-Exempt Area)	Martin/Palm Beach	10 mi.*
Palm Beaches Area (Slow and Idle Speed Areas)	Palm Beach	3 mi.*
Intracoastal Waters -- St. Lucie Inlet to Jupiter Inlet (Slow Speed Channel-Exempt Area)	Martin/Palm Beach	16 mi.*
Port Everglades Power Plant Area (Slow and Idle Speed Areas)	Broward	3 mi.*
Lauderdale Power Plant Area (Slow and Idle Speed Areas)	Broward	6 mi.*
Black Creek Area (Idle Speed Area)	Dade	3 mi.*
STATE PARKS AND RECREATION AREAS (FLORIDA DEPT. OF NATURAL RESOURCES)		
Bill Baggs Cape Florida St. Rec. Ar.	Dade	406 ac.
Hugh Taylor Birch State Park	Broward	180 ac.
John D. MacArthur Beach State Park	Palm Beach	225 ac.
John W. Lloyd Beach St. Rec. Area	Broward	244 ac.
Oleta River St. Rec. Area	Dade	1,000+ac.
PROPOSED LAND ACQUISITION ACQUISITION (FLORIDA CONSERVATION AND RECREATION LANDS PROGRAM)		
Deering Hammock and Addition	Dade	347 ac.
West Lake**	Broward	1,030 ac.

* Size of boat speed regulatory zones is provided as approximate length of waterway along channels or shoreline subject to regulation.

** The West Lake Project has been purchased.

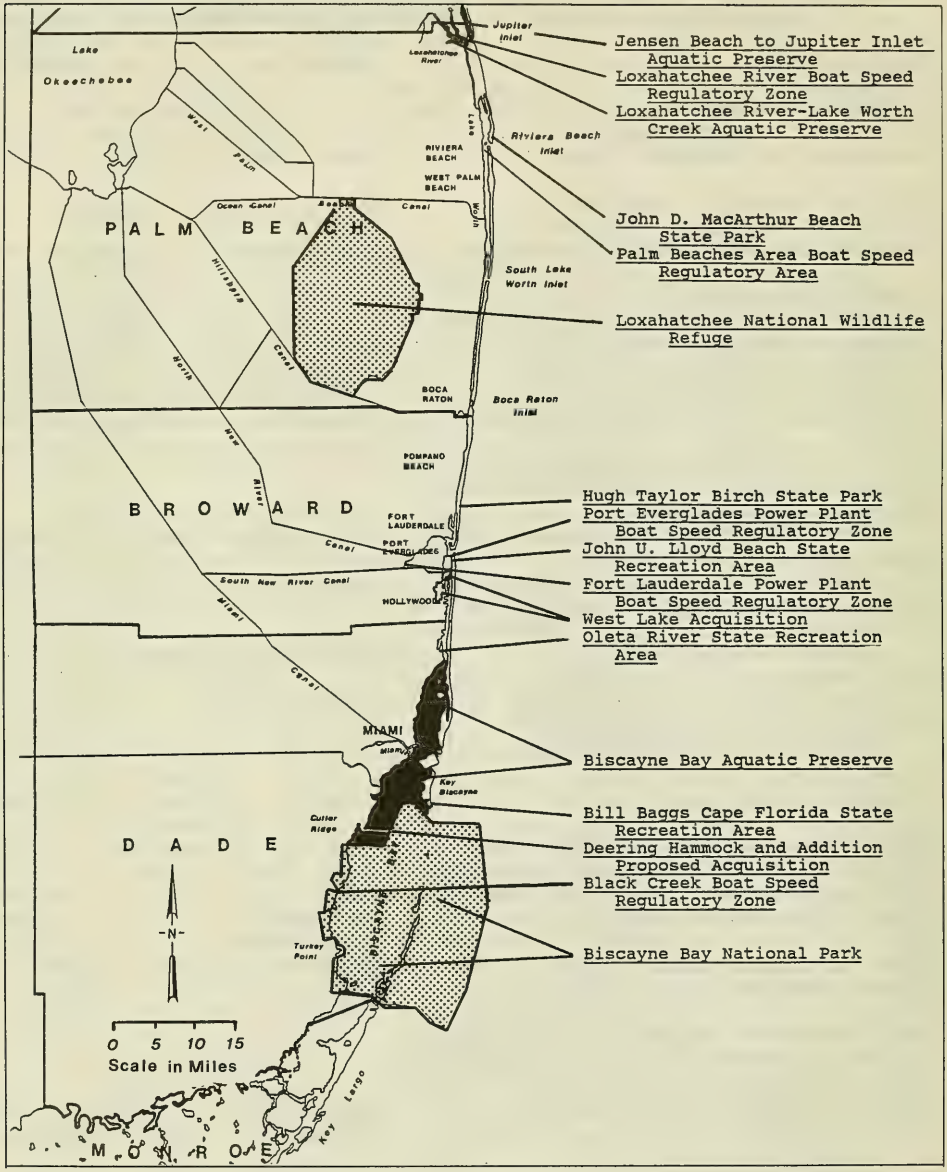

Figure 21. Location of Federal and State protected areas containing or adjacent to manatee habitat in the South Coast Region (Fla. Dept. of Envir. Reg. 1987).

dramatically (see for example Reynolds 1988), indicating that manatees are able to recognize and take advantage of areas effectively protected from disturbance by boat traffic. A half-mile length of the Intracoastal Waterway at the Riviera power plant also has been designated as an idle speed zone.

Three State Aquatic Preserves exist along the South Coast Region. The Biscayne Bay Aquatic Preserve includes all of Biscayne Bay from its north end near Maule Lake south to the northern boundary of the Biscayne Bay National Park. As noted above, grassbeds and channels along the west side of the Bay are used consistently by a large number of manatees in the winter and a smaller number in summer. A management plan for the Biscayne Bay Aquatic Preserve has not yet been developed.

Management plans have been completed for the remaining two Aquatic Preserves in the South Coast Region and provisions to protect manatees are essentially the same as those discussed in Chapter IV. Only a small portion of the Jensen Beach-Jupiter Inlet Aquatic Preserve is in the South Coast Region, but that portion includes submerged lands along 2 miles of Jupiter Sound north of Jupiter Inlet in Beach County. This area includes the most important part of the winter feeding area for animals overwintering at the Riviera Plant and one of the two most important winter feeding areas in the Region. It is also part of the principal north-south travel corridor for manatees. The Loxahatchee River-Lake Worth Creek Aquatic Preserve is also a feeding area and includes a very narrow critical segment of the East Coast manatee travel corridor. It is through this Creek that overwintering manatees travel on their way between the Riviera Plant and the principal winter feeding areas.

D. Analysis of Regional Habitat Protection Needs

The manatee habitats most in need of additional protection in the South Coast Region are the warm-water refuges created by the Riviera, Port Everglades, and Lauderdale Plants and their surrounding access corridors, and the winter feeding areas in Jupiter Sound and northern Biscayne Bay. Other important habitats where additional protection is warranted include: the Loxahatchee River; northern Lake Worth; the South Lake Worth Inlet area; and the Little River, Oleta River, and Coral Gables Waterway, which empty along the west side of Biscayne Bay. Actions needed in these areas include: reducing or eliminating the hazard of boat traffic for manatees at warm-water refuges, feeding and resting areas, and travel corridors; and protecting or restoring grassbeds. Because of the critical importance of the Region's artificial warm-water refuges, continuing attention is also needed to ensure, to the extent possible, that warm-water sources remain available for overwintering animals.

With respect to the latter point, the heated effluent from power plants along southeast Florida have made this Region the

primary wintering area for the East Coast manatee population. Power plants, however, are not permanent features and their operation is subject to management decisions dictated by economic conditions unrelated to biological requirements of manatees. While decisions regarding power plant operations clearly can not be based solely on any dependence manatees may have come to acquire on their presence, in at least some cases, planning may provide opportunities for innovative actions or schedules that accommodate manatee protection needs without causing an excessive burden on the industry.

For example, Florida Power & Light Company recently adjusted effluent discharge patterns at its Riviera Plant to accommodate manatees while curtailing some plant operations. Specifically, it installed a siphon to redirect heated effluent from plant units whose operations were not being reduced to a discharge area preferred by manatees and more removed from boat traffic (Beeler and O'Shea 1988).

To help prepare for changes that might affect the availability of warm-water discharges used by manatees, cooperative arrangements should be developed between the Fish and Wildlife Service, the Florida Department of Natural Resources, and industries responsible for operating plants which incidentally provide warm-water refuges for manatees. The objective of these arrangements should be to foresee changes in plant operations that could affect the availability of warm-water refuges and, as possible, to identify whether and what steps might be possible and reasonable to lessen or avoid possible effects on manatees. Such arrangements are being contemplated in the West Indian Manatee Recovery Plan now being updated (U.S. Fish and Wildlife Service 1988) and should be included in the final revised Recovery Plan.

With respect to mitigating effects of boat traffic on manatees, the Florida Department of Natural Resources, the Fish and Wildlife Service, and officials responsible for developing Local Growth Management Plans should examine measures to strengthen and expand boat speed regulatory provisions at warm-water refuges, feeding areas, resting areas, and travel corridors. The areas most in need of such attention are: around the Port Everglade and Lauderdale Plants in southern Broward County; northern Biscayne Bay, Dumfoundling Bay, the Little River Canal, the Oleta River, and the Coral Gables Waterway in northern Dade County; and the Riviera Plant outfall and the South Lake Worth Inlet in Palm Beach County. Specifically, it is recommended that the following actions be considered for adoption:

-- Modify and expand the existing boat speed regulatory zone at Port Everglades: Existing slow speed areas at the Port Everglades boat speed regulatory zone should be converted to idle speed and extended three-quarters mile north to the mouth of the New River. This would expand the length of the existing idle speed area from one-half mile to 3.75 miles. The current period during which

this zone is effective (November through March) would not be changed and the existing idle speed and restricted access provisions would remain in effect. This area is a major concentration point for recovery of boat-killed manatees, five of which were recovered during winter months between January 1986 and June 1988.

-- Expand and modify the existing boat speed regulatory zone near the Lauderdale Plant: The South Fork of the New River and the Dania Cutoff Canal provide essential access routes for manatees moving to and from the Lauderdale Plant's warm-water refuge. Portions of both waterways are included in the existing Lauderdale Plant boat speed regulatory zone. Although the Lauderdale Plant attracts fewer manatees than the nearby Port Everglades Plant, the Florida Power & Light Company is considering plans to upgrade facilities. It is expected this would increase the consistency with which heated effluent is discharged and thereby attract more manatees. The narrow canals near the plant create a high risk of collisions between manatees and boats and seven boat kills have been recovered from surrounding areas. In view of possible changes at the Lauderdale Plant, it is recommended that surrounding access channels be studied with a view towards strengthening existing boat speed limits. It is suggested that the existing slow speed areas be converted to idle speed areas and that slow speed areas be extended down both the South Fork of the New River and the Dania Cutoff Canal to the Intracoastal Waterway.

-- Establish new boat speed restrictions in northern Biscayne Bay and Dumfoundling Bay: A new year-round channel-exempt slow speed zone should be established along the five-mile stretch of Intracoastal Waterway from the Dade County line south through Dumfoundling Bay to Bakers Haulover Canal in northern Biscayne Bay. Four boat-killed manatees have been recovered in this area and several large new marinas are presently being developed, which will increase the likelihood of further collisions. In addition, a new shoreline idle speed zone should be established including all waters west of the Intracoastal Waterway from the Bakers Haulover Canal south to the Rickenbacker Causeway (a distance of about 10 miles) and within 1.5 miles of the northwest coast of Virginia Key. The areas south of Bakers Haulover Canal contain grassbeds that are vital feeding areas for manatees overwintering at power plants to the north and may also be used regularly by non-winter residents. There is no apparent seasonal pattern in the occurrence of boat kills in Dade County and it is recommended that these new boat speed zones be in effect year-round.

-- Establish new boat speed restrictions in selected creeks and canals in Dade County: New winter idle speed zones should be established in the Oleta River, Little River, and Coral Gables Waterway in those areas not already designated slow or idle speed for purposes of property protection. Substantial aggregations of manatees have been observed in each of these areas, which afford resting areas and sources of freshwater. The Oleta River speed zone should extend from the Intracoastal Waterway up to and including Maule Lake (about a four-mile length); the Little River speed zone should extend up to the flood control gate (about 2 miles), and the Coral Gables Canal speed zone should extend approximately 4 miles upstream from its mouth on Biscayne Bay.

-- Establish a new boat speed zone around South Lake Worth Inlet: A new winter channel-exempt slow speed regulatory zone should be established in Palm Beach County along the Intracoastal Waterway from a point about two miles north of the South Lake Worth Inlet to a point about two miles south of the Inlet. Manatees tend to occur more frequently around Inlet areas such as this and four boat-killed manatees have been recovered from this area. All recoveries have been between December and March.

-- Establish a new restricted access area at the Riviera Plant warm-water outfall: A new restricted access area should be established within the discharge basin at the Riviera Plant effluent outfall. The restricted area should be closed to access by boats other than those servicing the power plant between November and March.

In addition to the above actions, consideration also should be given to establishing speed limits (e.g., 20 miles per hour) and no passing restrictions in Lake Worth Creek to create a more linear flow of boat traffic. The narrow nine-mile stretch of the Intracoastal Waterway through this Creek connects Lake Worth and the Loxahatchee River and is a vital travel corridor for manatees moving between feeding areas in Jupiter Sound and Hobe Sound and the Riviera Plant warm-water refuge. It is also part of the major north-south travel corridor for perhaps three-fourths of the the East Coast manatee population. Several major new boating facilities are being developed in this area, which will increase boat traffic through the Creek. As noted with respect to Lake Worth Creek in the Indian River Region, speed limits and passing restrictions through particularly narrow waterways such as this may reduce traffic close to channel margins where manatees may be more likely to be struck. In addition, speed limits, which would make boats travel at a more constant speed, may enable manatees to learn to anticipate the movements of, and thereby avoid, oncoming boats. If such provisions fail to prevent boat kills in the area, the area should be established as a slow speed area.

With respect to protecting manatees at essential feeding and resting areas in Jupiter Sound (and also Hobe Sound to the north), steps should be taken to establish provisions in the Jensen Beach-Jupiter Inlet Aquatic Preserve management plan and Local Growth Management Plans to prohibit new marinas and multi-family boat docks in the Jupiter Sound/Jupiter Inlet area. Major new boating facilities on Jupiter Sound would prompt additional boat traffic in shallow non-channel feeding areas and travel corridors essential for overwintering manatees and thereby increase the probability of collisions between manatees and boats. A possible alternative to this action that might afford adequate protection to manatees, while permitting a limited number of additional boating facilities, would be converting the current channel-exempt slow speed zone to a channel-inclusive slow speed zone, and making non-channel areas idle speed, rather than slow speed, areas. Similar actions are warranted with respect to northern Biscayne Bay.

Special precautions should be taken to ensure that remaining grassbeds used by manatees for feeding are not damaged or reduced as a result of coastal development. As indicated above, Jupiter Sound at the north end of the South Coast Region (along with Hobe Sound in southern Martin County) is one of the two most important manatee feeding areas in the Region (northern Biscayne Bay may be equally important). Coastal developments such as dredging or bulkheading shorelines along areas where seagrasses occur should be prohibited unless there is clear evidence that the proposed action will not diminish the availability of grassbeds to manatees or alter their species composition. Grassbeds in northern Lake Worth and the Loxahatchee River also used by manatees probably should be accorded similar protection. Provisions to accomplish this should be included in management plans for the Loxahatchee River-Lake Worth Creek and the Jensen Beach-Jupiter Inlet Aquatic Preserves and in Local Growth Management Plans.

VIII. SUMMARY ASSESSMENT OF PRIORITY HABITAT PROTECTION NEEDS FOR EAST COAST MANATEES

Based on the best available information, the number of East Coast manatees is estimated to be between 700 to 900 animals. In 1987, the manatee salvage program recovered 73 manatee carcasses from the East Cost study area. Of these, 32 had been struck by boats, trapped in flood gates, or killed by other human-related causes. Assuming this population estimate is reasonable and that all dead manatees were found and reported, the annual mortality rate for the East Coast population in 1987 was between 8.1% and 10.4%, with between 3.6% and 4.6% caused by man. Boat/barge collisions alone accounted for 27 animal deaths or between 3.0% and 3.9% of the estimated total East Coast population size.

Based on winter aerial surveys at major warm-water refuges along the coast and counts at Blue Spring, maximum calf counts for the East Coast population over the past three years have been 47 in 1986 (40 at power plants and 7 at Blue Spring); 34 in 1987 (33 at power plants and 1 at Blue Spring); and 48 calves in 1988 (46 at power plants and 2 at Blue Spring) (Reynolds 1986, 1987, and 1988, and Sirenia Project, U.S. Fish and Wildlife Service, unpublished data). Cow-calf pairs usually remain closer to warm-water refuges than other manatees and, thus, are more likely to be counted during surveys. If the above counts include most young of the year, it would suggest that current recruitment rates into the population are lower than mortality rates and that the population is declining.

Because of the species' inherently low reproductive rate and the increasing development and human activity throughout most of its Florida range, the long-term survival of the East Coast population of manatees is in serious doubt. Given the above information, eliminating the threat posed by boats and barges in important manatee habitats may well make the difference between an increasing or stable population and one that could be declining.

In order to ensure the continued survival of manatees on the East Coast, human development and use decisions affecting coastal waters and rivers important to manatees must balance the resource use needs of both wildlife and humans. Coastal waters must be regarded as public resources to be shared by coastal users and wildlife communities, rather than as a private domain where the rights of the individual user are always paramount. All parties must share responsibility for protecting manatees and other

natural resources in coastal waters and rivers. Education efforts are essential to achieve broad acceptance of this principle.

To help identify specific habitat protection actions needed for East Coast manatees, this report provides a preliminary assessment of essential manatee habitats, manatee habitat use patterns, and actions needed to better protect the most essential areas and the manatees that use them. With respect to the latter point, this report identifies needed actions in four areas: (1) actions to ensure that boating activity in essential habitats does not pose undue hazards for animals which depend upon them; (2) actions to protect seagrass communities that provide essential winter and summer feeding areas for manatees; (3) actions to expand the existing network of refuges, reserves, parks, and preserves to better protect remaining undeveloped manatee habitat; and (4) actions to help ensure the availability of artificial warm-water refuges used by manatees during the winter months. In addition to these habitat protection actions, opportunities also should be taken to restore and enhance manatee habitat. Actions identified in this report for each of these five areas are summarized below.

A. Actions Relating to Boating Activity in Essential Manatee Habitats

As indicated above, the estimated mortality rate for the East Coast manatee population in 1987 was between 8.1% and 10.4% with human-related causes accounting for between 3.6% and 4.6%. In 1987, 27 boat-killed manatees were recovered on the East Coast which would account for between 3.0% and 3.9% of the total East Coast manatee population. These data suggest that boat/barge mortality may well be the difference between a stable or increasing population and one that could be declining in size.

The key to reducing the number of boat-related deaths and injuries is to identify and implement a code of conduct for boaters that will reduce the probability of collisions. This will require a coordinated, well directed program involving education, enforcement, and regulatory actions. It is not enough just to advise boaters where manatees occur and hope that collisions are then avoided. For the most part, manatees are invisible to boaters. Even trained observers watching manatees from a dock can overlook animals just a few yards away because of typically turbid waters. Expecting boaters not trained in observing manatees to spot animals from a rapidly moving boat, often in poor sighting conditions, and to avoid hitting them is unrealistic.

Given this, it appears necessary to establish a system to regulate boats operating in areas where the risk of striking a manatee is high. Such a code would: a) establish speed limits that would give manatees a chance to avoid oncoming boats; and b) direct high speed boat traffic to parts of waterways where the risk of striking a manatee is low.

Successful implementation of such regulations will require strong education and enforcement efforts to achieve public understanding and acceptance. These efforts should be designed to reach boaters at home (e.g., by public service announcements and brochures explaining why, what, and where provision are being established); at staging areas (e.g., posters at marinas, boat ramps, and fuel stations to remind boaters of on-the-water requirements); and on the water (e.g., posted signs advising boaters of what and where requirements are in effect, and vigorous enforcement of those requirements). To provide maximum benefit to manatees, regulations should be focused on places and times when manatees and boats are most likely to encounter each other. This, in turn will require detailed information on manatee habitat use patterns and on local boat/barge activity patterns.

To help identify areas most in need of regulatory measures, this report reviews information on boat-related manatee mortality from the manatee salvage and necropsy program. Data on boat-kill recovery sites indicate that the areas that pose the greatest threat are either: a) along essential manatee travel corridors with high levels of boat traffic, particularly where waterways narrow; b) around shallow grassbeds used extensively by manatees as feeding and resting areas; and c) in waterways surrounding warm-water refuges.

Data on boat-kill recovery sites may be somewhat misleading because manatees could drift some distance from the actual location where they were hit. However, manatees have been recovered in largest numbers from areas where one would expect the highest risk of boat strikes. In addition, there is evidence that behavior of animals struck, but not instantly killed, would prevent carcasses from drifting long distances. In 1979 (Bengtson 1981) and 1987 (Sirenia Project, U.S. Fish and Wildlife Service, unpublished data), animals struck by boats near Blue Spring, but not killed instantly, were observed before their deaths. In both instances, struck animals sought quiet, shallow areas away from currents to rest and try to recover. They moved very little. Such tendencies to "hole up" in areas would make it less likely that an animal would be carried away by currents or wind after death.

Several manatee behavior patterns affect probabilities of being struck by boats. In narrow channels with high levels of boat traffic, manatees are often seen traveling along channel or shoreline margins, perhaps attempting to avoid channel centers where boat traffic is greatest and/or where currents are fastest. Manatees also are able to move rapidly in short bursts of speed. They appear able to detect and dodge oncoming boats, provided boats are moving slowly. However, when feeding, manatees appear to be less wary of boats and, in shallow feeding areas, they are unable to dive beneath oncoming boats to avoid collisions. In shallow grassbeds, erratic traffic patterns created by small boats moving rapidly across shallow non-channel areas may be the most frequent cause of boat strikes. Given these points, it appears

that the probability of collisions between manatees and boats would be reduced substantially if boats moving through preferred habitats, such as shallow grassbed feeding and resting areas and waterway margins, traveled at slow or idle speeds.

For this reason, the Florida Legislature and the Florida Department of Natural Resources have established 13 slow and/or idle boat speed regulatory zones to protect manatees along the east coast of Florida. An additional area has been established by local authorities at Sykes Creek. These zones cover approximately 75 miles of waterway, most of which is designated as "channel-exempt" to minimize inconvenience to boaters while providing protection for manatees adjacent to channels. Also, Blue Spring Run and two small areas in the warm-water discharge canal at the Port Everglades Plant have been closed to boats to protect manatees. An additional 9 miles of waterway in the northern Banana River (about 7 miles) and Haulover Canal (about 2 miles) in the Merritt Island National Wildlife Refuge were designated as slow speed zones in 1978 by the Fish and Wildlife Service. It appears that these zones are effective in reducing the probability of collisions with boats. For example, at the Haulover Canal, a narrow corridor used extensively by both manatees and boats, no boat kills have been recovered.

As indicated in this report, many important manatee habitats where boat kills have occurred most frequently are not within the system of boat speed regulatory zones or are in areas where designated speed zones are channel-exempt or effective only during the part of the year when manatees are present. It is therefore recommended that the Florida Department of Natural Resources and the Fish and Wildlife Service, in cooperation with officials responsible for preparing Local Growth Management Plans, cooperate in a review of relevant data on boat-killed manatees and vessel traffic patterns, and substantially expand the system of boat speed regulatory zones to include other essential manatee habitats. This report identifies recommendations for establishing 22 new boat speed regulatory zones along approximately 195 miles of waterway and expanding or otherwise modifying six existing boat speed regulatory zones (see Table 9).

The waterways in which new or strengthened boat speed zones are most urgently needed include: the lower St. Johns River through and downstream from the city of Jacksonville (particularly the stretch through Jacksonville) in Duval County; the Banana River and Indian River adjacent to Merritt Island in Brevard County; northern Biscayne Bay in Dade County; areas around the Port Everglades and Lauderdale Plants in Broward County; and waters between the lower St. Lucie River and northern Hobe Sound.

The areas identified in Table 9 include those where the greatest concentrations of boat kills occur and many of the most important manatee habitats. However, manatees also are at risk in other areas. Therefore, educational materials directed at boaters

Table 9. Summary of recommendations for new or modified boat speed regulatory zones to protect manatees in essential habitats on the East Coast of Florida and the St. Johns River

Location	Status	County	Type of Restriction	Season	Approx. Length	Description
Fernandina Beach	New	Nassau	Slow Speed/ Chan.-Exmt.; Idle Speed	March to November	2 mi.	The Amelia River from the southern end of the Fernandina Beach waterfront to the north end of Amelia Island would be designated as a slow speed channel-exempt zone during non-winter months. In addition, water north of the Intracoastal Waterway around the mouth of Tiger Creek would be designated idle speed.
Lower St. Johns River -- Trout River to mouth at Mayport)	New	Duval	Slow Speed/ Chan.-Exmt.	All Year	18 mi.	The lower St. Johns River from its mouth at Mayport to Chaseville would be designated a year-round channel-exempt slow speed zone. The upstream end of the zone would be a line across the river from Reddie Point to the north shore of the mouth of the Trout River. The channel loop north of Blout Island would be designated slow speed. Certain non-channel areas used infrequently by manatees may be designated as exempt from speed restrictions to permit water-skiing, jet skis, etc.
Pablo Creek	New	Duval	Speed Limit (e.g. 20mph); Parts No Passing	March to November	9 mi.	A boat speed limit of about 15 mph and no passing zones in particularly narrow portions would be designated from the mouth of Pablo Creek on the St. Johns River upstream to the bridge at Route 202. The purpose of these restrictions is to create a more constant speed of traffic which would make it easier for manatees to avoid oncoming boats and to reduce traffic along channel margins where manatees are most likely to occur.
Lower St. Johns River -- Jacksonville	New	Duval	Slow Speed/ Chan.-Exmt.; Slow Speed; & Idle Speed	All Year; idle speed area winter only	9 mi.	The St. Johns River through Jacksonville from the Fuller-Warren Bridge to Chaseville would be designated as a year-round channel-exempt slow speed zone with sections of the channel also designated as slow speed. The downstream end would be at a line across the river from Reddie Point to the north shore of the mouth of the Trout River. Slow speed sections of the channel would include the 5.5-mile section from the Fuller-Warren Bridge downstream to the Mathew Bridge and a 2.5-mile channel section from a point one mile north of the Alton Package Corporation Plant to a point one mile south of the Kennedy Generating Station. From November to March, the latter slow speed area would be idle speed.

Table 9. Continued: Recommended boat speed zones.

Location	Status	County	Type of Restriction	Season	Approx. Length	Description
Lower St. Johns River -- Jacksonville to Green Cove Springs	New	Duval Clay St. Johns	Shoreline Idle Speed	All Year	30 mi	The St. Johns River from the Fuller-Warren Bridge to the State Route 16 Bridge south of Green Cove Springs, including Doctors Lake, would be designated as a shoreline idle speed zone including all waters within one-quarter mile of shore. Certain non-channel areas used infrequently by manatees may be exempt from speed restrictions for water-skiing, jet skis, etc.
Upper St. Johns River -- Lake Dexter to the Wekiva River	New	Volusia Lake	Shoreline Idle speed; & Idle Speed	All Year	25 mi.	All waters within 50 feet of shore on the St. Johns River, Lake Dexter, Lake Woodruff, the Norris Dead River, the Zeigler Dead River, Lake Woodruff, the Hontoon Dead River, and associated logging canals would be be designated as idle speed areas. River and Canal sections narrower than 100 feet would be designated as idle speed only. More stringent speed and access restrictions now in effect around Blue Spring would remain in effect.
Tomoka River/ Tomoka Basin	New	Volusia	Slow Speed/ Chan.-Exmt; Slow Speed; & Idle Speed	March to November	10 mi.	The Tomoka River from its mouth upstream to the Route 95 Bridge would be designated as a slow speed zone. The Tomoka Basin would be designated as a slow speed channel-exempt area. Thompsons Creek and Stricklands Creek off the south shore of the Tomoka River in the Tomoka State Park would be designated as idle speed. All zones would be in effect only in non-winter months.
New Smyrna Beach	New	Volusia	Slow Speed/ Chan.-Exmt.; & Slow Speed	March to November	14 mi.	Intracoastal waters from a point about two miles north of Ponce de Leon Inlet, including Turnbull Bay and lower Spruce Creek, south to Edgewater would be designated as a channel-exempt slow speed zone from March to November. A two-mile segment of the channel north of the route A1A causeway to New Smyrna Beach would be designated slow speed. Non-channel areas used infrequently by manatees may be exempt from speed restrictions for water-skiing, jet skis, etc.
Oak Hill	New	Volusia	Slow Speed/ Chan.-Exmt.	March to November	4-5 mi.	Intracoastal waters 2 to 2.5 miles north and south of the town of Oak Hill would be designated as a channel-exempt slow speed zone.

Table 9. Continued: Recommended Boat Speed Zones

Location	Status	County	Type of Restriction	Season	Approx. Length	Description
Hanger AF Turnbasin	Modification	Brevard	Restricted Access	March to November	7 mi.	The Hanger AF Turnbasin in the northern Banana River between the Florida Barge Canal and the NASA Causeway which is now in the Merritt Island National Wildlife Refuge and is designated as a slow speed zone, would be designated as a ten year experimental restricted area with access permitted according to provisions established by the Fish and Wildlife Service.
Central Banana River	New	Brevard	Idle Speed/ Chan.-Exmt.; & Shoreline Idle Speed	March to November	13 mi.	The central Banana River from Buck Point at the mouth of Newfound Harbor north to the Barge Canal would be designated as a channel-exempt idle speed zone. All waters within one-quarter mile of shore south of Buck Point (including shoreline waters north of Buck Point in Newfound Harbor) to the Pineda Causeway (State Route 404) would be designated as idle speed areas. Certain areas used infrequently by manatees would be exempt from speed restrictions to provide opportunity for water-skiing, jet skis, etc.
Grand Canal	New	Brevard	Idle Speed	March to November	3 mi.	Those sections of the Grand Canal and its access channels to the Banana River not already designated idle speed would be so designated during non-winter months to protect manatees.
Indian River: Titusville to Rockledge	Expansion	Brevard	Shoreline Idle Speed; & Idle Speed	All Year	23 mi.	The existing winter idle speed zones at the two power plants south of Titusville would be expanded to include all waters between the two zones. An adjacent winter slow speed zone would be extended across the Indian River (including the Intracoastal Waterway) to the east bank of the river. A year-round shoreline idle speed zone including all waters within one-quarter mile of shore also would be designated from the railroad bridge across the Indian River north of Titusville south to the Route 528 Causeway at Rockledge. Shoreline areas used infrequently by manatees would be designated as exempt from speed restrictions to provide opportunities for water-skiing, jet skis, etc. Important manatee feeding areas that extend beyond one-quarter mile of shore, such as at the mouth of Banana Creek, would be included within the shoreline idle speed zone.
Eau Gallie	New	Brevard	Idle Speed	March to November	2 mi.	The lower two miles of the Eau Gallie River not already designated idle speed to protect private property would be so designated during non-winter months to protect manatees.

Table 9. Continued: Recommended boat speed zones.

Location	Status	County	Type of Restriction	Season	Approx. Length	Description
Melbourne	New	Brevard	Idle Speed	March to November	2 mi.	The lower two miles of Crane Creek not already designated as idle speed to protect private property would be so designated during non-winter months to protect manatees.
Mullet Creek	New	Brevard	Idle Speed	March to November	2 mi.	Mullet Creek and the network of creeks around the Mullet Creek Islands would be designated as an idle speed zone during the non-winter months.
Sebastian Creek	New	Brevard Ind. Riv.	Idle Speed	March to November	3.5 mi.	Sebastian Creek, including the north prong up to the flood control structure, would be designated as an idle speed zone during the non-winter period.
Lower St. Lucie River to Northern Hobe Sound	New	Martin	Speed Limit (e.g. 20mph); Parts No Passing	All Year	11 mi.	A speed limit of about 15 mph, with narrow sections designated as no passing would be established from Snug Harbor just north of the route A1A Bridge over the lower St. Lucie River to route 708 Bridge just north of Hobe Sound. The purpose would be to create a more linear, constant flow of traffic that would enable manatees to better avoid oncoming boats.
Hobe Sound	Modification	Martin	Slow Speed	All Year	6.5 mi.	A 6.5-mile stretch of the Intracoastal Waterway south of the Route 708 bridge in the Hobe Sound National Wildlife Refuge that is now part of a channel-exempt slow speed zone would be designated as an experimental slow speed zone including the channel for 2 years to study boat-induced turbidity effects on grassbeds.
Lake Worth Creek	New	Palm Beach	Speed Limit (e.g. 20mph) Parts No Passing	November to March	8 mi.	Speed limits and passing restrictions would be established along the nine-mile stretch of Lake Worth Creek between the Loxahatchee River and northern Lake Worth to establish a more linear, constant flow of boat traffic that would improve the probability that manatees would be able to avoid oncoming boats.
Riviera Beach	Modification	Palm Beach	Restricted Access; Idle Speed; Slow Speed	November to March	3 mi.	Waters within the Riviera Plant discharge basin would be changed from idle speed to a restricted access zone limited to vessels servicing the power plant. Existing idle and slow speed zones would remain in effect.
South Lake Worth Inlet	New	Palm Beach	Slow Speed/ Chan.-Exmt.	November to March	4 mi.	The waters in Lake Worth two miles north and south of Lake Worth Inlet would be designated as slow speed/ channel-exempt during winter months.

Table 9. Continued: Recommended Boat Speed Zones

Location	Status	County	Type of Restriction	Season	Approx. Length	Description
Port Everglades	Modification & Expansion	Broward	Idle Speed; & Restricted Access	November to March	3 mi.+ .75 mi. added	The existing winter slow speed zones around Port Everglades would be converted to idle speed and expanded north to the mouth of the New River. The existing restricted access area would be retained.
Fort Lauderdale	Modification & Expansion	Broward	Idle Speed; & Restricted Access	November to March	6 mi.+ 7 mi. added	The existing winter slow speed zone along the South New River Canal, the North New River Canal, and the Dania Cutoff Canal would be converted to idle speed and extended down the North Fork of the New River and the Dania Cutoff Canal to where it would connect with the expanded Port Everglades boat speed zone. The existing restricted access zone would remain.
North Biscayne Bay & Dumfoundling Bay	New	Dade	Idle Speed/ Chan.-Exmt.	All Year	15 mi.	Waters adjacent to the Intracoastal Waterway from the Bakers Haulover Canal north 5 miles to the Dade County line including Dumfoundling Bay would be designated channel-exempt idle speed. All waters in northern Biscayne Bay west of the Intracoastal Waterway from Bakers Haulover Canal south to the Rickenbacker Causeway, including access channels from the mainland side of the Bay, would be idle speed. In addition, waters within 1.5 miles of the northwest half of Virginia Key would be idle speed only.
Oleta River	New	Dade	Idle Speed	March to November	4 mi.	The four-mile stretch of the Oleta River from Maule Lake to its connection with the Intracoastal Waterway not already designated idle speed to protect private property would be so designated during winter to protect manatees.
Little River Canal	New	Dade	Idle Speed	March to November	2 mi.	The lower two miles of the Little River Canal below the flood control gate not already designated idle speed to protect private property would be so designated during winter months to protect manatees.
Coral Gables Waterway	New	Dade	Idle Speed	March to November	4 mi.	The lower four miles of the Coral Gables Canal not presently designated idle speed to protect private property would be so designated during winter months to protect manatees.

should focus not only on the rationale and provisions for regulations, but also should encourage precautions that boaters might take outside of designated regulatory zones. For example, boaters should be advised that manatees prefer shoreline areas and channel margins, and that, whenever possible and consistent with safe boating practices, boaters should try to avoid those areas, particularly when moving at high speeds. If boaters were to use the centers of marked channels, such as the Intracoastal Waterway, rather than the margins, which are used more frequently by tarveling manatees, the probability of striking manatees would be reduced.

B. Actions to Protect Feeding Areas

Manatees feed on various forms of aquatic vegetation depending on availability. These include submerged vascular plants rooted in the bottom, various species of algae growing on the bottom and exposed surfaces, floating aquatic plants, and emergent bank vegetation. Beds of submerged rooted plants appear to be preferred food sources.

During winter months, manatees rely on vegetation located near warm-water refuges (usually within 20 miles). Grassbeds in these areas can suffer substantial impacts by grazing and rooting manatees. In addition, pollution and human development can reduce the extent of grassbeds and thereby threaten food supplies for overwintering animals. Studies of grassbeds in Jupiter Sound found that grazing and rooting by animals overwintering at the Riviera power plant disturbed 40% of the grassbeds, with much of the undisturbed seagrass located in waters too shallow (<50cm) for manatees to use (Packard 1984). Protecting the integrity of grassbeds near warm-water refuges is therefore a high priority.

The Jupiter Sound and Hobe Sound grassbeds are particularly important for manatees wintering at the Riviera Plant. Grassbeds in northern Biscayne Bay may be of similar importance to manatees wintering at the Port Everglades and Lauderdale Plants. To ensure that these areas are adequately protected, it is recommended that the ongoing study by the National Marine Fisheries Service, the Fish and Wildlife Service, and the Florida Department of Natural Resources on the effects of boat-induced turbidity on seagrasses in Hobe Sound be completed and that the experimental slow speed zone in the Intracoastal Waterway, which is an integral part of the study, be established.

In addition, it is recommended that management plans for State Aquatic Preserves that include winter feeding areas (i.e., the Jensen Beach-Jupiter Inlet Aquatic Preserve, the Loxahatchee River-Lake Worth Creek Aquatic Preserve, and the Biscayne Bay Aquatic Preserve) be reviewed and modified as necessary to prevent development that could adversely affect grassbed feeding areas or the manatees which depend on them. In particular, new development activities, such as bulkheading, dredging, and marina development

in or immediately adjacent to these areas, should be prohibited. These provisions also should be incorporated into Local Growth Management Plans.

Grassbeds in the Banana River and St. Johns River between Jacksonville and Green Cove Springs are particularly important feeding areas for manatees in non-winter periods and also need protection. Provisions to protect areas in the Banana River Aquatic Preserve are identified in the Preserve's Management Plan; however, if it has not already been done, it is important to identify and map specific grassbed feeding areas where development restrictions will apply. As a general matter, grassbeds important to manatees should be monitored regularly to ensure that provisions are adequate to prevent further reductions in size.

C. Actions to Incorporate Additional Manatee Habitat into Refuge and Reserve Systems

More than 50 Federal and State Parks, Refuges, Preserves and other protected areas containing or adjacent to manatee habitat used by East Coast manatees were identified during this study. Most of these areas contribute to manatee protection by virtue of their essentially natural undeveloped or minimally developed state. Because protected areas are often destinations or staging areas for water sports and for those wishing to observe or learn about wildlife, these areas also are excellent places to post or distribute information on manatees and manatee protection provisions. A few of these areas, most notably Blue Spring and Hontoon Island State Park, Merritt Island and Lake Woodruff National Wildlife Refuges, and several of the State Aquatic Preserves, include particularly important manatee habitats and are operated under management provisions directed at manatee protection.

Opportunities to expand this system by acquiring additional areas, while limited, would clearly benefit manatee habitat protection. To examine opportunities for acquiring undeveloped areas important to manatees, this study reviewed the 69 land acquisition proposals currently listed on the recommended land acquisition list for the State Conservation and Recreation Lands Program and also considered other potential opportunities for expanding existing protected areas. Based on that review, two existing land acquisition proposals under the State Program were identified as particularly important for purposes of manatee habitat protection.

The two projects are the St. Johns River Project and the Goldy/Bellemead Project. The former includes 8,290 acres of riparian lands along the St. Johns River south of Hontoon Island State Park and is currently ranked number 48 on a list of 69 projects. The adjacent river segment is used by manatees in both winter and summer as a feeding and resting area. The latter includes 716 acres of marsh adjacent to the Tomoka State Park and is currently ranked number 49. The Tomoka River is one of the

most important stopping points for manatees migrating to and from the North Coast Region of the study area. The importance of both projects to manatees should be brought to the attention of State Land Acquisition Selection Committee, which assigns Program priorities, and both projects should be purchased.

Three other projects adjacent to manatee habitat listed on the State land acquisition list were also identified as sites whose acquisition could help protect manatees: the Fort George Island Project near the mouth of the St. Johns River (900 acres, ranked number 7); the Mullet Creek Islands Project on the Indian River in southern Brevard County (200 acres, ranked number 62), and the North Fork of the St. Lucie River/North Port Marina Project (1,350 acres, ranked number 20). Although lower in priority relative to manatees, their acquisition also is encouraged.

With respect to opportunities for developing new land acquisition proposals that would help strengthen manatee habitat protection, it is recommended that representatives of the Florida Department of Natural Resources consider additional purchases along the Tomoka River, and that the Department and the Fish and Wildlife Service consider cooperative efforts aimed at consolidating existing protected areas along a 30-mile stretch of the upper St. Johns River between Lake Woodruff and Lake Monroe. In the Tomoka River area, it is suggested that the Department consider initiating a new project to acquire undeveloped property along the north side of the river opposite the State Park and/or areas along the river further upstream.

With respect to the upper St Johns River, it is suggested that the Service consider expanding the Lake Woodruff National Wildlife Refuge southward to include additional undeveloped lands along the St. Johns River between the Refuge and Blue Spring State Park, and that the Department consider initiating a new land acquisition project that would include undeveloped shorelines along the east bank of the River (including islands in the River) south of the Blue Spring State Park. Together, these areas include most of the critical winter feeding grounds for manatees overwintering at Blue Spring. Adding them to the areas already protected would establish an outstanding basis for securing the long-term protection of the broader ecosystem that supports manatees, as well as other wildlife.

D. Actions Relating to Artificial Warm-water Refuges

Power plants and other industrial facilities that discharge warm water into coastal areas accessible to manatees have become essential wintering habitats for East Coast manatees. These facilities, however, have finite operational lives and it is clear that industry decisions to terminate or modify plant operations will be based on economic conditions that are independent of any reliance manatees may have come to acquire on its warm-water

outfall. The impermanent nature and uncertain future of artificial warm-water refuges poses long-term as well as short-term threats to the East Coast manatee population.

Little can be done to eliminate the impermanent nature of artificial warm-water refuges. However, long-term threats might be addressed, at least in part, by local planning and zoning provisions. Specifically, local officials should recognize that industries that regularly discharge clean heated effluents in areas away from boat channels are beneficial to manatees and that manatees learn to depend on certain effluent outfalls. Thus, to the extent possible, it is recommended that appropriate planning and zoning authorities attempt to reserve sites currently occupied by power industries which produce warm-water outfalls for the same or other warm-water producing facilities.

Day-to-day decisions by plant operators may affect the short-term availability of warm water for manatees during winter months. Temporary interruptions of warm-water discharges may cause the death of some animals if they occur abruptly during cold periods when alternative warm-water sources are not available or cannot be reached quickly. To identify and, if possible, avoid or mitigate possible adverse effects from such industry decisions, cooperative arrangements should be developed between the Fish and Wildlife Service, the Florida Department of Natural Resources, the Florida Department of Environmental Regulation, and relevant industries. These arrangements should encourage consultations between the parties at the earliest possible time to review anticipated changes in plant operations, such as scheduled shut downs or planned plant closures, that would result in a significant reduction, movement, or other alteration in the discharge of heated effluent used by manatees. The objective would be to identify reasonable alternatives, if any exist, that might be taken to mitigate the effects of disrupting warm-water sources upon which manatees have come to depend.

Exemplary actions by Florida Power & Light Company have demonstrated that industry can, in some cases, take action to accommodate manatee needs for warm water, while adjusting or reducing plant operations. While cooperative government-industry efforts will not eliminate the fundamental impermanence of artificial warm-water refuges, they may introduce a greater degree of stability in the availability of these essential habitat features than might otherwise be the case and thereby avoid the possible cold-related death of some animals. Such arrangements are now being contemplated as part of the process for updating the Recovery Plan for West Indian manatees in Florida. This provision should be included in the final Plan.

E. Actions to Restore and Enhance Manatee Habitat

Important opportunities for both restoring and enhancing manatee habitat are identified in this report. With respect to

habitat restoration, the National Aeronautics and Space Administration and the Fish and Wildlife Service should investigate alternative measures to reconnect the Banana River and Banana Creek. Historically, Banana Creek provided an open water access route for manatees to move between the northern Banana River and the Indian River. The connection was severed by construction of the solid fill shuttle crawlerway built to carry the space shuttle from the Vehicle Assembly Building to the launch pad along the Atlantic coast.

The number of manatees feeding and resting in the Banana River north of Port Canaveral has increased significantly in recent years. Recent counts of nearly 300 animals in this area during the spring suggest that it is a major feeding and resting stop for animals migrating northward along the coast. With the open water connection between the river and creek blocked by the shuttle crawlerway, the shortest route back to the Indian River travel corridor is through Sykes Creek and the Barge Canal located about 15 miles south of the shuttle crawlerway. Sykes Creek has been one of the worst areas for boat killed manatees in all of Florida and is probably a site where many non-lethal boat-related injuries also occur.

Banana Creek and the northern end of the Banana River are closed to public boat traffic for security reasons and, if the connection with Banana Creek could be reestablished, it would provide a safe travel corridor for animals that would avoid the gauntlet of boats through which manatees now must pass. Two possible alternatives for reconnecting the two waterways are: a) dredging a canal from the turning basin at the north end of the Banana River adjacent to the Vehicle Assembly Building around the west side of the building to Banana Creek; and b) building a culvert under the shuttle crawlerway. Both alternatives may be possible without preempting undisturbed natural areas important to other wildlife. In addition to facilitating access to and from the Banana River for migrating manatees, it could facilitate use of the Banana River by animals wintering at the Canaveral and Indian River power plants in Brevard County. Rejoining the two waterways also may help restore a more natural water circulation pattern through the river and creek which could help improve water quality.

Recent counts of manatees in the northern Banana River and new information on manatee movement patterns and boat kills in Sykes Creek warrant initiation of consultations between the National Aeronautics and Space Administration and the Fish and Wildlife Service under the provision of section 7 of the Endangered Species Act and it is recommended that the two agencies investigate and, as possible, implement an approach for reconnecting the Banana River and Banana Creek as a matter of high priority.

With respect to habitat enhancement, it is recommended that the Fish and Wildlife Service, the Florida Department of Natural Resources, and the Corps of Engineers investigate the possibility

of dredging a series of channels and basins off the Intracoastal Waterway into shallow grassbeds and/or marsh areas to create new protected resting and feeding areas for manatees. Most of the Indian River and Mosquito Lagoon between the St. Lucie Inlet in Martin County and Ponce de Leon Inlet in Volusia County contain grassbeds and marshes that could be used by manatees for feeding and resting; however, they are in waters too shallow to be reached by manatees.

As a result, manatees tend to travel along the margins of the Intracoastal Waterway, stopping periodically to rest, feed, and drink freshwater in the various creeks and waterways draining along the west side of the river. However, where they exist, channels dredged to provide boat access to and from the barrier islands and barrier beaches to the east also are used as feeding and resting areas by manatees, particularly those channels which pass through shoal areas with grassbeds and around marsh islands.

Manatees following the narrow Intracoastal Waterway face a high risk of collisions with fast-moving boats. While travel up creeks with somewhat fewer boats may provide manatees with feeding and resting areas that are safer than the Intracoastal Waterway, the risk of injury or death is still significant. Therefore, if a series of dredged channels closed to boat traffic could be constructed off the Intracoastal Waterway into shallow grassbeds and/or near marshes presently too shallow for manatees to reach, new feeding and resting habitats could be opened that might draw animals away from hazardous areas with heavy boat traffic. Ideally, these areas might include an artificial freshwater source, perhaps created by a well or a hose from a nearby water supply. Such enhancement efforts could be somewhat analogous to creating impoundments in coastal wetlands for migratory waterfowl or to forest management practices applied to improve feeding areas for moose.

To assess the possibility of creating such habitats, it is recommended that the Fish and Wildlife Service, the Florida Department of Natural Resources, and the Corps of Engineers undertake a pilot study to identify potential areas, assess critical factors (e.g., effects on other natural resources, optimal channel depths and configurations, costs, etc.), and undertake to construct a test "Manatee Habitat Enhancement Reserve." To ensure that boat access can be controlled, it would be desirable to do initial testing under the authority of existing protected areas such as the Canaveral National Seashore, the Merritt Island National Wildlife Refuge, or the Pelican Island National Wildlife Refuge. The purpose of the pilot study, therefore, should be to determine if suitable habitats could be created that will be used by manatees and, if so, the critical design elements that should be considered to create them.

Available information suggests that manatees will learn to use areas that afford suitable feeding and resting areas, particularly those where boating activity is restricted. If successful,

a series of Manatee Habitat Enhancement Reserves might be constructed at strategic locations along the Indian River-Mosquito Lagoon section of the East Coast manatee travel corridor.

F. Conclusions

The East Coast manatee population faces a precarious and uncertain future due to increasing levels of boat traffic and development in its essential habitats. Although constructive steps have been taken to help reduce these threats, they are not sufficient to assure the population's continued existence. New information on manatee habitat use patterns is being developed and should provide an improved basis for identifying additional steps to protect manatees and essential manatee habitats. This report provides a preliminary analysis of that information and needed actions.

Immediate steps must be taken to strengthen protection and, as a matter of highest priority, the following are recommended: (1) expand the existing system of boat speed regulatory areas to include additional essential manatee habitat and to strengthen certain existing zones; (2) ensure that grassbeds used as feeding habitat by manatees, particularly grassbeds important to winter concentrations of manatees, are not damaged or destroyed by human development and use; (3) pursue efforts to acquire undeveloped lands along important manatee habitat on the St. Johns River north and south of Blue Spring in Brevard and Lake Counties, and along the Tomoka River in Volusia County; (4) establish cooperative arrangements between industry and government to assess and, as possible, mitigate adverse effects associated with anticipated industry decisions affecting the availability of artificial warm-water refuges used by manatees as wintering areas; (5) reconnect Banana Creek and the Banana River to restore a former manatee travel route that would facilitate both summer and winter access to northern Banana River feeding areas and that also would open an alternative route around one of the most hazardous areas for manatees in the State (i.e., the central Banana River and Sykes Creek); and (6) undertake a pilot study to investigate the feasibility of creating a series of Manatee Habitat Enhancement Reserves by dredging deep-water channels and basins closed to boats into areas presently too shallow for manatees to reach.

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