PROPOSED RESEARCH/MANAGEMENT PLAN FOR CRYSTAL RIVER MANATEES

VOLS. 1- 3

SUBMITTED BY DAN HILLIARD

PROPOSED RESEARCH/MANAGEMENT PLAN FOR

CRYSTAL RIVER MANATEES

VOLUME I

FLORIDA COOPERATIVE FISH
AND WILDLIFE RESEARCH UNIT

UNIVERSITY OF FLORIDA

PREFACE

This summary of the Proposed Research Management Plan for Crystal River Manatees was written by J. Packard and C. Puckett. The conceptual design was inspired by O. Wetterqvist, who provided valuable input throughout the preparation of the plan. This volume was designed and produced by J. Ponikvar. Numerous citizens, agencies, and a project team contributed ideas and information in preparation of the plan, as acknowledged in Volume II. We thank all who assisted, but the views and opinions expressed are those of the project leader and are not necessarily shared by the individuals or agencies that assisted with or funded the project. Funding was provided by the U.S. Fish and Wildlife Service and the Marine Mammal Commission under Cooperative Agreement 14-16-0009-1544, Research Work Order No. 1. Copies may be requested from Florida Cooperative Fish and Wildlife Research Unit, 117 Newins-Ziegler Hall, University of Florida, Gainesville, FL 32611. Ask for: Packard, J.M. 1983. Proposed Research/Management Plan for Crystal River Manatees. Volume I. Summary. Technical Report No. 7. Florida Cooperative Fish and Wildlife Research Unit, University of Florida, Gainesville, FL. 31 pp.

Florida Cooperative Fish and Wildlife Research Unit
School of Forest Resources and Conservation
Institute of Food and Agricultural Sciences
University of Florida

COVER PHOTO: Courtesy Galen Rathbun, Sirenia Project, FWS

TABLE OF CONTENTS

INTRODUCTION

This booklet summarizes a research/management plan developed for manatees in South Big Bend—an area that extends from the Suwannee River to the Chassahowitzka River and includes the famous wintering waters of Crystal River. Big Bend and the Everglades are the only two intact coastal ecosystems remaining along Florida's coasts. Protection of the southern portion of Big Bend will maintain a haven for manatees and exceptional recreational opportunities for humans. However, Citrus and Hernando counties, which are adjacent to South Big Bend's coastline, are part of the growth centers of Florida. With planning, the needs of South Big Bend's manatees can be met—even as human communities develop.

State and federal agencies are mandated by law to aid recovery of the West Indian manatee population. However, the United States Fish and Wildlife Service recognizes that manatees inhabiting different geographical regions are faced with distinct problems. Thus, plans must be developed to protect each regionally separate manatee group, called a subpopulation.

Site-Specific Plan for Crystal River Manatees

The Crystal River manatee subpopulation was chosen for this pilot site-specific research/management plan for several reasons:

- The opportunity is still available to protect vital manatee habitat that, as yet, is relatively undisturbed.
- The growth rate of the subpopulation has recently slowed.
- This subpopulation is a substantial part of the nation's total manatee population.
- Crystal River offers a unique opportunity for the public to view manatees and for scientific research.

Local Participation is Important

Local governments possess most of the powers required to balance human and manatee needs. By responding to their constituents, local governments will receive the credit for protecting their manatees, as well as for maintaining recreational and commercial values of coastal waters.

During development of this research/management plan, local citizens and agencies provided input. A team of scientists, lawyers and other experts evaluated existing information and identified essential actions required to meet the objectives of the plan.

Citizen support of their local and state agencies is crucial for successful implementation of the long-term actions needed to protect Crystal River manatees. If local citizens and governments do not take sufficient action to protect their manatees, then state and federal agencies will be required to exercise their authority to insure survival of a nationally significant endangered species.

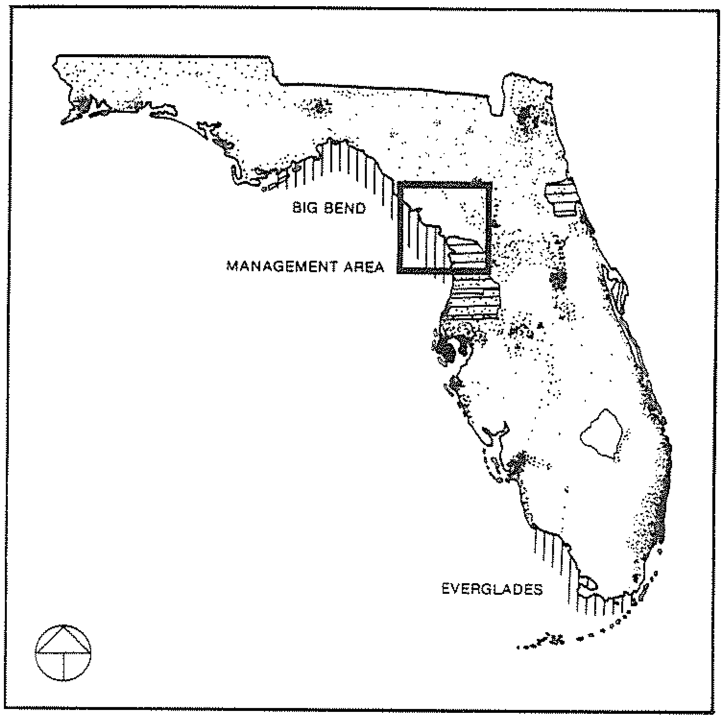
A Guide to the Plan

This summary (Volume I), provides an overview of what is known about Crystal River manatees and the actions needed to protect them as described in the technical plan (Volume II). Background information used in developing the technical plan is available in a compendium (Volume III).

REFER TO SECTION I, II.1 AND II.2

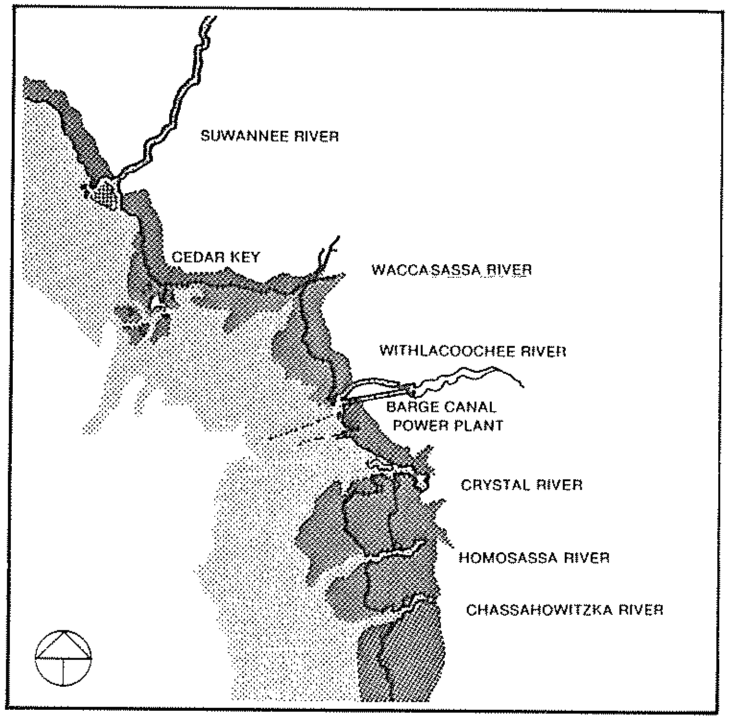
||||| Undisturbed coastline
Urban growth centers
Urban areas

FLORIDA
UNDISTURBED COASTAL ECOSYSTEMS



Waters accessible to manatees
Wetlands and shallows

SOUTH BIG BEND
MANAGEMENT AREA



South Big Bend Management Area
Regional coordination is vital, for Crystal River manatees roam the waters of at least four counties—Dixie, Levy, Citrus, and Hernando. Manatees that spend their winters in Crystal River wander throughout much of the northwestern Gulf Coast during the warm months. They are most frequently sighted between Horseshoe Cove, slightly north of the Suwannee River estuary, and the Chassahowitzka River.

At present, South Big Bend provides one of the least disturbed segments of coastal waters available to the West Indian manatee in the United States. However, the counties that line this part of South Big Bend are among the fastest growing regions in Florida today. The area is beginning to experience habitat alteration, pollution, and other side effects associated with unplanned human growth. Elsewhere in Florida, residents have watched unplanned development irreversibly alter the healthy functioning of ecosystems. Once an ecosystem is altered, repair is a costly and arduous process—if even possible. By protecting the habitat essential for manatees in South Big Bend, we will also preserve a unique area for the enjoyment of future generations.

Six rivers drain this southern portion of Big Bend: the Suwannee, Waccasassa, Crystal, Homosassa, Withlacoochee and the Chassahowitzka. In this region, the floor of the Gulf of Mexico is a low gently rolling plateau that gradually slopes toward the deep waters off the continental shelf. Throughout South Big Bend, thousands of shallow channels snake in intricate mazes through vast salt marshes, whose expanses are broken by occasional palm and hardwood hammocks found on slightly elevated lands.

By land, the management area is bordered by an almost continuous ribbon of saltwater marshes and by occasional wooded swamps. The offshore boundary occurs at water depths of 20 feet (6 meters), beyond which few submerged plants grow to entice manatees. This shallow water extends as far as 10 miles (16 km) offshore. Manatees rarely occupy waters shallower than 3 feet (91 cm).

Within the management area, marine, freshwater and wetland plant communities are interrelated by the flow of water from uplands to the sea and by the ebb and flow of tides. All components of this coastal ecosystem are important for the long-term survival of manatees.

OBJECTIVES

The purpose of this plan is to provide decision-makers and citizens with guidelines necessary for the increase and continued survival of manatees in South Big Bend's waters. To meet this goal, the objectives of the plan address both the direct effects of human activities on manatees and their indirect effects on manatees' essential habitat. This plan outlines specific criteria to evaluate our progress in meeting the objectives.

Crystal River manatees have been intensively studied since the late 1960's. The slow but steady manatee increase over the last decade indicates that the area has provided good habitat.

National and Long-Term Goals

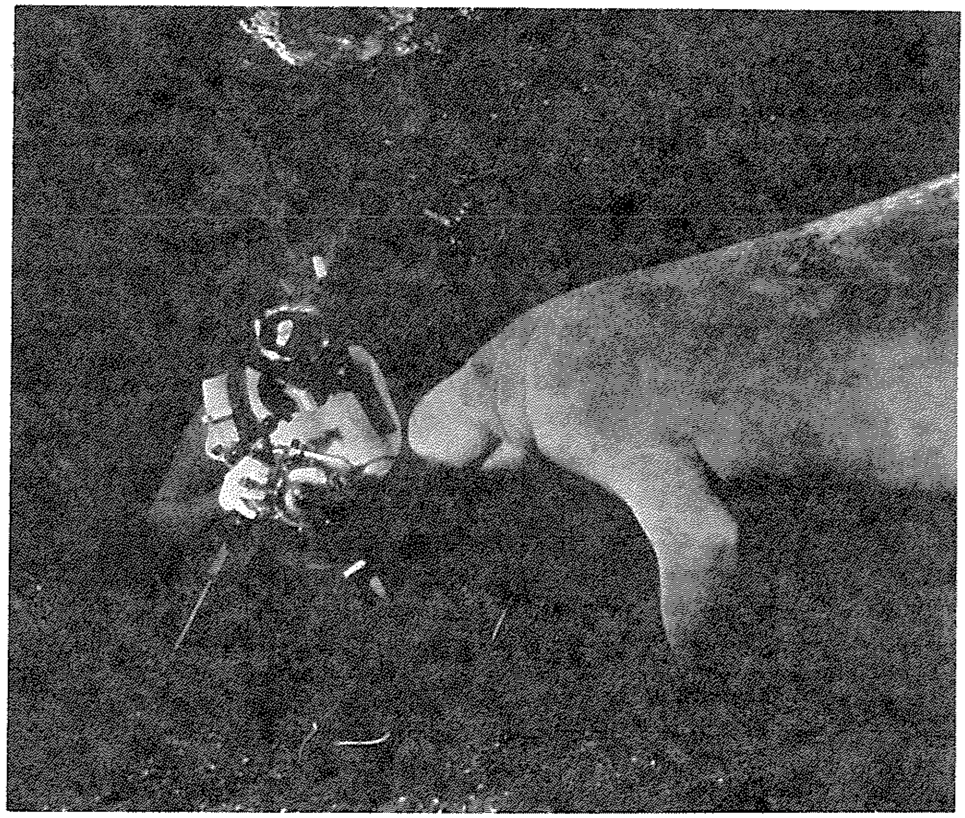
The long-term goal of the national manatee recovery plan is to encourage the recovery of manatees in United States' waters so that eventually the species can be removed from its endangered listing. Because manatee habitat is quickly dwindling in other parts of the state, this goal probably can only be accomplished by encouraging growth of manatee groups in areas of optimum habitat. Therefore, the long-term goal for management of Crystal River manatees is to maintain the subpopulation at a level that can be sustained by South Big Bend's healthy, naturally functioning ecosystem.

Short-Term Goals and Objectives for South Big Bend

To meet the long-term goals, more specific short-term goals and objectives were identified. The short-term goal of this site-specific plan is to encourage the increase of manatees in South Big Bend through the next decade. To achieve this goal, the following objectives must be fulfilled:

- Human-caused mortality: Keep the number of human-caused manatee deaths from increasing above its present low annual rate.
- Calf mortality: Determine causes of calf mortality and, by the end of the decade, reduce human-related mortality.
- Harassment: Determine the cumulative effects of recreational water activities on the distribution and number of manatees, and reduce adverse effects of these activities.
- Food resources: Preserve the amount and the diversity of freshwater and marine plant communities in which manatees feed.
- Contaminants: Reduce the exposure of manatees to environmental contaminants such as herbicides, wastewater and urban runoff.
- Warm-water refuges: Maintain the flow of South Big Bend's natural springs and keep these warm-water refuges accessible to manatees.
- Public involvement: Maintain the aesthetic, scientific and recreational value of the ecosystem that supports manatees such that people may continue to enjoy and benefit from manatees' presence.

REFER TO SECTION III



MANATEE
APPROACHES DIVER
PHOTO: P. ROSE

The spring waters of Kings Bay, headwaters of Crystal River, still reflect the clarity for which the river was named and offer humans an experience to be found nowhere else in the world. The river's warmth in winter, its proximity to the Gulf, and its abundant aquatic vegetation lure manatees throughout the seasons. And, although manatees gather during the winter at other warm-water sites in Florida, in no other clear-water refuge are humans allowed to don masks, snorkels, and fins to enter the water world of these large marine mammals and watch them conduct their daily activities. Although swimmers are not allowed to disturb manatees, the temptation to touch when approached is almost irresistible. It is the intention of this management plan to preserve this experience for future generations.

When you dive or swim in Kings Bay, you are in the manatees' home, a temporary, courteously treated visitor, able to marvel at sights you can see only here. You may, if it is a cold day, see groups of manatees around the Main Spring, an odd one sleeping belly up on a limestone ledge, others resting on the bottom of the bay, periodically floating to the surface for a breath of air or a bite of food. You may be so close you are tempted to reach out and touch a large manatee as it swims by, the sun's rays through the blue water rippling in dappled patterns over the animal's body. At this distance, a glimpse of the elephant-like toenails on its front flippers may remind you that manatees and elephants share an ancient plant-eating ancestor.

Through the clear waters, you may see a giant creature emerge from under a hydrilla patch and watch its massive lips curl around the tender leaf tips. If shy, the manatee may swim away but if you are quiet and the manatee is accustomed to humans, he may stay near you, the coarse bristles on his muzzle moving with each bite of food.

Although protective females rarely trust people near their calves, you may see a small dark calf suckling its mother's teat under her front flipper and another playfully twisting and tumbling through the water in the Banana Island sanctuary. And, if you are lucky, a manatee may, just may, glide up to you, peer in your masked eyes, and with a polite but hefty bump, request a friendly scratch.

BENEFITS

Every year more than 200,000 people move to Florida—61 percent of these new residents are expected to settle along already heavily populated coasts. With intensively developed coastal areas in much of Florida, the aesthetic value of South Big Bend will become increasingly important. If South Big Bend residents take the actions necessary to protect manatees and their habitat, their local communities will benefit by increased tourism, higher land values and educational opportunities. Fisheries, recreation, and opportunities for the public to view manatees will be enhanced. With protection, the number of manatees in the Crystal River subpopulation is expected to increase, and this larger herd may aid in clearing waterways clogged with vegetation.

In South Big Bend, manatees are like the coal miner's canary, which stops singing when toxic gases build up in a mine shaft. Similarly, the health problems of Crystal River manatees will warn residents of environmental degradation before effects are irreversible. If a healthy environment is maintained for manatees, it is also maintained for humans.

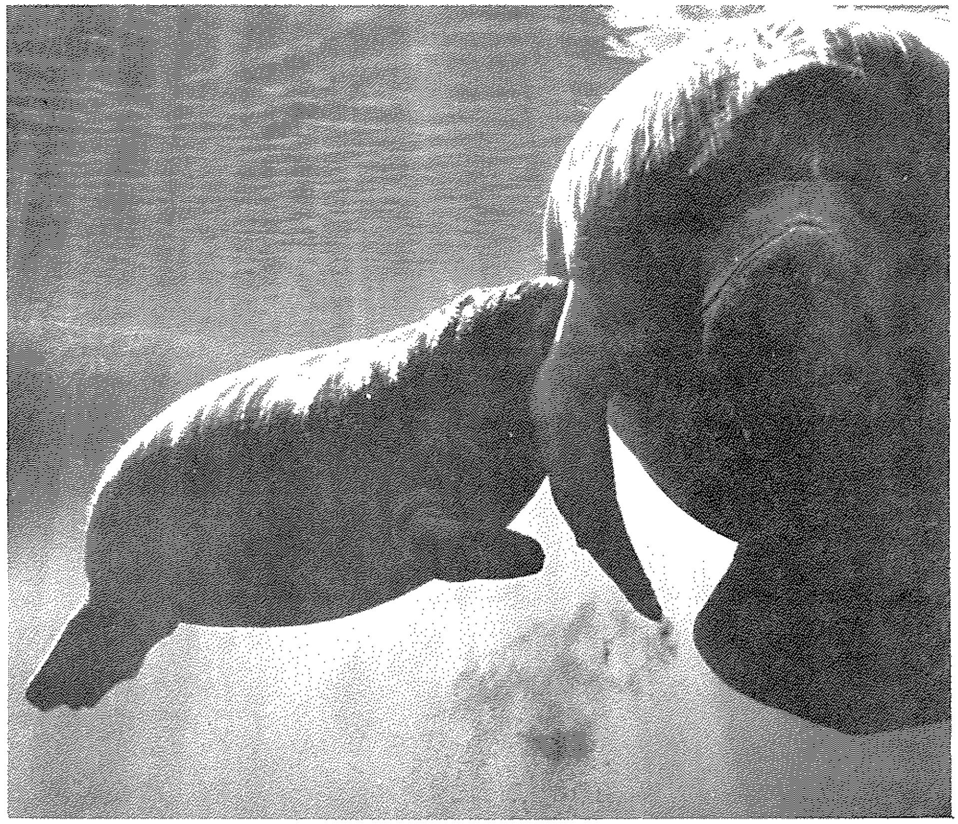
Tourism and Recreation
Manatees are not only intrinsically fascinating, but they are also economically beneficial. Visitors come to South Big Bend to enjoy the recreational attributes the intact coastal ecosystem offers. They come to fish, boat, ski, swim, or to dive in its clean, clear waters. And they come to see manatees. Dive shop owners in Crystal River estimated that 800 to 1200 divers rented scuba equipment each week during the 1982-83 winter manatee season (October 15 to March 15). Many of these divers came from northern states, some from other countries. Other businesses also benefit from the tourism.

Fisheries
Shrimp, crab, oyster and fish are as dependent as manatees on a healthy coastal ecosystem. About 100 to 125 commercial fishing boats and guides operate out of Crystal River.

Education
The Citrus County Marine Science Station in Crystal River offers unique hands-on educational programs for students of all ages. Students find manatees one of the most fascinating animals to observe. By learning about manatees and the components of their habitat, these students begin to appreciate the complexities of the relationships among marine organisms. In 1982 alone, some 8,000 to 10,000 students attended the center's programs. The clear waters of Crystal River also offer educational filmmakers and researchers the rare opportunity of observing the underwater activities of manatees. Films will be used to supplement manatee educational programs around the state.

Aquatic Weed Control
An adult manatee can eat as much as 110 pounds (50 kg) of vegetation a day. Manatees are one of the few native species that can help control unwanted plant growth in coastal rivers. Although present numbers of manatees are insufficient to keep waterways free of thick vegetation, as the herd grows, less weed control may be necessary.

REFER TO SECTION II.1.2



NURSING MANATEE CALF
PHOTO: SIRENIA PROJECT/FWS

Scientific Value
Piety, officially identified as CR 71, is a 14-to 15-year-old manatee. The 16 parallel scars on her right shoulder, her docile, gentle demeanor and her acceptance of humans make her particularly well known among divers and manatee-watchers at Crystal River.

Piety and other identified females are giving U.S. Fish and Wildlife Service scientists the vital reproductive information they need to effectively protect the Crystal River subpopulation.

When scientists first saw Piety in winter 1972-73, she was a juvenile between the age of 3 and 4, and had just been hit by the rotating blades of a boat's prop—the wounds on her shoulders were raw, ragged and deep. On July 6, 1976, tourists at Manatee Springs on the Suwannee River excitedly reported that a manatee was swimming at the mouth of the spring. It was Piety—the first Crystal River animal identified in the Suwannee.

Piety mated and by the time she showed up at Crystal River in the late fall, her naturally bulky form was even heavier with a calf. One spring day, Piety slipped away from Kings Bay, perhaps seeking a secluded creek in which to give birth, far from the prying eyes of humans and other animals. No one saw or heard anything of Piety that summer, but somewhere she had given birth, somewhere she had taught her young calf the rudiments of manatee life—patiently nudging it to the surface for air in its first few days of life, letting it rest on her back, suckling it and enticing it to nibble aquatic plants with her. The calf thrived and on November 13, Piety returned to Crystal River with her small daughter, whom researchers identified as CR 104, and later named Constance.

For two years, Piety and her calf were inseparable. But in the winter of 1979-80, when researchers saw the two in the Main Spring of Kings Bay, Constance was independent and Piety was pregnant.

The next fall, Piety returned to Kings Bay with her second calf. But this calf either died or was weaned early during the summer of 1981. When Piety returned the next winter, she was visibly pregnant once again—showing researchers that a female can produce a calf every two years.

Throughout the summer, Piety stayed near the Suwannee River but her new calf was never seen. Because manatees are so secretive when calving, scientists find it difficult to determine why her third calf died.

The next winter, Piety returned to Crystal River—once again pregnant. So far, out of three pregnancies, only one calf definitely survived, and one other may have lived.

In 1981, scientists saw 4-year-old Constance "cavorting" with a group of manatees. The group resembled a mating herd, but because of Constance's youth, researchers were skeptical. Existing evidence indicated that females did not mature until about their eighth year.

But it soon became obvious that Constance was pregnant. Thus, scientists received their first concrete knowledge of the age at which some Crystal River animals can give birth.

RECOMMENDATIONS

This plan should be reviewed and implemented by a steering committee organized by the U.S. Fish and Wildlife Service. South Big Bend should be designated an Area of Critical State Concern, if necessary, to aid local governments in resolving pressing needs for regional planning regarding boating facilities, water quality and wetland protection. Additional research is needed regarding regional needs for docking facilities, the effects of human activities on manatee behavior, water quality in the Kings Bay area, and the factors influencing the flow of natural springs used by manatees. Ongoing studies on manatee abundance, distribution, ecology, and behavior should also be continued.

Staff at the new Crystal River Manatee National Wildlife Refuge should take the lead in implementing and updating this plan. An associated private educational/research center should be developed with attractive displays and an active interpretive program to provide a focus for community pride. Through an enhanced public education effort, harm to wintering manatees may be minimized, thus avoiding the need for additional regulations.

SALTMARSH NEAR CRYSTAL RIVER
PHOTO: J. PACKARD

REFER TO SECTION V

For this plan to be effective, the coordinated action of numerous agencies, private groups and citizens is needed. The following actions are recommended in the plan.

Steering Committee
A steering committee composed of representatives from appropriate agencies and groups should oversee and coordinate the implementation of this plan. This committee should meet regularly to identify tasks to be completed each year, to resolve difficulties in completing tasks and to respond to changes that are needed as the plan is updated. Specific tasks required of each agency are listed in the plan.

Area of Critical State Concern
Local regulations in Citrus County and the City of Crystal River currently do not meet the recommendations outlined in their comprehensive plans regarding protection of manatees, fish, wildlife and coastal resources. The challenge for the future lies in maintaining essential features of manatee habitat while providing for planned development in South Big Bend. A Resource Planning and Management Committee should be appointed under provisions of the Florida Land and Water Management Act to aid local governments in revision of regulations. Cumulative impacts that need to be addressed include location of multislip docks and other boating facilities, permits and facilities for sewage treatment, zoning of wetlands, and construction affecting wetlands. If local regulations are not revised to be consistent with the management policies outlined in this plan, South Big Bend should be designated an Area of Critical State Concern.

Moratorium
Unplanned development potentially affecting manatee habitat should be avoided until appropriate local, state, and federal authorities adopt regulations consistent with the management policies of this plan. Issuance of new permits for boating facilities, dredge, fill, septic systems, sewage treatment services and construction in or adjacent to wetlands should be based on an evaluation of cumulative effects and should not proceed until means of assessing such effects are implemented.

Boat Traffic Study
Current boat traffic patterns and future needs for docking facilities in South Big Bend must be studied to better define human needs. This plan specifies where docking facilities can be placed with the least harm to manatees and their habitat.

Water Quality Model
Baseline information on Kings Bay water quality needs to be obtained to enforce existing regulations. A water quality model for Crystal River needs to be developed by the Florida Department of Environmental Regulation to establish effluent standards based on quality of the water body. This model will also provide the information that is necessary to effectively regulate cumulative effects of small sewage systems, septic tanks, stormwater discharge, and other factors influencing water quality.

Aquatic Plant Control
Adequate food for manatees needs to be maintained, especially near winter refuges, and risks due to herbicides need to be reduced. Alternatives to chemical plant control, such as mechanical harvesting, need to be evaluated experimentally.

National Wildlife Refuge
The staff of the new Crystal River Manatee National Wildlife Refuge needs to assume an active role in implementing, reviewing and revising this plan. Crystal River provides a unique opportunity for public enjoyment of manatees. The refuge should develop an active educational program to enhance the experiences of visitors while protecting manatees. Refuge personnel should monitor manatee abundance and distribution in South Big Bend. Lands included in the refuge should be expanded as needed to protect the ecosystem upon which Crystal River manatees are dependent.

Educational Center
A Kings Bay manatee educational center should be established to provide a focal point where visitors can learn about manatees and the ecology of South Big Bend. This center, which could be partially staffed by local volunteers, could enhance community involvement by providing office facilities for agencies and groups involved in protecting manatees.

Manatee Research
Manatee population status should be monitored. To effectively protect the species, studies must be continued on manatee abundance, distribution, reproduction, mortality, behavior, and physiological ecology.

Manatee/Human Interaction Study
Criteria should be developed to determine how human activities alter the normal behavior of manatees. This study will provide decision-makers with a scientific basis to evaluate the need for additional regulations regarding harassment of manatees by divers and boaters.

MANATEE NEEDS

The survival of manatees is dependent on a plentiful and varied supply of aquatic plants, appropriate water depths, shallow secluded areas for calving, warm winter refuges, sources of fresh water, and safe travel routes among refuges and summer ranges. The coastal ecosystem that supplies manatees with these needs includes rivers, estuaries, marine waters and the associated wetlands that influence water quality and plant growth.

Foods

Aptly named sea cows, manatees are the only North American marine mammal that grazes on aquatic plants. They feed primarily in fresh and estuarine waters but may crawl partway onto a bank to reach overhanging shoreline vegetation. A variety of plant foods is probably necessary to meet their nutritional requirements.

Manatee Feeding Behavior

To the boater whose prop repeatedly stalls in the tangles of hydrilla in Kings Bay, there must appear to be enough "manatee food" to support many times the number of animals now in the area. However, hydrilla is new to the bay and in the past manatees probably fed primarily on estuarine seagrasses. Their wandering habits may prevent overgrazing on plants that recover slowly. It may be hard for manatees to change a feeding pattern well adapted to the environment in which they have lived for millions of years.

Water Depth

Access of manatees to vegetation and freshwater is limited by water depth. Because animals rarely enter water less than three feet deep (91 cm), many creeks among the salt marsh islands are impassable at low tide. Manatees seldom are seen in waters deeper than 20 feet (6m).

Secluded Areas

Few people have witnessed the birth of a manatee calf in South Big Bend. Available information suggests that females are sensitive to human intrusion and seek shallow secluded creeks or even canals for birthing.

Warm Water

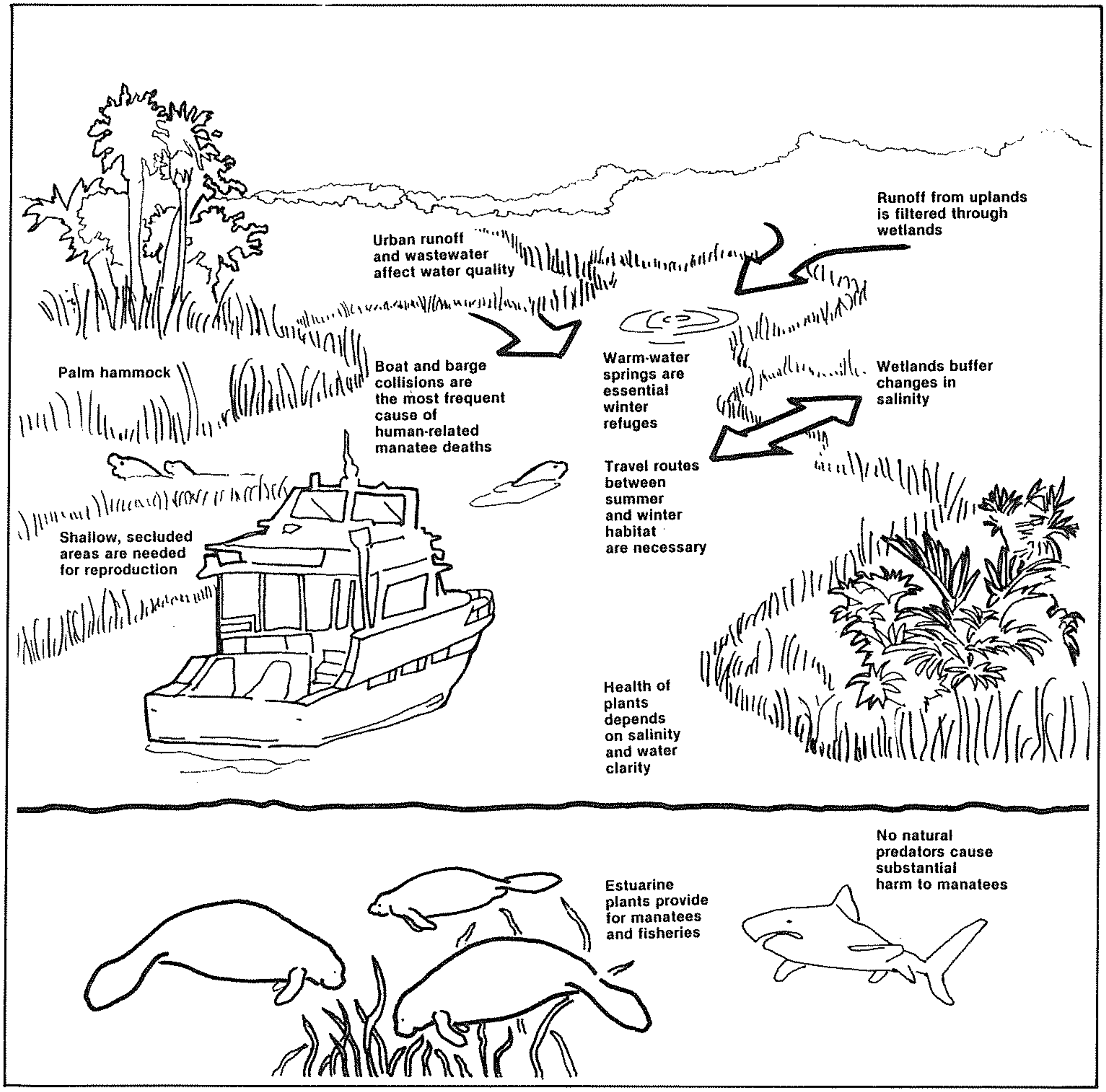
Manatees cannot tolerate prolonged water temperatures below 61°F (16°C) and usually avoid waters colder than 68°F (20°C). Individuals severely stressed by cold may die or become more susceptible to disease and infection.

Travel Routes

Manatees traveling between familiar summer and winter ranges seem to remain near the coast. There probably is some exchange of manatees between South Big Bend and areas farther south, perhaps keeping the subpopulation from becoming genetically isolated and vulnerable to the effects of inbreeding.

REFER TO SECTION II.2, II.3, II.4

MANATEE ECOSYSTEM



HABITAT EVALUATION

Some sites in South Big Bend provide manatees with many or all of their requirements, hence are core centers of activity; others are not used as intensely but are essential for specific activities. The plan identifies Crystal, Homosassa and Suwannee rivers as areas of core habitat and recommends that these rivers are of the highest priority to protect. Core centers, however, are not enough to support Crystal River manatees; connecting travel routes must also be maintained.

Seasonal Changes in Habitat

The distribution of manatees in South Big Bend changes between summer and winter. In the winter (October through April), manatees take shelter from cold Gulf waters by gathering primarily in the warm spring-fed waters of Kings Bay and Homosassa River. In the spring, as coastal and riverine waters warm once again, manatees return to secluded summer ranges throughout South Big Bend. Six estuaries provide fresh water and plant food but Crystal River and the large Suwannee estuary attract the most "summering" manatees. Manatees are rarely sighted in the Waccasassa River or near Cedar Key.

Habitat Importance

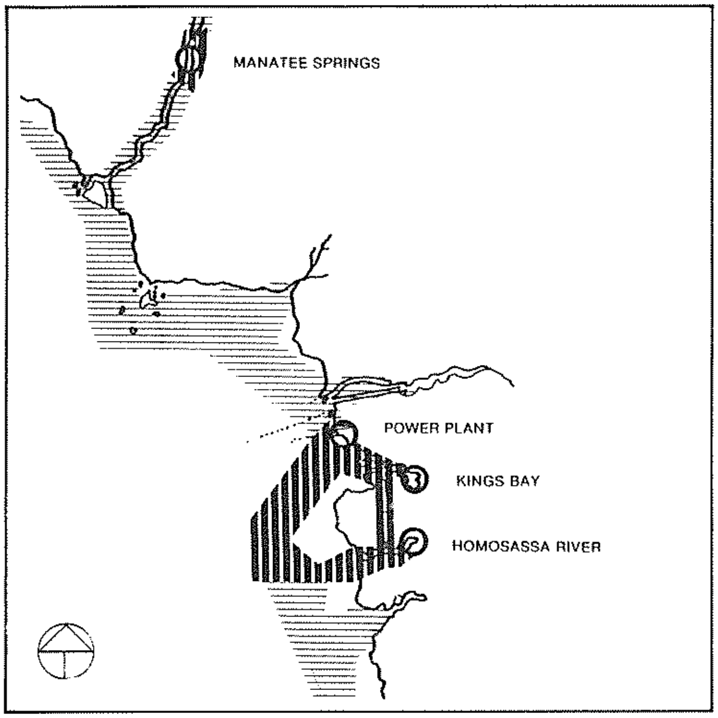
The map at right is a summary of South Big Bend manatee habitat. It is the result of grid-square analysis to rank areas in terms of the importance to manatees. This map provides a basis for further analysis of the impacts of human activities on manatee habitat. The habitat ranking is as follows:

- Essential Areas: Warm-water refuges at Crystal River, Homosassa River, the Crystal River power plant and Manatee Springs on the Suwannee River are essential for survival of manatees. Because South Big Bend is at the northern extreme of the species' winter range, manatees could not remain in the area without access to these warm-water refuges.
- Core Activity Centers: Areas where manatees have been sighted during aerial surveys indicate core centers where several activities occur such as feeding, resting, mating and possibly calving. Disturbance in these areas could influence the rate at which the population grows or declines.
- Travel Route: Core areas fulfilling manatees' winter and summer needs must remain connected by travel routes. Activities in these areas are not well known, and a cautious approach is needed to avoid changes in travel routes until their functions for manatees are better understood.
- Supporting Ecosystem: The vegetation adjacent to areas used by manatees is an important part of their ecosystem. Essential hydrological and biological functions of wetlands and offshore marine meadows must be maintained to insure the quality of manatee habitat.

REFER TO SECTION II.4

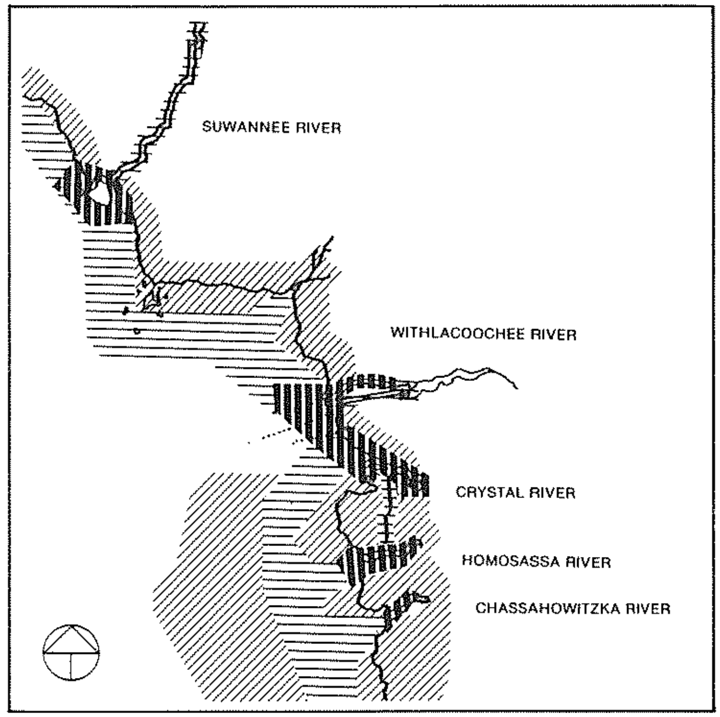
Winter warm-water refuges
Winter & summer habitat
Summer habitat

SOUTH BIG BEND
SEASONAL CHANGES IN HABITAT



Core activity centers
Travel routes
Supporting ecosystem

SOUTH BIG BEND
HABITAT IMPORTANCE



Scientists gather information on manatee habitat during biweekly aerial surveys and by following recognizable radiotagged individuals. For example, Gus is an old, rather ragged-looking male manatee with scaly skin, an aged face and distinctive scars from a boat collision—he is officially known as CR 108. He has taught scientists about long-distance travel routes and movements between winter refuges.

To follow Gus' travels during 1980, researchers attached a radiotag to his tail. Two days later, the radio signals led scientists to Gus' familiar form in a mating herd of one female and several males. Later, that summer, Gus apparently traveled 174 miles south— his tag was found on a Sanibel Island beach in July.

In the fall, Gus reappeared in Kings Bay and was retagged. One evening, he swam from Kings Bay down to the mouth of Crystal River and waited. Several hours later, the tide rose and Gus swam down the shallow Salt River toward Homosassa. Like other manatees, Gus is active both day and night. By the first light of the next morning, he was back in Kings Bay, having informed researchers of an inland travel route of which they were previously unaware.

Cruz, who is named for the cross-shaped scar that mars his back, was first identified in Crystal River on December 19, 1978. His movements illustrate how manatees use the entire South Big Bend as their summering grounds—one area does not provide all of an animal's needs.

Cruz's movements in Kings Bay have been followed for three winters. Typically, he takes refuge in the Main Spring in the evening when water temperatures drop elsewhere in the river. In the mornings, Cruz remains in the Main Spring until surface waters warm or until he tires of interacting with divers. Then, he slowly meanders to the middle part of the bay, alternately feeding and resting throughout the day. At night Cruz returns to the Main Spring—a daily pattern typical of most manatees in Kings Bay.

On January 25, 1983, scientists radiotagged Cruz in Kings Bay. On March 16, researchers sighted him in the warm-water discharge canal at the Crystal River power plant. Like other Crystal River manatees, Cruz was using the power plant canal as a temporary refuge when moving to or from winter sanctuaries.

Three days later, after temperatures had fallen, Cruz returned to Bagley Cove in Crystal River. On March 26, he was still in Kings Bay, but by April 2, he had traveled to the mouth of the Withlacoochee River. Three days later, scientists saw Cruz in the canal systems of Yankeetown on the Withlacoochee River, an area where manatees are seen mating and feeding.

In early May, scientists on an aerial survey were surprised to see Cruz traveling from the Withlacoochee toward the Suwannee River. Somewhere between the Withlacoochee and Cedar Key, Cruz's tail had been severely cut by a motorboat.

On May 10, Cruz was seen at the mouth of East Pass on the Suwannee River, an extremely important feeding and summering area for Crystal River manatees. Cruz joined other manatees that were cavorting in the pass--rubbing, hugging and chasing each other. He had traveled at least 30 miles (50 km) in seven days.

THREATS TO SURVIVAL

Fewer than 150 manatees live in South Big Bend. So far these animals have escaped the risks associated with the rapidly dwindling coastal habitat in the rest of Florida: barge and boat collisions; poor water quality; destruction of aquatic vegetation; dams that limit access to waterways; locks that crush manatees; human disturbance during birthing; and unreliable warm-water refuges. The species reproduces very slowly, hence, could not offset these threats unless farsighted management actions are taken now to minimize such changes in South Big Bend.

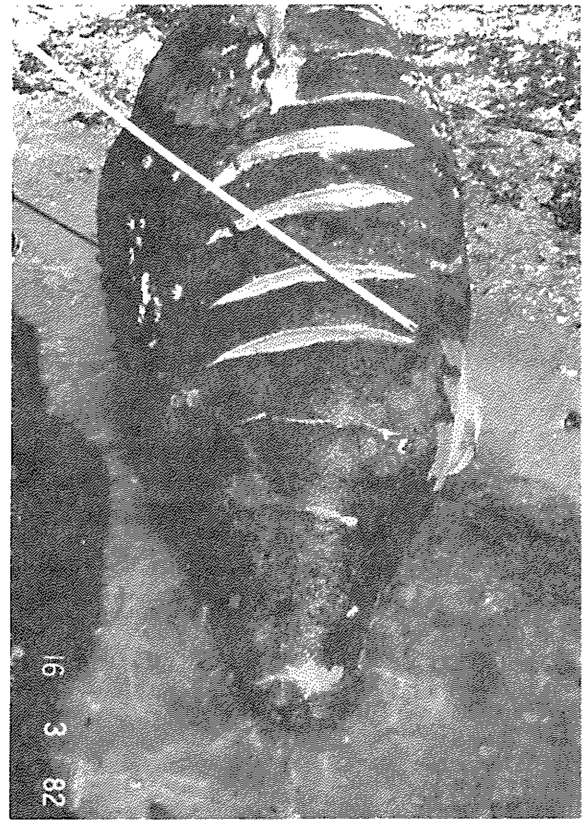
Abundance
There are precariously few manatees in South Big Bend. During aerial surveys in winter 1982-83, a maximum of 116 manatees were counted at one time in Crystal River and 21 manatees in Homosassa River. Because some manatees are not visible during surveys, counts are used to monitor trends in abundance, rather than representing exact totals. However, abundance of Crystal River manatees is well below the level (about 1,000 animals) at which scientists become concerned about negative effects of inbreeding. If the subpopulation were to become isolated from other groups father to the south, concerns about maintaining a healthy population would increase.

Trends in Abundance
The Crystal River manatee subpopulation is no longer growing at the slow but steady rate that was recorded over the last 15 years. For example, between the winters of 1977-78 and 1981-82, the numbers of manatees counted in Crystal River increased from 78 to 116. In contrast, maximum counts of manatees did not increase between winter 1981-82 and 1982-83. Researchers do not know how many manatees South Big Bend can support, but it is certain that habitat maintenance is vital for continued growth.

It takes many years for a population of manatees to increase due to the species' low reproductive rate. A female usually produces one calf every two or three years. Even if the calves successfully make it through the few critical years after weaning, it will take them as long as 5 to 8 years to reach breeding age. An average of nine calves are sighted in Crystal River each year. Some manatees probably move into South Big Bend escaping from the unfavorable conditions farther south—approximately 10 to 20 percent of the mantees identified in Crystal River each winter have never been identified in the area before.

Deaths
No natural predators are known to kill manatees. However, over the last eight years, an average of three manatee carcasses per year have been recovered in South Big Bend as part of a statewide program. Probably not all the manatees that die are collected by the salvage team. However, those that are examined provide information on threats to their survival.

REFER TO SECTION II.5



BOAT KILLED MANATEE
PHOTO: SIRENIA PROJECT/FWS

It is August 31, 1978. The phone rings in the manatee salvage team's office at the USFWS lab in Gainesville. The Florida Marine Patrol reports that a boater has sighted a dead manatee at the junction of Salt and Crystal rivers.

The next morning, members of the salvage team load up a truck and head for Crystal River. They find the animal directly across from a marina, her large bulk floating in the shallow channel. The manatee is hauled to shore, lifted onto a trailer and taken to the Gainesville lab. That same day, researchers examine the manatee to determine the cause of its death and take tissue samples for analysis of contaminants. Many manatee carcasses are too decomposed to determine the cause of death, but this one will provide valuable information. A researcher writes this terse report:

Sex of specimen: Female M-126 Length: 257 cm (8.4 ft.)
Cause of death: Six broken ribs, right side, punctured lung, diaphragm torn from cavity wall. Boat/barge collision.
Comments: Probable boat kill, animal was recovered directly across from marina. The heavily used channel is narrow and shallow. A narrow, superficial, long cut indicated the area that had been injured.

From 1974 through March 1982, the salvage team recovered and examined 28 manatee carcasses from South Big Bend. Of those cases where the cause of death could be determined, one fourth were human-related: two manatees died after being hit by boats, three were crushed by barges, one was crushed when a canal lock closed while it was passing through, and one death was probably related to toxins.

Almost half of the animals recovered were dependent calves—aborted fetuses, stillborn, or still nursing. These calves were found in Kings Bay, the Withlacoochee River, Cross Florida Barge Canal, Suwannee River and Cedar Key. More information needs to be collected to determine potential causes of calf deaths.

Boats are the most frequent human-related cause of adult manatee mortality in Florida. In South Big Bend, boat-related manatee mortality is relatively low, but will most likely increase if future facilities influencing boating traffic are not carefully planned.

Several manatees in Florida have been drowned in fishing nets, or died due to infections resulting from entanglement in crab-trap buoys or fishing lines. One Crystal River manatee lost a flipper after it became entangled in monofilament line.

Although concentrations of contaminants such as pesticides, mercury, lead and cadmium measured in tissues of dead manatees as yet have been within safe ranges, copper levels have been abnormally high. Concentrations of copper found in the liver of manatees recovered in northwestern Florida were significantly higher than in manatees recovered from other parts of the state. Manatees probably swallowed this copper with their food when the herbicide was applied in large quantities in the late 1970's in South Big Bend's rivers. Manatees also may be vulnerable to diseases and parasites carried in poorly treated human and animal wastewater.

BOATING FACILITIES

To avoid the need for restrictive regulations regarding boat operation, this plan provides guidelines for the development and location of future navigation channels and docking facilities—marinas, docks, and boat ramps. By locating future development of boating facilities in areas where the overlap of boat traffic and manatee habitat is low, the expected increase in boat-caused manatee deaths, degradation of aquatic plant food, and manatees' exposure to contaminants will be minimized.

Risks to manatees are high where boat traffic occurs in waterways frequently used by manatees. These risks can be reduced by controlling the manner in which boats are operated, for example, by slow speed zones. However, in South Big Bend, we still have the opportunity to avoid the need for additional regulations by planning the location and design of boating facilities.

Direct Impacts on Manatees
Characteristics of boat traffic that increase the chances of injury, death or disturbance of manatees include:
- location of boating facilities near manatee areas;
- high boat density increasing collision probabilities;
- large boats, which are more likely to kill manatees than small boats;
- shallow water, where manatees are more vulnerable.

Indirect Impacts on Manatee Habitat
Construction and operation of boating facilities can adversely affect manatee habitat by:
- reducing the amount of aquatic vegetation;
- changing drainage patterns from wetlands;
- reducing plant growth due to increased water turbidity;
- increasing contamination of waters and sediments.

Adverse impacts of boating facilities on manatee habitat can be minimized by appropriate design and location of marinas, docks, and channels. Facilities should be clustered in areas that do not require seawalls, that have deep and well flushed channels, and that do not disturb aquatic vegetation.

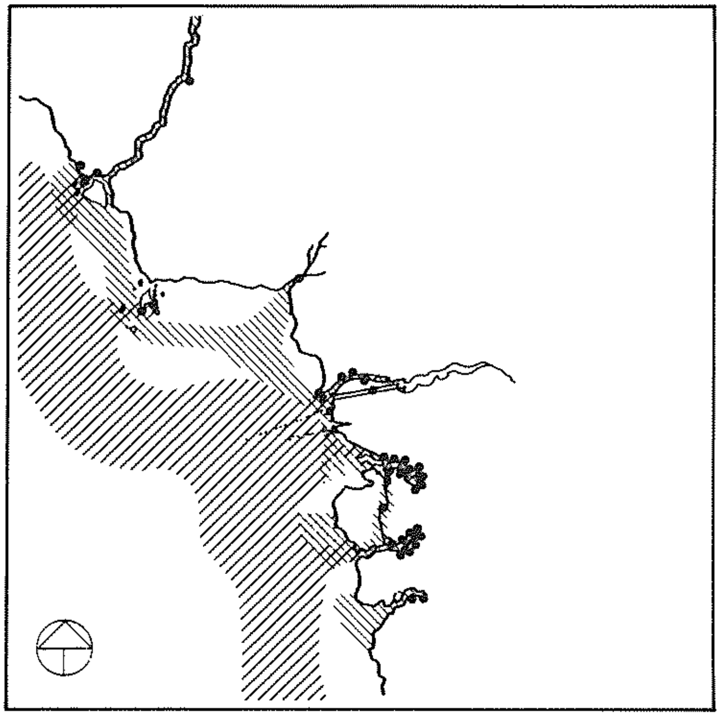
Current Regulations
Present local, state and federal regulations do not adequately address the cumulative effects of boating facility construction. For example, although the comprehensive plans of Citrus County and the City of Crystal River recommend protection of estuarine resources, no local regulations currently limit the number or size of docks. State and federal regulations do not require permits for docks below a specified size, although state law clearly requires protection of endangered species habitat.

Under state law, a procedure exists for making local regulations consistent with state policy. An area with significant environmental problems may be designated an Area of Critical State Concern. If local regulations are not revised according to the recommendations of a

REFER TO SECTION IV.1

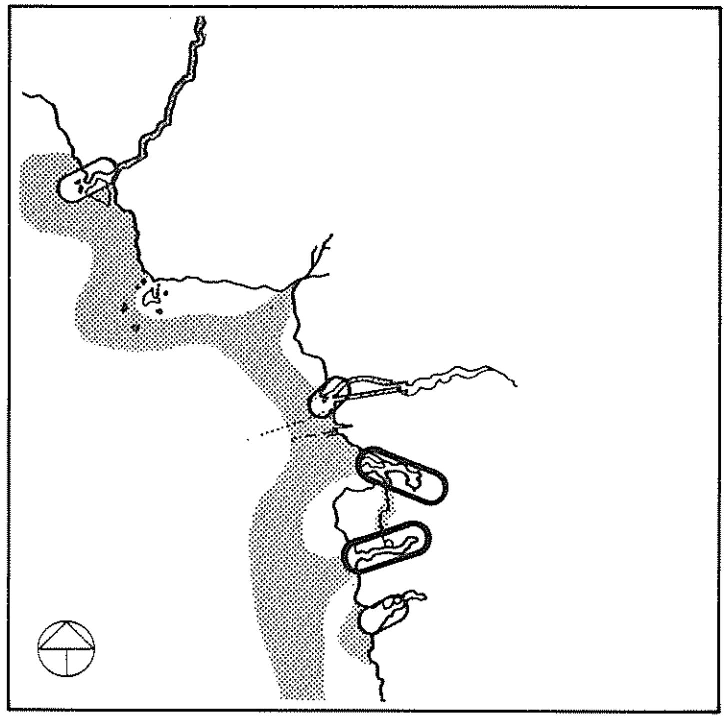
• Access points: marinas, ramps
Large boats or barges
Small boats

SOUTH BIG BEND
BOAT TRAFFIC AND FACILITIES



High overlap
Medium overlap
Low overlap

SOUTH BIG BEND
MANATEE/BOAT OVERLAP



Resource Planning and Management Committee, the state authority may be invoked to supercede local authority until appropriate measures are taken. However, substantial unplanned development may occur in the interim unless involved agencies agree to a moratorium until the satisfactory regulations are adopted.

Regional Evaluation
By analyzing the overlap of current boat traffic and manatee habitat, major areas of concern within South Big Bend were identified (see maps on this page). Important manatee habitats in Crystal, Homosassa, Suwannee, Withlacoochee, and Chassahowitzka rivers are already centers for boating activity. The shallow Waccasassa River is relatively inaccessible to boats or manatees; however, small fishing boats cluster in the estuary where manatees are occasionally sighted. Although Cedar Key is becoming a center for boating activity, it does not attract many manatees. The barge canal, currently undeveloped, stands out as a navigable channel with minimal overlap of manatee habitat.

Plans already exist for construction of two major navigation channels that would create significant adverse effects on manatee habitat in South Big Bend. The Cross Florida Barge Canal is still authorized although construction was stopped before it was completed. An Intracoastal Waterway from Tampa Bay to St. Marks has been proposed and further studies have been recommended by the Withlacoochee Regional Planning Council. Currently, large boats travel in offshore waters at depths infrequently used by manatees and dock at Crystal, Homosassa, Suwannee and Withlacoochee rivers. Construction of major navigation channels such as the Intracoastal Waterway or the barge canal would encourage more inshore large-boat traffic, substantially increasing the probability of manatee deaths due to boat/barge collisions.

To identify locations where construction of boating facilities in South Big Bend will minimize impacts on manatee habitat, areas with substantial overlap of boat traffic and core habitat were analyzed at a larger scale for each river system. Sites were evaluated as suitable for construction of boating facilities only if they satisfied both of the following criteria: (1) minimize the amount of boat traffic in areas where manatees are frequently sighted, and (2) minimize disturbance to wetlands.

Crystal River
Ten boat ramps and marinas are located in the Crystal River area. Commercial fishing boats travel the entire length of the river to gain access to Gulf waters from Kings Bay. Throughout the year, manatees are frequently sighted in the estuary and the river channel is their only access to the warm headwaters during the winter. Thus, the current overlap of boat traffic and manatee habitat in Crystal River is high.

No sites suitable for construction of multislip docking facilities were identified in Crystal River or Kings Bay. In general, overlap of boat traffic and manatee travel routes would be minimized by locating boating facilities at the mouth of the river. However, these areas are primarily wetlands and are unsuitable for marina development. The water is generally too shallow in Dixie Bay, and traffic from canals adjacent to the river would increase boat density in the river.

This analysis indicates that the capacity for multislip docking facilities on Crystal River and Kings Bay has been reached. Thus, existing facilities should not be expanded and future development should be redirected outside of core manatee habitat, to areas such as the barge canal.

Homosassa River
Boat traffic from the nine marinas and ramps located on the Homosassa River travels along the same route used by manatees traveling between estuarine feeding areas and the warm headwaters. No sites met both criteria as suitable for further development of multislip docks. This preliminary analysis indicates that development of boating facilities should be redirected to locations outside of the core manatee habitat in Homosassa River, although a more detailed analysis is recommended.

Withlacoochee River and Barge Canal
Compared to other areas in South Big Bend, the barge canal is most suitable for future development of multislip docking facilities. Well-drained land is adjacent to the canal east of a band of coastal wetlands. The canal is infrequently used by manatees and does not contain a significant source of food for manatees. The canal is deep enough to allow manatees to dive under approaching boats. Although much of the lower Withlacoochee River is not bordered by wetlands, development of docking facilities along the river would generate boat traffic that would travel through areas used by manatees in the summer.

Suwannee River
Manatees are sighted frequently during the summer at the Suwannee estuary and also travel up the Suwannee River at least as far as Manatee Springs. If more docking facilities are constructed along the river, the risk of injury and death to manatees would increase. Most of the waterways at the mouth are surrounded by wetlands and therefore are unsuitable for development of marinas.

Chassahowitzka River
No suitable areas for development of docking facilities on the Chassahowitzka River could be located. The entire river is surrounded by wetlands and is shallow. Manatees are sighted in the estuary during the summer and boat traffic from the river travels through the estuary.

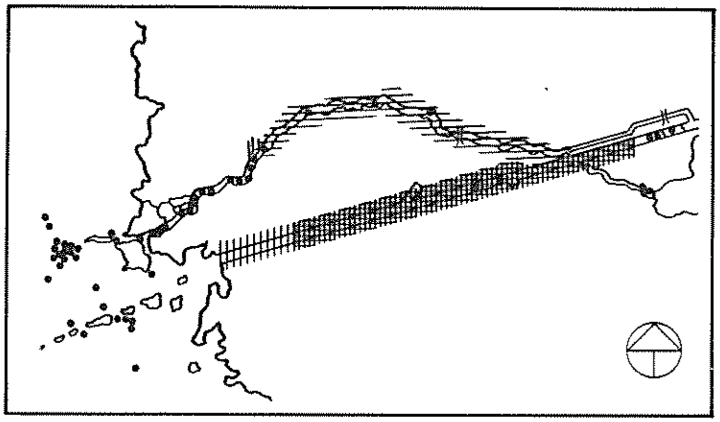
Information Needs
This analysis indicates that severe problems will occur in the future if unplanned development of docking facilities in South Big Bend continues. However, a more detailed analysis of boat traffic trends is needed to draft and implement regulations to avoid such problems. Regional planning that considers the cumulative effects of development of boating facilities in South Big Bend is needed.

Management Policy
To meet the objectives of this plan, future actions in South Big Bend should be consistent with the following management policy:

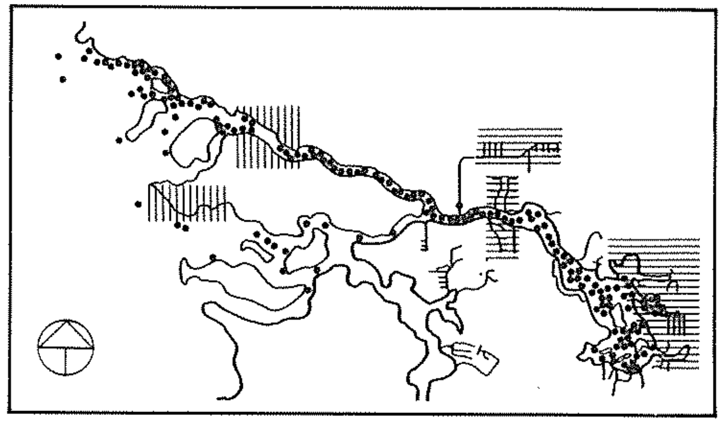
- Approve permits for construction of new (or expanded) boating facilities only where it can be shown that the overlap of boat traffic and manatee habitat will not increase, vegetation eaten by manatees will not be reduced and the role of wetlands in maintaining water quality and estuarine vegetation will not be altered.
- Determine and implement a process for evaluating the cumulative effects on boat traffic during review of permit applications for construction of boating facilities.
- Redirect new development of multislip docking facilities and boat ramps to the barge canal between Lake Rousseau and coastal wetlands.
- Encourage relocation of existing facilities to areas that will reduce overlap of boat traffic and manatee habitat.
- Establish and require design standards for construction of boating facilities.
- Issue permits for maintenance dredging only where large boat traffic in core manatee habitat will not increase, and aquatic vegetation utilized by manatees will not be reduced.
- Allow one small dock per existing waterfront lot.

REFER TO SECTION IV.1

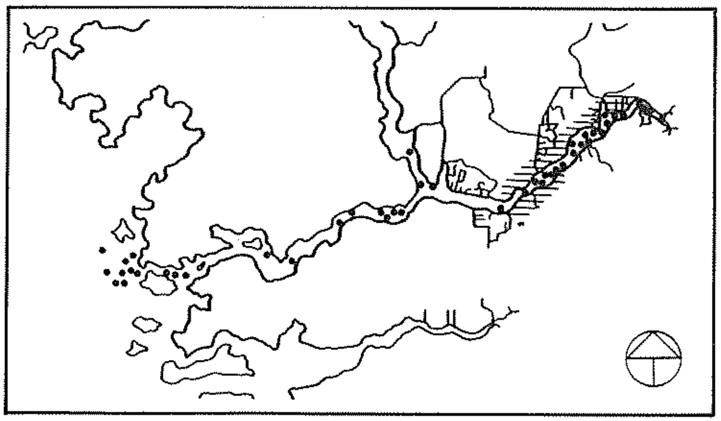
WITHLACOOCHEE RIVER
AND BARGE CANAL



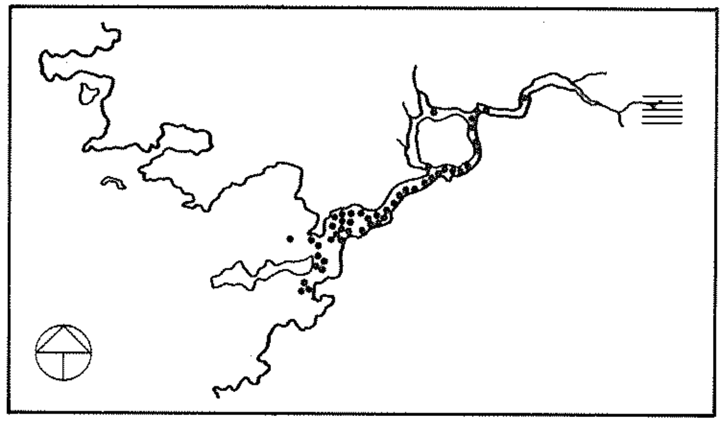
CRYSTAL RIVER



HOMOSASSA RIVER



CHASSAHOWITZKA RIVER



GUIDELINES FOR MARINA SITING

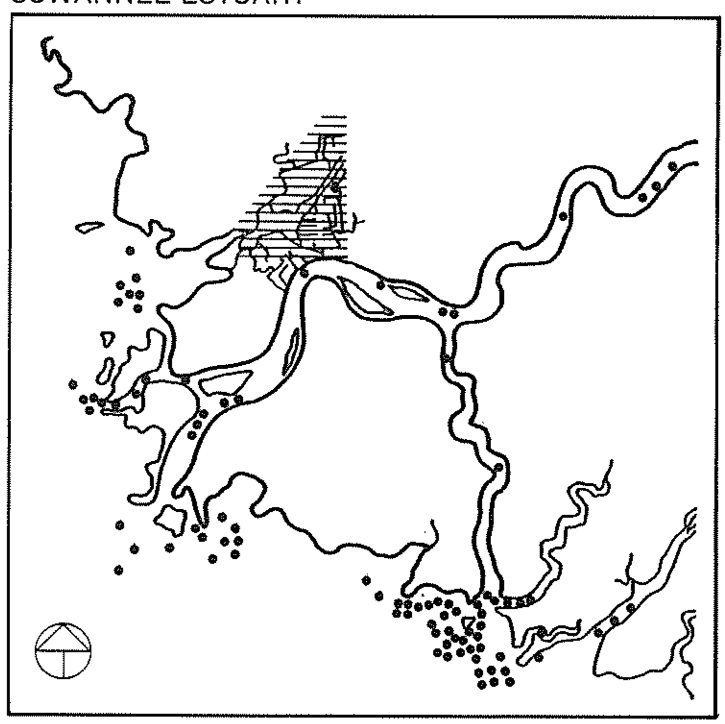
Suitable site: meets criteria 1 & 2

Meets criterion 1: minimizes manatee/boat traffic overlap and disturbance of aquatic plants

Meets criterion 2: minimizes disturbances to wetlands and supporting manatee habitat

Manatee sightings

SUWANNEE ESTUARY



BOATING, SWIMMING and FISHING

Opportunities for the public to view manatees should be preserved and enhanced; however, additional effort is needed to enforce regulations that protect manatees from injury, harm and harassment, and to investigate the effects of human activities on manatees. The need for further regulations may be avoided by developing an effective public education program that explains rules of conduct in manatee areas. Development of the Crystal River Manatee National Wildlife Refuge and an associated educational center is essential.

Manatees and humans are attracted to the same areas in South Big Bend. However, it is possible to minimize the effects of recreational activities on manatees, by minor adjustments in the manner in which these activities are conducted.

Impacts on Manatees

Boating, snorkeling, diving and fishing in winter refuges may cause manatees to leave warm-water areas, exposing them to cold stress. Factors increasing to the likelihood of manatee injury, mortality and disturbance include:

- fast or unpredictable operation of boats;
- disturbance during cold compared to warm periods;
- behavior and density of boats, divers and snorkelers;
- crab-trap lines and discarded monofilament line.

Current Regulations

Except for the Suwannee estuary, boat speed is regulated in each of the areas of core manatee habitat within South Big Bend and all activities are excluded from three small sanctuaries in Kings Bay during months that manatees are present. Activities resulting directly or indirectly in injury, death, harm or harassment of manatees are prohibited, wherever they may occur, by state and federal laws.

Management Policy

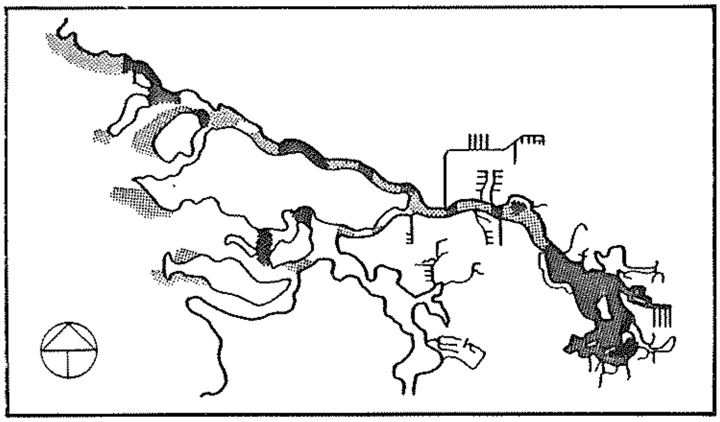
To meet the objectives of this plan, future actions should be consistent with the following management policy:

- Improve regulatory means of reducing harm to manatees, for example, by increasing enforcement manpower, repairing signs, posting signs, extending dates of boat speed regulations, and establishing boat speed zones in shallow waters adjacent to the Crystal River channel.
- Develop an active interpretive program at the Crystal River Manatee National Wildlife Refuge and an educational center in Crystal River to strengthen appreciation, awareness and citizen involvement in protection of manatees.
- Monitor and evaluate the effects of human activities on manatees in Kings Bay, to develop objective criteria for determining the need for additional regulations.
- Emphasize voluntary time-sharing of areas where manatees and human activities overlap to avoid the need for additional regulations.
- If voluntary compliance with guidelines for minimizing harm to manatees is inadequate, establish regulations as necessary.

REFER TO SECTION IV.2

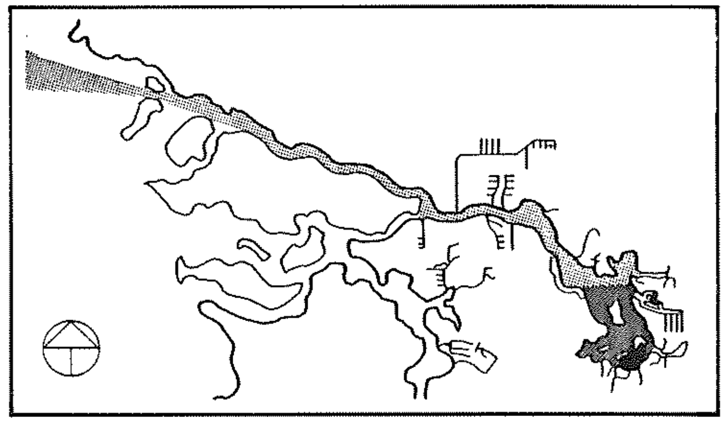
High
Moderate
Low

CRYSTAL RIVER
DENSITY OF MANATEE SIGHTINGS



Diving/snorkeling
Water skiing
Large boat traffic

CRYSTAL RIVER
HUMAN ACTIVITIES



Site-specific Evaluation
The greatest overlap of human waterborne activities and core manatee habitat occurs in Crystal and Homosassa rivers—areas essential to survival of manatees in South Big Bend. Analysis of each of the areas of core habitat indicates that regulations are currently not adequately enforced and effort should be focused on a positive program of public education to aid enforcement.

An estimated 600 to 800 people rent equipment from Kings Bay marinas and dive shops each winter weekend. The major attraction, the Main Spring, is also the major warm-water refuge for manatees. As many as 33 boats have been counted clustered at one time in the Main Spring area adjacent to no-entry manatee sanctuaries.

The small sanctuaries do not exclude people from fishing holes, navigation channels or recreational diving at the Main Spring. Manpower for law enforcement and funding for signs are inadequate—local residents report numerous violations of the rules. One problem is that a visitor new to the area is unlikely to encounter information explaining rules of conduct in manatee areas.

Areas where manatees are sighted most frequently in Kings Bay, are appropriately protected by slow and idle speed zones. Time sharing occurs—boaters enjoy water-skiing during summer months when manatees are sighted less frequently. However, the current period of speed zones (November 15 to March 15) does not adequately cover the period that manatees are sighted in the bay (October 15 to April 15). Boat speed is not restricted in the Crystal River channel where boat traffic is frequent. Manatees are vulnerable in shallow areas adjacent to the unmarked channel.

Opportunities to develop an effective educational program exist. Recently, a voluntary Manatee Watch involving private citizens was organized to patrol Kings Bay. It will educate the public regarding guidelines for conduct in manatee areas, and provide law enforcement officers with information necessary to enforce existing laws. Five commercial dive shops direct customers to areas where manatees can be viewed and most provide some information on manatee regulations. The Citrus County Marine Science Station provides supervised field trips to view manatees. Two rehabilitated captive manatees are on display at a commercial attraction in Homosassa.

WATER QUALITY and VEGETATION

Clean, unpolluted water and plentiful vegetation are vital not only to manatees but also to fisheries and recreation. Maintenance of water quality in Crystal River is still possible if standards for permitting effluents and individual sewage systems are based on a water quality model that includes all inputs to the river. Use of herbicides in South Big Bend should be reduced due to their potential negative effects on health of manatees.

Impacts on Manatees

Contaminants such as human and animal wastes, heavy metals, industrial by-products, or pesticides and radioactive wastes may influence manatees' susceptibility to disease and may affect their reproduction. Sources of these contaminants may include sewage, stormwater runoff, aquatic herbicides, or industrial effluents. The diversity and abundance of aquatic plants eaten by manatees is influenced directly by weed control programs and indirectly by water quality.

Current Regulations

Selected manatee feeding areas in Kings Bay are protected from herbicide treatment, and application of chemicals evaluated as potentially most hazardous to manatee health has been reduced due to coordinated effort of county, state and federal agencies. Because Crystal River is classified as an Outstanding Florida Water, new point sources of pollution must not degrade water quality below current levels. However, baseline water quality conditions in Kings Bay have not been established, making enforcement difficult. State regulation of septic tanks and small package treatment plants is not adequate in areas draining into Crystal River.

Management Policy

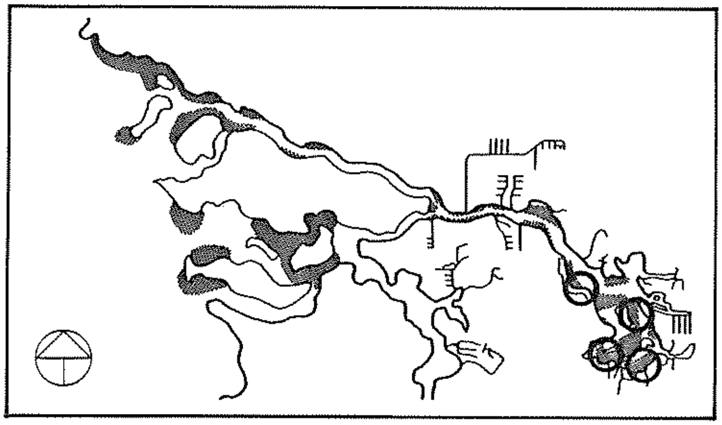
To meet the objectives of this plan, the following management policy should be implemented:

- Establish and maintain water quality standards in Crystal river based on baseline water quality information.
- Establish water-body based effluent standards, by modeling the Crystal River aquatic ecosystem.
- Control the construction of individual sewage systems in areas that influence water quality in manatee habitat.
- Provide future sewage treatment facilities that do not degrade coastal waters.
- Provide for independent monitoring of effluents discharged into Crystal and Homosassa rivers, and enforce permit requirements.
- Reduce the exposure of manatees to aquatic herbicides used in South Big Bend, i.e. by a program of mechanical harvesting that is designed to be safe for manatees, and by restoring water quality to decrease the need for aquatic weed control.

REFER TO SECTION IV.3

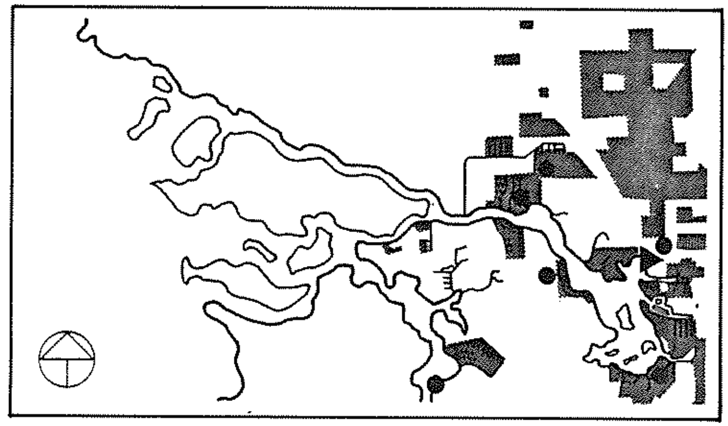
Feeding areas
Herbicides restricted

CRYSTAL RIVER
MANATEE FEEDING AREAS



Sewage plant discharge
Sewage treatment problem
Urban areas-runoff

CRYSTAL RIVER
FACTORS INFLUENCING WATER QUALITY



Site Specific Evaluation
In South Big Bend, the poorest water quality and the greatest use of herbicides occurs in rivers that are core manatee habitat—Crystal River, Homosassa River, and the Suwannee River. In this plan, analysis focuses on maintaining water quality and vegetation in the most urbanized area within South Big Bend, Crystal River.

Wastewater treatment facilities draining into Crystal River include a secondary sewage treatment plant, at least 13 sewage treatment package plants and numerous septic systems. Four package plants and two septic systems have already been identified as not meeting water quality standards. Manatees are susceptible to diseases and parasites carried in inadequately treated wastewater.

Because of high fecal coliform levels, shellfish harvesting has been closed each winter for the last three years in the Crystal River area, and the Hunters Spring swimming beach has been closed several times. The Department of Natural Resources identified the Crystal River and Dixie Shores wastewater treatment plants as the worst sources of bacterial pollution along the Citrus County coast and noted that septic systems with poor drainage probably contributed to the problem.

Enriched with nutrients from sewage and runoff from residential gardens, the waters of Kings Bay now favor plant growth more than in the past. Use of herbicides to control aquatic plants may contribute to the problem—decaying plants release silt and nutrients into the water. Although sufficient food for manatees is assured by limiting herbicide treatment in selected manatee feeding areas, manatees are still exposed to herbicides applied in other parts of Kings Bay and adjoining canals.

Information Needs
Additional information is needed to determine a long-term solution to maintaining water quality and controlling vegetation in Kings Bay and Crystal River. A water quality model needs to be developed to provide a scientific basis for evaluating the cumulative effects of effluents and seepage from septic systems located in poorly drained soils. To aid in reducing herbicide treatments, the feasibility of mechanical harvesting of aquatic plants should be evaluated.

LAND DEVELOPMENT

Development of land adjacent to manatee habitat should be planned such that it does not disturb the natural functions of the coastal ecosystem. By setting design standards and clustering development in appropriate locations, the vast expanses of wetlands, which are so important to water quality and the beauty of the area, may be preserved. Developers will know the guidelines within which to plan their projects, thereby easing current uncertainties.

Effects of Unplanned Development

Although the effects of land development on manatees are indirect, they nevertheless are important. Viewed on a case by case basis, it may be difficult to see how each development project would have a substantial impact on the coastal ecosystem as a whole. However, when viewed in terms of the total development that could take place in the next decade in Citrus County coastal areas, the impact could be substantial. Dredged canals, fill, and seawalls required to develop wetlands can alter drainage patterns, nutrient exchange, and filtering functions, all of which are important to maintain healthy estuarine plants and water quality.

Current Regulations

Contrary to guidelines of their comprehensive plans, the city of Crystal River and Citrus County zoning regulations have few provisions for maintaining the quality of coastal areas. For example, lands adjacent to Crystal River are zoned residential, commercial, industrial and agricultural (see map on page 25). State and federal agencies that regulate dredge and fill activities have clear guidelines to consider cumulative effects on the habitats of endangered species. However, there is currently no accepted procedure for assessing those cumulative effects.

Management Policy

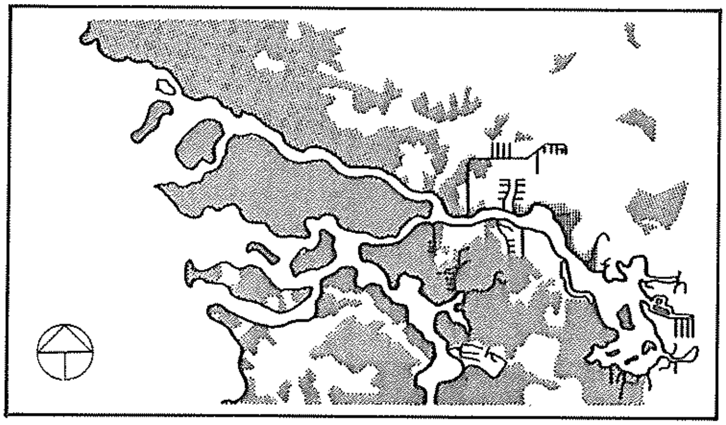
To meet the objectives of this plan, future actions should be consistent with the following management policy:

- Protect the natural condition of wetlands adjacent to manatee habitat by means of specified conservation zones.
- Identify buffer zones suitable for limited development under design standards that minimize disruption of ecosystem functions, and specify the type of development that will be permitted to meet such standards, for example, cluster housing, stilt houses and boardwalks.
- Redirect high-density development to locations where drainage from uplands into wetlands will not be changed.
- Reduce unplanned development affecting manatee habitat until a regional plan addressing the cumulative effects of development is prepared and implemented.

REFER TO SECTION IV.4

Marshes and Wooded Wetlands

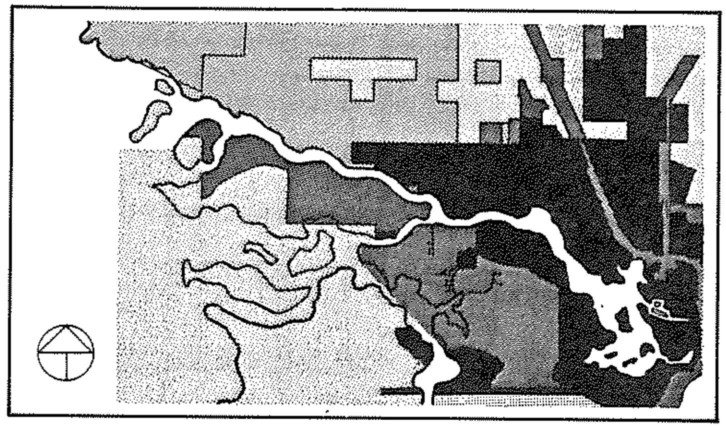
CRYSTAL RIVER
WETLANDS



Residential
Commercial

Industrial
Agricultural

CRYSTAL RIVER
CURRENT ZONING



Site Specific Evaluation
The major area of proposed compact urban development in South Big Bend includes wetlands on the Salt, Crystal and Homosassa rivers. The second largest area of proposed development is along the north bank of the Withlacoochee, including the communities of Yankeetown, Crackertown and Inglis. Therefore, the major overlap of proposed development and lands adjacent to manatee habitat occurs on the Crystal, Homosassa and Withlacoochee rivers.

This study focused on an analysis of land use adjacent to the most important manatee habitat, Crystal River. Existing and pending permits indicate that development is proposed in the immediate future along the southern and northern shores of Crystal River. These are primarily marshes and wooded wetlands less than 5 feet above sea level, except for scattered hammock islands and existing fill.

Wetlands adjacent to Crystal River and Dixie Bay maintain water quality and plant growth in the estuary frequented by manatees. Under current zoning, these wetlands could be divided into lots ranging from about one to two acres and could be developed for a variety of purposes, including residences, commercial activities and industry. Essential biological and hydrological functions of wetlands will be impaired if these low lands are developed—thus, wetlands should be conserved in their natural state.

Limited development should be allowed to occur on lands adjacent to wetlands only if it meets stringent standards. Zoning regulations are needed in these areas to specify the performance standards necessary to maintain environmental quality, for example, by requiring low density, cluster housing, stilt construction, and centralized sewage treatment.

Information Needs
The boundaries of the salt and freshwater wetlands adjacent to Crystal River need to be mapped in sufficient detail to provide guidance for developers, permitting agencies and for revision of local zoning regulations. Drainage patterns need to be determined to evaluate the effects of proposed developments on coastal marshes and on salinity fluctuations in the Crystal River estuary. Potential effects of development adjacent to Homosassa, Chassahowitzka, Withlacoochee and Suwannee rivers need to be determined.

PROTECTION OF MANATEE HABITAT

South Big Bend residents have the opportunity to maintain their productive coastal ecosystem by expanding the present system of state and federal refuges, reserves and preserves to include currently unprotected lands adjacent to manatee habitat. By protecting wetlands, fisheries and human recreational activities will also be preserved. Maintenance of good habitat is less costly than restoration.

An intact coastal ecosystem is essential to maintain good habitat for manatees. Despite regulations, the cumulative effects of human activities along the coast will inevitably reduce the quality of the manatee habitat. The most sensitive areas should be maintained intact, and placed in public or private trust.

Current Regulations
State lands managed as reserves protect unique features, whereas preserves and parks provide for recreational activities. Aquatic preserves specify protective guidelines for actions permitted on sovereignty submerged lands. National wildlife refuges are managed by the federal government for wildlife and commercial resources. Management plans developed for these public lands can include measures to protect manatees. Habitat protection can also be provided by federal designation of Critical Habitat for endangered species, and of national marine sanctuaries.

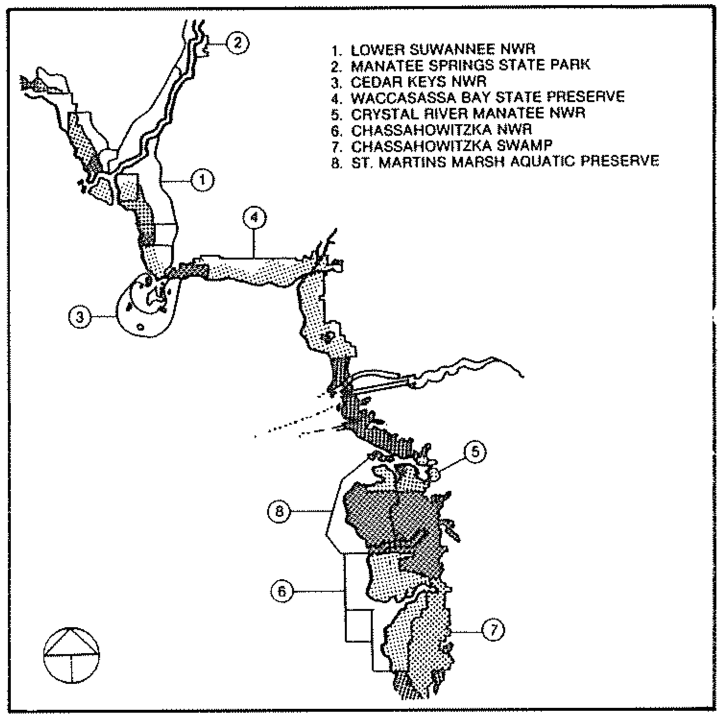
Information Needs
The current patterns of land ownership and the availability of funds for acquisition need to be determined before protective options can be fully evaluated. The movements of manatees outside Crystal River need to be studied to provide a better basis for identifying areas important for reproductive activities.

Management Policy
To meet the objectives of this plan, actions should be consistent with the following management policy:
- Encourage the expansion or addition of state refuges, reserves, preserves, parks, etc. in or adjacent to essential manatee habitat.
- Incorporate a full complement of essential summer, winter, and migratory habitat for manatees into the regional system of state and federal protected areas.
- Encourage the development of research/management programs that address manatee protection at established refuges, reserves, preserves, and parks that contain essential manatee habitat.
- Designate waterways identified as core manatee habitat as Critical Habitat.

REFER TO SECTION IV.5

Unprotected
Proposed aquisition
Protected public lands

SOUTH BIG BEND
WETLAND PROTECTION



Site-Specific Evaluation
A continuous band of wetlands lines the coast of the management area. Many of these wetlands are already included in existing refuges, reserves, and preserves. Proper management of these areas will help protect the integrity of the coastal ecosystem that supports South Big Bend's manatees. Although many of the areas already protected contain important manatee habitat, some of the most vital habitat remains unprotected. Coastal wetlands that are not currently protected in South Big Bend include portions near the Suwannee River, a segment between the Withlacoochee and Homosassa rivers, and areas east of Chassahowitzka National Wildlife Refuge.

Completion of proposed federal acquisitions for the Lower Suwannee National Wildlife Refuge, and proposed state acquisitions of lands adjacent to Cedar Scrub State Reserve, lands south of Crystal River, and the Chassahowitzka Swamp will contribute substantially to the protection of manatee habitat. Also, the proposed Big Bend Grassbeds National Marine Sanctuary would protect seagrass meadows north of Suwannee.

Existing state lands adjacent to manatee habitat include Manatee Springs State Park, Cedar Scrub State Reserve, Waccasassa Bay State Preserve, St. Martin's Marsh Aquatic Preserve and a parcel adjacent to Crystal River. Protected federal lands include the Cedar Key, Chassahowitzka, Crystal River Manatee and portions of the Lower Suwannee national wildlife refuges. Crystal River is designated Critical Habitat for manatees.

Therefore, wetlands adjacent to core manatee habitat are partially protected near the Suwannee, but not protected near Crystal River. Only a portion of important manatee habitat in South Big Bend has been designated Critical Habitat. The lower Suwannee, lower Withlacoochee, and Homosassa rivers should be designated as Critical Habitat. Expansion of the Crystal River Manatee, Lower Suwannee, and Chassahowitzka national wildlife refuges is needed to provide full protection of core manatee habitat.

WARM-WATER REFUGES

The quantity of water flowing from South Big Bend's springs needs to be maintained to insure the protection of essential warm-water refuges for manatees. If water withdrawal from the aquifer that provides spring water exceeds recharge rates, the volume of water warmed by springs may drop, salinity of river waters may increase, and flow patterns could change or cease. Estuarine and even marine vegetation could be altered. The preservation of the natural flow of these springs should merit priority over other water uses, not only due to their importance for manatees, but also for fisheries and recreational values.

Impacts

The quantity or salinity of water flowing from natural springs in Kings Bay or Homosassa River might be altered by water withdrawal from the aquifer or reduction of recharge areas. If the volume of water flowing from springs decreases, water temperature around springs may drop, increasing manatees' exposure to cold waters and its associated health risks. Over the long-term, manatees would be more likely to leave the area for warmer refuges. The salinity of estuaries and rivers could change, resulting in degradation of estuarine vegetation and fewer sources of fresh water for manatees.

Current Regulations

Water management districts, which regulate consumptive use of water, can deny permits for uses that are not in the public interest. Any water-use substantially reducing the flow of springs in Crystal and Homosassa rivers is clearly contrary to the public interest. However, the State Water Use Plan does not currently designate preservation of natural springs in Crystal and Homosassa rivers as a priority water-use. Studies are now in progress to establish minimum flow standards for the rivers in South Big Bend.

Information Needs

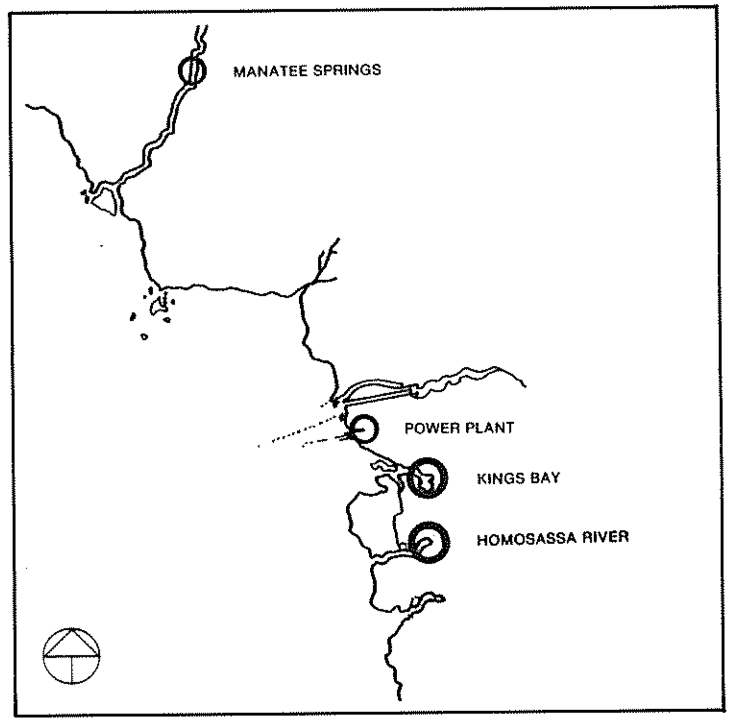
The effects of springs on water temperature in Kings Bay and the headwaters of the Homosassa River need to be determined. A model needs to be developed to predict the effects of water withdrawal and alteration of recharge areas on the flow of springs in Crystal and Homosassa rivers.

Management Policy

To meet the objectives of this plan, actions should be consistent with the following management policy:

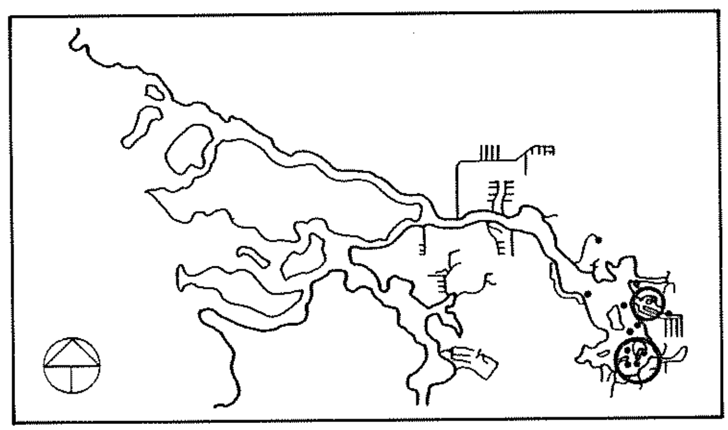
- It is in the public interest to maintain the flow of springs that manatees use as warm-water refuges; and these springs merit priority over consumptive use of water in the Withlacoochee region.
- When permitting consumptive water uses, agencies must consider the cumulative effects of water withdrawals from the aquifers that supply the region's springs.
- The needs of manatees should be considered in setting minimum flow standards for the rivers in South Big Bend.

REFER TO SECTION IV.6



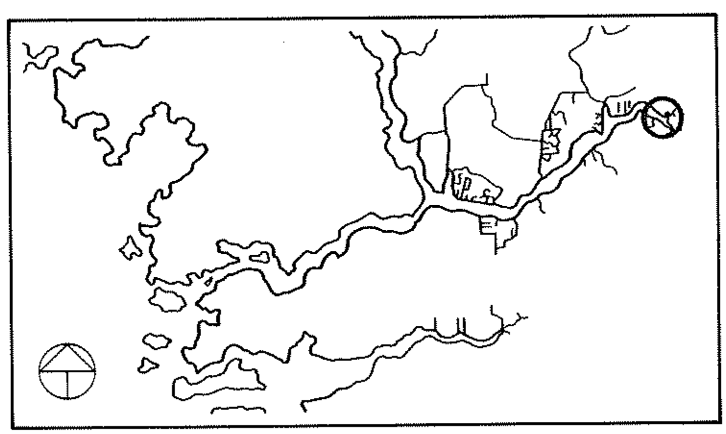
O Major refuges
O Minor refuges

SOUTH BIG BEND
WARM-WATER REFUGES



• Natural spring
O Site where manatees gather

CRYSTAL RIVER
WARM-WATER REFUGE



• Natural spring
O Site where manatees gather

HOMOSASSA RIVER
WARM-WATER REFUGE

CONCLUSIONS

Manatees have captured the imagination, respect, and scientific interest of people throughout the nation and the world. Current development trends threaten the integrity of the coastal ecosystem that supports manatees in South Big Bend. With foresight, the survival and growth of the Crystal River manatee subpopulation can be assured if the recommendations listed in this plan are implemented.

Boating Facilities
By planning the location and size of future boating facilities in South Big Bend, risks to manatees can be reduced. Under current regulations, boat density and the proportion of large to small boats is expected to increase at almost all coastal access points. As a result of these probable changes, the probability of manatee mortality would increase.

Boating, Swimming and Fishing
The rare opportunity to view manatees in Crystal River should be preserved; however, the regulations that protect manatees must be enforced. An effective public education program will reduce the need for further regulations. If recommendations of this plan are not implemented, the density of boats and swimmers in Kings Bay will increase, disturbing manatees and exposing them to cold stress and injury.

Water Quality and Vegetation
Maintenance of good water quality in Crystal River is still possible if permitting standards are based on a comprehensive water quality model. The use of herbicides in South Big Bend's waters should be reduced because of their potential harm to manatees. Under current regulations, manatee food resources in Kings Bay will remain adequate, but estuarine vegetation will decline due to adverse changes in water quality and salinity. Chemical contaminants and risk of disease from inadequately treated wastewater will increase, possibly impairing the health of manatees.

Land Development
By setting design standards and clustering land development in appropriate locations, the natural functions of the coastal ecosystem can be preserved. If recommendations of this plan are not implemented, the cumulative effects of unplanned land development will severely reduce the quality of manatee habitat.

Land Protection
The productive South Big Bend coastal ecosystem can still be maintained by expanding the present system of state and federal refuges, reserves and preserves. If wetlands are left unprotected, patterns of water flow and water quality could be altered, reducing the ability of the area to support manatees.

Warm-Water Refuges
Natural springs are the Crystal River manatees' essential refuges from cold winter waters. Regulations should be enforced to insure that human water demands do not adversely affect the flow of these springs.

REFER TO SECTION VI

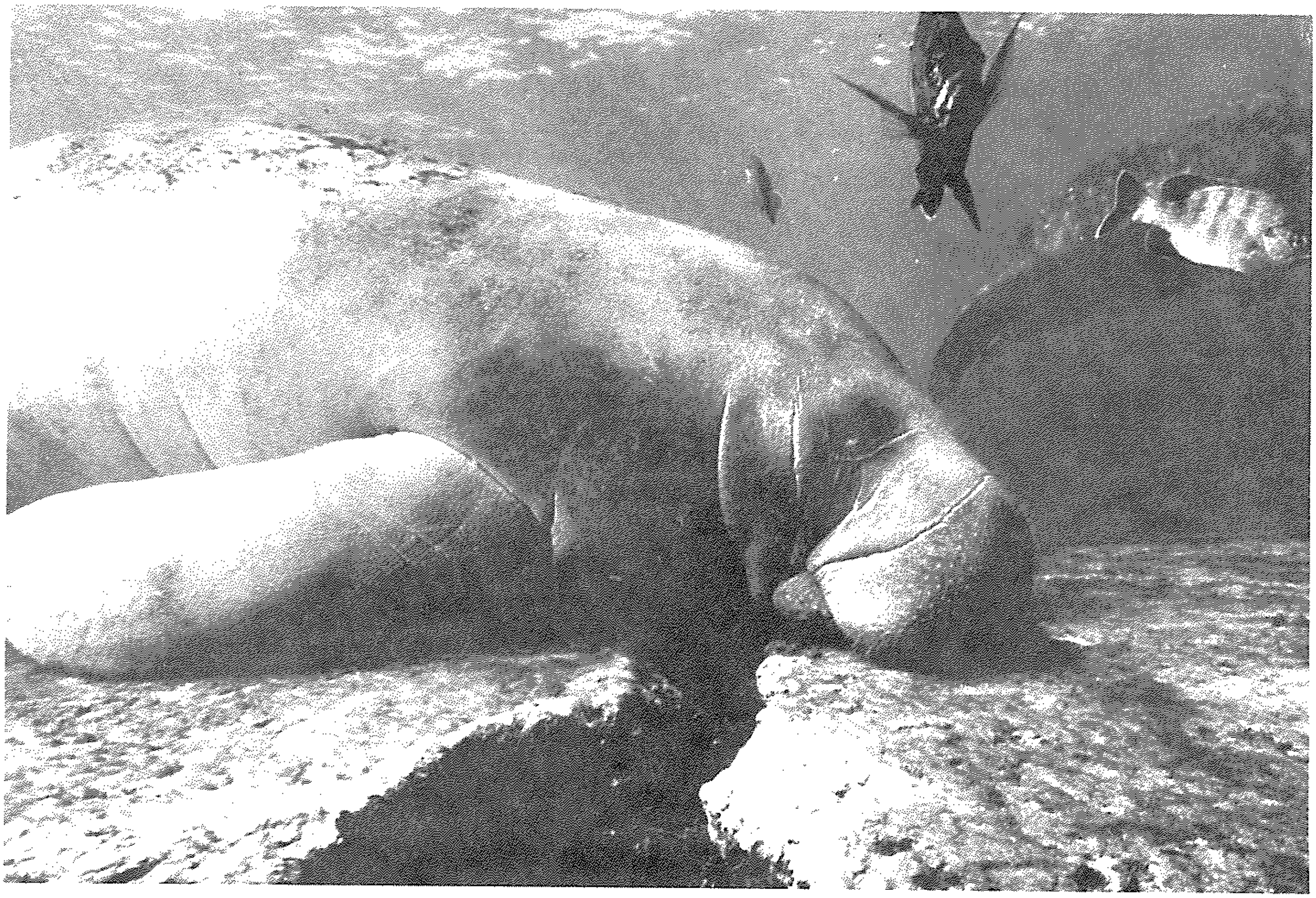


PHOTO: P. ROSE

"Why all the bother, why care about jeopardizing the manatee? What good is a manatee anyway? Aside from the obvious importance of the Crystal River manatees to the Citrus County economy from tourism, there are important philosophic aspects to such questions. Every species is a wonderful, unique, irreplaceable entity. Society should not stand for the extinction of a species any more than it should stand for the desecration of some great sculpture. Yet with the loss of a work of art there is always the hope that some talented genius may someday recreate that object; with the loss of species that hope can never be raised. Each human-related extinction signals the fact that we have in some way irrevocably changed the environment. It means that our planet can no longer support yet another form of life. The earth becomes a little less healthy, and we all become a little less human." (T. J. O'Shea, Research Biologist)

PROPOSED RESEARCH/MANAGEMENT PLAN FOR

CRYSTAL RIVER MANATEES

VOLUME II

FLORIDA COOPERATIVE FISH
AND WILDLIFE RESEARCH UNIT

UNIVERSITY OF FLORIDA

TECHNICAL REPORT NO. 7

PROPOSED RESEARCH/MANAGEMENT PLAN FOR

CRYSTAL RIVER MANATEES

Volume II
Technical Plan
Final Report

Prepared by:
Jane M. Packard - Project Leader

December 1983

Submitted to:

Florida Cooperative Fish and Wildlife Research Unit
117 Newins-Ziegler Hall
University of Florida
Gainesville, FL 32611

Supported by:

U.S. Fish and Wildlife Service
75 Spring St. S.W.
Atlanta, GA 30303

Marine Mammal Commission
1625 I Street, N.W.
Washington, D.C. 20006

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Work Order No. 1

DISCLAIMER

The views, ideas and opinions expressed in this report are those of the author and are not necessarily shared by any of the individuals, agencies or agency staffs that provided advice, financial or technical support to the study.

NOTE

This document is the second of a three-volume report:

Volume I: Summary
Volume II: Technical Plan
Volume III: Compendium

Citation of this volume should read: Packard, J. M. 1983. Proposed Research/Management Plan for Crystal River Manatees. Volume II. Technical Plan. Technical Report No. 7. Florida Cooperative Fish and Wildlife Research Unit. University of Florida. Gainesville, Florida. 235 pp.

COVER PHOTO: Courtesy Galen Rathbun, Sirenia Project, FWS

PROJECT TEAM

Leader:

Jane M. Packard, Postdoctoral Associate
School of Forest Resources and Conservation
University of Florida

Consultants:

David Gluckman, Attorney at Law
Tallahassee, Florida

Richard Hamann, Assistant Director
Center for Governmental Responsibility
University of Florida

Catherine Puckett, Graduate Student
College of Journalism and Communications
University of Florida

Orjan Wetterqvist, Associate Professor
Department of Urban and Regional Planning
University of Florida

Assistants:

Jimmy Franko
Douglas Graham
Paloma Ibarra
Jack Ponikvar
Holly Price
Debby Stinson
Robert Wolf
Maria Zifou
Wendy Zomlefer

Fish and Wildlife Service Liaison Officer:

Richard W. Gregory, Unit Leader
Florida Cooperative Fish and Wildlife Research Unit

PREFACE

In 1980, the U.S. Marine Mammal Commission (MMC) recommended to the U.S. Fish and Wildlife Service (FWS) that site-specific research and management plans be prepared for the various subpopulations of manatees in Florida and that the development of a plan for the Crystal River area be undertaken as a pilot program to serve as a model for future plans. The MMC transferred $25,000 as its contribution to the FWS for this purpose and recommended specific terms of reference for the study. Supplemented by additional funds from the FWS, this project was conducted under a Research Work Order negotiated between the University of Florida and FWS through the Florida Cooperative Fish and Wildlife Research Unit (FCFWRU). The FCFWRU has as cooperators the FWS, University of Florida, the Florida Game and Fresh Water Fish Commission and the Wildlife Management Institute. The project was administered by the School of Forest Resources and Conservation, Institute of Food and Agricultural Sciences, University of Florida.

A steering committee guided preparation of the plan, and reviewed each draft. The committee included: John Christian, Regional Office, FWS; Casey Gluckman, Division of Resource Management, Florida Department of Natural Resources; Marshall Jones, Regional Office, FWS; David Laist, MMC; David Peterson, Endangered Species Field Office, FWS; Galen Rathbun, Sirenia Project, FWS; Patrick Rose, Florida Department of Natural Resources.

This proposed plan represents recommendations to the various agencies involved. We anticipate that those agencies will review the information and solicit comments from the public prior to preparing and adopting a final plan.

Volume II
TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd.)

TABLE OF CONTENTS (cont'd.)

ACKNOWLEDGMENTS

This project was funded by the U.S. Fish and Wildlife Service (FWS) and the Marine Mammal Commission (MMC). Administrative and logistical support was provided by the Florida Cooperative Fish and Wildlife Research Unit (FCFWRU) and the School of Forest Resources and Conservation (SFRC), Institute of Food and Agricultural Sciences, University of Florida. We thank Richard Gregory (Unit Leader, FCFWRU), H. Franklin Percival, (Research Biologist, FCFWRU), Arnett Mace (Director, SFRC) and a fine staff for their support and assistance.

We are sincerely grateful for the interest, cooperation, and information provided by many individuals and citizens' groups during this project. Insight regarding potential problems associated with manatee protection was furnished during discussions with a number of local residents of Crystal River and Homosassa Springs, including: Marie Bienkowski (resident, Crystal River), Edward Ashley Benziger (manager, Port Paradise Marina), Charles Black (Black and Cannon Realty), Melvin and David Bordine (shrimp fishermen, Crystal River), Mr. and Mrs. Donald Briercheck (residents, Crystal River), James Brown (owner/manager, Brown's Crab House), Gertrude Card (resident, Crystal River), Hank and Miriam Cohen (Concerned Citizens of Citrus County, Inc.), Phillip and Gay Courtier (residents, Crystal River), Robert and Pearl Dick (residents, Crystal River), John Elmer (fishing guide, Crystal River), Russ Fee (sportswriter, Citrus County Chronicle), Robert and Shirlee Foster (shrimp fishermen, Crystal River), Linda Goodman, (resident, Crystal River), Pat Hammer (owner, Berry's Scuba), Mike Hampton (manager, Cedar Key Seafood), Bruce Hasset (manager, Berry's Scuba), Jerry Hogan (owner, Crystal Lodge Dive Center), Doris Howze (member, Manatee Technical Advisory Council), Jim Hunter, (reporter, Citrus County Chronicle), Marion Knudsen (chairman, Citrus County Protective Association, Inc.), Phillip Kofmel (Crystal River Seafood), James LeGrone (Black and Cannon Realty), Sam Lyons (president/general manager, Plantation Inn Marina), Bob Marvin (fisherman, Withlacoochee River), Peter Newton (Seasweet Crab Meat, Co.), Don Owens (owner, Knox's Bait House), Renee Priest, (administrator, Save the Manatee Committee), Fred Reed (instructor, Crystal Lodge Dive Center), Ernie and Irene Schustik (residents, Crystal River), Bob Saunders (employee, Pete's Pier), John Sikes (manager, Homosassa Seafood), Helen Smith (president, Citrus County Audubon Society), Virginia Splitt (resident, Yankeetown), Charles D. Talley (owner, Talley's Pro Dive), Mike Walls (shrimp fisherman, Crystal River), Wilbur Wisenbaker (manager, Pete's Pier), Lois Worley (owner/manager, Brown's Crab House).

Information was also provided by Florida Defenders of the Environment, Suwannee River Coalition, the Florida Chapter of The Nature Conservancy, Concerned Citizens of Citrus County, Inc., and Citrus County Protective Association.

The cooperation of local government agencies has been particularly valuable during development of this plan, because they are in a position to balance the needs of local citizens and the interests of the state and nation. Valuable input was provided by: George Allen (Director, Citrus County Department of Safety), John Barnes (Commissioner Citrus County

Commission), Charles Bradley (Director, Environmental Health, Citrus County Health Department), David Conrad (Sanitarian Supervisor, Citrus County Health Department), Avis Craig-Ayotte (Director, Citrus County Planning Division), Tom Dick (Director, Citrus County Aquatic Services Division), Ed Dougherty (Director, Citrus County Department of Public Works), John Morrison (previous City Manager, Crystal River), Pat Purcell (Citrus County Marine Science Center), Ken Reddeman (Citrus County Planning Division), Ed Sell (Citrus County Aquatic Services Division), and John Wishart (Director, Citrus County Department of Development).

Cooperation of regional agencies has been invaluable, including: Withlacoochee Regional Planning Council, Southwest Florida Water Management District, and the Suwannee River Water Management District.

We thank Casey Gluckman, Pat Rose, and Dale Adams (Department of Natural Resources) for their assistance in contacting state agencies. Useful information was provided by the Department of Natural Resources (Division of Resource Management, Bureau of Aquatic Plants Research and Control, Division of State Lands, Division of Recreation and Parks, Marine Patrol, Office of Information and Education), the Department of Environmental Regulation (Bureau of Water Management, Office of Coastal Zone Management), Florida Sea Grant Program, Florida State University (Communication Research Center), University of Florida (Aquatic Weed Research Center, Wetlands Center).

We are very grateful to Galen Rathbun, Tom O'Shea, Buddy Powell, Bob Bonde, and Cathy Beck of the Sirenia Project, Denver Wildlife Reserch Center FWS , for providing information regarding the Crystal River subpopulation of manatees. This project would not have been possible without the results of their long-term research and their assistance.

The support and encouragement of John Christian (Assistant Regional Director for Federal Assistance Atlanta FWS Regional Office) throughout this project have been essential to its completion. Both Marshall Jones (FWS, Atlanta) and Dave Peterson (FWS, Jacksonville) have been instrumental in many aspects of the project. Other FWS officers providing assistance include the Endangered Species Field Office (Jacksonville, FL), National Coastal Ecosystems Team (Slidell, LA), and the Chassahowitzka National Wildlife Refuge (Homosassa, FL). The Marine Mammal Commission's Executive Director, John Twiss, and staff members, David Laist, and Peter Major, contributed substantially to defining the direction and scope of this project and in its completion. Information was provided by the Jacksonville, Vicksburg, and Crystal River offices of the Army Corps of Engineers.

All members of the project team and steering committee contributed a great deal of thought and effort in preparation, review, and revision of drafts of this document. The draft report was also reviewed in detail by John Reynolds and Dan Odell. We thank all persons, even those who are not here mentioned by name who directly or indirectly contributed to this project.

LIST OF TABLES

LIST OF TABLES (cont'd.)

LIST OF FIGURES

LIST OF FIGURES (Cont'd.)

LIST OF FIGURES (Cont'd.)

LIST OF FIGURES (Cont'd.)

LIST OF ACRONYMS

Acronym	Meaning
ACS	Florida Department of Agriculture and Consumer Services
ACSC	Area of Critical State Concern
ASD	Citrus County Aquatic Services Division
CC	Citrus County
CCC	Citrus County Commission
CCPD	Citrus County Planning Department
CCSD	Citrus County School District
COE	U.S. Army Corps of Engineers
CORM	U.S. Office of Coastal Ocean Resource Management
CR	City of Crystal River
CRC	Crystal River City Council
CRPD	Crystal River Planning Department
CZM, CZP	Florida Bureau of Coastal Zone Management
DCA	Florida Department of Community Affairs
DER	Florida Department of Environmental Regulation
DHS	Florida Department of Health and Rehabilitative Services
DNR	Florida Department of Natural Resources
DRI	Development of Regional Impact
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FCFWRU	Florida Cooperative Fish and Wildlife Research Unit
FEMA	Federal Emergency Management Agency
FL	Florida Legislature

LIST OF ACRONYMS (cont'd.)

Acronym	Organization
FMSA	Florida Manatee Sanctuary Act
FWS	U.S. Fish and Wildlife Service
GC	Florida Governor and Cabinet
GFC	Florida Game and Fresh Water Fish Commission
NCFRPC	North Central Florida Regional Planning Council
NWR	National Wildlife Refuge
MMC	U.S. Marine Mammal Commission
MMPA	Marine Mammal Protection Act
MP	Florida Marine Patrol
NOAA	National Oceanic and Atmospheric Administration
OCM	Office of Coastal Management
RPMC	Regional Planning and Management Committee
SFRC	School of Forest Resources and Conservation
SMC	Save the Manatee Committee
SRWMD	Suwannee River Water Management District
SWFMD	Southwest Florida Water Management District
TIIF	Trustees of Internal Improvement Trust Fund
TNC	The Nature Conservancy
USGS	U.S. Geological Survey
WRPC	Withlacoochee Regional Planning Council
WRWSA	Withlacoochee Regional Water Supply Authority
ZBA	Citrus County Zoning Board of Adjustments

Section I

SECTION I

INTRODUCTION

Without protection, the West Indian manatee (Trichechus manatus) would be in danger of extinction in Florida (FWS 1980). To aid in recovery of the endangered Florida population of manatees, the U. S. Fish and Wildlife Service (FWS) has determined the need for planning on a site-specific basis (FWS 1981a) because the difficulties involved in protection of manatees differ from one location to another.

The area inhabited by Crystal River manatees has been chosen as the first site for an in-depth analysis of the overlap between human activities and manatee needs. Crystal River manatees are sighted most frequently in the coastal region between (and including) the Suwannee and Chassahowitzka rivers (Figure 1). This area, South Big Bend, is part of a relatively undisturbed section of coast in northwestern Florida, called Big Bend (Figure 1). Only two intact coastal ecosystems remain in Florida: Big Bend and the Everglades (Carter 1974). Although the Everglades coast is protected as a national park, the majority of the Big Bend coast is not protected. Manatees are more common in the southern than in the northern portion of Big Bend, probably due to the existence of natural springs that provide warm-water winter refuges.

Human population centers have drastically altered the character of the remaining Florida coast, reducing its value as manatee habitat. If a catastrophic kill of manatees occurred in those areas, the South Big Bend region could remain one of the last secure centers from which manatees could disperse to repopulate adjacent areas. In addition, the Crystal River area offers a unique opportunity for the public to view and interact with manatees. However, Crystal River is adjacent to one of the growth centers of Florida (Figure 1).

One of the purposes of this plan is to make accessible to citizens and to all levels of government, the information needed for a coordinated effort to protect manatees and their habitat in South Big Bend. With careful planning, the cumulative effect of human activities need not approach a trade-off where preservation of an endangered species receives lower priority than human economic welfare. However, this planning must be implemented on a local basis, where it is often most difficult to assess cumulative effects of human activities, and where resources are usually not available to assess the needs of an endangered species.

The West Indian manatee is a unique species. It is the only herbivorous (plant eating) marine mammal that inhabits the waters of the United States. Its plant-eating habits bring it into shallow estuaries and river systems where it is more easily sighted than marine mammals that feed in deeper waters. The low metabolic rate associated with herbivory may partially account for its slow-moving and seemingly gentle nature which has won public appeal. Manatees do not directly compete with humans for resources of economic value, but were hunted for meat, fat and hides prior to depletion of

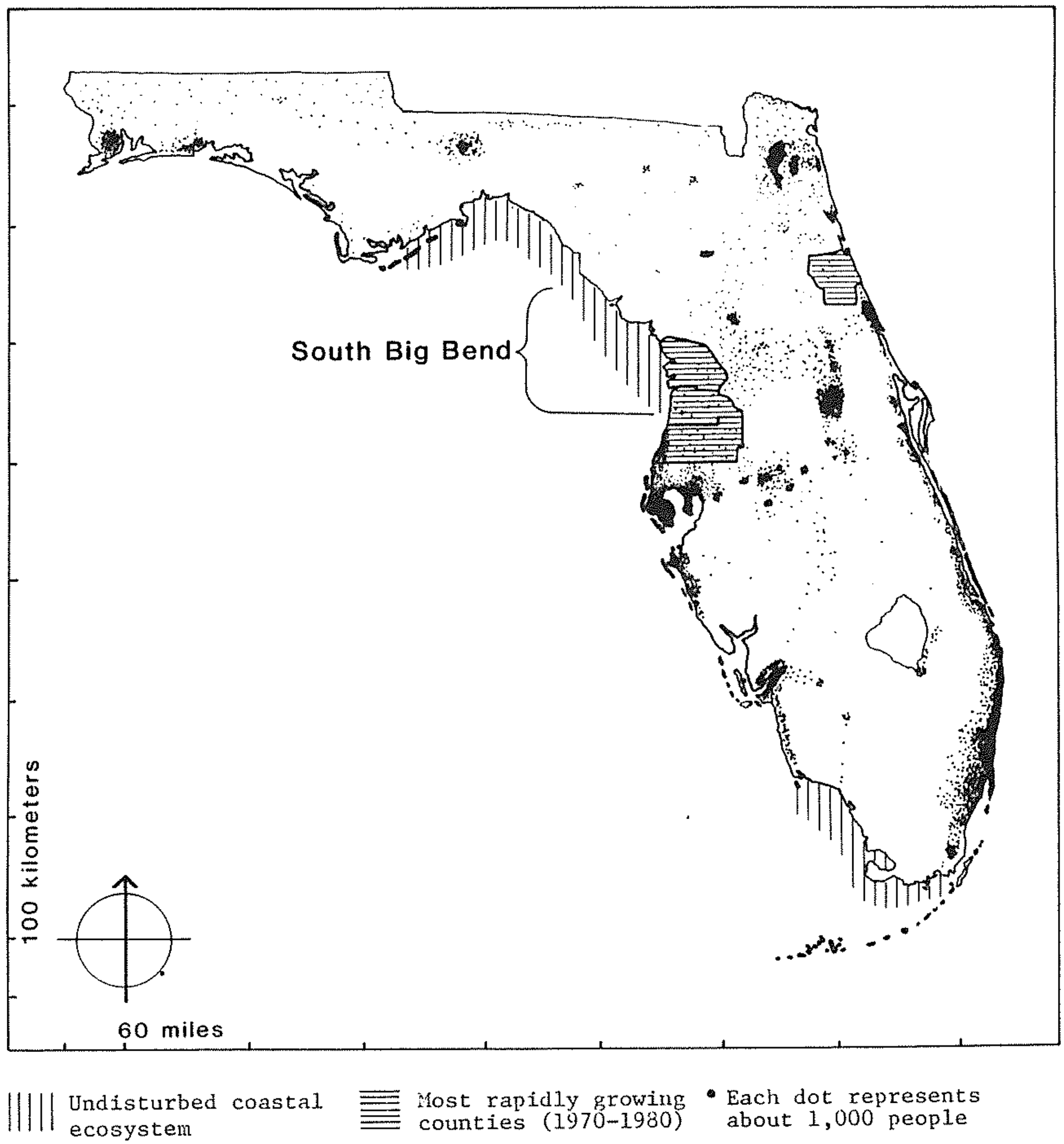


FIGURE 1: RELATION OF THE MANAGEMENT AREA TO URBAN CENTERS AND GROWTH CENTERS IN FLORIDA.
Data are from Carter (1974) and Fernald (1981).

the population. Manatees can coexist with human activities when given the essential elements of protection; for example, boat basins and canals are often favored resting sites for manatees. However, this tolerance of humans also exposes manatees to the risks of human activities.

1. DEVELOPMENT OF THE PLAN

To identify current conflicts and opportunities to avoid future risks, citizens and agencies at the city, county, regional, state, and federal levels were contacted during development of this plan. A large number of people (see pages v-vi) cooperated in providing the information that was compiled, and in identifying information needs.

The scientific basis for defining the needs of manatees (Section II) was provided by results of research conducted in Crystal River and statewide, since 1972. This research was initiated by Daniel S. Hartman and continued by the FWS Sirenia Project. Additional information was obtained during site visits, but active research was not required.

Land-use planning techniques (Ray et al. 1978) were used to analyze the overlap of manatee habitat and human activities. This technique aids in defining the functional aspects of habitat critical to the survival of manatees. Recognizing that it may be very difficult to exclude all human activities from areas important to manatees, the focus was on maintaining essential functions of manatee habitat, while providing for planned development. Whenever available information was inadequate for conclusive analysis, research needs were noted, and recommendations were made contingent on collection of additional information.

A review of laws and regulations pertaining to protection of manatees and their habitat was an essential component in development of this plan. Current regulations were reviewed to evaluate the adequacy of controls over the impacts of human activities on manatees. The legal review provided insight in defining alternative management options.

This proposed research/management plan presents, as much as possible, the wide range of views of persons actively involved in, or affected by, manatee protection in South Big Bend. Its emphasis is on presenting information and clarifying issues to aid decision-makers at all levels of government.

Further development of this plan will involve a period of review by the public and all involved agencies prior to preparation and publication of a final draft by the FWS. Even when the final plan is adopted, it should be periodically reviewed and revised. This plan initiates a dynamic process of problem-resolution, and provides a framework for coordinated effort to protect an invaluable resource for future generations.

2. USER'S GUIDE TO THE PLAN

This proposed research/management plan consists of three volumes: a condensed summary, the technical plan and a compendium of information that was utilized in preparation of the plan. This format was chosen to make the information accessible to readers with a variety of interests and backgrounds. The following brief description of the information contained in each of these volumes will aid you in finding those sections of the plan that are most relevant to you.

Volume I. Summary: The first volume is a short summary of the technical plan that will serve as an introduction and overview. The information is presented in a non-technical manner. If you are an interested citizen, or a public official, the summary will probably provide sufficient information for your interests. If you want more details, or are in a planning agency, in a permitting office, or otherwise involved in resource management, you may want to use the summary to gain an overview of the plan and as a guide to identify the sections of the plan that provide the information you need.

Volume II. Technical Plan: This volume contains technical details of the proposed research/management plan. It is organized so that you do not need to read the entire document if time is short, but can turn to the information most relevant to you.

The plan is in loose-leaf format to facilitate future revisions. Titles of sections and subsections appear at the lower right corner.

If you are interested in a general overview, turn first to the executive summary (Section VI). The step-down plan (Section V) is presented in outline form following analysis of the issues (Section IV). Both these sections are subdivided into categories somewhat representative of the jurisdictions of government agencies: a) location of boating facilities and navigation channels, b) operational aspects of waterborne activities, c) water quality and vegetation, d) development of lands adjacent to manatee habitat, e) protection of manatee habitat, and f) effects of water demands on warm-water springs. Topics covered in these categories and agencies for whom the information is targeted are listed in Table 1.

If you are interested in the analysis that led to the list of actions in the step-down plan, refer to Section IV. Each of the subject categories is subdivided in the same manner. First, the overlap of manatee habitat and human activities is analyzed on a site-specific basis. Second, current regulations and their relevance to site-specific issues are reviewed. The alternative management actions are then listed, and evaluated as to suitability in meeting the objectives of the plan. Next, additional information that is needed to make management decisions is identified. Finally, the management policy and recommended actions for each agency or group are listed. If you want to focus in the actions recommended for a particular agency, turn to the appropriate subheading at the end of each subject category in Section IV. Recommendations are outlined in more detail in Section IV than in the step-down plan (Section V).

Table 1. Index to topics covered in Sections IV and V.

Subsection of Plan		Topics Covered	Target Agencies[1]	
IV. 1.	Location of Boating Facilities and Navigation Channels	Factors influencing location of boat traffic	NCFRPC	DNR
		Marina-siting	CC	TJIF
		Multiple-slip docks	COE	WRPC
		Boat ramps	CR	
		Dredge and fill	DCA	
			DER	
IV. 2.	Operational Aspects of Waterborne Activities	Public viewing and education	CC	SMC
		Boat speed zones	COE	
		No-entry sanctuaries	DNR	
		Fishing practices	FWS	
		Snorkeling and diving	GFC	
		Harassment	MP	
IV. 3.	Water Quality and Vegetation	Aquatic plant control	CC	FWS
		Point-source effluents	COE	USGS
		Seepage from septic tanks	DER	WRPC
		Water contaminants	DHS	
		Stormwater runoff	DNR	
		Water clarity	EPA	
IV. 4.	Development: Seawalls, Dredge and Fill, Zoning	Land-use adjacent to manatee habitat	NCFRPC	FWS
		Seawalls	CC	WRPC
		Dredge and fill in wetlands	COE	
		Drainage from uplands	DCA	
		Performance standards	DER	
			DNR	
IV. 5.	Protection of Manatee Habitat	Land acquisition	CC	
		National Wildlife Refuges	DNR	
		Management plans for state reserves and preserves	FWS	
			CORM	
		Marine Sanctuary	SMC	
		Aquatic Preserve	TNC	
IV. 6.	Warm-water Springs, Water Demands	Consumptive water-use	DER	WRPC
		Minimum flow	SRWMD	
		Aquifer recharge	SWFMD	
		Warm industrial effluents	USGS	

[1]See List of Acronyms (pg viii) for agency names. Agencies are listed alphabetically.

Objectives of this plan (Section III) provide the basis for evaluation of alternative management options. When possible, quantitative evaluation criteria are listed for each objective, to aid in monitoring progress in meeting objectives. Background information required to formulate these objectives is presented in Section II. Data on the legal status, management area, abundance and distribution of manatees, habitat evaluation and potential impacts of human activities are compiled in Section II.

In other words, this document follows a logical progression from basic information, to objectives, to analysis and ending with recommendations. If you do not have the time to follow the entire sequence, it is organized so that you can turn directly to most relevant sections.

Volume III. Compendium of Information: The information in the management plan has been taken from published and unpublished manuscripts that may not be readily available. These manuscripts have been compiled in the compendium, for the reference of readers who desire more background information or who have questions that are not addressed directly in the plan. Wherever relevant, the compendium is referenced to support summary statements that appear in the plan.

Section II

SECTION II

BACKGROUND INFORMATION

The information in this chapter provides the background needed to define objectives and the means of meeting those objectives in following chapters (Sections III and IV respectively). The first subsection, regarding legal protection and public involvement, provides a basis for why manatees should be protected. Geological, biological and geographical aspects of the management area are described in the second subsection. In the third subsection, distribution, abundance and demographic trends of South Big Bend manatees are reviewed. The spatial location of manatee needs is evaluated in the fourth subsection on habitat requirements of manatees. Finally, the direct and indirect effects of human activities on manatees throughout Florida are briefly reviewed to provide a basis for identifying potential problems in protecting the manatees of South Big Bend.

1. LEGAL PROTECTION AND PUBLIC INVOLVEMENT

Manatees have captured the imagination, respect, and scientific interest of people throughout the nation and the world. The legal framework that protects manatees reflects this widespread interest and concern. The chronological development of laws protecting manatees is described in subsection II.1.1. A more detailed listing of state and federal laws relevant to protection of manatees and their habitat has been compiled by Gluckman and Hamann (1983). Operation of these laws is described in more detail in Section IV under headings of "Current Regulations." Beyond the legal reasons for protecting manatees, there are socio-economic reasons for protecting the species and its habitat, as described in Section II.1.2.

1.1 Legal Protection

The need for protection of manatees was recognized as early as 1893 when the Florida Act (Ch. 4208.94) was passed, and has continued to the present (Table 2). Apparently, the number of manatees had been reduced to low levels during the Spanish occupation (Hartman 1974); possibly in part because Indians supplied manatee meat to the Spaniards (Canova 1885, cited in FWS 1980). In 1907, the 1893 law was made more effective when an amendment (Ch. 370.12) was added imposing penalties for killing or molesting a manatee. To allow capture for scientific or educational purposes, the 1907 statute was further amended in 1953. Despite this protection, manatees apparently were poached for meat during the Depression and World War II. Although quantitative data are not available, the manatee population in Florida did not appear to increase appreciably during this period (Hartman 1974).

Manatees were recognized to be of national significance in 1967 when the species was listed as endangered under the federal Endangered Species Preservation Act of 1966. The State of Florida's Department of Natural Resources and Game and Fresh Water Fish Commission were given responsibility for manatee protection and the federal program authorized acquisition of habitat. The manatee was listed again as endangered when the Endangered Species

Table 2. Major state and federal actions protecting manatees in Florida.

Year Enacted	Legal Status	Responsible Agency
Florida		
1893	Protection	Department of Natural Resources
1907	Penalty for killing or molesting	Department of Natural Resources
1953	Allow capture for scientific or educational purposes	Department of Natural Resources
1977	Endangered and Threatened Species Act (Florida) - endangered species	Game and Fresh Water Fish Commission Department of Natural Resources
1978	Manatee Sanctuary Act	Department of Natural Resources
United States		
1967	Endangered Species Preservation Act - endangered status	Department of Interior
1972	Marine Mammal Protection Act - depleted status	Department of Interior
1973	Endangered Species Act (federal)	Fish and Wildlife Service
1976	Cooperative agreement between state and federal governments	Fish and Wildlife Service Department of Natural Resources Game and Fresh Water Fish Commission
1980	Recovery Plan completed	Fish and Wildlife Service
1981	Comprehensive Work Plan completed	Fish and Wildlife Service

Conservation Act of 1969 superceded the 1966 Act. The 1969 Act extended protection worldwide and regulated importation.

State jurisdiction over manatees was pre-empted by the Marine Mammal Protection Act (MMPA) of 1972 (P.L. 92-522; 80 Stat. 1027), which vested jurisdiction in the Department of the Interior. The MMPA established a national policy recognizing the importance of maintaining the health and stability of the ecosystems that support marine mammals, a mandate that may go beyond the jurisdiction of one state. The MMPA is designed to "protect marine mammals to obtain and maintain optimum sustainable population levels consistent with the health and stability of the ecosystem" (FWS 1980, pg. 9). As provided for under the MMPA, the state may submit an application to the Secretary of the Interior requesting that management authority for manatees be returned to the state. To date, Florida has not filed such a request. The MMPA establishes a moratorium, with certain exceptions, on the "take" (including harass, hunt, capture, kill or attempting any of these activities) of any marine mammal. A federal permit may be issued to "take" marine mammals for purposes of scientific research or public display; however, since manatees are considered "depleted" under the Act, permits are limited to scientific research activities.

Federal protection of manatees was increased when the Endangered Species Act (ESA) of 1973 (P.L. 94-359; 90 Stat. 913) superceded the 1969 Act. The ESA provides legal protection (illegal to harass, harm, pursue, hunt, shoot, wound, kill, capture or collect) and regulates importation and exportation of endangered species. Permits are required for actions (which would otherwise be prohibited) to enhance the survival of the species or for scientific research. The ESA also requires that all actions of federal agencies must provide for and not jeopardize continued existence of endangered species such as the manatee. In 1976, Critical Habitat was designated, including Crystal River, as containing "elements necessary to the normal needs or survival" of the manatee (Fed. Reg. 41 (187)). Federal manatee sanctuaries excluding waterborne activities were established in Kings Bay under the authority of both the ESA and MMPA. A regulation limiting boat speeds on the Chassahowitzka River has been renewed annually since 1980 as part of the management program for the Chassahowitzka National Wildlife Refuge. The ESA also authorized cooperative agreements between states and the federal government providing funding (2/3 federal and 1/3 state) for management, research, and law enforcement.

Florida established the first manatee sanctuary in 1973, regulating boat speeds and restricting access by boaters and swimmers in Blue Spring State Park. In 1976, the efforts of the state were aided by the federal government when a cooperative agreement among the U.S. Fish and Wildlife Service (FWS), Florida Department of Natural Resources (DNR), and Florida Game and Fresh Water Fish Commission (GFC) was signed. The Florida Manatee Sanctuary Act of 1978 (Section 370.12(2), F.S.) provides for regulation of boat speeds in areas where manatees gather, and establishes the entire state of Florida as a "refuge and sanctuary for the manatees." The state and federal governments have worked together on similar goals, and in 1979 an application from the DNR for federal funds for law enforcement and an information and education program on manatees was approved by FWS. The manatee has been designated the state marine mammal of Florida.

The ESA stipulates that the FWS is responsible for preparing a "recovery plan" to prevent further decline and to encourage recovery of manatees in waters of the United States. The ultimate goal of the nationwide Recovery Plan is to restore the species to a status where it may be removed from the endangered species list. A Recovery Plan was completed, and approved by the FWS Director in 1980 (FWS 1980). The objectives of the Recovery Plan include minimization of human-caused mortality, habitat degradation, and harassment of manatees. The Recovery Plan was augmented by a detailed Comprehensive Work Plan (FWS 1981a), which called for the development of site-specific plans such as this one. Preparation and implementation of this research/management plan for the Crystal River subpopulation of manatees is thus one of several tasks that will contribute to meeting the objectives of the statewide Recovery Plan and Comprehensive Work Plan.

1.2. Public Involvement

Local interest for the protection of manatees is also strong. The species has a high profile in the Crystal River community, and is generally regarded by local residents as a source of pride and of economic benefit due to attraction of tourists (Table 3). Protection of features that are essential to manatee habitat (e.g., seagrass beds, wetlands) also protects the commercial and sport fisheries important to the community. Local support of efforts to protect Crystal River manatees was expressed overwhelmingly during the recent efforts to purchase islands in King's Bay, to designate Crystal River as an Outstanding Florida Water, and to purchase lands adjacent to Crystal River under the state Conservation and Recreational Lands program (Puckett 1983).

However, the enthusiasm for protection of manatees wanes when a proposed action is perceived as imposing economic constraints on local enterprises. For example, several dive-shop owners perceived federal sanctuaries established in 1980 as a threat to their business, and were fearful that eventually the entire King's Bay would be closed to recreational activities (Gluckman 1983a). In general, there seems to be a consensus that wherever possible, local regulations protecting manatees are preferable to general regulations imposed by the state or federal government. As local governments are probably most sensitive to the needs of their citizens, they are in a unique position to balance the rights of the individual with the needs of the community as a whole.

Local governments have the legal power to implement several policies that would protect manatees. However, such agencies usually have limited resources for conducting studies or enforcing regulations. Therefore, this management plan aims to voice the needs of local governments and to facilitate coordination with state and federal programs.

Table 3. Indications[1] of the value of manatees and their habitat to the local community.

Item	Estimated Number
Businesses directly or indirectly benefiting from tourism associated with manatees	
Dive shops (Crystal River)	5
Motels, hotels, campgrounds on Crystal River	6
Restaurants in Crystal River	27
Service stations in Crystal River	13
Marinas on Crystal River	6
Fish and seafood (wholesale and retail) on Crystal, Homosassa, and Chassahowiztka rivers	10
Educational programs: students attending the Citrus County Marine Science Center per year (fourth grade through college)	8,000 to 10,000
Divers renting equipment from dive shops	
Per weekend in manatee season (October-March)	580 to 800
Per week (Mon-Fri) in manatee season	420 to 390
Publicity (Citrus County Chronicle: Oct. 82-Mar. 83)	
Newspaper articles related to manatees	40
Editorials related to manatees	6
Support for purchase of the Kings Bay Manatee Sanctuary by the Nature Conservancy	
Local donors (Citrus County)	270
Non-local donors	2,726
Businesses donating goods for auction	79
Local artists donating goods for auction	12

[1] From Puckett (1983).

2. THE MANAGEMENT AREA

The Crystal River manatee management area extends from Horseshoe Cove northwest of the Suwannee River, to the Chassahowitzka River and is referred to in this plan as "South Big Bend" (Figure 2). This is the southern portion of the coastal ecosystem known as the "Big Bend" of Florida, and is located between 28°30' and 29°30' north latitude. It includes the Suwannee River up to Manatee Springs and the Withlacoochee River up to Lake Rousseau. The management area covers regions most frequently occupied by the manatees that winter in the Crystal River area, although manatees are occasionally sighted farther north (Rathbun, pers. comm.) and may move from Crystal River to Anclote Keys or areas farther south (Powell and Rathbun 1983). Inland, the management area is bordered by the marshes, wooded swamps and upland areas draining into the Gulf. The offshore boundary is approximately the 6-meter (18 foot) depth contour. The geography/hydrology, plant communities, ecosystem relations and jurisdictional boundaries within the study areas are described in the following subsections. Maturo and Woodbury (1982) list additional references regarding the management area south of Waccasassa River.

2.1 Geography/Hydrology

The gradual slope of the continental shelf in the Gulf of Mexico provides a low-energy coastline with extensive shallow areas of water bordered by a wide band of lowlands (Figure 3), which are tidally influenced (Leadon and Langeland 1982). Hartman (1979:pp. 1-2) provides a good description:

> "At low water, depths of less than 2 meters occur as far as 10 kilometers offshore. The floor is broken by oyster reefs, shell deposits, limestone outcrops, and sandbars (Vernon, 1951). Although many bars are exposed at low tide, depths of up to 3 meters occur in the interbar waters and in the cuts through the oyster reefs (Dawson, 1955). In contrast, the inshore or "back-swamp" waters that flow through the network of islands are exceptionally shallow, averaging approximately 0.5 meter in depth at mean low tide (Dawson, 1955). According to the Tide Tables of the U.S. Coast and Geodetic Survey, the diurnal tidal range is 1 meter. Maximum tidal fluctuations of more than 2 meters have been recorded. Tides tend to be higher in summer under prevailing west and southwest winds, and lower in winter when east and northeast winds predominate."

Within the management area, six rivers drain into the Gulf; the Suwannee (Figures 4-6) and Withlacoochee (Figure 7) rivers begin and receive drainage from areas well beyond the coastal ecosystem. The Waccasassa River is very shallow with an intricate network of streams draining from the coastal marsh. Because it is not generally accessible to manatees, the Waccasassa River is not considered one of the major rivers in this plan. Crystal (Figure 8) and Homosassa (Figure 9) rivers are primarily spring-fed. The Chassahowitzka River (Figure 10) receives drainage from coastal marshes as well as a spring. The Suwannee River also has numerous springs, many of which are submerged, along its course. Details are available from Hartman (1979:pp. 6-7):

> "whereas the three spring-fed rivers of the study area are mostly broad, straight, and shallow, the Withlacoochee is comparatively

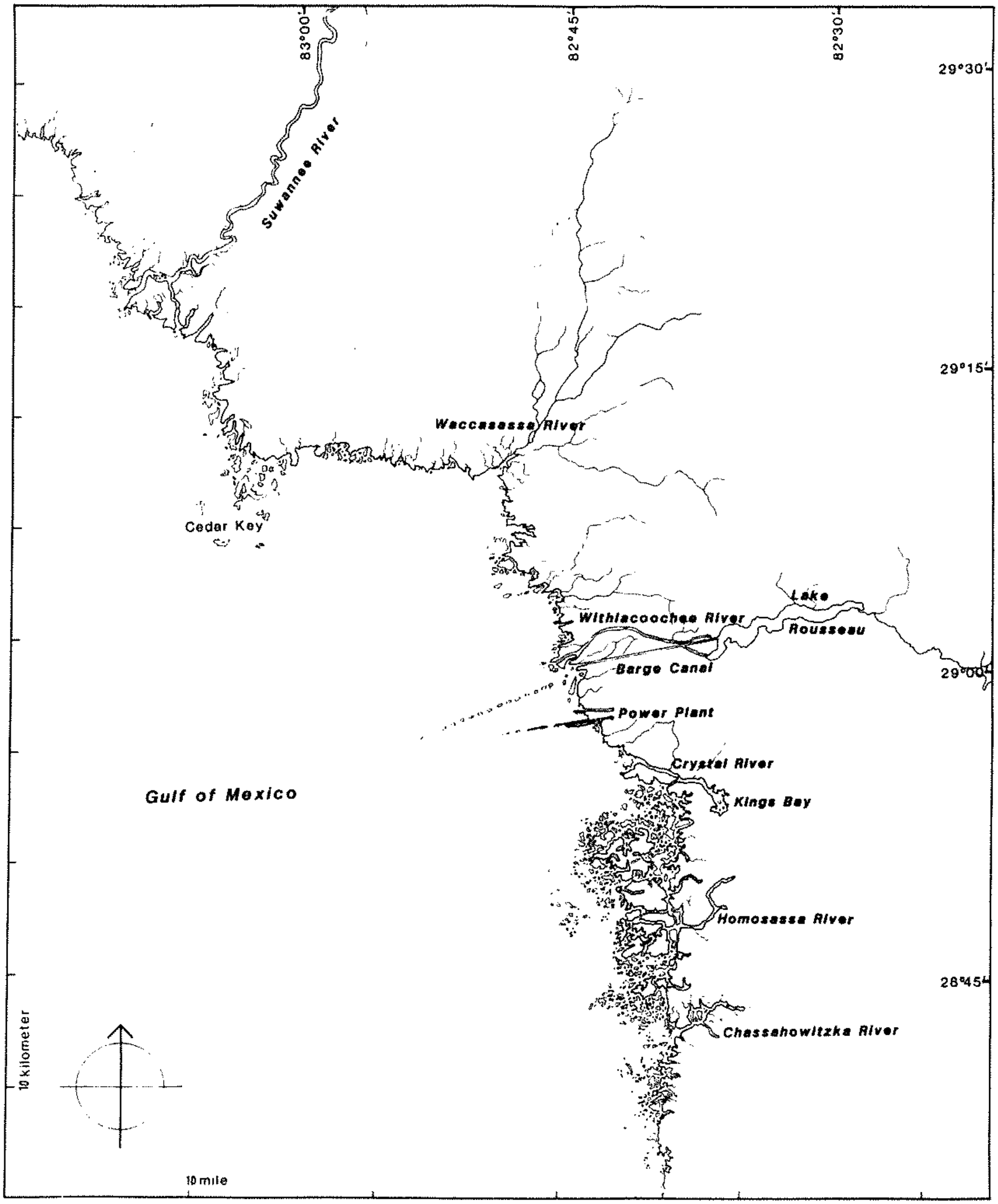
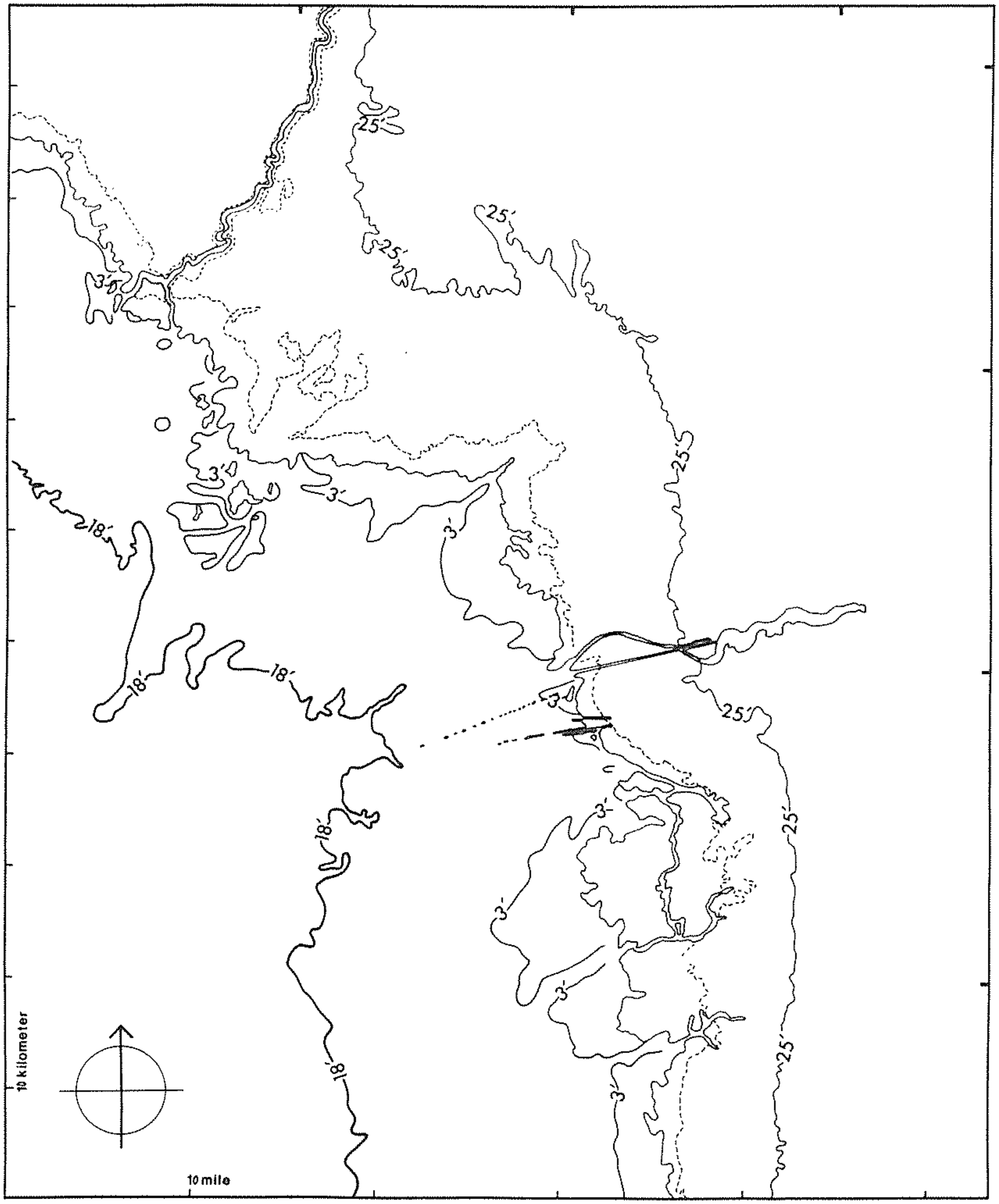


FIGURE 2: GEOGRAPHIC FEATURES OF THE SOUTH BIG BEND MANAGEMENT AREA.

Map compiled from U.S. Geological Survey (USGS) topographic maps dated 1955, at a scale of 1:250,000, labeled Tarpon Springs (NH17-10) and Gainesville (NH17-7). Updated from FWS (1981b).



-18'- 18 ft (6 m) water depth	-3'- 3 ft (1 m) water depth	...... Woods/brush line	-25' 25 ft (8 m) elevation

FIGURE 3: BATHYMETRY/TOPOGRAPHY OF SOUTH BIG BEND.

Data are from USGS topographic maps NH17-7, NH17-10, and National Oceanographic and Atmospheric Administration (NOAA) Nautical Charts 11408 and 11409.

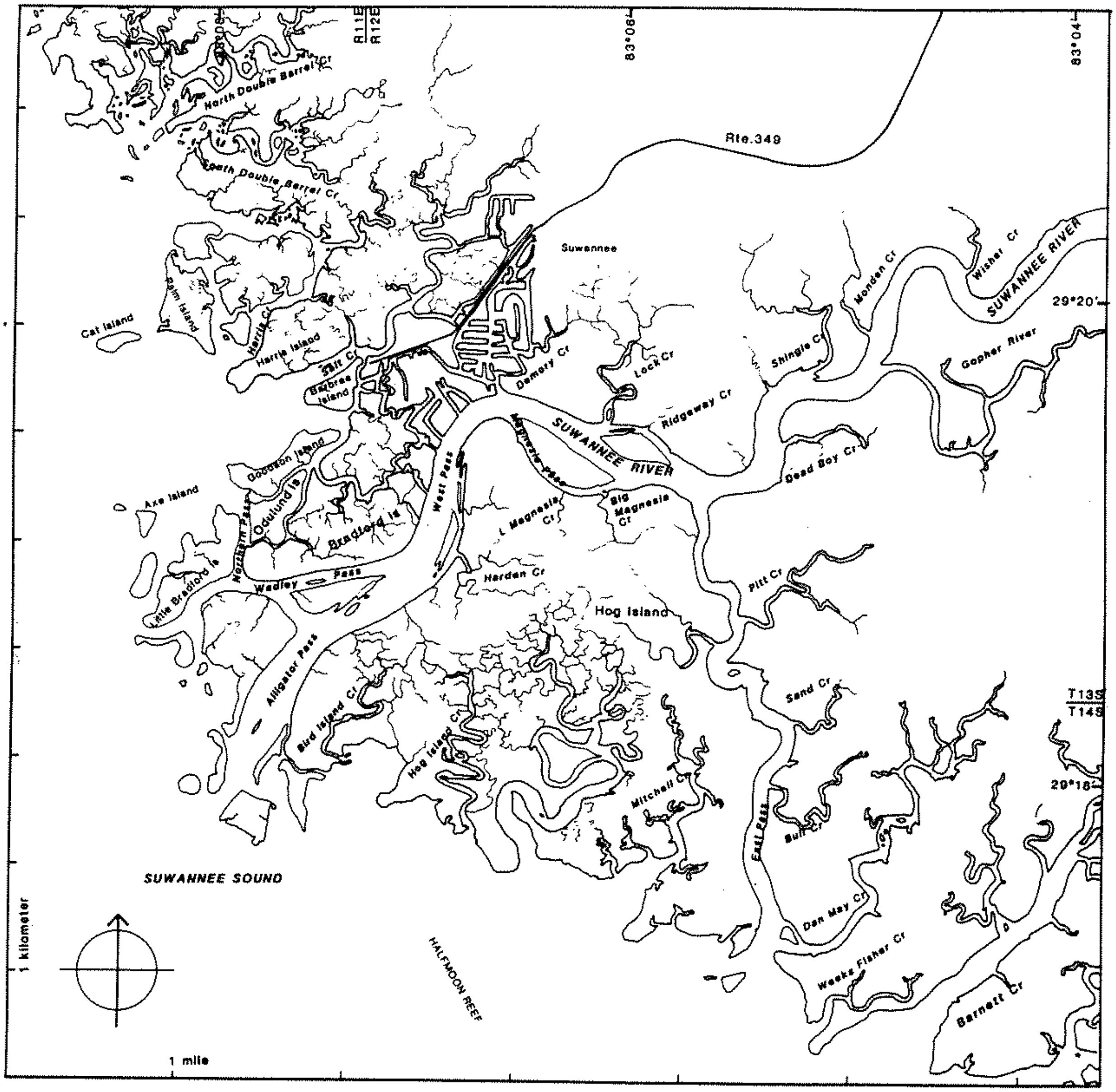


FIGURE 4: GEOGRAPHIC FEATURES OF THE SUWANNEE ESTUARY.

Map is compiled from USGS topographic maps (1:24,000), dated 1955, and labeled Suwannee and East Pass. Updated from NOAA aerial photograph 79CR8117.

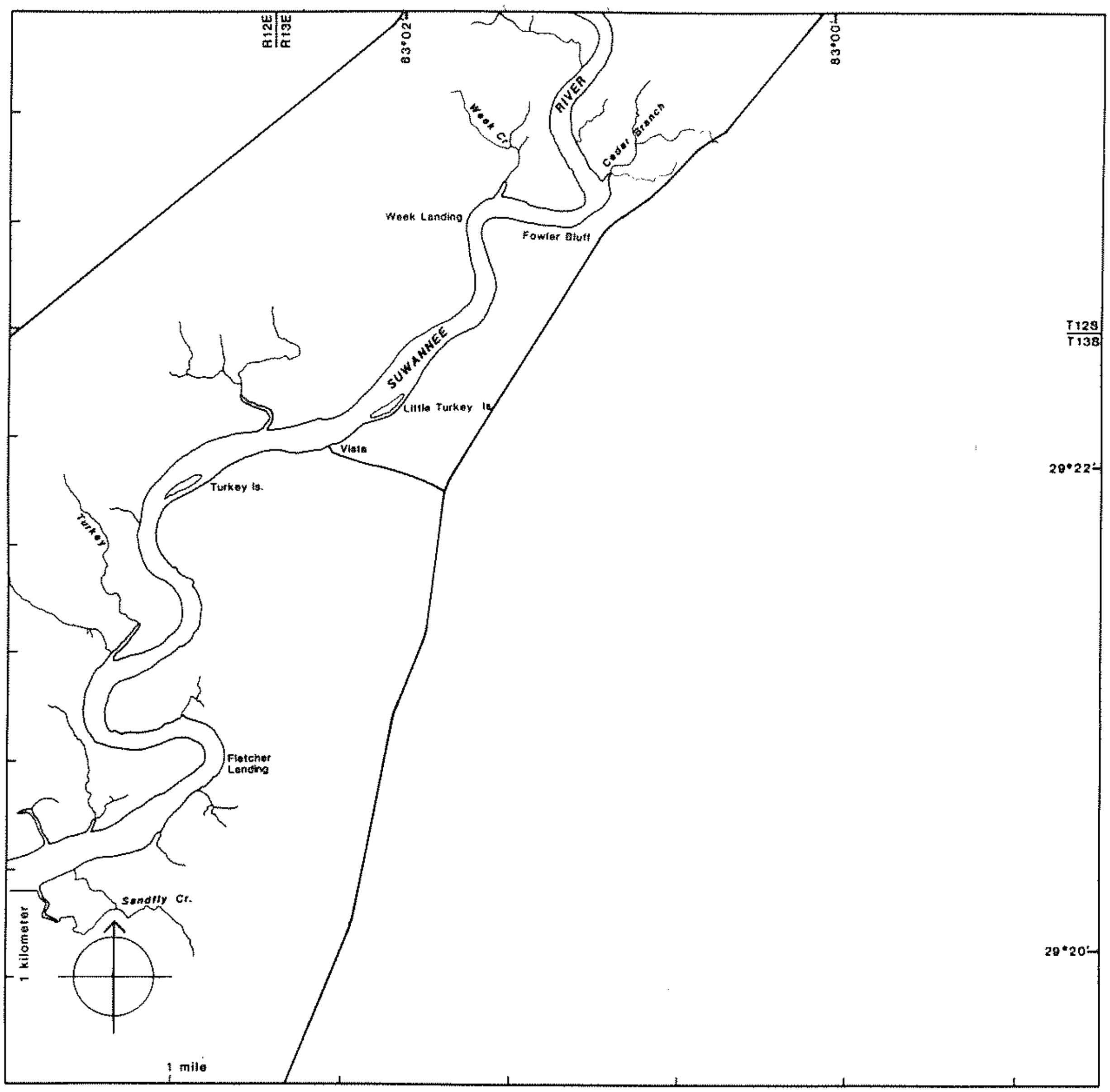


FIGURE 5: <u>GEOGRAPHIC FEATURES OF THE SUWANNEE RIVER NEAR FOWLER BLUFF</u>.

Map is compiled from USGS topographic quadrants (1:24,000) labeled East Pass and Vista, dated 1954.

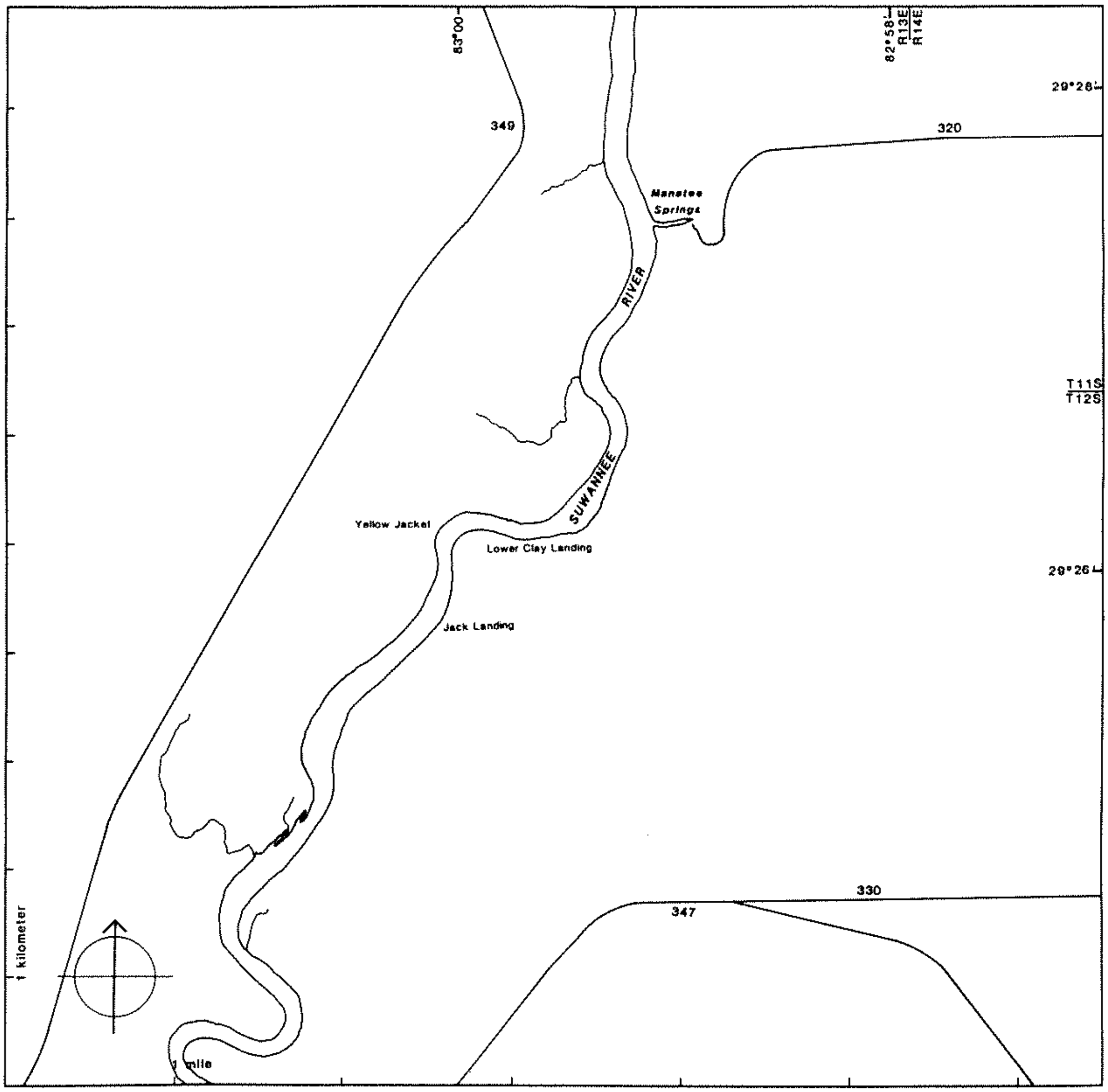


FIGURE 6: GEOGRAPHIC FEATURES OF THE SUWANNEE RIVER NEAR MANATEE SPRINGS.

Map is compiled from USGS topographic quadrants (1:24,000) labeled Vista, Manatee Springs and Suwannee River, dated 1954.

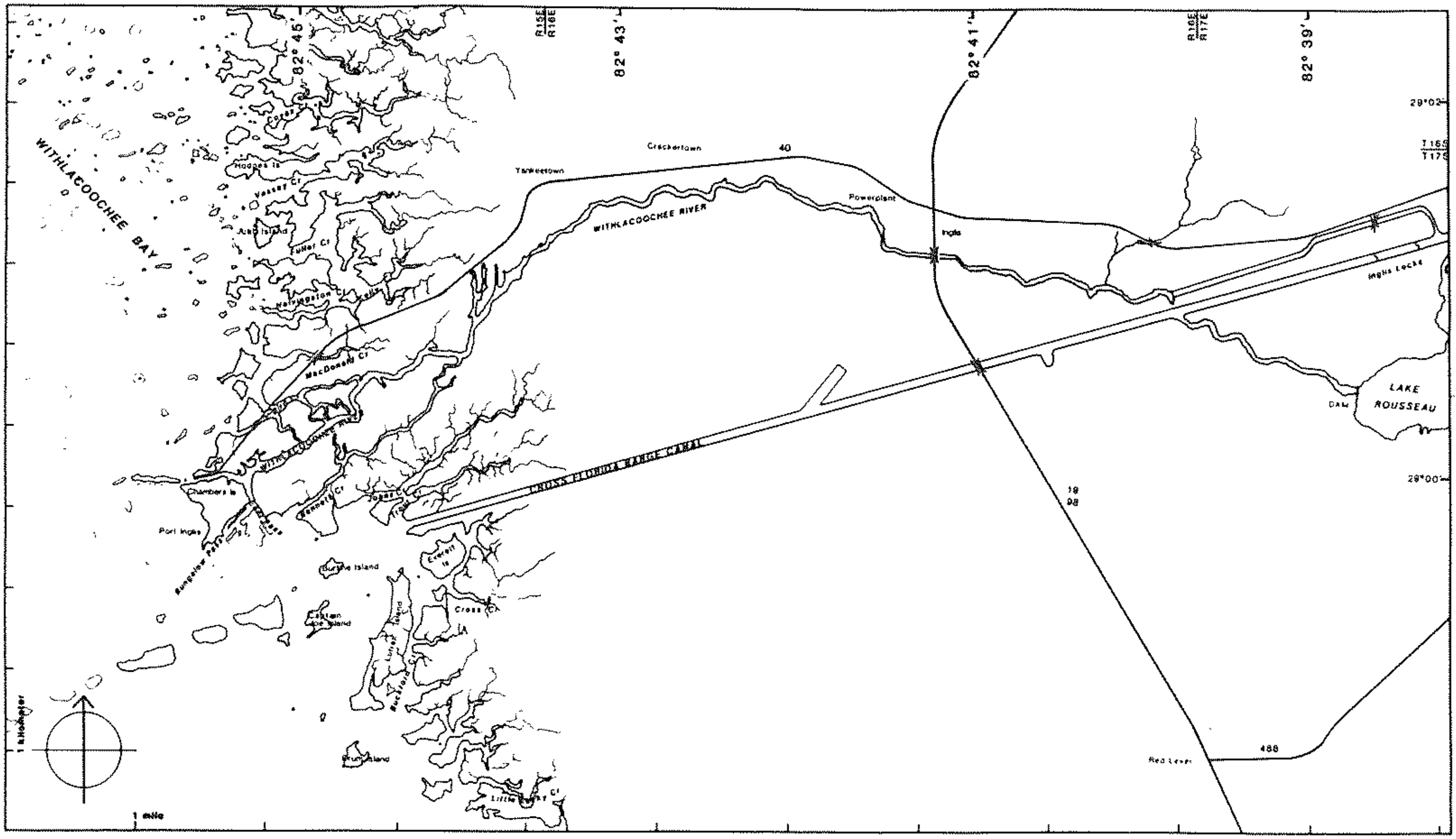


FIGURE 7: GEOGRAPHIC FEATURES OF THE WITHLACOOCHEE RIVER AND BARGE CANAL.

Map is compiled from USGS topographic quadrants (1:24,000) labeled Withlacoochee Bay, Yankeetown, and Yankeetown S.E., dated 1955. It is updated from NOAA aerial photograph 79CR0078, FDOT Levy County General Highway Map (1976) and Southwest Florida Water Management District map "Yankeetown" Sheet No. 2, 1978, 1:1,000.

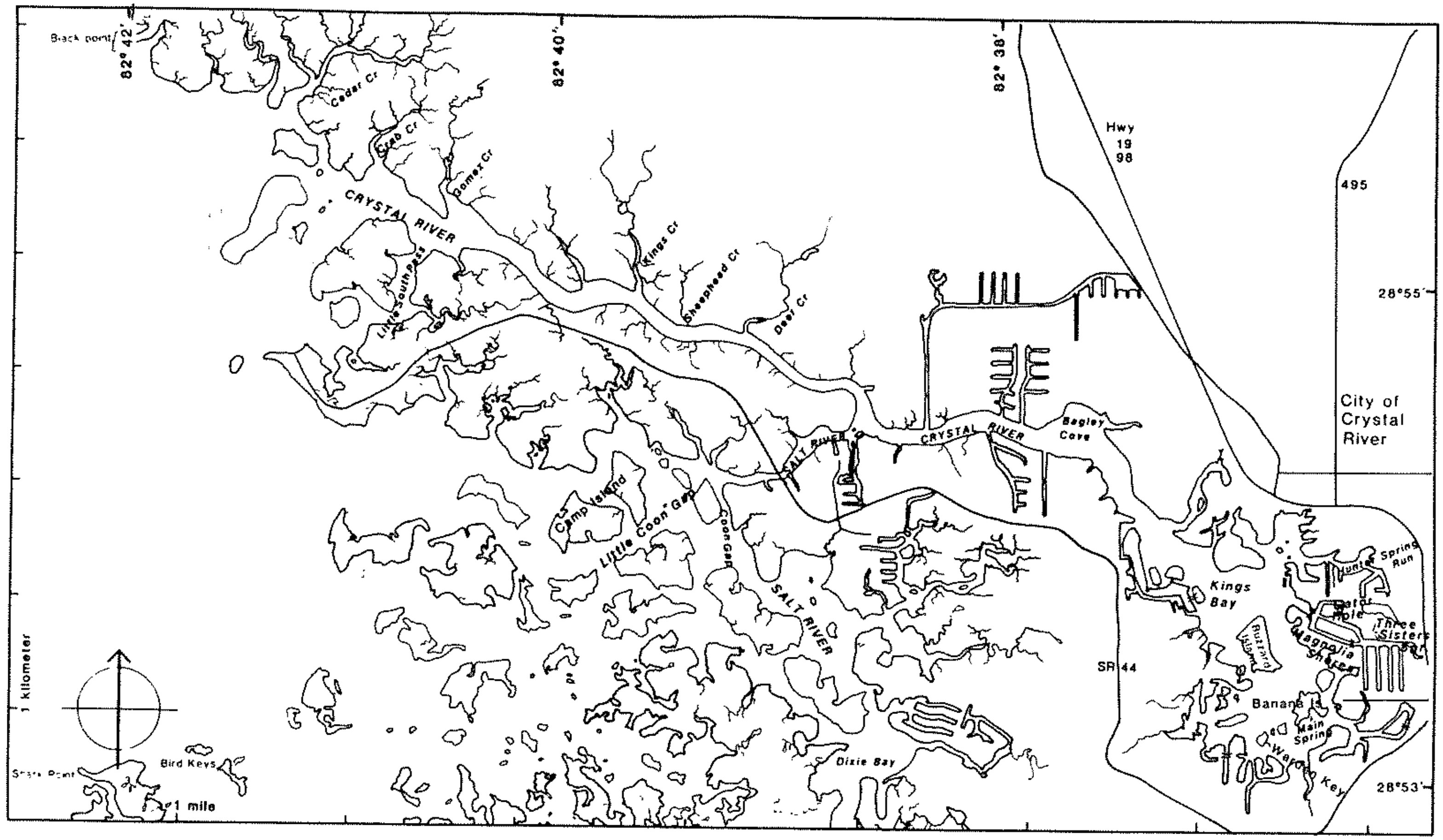


FIGURE 8: GEOGRAPHIC FEATURES OF CRYSTAL RIVER INCLUDING KINGS BAY.

Map is compiled from USGS topographic quadrants (1:24,000) labeled Crystal River, Red Level, Ozello and Homosassa, dated 1954. It is updated from NOAA aerial photo 79CR0062.

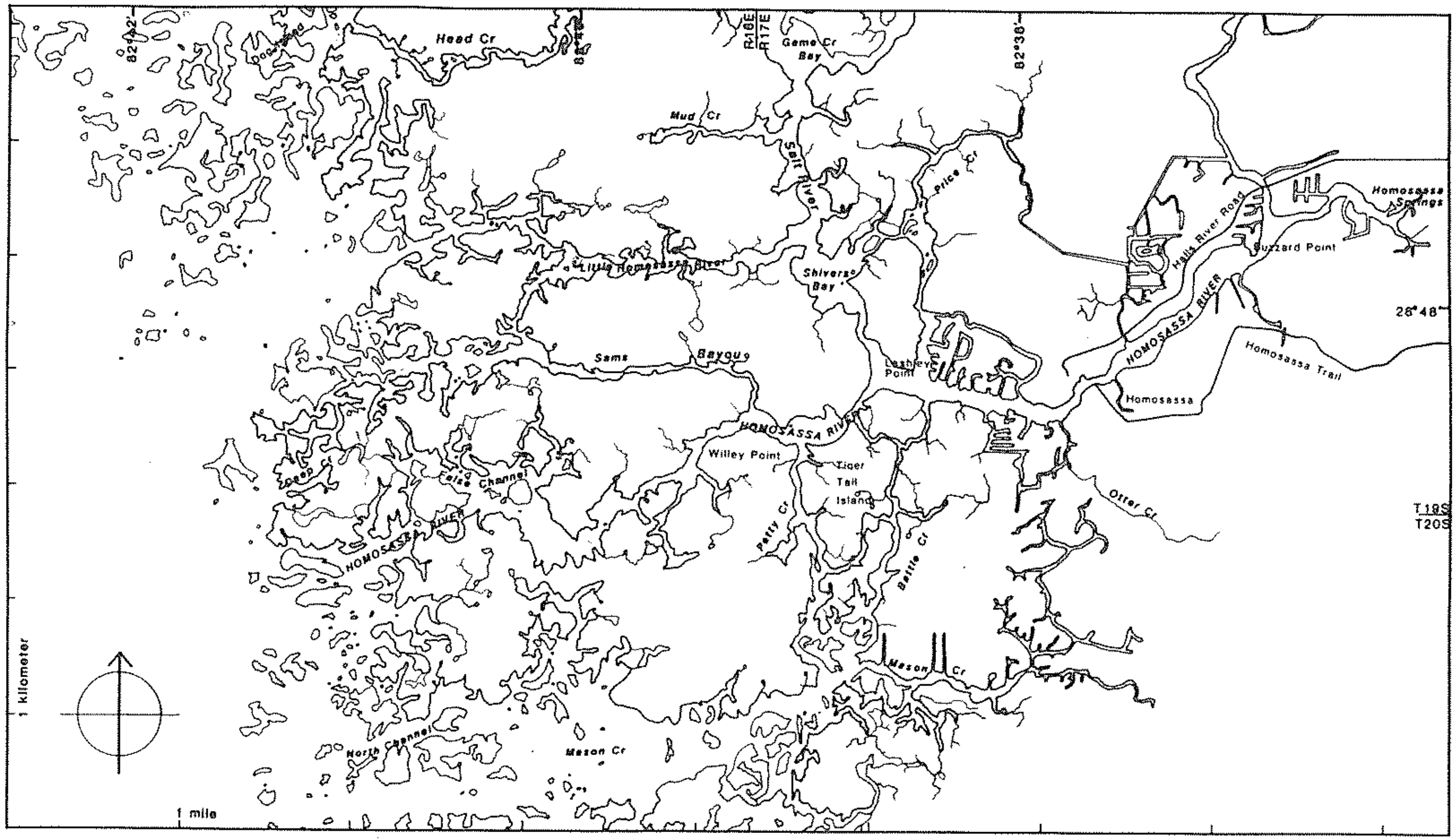


FIGURE 9: <u>GEOGRAPHIC FEATURES OF HOMOSASSA RIVER.</u>

Map is compiled from USGS topographic quadrants (1:24,000) labeled Ozello and Homosassa, dated 1954. It is updated from NOAA aerial photograph 79CR0060.

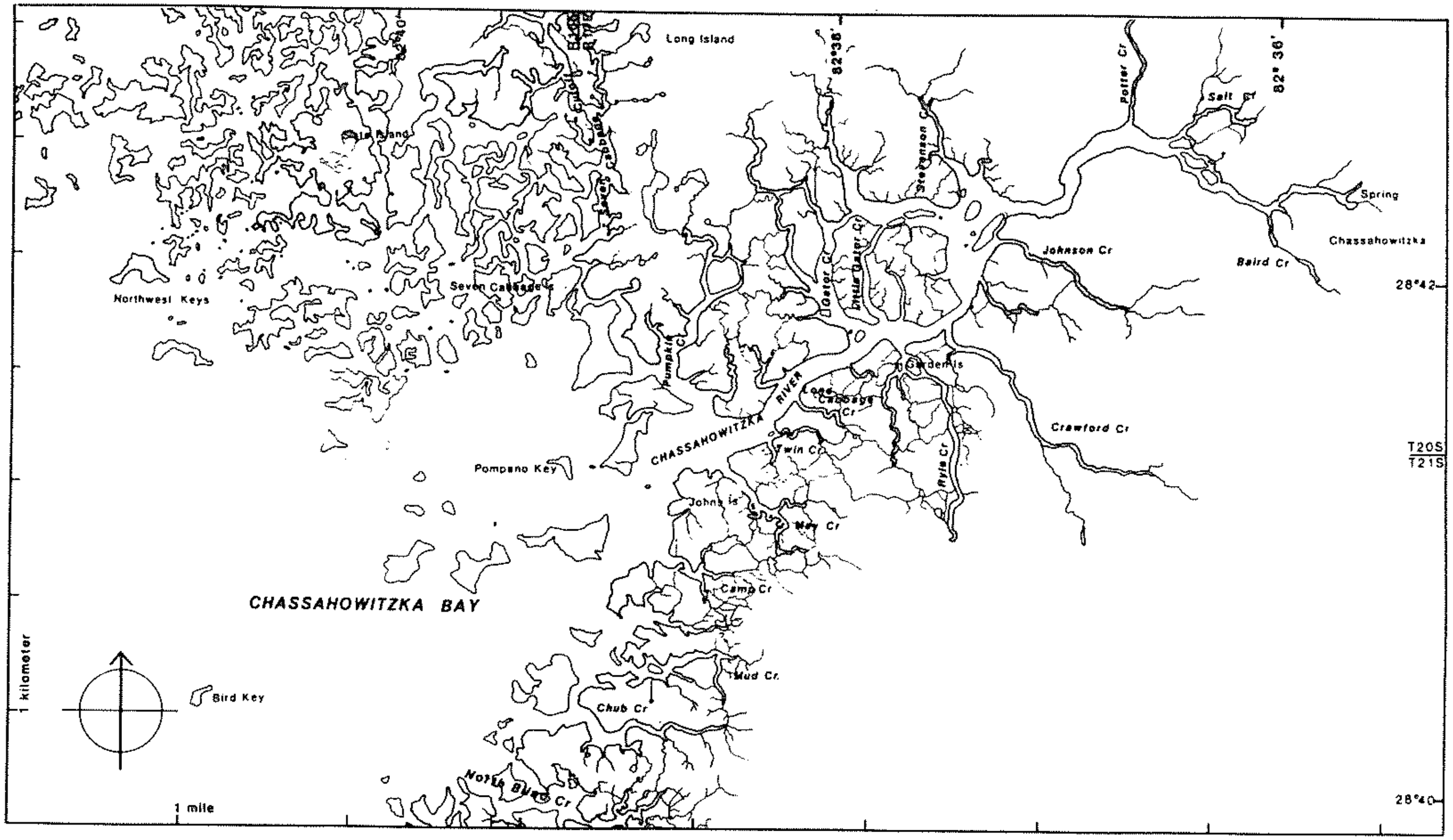


FIGURE 10: <u>GEOGRAPHIC FEATURES OF CHASSAHOWITZKA RIVER.</u>

Map is compiled from USGS topographic quadrants (1:24,000) labeled Chassahowitzka and Chassahowitzka Bay, dated 1954.

narrow, winding, and deep. It averages 25-30 meters in width and has a controlled depth of 3 meters at mean low water. A channel for small craft has been cut through the bars from its mouth to offshore waters. Twenty kilometers upstream from the Gulf, a flood control dam presents an insurmountable barrier to manatees. Unlike the relatively clear waters of the spring-fed rivers, those of the Withlacoochee are darkened by tannic acid...

Of the three spring-fed rivers in Citrus County, the Chassahowitzka is the smallest, shortest (9 kilometers), and shallowest. Except for a channel 2 to 3 meters in depth in its lowest reaches, it is exceedingly shoal, with depths rarely greater than 1 meter at low tide. No access channel has been dredged from offshore waters to the mouth of the river.

The Homosassa River is longer (12 kilometers) and deeper than the Chassahowitzka. It consists of a chain of bays linked by narrows. Before reaching the Gulf its waters merge with a series of branch waterways that are actually tidewater extensions. A natural offshore channel 2 to 5 meters deep leads to its mouth. The depth of the river at mean low water ranges from 1 to 3 meters. The main boil at the river's headwaters is the feature of a tourist attraction. The Halls River, a spring-fed tributary entering 1 kilometer downstream, is unnavigable.

The Crystal River enters the Gulf of Mexico 25 kilometers north of the Homosassa. The Crystal varies in breadth from 100 to 200 meters and flows 11 kilometers from its headwaters to the Gulf. From its mouth a channel 18 meters wide has been dredged through the oyster bars offshore to permit the passage of small craft. The channel's controlled depth at mean low water is 2 meters. Maximum depths of the river range from 2 to 4.5 meters at low tide. Six-and-a-half kilometers upstream, a shallow tidal creek, the Salt River, diverts a portion of the Crystal River's backflow to the southwest and connects circuitously with the Homosassa River. At its head, the Crystal River expands into Kings Bay.

During normal tidal cycles, maximum flow in the main channel of the Crystal River is approximately 112 cubic meters per second (m^3/s) (Mann and Cherry, 1969). Velocities higher than 6 kilometers per hour (km/hr) have been recorded in gaps at the mouth of the Crystal and in the Salt River (Dawson, 1955). During hurricanes, the Crystal River's flow has been estimated at more than 280 m^3/s (Mann and Cherry, 1969).

The mineral content of water in the Crystal River is subject to wide variation. The concentration of dissolved solids, principally sodium chloride, is dependent on both seasonal and diurnal tidal cycles. During a two-and-a-half year period from 1964 to 1966, the concentration of dissolved minerals in the river fluctuated between 300 and 15,000 milligrams per liter (mg/l) (Mann and Cherry, 1969)."

The springs in South Big Bend vary in flow rates (Table 4). The average flow of springs in Crystal River during 1964-66 was greater than that of the Homosassa and the Chassahowitzka (Mann and Cherry 1969). Manatee Springs has not been as intensively studied, but average flow was reported as similar magnitude to Chassahowitzka Springs (Ferguson et al. 1947).

Dredging has altered the coast and channels in some locations (Powell and Rathbun 1983). Major ports at the mouth of the Suwannee and Withlacoochee rivers are no longer active. In 1957, Florida Power Corporation constructed the Crystal River power plant 5 km (3 mi) north of the mouth of Crystal River. Intake and effluent canals were dredged with spoil areas extending 12 km (7 mi) into the Gulf. Physical characteristics of the region and the canals are described in FPC (1974) and the Draft Environmental Impact statement for two Units (4 and 5) that were completed in 1983 (EPA 1980a, 1980b). The Withlacoochee River has been dammed to regulate Lake Rousseau, which was a source of cooling water for a nearby power plant. A portion of the Cross Florida Barge Canal was dredged between 1961 and 1968 before the project was officially stopped in 1973. The dredged canal (10 km, 6 mi) bisects the lower portion of the Withlacoochee 14 km (1 mi) upstream from the mouth. The lower portion connects to the barge canal via a bypass canal with a water control structure. The upper portion between the canal and dam is no longer directly connected to the lower portion. Water flow from Lake Rousseau through the barge canal is controlled by Inglis Locks as well as the dam.

2.2 Plant communities

Major types of plant communities in or bordering waterways within the management area include: freshwater aquatics, seagrasses, brackish and freshwater marsh, and wooded swamp (Figure 11). Freshwater aquatics are most abundant in Crystal River, followed in importance by Homosassa River, Chassahowitzka River and the Withlacoochee River. The dark waters of the Suwannee River limit aquatic vegetation to springs, bends of the river bordered by marsh and swamp, scattered patches near the delta, and canals in the town of Suwannee. Seagrass beds extend 23 to 30 km (14 to 19 mi) offshore between Crystal River and Chassahowitzka River, and are narrower (7 to 10 km, 4 to 6 mi) in the northern portion of the management area. Emergent plants in brackish marshes cover almost a continuous band along the coast, ranging in width from almost 10 km (6 mi) in the area of the Homosassa and Chassahowitzka Rivers to less than 5 km (3 mi) north of Crystal River. Much of the Suwannee River that is in the study area is bordered by wooded swamp (Leadon and Langeland 1982).

The freshwater aquatic plant community found in Crystal River is similar to that of the other spring-fed rivers and to that of the Withlacoochee, but differs somewhat from that of the Suwannee River (Table 5). Prior to introduction of non-native species in the early 1960's, the aquatic community in the upper Crystal River probably consisted primarily of mixed stands of tapegrass, coontail, southern naiad, and arrowhead (Powell and Rathbun 1983). The plant community in King's Bay is now dominated by non-native species, i.e. hydrilla, milfoil and water hyacinth (Hartman 1979, Powell and Rathbun

Table 4. Discharge of springs on rivers within the management area.

Spring Complex	Measurement Period	Discharge in million gallons per day			Number of Measurements
		Average	High	Low	
Crystal River[3] Continuous	1964-66[1]	600	4,340[2]	-1,520[2]	Record
Homosassa[3]	1932-60	129	166	81	25
Homosassa[3]	1964-66[1]	145	166	110	12
Chassahowitzka[3]	1964-66	90	127	21	18
Manatee Springs[4]	1932-46	108	141	88	3

[1] January 1964 to June 1966.

[2] Daily mean (negative sign indicates upstream flow).

[3] Data from Mann and Cherry (1969).

[4] Data from Fergusen et al. (1947).

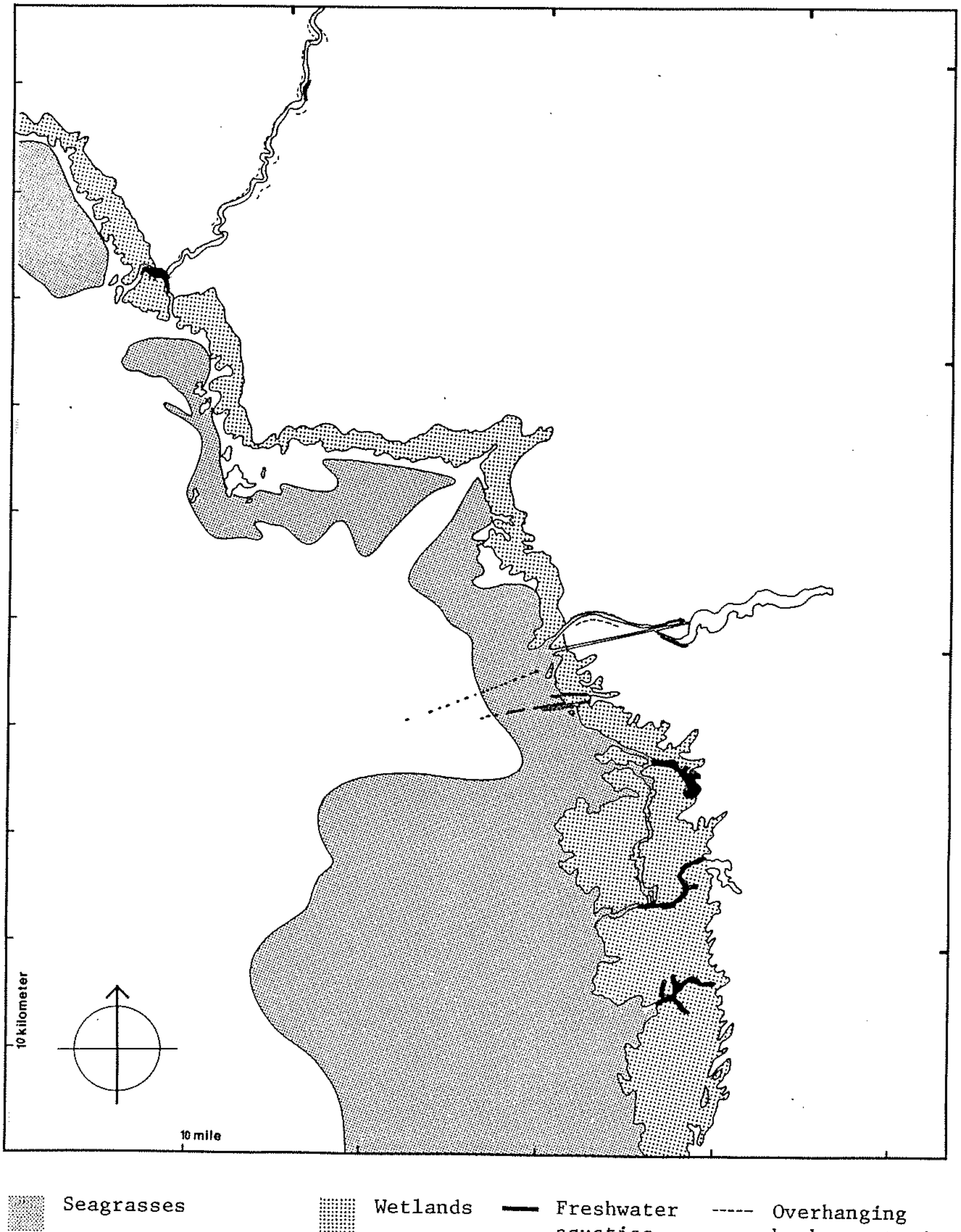


FIGURE 11: VEGETATION IN SOUTH BIG BEND.

Compiled from National Wetlands Reconnaissance Survey (FWS 1981b) and Gulf Coast Ecological Inventory (FWS 1982) maps labeled Gainesville and Tarpon Springs.

Table 5. Rivers in which freshwater aquatic plant species have been identified.[1]

Common Name	Scientific Name	Rivers[2]: SR	WR	CrR	HR	ChR
hydrilla	Hydrilla verticillata	++	++	++	++	++
milfoil	Myriophyllum spicatum		++	++	+	
tapegrass	Vallisneria neotropicalis	+		++	++	
coontail	Ceratophyllum demersum		++	+		
pondweed	Potamogeton pectinatus	+		+		+
	P. pusillus		+	+		
	P. illinoensis		+			
	Elodea densa		+	+		
widgeon grass	Ruppia maritima	++	++	++	++	++
water hyacinth	Eichhornia crassipes	+	+	++	++	++
common salvinia	Salvinia rotundifolia	+	+	+	+	
spatterdock	Nuphar luteum	+				
fanwort	Cabomba caroliniana	++				
	Zannichellia palustris			+		
southern naiad	Najas guadalupensis		+	+		+
water lettuce	Pistia stratiotes		+	(+)	+	
duckweed	Lemna perpusilla		+	(+)		
azolla	Azolla caroliniana			(+)		
algae	Enteromorpha			+		
	Cladophora			+		
	Oscillatoria			+		
water silk	Spirogyra			+		
water net	Hydrodictyon			(+)		
	Ectocarpus			(+)		

[1]++: abundant; +: present; (+): rare; no symbol does not mean absence of a species from a given river rather that its presence has not been reported. Observations updated by G. Rathbun (pers. comm.).

[2]SR: Suwannee River (DNR 1979, Leadon 1979); WR: Withlacoochee River (Hartman 1974); CrR: Crystal River (Hartman 1979); HR: Homosassa River (DAS, pers. comm); ChR: Chassahowitzka River (DAS, pers. comm.) No systematic survey has been done in Homosassa and Chassahowitzka rivers.

1983, Kochman et al. 1983). Several species of algae are also abundant (Hartman 1979).

Seagrass communities consist primarily of shoal grass (Halodule) and manatee grass (Syringodium) in nearshore areas, with a combination of turtle grass (Thalassia) and manatee grass offshore (Table 6). Widgeon grass (Ruppia) grows in brackish water between marine and freshwater communities, being tolerant of a wide range of salinity. A large number of algal species (46 taxa) are often associated with seagrass beds in the management area (Hartman 1979). Distribution of seagrass species between St. Marks and Tarpon Springs is described in Bittaker and Iverson (in press).

The coastal marshes are dominated by needle (black) rush, cordgrass, and sawgrass in the southern part of the management area (Hartman 1979) and by needle rush, smooth cordgrass and some salt grass in the area near the Suwannee (Leadon and Langeland 1982) (Table 7). These marshes are characterized by a salinity gradient; areas near the coast are penetrated by saline water, which pushes freshwater inland with the tides. A number of less abundant plant species may be found along this gradient according to salinity tolerances (Table 7).

Swamp forests bordering the Suwannee River are dominated by tupelo and cypress and may include cabbage palm, red cedar, bay and wax myrtle (Leadon and Langeland 1982) (Table 8). Cabbage palm and temperate hammocks (tree islands) grow on slightly elevated lands in the coastal marshes, and may include species found in the swamp forest (Hartman 1979, EPA 1980b).

2.3 Ecosystem Relations

The management area is at the interface of marine and freshwater systems. The inland boundary has been chosen to include the marshes, wooded swamps and upland areas that drain into marine waters. The offshore boundary corresponds to water depths beyond which few submerged plants grow. Unlike sedentary species typical of these two systems, manatees move between freshwater and marine systems. Both these systems are essential for the long-term support of the habitat upon which manatees are dependent.

At this stage, the major components of the ecosystem supporting manatees and relationships among those components are known (Figure 12). However, the sensitivity of each component to disturbances in other parts of the system is unknown.

Relations among the physical and biological components of this ecosystem are complex. Manatees are dependent on energy (primary production) that is captured in marine plant communities, freshwater plant communities, and the wetlands (marshes and wooded swamps) that are on the interface between freshwater and saltwater zones. The composition of these plant communities in turn is influenced by physical factors. For example, marine communities are influenced by tides and dissolved compounds imported from outside the system through sea water and upland drainage. A slightly different set of factors (e.g. springs, rainfall, and upland drainage) influences the freshwater communities. In addition, the amount of light available to

Table 6. Plant species of seagrass communities in South Big Bend[1].

Common Name	Scientific Name	Comments
turtle grass	*Thalassia testudinum*	offshore
manatee grass	*Syringodium filiforme*	nearshore and offshore
widgeon grass	*Ruppia maritima*	brackish-fresh
halophila	*Halophila engelmani*	
shoal grass	*Halodule wrightii* (*Diplanthera w.*)	nearshore
algae	*Acetabulum* *Caulerpaa* *Gracilaria* *Halimeda* *Hypnea* *Penicillus* *Polysiphonia* *Sargassum* *Udotea*	commonly associated with seagrasses
Algal ephiphyte	*Melobesia farinosa*	

[1]From Hartman (1979).

Table 7. Plant species of tidal marshes in South Big Bend.

Common name	Scientific name	Salinity Tolerance (ppt)
needle (black) rush[1,2]	Juncus roemerianus	1.2-44.3
saw grass[1]	Cladium jamaicense	"
cordgrass[1]	Spartina patens	"
smooth cordgrass[2]	S. alterniflora	"
salt grass[2]	Distichlis spicata	"
maidencane[2]	Panicum hemitomon	0.0
sawgrass[2]	Cladium jamicense	0.0-2.0
pickerelweed[2]	Pontederia cordata	0.0-8.9
arrowhead[2]	Sagittaria lancifolia	0.0-8.9
swamp lily[2]	Crinum americanum	2.1-5.3
marsh morning glory[2]	Ipomea sagittata	2.3-20.4
roseau cane[2]	Phragmites communis	0.0-20.4

[1]From Hartman (1979).

[2]From Leadon and Langeland (1982).

Table 8. Plant species of wooded swamps, palm and temperate hammocks in tidal marshes of South Big Bend.

Common name	Scientific name	Reference[1]
cabbage palm	*Sabal palmetto*	a, b
red bay	*Persea borbonia*	a
swamp bay	*Persea palustris*	b
magnolia	*Magnolia virginiana*	a
wax myrtle	*Myrica cerifera*	a, b
swamp holly	*Ilex cassine*	a
yaupon holly	*Ilex vomitoria*	a
red cedar	*Junpiperus silicicola*	a, b
cypress	*Taxodium distichum*	b
water tupelo	*Nyssa aquatica*	b
black tupelo	*Nyssa sylvatica*	b
salt bush	*Baccharus angustifolia*	b

[1] a: Hartman (1979), b: Leadon and Langeland (1982).

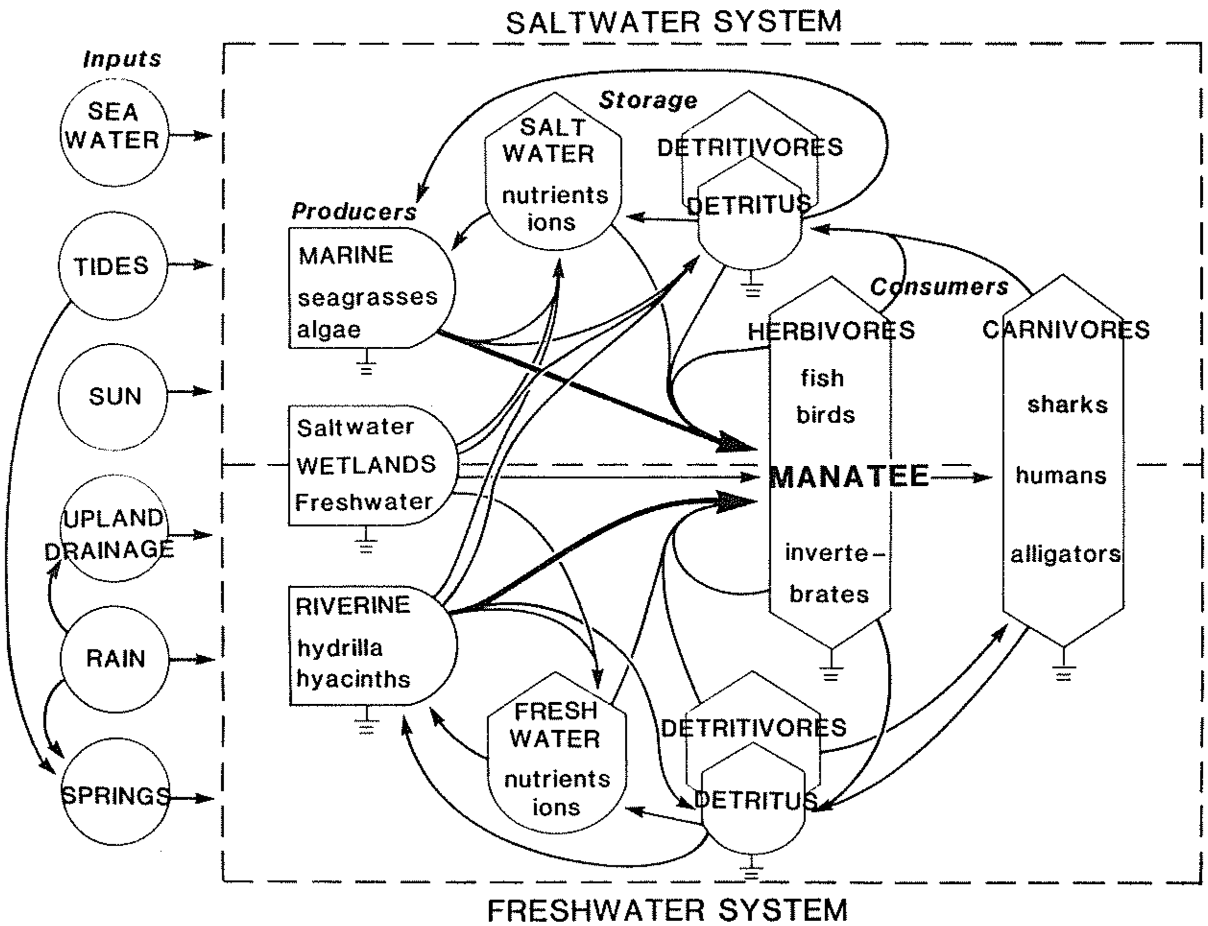


FIGURE 12: SCHEMATIC DIAGRAM OF RELATIONS AMONG ECOSYSTEM COMPONENTS.

aquatic plant communities is dependent on solids suspended in water, which reduce light penetration.

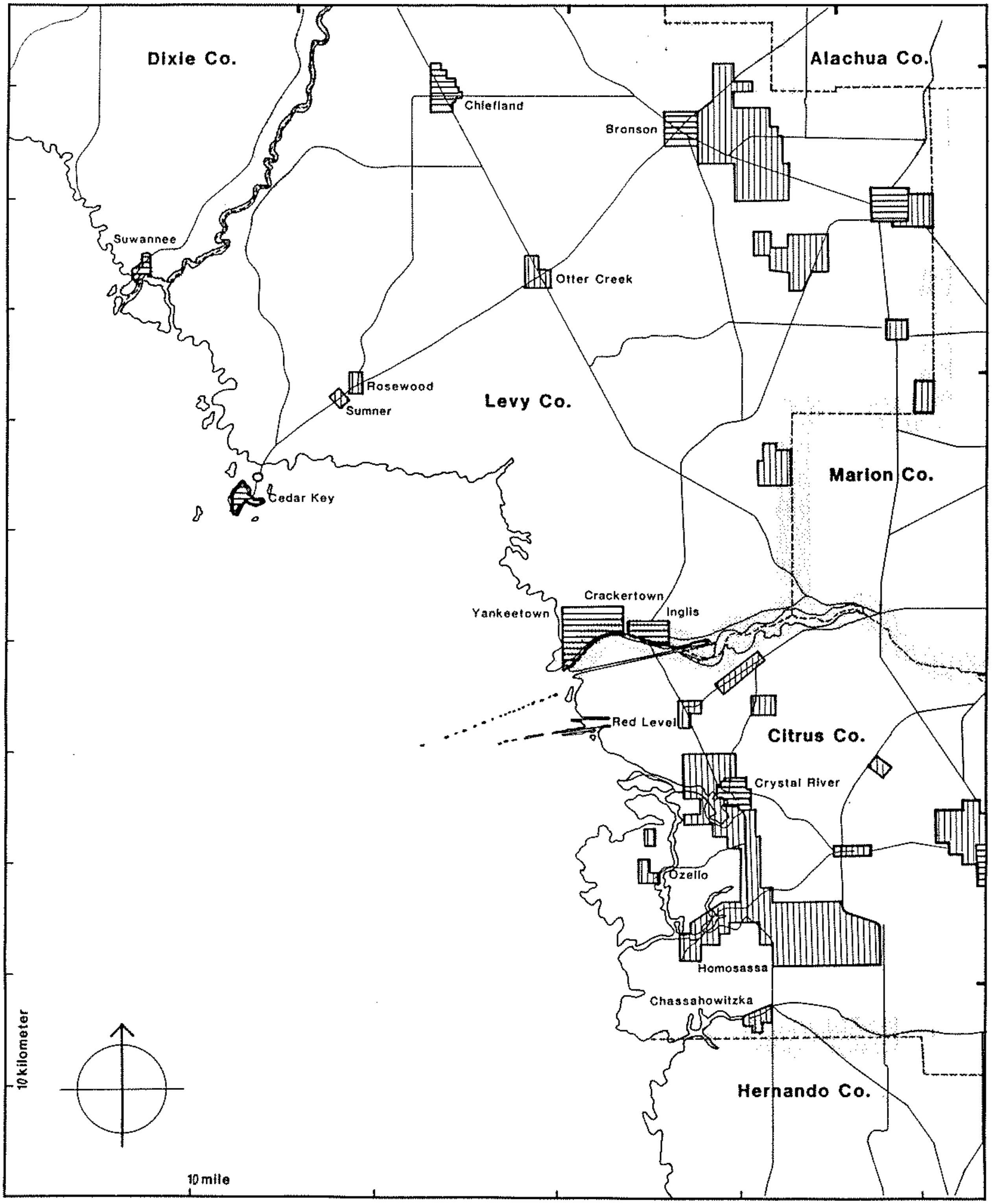
The wetlands not only provide nutrients for aquatic systems, they also function as a buffer between uplands and freshwater or marine systems (Clark et al. 1980). Up to a threshold, chemicals carried in upland drainage may be captured in wetlands and not enter aquatic systems (Ewel et al. 1982). Wetlands also store stormwater runoff, spreading over a longer period of time the pulse of freshwater entering estuarine systems (Clark et al. 1980). Likewise, wetlands store tidal water, reducing the magnitude and duration of salinity fluctuations due to tides. This buffering capacity can be important for the survival of species that are intolerant of low salinities. During prolonged periods of low rainfall, the water stored in wetlands contributes to maintaining the flow of rivers such as the Suwannee, reducing the magnitude of long-term fluctuations in salinity of estuaries.

Manatees consume primarily aquatic vegetation, although they will feed on marsh and overhanging bank vegetation where it is accessible (Hartman 1979). Items swallowed incidentally during feeding may include small animals associated with plants, detritus, and compounds carried in water or attached to plants (Hartman 1979). Few other herbivores compete significantly with manatees. Due to large body size, the amount of energy consumed per individual is higher for manatees than for other herbivores in the system, but total biomass consumed depends on population abundance. For example, a dense population of sea urchins is capable of denuding seagrass beds (Camp et al. 1973); however, sea urchins would not usually be considered competitors for manatee food. Large concentrations of manatees at winter refuges may have a significant impact on the biomass of seagrass beds where other vegetation is not available (in press). However, the rate of regeneration of freshwater plants such as hydrilla is high enough that at current manatee densities in Crystal River, manatees reduce hydrilla biomass only at localized sites. Under certain conditions, grazing by manatees may increase plant species diversity by creating openings for colonizer species (in press). However, the function of manatee herbivory in coastal systems has not yet been fully determined.

Although manatee carcasses may provide food for scavengers, no evidence exists to indicate that natural predators kill manatees (Hartman 1979). It seems possible that calves would be vulnerable to alligators or sharks, but the large body size and thick skin of adults probably reduce their vulnerability to these predators. In the past, manatees in Florida were hunted by humans, and they still are hunted in other parts of their range (FWS 1980).

2.4 Jurisdictional Boundaries

The integrity of the coastal ecosystem within the management area is dependent in part on the insight of agencies with jurisdiction over the area. The management area lies within four counties: Dixie, Levy, Citrus and Hernando (Figure 13). Dixie County is included in the North Central Florida Regional Planning Council and the other three counties are included in the Withlacoochee Regional Planning Council. The Waccasassa River, and the rivers south of it, are under the jurisdiction of Southwest Florida Water



Municipalities | Urban area (proposed or existing) | County line | Major road

FIGURE 13: POLITICAL JURISDICTIONS IN SOUTH BIG BEND.

Map is compiled from FDOT General Highway Maps of Dixie, Levy, Citrus and Hernando counties, dated 1976, and from USGS topographic maps NH17-7 and NH17-10.

Management District. The Suwannee River Water Management District covers the rest of the management area.

Several areas of state protection or proposed protection exist within the management area (Figure 14). Areas owned by the State of Florida include: Manatee Springs State Park, Cedar Key Scrub State Preserve, Cedar Keys State Museum, Waccasassa Bay State Preserve, lands adjacent to the Cross Florida Barge Canal, filled spits adjacent to the canals dredged at the Crystal River power plant, Crystal River State Archaeological Site, the Williams estate on Crystal River, Fort Island and associated parcels in St. Martin's Marsh. Proposed state acquisitions are located: north of Cedar Key Scrub State Reserve, on the south bank of Crystal River, and the Chassahowitzka Swamp adjacent to Chassahowitzka National Wildlife Refuge. Areas protected by the state include: Outstanding Florida Waters in Suwannee River, Waccasassa Bay and Crystal River, and adjacent to St. Martin's Marsh Aquatic Preserve. The Steinhatchee and Gulf Hammock Wildlife Management Areas are adjacent to the coastal zone within the management area. Boat speed regulations protecting manatees are in effect during the summer on the Withlacoochee and Chassahowitzka rivers and during the winter on the Crystal and Homosassa rivers.

Four areas are covered by federal protection or proposed protection (Figure 14). Federal lands include Cedar Key Wilderness and National Wildlife Refuge, and Chassahowitzka Wilderness and National Wildlife Refuge. Plans for acquisition of land include the Lower Suwannee National Wildlife Refuge and the Crystal River Manatee National Wildlife Refuge. Crystal River has been designated as Critical Habitat for manatees under the Endangered Species Act of 1973, and protective measures are thus under the jurisdiction of the Secretary of the Interior.

3. BIOLOGICAL STATUS OF MANATEES

Abundance and distribution of manatees in the management area have been reported by Hartman (1971, 1974, 1979), Powell (1981), and Powell and Rathbun (1983). This subsection provides information on (a) abundance and population trends, (b) mortality and reproduction, and (c) distribution.

3.1 Abundance and Population Trends

Abundance of manatees is monitored annually by aerial surveys, which more accurately reflect the number of manatees present than boat surveys (Powell 1981). Counts made in Crystal and Homosassa rivers during the winter period of aggregation in warm water provide the best index of abundance (Powell and Rathbun 1983). These counts are a minimum estimate of total abundance, because some animals may not be in the area surveyed or may not be visible at the time of the count. Nevertheless, maximum counts from aerial surveys indicate trends in population size from one year to the next.

Maximum winter counts in Crystal River have increased from 78 to 116 manatees between the winters of 1977-78 and 1981-82 (Table 9). Maximum counts in the Homosassa River ranged from 11 to 29 manatees during the same period, with 20 manatees counted in winter 1981-82. As movement between Crystal and Homosassa rivers has been documented (Powell and Rathbun 1983),

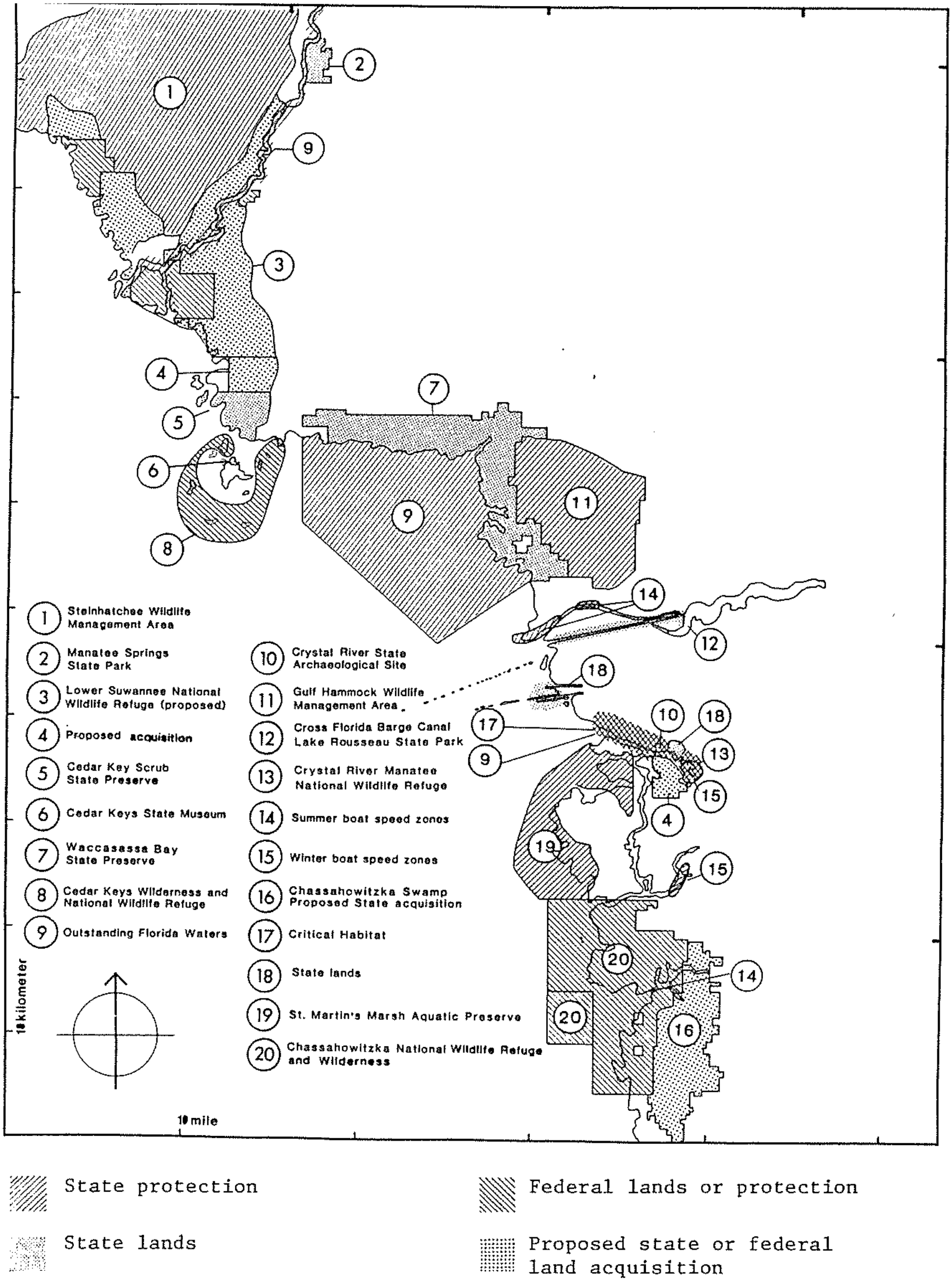


FIGURE 14: <u>PROTECTIVE JURISDICTIONS IN SOUTH BIG BEND.</u>

Information is from Division of State Lands, Department of Natural Resources, Tallahassee, Florida.

Table 9. Winter manatee counts in the Homosassa River and Crystal River based on aerial surveys and ground (water) observations of individuals[1].

Season	Aerial Survey Maxima: Homosassa River	Aerial Survey Maxima: Crystal River Calves	Aerial Survey Maxima: Crystal River Total	Flight frequency	Ground Observations: Total individuals identified at Crystal River
1967–68	8[3]	—	38[2]	Cold fronts	50
1968–69	—	—	44[2]	Cold fronts	48
1972–73	12[2]	—	45[4]	Cold fronts	38
1973–74	18[2]	—	44[4]	Intermittent	—
1974–75	—	—	47[4]	Intermittent	—
1975–76	—	—	51[4]	Intermittent	—
1976–77	—	—	37[4]	Twice/month	49
1977–78	11	9	78	At least weekly	86
1978–79	29	8	80	At least weekly	81
1979–80	16	10	87	At least weekly	89
1980–81	24	13	99	At least weekly	108
1981–82	20	10	116	Cold fronts	92

[1]From Table 2 in Powell and Rathbun (1983).

[2]Hartman (1979).

[3]Hartman (1971).

[4]Powell (1981).

an estimate of total size of the subpopulation would include counts from both areas. However, the numbers in Table 9 are not additive, as a maximum count made in one river may not have been made on the same date as the maximum count for the other river. Therefore, the winter counts from Crystal River including Kings Bay are considered to be the best available index for trends in the abundance of manatees in the management area.

Information regarding manatee abundance between 1967 and 1977 is less reliable, because aerial surveys were done intermittently; maximum aerial counts ranged from 38 to 51 manatees. The total number of individuals identified by scar patterns has been slightly greater than the maximum aerial counts for all winters except 1972-73 and 1981-82.

Therefore, the subpopulation at Crystal River has shown a slow but steady increase over the past 15 years. The Crystal River subpopulation represents a significant portion of the estimated total number of manatees in the state (Figure 15).

The rate of increase of the subpopulation has increased over the last five years, but such rapid growth is not expected to continue indefinitely. The rate of increase (r = finite growth rate) is calculated as the number counted in one year divided by the number counted in the previous year (N_t / N_{t-1}). This rate has increased from 1.03 between 1977-78 and 1978-79 to 1.17 between 1980-81 and 1981-82 (Powell and Rathbun 1983). The acceleration rate (change in the growth rate) has declined during this period, suggesting that the rate of population increase will stabilize. Indeed, there was no change in maximum counts at Crystal and Homosassa rivers between winters 1981-82 and 1982-83 (Rathbun pers. comm.).

Compared to other marine mammal populations, with similar reproductive characteristics, a growth rate of 1.17 is quite high. Examination of calf counts from Crystal River suggests that the observed rate of population growth cannot be attributed solely to recruitment of young, but must be in part due to emigration from other areas. Hartman (1979) believed that there was movement between the Crystal River subpopulation and areas farther south; strong evidence exists regarding such movement by one radio-tagged manatee (Powell and Rathbun 1983).

Predictions regarding the size of the subpopulation in 10 years depend on the rate at which the population continues to grow (Figure 16). At the maximum expected growth rate (r = 1.15), the number of manatees at Crystal River could increase to 540 by 1993. It is unlikely that this maximum growth rate would be sustained indefinitely. Therefore, a better prediction would be between 120 and 330 manatees, the numbers predicted at growth rates of r = 1.0 and r = 1.1, respectively. At a growth rate of r = 1.1, about 60 manatees predictably would winter at Homosassa River in ten years.

3.2 Recruitment and Loss

The growth rate of the population is influenced by the number of manatees that enters the population (recruitment) via reproduction and immigration, and the number that leaves the population (loss) via death (mortality)

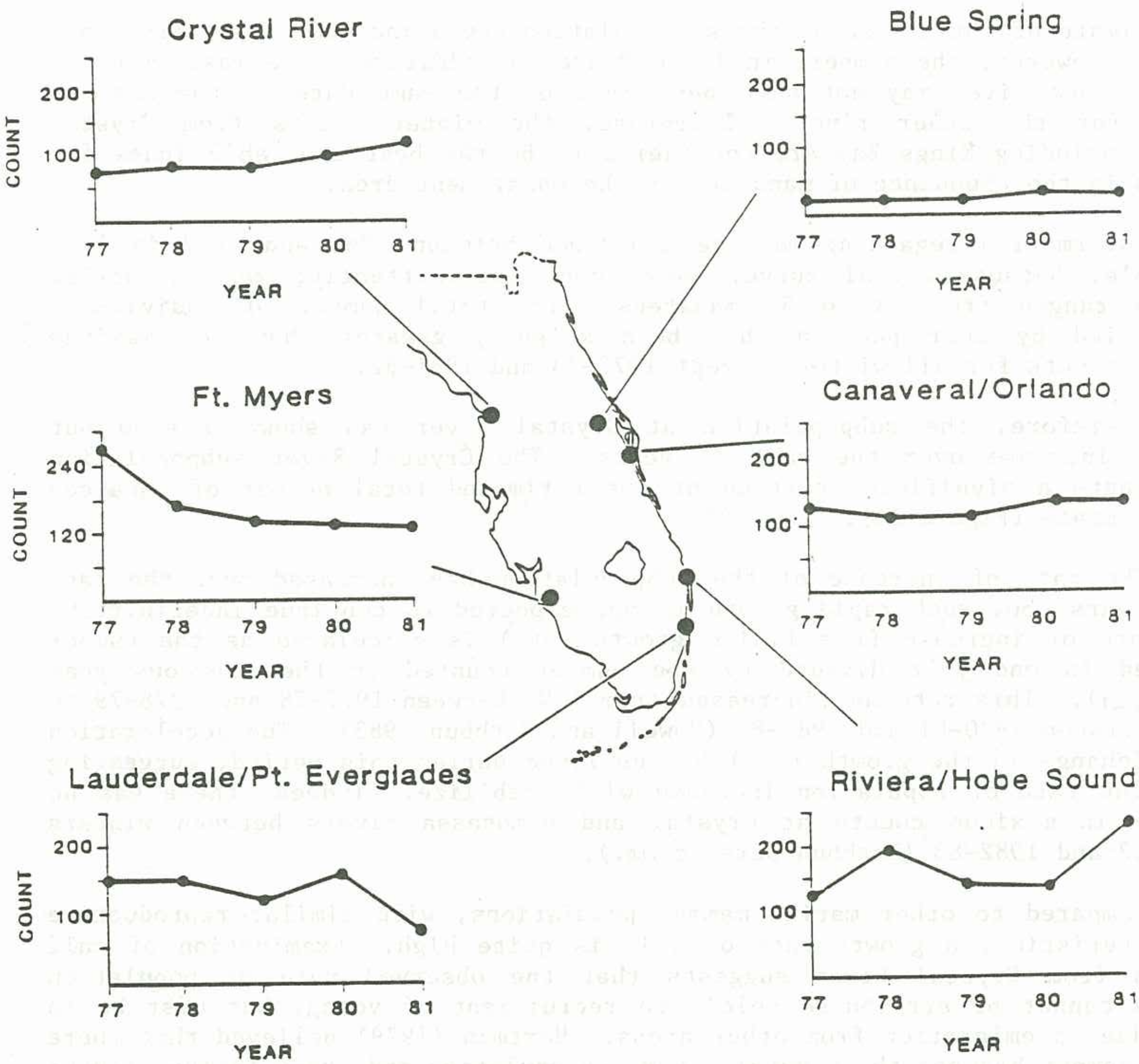


FIGURE 15: <u>TRENDS IN THE CRYSTAL RIVER MANATEE SUBPOPULATION RELATIVE TO OTHER SITES IN FLORIDA.</u>

From Eberhardt (1982).

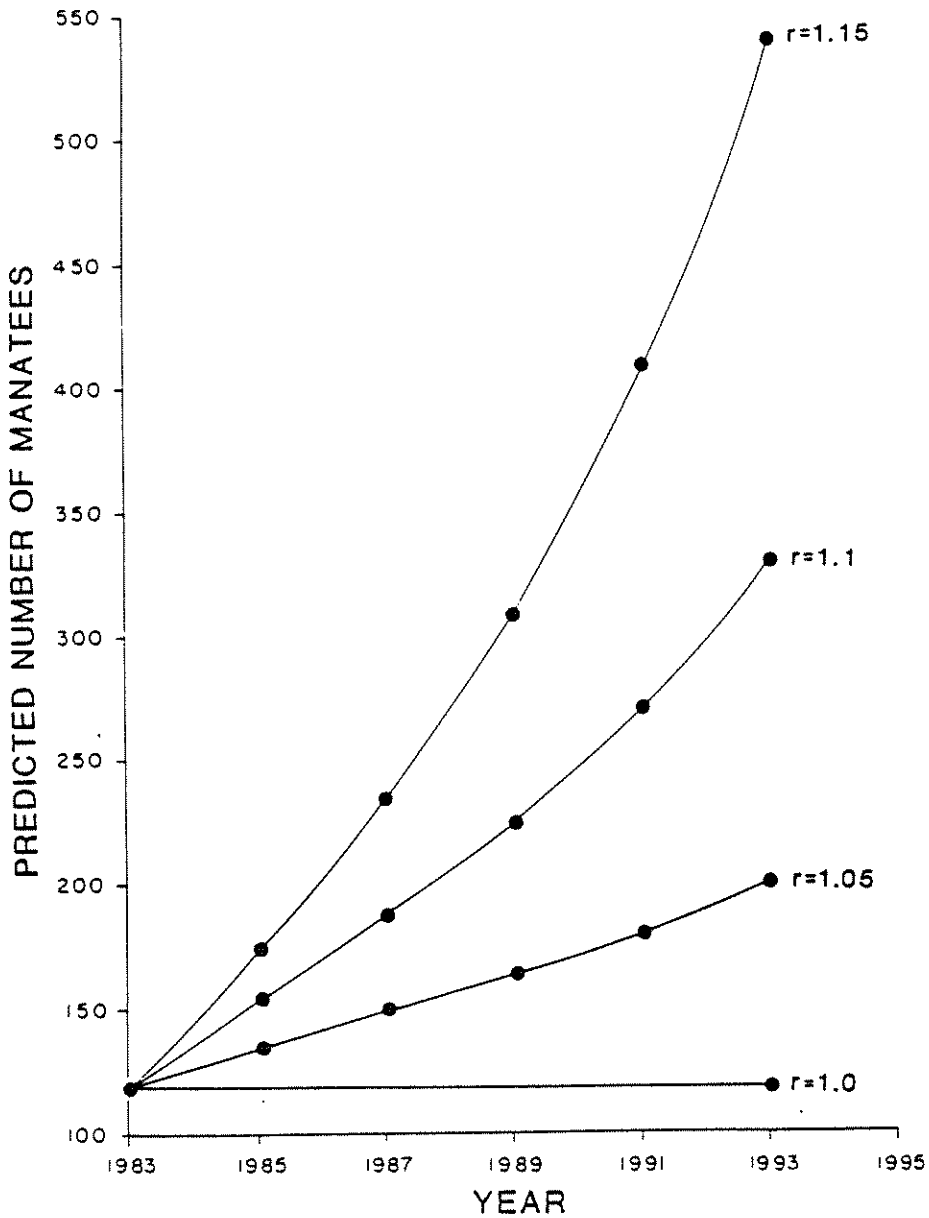


FIGURE 16: PREDICTED NUMBER OF MANATEES AT FOUR RATES OF POPULATION GROWTH (r).

and emigration. Mortality, reproduction, immigration and emigration from the Crystal River subpopulation are described in this subsection.

Mortality is monitored by the recovery of carcasses by a statewide salvage program (FWS 1980). However, due to the difficulty of sighting, reporting and retrieving carcasses, the information obtained represents minimum estimates of mortality. The proportion of dead manatees that are not recovered via the salvage program has not been determined (Eberhardt 1982). Carcasses are necropsied to determine cause of death. From 1974 through March 1982, 28 carcasses from South Big Bend have been examined (Powell and Rathbun 1983). The number of carcasses recovered per year ranged from 1 to 7, with an average of 3±2 (Table 10). Fifty percent of the deaths were dependent calves, 25% were attributed to human-related causes, one death was possibly related to toxins, and the cause of death could not be determined for the rest of the carcasses.

Concentrations of contaminants in the tissues of manatees in Florida have been investigated by O'Shea et al. (1983). Liver samples from carcasses collected from 1977-1981 contained concentrations of copper (up to 1,200 ppm dry weight) higher than all previously reported values for species of wild mammals from free-ranging populations. Concentrations of organochlorides in fat, of mercury in muscle and liver, of lead in liver, and of lead and cadmium in kidneys were below levels that are considered toxic (Table 11).

Manatee deaths attributed to human-related causes have been relatively low, ranging from none to three carcasses per year (Table 10). An index of human-related mortality was calculated by dividing the number of human-related deaths by the maximum aerial counts in each year. This index ranges from 0 to .06 (Table 10). Of the eight human-related deaths, two were caused by boat collisions, three were caused by barge collisions, one occurred in a canal lock, and the other was unspecified. The proportion of deaths caused by humans is 25% of the total carcasses recovered, and this index has ranged from 0 to 1.0 for each year.

Calf mortality was the most frequently identified cause of death (14 carcasses). The number of calf carcasses recovered per year ranged from 0 to 4 (Table 10). Half of these carcasses were of calves that were very young (1 fetus, 2 probably stillborn, and 4 probably newborn). The rest were classified as dependent calves (7 carcasses). An index of calf mortality was calculated by dividing the number of calf carcasses by the maximum calf count in Crystal River for each year (Table 10). Calf counts were available for 1978 through 1982. This index of calf mortality ranged from .12 to .40 with a mean of .26.

Reproductive rates may be determined from the record of individual manatees identified from their scar patterns (Table 12). The number of calves ranged from 4 to 15 during the study period (1972, 1976-1982). A reproductive index was calculated by dividing the number of calves by the total number of manatees identified each year. Calves represented from 9 to 20% of the subpopulation each year, which is comparable to manatee reproductive rates in other parts of the state (Rathbun pers. comm.). The proportion of females with calves (termed female success in Table 12) ranged from .16 to

Table 10. Trends in manatee mortality documented in South Big Bend: cause of death by year and mortality indices.[1]

Cause	1974	1975	1976	1977	1978	1979	1980	1981	1982	Total
	YEAR									
Human Related										
Boat	1				1					2
Barge		3								3
Canal lock							1			1
Other				1						1
Dependent calf (DC)			1		2	1	4	2	4	14
Undetermined		1		3		1	2			7
TOTAL (T)	1	4	1	4	3	2	7	2	4	28
Total Human Related (HR)	1	3	0	1	1	0	1	0	0	7
Max. Count in Crystal River (N)[2]	44	47	51	37	78	80	87	99	116	
Human-related mortality index (HR/N)	.02	.06	0	.03	.01	0	.01	0	0	
Proportion human-related mortality (HR/T)	1.0	.75	0	.25	.33	0	.14	0	0	
Max. Calf Count in Crystal River (N_c)	—	—	—	—	9	8	10	13	10	
Calf mortality index (DC/N_c)					.22	.12	.40	.15	.40	

[1] Data are from Powell and Rathbun (1983).

[2] From Table 9.

Table 11. Concentrations of contaminants in tissues of manatees in Florida.[1]

Tissue and metal	N	N detected	range	X	SD	CV(%)
Kidney						
Cadmium	38	36	ND[2] - 190	25.7	42.6	166
Lead	20	20	3.3 - 7.1	5.2	1.0	20
Liver						
Copper	54	54	4.4-1,200	175	255	146
Iron	35	35	460-8,200	1,920	1,450	75
Lead	19	19	1.8 - 4.4	2.7	0.6	22
Mercury	19	1	ND - 0.2	0.23		
Selenium	19	11	ND - 1.1	0.42	0.4	98
Muscle						
Mercury	27	0				

[1]Table is from O'Shea et al. (1983).

[2]ND = not detected, entered in computations as zero.

Table 12. Number of manatees identified at Crystal River[1] and indices of reproduction.

Manatees	Winter[2] 1972	1976	1977	1978	1979	1980	1981	Mean ± s.d.
Males	16	19	33	30	32	42	35	31 ± 8
Females	18	20	43	44	49	51	45	39 ± 14
Calves	4	10	10	7	8	15	12	9 ± 4
Total Adults	34	39	76	74	81	93	80	70 ± 21
Total (adults and calves)	38	49	86	81	89	108	92	79 ± 23
Reproductive Index (calves/total)	.11	.20	.12	.09	.09	.14	.13	.13 ± .04
Female Success (calves/female)	.22	.50	.23	.16	.16	.29	.27	.26 ± .12
Adult Sex Ratio (males/adults)	.47	.39	.43	.41	.40	.45	.50	.44 ± .04

[1]From Powell and Rathbun (1983): Table 2.

[2]Beginning in December of year listed.

.50 with a mean of .26±.12. The sex ratio of adults in Crystal River has been skewed slightly toward females, with a mean of .44±.04. However, it is not known to what extent the manatees studied at Crystal River represent the total subpopulation of South Big Bend.

Some of the calves born into the subpopulation remain in the area. At least six calves born to identified females have returned in subsequent years (Rathbun pers. comm.). However, a high proportion of calves are not identified again after their first winter; many do not have distinguishing marks.

A large proportion of manatees return each winter to Crystal River (Figure 17), indicating that a distinct group inhabits the south Big Bend region. Between 1978 and winter 1980-81, 73% to 81% of the manatees identified the previous year returned (Powell and Rathbun 1983). However, not all individuals are identified each year; this may be due to the difficulty of observing individuals or because they wintered elsewhere. Some individuals have switched wintering locations between the Homosassa River and Crystal River. If returns of individuals identified in all previous years are considered, the average proportion of manatees that return is 82%. Approximately 18% of the manatees identified each year have not been previously identified, suggesting that there is some immigration from adjacent areas, probably from the south. This indicates that the Crystal River subpopulation of manatees probably maintains some genetic interchange within the Florida population of manatees.

3.3 Manatee Distribution

The locations of manatee sightings made during aerial surveys indicate which areas are used most frequently by manatees on a year-round basis (Powell and Rathbun 1983) (Figure 18). Manatees are sighted significantly more frequently in Crystal River and the lower portion of the Suwannee River than in the Withlacoochee River, Chassahowitzka River, Cross Florida Barge Canal, and Crystal River Power Plant (Table 13). Sightings in the Waccasassa River have been rare, although this river has not been included in surveys on a regular basis. The flight path on aerial surveys focuses on the five major rivers (Powell and Rathbun 1983), so a lack of sightings in other areas does not necessarily preclude manatee use of the area.

Manatee distribution changes seasonally as water temperature in the Gulf drops below the temperature of natural springs (23.7°C) (Hartman 1979). Manatees aggregate in the relatively warm water of Crystal River, Homosassa River, and to a lesser extent, at the power plant warm-water discharge and Manatee Springs on the Suwannee River (Figure 19). Due to this shift in distribution, two of the rivers (Crystal River and Homosassa River) have been identified as most significant winter habitat, and four rivers have been identified as significant summer habitat (Suwannee, Withlacoochee, Crystal and Chassahowitzka rivers) (Powell and Rathbun 1983) (Figure 20). Manatees are sighted in Crystal River during all months.

Manatees start to aggregate at the headwaters of Crystal River and Homosassa River beginning in October. In winters 1967-68 and 1968-69,

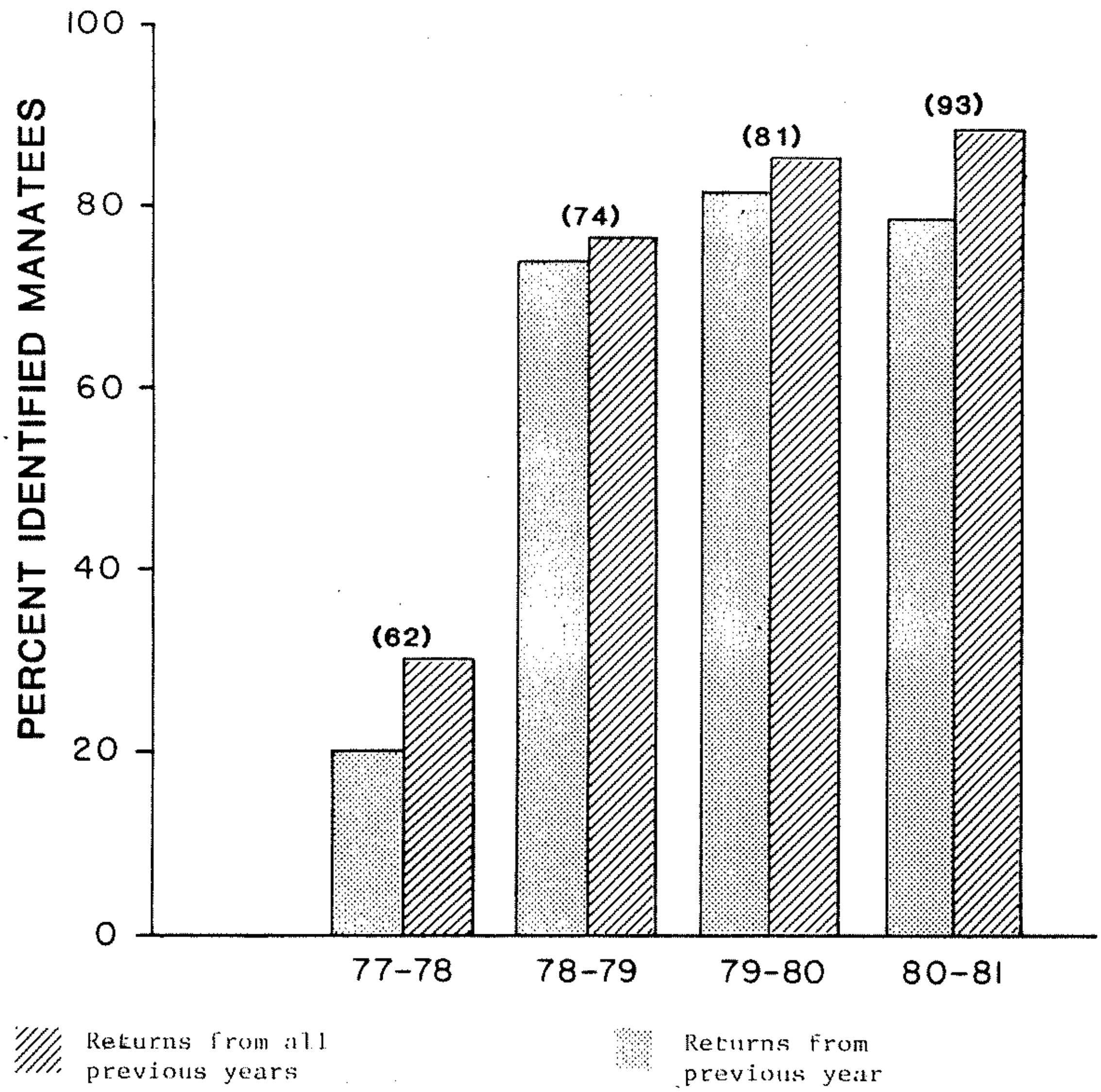
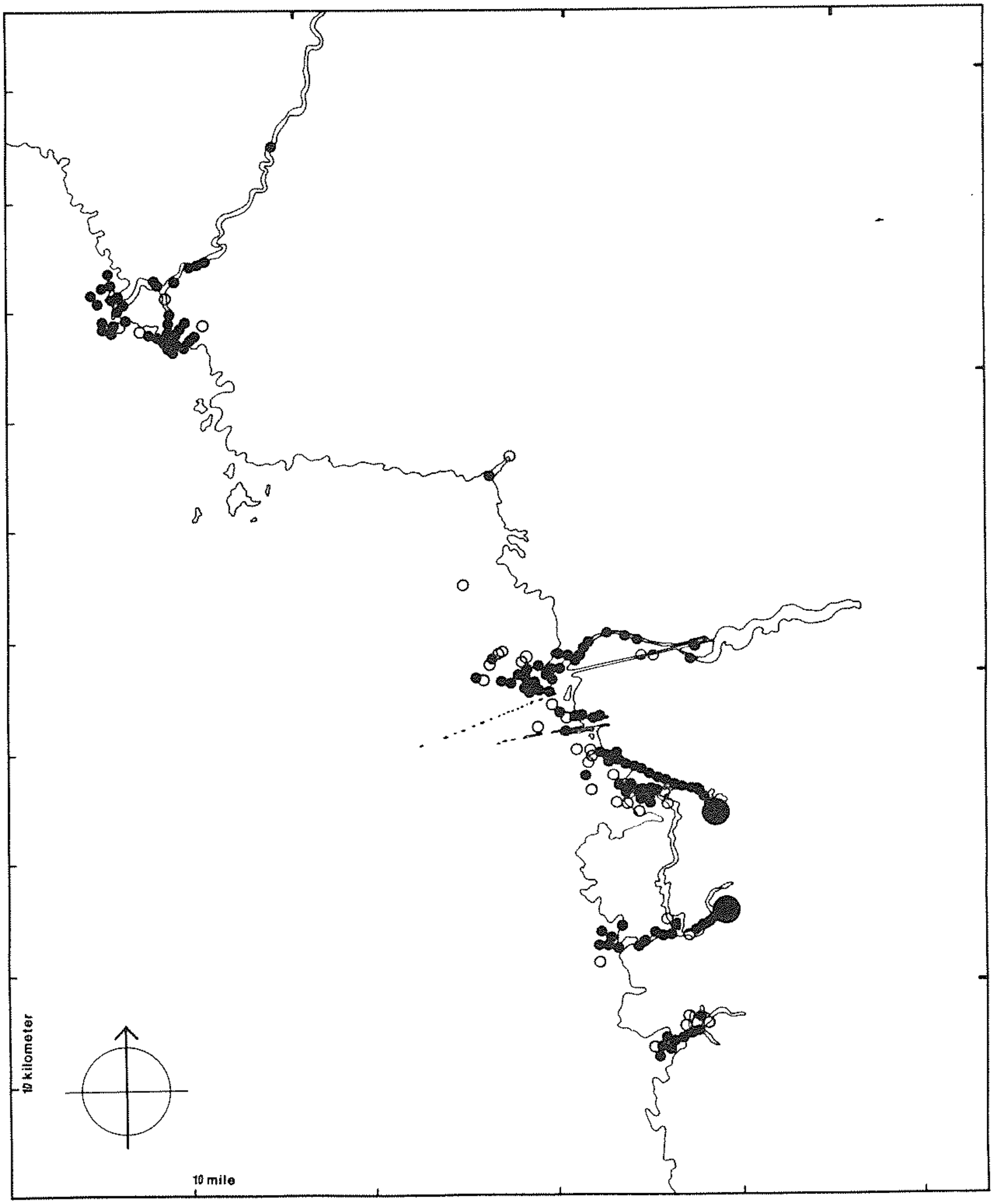


FIGURE 17: PROPORTION OF MANATEES RETURNING TO CRYSTAL RIVER ANNUALLY.

Numbers in parentheses are the total identified manatees for each year. Data are based on individuals identified by scar patterns (Powell and Rathbun 1983).



● More than 100 sightings

• More than 2 sightings

○ 1-2 sightings

FIGURE 18: MANATEE DISTRIBUTION IN SOUTH BIG BEND.

Data are from aerial surveys (N= 48) that were conducted from January 1978 to March 1981 (from Powell and Rathbun 1983).

Table 13. Comparison of summer aerial survey manatee counts among six waterways on the central west coast of Florida from 1979 through 1981[1].

River (No. flights)	Unweighted mean[2]	Minimum count	Maximum count
Suwannee River (37)	11.1[a]	0	33
Withlacoochee River (37)	2.6[b]	0	20
Cross Florida Barge Canal (37)	0.3[b]	0	3
Crystal River (37)	14.0[a]	0	58
Homosassa River (37)	2.3[b]	0	15
Chassahowitzka River (37)	2.4[b]	0	8

[1]From Powell and Rathbun (1983); surveys conducted April through October.

[2]Mean number of manatees per flight per year averaged over 3 years. Means with same superscript are not significantly different. Statistical analysis based on square root transformation.

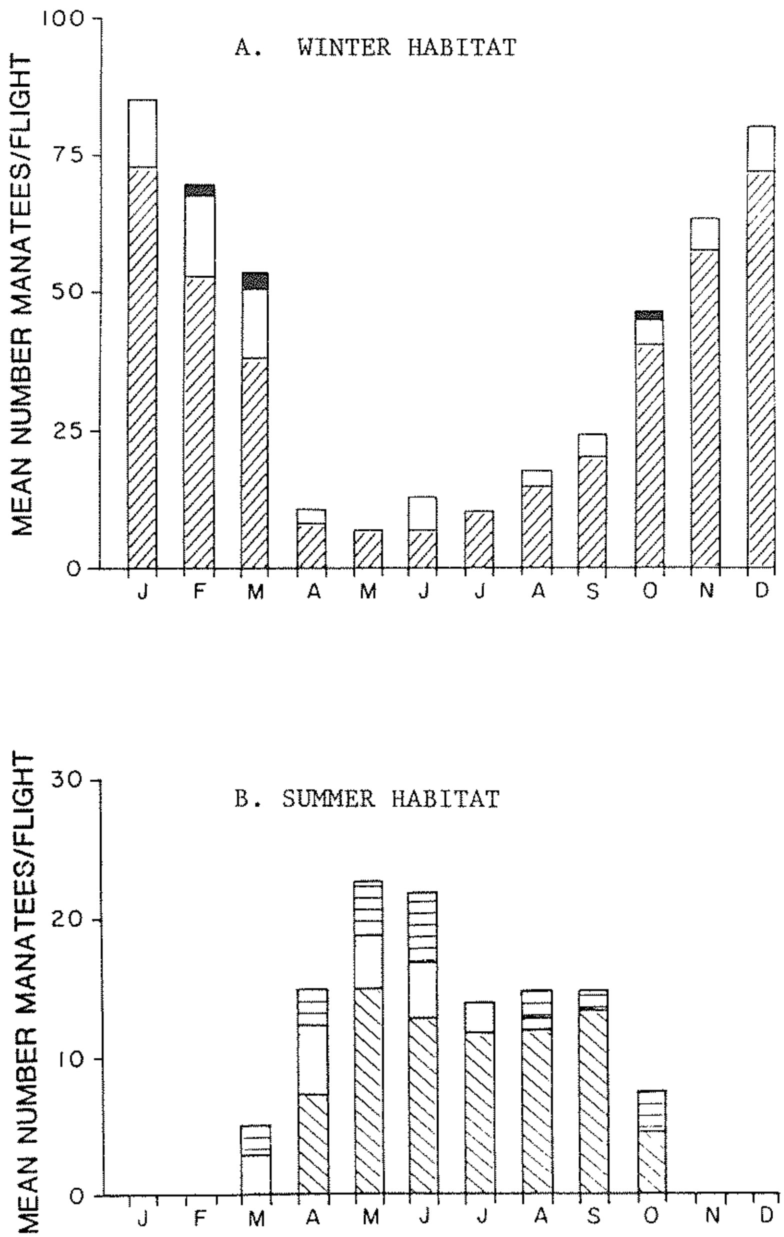


FIGURE 19: SEASONAL TRENDS OF MANATEE DISTRIBUTION IN WINTER AND SUMMER SITES.

Winter habitat includes Crystal River (diagonal lines), Homosassa River (white bar) and Crystal River power plant (black bar). Summer habitat includes Suwannee River (diagonal lines), Chassahowitzka River (horizontal lines) and Withlacoochee River (dotted bar). Data are from Powell and Rathbun (1983). The shading indicates relative proportion of total manatees observed in each river. The mean number of manatees observed per flight in each type of habitat is indicated by height of the entire bar.

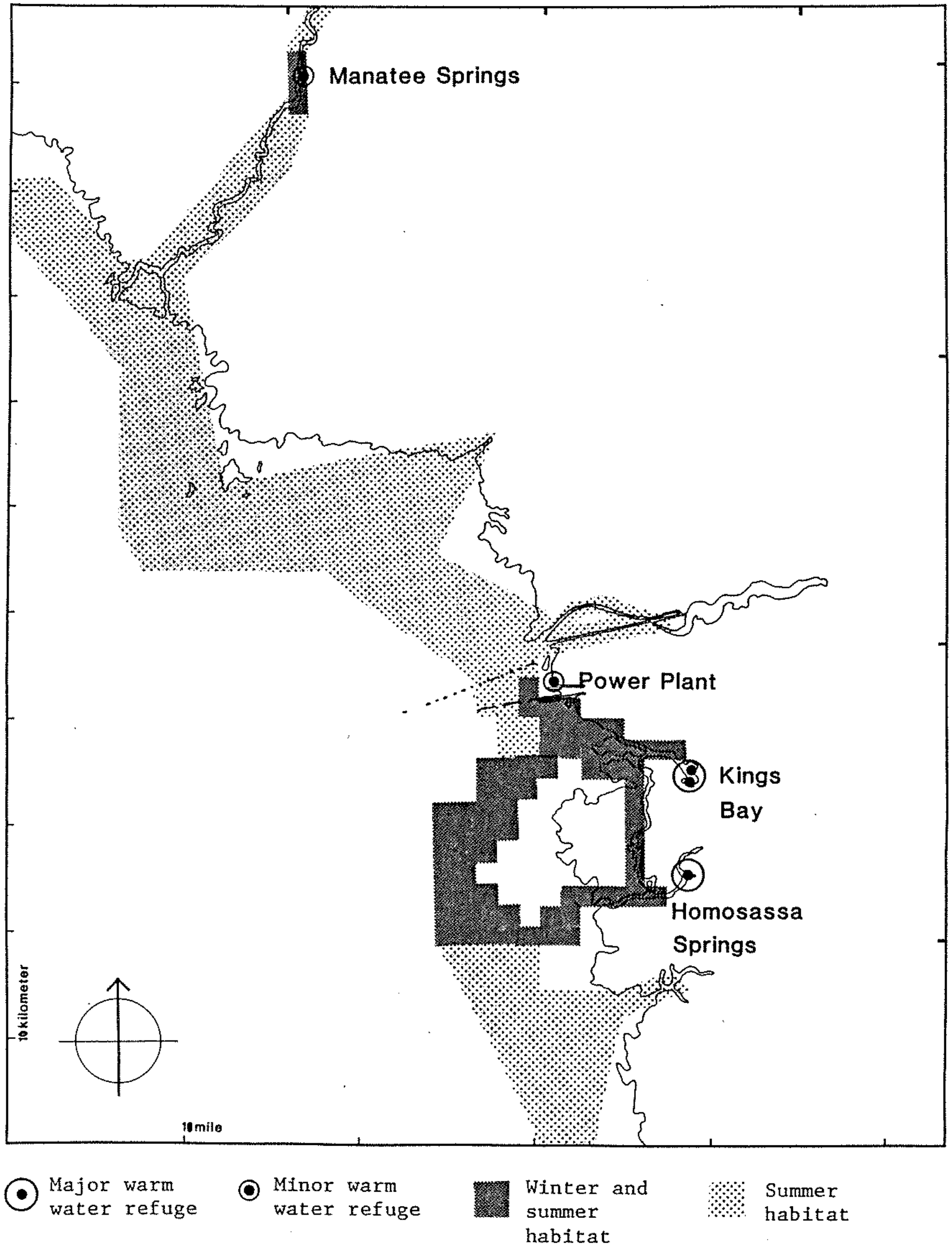


FIGURE 20: LOCATION OF SUMMER AND WINTER MANATEE HABITAT.

Information is from Powell and Rathbun (1983).

manatee sightings in these two rivers increased in frequency in the middle of October (Hartman 1979). During winters 1980-81 and 1981-82, the frequency of sightings increased as early as September (Powell and Rathbun 1983) (Figure 19).

Winter aggregations in Crystal River disperse by April, although frequency of sightings begins to decrease in mid-March (Hartman 1979, Powell and Rathbun 1983). However, the peak period of aggregation in Crystal River extends from November through February.

Peak periods of aggregation at Homosassa River and the power plant tend to lag somewhat behind that of Crystal River (Figure 19). Manatees were sighted most frequently in the Homosassa River from January through March, and at the power plant in February and March (Powell and Rathbun 1983). These observations might lead to the hypothesis that manatees pause at Homosassa River and the power plant as they disperse from Crystal River to locations along the coast.

Peak counts of manatee sightings in the Chassahowitzka and Withlacoochee rivers occur in the early summer (April through June), slightly before the peak for the Suwannee estuary (May through December) (Figure 19). However, Manatee Springs on the Suwannee attracts a few manatees (up to 6) all year. Sightings made opportunistically by park personnel and others since 1976 suggest that manatees have been sighted less frequently during spring and fall than during winter and summer (Figure 21).

Areas important for feeding, resting, traveling and reproductive activities (Figure 22) are also known from anecdotal observations (Hartman 1979, Powell and Rathbun 1983, Rathbun pers. comm.). Manatees have been observed feeding at Manatee Springs, the Suwannee estuary, below the dam on Lake Rousseau, the mouths of the Withlacoochee, Crystal, Homosassa, and Chassahowitzka Rivers, and the headwaters of Crystal and Homosassa Rivers. Pregnant females have been sighted at Manatee Spring and Crystal River. Calves have been sighted at the Suwannee estuary, Manatee Spring, Crystal, Homosassa and Chassahowitzka rivers. Mating herds have been observed at the mouth of the Suwannee, Withlacoochee and Chassahowitzka rivers, the headwaters of the Homosassa, and most frequently in Kings Bay. Travel occurs among all the river systems; although exact routes of travel are poorly documented, it is probable that manatees remain fairly close to shore (Rathbun pers. comm.). Hartman (1979) reported that fishermen encountered a manatee 5 km (3 mi) from shore.

Distribution of manatee sightings within each river is related to the characteristics of the river (Powell and Rathbun 1983). In the Suwannee River (Figure 23) and Chassahowitzka River (Figure 24), manatees are sighted significantly more frequently in the estuary than in the river or Gulf waters. In the Withlacoochee River (Figure 25), manatees are sighted significantly more frequently in the river than Gulf waters, although estuarine sightings, which are of intermediate frequency, do not differ significantly from sightings in the river or Gulf areas. In Crystal River (Figure 26), manatee sightings are significantly more frequent in the river than in the

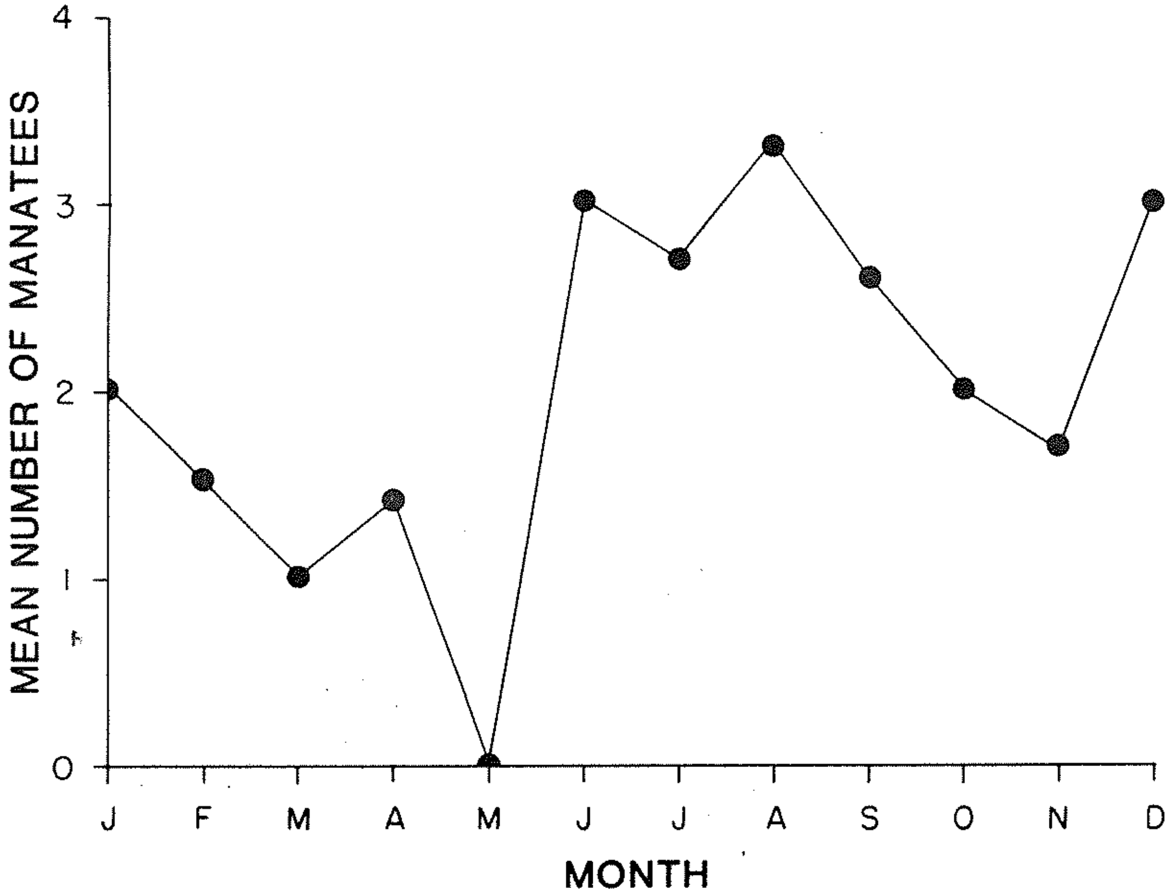
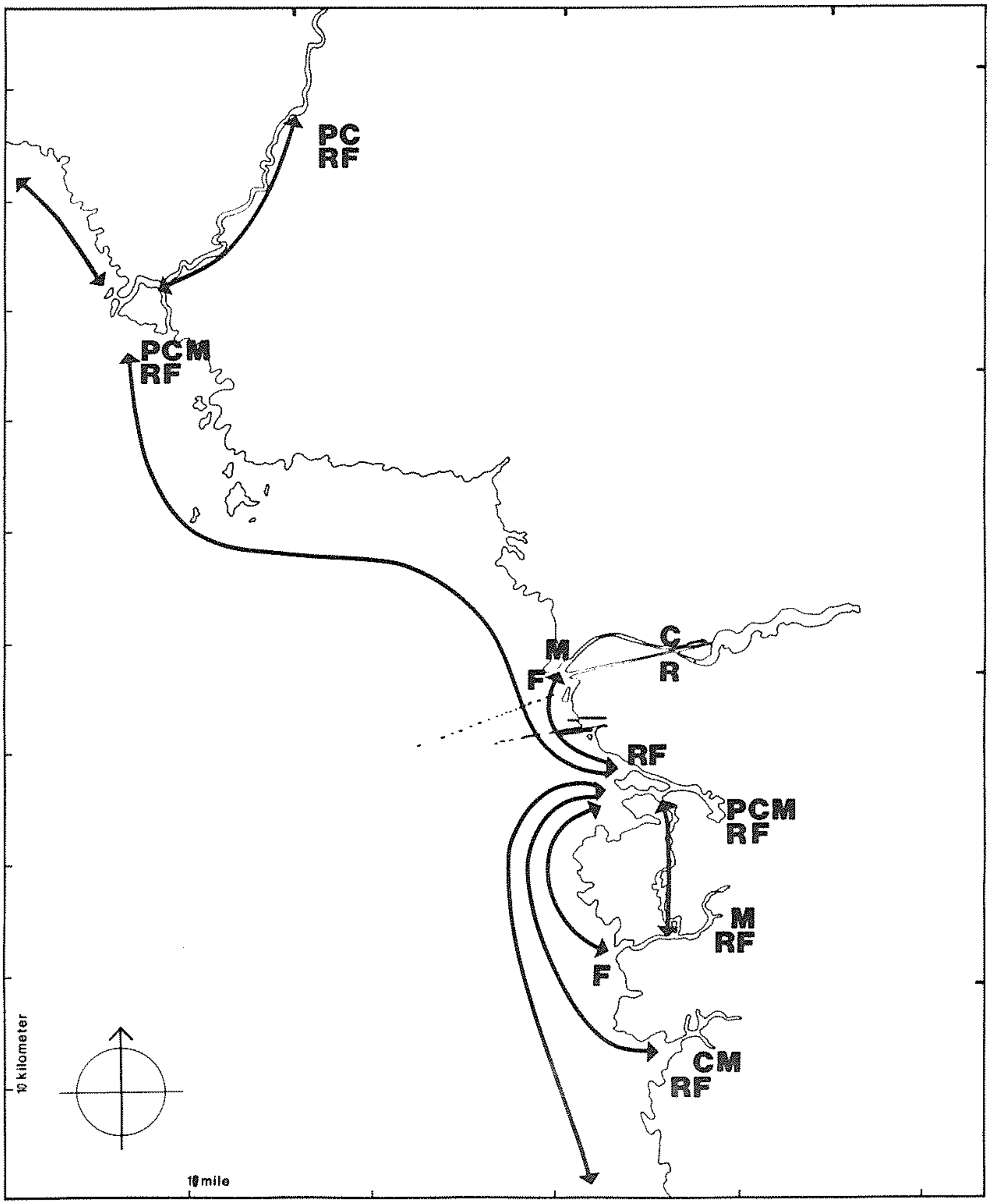


FIGURE 21: SEASONAL TRENDS IN MANATEE SIGHTINGS AT MANATEE SPRINGS STATE PARK.

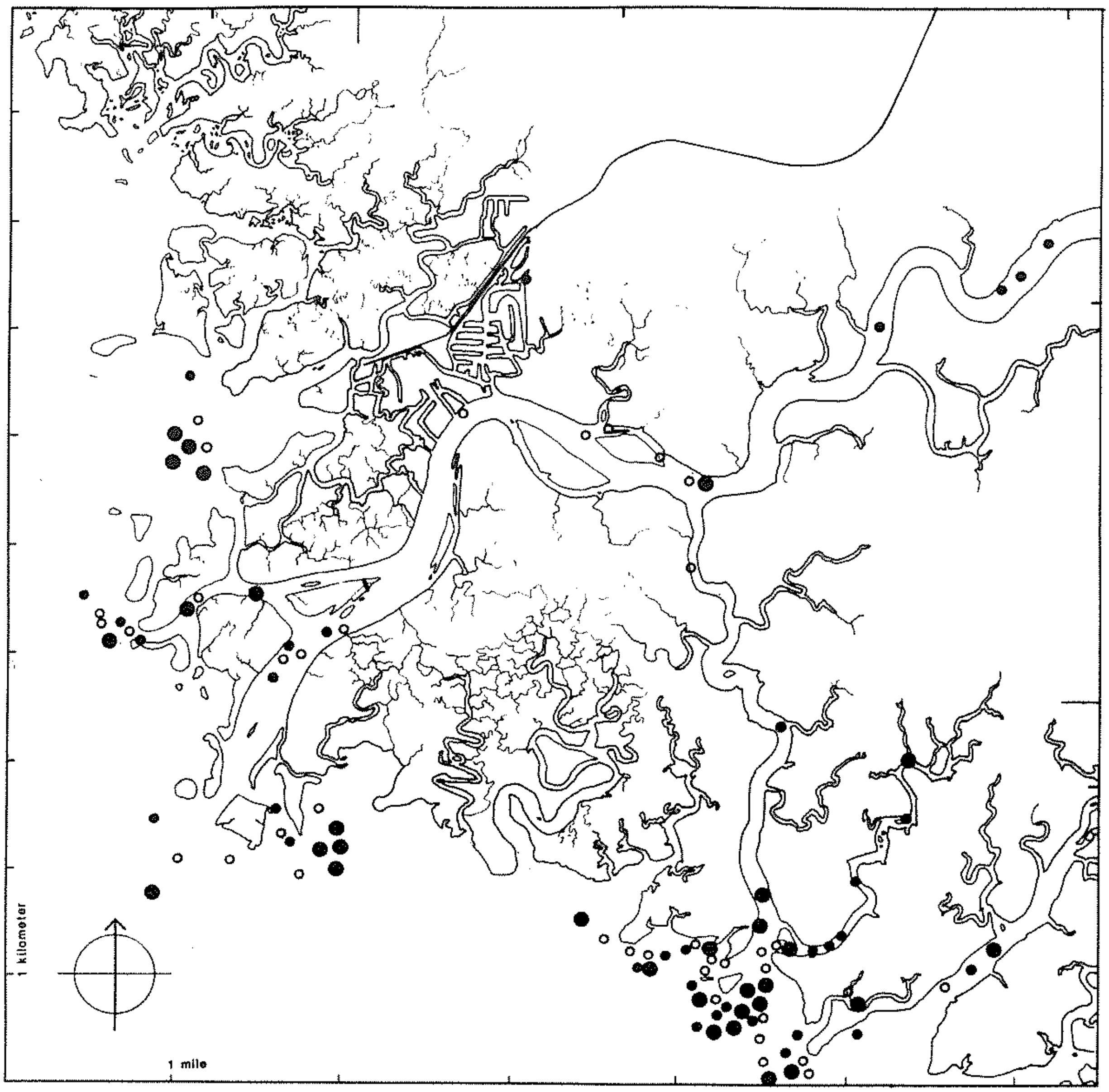
Data are from the reported number of manatees sighted per day from 1976 through 1982 by park personnel (Rathbun, pers. comm.). No correction was made for variation in observation effort.



Travel routes
C Calves sighted
F Feeding activity
M Mating groups
P Pregnant females
R Resting activity

FIGURE 22: MANATEE ACTIVITIES IN SOUTH BIG BEND.

Data are from Powell and Rathbun (1983).



● More than 5 sightings • 3–5 sightings ○ 1–2 sightings

FIGURE 23: MANATEE SIGHTINGS IN THE SUWANNEE ESTUARY.

Data are from aerial surveys (N = 28) conducted during January 1978 through March 1981 (Powell and Rathbun 1983).

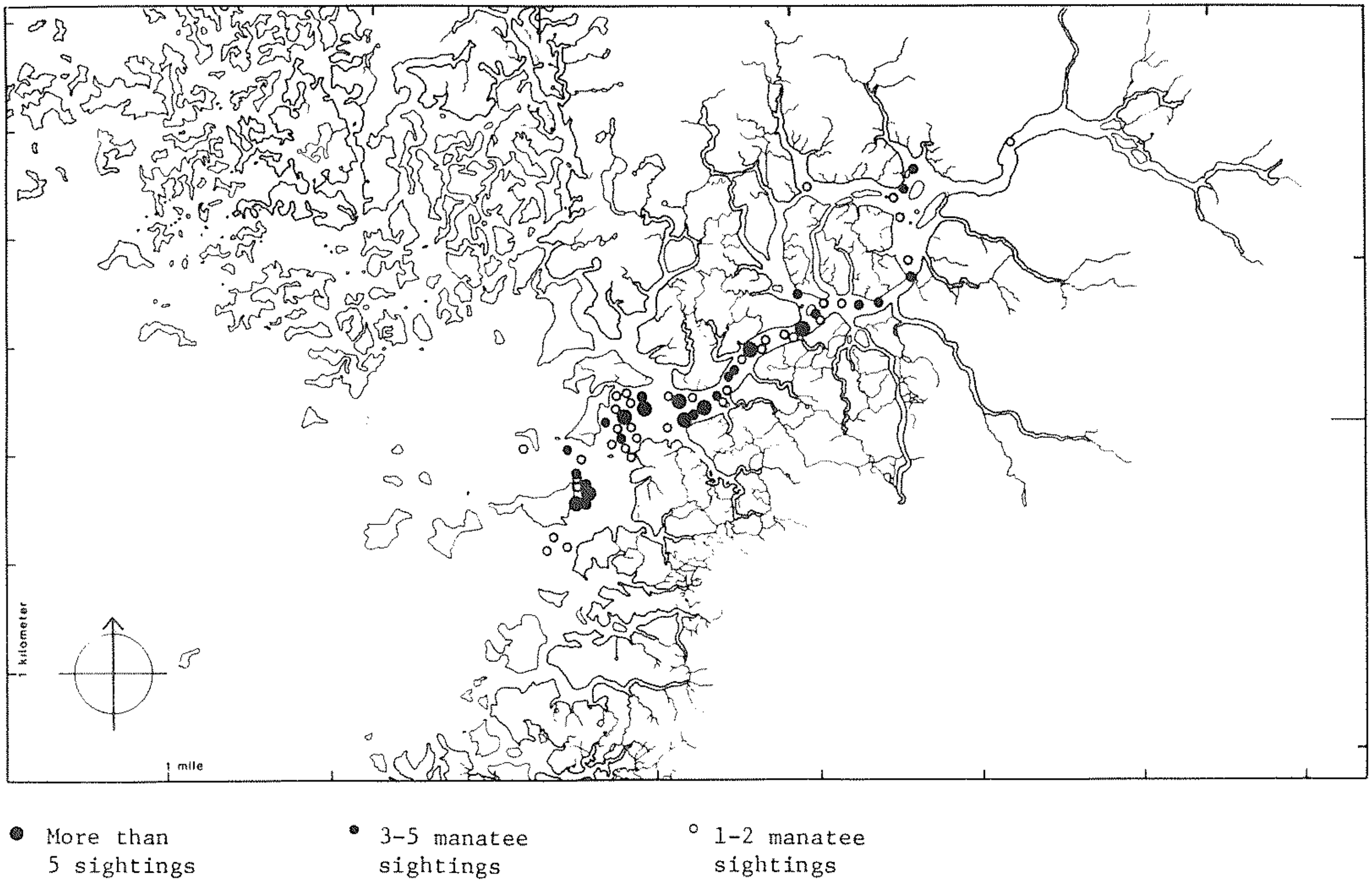
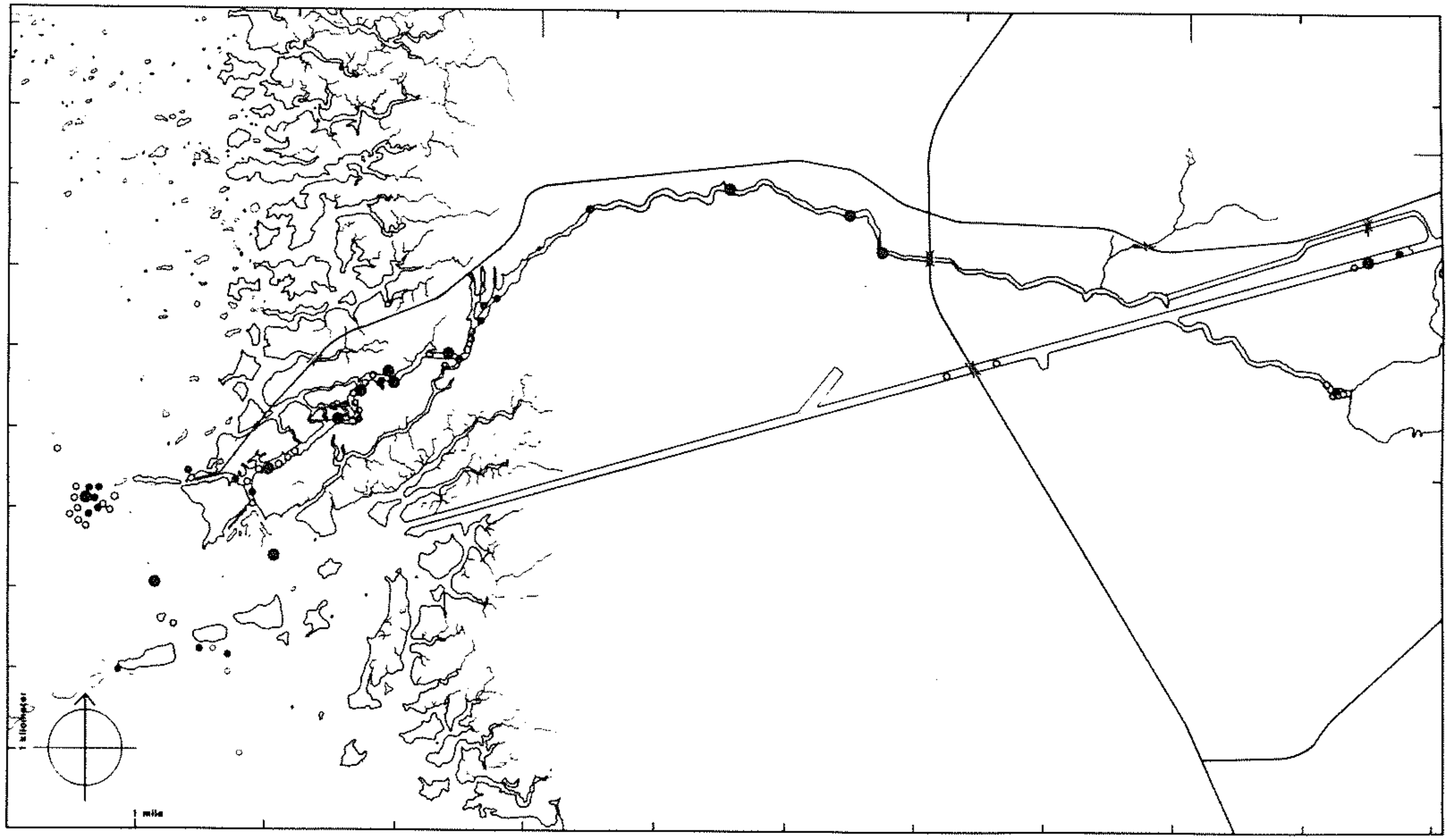


FIGURE 24: MANATEE SIGHTINGS IN THE CHASSAHOWITZKA RIVER.

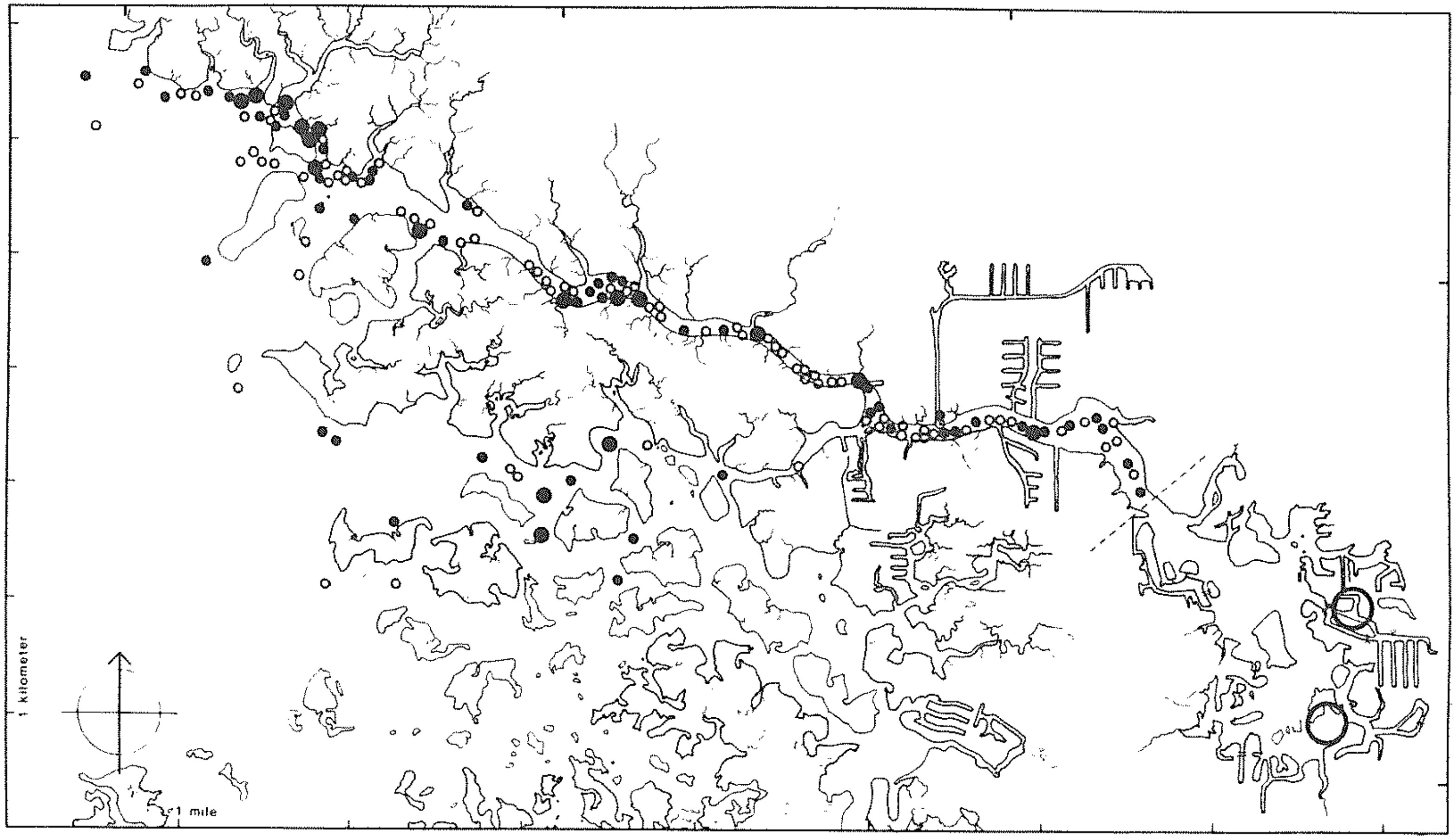
Data are from aerial surveys (N = 48) conducted during January 1978 through March 1981 (Powell and Rathbun 1983).



● More than 5 sightings
• 3-5 manatee sightings
° 1-2 manatee sightings

FIGURE 25: MANATEE SIGHTINGS IN THE WITHLACOOCHEE RIVER.

Data are from aerial surveys (N = 48) conducted during January 1978 through March 1981 (Powell and Rathbun 1983).



● More than 5 sightings   • 3–5 manatee sightings   ∘ 1–2 manatee sightings   ○ Site of winter aggregation

FIGURE 26: MANATEE SIGHTINGS IN THE LOWER CRYSTAL RIVER.

Data are from aerial surveys (N = 48) conducted during January 1978 through March 1981 (Powell and Rathbun 1983). Sightings upstream from the dashed line are not included because they were too numerous. Details are available in Kochman et al. (1983).

estuary, and more frequent in the estuary than in the Gulf. In Homosassa River (Figure 27), sightings are significantly more frequent in the river than in the estuary or Gulf, but there is little difference between the estuary and the Gulf. Manatees are sighted more frequently in the effluent canal at the Crystal River power plant than in adjacent areas (Figure 28).

4. HABITAT REQUIREMENTS OF MANATEES

Based on the information discussed above, five essential characteristics have been used in this study to determine habitat for manatees: water depth, vegetation, warm-water refuges, manatee sightings from aerial surveys, and observed (or inferred) manatee activity. These factors have been plotted on a map at the regional scale to determine which are the most important localities to analyze at a larger scale.

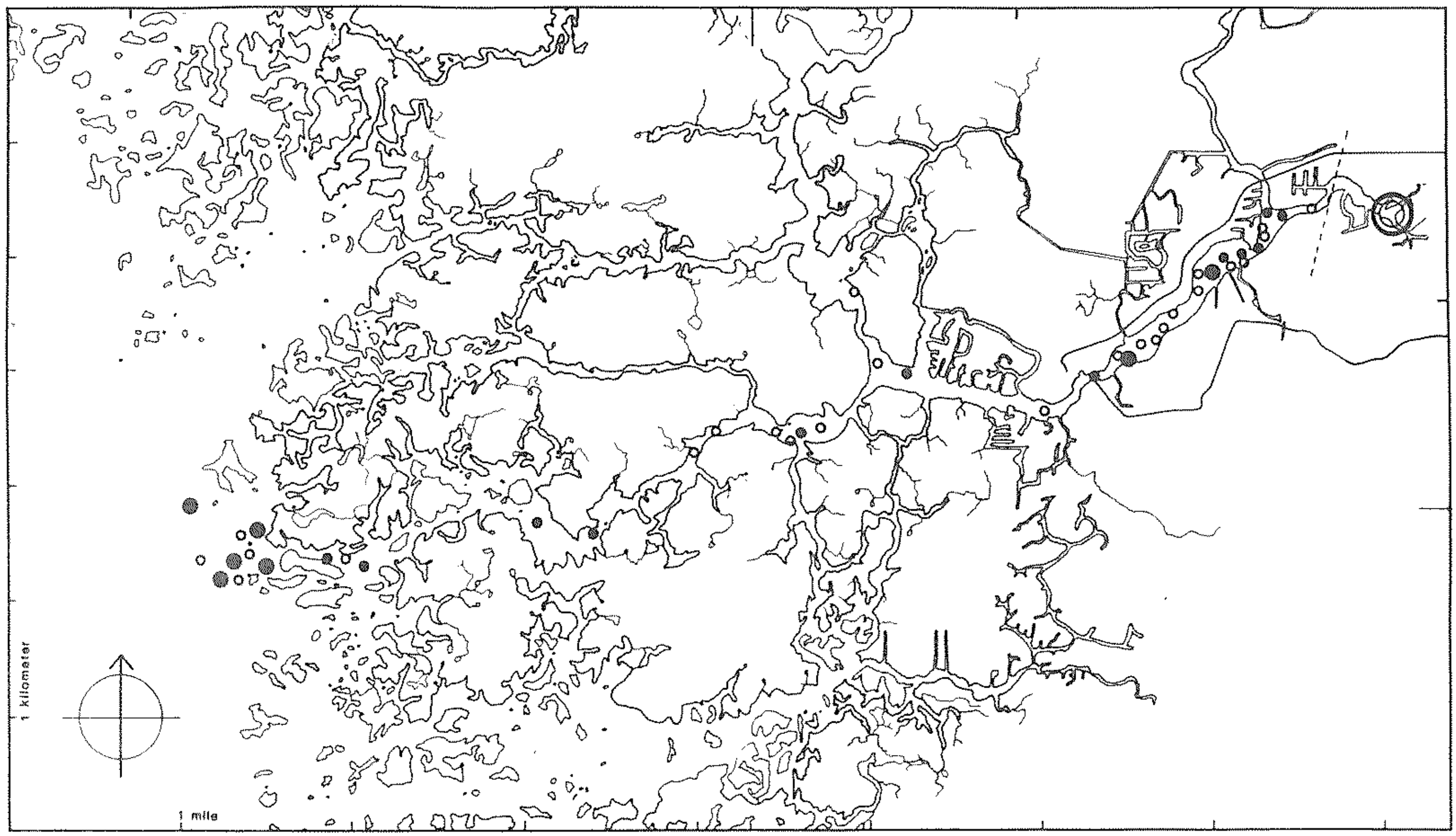
Manatee habitat may be characterized by these factors for the following reasons. Water depth limits the access of manatees to essential resources, because manatees rarely go into areas less than 90 cm (3 ft) deep, or probably greater than 6 m (20 ft) deep (Hartman 1979). Vegetation provides their food resources, and water warmer than 20°C (68°F) is essential for their survival over prolonged periods (Irvine 1983). The distribution of manatees sighted on aerial surveys provides a consistent means of comparison among locations. However, it is often difficult to sight manatees in areas of turbid water, so direct observations must be supplemented with information on travel routes and other activities observed at times other than standardized surveys. Information on manatee distribution and activities in the management area should be considered incomplete at this time. Additional information is needed to refine understanding of which areas are most important for essential life functions such as mating, calving, feeding, traveling, resting, etc.

In this subsection, manatee habitat in South Big Bend is evaluated, to identify areas of primary importance. Two of these core areas of habitat (Crystal River and Homosassa River) are then examined in greater detail at a larger scale.

4.1 South Big Bend

A land-use planning technique known as "Systems Analysis Mapping" (Ray et al. 1978) was adopted to evaluate manatee habitat in South Big Bend. The information that was mapped included characteristics of manatee habitat: warm-water refuges (Figure 29), manatee sightings from aerial surveys (Figure 30), manatee travel routes as inferred from the best available data (Figure 31), and vegetation (Figure 32). A two-kilometer grid was overlaid on the South Big Bend basemap, and the presence of each habitat characteristic was tallied for each square of the grid. Squares with the most essential habitat elements were shaded the darkest, providing a picture of the relative importance of areas to manatees (Figure 33). The importance ranking assigned to habitat elements is as follows.

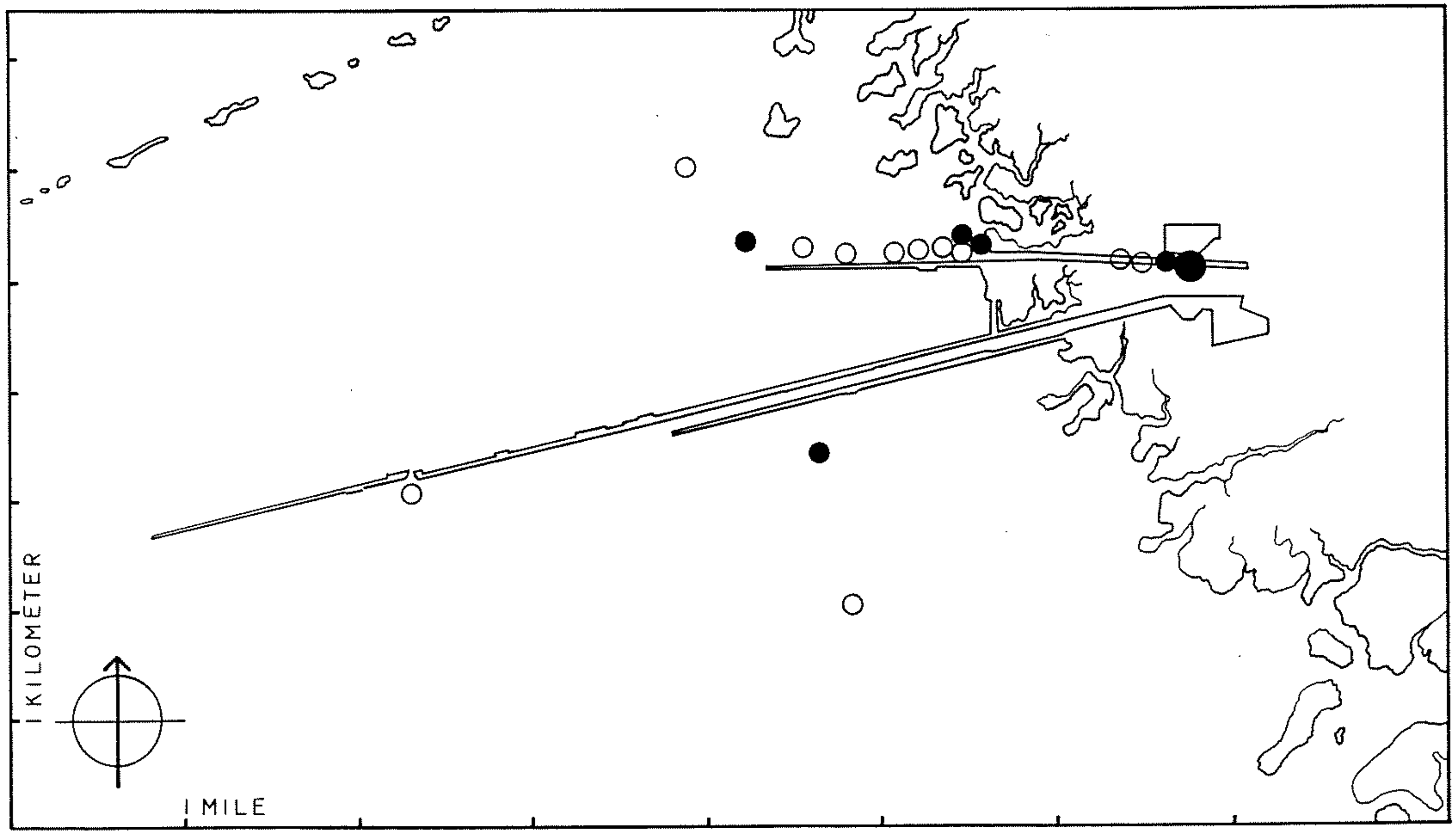
1. Essential Areas: Four important warm-water refuges occur in the South Big Bend Region (Figure 20). Kings Bay and Homosassa River are of major



● More than 5 sightings • 3–5 manatee sightings ∘ 1–2 manatee sightings ◎ Site of winter aggregation

FIGURE 27: MANATEE SIGHTINGS IN THE HOMOSASSA RIVER.

Data are from aerial surveys (N = 48) conducted during January 1978 through March 1981 (Powell and Rathbun 1983). Sightings upstream from the dashed line are not included because they were too numerous.



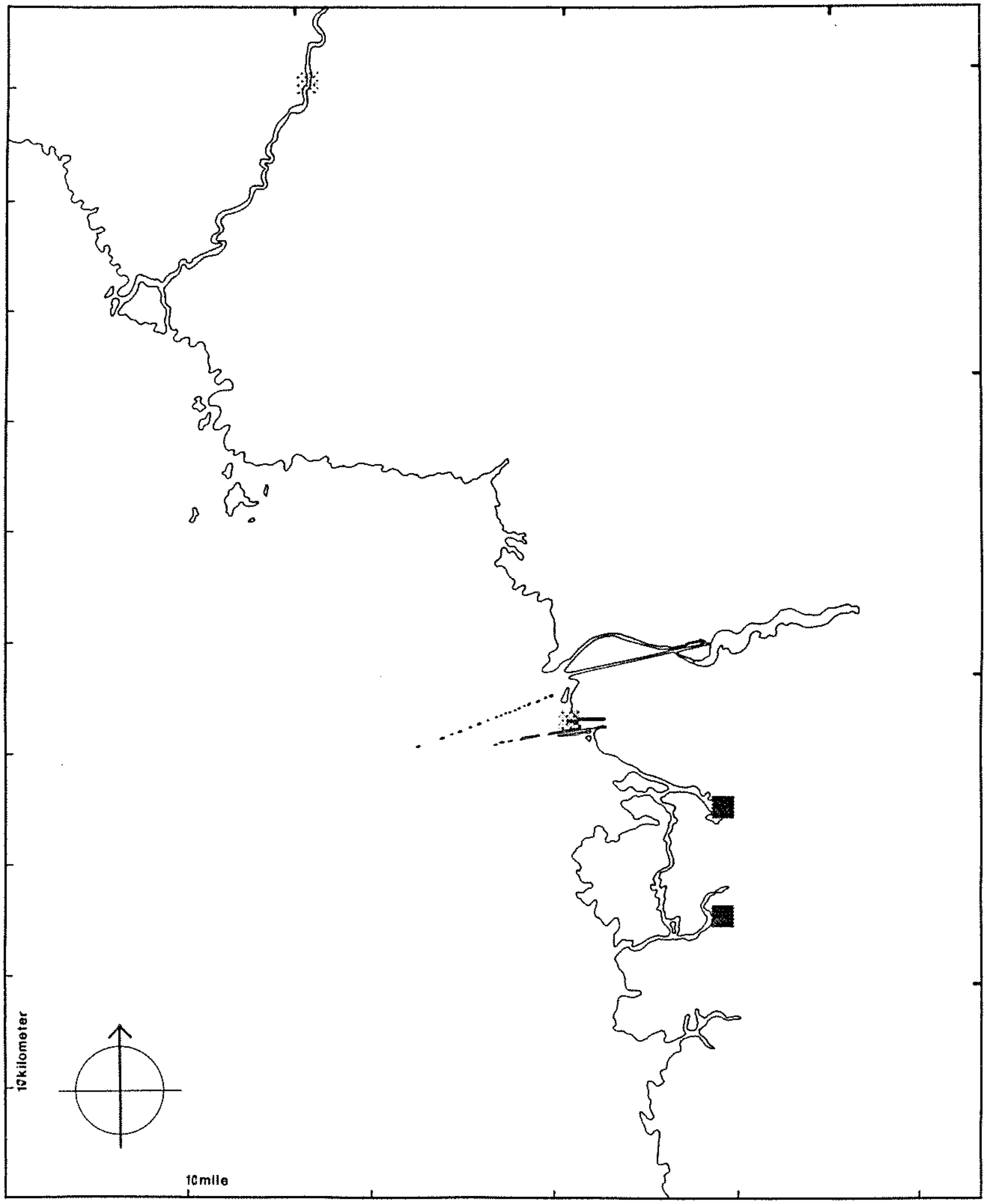
More than 5 sightings

3-5 manatee sightings

1-2 manatee sightings

FIGURE 28: MANATEE SIGHTINGS AT THE CRYSTAL RIVER POWER PLANT.

Data are from aerial surveys (N = 48) conducted during January 1978 through March 1981 (Powell and Rathbun 1983).

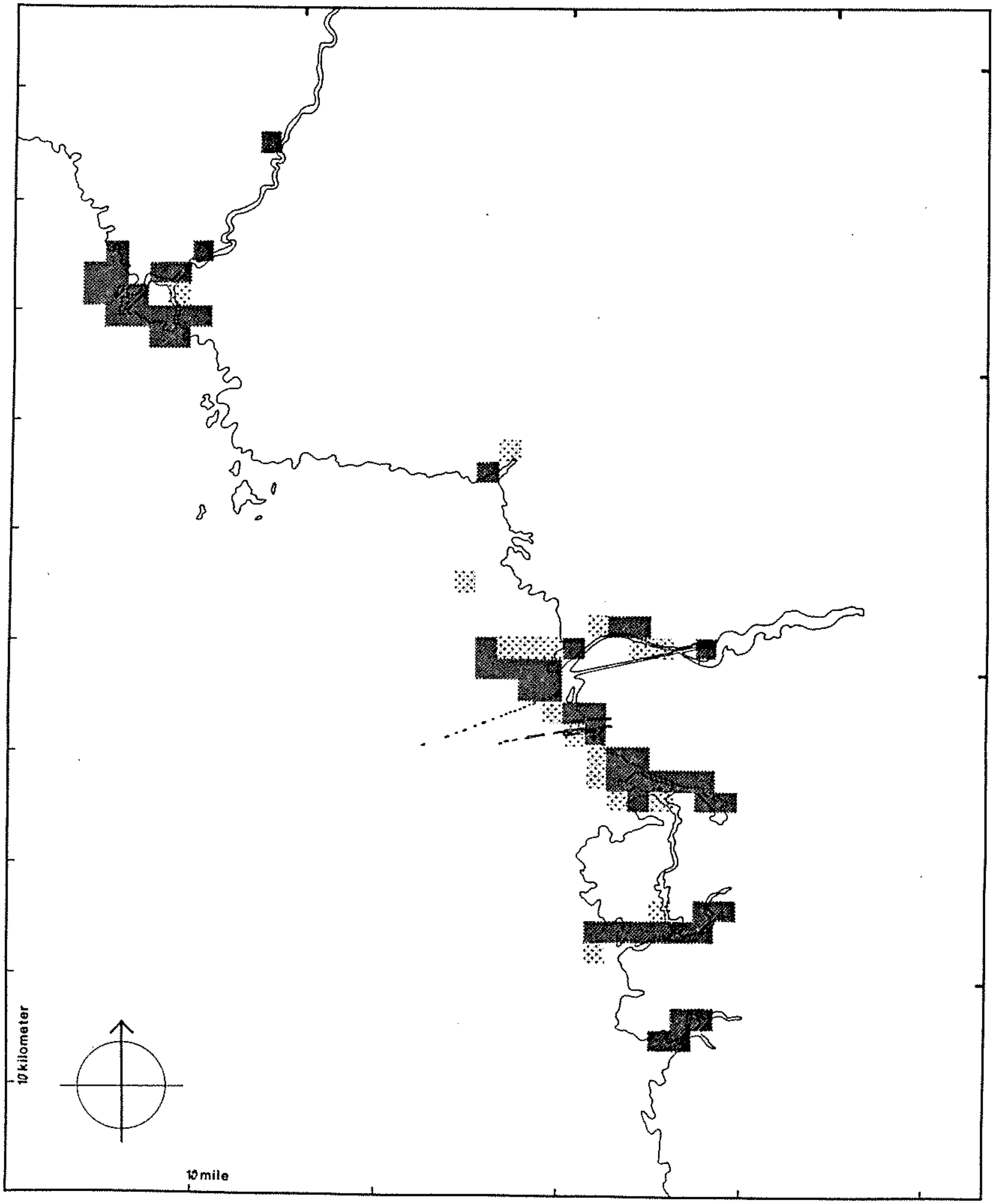


Major warm water refuge

Minor warm water refuge

FIGURE 29: WARM-WATER REFUGES IN SOUTH BIG BEND.

Based on Figure 20.

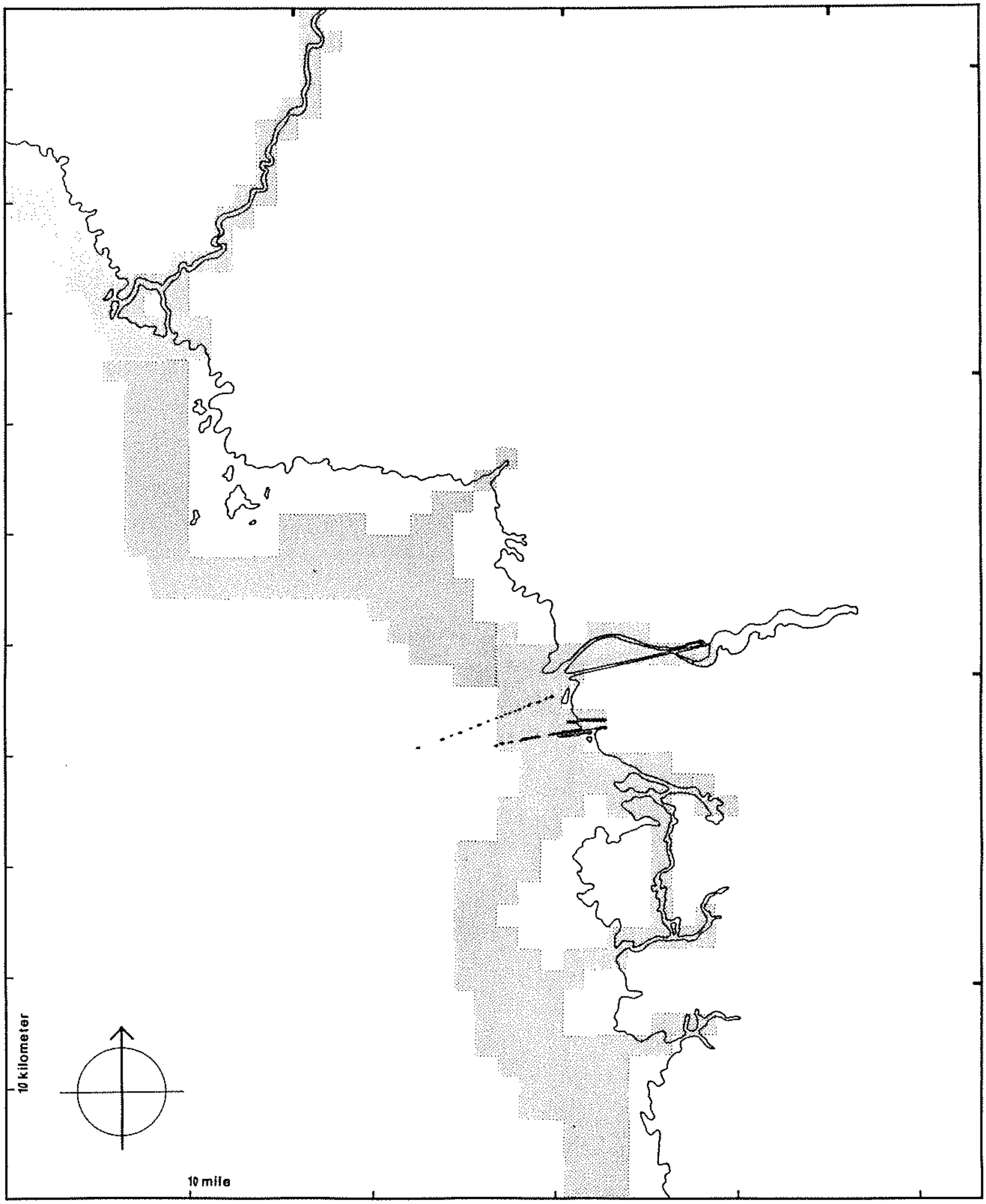


More than 2 manatee sightings

1–2 manatee sightings

FIGURE 30: RELATIVE DENSITY OF MANATEE SIGHTINGS IN SOUTH BIG BEND.

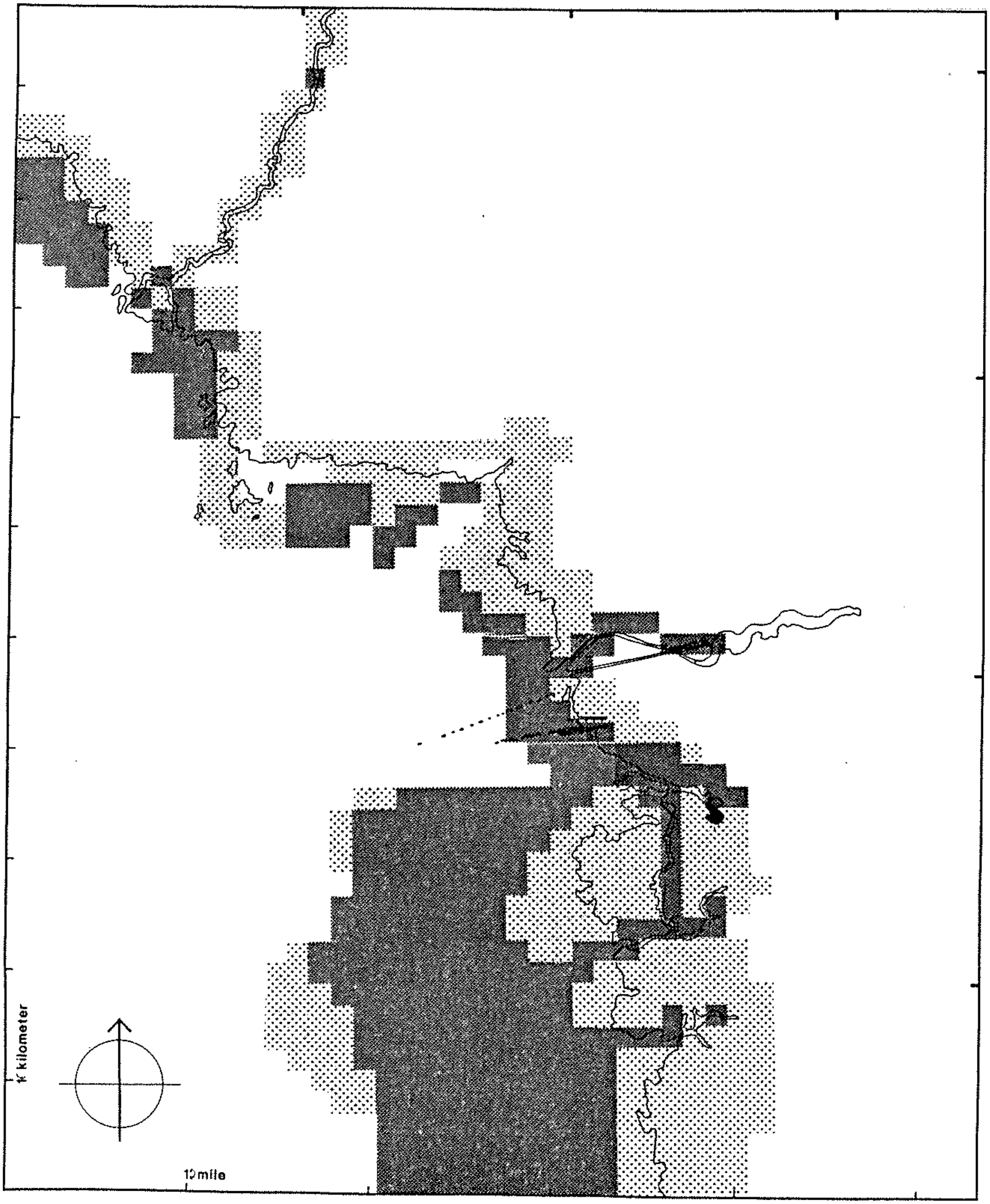
Grid cells that are shaded indicate the relative density of manatee sightings as shown in Figure 18.



Inferred manatee travel routes

FIGURE 31: <u>MANATEE TRAVEL ROUTES IN SOUTH BIG BEND.</u>

Grid cells that are shaded indicate waters of appropriate depth for manatee travel as shown in Figure 22 and Figure 3.



Vegetation at depths available to manatees

Supporting ecosystems (wetlands or deep seagrasses)

FIGURE 32: POTENTIAL FEEDING AREAS OF MANATEES IN SOUTH BIG BEND.

Grid cells that are shaded indicate presence of vegetation at water depths of 1-4 m (3-18 ft), or areas exporting detritus into such regions as shown in Figure 11 and Figure 3.

Essential habitat

Core activity centers

Travel routes

Potential off-shore feeding

Supporting Ecosystem

FIGURE 33: SUMMARY OF MANATEE HABITAT IN SOUTH BIG BEND.

Summary by grid cell of information on Figures 29 through 32.

importance and Manatee Springs and the Crystal River power plant are of minor importance (refer to Subsection 3.3). Because South Big Bend is at the northern extreme of the species' range, manatees could not remain in the area without access to these warm-water refuges; therefore protection of such areas is essential.

2. Core Activity Centers: Manatees are sighted during aerial surveys much more frequently in freshwater rivers and estuaries than offshore (Figure 18). Grid cells where three or more manatees had been sighted were considered of major importance and cells with only 1-2 sightings were of minor importance (Figure 30). Areas where manatees have been sighted indicate core centers where several activities such as feeding, mating, resting, and possibly calving occur (Figure 22). Disturbance in these areas could influence the rate at which the population grows or declines.

3. Travel Routes: Manatees are known to travel between the river systems where they are sighted (Hartman 1979, Powell and Rathbun 1983). Such travel routes probably also provide food, reproductive needs and individual space; however, such functions are currently poorly understood. The grid squares shaded in Figure 31 represent suitable water depths along the travel routes shown schematically in Figure 22. Travel routes linking core activity centers are important to maintain free movement of manatees between summer and winter ranges. Changes in these areas should be avoided until their functions for manatees are better known.

4. Accessible Vegetation: Potential feeding areas for manatees occur where there is vegetation at water depths between 1-6 m (3-20 ft) (Figure 32). This area was determined by overlaying the map of vegetation (Figure 11) and the map of water depths (Figure 3). The degree to which offshore seagrass meadows are utilized by feeding manatees has not been fully evaluated. Although current evidence suggests that manatees rarely use these areas, offshore vegetation may become more important in the future as manatee abundance increases.

5. Supporting Ecosystem: Even though manatees may not consume wetland vegetation or aquatic vegetation in very shallow or deep waters, such communities contribute to maintenance of other plant communities used by manatees. Essential biological functions of these wetlands and marine meadows must be maintained to insure the quality of manatee habitat.

The characteristics of manatee habitat in South Big Bend are summarized in Figure 33. Grid squares overlaying the most essential features are shaded the darkest. All characteristics of good habitat overlap at Crystal River and Homosassa River; therefore these areas are of highest priority to protect. Although there is not a warm-water refuge at the mouth of the Suwannee River, it clearly has a high degree of overlap of the other characteristics and is within traveling distance of a warm-water refuge. Protection of the lower Suwannee River is of second highest priority. Other areas identified as core habitat serve essential functions; manatees need all elements of habitat to maintain a viable population. Specification of the function of each area should allow management actions that match protective measures to the specific needs of manatees in the area.

Clearly, if Crystal River and Homosassa River become unsuitable habitat for manatees, the subpopulation would not persist in South Big Bend. If the Suwannee River habitat suffered degradation, the number of manatees would probably decline. Therefore protective effort should be focused on these areas. Available information regarding manatee habitat in Crystal and Homosassa rivers is summarized below. Manatee habitat in the lower Suwannee River has not been studied in detail.

4.2 Crystal River

Manatee habitat and activities at the headwaters of Crystal River have been mapped in detail by Hartman (1979) and Kochman et al. (1983). The information that follows is summarized from those accounts.

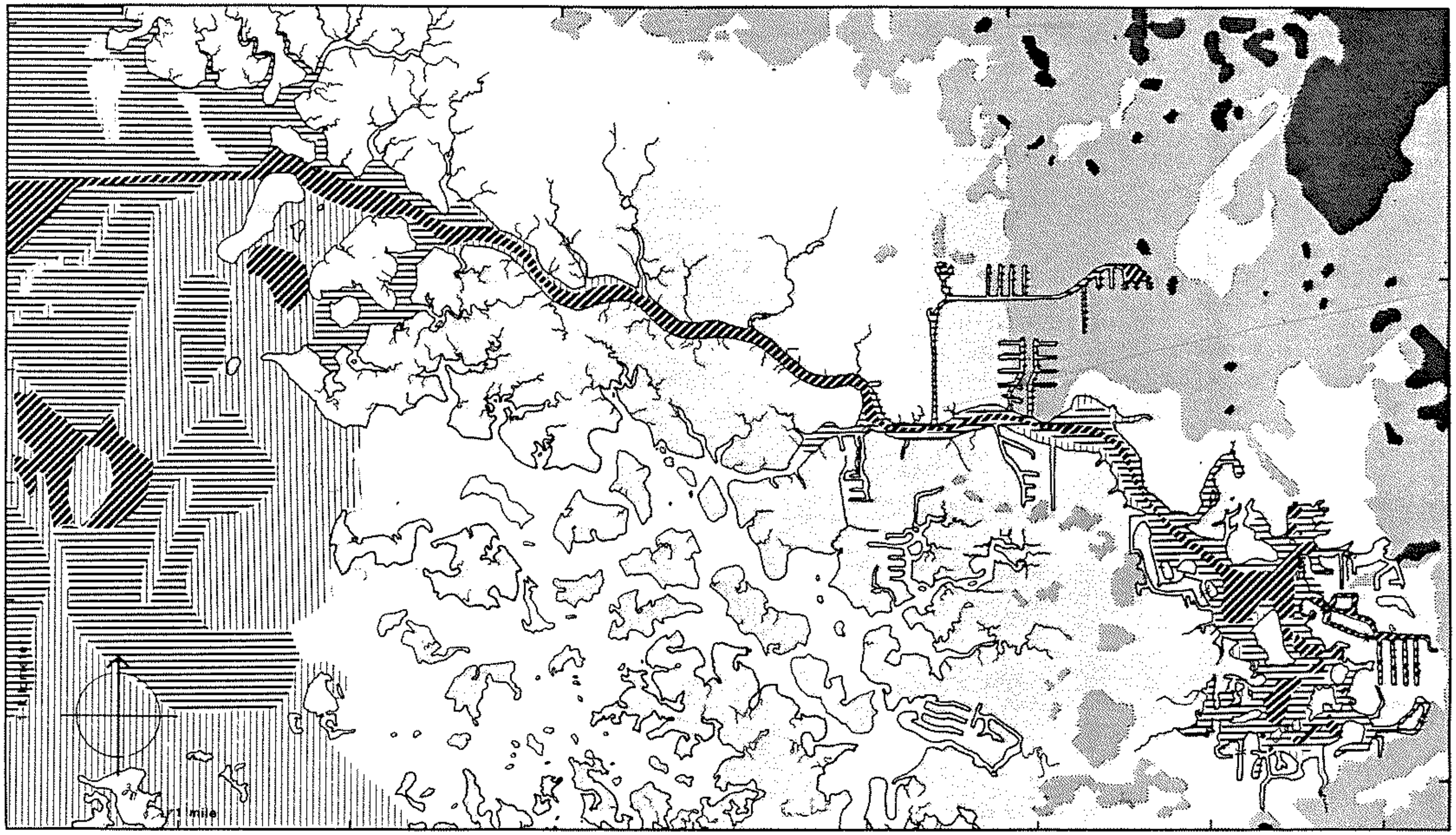
Kings Bay is relatively shallow (1-4 m, 4-16 ft), and drains through the Crystal River channel that is about 1.5 m (6 ft) deep up to the Salt River, beyond which the channel deepens to almost 4 m (16 ft) (Figure 34). The Salt River is shallow (60-120 cm, 2-4 ft) where it branches from Crystal River. Areas inaccessible to manatees are primarily along the perimeter in Kings Bay, particularly the southwest portion, and along the perimeter of the islands. Portions of Dixie Bay and the coast southwest of the Salt River are also too shallow for manatees.

Vegetation is densest in Kings Bay, with patches along the shore and in the river channel east of the Salt River, and a sparse, narrow band along the shore west of the Salt River (Figure 35). Vegetation that occurs among the oyster bars in the estuary has not been well mapped; for example, seagrass in Figure 35 is shown schematically from interpretation of an aerial photograph taken in 1972.

Mean water temperature in several parts of Kings Bay is above 20°C due to warm water from about 30 springs (Figure 36). The warmest (and deepest) areas are near the Main Spring (Tarpon Springs), Magnolia Springs (Gator Hole) and the northeastern cove.

Manatee distribution in Crystal River varies seasonally, with aggregations near warm-water springs in the winter (October through March) (Figure 37). The southern portion of Kings Bay (near Main Spring) is used most heavily from November through February and the Magnolia Springs area is used, less heavily, from January through February (Kochman et al. 1983). During the spring through fall months (April through September), manatees have been sighted throughout the bay in lower numbers than during winter. Manatees were sighted along the lower Crystal River during all months, although most frequently in winter. Thus, Crystal River is significant summer as well as winter habitat.

Areas important for four types of manatee activity (travel, resting, feeding and social interaction) have been mapped (Figure 38) from the accounts of Hartman (1979) and Kochman et al. (1983). All four types of activity are observed south of Banana Island and Warden Key (see Figure 8 for place names). Social interaction and resting is also observed west of Warden Key and around the Magnolia Springs. Manatees feed and rest frequently north



Above 10 ft (2.5 m) elevation

5–10 ft (1.2–2.5 m) elevation

0–5 ft (0–1.2 m) elevation

5 ft (1.2 m) or more water depth

3–4 ft (1 m) water depth

Less than 3 ft (1 m) water depth

FIGURE 34: BATHYMETRY/TOPOGRAPHY OF CRYSTAL RIVER.

Water depths are specified for mid tide. Data for the estuary are extrapolated from NOAA Nautical Chart 11408. Data for Kings Bay are from Kochman et al. (1983). Data for Crystal River are schematic (Packard, field notes). Water depths have not been mapped in areas indicated in white. Elevation contours are from USGS topographic maps Crystal River, Ozello, Red Level, and Homosassa, dated 1954.

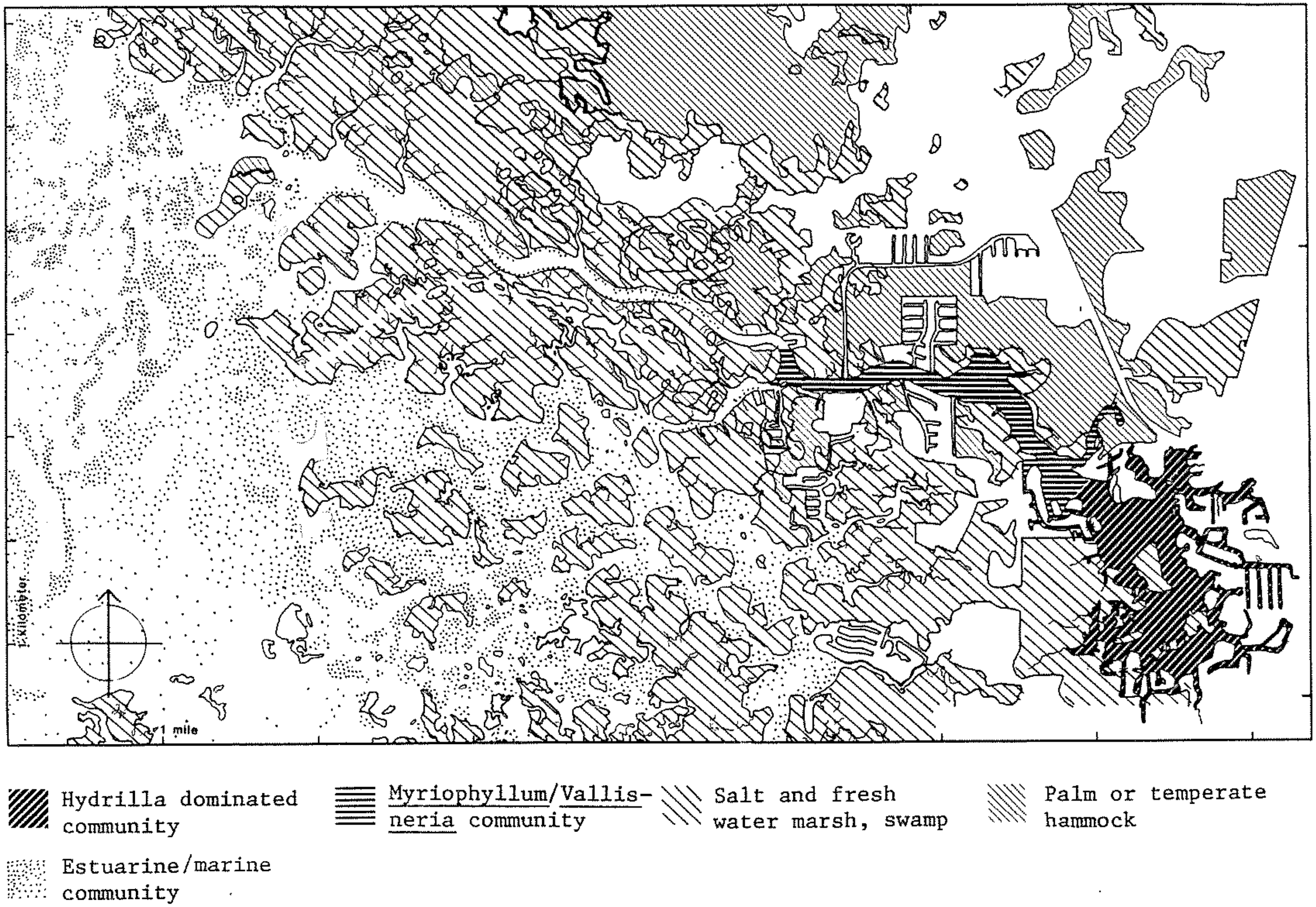


FIGURE 35: VEGETATION IN THE CRYSTAL RIVER AREA.

Data are represented schematically. Terrestrial vegetation is from Florida's DOT Land Use and Vegetation Inventory (1:24,000), maps of Red Level (333) and Crystal River (359), dated 1976. Aquatic vegetation is compiled from Kochman et al. (1983), field notes (Packard, personal observation), Sell (pers. comm.), photointerpretation of aerial photo "Red Level" No. 333 (Mark Hurd, Inc. 1972-1973). White areas on land are either disturbed or other vegetation, not here specified.

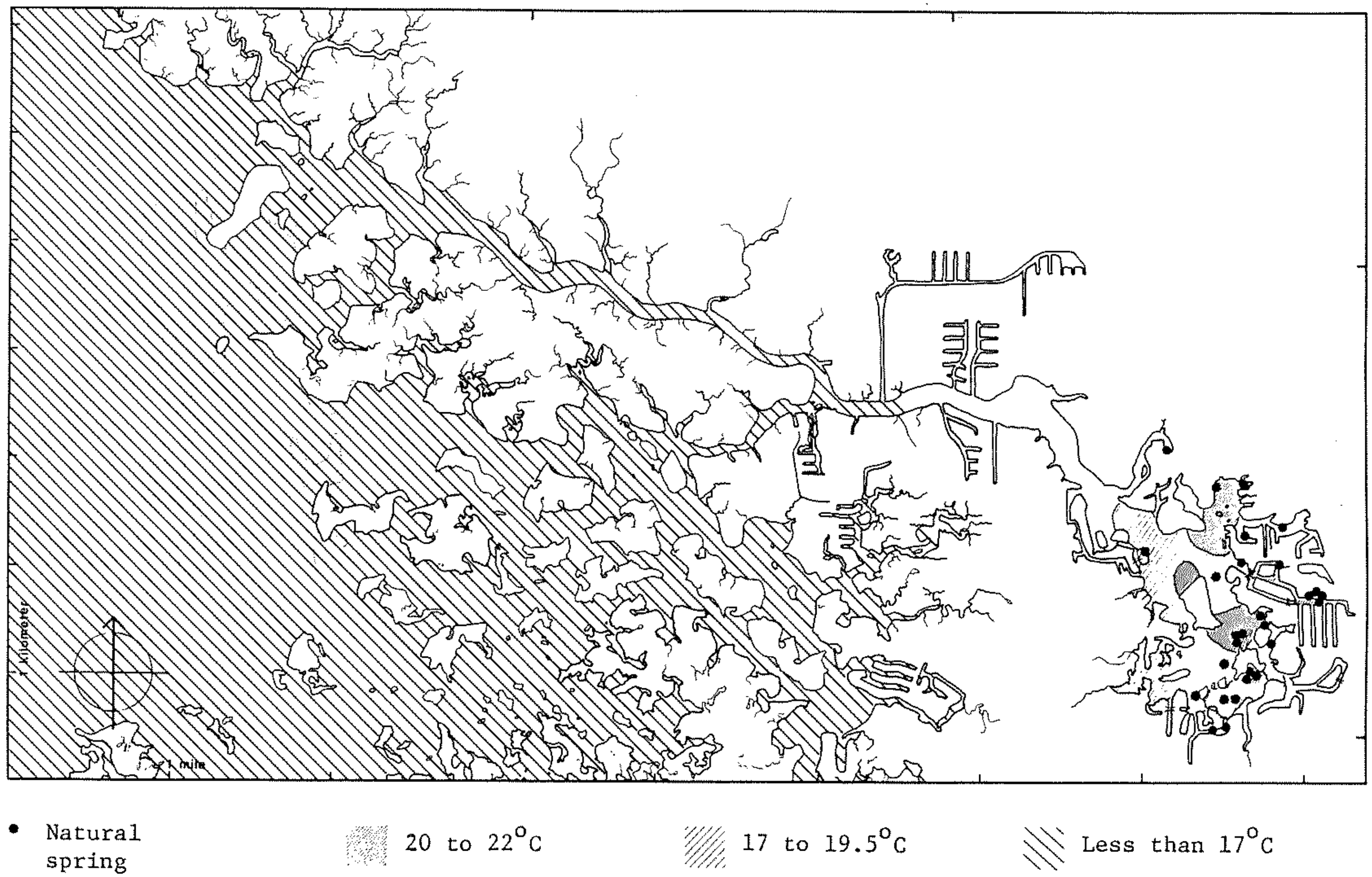


FIGURE 36: NATURAL SPRINGS AND MEAN WINTER WATER TEMPERATURES IN KINGS BAY AND CRYSTAL RIVER.

Data are from Kochman et al. (1983). Gulf water temperatures are shown schematically, based on intake temperatures at the Florida Power Corporation plant. Temperature varies with tide in the rest of the river, data were not available for unshaded areas.

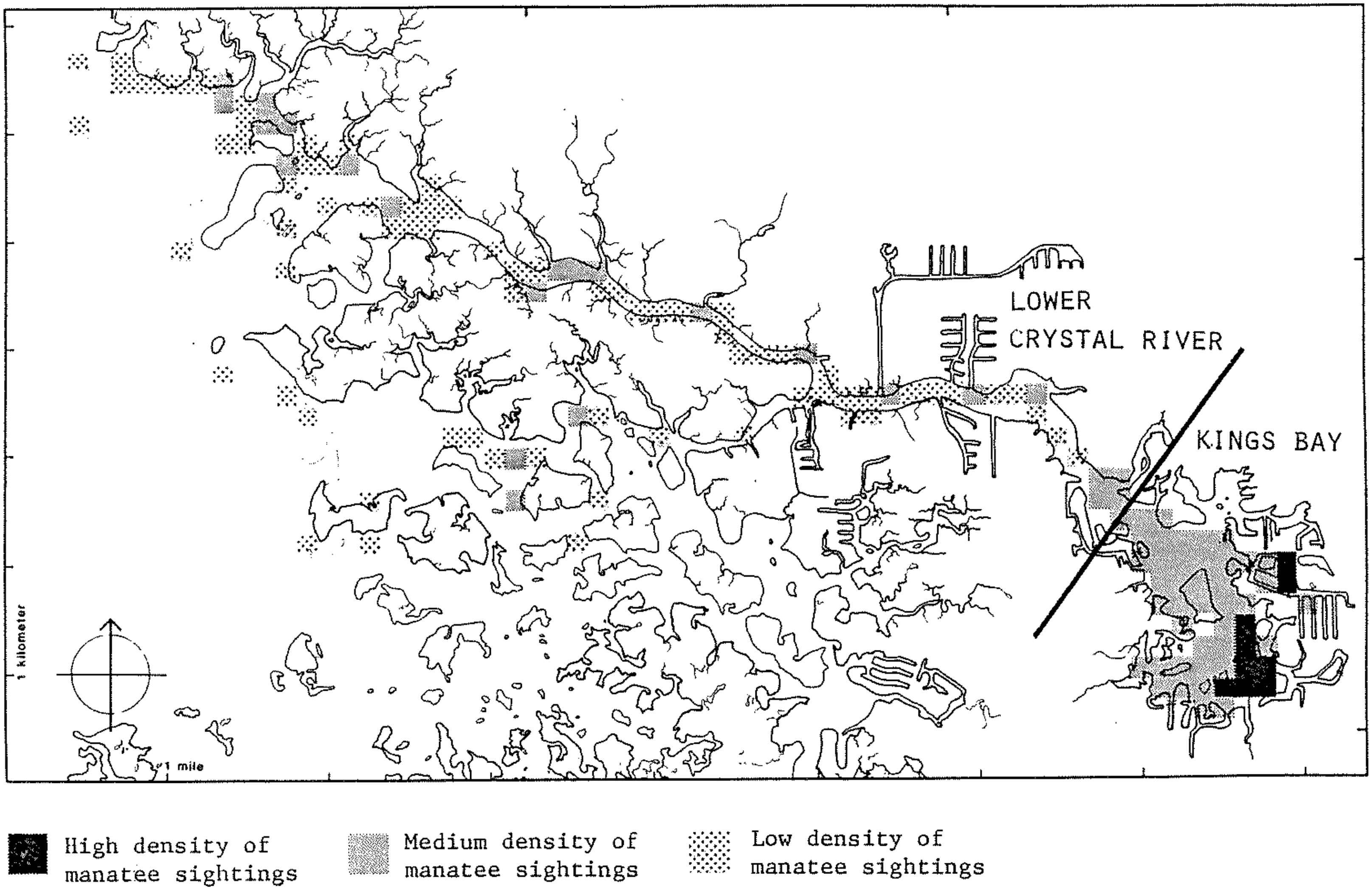
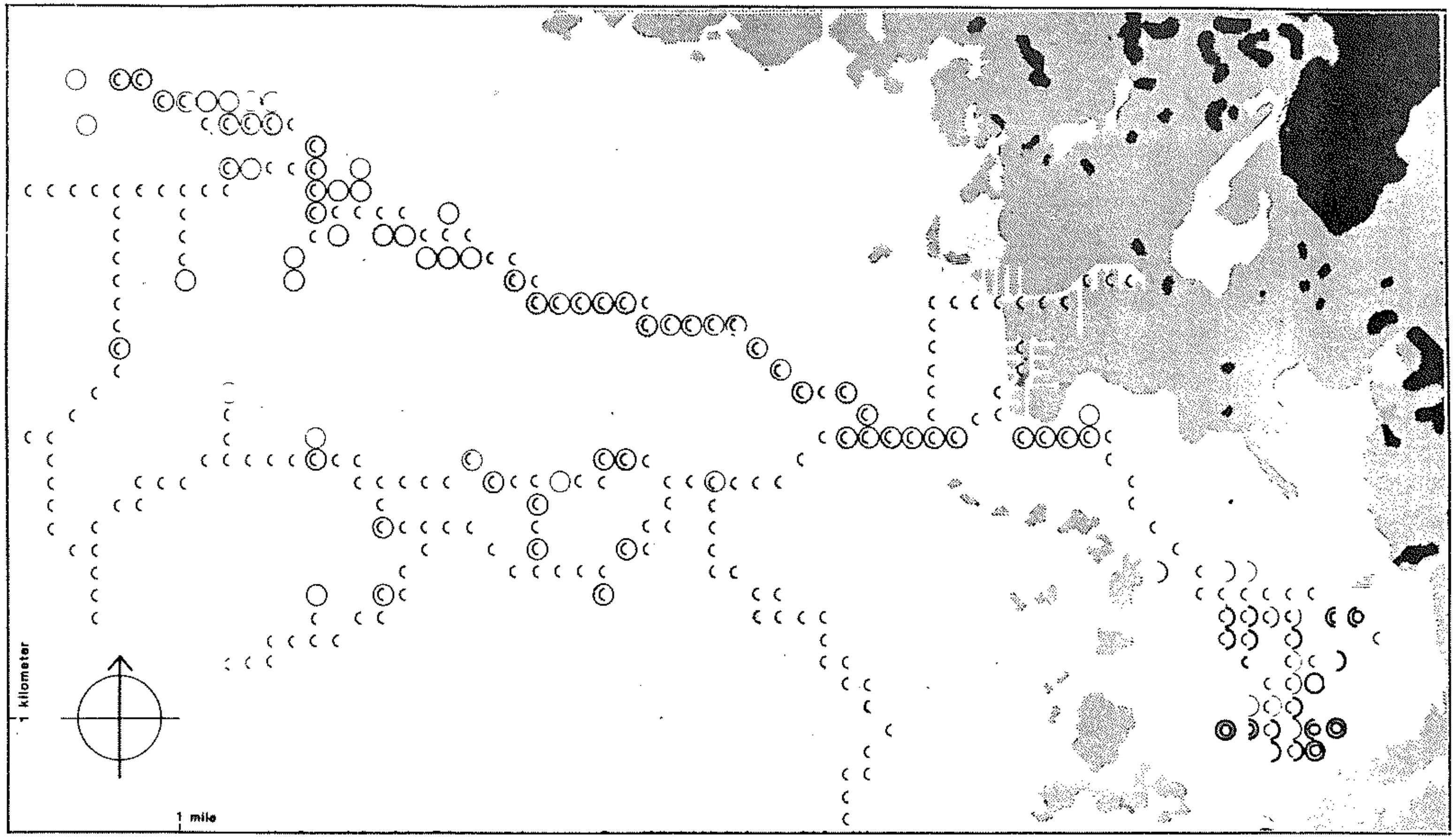


FIGURE 37: RELATIVE DENSITY OF MANATEES IN LOWER CRYSTAL RIVER (YEAR-ROUND) AND KINGS BAY (WINTER).

Sightings in the lower Crystal River are from Powell and Rathbun (1983) and Kings Bay sightings are from Kochman et al. (1983). High density sightings correspond to greater than 1.0 manatees per flight. Medium density sightings correspond to less than 1.0 manatees per flight in Kings Bay and mor than two sightings in the lower Crystal River. Low density sightings were 1-2 manatees per 0.04 km^2.



(Frequent resting) Frequent feeding ‹ Frequent travel › Frequent social interaction

(Resting) Feeding ‹ Travel › Social interaction

FIGURE 38: MANATEE ACTIVITIES IN CRYSTAL RIVER.

Data are from Powell and Rathbun (1983), Kochman et al. (1983) and Rathbun (pers. comm.). Concentric circles indicate centers where all activities occur. Shaded areas represent land.

of Banana Island and north of Parker Island. Feeding activity is observed frequently north, south, and east of Buzzard Island and along the west shore south of Shark Sink. Feeding and resting activity also occur along Crystal River, and near Camp Island in the estuary. Manatees travel throughout the area, and probably use the Salt River as a route to the Homosassa River.

4.3 Homosassa River

Manatee habitat in the Homosassa River has not been studied in as much detail as at Crystal River. Hartman (1979) describes physical characteristics and the winter aggregation of manatees, and Powell and Rathbun (1983) describe general features and manatee distribution.

A natural channel 2-5 m (7-16 ft) deep leads to the mouth of the Homosassa River and the river ranges from 1-3 m (3-10 ft) at mean low water. The Halls River, which joins Homosassa River 1 km (0.6 mi) from the headwaters, is unnavigable (Hartman 1979). Homosassa River was dredged in 1936 (Powell and Rathbun 1983). Canals and seawalls have been constructed on the north shore. Detailed measurements of depth have not been made.

The distribution of vegetation has not been determined quantitatively, but general features are known (Figure 39). Most vegetation is located downstream from the Halls River (DAS, pers. comm., G. Rathbun, pers. comm.). Vegetation is less dense along the shores downstream from Homosassa, and estuarine grasses are located along the shallows in the estuary.

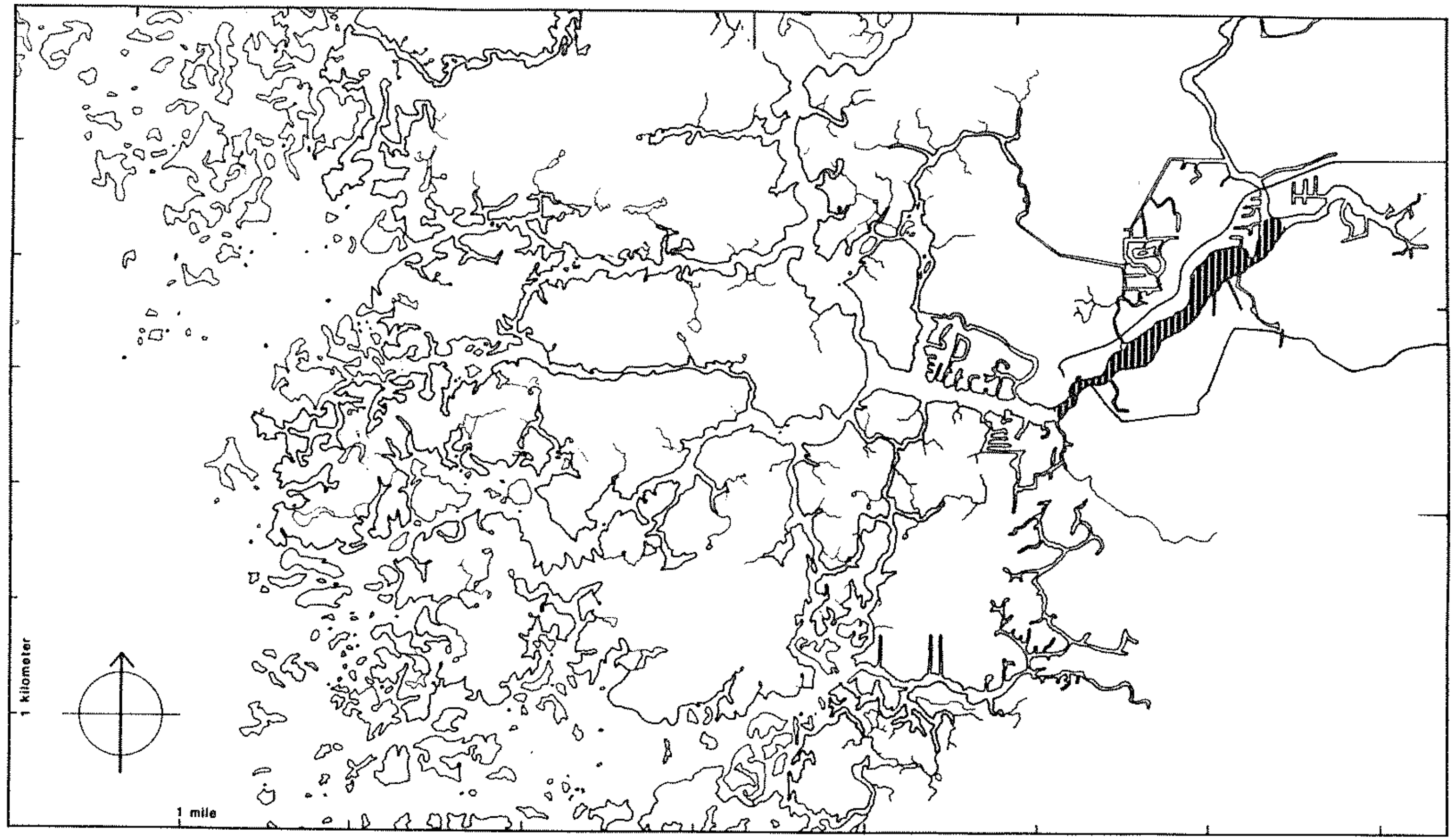
Manatees are sighted most frequently at the headwaters during the winter, and moderately frequently in the estuary and upstream from Homosassa (Figure 27). Most of the meandering waterways in the salt marsh are apparently too shallow for manatees.

Several springs at the headwaters of Homosassa River are enclosed in the Homosassa Attraction. The major spring (Blue Water) is accessible to manatees only at high water, although they aggregate near its warm flow. Water temperature measured in April 1946 was 75°F (Ferguson et al. 1947).

Manatees are most often observed resting at the headwaters, although resting behavior is also seen in the river upstream from Homosassa and in the estuary (Figure 40). The most important feeding area is downstream from the Halls River, although manatees are also observed feeding in the estuary and near the springs. The entire river is a travel route, and manatees probably travel along the Salt River at high tide.

5. EFFECTS OF HUMAN ACTIVITIES

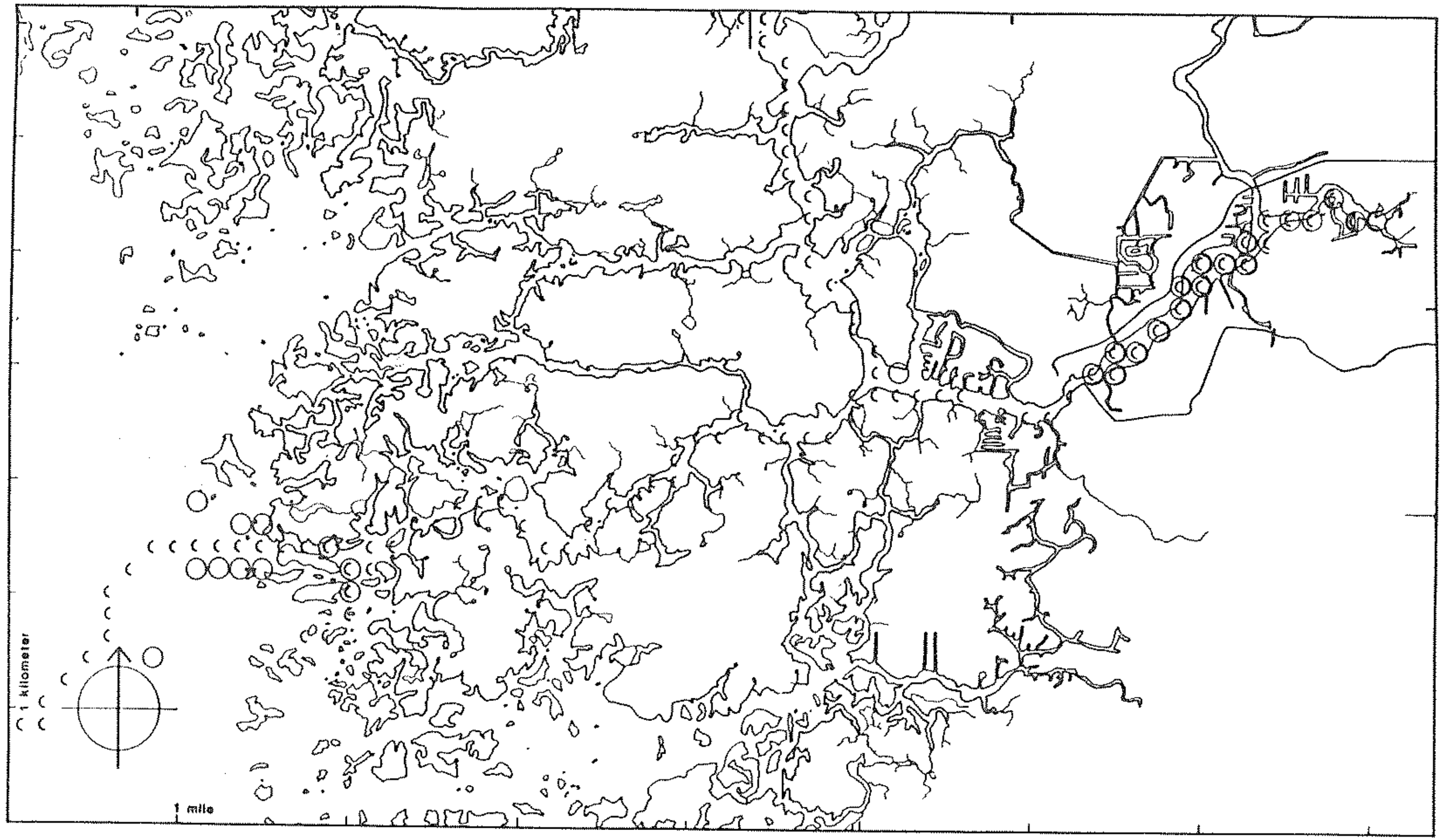
As outlined in the previous subsections, in order to protect manatees and their habitat, it is necessary to address the effects of human activities on: (a) manatee mortality, (b) manatee reproduction and recruitment, (c) manatee distribution and behavior, (d) the abundance and distribution of vegetation upon which manatees feed, (e) the condition and availability of warm-water refugia, (f) chemical contaminants and pathogens affecting manatees,



Abundant vegetation available to manatees

FIGURE 39: VEGETATION IN HOMOSASSA RIVER.

Information is schematically represented, from Sell (pers. comm.), Rathbun (pers. comm.) and field notes (Packard, personal observation).



(Frequent resting) Frequent feeding (Freqent travel) Freqent social interaction

(Resting) Feeding (Travel) Social interaction

FIGURE 40: MANATEE ACTIVITIES IN HOMOSASSA RIVER.

Data are from Powell and Rathbun (1983) and Rathbun (pers. comm.).

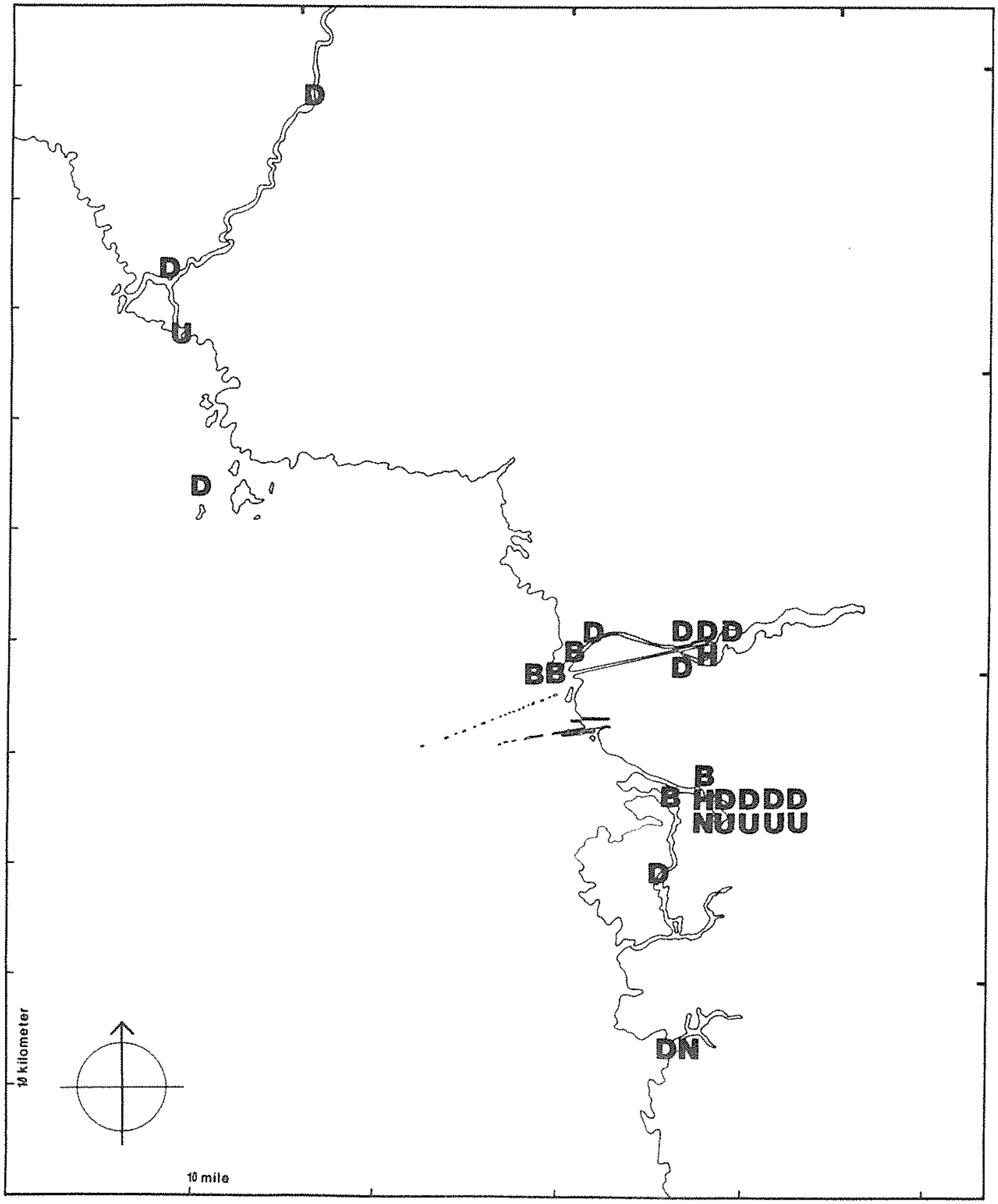
and (g) vital physical, chemical and biological processes that characterize the region's coastal ecosystem. In this chapter, human activities potentially having an effect on each of these factors are explained to provide an integrated overview of the subject areas which are analyzed in more detail in Section IV. The analysis of required actions needs to correspond to such categories because government agencies are organized according to types of human activities, e.g. dredge and fill, boating, fishing, water quality regulation, etc. In essence, this subsection translates "the manatee perspective" to "the human perspective".

5.1. Manatee Mortality

Boat or barge collisions are the most frequent human-related cause of manatee mortality in Florida (Irvine et al. 1981). Crushing blows from the hull of boats and barges are often lethal. Propellers and skegs cause lacerations that may result directly in death due to blood loss or injury to the major organ systems, or indirectly result in infection, which leads to death. Injuries caused by large props (typical of boats larger than 7 m, or 23 ft) have been shown to be lethal more frequently than are injuries due to small props (Beck et al. 1982). Boats operated at high speeds or with unpredictable and quick changes in the direction of travel are more likely to injure or kill manatees, because the animals do not have sufficient time for evasive behavior when the boat is detected. Some manatees have learned to dive when a boat approaches (Hartman 1979, pg. 127), and they probably are capable of learning to avoid predictable patterns of boat traffic. Shallow areas where manatees cannot dive to avoid boats or may be crushed by large vessels probably present more of a risk than deep channels (Kinnaird 1983b).

Factors influencing the relationship between boat density and boat-related manatee deaths have been examined (Kinnaird 1983a). In Florida, more manatees killed by boats and barges have been recovered in the northeastern quarter than in the other parts of Florida (O'Shea 1983b). More boats are registered in coastal counties in the northeastern quarter of the state than in other quarters (Kinnaird 1983b). Although available information is still incomplete, the following guidelines appear valid. Boat traffic density is related to the density of docking facilities (wet slips, dry slips, parking capacity at boat ramps). Boat-related manatee mortality is more likely in river basins with aquatic vegetation where manatees may be hit while feeding. In regions where boat-related mortality occurs (e.g. river basins in Brevard County), it is significantly correlated with the density of docking facilities (Kinnaird 1983b).

Crushing injuries resulting from the impact of a boat hull or entrapment of a manatee between a barge and the side of a channel have also been reported (Beck et al. 1982). In South Big Bend, three deaths attributed to boat/barge collisions occurred in the Withlacoochee River and one near a shallow portion of Crystal River (Figure 41). The manatee carcasses recovered on the Withlacoochee River were killed by crushing blows typical of barge collisions. Barge traffic on the Withlacoochee River was discontinued in June 1978 (Powell and Rathbun 1983).



B Boat or barge **D** Dependent calf **H** Human related

N Natural **U** Undetermined

FIGURE 41: LOCATIONS AND CAUSE OF DEATH OF MANATEE CARCASSES SALVAGED IN SOUTH BIG BEND FROM 1974 THROUGH MARCH 1982

Data are from Powell and Rathbun (1983).

Manatees can become trapped in locks or flood control structures, and drown or be crushed (Odell and Reynolds 1978). One such death in South Big Bend was reported at the Inglis lock on the Cross Florida Barge Canal (Figure 41).

Fishing gear can cause death by drowning, or entanglement may cause injuries resulting in infection leading to death. Such deaths and injuries do not occur frequently in Florida, but causes include: a shrimp net, a mullet net, hoop nets used for catfish, monofilament or crab-trap lines wrapped around the flipper and knotted so tightly that septicemia resulted, and hooks or lures imbedded in the lips or ingested (FWS 1980, Beusse et al. 1981).

Vandalism and poaching are potential causes of death, although few cases have been reported within the last decade for the entire state (FWS 1980). Verbal threats to the well-being of manatees have been reported in the context of controversy over boat speed regulations in Crystal River (Puckett 1983). A manatee was shot in the head in the Withlacoochee River (Hartman 1979).

5.2. Reproduction and Recruitment

Deaths of young calves (aborted fetus, stillborn, dependent) have been reported in the Suwannee River, Cedar Key, Withlacoochee River, Barge Canal, Crystal River and Homosassa River (Figure 41). Causes of these deaths have not been determined, but factors that need to be examined include: disturbance at the time of birth, separation of mothers and dependent calves, and chronic levels of contaminants in females.

The long period of association between a female and her calf (usually 1-2 years) suggests that the mother-offspring bond is very important for survival of calves. Nursing continues for one and possibly two years. Calves may learn seasonal patterns of movement, where to find food and warm water, and how to avoid danger during the period of dependency (Hartman 1979). Therefore, separation of a mother and calf may expose calves to risks that they cannot avoid. Possible causes of female-calf separation include: (a) locks where one of the pair pass, but not the other, (b) boat traffic, and (c) harassment by swimmers.

Female manatees apparently seek the safety and seclusion of narrow, shallow channels and inlets near the time of birth (Hartman 1979). At such times, they may be easily disturbed by humans, even by observers standing on the bank (McNerny 1981). Birth is rarely observed, suggesting that females seek locations where humans are not present. Flood control structures may restrict access of females to such secluded areas. If secluded locations are not available, females may be disturbed during parturition. The first hour after birth appears to be critical for survival of the calf, as the mother helps it to establish a breathing rhythm (Hartman 1979). For the first few days of life, calves appear to be vulnerable, as they swim only with the flippers, and occasionally rest on the back of the female. Hartman

(1979) expressed the opinion that newborn calves are less tolerant than adults to cold temperature, suggesting that if a female is inhibited from bringing her young calf to a warm-water refuge, the calf may die of cold exposure.

The effects of contaminants on reproduction and neonatal survival of manatees are unknown. Symptoms similar to effects of organochlorides on other mammals could be expected, such as premature births, or low birth weight. However, in most of the studies where these effects have been shown, exposure levels were much higher than the concentrations manatees would be expected to encounter, given their herbivorous food habits. Effects on nervous system function may be too subtle to measure, but associated with other factors could cause slightly abnormal behavior of either the mother or young resulting in a higher probability of deaths of newborn calves.

5.3. Distribution and Behavior

Human activities that alter the normal behavior of manatees constitute "harassment", legally defined as "... an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering" (FWS 1980, pg. 8, also see Gluckman 1983a). Hartman (1979:pp. 126) describes causes of harassment:

> "The most constant sources of harassment to the Crystal River manatees were power boats and divers. The travel routes utilized by manatees were also the principal thoroughfares for boats. The approach of boats often caused animals to interrupt activities or alter their course. Boat traffic was especially heavy on weekends and harassment was compounded by tourists and divers patrolling in search of manatees. Divers daily invaded the Main Spring with SCUBA and snorkel equipment and when manatees were present, bothered the animals by trying to "ride" them. Invariably, the manatees were chased from the spring. The activity of divers, however, was generally restricted to the spring and rarely disrupted the activities of manatees elsewhere in the bay. Turbid water at the head of the Homosassa River discouraged divers, and the manatees there remained unmolested".

Such activities may drive manatees away from warm-water areas into colder water where they may be more prone to disease, or may separate a female and her calf (FWS 1980). Pleurisy and bronchial pneumonia from cold exposure are reputed to have caused the deaths of manatees, indicating that cold stress can increase susceptibility to disease (Hartman 1979, pg. 123, Irvine et al. 1981).

Many divers, who have experienced repeated contact with manatees that appear to solicit petting and are tolerant of photography, do not perceive interaction between swimmers and manatees as harassment (Puckett 1983). However, they would have little opportunity to be aware of the number of manatees that are disturbed by mere human presence and leave quietly. The number of manatees swimming away from the Main Spring in Crystal River peaked at the same time of day as the peak number of boats present in the area (about 2:00 p.m.) (Kochman et al. 1983). However, this is also the time of day when air and water temperature are highest; the causative relationship between human activity and changes in manatee behavior is very difficult to prove by means of correlations.

Individual manatees differ in their sensitivity to human disturbance. Probably only about 20-40% of the manatees in Kings Bay are tolerant of human activity in the Main Spring area (Purcell, pers. comm.). Hartman (1979, pg. 37) describes a female with a calf, which balked and doubled back five times in four hours before passing through a shallow area under a bridge after being spooked initially by a fisherman who tried to hook her with a large rubber lure. Females with calves may be more sensitive to human activities than other manatees.

Although the effects have not been documented, construction of docks along manatee travel routes may alter normal behavior. Manatees tend to move along the edge of a channel where it is shallow, occasionally pausing to feed or rest (Hartman 1979). However, when disturbed by boats, they move quickly into the deeper channel. Docks located in shallow areas adjacent to a channel may obstruct normal movement patterns, influencing manatees to move into the channel where they may be more vulnerable to boat traffic.

Maintenance of normal travel routes is important to assure existing patterns of genetic exchange between the subpopulation and the larger population. If harassment within the management area influences manatees to leave the area, the rate of population growth would decline. If areas south of the management area inhibit travel of manatees, the subpopulation might become geographically isolated and would not contribute to recovery of the Florida population as a whole.

5.4. Vegetation

Human activities directly impacting vegetation utilized by manatees include: dredge and fill, construction of seawalls, aquatic weed control, boat scrapes, and construction of docks and piers that shade vegetation. Indirect effects include: (a) increased turbidity (due to boat traffic, dredging, run-off, or high levels of nutrients) that may reduce plant biomass or change species composition by reducing light penetration or favoring epiphytic growth of algae, (b) alteration of drainage from wetlands, which can increase the magnitude of salinity fluctuations in an estuary, potentially affecting species composition and biomass (see pages I-13), (c) reduction of wetlands, which can affect the chemical composition of the water supporting aquatic plants, by reducing detritus entering the system, and by not filtering compounds carried from upland drainage, and (d) water draw-down from rivers, which can change the salinity gradient in an estuary.

Area and species composition of vegetation are important factors for maintaining food for manatees. Due to the slow regeneration rates of some rooted aquatics upon which manatees feed, it appears important that large areas of vegetation are available such that the grazing impact in any one area is not too great (in press). Seagrasses such as Halodule have more nutritional value for manatees than rapid-growth aquatic weeds such as Hydrilla (Powell and Rathbun 1983). Therefore, it appears that the maintenance of a variety of plant species is important to meet the nutritional requirements of manatees. Due to general physiological difficulties of mammals in maintaining a salt balance, Hartman (1979) suggested that manatees probably cannot spend prolonged periods of time without access to freshwater. For this reason, it is unlikely that offshore seagrass beds are utilized by manatees as much as seagrasses within estuaries where salinity is lower (Powell and Rathbun 1983). However, several manatees were sighted briefly near the Dry Tortugas, which is about 144 km (90 mi) west of the nearest source of fresh water (Reynolds and Ferguson, in press).

5.5. Warm Water Refuges

Manatees in South Big Bend are dependent on predictable sources of warm water to provide refuge from cold temperatures in the winter (see Subsection 3.3). Natural springs and warm water discharge from the Crystal River power plant provide such refuge. Human activities that can influence the availability of warm water to manatees include: (a) power plant shutdown of cooling operations, (b) restriction of physical access, (c) water withdrawal from the aquifer, reducting of the volume of flow from springs, (d) direct capping and use of water from springs, and (e) alteration of recharge areas that replenish the aquifer supplying springs. A source of freshwater near a warm-water refuge is probably desirable (Hartman 1979).

In areas where manatees are dependent on industrial effluents for warm water, temporary shutdowns during periods of extreme cold weather can expose manatees to cold temperatures, increasing the probability of death (Irvine et al. 1981). One unit at the Crystal River power plant has a history of frequent shutdowns. Therefore, natural springs are more reliable warm-water refuges for manatees than are industrial effluents. Ideally, industrial effluents that are likely to attract manatees should be sited within 30 km (19 mi -- a one-day trip for a manatee) of an alternative warm water source, near sources of food and fresh water, and not adjacent to major boat traffic.

The design of any construction near warm-water refuges should also be planned to meet manatee needs. Temperature gradients drop as a function of distance from a point source of warm water. Physical barriers or shallow water can prevent manatees from attaining access to locations with optimal water temperature. If areas around warm water sources are physically restricted, and a large number of manatees congregate, some individuals may be excluded from the warm water as a function of social behavior. Manatees have entered and become wedged in narrow passages (1 m wide) such as sewer pipes (FWS 1980), so grates should be placed over such hazards.

Concern has been expressed over the cumulative effects of water withdrawal on flow of natural springs (WRWSA, WRPC and COE 1981). Estimated water use within the Withlacoochee Region in 1977 totaled 112.7 million gallons per day (MGD), of which 23% was used for public supply and rural domestic use, 31% for agriculture, and 46% for industry (from Table 32 in WRWSA, WRPC and COE 1981). The projected water demands by the year 2030 vary, according to the method of calculation, from 199.2 to 748.7 MGD with a most probable projection of 380.6 MGD (from Table 40 in WRWSA, WRPC and COE 1981). The potential effect on discharge of springs in the area has not been predicted. In comparison, Crystal River discharges 600 MGD (Table 4).

The Withlacoochee Region was previously identified as a water surplus area, and plans to provide water for other areas were proposed. However, the Withlacoochee Regional Water Supply Authority is "opposed to any water supply plan to direct water out of the region without additional studies to document the region's internal needs" (WRWSA, WRPC and COE 1981; pg. II-1).

During the planning phase for the Crystal River power plant, alternatives considered for water supply included: (a) capping spring(s) in Crystal River, and (b) several wells. The use of a saltwater cooling system was eventually chosen, such that additional demands on local ground water supplies were not made. However, future industrial development is planned for the Crystal River area (Citrus County 1979) and additional water demands could be expected.

The flow of coastal springs is affected by local recharge of groundwater supplies, as rate of flow varies with rainfall (Mann and Cherry 1969). Development in recharge areas could reduce the amount of seepage if drainage patterns are changed or if large areas are covered with an impenetrable surface. The general recharge area covers the Withlacoochee drainage basin in Citrus, Hernando, Pasco, Sumter, and Polk counties (Mann and Cherry 1969). Ground water seepage in certain parts of this general area may contribute more directly to flow of one spring than another, but such flow patterns have not yet been identified.

Even if water demands do not appreciably reduce the volume of flow of springs in the future, they might have an influence on the salinity of spring water. The freshwater/saltwater interface of groundwater crosses under Kings Bay (Causseaux and Fretwell 1982). If manatees are dependent on freshwater, significant saltwater intrusion into Kings Bay would be disadvantageous for them.

5.6. Chemical Contaminants and Pathogens

Chemical contaminants that could adversely affect the health of manatees include: heavy metals (e.g. copper, lead, mercury, selenium), organochloride pesticides (e.g. DDT, dieldrin, oxychlordane, endrin, mirex, toxaphene), polychlorinated biphenyls (PCB), petroleum products and radioactive wastes (O'Shea et al. 1983). Manatees may be susceptible to a number of viruses and bacteria present in human and animal wastes, and may be susceptible to parasites transmitted through animal fecal material (e.g. *Toxoplasma gondii*) (Beck 1983). To date, knowledge regarding effect on manatees of contaminants and pathogens is incomplete.

The greatest source of copper input to estuarine systems in South Big Bend is the use of herbicides for aquatic weed control. Copper concentrations in livers of manatee carcasses recovered from areas where high amounts of copper were used in aquatic weed control (northwestern counties) were significantly higher than from other parts of Florida (O'Shea et al. 1983). In the late 1970's, substantial amounts of copper were used in the Crystal River area; over 6 metric tons of elemental copper were applied in the annual period ending 1 November 1979 (O'Shea et al. 1983).

The potential toxic effects of herbicides vary depending on (a) the rate of biodegradation, (b) the amount absorbed by plants and sediments, (c) synergistic interaction with other compounds, and (d) the tissues affected in sensitive organisms. Characteristics of three herbicides used in estuarine systems in the South Big Bend region have been reviewed by O'Shea (1983a). Endothall (Aquathol-K), diquat, and copper are used in herbicide control programs in Citrus County (DAS 1982).

Endothall was evaluated as presenting the least threat to manatees (O'Shea 1983a). It is biodegradable; under aerobic conditions, the compound is broken down fairly rapidly and in a New York pond was not detectable in water at 5 weeks and in sediments at 6 weeks post-application. When applied at concentrations of .1 and 5.0 ppm, endothall is concentrated by plants, reaching levels of 10 and 20 ppm. Although information on toxicity to mammals is limited, the threshold of toxicity appears to be high; the acute oral dose (LD50) for rats is 38 mg/kg. There were no effects of chronic exposure on dogs and rats, and it is rapidly excreted. Endothall was not detected in fat or milk of lactating female rats given an oral dose.

Diquat is not readily broken down by microbes in aquatic systems, because it becomes attached to sediments. However, there is no indication in the published literature that it would present a significant threat to manatees. According to O'Shea (1983a; pg. 4):

> "Although persistent, (diquat) would not be available to manatees in food except at the time of application. Diquat on plants would then be available for just a few days prior to plant death. Concentrations under these circumstances do not appear to approach levels toxic to animals, given normal application rates of 2.5 ppm or less. Plant tissues disintegrate long before chronic effects would be produced in laboratory animals. Ingested diquat is excreted or broken down rapidly; residues should not be detectable in manatee tissues."

The two copper compounds available for use as herbicides differ in the degree to which are they bound by organic molecules. Copper sulfate, which is no longer as widely used as an herbicide in the study area, precipitates more readily than the chelated copper compounds, which are currently used (Joyce, pers. comm.). Copper salts (Komeen, Cutrine-plus) precipitate in hard water and are chemically bound in sediments and plants. Copper accumulates in sediments, and little is exported from an ecosystem. Copper and diquat are usually applied simultaneously because diquat enhances the uptake and toxicity of copper (Dick, pers. comm.).

Evaluation of the potential effects of copper on manatees is difficult because the toxicity of copper varies immensely among mammalian species (O'Shea 1983a). Two major effects on sheep are (a) accumulation in the liver at a threshold concentration where acute damage occurs, leading to breakdown of red blood cells and to death, (b) negative effects on the beneficial bacteria that aid digestion in ruminants. However, manatees are not ruminants, so care is required in interpreting results of existing studies to infer toxicity for manatees. The exposure of manatees to copper taken up by plants is also difficult to assess because the high concentrations measured in plants under laboratory conditions may not be typical of field conditions where there is a water current that disperses the herbicide, as is the case in Crystal River.

The precautions specified by permitting agencies are listed on the "labels" for each herbicide (Table 14). Copper and diquat labels contain warnings against contamination of feed for livestock. Water treated with diquat, endothal or fluridone should not be used for watering livestock within specified periods following application. In general, the precautions of permitting agencies are conservative, indicating the most prudent approach to be taken when more specific information is not available. Precautions established for livestock logically should apply also to similar wild species, such as manatees. However, as in the case of copper, there may be factors that are specific to manatees, which indicate the need for more precautions.

Exposure of manatees to other chemical contaminants would be dependent in part on the level of industrial activity in an area, the methods of waste disposal, and run-off from agricultural and urban areas. Release of heavy metals and PCB's (poly-chlorinated biphenyls) into the environment may be associated with industrial waste. Although strict controls govern disposal of radioactive wastes, the possibility of an accidental discharge from a nuclear power plant (e.g. Crystal River power plant) cannot be discounted. Little is known about other potential sources of low level radioactivity, such as coal flyash. Organochlorides may enter the water system from residential gardens as well as from agricultural sources upstream. However, many of the organochloride pesticides, which have caused environmental problems in the past, are now restricted or prohibited.

Urban run-off can be the source of a variety of contaminants. Petroleum products and associated heavy metals that accumulate on roads and lots can be washed into the water system during heavy storms. Overflow of sewage and septic systems during the wet season can carry pathogens and contaminants, which are otherwise filtered by seepage. Heavy rains can flush bacteria from wetlands, causing periodic peaks in contaminant levels.

Spillage of petroleum products during shipping or from oil exploration could contaminate manatees directly, possibly causing respiratory problems. Oil spills could also degrade the quality of aquatic plants that provide food for manatees.

Table 14. Label precautions of herbicides approved for use in South Big Bend.[1]

Brand Names (Active Ingredient)	Target Species	Label Precautions
Cutrine-plus Komeen (copper)	Algae: chara, nitella	None for drinking water, swimming, fishing, irrigation of ornamental plants, livestock watering. Do not contaminate feed or foodstuffs.
Diquat (diquat dibromide)	Bladderwort, coontail, elodea, naiad, pondweed, milfoil, pennywort, salvinia, water hyacinth, water lettuce, algae, cattails	Do not contaminate feed, foodstuffs, or drinking water. Do not feed forage from treated crops to livestock. Do not use treated water for animal consumption, spraying or irrigation within 10 days after treatment. Do not use treated water for drinking within 14 days after treatment
Aquathol K Hydrothol 191 (Dipotassium salt of endothall. Mono salt of endothall	Coontail, hydrilla, milfoil, pondweed, bass weed	Do not use fish from treated water for food or feed within 3 days of treatment. Do not use treated water for watering livestock, for preparing agricultural sprays, for irrigation or for domestic purposes within periods of 7-25 days depending on application rate. Restrict swimming 24 hours after applications.
Sonar (fluridone)	Cattail, elodea, hydrilla, milfoil, paragrass, arrowhead, torpedograss	Do not use treated water for irrigation, watering livestock, swimming, drinking, or domestic purposes until 150 days after application to a pond and 7 days to a lake. Fishing prohibited for 150 days after application. Experimental. To be used in ponds or lakes with no outflow.
Banvel-720 (Dimethylamine salts of dicamba, 2, 4-D and related acids.)	Water hyacinth, milfoil, arrowhead, cattail, alligator weed, pickerelweed, smartweed, pennywort, frogbit.	Do not use treated water for irrigation within 14 days of application.
Nalquatic (Poly-carboxylate polymer)	For use with herbicide to improve sinking, confinement and contact.	Transient eye or skin irritation upon prolonged or repeated exposure. Not to be taken internally.

[1]Information provided by Bureau of Aquatic Research and Control, DNR. Brand names are registered trademarks.

5.7. Ecosystem Processes

Effects of human activities on ecosystem processes are cumulative and at this stage many of these processes are still poorly understood. Analysis of the sensitivity of natural systems is often conducted by comparing disturbed and undisturbed systems. South Big Bend remains as one of the last intact ecosystems along the coast of Florida against which disturbed systems can be compared. It is prudent to avoid disrupting the complex interactions within the system as a whole, until the knowledge exists to distinguish which actions can be tolerated by the system, without irreversible change in the system.

Subtle changes are occurring now, which influence the merit of the area as a scientific, educational and recreational resource and therefore indirectly affect protection of manatees. Water clarity in Kings Bay has decreased in the last decades, probably from a variety of sources, including: sewage discharge, seepage from septic tanks, run-off of fertilizer from lawns, and accumulation of sediments from decomposed aquatic weeds. This decline in water clarity makes it more difficult to study manatees and to acquire the information so necessary to their continued survival.

A large number of people are undoubtedly attracted to Crystal River and other coastal towns due to the aesthetic appeal of the clear water, undisturbed landscape, and recreational value. While in the area, they learn about manatees and such public awareness is essential to support programs that protect the species. Urban development that is not carefully planned could irreversibly change the natural character of the area, disrupting ecosystem processes and reducing its recreational and scientific value.

Section III

SECTION III

GOALS AND OBJECTIVES

The goal established by the West Indian Manatee Recovery Team for recovery of manatee populations in the United States has been used as a guideline for identifying the long and short-term goals for protecting the manatee subpopulation in South Big Bend. The primary goal of the nationwide recovery plan is:

> "To re-establish and maintain optimum sustainable populations of West Indian Manatees in natural habitats throughout their historical range in the United States" (FWS 1980, pg. 11).

Because the South Big Bend region is part of the last two undisturbed coastal ecosystems in Florida (Figure 1), recovery of the manatee subpopulation in this area is essential to the recovery and long-term persistence of manatees in the state as a whole.

1. LONG TERM GOAL

The long-term goal of this Research/Management plan is: TO DETERMINE AND MAINTAIN AN OPTIMAL AND SUSTAINABLE ABUNDANCE OF MANATEES IN THE SOUTH BIG BEND REGION.

Additional information is needed before long-term management policies can be formulated to assist in achieving this goal. Such information should be acquired by means of a long-term research effort, including studies that:

1) Monitor abundance, distribution, reproductive rates, mortality rates, emigration and immigration.

2) Investigate social structure, behavior and physiology to better define the influence of environmental factors on individuals and on the subpopulation.

3) Determine the effects of density on reproduction, mortality, emigration, immigration and behavior.

4) Identify factors limiting the rate of increase of the subpopulation.

5) Determine the long-term effects of manatee herbivory on stability of plant communities.

6) Develop criteria for defining a sustainable level for the subpopulation, which is optimal for the health and stability of the ecosystem.

The research listed above will contribute toward the identification of management actions needed to maintain the Crystal River subpopulation once it has reached optimal sustainable abundance (yet to be determined). The following short-term goals and objectives are defined in order to guide management actions necessary to encourage the subpopulation to increase to such levels.

2. SHORT TERM GOAL

To guide research and management actions within the next decade, the short term goal and objectives required to achieve that goal are outlined below. Evaluation criteria, which provide a means of measuring progress, are listed for both the overall goal and the specific objectives.

SHORT TERM GOAL: FROM 1983 THROUGH 1993, MAINTAIN A POSITIVE YEARLY GROWTH RATE OF THE SUBPOPULATION.

The subpopulation is increasing if one or both of the following criteria are met (refer to Subsection II.3.1.):

1) annual growth rate (N_t/N_{t-1}) above 1.0 as determined by standard aerial surveys to count the maximum number of manatees (N) sighted at warm water refuges during the winter of each year (t), or

2) maximum winter aerial counts above 120 manatees (possibly as high as 330 manatees) in Crystal River, and above 20 (possibly as high as 60 manatees) in Homosassa River.

If these criteria are not met in any given year, the Fish and Wildlife Service in cooperation with other involved agencies should evaluate the cause for the decline and reestablish research and management priorities as needed in order to reduce the decline.

To achieve both the short- and long-term goals, the following objectives must be fulfilled. These objectives in turn serve as a guide to identify specific tasks to be included in the research/management plan (Section IV).

OBJECTIVE 1: KEEP THE FREQUENCY OF MORTALITY RELATED TO HUMAN CAUSES FROM INCREASING ABOVE THAT WHICH HAS OCCURRED OVER THE LAST FIVE YEARS

Evaluation Criteria:

1. Index of human-related mortality relative to maximum aerial counts remains at or below 0.6 (see Subsection II.3.2.).

2. Proportion of human-related deaths relative to total carcasses recovered remains below 27% per year (see Table 10).

OBJECTIVE 2: DETERMINE CAUSES OF PERINATAL MORTALITY AND REDUCE THE FREQUENCY OF HUMAN-RELATED DEATHS OF MANATEE CALVES

Evaluation Criteria:

1. Index of perinatal mortality relative to maximum aerial counts should be below 0.4 each year (see Table 10).

2. Proportion of perinatal deaths relative to total number of carcasses recovered should be below 26% each year (see Table 10).

3. The causes of perinatal and juvenile mortality should not be human-related; the causes of perinatal and juvenile mortality should be investigated.

OBJECTIVE 3: BY 1987, IDENTIFY AND MEASURE OBJECTIVE CRITERIA FOR DETERMINING CUMULATIVE IMPACTS OF HUMAN RECREATIONAL ACTIVITIES ON DISTRIBUTION AND ABUNDANCE OF MANATEES; FROM 1988 THROUGH 1993, MAINTAIN OR REDUCE THE LEVEL OF SUCH HARASSMENT IN CORE AREAS

Evaluation Criteria:

1. Criteria are to be determined (refer to Subsection II.5.3.).

2. Areas of core habitat should be maintained as shown in Figure 33.

OBJECTIVE 4: MAINTAIN THE AREA AND SPECIES DIVERSITY OF VEGETATION ACCESSIBLE TO MANATEES

Evaluation Criteria:

1. The area of freshwater plant communities needs to be maintained as shown in Kochman et al. (1983) and (Figure 11).

2. Marine plant communities: (Figure 11) estimates of biomass, area, and species diversity need to be determined.

OBJECTIVE 5: MAINTAIN RELIABLE WARM-WATER REFUGES ACCESSIBLE TO MANATEES DURING THE WINTER

Evaluation Criteria:

1. The average annual flow of natural springs (Table 4) should be maintained such that thermal characteristics (volume of water above 20°C) is not reduced by more than 20%.

2. Springs and industrial effluents that are warm-water refuges (Figure 20) should remain accessible to manatees.

OBJECTIVE 6: <u>REDUCE EXPOSURE OF MANATEES TO ENVIRONMENTAL CONTAMINANTS</u>

Evaluation Criteria:

1. Meet existing ambient water quality standards established by the state of Florida for each area (EPA 1980b; Table 2, 5-3a).

2. Reduce exposure of manatees to herbicides.

3. Levels of contaminants measured in tissue samples from carcasses should be at or below baseline levels (Table 11).

OBJECTIVE 7: <u>MAINTAIN THE AESTHETIC, SCIENTIFIC, AND RECREATIONAL VALUE OF THE ECOSYSTEM THAT SUPPORTS MANATEES</u>

Evaluation Criteria:

1. Measure baseline water quality and maintain water clarity at a level that meets or exceeds 1984 values.

2. Ecosystem components and presumed relations among components are diagrammed in Figure 12. All components should be considered essential until it can be shown that human-induced change in one component will not induce change in one or more other components.

Section IV

SECTION IV

MANAGEMENT ALTERNATIVES AND RECOMMENDATIONS

To manage the effects of human activities on manatees (described in Subsection II.5), the problems need to be defined in terms that can be addressed by the government agencies, private developers, and citizens involved. For purposes of this analysis, the jurisdictions of government agencies and interests of the public have been divided in the following categories: (a) regulation of dredge and fill associated with structures and channels that influence boat traffic (marinas, docks and navigation channels), (b) regulations and public education regarding boat speeds, swimmer/manatee interactions and fishing gear, (c) regulation of point and non-point sources of pollutants, aquatic weed control and other activities that indirectly affect vegetation by influencing water quality, (d) regulation of the manner in which land is used and developed e.g. seawalls, dredge and fill in wetlands, zoning, (e) protection of ecosystem processes by holding lands in the public or private trust and (f) planned use of water resources that could affect the function of springs, and of industrial discharges that are used as warm-water refuges by manatees.

In this section of the research/management plan, you will find a detailed analysis of problems and management options within each of the categories listed above. In each subsection, the analysis is presented in the same format. First, the overlap of human activities and manatee needs is analyzed on a site-specific basis. Relevant regulations are then described briefly and alternative management options are identified. Data gaps are identified after evaluating management options, to focus on research needs. Finally, recommended management actions are presented. Each subsection is fairly independent, so you may choose to turn directly to that subsection that best matches your interests or jurisdiction.

1. LOCATION OF BOATING FACILITIES AND NAVIGATION CHANNELS

As discussed above (Subsection II.5), marinas, docks, boat ramps and/or navigation channels may have a direct effect on manatees and their essential habitat by: (a) reducing aquatic vegetation in feeding areas, (b) obstructing manatee movements along shallow shorelines, (c) providing a source of contaminants (e.g. pollution from gas and oil spills, trash, land runoff, engine exhaust and fueling, noise, etc), and (d) disrupting function of wetlands by dredge and fill. More importantly, the location of boating facilities indirectly affects manatees by influencing the density and pattern of boat traffic, which may injure, kill or disrupt existing manatee activity patterns. Whereas this subsection considers management of boat traffic by planned location of boating facilities (Table 15), the following subsection (Subsection IV.2) considers operation of boats in waterways used by manatees. Both aspects are important in addressing the potential effects of boat traffic on manatees.

1.1 Site-specific Evaluation of Impacts

In this subsection, the overlap of manatee habitat and boat traffic is analyzed in order to distinguish the relative vulnerability of specific areas to development of docking facilities. Sites suitable for development of boating facilities should meet the following criteria: a) minimize increase of boat travel in areas where manatees are sighted, b) no destruction of aquatic vegetation eaten by manatees, and c) meet design standards in wetlands (e.g. DNR 1983). This analysis is used in identifying and evaluating management options in Subsection 1.3.

1.1.1 South Big Bend Region

General patterns of boat traffic, marinas, and boat ramps in South Big Bend are shown in Figure 42. In general, the larger craft (longer than 9 m (30 ft)) travel offshore beyond the 3 m (10 ft) contour. For docking facilities, they may enter the dredged channels at Suwannee, Cedar Key, Yankeetown, Crystal River, and to a lesser extent, Homosassa River. Larger craft in these waters are primarily commercial fishermen (shrimpers, crabbers) and large pleasure boats. Barges travel regularly from the Gulf to the Crystal River power plant to deliver coal. Small fishing boats travel from docks and ramps in the rivers to shallow fishing areas around the estuaries and mostly within the 3 m (10 ft) contour of water depth.

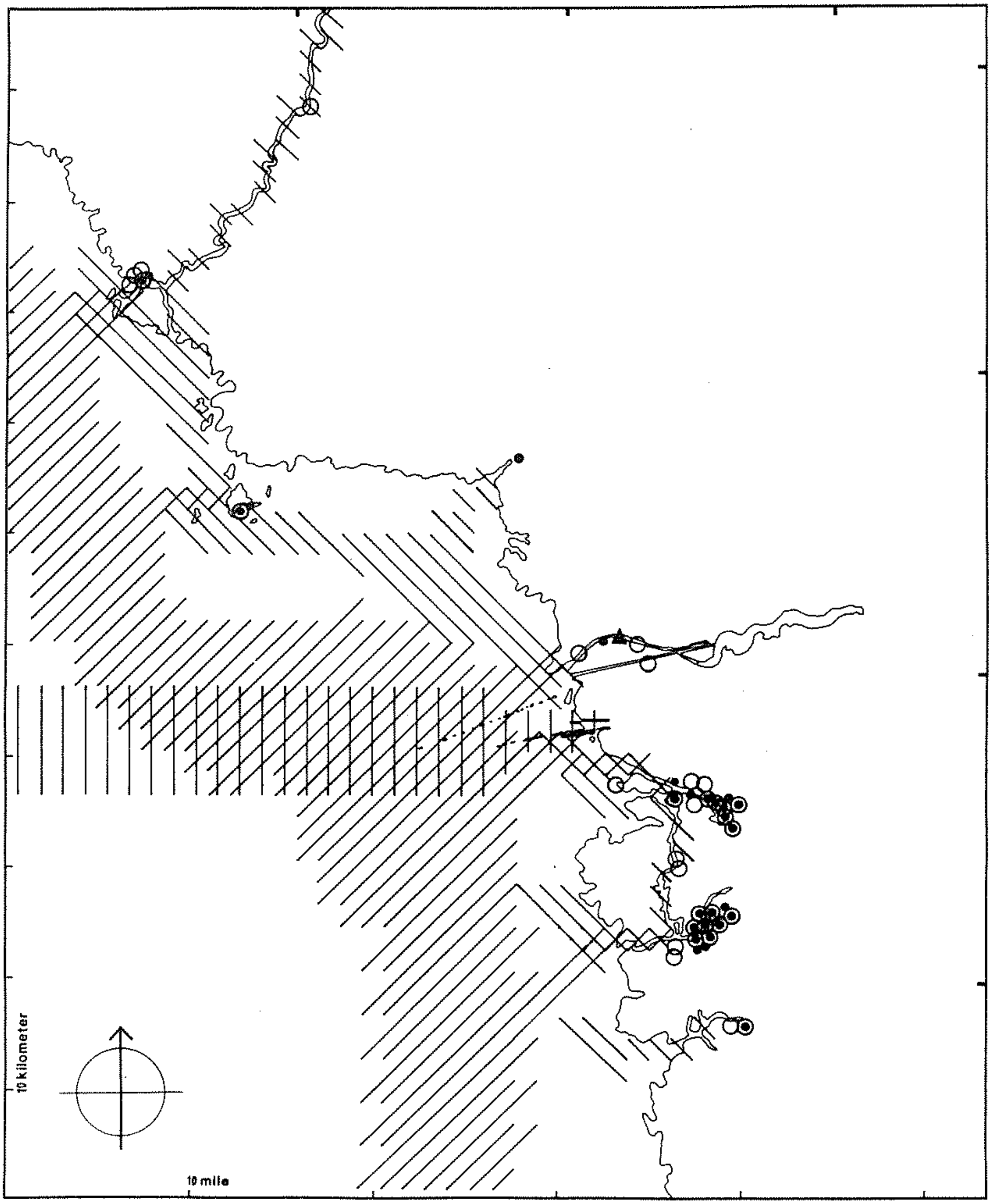
Boating facilities in South Big Bend are already well developed. The most boat ramps and marinas are located in Crystal River (10) and Homosassa River (9). Suwannee has six boat ramps and marinas. Withlacoochee River and the Barge Canal have about five ramps and three marinas. Two ramps are located at Ozello, one ramp and two marinas at Cedar Key, one fishing camp is on the Waccasassa River and there are two ramps and one marina on the Chassahowitzka River.

Table 15. Impact Statement: Boat traffic

Potential effect	Factors influencing probability of effect	Explanation
Death/severe injury as a result of boat collisions	Boat density	High boat density leads to higher probability of collison. Boat density is a function of both the number of boats and the frequency with which they are used.
	Boat size	Large boats are more likely to cause death than small boats, while small boats are more likely to move unpredictably.
	Traffic flow patterns	Predictable traffic in deep channels can be avoided by manatees; erratic boat movements in shallow areas presents more of a risk for feeding or resting manatees.
	Overlap of manatee travel and boat traffic	If manatees travel along shallow areas at edge of channel, construction of structures in those areas could cause manatees to move into channel and be more vulnerable to boat collisions.
	Depth of channel	Restricted areas where there is shoaling present a higher risk for manatees.
	Type of boat	Non-motorized vessels (eg. sail boats) are less of a risk than motorized vessels. Boats with recessed propellers or propeller guards present less of a risk of cutting injury, although they may cause a crushing blow.

Table 15. Impact Statement: Boat traffic (continued)

Potential effect	Factors influencing probability of effect	Explanation
Reduction of food resources	Direct disturbance of vegetation	Total area of rooted aquatic plants may be reduced by construction, dredging, skeg scrapes, shading; a variety of plant species may be needed to provide nutritional requirements; a larger area is needed to provide sustainable food resources from plant species with slow regeneration time; seawalls reduce availability of shoreline vegetation.
	Reduction of light penetration	Plant biomass may be reduced and/or species composition be changed when light intensity is reduced; turbidity caused by boat traffic or direct shading from a structure may reduce light intensity.
	Limited access	Manatees sensitive to human activities may not feed in areas adjacent to actively used marinas or docks.
Health complications	Heavy metals from petroleum products may accumulate in sediments under marinas	Manatees occasionally root in detritus and sediments, appearing to swallow material; lead and mercury may thus be ingested in quantities higher than normal.
	Spills of petroleum	Petroleum products may irritate skin membranes of eyes and nose, be inhaled or ingested.
Public appreciation	Boat density and location	At low boat densities, manatees will be less disturbed, hence more visible to boaters.



Small boats
Large boats
Barges
Boat ramp
Marina
Coast Guard station

FIGURE 42: BOAT TRAFFIC PATTERNS AND FACILITIES IN SOUTH BIG BEND.

Data are compiled from Division of Recreation and Parks (DNR), Army Corps of Engineers, and interviews. Data have not been verified by ground truthing.

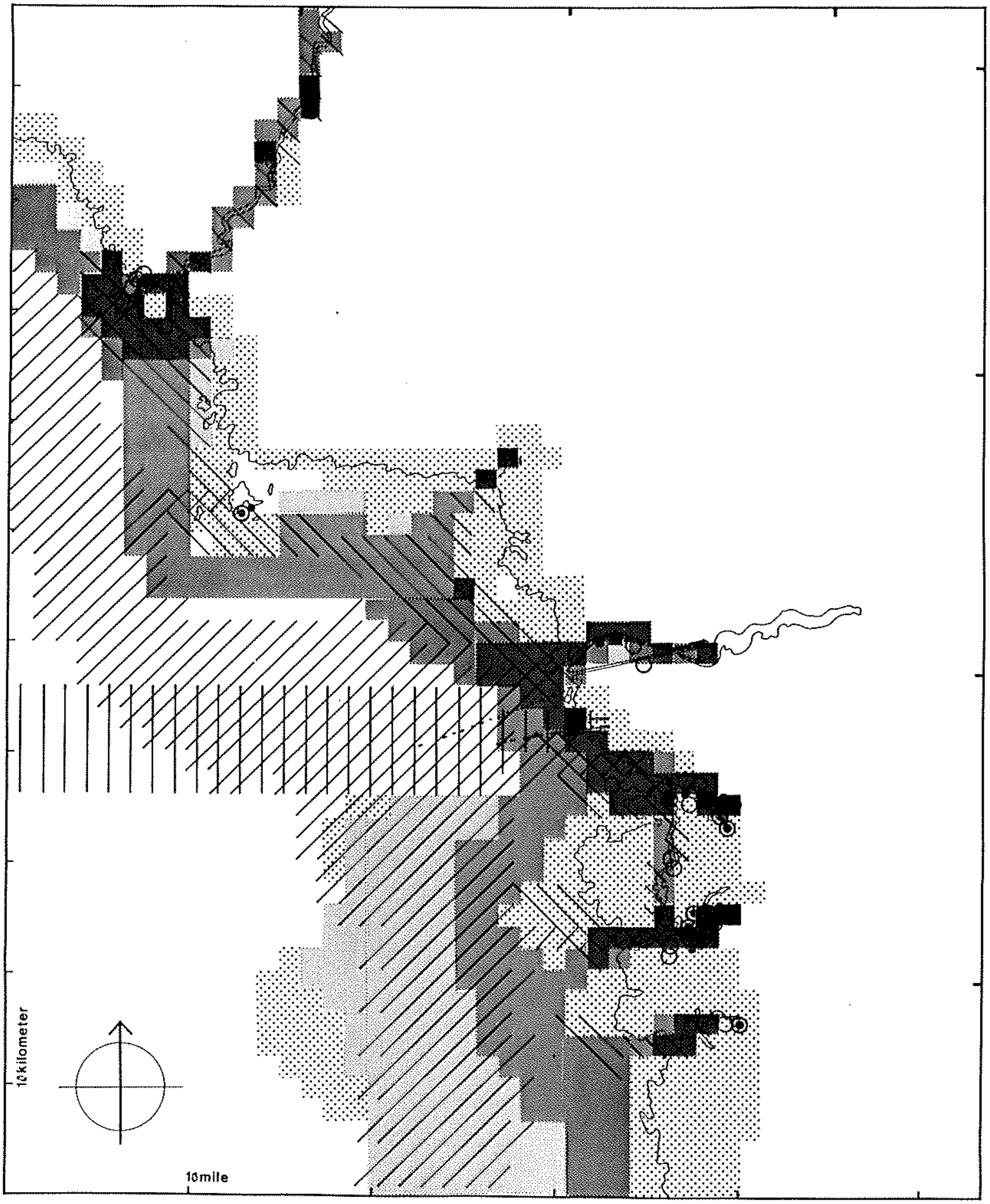
When the map of boat traffic (Figure 42) is overlaid on the map of manatee habitat (Figure 33), the major areas of overlap between human activities and manatee needs can be readily identified (Figure 43). Crystal River and Homosassa River are both core areas of manatee habitat and centers for boating activity in the region. This suggests that long-term planning is needed to redirect any further development of boating access to areas that are not as important for manatees, e.g. areas adjacent to the Cross-Florida Barge Canal. The current low degree of overlap between boats and manatees in the Chassahowitzka River is mainly due to the shallow nature of the river, which does not encourage entry of large boats. In view of the importance of the Chassahowitzka as summer habitat for manatees, dredging of a deeper channel, which would permit entry of larger boats, would be disadvantageous for manatees. Likewise, development of marinas and boat ramps along the lower Suwannee River would increase the risk for manatees utilizing the Suwannee estuary as summer habitat.

Large boats present more of a lethal threat to manatees than do small boats (Beck et al. 1982). There appears to be little current overlap between offshore traffic of large boats and manatee habitat. However, construction of the "missing link" of the Intracoastal Waterway between St. Marks and Tampa Bay has been proposed (Kaufman, unpublished). If this waterway were to be constructed, it would bring large boats into the estuaries where there would be more overlap with important areas of manatee habitat. In addition, overlap would probably increase because manatees are likely to use the Intracoastal Waterway as a travel route, and more large boats and barge traffic would be attracted to the area. Such development would constitute a significant negative impact on manatees and their habitat.

Barge traffic on the lower Withlacoochee would increase the probability of manatee mortality. Three carcasses killed by crushing impact that is typical of barge collisions were recovered from the Withlacoochee in 1975 (Powell and Rathbun 1983). If barge traffic were to resume, it might be desirable to resume regular maintenance dredging of the channel in order to maintain sufficient clearance for manatees. However, such dredging should not be permitted if it has a significant direct or indirect impact on aquatic vegetation.

Maintenance dredging of navigation channels in Crystal and Homosassa rivers would increase the probability of lethal boat collisions with manatees if it increased boat density and the size of boats in these rivers. However, if manatees are repeatedly hit or killed in areas where shoaling occurs in the channel, localized maintenance dredging may be warranted.

The areas where manatees are most vulnerable to boat traffic are the Suwannee estuary, the Withlacoochee estuary, Crystal River, Homosassa River, and the Chassahowitzka estuary (Figure 44). These areas are analyzed in further detail in the following subsections.

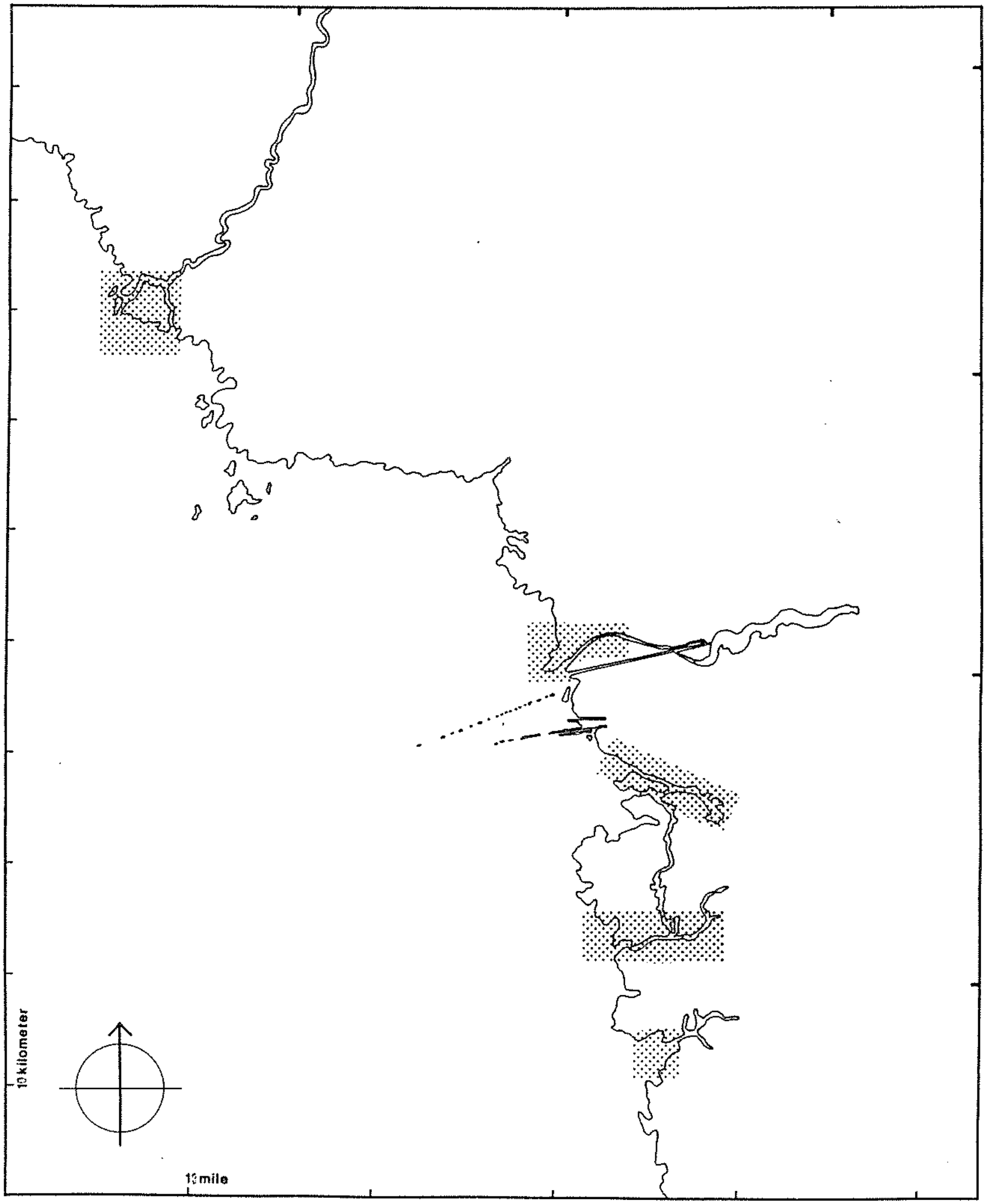


Small boats   Large boats   Barges

Boat ramp   Marina   Coast Guard station

FIGURE 43: OVERLAP OF BOAT TRAFFIC AND MANATEE HABITAT IN SOUTH BIG BEND.

The density of shading indicates the relative importance of manatee habitat as summarized in Figure 33.



Sites with existing overlap of boat traffic and manatee habitat

FIGURE 44: SITES ANALYZED IN FURTHER DETAIL REGARDING POTENTIAL IMPACT OF FUTURE BOATING FACILITIES ON MANATEES IN SOUTH BIG BEND

Sites were identified from the overlap of boat traffic and manatee habitat shown in Figure 43.

1.1.2 Crystal River/Kings Bay

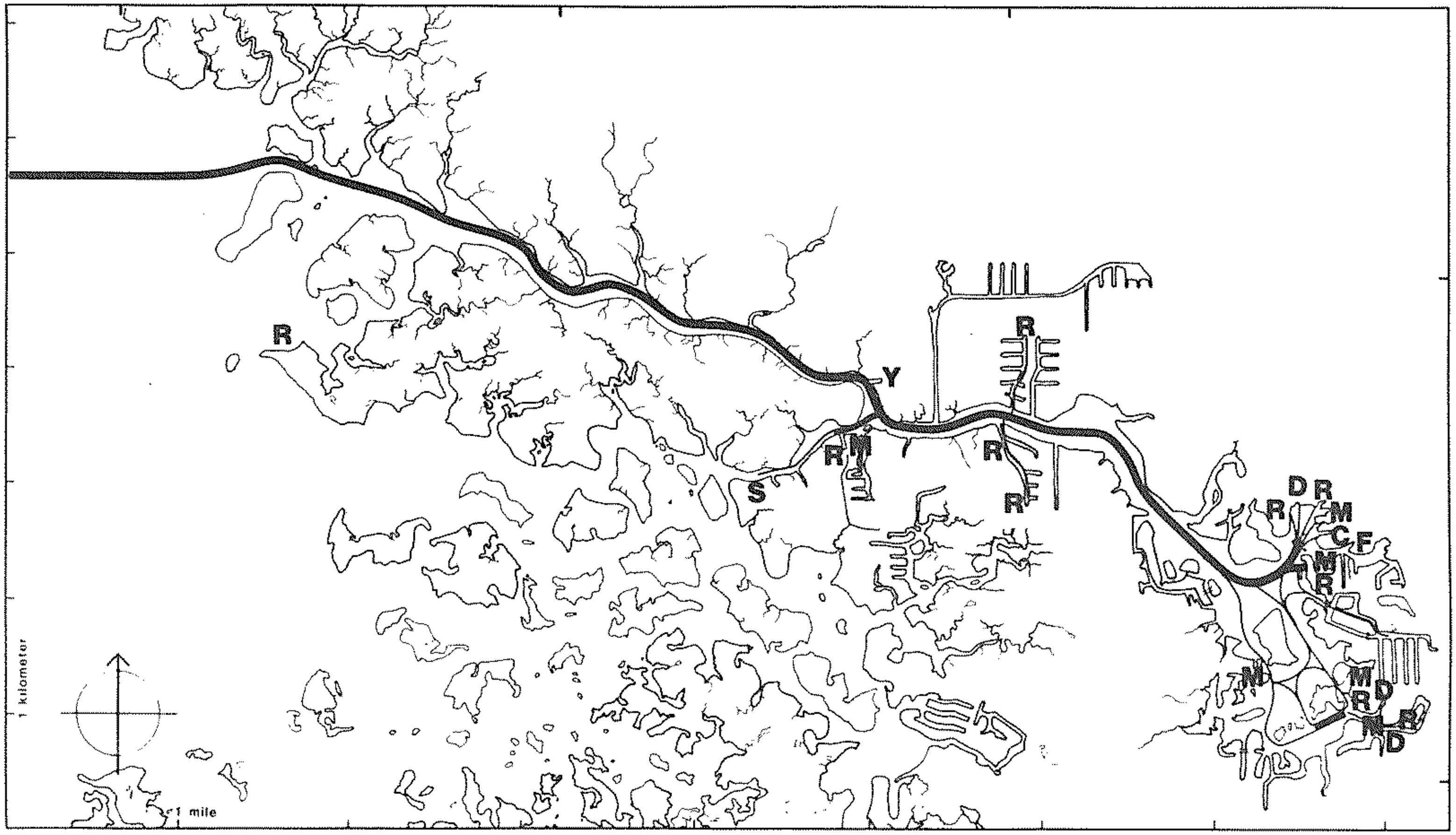
Existing boating facilities and waterborne vessel traffic in Kings Bay and the lower Crystal River appear to have reached densities at which increased levels could seriously threaten both the survival of individual manatees and the capacity of the area to support an increase in the number of over-wintering manatees. For example, an increase in the number of boating facilities and associated vessel traffic on the river and bay could alter manatee movements and behavior, increasing the probability of harassment, injury and death of manatees.

Most of the predictable large boat traffic is between the mouth of Crystal River and the northeastern cove of Kings Bay (Figure 45). Docking facilities in the northeastern cove include: one marina and one dry-dock, a seafood processing plant, and three boat ramps. In addition, there is a marina, dry-dock and boat ramp at the branch of the Salt River and Crystal River. Shrimp-boat docks located downstream from the Salt River on Crystal River will be converted to a yacht club, and docking facilities for the large shrimp boats are currently being sought. Four boat ramps are located on canals connected to Crystal River. Within Kings Bay, most of the traffic is small boats. In all seasons, skiffs that are rented by two dive shops in the northern bay and two dive shops in the southern bay, travel among the islands. In the summer, the southern bay is a favorite area for water skiing. Boats from the Marine Science Center on the Salt River regularly bring students to the southern bay and to the estuary for educational programs during all seasons.

When the map of boat traffic patterns is overlaid on the map showing relative density of manatee sightings, the Crystal River channel stands out as the major area of overlap between large boat traffic and manatee distribution (Figure 46). Although manatee density is higher in Kings Bay than in the channel, Kings Bay is frequented more by small boats than by large boats. Manatees are not observed frequently in the northeastern part of Kings Bay where marinas and boat ramps are concentrated.

Construction of a marina or ramp in the southern bay where manatee densities are highest would clearly constitute a substantial negative impact on habitat. In the past, manatee carcasses have been recovered near areas of shallow water, e.g. Salt River and Bagley Cove (Figure 47). Any new construction increasing frequency of boat traffic in shallow areas would be disadvantageous to manatees because it would increase the probability of mortality.

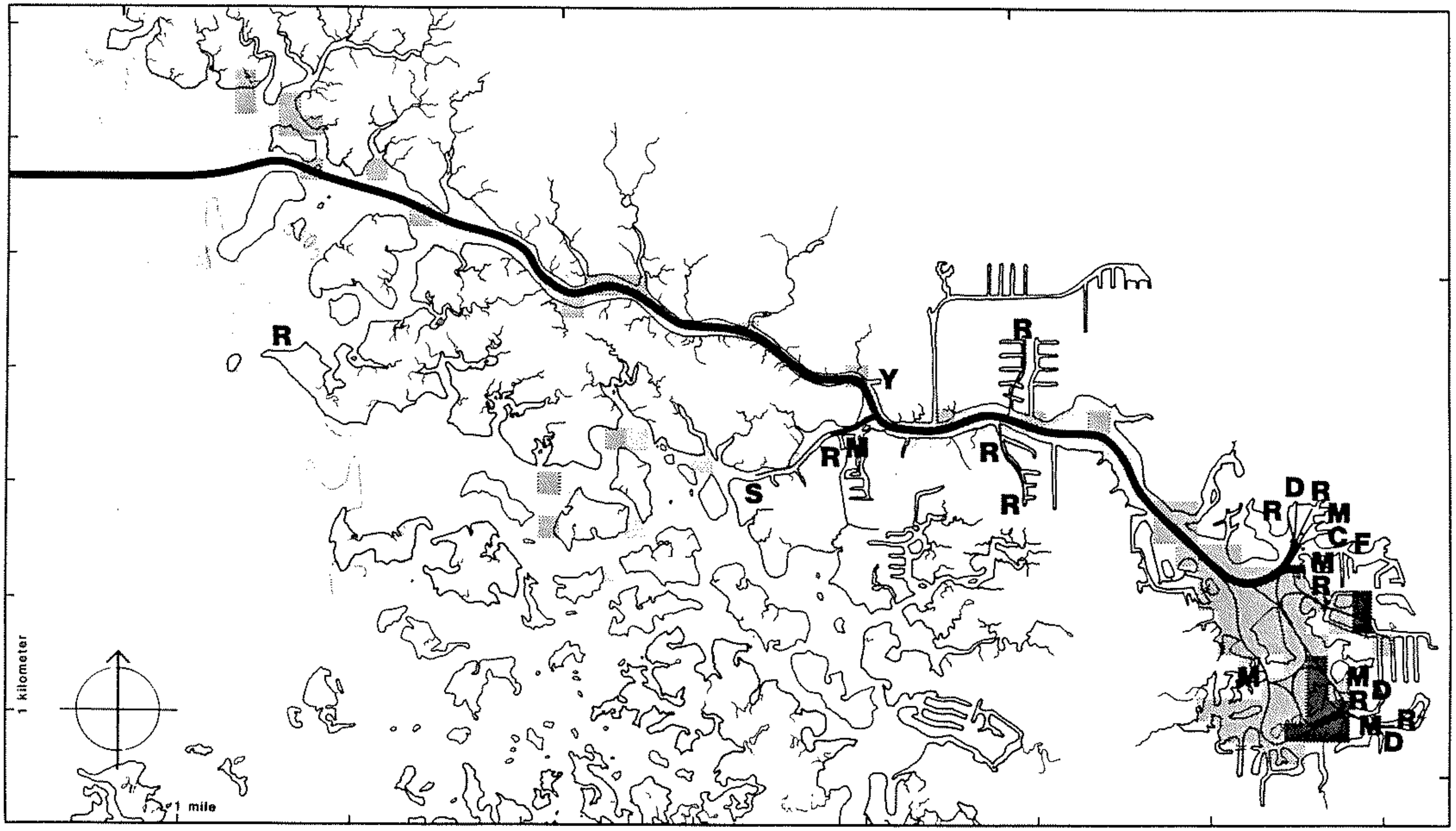
The eastern portion of Kings Bay and parts of the upper Crystal River have been subdivided and platted as small lots (Figure 48). The actual and potential density of piers and boat slips in these areas is high, because state and federal laws allow owners of waterfront property to build docks. Additional subdivision of land along the waterfront could significantly increase the docking facilities, hence increasing boat traffic and the



C	Commercial fishing dock	**D**	Dive shop	**F**	Fishing guides	**M**	Marina
R	Boat ramp	**S**	Science education center	**Y**	Yacht club	▬	Boat traffic route

FIGURE 45: BOAT TRAFFIC PATTERNS IN CRYSTAL RIVER.

Data are from Division of Parks and Recreation (DNR), map prepared by Division of Aquatic Services (Citrus County), and Puckett (1983).



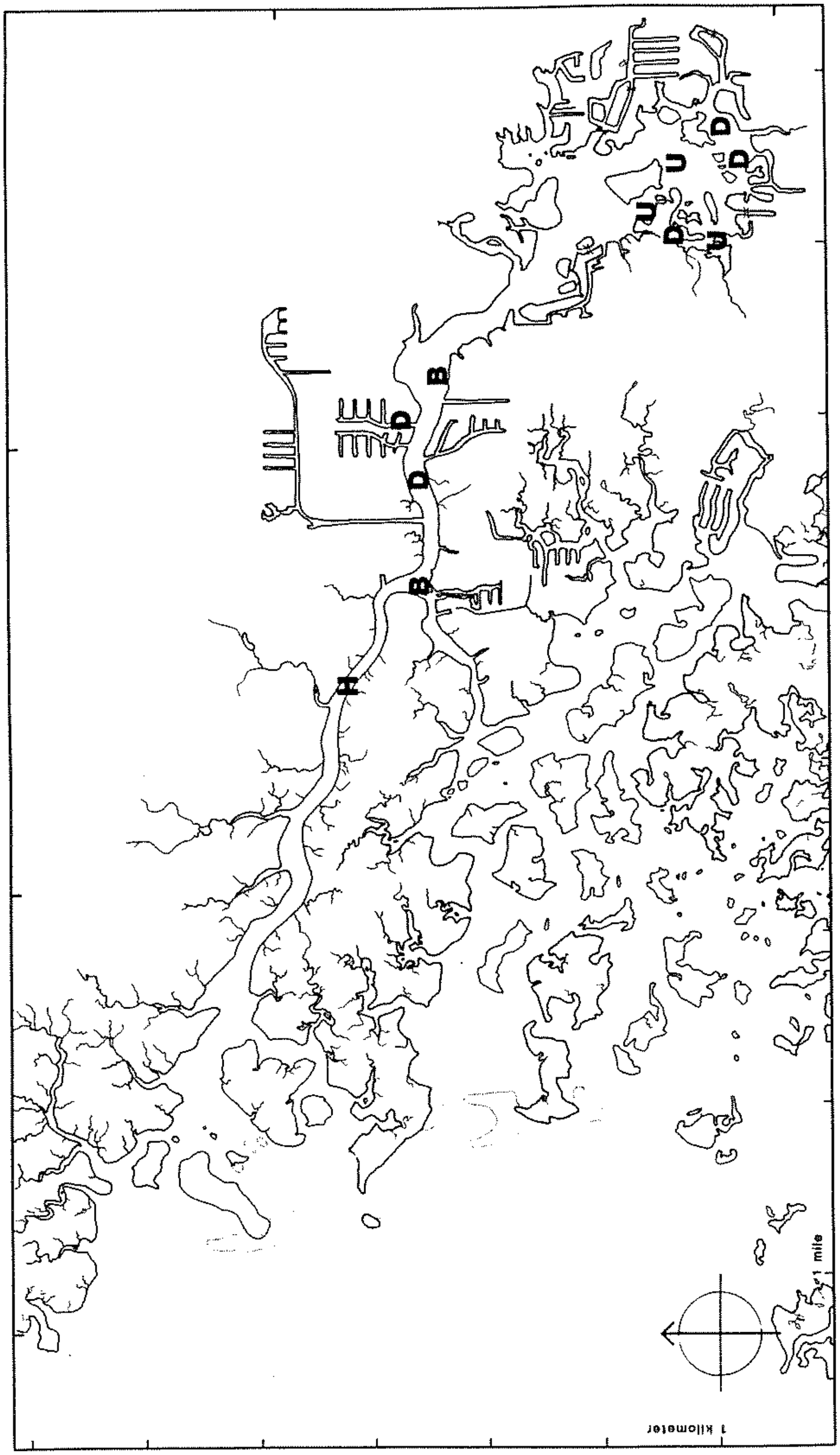
Density of shading indicates relative density of manatee sightings

Lines indicate boat traffic routes

D Letters indicate boat access facilities

FIGURE 46: OVERLAP OF BOAT TRAFFIC AND MANATEE DENSITY IN CRYSTAL RIVER.

Data are from Figures 37 and 45.



B Boat/barge **D** Dependent calf **H** Human related **U** Undetermined

FIGURE 47: LOCATION AND CAUSE OF DEATH OF MANATEE CARCASSES SALVAGED IN CRYSTAL RIVER.

Data are from Powell and Rathbun (1983).

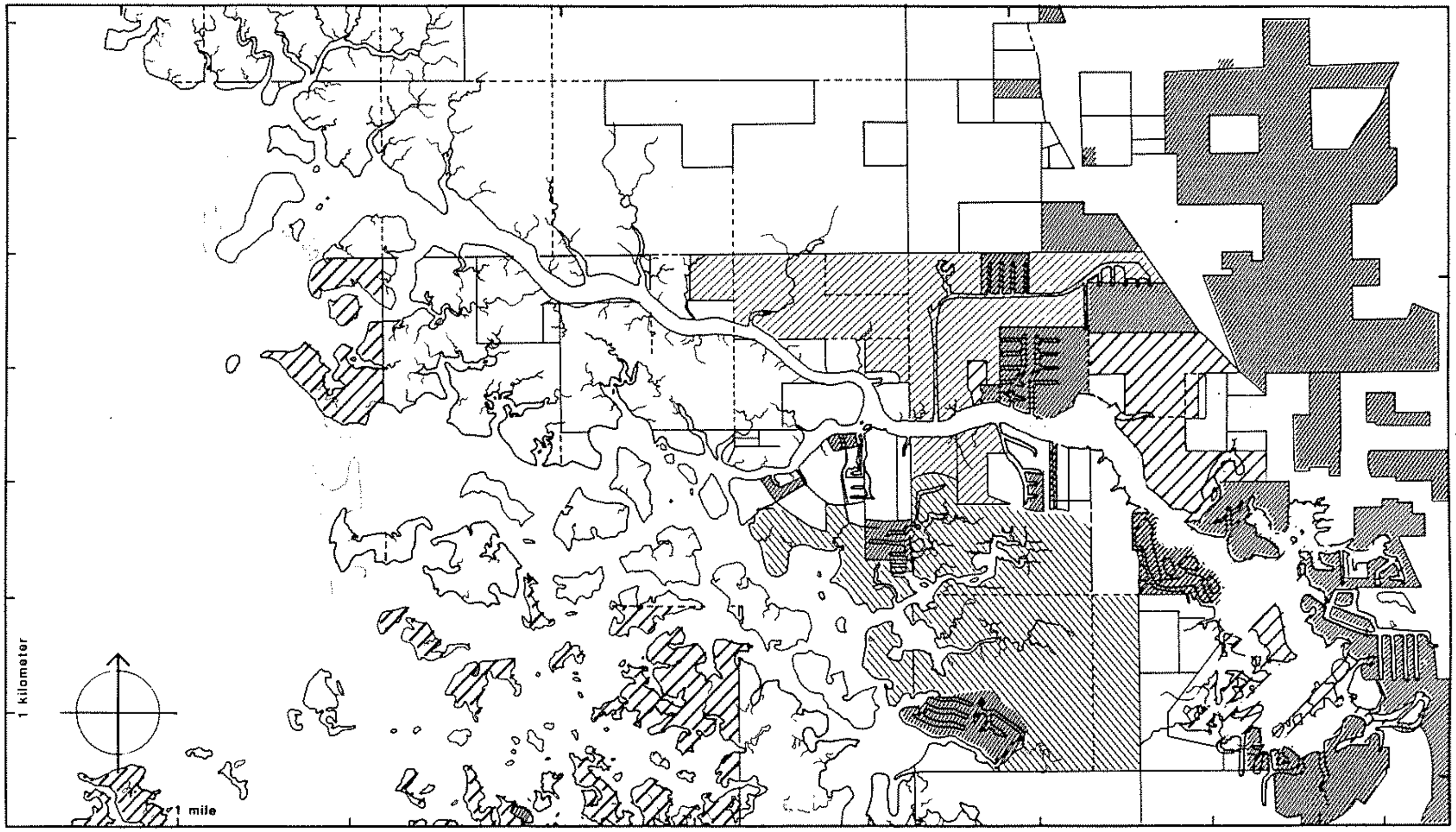


FIGURE 48: <u>LAND USE AND OWNERSHIP AROUND CRYSTAL RIVER</u>.

Data are from the Citrus County land platte book (Anonymous 1982), Department of Planning and Zoning (Citrus County), Division of State Lands (DNR). All submerged lands except for a parcel south of Banana Island are owned by the State of Florida as sovereignty submerged lands.

probability of boat-related injury to manatees. Construction of small piers and boat slips should be evaluated in terms of the cumulative impact on boat traffic and aquatic vegetation. Small docks in areas with aquatic vegetation (Figure 35) and adjacent to areas where manatees are sighted frequently (Figure 37) would constitute a negative impact on manatee habitat.

Construction of additional docking facilities for small craft in existing canals that do not contain native plant species would not pose a significant impact on manatee food resources. However, if such construction increased the ratio of large to small craft, or increased the density of boats using the waterways used by manatees, the impact would be negative.

Relocation of existing large-boat docking facilities to areas that reduce the length of travel through manatee habitat would be an improvement. For example, it might be better to relocate facilities used by commercial fishermen closer to the mouth of Crystal River, such that these boats do not travel the entire length of the river to Kings Bay.

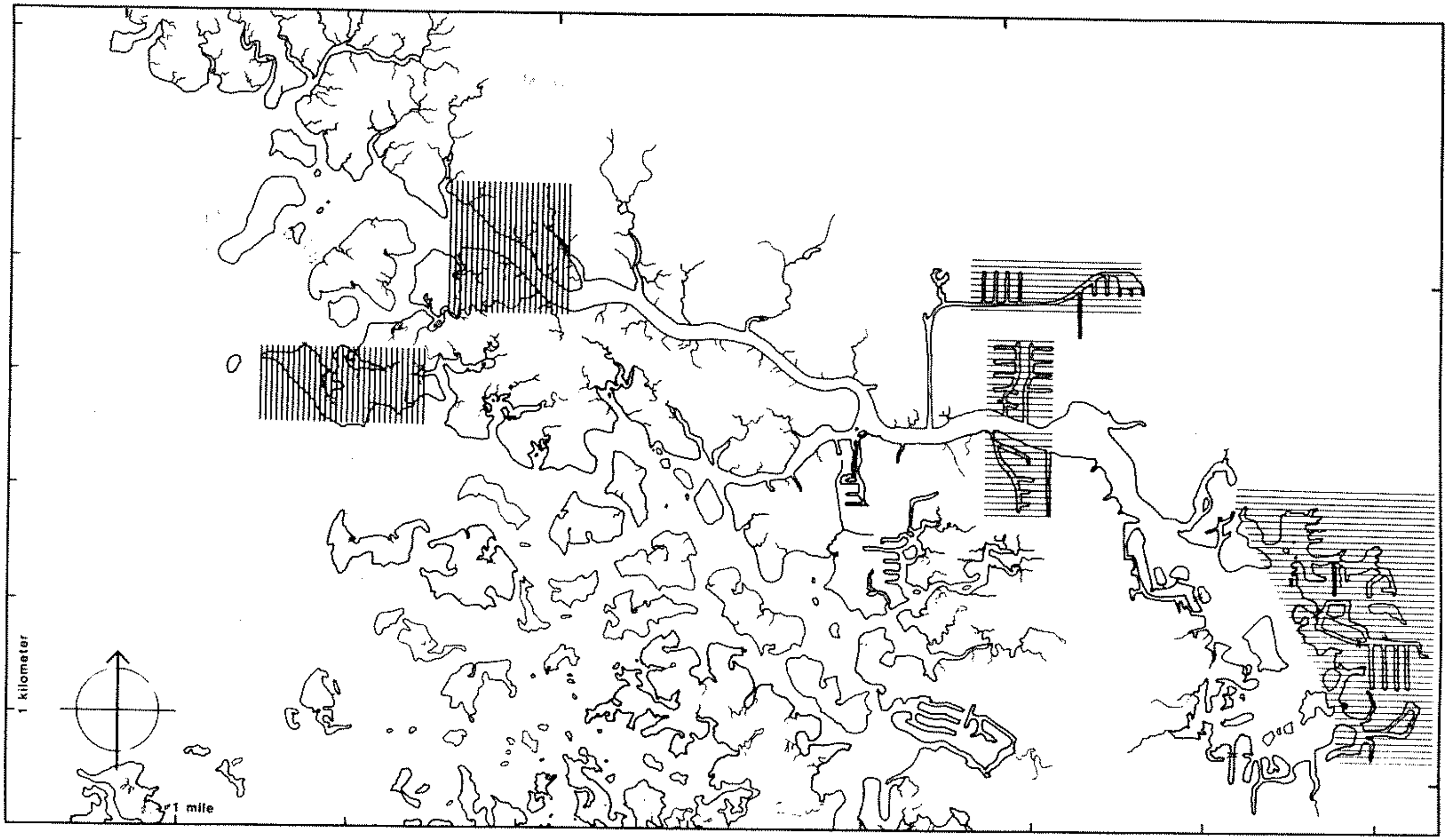
A substantial portion of the boat traffic in Crystal River appears to be non-residents. Ninety five boat trailers were counted on one day at Crystal River ramps, and 84% of the license plates were from outside Citrus County (Tabb, pers. comm. cited in Puckett 1983). The number of non-resident boats using Crystal River can be controlled by limiting the size of parking facilities at boat ramps, and the number of boat ramps.

The vulnerability of manatee habitat to development of docking facilities on Crystal River is summarized in Figure 49. Manatees are vulnerable to boat traffic in Kings Bay, the lower Crystal River and the island area south of Fort Island. Construction of docking facilities could destroy or degrade natural vegetation in Crystal River between the Salt River and Miller's Creek, around the islands in Kings Bay, and in the western area of the bay. In many other parts of the bay, construction of seawalls has already destroyed native vegetation and non-native vegetation (hydrilla, milfoil) is abundant. Wetlands are adjacent to Crystal River west of the State Archaeological Museum. Along the southern portion of the Salt River, wetlands extend further inland. Construction of docking facilities in wetlands would disrupt the ecosystem supporting manatees. Appropriate design of docking is essential to minimize habitat degradation (DNR 1983).

1.1.3 Other river systems

The analysis of the overlap between boat traffic patterns and manatee habitat is preliminary for river systems other than Crystal River, and is based on available information, which may be incomplete. However, the areas where boat traffic presents the highest risk for manatees have been identified as follows.

On the lower Suwannee River (Figure 50), manatees are most vulnerable to boat traffic in the river channel, at the mouth of East and West pass. They are sighted less frequently at the mouth of Salt Creek. Vegetation utilized by manatees has not been mapped. Almost the entire area adjacent to the



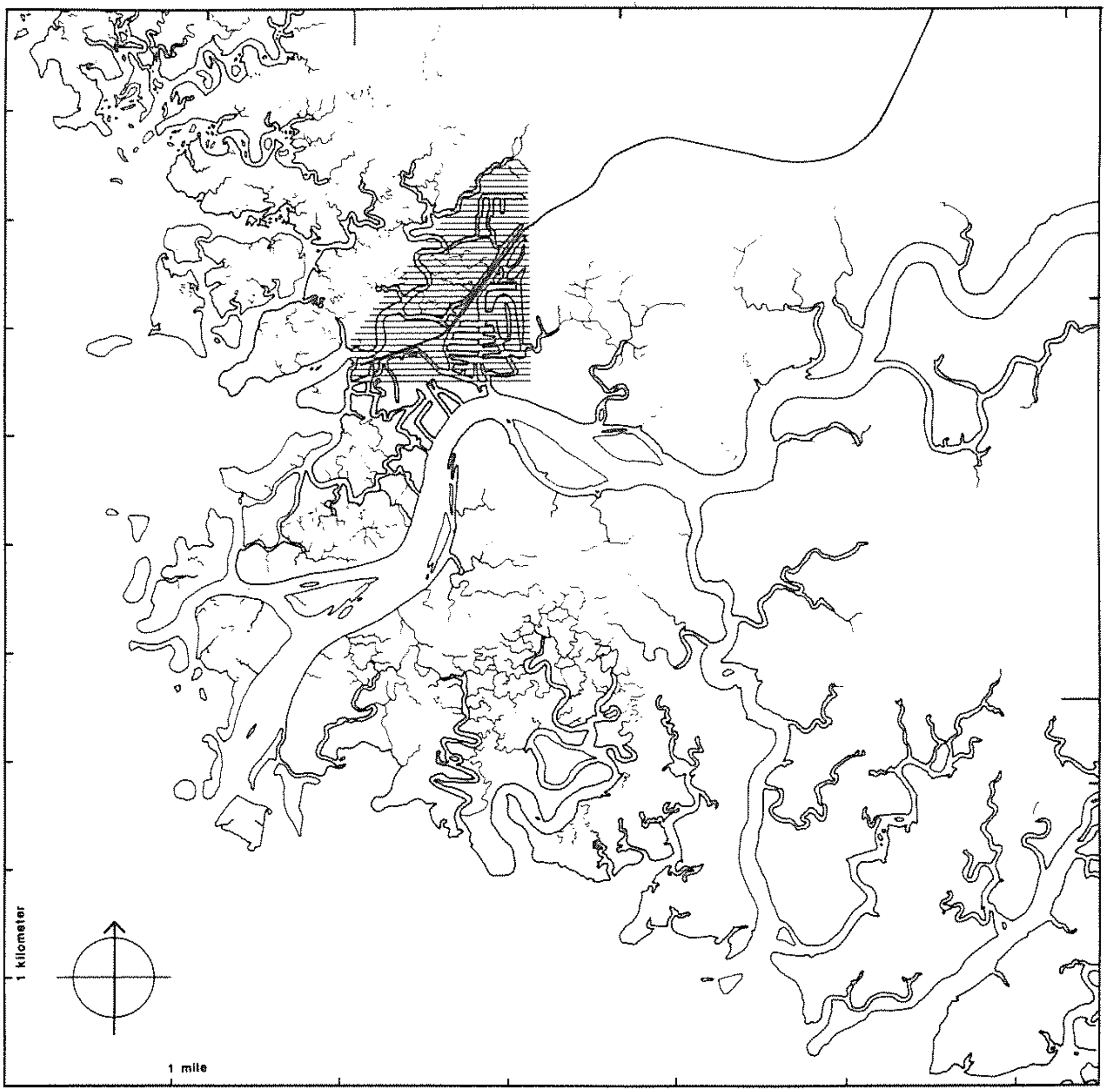
Suitable site: meets all criteria

Site minimizes boat/manatee overlap

Site minimizes disturbance of wetlands

FIGURE 49: SITES MINIMIZING IMPACT OF FUTURE BOATING FACILITIES ON MANATEES IN CRYSTAL RIVER.

Suitable sites should both minimize boat/manatee overlap and disturbance of wetlands. No such sites were located in this region by analyzing the overlay of Figures 35 and 37.



Suitable site | Site minimizes manatee/boat overlap | Site minimizes wetlands disturbance

FIGURE 50: SITES MINIMIZING IMPACT OF FUTURE BOATING FACILITIES ON MANATEES IN THE SUWANNEE RIVER.

Suitable sites should both minimize manatee/boat overlap and disturbance of wetlands. No such sites were located in this area by analyzing the overlap of Figure 23 and USGS topographic maps "Suwannee" and "East Pass".

lower Suwannee River is wetlands, with an important role in maintaining the estuarine system used by manatees. Manatees also travel at least as far upstream as Manatee Springs State Park. Thus any development that would increase boat traffic in this section of the Suwannee might increase risks to manatees.

On the Withlacoochee River (Figure 51), manatees are more vulnerable to boat traffic in the river and estuary than in the Cross Florida Barge Canal. Native aquatic vegetation that could be disturbed by construction of docking facilities is in the lower portion of the river. Wetlands that could be disturbed occupy a relatively narrow band along the coast. Development of docking facilities on the Barge Canal east of the wetlands would present relatively little risk for manatees if the traffic pattern was directed along the chain of spoil banks in the existing channel.

On the Homosassa River (Figure 52), manatees are vulnerable to boat traffic along the entire length of the river. Vegetation that could be destroyed or degraded by development of docking facilities is between Homosassa and the Halls River. Almost the entire river is in the coastal zone of wetlands that are less than 1 m (5 ft) elevation. Little is known about manatee use of Mason Creek. However, due to its inclusion in the Chassahowitzka National Wildlife Refuge, it does not appear suitable for development of marinas.

On the Chassahowitzka River (Figure 53), manatees are vulnerable to boat traffic downstream from the wide shoals at the mouth of Stevenson Creek. Vegetation utilized by manatees has not been mapped, but reportedly occurs in the lower portion of the river. Almost the entire river is bordered by wetlands. Therefore no sites on the Chassahowitzka River were identified that would satisfy the criteria required for suitable development of marinas.

1.2. Current Regulations

A detailed review of laws and regulations related to marina siting, dredge and fill has been prepared by Hamann (1983a). The information from Hamann's review is briefly summarized in this subsection, to provide the background for management options identified in the next subsection.

The local city and county governments have the authority to regulate developments that influence boat traffic (Hamann 1983a). Zoning regulations, permitting standards and review of state and federal actions could be used to protect manatees at the local level, but currently there are no provisions to do so. Under the Local Government Comprehensive Planning Act, the county and city have adopted comprehensive plans that are updated every five years. Local regulations must be consistent with the adopted plan, which includes elements guiding conservation of natural resources (including wildlife) and coastal zone protection. The current Citrus County and Crystal River Comprehensive Plans deal with environmental protection in a vague and ambiguous manner. Additional guidelines pertaining specifically to protection of manatees could be included in the next revision of these plans. The city of Crystal River has jurisdiction over lands adjacent to the north

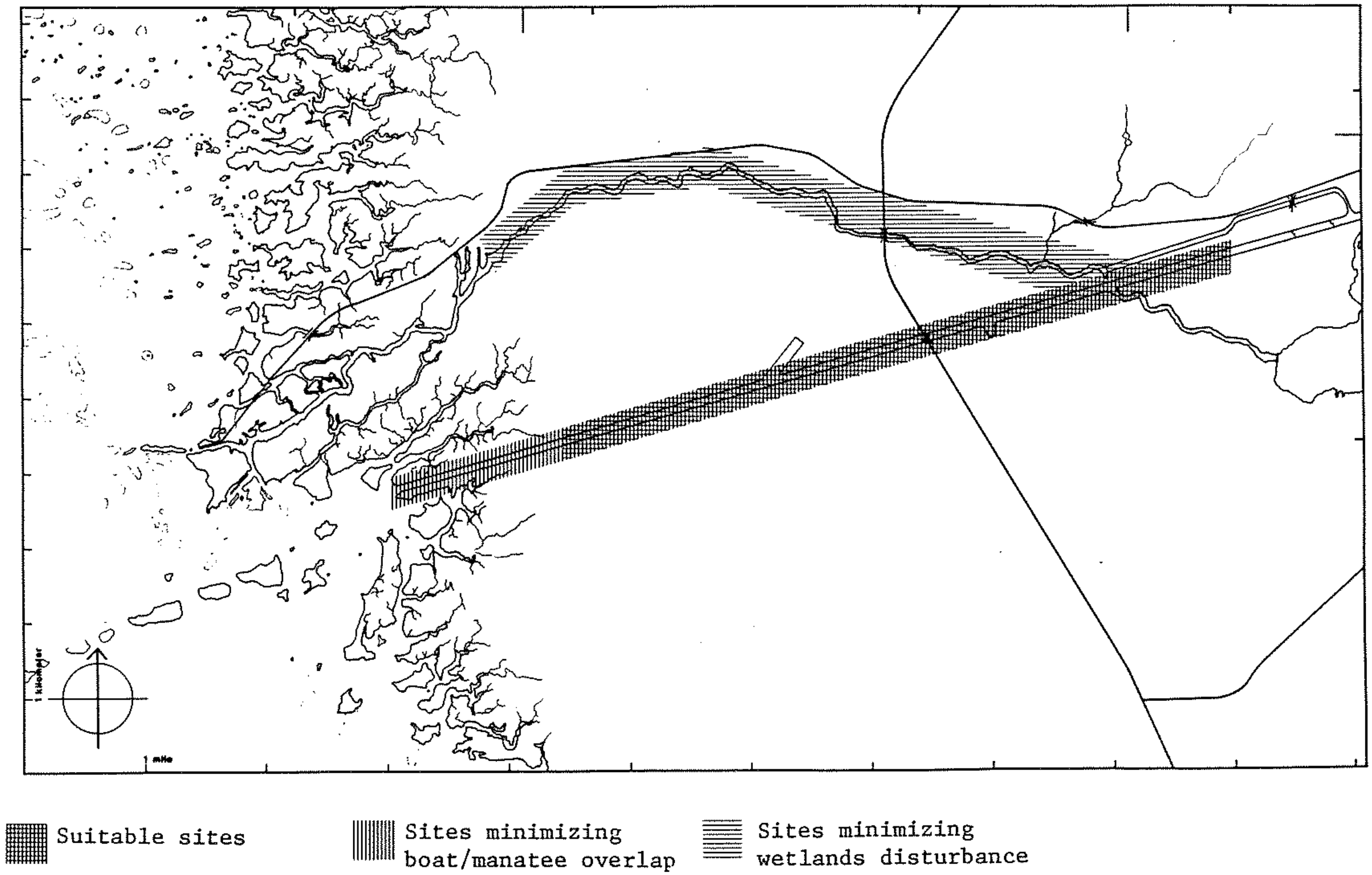


FIGURE 51: <u>SITES MINIMIZING IMPACT OF FUTURE BOATING FACILITIES ON MANATEES IN THE WITHLACOOCHEE RIVER AREA</u>.

Suitable sites meet two criteria; they minimize boat/manatee overlap and disturbance of wetlands. Sites were located by analyzing the overlay of Figure 25 and USGS topographic maps "Withlacoochee Bay", "Yankeetown" and "Yankeetown S.E.".

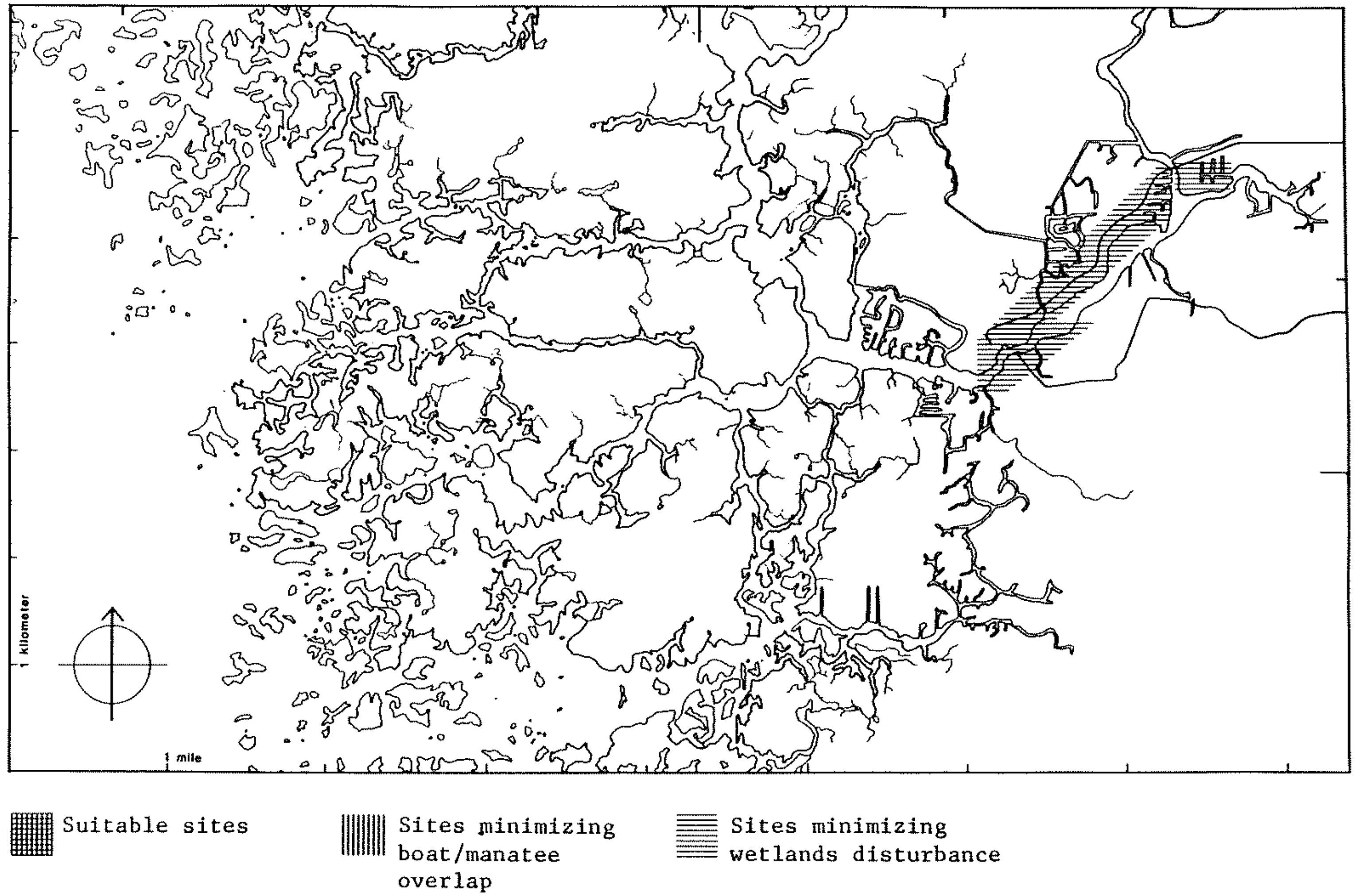


FIGURE 52: SITES MINIMIZING IMPACT OF FUTURE BOATING FACILITIES ON MANATEES IN THE HOMOSASSA RIVER.

Suitable sites should minimize both boat/manatee overlap and disturbance of wetlands. No such sites were found by analyzing the overlay of Figure 27 and USGS topographic maps "Ozello" and "Homosassa".

and eastern shores of Kings Bay (Figure 48). The rest of the lands adjacent to Crystal River are under Citrus County jurisdiction.

Current state regulations are inadequate to address the cumulative impacts of construction of boating facilities (CZM and OCM 1981:p. II-211). In Citrus County, no special approval is needed to construct boat docks that serve single family or duplex units. Marinas incidental to hotels do not require special permitting. The Zoning Board of Adjustments approves commercial marinas by means of a special exemption; however, there are no standards specified for marina permitting.

To encourage and implement changes in local government policies to improve consistency with state policies, the state of Florida has a process of designating Areas of Critical State Concern (ACSC). In an area where local policies conflict with regional policies, a Resource Planning and Management Committee may be appointed by the Department of Community Affairs to assist in resolving the conflict. If voluntary compliance is not sufficient, the area may be declared an ACSC, which requires local regulation be consistent with state goals. If the local agencies fail to pass adequate regulations, state regulations will be invoked that overrule local authority. The ACSC designation may be lifted when changes in local regulations are approved.

Although most development is regulated by local governments, there is a process for state review of major developments that would have a substantial impact on citizens of more than one county. Marinas of 100 slips or more and residential developments of 750 units are identified as Developments of Regional Impact (DRI) requiring more critical review of permits. A DRI is reviewed by the Regional Planning Council and state agencies prior to approval by the local government. The decision of the local government may be appealed by the developer, the Regional Planning Council, or the Department of Community Affairs, in which case the Governor and Cabinet make the final decision on whether to approve the local government's development order.

The rules classifying a development as a DRI are based on fixed numbers rather than performance standards. For example, a marina with slightly less than 100 boat slips would not be required to undergo the review of a DRI. A marina of that size could still have a substantial impact on manatees, which are a resource of concern to the citizens of more than one county, therefore of regional concern. With sufficient evidence in specific cases, the Department of Community Affairs could overcome the presumption established by the administrative guidelines regarding determination of whether a development is a DRI. The guidelines can be changed by the Governor and Cabinet with legislative approval. Such changes would affect plans for developments throughout the state, which were submitted after approval.

The state process for permitting construction in wetlands and navigable waters is complex. It involves both the Department of Natural Resources (DNR) and Department of Environmental Regulations (DER) under two sets of laws (Chapters 253 and 403). Submerged lands belong to the state (sovereignty submerged lands) except where private ownership has been deeded, and approval of all activities that use sovereignty submerged lands is vested in the Trustees of the Internal Improvement Trust Fund (Governor and Cabinet). Application for approval of activities conducted on state lands is made to DNR. A number of activities are granted a consent of use by rule and do not require special approval, e.g. installation of docks less than 1,000 square feet (500 square feet in an area designated as Outstanding Florida Waters), and construction of a seawall within three feet of mean high water. A lease must be obtained for larger projects or activities that generate income. The rules governing review of proposals specifically state that activities with an adverse impact on sovereignty lands and associated resources shall not be approved, and special attention should be given to habitat of endangered species. Although no specific provisions guiding approval in manatee habitat are given, the rules provide for consideration of special reports. The state's Blue Ribbon Marina Committee specified that marinas should not be sited in locations that will disturb manatee habitat (DNR 1983).

Applications for activities on submerged lands require special review if the lands are in a designated Aquatic Preserve or State Manatee Sanctuary. Standards for review of activities in Aquatic Preserves do not differ much from submerged lands in general, with the possible exception that more consideration may be given to the cumulative impacts. A management plan that provides additional guidelines for reviewing proposals should be written for each preserve. However, the Aquatic Preserve rules protect the riparian rights of landowners, which may conflict with protection of manatee habitat.

Construction of docking facilities usually involves dredge and fill in some form (pilings are considered "fill"). The DER directly regulates dredge and fill of navigable waters (under Chapter 253) and indirectly controls it by regulation of activities that affect water quality in waters and wetlands (Chapter 403). Chapter 253 stipulates that a biological, ecological and possibly hydrological study must be conducted to evaluate the potential impacts of the proposed work. If the studies show that the work will interfere with conservation of wildlife or natural marine habitats such as grass flats to such an extent as to be contrary to the public interest, this constitutes grounds for denial of a permit. However, Chapter 403 does not directly consider effects on wildlife, except as they may be influenced by degradation of water quality.

The overlapping jurisdictions of DNR and DER cause confusions that occasionally result in an applicant starting construction without the necessary permit approval. For example, docks under 1,000 square feet (929 m^2) are exempted from special approval by both DNR and DER. However, DNR calculates the area of the dock from the outer perimeter of pilings to the shore (water preempted) and DER calculates square footage of the structure. This difference in definition of dock size has caused confusion when a dock of a size exempt from DER permitting was not exempt from the DNR consent of use (Tunstall 1982). Also, the boundaries of jurisdiction are not easily identified. Navigable waters under DER jurisdiction include some areas that are not sovereignty submerged lands. The criteria for defining navigable waters and wetlands are complex (Figure 54), and not easily applied to a specific site. The mean high water line is used to define navigable waters in tidal areas, but it has not been mapped for many areas such as Crystal River. Boundaries of wetlands are established by indicator plant species, but the list may not include wetland species found in specific locations such as coastal or wooded wetlands.

Review of dredge and fill permit applications is coordinated between DER and the Army Corps of Engineers (COE). Under the Rivers and Harbors Act, and Clean Waters Act (Sect. 404) the COE has jurisdiction over dredge and fill in waters of the United States, which is essentially the same as the jurisdiction of DER. For a permit to be approved by COE, it must have certification of approval by DER. Both permits are required prior to construction. The COE also allows general permit authorizations, such as docks under 1,000 square feet (929 m^2). Nationwide permits allow minor dredge and fill that does not disrupt wetlands or adversely affect endangered species or their critical habitat. To date, the effect on manatees of the COE general permit program or nationwide permits has not been evaluated through the Section 7 consultation process.

A permit from the COE is required for discharge of any dredge or fill material to waters of the United States (The Clean Water Act of 1977, Section 404). Jurisdiction includes all waters subject to Section 10 regulation as well as wetlands adjacent or connected to navigable waters, and large inland wetlands. General permits have been issued for minor activities such as dredge or discharge of 10 cubic yards (7.6 m^3) or less of fill. Although activities conducted under general permits are not supposed to occur in areas that would jeopardize an endangered or threatened species, there has been little attempt to evaluate impacts either prior to or after several years that general permits have been in effect. In particular, there has been no consideration of the cumulative effects of activities under general permits. Division engineers have authority to require individual permits in specified areas, but do not do so in the management area.

In the management area, a substantial amount (38%) of dredge and fill activity recorded by the COE occurs under general permits or nationwide permits and is thus not regulated (Table 16). Over the last five years, the COE has processed 391 permit applications within the management area. These applications include piers, bulkheads, boat ramps, boat slips, revetment, dredging, upland fill, moorings, piles, and signs. Major areas of activity are Crystal River and Homosassa River.

Several federal agencies have the responsibility of reviewing Corps permit applications. The Environmental Protection Agency has veto power over actions that would violate the intent and regulations governing Section 404 programs including actions having adverse impacts on wildlife. Under the Fish and Wildlife Coordination Act, the Fish and Wildlife Service is entitled to review COE permit applications.

Under the provisions of Section 7 of the Endangered Species Act, the COE, in consultation with the Fish and Wildlife Service, is required to

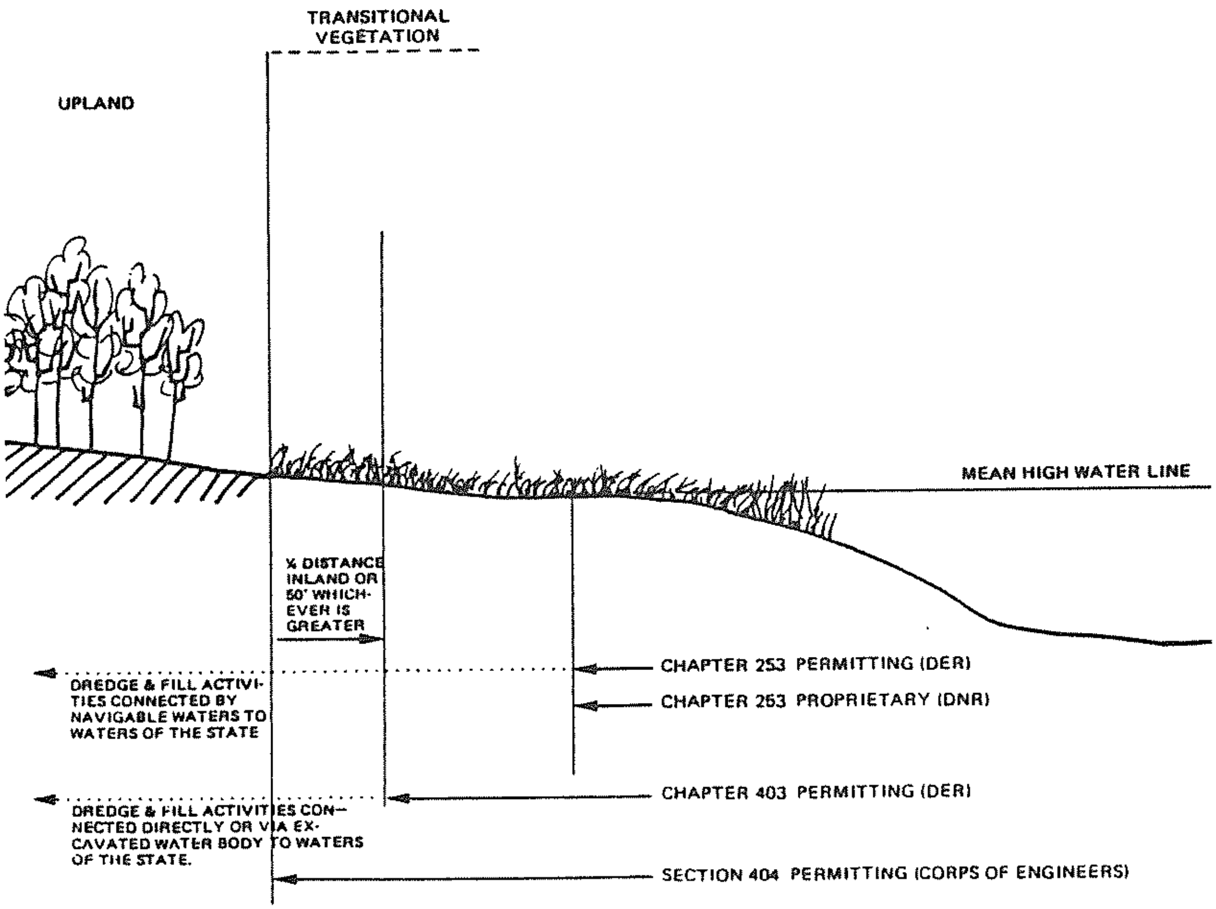


FIGURE 54: <u>COMPARISON OF GENERAL DREDGE AND FILL JURISDICTIONS OF STATE AND FEDERAL AGENCIES</u>.

This figure is from CZM and OCM (1981), pp II-48.

Table 16. Permit applications recorded by the Army Corps of Engineers in South Big Bend (1977-1982)[1]

	Expired/ Deactivated	Denied	Active (3/83)	General Permit[2]	Permit Nationwide or Not Required[2]	Total
Suwannee River	6	5	3	1	1	16
Cedar Key	2	0	0	3	2	7
Waccasassa River	2	0	1	1	0	4
Withlacoochee/Barge Canal	11	0	12	16	2	41
Crystal River/Salt River	43	6	14	58	45	166
St. Martins River/Ozello	3	0	2	24	20	49
Homosassa River	17	0	6	38	19	80
Chassahowitzka River	1	1	0	4	0	6
Gulf of Mexico	14	0	4	3	1	22
Total	99	12	42	148	89	391

[1]From data file of the Army Corps of Engineers, Jacksonville, FL.

[2]No application is necessary, so numbers represent an incomplete record of total dredge and fill activity.

ensure that its actions (including the issuance of permits) are not likely to jeopardize the continued existence of the manatee or result in the destruction or adverse modification of its designated habitat. The entire Crystal River has been designated as Critical Habitat for manatees. If the COE determines that any of its actions may affect the manatee or its Critical Habitat, the Fish and Wildlife Service is responsible for providing a biological opinion to the COE, which details the effects of the action and suggests reasonable and prudent alternatives that can be taken. A procedure exists for obtaining an exemption to regulations of the Endangered Species Act, prior to initiation of the project to be exempted.

Provisions of the National Environmental Policy Act require preparation of an Environmental Impact Study for major federal actions significantly affecting the quality of the environment. This would apply to any large federal project (e.g. completion of the Intracoastal Waterway or Cross Florida Barge Canal) or private project that requires federal permit approval (e.g. additional generating units at the Crystal River Power Station).

1.3 Alternative Management Options

Options for managing boat traffic by planned development of docking facilities can be addressed at both the regional level (South Big Bend) and local level (specific rivers). The alternatives are described in this section and recommendations regarding implementation of the best alternatives are described in Subsection 1.5.

1.3.1 Regional Planning

Alternative management options that could be considered on a regional scale are listed in Table 17 and described below. The predicted manner in which each alternative would affect factors relevant to protection of manatees (from Table 15) is outlined.

Alternative 1: No action

Under existing regulations, boat density and the proportion of large to small boats is expected to increase at all coastal access points (except possibly Chassahowitzka) because there are no limits to the construction of multi-slip docking facilities. Overlap of boat traffic and manatee travel routes would probably increase. As a result of these changes, an increase in the probability of manatee mortality would be predicted. Due to dredge and fill associated with construction of docking facilities, vegetation would be reduced. This alternative would be contrary to Objectives 1 and 4 of this plan (pages III-3, III-4).

Alternative 2: Construction of deep shipping canals or maintenance dredging of old channels

If an Intracoastal Waterway or other shipping canal were constructed or completed, the rate of increase in the number of boats and the proportion of large boats would be greater than Alternative 1. Large boats would be

Table 17. Alternatives: Regional boat traffic planning.

Alternatives	Number of Boats	Boat Size	Overlap of boat traffic/manatee travel
1. No action	increase at all coastal access points	increased proportion of large boats at all but Chassahowitzka	increase
2. Construct ICW or other deep channels	encourage rapid increase	encourage more large boats	more overlap
3. Deny approval of new navigation channels	dependent on development at access points	dependent on development at access points	maintain large boat traffic offshore
4. Redirect location of new multislip facilities	increase	increase proportion of large boats	reduced
5. Establish boat carrying capacity	limited increase	regulate proportion of large boats	dependent on where new facilities are built
6. Combination of 3, 4, and 5	allow increase in less sensitive habitat; regulate increase in sensitive habitat	allow large boats in less sensitive habitat; limit increase in sensitive habitat	redirect development to reduce overlap

encouraged to travel inland, increasing the overlap of manatee travel routes and boat traffic. A substantial increase in manatee mortality would be predicted. Drainage patterns of coastal marshes would be affected with possible irreversible ecosystem effects, particularly on estuarine vegetation. Maintenance dredging of channels in Crystal and Homosassa rivers would encourage large boat traffic in the rivers, disposal of spoils could affect estuarine vegetation, and river vegetation would be dredged. This alternative would be contrary to Objectives 1 and 4 of the plan.

Alternative 3: <u>Require approval of new navigation channels and maintenance dredging to be contingent on demonstration that direct or indirect effects of construction will not adversely affect manatees</u>

If no new navigation channels in the coastal zone are constructed, changes in the number and size of boats would be dependent on development at coastal access points. Large boat traffic would remain offshore, and the probability of manatee mortality would remain the same. Natural siltation in channels will discourage large boats in Homosassa and Crystal rivers. This alternative would be consistent with Objectives 1 and 4 of the plan, but would not be sufficient to meet those objectives.

Alternative 4: <u>Redirect location of new multislip facilities</u>

Development of new multislip docking facilities could be approved only in specified areas that would minimize the overlap of boat traffic with manatee habitat. Such areas could be specified outside areas of core habitat, e.g. uplands adjacent to the Cross Florida Barge Canal, or Cedar Key (Figure 44). The number of boats and proportion of large boats would still increase, but the increased overlap between boats and manatees would be minimized. The probability of mortality predictably would increase at a moderate rate. This alternative would be consistent with Objectives 1 and 4, but would not be sufficient to meet those objectives.

Alternative 5: <u>Establish boat carrying capacities in core manatee habitat</u>

The density, size, and distribution of boats within core manatee habitat can be influenced by controlling the number and size of boating facilities permitted on Crystal River, lower Suwannee, lower Withlacoochee, Homosassa and Chassahowitzka rivers. The boat carrying capacity of each area could be defined and approval for the construction of boating facilities would be contingent on demonstration that the carrying capacity in these areas would not be exceeded. Projects that would exceed capacity of one river basin could be redirected to other more suitable locations in South Big Bend. As the carrying capacity for boats may be above current levels on some rivers, this option would allow for some development of docking facilities over the long-term, but in a manner that would present a minimal increase of the risk to manatees. This alternative would contribute, but not be sufficient, to meet Objectives 1 and 4.

Alternative 6: Combination of Alternatives 3, 4, and 5

Maximal protection for manatees, while still allowing for planned development of docking facilities in South Big Bend, would be provided if no new navigation channels were dredged, development of new multi-slip facilities was directed to specified areas outside core habitat, and a carrying capacity for boats was established for the major summer and winter areas of core habitat. Implementation of this alternative would allow an increase in boat density where manatees are least vulnerable (Figure 44), but would regulate the increase in core habitat. The average size of boats would increase outside but not in core habitat. Development would be redirected such that the current overlap between boat traffic and manatee habitat is not exceeded. Predictably, the rate of manatee mortality would not increase substantially. This alternative would be sufficient to meet Objectives 1 and 4 of this plan and is recommended.

1.3.2 Local planning

Several options may be considered for planned development of docking facilities in each of the river systems, although the alternatives for each river may be evaluated separately. The order of geographical priority in which planning should be implemented is as follows: Crystal River, Suwannee River, Homosassa River, Withlacoochee River, and Chassahowitzka River. The following list of alternatives for Crystal River (Table 18) may serve as an example for planning in the other rivers.

Alternative 7: No action

Under current regulations, the number of boats, size of boats and overlap between manatee habitat and boat traffic will increase. Construction of docking facilities in the upper portion of Crystal River could reduce the area of native plant communities. An increase in the probability of manatee mortality and decrease in variety and/or quantity of food resources would be predicted under current regulations. This option would not meet objectives of this plan.

Alternative 8: Small docks for existing lots in Crystal River

Dock size and number could be limited for each lot adjacent to natural waterways where manatees are vulnerable to boat traffic (Figure 37). The number of docks could be limited to one per existing lot with waterfront. The permissable size of "small docks" could be based on performance standards: no larger than required to dock a maximum of two boats under 24 ft (8 m) length without dredging to allow access, and under 500 ft^2 (46 m^2) preempted space. This option would establish an upper limit (carrying capacity) to the number of boats in the area, and discourage an increase in the number of large boats. The increase in traffic overlap would be minimal, and degredation of vegetation would be minimal. The probability of manatee mortality predictably would increase because more docking facilities would be permitted; however, the probability would be lower than for Alternative 7.

Table 18. Alternatives: Boat traffic planning in Crystal River.

Alternatives	FACTORS WITH POTENTIAL NEGATIVE IMPACT ON MANATEES			
	Number of Boats	Boat Size	Overlap of Traffic	Degradation of Vegetation
7. No action	no restriction; increase	more large boats	more traffic in upper Crystal River	in upper Crystal River due to boat docks and traffic
8. Small size docks only for existing lots	limit to increase	maintain status quo	minimal increase	minimal degradation
9. Multi-slip docks on artificial waterways	increase	more large boats	increase	minimal because location in canals
10. Relocate commercial docks contingent on specified criteria	maintain status quo	maintain status quo	reduction	minimal
11. Combination of 8, 9 and 10	allow for some increase in least sensitive areas	allow for some increase in least sensitive areas	increase in private boat traffic, decrease in commercial	minimal

Alternative 9: <u>Multi-slip docks in artificial waterways</u>

Permitting of multi-slip docking facilities in artificial waterways in the Crystal River area could be contingent on demonstration that the facility would not exceed a pre-established carrying capacity. One option for setting a carrying capacity would be to establish Transferable Development Rights (TDR) for docking facilities (Hamann 1983). A developer wishing to build a marina could purchase unused TDR's, thus demonstrating that the development was within the carrying capacity of the area. However, boat traffic from all artificial waterways in Crystal River would travel along the main channel, hence would increase the probability of collisions with manatees. Although aquatic vegetation eaten by manatees would not be directly disturbed by construction along canals, water quality and clarity would probably be reduced. This alternative would not meet the objectives of this plan.

Alternative 10: <u>Relocate commercial docks to reduce the amount of boat traffic in areas where manatees are vulnerable</u>

Existing fishing docks and marinas could be relocated to areas that would reduce the amount of overlap between boat traffic and manatee habitat e.g. the Barge Canal or the mouth of Crystal River. Approval of permits could be contingent on demonstration by the applicant that the new facility would not increase the amount of boat traffic in areas where manatees are vulnerable (Figure 37) and that it would meet specified criteria protecting wetlands and water quality (see sections IV-3 and IV-4). To provide access to some of the potential locations at the mouth of the river, dredging of a boat channel and fill for land access would be required in wetland areas. Such disturbances could be justified only if disturbances in other areas were reduced. Relocation of commercial fishing facilities could reduce overlap between boat traffic and manatee habitat without increasing the number or size of boats utilizing the area. Some vegetation might be disturbed during construction, but the dock could be limited in area and could be located in an area infrequently used by manatees or adjacent to a deep channel where they are less vulnerable. Thus, the overall risk to manatees would be reduced. This alternative would contribute, but not be sufficient, to meet objectives of this plan.

Alternative 11: <u>Combination of Alternatives 8, and 10</u>

The size of docks in areas where manatees are vulnerable could be regulated, and the total number of boat slips in the area could be limited to a specified carrying capacity. New multi-slip facilities for private boats could be located in areas minimizing impacts on manatees (Figure 44), and existing commercial docking facilities could be relocated to the mouth of the river. Under this alternative, a limited increase in the number and size of boats would be allowed. Although the overlap of manatee habitat and private boat traffic might increase, overlap of manatee habitat and commercial boat traffic would decrease. Degradation of vegetation would be minimal. Some increase in the probability of manatee mortality would be predicted, but it would be minimized. This alternative is recommended to meet objectives of the plan.

1.4 Information Needs

Although it is possible in this plan to specify the needs of manatees with respect to protection from boat traffic and habitat degredation, sufficient information was not available to evaluate human needs for development of recreational facilities in the management area. Quantitative information is needed regarding:

a) frequency of boat traffic in areas where manatees are vulnerable;
b) size of boats;
c) seasonal changes in boat traffic;
d) registration addresses of boats;
e) perceived need for additional facilities
f) extent to which existing facilities are used to capacity;
g) relation of boat traffic patterns to marina and ramp locations.

A thorough analysis of boat traffic patterns and needs for boat-related development in Crystal River and other river systems within South Big Bend is beyond the scope of this plan. As an example, a marina system plan that has been prepared for Dade County marinas (Connell et al. 1978) was a nine-month project. Quantitative predictions regarding changes in boat traffic patterns are difficult to make as they are dependent on changes in a number of factors, such as population growth in local and surrounding communities, zoning and development regulations, and economic factors.

One of the options described for South Big Bend involves the establishment of a "carrying capacity" for boats (page IV-25). If limits are set on the number of recreational facilities, the limits need to be determined in a rational, justifiable manner that reflects the values of the local community as well as state and national priorities. More information is needed in order to quantitatively define and to implement boat carrying capacities.

The quality of information regarding vegetation in Kings Bay is quite good. However, vegetation in Crystal River has only been mapped schematically, and has not been evaluated systematically for the other river systems in South Big Bend. Because one of the criteria for approval of dredge and fill permits is the presence of vegetation that might be disturbed, better information on distribution of vegetation is needed to aid evaluation of applications by permitting agencies. The line of mean high water needs to be mapped in Crystal River, to clarify the areas of jurisdiction of permitting agencies.

1.5 Recommendations

Recognizing that manatees are a significant resource for local communities, local governments should take the leading role in planning boat facilities to insure the protection of manatees. The policies of state and federal agencies should be made consistent in order to support development and implementation of local plans. In this section, the recommended management policy is described, then the specific actions of each agency that would be required to implement the policy are listed. The recommended sequence of all actions is outlined in Section V.

1.5.1 Management policy

Evaluation of the alternatives described in Subsection 1.3 clearly indicates that the options most likely to achieve Objectives 1 and 4 of this plan are Alternative 6 of the regional scale and Alternative 11 on the local scale. Therefore, the management policy should consist of the following elements:

a) Approve permits for construction of new (or expanded) multi-slip docking facilities, boat ramps, navigation channels and developments of regional impacts only where it can be shown that the overlap of boat traffic and manatee habitat will not increase, vegetation eaten by manatees will not be reduced and the role of wetlands in maintaining water quality and estuarine vegetation will not be altered;

b) determine and implement a process for evaluating the cumulative effects on boat traffic during review of permit applications for construction of boating facilities;

c) redirect new development of multi-slip docking facilities and boat ramps to the barge canal between Lake Rousseau and coastal wetlands;

d) encourage relocation of existing facilities to areas that will reduce overlap of boat traffic and manatee habitat;

e) establish and require design standards for construction of boating facilities;

f) issue permits for maintenance dredging only where large boat traffic in core manatee habitat will not increase or aquatic vegetation utilized by manatees will not be reduced;

g) allow one small dock (as defined under Alternative 8) per existing waterfront lot.

1.5.2 Local governments

The city and county governments should not permit construction of new multi-slip docking facilities in Crystal River and should redirect such development to the Cross Florida Barge Canal. Zoning regulations and permitting procedures should be revised to implement this policy. The Zoning Board of Adjustment should deny special exceptions for construction of new marinas that would not be consistent with the management policy of this plan. The Board could consider requests to relocate existing facilities to areas that would reduce the present degree of overlap between boat traffic and vulnerable manatee habitat; however, the state standards for marina siting must be upheld if such sites involve wetlands. No exceptions to subdivision regulations should be permitted on lands adjacent to waterways, or if land is subdivided, it should be with clear specifications that the right of dock construction is not associated with lands platted after January 1, 1984.

The city and county should deny dredge and fill permits that would disturb or degrade native aquatic vegetation or change the functions of wetlands adjacent to Crystal River (Figure 49). On the basis of this plan, the local government should deny developments of Regional Impact that would increase boat traffic or disturb vegetation in areas designated as vulnerable.

The recommended management policy (Subsection 1.5.1) should be added to the comprehensive Plans of Citrus County and Crystal River, to provide guidelines for revision of zoning and permitting procedures. To control the cumulative effects of small construction projects, permits should be required for all construction below mean high water.

The local planning departments should work closely with a Resource Planning and Management Committee (RPMC) to be appointed by the Department of Community Affairs. The RPMC can assist in regional planning to resolve several threats to manatees, while providing for planned development. The county and city commissions should act on the recommendations of the RPMC.

1.5.3 Regional Planning Councils

The Withlacoochee and North Central Regional Planning Councils can support the efforts of the local governments to implement the management policy. They can assist in revision of comprehensive plans and any associated regional planning that is needed. The management policy should be included in the regional plans.

If local governments have difficulty recognizing the regional value of policies protecting manatees, the Regional Planning Councils can provide this perspective. The councils should recommend against approval of any DRI's that are contrary to the management policy, and appeal decisions of local governments that are not consistent with the management policy.

The Regional Planning Councils can play an important role in initiating a study of the recreational needs of the management area (see Subsection 1.4) in order to develop a marina system plan. Lead agencies, the scope of work and funding need to be identified.

A procedure should be established to provide an active role of the Regional Planning Councils in review of whether local government actions are consistent with the management policy adopted in their comprehensive plans. The planning councils should to prepare reports to be included in the annual update of this management plan.

1.5.4 Department of Community Affairs

A Resource Planning and Management Committee should be appointed to assist local governments in regional planning to implement the management policies of this plan. If local governments do not implement such policies, the DCA should recommend designation of South Big Bend as an Area of Critical State Concern and implement the recommended management policy (Subsection 1.5.1).

Any development that would increase boat traffic in areas where manatees are vulnerable (Figures 52-56) should be classified as a Development of Regional Impact. The current administrative guidelines designating DRI's on the basis of number of slips are inadequate to deal with the cumulative effects of development. Therefore the DCA should issue binding letters identifying large developments as DRI's if they are not consistent with the recommended management policy (Subsection 1.5.1).

1.5.5 Department of Environmental Regulation

Dredge and fill permit applications that are inconsistent with the recommended management policy (Subsection 1.5.1) should be denied. Pending adoption of the management policy by local governments, a moratorium on permitting should be established. Via commenting procedures, DER should recommend against any DRI's and COE permit applications that are not consistent with the management policy.

The exemptions currently provided by general permits make it difficult to evaluate or control the cumulative effects of development in the management area. Guidelines establishing the general permit procedure should be changed to exclude areas designated as core manatee habitat (Figure 33). The criteria for exemptions under general permits (e.g. 1000 ft dock) should be made consistent with those of DNR (see page IV-11). DER should send all permit applications to DNR, regardless of whether the construction is exempted under DER guidelines.

DER can assist the Regional Planning Council in evaluating the cumulative effects of dredge and fill, by providing a report summarizing permitting activities on an annual basis. In order to clarify its areas of jurisdiction, DER should adopt a wetlands map such as is available from the FWS National Wetlands Inventory.

1.5.6 Department of Natural Resources

Consent of use permits should not be granted for any activities that are inconsistent with the recommended management policy (section 1.5.1). A moratorium on exemptions from consent of use should be established until the guidelines are modified to exclude core manatee habitat (Figure 33) from exemption. Staff reports regarding lease of submerged land should clearly indicate if the lease would be consistent with the recommended management policy. Permit applications received by the COE and DER should be reviewed and denial recommended if they are not consistent with the management policy.

To insure coordinated action, the management policy should be added to the State Lands Management Plan, the Aquatic Preserve Management Plans, the Sovereignty Land Management Rules and the Aquatic Preserve Rules adopted by the Governor and Cabinet. DNR should determine the mean high water line in Crystal River to aid local government planning and to aid enforcement of the policies of DNR.

DNR should cooperate with DER in preparation of an annual report summarizing activities related to boat traffic planning. The report should be included in updating this plan.

1.5.7 Trustees of the Internal Improvement Trust Fund

Leases of submerged lands should be denied for docking facilities that are inconsistent with the recommended management policy. Developments of Regional Impact that are inconsistent with the management policy should not be approved if the decision of the local government is appealed.

1.5.8 Land and Water Adjudicatory Commission

To aid in implementing the recommendations of this plan, the Commission should change, with legislative approval, administrative guidelines regarding designation of Developments of Regional Impact. Developments in sensitive habitat of endangered species such as the manatee should be given special consideration dependent on the particular risks for the species. Binding letters designating developments as DRI's should be based on the cumulative effects of boating facilities in manatee habitat. Establishments of Aquatic Preserves in Crystal River and Homosassa River would also aid in regulating the cumulative effects of boat traffic.

1.5.9 Game and Fresh Water Fish Commission

The GFC should review and comment on permit applications in State Manatee Sanctuaries, Aquatic Preserves and DRI's. Denial should be recommended if the proposed action is not consistent with the management policy (Subsection 1.5.1). Review comments should be included in the information updating this plan. A representative from GFC should be on the steering committee for this plan.

1.5.10 Army Corps of Engineers

Permit applications that are not consistent with the recommended management policy (Subsection 1.5.1) should be denied. In order to manage the cumulative effect of construction that occurs under general permits, the district engineer should assert discretionary authority over the general and nationwide permitting processes and require individual permits in South Big Bend. Regional conditions to general permits should be established to aid evaluation of cumulative impacts over the long term. Individual permits should be required in areas identified as core habitat for manatees (Figure 33).

1.5.11 Fish and Wildlife Service

The manatee coordinator and manager of the Crystal River Manatee NWR should review COE permits and projects to evaluate if they are consistent with the recommended management policy (Subsection 1.5.1). If a large scale dredge and fill project that is inconsistent with the management policy is approved by the COE, the FWS should issue a jeopardy ruling under the Endangered Species Act. Review comments should be included in the annual update of this plan.

The Crystal River Manatee NWR manager should review the annual reports on dredge and fill from DNR and DER that are included in the update of the plan. The refuge manager should update the plan annually to evaluate if the objectives of the plan have been met and recommend additional action as needed.

1.5.12 Environmental Protection Agency

The management plan should be used in review of COE projects and permits. If a proposed project is inconsistent with the recommended management policy, denial should be recommended. If the COE approves an unacceptable project, the EPA should use its power of veto. Dredge and fill discharge should be prohibited in areas where it would adversely affect aquatic vegetation that provides food for manatees. If plans for the Intracoastal Waterway, (or other large projects) proceed, the EPA should require an environmental impact statement that includes an evaluation of the potential impact on manatee habitat. Copies of review comments and veto rulings should be included in the annual update of this plan.

2. OPERATIONAL ASPECTS OF WATERBORNE ACTIVITIES

Snorkeling, diving and boating in manatee areas provide opportunities for the public to view manatees, and hence to meet Objective 7 of the plan. However, the effects on manatees of boating, diving, snorkeling and fishing (Subsection II-5) present problems in meeting Objectives 1, 2 and 3. These hazards include: (a) injury or death from boat collisions, (b) harassment resulting in exposure to cold or other stressful factors, (c) injury due to entanglement with fishing gear (Table 19). The probability of injury due to boat collision is influenced by boat speed, erratic (unpredictable) operation of boats, exposure to propellers, and season of the year. Factors influencing harassment include the number and behavior of swimmers and boats near manatee congregations, and the temperature differential between warm and cold water (which changes with the seasonal and daily cycle). Entanglement with fishing gear is influenced by the location, type of gear and disposal practices.

Actions influencing the density and location of boat traffic by planned development of boating facilities were addressed previously (Subsection IV-1). The sequence of recommended actions based on the analysis in this section is outlined in Section V.

2.1 Site-specific Evaluation of Impacts

In this subsection, the overlap of manatee habitat and recreational activities is analyzed in order to distinguish areas where management may be needed.

2.1.1 South Big Bend Region

Areas where recreational activities and commercial fishing occur in South Big Bend are summarized in Figure 42. Each of the major rivers and their estuaries are fishing areas, as well as shallow regions along the coast and offshore grassbeds. Slow speed zones are in effect during the winter (November 15th through March 31st) in Crystal River and Homosassa River, and during the summer (March 1 to September 30) in Withlacoochee River and Chassahowitzka River (Figure 14). Water skiing that occurs in Kings Bay is thus restricted to non-winter months. The number of people snorkeling and scuba diving in Kings Bay is greater in the winter, partly because they come to observe manatees.

The major area of overlap between manatee habitat and recreational activities is Crystal River. Water sports such as swimming and water skiing are not as popular in the other rivers of the area. The Suwannee is the only estuary that has frequent boat traffic but no slow speed zones in areas where manatees have been sighted. In the next subsections, these areas are examined at a larger scale to evaluate the nature of the overlap between habitat and recreation.

Table 19. Impact of waterborne activities.

Potential effect	Factors influencing probability of effect	Explanation
Public appreciation	Density of people and boats.	When many people and boats are present manatees leave or are shy, reducing quality
	Esthetic environment	Clean water, natural vegetation enhances appreciation and non-disturbing activities.
Injury from boat collision	Speed of boat	The faster a boat travels, the more likely that a lethal injury will be inflicted, and less likely that manatees will detect and move away from the path of the boat.
	Propeller guards	Boats with recessed propellers within the hull, or with a propeller guard, will not cause lacerating injury. (Although the impact of the boat can cause injury.)
	Erratic movement	Activities such as water skiing, where boats move at high speeds across channels or shallow areas may present a higher probability of collision.
	Time of year	More manatees are present in winter, therefore increased probability of impact.
Harassment resulting in manatee exposure to cold and other possibly lethal factors	Number of boats near warm-water refuge	Assuming there is a "flight distance" at which a manatee detects a boat, the higher the density of boats, the higher probability that more individuals will detect boats and be stimulated to leave the area.
	Operation of boats	Entry and exit from aggregation areas may cause disturbance; also turning motor on and off.

Table 19. Impact of waterborne activities (continued).

Potential effect	Factors influencing probability of effect	Explanation
	Temperature differential between warm and cold waters	When the temperature differential is low, exposure to hazards is not as great as on extremely cold days.
	Number of divers/ snorkelers	Same explanation as for number of boats.
	Behavior of divers/ snorkelers	Swimmers passively moving at the surface of the water, interacting only with manatees that approach them, are less likely to elicit escape response than those which actively approach or follow (chase) manatees.
	Time of activity during the daily cycle	Temperature differential typically is lowest in the late afternoon and greatest in the early morning. Recreational activity in the morning is more likely to increase hazards than in the afternoon.
Injury due to gear entanglement	Monofilament or crab-trap lines	Manatees become entangled in fishing lines or the lines attaching floats to traps. Often the line wraps around the flipper, reducing blood circulation. A tube or plastic sleeve on the line reduces this problem.
	Shrimp nets	Occasionally manatees become trapped in shrimp nets which are towed across seagrass beds. A deflection device across the opening of the net reduces this probability.

Table 19. Impact of waterborne activities (continued).

Potential effect	Factors influencing probability of effect	Explanation
	Discarded gear	If discarded fishing line or other gear becomes entangled in vegetation, and is eaten by manatees, there is danger of abrasion of the lining of the stomach or intestines. Blockage of the intestine may result in death.
	Snagging	If fishing gear is cast onto manatees they may become hooked. Although snags by hooks cause minimal injury, line attached to hooks may become entangled or swallowed.
	Location	Injury is more probable in areas more frequently used by manatees.

2.1.2 Crystal River

Recreational activities in Kings Bay occur in areas where manatees are attracted during the winter. Dive shops direct customers to the Main Spring south of Banana Island and to other springs that have caverns of lesser depths (refer to Figure 8). These are the areas where manatees are attracted when adjacent waters drop below the temperature of the ground water flowing from the springs (refer to Figure 36). During the fall and spring (or whenever the temperature gradient is not as extreme), manatees are sighted throughout Kings Bay. On warm days during these seasons, recreational boating and water skiing among the islands in the bay are popular when the slow speed zones are not in effect.

The existing slow speed zones (Figure 55) adequately cover the major areas of winter aggregations of manatees (refer to Figure 37). Boat speeds are not restricted in the Crystal River channel, despite the knowledge that two boat-killed manatee carcasses were recovered from the river (refer to Figure 47). The federal sanctuary zones, which exclude waterborne activities, function primarily as areas to which manatees can go to escape interaction with humans. Sanctuaries south of Banana Island are located adjacent to, but do not include, the warm water boil at the Main Spring. The Banana Island sanctuary does include a spring (Grand Canyon) at the west end. The sanctuaries are relatively shallow, and although accessible to manatees, are not the major areas where manatees aggregate when divers are not present (Kochman et al. 1983). In the year that the sanctuaries were first established, manatees were sighted more frequently in the sanctuary areas than during the three years prior to establishment of the sanctuaries (Kochman et al. 1983). These observations suggest that some manatees are sensitive to human presence and may learn to avoid people by moving into areas where they are not present. The Magnolia Spring sanctuary excludes waterborne activity from a spring where manatees aggregate. Manatees also spend time in the channel adjacent to the sanctuary, an area where they have contact with snorkelers.

Line fishing occurs throughout Kings Bay, primarily in deep spots (refer to Figure 34). Crab traps are set throughout Kings Bay and along Crystal River upstream from the Salt River).

Existing regulation of waterborne activities in Crystal River is a compromise between the needs of manatees and human needs. For example, a manatee sanctuary that was established south of Warden Key in 1979 was abolished because it was opposed by fishermen that were accustomed to casting in a deep hole within the former sanctuary (Rathbun, pers. comm.). The boundaries of existing sanctuaries were set such that they do not exclude divers from springs that are used for classes in diving techniques. Manatees leave the main spring when divers and snorkelers appear in the morning (Kochman et al. 1983). There currently are no slow speed zones on the lower Crystal River (outside Kings Bay) as a concession to commercial fishermen and guides who have a long distance to travel from the north arm of the bay to the mouth of Crystal River. The period of boat speed regulation is short relative to the duration that manatees aggregate in Kings Bay. Manatee

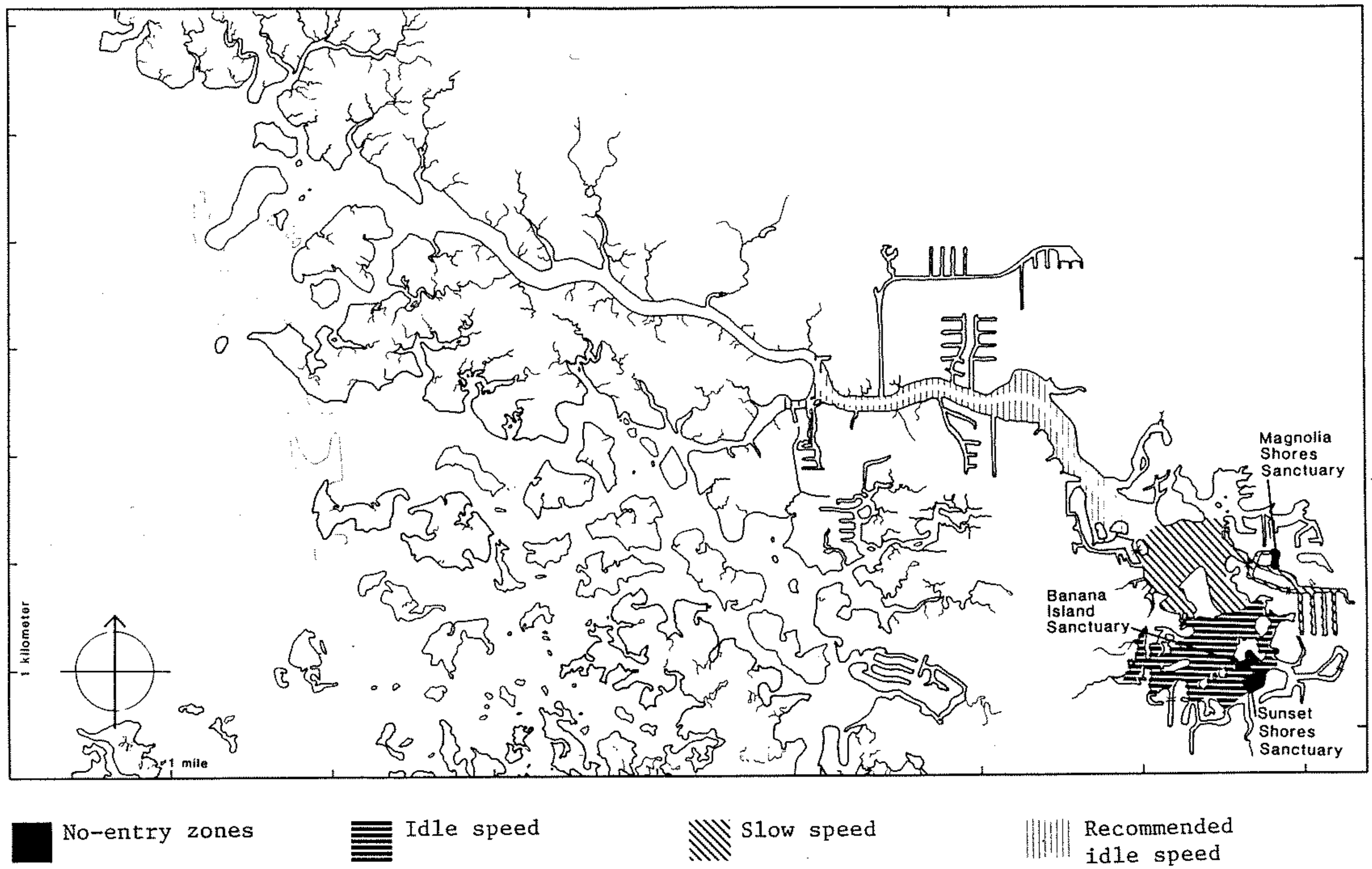


FIGURE 55: WINTER BOAT SPEED RESTRICTIONS IN CRYSTAL RIVER.

Data are from DNR, recommended idle speed zone is from analysis of the overlays of Figures 46 and 34.

numbers increase as early as October and remain high as late as April (Hartman 1979, Kochman et al. 1983). Prior to June 1983, the speed zones have been in effect from November 15th to March 31st although DNR may change this period by administrative ruling, as passed by the 1983 legislature.

Compliance with existing regulations rather than a need for more regulations is the problem in Crystal River. Speed zones are not adequately posted, and there have been long delays in repairs to poorly implanted signs that have fallen apart. Although some dive shops (Crystal Lodge, Plantation Inn) explain boating regulations to customers, persons new to the area are not necessarily exposed to the guidelines of how to interact with manatees in a manner that is not harassment. No information is posted at public boat ramps; and the buoys designating "no entry" zones provide little information to the naive newcomer. Local residents report numerous innocent or flagrant violations of the regulations at times when law enforcement officers are not present.

Regulations are effectively enforced when officers are present, but the effort that is allocated to Crystal River is insufficient. Only twelve Marine Patrol officers patrol the four counties in South Big Bend. Three FWS special agents include enforcement at Crystal River among their other duties. Federal officers from Chassahowiztka National Wildlife Refuge enforce regulations in the Chassahowitzka River, which is about 35 km distant from Crystal River; they place the buoys that mark the federal sanctuaries in Kings Bay. In winter of 1982-83, 59 citations were issued, primarily for entry by snorkelers and swimmers in the sanctuaries (Table 20). Federal special agents wrote most (61%) of the citations and the remainder were written by refuge officers (22%) and the Marine Patrol (17%).

Although the spatial overlap between manatee and human activities in Kings Bay is great, there is potential for reducing the overlap in time. For example, current speed zones provide for human waterborne activities to occur in the summer when low numbers of manatees are present, while meeting the needs of manatees in the winter. Speed regulations that better match the aggregation periods of manatees would reduce such overlap. The high degree of overlap between human activity and manatee aggregation south of Banana Island could be reduced if humans avoided the area when the water temperature gradient is high, e.g. mornings and cold days.

2.1.3 Other River Systems

Although manatees are sighted frequently in the Suwannee estuary during the summer (Figure 23), no slow speed zones have been established in the area. Boat traffic is more frequent on West Pass, which is a dredged channel, than on East Pass. Despite reports of boats traveling at high speeds in areas where manatees might be vulnerable, only one manatee carcass (a dependent calf) has been recovered from the Suwannee. However, not all carcasses are recovered under the salvage program, and manatees that are injured, but not killed, may leave the area. Manatees have been sighted most frequently at locations distant from the main channel. The possibility that boat traffic influences their distribution should be examined. Manatee behavior in the Suwannee estuary has not been studied in detail.

Table 20. Citations written for violations of manatee sanctuaries and speed zones in Crystal and Homosassa Rivers during winter 1982-83[1]

Type of Violation	Month Dec.	Jan.	Feb.	Mar.	Total
Swimmers/Snorkelers	0	13	26	5	44
Divers	0	5	0	4	9
Canoeists	0	1	3	0	4
Boat speed	1	1	0	0	2
Totals	1	20	29	9	59
Issued by					
Refuge Officers	1	12	0	0	13
Marine Patrol	0	6	0	4	10
FWS Special Agents	0	2	29	5	36

[1]From R. Prather (pers. comm.); data do not include cases prosecuted in county courts.

In the Withlacoochee River, idle speed zones exist in two narrow sets of waterways adjacent to the main channel (Figure 56). Manatees were sighted during aerial surveys more frequently in the main channel (Figure 25), which is a slow speed zone and caution zone. Signs defining the speed zones have not yet been posted (Arnold, pers. comm.). Three manatee carcasses recovered from the lower portion of the river were apparently crushed by barges. These deaths occurred in 1975 while barges regularly delivered oil to the Inglis storage facility. There have not been any deaths due to crushing impact (presumably barges) since the barge traffic stopped in the Withlacoochee (Powell and Rathbun 1983).

In the Homosassa River, slow speed zones extend from the springs to Price Creek, just beyond the town of Homosassa (Figure 57). The headwaters, where manatees congregate and rest in the warm waters (Figure 40), is protected by an idle speed zone, as is a narrow portion of the river upstream from Homosassa. Although manatees are sighted frequently at the mouth of the river, no signs are posted to caution boaters.

In the Chassahowitzka River, a slow speed zone extends from the refuge boundary to the county line (Figure 58). This zone includes most of the area where manatees are sighted frequently (Figure 24). The speed zone functions effectively (Collinsworth, pers. comm.).

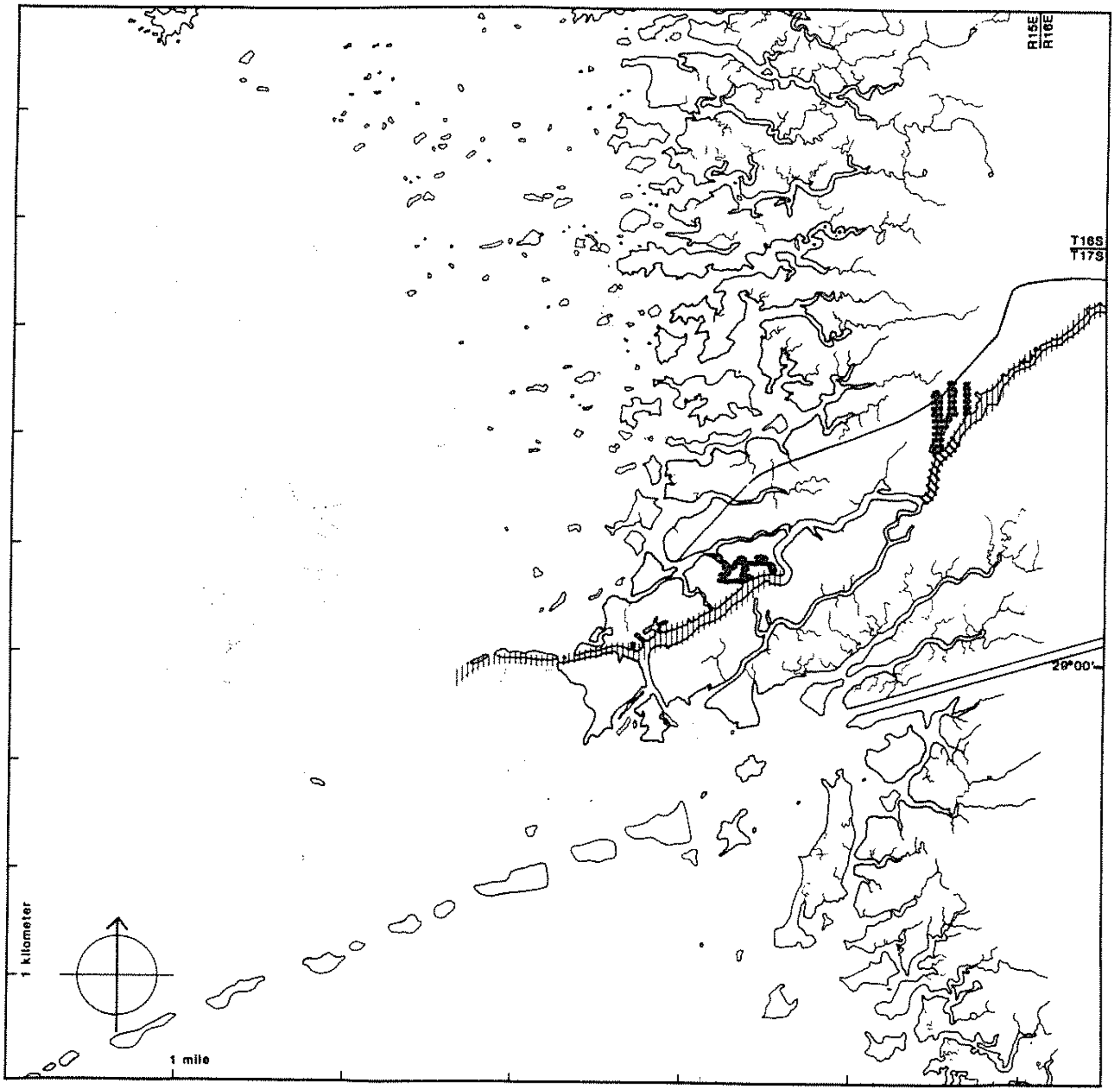
2.2 Current Regulations

Regulations of waterborne activities that are described below include: (a) intentional or negligent harm to manatees by humans, regardless of whether it occurs during boating, swimming, fishing or otherwise, (b) boat speeds in specified locations and during specified periods, (c) exclusion of waterborne activities and (d) use and/or disposal of fishing gear. These regulations are reviewed in more detail by Gluckman (1983a).

2.2.1 Intentional or negligent harm to manatees

Without a permit, it is illegal to "take" manatees under the Endangered Species Act (ESA), the Marine Mammal Protection Act (MMPA), and the Florida Manatee Sanctuary Act (FMSA). Although "taking" is defined differently in each act, it generally means to kill, injure, capture or harass. To "take" refers to intentional as well as unintentional or negligent acts and includes attempted actions. The FMSA is more restrictive than the other Acts in defining illegal actions, and may be adopted in federal prosecution of violations.

The meaning of "harassment" is less easily defined. Under the MMPA, harassment refers to any action that alters the normal behavior of a marine mammal. Operationally, harassment is difficult to define, because often "normal" behavior is difficult to assess. Consequently, there has been confusion regarding which interactions between swimmers and manatees are considered harassment (Puckett 1983). Public education brochures state that it is illegal to dive down to touch a manatee (FWS, DNR, MP. "Diving Regulations in Manatee Areas"). Swimmers and dive-shop operators who have



Idle speed   Slow speed   Caution zone

FIGURE 56: SUMMER BOAT SPEED RESTRICTIONS ON THE WITHLACOOCHEE RIVER.

Data are from DNR.

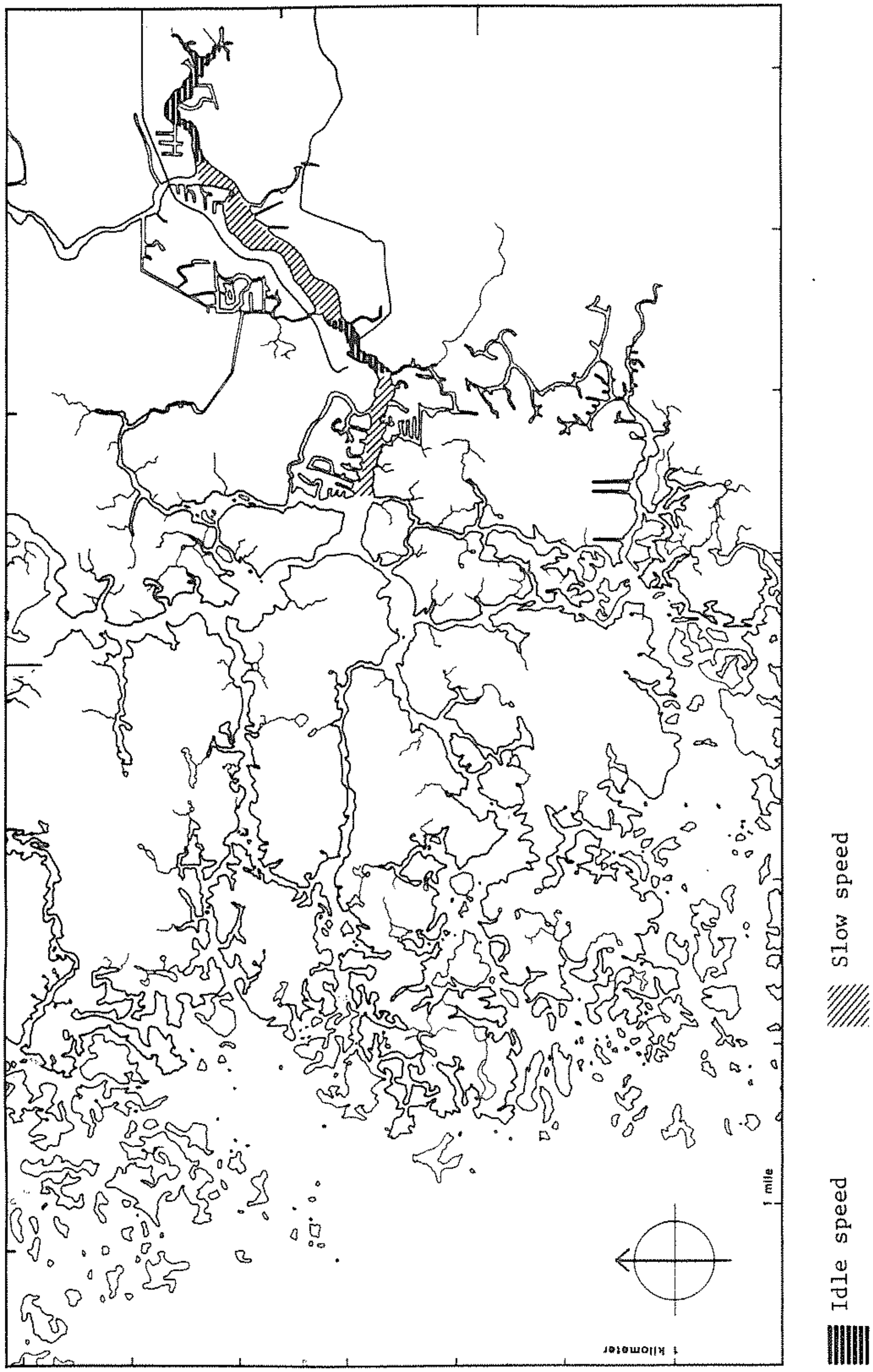


FIGURE 57: WINTER BOAT SPEED RESTRICTIONS ON THE HOMOSASSA RIVER.

Data are from DNR.

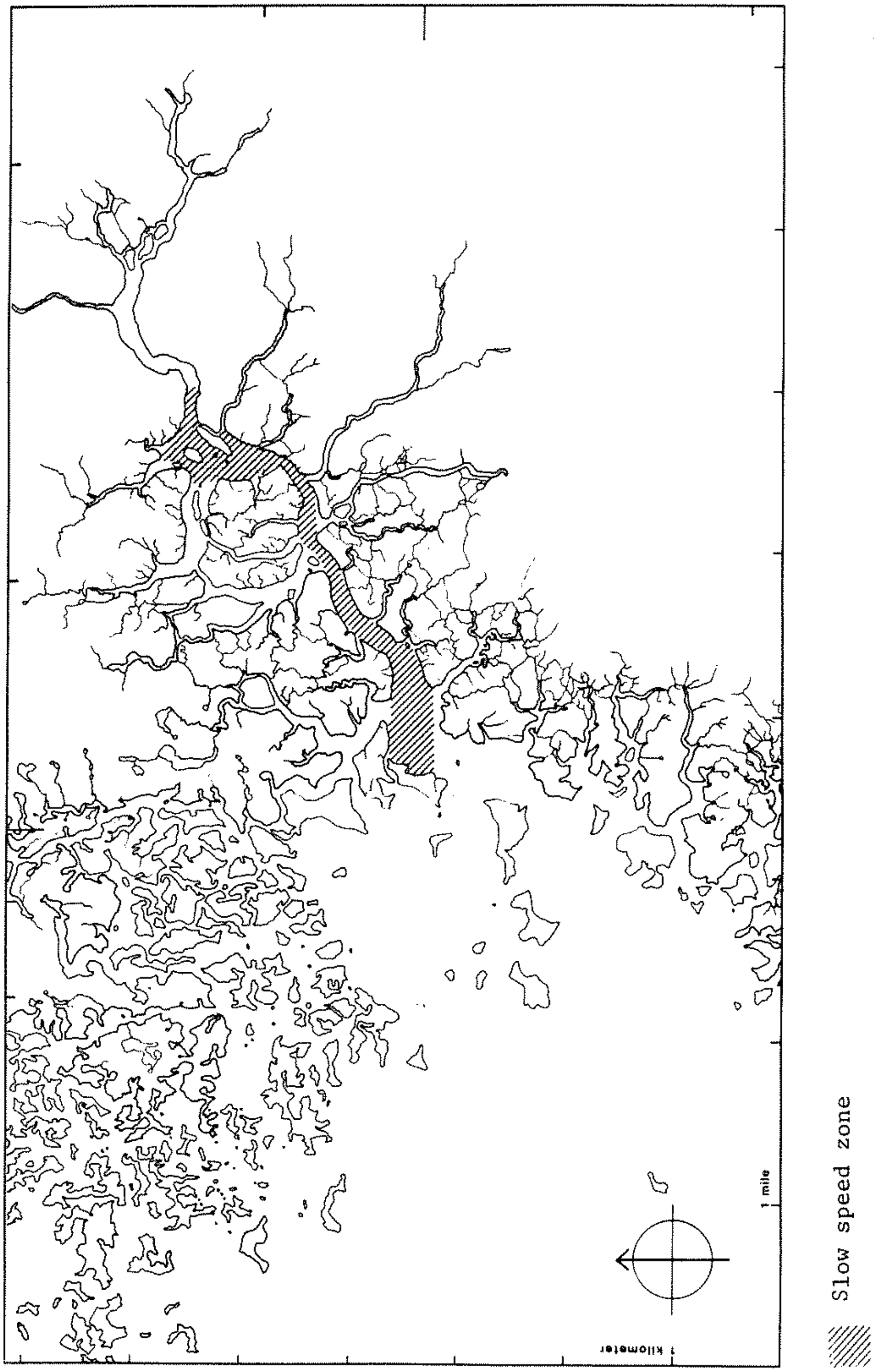


FIGURE 58: SUMMER BOAT SPEED RESTRICTIONS ON THE CHASSAHOWITZKA RIVER.

Data are from Collinsworth (pers. comm.).

experienced the approach of certain manatees that appear to enjoy the petting of delighted people, do not perceive "touching" to be harassment. An alternative definition of harassment is commonly expressed: it is acceptable to touch a manatee that approaches a swimmer, but it is illegal to pursue a manatee that swims away from the human.

Whichever definition of harassment is accepted, it is very difficult for an enforcement officer to evaluate the underwater interaction of a swimmer and manatee, unless the violation is flagrant, such as riding the manatee. Also, enforcement on a case by case basis does not address some of the more subtle forms of harassment. For example, if the mere presence of humans (in the water or in boats) near a warm-water refuge causes manatees to leave the area, normal behavior of the manatees has clearly been altered. However, changes in manatee distribution due to human activities are difficult to document via correlations (Kochman et al. 1983) hence, research specifically directed to the question is needed.

In order to aid in public education when enforcement officers are not present, a voluntary Manatee Watch has been organized to begin in winter 1983-84 (Prather, pers. comm.). Citizens will carry a "Manatee Watch" sign on the side of their boats and will be available to explain guidelines for swimming and boating in manatee areas. They will not have enforcement authority.

2.2.2 Boat speed restrictions

Injury to manatees due to boat collisions is presumably unintentional, and incidental to normal boating activities. To reduce the probability and injury inflicted by boat collisions, the FMSA provides for speed restrictions in manatee sanctuaries. The speed restrictions in the Withlacoochee, Crystal and Homosassa rivers are established under the FMSA, while the restrictions on the Chassahowitzka River are federal (being within the federal refuge). Although local governments have the right to impose speed restrictions that do not interfere with state and federal policy, local governments within the study area have not restricted boat speeds to protect manatees (Gluckman 1983a).

The dates during which boat speed restrictions have been in effect do not provide the protection needed in Crystal River. An amendment to the Florida Manatee Sanctuary Act was passed in the 1983 legislative session to allow establishment of the dates for speed zones according to local conditions.

Funding currently available for posting and enforcing speed restrictions is inadequate. Although the Marine Patrol is provided with funds for manatee enforcement, the manpower simply is not available within the South Big Bend region to adequately enforce restrictions. Higher priority is given to posting new areas than to repair of signs, which may be overlooked when funds are limited. Due to limited funds, speed zones in the Withlacoochee were not posted in 1983, hence were not enforced (Tunstall 1983). Requested repairs and signs needed in Kings Bay have not been provided (Rathbun, pers. comm.).

2.2.3 Exclusion of waterborne activities

The U.S. Department of Interior may establish whatever restrictions are necessary for protection of Endangered Species, and therefore it has the right to exclude all waterborne activities from designated areas such as the three manatee sanctuaries in Kings Bay. Such extreme measures are more likely to be approved in areas already identified as important for wildlife, such as critical habitat or wildlife refuges. The legal basis for state or local governments to exclude waterborne activities is less substantial (Gluckman 1983a).

Under the management plans for state parks, provision may be made for exclusion of waterborne activities in areas where such activity would interfere with implementation of park policy. Swimmers are excluded from the spring run at Manatee Springs State Park during the winter. Exclusion of boats from the spring run is also under consideration by DNR's Division of Recreation and Parks.

2.2.4 Hazardous fishing gear

Florida's Department of Natural Resources and the Game and Fresh Water Fish Commission have the authority to control all aspects of fishing in saltwater and freshwater systems, respectively. Although they have not yet done so, they could adopt requirements for biodegradable nets and sleeves for crab trap lines. Spearfishing is illegal in freshwater and is restricted in salt water. However, there is little spearfishing in South Big Bend at the present time (Gluckman 1983a).

2.3 Alternative Management Options

In this subsection, management alternatives are listed separately to meet each of the following objectives: (a) reduction of boat collisions (b) reduction of harassment, (c) reduction of gear entanglements and (d) create opportunities for public appreciation of manatees while minimizing disturbance. The alternatives are evaluated below, and recommendations regarding implementation of the alternatives that would best meet the objectives of this plan are described in Subsection 2.5.

2.3.1 Reduction of boat collisions

Alternative management options for reduction of boat collisions with manatees are listed in Table 21 and described below. The predicted manner in which each alternative would affect factors relevant to protection of manatees (as described in Table 21) is outlined.

Alternative 1: No Action

If no action is taken, the probability of boat collisions with manatees will increase due to the predicted increase in boat traffic and manatees. This alternative would not meet Objectives 1-3 of the plan.

Table 21. Alternatives: Reduce boat collisions.

Alternatives	FACTORS INFLUENCING POTENTIAL IMPACT				
	Boat Speed	Propeller	Erratic Movement	Time of Year	Water Depth
1. No action	more collisions probable in Suwannee	no guards will be required	water skiing in Kings Bay likely to increase probability of collision	probability of collision in October and March will be high	collisions likely in shallow areas of channels
2. Post caution zones in channel	some reduction	same as above	same as above	same as above	reduction compared to Alt. 1
3. Restrict boat speeds in channels	reduction of probability of collision	same as above	same as above	same as above	reduce collision probability
4. Establish idle speed zone adjacent to Crystal River channel	reduced adjacent to channel	same as above	same as above	same as above	reduce collisions in shallows
5. Extend period of restric- tions	reduction of probability of collision	same as above	reduce collision probability	reduce collison probability	not applicable
6. Better en- forcement of existing restrictions	same as above	same as above	water skiing still occurs out of season	no effect	no effect

Table 21. Alternatives: Reduce boat collisions (continued).

Alternatives	FACTORS INFLUENCING POTENTIAL IMPACT				
	Boat Speed	Propeller	Erratic Movement	Time of Year	Water Depth
7. Propeller guards	crushing injury still possible, reduce laceration	reduce probability of injury	no effect	no effect	no effect
8. Enhanced public education and volunteer patrol	voluntary compliance	some voluntary compliance, but not likely	voluntary compliance	some voluntary compliance	some voluntary compliance
9. Combination of Alternatives 4, 5, 6 and 8	reduce collision	some voluntary compliance	reduce collisions	reduce collisions	reduce collisions

Alternative 2: Post caution zones along river channel and informational signs at marinas, ramps sanctuaries

Caution zones could be posted in the navigation channels on the Suwannee, Crystal and Homosassa rivers to warn boaters of shallow or restricted areas where manatees are vulnerable. Signs could be attached to existing posts, and additional posts could be installed near shallow areas along the channel. On Crystal River, signs are needed near the shallow bar south of Bagley Cove, near the branch of the Salt River, and in the estuary. As caution zones do not require legal compliance, protection would be minimal. Boaters who are not familiar with the area might be more affected than local boaters who habitually use the channel. Informational signs at access points (marinas, ramps) would help remind and inform boaters of the rules and need for caution. This option would be most effective if done in connection with increased local public education (Alternative 7). Additional caution zones would contribute, but would not be sufficient, to meet objectives of this plan.

Alternative 3: Restrict boat speeds on channel

Additional boat speed restrictions could be established in the Crystal River channel where manatees are sighted frequently, but which are not currently regulated. This option probably would be rejected by boaters that habitually use the channel to gain access to Gulf waters. Considering the apparent ability of manatees to avoid boats by diving in deep water, the magnitude of the problem, as currently evaluated, does not warrant establishment of additional speed zones in navigation channels. If an increase in manatee mortality due to boat collisions is detected in future years, this option would be justified.

Alternative 4: Establish idle speed zones adjacent to a marked channel in Crystal River

Shallow areas adjacent to the Crystal River channel could be designated idle speed zones. This would protect manatees in areas where they are most vulnerable, while allowing boat traffic to continue unimpeded in the channel. This option would contribute to, but not be sufficient, to meet the objectives of this plan.

Alternative 5: Extend period of restrictions

The beginning and closing dates of speed restrictions could be established to better match manatee abundance during each season. When manatee abundance in Kings Bay (as determined by aerial surveys) reaches a certain level in the fall, speed restrictions could be posted. The restrictions would not be removed until manatee abundance had declined in the spring. The posting of a flexible season will require a public relations effort such that citizens understand the need for extended restrictions, as well as the basis upon which the restrictions are established and lifted. This option will contribute, but will not be sufficient, to meet Objectives 1-3 of this plan.

Alternative 6: Better enforcement of existing restrictions

Signs need to be repaired and additional zones posted. An enforcement officer could be hired primarily for the purpose of enforcing speed restrictions in winter and summer manatee sanctuaries. Now that the islands in Kings Bay will be part of the National Wildlife Refuge system, it would be desirable to have a refuge office in Crystal River to facilitate enforcement, public relations, and implementation of management policies. This option will contribute greatly to meeting Objectives 1-3 of this plan.

Alternative 7: Propeller guards required in idle speed zones

Some form of protection around propellers could be required for boats in specified areas; e.g. boats with recessed propellers or prop-guards. This option is not acceptable to fishermen who argue that gas mileage is reduced by prop guards. Law enforcement is difficult unless officers can inspect boats. Currently, the magnitude of the problem probably is not great enough to justify such regulations, but the option could be considered in the future if mortality rates increase. Propeller guards would not reduce the risk of injury or mortality due to the impact of collision.

Alternative 8: Public education and volunteer patrol

An educational center could be established in Crystal River, which could provide a focus for a volunteer Manatee Watch by local citizens. One purpose of the volunteer patrol could be to monitor the availability of information regarding speed regulations to boaters, and to provide such information. The emphasis could be on promoting voluntary compliance with guidelines of safe boat operation in areas of manatee abundance, via an active interpretive program. Although volunteers would not have enforcement powers, they could provide information regarding violations to enforcement officers. The Coast Guard Auxillary could be trained to serve a similar function. This option would contribute substantially, but would not be sufficient to meet Objectives 1-3 of the plan.

Alternative 9: Combination of Alternatives 4, 5, 6 and 8

A combination of Alternatives 4, 5, 6 and 8 would be sufficient to meet objectives of this plan. Posting of idle speed zones adjacent to navigation channels (Alternative 4) would reduce the probability of collisions in shallow areas adjacent to the channel. Such voluntary compliance would be more likely to occur if there was a volunteer patrol and educational campaign (Alternative 8) to inform boaters of the need for such caution. If existing restrictions are better enforced (Alternative 6) and the period of speed restrictions is extended to match actual manatee abundance (Alternative 5), additional restrictions will not be necessary. An active interpretive program is needed to coordinate these efforts. This option is the recommended alternative to reduce the probability of manatee/boat collisions.

2.3.2 Reduction of harassment

Even if the probability of boat collisions is maintained at the current level, the predicted increase in numbers of boaters and swimmers using Crystal River in the future could be sufficient to alter manatee distribution. Alternative management options to reduce such harassment are listed and evaluated in Table 22.

Alternative 10: No action

If no action is taken, the density of swimmers and boaters will increase and there will be little improvement in the type of interactions between manatees and humans. A higher rate of manatee mortality due to cold exposure would be predicted, because manatees would leave the warm-water areas where they encounter boats and swimmers. This option would not meet Objectives 1-3 of this plan.

Alternative 11: Public education and volunteer Manatee Watch

An educational center could be established at a location where the public could view manatees without boating or swimming. Through an active interpretive program organized by the educational center, the public could be educated to the need to restrict human harassment during periods of extreme cold. The public could be requested to keep motorized vehicles out of idle-speed zones during morning hours and cold days. The voluntary Manatee Watch could provide on-the-spot information to swimmers and boaters regarding behavior that disturbs manatees, and could report violations to an enforcement officer. The rate of increase of boat and swimmer density in idle speed zones could be reduced by providing an alternative way of viewing manatees and by voluntary compliance to maximum densities as monitored by the patrol. This option would contribute, but not be sufficient, to meet objectives of this plan.

Alternative 12: Restrictions specifying temperature or time

Entry to specified warm-water zones could be restricted when the temperature differential between the zone and adjacent waters meets specified criteria. This option would be analogous to a "fire-watch" restriction posted in National Forests. It would require intensive effort to monitor and enforce. Currently, public opinion would probably be opposed to such additional restrictions. The option should be considered if voluntary compliance is not sufficient or if research indicates it is necessary. This option would contribute to meeting Objectives 1-3 of this plan.

Alternative 13: Require permits for entry to current idle-speed zones

If the mere presence of humans near warm-water refuges is determined to be a form of harassment, permits could be required under federal laws. Permits might be given to dive shops for supervised dives. Individuals could schedule visits in advance by applying for permits. Such restrictions would be analogous to permits required for camping in parks where visitor-use must be restricted in order to preserve the natural beauty of the area. This

Table 22. Alternatives: Reduce harassment

Alternatives	FACTORS INFLUENCING POTENTIAL IMPACT				
	Boat density	Boat operation	Temperature	Swimmer density	Swimmer behavior
10. No action	will increase	no improvement	increased exposure to cold due to harassment	will increase	no improvement
11. Public education and volunteer patrol	may spread it out in time, may reduce if other viewing sites	voluntary compliance	voluntary compliance	same as for boat density	voluntary compliance
12. Restrictions specifying temperature or time	reduction at critical times	no effect	protection during coldest periods	reduction at critical times	no effect
13. Require permits	could regulate	require compliance	same as above	could regulate	improvement
14. Non-motorized vehicles only in current idle zone	reduction	improvement	no effect	reduction	no effect
15. Better enforcement of existing regulations	no effect	improvement maybe	no effect	no effect	improvement
16. Extend sanctuaries	exclude boats	boats excluded	maximal protection	excluded	swimmers excluded
17. Combination of Alternatives 11 & 15	may reduce	improvement	voluntary compliance	may reduce	improvement

option may be perceived by dive-shop operators as threatening to private enterprise. This option should be considered if voluntary compliance is not sufficient or if research indicates it is necessary. This option would be sufficient to meet Objectives 1-3 of this plan.

Alternative 14: Non-motorized watercraft only in current idle-speed zones

If only non-motorized vessels were allowed in current idle-speed zones, the density of boats and swimmers would be reduced. Sailboats, catamarans and sail-surfboards would not injure manatees, although they may harass manatees. Evaluation of this option is similar as for Alternative 11.

Alternative 15: Better enforcement of existing regulations

Presence of a law enforcement officer at sites where humans interact with manatees could reduce the frequency of overt harassment; however, it would not solve the problem of an increase in boat and swimmer density. This option would contribute, but would not be sufficient to meet Objectives 1-3 of the plan.

Alternative 16: Expand sanctuaries

Federal sanctuaries could be expanded to include current idle-speed zones. Evaluation of this option is the same as for Alternative 11.

Alternative 17: Combination of Alternatives 11 and 15

The objectives of this plan could be met by a combination of Alternatives 11 and 15 until such time that the need for additional restrictions is documented. With this combined approach, the public could demonstrate its willingness to protect manatees without the need for imposing additional regulations, and overt harassment would be minimized. This option is the recommended action for reducing harassment of manatees.

2.3.3 Reduction of fishing gear entanglement

Options for reducing the probability of injury to manatees due to fishing gear entanglement are listed and evaluated in Table 23.

Alternative 18: No Action

If no action is taken, the probability of entanglement in crab trap lines will probably increase, because an increase in the number of crab traps is expected. Injury due to entanglement of discarded fishing lines would probably increase because the lines do not decompose. This option would not be sufficient to meet Objectives 1-3 of this plan.

Alternative 19: Public education and voluntary Manatee Watch

By means of public education, voluntary compliance of crabbers and line-fishermen to reduce risks to manatees could be enhanced. This might be most effective if the Manatee Watch volunteers could communicate the desire

Table 23. Alternatives: Reduce fishing gear entanglement.

Alternatives	FACTORS WITH POTENTIAL NEGATIVE IMPACT ON MANATEES			
	Crab traps	Shrimp nets	Discarded lines	Snagging
18. No action	probability of entanglement will increase	no change	increase	no change
19. Public education and voluntary patrol	some voluntary compliance	some voluntary compliance	some voluntary compliance	some voluntary compliance
20. Require line sleeves in designated zones	reduction of risk	not applicable	not applicable	not applicable
21. Prohibit fishing in specified zones	reduction	not applicable	reduction	reduction
22. Combination of Alternatives 19 and 20	reduction of risk	some voluntary compliance	some voluntary compliance	some voluntary compliance

of the community for voluntary compliance (e.g. social pressure). This option would be sufficient to meet the objectives of this plan, considering current evaluation of the magnitude of the problem.

Alternative 20: Require line sleeves on traps in designated zones

Plastic sleeves that reduce the probability of entanglement with crab trap lines could be required in areas designated as slow and idle speed zones. This option would contribute to, but not be sufficient to meet Objectives 1 and 3 of this plan.

Alternative 21: Prohibit fishing in specified zones

If fishing is prohibited in areas where manatees feed, there would not be an increase in the probability of entanglement with discarded gear. However, fishermen would probably object strongly to this option. If public education is not sufficient and the frequency of gear entanglement increases, this option may be necessary to meet Objectives 1-3 of this plan.

Alternative 22: Combination of Alternatives 19 and 20

The recommended means of reducing risks of injury due to fishing gear entanglement would be a combination of Alternatives 19 and 20.

2.4 Information Needs

Additional information is essential in order to evaluate the need for (a) establishing caution or speed zones on river channels where restrictions are not already in effect, (b) the effect of boats and swimmers on manatee distribution and behavior, and (c) the effectiveness of current restrictions.

Objective criteria for evaluating harassment of manatees need to be developed. Baseline information on individual manatees in Crystal and Homosassa rivers should continue to be collected via radio telemetry, both within warm-water refuges and as manatees disperse to summer habitat. Research should be designed to compare periods with normal human activity to periods with experimentally restricted activity. If experimental restriction of human activity near manatee sanctuaries is not possible via voluntary agreement, it could be imposed by federal regulation.

The effectiveness of current restrictions should be monitored, and the influence of the volunteer Manatee Watch evaluated. For example, behavior of boaters and swimmers in the presence of a law-enforcement agent, a voluntary patrol, and with no authority-figure present should be compared.

Economic impacts of regulations in manatee areas should be evaluated if regulations are not accepted. For example effects on dive shops of restricting access to idle-speed zones during extremely cold temperatures could be evaluated. Such information could contribute to evaluating the need for a "Manatee Watch" to reduce harassment during critical periods.

2.5 Recommendations

Local, state and federal agencies should work with citizens groups to insure that the negative effects of waterborne activities on manatees do not reach a magnitude such that additional restrictions, which might create an economic burden, would need to be imposed. Although the primary effort may be directed at enhancing voluntary compliance with additional policies to protect manatees, an immediate need exists for better enforcement of current regulations. Development of an interpretive program to enhance community support and coordination of actions needed for manatee protection in the Crystal River area will be essential to meet the objectives of this plan. In this section, the recommended management policy is described, then the specific actions of each group that would be required to implement the policy are described.

2.5.1 Management policy

Evaluation of alternative management actions in Subsection 2.3 indicated that several actions need to be combined in order to reduce the negative effects of waterborne activities. Therefore, the management policy should consist of the following elements:

a) develop an active interpretive program at the Crystal River Manatee National Wildlife Refuge and an educational center in Crystal River to enhance appreciation, awareness and citizen involvement in protection of manatees; provide for carefully controlled opportunities for above and below water viewing of manatees;

b) improve regulatory means of reducing harm to manatees, for example, by increasing enforcement manpower, repairing signs, posting signs, extending dates of boat speed regulations, establishing idle speed zones in shallows adjacent to the Crystal River channel;

c) monitor and evaluate the effects of human activities on manatees in Kings Bay, to develop objective criteria for determining the need for additional regulations;

d) emphasize voluntary time-sharing of areas where manatees and human activities overlap to minimize negative effects on manatees during coldest periods and avoid the need for additional regulations;

e) if voluntary compliance with guidelines for minimizing harm to manatees is inadequate, establish regulations as necessary to do so.

2.5.2 Department of Natural Resources

To meet the objectives of this plan, the following actions are needed:

a) extend the period of speed zones in Crystal and Homosassa rivers to October 1st through March 31st;

b) establish idle speed zones adjacent to the Crystal River channel;

c) acquire funds (e.g. by a boat license tax) for educational programs, additional enforcement by the Marine Patrol, repair and posting of signs.

2.5.3 Fish and Wildlife Service

The new Crystal River Manatee National Wildlife Refuge needs to be developed as a focus for public education, research and enforcement to protect manatees in South Big Bend. The refuge offices should be established in Crystal River. Staff should include an assistant refuge manager, an additional law enforcement officer, and an interpretive naturalist. Chassahowitzka NWR has already requested an additional enforcement officer to patrol Crystal River during the winter and the Suwannee and Chassahowitzka during the summer (Collinsworth, pers. comm.). This request should be implemented by the Fish and Wildlife Service.

The assistant refuge manager should have the duties of working with the local community to implement this management plan, updating this plan, conducting aerial surveys of manatees in South Big Bend, and planning acquisition of additional areas to be included in the refuge (see Subsection IV-5).

The interpretive naturalist would have the duties of training and organizing the voluntary patrol. There has already been a meeting at Chassahowitzka NWR of persons interested in participating in the voluntary patrol (Prather and Basemore, pers. comm.). The Coast Guard Auxillary should be contacted regarding cooperation in the Manatee Watch. The intepretive naturalist would coordinate with the Marine Science Center and County School System to develop displays that would contribute to the county environmental education program. The naturalist would also work with the community to develop financial and volunteer support for development of the educational center.

The refuge office should be in close physical proximity to a facility designed to enhance public education and research in the area. FWS needs to explore opportunities to work with private organizations (e.g. Save the Manatee Committee) or the state university system to build this facility. The educational center should be in a location where visitors can view manatees and an attractive building should house both passive and interactive displays. It would provide an opportunity to display the results of FWS research and for visitors to the area to learn more about the ecology of manatees and their habitat. Consideration should also be given to providing space for researchers, such as a field station for the FWS Sirenia Project that is based in Gainesville.

In order to evaluate the effectiveness of existing regulations, the volunteer patrol and the interpretive program, FWS should consider contracting with a social science researcher. Although it would be ideal, it would also be unlikely that refuge personnel could be found that would have the necessary background for such research.

A contract should also be let to develop objective criteria for evaluating the effects of human activity on manatee behavior and distribution. Although such work could be done in cooperation with the FWS Sirenia Project, it is peripheral to their major research objectives. Support should be provided for the research planned by the Sirenia Project to investigate manatee movement patterns between winter and summer ranges, and basic patterns of behavior.

2.5.4 County School District

A workshop may be hosted by the Marine Science Center for teachers interested in developing materials to include manatees in the county school curriculum (Purcell, pers. comm.). Those teachers who are interested may apply to the Florida Department of Education for a grant to fund the project.

County schools may be able to provide a rotating display of student artwork or essays for the nature center. Needs of the schools for the types of displays to be included in an educational center should be expressed during the development of the center. The director of the Marine Science Center should have input into development of the manatee educational center so that displays are complementary to the programs of the Science Center.

2.5.5 Crystal River Chamber of Commerce

The Chamber of Commerce could provide input to development of an educational center, such that it is an attraction for the community. The center could provide a focus for tourists. It could be oriented to the interests of visitors who do not patronize the dive shops. When visitors are drawn to the educational center and learn about manatees and the area, they could also be provided with information regarding recreational opportunities available in the area. The center could provide an attraction outside the manatee season, and during inclement winter weather.

2.5.6 Non-profit organizations

Several groups of citizens concerned about the Crystal River environment could provide valuable support for development of an educational center. These groups include: the local chapter of the Audubon Society, Concerned Citizens of Citrus County, Citrus County Protective Association, Homosassa Garden Club, Crystal River Garden Club. Both financial and volunteer support could be essential in development of a continuing program. An active outreach program could be developed, whereby members of the community who object to manatee protection policies could be contacted by neighbors to discuss and resolve issues.

The Save the Manatee Committee should take the lead in raising financial support for development of an educational center. Resources of other non-profit organizations, such as the University of Florida Foundation or The Nature Conservancy might be coordinated to build facilities.

The center could be maintained by leasing space to the Fish and Wildlife Service and other interested organizations. A bookstore and gift shop staffed by volunteers could also help provide financial support for the center and a focus for community involvement.

2.5.7 Game and Fresh Water Fish Commission (GFC)

Plastic sleeves should be required on crab-trap lines and other buoys in areas where manatees aggregate. The GFC should place such regulations on slow and idle speed zones on the Crystal and Homosassa rivers.

Subsection IV-3

3. WATER QUALITY AND VEGETATION

The effects on manatees of degraded water quality and aquatic plant control have been described in Subsection II.5 and are summarized in Table 24. Briefly, manatees may be susceptible to a variety of water contaminants, including pesticides, herbicides, industrial byproducts (PCB's, radioactive wastes) and pathogens associated with human sewage. Food resources utilized by manatees may be directly affected by aquatic weed control, or indirectly by degradation of water quality. In order to meet Objectives 2, 4, 6, and 7 of this plan, consideration must be given to maintaining water quality and vegetation. The sequence of actions recommended on the basis of this evaluation is outlined in Section V.

3.1 Site-specific Evaluation of Impacts

In this subsection, the overlap of aquatic plant control programs and manatee feeding areas is evaluated. General problems of water quality in Crystal River are identified.

3.1.1 Aquatic plant control

Aquatic vegetation is treated with herbicides in five rivers within South Big Bend (Table 25). The Suwannee River Water Management District treats the Suwannee River, and the Southwest Florida Water Management District (SWFMD) treats the Withlacoochee River. Citrus County Division of Aquatic Services (DAS) conducts aquatic plant control in Crystal, Homosassa, and Chassahowitzka Rivers. Compared to the other rivers, Crystal and Homosassa rivers receive the highest volume of copper treatment per year (Table 25). Due to concern regarding the effects of copper on manatees, copper treatment in Kings Bay is minimized, hence treatment with Aquathol-K is high. In contrast with the other rivers, treatment of hyacinths with 2, 4-D is high in the Suwannee. During the period of winter aggregation, manatees feed primarily on the vegetation in Crystal and Homosassa rivers (Figures 38 and 40). Overlap of feeding areas and aquatic weed control is lower in the summer when manatees feed primarily in estuaries.

According to the summer treatment plan in Crystal River, as recently modified during a meeting in December, 1983, between the Citrus County DAS, the Florida Department of Natural Resources, the Corps of Engineers, as the U. S. Fish and Wildlife Service, the area is divided into four treatment areas (see Figure 59). In the first area, which encompasses the main portion of Crystal River and Kings Bay, treatment can be at the discretion of Citrus County using aquathol-K or aquathol granular. This includes the remainder of the river and tributary streams to the west. Canals and other areas around the eastern, western, and southern margins of Kings Bay may also be treated with aquathol products, diquat, and copper at the discretion of Citrus County. A third area, including the southern portion of Kings Bay and canals near Three Sisters Spring may be treated to keep navigation channels open. Aquathol-K, aquathol granular, or mechanical harvesting may be used. The fourth area, adjacent to Buzzard Island, has been established as a no treatment zone, except with the written approval of the Fish and Wildlife Service. This plan is

Table 24. Impacts on manatees due to changes in water quality and vegetation.

Potential impact	Factors influencing probability of impact	Explanation
Contaminants (e.g., heavy metals, PCB's, organochlorides, radioactive wastes) may influence susceptibility to disease, reproduction, neonatal mortality	Sewage treatment	Primary treatment may allow discharge of contaminants--virus, bacteria, parasites.
	Aquatic weed control	Potential source of copper, diquat, 2, 4-D.
	Stormwater runoff	May carry heavy metals from roadsides and parking lots (e.g., lead, mercury); pesticides and/or nutrients from residential gardens.
	Agricultural land use	Potential source of organochlorides carried in rivers to coastal areas.
	Industrial effluents	Potential source of PCB's, radioactive wastes when there is accidental spillage; hot water discharge - plant shutdowns.
Decline in quality or quantity of food	Herbicides	Proliferation of primarily exotic plant species fills the water column impeding boat traffic; citizens demand control of acquatic weeds, which are a food source for manatees. Decomposition of dead plants contributes to siltation and suspended solids.

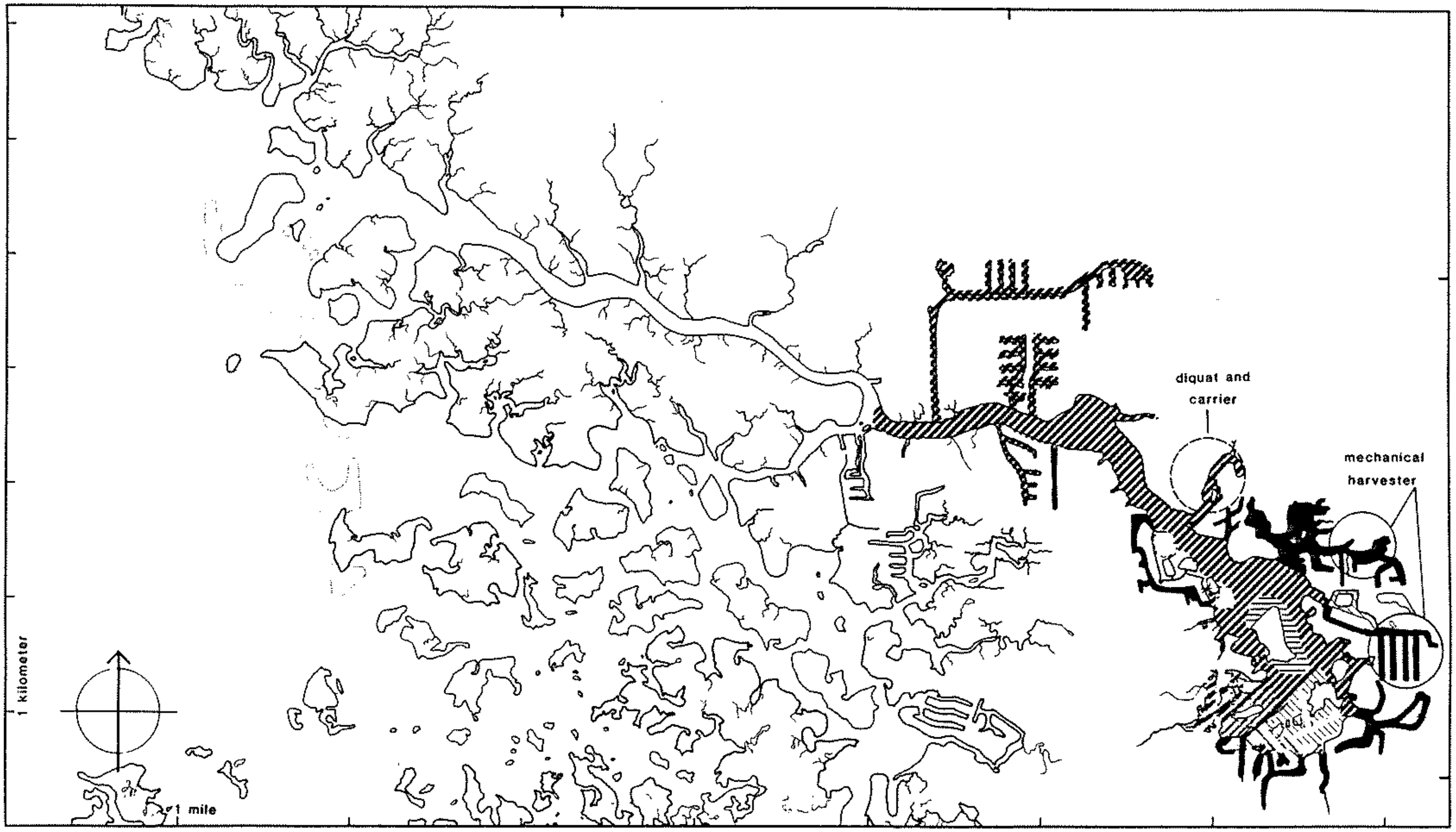
Table 24. Impacts on manatees due to changes in water quality and vegetation (continued).

Potential impact	Factors influencing probability of impact	Explanation
	Wastewater input (sewer and septic)	Increased nutrient levels encourage growth of aquatic plants. Up to a point this may be beneficial by providing food for manatees. However, over-stimulation of plant growth increases demand for control of aquatic weeds. Nutrient levels encourage growth of epiphytic algae on native submerged species. Increased suspended solids decrease light penetration to submerged native species. Plant community tends to decline in diversity, favoring species in the water column which shade out submerged species. Manatees may have nutritional requirements optimally met by a choice of plant species.
	Land development	Alteration of coastal marshes may impact freshwater drainage and nutrient flow patterns required for saltwater plant communities.

Table 25. Aquatic plant control: Gallons and acres of treatment in 1982[1].

Treatment	Crystal River	Homosassa River	Chassahowitzka River	Suwannee River	Lower Withlacoochee
<u>Chemical</u> (gallons)					
2,4-D				1,945	
Diquat	41	2	5	149	
Copper	474	570	140	423	
Invert Oil	2,199	843	194		
Xylene	80				
Aquathol K	8,038	939	176		80-160
Other	23				
<u>Plants</u> (acres)					
Water hyacinth	62	8	32	446	
Hyacinth/lettuce				74	
Hydrilla	1,307	203	45	61	20
Milfoil				5	
Other				37	

[1]Information regarding the Crystal, Homosassa, Chassahowitzka, and Suwannee rivers is from the DNR. Information regarding the lower Withlacoochee river is estimated, and is from SWFMD.



- Treatment at discretion of Citrus County (copper or diquat)
- Treatment at discretion of Citrus County (aquathol products or mechanical)
- Treatment only with concurrence of FWS
- Treatment contingent on specific criteria (navigation trails where aquathol products or mechanical may be used are not shown)

FIGURE 59: SUMMER AQUATIC PLANT CONTROL TREATMENT PLAN FOR CRYSTAL RIVER.

Data are from DAS (1982). as modified by DNR-FWS-COE-DAS meeting December 1983 effective from approximately April 1 to September 31 of year, actual dates To be determined by Fish and Wildlife Service surveys of manatees. to insure that overwintering manatees are not exposed to concentrations of copper, the copper and diquat use areas revert to aquathol-K one and one half months before implementation of the winter plan. Also, to insure sufficient vegetation remains to feed wintering manatees, the areas where treatment is contingent on criteria to keep navigation channels open revert to the same restrictions as the fourth area (treatment with Fish and Wildlife Service approval only) one month before implementation of the winter plan.

The winter treatment plan involves three categories of treatment, as shown in Figure 60. The upper portion of Crystal River and most canals and bays adjacent to Kings Bay may receive treatment at the discretion of Citrus County. Most of Kings Bay itself may be treated based on criteria to keep navigation channels open to a depth of four feet below the water surface or the bottom, whichever is more shallow, and to keep the remainder of the area clear to a depth of two feet below the surface. In the third area, which includes prime manatee feeding and congregation areas, treatment may be performed only upon written approval of the Fish and Wildlife Service, except to keep designated navigation channels open by mechanical means only, with a Fish and Wildlife Service employee present as an observer in areas within the designated manatee refuge.

3.1.2 Water quality

Crystal River is the most urbanized area within South Big Bend. Wastewater treatment facilities include a secondary sewage treatment plant, at least 13 sewage treatment package plants and numerous septic systems (Figure 61). The current capacity of the City of Crystal River water and wastewater utility is 0.25 million gallons per day, and completed construction of a 0.75 million gallons per day wastewater treatment facility was scheduled for mid 1983 (Glace and Radcliffe, Inc. 1982). However, projections indicate that the new sewer plant will only satisfy the city's needs for five years (Dyer 1983). Discharge of treated effluent from the current sewage plant is in the northeastern cove of Kings Bay near Knox's Bait House (Figure 61). The new plant will incorporate the old plant and will have the same discharge location.

Crystal River is in an area designated as having severe soil limitations for septic tanks (WRPC 1977). Three soil-type zones were defined, as indicated in Figure 61: <u>Broward-Boca Association</u> (Type 4) is nearly level somewhat poorly drained sandy soils with loamy subsoil; <u>Freshwater Swamp Association</u> (Type 10) is nearly level very poorly drained soils subject to prolonged flooding; and <u>Saltwater Marsh Association</u> (Type 11) is nearly level very poorly drained soils subject to frequent flooding by tidal waters. Four package plants and two septic systems have been identified as not meeting water quality standards (Figure 61). Problems associated with urban runoff are greatest in the Hunters Spring area.

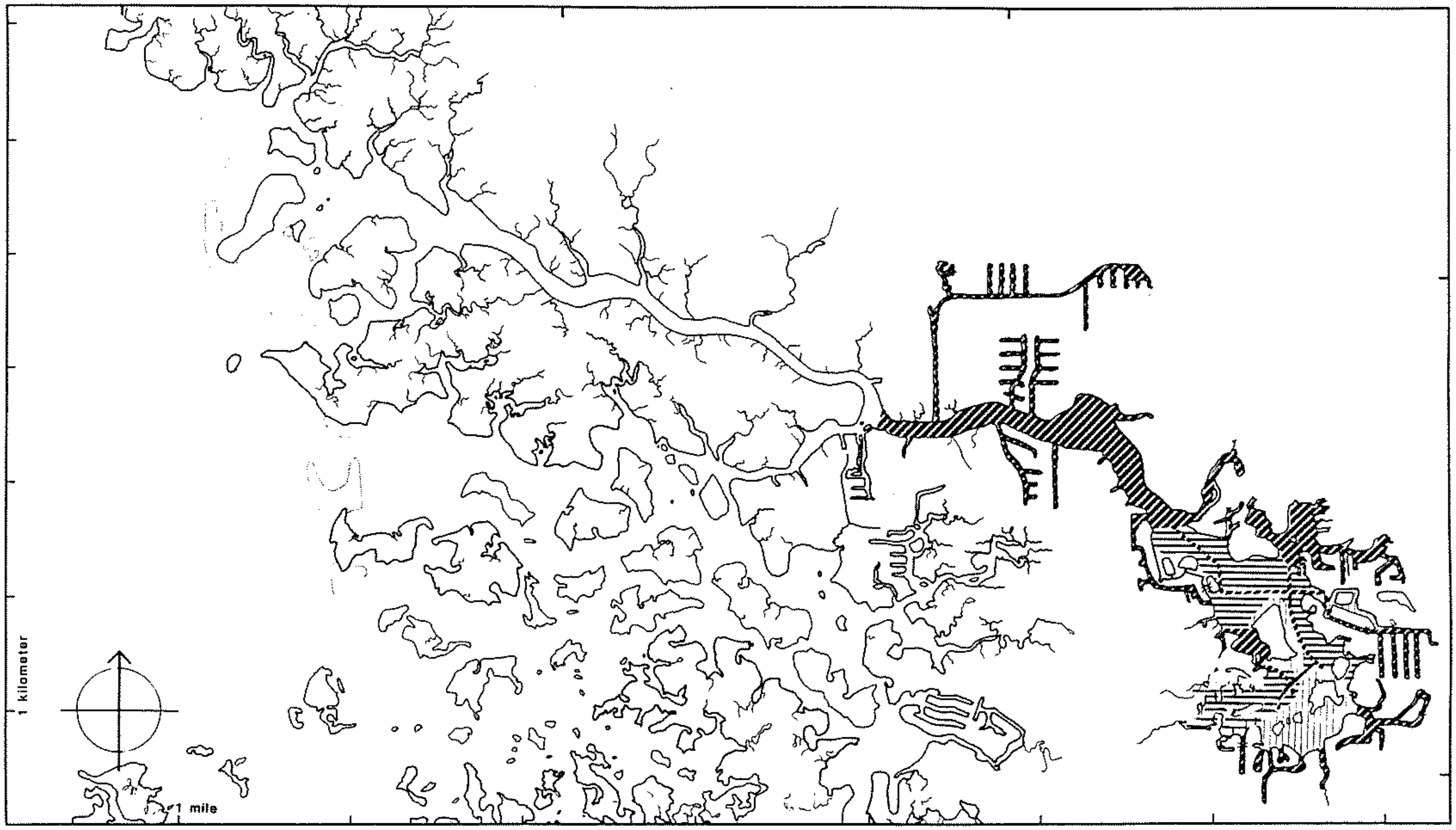
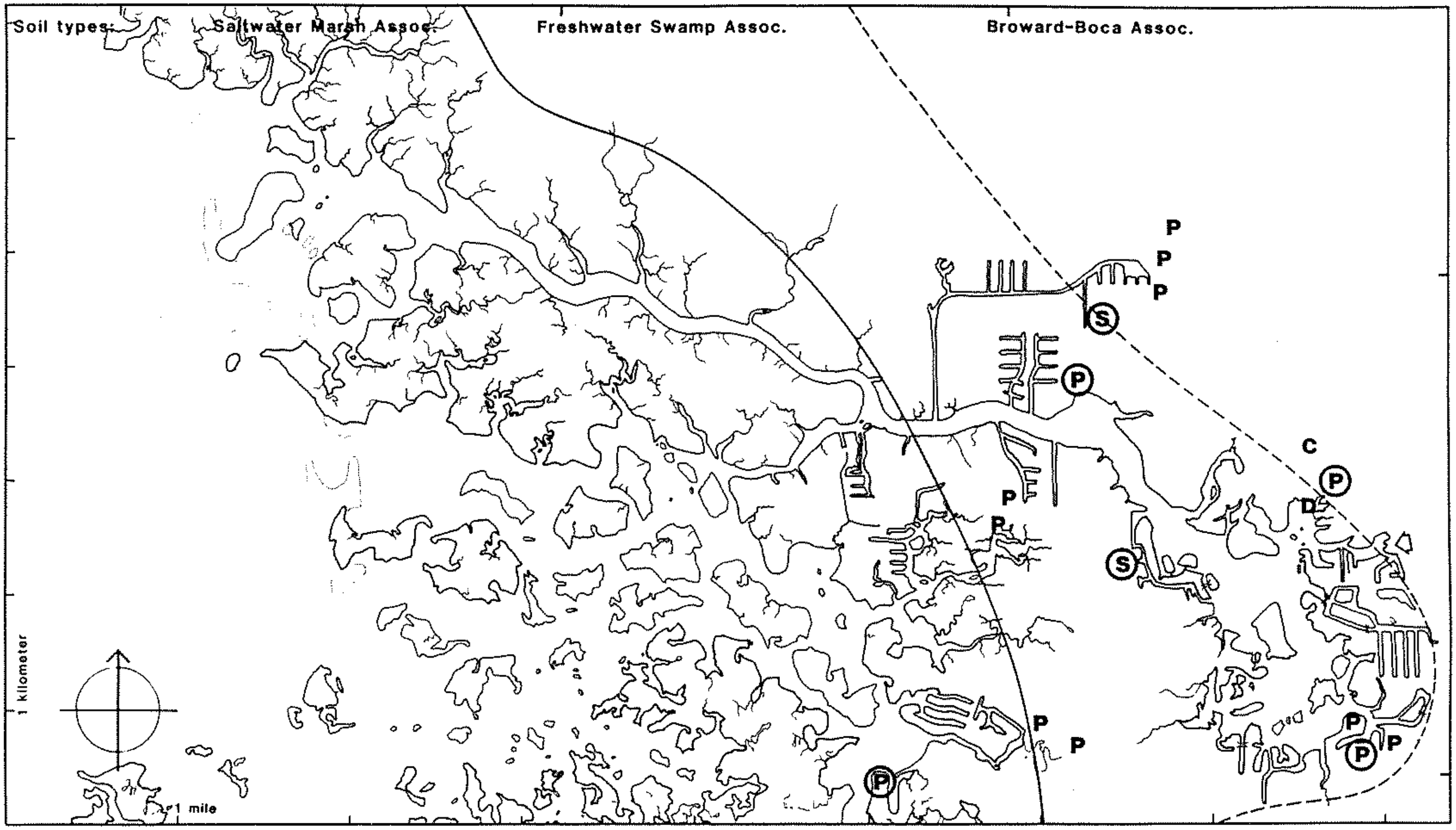


FIGURE 60: WINTER AQUATIC PLANT CONTROL TREATMENT PLAN FOR CRYSTAL RIVER.

Data are from DAS (1982). as modified by DNR-FWS-COE-DAS meeting December 1983



C Central sewage processing plant

D Discharge of C

P Package plant

S Septic system

○ Health problem recorded

△ Urban runoff

FIGURE 61: FACTORS INFLUENCING WATER QUALITY IN THE CRYSTAL RIVER AREA.

Data are from the Withlacoochee Regional Planning Council and CZP (1975). Septic systems that are not a problem have not been plotted.

There is much concern over concentrations of fecal coliform in the Crystal River system (DER 1982: pg. 17). Shellfish harvesting areas have been closed each winter for the last three years, and the Hunters Spring City Park has been closed several times due to high fecal coliform counts (DER 1982, Hunter 1983a). The DNR has identified the Crystal River and Dixie Shores wastewater treatment plants as the worst sources of bacterial pollution in Citrus County coastal rivers and waters and has noted that existing septic systems with poor drainage, which were built under earlier rules, probably contribute to the problems (Hunter 1983a). Fecal coliform counts were higher in Kings Bay, decreasing at sampling stations closer to the Gulf; counts were also high near Ozello.

Existing regulations do not adequately control construction of additional small sewage treatment package plants that could affect water quality in Dixie Bay and Kings Bay. For example, a proposed .0096 million gallons per day plant for River Cove Landing has been evaluated as environmentally unsound by DNR, although DER issued an intent to grant the permit (Hunter 1983a). Permission has been granted by Citrus County for a drainfield to service the proposed Sawgrass Landing, a 58-unit motel-condominium project north of CR 44 West. Although local residents contend the drainage area is often flooded, Department of Environmental Regulation (DER) and COE have determined the drainage site does not meet their definitions of wetlands and therefore is not under their jurisdiction (Saul 1983). The state rules enforced by the county health department prohibit drainfields in areas where flooding is frequent (once every two years on the average) and of long duration (at least seven consecutive days). However, at the proposed Sawgrass Landing drainfield site, flooding is not of long duration, although it is frequent (five to six times a year) (Bradley, pers. comm.).

Water quality in Crystal River has been monitored during 1966-1978 by the U.S. Geological Survey (USGS) at a guaging station upstream from the confluence with Salt River (DER 1982). Peaks in total nitrogen, phosphorous, turbidity, and BOD (biological oxygen demand) levels have increased during the 8 years monitoring occurred. Little information is available regarding water quality in Kings Bay, which is surrounded by urban development.

A study of ambient water quality in the Suwannee River is in progress. It will be conducted by DER and funded by a settlement from an industrial polluter (Hood, pers. comm.). Although information was not available at the time this plan was written, water quality in the Homosassa River needs to be examined, because the adjacent lands are also being developed. Concern regarding pollution of the Chassahowitzka River has been expressed by a local resident (Hunter 1983b).

3.2 Current Regulations

Laws and regulations regarding water quality and aquatic plant control have been reviewed by Gluckman (1983b), and are summarized briefly in this subsection.

3.2.1 Aquatic plant control

Chemicals used in aquatic plant control are certified by the U.S. Environmental Protection Agency (EPA) and registered within the state by the Florida Department of Agriculture and Consumer Services (ACS). If injury to an Endangered Species is documented, registration of a chemical may be removed via a special "fast-track" process. Herbicide applicators must be registered by EPA or ACS.

Funding for aquatic plant control is provided by the COE to DNR, who add matching funds. The COE is responsible for maintaining navigation in the waters of the United States under the Rivers and Harbors Act. It has some funding for research, for example, COE contracted with the University of Florida's Center for Aquatic Weeds to evaluate persistence of herbicides applied in Kings Bay. Although COE conducts some aquatic plant control in other parts of the state, they do not do so in South Big Bend.

The DNR provides funding to Citrus County and the Suwannee River Water Management District to conduct aquatic plant control programs in South Big Bend. The DNR retains authority over how these control programs are conducted. Research regarding aquatic plant control is conducted by DNR and they have authority in permitting the application of chemicals. Although the Game and Fresh Water Fish Commission (GFC) is involved in research regarding the use of grass carp and hybrids for aquatic plant control in closed water systems, they are not actively involved in the plant control programs in South Big Bend. The GFC is involved in the review of aquatic plant control methods within the management area.

Under the Fish and Wildlife Coordination Act, the Habitat Resources office of the FWS commented on the COE environmental assessment of aquatic plant control programs funded by the COE. Under Section 7 of the Endangered Species Act, staff of the FWS Endangered Species Program comments on ongoing aquatic plant control programs funded by COE. The EPA must consult with the FWS on approval of chemicals and labelling.

To summarize, the current aquatic plant control program conducted by Citrus County's Division of Aquatic Services must be approved by the DNR, COE and FWS. Changes in the program aimed at reducing the amount of copper applied during periods of manatee aggregation have resulted from the cooperation of these four agencies.

3.2.2 Water quality

Separate sets of regulations cover the following sources of water contamination: (a) major discharge of effluents from sewage treatment (greater than 0.005 million gallons per day) or industry, (b) septic tanks, and (c) stormwater discharge (Gluckman 1983b). Additional water quality controls cover oil spills, pesticides, and nuclear power plants. Regulations regarding sewage disposal and stormwater are of most immediate concern in Crystal River, and therefore are briefly described below.

Standards regarding discharge of major effluents are set by the EPA and adopted by DER. DER has generally adopted federal effluent regulations, and also sets standards that control the actual conditions of the body of water receiving the effluent. If a discharge meets effluent standards but will cause the body of water to not meet state standards, DER can impose more stringent effluent standards, which will be used by EPA in permit review. The FWS also reviews these EPA discharge permits (Section 402) under the Fish and Wildlife Coordination Act and the Endangered Species Act.

The Crystal and Suwannee rivers are designated as Outstanding Florida Waters (Rule 17-3.041, Florida Administrative Code). This designation assures that no new point-sources of effluent will be permitted if they would degrade water quality to below baseline (1983) levels. However, the baseline quality of water in Kings Bay has not been adequately characterized, and is perceived by local residents as already substantially lower than water quality several decades ago. The rivers of South Big Bend are class III waters with standards defined by DER (EPA 1980b)

The quality and quantity of effluent discharged is monitored by the operator of the sewage treatment plant (or industry), and reported to DER. If discharge does not meet permitted standards, the plant may be closed, moratoria imposed, or certification of the operator may be revoked if the plant is improperly operated. If an Endangered Species is negatively affected by water quality at the established standards, the standards may be changed and permits altered appropriately. Currently, no agency adequately monitors the validity of reported effluent quality, nor the potential effects on fish and wildlife of the quality of the water in Crystal River.

Although sewage hookups should be prohibited after a plant exceeds its treatment capacity, this policy is often overlooked when no alternative means of sewage treatment is available, or when other alternatives are more environmentally destructive or costly. Plant capacity may quickly be exceeded in Crystal River if predictions are correct that the capacity of the new plant will be met in five years (Dyer 1983). Considering the amount of time required to obtain financial support, to plan, and to construct a third plant, significant problems in meeting water quality standards may be anticipated.

The Endangered Species Act (ESA) specifies that no federal action may threaten the existence of an Endangered Species; thus, EPA may not issue permits that would threaten the health of manatees due to degraded water quality. The FWS may comment on EPA actions according to the specifications of the ESA and Wildlife Coordination Acts.

Septic tanks and small package treatment plants (under 0.005 million gallons per day) are regulated by the Florida Department of Health and Rehabilitative Services (DHS) through the county health departments. Individual sewage disposal permits are generally issued at the same time as building permits, and are usually evaluated on a case by case basis.

Under previous regulations, septic tanks and drain fields were constructed at ground level, which may only be a few feet above normal ground water levels and below high tide levels in coastal areas. Under existing regulations, the density of septic systems is controlled and elevated drain fields may be required. State rules specify that permits for septic systems should be denied in areas that are flooded frequently and for long duration. However, these rules are inadequate to address recognized problems of water quality in the Crystal River area (see Subsection 3.1.2).

There are no established programs to routinely check operation of individual sewage facilities, although corrective measures may be required if a health problem is detected. The difficulties of assessing and controlling the cumulative effects of individual sewage systems on the quality of a water body are recognized. The need for better controls of septic systems has been at least partly addressed in legal revisions passed by the 1983 legislature.

State regulations assume that individual sewage systems will be connected to regional systems that become available. However, lack of funding for regional systems, and high hookup fees discourage this solution to water quality problems.

State regulations require permits for all new and existing stormwater discharge from pipes and discrete structures, and for new sources of sheetflow. EPA permits are required for discharges from pipes and discrete structures. However, few existing structures have permits, and there are few realistic (economically feasible) limitations that can be imposed on their discharge.

3.3 Alternative Management Options

Options for maintaining water quality and food resources required by manatees are listed in this subsection. Recommendations regarding implementation of the alternatives that best meet the objectives of this plan are described in Subsection 3.5.

3.3.1 Aquatic vegetation

The following alternatives may be considered in order to provide adequate vegetation for manatees, to minimize application of herbicides that may be harmful to manatees and to provide some means of aquatic plant control to maintain the esthetic and recreational values of the management area.

Alternative 1: No action

Under the current aquatic plant control program of Citrus County, adequate food resources for manatees in Kings Bay are assured. However, the concentrations of copper in the sediments of canals would be expected to increase. Water turbidity is expected to increase, as silt builds up from the decomposition of plants killed by herbicides. Manatees potentially may receive direct contact with Aquathol-K that is applied to keep navigation channels open during the winter control program, or to control the level of vegetation during the summer. The health effects of skin contact, drinking and ingestion of vegetation treated with herbicides will remain undetermined, because it is not being monitored (although acute toxicity may be determined by necropsy of salvaged carcasses). This alternative is sufficient to meet Objective 4 of this plan, but may not meet Objectives 2, 6 and 7.

Alternative 2: No treatment in slow speed zones

The DNR has recommended that herbicides not be applied in areas designated as slow speed zones, during the periods that those zones are in effect. This option would substantially reduce exposure of manatees to herbicides. Considering that the manatee population is expected to increase, and that plant growth is minimal during the winter, the need for aquatic plant control may not be as great as perceived. This alternative would meet the objectives of this plan.

Alternative 3: Mechanical harvesting

Navigation trails could be maintained by mechanical harvesting during periods of manatee congregation, or on a year-round basis. This option is currently being evaluated with respect to its cost-effectiveness, and its impacts on larval fish. Mechanical harvesting would remove biomass from the system and therefore would reduce the rate of accumulation of silt. Appropriate measures would need to be taken to assure that manatees are not injured or disturbed by mechanical harvesters. This alternative would meet the objectives of this plan.

Alternative 4: Restore water quality that encourages growth of native submerged plant species

Because hydrilla grows to fill the water column, it poses more of a problem to navigation than native species such as tapegrass (*Vallisneria*), which rarely grows longer than 75 cm (3 ft). Native species are declining, probably due to competition with hydrilla and increasing water turbidity. If water quality and clarity were restored, native species might a have better chance at competition. However, hydrilla has very low requirements for nutrients and light, so probably, clean and clear water would not be a solution to eliminate the competitive advantage of hydrilla (Joyce, pers. comm.). The possibility of eliminating hydrilla is low, due to its ability to regenerate from fragments. Ideally, the amount of weed control required might be reduced if conditions were more favorable for rooted aquatics and less favorable for hydrilla. This alternative would contribute, but not be sufficient, to meet the objectives of this plan.

3.2.2 Water quality

The following alternatives may be considered in order to maintain water quality for manatees.

Alternative 5: No action

Under current regulations, the quality of water in Crystal River will continue to decline. The cumulative input of nutrients from sewage, septic leachate, runoff from gardens and decomposition of aquatic vegetation will reduce water clarity and increase biological oxygen demand (BOD). When sewage treatment facilities are overtaxed, the probability of high fecal coliform counts and concentrations of pathogens will probably increase. The diversity of plant species available to manatees will probably decline, manatees may avoid areas of poor water quality, and the frequency of deaths related to disease may increase. This option is not adequate to meet the objectives of this plan.

Alternative 6: Strengthen existing regulations

Minor regulatory changes by DHS could strengthen the ability of local agencies to control effects of individual sewage systems on water quality. Enforcement of state regulations regarding stormwater runoff and construction in wetlands could aid in maintaining water quality. The Crystal River sewage treatment plant discharge could be monitored regularly by DER to insure that its capacity is not exceeded, and appropriate enforcement measures taken if water quality standards are not met. This alternative would contribute, but would not be sufficient, to meet the objectives of this plan.

Alternative 7: Establish water body based effluent standards

The DER could establish water quality standards for effluents discharged into Kings Bay based on a hydrological model of the bay. If DER did not take this action, then the EPA could use its power to set federal standards. This option would contribute, but would not be sufficient, to meet the objectives of this plan.

Alternative 8: Independent monitoring of water quality

Baseline concentrations of lead, copper, contaminants, pathogens, ions, pH, nutrients, biological oxygen demand (BOD) and turbidity could be monitored by DER or EPA to determine the need for additional action. This option would contribute, but not be sufficient, to meet the objectives of this plan.

Alternative 9: Adopt ordinances regarding stormwater runoff and construction in wetlands

On-land retention of stormwater runoff could be required by a local ordinance, such that contaminants and suspended solids, are removed from water before they enter Crystal River. The amount and type of development in wetlands could be regulated by a local ordinance. This option would slow the degradation of water quality in Kings Bay. It would contribute, but would not be sufficient, to meet the objectives of this plan.

Alternative 10: Combination of Alternatives 2,3,4,6,7,9

A combination of management actions is needed to maintain water quality in Kings Bay. Leachate from individual sewage systems needs to be controlled (Alternative 6), and permits for effluent and stormwater discharge need to be based on standards for the water body (Alternatives 7 and 9). Reduction of nutrient levels in Kings Bay may partially reduce the rate of aquatic plant growth (Alternative 4), reducing the need for aquatic plant control. Removal of nutrients from the system by mechanical harvesting of plants (Alternative 3) would aid in restoring water clarity by reducing the rate of sediment deposition. A policy of no winter treatments in slow speed zones would provide maximum protection against undetermined effects of herbicides on manatees (Alternative 2).

3.4 Information Needs

Additional information is needed to determine a long-term solution to control of vegetation in Kings Bay and Homosassa River, as well as evaluating potential effects of water quality on manatees and fisheries. The aquatic ecosystem in Crystal River (including Kings Bay) and Salt River needs to be modelled in terms of biological and human-related inputs and outputs. Such a model would aid in monitoring cumulative effects of wastewater, runoff and septic leachate as well as providing a basis for water quality standards. More information is needed regarding the seepage of septic tanks into surface waters.

The feasibility of controlling aquatic weeds by means of mechanical harvesting needs to be evaluated. A model (HARVEST) evaluating economic feasibility of mechanical harvesting has been developed by the COE, and is now available to evaluate cost effectiveness on a local basis (Sabol, pers. comm.). Although a county program of biomass disposal, equipment purchase, and maintenance has been evaluated as not cost-effective, alternatives may be considered, e.g. contracting by the acre to an experienced private firm.

The difference in cost between mechanical and chemical plant control in a flowing system such as Crystal River needs to be determined. Much of the research on aquatic plant control is conducted on closed water systems rather than free-flowing systems. Application of chemicals under recommended treatment procedures often are not sufficient to achieve plant control in free-flowing systems. If the costs of mechanical harvesting are higher than chemical control, environmental effects need to be determined to evaluate if benefit to fish and wildlife merit the extra cost.

The effects of water quality (including herbicides) on manatees are still largely undetermined, although several potential health impacts have been identified. For example, although the tests required to certify chemicals have evaluated acute toxicity for mammals, they do not examine long-term effects of chemicals and their break-down products on reproductive success or neonatal survival. Because species differ in response to the herbicides in question, and effects of the chemicals may vary depending on synergistic interactions with other substances, risk-evaluation is very difficult. Continued documentation of pathology in manatee carcasses recovered within the management area is essential. Basic information on reproductive rates, maternal behavior, calving areas and neonatal survival is also needed. However, the probability of determining effects of water quality on manatees via correlative studies is low, and direct experimentation may not be permissible because manatees are an Endangered Species. Guidelines from the EPA and ACS regarding application of chemicals and maintenance of water quality in a water body that is critical habitat for manatees are needed.

The overlap of manatee feeding areas, aquatic plant control and water quality has not been evaluated for rivers and estuaries other than Crystal River. These systems should be analyzed in further detail.

3.5 Recommendations

Maintenance of water quality and vegetation required by manatees will contribute to the esthetic and recreational value of the Crystal River area. In this section, the recommended policy is outlined; then the specific actions of each agency that would be required to implement the policy are described.

3.5.1 Management policy

Evaluation of alternative management actions in Subsection 3.3 indicated that several actions need to be combined in order to maintain water quality and vegetation (Alternative 10). Therefore, the management policy should consist of the following elements:

a) establish and enforce water quality standards in Crystal River, based on baseline water quality information;

b) establish water-body based effluent standards, by modelling the Crystal River aquatic ecosystem;

c) control the construction of individual sewage systems in areas that drain into and influence water quality in manatee habitat;

d) provide future sewage treatment facilities that do not degrade coastal waters and rivers;

e) provide for independent monitoring of effluents discharged into Crystal, Salt, and Homosassa rivers, and enforce permit requirements;

f) reduce the exposure of manatees to aquatic herbicides used in South Big Bend, e.g. by a program of mechanical harvesting (designed to be safe for manatees), and by restoring water quality to decrease the need for aquatic plant control;

g) maintain the amount of vegetation available to manatees as food.

3.5.2 Local governments

The following actions would aid in meeting the objectives of this plan.

a) A moratorium on permitting by Citrus County Health Department of individual septic systems should be imposed, until the administrative rules are revised by DHS (see 3.5.4).

b) The Citrus County Aquatic Services Division should be supported in its search for alternatives to chemical control of plants in Crystal River.

c) The City of Crystal River and Citrus County need to work together on a regional solution to sewage treatment and disposal.

d) The county needs to adopt a stormwater ordinance that provides for on-land retention of runoff adjacent to manatee habitat.

e) The County Commission needs to endorse studies of water quality as stated in the Comprehensive Plan (Citrus County 1979, pg. 3-3). To initiate a study, and adopt appropriate ordinances, they need to contact the DER, EPA and the Office of Coastal Zone Management.

3.5.3 Department of Environmental Regulation

The following actions would aid in meeting the objectives of this plan.

a) A moratorium needs to be placed on permitting of sewage package plants and other effluents, pending completion of a model and adoption of water quality based effluents standards for Crystal River and Dixie Bay. DER needs to be the lead agency in arranging to have an ecosystem model developed and validated. The accumulation of contaminants (e.g. copper, lead, mercury, PCB's, pesticides and their breakdown products) needs to be monitored as well as the usual aspects of water quality.

b) If DER is not able to validate adequately the reported quality of effluents discharged into Crystal River, they need to arrange for monitoring that is independent of self-monitoring. The Office of Coastal Zone Management should investigate sources of funding for such studies.

c) Clear guidance need to be given to the City of Crystal River to indicate that certification will not be renewed if the sewage plant exceeds capacity.

d) Stormwater runoff regulations need to be enforced in the Salt and Crystal rivers.

3.5.4 Department of Health and Rehabilitative Services

The following actions would aid in meeting the objectives of this plan.

a) The DHS needs to change administrative rules to provide a basis for denial of permits for individual sewage disposal systems in coastal areas with frequent but short duration tidal flooding.

b) Guidelines for issuing permits should be based on cumulative effects on water quality as determined by a hydrologic model (see Subsection 3.5.3).

3.5.5 Department of Natural Resources

The following actions would aid in meeting the objectives of this plan.

a) The recommendation by DNR that chemical treatment of vegetation be discontinued in slow-speed zones (while they are in effect) is appropriate. However, a no-treatment policy needs to be coordinated with a public-awareness program regarding the potential health effects of chemicals on manatees and the use of mechanical harvesting to clear navigation channels. The county ASD receives complaints from citizens who want vegetation controlled. A potentially controversial situation could arise if those citizens perceive that their needs are not met due to a no-treatment policy that they believe is unnecessary.

b) The alternative of mechanical harvesting in canals and necessary boat channels should be evaluated, on an experimental basis.

3.5.6 Department of Agriculture and Consumer Services

The following actions would aid in meeting the objectives of this plan.

a) The certification of herbicides and pesticides that enter into aquatic systems connected to manatee habitat needs to be reviewed. If chemicals are not considered safe as additives to livestock food or water, they should be carefully evaluated as to effects on manatees.

b) Where appropriate, label precautions need to be changed or the chemicals should not be certified for use in manatee habitat.

3.5.7 U.S. Fish and Wildlife Service

The following actions would aid in meeting the objectives of this plan.

a) Under the Fish and Wildlife Coordination Act, the FWS needs to request that EPA deny any permits to discharge effluent into Crystal River, until DER has established water-quality based effluent standards.

b) The FWS needs to request guidelines from EPA regarding use of registered herbicides in manatee habitat. If there are indications that herbicides have an impact on health and reproduction of manatees, the FWS needs to request deregistration of the chemicals. Under the current treatment plan (specified page IV-54), requests by the county (via the COE) to treat plants within federal manatee sanctuaries should be denied unless the vegetation is so dense that it cannot be penetrated by manatees.

c) The necropsy program and collection and analysis of contaminants in tissues sampled from manatee carcasses should be continued.

3.5.8 Environmental Protection Agency

The following actions would aid in meeting the objectives of this plan.

a) EPA needs to deny new permits to discharge effluent into Crystal River, pending adoption of water-quality based effluents standards established by DER.

b) If the Crystal River sewage treatment plant exceeds capacity, the facility should not be recertified.

c) Guidelines for the use of herbicides in manatee habitat should be provided to clarify the apparent discrepancies between label precautions and review of published research (see Subsection II.5).

d) If the state fails to establish suitable water quality standards then EPA should use its powers under Section 303(c) of the Clean Water Act to set federal standards.

3.5.9 Army Corps of Engineers

The following actions would aid in meeting the objectives of this plan.

a) The COE needs to evaluate the feasibility of mechanical harvesting in manatee habitat. As an initial step, the economic model developed by the Waterways Experimental Station needs to be applied and validated for the Crystal River system. In considering the relative costs of mechanical harvesting versus chemical treatment to control aquatic vegetation, the COE should take environmental benefits or costs into consideration as well as direct costs.

b) The COE should comply with recommendations of the FWS regarding county requests for treatment in federal manatee sanctuaries and areas designated as feeding zones.

c) A yearly summary of chemical treatments in the management area needs to be submitted by the COE to update this plan.

3.5.10 Suwannee River and Southwest Florida Water Management Districts

The following actions would aid in meeting the objectives of this plan.

a) Herbicide applications in the Suwannee and Withlacoochee rivers should be consistent with the management policy of this plan (Subsection 3.5.1).

b) A yearly summary of chemical treatments on the Suwannee and lower Withlacoochee rivers should be submitted to the FWS for inclusion in the annual update of this plan.

4. DEVELOPMENT: SEA WALLS, DREDGE AND FILL, ZONING

The effects of land development on manatees are indirect. Unplanned development can affect the quality and quantity of food resources for manatees, as well as the probability of injury, harassment and mortality due to waterborne activities (Table 26). Construction of sea walls and dredge and fill to create waterfront communities can alter the natural functions of coastal wetlands in maintaining water quality necessary for the health of manatees and their food resources. High density developments attract more people to an area, increasing boat traffic and other recreational activities that contribute to the probability of harassment, injury or mortality of manatees. The sequence of recommended actions based on this analysis is outlined in Section V.

4.1 Site-specific Evaluation of Impacts

In this subsection, the overlap of planned urban development and wetlands adjacent to manatee habitat is evaluated, to identify areas where management action may be needed.

4.1.1 South Big Bend Region

The major area of planned compact urban development in South Big Bend includes wetland areas on the Salt, Crystal and Homosassa rivers and the uplands along HWY 19-98 that connects these communities (Figure 13). The second largest area of planned development is along the north bank of the Withlacoochee River, including Inglis. Extensive development around the towns of Suwannee and Cedar Key is unlikely at this time. Therefore, the major overlap of planned development and lands adjacent to manatee habitat occurs in Crystal River and Homosassa. An analysis of land development trends in Homosassa River was not available at the time this plan was written.

4.1.2 Crystal River

Existing and pending permits indicate that development is planned in the near future along the south shore of Crystal River as far west as the Salt River, and along the north shore as far west as Sheephead Creek (Figure 51). Much of this area is marsh or wooded wetlands (Figure 35) and except for scattered islands, is below the 5-ft elevation contour (Figure 34). The area north of State Road No. 44 drains into Crystal River, and south of the road drains into Dixie Bay, both of which are manatee habitat. Almost all the shoreline along subdivisions and small land-holdings (Figure 48) has been sea-walled.

4.2 Current Regulations

Under county jurisdiction, the south shore of Crystal River and Dixie Bay are zoned General Commercial, General Agriculture, Single Family Residential and Single Family (Mobile Home) Residential (Figure 62). The north shore is zoned Light Industrial, General Industrial, General

Table 26. Impacts of land development.

Potential impact	Factors influencing probability of impact	Explanation
Quality and quantity of food resources	Alteration of drainage from coastal marshes	Marshes buffer estuarine salinity fluctuations due to tides and storm water runoff. Extreme or frequent surges of freshwater can kill plant species which are intolerant of low salinity. Maintenance of diverse plant communities is probably beneficial to manatees.
	Cumulative effect of non-point source seepage and runoff	Nutrients from septic systems and runoff of fertilizer from lawns can contribute to algal growth. Phytoplankton and epiphytic growths can reduce competitive ability of native plant species.
	Seawalls	Sewalls disturb shoreline vegetation and reflect waves, increasing turbidity.

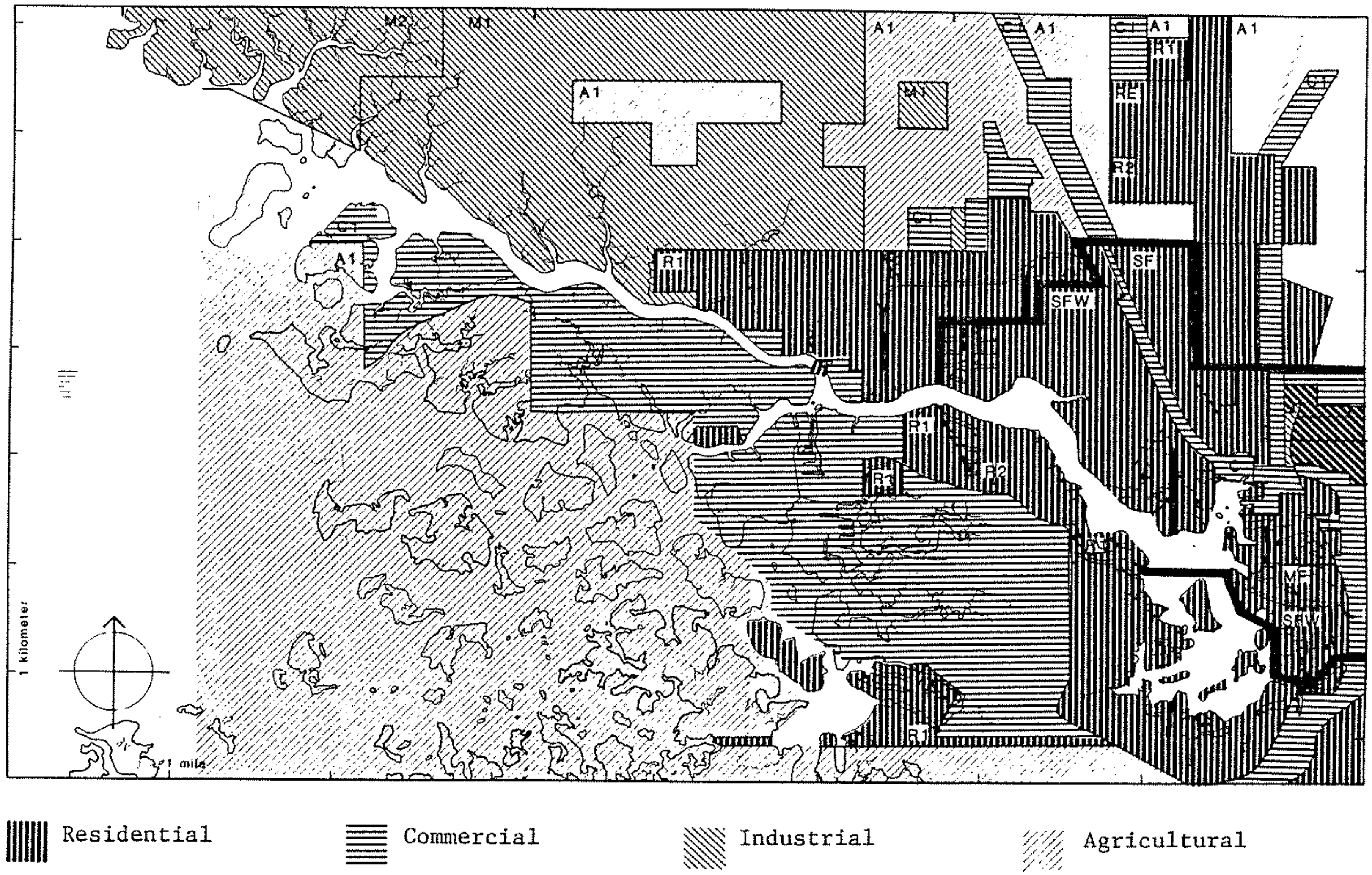


FIGURE 62: ZONING IN THE CRYSTAL RIVER AREA.

Data are from Citrus County (1980) and Crystal River Planning Department. For explanation of codes, see Table 27. Zoning boundaries in the City of Crystal River are not shown in detail.

Commercial, and Single Family Residential. In the city of Crystal River, most of the waterfront is zoned Single Family, with the exceptions of Multiple Family, and various commercial categories around the northeastern cove in Kings Bay.

A high density and wide variety of uses are permitted within these zones (Table 27). The minimum lot size ranges from less than a quarter-acre (R-1, R-2, C-1) to about one acre (A-1, M-1) or 2.3 acres (M-2) (Citrus County 1980).

Special approval from the Citrus County Zoning Board of Adjustment (ZBA) is required for fill within all the county zones indicated in Table 27. However, despite recommendations of the Comprehensive Plan (Citrus County 1979 pg. 2-5, 2-7) the ZBA has no clear guidelines for denial of fill permits in wetlands, and generally follows the decisions of the Department of Environmental Regulation (DER) or Army Corps of Engineers (COE) where these two agencies have jurisdiction. As described in Subsection IV.1.2, the jurisdictional boundaries of the DER and COE have not been well-defined in the Crystal River area.

Requests for dredge and fill permits may be expected to increase when the 100-yr flood plain levels are adopted, which will specify elevations required to qualify homeowners for flood insurance from the Federal Emergency Management Agency (FEMA). Although there is some dispute regarding exact elevations (Wessel 1983), most of the area of potential land development lies within flood elevations of 10 feet (2.5 m) or more (Figure 63). FEMA regulations specify that the first floor of homes must be at least one foot (30 cm) above the 100-yr base flood elevation (BFE) to qualify for insurance.

Due to the nature of the topography in this wetland area, application for discharge of dredged or fill material is also needed to provide road access and utilities to the disjunct upland areas. The courts have clearly supported denial by COE of a fill permit on the grounds that construction of a roadway in wetlands adjacent to Crystal River had a "serious adverse impact on natural biological functions of affected wetlands, especially production and export of detritus" (United States vs. Weisman, 489 F. Spp. 1331, 1980).

A consent of use from the Department of Natural Resources (DNR) is required for seawalls constructed at or within three feet (80 cm) waterward of mean high water. Guidelines mandate that actions such as construction of seawalls on sovereignty lands shall not adversely affect fish and wildlife habitat, especially that of Endangered Species. DER and COE have jurisdiction over fill required to construct seawalls in wetlands including areas above the jurisdiction of DNR (Figure 54). The applicants for fill under DER jurisdiction must provide reasonable assurance that the short- and long-term effects, including cumulative effects, will not violate state water quality standards (CZM and OCM 1981; pp II-50 to II-52). Criteria for permit review specify that marine productivity shall not be destroyed, and recognize the importance of grass flats and natural shoreline processes (CZM and OCM 1981; pp II-53 to II-55).

Table 27. Selected zoning codes for Citrus County and Crystal River.

Code	Classification	Permitted Uses	Minimum Lot (acres)[1]
County[2]			
F-R	Forest-Recreation	Public holdings; public buildings, farms	5
A-1	General Agricultural	All forms of agricultural uses; lands characterized by poorer soils, drainage, and other limiting characteristics which make them less suitable for preservation for agriculture, thus permitting residences, farms, schools, golf, parks, nurseries, private docks, etc.	1
R-E	Residential Estate	Single family residential estate homes in a semi-rural environment	5
R-1	Single-Family Residential	Either conventionally constructed homes or approved modular units; includes farms, parks, schools, private boat docks, etc.	0.22
R-2	Single-Family (Mobile Home)	Permits single-family mobile homes, conventional homes or modular units; approval needed for mobile home parks; similar to R-1	0.22
C-1	General Commercial	All kinds of businesses and services; multi- and single-family dwellings, museums, schools, etc.	0.22
M-1	Light Industrial	Industrial developments where all operations are confined within a building; includes harbors, piers and wharves, etc.	0.92
M-2	General Industrial	General industrial operations utilizing both enclosed and unenclosed space for storage, fabricating, and manufacturing; similar to M-1	2.30

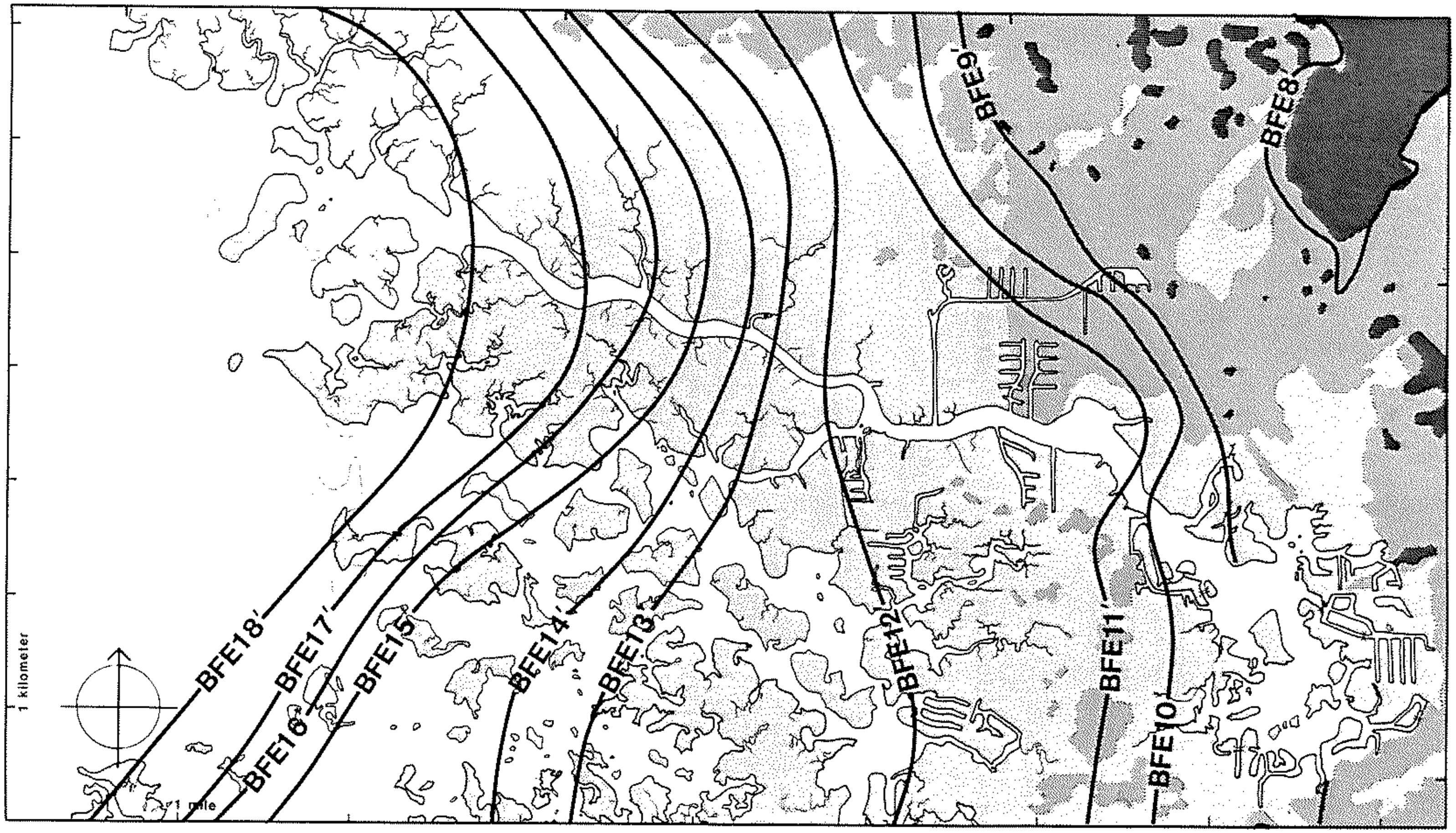
Table 27. Selected zoning codes for Citrus County and Crystal River (continued).

Code	Classification	Permitted Uses	Minimum Lot (acres)[1]
City[3]			
SF	Single Family		
SFW	Single Family-Waterfront		
MF	Multiple Family, MF Duplex		
C	Commercial, Restricted Retail, Commerical Retail		
CB	Central Business		
RI	Restricted Industrial		
PB	Planned Business		
M	Marina		

[1]For conversion to metric units, one acre is 0.4 hectares.

[2]From Citrus County (1980); zones indicated in Figure 62.

[3]Codes are not official; zones are from Crystal River Planning Department. Zones indicated schematically in Figure 62 combine SF, SFW, MF as residential, and C, CB, RI, PB, M as commercial.



Above 2.5 m (10 ft) elevation

1.2-2.5 m (5-10 ft) elevation

Below 1.2 m (5 ft) elevation

Estimated water depth at 100 yr flood

FIGURE 63: CONTOURS OF PRELIMINARY 100-YR FLOOD ELEVATION ESTIMATES FOR THE CRYSTAL RIVER AREA.

Data are from a preliminary study by Jensen Engineers, drawing 120063-R13, Nos. 3,4,7,8, dated 1981, and USGS topographic maps "Crystal River" and "Red Level".

Although the Florida Coastal Management Program clearly recognizes the need to protect estuarine systems, it provides no additional regulations to implement such policies (CZM and OCM 1981; pp II-186 to II-191). For example, even though areas adjacent to Crystal River are classified as Preservation and Conservation zones (CZP 1975), no action has been taken by the county to adopt zoning or guidelines that would reflect a protective policy and the use of such zones was explicitly rejected by the state legislature (Section 380.25, Florida Statutes, 1981). However, the Office of Coastal Zone Management is responsible for assisting existing management programs to address the issues of estuarine protection by improving coordination between research efforts, state management and regulatory agencies. An opportunity exists to combine efforts aimed at conserving marine productivity and efforts to maintain manatee habitat.

4.3 Alternative Management Options

Options for maintaining the integrity of the ecosystem that supports manatee habitat are listed in this subsection. Recommendations regarding implementation of options that best meet the objectives of this plan are described in Subsection 3.5.

Alternative 1: No action

Under current county regulations, waterfront development of a commercial and residential nature could proceed along the entire south shore, part of the north shore of Crystal River, and Dixie Bay. Industrial development along the north shore near the estuary would also be possible. Substantial fill and sewage treatment capacity would be required to develop these lands. Seawalls would probably be constructed along the waterfront of all developable land. Although DER and COE have the legal authority to deny permits for filling in wetlands, their decisions probably will be contested by developers. In addition, the COE has been considering a relaxation of restrictions on filling. If strict guidelines regarding fill in wetlands are not followed, the result would be a significant deterioration of water quality. Estuarine vegetation would decline due to extreme fluctuations in salinity caused by storm runoff, a decline in detritus exported from the marshes and increased turbidity. Recreational and aesthetic values of the area would be reduced as fisheries decline and the natural shoreline is altered. This alternative would not meet the objectives of this plan.

Alternative 2: Aquatic Preserve designation

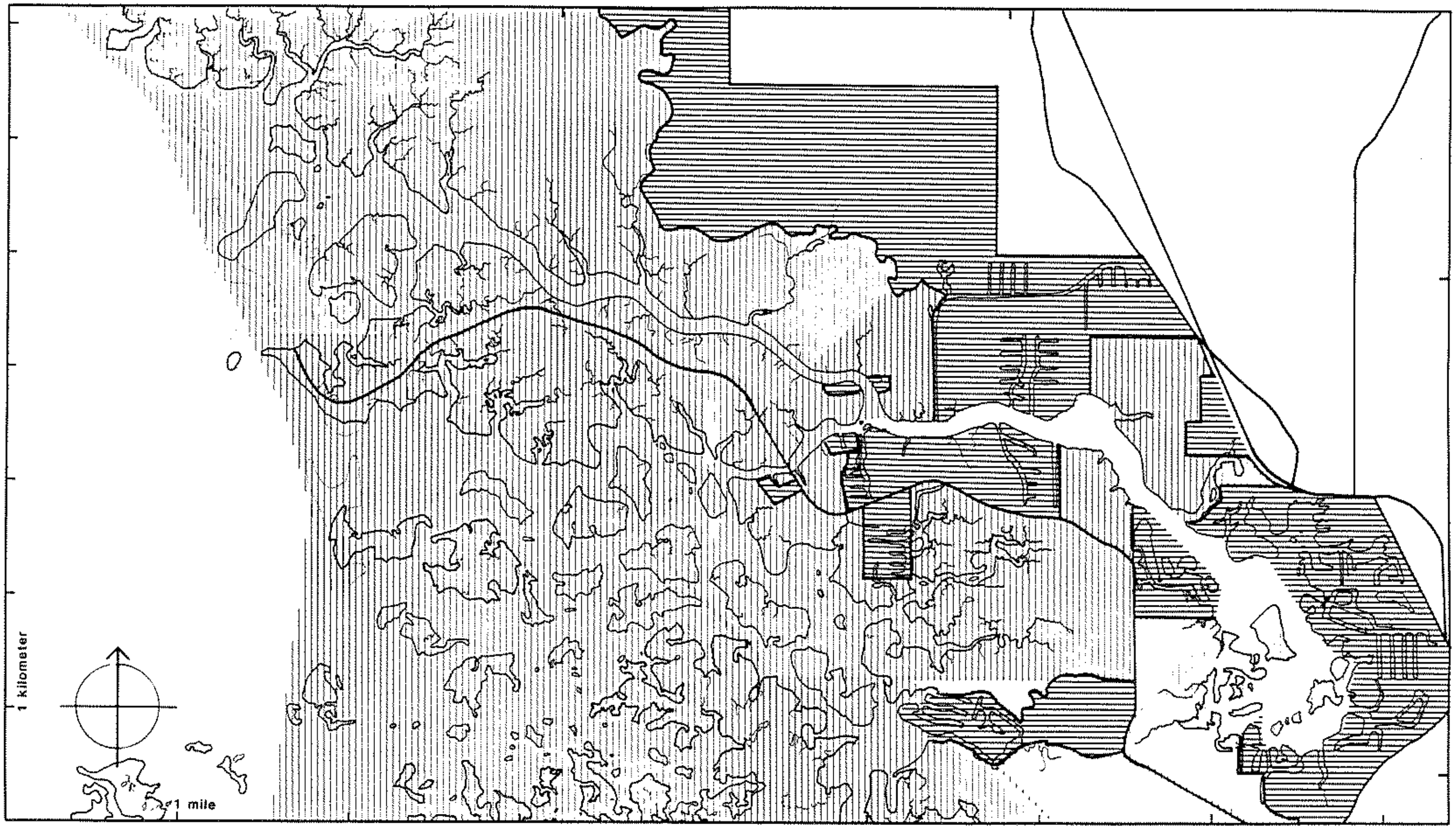
Crystal and Homosassa rivers could be designated an Aquatic Preserve or included in St. Martins Marsh Aquatic Preserve. Actions that would be prohibited (dependent on determination of the public interest) would include: (a) sale, lease or transfer of state submerged lands, (b) dredging and filling below mean high water line, excepted for authorized projects (e.g. navigation channels, marinas, piers etc.), (c) gas or oil wells, (d) erection of certain structures, and (e) discharge of wastes or effluents if against the intent of the act (CZM and OCM 1981: pp. II-151). Under Aquatic Preserve designation, a management plan for the area would be developed that could specify selected coastal marshes in need of protection. For example, the plan could remove exemptions for seawalls under 30 ft (8 m), and require stabilization of banks with natural vegetation. However, regulation within preserves cannot interfere with traditional public uses such as fishing, boating and swimming, and it does not extend beyond the mean high water line. To enforce guidelines for management of the Aquatic Preserve, it would be necessary to determine the mean high water line and thus define the coastal marshes to be protected. This option would help preserve the integrity of the ecosystem west of Salt River and south of State Road No. 44. However, it would not affect dredge and fill activities in wetlands above mean high water, or in wooded swamps that are not directly connected to state waters, both of which contribute to the hydrological system of coastal marshes. This option would contribute, but would not be sufficient, to meet the objectives of this plan.

Alternative 3: Strengthen existing regulatory programs

The following changes in existing regulatory programs would improve the ability of the DER and COE to protect coastal wetlands. Construction currently permissible under general and nationwide permits of the COE could be disallowed in the Crystal River area and statutory exemptions of DER and DNR could be removed. Individual permits could be granted only if it is shown that cumulative effects do not excede a threshold required to maintain existing quality of manatee habitat. In wetlands and adjacent lands that drain into wetlands, more stringent criteria for identifying DRI's could be established. A procedure for identifying cumulative impacts could be developed, in order to provide DER and COE with a means of implementing their mandated consideration of cumulative effects. For example, the water quality model developed by DER could provide a basis for evaluating the long-term effects on water quality due to the effects on wetland vegetation of dredge and adjacent to wetlands. Also, permitting of boating facility construction should consider implications of resulting boat traffic on manatees as well as the actual facility istelf. This option could contribute, but not be sufficient, to meet the objectives of this plan.

Alternative 4: Revision of Citrus County zoning regulations

The county could issue a moratorium on all building permits in the coastal zone from the Withlacoochee to Chassahowitzka rivers, pending adoption of zoning revisions that are currently in progress. Zoning should be consistent with the policies of coastal management stated in the Comprehensive Plan. Wetlands unsuitable for development should be protected by a conservation zone (Figure 64). A new overlay zone (Figure 64) could be adopted for sensitive areas where development will be allowed adjacent to manatee habitat. The overlay zone should include areas identified by the Soil Conservation Service as having severe soils limitations for dwellings and within the 10 foot 100 year flood elevation. Existing development could be accommodated by the appropriate single-family residential zoning. Development within the overlay zone could be required to obtain special approval and meet specified conditions and standards. These performance standards should include the following:



Conservation zone

Overlay zone that specifies design criteria for development

FIGURE 64: RECOMMENDED CONSERVATION AND OVERLAY ZONES FOR THE CRYSTAL RIVER AREA.

Recommendations are from analysis of the overlays of Figures 35, 48, and 62.

a. low density, e.g. 1 unit per five acres;

b. restrictions on the percentage (e.g. 5%) of a lot that may be cleared, filled, paved or otherwise altered;

c. restriction of docking facilities to one per lot platted as of January 1, 1983 (see Subsection 1.3)

d. provisions allowing the transfer of density, dock, or development rights to more suitable areas;

e. requirements for clustering of units in subdivisions coupled with open space preservation;

f. restrictions on the alteration of runoff requiring maintenance of the natural volume, rate, velocity, timing, quality and location of discharge;

g. elevation of buildings and roads on pilings rather than fill;

h. dredged canals or other artificial bodies of water must not alter drainage of wetlands and must be well flushed to maintain water quality;

i. setbacks from marshes and waterbodies:

This option would be sufficient to meet the objectives of this plan.

Alternative 5. <u>Combination of Alternatives 2, 3 and 4</u>

Although the combined action of DNR (Alternative 2), DER and COE (Alternative 3) would be effective in maintaining the integrity of coastal marshes and the marine system dependent upon them, without a complementary change in county zoning (Alternative 4) there will be continued conflict between the private sector and public policies designed to maintain marine productivity and manatee habitat. The coordinated action of local, state and federal agencies would be effective in meeting objectives of this plan. This is the recommended management option.

4.4 Information Needs

The following information is needed for revision of county zones and guidelines regarding review of building, dredge, and fill permits.

a) The boundaries of salt- and freshwater wetlands adjacent to Crystal River need to be mapped in sufficient detail to provide guidance regarding jurisdiction of government agencies.

b) Drainage patterns need to be documented in order to evaluate the effects of proposed development on coastal marshes, water quality, and vegetation eaten by manatees.

c) Potential effects of development adjacent to Homosassa, Chassahowitzka, Withlacoochee, and Suwannee rivers need to be evaluated.

4.5 Recommendations

Although coastal management planning clearly indicates the need to protect the marshes that are an integral part of the ecosystem supporting marine productivity, specific actions to implement this policy in South Big Bend have been lacking. County governments can take valuable steps in implementing these policies, and need to be supported by clear guidelines from state and federal regulatory agencies. In this subsection, the recommended management policy is described, then the specific actions of each group that would be required to implement the policy are described.

4.5.1 Management policy

Evaluation of alternative management actions in Subsection 4.3 indicated that several actions (Alternative 5) need to be combined in order to maintain the integrity of the ecosystem that supports manatee habitat. Therefore, the management policy should be as follows:

a) identify zones that would require substantial fill to be developed, and insure the protection of such wetlands in the natural condition;

b) identify buffer zones suitable for limited development under design standards that minimize disruption of ecosystem functions, and specify the type of development that will be permitted to meet such standards, e.g. cluster housing, stilt houses, boardwalks, etc;

c) require that developments are consistent with the management policy regarding construction of boating facilities (Subsection 1.5);

d) redirect high-density development to locations that will not alter drainage from uplands into wetlands, will not change the drainage patterns and vegetation in wetlands, and will not disturb aquatic vegetation; and

e) reduce unplanned development affecting manatee habitat until a regional plan addressing the cumulative effects of such development is prepared and implemented.

4.5.2 Local governments

To meet the objectives of this plan, zoning specifications for coastal marshes in South Big Bend need to be revised such that uses contrary to the stated policy of protection will not be allowed.

a) In Citrus County, wetlands adjacent to manatee habitat should be rezoned as Forest-Recreation, or some other suitable classification should be developed that would conserve marshes and wetlands.

b) Development in upland areas and wooded swamps that drain into coastal marshes needs to be carefully regulated, to maintain the normal patterns of drainage and esthetic values of coastal areas.

c) Design criteria for development in coastal areas (e.g. cluster housing, stilt houses, percent coverage) need to be adopted and enforced by the ZBA.

d) A moratorium on development in coastal areas needs to be adopted pending such revisions in order to avoid hasty and unplanned decisions that are virtually impossible to correct.

e) Applications for DRI's within the coastal zone should be denied if they are not consistent with the management policy of this plan.

4.5.3 Department of Community Affairs

The current Citrus County zoning ordinance and permitting process in coastal areas is clearly not in compliance with the comprehensive plan. To correct this situation, the following actions are needed.

a) The DCA should appoint a Resource Planning and Management Committee to aid the county in revision of its ordinances and permitting processes.

b) If the appropriate revisions are not made, the DCA should recommend designation of South Big Bend as an Area of Critical State Concern.

4.5.4 Department of Natural Resources

The following actions would aid in meeting objectives of this plan:

a) request the legislature to designate Crystal River and its estuary as an Aquatic Preserve or to expand St. Martins Marsh Aquatic Preserve to include Crystal, Salt and Homosassa Rivers;

b) prepare a management plan for the area that provides the highest degree of protection to maintenance of coastal wetlands and marine grassbeds;

c) map the mean high water; if funds are not available within DNR, the Office of Coastal Management Zone needs to assist in identifying and obtaining funding;

d) adopt the recommendations of this plan as part of the State Lands Management Plan.

4.5.5 Department of Environmental Regulation

The following actions are needed to maintain coastal wetlands that are essential to the maintenance of water quality and marine grassbeds:

a) exclude the Crystal River area from the general permitting process;

b) evaluate the cumulative effects of development by projecting the total potential alteration that might be reasonably expected (as determined by a Resource Planning and Management Committee) and determining the effects of such development;

c) evaluate the cumulative effect of smaller incremental changes by reference to the a study described above in (b);

d) include plant species found in the Crystal River area in the revision of indicator species used to identify wetlands;

e) map wetlands under the jurisdiction of DER in the Crystal River area;

f) draft legislation needed to consider impacts other than water quality (e.g. effects on salinity, hydrology, wildlife habitat and wetland vegetation) in evaluation of permit applications for dredge and fill above mean high water (under Chapter 403); and

g) develop and require design criteria or performance standards for construction in and adjacent to wetlands, which will maintain the function of wetlands in the ecosystem.

4.5.6 Governor and Cabinet

The following actions would aid in meeting objectives of this plan:

a) adopt a resolution to include Crystal River in an Aquatic Preserve as recommended by DNR;

b) establish lower thresholds and special criteria for identifying DRI's adjacent to manatee habitat, as specified in Figure 33;

c) deny approval of DRI's that are not consistent with the management policies of this plan; and

d) approve ACSC designation of Crystal River if recommended by the DCA.

4.5.7 Florida Legislature

The following actions would aid in meeting objectives of this plan:

a) confirm establishment of the Aquatic Preserve by the Trustees;

b) remove statutory exemptions for dredge and fill and use of submerged lands between and including Crystal and Homosassa rivers;

c) give authority to DER to consider indirect effects of dredge and fill on endangered species (e.g. boat traffic generated by subdivision or docking facilities) and on coastal wetlands that indirectly are important to maintenance of water quality and salinity in estuaries (under Chapter 403).

4.5.8 U.S. Army Corps of Engineers

The following actions would aid in meeting objectives of this plan:

a) establish a procedure for evaluating individual permit applications in terms of cumulative effects (see Subsection 4.5.5, Item b) and deny individual permits unless it is demonstrated that an allowable cumulative impact will not be exceeded;

b) exempt Crystal River or critical habitat for Endangered Species in general from the nationwide and general permitting process;

c) adopt a map specifying areas of jurisdiction in Crystal River; and as required to implement the management policies of this plan,

d) deny or condition permits in Critical Habitat for manatees in South Big Bend.

4.5.9 U.S. Fish and Wildlife Service

The following actions would aid in meeting the objectives of this plan:

a) wetlands in the Crystal River area should be mapped on a large scale by the Soil Conservation Service to provide necessary information to planning and regulatory agencies;

b) comment on COE permit applications that would alter drainage into coastal wetlands, reduce water quality or vegetation eaten by manatees, increase boat traffic in Critical Habitat or otherwise reduce the existing quality of manatee habitat in South Big Bend;

c) issue a jeopardy opinion if a permit that is not consistent with the management policies of this plan is issued, and offer reasonable and prudent alternatives that are consistent with the management policies; and

d) request a Section 7 consultation regarding the effects of COE general and nationwide permits on manatee Critical Habitat as specified by the Endangered Species Act.

4.5.10 Non-Profit Organizations

If any federal agency ignores a jeopardy opinion from the FWS and takes any action that is not consistent with the management policies of this plan, that agency should be sued for violation of the Endangered Species Act.

4.5.11 Environmental Protection Agency

The EPA should deny permits that are not consistent with the management policies of this plan (as recommended by the FWS) under the authority of Section 402(c).

5. PROTECTION OF MANATEE HABITAT

Incorporation of essential manatee habitat into existing state and federal systems of refuges, parks, reserves, preserves, etc. can provide an appropriate and valuable approach for protecting the integrity of coastal ecosystems while providing for human activities and uses that are compatible with protection of manatees and other wildlife. Some of the potential human-manatee interactions that could be addressed within the context of management programs for established sanctuaries, refuges, parks, reserves, and preserves are identified in Table 28. The importance of certain areas as manatee habitat and the need for particular caution with regard to development and use can also be highlighted through designation of "Critical Habitat" under the Endangered Species Act. The following section provides information and alternatives relating to the authorities for refuges, parks, reserves, preserves, marine sanctuaries, critical habitat, etc. for protection of essential manatee habitat in the management area.

5.1 Site-specific Evaluation of Impacts

Coastal wetlands, estuarine and marine vegetation are essential to the maintenance of manatee habitat (see pp I-12 to I-14, III-14). This subsection examines the overlap of protective jurisdictions and areas important to maintain manatee habitat. Sensitive areas that are in need of protection are identified.

The estuarine and marine vegetation along the coast of South Big Bend is currently unprotected. A proposed Marine Sanctuary, Big Bend Grassbeds (NOAA 1983), would include vegetation important for manatees between Cedar Key and the Suwannee estuary. Extension of the boundaries of the proposed sanctuary to include beds further south (e.g. Crystal Bay and estuary) has been recommended (H. Hood, Letter to J. P. Packard, dated Aug. 11, 1982 on behalf of Florida Defenders of the Environment). Although a Marine Sanctuary would provide a management plan to regulate activities in estuarine and marine habitat important to manatees, it would not address the indirect effects of commercial and residential development in coastal wetlands adjacent to the seagrass beds.

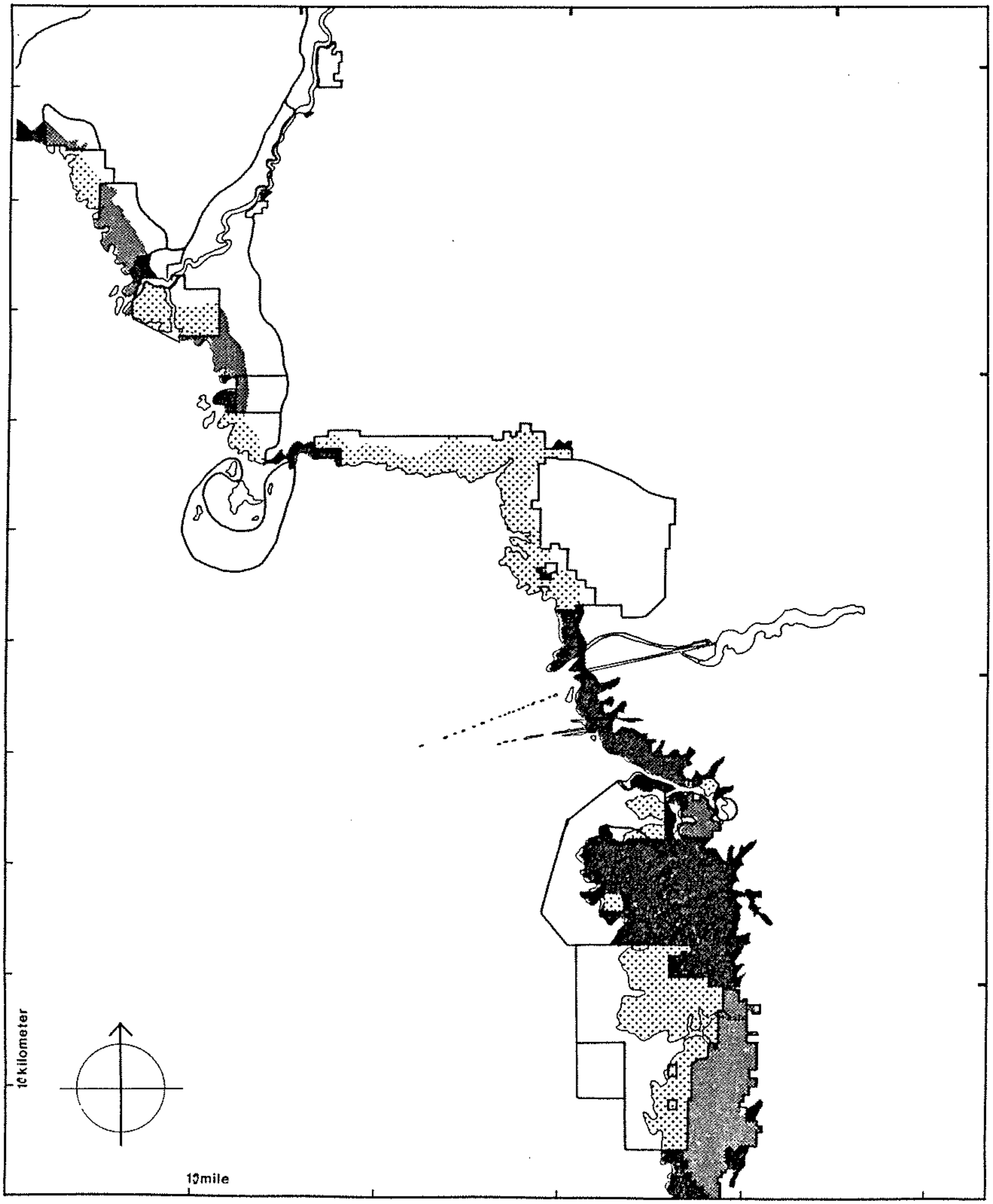
A continuous band of wetlands exists along the coast of the management area. A substantial portion of these wetlands is included in existing refuges, reserves and preserves (Figure 65).

Management of these areas provides a valuable basis for protecting the integrity of the coastal ecosystem that supports the area's manatee subpopulation. Although many of these protected areas contain important manatee habitat, much of the area identified as core manatee habitat (Figure 33) is not presently included. Established areas under state jurisdiction that contain or are adjacent to core manatee habitat include the Manatee Springs State Park (DNR 1979), the Williams Estate on Crystal River, and the St. Martin's Marsh Aquatic Preserve. Proposed state acquisitions along the south shore of Crystal River and in the Chassahowitzka Swamp would also complement manatee habitat protection if and when completed. Established

Table 28. Impacts on manatees due to lack of land protection.

Potential impact	Factors influencing probability of impact	Explanation
Harassment (human activity) alters distribution; disturbance in calving areas	Density of human structures	More homes and docks increase potential disturbance.
	Number of people using facilities	Land use that attracts more people may result in greater disturbance.
	Compatible activities	Quiet, inobtrusive recreational activities such as photography, canoeing, etc., are less likely to disturb manatees than activities
Disruption of natural functions of the ecosystem (some as yet undetermined)	Destruction of vegetation	Effects can be controlled when land is under public ownership.
	Alteration of drainage	Small private holdings may be developed without consideration for cumulative effects. The hydrologic system influences species composition of vegetation eaten by manatees.
	Compatible land-use	Recreational land-use e.g., areas used for canoeing, hunting, and fishing is less likely to disrupt natural systems, where users are oriented toward protection of natural values.

involving motorboats, gunshot noise, etc.



Unprotected wetlands

Proposed acquisition

Protected wetlands

Boundaries of protective jurisdictions

FIGURE 65: OVERLAP OF COASTAL WETLANDS AND PROTECTIVE LAND JURISDICTIONS.

Data are from analysis of overlays of Figures 11 and 14.

federal areas in or adjacent to important manatee habitat include acquired portions of the Lower Suwannee National Wildlife Refuge (NWR), the Cedar Key NWR, Crystal River Manatee NWR (FWS 1979) and the Chassahowitzka NWR. Proposed federal additions to the Lower Suwannee NWR will contribute to the protection of essential manatee habitat.

Wetlands that are currently under private ownership include portions of the proposed boundaries of the Lower Suwannee NWR (FWS 1978), and a proposed state acquisition adjacent to it, a section west of Waccasassa Bay State Preserve (WBSP), most of the wetlands between WBSP and Chassahowitzka NWR, the Chassahowitzka Swamp, and a proposed state acquisition east of Chassahowitzka NWR (Figure 65).

As noted in Subsection II-4 (Figure 20), the most important winter habitats for manatees are the Kings Bay and Homosassa Springs warm water refuges. In addition, since the Crystal and Homosassa rivers are essential access corridors to these refugia, these two rivers are also considered as particularly important winter habitat. Based on available sighting data, the most important summer habitat appears to be the lower portions of the Suwannee, Crystal, Withlacoochee, Homosassa, and Chassahowitzka rivers. The continued existence and growth of the area's manatee subpopulation will depend on the protection of habitat essential for all life stages even though those habitats may only be used on a seasonal basis. A full complement of winter, summer, and migratory habitat must be protected.

If it is necessary to assign priorities to lands under consideration for public acquisition, geographic areas may be ranked based on importance as manatee habitat and on indications that detrimental human activities in those areas will expand in the near-future. The overlap between human activities and important manatee habitat is greatest in the lower Suwannee, Crystal, and Homosassa rivers (Figure 43). Therefore, expansion of the wildlife refuge on Crystal River, completion of land acquisition for the Lower Suwannee NWR, and protection of the undeveloped wetlands adjacent to the Homosassa River and north of Chassahowitzka NWR are of highest priority.

Land acquisition proposals of secondary priority include the extensive wetlands between Crystal and Homosassa rivers, which contain many small channels that provide a travel route for manatees between Crystal and Homosassa Rivers, and may be important as calving areas. Lands along the lower Withlacoochee would also be secondary priority due to the probable development along the riverbank.

Unprotected lands of less urgent priority for acquisition include wetlands between the Barge Canal and Crystal River. Because these lands are within view of the Crystal River power plant, they are less attractive for development as residential sites. In this area, industrial development can probably be regulated by county zoning and dredge and fill permits; however, if such regulation is not achieved, the area would be sixth priority for land acquisition. Protection of the Chassahowitzka River segment included in the proposed Chassahowitzka Swamp state acquisition is of less urgent priority; however completion of this proposed acquisition would contribute substantially to maintenance of the quality of manatee habitat in the area.

5.2 Current Regulations

Existing programs to manage state and federal lands can provide for the maintenance of wildlife habitat, while still providing for compatible use of the area. The State Department of Natural Resources (DNR) manages preserves, reserves and parks (respectively lowest to highest recreation priority). The national system of wildlife refuges, administered by the Department of Interior, manages land for wildlife as well as commercial resources. Federal wilderness areas are managed with conservation as high priority, and national parks provide recreational opportunities. Estuarine and marine sanctuaries, administered by the Office of Coastal Zone Management, set aside areas of particular concern (NRDC 1976). The estuarine sanctuary program established by the Coastal Zone Management Act (Section 312) is targeted toward preservation of a few exceptional sites to serve as natural field laboratories and educational centers. The marine sanctuaries program, established by the Marine Protection, Research and Sanctuaries Act of 1972, provides a means of managing activities in kelpbeds and other areas of inshore, coastal and ocean waters, which have conservation, recreational, ecological or esthetic values.

Land acquisition programs on the state, federal and local levels have been described by Gluckman (1983c). Although local governments have the authority to raise funds for land purchase, they usually are limited to educational or recreational facilities. Five programs provide funding for land acquisition by the state (Table 29). The Conservation and Recreational Lands (CARL) program has been used to purchase lands adjacent to Crystal River (Williams estate) and additional lands south of Crystal River are listed for acquisition. The Save our Rivers program is used to purchase flood plains and could be appropriate for lands adjacent to the Suwannee and other rivers in South Big Bend. The Water Resources Restoration and Protection fund might be appropriate for purchase of lands required to maintain or restore water quality in Crystal, Homosassa and Chassahowitzka Rivers. Lands adjacent to Manatee Springs State Park may be purchased via the State Park Trust Fund, although the money available in this fund is limited. The proposed state acquisitions (adjacent to Cedar Key Preserve and Chassahowitzka Swamp) would be purchased under the Lands Acquisition Trust Fund.

At least five federal programs provide funds for land acquisition (Table 29). The Endangered Species Act provides for acquisition of land necessary to protect areas of value to listed Endangered and Threatened Species (e.g. Crystal River). Lands adjacent to national wildlife refuges may be purchased with funds from the Wildlife Refuge Act. The National Wild and Scenic Rivers Act provides for acquisition of lands adjacent to rivers such as the Suwannee. Coastal wetlands that provide habitat for waterfowl and bald eagles may be purchased under the Migratory Bird Conservation Fund. The Coastal Zone Management Act provides financial assistance to states on a matching basis to help acquire, develop and operate estuarine sanctuaries.

The Nature Conservancy (TNC), a private, non-profit organization, has been instrumental in acquiring lands that cannot be acquired by means available to government programs. TNC holds lands in private trust, until such time as the lands may be included in state or federal programs.

Table 29. Alternative programs for habitat protection in South Big Bend.[1]

Program	Areas in need of protection[2]							
	CR	SR	HR	WR	CB	SMM	ChR	BBSB
City Park	+							
County Park	+							
Conservation and Recreational Lands	+		+		+	+		
Save our Rivers		+	+	+			+	
Water Resources Restoration and Protection	+		+	+			+	
State Park Trust Fund		+						
Lands Acquisition Trust Fund		+				+	+	
Endangered Species Act	+							
Wildlife Refuge Act	+	+	+		+	+	+	
National Wild and Scenic Rivers Act		+						
Migratory Bird Conservation Fund	+			+	+	+		
Coastal Zone Management Fund				+	+	+		
Marine Sanctuary								+

[1]A plus indicates that the program could be considered as (or is) a source of funds for the area indicated; from Gluckman (1983c).

[2]CR: Crystal River; SR: Suwannee River below Mantee Springs State Park; HR: Homosassa River; WR: Withlacoochee River below Yankeetown; CB: Crystal Bay between the Barge Canal and Crystal River; SMM: St. Martin's Marsh; ChR: Chassahowitzka River; BBSB: Big Bend Seagrass Beds.

5.3 Alternative Management Options

Options for maintaining the ecosystem that supports manatee habitat are listed and evaluated in this subsection. Recommendations regarding the options that best meet the objectives of this plan are described in Subsection 5.5.

Alternative 1: No action

Proposed state and federal acquisitions likely to complement manatee habitat protection objectives are in progress. These include state acquisition efforts at Crystal River and Chassahowitzka Swamp and federal acquisitions in the proposed boundaries of the Lower Suwannee NWR and the Crystal River Manatee NWR. The resulting system of refuges, reserves, preserves, parks, etc. will help protect the integrity of the region's coastal ecosystem and certain important manatee habitats. However, many of the most important manatee habitats would not be incorporated into the system of protected areas and a full complement of essential winter, summer, and migratory habitat would not receive the benefit of their protective authorities. Certain coastal marshes and creeks that are particularly important components of the region's broader coastal and marine ecosystems would remain vulnerable to the effects of incremental development which would disrupt vital ecosystem parameters (e.g. patterns of water flow, water quality, nursery habitats, etc.) and reduce the capacity of essential manatee habitat to support manatees. This alternative will make it very difficult to meet Objectives 2, 4 and 7 of this plan.

Alternative 2: Establish the Crystal River Manatee National Wildlife and State Reserve

Following FWS acquisition of the Kings Bay islands, a Crystal River Manatee National Wildlife Refuge will be established. With an office in Crystal River, this refuge could provide many of the research, educational and enforcement needs outlined in Subsection 2.5. The refuge could be expanded to include wetlands adjacent to Crystal River. Because these wetlands provide habitat for waterfowl and bald eagles, the Migratory Bird Conservation Fund and funding authorized under the Wildlife Refuge Act might be appropriate sources for land acquisition. Funds authorized under the Endangered Species Act would also be appropriate because the wetlands are essential to maintain the critical habitat for manatees in Crystal River. The state lands purchased under the CARL program could be designated a reserve, and managed according to policies of the NWR. The proposed state acquisition south of Crystal River could be completed and included in the reserve. This alternative would contribute substantially to protection of manatees at the most important winter refuge, but summer habitat would remain unprotected.

Alternative 3: <u>Complete acquisition of the Lower Suwannee NWR and assess additional shoreline acquisition needs along the Suwannee River downstream from Manatee Springs State Park</u>

Completion of proposed land acquisition for the Lower Suwannee NWR would contribute substantially to protection of important summer habitat and access to a minor warm-water refuge at Manatee Springs State Park. However, the Lower Suwannee NWR does not extend as far as the state park. Additional shoreline between the NWR and Manatee Springs State Park could be evaluated for acquisition under several programs, including the Florida Save Our Rivers program and the State Park Trust Fund. This alternative would protect major summer habitat for manatees and a minor winter refuge; it would contribute, but not be sufficient, to meet the objectives of this plan.

Alternative 4: <u>Expand the Chassahowitzka National Wildlife Refuge to incorporate shorelines along the lower Homosassa River</u>

Addition of lands adjacent to Chassahowitzka Refuge would protect the lower Homosassa River and estuary. This acquisition could be authorized under either the Wildlife Refuge Act or the Migratory Bird Conservation Fund. This alternative would aid in protection of manatee access to an important winter refuge and summer habitat in the estuary. It would contribute, but not be sufficient, to meet the objectives of this plan.

Alternative 5: <u>Acquire wetlands adjacent to St. Martins Marsh Aquatic Preserve</u>

Wetlands adjacent to St. Martins Marsh Aquatic Preserve could be acquired by state programs, possibly with matching funds from federal programs. Some of the islands in the preserve are already owned by the state; however, lands on both sides of the Salt River need to be protected. This area is migratory bird habitat, adjacent to proposed additions to Chassahowitzka NWR, and it also contains islands essential to protection of the coastal zone; therefore funding from three federal programs might be appropriate. This alternative would contribute to protection of a travel route between the winter refuges, summer habitat and possibly calving areas. This alternative would contribute, but not be sufficient, to meet the objectives of this plan.

Alternative 6: <u>Expand the Waccasassa Bay State Preserve to incorporate wetlands and creeks along the lower Withlacoochee River</u>

Wetlands at the mouth of the Withlacoochee River could be considered for state acquisition to be included in the Waccasassa Bay State preserve. Some of the islands at the mouth of the river are also of historic value possibly making them appropriate for acquisition by the Coastal Zone Management program. Because the Withlacoochee estuary is important summer habitat for manatees, this alternative would contribute, but not be sufficient, to meet the objectives of this plan.

Alternative 7: Designate additional areas of Critical Habitat

Land acquisition programs (as well as regulatory programs) may be enhanced by official designation of core areas of manatee habitat as "Critical Habitat" under the Endangered Species Act. From a biological perspective, areas critical for continued increase of Crystal River manatees include: the entire Homosassa River; the estuaries and lower portions of the Suwannee, Withlacoochee, and Chassahowitzka rivers; and travel corridors adjacent to the coast between the Withlacoochee and Homosassa rivers. At a minimum, the Homosassa and lower Suwannee rivers should be designated Critical Habitat. This alternative will contribute, but not be sufficient, to meet objectives of this plan.

Alternative 8: Negotiate lesser-than-fee rights to manage development in coastal wetlands between the Withlacoochee and Crystal Rivers

Considering current land-use adjacent to the Crystal River power plant, it may be possible to maintain essential functions of surrounding wetlands by negotiated agreement rather than land purchase. This alternative would contribute, but not be sufficient, to meet the objectives of this plan.

Alternative 9: Designate the Big Bend Seagrass Beds as a Marine Sanctuary

Marine habitat for manatees could be protected by designation of the Big Bend Grassbeds as a Marine Sanctuary. Proposed boundaries should be expanded to include more of the seagrass beds within the South Big Bend Manatee management area. Development along the coast could still occur adjacent to the Marine Sanctuary. This alternative would contribute, but not be sufficient, to meet the objectives of this plan.

5.4 Information Needs

The current patterns of land ownership and availability of funds need to be determined before the feasibility of these options can be fully evaluated. Additional information on the movements of manatees outside Crystal River needs to be obtained to provide a better basis for evaluating land acquisition needs.

5.5 Recommendations

To assure the maintenance of the current quality of manatee habitat, all seagrass beds and coastal wetlands in South Big Bend need to be protected (Alternatives 2-9). Land acquisition should proceed in the priority listed, but all options need to be explored and the finalization of any portion thereof will contribute more to meeting the objectives of this plan than no action. In this subsection, the recommended management policy is outlined, then the actions needed to implement this policy are described.

5.5.1 Management policy

The management policy should consist of the following elements:

a) encourage the expansion or addition of State and Federal refuges, reserves, preserves, parks, etc. in or adjacent to essential manatee habitats;

b) incorporate a full complement of essential summer, winter, and migratory habitat for manatees into the regional system of state and federal protected areas;

c) encourage the development of research and management programs and plans at established refuges, reserves, preserves, and parks which contain essential manatee habitat such that they address manatee protection needs to the extent possible; and

d) designate as Critical Habitat those areas identified as core manatee habitat.

5.5.2 Local governments

The value of wetlands for fish and wildlife resources needs to be recognized by local governments, such that local actions do not interfere with the management policy listed above (Subsection 5.5.1). The following actions are needed:

a) hold action on improvements (sewer, utilities) to areas under consideration for acquisition by state and federal programs until land-acquisition decisions are finalized;

b) zone wetlands for conservation and recreational uses such that the land has no value for residential or commercial use;

c) determine the feasibility and need for acquiring fee title or development rights to wetlands between the Withlacoochee and Crystal rivers.

5.5.3 Department of Natural Resources

The Division of State Lands and the Division of Parks and Recreation need to:

a) recommend acquisition of the lands listed under the CARL program, which are adjacent to Crystal River;

b) recommend acquisition of the addition to Cedar Key Scrub State Reserve;

c) list lands between the proposed boundaries of the Lower Suwannee NWR and Manatee Springs State Park as under consideration for acquisition;

d) list lands adjacent to St. Martins Marsh Aquatic Preserve as being under consideration for acquisition;

e) list wetlands adjacent to the lower Withlacoochee as under consideration as an addition to the Waccasassa Bay State Preserve;

f) determine the feasibility and need for acquiring fee title or development rights to wetlands between the Barge Canal and Crystal River;

g) recommend acquisition of Chassahowitzka Swamp; and

h) provide for protection of manatees in the management plans of state preserves within South Big Bend.

5.5.4 Trustees of the Internal Improvement Trust Fund (Governor and Cabinet)

In order to implement this management policy, the governor and cabinet need to:

a) approve acquisition of listed CARL lands adjacent to Crystal River;

b) approve acquisition of Cedar Key Scrub State Reserve;

c) request recommendations regarding additional acquisitions along the Suwannee River adjacent to Manatee Springs State Park;

d) request recommendations regarding land acquisition adjacent to St. Martins Marsh Aquatic Preserve

e) request recommendations regarding acquisitions between Waccasassa Bay State Preserve and Withlacoochee River; and

f) approve acquisition of Chassahowitzka Swamp.

5.5.5 U.S. Fish and Wildlife Service

Action needs to be initiated within the Department of Interior to:

a) establish the Crystal River Manatee National Wildlife Refuge with a budget for a refuge manager, interpretive naturalist, enforcement officer, research, interpretive program, and office in Crystal River;

b) conduct an on-site biological inspection of wetland and upland areas along the Crystal River and prepare an ascertainment report assessing the merits of adding such areas to the proposed Crystal River Manatee NWR;

c) complete acquisition of the Lower Suwannee NWR;

d) list lands adjacent to the northern boundary of Chassahowitzka NWR as under consideration for addition to the refuge; and

e) list the lower Suwannee, lower Withlacoochee, Chassahowitzka and Homosassa rivers as Critical Habitat under the provisions of the Endangered Species Act;

f) recommend extension of the proposed Big Bend Grassbeds Marine Sanctuary to include all seagrass beds in the South Big Bend management area; and

g) provide for protection of manatees in the management plans of federal refuges within South Big Bend.

5.5.6 Office of Coastal Ocean Resource Management

The following actions would aid in meeting the objectives of this plan:

a) expand the boundaries of the proposed Big Bend Grassbeds Marine Sanctuary to include Crystal Bay; and

b) approve designation of the Big Bend Grassbeds site as a Marine Sanctuary.

6. WARM WATER SPRINGS: WATER DEMANDS

If the quantity or salinity of water flowing from natural springs in Kings Bay and Homosassa River were altered, the value of those areas as warm water refuges for manatees could change (see Subsection II.5). At a reduced flow rate, a smaller volume of water would be warmed during the winter, and manatees would be more likely to be exposed to cold stress (Table 30). Reduced flow or increase salinity could also result in degradation of estuarine vegetation and changes in plant communities in Kings Bay. The sequence of recommended actions, which are based on the following analysis, is outlined in Section V.

6.1 Site-specific Evaluation of Impacts

The locations of warm water refuges in South Big Bend are shown in Figure 29; Crystal River and Homosassa River are the most important refuges. There are many springs in Kings Bay, headwaters of Crystal River (Figure 36), of which manatees aggregate primarily at the Main Spring and at Gator Hole (Figure 37, Kochman et al. 1983).

The major spring on the Homosassa River, Blue Waters, is inaccessible to manatees except at high water. Manatees aggregate in the warm water plume flowing from the spring (Figure 27). Springs on the Chassahowitzka River are in water too shallow for manatee access. Manatees enter the spring run at Manatee Springs but water depths are too shallow for them to rest at the edge of the Spring. Although manatees are attracted to the warm-water discharge of the Crystal River power plant, it is not used consistently as a warm-water refuge (Powell and Rathbun 1983).

Although the general areas of recharge for these springs are known (Mann and Cherry 1969), groundwater flow in the area is not known in detail. The area in which wells would withdraw water from the aquifer that feeds Crystal and Homosassa Rivers is not known, nor is the exact area of recharge. However, the aquifer is under consideration as a possible source of water for urban areas outside the Withlacoochee Region (refer to Subsection II.5.5).

If spring discharge is altered, the thermal gradients in Kings Bay would be affected, but the extent has not been determined. For example, it is unknown whether some springs would cease to flow, or if the rate of flow of all springs would be reduced equally.

6.2 Current Regulations

The consumptive use of water in South Big Bend is regulated by the Suwannee River Water Management District (SRWMD) and the Southwest Florida Water Management District (SWFMD). Although domestic consumption of water by individual users is exempt from regulation, a permit is required for all other uses (Hamann 1981b). Applicants must show that the proposed water use is "reasonable-beneficial", will not interfere with existing water uses, and is consistent with the public interest.

Table 30. Impacts on manatees due to changes in warm water refuges.

Potential impact	Factors influencing probability of impact	Explanation
Exposure to cold stress, increased vulnerability to lethal factors, emigration	Reduced flow from natural springs	If hydrostatic pressure of the aquifer is reduced due to wells, mining, dredging, or reduced recharge, the volume of warm-water may be reduced. Water around springs may drop in temperature. Exposure of manatees to cold may increase. Under cold stress, manatees are more susceptible to lethal factors such as disease, parasite loads, and they may be sluggish in avoiding boat collisions. Over the long term, manatees are likely to leave the area for warmer refuges.
	Industrial effluents	If warm-water industrial discharge is interrupted when industrial operations cease, manatees may be vulnerable to cold stress.

Thus, water management districts have the authority to deny permits for uses that are not in the public interest (Maloney and Hamann 1981). Any use that substantially reduces the flow of springs in Crystal and Homosassa Rivers could be determined to be contrary to the public interest in maintaining critical elements of manatee habitat (as well as maintaining recreational values and commercial fisheries).

The Department of Environmental Regulation (DER) or the water management districts can designate an existing water use that should be given preference in granting of consumptive use permits (Maloney and Hamann 1981). Future uses of designated water resources may also be prohibited if inconsistent with the protection of wildlife. Although the State Water Use Plan does not currently provide specific protection for discharge of natural springs in Crystal and Homosassa rivers, these designations could be added to the plan.

State law also provides for the determination of minimum flows for surface water, and minimum levels for lakes and groundwater (Maloney and Hamann 1981). The SRWMD is currently conducting studies to determine minimum flow for the Suwannee River, and the SWFMD is in the planning stage of studies to determine minimum flows for the rivers along the west coast from Waccasassa to Anclote Keys. Maintenance of estuarine ecology and wildlife habitat are to be considered in establishing minimum flow rates.

Water management districts can comment on land-use management by local governments. However, the regional planning council is in a better position to coordinate land-use planning in the counties that contain recharge areas. Both agencies also aid in development of regional water supply systems. The Withlacoochee Regional Water Supply Authority (WRWSA) is currently examining the possibility of becoming a major supplier for counties in the Withlacoochee region (Swetman 1983).

The WRWSA and Withlacoochee Regional Planning Council (WRPC) requested a study, which has been completed by the Army Corps of Engineers, to identify alternative water supply plans (Swetman 1982). If the environmental effects of water withdrawal becomes an issue, the WRPC and SWFMD are in a position to request a study of recharge areas supplying Gulf Coast springs, and to act upon land-use recommendations.

6.3 Alternative Management Options

Options for maintaining warm water refuges in South Big Bend are listed in this subsection. Recommendations regarding implementation of options that best meet Objective 5 of this plan are described in subsection 6.5.

Alternative 1: No action

Under current regulations, SWFMD and SRWMD are conducting studies to determine minimum flow for the Gulf Coast rivers under their jurisdictions. Because sufficient flow to sustain the estuarine ecology will be maintained, it is unlikely that water uses that substantially reduce the flow of springs will be permitted. However, if those studies determine that minimum flow may be set at levels lower than current flow, the effects on thermal gradients and subsequent effects on manatee behavior will need to be determined. The possibility that this option will meet Objective 5 of this plan will thus be dependent on the outcome of minimum flow studies.

Alternative 2: Add manatee needs to State of Florida Water Use Plan

Preservation of the flow from natural springs supplying Gulf Coast rivers could be specified in the State Water Use Plan as having priority over consumptive use of water in the Withlacoochee Region. Reduction of spring flow would negatively affect estuarine vegetation and Aquatic Preserves as well as manatee refuges. Any use that reduced the flow of springs could thus be denied permits by SWFMD. However, without a hydrological study, there would be no basis for determining the level of withdrawal that would affect the springs. This option would contribute, but in the long-term may not be sufficient, to meet Objective 5 of this plan.

Alternative 3: Hydrological study of warm-water springs

The effects of different flow rates on the winter thermal characteristics of Kings Bay and Homosassa River could be modeled. This would provide the information needed to evaluate the effect on manatees of minimum flow that is determined by SWFMD to be necessary to maintain the estuarine ecology of the region. Evaluation of this alternative is the same as for Alternative 1.

Alternative 4: Allow additional construction of an industrial plant with warm-water discharge

Artificial warm-water refuges created by industrial effluents can present hazards to manatees if operation is interrupted during cold periods or if manatees can become trapped (Subsection II.5.5). Industrial effluents are not suitable alternatives to maintenance of natural warm-water springs. This alternative would not meet the objectives of this plan.

6.4 Information Needs

More information is needed regarding (a) the effect of water withdrawal and alteration of recharge areas on the flow of springs in Crystal, Homosassa and Chassahowitzka rivers, and (b) the effect of flow rates on thermal gradients in Kings Bay and the headwaters of the Homosassa River. These factors are essential to establish both a minimum flow that would maintain warm water refuges for manatees, and the allowable water consumption permitted to maintain this flow.

6.5 Recommendations

Decisions regarding long-range planning of consumptive water use in the Withlacoochee Region will be made in the next few years. The needs of manatees for warm water refuges in South Big Bend must be included in water-use plans (Alternative 2) and the thermal effects of a reduction in spring discharge should be modelled (Alternative 3). In this subsection, the recommended management policy is outlined, then the specific actions that would be required to implement the policy are described.

6.5.1 Management policy

To maintain warm-water refuges for manatees, the management policy should consist of the following elements:

a) it is in the public interest to maintain the flow of springs that serve as warm-water refuges for manatees;

b) the springs in Crystal River and Homosassa River merit priority use over consumptive use of water in the Withlacoochee Region, due to their value for recreation, education, scientific inquiry and habitat preservation for an Endangered Species;

c) consumptive use permits that would reduce the flow of the springs, considering cumulative effects of water withdrawals from the aquifer supplying the springs, should be considered contrary to the public interest and as interfering with existing water use;

d) a scientific basis should be provided for determining the effects of water uses, and of land-use in recharge areas, on warm-water refuges for manatees;

e) warm industrial discharges are not a suitable alternative to natural springs to provide winter refuges for manatees; and

f) warm-water springs and discharges should be maintained in a manner that they are accessible to manatees.

6.5.2 Department of Environmental Regulation

The importance of maintaining the flow of springs in Crystal and Homosassa Rivers needs to be included in the State Water Use Plan. The plan should identify the high priority of existing use of water supplying these rivers due to recreational, scientific, educational and wildlife values. If SWFMD authorizes a permit for consumptive use that would interfere with the flow of the springs, DER needs to challenge the action.

6.5.3 Southwest Florida Water Management District

In addition to investigating the effects of minimum flow from Gulf coast rivers on benthic ecology, SWFMD needs to consider the effects of minimum flow on warm-water refuges essential to survival of manatees in South Big Bend. A study of the effects of flow rates on the thermal characteristics of Kings Bay and Homosassa River needs to be conducted. Consumptive use permits that would reduce the value of springs as warm-water refuges for manatees should be denied. The cumulative effects of water withdrawals and potential changes in recharge rates need to be considered in evaluating the effects of proposed water consumption. Planning should provide for an adequate supply in drought years, because the manatees in South Big Bend have no alternative warm-water refuges. A hydrologic study is needed to determine patterns of groundwater flow that influence the spring flow rates, and recharge areas, e.g. via a contract with the U.S. Geological Survey. Once recharge areas have been identified, SWFMD needs to work with the Withlacoochee Regional Planning Council and local governments to insure that wastewater discharge and land use in recharge areas does not reduce recharge rates. If unsuccessful, SWFMD should implement stronger regulations under Part IV of Chapter 373 to protect recharge areas.

6.5.4 Withlacoochee Regional Planning Council

The WRPC needs to work with the counties that contain portions of the recharge area for coastal springs, in order to insure that recharge rates will not be reduced. Activities such as the creation of impermeable surfaces, and discharge of wastewater and stormwater into flowing waterways may need to be regulated by county ordinances.

6.5.5 U.S. Fish and Wildlife Service

Behavior of manatees relative to temperature gradients in Kings Bay and Homosassa River needs to be investigated. This should be done as part of the studies investigating the effects of human behavior on manatees (see Subsection 2.5.3).

Section V

SECTION V

STEPDOWN PLAN

Recommended actions, as identified in Section IV, are summarized and coordinated in the following Stepdown Plan. The plan specifies responsibilities of lead agencies and cooperating agencies. The implementation schedule is indicated by initiation dates. Many regulatory actions, which do not require funding or collection of additional information, can be accomplished immediately. Where actions require additional input for implementation, the plan specifies actions needed to avoid any irreversible alterations until required funding, information, and/or planning is completed. Required funding is estimated where possible.

The Stepdown Plan is organized in the same categories used in Section IV for analysis: 1) location of boating facilities and navigation channels, 2) operational aspects of waterborne activities, 3) water quality and vegetation, 4) land development adjacent to manatee habitat, 5) habitat protection, 6) effects on warm-water refuges utilized by manatees. In addition, there are subsections on research and monitoring programs, and on implementation of this plan.

LEAD AGENCIES	COOPERATING AGENCIES	TASKS	INITIATION DATE (Funding)
		1. Construction of Boating Facilities	
COE DER	FWS DNR GFC	1.1 Prohibit dredging of major channel projects likely to increase the frequency of vessel-manatee interactions, and/or to reduce or degrade aquatic vegetation utilized by manatees.	Immediately (none)
		1.2 Reduce unplanned construction of boating facilities in and adjacent to Crystal, Salt, and Homosassa rivers until a regional plan is adopted and implemented (see 1.4 below).	
ZBA DNR DER COE	FWS GFC	1.2.1 Limit dock size by denying permits for ramp, dock or marina construction, expansion and improvement, but allowing small docks for which permits are not required.	Immediately (none)
COE DNR DER	FL	1.2.2 Monitor cumulative effects of minor dredge and fill projects by withdrawing COE general and nationwide permits, DNR consent of use by rule for activities on sovereignity submerged lands, and DER exemptions and general permits under chapters 253 and 403 and COE approval of state actions under SAJ49.	Immediately (none)
TIIF	DER DNR	1.2.3 Continue the moratorium on DNR permits for construction of docking facilities until actions 1.2.1, 1.2.2 and 1.4 are implemented.	Ongoing (none)
COE	FWS	1.2.4 Place a moratorium on COE individual permits for dredge and fill adjacent to manatee Critical Habitat.	Immediately (none)
		1.3 Plan for the development of docking facilities that will meet the management policy of this plan (Section IV.1.5).	

LEAD AGENCIES	COOPERATING AGENCIES	TASKS	INITIATION DATE (Funding)
DCA	DER GFC DNR FWS COE WRPC NCFRPC CCPD CRPD	1.3.1 Appoint a Resource Planning and Management Committee (RPMC) to develop a plan specifying the location, size and design constraints for boating facilities. (See also Tasks 3.2.1 and 4.2.3).	Immediately (none)
WRPC	DNR FWS CZM	1.3.2 Contract for a study of current and projected patterns of boat traffic under several alternative plans for development of boating facilities, and identify the optimum plan that will meet the manatee management policy and the needs of the boating public.	Within 4 mo. following first RPMC meeting ($50,000)
DNR	DER COE FWS	1.3.3 Prepare and adopt a management plan for the St. Martin's Marsh Aquatic Preserve that is consistent with the manatee management policy specified in Section IV.1.5.	Immediately (none)
DNR	CZM	1.3.4 Determine mean high water line in Crystal River.	FY 85 ($10,000)
		1.4 Implement a plan specifying the number, size, location and design constraints of marinas, docks, ramps, slips and navigation channels in South Big Bend, such that the cumulative development, existing and future, will not exceed a boating carrying capacity established for South Big Bend.	
RPMC	Same as 1.3.1	1.4.1 Specify the actions required to implement the plan.	March 1986 ($15,000)

LEAD AGENCIES	COOPERATING AGENCIES	TASKS	INITIATION DATE (Funding)
CCC CRC	DER DNR COE FWS GFC	1.4.2 Adopt the regulatory measures required to implement the plan.	Within 6 mo. after Task 1.4.1 (none)
TIIF	DER DNR COE CCPD CRPD ZBA GFC	1.4.3 If appropriate regulatory measures are not adopted, designate South Big Bend to be an Area of Critical State Concern and implement regulations consistent with the manatee management policy until such regulations are adopted.	December 1985 (none)
FWS COE EPA		1.4.4 If appropriate regulatory measures are not adopted by local or state authorities, implement the tasks identified in 1.4.1 under federal authority over manatee Critical Habitat.	June 1986 (none)
		2. <u>Operational Aspects of Waterborne Activities</u>	
		2.1 Strengthen regulatory measures to reduce injury, death and harassment of manatees in South Big Bend.	
DNR	COE	2.1.1 Mark the channel in Crystal River and establish idle speed zones in shallow areas between the channel and the shoreline.	April 1984 (to be determined)
DNR	FWS	2.1.2 Extend the period of state speed regulations and federal sanctuaries to better cover the period that manatee aggregate in Crystal River, e.g. October 1st through March 31st.	April 1984 (none)
FWS DNR	GFC	2.1.3 Improve law enforcement capability by assigning additional officers' time.	FY 85 ($50,000)

LEAD AGENCIES	COOPERATING AGENCIES	TASKS	INITIATION DATE (Funding)
DNR	COE	2.1.4 Post and maintain regulatory signs required for enforcement of speed zones.	Ongoing
DNR	FWS GFC	2.1.5 Require tangle-resistant sleeves on crab trap lines and other buoys placed in Kings Bay, Crystal River and Homosassa River.	October 1984 (none)
		2.2 Strengthen non-regulatory measures to reduce negative effects on manatees of boating, fishing, diving and snorkeling.	
FWS DNR		2.2.1 Train volunteer Manatee Watch patrol to provide on-site information to the public on proper conduct in manatee areas, and to provide authorities with information that enhances law enforcement.	Ongoing (none)
FWS DNR	CCSD SMC	2.2.2 Develop an active interpretive program in Crystal River to educate the public about manatees (See Tasks 2.2.3, 5.1.2).	FY 85 ($50,000)
SMC	FWS DNR	2.2.3 Plan, raise funding and construct a nature center to provide facilities for an interpretive program and a year-round display of manatee information for the public (See Task 5.1.4).	
DNR	FWS COE SMC	2.2.4 Post signs at all water access points and federal sanctuaries to explain regulations in manatee areas (See Task 5.1.2) and caution signs at hazardous sites.	February 1984 ($50,000)
		2.3 Evaluate the need for additional regulation of waterborne activities.	

LEAD AGENCIES	COOPERATING AGENCIES	TASKS	INITIATION DATE (Funding)
FWS DNR		2.3.1 Investigate the effects on manatee distribution and behavior of human activities in Kings Bay/Crystal River (See Task 5.1.2).	FY 85-86 ($150,000)
FWS DNR		2.3.2 Evaluate the effectiveness of non-regulatory measures for reducing harm inflicted on manatees (See Task 5.1.2).	FY 85-86 (included in Task 2.3.1)
		3. Water Quality and Aquatic Vegetation	
		3.1 Quantify water quality standards for Kings Bay/Crystal River.	
DER		3.1.1 Quantify water quality in Kings Bay and develop interim water quality standards.	March 1984
DER	FWS DNR USGS EPA COE	3.1.2 Prepare and validate a hydrologic model required to establish water-body based effluent standards for areas in Kings Bay/Crystal River designated as OFW; model should include human related inputs from upland drainage, septic systems, stormwater runoff and point source effluents as well as natural physical and biological inputs and should asses periodic peaks as well as chronic conditions.	March 1984 ($150,000)
DER	FWS DNR	3.1.3 Monitor water quality at the Crystal River sewage treatment plant effluent and adjacent to package plants; and define mixing zone.	March 1984
		3.2 Strengthen enforcement of regulatory measures to maintain water quality in coastal waters and rivers.	
CCC		3.2.1 Adopt ordinances regarding construction in wetlands and stormwater runoff.	Immediately (none)

LEAD AGENCIES	COOPERATING AGENCIES		TASKS	INITIATION DATE (Funding)
DER HRS	COE	3.2.2	Change rules governing permitting of individual sewage systems to restrict use in coastal areas flooded frequently even if not for long duration and having severe soil limitations for percolation.	Immediately (none)
DER DRS	FWS COE	3.2.3	Clarify agency jurisdiction over wetlands adjacent to Crystal River by defining mean high water line and adopting a map specifying areas unsuitable for individual sewage systems or fill to install such systems (See Task 1.3.4).	Immediately
DHS	CHD	3.2.4	Require sewage line hook-ups for new construction in soil types with severe restrictions for septic systems; and deny permits for new construction of individual septic systems in such areas until a plan to control the cumulative effects of drainage from individual sewage systems has been implemented.	Immediately (none)
DER	EPA	3.2.5	Require that new construction of stormwater drainage systems provides on-land water-retention facilities.	Immediately (none)
DER	EPA	3.2.6	Enforce effluent discharge standards (including mixing zone limitations) permitted for the Crystal River sewage treatment plant utilizing information from Tasks 3.2.1 and 3.2.2 as relevant.	Immediately (none)

LEAD AGENCIES	COOPERATING AGENCIES	TASKS	INITIATION DATE (Funding)
		3.3 Develop and implement long-range plans for accomodating increased needs for sewage treatment in the Crystal River/Ozello/Homosassa area, while meeting the manatee management policy described in Section IV.3.5.	
CCR	DER EPA DHS	3.3.1 Deny permits for sewage hook-ups that would exceed the planned capacity of the Crystal River sewage treatment plant.	Immediately (none)
RPMC	DER FWS EPA CC ZBA	3.3.2 Utilizing the results of Task 3.1, revise local regulations to maintain water quality standards, considering the cumulative effects of wastewater inputs to coastal waters (coordinate with Task 1.3.1).	6 mo. after Task 3.1 (included in Task 1.4.1)
CCC	CRPC WRPC	3.3.3 Develop plans for construction by 1993 of additional sewage treatment facilities in western Citrus County, with on-land retention of wastewater.	Immediately (to be determined)
		3.4 Maintain quantity and quality of acquatic vegetation available to manatees and minimize exposure to aquatic herbicides.	
DNR	FWS CCSD	3.4.1 Educate the public regarding potential effects of aquatic weed control on manatees.	January 1983 (ongoing)
DNR	ASD COE FWS	3.4.2 Discontinue use of herbicides in areas designated as slow speed zones, during periods that those zones are in effect.	October 1984

LEAD AGENCIES	COOPERATING AGENCIES	TASKS	INITIATION DATE (Funding)
ASD COE	DNR FWS	3.4.3 On an experimental basis, evaluate the feasibility of mechanical harvesting to maintain navigation channels in manatee feeding areas.	October 1984
DNR		3.4.4 Relative to 1982 quantities, (Table 19) reduce the gallons of herbicides applied annually to aquatic weeds in South Big Bend.	October 1984 (none)
		3.5 Monitor effects of water quality on aquatic organisms in the management area.	
FWS	DNR	3.5.1 Continue the manatee carcass salvage/ necropsy program, including analysis of contaminants in tissue samples.	Ongoing
		4. <u>Development: Seawalls, Dredge and Fill, Zoning</u>	
		4.1 Reduce unplanned development affecting manatee habitat until a regional plan meeting the manatee management policy (Section III.4.5) is adopted and implemented.	
CCPD	DNR DER COE FWS	4.1.1 Hold action on permits for seawalls, dredge and fill in areas adjacent to manatee habitat and for construction in areas draining into waterways of, or wetlands adjacent to, manatee habitat (see Tasks 1.2.3, 1.2.4).	Immediately (none)
COE DER DNR	FWS	4.1.2 Monitor cumulative effects of minor projects by withdrawing general permits and exemptions for land adjacent to core manatee habitat. (See Task 1.2.2).	Immediately (none)

LEAD AGENCIES	COOPERATING AGENCIES	TASKS	INITIATION DATE (Funding)
		4.2 Plan for the development of coastal lands in a manner that meets the manatee management policy (Section IV.4.5).	
CCPD	FWS DNR	4.2.1 Recommend revisions to the Citrus County Zoning Ordinance that are consistent with the Comprehensive Plan goals to conserve estuarine and coastal resources (See IV.4.5).	Immediately (ongoing)
DNR	CCPD CRPD	4.2.2 Identify areas adjacent to the City of Crystal River that are not suitable for annexation due to the potential impacts of development on manatee habitat (See IV.5.).	Immediately (none)
RPMC	WRPC NCFRPC CCPD	4.2.3 Identify areas in South Big Bend that are suitable for high density or cluster development and coordinate with regional plans for development of docking facilities and wastewater treatment (see Tasks 1.4.1, 3.3.2).	Immediately following completion of Task 1.3.1 (none)
		4.3 Implement the plan developed in Task 4.2.	
CCC		4.3.1 Revise Citrus County Zoning ordinance.	Following Task 4.2.1 (none)
CCC	CRC	4.3.2 Deny annexation of lands identified as unsuitable for high-density development.	Following Task 4.2.2 (none)
CCC CRC	ZBA RPMC	4.3.3 Revise ordinances and guidelines for approving variances to ordinances as recommended in 4.2.3.	Following Task 4.2.3 (none)

LEAD AGENCIES	COOPERATING AGENCIES	TASKS	INITIATION DATE (Funding)
		5. Protection of Manatee Habitat	
		5.1 Establish Crystal River Manatee National Wildlife Refuge.	
FWS	DNR TNC	5.1.1 Designate the islands of Kings Bay as the Crystal River Manatee National Wildlife Refuge.	Immediately
FWS	DNR	5.1.2 Prepare a refuge management plan and provide an operating budget for a full time refuge manager, an interpretive naturalist, an enforcement officer, an interpretive program, research, and posting and repair of signs (See Tasks 2.1.3, 2.1.4, 2.2.1, 2.2.2, 2.2.4, 2.3.1, 2.3.2, 5.1.3, 8.2)	FY 84
FWS		5.1.3 Conduct aerial surveys of manatees in South Big Bend (See Task 7.1.1, 7.1.3.).	FY 84
FWS	SMC DNR	5.1.4 Acquire and develop a suitable facility for refuge headquarters in Crystal River (See Task 2.2.3).	FY 84
FWS		5.1.5 Assign principal responsibility to the refuge manager for monitoring and coordinating implementation of this plan (See Task 8.2).	FY 84
FWS	TNC DNR	5.1.6 Conduct biological inspection of wetlands and associated uplands adjacent to Crystal River and prepare ascertainment report regarding acquisition of such areas.	FY 84

LEAD AGENCIES	COOPERATING AGENCIES	TASKS	INITIATION DATE (Funding)
FWS	TNC DNR	5.1.7 As appropriate, acquire additional shoreline areas for incorporation into the National Wildlife Refuge system.	After Task 5.1.6
FWS	DNR TNC	5.2 Complete acquisition of lands planned for inclusion in the Suwannee River National Wildlife Refuge and provide in its management plan and budget for actions related to manatee protection, such as public education, enforcement, sign posting and repair.	Ongoing
DNR	TNC	5.3 Complete proposed state acquisitions within South Big Bend.	
		5.3.1 Purchase the wetlands south of Crystal River; combine with the parcel north of the river into a state preserve; prepare a management plan for the preserve which provides for manatee protection.	Ongoing
		5.3.2 Purchase the proposed acquisition adjacent to Cedar Key Scrub state preserve and include it in the preserve; prepare a management plan that includes provisions for manatee protection.	Ongoing
		5.3.3 Purchase the proposed Chassahowitzka Swamp acquisition.	Ongoing
		5.4 Increase protective measures regarding non-public lands adjacent to manatee habitat.	
FWS		5.4.1 Designate core manatee habitat in the Homosassa River, lower Withlacoochee River and Suwannee River as Critical Habitat.	Immediately (none)

LEAD AGENCIES	COOPERATING AGENCIES	TASKS	INITIATION DATE (Funding)
DNR	GC FL	5.4.2 Designate Crystal River as an Aquatic Preserve or expand St. Martins Marsh Aquatic Preserve to include the Crystal, Salt, and Homosassa rivers.	Immediately (none)
DNR	CCPD	5.4.3 Negotiate and purchase a less than fee interest in the coastal wetlands between the Withlacoochee River and Crystal River to control development activities.	January 1985
NMFS	FWS	5.5 Designate the Big Bend Grass Beds Site (GC-6) as a Marine Sanctuary.	Immediately (ongoing)
		6. <u>Warm-water Springs: Water Demands</u>	
DER	SWFWMD SRWMD	6.1 List the flow from springs on the Crystal, Homosassa, Suwannee and Chassahowiztka rivers as a priority consumptive water use in the State Water Use Plan	Immediately (none)
SWFWMD SRWMD		6.2 Deny water use permits for activities likely to reduce the flow of water from springs listed in 6.1.	
SWFWMD	USGS	6.3 Conduct hydrologic studies of the springs at Kings Bay and Homosassa to determine flow rates, recharge areas and the effects of flow rates on thermal gradients surrounding the springs.	FY 86 ($100,000)

LEAD AGENCIES	COOPERATING AGENCIES	TASKS	INITIATION DATE (Funding)
		7. <u>Research and Monitoring Programs</u>	
		7.1 Monitor trends in manatee abundance, reproduction, recruitment, mortality, distribution immigration and emmigration in South Big Bend.	
FWS		7.1.1 During winter aggregations, conduct same-day aerial surveys of manatees at all four warm-water refuges in South Big Bend (See Task 5.1.2).	Ongoing ($3,000)
FWS	DNR	7.1.2 Continue manatee salvage/necropsy program to monitor causes of manatee mortality, rates of human-related mortality, and rates of perinatal mortality (See Task 3.5.1).	Ongoing
FWS		7.1.3 Determine summer distribution of manatees by aerial surveys of rivers in South Big Bend (See Task 5.1.5).	Ongoing
FWS		7.1.4 Continue identification and resighting studies to monitor individual reproductive rates and movements.	Ongoing
FWS		7.2 Characterize manatee activities within summer habitat by continuing and expanding radio tracking studies.	Ongoing
FWS		7.3 Assess ecological and social factors influencing population dynamics, such that criteria for determining levels of optimum sustainable abundance may be identified.	Ongoing

LEAD AGENCIES	COOPERATING AGENCIES	TASKS	INITIATION DATE (Funding)
FWS		7.3.1 Determine patterns of social behavior influencing individual reproductive success, such as spacing, mate selection, maternal care, etc.	Ongoing
FWS		7.3.2 Determine patterns of foraging behavior and influences on renewal of food resources.	FY 86
FWS		7.3.3 Determine salinity tolerances and implications for feeding on marine vegetation.	FY 86
		8. <u>Implementation of this Plan</u>	
		8.1 Coordinate actions recommended in this plan, oversee implementation and, as necessary, change the plan as more information becomes available.	
FWS DNR	All Agencies	8.1.1 Organize a Steering Committee consisting of representatives from agencies and groups involved in recommended actions.	Immediately
DNR FWS	All Agencies	8.1.2 Convene the Steering Committe at least annually to coordinate tasks, evaluate progress in meeting objectives, revise tasks, lead agencies, target dates and funding levels as needed.	
FWS		8.2 Assign a person whose primary responsibility is working with citizens, local, state and federal agencies to implement the plan, evaluating effectiveness of actions, and preparing an annual update; the manager of Crystal River Manatee National Wildlife Refuge should assume these responsibilities when hired (See Task 5.1.5).	Immediately

Section VI

SECTION VI
EXECUTIVE SUMMARY

1. Background: This proposed research/management plan has been developed to protect manatees in South Big Bend--an area that extends from the Suwannee River to the Chassahowitzka River and includes the famous wintering waters of Crystal River. As part of Florida's few remaining intact coastal ecosystems, South Big Bend provides a haven for manatees as well as exceptional recreational opportunities. Adjacent counties are part of the growth centers of Florida. Planning is imperative to meet the needs of South Big Bend's manatees--even as human communities develop.

2. Objectives: The purpose of this plan is to provide decision-makers and citizens with guidelines necessary for the increase and long-term survival of manatees in South Big Bend's waters. To meet this goal, objectives of the plan address both the direct effects of human activities on manatees and indirect effects on their essential habitat. This plan outlines specific criteria to evaluate progress in meeting the objectives.

3. Recommendations: This plan should be reviewed and implemented by a steering organized appointed by the U.S. Fish and Wildlife Service. A Resource Planning and Management Committee should be appointed by Florida's Department of Community Affairs to aid local governments in resolving pressing needs for regional planning regarding boating facilities, water quality and wetland protection. South Big Bend should be designated as an Area of Critical State Concern if necessary to implement such plans.

Additional information is needed regarding regional needs for docking facilities, the effects of human activities on manatee behavior, water quality in the Kings Bay area, and the factors influencing the flow of natural springs used by manatees. Research to provide such information should be immediately initiated to aid long-range planning. Ongoing studies on manatee abundance, distribution, ecology and behavior should be continued.

Staff at the new Crystal River Manatee National Wildlife Refuge should take the lead in updating the plan and protecting Crystal River manatees and their habitat. An associated private educational/research center should be developed to provide displays and an active interpretive program. Through an enhanced public education effort, harm to wintering manatees may be minimized, thus avoiding the need for additional regulations.

4. Benefits of Recommendations: Every year more than 200,000 people move to Florida--61 percent of these new residents are expected to settle along already heavily populated coasts. With intensively developed coastal areas in much of Florida, the aesthetic value of preserving, living in and visiting South Big Bend will become even more important. If South Big Bend residents take the actions necessary to protect manatees and their habitat, their local communities will surely benefit by increased tourism, higher land values and educational opportunities. In addition, fisheries, recreation and educational opportunities will be enhanced. An increase in the Crystal River manatee herd may aid in clearing waterways clogged with vegetation.

5. Manatee Needs: The survival of manatees is dependent on a plentiful and varied supply of aquatic plants, appropriate water depths, shallow secluded areas for calving, warm winter refuges, sources of fresh water, and safe travel routes among refuges and summer ranges. The coastal ecosystem that supplies manatees with these needs includes rivers, estuaries, marine waters and the associated wetlands that provide nutrients, filter upland run-off and buffer salinity fluctuations.

6. Habitat Evaluation: Some sites in South Big Bend provide manatees with many or all of their requirements, hence are core centers of activity; others provide a vital few necessities. The plan identifies Crystal, Homosassa and Suwannee rivers as areas of core habitat and recommends that these rivers are of the highest priority to protect. However, core centers are not enough to support Crystal River manatees; travel routes between these centers must also be maintained.

7. Threats to Survival: Fewer than 150 manatees live in South Big Bend. So far these animals have escaped the risks associated with the rapidly dwindling coastal habitat in the rest of Florida: barge and boat collisions; poor water quality; destruction of aquatic vegetation; locks and dams that limit access to waterways; human disturbance during birthing; and inadequate warm-water refuges. The species reproduces very slowly, hence, cannot offset these threats unless farsighted management actions are taken now to minimize such changes in South Big Bend. Maintenance of good habitat is less costly than restoration.

8. Location of Boating Facilities: To avoid the need for restrictive regulations regarding boat operation, this plan provides guidelines for the development and location of future navigation channels and docking facilities-marinas, docks, and boat ramps. By locating future development of boating facilities in areas where the overlap of boat traffic and manatee habitat is minimal, the expected increased in boat-caused manatee deaths, degradation of aquatic plant food, and exposure to contaminants will be minimized.

If recommendations of this plan are not implemented, the number of boats and the proportion of large to small boats is expected to increase at all coastal access points, except perhaps on the Chassahowitzka River. Overlap of boat traffic and manatee travel routes will probably remain the same or increase. As a result of these changes, an increase in the probability of manatee mortality is predicted. In addition, dredging and filling for docking facilities, seawalls and increased water turbidity will reduce the amount and/or quality of vegetation available to manatees.

9. Boating, Swimming and Fishing: The opportunities for the public to view manatees should be preserved and enhanced; however, regulations that protect manatees from injury, harm and harassment, must be enforced and manatee/human interactions should be studied. Via an effective public education program that explains rules of conduct in manatee areas, the need for further regulations may be avoided. Development of the Crystal River Manatee National Wildlife Refuge and an associated educational center is essential.

If recommendations of this plan are not implemented, the number of boats and swimmers around the springs in Kings Bay is expected to increase, limiting the access of manatees to warm-water refuges. Health complications or death due to cold stress will increase the probability of manatee mortality. The chances of manatee entanglement in fishing gear will increase.

10. Water Quality and Vegetation: Clean water and plentiful vegetation are vital not only to manatees but also to fisheries and recreation. Maintenance of water quality in Crystal River is still possible if permitting standards are based on a water quality model. The use of aquatic herbicides in South Big Bend should be reduced due to their potential harm to manatees.

If recommendations of this plan are not implemented, food resources for manatees in Kings Bay will remain adequate, but estuarine vegetation will decline in quantity and quality due to changes in water quality and salinity. Concentrations of copper herbicide in canal sediments will increase, as will water turbidity from nutrient loads, such as decomposition of aquatic plants killed by herbicides. Chemical contaminants and pathogens from wastewater will increase, with possible negative effects on health of manatees.

11. Land Development: Development of land adjacent to manatee habitat should be planned such that it does not disturb the natural functions of the coastal ecosystem. By setting design standards and clustering development in appropriate locations, the vast expanses of wetlands, which are so important to water quality and the beauty of the area, may be preserved. Developers will know the guidelines within which to plan their projects, thereby easing current uncertainties.

If recommendations of this plan are not implemented, waterfront development (commercial and residential) could occur along most of the Crystal, Salt and Homosassa rivers. The biological and hydrological functions of wetlands would be altered by fill in uplands and wetlands. Water quality would decline as a result of over-burdened sewage treatment facilities and individual septic systems built in soils with severe drainage limitations. Seawalls could be constructed along shorelines, destroying existing vegetation and altering the physical parameters required for regeneration of vegetation. These cumulative effects would substantially reduce the quality of manatee habitat and its ability to support manatees.

12. Land protection: The opportunity still exists to maintain the productive South Big Bend coastal ecosystem by expanding the present system of state and federal refuges, reserves and preserves to include manatee habitat that is currently unprotected or threatened.

Under existing regulations, wetlands in Waccasassa Bay and Chassahowitzka will be protected. The Suwannee estuary and adjacent wetlands will be protected when acquisition of the Lower Suwannee National Wildlife Refuge is completed. The islands in Kings Bay will be protected by the new Crystal River Manatee National Wildlife Refuge, and the Bagley Cove area on Crystal River will be protected by the state. However, the remaining wetlands between Homosassa and Withlacoochee rivers are unprotected, although two areas are under consideration for land acquisition by the state.

13. Warm water refuges: The quantity of water flowing from South Big Bend's springs needs to be maintained to insure the protection of essential warm-water refuges for manatees. If water withdrawal from the aquifer that provides spring water exceeds recharge rates, the volume of water warmed by springs may drop, salinity of river waters may increase, and flow patterns could change or cease. Estuarine and even marine vegetation could be altered. The preservation of the natural flow of these springs should merit priority over other water uses, not only due to their importance for manatees, but also for fisheries and recreational values.

Due to the state mandate to maintain minimum flows in rivers, the flow of the springs in Crystal and Homosassa Rivers will probably be protected against the effects of human water withdrawals from the aquifer that supplies the springs. However, the water flow from the springs is not currently recognized as priority use, nor has the effect of water demands on spring flow been determined. Therefore, even though current programs would appear to be operating sufficiently, the situation could change in the future as the human population grows and the demand for water is great.

14. Conclusion: Manatees have captured the imagination, respect, and scientific interest of people throughout the nation and the world. Crystal River is one of the major sites where the public can view manatees in Florida. Current development trends threaten the integrity of the coastal ecosystem that supports manatees in South Big Bend. With foresight, the survival, and growth of the Crystal River manatee subpopulation can be assured if the recommendations listed in this plan are implemented.

Section VII

SECTION VII

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Personal Communications:

Lt. Arnold, Florida Marine Patrol
Charles Bazemore, U.S. Fish and Wildlife Service
Charles Bradley, Citrus County Health Department
Edward Collinsworth, Chassahowitzka National Wildlife Refuge
Tom Dick, Citrus County Division of Aquatic Services
Helen Hood, Suwannee River Coalition
Joe Joyce, Center for Aquatic Weeds, University of Florida

Robert Prather, U.S. Fish and Wildlife Service
Patrick Purcell, Citrus County Marine Science Center
Galen Rathbun, U.S. Fish and Wildlife Service
Bruce Sabol, U.S. Army Corps of Engineers, Waterways Experiment Station,
Vicksburg, MI.

Appendices

APPENDIX A

APPENDIX A (cont'd.)

PROPOSED RESEARCH/MANAGEMENT PLAN FOR

CRYSTAL RIVER MANATEES

VOLUME III

FLORIDA COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT

UNIVERSITY OF FLORIDA

Technical Report No. 7

PROPOSED RESEARCH/MANAGEMENT PLAN

FOR CRYSTAL RIVER MANATEES

Volume III

Compendium

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Jane M. Packard, Project Leader

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117 Newins-Ziegler Hall

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U.S. Fish and Wildlife Service
75 Spring St. S.W.
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1625 I Street
Washington, D.C. 20006

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CONTRIBUTORS

David Gluckman
Attorney at Law
Route 5, Box 3965
Tallahassee, FL 32301

Richard Hamann
Center for Governmental Responsibility
Holland Law Center
University of Florida
Gainesville, FL 32611

Howard I. Kochman
Denver Wildlife Research Laboratory
412 N.E. 16th Ave., Room 250
Gainesville, FL 32601

John F. Moore
Patuxent Wildlife Research Center
Laurel, MC 20811

Thomas J. O'Shea
Denver Wildlife Research Laboratory
412 N.E. 16th Ave., Room 250
Gainesville, FL 32601

James A. Powell
Denver Wildlife Research Laboratory
412 N.E. 16th Ave., Room 250
Gainesville, FL 32601

Catherine Puckett
117 Newins-Ziegler Hall
University of Florida
Gainesville, FL 32611

Galen B. Rathbun
Denver Wildlife Research Laboratory
412 N.E. 16th Ave., Room 250
Gainesville, FL 32601

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COVER PHOTO: Courtesy Galen Rathbun, Sirenia Project, FWS

PREFACE

The papers in this volume provide background information for the Proposed Research/Management Plan for Crystal River Manatees. Several of the papers were prepared for this compendium and others have been or will be published elsewhere. They are gathered in one volume to aid those readers of the plan who are looking for more specific information than is presented in the plan.

The legal reviews were prepared by Richard Hamann and David Gluckman under contract to Florida Cooperative Fish and Wildlife Research Unit as part of the preparation of the Research/Management Plan (Research Work Order No. 1). The description of public opinions was prepared by Catherine Puckett as part of this project.

We are very grateful to Galen Rathbun, James Powell and Howard Kochman for preparing two articles summarizing the results of the ongoing research in the Crystal River area, which is conducted by Sirenia Project of the U.S. Fish and Wildlife Service's Denver Wildlife Research Center. Thomas O'Shea kindly agreed to include a review of herbicides, which was prepared for informal distribution, and a draft of a manuscript regarding levels of contaminants in manatee tissues, which has been submitted to the Journal of Wildlife Management. The Florida Department of Natural Resources gave permission to reprint the article by James Powell, which appeared in publication for which they hold the copyright.

The authors of each of these manuscripts are responsible for the accuracy of the information contained therein. The ideas, views and opinions expressed in these manuscripts are those of the authors and are not necessarily shared by any of the agencies or individuals involved in support of the work.

TABLE OF CONTENTS

DISTRIBUTION AND ABUNDANCE OF MANATEES ALONG THE NORTHERN COAST OF THE GULF OF MEXICO [a]

James A. Powell and Galen B. Rathbun
U.S. Fish and Wildlife Service
Sirenia Project
412 N.E. 16th Ave., Rm. 250
Gainesville, FL 32601

ABSTRACT: A review of historical and current records of manatee (Trichechus manatus) sightings along the coast of the northern Gulf of Mexico indicates that their numbers have declined in Texas, but increased in Louisiana and Mississippi. This is due to their extirpation in Mexico and dramatic increase along the southern Big Bend coast of northwestern peninsular Florida. The distribution of manatees along the southern Big Bend coast is related to their need for warm water and the distribution of freshwater and submerged aquatic and marine food plants. The spring-fed headwaters of Crystal and Homosassa Rivers are important warm water winter refuges, with nearly 90% of the same individuals returning each winter. The estuaries and grass beds associated with these two rivers and the Suwannee, Withlacoochee, and Chassahowitzka Rivers are the principal summer habitats. The Suwannee and Crystal Rivers are "high-use" rivers, while the other three are "low-use" rivers. Low human-caused mortality, high fecundity, some immigration, and high site fidelity are responsible for the increasing numbers of manatees using the southern Big Bend coast. Since this region of Florida has experienced relatively little development compared to the rest of the state, the best long-term future for this endangered marine mammal in the United States lies along the southern Big Bend coast.

[a] In press. Northeast Gulf Science.

INTRODUCTION

West Indian manatees (Trichechus manatus) are distributed along the northern Atlantic coast of South America, the Caribbean coasts of South and Central America, and the Greater Antilles. Though generally tropical in distribution, they are also found in the more temperate climate of Florida (Husar, 1977), where they utilize natural and artificial warm water refuges to maintain thermal homeostasis during cold weather (Hartman, 1974; Rose and McCutcheon, 1980; Irvine, 1983; Shane, in press).

Most of the information on the biology of the West Indian manatee has been collected from winter aggregations in Florida (Moore, 1956; Hartman, 1979; Bengtson, 1981; Shane, in press). There are few data available on manatees when they move away from these winter refuges. This paper is the result of nine years of research and observations of manatees in the northern Gulf of Mexico (Fig. 1). Our major emphasis has been on the population of manatees found along the southern Big Bend coast of western Florida (Dixie, Levy, Citrus, and Hernando counties; Fig. 2). The manatees along this coast spend each winter in the natural warm water refuges of Crystal River and Homosassa River. Hartman (1979) was the first to study the winter aggregation at Crystal River in the late 1960's and early 1970's. Our study builds on Hartman's foundation, with additional information about the use of the northern Gulf of Mexico coast by manatees, including a discussion of their historical and recent distribution, habitat requirements, and movements.

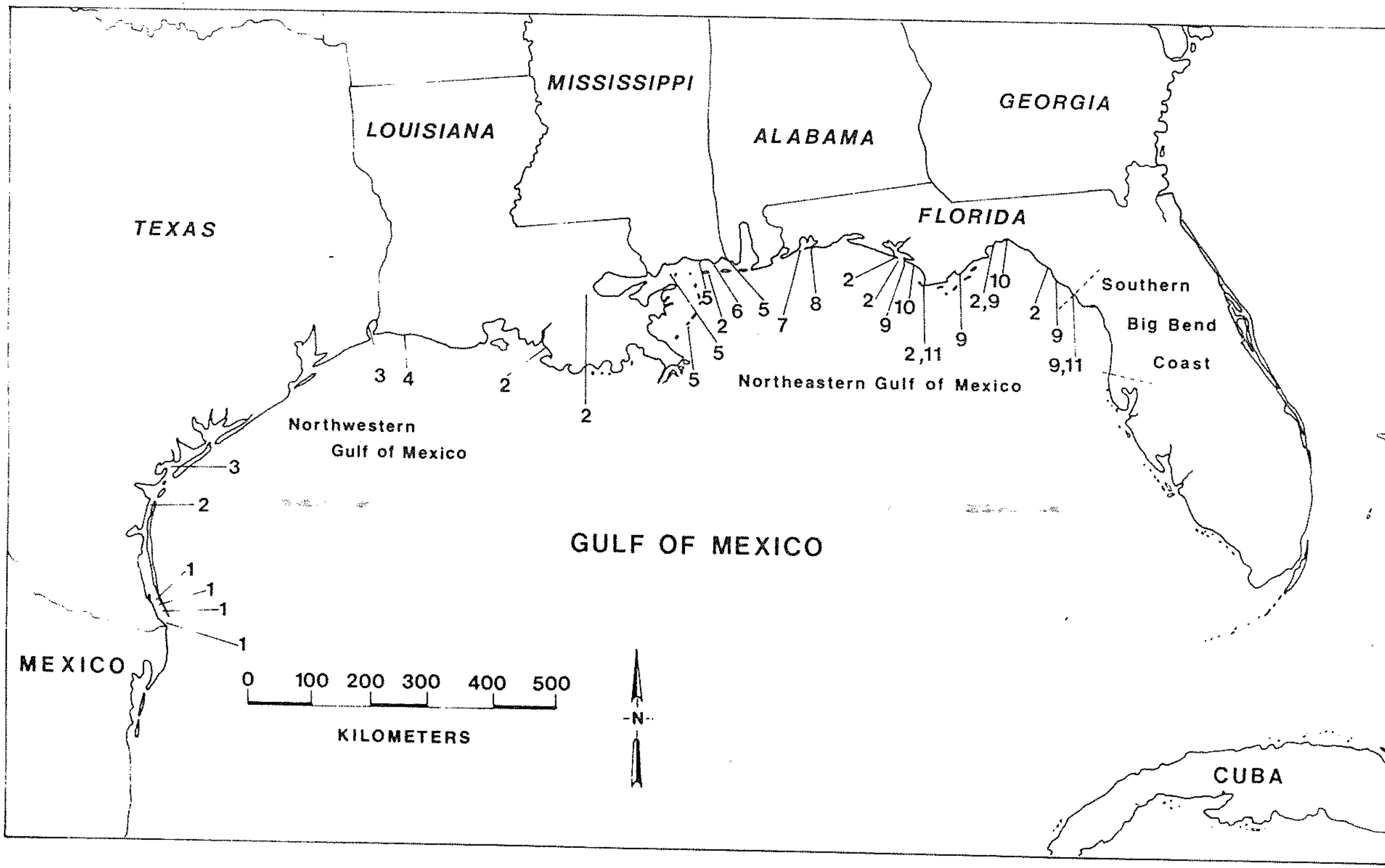


Fig. 1. The northern Gulf of Mexico, depicting the three principal areas in this study: northwestern Gulf of Mexico, northeastern Gulf of Mexico, and southern Big Bend coast (between dashed lines). Numbers refer to locations and sources (Table 1) of manatee sightings along the northern Gulf of Mexico coast between the Rio Grande, TX and the Suwannee River, FL.

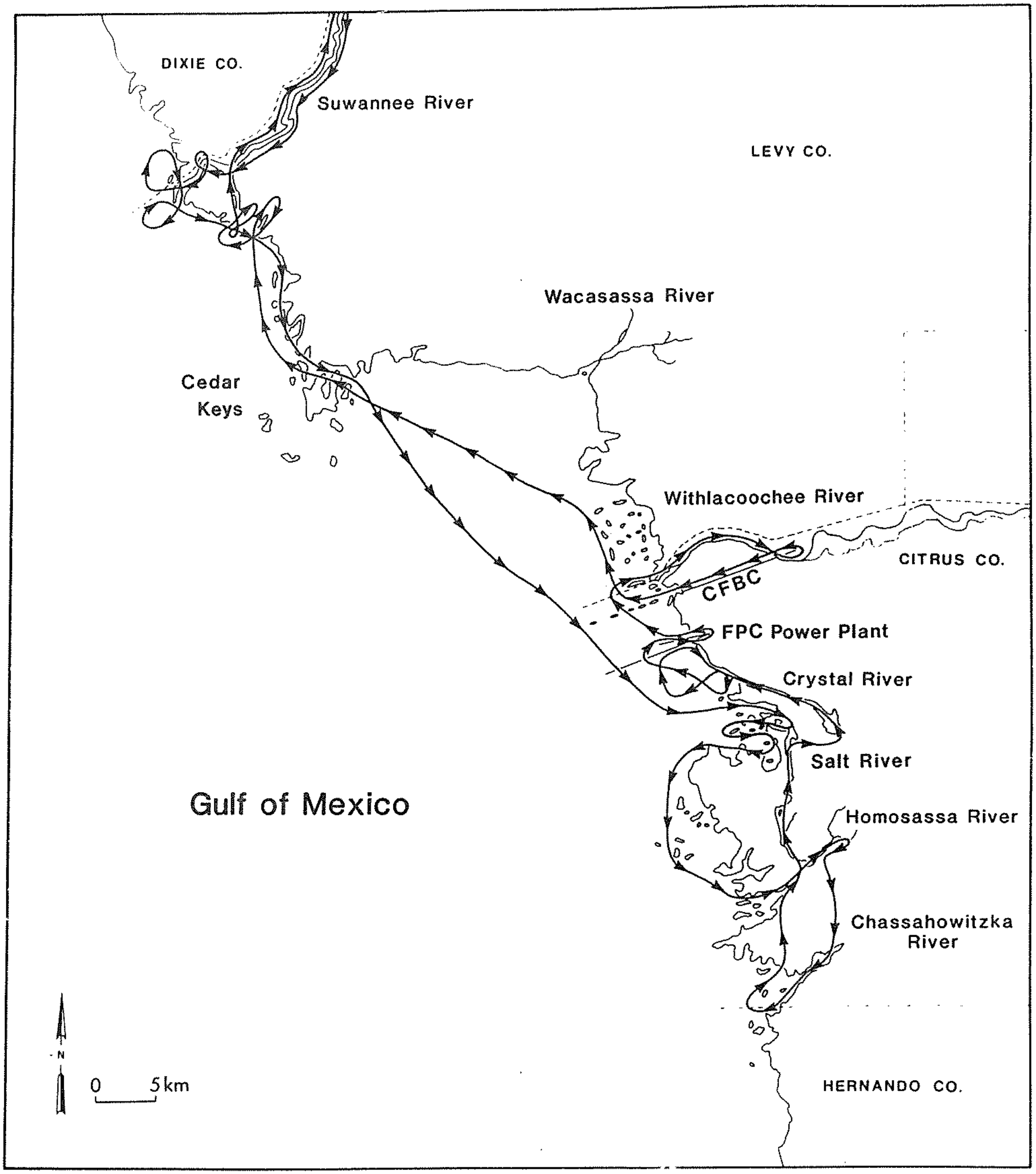


Fig. 2. Southern Big Bend coast study area, depicting counties (dashed lines), principal waterways, and aerial survey flight path (April through October). The flight path north of the Withlacoochee River was discontinued between November and March. CFBC = Cross Florida Barge Canal. FPC = Florida Power Corporation.

METHODS

Aerial Surveys

Ground and aerial surveys conducted along the southern Big Bend coast of Florida, completed during the late 1960's and early 1970's (Hartman, 1979; Powell, 1981), were used to determine the aerial flight paths followed between 1979 and 1982. From April through October rivers, canals, and nearshore areas about 1 km from shore were surveyed by air every 2 weeks (Fig. 2). The Waccasassa River was not flown regularly since Hartman (1974) determined that manatees did not use the river, probably because of the extensive shoals associated with Waccasassa. During the winter or cold season (November through March) the flight path north of the Withlacoochee River was discontinued and more time was spent circling aggregation sites at Crystal River and Homosassa River. Summer and winter flights were about 3 hours in duration. In addition to the long flights, short one hour surveys were flown over Crystal River and Homosassa River after the passage of cold fronts. Occasional surveys were flown as far north as the Steinhatchee River and south to the Anclote River during the warm months, but manatees were rarely seen beyond the Suwannee River or Chassahowitzka River. The aerial surveys were conducted from a single engine high-wing aircraft at altitudes between 160 and 250 m and airspeeds of 80-100 km/hr. A single observer sat in the front right seat with the door removed for better visibility.

Habitat Analysis

Aerial survey data collected during April through October from 1979 through 1981 were analyzed to determine summer habitat preferences of manatees. Each river was divided into riverine habitat, estuarine habitat, and marine habitat within about 1 km of its mouth (U.S. Fish and Wildlife Service, 1982; Fig. 3). The effects of habitat and river system upon the frequency of manatee sightings were evaluated by treating the survey flights as experimental units in a repeated measures analysis of variance (Winer, 1981). Survey flights were nested within each of 3 years and completely crossed with each river and habitat. This design was analyzed as a year x river x habitat factorial, with repeated measures on the last two factors. The number of manatee sightings per flight in each river x habitat combination served as the dependent variable and was transformed to square-root scale ($\sqrt{\text{count} + 0.5}$) prior to analysis.

Since a preliminary analysis indicated an extremely significant river x habitat interaction ($P < 0.0001$), subsequent analyses of habitat effects were simplified to a series of separate year x habitat factorials for each river, with repeated measures on the habitat factor. Similarly, variation among rivers was evaluated by summing manatee sightings over habitats and analyzing the counts as a year x river factorial, with repeated measures on the river factor. To adjust for the unequal number of survey flights in each year, significance tests for main effects and interactions were based on a complete least-squares analysis, implemented through the Type III sums of squares reported by the GLM procedure of the Statistical Analysis System (Helwig and Council, 1979; Freund and Littell, 1981). Multiple comparisons were conducted as pairwise linear contrasts between the adjusted means of the three habitats and six waterways. The

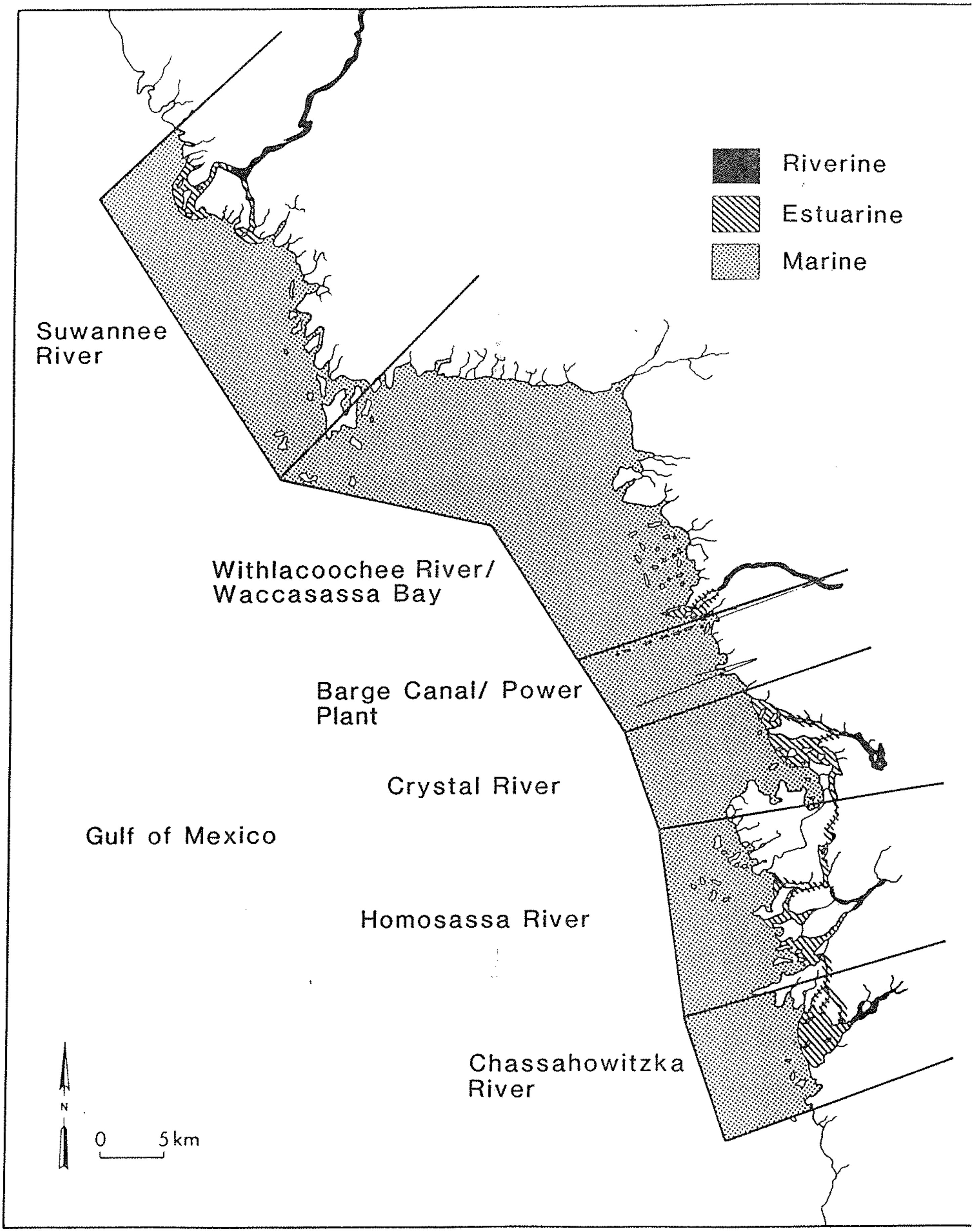


Fig. 3. The three ecological regions associated with the principal waterways along the southern Big Bend coast.

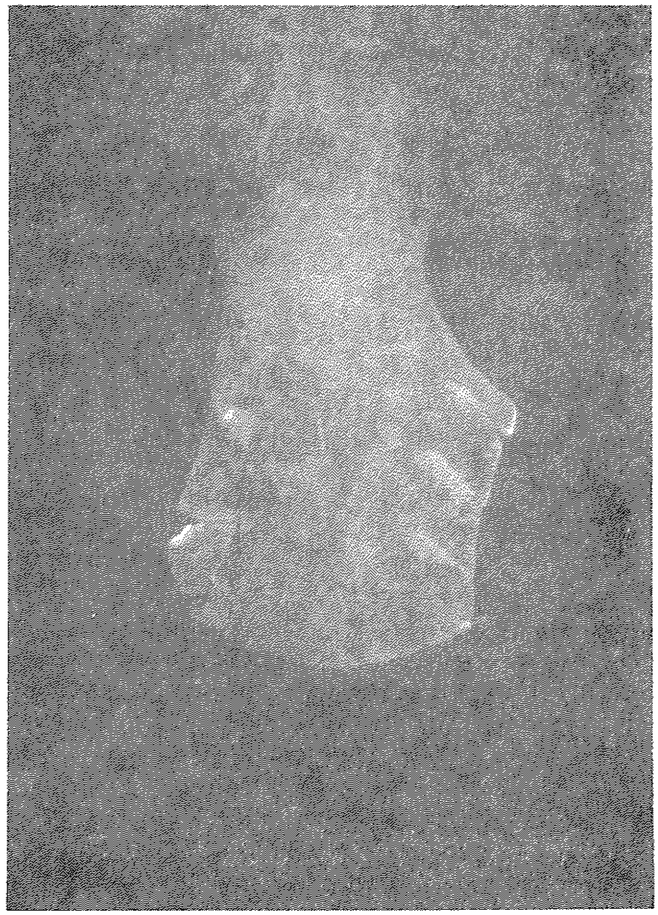
significance of each contrast was based on the Bonferroni _post hoc_ criterion (Harris, 1975) at an experimentwise error rate of $P < 0.05$.

Individual Identifications, Radio Telemetry and Sightings

Underwater and surface observation of manatees were conducted in Crystal River nearly weekly during the winter, occasionally in Homosassa River during the winter, and other rivers during the summer from 1977 through 1982. Underwater notes of manatee behavior were made on white plastic slates with a graphite pencil while snorkeling. Sketches of scars were made on standard outlines of manatees on the slates. Underwater photographs were taken with a 35 mm Nikonos camera with a 28 mm wide-angle lens and Kodak Ektachrome 200 transparency film (use of trade names does not imply U.S. Fish and Wildlife Service endorsement of the product). Color prints (4 x 10 cm) were made from the slides that best illustrated each animal's identifying traits. The photographs and information from the field notes were assembled into a photographic identification and sighting catalog.

Permanent identifying marks on manatees include wounds, scars, and mutilations caused by boat propellers and skegs, and morphological peculiarities such as skin folds, wrinkles, and medial tail notches (Fig. 4). To positively identify an animal, at least two different types of marks were used. Single gross mutilations were distinctive enough to positively identify certain individuals. White, unpigmented scar tissue gradually darkened to gray over time; the rate and extent of the darkening depended on the severity, size, and location of the

A.



B.

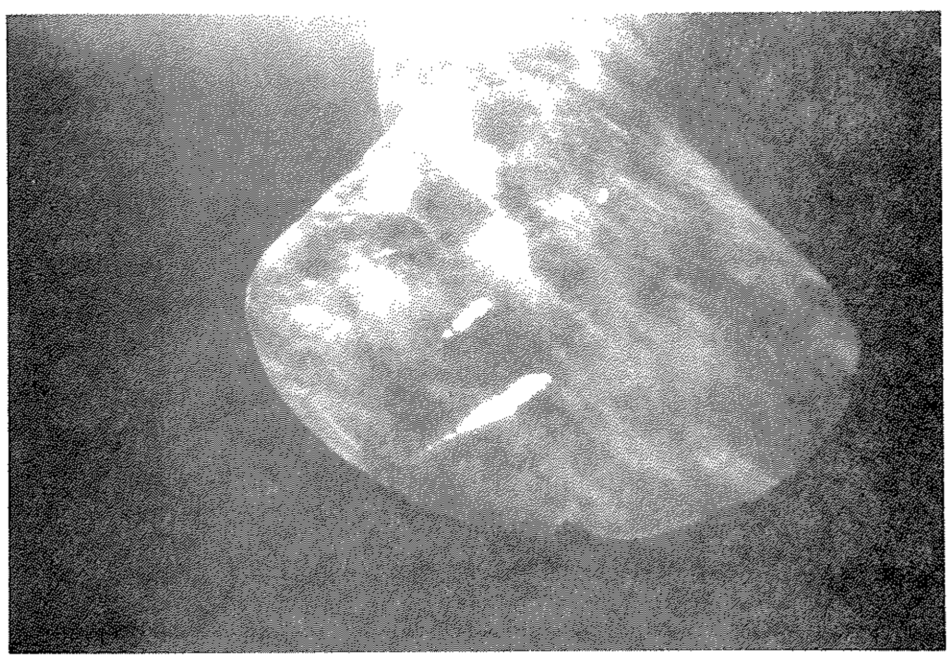


Fig. 4. Distinctive features, including natural natural notches and creases and wounds and scars caused by boat strikes, were used to individually identify manatees. A. Tail mutilations on CR 78♂ (28 November 1978). B. White scar tissue and medial tail notch on CR 41♀ (7 November 1982).

wound and the salinity of the water (abrasions and lesions tend to heal faster in saltwater; Hartman, 1974; Brownell et al., 1981). Epidermal scrapes and scratches did not persist more than a single winter season and often disappeared within 3 months. Scar tissue resulting from lacerations over about 2 cm wide, or cuts that penetrated more than 1.5 cm deep into the dermal layer, remained the longest. Gross mutilations were essentially permanent. Sex was used to aid in identification. Skin coloration was not sufficient for long-term identification since it often was masked with a coat of algae (Lyngbya, Compsopagon) or diatoms (Sygnema, Navicula) (Hartman, 1979).

The reliability of natural marks to identify individual manatees over long periods of time depended on several factors. The marks needed to be distinct and unambiguous. If there were no permanent mutilations or morphological peculiarities, then wounds or scars were used that would persist for at least two seasons, permiting an update of the photographic catalog while the marks were still recognizable. Many manatees in Crystal River were hit and scarred by boats every year so that continuous updating of the catalog was necessary to provide an unambiguous record of each individual. It was imperative to examine closely each photograph of a seemingly new animal to be sure that it was not a previously identified animal with new marks or scars.

Eleven manatees were tagged with radio transmitters between January 1980 and March 1982, four during the first winter, three during the second, and four during the last. Ten of the units were designed and built by Cedar Creek Bioelectronics Laboratory, University of Minnesota.

Each transmitter package was a 27 x 5 cm cylinder with a 40 cm long stainless steel whip antenna covered with plastic. The transmitters were fastened by stainless steel hose clamps to a belt made of 0.5 cm thick and 2.8 cm wide rubberized nylon machine belting covered with latex rubber surgical tubing. The tubing was impregnated with clear G.E. silicone rubber to prevent the belting from twisting (Bengtson, 1981). The estimated life of the transmitters was 1 year. The belt was secured around the caudal peduncle of tame, free-ranging manatees with a 1-inch nylon snap buckle (Tufbuc, Fastex Closure Products). The buckles were attached to the belting with steel bolts and brass nuts, which formed a corrodible link. The two metals corroded away, releasing the package from the animal in about 9-12 months. In practice, all of the plastic buckles broke before the link corroded. The eleventh transmitter was made by AVM Instrument Co., and measured 18 x 6 cm, had a predicted 2-year life, and less power than the Cedar Creek units. In other characteristics, it was similar to the Cedar Creek models.

The frequencies of the transmitters were between 164 and 165 mHz. The radio receivers were 64 channel manual and scanning models constructed by Cedar Creek. Radio-tagged manatees were located by triangulation from a boat with a pole-mounted, hand-rotated yagi antenna or by a dual antenna system mounted on the wing struts of an aircraft (Bengtson, 1981). Manatees were radio-tracked during all aerial surveys after January 1980. Radio-tagging activities were carried out under Federal Wildlife Permits PRT 2-4405 and PRT 2-8430.

Historical and recent information on manatee distribution was obtained from interviews and published literature. Sightings were solicited from the public between 1974 and 1979 by distributing posters and prepaid postcards along the Gulf coast from Florida to Texas.

Vegetation Analysis

Vegetation in Kings Bay (headwaters of Crystal River), Weeki Wachee Spring (Hernando Co.), Silver Spring (Marion Co.), and Alexander Spring (Lake Co.) was sampled once in August 1979 in order to compare the exotic dominated submerged vegetation of Kings Bay with spring runs that did not support any exotic plants. Ten sample plots, 30 m on a side, were chosen along the length of each spring run and fifteen plots were chosen in Kings Bay (see Kochman, et al., 1983). Each plot was randomly sampled 10 times. At each sample point, a staff with a sliding four-point cross, 1 m from tip to tip, was dropped to the surface of the vegetation (Osborne, 1981). The depth of water, height of vegetation, and species composition within 5 cm of the staff and the four points of the cross were measured at each sample point.

RESULTS

Manatee Distribution West of the Suwannee River

Historical Records

Prior to 1970, 15 records of manatee sightings, including 21 individuals, were reported along the coast from the Rio Grande, TX, to the Suwannee River, FL (Fig. 1; Table 1). In Texas, Gunter (1941) reported one specimen from Copano Bay, one from Brazos, and another

Table 1. Sources of manatee sightings from the northern coast of the Gulf of Mexico between the Rio Grande, TX, and the Suwannee River, FL, plotted in Figure 1.

Reference or Source	Sighting numbers reported in Figure 1		
	Pre 1970 Sightings	Post 1970 Sightings	Carcasses
True, 1884	8		
Gunter, 1941	1		3
Moore, 1951	10		
Lowery, 1974			4
Collard, et al., 1976		7	
Gunter and Corcoran, 1981		5	6
Hartman, 1974, 1979	9	11	
Fish and Wildlife Service, Sirenia Project		2	

on the border of Louisiana in Sabine Lake. He presumed that these animals originated from Mexico. Two manatees were captured in the Rio Grande around 1914 and between 1911-1912 at least five manatees were captured from the lower Laguna Madre for public display (Gunter, 1941). In Louisiana, one specimen was recovered from Calcasieu Lake in January 1929 (Lowery, 1974). There are no records known from Mississippi or Alabama prior to 1970. Mr. Silas Stearns (in True, 1884) states that they occasionally were seen from Pensacola to New Orleans and had previously been more abundant. In 1880, Stearns saw a single animal in Santa Rosa Sound (Santa Rosa Co., FL). Moore (1951) reported that the northern limit of the manatees' range on the western coast of Florida was Charlotte Harbor (Charlotte Co.). However, Moore had several confirmed sightings further north, including a butchered individual off Beacon Hill (Gulf Co.) and a sighting in the Wakulla River (Wakulla Co.). Hartman (1974) obtained several additional pre-1970 sightings from western Florida during his 1973 survey. These included four in Dixie Co., two in Wakulla Co., and one in Bay Co.

Recent Sightings

Since 1970, there have been 23 reports of manatee sightings from the northern Gulf of Mexico coast (Fig. 1; Table 1). One sighting in Texas was reported from Fish Pass near Corpus Christi (Nueces Co.) on 2 October 1979 (R. G. Whistles, pers. comm.). In Norco, LA, a single adult was seen for several days beginning on 8 April 1975 by employees at the Norco Shell Oil Plant. Another single animal was reported by

Mr. Oscar Zeringue (pers. comm.) on 10 July 1976 in the Atchafalaya River Swamp, 7 km SW of Morgan City, LA. A fisherman saw a manatee in water 14.6 m deep, 19 km west of Breton Island, LA, on 4 July 1979 (Gunter and Corcoran, 1982).

In Mississippi, single sightings were reported on 31 December 1978 and 1 January 1979 in the Wolf River, near the Cueres Bridge. On 3 and 5 January 1979, single sightings were reported from the Gulfport Coast Guard Station and Gulfport Harbor, about 32 km by water from the Cueres Bridge sightings. A male manatee was captured by Sea World of Florida in Gulfport Harbor on 6 January 1979 (not 7 January 1979, as reported in Gunter and Corcoran, 1982). The captured animal was underweight and had difficulty breathing, so was taken to Sea World in Orlando, FL, for recuperation (Federal Wildlife Permit PRT 2-3058; SWF-TM-901B, Beauraguard). The four sightings prior to the capture may represent more than one animal due to the distance (32 km) between the 1 January and 3 January records. According to Gunter and Corcoran (1982) single sightings were reported from the Pascagoula River, MS, on 18 January 1979 and from the Gulf of Mexico south of Mississippi (Breton Island, LA) on 4 July 1979. The seven sightings (including one confirmed by capture) from the vicinity of Mississippi indicate that there were at least two individuals in the area between December 1978 and July 1979.

There were 16 separate manatee sightings made in the vicinity of Biloxi Bay, MS, between 28 November 1979 and 19 January 1980 (G. Corcoran, pers. comm.). On 3 January 1980 a single female (230 cm long) was found dead on Ships Island, MS, 19.3 km south of Biloxi (Sirenia

Project, salvage records; M-179). The cause of death was related to anorexia and probable cold stress. Three of the 16 sightings were made after the dead individual was found on Ships Island, indicating that there were at least 2 animals in the Biloxi Bay area. During this time the Gulf Coast Marine Laboratory initiated a local media campaign soliciting manatee sightings, which probably resulted in many sightings of only a few individuals. The most recent sighting was reported by a net fisherman, who caught and released a manatee about 1.8 m long near Graveline Bayou, MS, on 5 December 1981 (Corcoran, pers. comm.).

Based on reports and aerial surveys, the Suwannee River appears to be the present northern limit of the manatees' usual range on the Gulf coast of Florida. A sighting of a single animal was reported by Collard et al. (1976) from western Florida at Santa Rosa Sound (Santa Rosa Co.) on 30 June 1975. Manatees have been sighted between Panama City (Bay Co.) and the Suwannee River about 3 times a year between 1976 and 1982 and total 14: 3 in Bay Co., 4 in Gulf Co., 2 in Wakulla Co., 1 in Taylor Co., and 4 in Dixie Co.

The Manatee Population along the Southern Big Bend Coast

Recent History and Description of Study Area

Manatee distribution along the southern Big Bend coast has been affected by human activities and changes in coastal and fluvial habitats. During the late 19th and early 20th centuries, the Suwannee River was a major commercial shipping port for northern Florida (Vernon, 1951). The mouth was dredged to 2 m in 1909 to provide greater access to the river for large, deep-draft vessels. However, due to the construction of railroads and highways, commercial traffic on the river has diminished and residential development and recreational boat traffic have increased.

Manatee Spring, 45 km from the mouth of the Suwannee River, apparently has been used as a "country swimming hole" since the late 1800's. Boats have been launched at the spring headwaters at least since the 1900's (Ellison Hardy, pers. comm.). The area was purchased by the State of Florida and incorporated into the state park system in 1949. Presently the park is used by the public for picnicking, swimming, and boating. The cement boat ramp near the headwaters and the wooden boardwalk leading down to the mouth of the spring were built in the mid-1950's.

The Withlacoochee River was dredged to 3 m in 1915 and, like the Suwannee River, was used heavily by commercial vessels in the early 1900's. Port Inglis was located at the mouth of the river and was a major port for the phosphate industry. The port no longer exists. The upper Withlacoochee River was dammed for hydroelectric power creating Lake Rousseau in 1907. The Florida Power Corporation (FPC) power plant at the present town of Inglis and the Tenneco petroleum storage facility located about 2-1/2 km downriver from the plant, were built in the early 1940's. Oil was delivered to both facilities by barges ascending the river. The power plant was closed in 1974, and oil deliveries to Tenneco were discontinued in June 1978.

The most dramatic changes to the coastline have occurred due to the construction of the FPC Crystal River power plant in 1957 and the Cross Florida Barge Canal (CFBC) between 1961 and 1968. The CFBC was designed to enable barges to cross Florida, thus avoiding the long trip around the peninsula. However, the project was only partially completed when it was officially stopped in 1971. The 10 km long dredged canal from the lock at Lake Rousseau to the Gulf bisects the lower portion of the Withlacoochee River 14 km from its mouth. The water in the two sections of the river below the lake is controlled by spillways. The lower section is navigable from the mouth to a spillway near the lock, and the upper section is navigable from midway up the barge canal to the dam.

The FPC Crystal River power plant, located on the coast of Citrus Co. 5 km north of the mouth of Crystal River, contains two fossil fuel generating units and one nuclear unit. Two additional fossil fuel units are under construction. The cooling water for the plant is drawn through an intake canal on the southern side of the plant and discharged into a separate canal on the northern side. The intake canal also is used by ocean-going barges for delivery of coal. The spoil areas created by the dredging of the intake and effluent canals form a spit extending 12 km into the Gulf (Fig. 2). Two gaps were left in the spits, 5 and 6 km from shore, allowing small fishing boats to pass.

The mouth of Crystal River was dredged to 2 m in 1906 and Homosassa River was dredged to 1.5 m in 1936. Both rivers have been used by a small fishing fleet and recreation boaters for the past 30 years. Since 1960, the human population in Citrus County has increased dramatically, resulting in both rivers being further modified with adjoining canal systems, cement bulkheads, dredging and filling, and numerous boat ramps and multi-slip boat marinas.

The most obvious change in the ecology of the Crystal and Homosassa Rivers has been the introduction of exotic aquatic vegetation, principally

Hydrilla verticillata, Myriophyllum spicatum, and Eichhornia crassipes. Hydrilla and Myriophyllum erupted to noxious levels in the two rivers in the early 1960's (Hartman, 1979), supposedly after a Miami based aquarium industry planted the exotics. Attendant with the eruptions have been various attempts to control the weeds by several agencies and methods. Prior to the introduction of the exotic weeds, the headwaters of the two rivers were typical of artesian spring runs in Florida. They had clear, low nutrient water with mixed stands of plants such as Vallisneria americana, Ceratophyllum demersum, and Najas guadalupensis (A. Carr, pers. comm.). These plants formed widely spaced beds interspersed with extensive areas of clean white calcareous sand with no vegetation. Unfortunately, there are no quantitative data on the abundance and distribution of native aquatic plants in the Crystal and Homosassa Rivers before the introduction of exotics. An estimate of the changes that may have resulted from the proliferation of the exotics was obtained by sampling the species composition and abundance of vegetation in Kings Bay and three springs similar to Kings Bay, but not infested with exotics (Weeki Wachee Spring, Silver Spring, and Alexander Spring). In Kings Bay, the dominant plant was Hydrilla (55% of the sample points). The dominant plant(s) in the Weeki Wachee was Najas (40%); Silver Spring, Vallisneria (35%) and Sagitarria (20%); and in Alexander Spring, Vallisneria (20%) and various algae (20%). The abundance of vegetation in each of the three "natural" spring runs was less than in Kings Bay. The proportion of the bottom covered by aquatic plants in Kings Bay was 81%, compared to a mean of 60% for the three natural springs. The proportion of the water column occupied by vegetation was about 2.5 times greater in Kings Bay than the average for the other three springs (Fig. 5). These data indicate that the standing biomass of aquatic vegetation in Kings Bay may have increased due to the presence of exotic forms, especially Hydrilla.

Historical Records

There are few records of manatees using the coast from the Suwannee River south to the Chassahowitzka River prior to the mid-1900's. Bartram (1791) reported that manatees used Manatee Spring on the Suwannee River during the winter in the mid-1770's. A single specimen in the U. S. National Museum (USNM 22773) was collected in the Homosassa River in 1879. Historical accounts written by sportsmen visiting the Crystal and Homosassa Rivers on fishing and hunting expeditions in the late 19th and early 20th centuries make no mention of manatees (Hallock, 1876). These accounts included detailed and illustrative descriptions of the local wildlife and fish seen in the clear spring runs. Since the sportsmen usually visited these areas during the winter, and the articles were written to lure their cohorts to Florida, presumably they would have mentioned anything as unusual as a manatee, but they did not. Moore (1951) found only a single record of a manatee in the Crystal River area and two other reports around 1950 from the Suwannee River. Mr. Paul G. Pearson and Mr. Kirk Strawn (in Moore, 1951) reported that Cedar Key was outside the manatee's range. Layne (1965) mentioned a single sighting in the Withlacoochee River in 1962 and Mr. Thomas Knotts (pers. comm.), whose family founded the fishing village of Yankeetown on the Withlacoochee River, first began to see manatees in the river around 1960. He could not

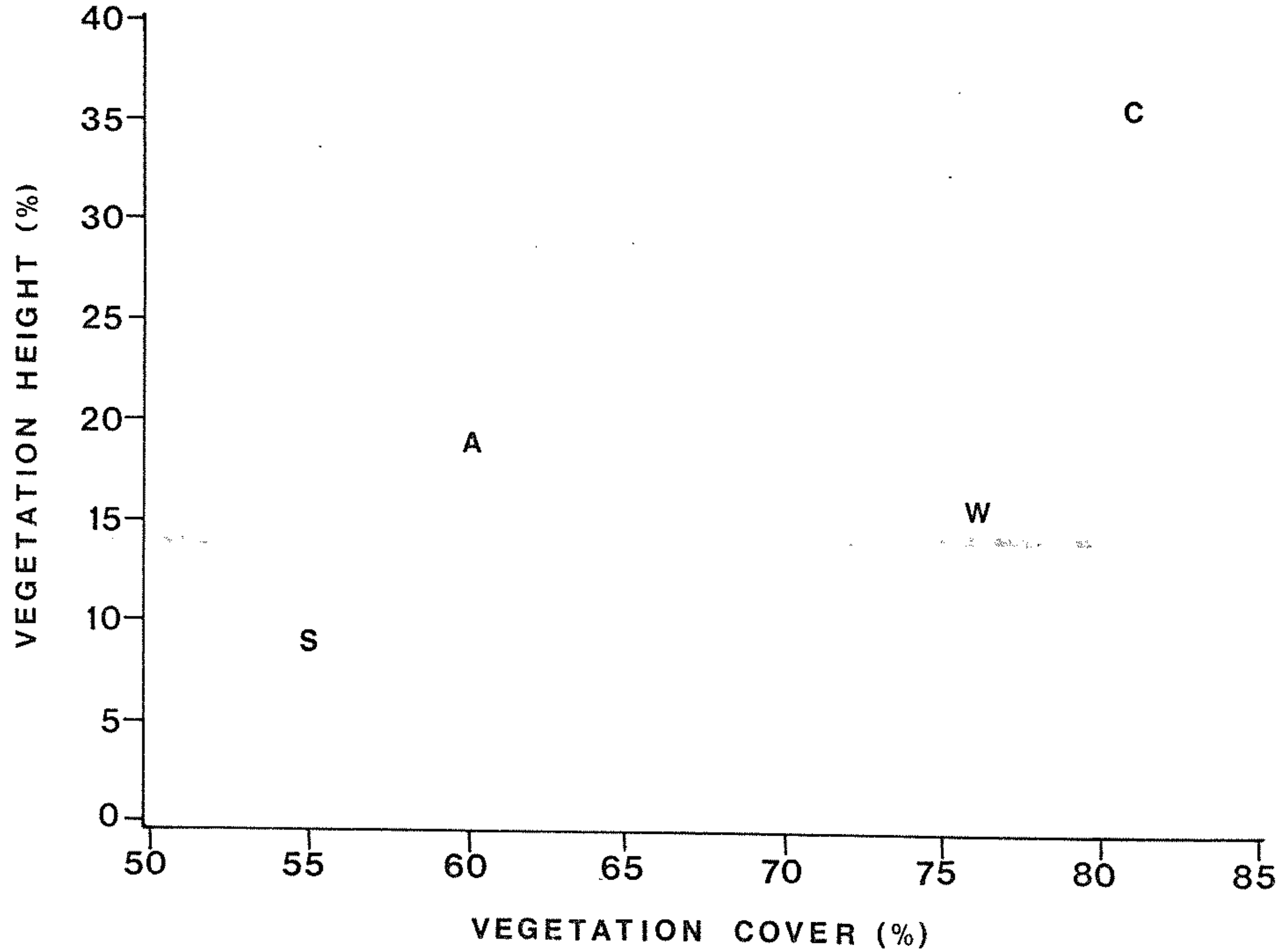


Fig. 5. The relationship between the proportion of the water column occupied by vegetation and the proportion of the substrate covered by vegetation in four Florida artesian spring runs sampled in August 1979. Silver Spring (S), Alexander Spring (A), and Weeki Wachee River (W) did not have exotic plant species. Crystal River (C), contains exotic introductions.

remember anyone discussing their presence prior to that time. Based on discussions with local fishermen, guides, and residents, Hartman (1979) suggested that manatees began commonly using the headwaters of Crystal River and Homosassa River in the early 1960's.

The Crystal River and Homosassa River Thermal Refuges

The present abundance and distribution of manatees along the southern Big Bend coast is dramatically different than it was 20 years ago. Manatees are now commonly seen along the coast, from the Suwannee River to the Chassahowitzka River (Fig. 6), but their temporal distribution is associated closely with the seasons. When the summer water temperatures of the Gulf (c.32^{o}C) drop below about 20^{o}C in the fall, manatees begin to move into the spring-fed headwaters of Crystal River and Homosassa River, where the water is a constant 23.5^{o}C (Fig. 7 C,D). Large numbers remain in these winter refuges until dispersing along the Gulf with the onset of spring (Kochman et al., 1983).

The total number of manatees using Crystal River as a refuge has increased markedly over the last 15 years. The largest aggregation counted on aerial surveys during the winter of 1967-68 was 38 (Hartman, 1979), while the 1981-82 maximum winter count was 116, a 205% increase (Table 2). The annual relative rates of increase over 5 consecutive years (aerial surveys beginning in 1977-78) were 2.5%, 8.7%, 13.8%, and 17.2%, with an average of 10.5%. Although the percent growth rates have increased over 5 years, the relative differences between the yearly rates have decreased (mean = 1.4% per annum), indicating that the population is approaching a constant relative rate of increase. The number of

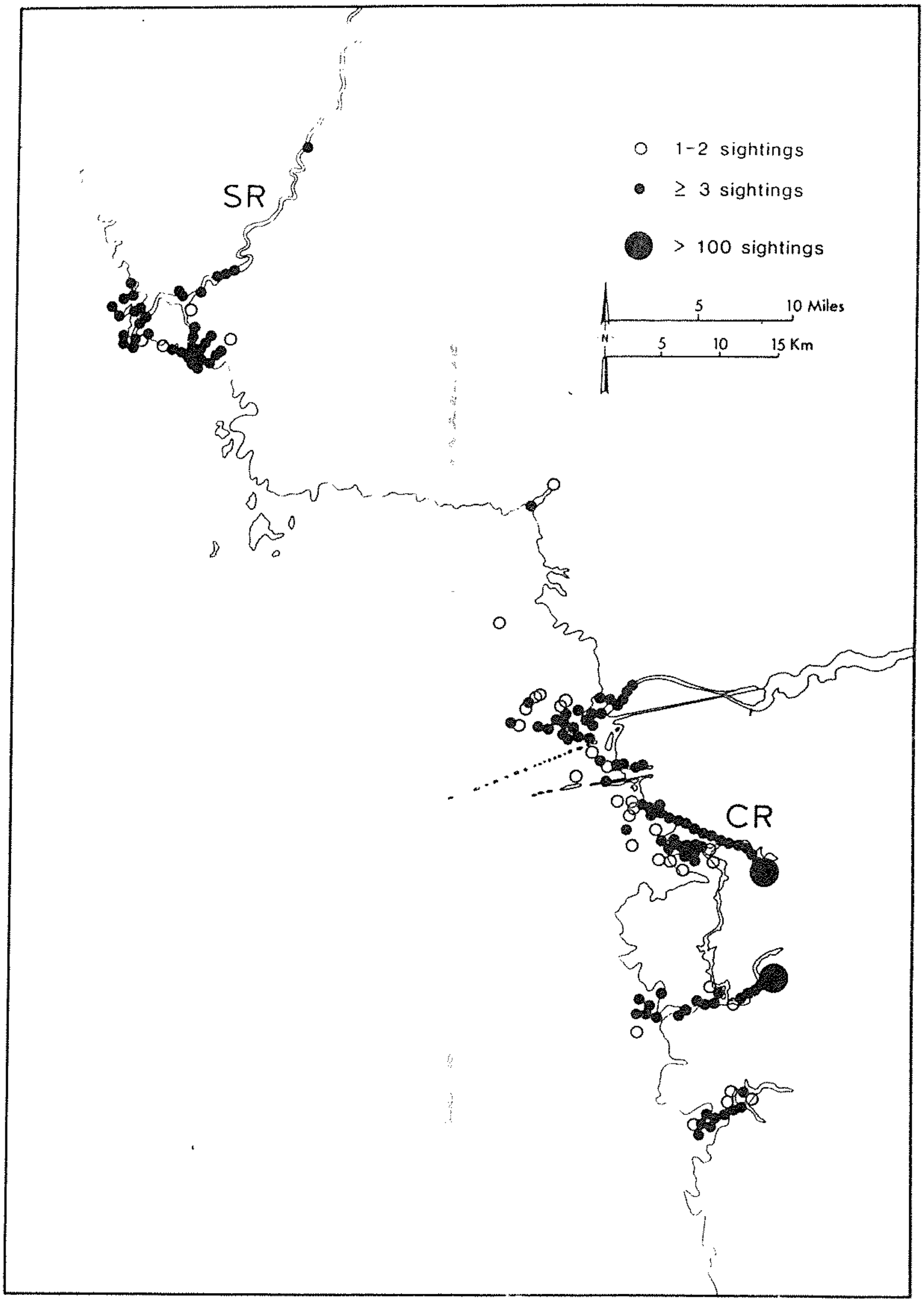


Fig. 6. Compilation of all manatee aerial survey sightings along the southern Big Bend coast from January 1978 through March 1981. SR = Suwannee River. CR = Crystal River.

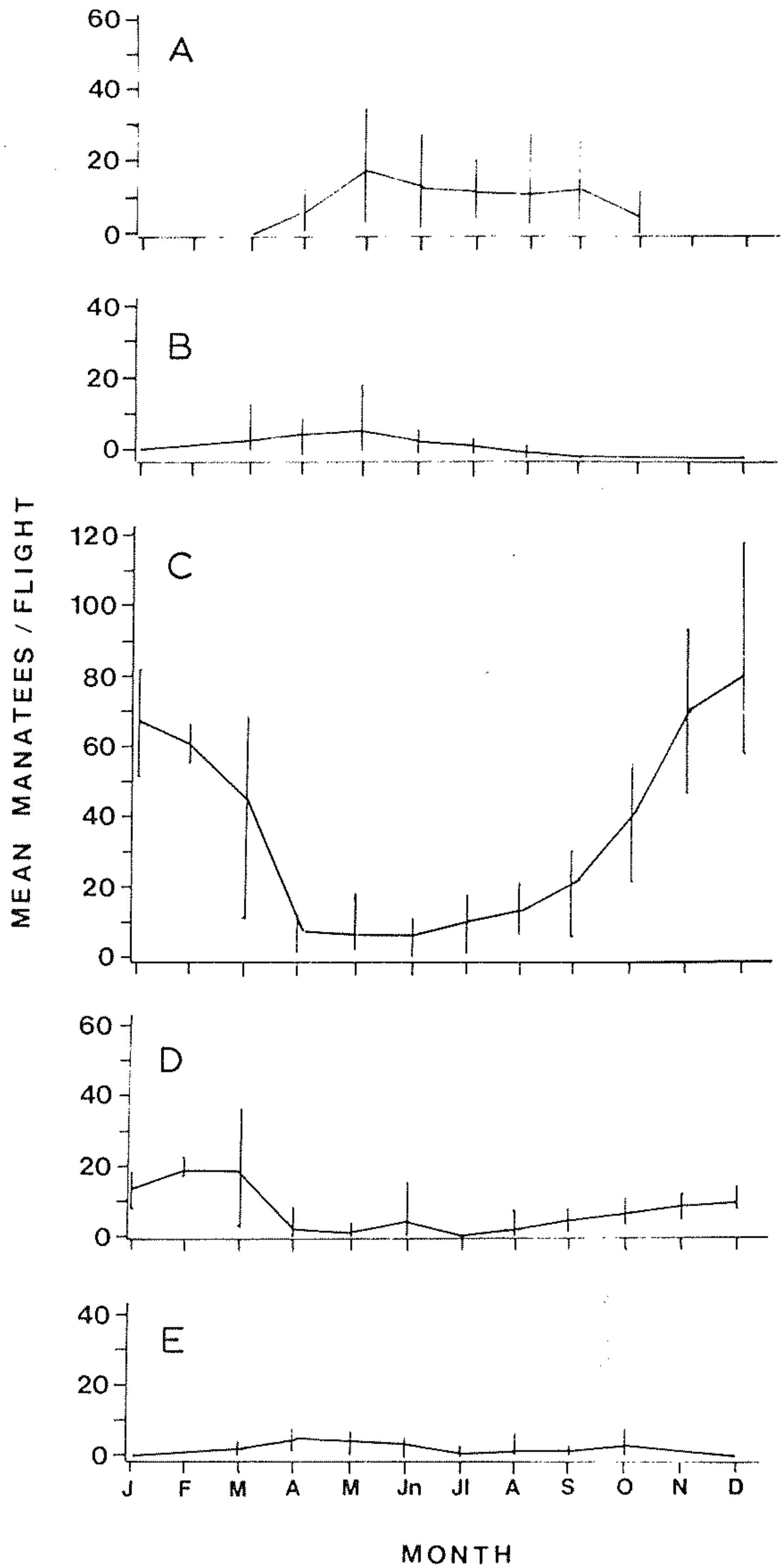


Fig. 7. Mean number of manatees seen in the Suwannee (A), Withlacoochee (B), Crystal (C), Homosassa (D), and Chassahowitzka (E) Rivers during coastal surveys from January 1979 through December 1981. The Suwannee River was dropped from the surveys during November through February and not all rivers were flown equally. Vertical bars are monthly ranges of sightings in each river.

Table 2. Winter manatee counts in the Homosassa River and Crystal River based on aerial surveys and individual identifications. A = flights flown during cold fronts, B = intermittent flights, C = flights flown twice a month, and D = flights flown at least weekly.

Season	Aerial survey maxima: Homosassa River	Aerial survey maxima: Crystal River Calves	Aerial survey maxima: Crystal River Total	Flight frequency	Individuals identified at Crystal River: Males	Females	Calves	Total
1967-68	8 (2)	--	38 (1)	A	25 (1)	25 (1)	--	50
1968-69	--	--	44 (1)	A	23 (1)	25 (1)	--	48
1972-73	12 (1)	--	45 (3)	A	16 (3)	18 (3)	4 (3)	38
1973-74	18 (1)	--	44 (3)	B	--	--	--	--
1974-75	--	--	47 (3)	B	--	--	--	--
1975-76	--	--	51 (3)	B	--	--	--	--
1976-77	--	--	37 (3)	C	19 (3)	20 (3)	10 (3)	49
1977-78	11	9	78	D	33 (3)	43 (3)	10 (3)	86
1978-79	29	8	80	D	40	44	7	91
1979-80	16	10	87	D	32	49	8	89
1980-81	24	13	99	D	42	51	15	108
1981-82	20	10	116	A	35	45	12	92

(1) = Hartman, 1979.

(2) = Hartman, 1971.

(3) = Powell, 1981.

reproductively active females identified in the population between 1976 and 1982 was high (35) as was the average annual percentage of calves (12.8%; Table 2).

Many of the same manatees return to Crystal River each winter, and at least six individuals have used the river for 14 years. The mean return rate for the four winters between December 1978 and March 1982 was 88.9%. Females had a greater average return rate (88.3%) than males (81.7%; Table 3). The high return rate suggests strong traditional use, which results in a fairly consistent and discrete group using Crystal River.

The sex ratio of all manatees identified in Crystal and Homosassa Rivers during six winters (1976-77 through 1981-82) was 1:1.02. However, the average yearly sex ratio for the six winters was 1:1.35. During any single winter, some males did not return, which resulted in more females using the refuge than males each winter.

Other Thermal Refuges

Six other sites besides Crystal and Homosassa Rivers have been identified along the southern Big Bend coast of Florida as winter refuges. These sites are not used continuously by manatees throughout the winter and appear to be only temporary sanctuaries. Manatees have been sighted sporadically in all seasons in Manatee Spring (Table 4). On 12 April 1982 three animals were identified in the run for 3 days during cool weather. Two (CR 71 ♀ and CR 104 ♀) were last seen in Crystal River on 9 March 1982 and two (CR 171 ♀ and CR 46 ♀) were in late pregnancy. One of the animals (CR 104 ♀) was the four-year-old daughter of CR 71 ♀.

Table 3. Number and sex of individual manatees identified during winter season in Crystal River and yearly return rates. Percent of total animals identified are in parentheses. Data do not include first year calves.

Column No.		1	2	3	4
Season	Sex	Returns from previous year	Returns from any previous year	Newly identified	Total identified (column 2 + 3)
	♂	30	30	10	40
1978-79	♀	34	36	8	44
Total		54 (73.0)	66 (89.2)	18 (24.3)	84
	♂	25	28	4	32
1979-80	♀	41	41	8	49
Total		66 (81.5)	69 (85.2)	12 (14.8)	81
	♂	28	33	9	42
1980-81	♀	45	46	5	51
Total		73 (78.5)	79 (84.9)	14 (15.1)	93
	♂	27	33	2	35
1981-82	♀	41	44	1	45
Total		68 (85.0)	77 (96.3)	3 (3.8)	80

Table 4. Manatee sightings at Manatee Spring State Park. No corrections made for effort. Sightings were normally in the Suwannee River, at the mouth of Manatee Spring Run.

Date	Total Number	Number of Calves	Identification #	Date	Total Number	Number of Calves	Identification #
9 Apr 1976	1			7 Aug 1982 a.m.	2		
10 Apr 1976	2			7 Aug 1982 p.m.	4		
6 Jul 1976	2		CR#71f	8 Aug 1982	4		
17 Jul 1976	6			9 Aug 1982 a.m.	2		
18 Jul 1976	2			10 Aug 1982 a.m.	2		
13 Dec 1977	3	2		10 Aug 1982 p.m.	3		
31 Jan 1980	1			11 Aug 1982 a.m.	2		
11 Mar 1980	1			11 Aug 1982 p.m.	4		
30 Oct 1980	2	1		12 Aug 1982	2		
7 Nov 1980	2	1		15 Aug 1982	2		
12 Nov 1980	2	1		16 Aug 1982 a.m.	1		
16 Nov 1981	1			16 Aug 1982 p.m.	2		
2 Jan 1982	1			17 Aug 1982 a.m.	2		
18 Feb 1982	3			17 Aug 1982 p.m.	2		
29 Mar 1982	1			26 Aug 1982	2		
12 Apr 1982	3		CR#'s 71f,104f,46f	10 Sep 1982	5	1	
13 Apr 1982	3		CR#'s 71f,104f,46f	11 Sep 1982 p.m.	5		
14 Apr 1982	3		CR#'s 71f,104f,46f	11 Sep 1982 p.m.	2		

Table 4. Continued.

Date	Total Number	Number of Calves	Identification #	Date	Total Number	Number of Calves	Identification #
31 Jun 1982	3			11 Sep 1982	4		
12 Jul 1982	2			12 Sep 1982	2		
13 Jul 1982	2			13 Sep 1982	2		CR 71f
14 Jul 1982	3		CR 71f	14 Sep 1982	2		
16 Jul 1982	3			15 Sep 1982 a.m.	2		
17 Jul 1982 a.m.	3			15 Sep 1982 p.m.	3		
17 Jul 1982 p.m.	3			17 Sep 1982 a.m.	2		
18 Jul 1982	2			17 Sep 1982 p.m.	2-3		
19 Jul 1982 a.m.	3			20 Sep 1982 a.m.	2		
19 Jul 1982 p.m.	2		CR 71f	20 Sep 1982 p.m.	1		
22 July 1982	3			21 Sep 1982	1		
23 Jul 1982	1			22 Sep 1982	3	1	CR 22f
28 Jul 1982	3			25 Sep 1982	2		
2 Aug 1982	6	1		26 Sep 1982	2		
3 Aug 1982 a.m.	5			30 sep 1982	4		
3 Aug 1982 p.m.	1			1 Oct 1982 a.m.	2		
3 Aug 1982 p.m.	2			1 Oct 1982 p.m.	3		
4 Aug 1982 a.m.	2		CR 71f	2 Oct 1982	2		
4 Aug 1982 p.m.	2			14 Oct 1982	1		
5 Aug 1982	2			18 Oct 1982	2	1	
6 Aug 1982 a.m.	2-4						
6 Aug 1982 p.m.	2-4						

There is a small seep in the CFBC at the Inglis Lock, and manatees were reported using the seep in 1976 by the Inglis lockmaster. A manatee was seen in Rainbow River, a spring-fed tributary of the Withlacoochee River, during an aerial survey on 31 December 1976. To gain access to this site, it had to travel up the CFBC, through the Inglis lock, across Lake Rousseau, and up the Withlacoochee River past Dunnellon to the mouth of Rainbow River. It is possible that this animal was trapped above the Inglis Lock during winter.

Manatees use the FPC Crystal River power plant effluent during cool weather, but only for short periods of time, usually in the Spring (Fig. 8). A single animal was reported using the headwaters of Chassahowitzka River during the winters of 1978 and 1979. In 1980 several manatees were reported in Jenkins Creek, a small spring-fed creek 6 km south of Weeki Wachee River, Hernando Co. There may be other temporary refuges along the southern Big Bend coast that have not been documented.

Summer Distribution and Ecology

There is little information on the spring dispersal routes and destinations of known individuals from the Crystal River and Homosassa River winter refuges. Outside of these two rivers, 29 identifiable manatees have been located on 41 occasions. Seventeen sightings were from the Suwannee River, 18 from the Withlacoochee River, four from the Chassahowitzka River and two from other areas (Table 5). All of the sightings were made from April through September, 1976 through 1982. Radio-tagged animals could only be located when they ascended freshwater rivers due to saltwater attenuation of radio signals.

Table 5. Manatees identified or radiotagged in Crystal River or Homosassa River that were found outside of their winter refuges between April and September. Eleven animals were radiotagged between January 1980 and April 1982. The number of sightings are given with the number of individuals involved in parentheses. There was no correction for effort.

	Location				
Year	Suwannee River	Withlacoochee River	Chassahowitzka River	Other	Total
1976	1 (1)	0	0	0	1 (1)
1977	0	1 (1)	0	0	1 (1)
1978	1 (1)	4 (3)	2 (1)	1 (1)1/	8 (6)
1979	0	0	1 (1)	0	1 (1)
1980	1 (1)	11 (7)	1 (1)	1 (1)2/	14 (10)
1981	3 (3)	2 (2)	0	0	5 (5)
1982	11 (5)	0	0	0	11 (5)
Total	17 (11)	18 (13)	4 (3)	2 (2)	41 (29)

1/ Cross Florida Barge Canal, Citrus Co.

2/ Sanibel Island, Lee Co.

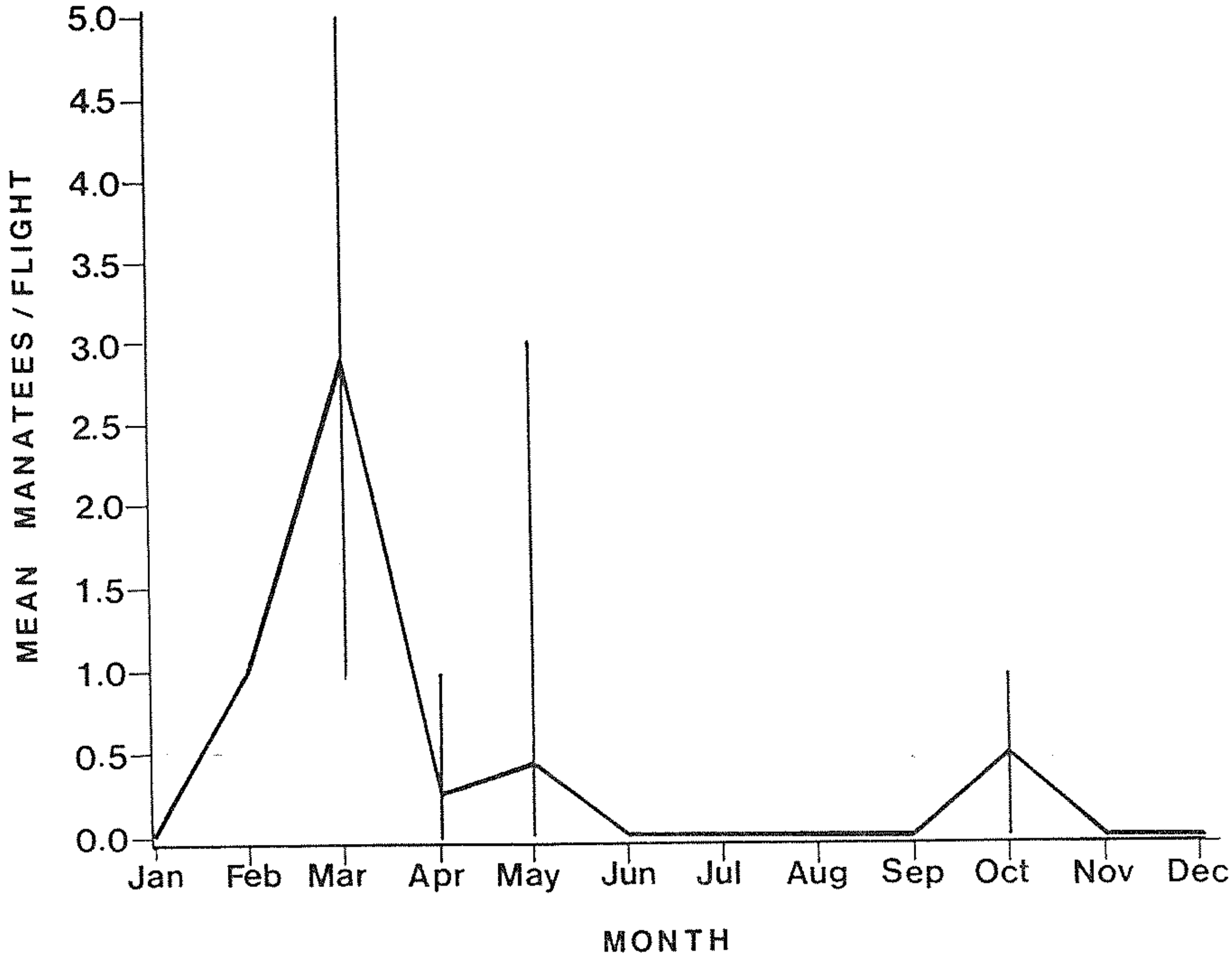


Fig. 8. Monthly mean number of manatees seen in the effluent of the Florida Power Corporation Crystal River Power Plant during aerial surveys (n = 50) conducted from January 1979 through December 1981. Vertical bars are monthly ranges.

On 31 January 1980 a large male (CR 108♂; Gus) was tagged in Crystal River, where he had been seen during the previous six winters. He was last seen in the river in March. On 14 July 1980 his radio belt was found washed ashore at Bowman's Beach, on the Gulf of Mexico side of Sanibel Island, Lee Co., FL. The plastic belt buckle had broken, but the transmitter was still functioning. Sanibel Island is 280 km south of Crystal River and there are no currents that could have transported the negatively buoyant package there. It is likely that the animal lost its tag off Bowman's Beach on one of the submerged tree snags that are present (pers. obs.). On 24 November 1980, the male was again seen in Crystal River.

Several manatees have been sighted during spring and summer aerial surveys near the boat gap in the FPC power plant spit, and two were seen passing through the gap. One was seen traveling towards Cedar Keys on a straight line from Turtle Creek Point, about 11 km north of the Withlacoochee River (Fig. 9). At least one manatee (possibly two) was reported in the summer of 1976 about 8 km offshore of the Withlacoochee River, heading on a straight course towards Cedar Keys (J. C. Dickenson, pers. comm.). When animals move north from Crystal River, they pass through the boat gap in the FPC spit and then either head directly towards Cedar Keys, or travel along the coast, passing near the Waccasassa River. From Cedar Keys they probably move along the coast to the Suwannee River.

In February 1980, a radio-tagged manatee (CR 108♂, Gus) was followed at night during a high tide from Crystal River to within 6 km

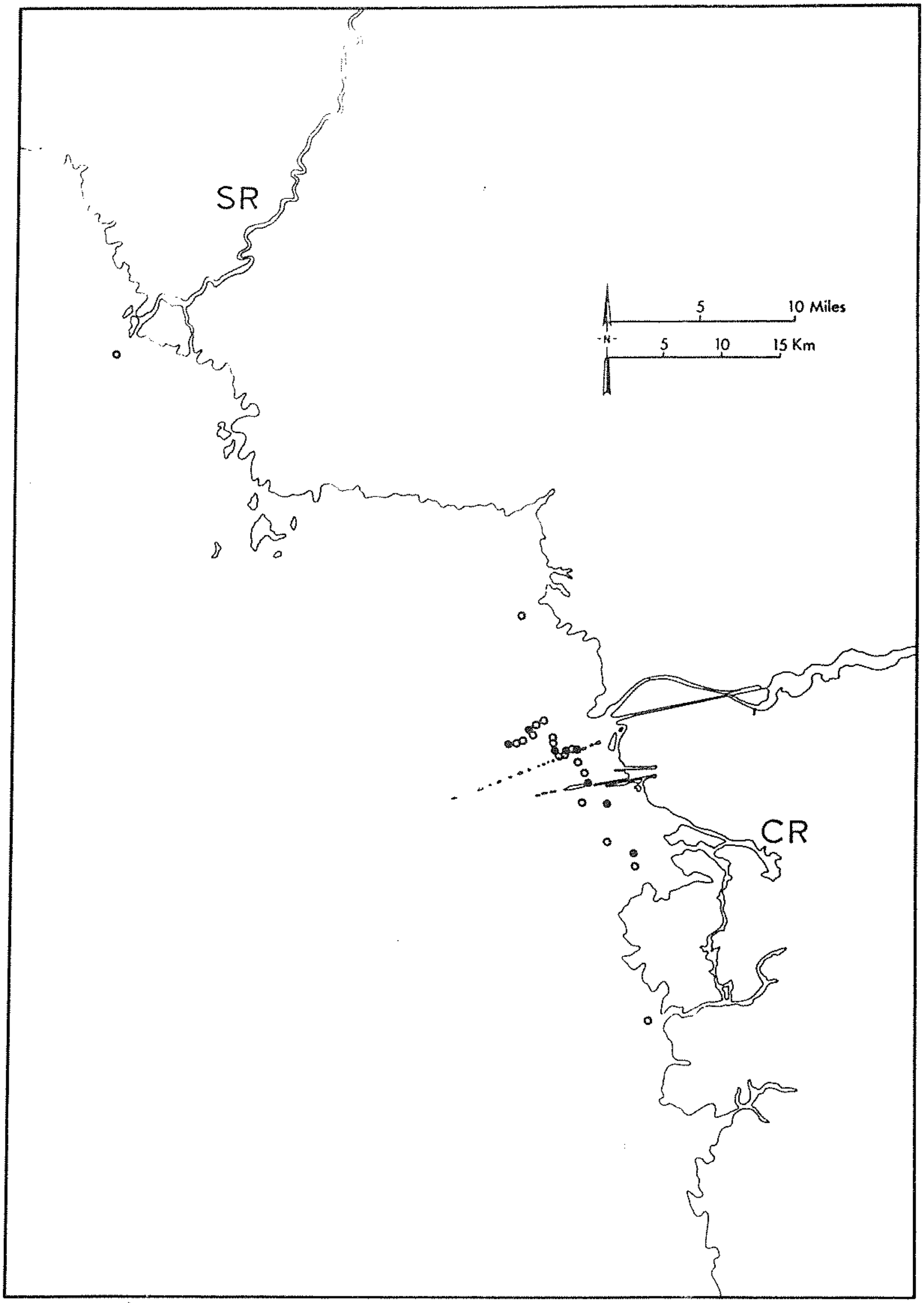


Fig. 9. Manatee sightings greater than 1 km from a river mouth along the southern Big Bend coast. Data compiled from all aerial surveys from January 1978 through March 1981. Open circles = 1-2 sightings. Closed circles = 3-5 sightings. SR = Suwannee River. CR = Crystal River.

of Homosassa River, via Salt River. By dawn the next day, he had returned to Crystal River. We have never seen manatees offshore between Crystal River and Homosassa River (Fig. 9), indicating that they use the Salt River to travel between the two rivers. Battle Creek connects Homosassa River and Chassahowitzka River, but even at high tide it is too shallow for manatees to navigate. They probably travel offshore between the two rivers.

During the warm months (April through October) manatees disperse from the winter refuges and concentrate near and in the major waterways of the southern Big Bend coast, including the Suwannee River, Withlacoochee River, CFBC, Crystal River, Homosassa River, and Chassahowitzka River (Fig. 7). Based on summer aerial survey counts from 1979 through 1981 there was no significant variation in the use of the waterways between the 3 years ($\underline{P} > 0.83$). However, the frequency of sightings averaged significantly higher in Crystal River and Suwannee River than in the other three rivers and the CFBC ($\underline{P} < 0.05$), resulting in low-use and high-use systems (Table 6). The mean number of manatees that used the Suwannee River and Crystal River during the summer was not significantly different ($\underline{P} > 0.05$), although the monthly pattern in each river was distinct. Manatees used the Suwannee River heavily all summer, whereas Crystal River was used mostly during late summer (Fig. 7). The Homosassa River was similar to the Crystal River pattern of use, while the Withlacoochee and Chassahowitzka Rivers were more similar to the Suwannee (Fig. 7).

Based on an ANOVA of data gathered during aerial surveys of the southern Big Bend coast from April through October, 1979 through 1981,

Table 6. Comparison of manatee aerial survey counts among six waterways on the southern Big Bend coast of Florida from April through October, 1979 through 1981.

River (No. flights)	Unweighted mean*	Minimum count	Maximum count
Suwannee River	11.1[a]	0	33
Withlacoochee River	2.6[b]	0	20
Cross Florida Barge Canal	0.3[b]	0	3
Crystal River	14.0[a]	0	58
Homosassa River	2.3[b]	0	15
Chassahowitzka River	2.4[b]	0	8

* Mean number of manatees per flight per year averaged over 3 years (n = 37 flights). Means with same superscript are not significantly different ($\underline{P} > 0.05$). Statistical analysis based on square root scale. Data presented in arithmatic scale.

the frequency of manatee sightings in river, estuarine, and marine habitats of the five river systems (the CFBC is not included) was significantly different ($P < 0.05$, Table 7). The pattern of habitat use between rivers also was different, as indicated by the significant river x habitat interaction ($P < 0.0001$) of the preliminary analysis. The year x habitat interaction was not significant ($P > 0.12$) for all rivers except the Chassahowitzka River ($P < 0.05$). Yearly variation also was not significant in all cases ($P > 0.24$).

Manatees in the vicinity of the Suwannee River were seen principally in large groups at the mouths of North Pass, West Pass, and East Pass (Fig. 10) feeding on beds of *Ruppia maritima* that grow on sandbars adjacent to channels. In the Withlacoochee River they were seen frequently feeding on *Ruppia* or *Halodule wrightii* growing on sandbars adjacent to the main channel at the river's mouth and just offshore of the mouth (Fig. 11). They also were seen resting and feeding in the vicinity of Bird Creek and in the area where the dredged residential canals at Yankeetown meet the river (Fig. 11). Few sightings were made in the Withlacoochee River between Yankeetown and the CFBC, in the CFBC itself, in the Withlacoochee River between the CFBC and Lake Rousseau (Fig. 12), or the FPC intake canal (Fig. 13). The distribution of sightings in the lower reaches of Crystal River was influenced greatly during the spring and fall by the large number of animals coming and going from Kings Bay. Manatees frequently used those areas of the river that had vegetated, shallow shelves or sandbars next to a channel, such as the *Ruppia* beds near the confluence of Salt River, 1/2 km

Table 7. Comparison of manatee aerial survey counts among three habitats within five rivers on the southern Big Bend coast of Florida from April through October, 1979 through 1981.

River (No. flights)	Habitat	Unweighted mean*	Minimum count	Maximum count
Suwannee River (38)	Estuarine	10.2[a]	0	33
	Riverine	1.1[b]	0	7
	Marine	0.1[b]	0	1
Withlacoochee River (39)	Estuarine	1.4[a]	0	14
	Riverine	1.2[a,b]	0	8
	Marine	0.4[b]	0	7
Crystal River (38)	Riverine	10.6[a]	0	57
	Estuarine	3.1[b]	0	11
	Marine	0.3[c]	0	5
Homosassa River (38)	Riverine	2.0[a]	0	15
	Estuarine	0.3[b]	0	7
	Marine	0.03[b]	0	1
Chassahowitzka River (38)	Estuarine	1.8[a]	0	8
	Riverine	0.6[b]	0	5
	Marine	0.02[b]	0	1

* Mean number of manatees per flight per year averaged over 3 years. Means with same superscript are not significantly different ($\underline{P} \geq 0.05$). Statistical analysis based on square root transformation. Data presented in arithmatic scale.

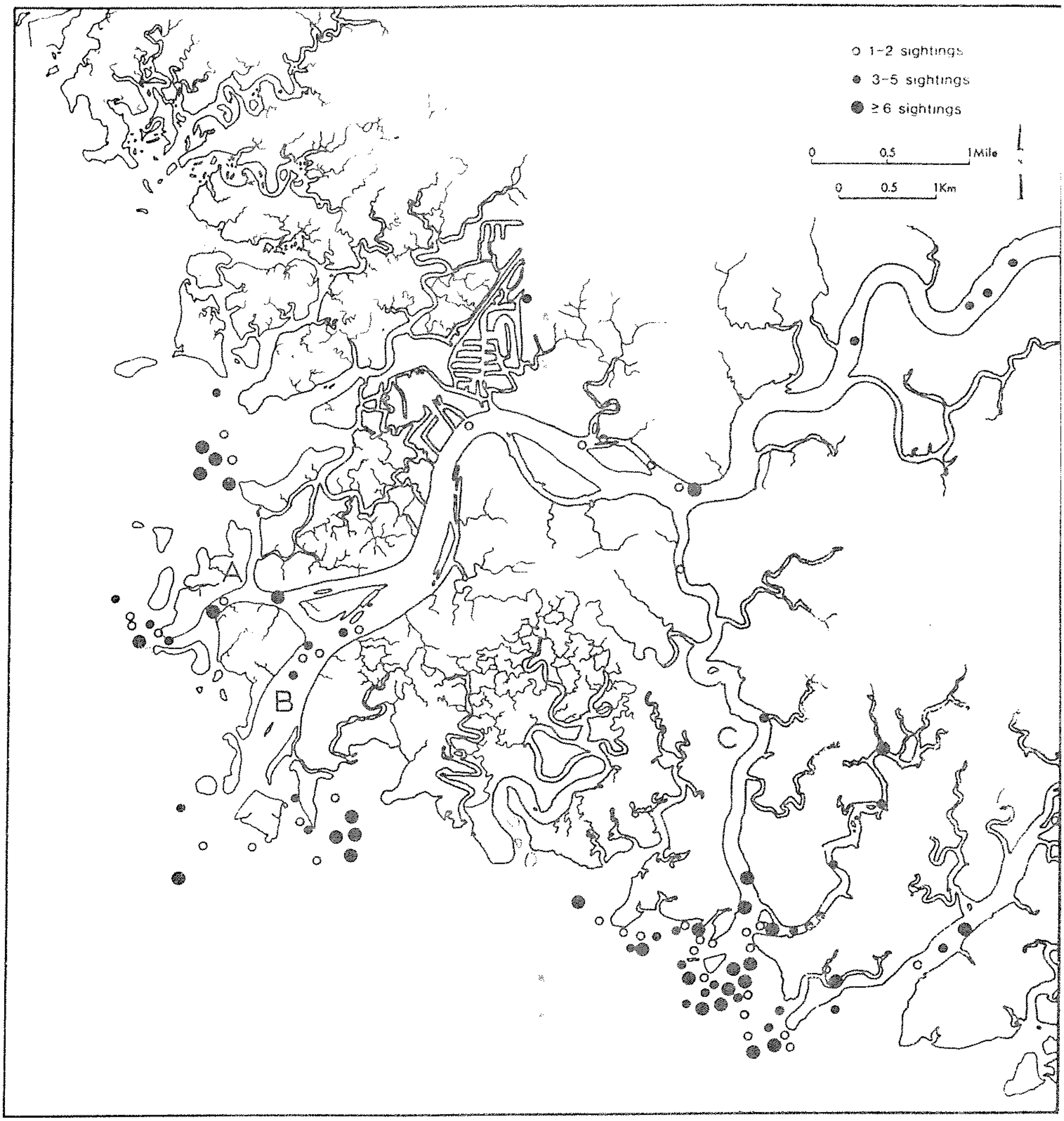


Fig. 10. Manatee sightings in the Suwannee River and within 1 km of its mouth. Data compiled from all aerial surveys from January 1978 through March 1981 (n = 36). A = North Pass. B = West Pass. C = East Pass.

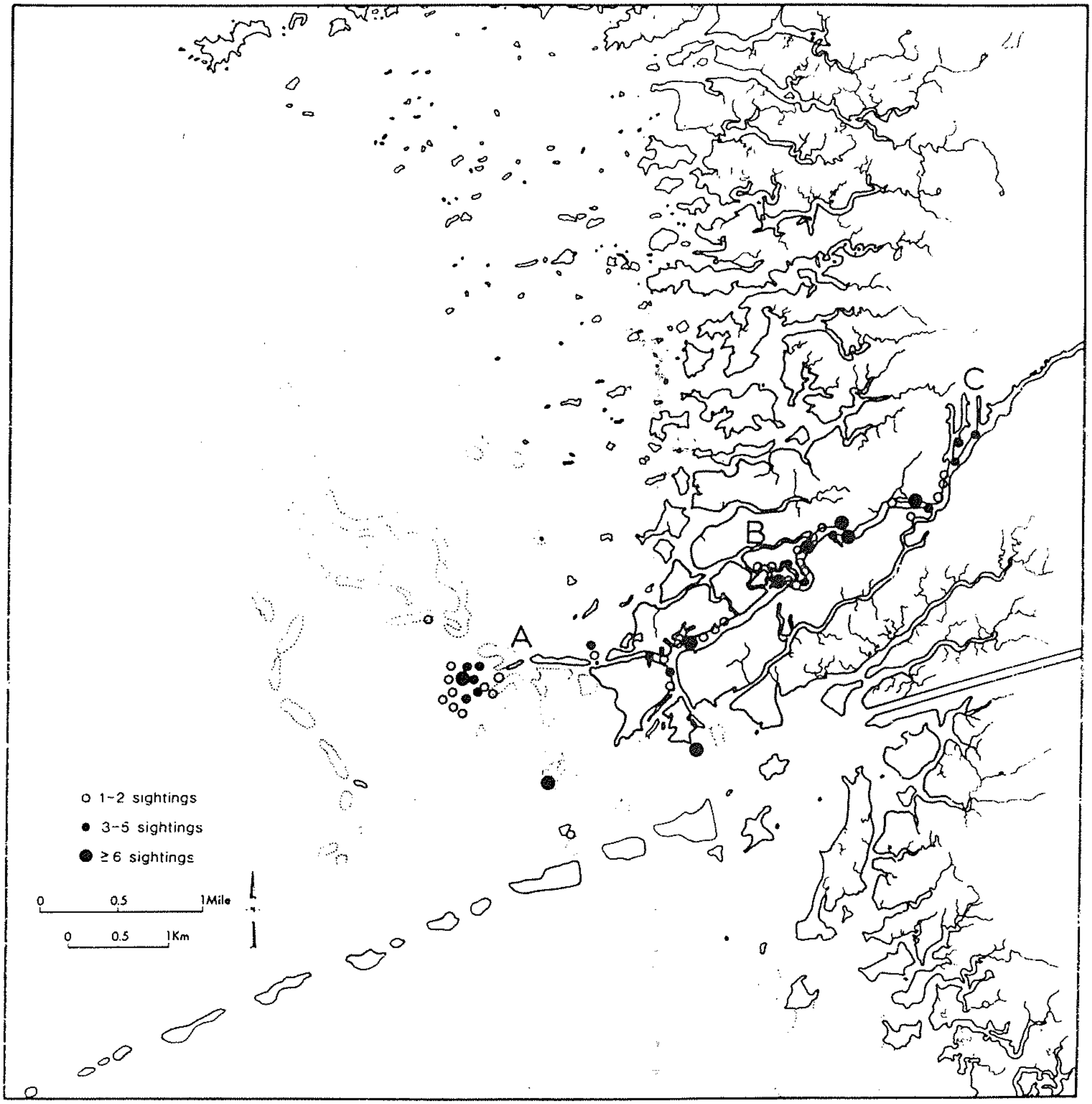


Fig. 11. Manatee sightings in the lower Cross Florida Barge Canal, lower Withlacoochee River, and within 1 km of the river's mouth. Data compiled from all aerial surveys from January 1978 through March 1981 (n = 46). A = Mouth of Withlacoochee River. B = Bird Creek. C = Yankeetown.

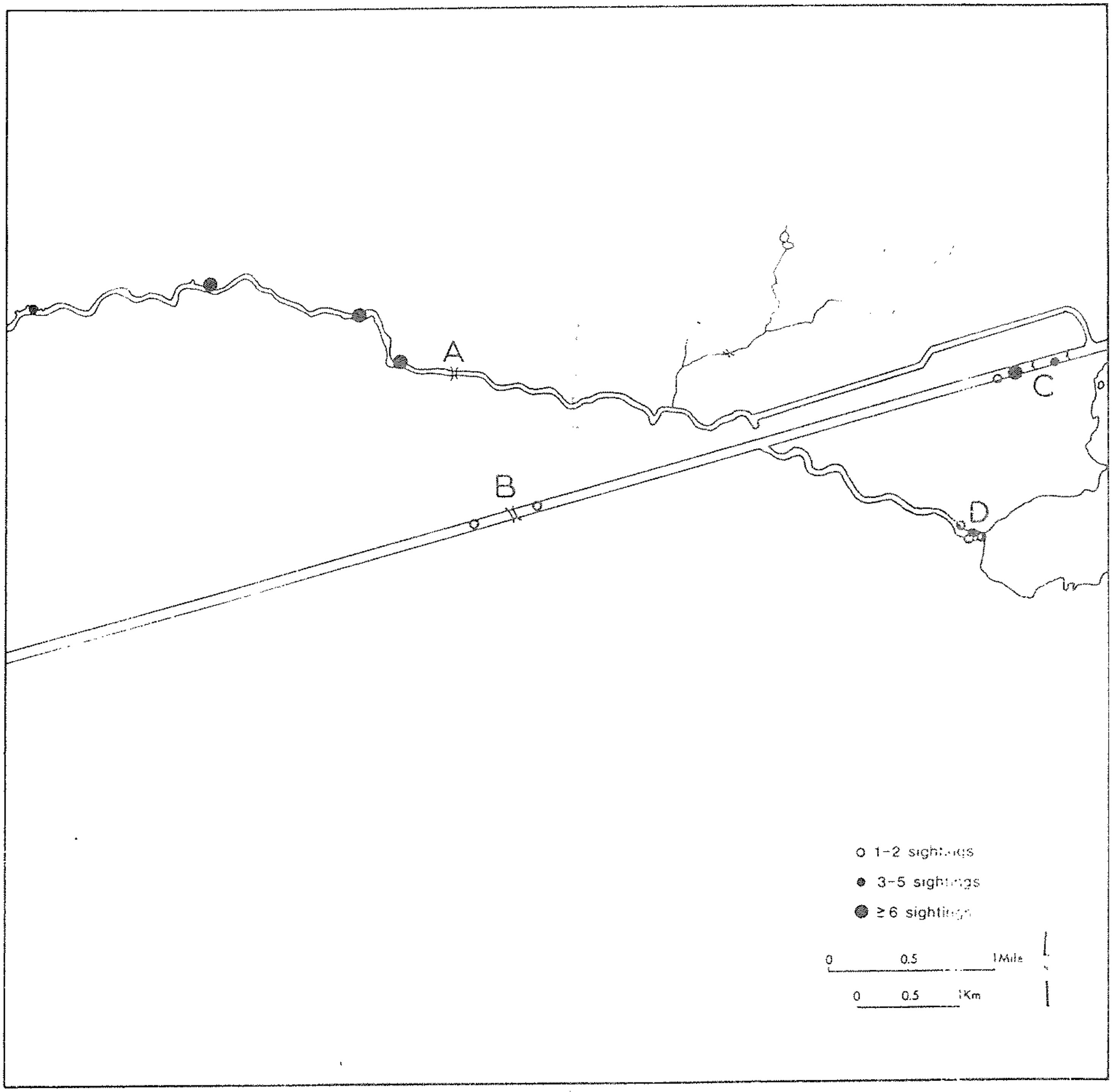


Fig. 12. Manatee sightings in the upper Cross Florida Barge Canal and upper Withlacoochee River. Data compiled from all aerial surveys from January 1978 through March 1981 (N = 46). A = U.S. Highway 19 bridge over the Withlacoochee River. B = Upper Cross Florida Barge Canal. C = Canal boat lock. D = Dam on the upper Withlacoochee River and Lake Rousseau.

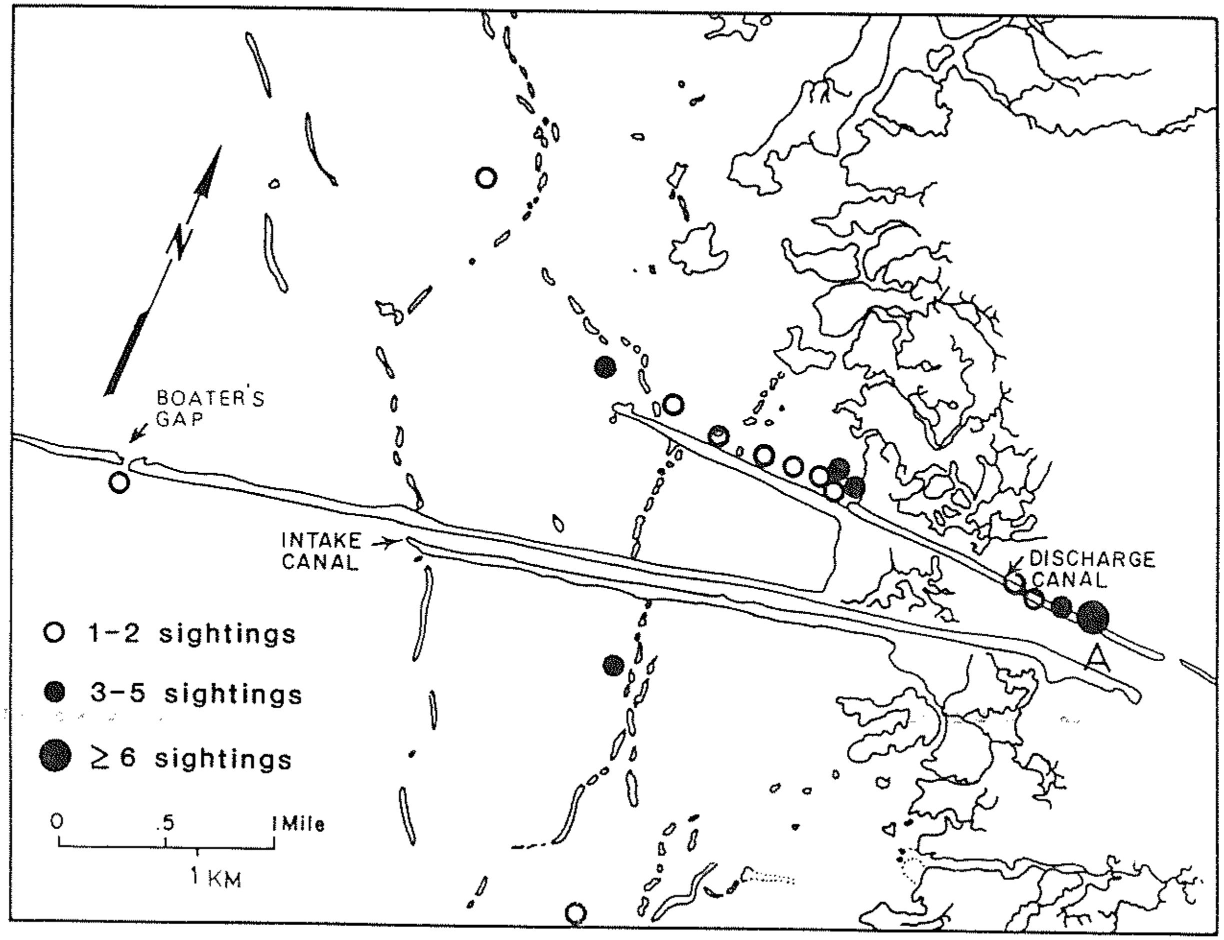


Fig. 13. Manatee sightings in the Florida Power Corporation Crystal River Power Plant (A) intake and discharge canals. Data compiled from all aerial surveys from January 1978 through March 1981 ($n = 46$).

downriver from "The Rocks", and around North Pass at the mouth of the river (Fig. 14). In the Homosassa River, manatees frequently were seen feeding on Ruppia and Halodule growing on sandbars at the river's mouth (Fig. 15). They also were seen feeding on Hydrilla and resting near the river's headwaters. Manatees in the Chassahowitzka River were seen resting, and feeding on Ruppia, along the channels and around the islands in the estuary at the mouth (Fig. 16). Animals rarely were seen in the Gulf of Mexico further than one kilometer from the mouth of a river (Fig. 9), with the exception of the shallow flats offshore of the Withlacoochee River, where they were occasionally observed moving slowly through the area. When seen in open Gulf waters between rivers they were always traveling.

Mortality Records

The manatee carcass salvage program of the Sirenia Project, U. S. Fish and Wildlife Service, has recovered and necropsied 28 animals from Citrus, Dixie, and Levy counties from April 1974 through June 1982 (O'Shea et al. in prep.). No recoveries were made from Hernando County. The causes of death were boat/barge, 5; navigation lock, 1; other human related, 1; dependent calf, 14; undetermined, 6; and other natural, 1. Three of the boat kills were recovered from the Withlacoochee River in 1975 and two from Crystal River. One manatee was killed by the Inglis Lock on the CFBC. Dependent calves were recovered from all major river systems except the Homosassa River (Table 8).

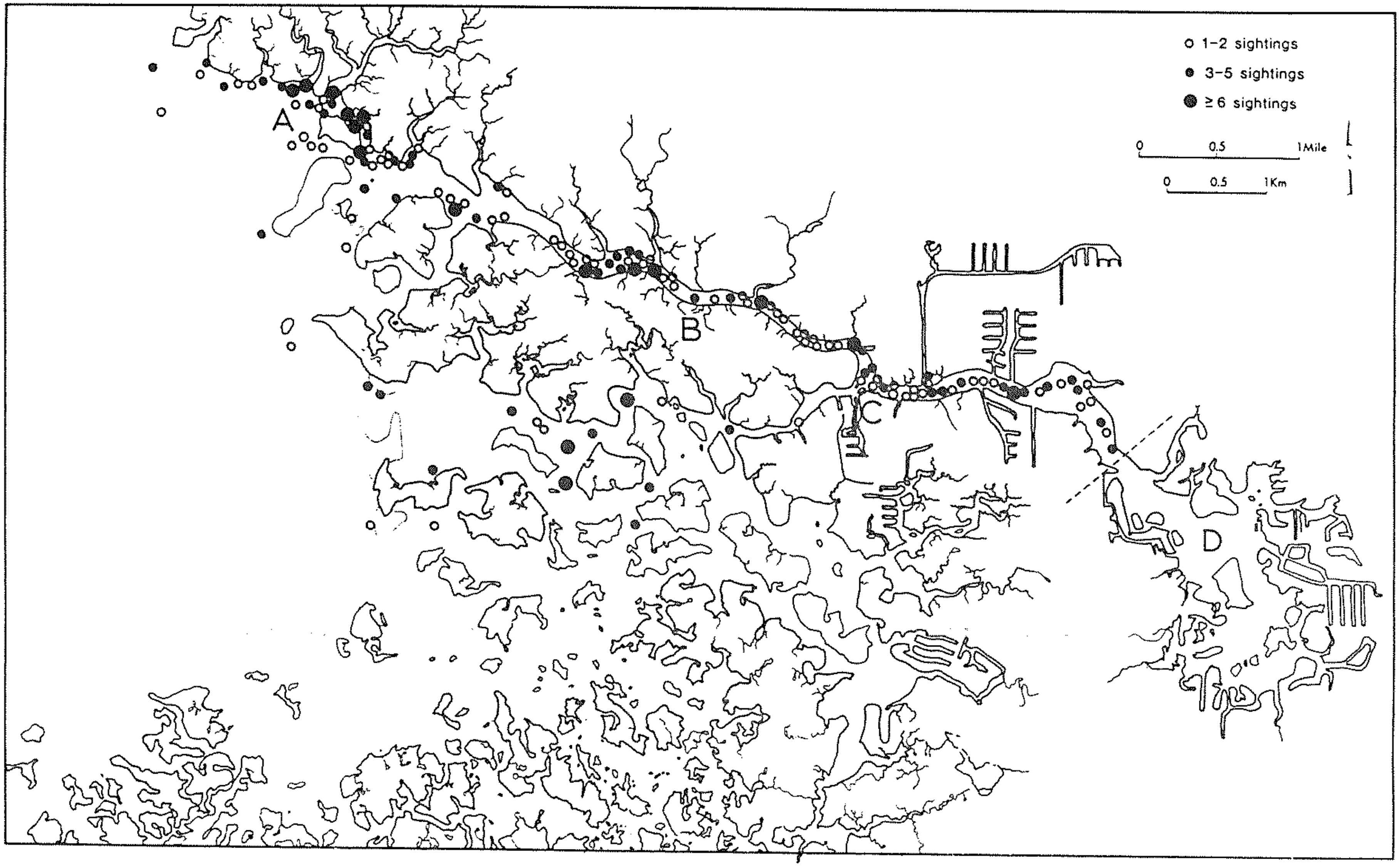


Fig. 14. Manatee sightings in the Crystal River and within 1 km of its mouth. Data compiled from all aerial surveys from January 1978 through March 1981 (n = 48). Sightings in Kings Bay (D, upriver of dashed line) are too numerous to be plotted (see Kochman et al. 1983). A = North Pass at mouth of Crystal River. B = The Rocks. C = Confluence of Crystal and Salt Rivers. D = Kings Bay.

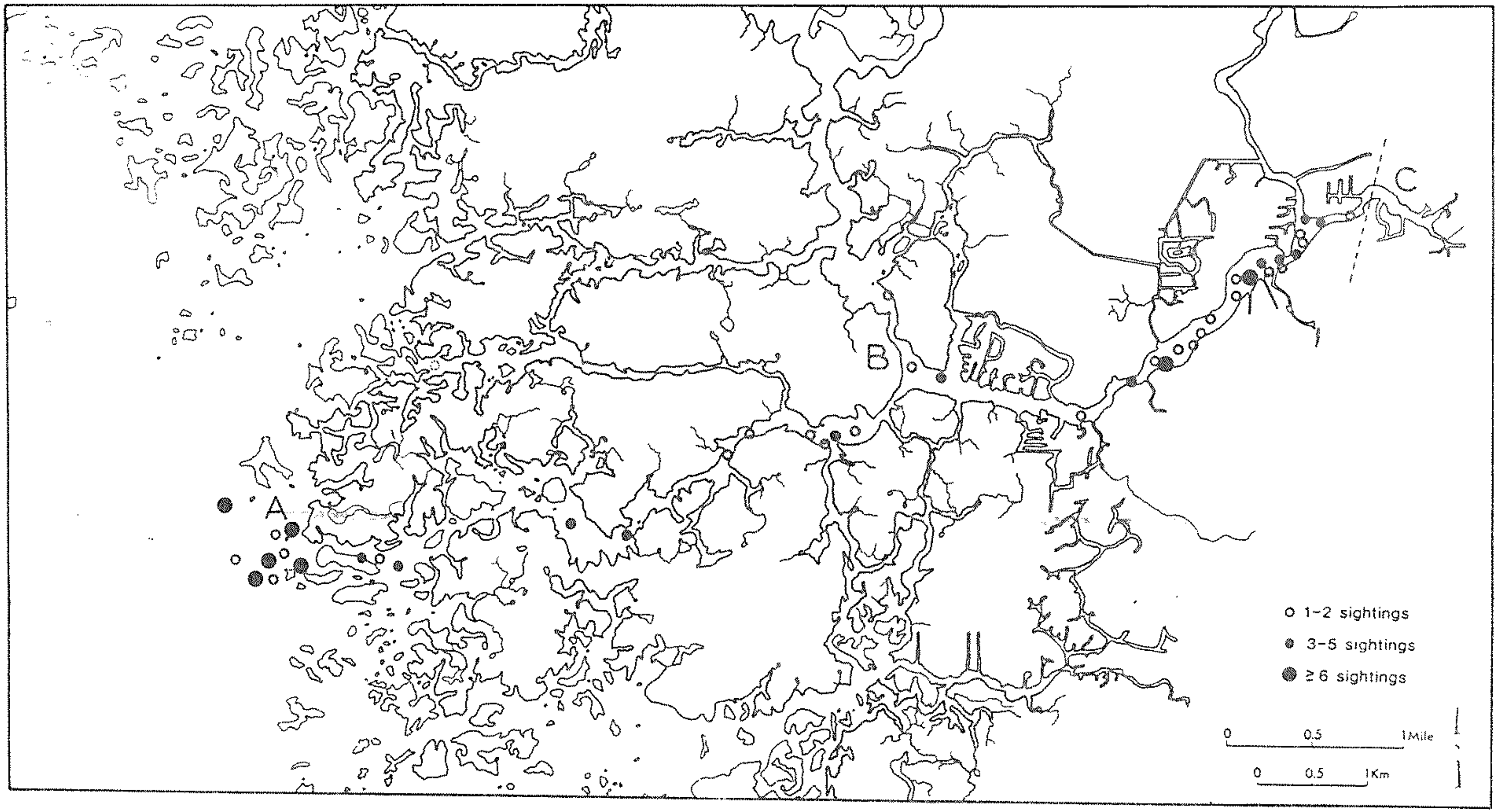


Fig. 15. Manatee sightings in the Homosassa River and within 1 km of its mouth. Data compiled from all aerial surveys from January 1978 through March 1981 (n = 46). Sightings in headwaters (C) are too numerous to be plotted (see Table 2). A = Mouth of Homosassa River. B = Confluence of Homosassa and Salt Rivers. C = Homosassa River headwaters.

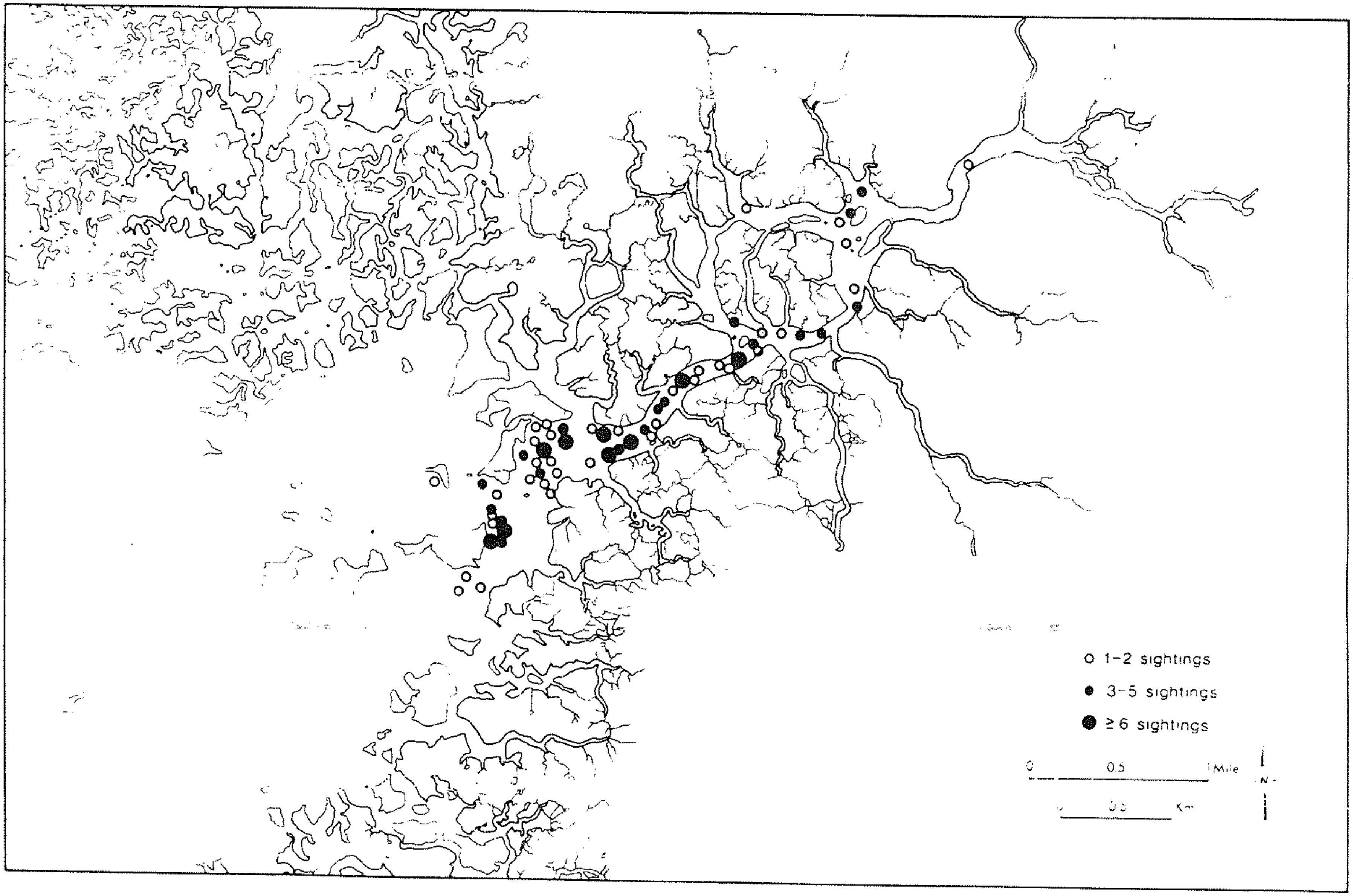


Fig. 16. Manatee sightings in the Chassahowitzka River and within 1 km of its mouth. Data compiled from all aerial surveys from January 1978 through March 1981 (n=47).

Table 8. Southern Big Bend manatee Mortality, April 1974 through June 1982. Data from Sirenia Project manatee salvage program, U. S. Fish and Wildlife Service.

County	Date	Field No.	Location	Cause of Death
Dixie	16 Jan 80	M 180	Suwannee, at mouth of the Suwannee River	Undetermined
	29 May 80	M 193	Suwannee River, Suwannee, ca. 1 km downstream of Lock Creek	Dependent calf
Levy	20 Mar 75	M 8	Withlacoochee River at marker 43	Boat/barge
	20 Mar 75	M 9	Withlacoochee River, 100 m upstream of marker 43	Boat/barge
	24 Oct 75	M 14	Withlacoochee River, drifted 2 mi down river from the boat marina, Yankeetown	Boat/barge
	13 Apr 76	M 22	Manatee Springs, in mouth of Manatee Springs Run at its confluence with Suwannee River	Dependent calf
	8 Apr 78	M 113	Withlacoochee River, Yankeetown, .5 km east of Yankeetown Boat Company	Dependent calf
	3 Jul 80	M 196	East pass of the Suwannee River, just W of the mouth	Undetermined
	2 Nov 80	M 212	Inglis, Cross Florida Barge Canal, Inglis Lock, immediately downstream of west gate	Gate/lock
	7 Dec 80	M 214	Cedar Key, found floating offshore between markers 16 and 18	Dependent calf
	15 Mar 81	M 228	Inglis, Cross Florida Barge Canal, Inglis Lock, immediately downstream of SW end of lock	Dependent calf

Table 8. Continued.

County	Date	Field No.	Location	Cause of Death
Levy	7 Mar 82	M 274	Barge Canal, Inglis Lock, on S side, outside of the downstream gate	Dependent calf
Citrus	25 Dec 74	M 2	Crystal River, Bagley Cove	Boat/barge
	29 Jan 76	M 16	Crystal River, King's Bay, S tip of Buzzard Island	Undetermined
	5 Jan 77	M 40	S side of Crystal River, 1 km downstream from conjunction with Salt River	Other human
	26 Jan 77	M 43	Crystal River, King's Bay, W shore of Buzzard Island	Undetermined
	4 Sep 77	77 43	Crystal River, Kings Bay, in creek on SW bank of bay	Undetermined
	16 Oct 77	M 92	Crystal River, Kings Bay	Undetermined
	11 Jan 78	M 97	Crystal River, canal running parallel to Palm Drive	Dependent calf
	31 Aug 78	M 126	Junction of Salt and Crystal Rivers across from Twin Rivers Marina	Boat/barge
	8 Feb 79	M 135	Chassahowitzka River, 300 yds E of Crawford Creek	Dependent calf
	16 Mar 79	M 141	Crystal River, Kings Bay, S shore of Three Grassy Islands, W of Banana Island	Dependent calf
	21 Feb 80	M 185	Crystal River, W bank of main channel of Crystal River, just S. of Bagley Cove, adjacent to Indian mounds	Dependent calf
	27 Feb 80	M 187	Crystal River, Kings Bay main boil	Other/natural
	22 May 81	M 241	St. Martins River at Ozello	Dependent calf

Table 8. Continued.

County	Date	Field No.	Location	Cause of Death
Citrus	22 Feb 82	M 269	South shore of the Barge Canal, approx. 1 km downstream of Inglis Lock, in bay E of Dolime Mineral Plant	Dependent calf
	28 Feb 82	M 271	South bank of the Withlacoochee River, between the Barge Canal and the Withlacoochee Dam	Dependent calf
	4 Mar 82	M 272	Crystal River, Kings Bay, in cove SW of Warden Key	Dependent calf

DISCUSSION

Manatee Distribution West of the Suwannee River

Manatees have been found along the entire coast of the northern Gulf of Mexico (Fig. 1). However, there is a spatial and temporal pattern to their distribution. Sightings along the northwestern Gulf, from Texas to Louisiana, have declined since the early part of this century and they all have occurred during the summer. Gunter's (1942) suggestion that these manatees originated from Mexico is probably correct. The recent decline of sightings from Texas probably is due to the extirpation of animals in northern Mexico (Alvarez, 1963). In contrast, the number of animals sighted along the norhteastern Gulf has increased recently, particularly in Mississippi. These extralimital sightings probably are due to animals moving north and west along the coast from the southern Big Bend coast, where their numbers have increased dramatically in the past 20 years (Table 2).

Along the northwestern Gulf coast, the sequence of sightings seems to indicate a historical movement pattern very similar to that found along the Atlantic coast of Florida, where manatees make a north-south seasonal migration in response to cold winter temperatures (Moore, 1951; Rathbun et al., 1982; Shane, 1983). Although there is no historical evidence for manatee migration along the eastern Gulf coast (Moore, 1951), manatees presently using Crystal River and Homosassa River as winter refuges seasonally disperse as far north as the Suwannee River and south at least to the Chassahowitzka River (Fig. 7). If the number of animals continues to increase along the southern Big Bend coast, resources may become limited, forcing spring migration further afield. Two factors probably act to inhibit longer distance movements to the north or south. First, the northwestern coast of Florida does not have a sheltered, continuous series of estuaries and bays connected by an intracoastal waterway along its entire length, as occurs along the Atlantic coast. These protected waters are favored by manatees (Hartman, 1974) and provide ideal corridors of travel. Secondly, Crystal River and Homosassa River provide large, reliable, and natural sources of warm water that free manatees from the necessity of moving south during the cold winter months.

The winter range of manatees will probably not extend further north than Crystal River, or perhaps Manatee Spring, because they are sensitive to cold temperatures (Irvine, 1983; Shane, in press). The minimum suitable water temperature is about 20^{o}C, and feeding may be inhibited at temperatures approaching 16^{o}C (Campbell and Irvine, 1981; Irvine, 1983). Even though the Mississippi and Louisiana coasts are located at about the same latitude as Jacksonville, FL (30-31^{o}N Lat.), where manatees often overwinter in warm water industrial outfalls (Hartman, 1974), the average winter Gulf water temperature in Mississippi in January, 1982 was 3.3^{o}C lower than in Jacksonville (National Oceanic and Atmospheric Administration, 1982). Industrial and electric generating plants along the northern Gulf coast do not raise the ambient water temperature sufficiently for wintering manatees. For example, the J. Watson Power Plant in Biloxi, MS, reported an average daily discharge temperature of only 15^{o}C during January 1980 (E. J. Holt, pers. comm.), the same month when animals were sighted in the vicinity of Biloxi. The dead and cold-stressed manatees found in Mississippi are further evidence that winter conditions are too cold along the northern Gulf coast.

Manatee Abundance and Distribution Along the Southern Big Bend Coast

Although Moore (1951) considered the southern Big Bend coast of Florida outside of the normal range of the manatee, there is considerable evidence that during the period of Indian dominance, animals populated this coast in sufficient numbers to be hunted. Manatee kill sites have been identified on the Sante Fe River (off of the Suwannee River), Withlacoochee River, and Crystal River (Cumbaa, 1980). Bone fragments with cuts and scrapes have been found in the Waccasassa River (pers. obs.). Presumably Manatee Spring was named because manatees were hunted in the spring run during the winter (Bartram, 1791). Although the evidence indicates that manatees were once abundant enough to be hunted by Indians, their numbers probably were kept at low levels. In the mid-19th century the southern Big Bend coast was occupied by white settlers. The Indians and first settlers probably found the animals wintering in the clear headwaters of Manatee Spring, Crystal River, and Homosassa River easy prey, which they subsequently hunted to near extinction. Thus, with the exception of Bartram's (1791) account, reference to manatees on the southern Big Bend coast virtually disappeared from the literature until the mid-1900's (Moore, 1951; Layne, 1965).

The recent population increase along the southern Big Bend coast can be attributed to several factors. Most important has been the reduction of hunting and poaching due to the enactment of strong protective laws and the emergence of a conservation ethic. Mr. T. R. Hodges (in Moore, 1951) remarked: "...they became almost extinct years ago...A law was passed prohibiting anyone from killing a manatee except for scientific purposes...the enforcement of this law was under my jurisdiction for fifteen years and was rigidly enforced, and the manatee became very plentiful..." Another factor has been the low mortality in recent years compared to other areas of the state (Irvine, et al., 1981; Beck, et al., 1981, O'Shea et al., in prep.). Large boats have been identified as a major cause of manatee mortality in Florida (Beck et al., 1982), but due to the shallowness of the southern Big Bend coast (Vernon, 1951) and the absence of an intracoastal waterway, relatively few large vessels utilize the area and few boat kills have been identified. An exception to this was the death of at least three animals in the Withlacoochee River in 1975 (Table 8), during the period when oil was being carried upriver by barges. There have been no boat mortalities reported in the Withlacoochee River since the barge traffic stopped.

The low manatee mortality and large proportion of calves in the Crystal River population compared to other areas of the state (Irvine and Campbell, 1978; O'Shea et al., in prep.) suggests that the population increase probably has primarily been due to intrinsic growth (Table 2). However, every year a few adult manatees, with large, old, and distinct scars are identified in Crystal River for the first time (Table 3; Hartman, 1979; Powell, 1981). These animals must be emigrating from the south, possibly due to human encroachment of their habitat (Hartman, 1979) and the destruction of seagrass beds (Phillips, 1960). The introduction of exotic macrophytes in the Crystal River (Hartman, 1979) is probably another factor contributing to an increase in manatee abundance. Our vegetation survey data (Fig. 5) suggest that before the introductions, there was less food available in Crystal River than at present. There may not have been enough submerged vegetation before the introductions to support the number of animals presently wintering in Crystal River.

The five principal rivers along the southern Big Bend coast have distinctive characteristics that influence the seasonal distribution of manatees (Fig. 7). Crystal River, Homosassa River, and Chassahowitzka River are unique in that they are spring fed and are relatively short in length. The Crystal and Homosassa rivers are fed by numerous large springs that have a constant temperature (23.5°C) throughout the year (Rosenau et al., 1977), and have channels that are greater than one meter deep, enabling manatees to reach the headwaters. The Chassahowitzka River, however, is fed by small springs (Rosenau et al., 1977) and its upper channel is normally too shallow for manatees (Hartman, 1979). Crystal River and Homosassa River are unique in that they form large, natural sources of warm water, whereas most other winter refuges in Florida are man-made, usually at electric generating plants (Hartman, 1974). The Suwannee River and Withlacoochee River are not spring fed and become too cold for manatees during the winter.

Manatees used the Crystal River FPC power plant effluent and other smaller springs as temporary "safe spots" and transition areas.

The greatest number were seen in the plant's warm water effluent during the early spring as they exited from Crystal River, and to a lesser degree in the fall when they returned (Fig. 8). Presumably they used the plant until the coastal water warmed sufficiently for their dispersal, or as immediate shelter during cold fronts before their arrival at Crystal River. The power plant and the other temporary refuges probably will not become established as permanent winter sanctuaries due to a lack of freshwater or adequate food, as well as their small size and difficulty of access.

During the warm months the five major rivers along the southern Big Bend coast form high-use (Suwannee River and Crystal River) and low-use (Withlacoochee, Homosassa, and Chassahowitzka rivers) systems (Table 6). This dichotomy is related to the different characteristics of the riverine, estuarine, and marine habitats of each river and the habitat requirements of manatees.

Estuarine conditions in the rivers of the southern Big Bend coast are created by several important physiographic features. Oyster bars form fringing reefs at the mouths of the Suwannee River, Withlacoochee River, Crystal River, and Homosassa Rivers. The bars at the mouth of the Suwannee River trap fresh water from the river and create the large, protected estuary that is heavily used by manatees during the warm season (Fig. 10, Table 7). The small estuary formed by large, marshy islands at the mouth of the Chassahowitzka River is also regularly used during this period (Fig. 16). Estuarine conditions in the Withlacoochee River, Crystal River, and Homosassa River are limited to relatively small portions of their channels upstream from their mouths. The rate of water flow is much less than that of the Suwannee River (EPA, unpubl. data) and the channels have been dredged at the mouths, which prevents freshwater from becoming impounded by the fringing oyster bars. This results in the large, shallow flats between the oyster bars and mouths of these three rivers being principally marine and infrequently used by manatees.

The riverine habitats of Crystal River and Homosassa River are used significantly more than the estuarine and marine habitats (Table 7), because animals begin to aggregate in both rivers during late September and early October in anticipation of cold weather (Fig. 7). This increases the average warm season counts. The riverine habitats of the Suwannee River and Chassahowitzka River are used significantly less than the estuarine habitats (Table 7). The channel in the Chassahowitzka River is well vegetated, but is normally too shallow for manatees to navigate, whereas the channel in the Suwannee River is deeper and wider, but supports little submerged vegetation suitable for feeding. The water of the Suwannee River is turbid, which prevents rooted submerged aquatic plants from growing, and the swift current prevents large mats of floating vegetation from forming along the banks. These conditions are not present in Manatee Spring, however, where the water is clear and several species of submerged aquatic plants attract manatees (Table 4).

Manatees are rarely seen in purely marine habitats along the southern Big Bend coast (Fig. 9). This is due to their habitat requirements, which probably relate to their phylogeny and physicological limitations. Domning (1982) presented evidence that the genus Trichechus (Family Trichechidae) evolved relatively recently (Pliocene) in freshwater habitats in the Amazon Basin of South America. He also suggested that the Amazonian manatee (Trichechus inunguis) is restricted to fresh water rivers because it is unable to osmoregulate in salt water. Another sirenian, however, the dugong (Dugong dugon; Family Dugongidae), is strictly marine, and presumably does not require access to fresh water (Bertram and Bertram, 1973). West Indian manatees that occur in salt water habitats are frequently seen drinking from fresh water sources, such as sewer effluents, offshore artesian springs, and water hoses (Morison, 1942; Hartman, 1974; Belitsky and Belitsky, 1980; Powell, et al., 1981; Shane, 1983). Hartman (1974, 1979) first proposed that the frequent association of manatees with fresh water in Florida was related to their poor osmoregulatory abilities. Manatees do not occur regularly around Caribbean islands that lack reliable sources of fresh water, such as the Lesser Antilles and Bahamas (Husar, 1977). In Florida (Hartman, 1974; Irvine and Campbell, 1978), Cuba (Cuni, 1910), Puerto Rico (Powell et al., 1981), and Honduras (Rathbun, et al., 1983) manatees are normally found in association with fresh water. Our data confirm this pattern on the southern Big Bend coast (Fig. 6). Clinical studies by Irvine et al., (1980) suggest that manatees have at least a limited ability to excrete salt while occupying marine habitats. Although the circumstantial evidence for fresh water dependency is strong, the extent of their dependency will remain speculative until appropriate physiological studies are completed.

The southward summer movement of Gus (CR 108♂) to Sanibel Island and then his return in the fall to Crystal River is intriguing for several reasons. First, it suggests a strong traditional use of the winter refuge. When Gus was at Sanibel Island he was within 30 km of the Tice Florida Power and Light Co. power plant, the largest known winter aggregation site on the west coast (Rose and McCutcheon, 1980). Rather than remain for the winter at this nearby warm water site, he traveled 320 km north to Crystal River. This northward movement is opposite to what might be expected as a response to impending cold weather and is the converse of the migratory movements on the east coast. Secondly, his summer movement out of the southern Big Bend coast may illustrate how reproduction influences male movements. Gus is a large male that had been seen participating in several mating herds during the previous six seasons. Bengtson (1981) found that males in the St. Johns River moved more frequently and further afield than females. This suggests that Gus's movement to Sanibel Island was related to his search for reproductive females, rather than a movement to avoid adverse seasonal temperatures or a limited resource, such as food.

Packard (in press) has shown that manatees on the east coast of Florida feed on dense beds of *Syringodium filiforme*, *Thalassia testudinum*, and *Halodule wrightii* and in some areas they entirely remove these species by excavating the substrate. Birch (1975) carried out some chemical analyses of several marine angiosperms in Australia, including *S. isoetiofolim*, *T. hemorichii*, and *H. uninervis*, and found that the sodium content of the plants (2.8 to 7.8%, dry weight) often exceeded that of sea water. Birch (1975) calculated that an average-sized dugong feeding on these marine angiosperms would consume about 61 g of sodium per day. This requires a considerable ability to eliminate salt. Fresh water macrophytes, such as *Hydrilla verticillata*, *Ceratophyllum demersum*, *Vallisneria americana*, and *Najas guadalupensis*, have low sodium concentrations (less than 1.5% dry matter; Easley and Shirley, 1974) compared to marine plants. The estuarine plant, *Ruppia maritima* is tolerant of a wide range of salinity, and its sodium content is intermediate to the marine and freshwater angiosperms (1-3%, dry weight; Walsh and Grow, 1972).

Vast seagrass beds, dominated by *T. testudinum*, *S. filiforme*, and *H. wrightii*, extend up to 25 km offshore along the southern Big Bend coast (Phillips, 1960; U.S. Fish and Wildlife Service, 1982). These three species have different tolerances to fluctuating salinities and exposure to air during low tides, which results in their zonation (Strawn, 1961). *Halodule* grows nearest to shore and around the mouths of the rivers, while *Thalassia* and *Syringodium* are found in deeper water further from shore, often outside the fringing oyster bars (pers. obs., Strawn, 1961). *R. maritima* is most tolerant of fluctuations in salinity and is abundant in the estuarine habitats at the mouths of the Suwannee and Chassahowitzka Rivers, and in the estuarine habitats of the lower Withlacoochee, Crystal, and Homosassa Rivers (pers. obs.; Hartman, 1979). Manatees along the southern Big Bend coast frequently were seen feeding on *Ruppia* and *Halodule* in and near the estuarine habitats at the mouths of the rivers during the summer, and in freshwater during the winter. They rarely were seen in association with the offshore beds of marine angiosperms. These observations are consistent with the hypothesis that manatees have poor abilities to osmoregulate and thus feed on plants with low salt concentrations (such as Ruppia) or on marine angiosperms that grow near fresh water (such as Halodule). Not enough is known about the distribution of manatees, food plants, and freshwater along the east coast of Florida to explain Packard's (in press) observations.

If the West Indian manatee has difficulty in excreting salt obtained by feeding on sodium-rich marine plants, then they might be expected to remain in the headwaters of the Crystal and Homosassa Rivers year round in order to feed on fresh water macrophytes with low sodium contents. There are two principal reasons why they do not. First, both rivers are urbanized with considerable recreational boat traffic during the summer. Manatees may avoid these activities when they are not seeking the warm spring water during the winter. The second and most important factor is the manatee's need to conserve body heat. During the warm months, the temperature at the headwaters of the two spring-fed rivers can be 13°C lower than the temperature of the other rivers or Gulf. Since these animals have relatively low metabolic rates and high heat conductances (Irvine, 1983) they would be expected to favor warmer water.

The Future of Manatees Along the Southern Big Bend Coast

We have presented data on the distribution and abundance of manatees that suggests that the population along the southern Big Bend coast has increased dramatically in the last two decades. Human-caused mortality has been low compared to the eastern and southwestern regions of the state (O'Shea et al., in prep.). Manatees along the southern Big Bend coast are doing well because large sections are relatively unpopulated, undisturbed, and undeveloped compared to other areas of the state (Fernald, 1981). Consequently, we feel that the best hope for the long-term existence of this endangered species in Florida is along the Big Bend coast. However, this could easily and rapidly change if the region develops without regard to the needs of the manatees. It is the responsibility of the various local, state, and federal governmental agencies, conservation organizations, and private companies to ensure that the Big Bend coast develops in harmony with manatees. This may be the last opportunity in the United States to use foresight to conserve manatees. The alternative is to mimic past efforts and base remedial actions on hindsight.

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USE OF KINGS BAY, CRYSTAL RIVER, FLORIDA BY THE WEST INDIAN MANATEE (*Trichechus manatus*)

Howard I. Kochman, Galen B. Rathbun, and James A. Powell
U. S. Fish and Wildlife Service
Denver Wildlife Research Center
412 N.E. 16th Ave., Rm. 250
Gainesville, FL 32601

INTRODUCTION

The distribution of the West Indian manatee (*Trichechus manatus*) in Florida varies seasonally in response to changes in water temperature (Moore, 1951; Hartman, 1979; Irvine, 1983). During spring and summer months, manatees are widely dispersed along the Gulf and Atlantic coasts of the Florida peninsula (Hartman, 1974; Powell and Rathbun, 1983). With the onset of cold weather during the fall, however, manatees begin to aggregate at specific wintering sites where water temperatures remain at 20 C or higher (Hartman, 1974; Rose and McCutcheon, 1980; Shane, 1981). Although most warm-water refugia in Florida are associated with thermal effluents from power plants, 6 of the 25 known sites are natural artesian springs (Hartman, 1974). The largest aggregations at a natural refugium occur in Kings Bay, at the headwaters of the Crystal River along the Gulf coast of north-central Florida.

Since Hartman's (1979) pioneering study of manatees in Kings Bay during the late 1960's, the number of animals using the site as a warm-water refuge has increased (Powell, 1981), as has human use of the bay. Recreational activities, aquatic weed control, dredging and construction have intensified to the point where serious conflicts with manatee conservation have developed. Such conflicts can be reconciled only through a detailed understanding of the manner in which manatees use Kings Bay.

Aerial surveys conducted over a 4-year period have enabled us to document spatial and temporal patterns that characterize manatee use of Kings Bay. The development of management practices based on these usage patterns should minimize resource conflicts and help ensure the future of the northwestern Florida manatee population.

METHODS

A total of 181 manatee surveys was flown over Kings Bay from November 1977 through October 1981. Surveys were conducted during daylight hours in a Cessna 172 airplane at an approximate altitude and air speed of 170 m and 80 km/hr, respectively. The right door of the aircraft was removed to provide better visibility for the single observer. The bay was surveyed 2-8 times per month (mean = 4.7) from October through March and 1-6 times per month (mean = 3.0) from April through September. No surveys were conducted in June 1979. The location and number of manatees sighted during each survey were recorded on a study area map overlaid with a grid scaled at 60 m x 60 m. Manatee behavior was noted during the flights when possible.

Variation in manatee counts among months and years was analyzed by the method of m-rankings (Sarle, 1981). This procedure is based on rank scores and makes no assumptions about the distribution of the dependent variable. The m-rank technique is a generalization of Friedman's method for randomized blocks and provides a nonparametric alternative to factorial analysis of variance. Multiple comparisions based on m-rankings were done as pairwise tests between all pairs of months and years. The significance of each comparison was tested with critical values determined by the Bonferroni inequality (Harris, 1975) at an experimentwise error rate of $\underline{P} \leq 0.05$. Analyses were performed using the MRANK procedure (Sarle, 1981) of the Statistical Analysis System (SAS Institute Inc., 1979).

Spatial characteristics of manatee distribution in Kings Bay were summarized on a monthly basis with computer-generated maps indicating the average number of manatees sighted at each location. Coordinates defining the outline of the bay and the location of manatee sightings were taken directly from the study area grid and mapped at a different scale. Maps were produced using the SYMAP program (Dougenik and Sheehan, 1975).

The diurnal movement of manatees to and from the southern portion of Kings Bay was monitored for 16 days from November-December 1980. An observer was stationed 3 m above the surface of the water on an anchored boat. As manatees passed the western tip of Warden Key (Fig. 1), the time, direction of travel and group size were recorded. Concomitant counts of the number of boats in the southern portion of Kings Bay (defined by the Main Spring to the east, Banana Island and Warden Key to the north, and the shoreline of the bay to the south and west) were made at the beginning of each hour. Hourly measurements were also taken of air temperature and surface water temperature at the anchored boat.

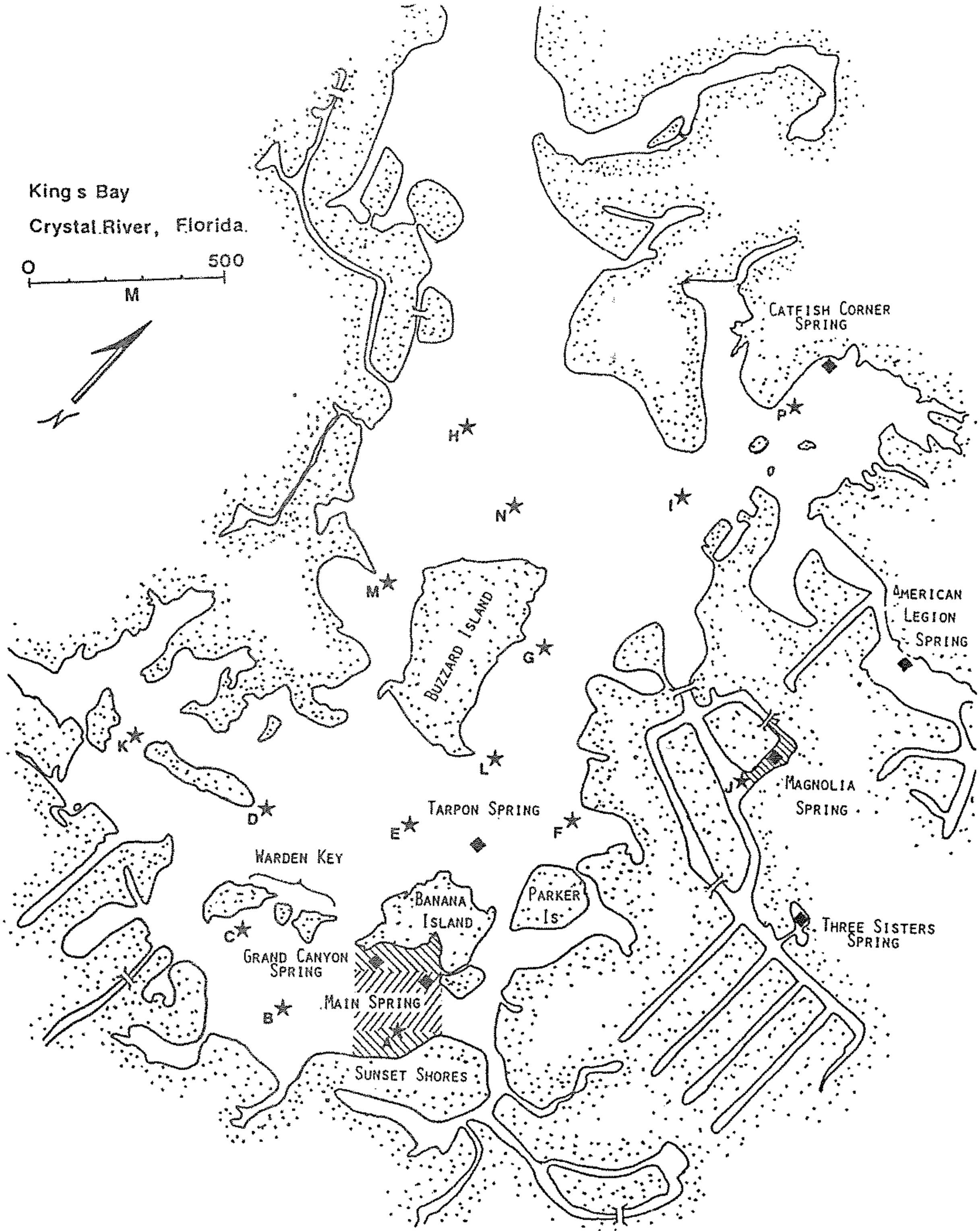

Fig. 1. Kings Bay study area. ★ = vegetation sample plots A-P (no plot O), ◆ = major artesian springs, \\\\\\\\ = no-entry warm-water manatee sanctuaries, //// = unrestricted warm-water area of Main Spring.

The species composition and height of submerged aquatic vegetation in Kings Bay were surveyed from July 1979 through June 1981. Monthly samples of 10 random points were taken at each of 15 study plots (30 m x 30 m) throughout the bay (Fig. 1). At each point, a graduated staff was dropped to the substrate and a perpendicular cross 1 m in diameter was lowered to the surface of the submerged vegetation. Plants within 5 cm of the four tips and the center point were identified. Vegetation height at the staff was recorded to the nearest 10 cm, with a value of "0" assigned at points where vegetation was absent. Mean vegetation height over the 2-year sample period for each month, plot and plant taxon was interpreted as an index of vegetation abundance. Surface water temperature at each plot was measured once during each monthly sample.

A survey to determine dominance patterns of submerged aquatic plants and water depth contours throughout Kings Bay was conducted on 28 and 30 May 1980. Samples were taken at 495 evenly spaced locations in the bay corresponding to the 60 m x 60 m grid cells of the aerial survey maps. At each location, a diver subjectively ranked the three most dominant plant taxa based on relative abundance. Water depth at each sample point was measured with a fathometer and tidal variation was recorded hourly to standardize depth readings to mid-tide. Maps depicting the observed dominance of each plant taxon throughout Kings Bay were produced with SYMAP. Map locations falling between sample sites were assigned the dominance at the closest data point. Depth profiles of the bay were interpolated by SYMAP and plotted as 3-dimensional oblique views by a companion program, SYMVU (Laboratory for Computer Graphics and Spatial Analysis, 1975).

Data processing was performed with resources of the Northeast Regional Data Center at the University of Florida, Gainesville.

STUDY AREA

Kings Bay is located adjacent to the town of Crystal River in Citrus County, Florida. The bay is approximately 2 km long and 1 km wide and forms the headwaters of the Crystal River, which empties into the Gulf of Mexico approximately 11 km to the northwest. Although Kings Bay is fed by at least 30 different subaqueous springs (Rosenau et al., 1977), several large springs (Fig. 1) account for most of the discharge. Total spring discharge from 1964-1975 averaged 25.9 m^3/s (Rosenau et al., 1977). Kings Bay is relatively shallow, approximately 1-3 m deep throughout most of its area, with some of the larger springs reaching depths of 10 m or more (Fig. 2). Although strictly a freshwater habitat, the bay is subject to tidal influence causing daily fluctuations in water level of approximately 60 cm.

During the winter, air temperature and boat traffic at Kings Bay exhibit similar diel cycles characterized by early morning minima and mid-afternoon peaks, while water temperature increases gradually through late afternoon (Fig. 3). Water temperature at the larger springs is buffered against wide fluctuations, resulting in local warm-water areas during cold winter periods (Fig. 4). Temperatures undergo extreme seasonal variation in the nearby Gulf of Mexico, however, which becomes much colder than the Kings Bay springs during winter months (Fig. 5).

Kings Bay has undergone dramatic changes since the 1940's, when it was relatively undisturbed. The northern, southern and eastern shores

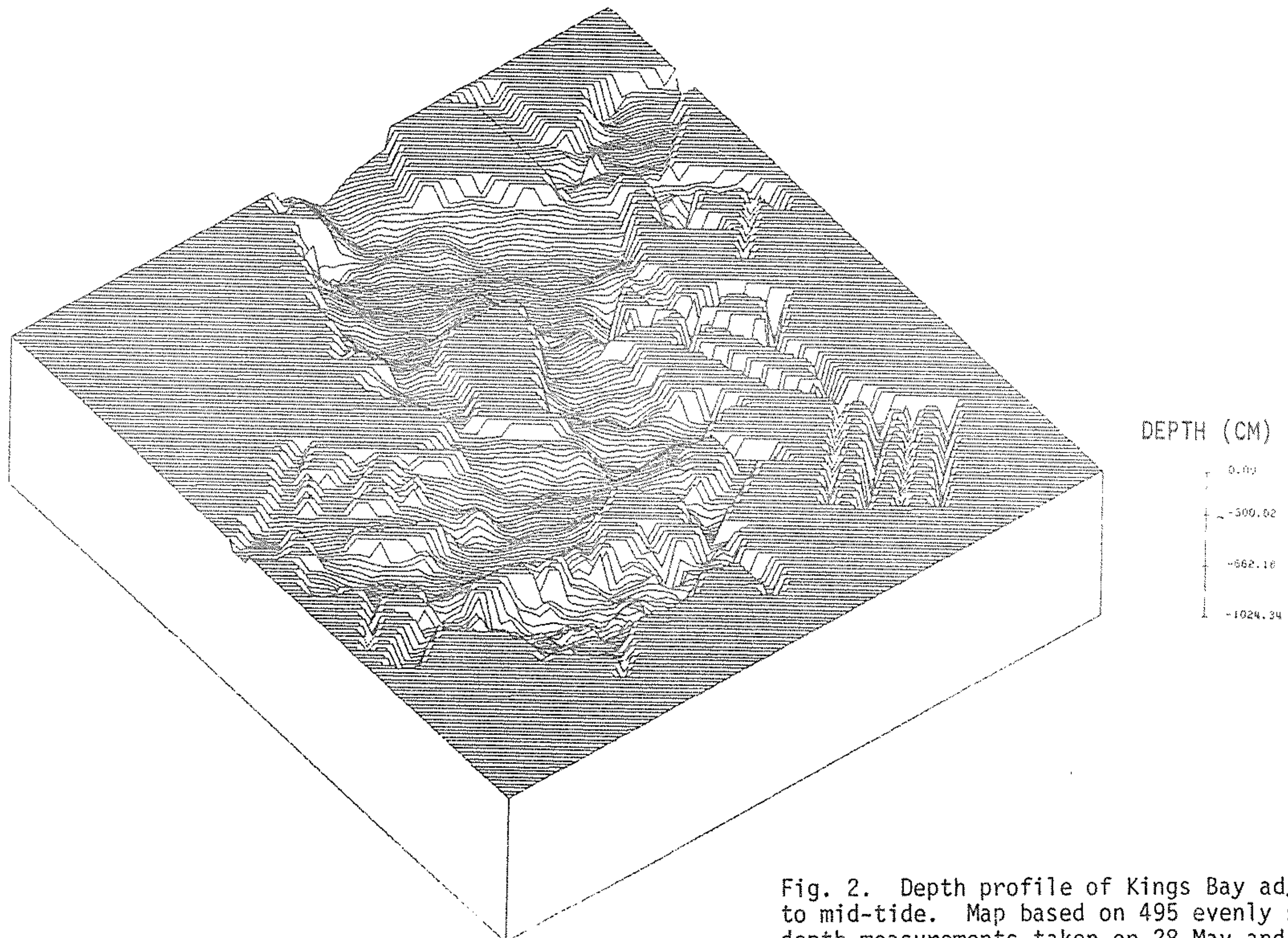

Fig. 2. Depth profile of Kings Bay adjusted to mid-tide. Map based on 495 evenly spaced depth measurements taken on 28 May and 30 May, 1980.

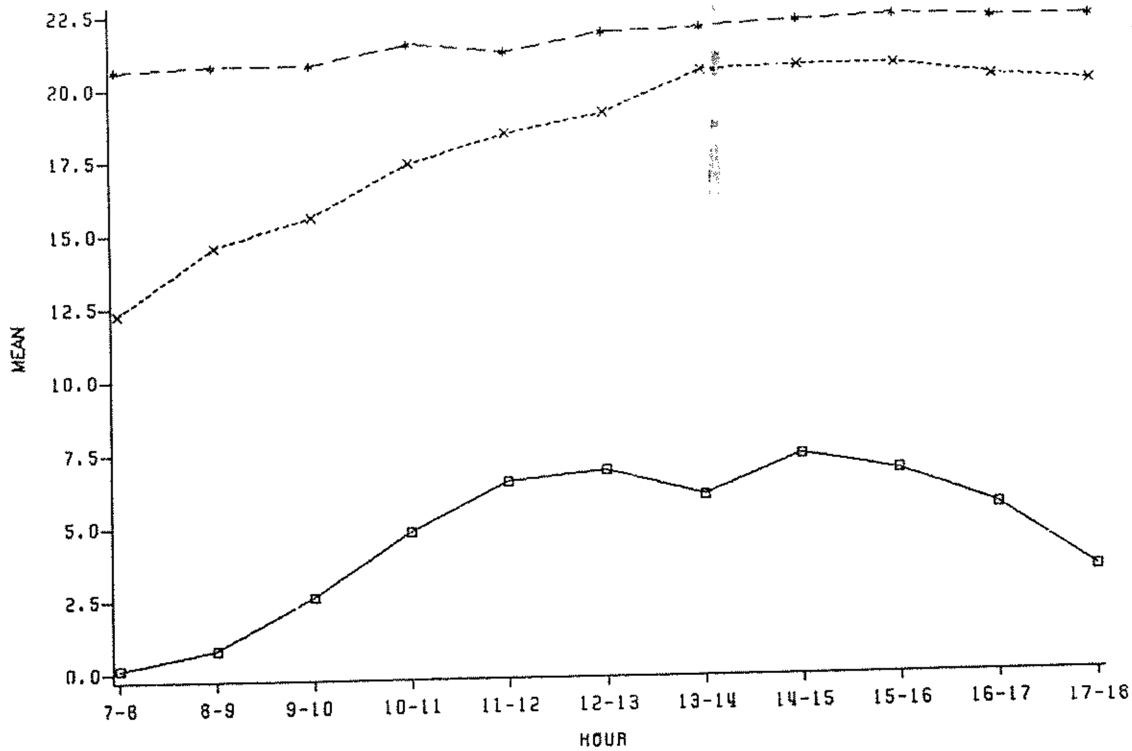

Fig. 3. Diel variation in water temperature (*), air temperature (x) and boat traffic (□) in the southern portion of Kings Bay averaged over nine days in November 1980. Temperatures (C) and boat counts were taken at the beginning of each hourly interval.

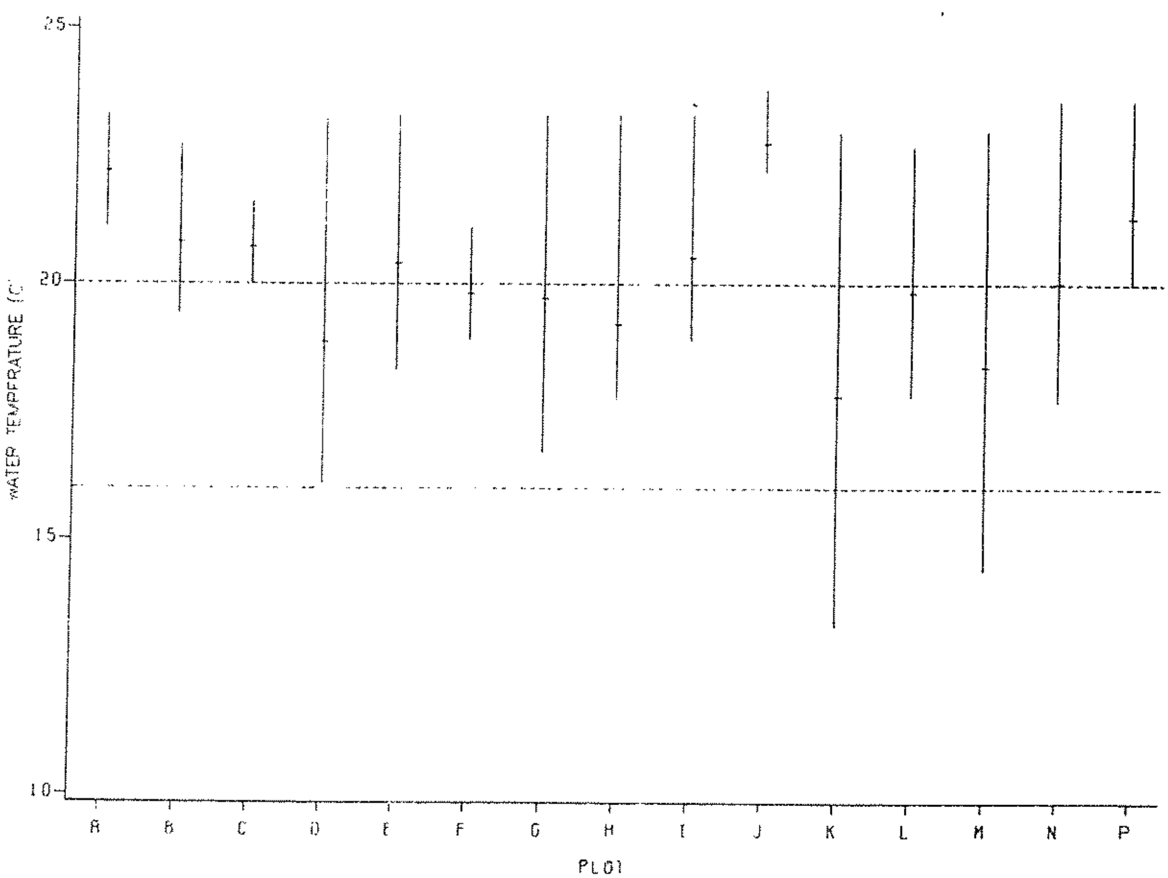

Fig. 4. Mean (horizontal bars) and range (vertical lines) of four water temperatures measured at Kings Bay vegetation plots during a cold winter season (21 Nov 80, 22 Dec 80, 22 Jan 81, 19 Feb 81). No data were collected at plots C and F in Feb 81. Plots A, B, C, J and P were located adjacent to springs. Dashed lines at 20 C and 16 C denote minimum suitable water temperature for the West Indian manatee and temperature at which feeding may be inhibited, respectively.

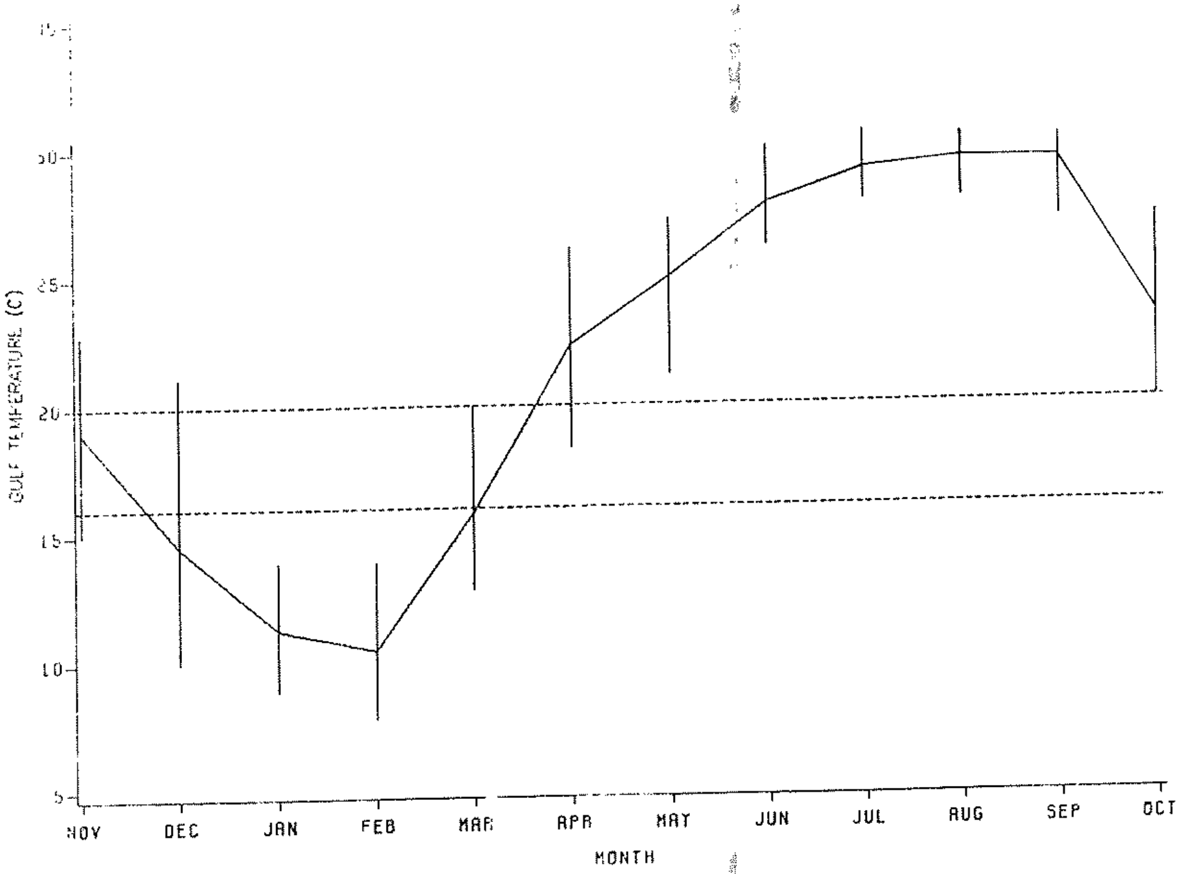

Fig. 5. Monthly variation in Gulf of Mexico water temperature (C). Temperatures based on daily measurements at 8:00 a.m. from Gulf intake canal of Florida Power Corporation Crystal River power plant (November 1977-October 1978). Curved line joins means, vertical lines = range. Dashed lines at 20 C and 16 C denote minimum suitable water temperature for the West Indian manatee and temperature at which feeding may be inhibited, respectively.

of the bay have been subject to residential development and are now largely defined by canal systems and cement bulkheads. Dredge and fill operations have expanded the extreme southern portion of the bay and created several coves and peninsulas on the western side of the mouth. The western shore, as well as most of the islands in the bay, however, has remained undeveloped, although Buzzard Island (Fig. 1) was inhabited in the 1940's. The undeveloped islands were purchased by The Nature Conservancy in 1982 to help protect the remaining manatee habitat. Two small islands in the northeastern part of the bay are currently dominated by residential structures.

The Main Spring in Kings Bay (Fig. 1) has been a popular SCUBA diving area since the 1950's. In the mid 1970's, manatees aggregating around the Main Spring also became an attraction, and by the late 1970's an obvious conflict had developed. Human disturbance was driving many of the animals away from the warm-water discharge of the spring and into colder surrounding waters. To mitigate this conflict, 3 no-entry sanctuaries were established at warm-water areas of Kings Bay in 1980. Sanctuary boundaries are currently implemented at Banana Island, Sunset Shores and Magnolia Spring (Fig. 1) from 15 November-31 March.

Exotic aquatic plants are now a dominant feature of Kings Bay. Water hyacinth (*Eichhornia crassipes*) has formed large mats along the shores of the bay since at least the 1950's. Exotic submerged plants, such as *Hydrilla verticillata* and *Myriophyllum spicatum*, are thought to have been introduced into Kings Bay in the early 1960's by the Miami-based aquarium industry and were already well established by the late 1960's (Hartman, 1979).

Eight taxa of submerged aquatic plants were identified during the monthly vegetation surveys of Kings Bay (Table 1). *Hydrilla* was the most frequent plant during all months and at most of the 15 sample plots. The overall frequencies of *Ceratophyllum*, *Vallisneria*, algae, and *Myriophyllum* were much lower than *Hydrilla*, while *Najas*, *Potamogeton*, and *Ruppia* ranged from uncommon to rare, respectively (Table 1). Similarly, the average abundance of *Hydrilla* throughout Kings Bay, expressed in terms of mean height, was many times higher than any of the other plant taxa (Table 2). *Hydrilla* was widely distributed throughout Kings Bay and was dominant at most (80%) locations sampled (Fig. 6). All other plant taxa were limited in distribution and attained maximum dominance in only several small areas (Figs. 7-12). Although *Zannichellia palustris* was not encountered in any of the 15 sample plots during the 2-year vegetation survey, it was found to occur on shallow sandbars at the northern and southern ends of Kings Bay. Monthly variation in mean height of submerged aquatic vegetation indicated maximum abundance during summer and fall, with a minimum during winter and early spring (Fig. 13). Spatial variation in mean vegetation height was also apparent, with the highest average abundance occurring at plots in the southern half of Kings Bay (Fig. 14).

RESULTS

The number of manatees sighted during aerial surveys over Kings Bay varied significantly among months (P = 0.0001) and years (P = 0.0001). Late fall and winter months (November-February) comprised a high-utilization period with significantly higher ($P < 0.05$) manatee counts than low-utilization

Table 1. Frequencies of submerged aquatic plant taxa sampled during Kings Bay vegetation surveys (July 1979 - June 1981).

Taxon	Frequency	Percent
Hydrilla[a]	9689	68.06
Ceratophyllum	1437	10.09
Vallisneria	1434	10.07
Algae	862	6.06
Myriophyllum[a]	653	4.59
Najas	135	0.95
Potamogeton	22	0.15
Ruppia	4	0.03

[a] Exotic introductions.

Table 2. Descriptive statistics for height (cm) of submerged aquatic plant taxa sampled during Kings Bay vegetation surveys (July 1979 - June 1981).

Taxon	Mean	Min	Max	SD[a]	SE[b]
Hydrilla[c]	51.3	0	420	69.90	1.17
Ceratophyllum	6.9	0	260	27.80	0.46
Vallisneria	4.5	0	210	19.66	0.33
Myriophyllum[c]	3.2	0	270	20.51	0.34
Algae	1.02	0	170	7.903	0.132
Najas	0.33	0	100	4.142	0.069
Potamogeton	0.06	0	100	2.013	0.034
Ruppia	0.004	0	5	0.1443	0.0024

Note: n = 3600 sample points (24 months x 15 plots x 10 points). Statistics for each taxon based on default height of "0" cm at all points where taxon was absent.

[a] Standard deviation.

[b] Standard error of mean.

[c] Exotic introductions.

Fig. 6. Dominance of Hydrilla in Kings Bay. Symbols depict dominance ranking at each location based on relative abundance: Ф = highest, 0 = second, • = third, "blank" = > third or absent. Solid black symbols represent land. Map based on 495 evenly spaced samples taken on 28 May and 30 May, 1980. Map locations between samples were assigned rank of closest data point.

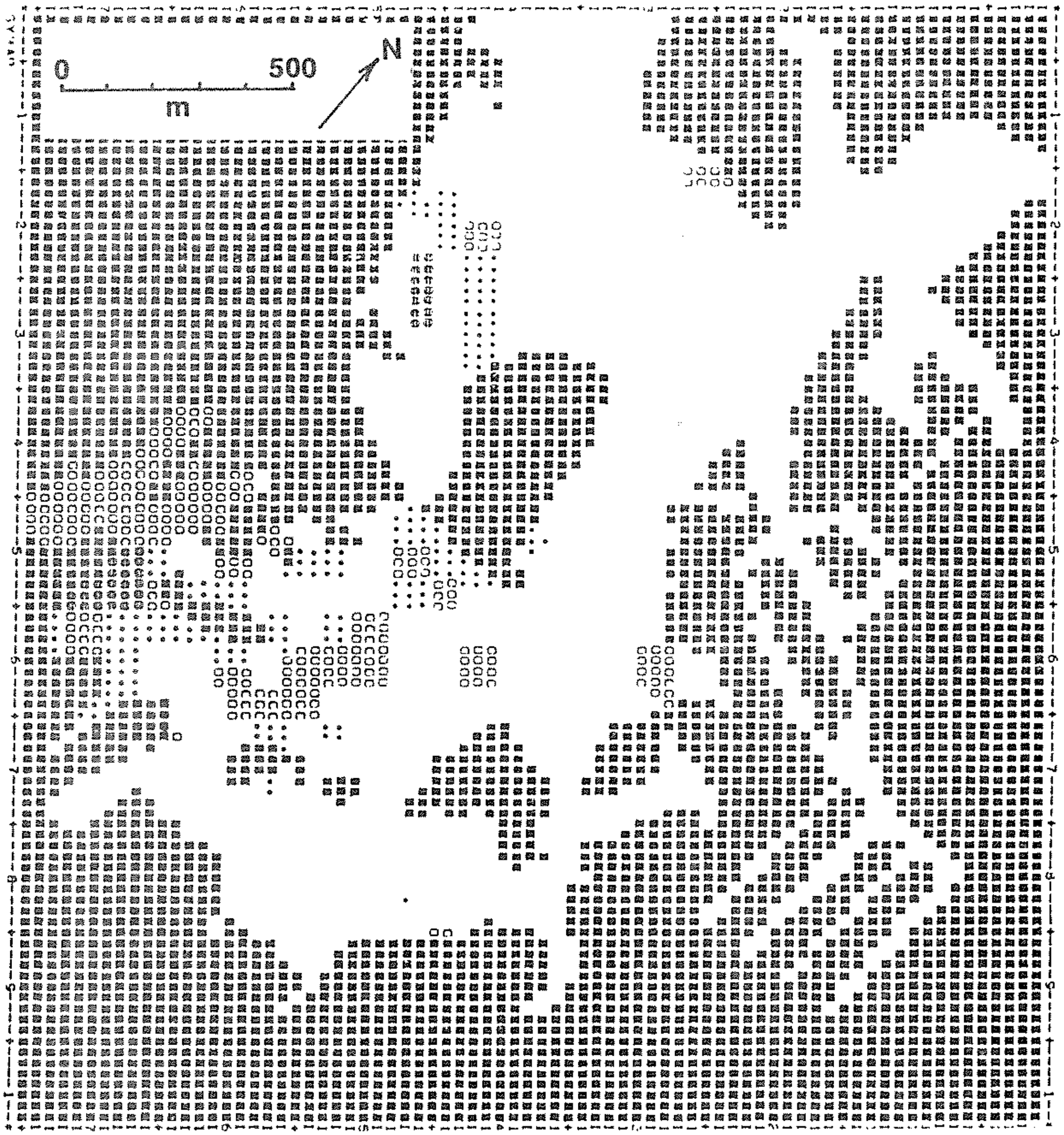

Fig. 7. Dominance of Ceratophyllum in Kings Bay. Refer to Fig. 6 for explanation of symbols.

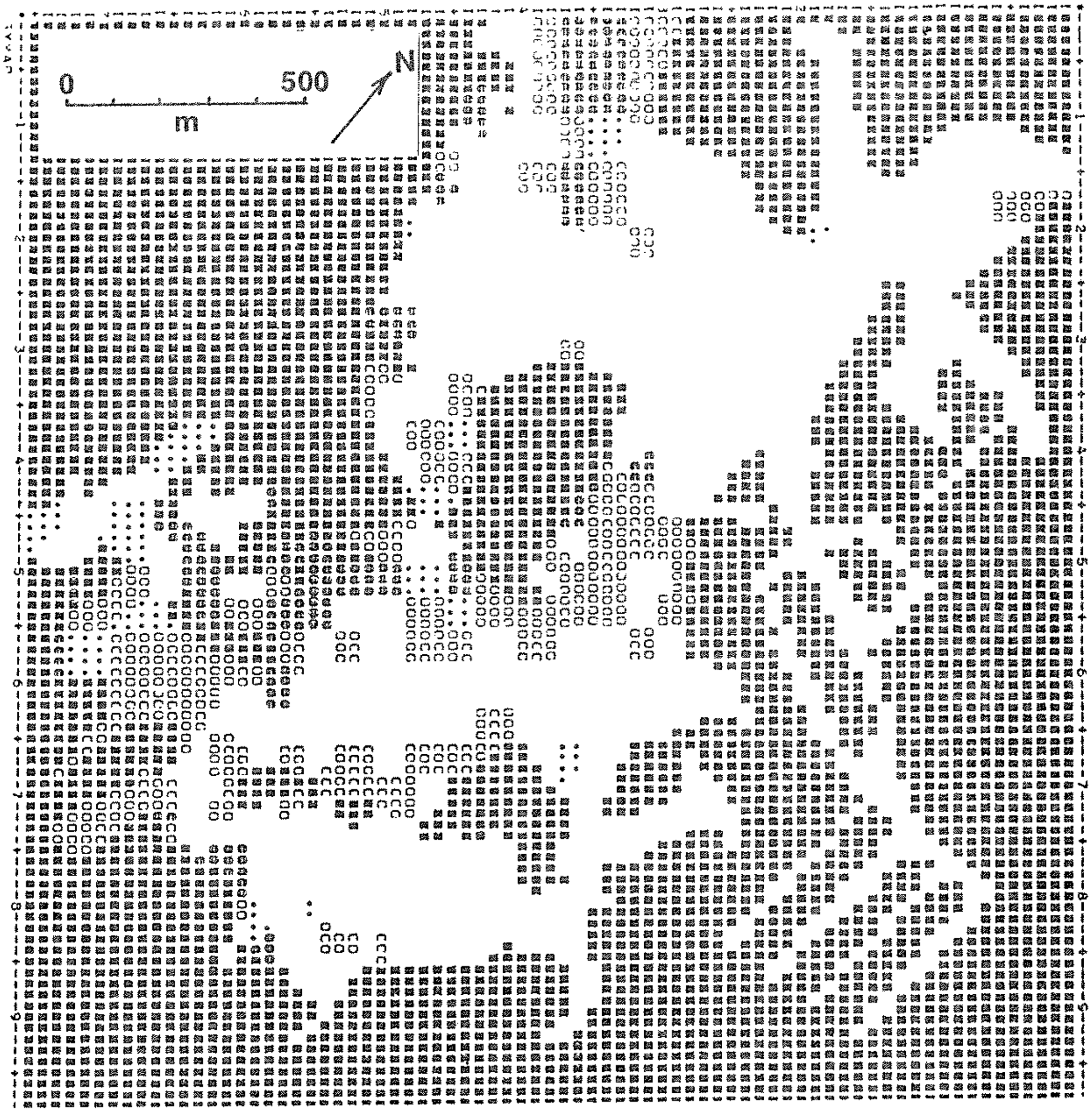

Fig. 8. Dominance of Vallisneria in Kings Bay. Refer to Fig. 6 for explanation of symbols.

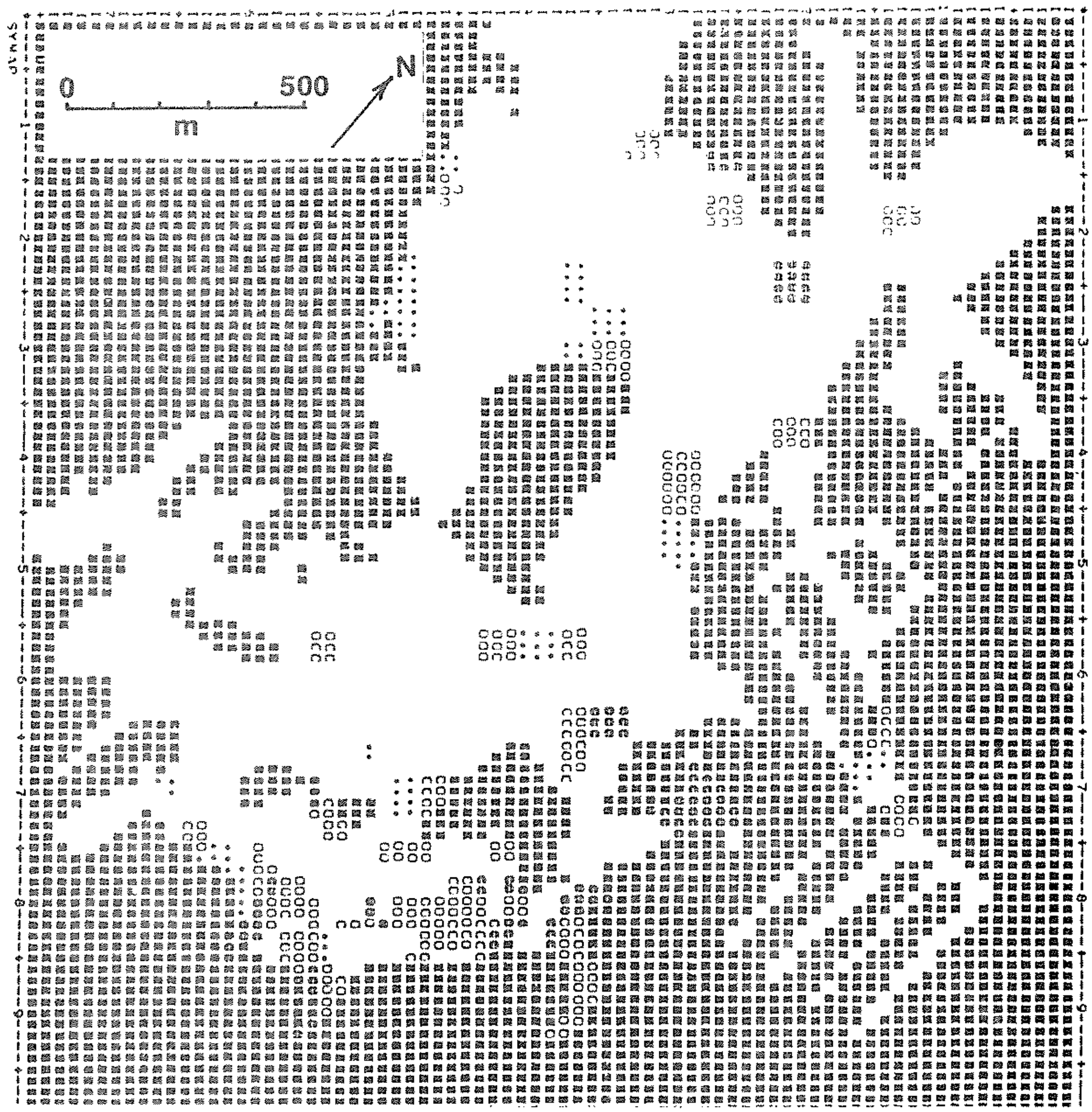

Fig. 9. Dominance of algae in Kings Bay. Refer to Fig. 6 for explanation of symbols.

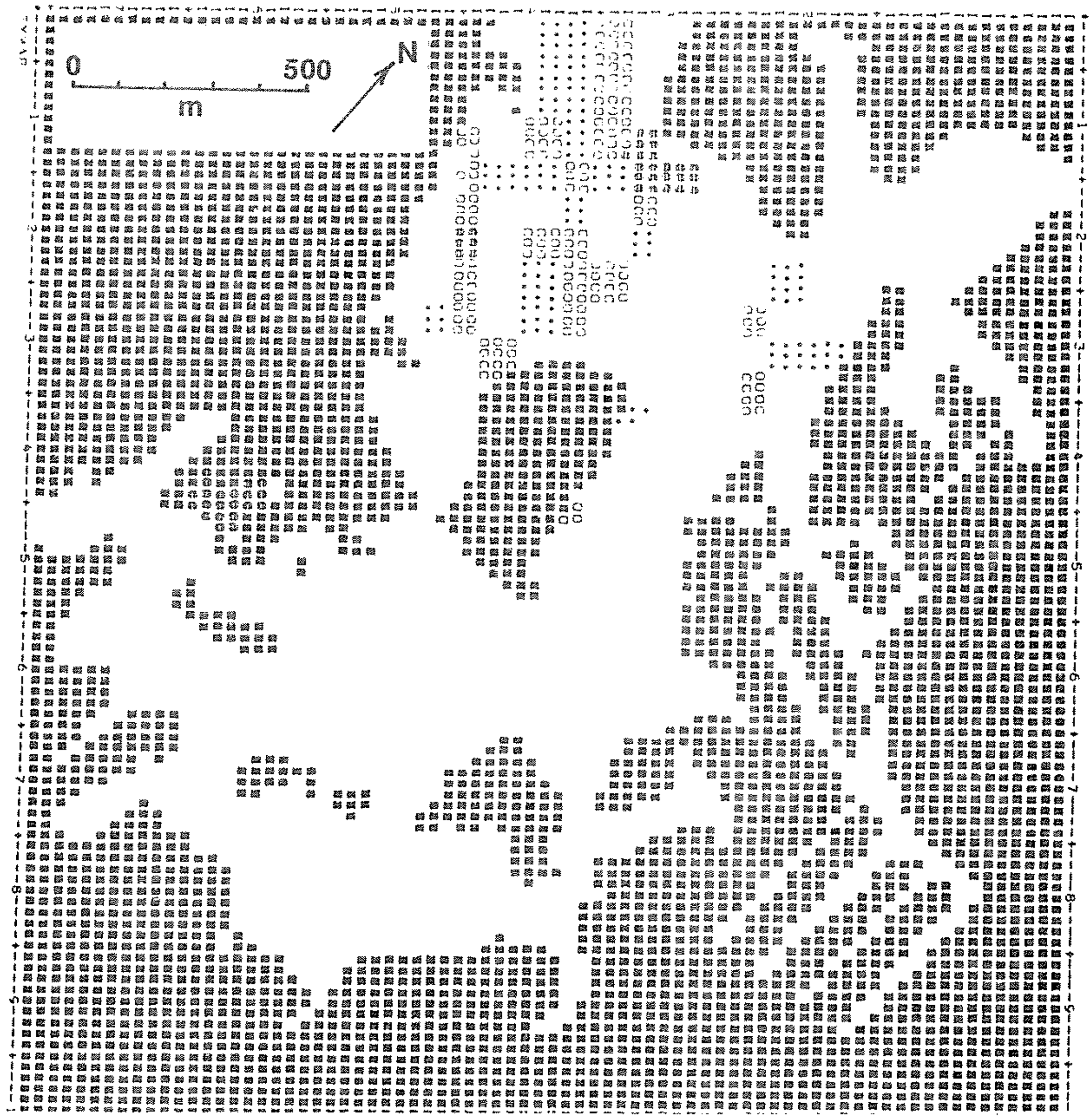

Fig. 10. Dominance of Myriophyllum in Kings Bay. Refer to Fig. 6 for explanation of symbols.

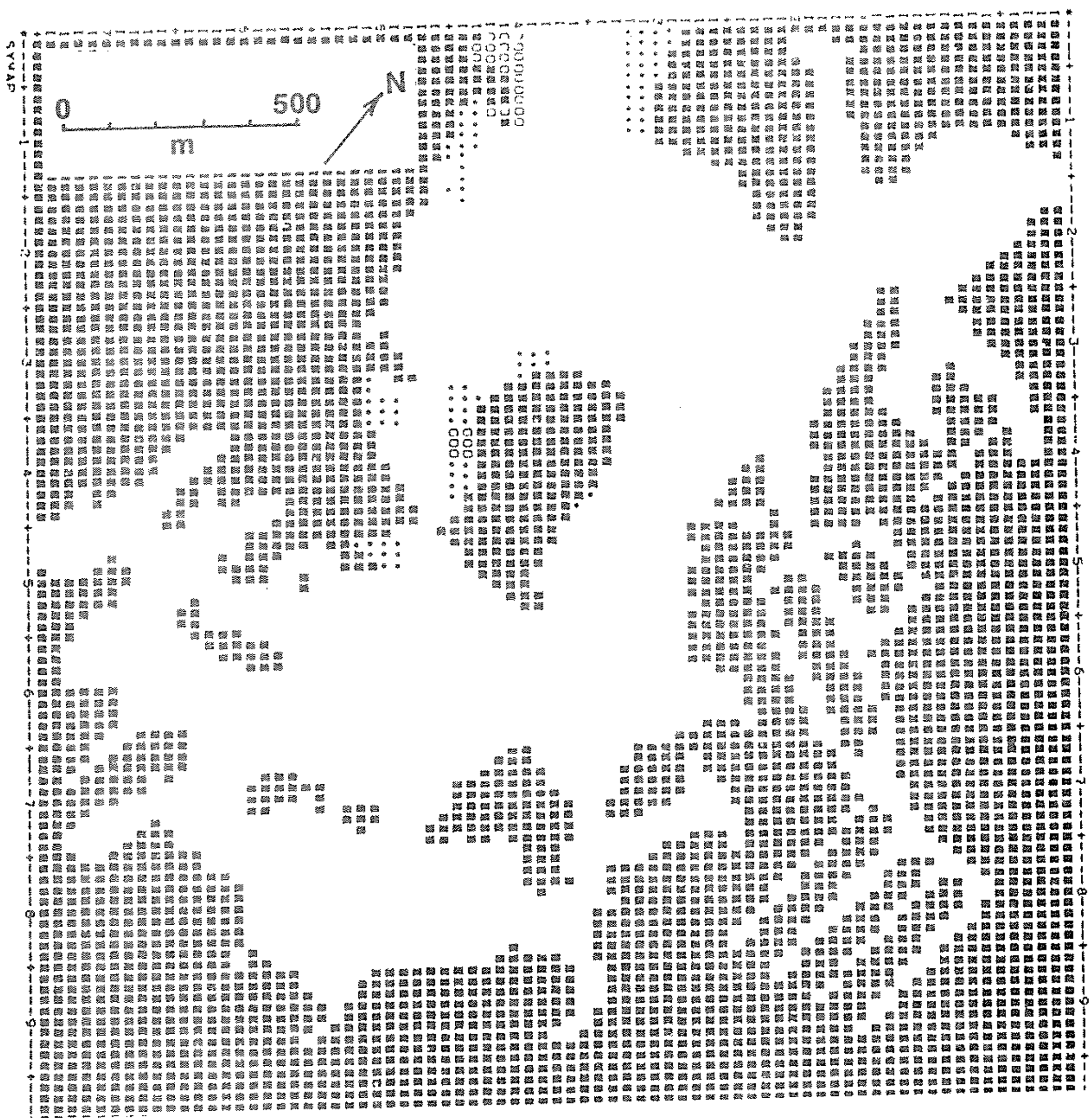

Fig. 11. Dominance of Najas in Kings Bay. Refer to Fig. 6 for explanation of symbols.

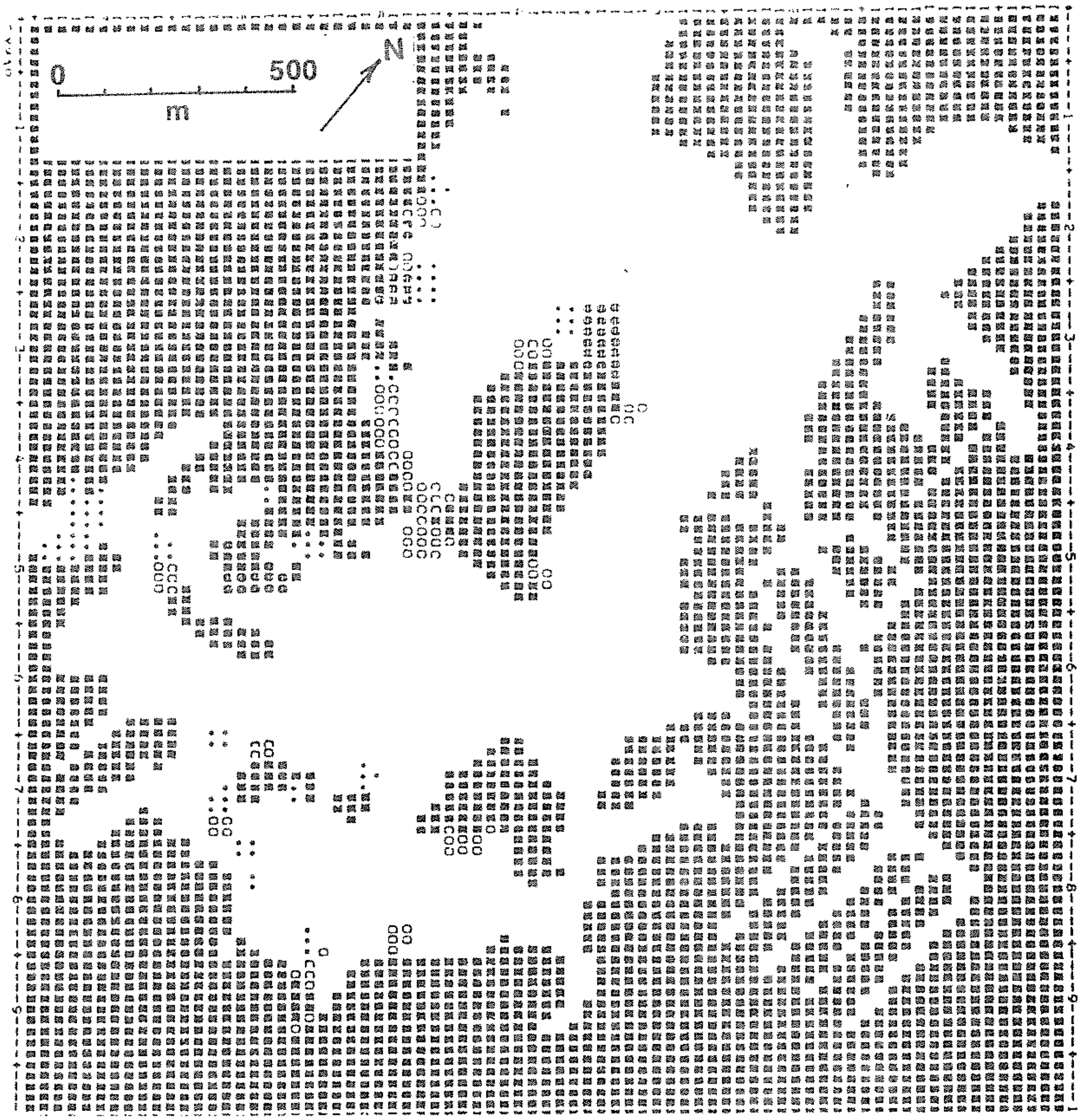

Fig. 12. Dominance of Potamogeton in Kings Bay. Refer to Fig. 6 for explanation of symbols.

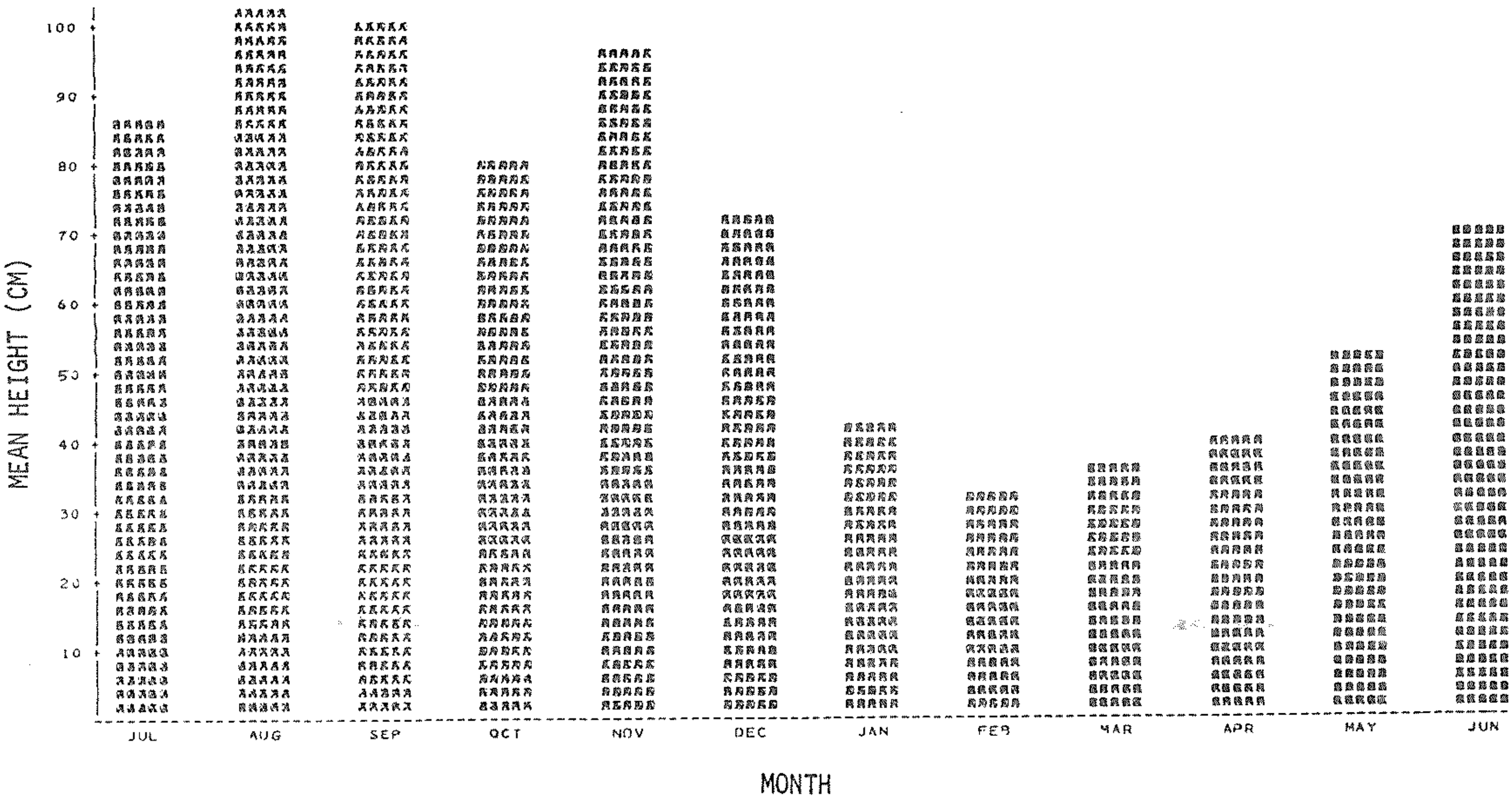

Fig. 13. Monthly variation in mean height (cm) of submerged aquatic vegetation in Kings Bay (July 1979 - June 1981). Each mean based on 300 sample points (15 plots x 10 points x 2 years).

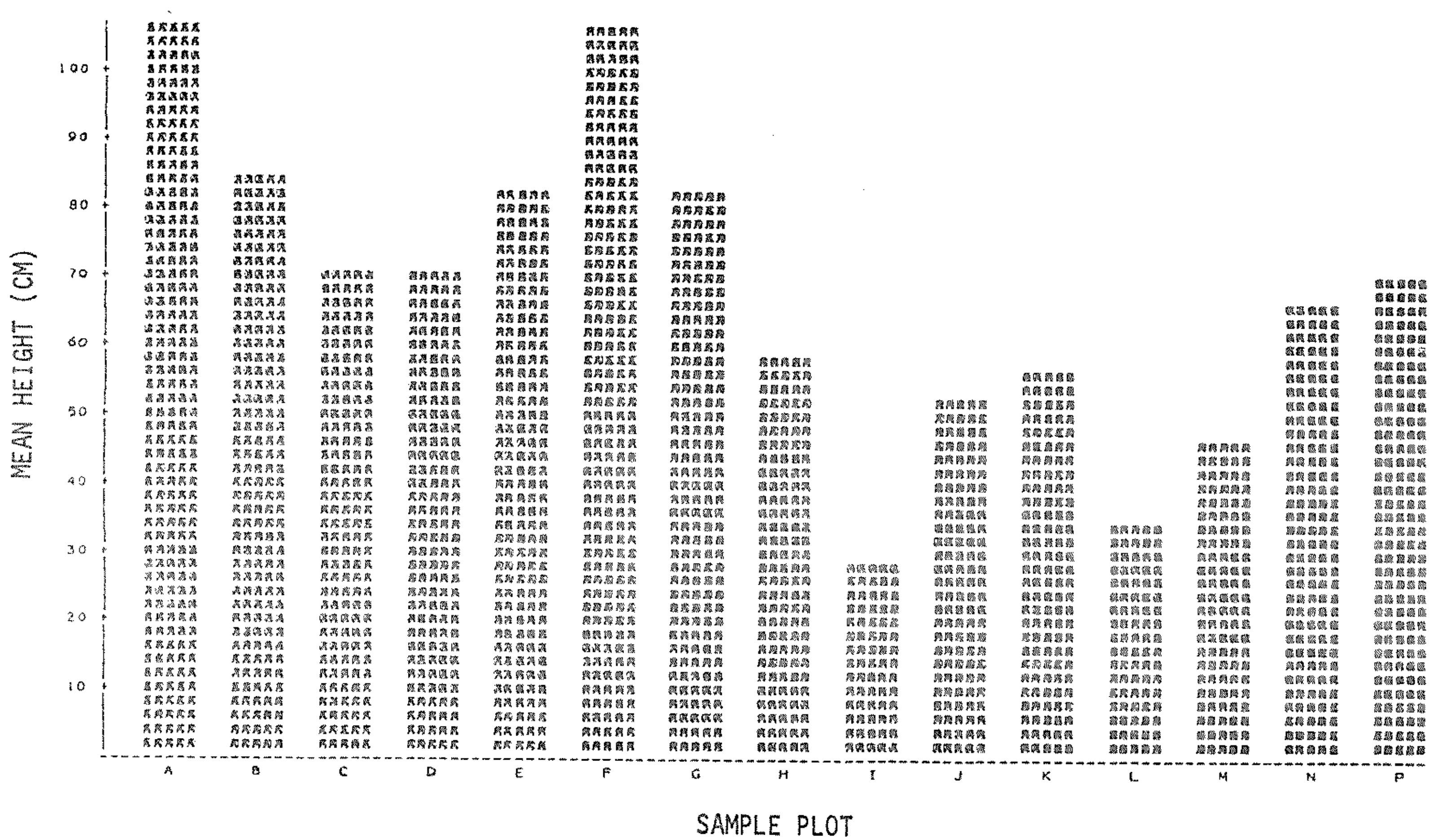

Fig. 14. Mean height (cm) of submerged aquatic vegetation at Kings Bay vegetation plots (July 1979 - June 1981). Each mean based on 240 sample points (12 months x 10 points x 2 years).

spring and summer months (April-September)(Table 3). October and March were transition periods of intermediate use preceding and following the winter season, respectively. Survey results during October and March exhibited a wide range of variation and were statistically indistinguishable from many of the months in both the high-utilization and low-utilization periods (Table 3). The seasonal pattern of manatee occurrence in Kings Bay was observed consistently during each of the 4 survey years (Fig. 15). Manatee counts during the fourth survey year (Nov 80-Oct 81) were significantly higher ($\underline{P} < 0.05$) than each of the 3 previous years (Nov 77-Oct 80), which did not differ from each other (Table 4).

The spatial distribution of manatees in Kings Bay varied seasonally and was strongly influenced by the location of artesian springs. Manatees were concentrated in the southern portion of the bay during the high-utilization period from November through February (Figs. 16-19). As the winter season progressed, aggregations became more localized in the warm-water area surrounding the Main Spring (Figs. 17-19). Smaller aggregations developed at Magnolia Spring during January and February (Figs. 18-19). Low but consistent use of the Tarpon Spring area north of Banana Island was apparent from October through March. Concentration of manatees in the southern part of Kings Bay was less pronounced during the transition months of March (Fig. 20) and October (Fig. 27). The relatively small number of manatees sighted from April through September avoided the major springs and occurred most frequently in the northern half of the bay (Figs. 21-26).

Table 3. Monthly summary statistics and multiple comparisons for total manatee count per flight during Kings Bay aerial surveys (November 1977 - October 1981).

Month[a]	Flights	Mean[b]	Min	Max	SD[c]
January	19	71.5	56	96	12.49
February	17	62.8	17	76	13.46
December	17	60.6	37	97	15.38
November	14	52.6	31	76	14.44
March	22	30.8	1	59	16.67
October	24	29.5	7	57	12.14
September	14	12.3	0	31	9.09
August	14	8.0	2	19	5.14
July	12	5.2	1	15	3.82
April	8	4.6	0	13	4.69
June[d]	7	2.0	0	7	2.98
May	13	1.3	0	5	1.64
	181				

[a] Manatee counts did not differ significantly among months connected by same line. Multiple comparisons based on nonparametric rank-score tests performed at experimentwise error rate of $P \leq 0.05$ (see Methods).

[b] Unweighted mean for each month based on average of corresponding means from each survey year.

[c] Standard deviation.

[d] No surveys conducted in June 1979.

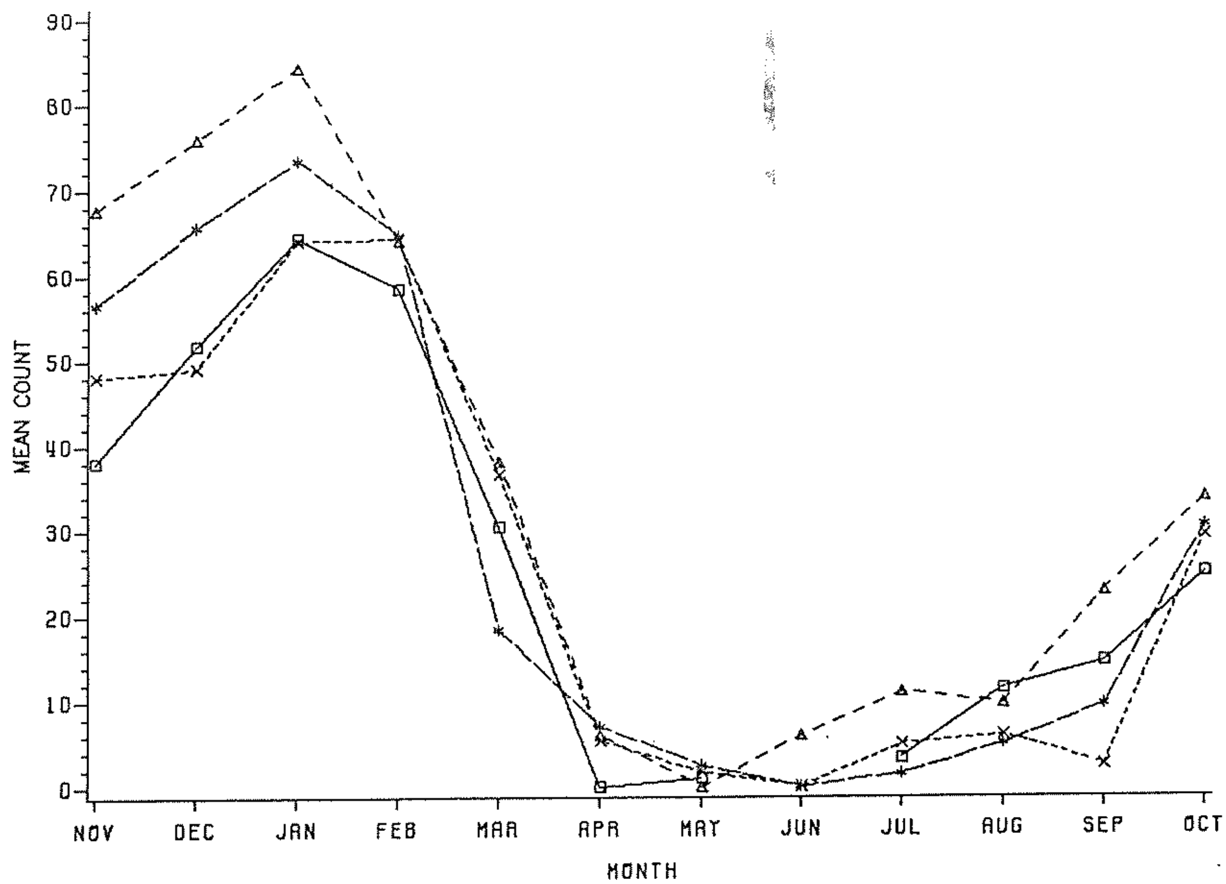

Fig. 15. Monthly variation in mean manatee counts during four years of aerial surveys over Kings Bay. x = Nov 77-Oct 78, □ = Nov 78-Oct 79, * = Nov 79-Oct 80, Δ = Nov 80-Oct 81. No surveys conducted during June 1979.

Table 4. Annual summary statistics and multiple comparisons for total manatee count per flight during Kings Bay aerial surveys.

Survey Year[a]	Flights	Mean[b]	Min	Max	SD[c]
Nov 77-Oct 78	52	26.0	0	78	25.22
Nov 78-Oct 79[d]	49	27.1	0	80	23.56
Nov 79-Oct 80	38	27.9	0	87	29.35
Nov 80-Oct 81	42	34.9	0	97	31.47
	181				

[a] Manatee counts did not differ significantly among survey years connected by same line. Multiple comparisons based on nonparametric rank-score tests performed at experimentwise error rate of $\underline{P} \leq 0.05$ (see Methods).

[b] Unweighted mean for each survey year based on average of corresponding means from each month.

[c] Standard deviation.

[d] No surveys conducted in June 1979.

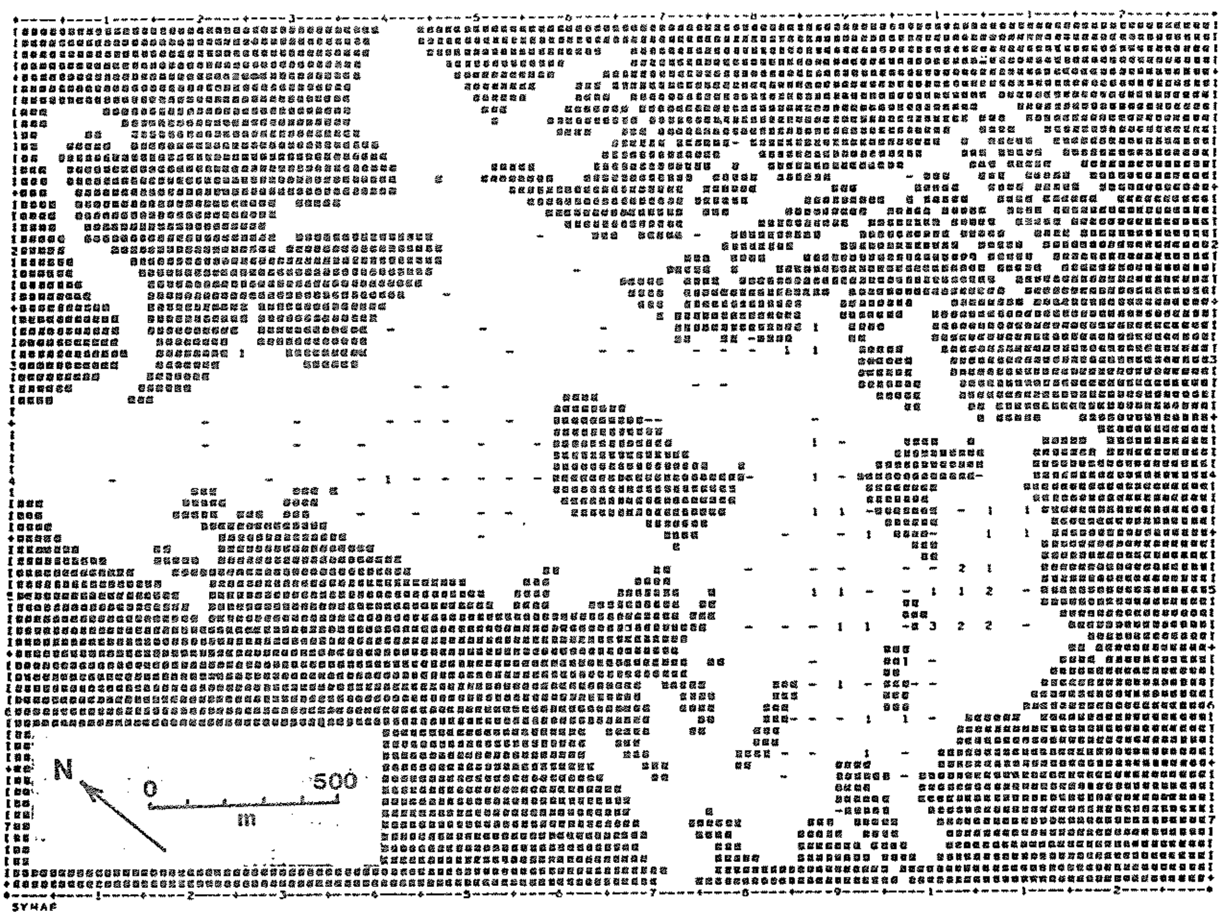

Fig. 16. Kings Bay manatee sightings averaged over 11 November surveys (1977-1979). Symbols represent average number of manatees sighted at each location during all aerial surveys for the month: - = < 0.5, 1 = 0.5-1.5, 2 = 1.5-2.5, 3 = 2.5-3.5, 4 = 3.5-4.5, 5 = 4.5-5.5, 6 = 5.5-6.5, 7 = 6.5-7.5, 8 = 7.5-8.5.

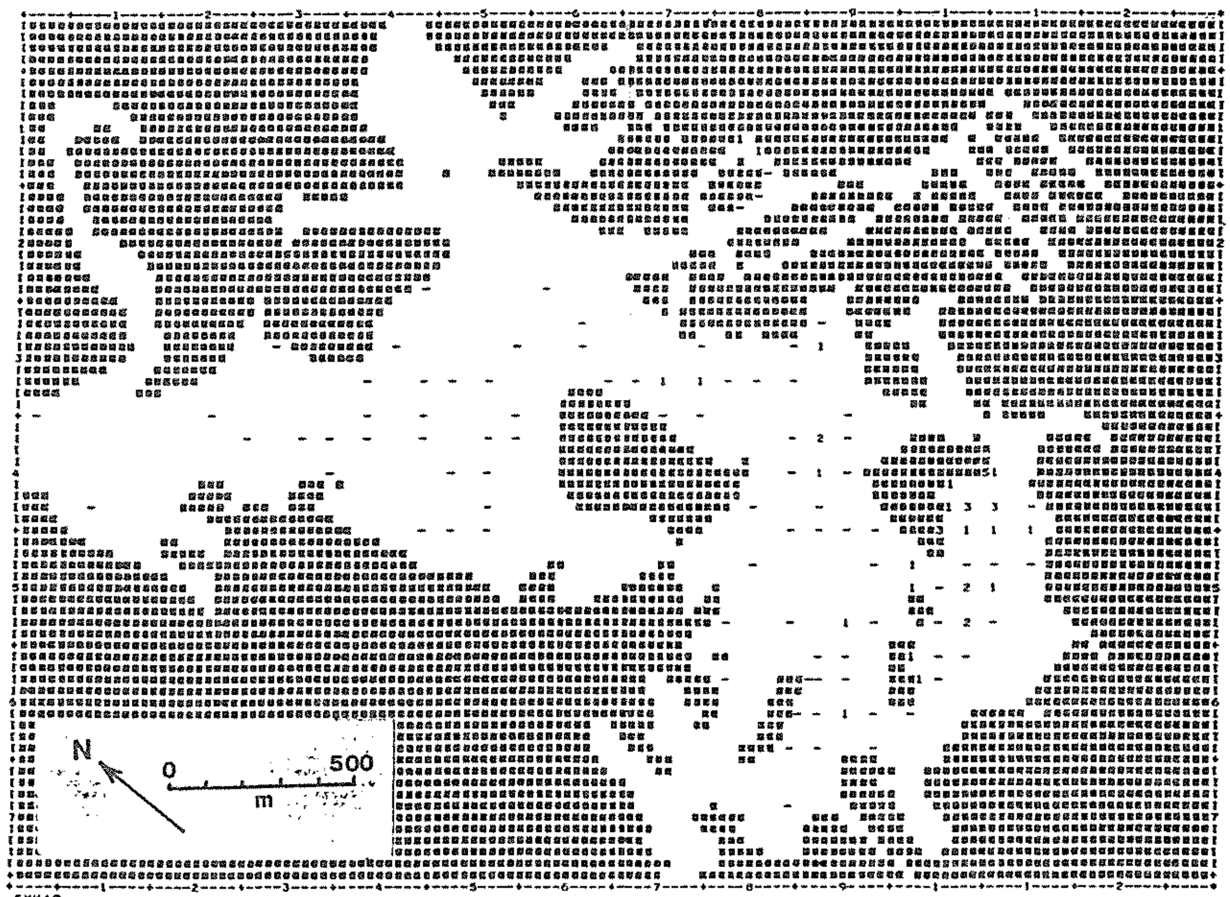

Fig. 17. Kings Bay manatee sightings averaged over nine December surveys (1977-1979). Refer to Fig. 16 for explanation of symbols.

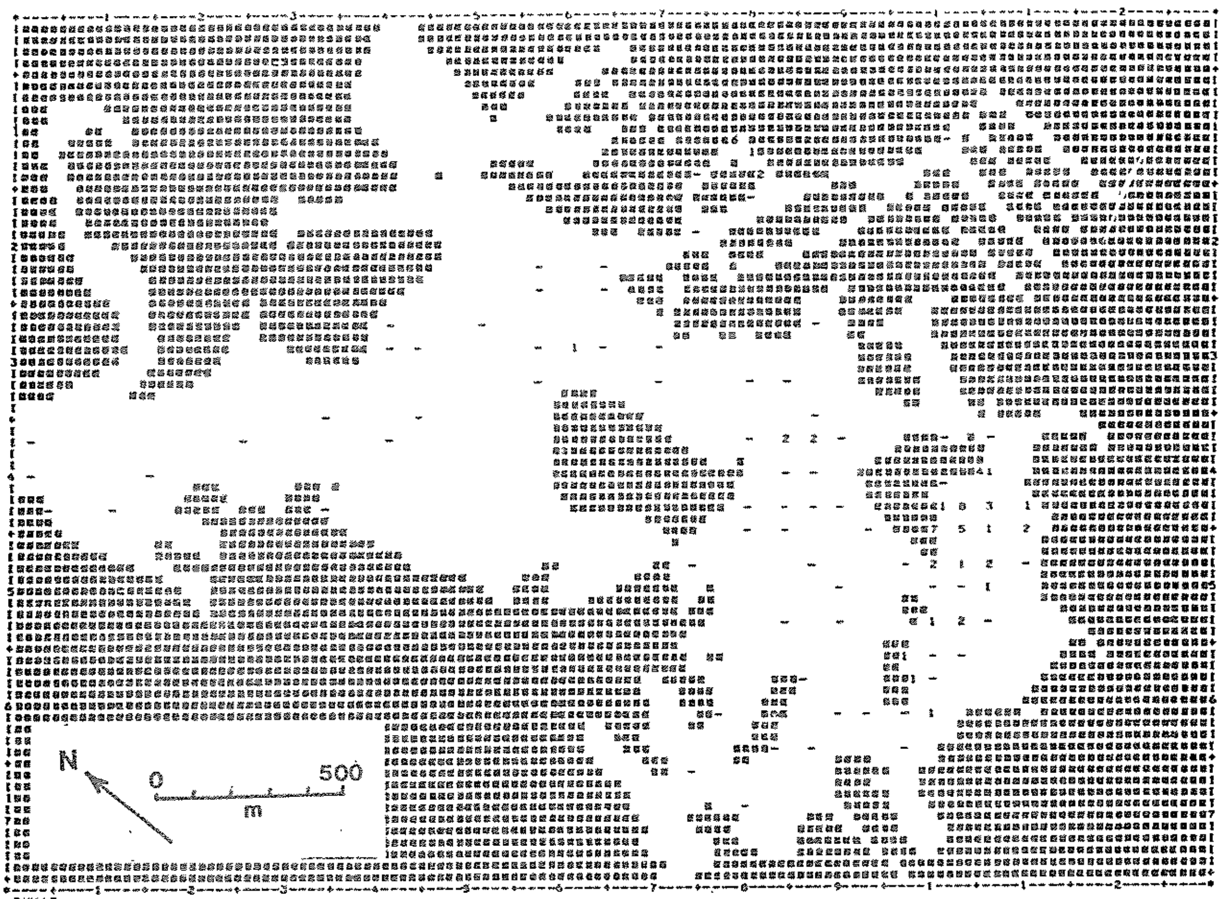

Fig. 18. Kings Bay manatee sightings averaged over 11 January surveys (1978-1980). Refer to Fig. 16 for explanation of symbols.

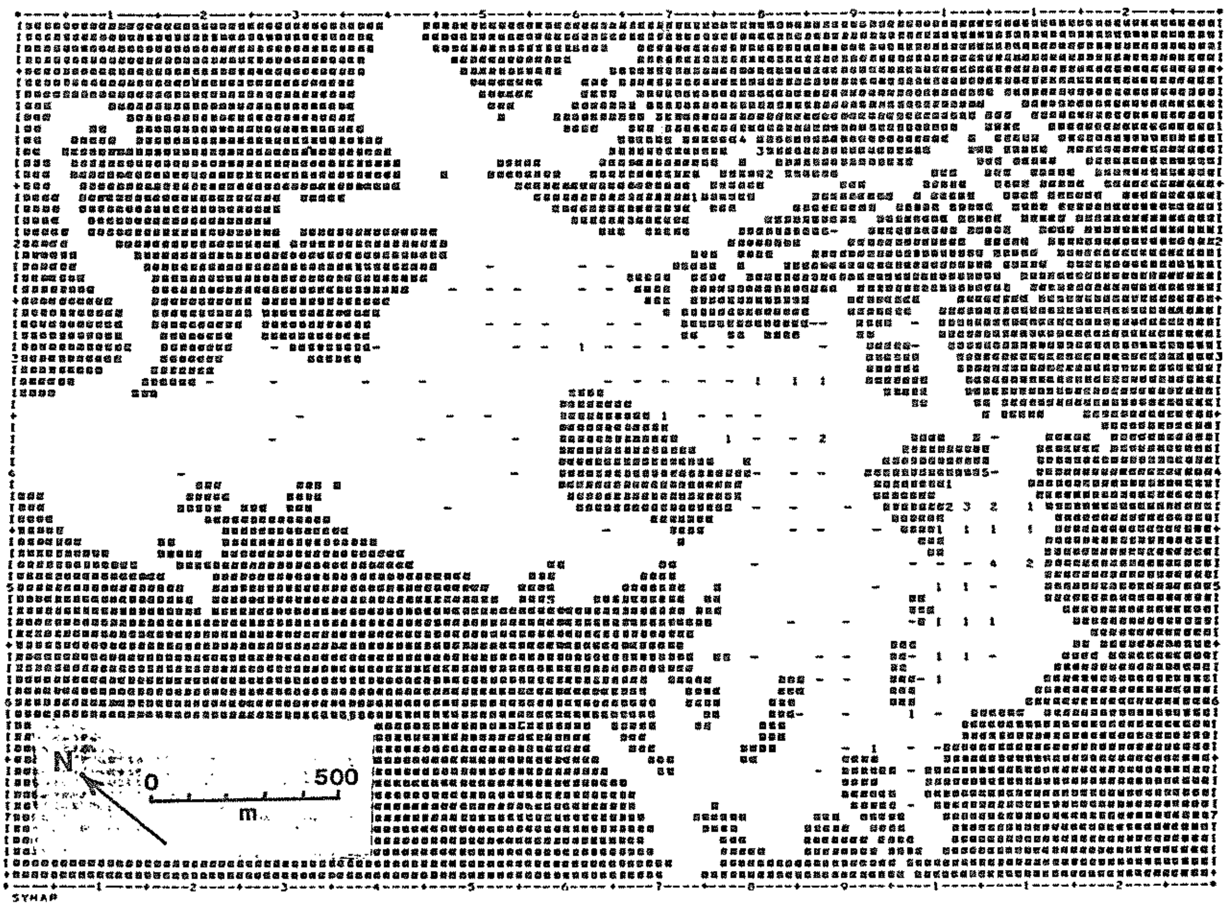

Fig. 19. Kings Bay manatee sightings averaged over 15 February surveys (1978-1980). Refer to Fig. 16 for explanation of symbols.

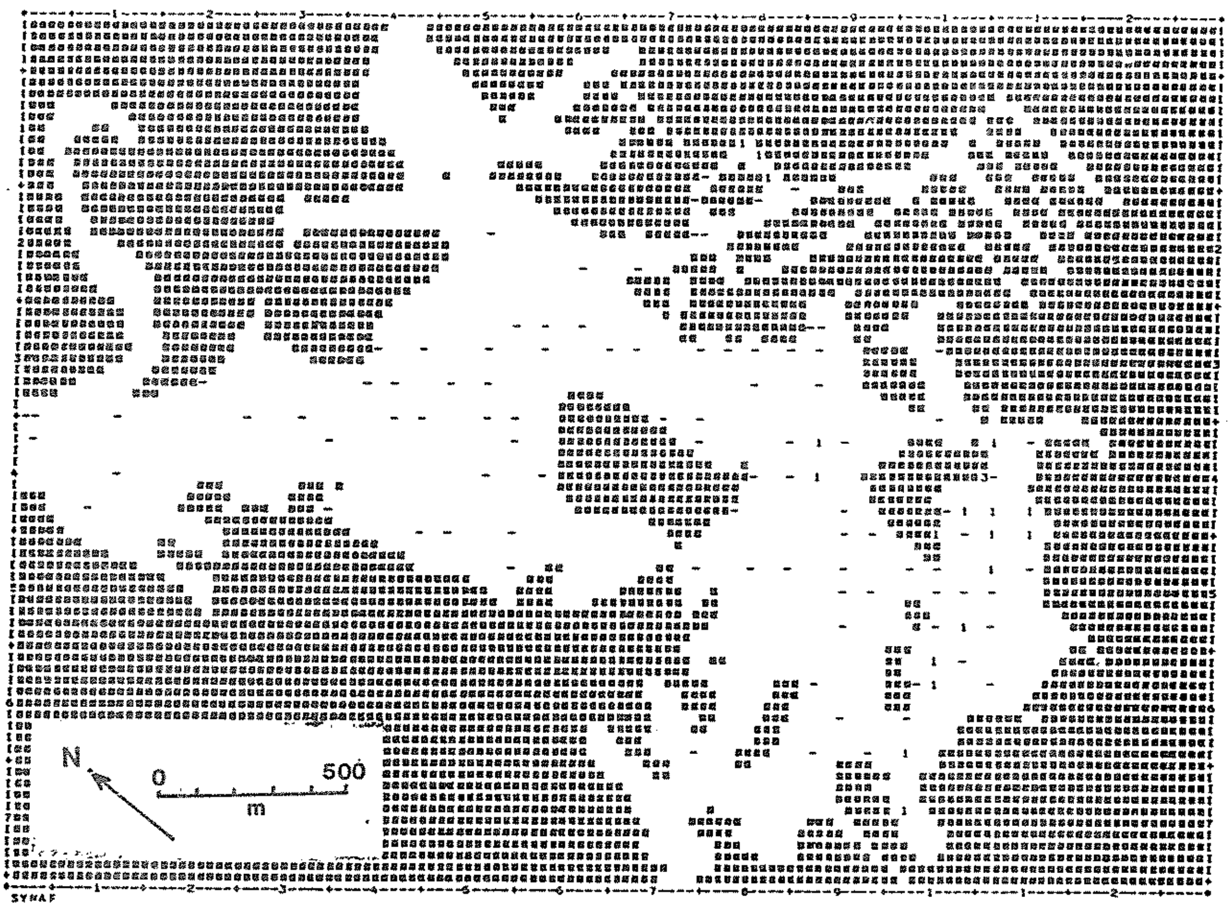

Fig. 20. Kings Bay manatee sightings averaged over 16 March surveys (1978-1980). Refer to Fig. 16 for explanation of symbols.

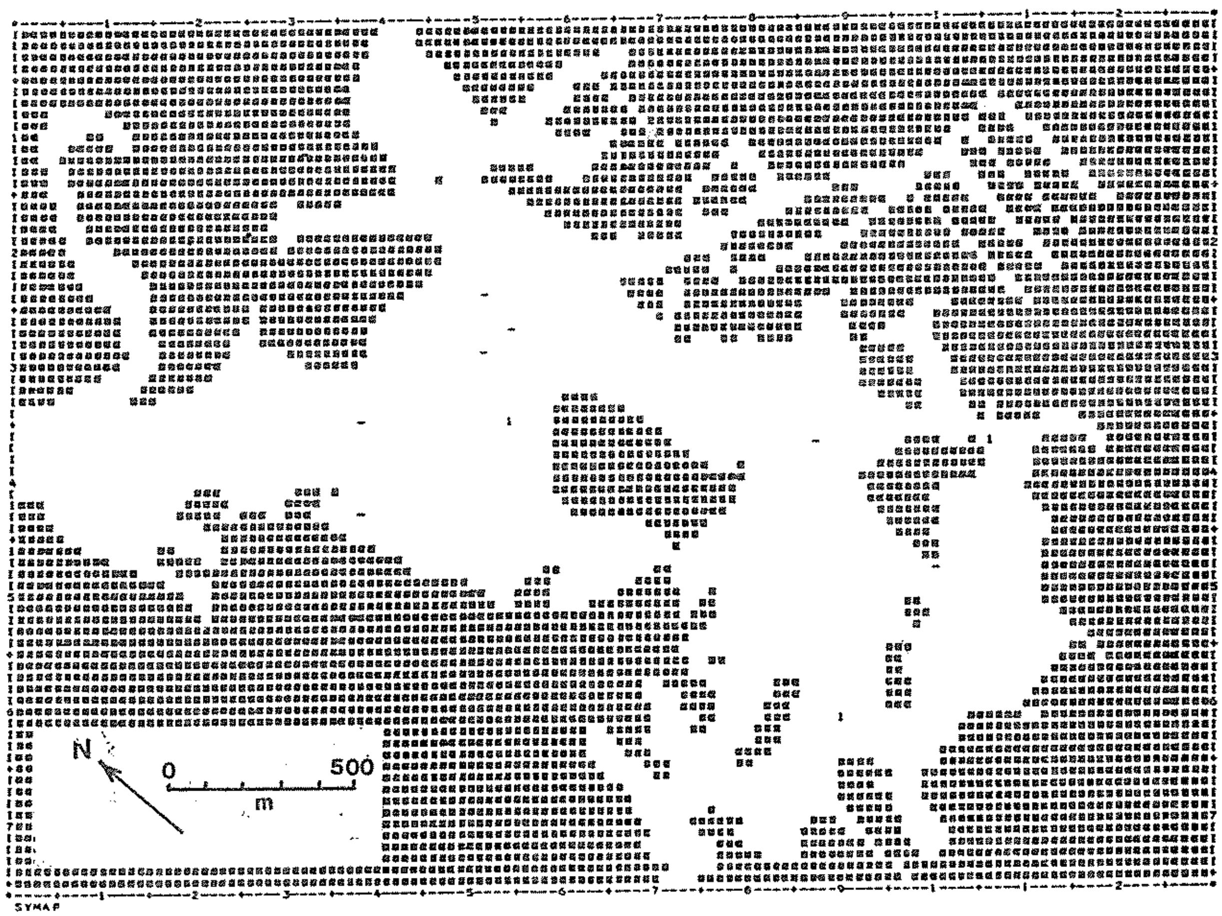

Fig. 21. Kings Bay manatee sightings averaged over seven April surveys (1978-1980). Refer to Fig. 16 for explanation of symbols.

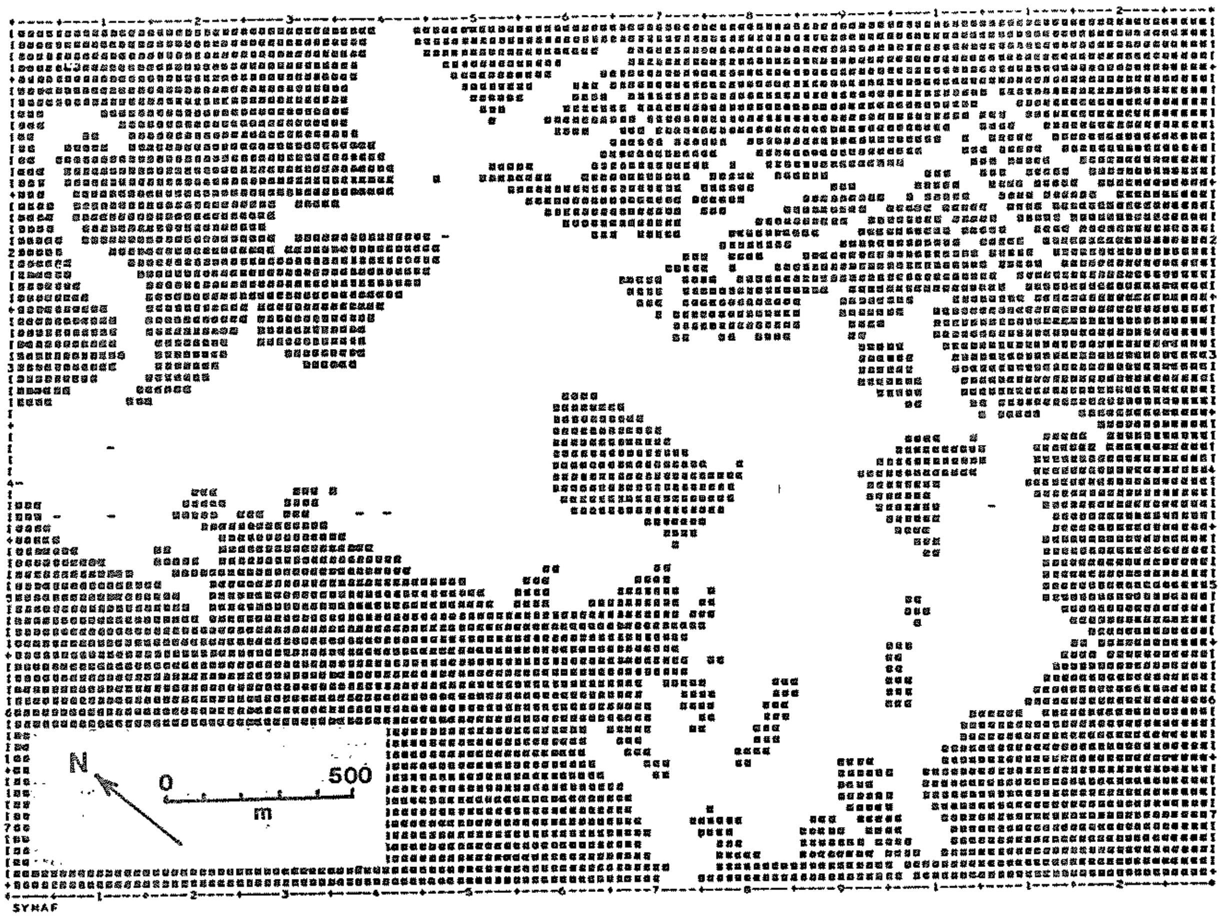

Fig. 22. Kings Bay manatee sightings averaged over 11 May surveys (1978-1980). Refer to Fig. 16 for explanation of symbols.

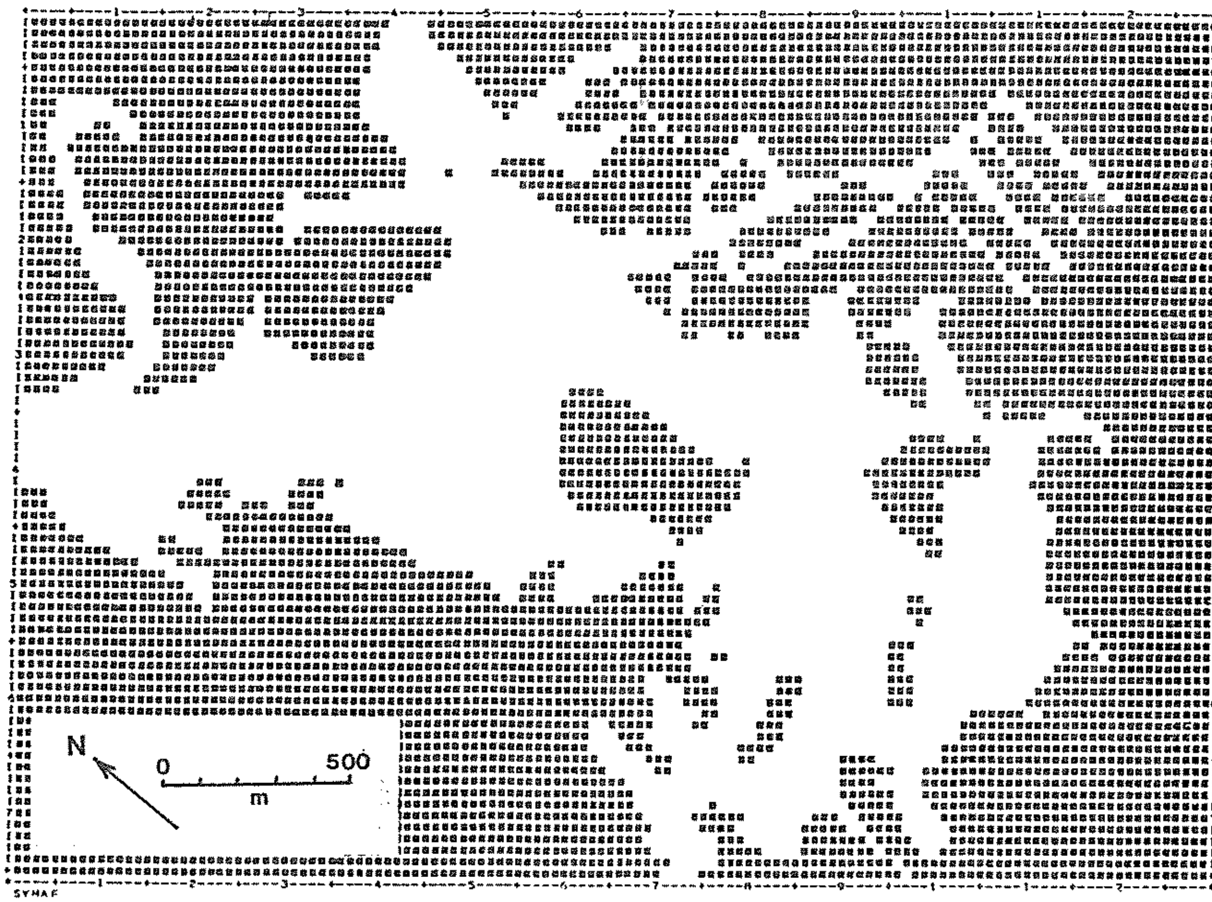

Fig. 23. Kings Bay manatee sightings averaged over five June surveys (1978+1980). No manatees sighted.

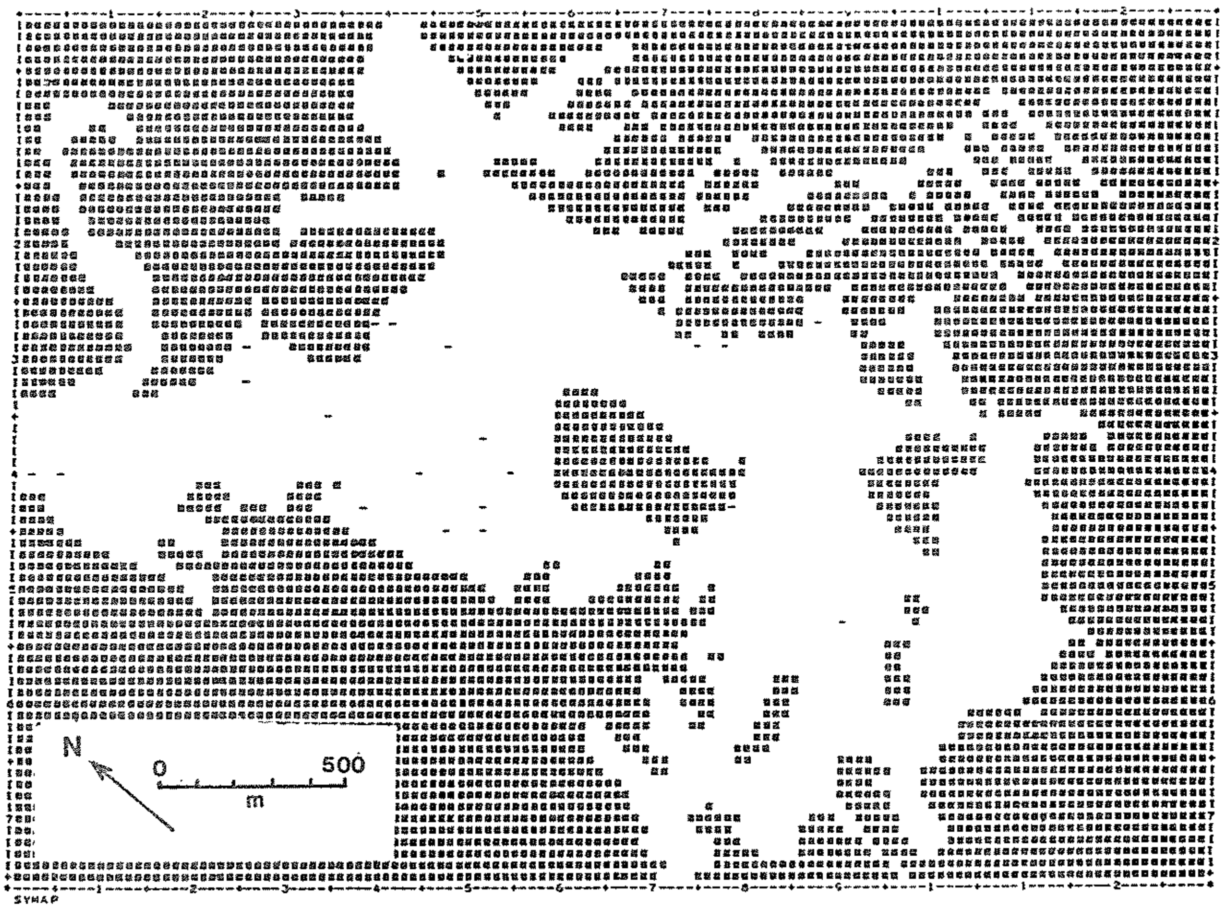

Fig. 24. Kings Bay manatee sightings averaged over 10 July surveys (1978-1980). Refer to Fig. 16 for explanation of symbols.

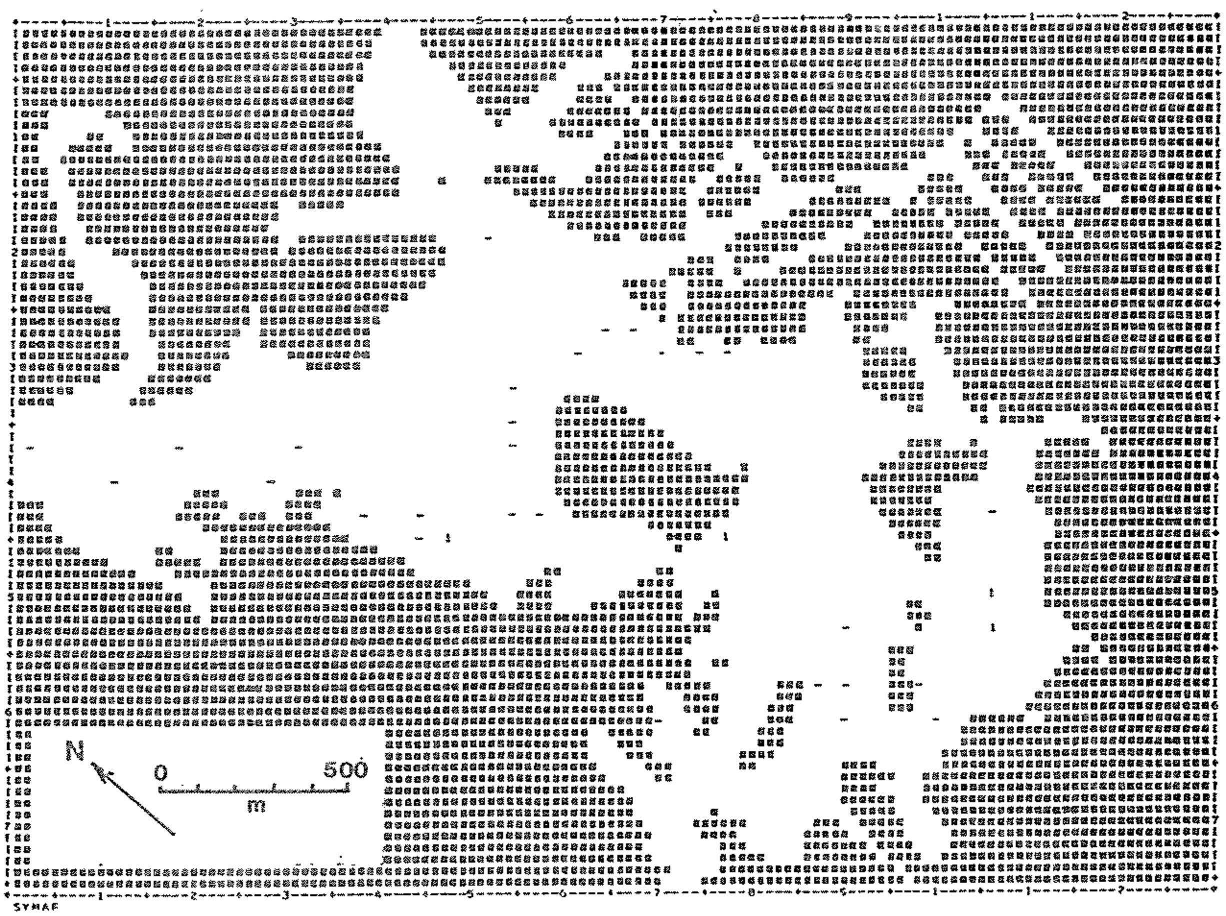

Fig. 25. Kings Bay manatee sightings averaged over nine August surveys (1978-1979). Refer to Fig. 16 for explanation of symbols.

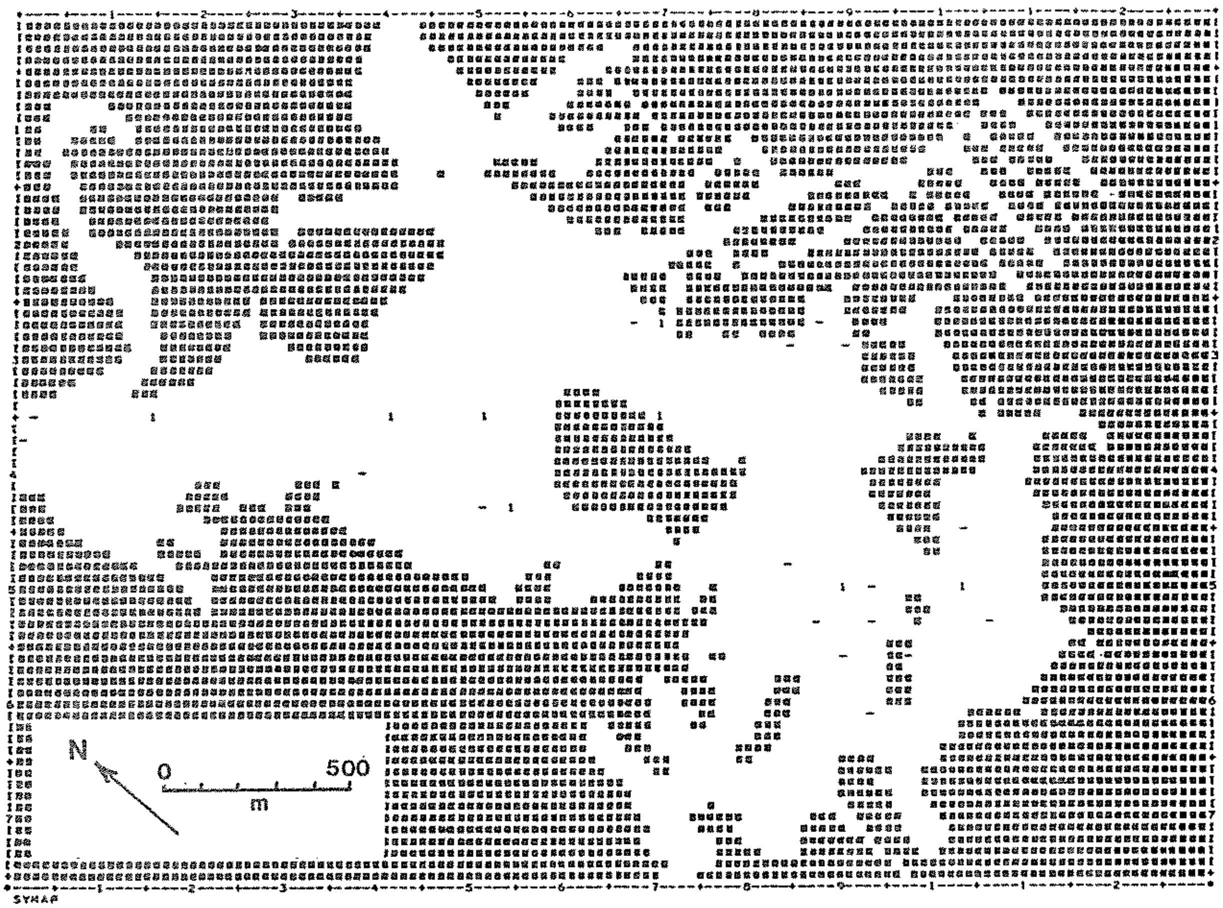

Fig. 26. Kings Bay manatee sightings averaged over eight September surveys (1978-1979). Refer to Fig. 16 for explanation of symbols.

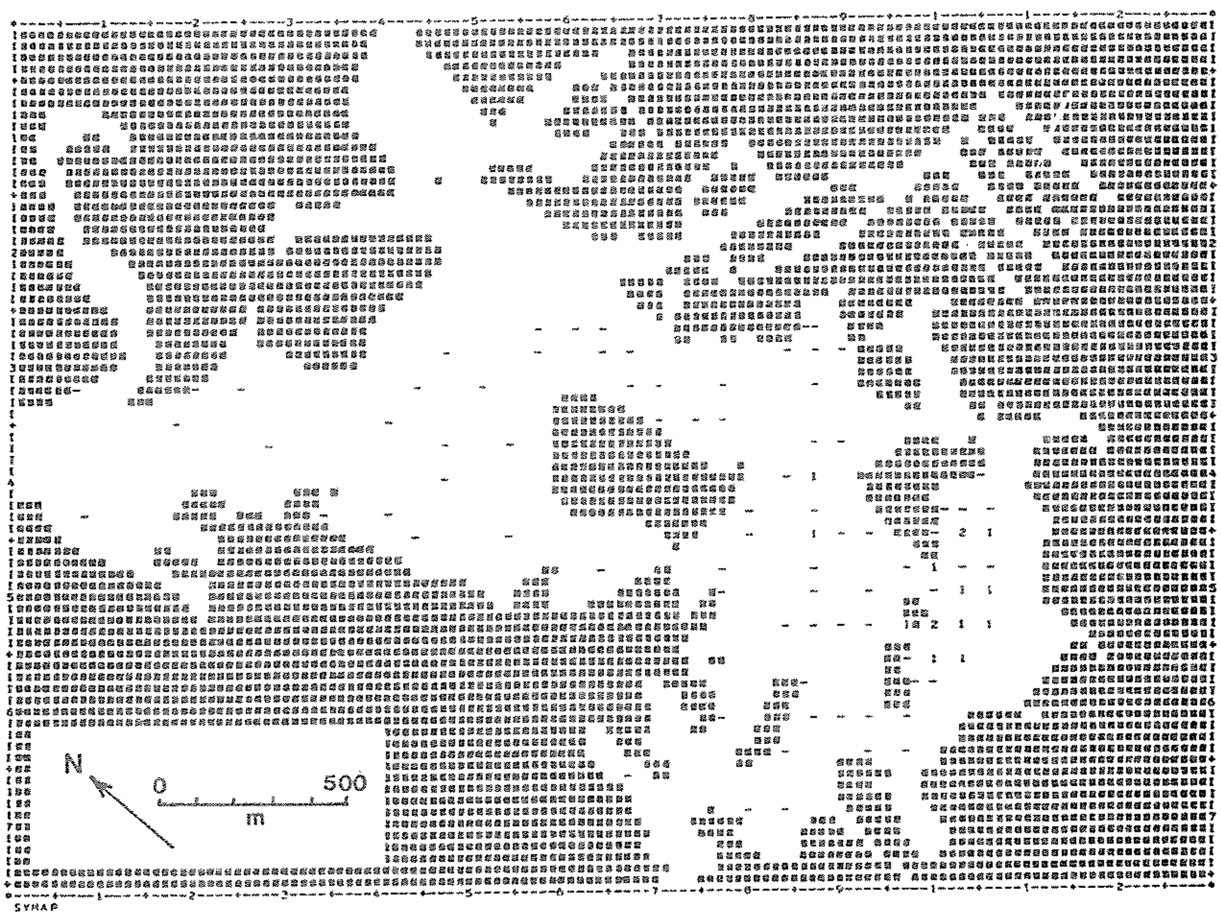

Fig. 27. Kings Bay manatee sightings averaged over 14 October surveys (1978-1979). Refer to Fig. 16 for explanation of symbols.

Establishment of no-entry sanctuaries at Banana Island and Sunset Shores (Fig. 1) appeared to influence the distribution of wintering manatees during periods of human disturbance. During the winter of sanctuary implementation (15 Nov 80-31 Mar 81), 53.5% of all manatee sightings between Banana Island and Sunset Shores at times of high human activity ($>$10:00 a.m.) were within sanctuary boundaries, compared to 29.7% during 3 winters prior to sanctuary operation (Fig. 28). When human activity was minimal ($\leq$10:00 a.m.), most sightings occurred in the unrestricted warm-water area outside the sanctuaries (Fig. 29).

Specific types of manatee behavior ranged from generally widespread to highly localized within Kings Bay. Feeding activity occurred widely throughout the bay (Fig. 30) and appeared influenced primarily by food availability and water depth. Resting (Fig. 31) and social behavior (Fig. 32) were limited to the extreme southern portion of Kings Bay and to the Magnolia Spring area. Directional movement occurred most frequently in the same 2 areas, but travel across the bay to and from the Crystal River was not uncommon (Fig. 33).

The majority (80.4%) of manatees observed at the western end of Warden Key from Nov 80-Dec 80 were travelling northward away from the Main Spring. Most sightings (75.9%) consisted of single animals, with groups of 2 accounting for another 19.5%. The frequency of northward movement was variable but averaged highest from 2:00 p.m.-3:00 p.m., with minimal activity during early morning hours (Fig. 34).

DISCUSSION

The seasonal use of Kings Bay by manatees corresponds to changes in Gulf of Mexico water temperature. Manatees in Florida require water of

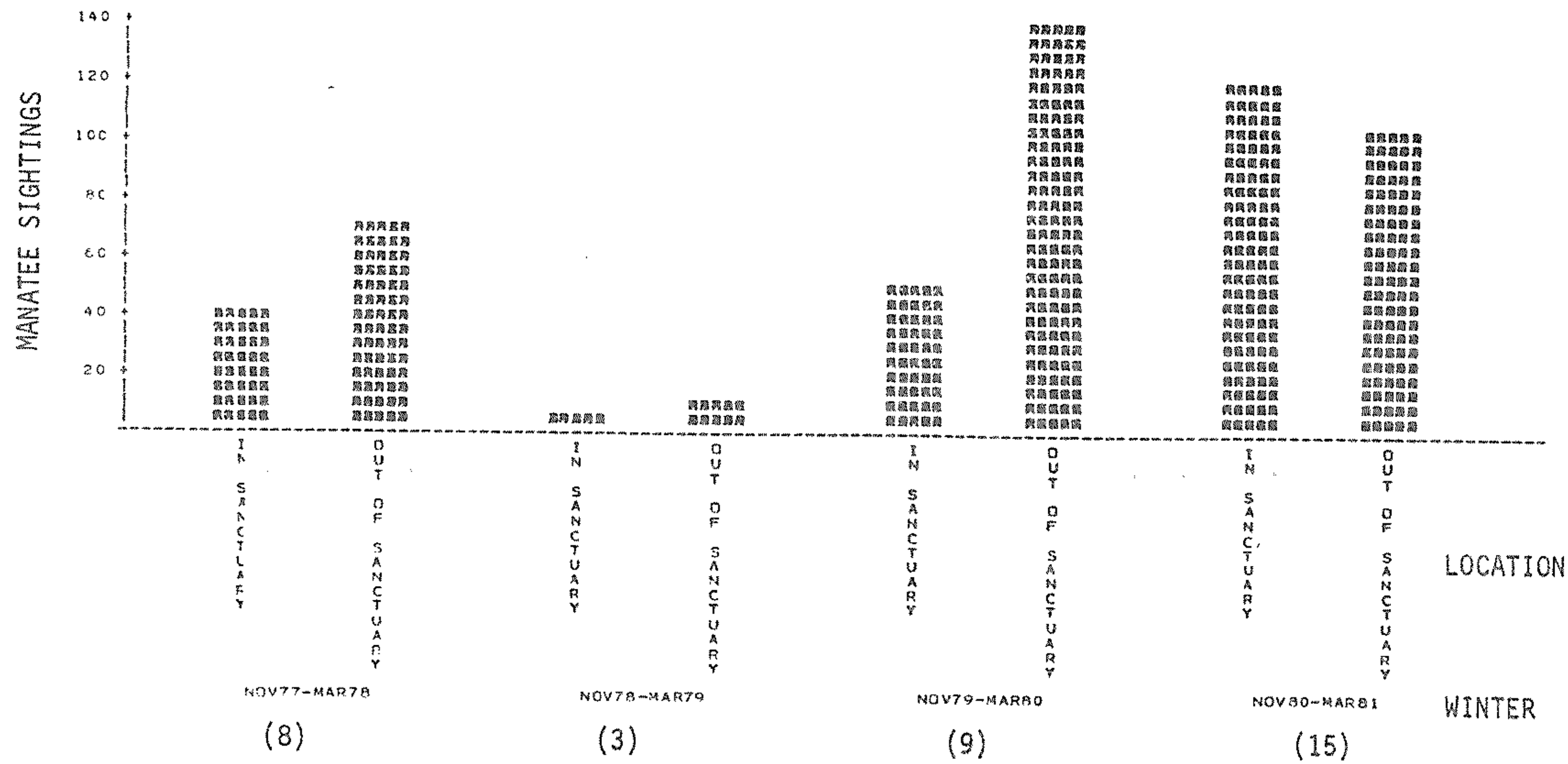

Fig. 28. Manatee utilization of Banana Island and Sunset Shores warm-water sanctuaries compared to unrestricted warm-water area during four winter periods of high human activity (> 10:00 a.m.). Sanctuary boundaries established during fourth winter only. Number of surveys indicated in parentheses.

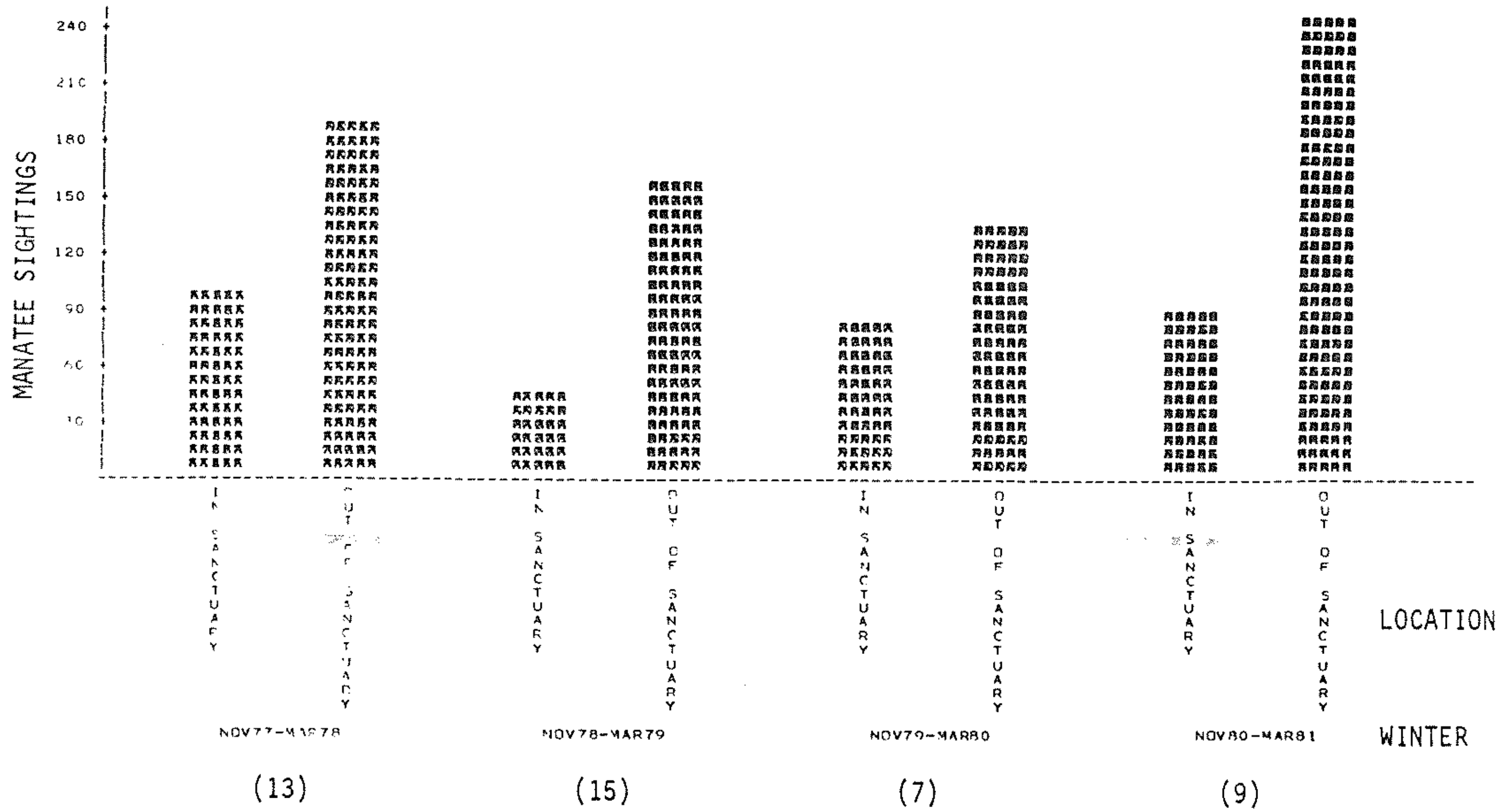

Fig. 29. Manatee utilization of Banana Island and Sunset Shores warm-water sanctuaries compared to unrestricted warm-water area during four winter periods of minimal human activity (≤10:00 a.m.). Sanctuary boundaries established during fourth winter only. Number of surveys indicated in parentheses.

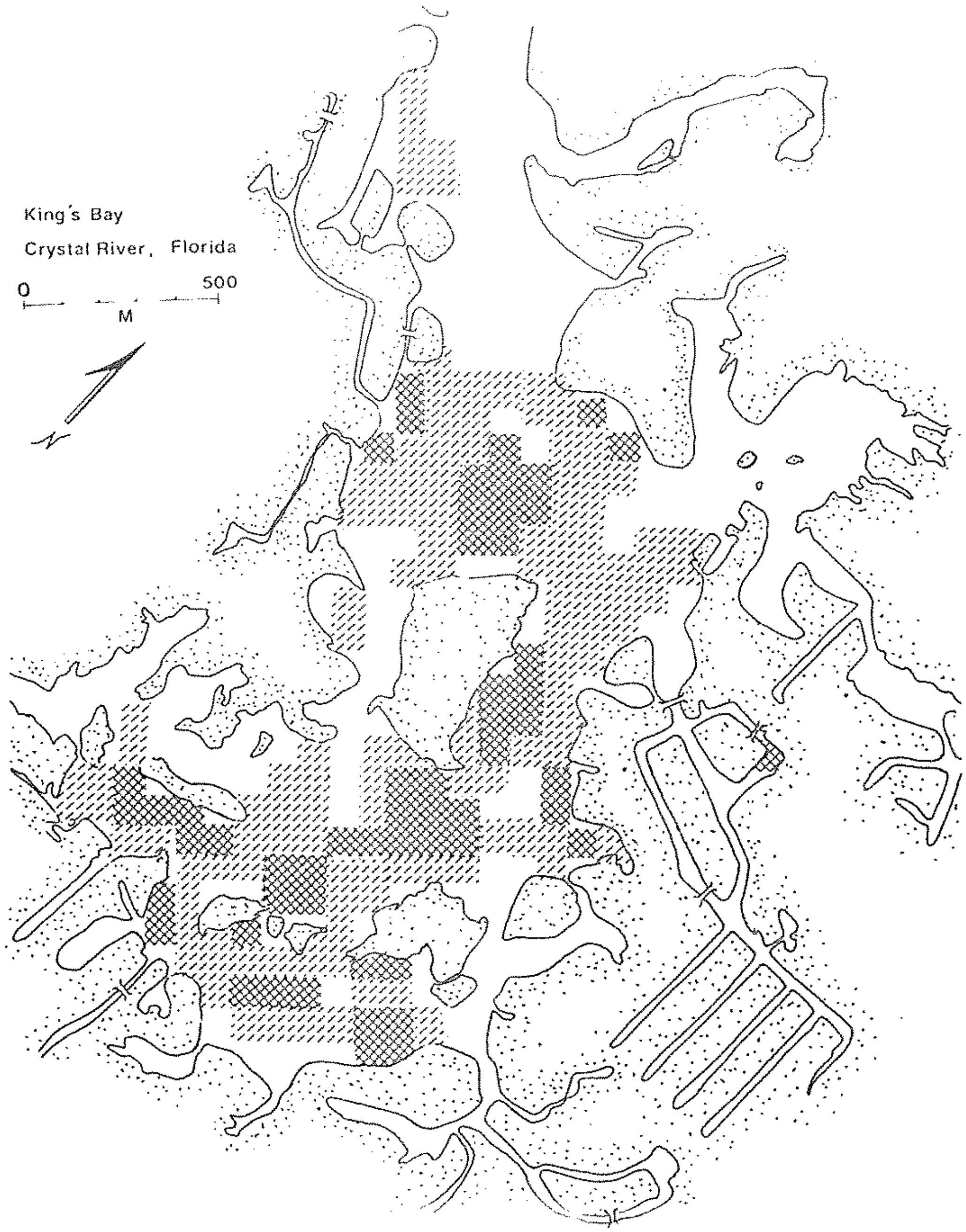

Fig. 30. Distribution of manatee feeding activity in Kings Bay. ⊠= high intensity, /// = medium intensity, "blank" = low intensity or absent.

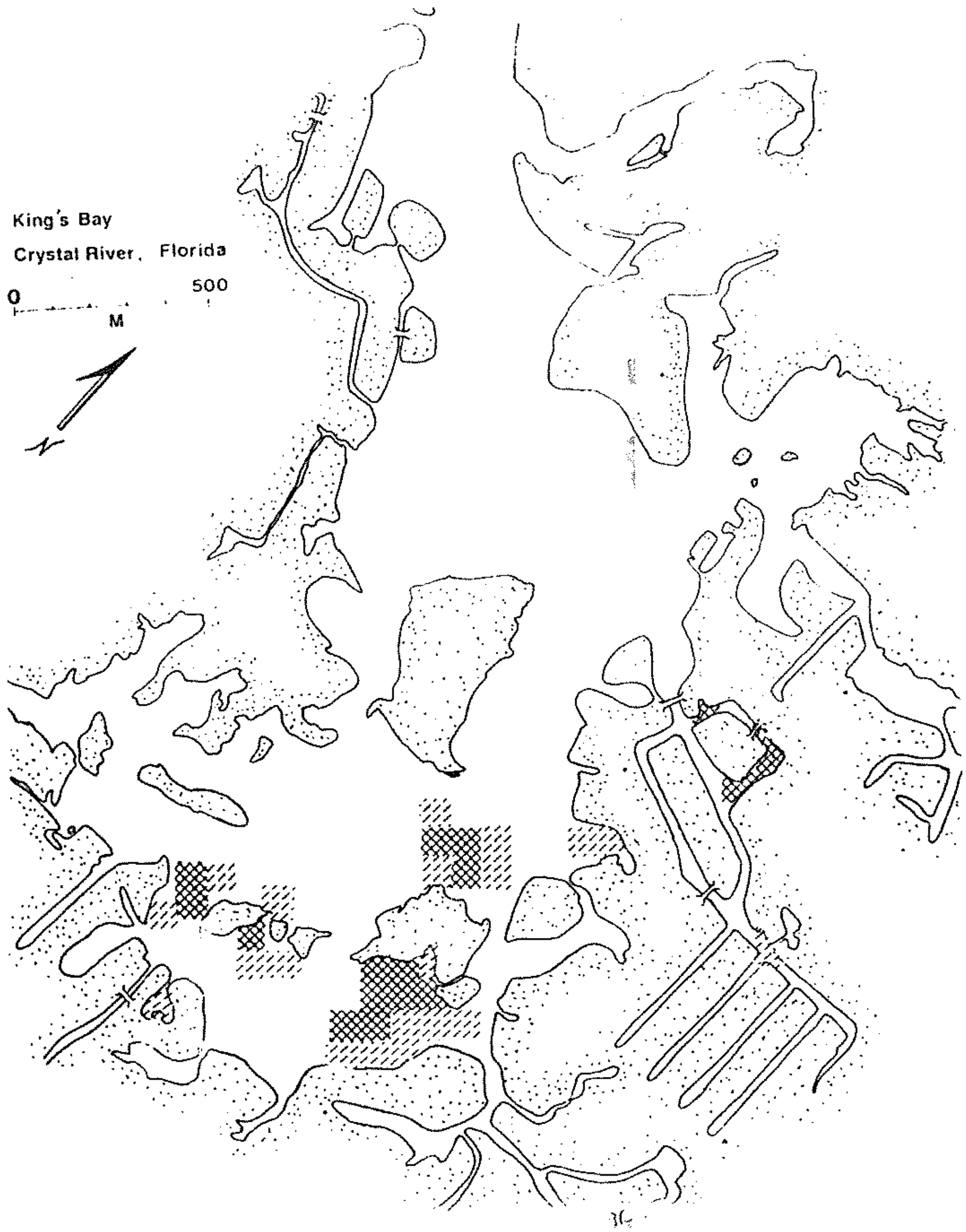

Fig. 31. Distribution of manatee resting sites in Kings Bay. Refer to Fig. 30 for explanation of symbols.

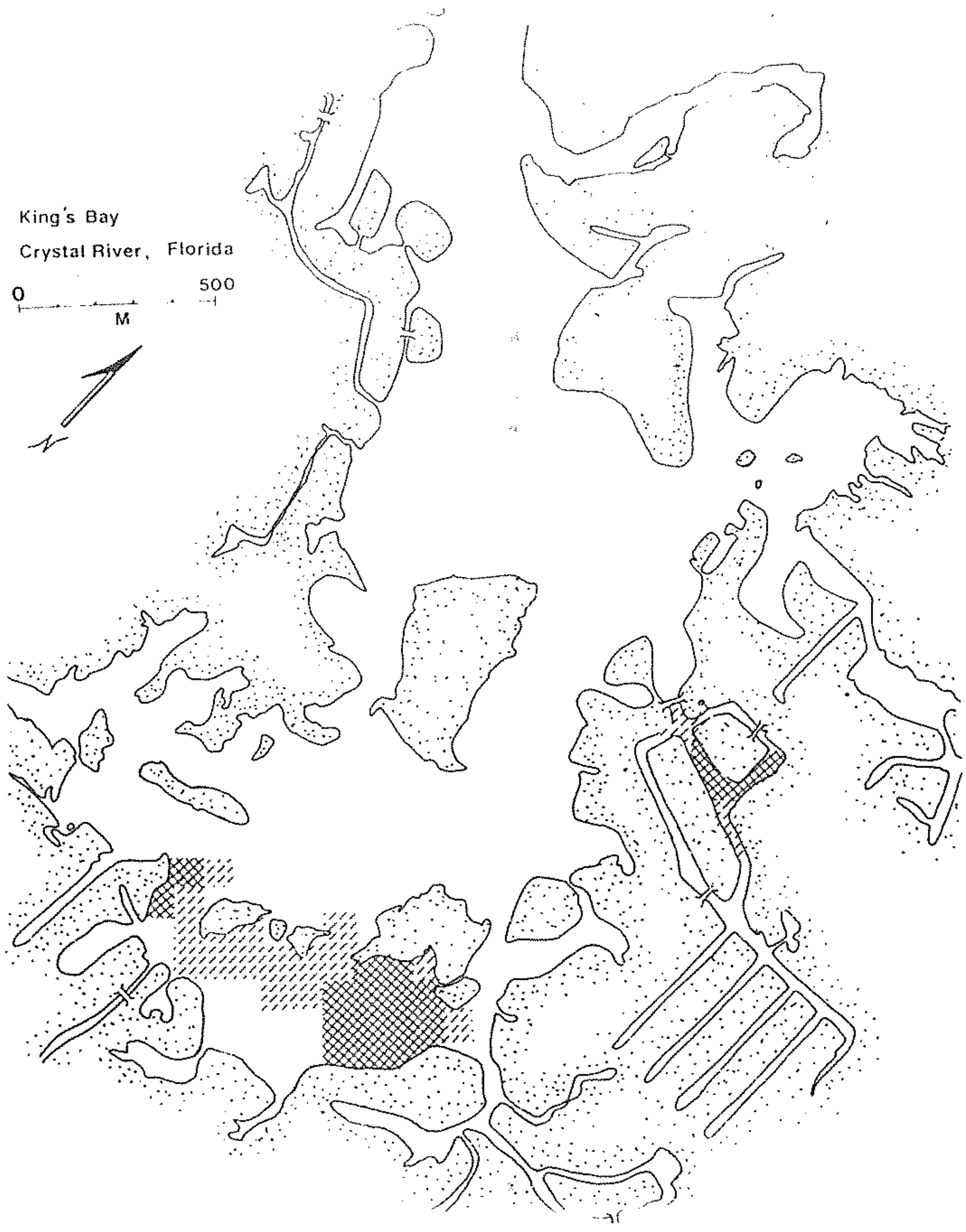

Fig. 32. Distribution of manatee social behavior in Kings Bay. Refer to Fig. 30 for explanation of symbols.

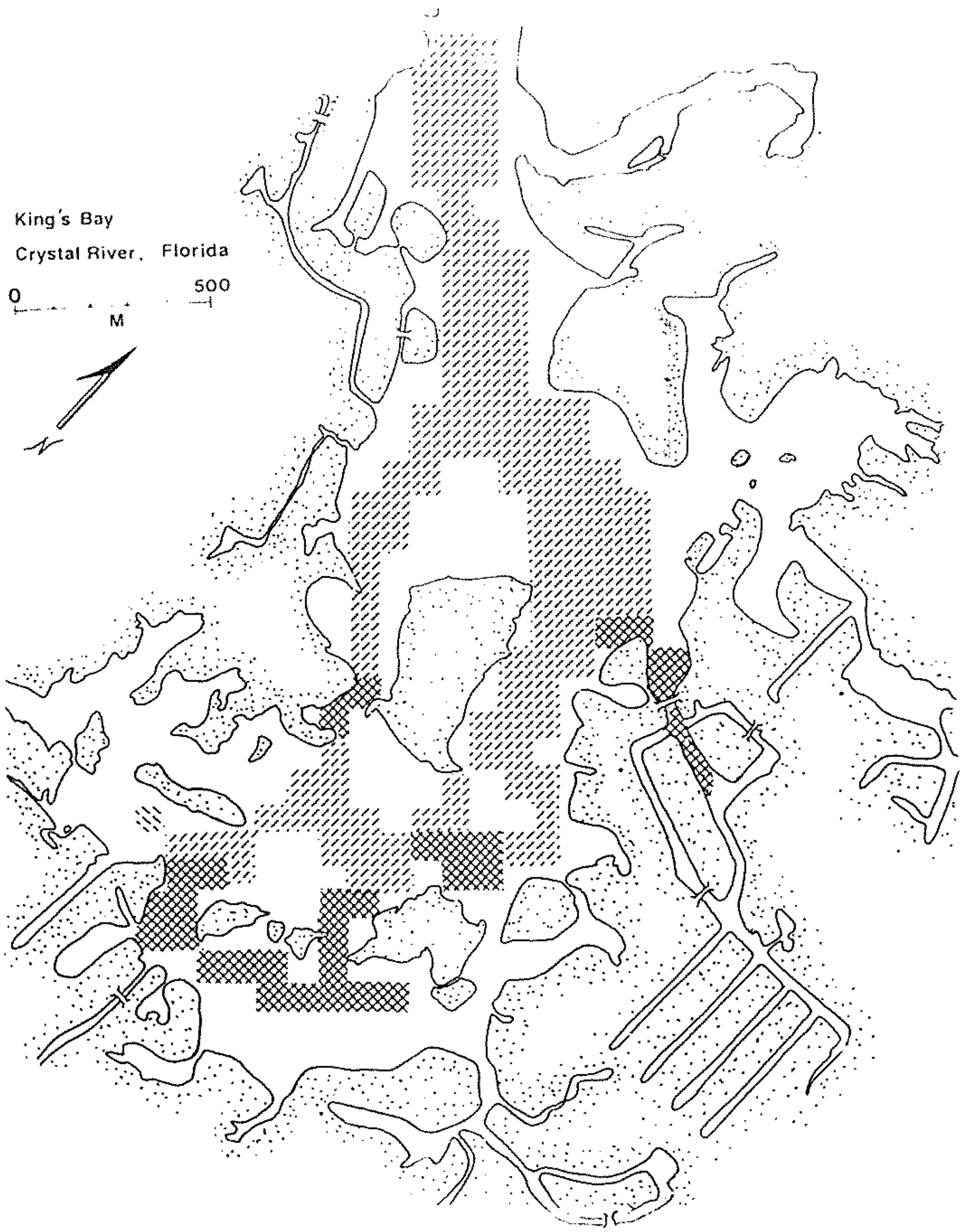

Fig. 33. Distribution of directional manatee movement in Kings Bay. Refer to Fig. 30 for explanation of symbols.

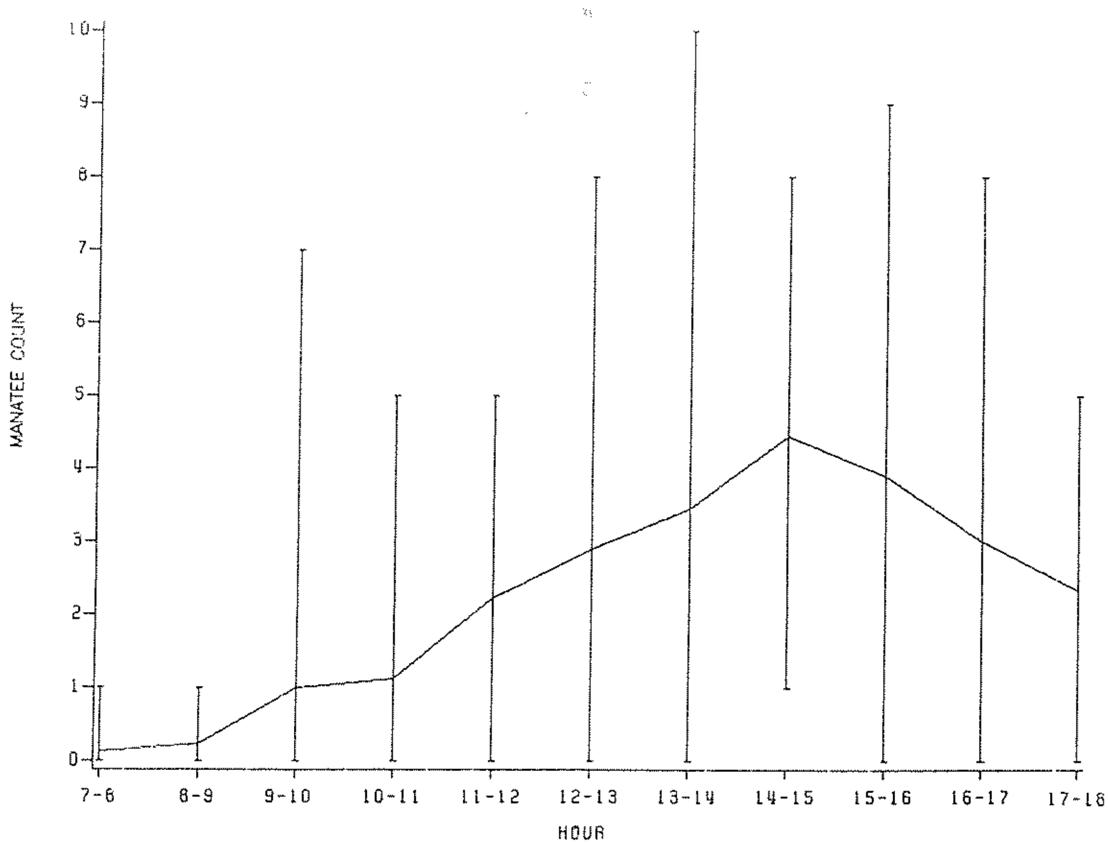

Fig. 34. Diel variation in the number of manatees travelling north along the western end of Warden Key during nine days in November 1980. Curved line joins means, vertical lines = range.

at least 20 C and appear stressed at lower temperatures (Campbell and Irvine, 1981; Irvine, 1983). Prolonged exposure to colder water imposes increased energetic demands on manatees and temperatures approaching 16 C may inhibit feeding (Campbell and Irvine, 1981; Irvine, 1983). From November through February, when manatee use of Kings Bay is highest (Table 3), water temperature in the Gulf of Mexico falls far below 20 C and may remain below 16 C during the coldest months (Fig. 5). Intermediate and variable utilization during March corresponds to a warming trend in the Gulf when manatees begin to leave the bay and disperse along the coast (Powell and Rathbun, 1983). Although manatees occur in Kings Bay from April through September, the Gulf is sufficiently warm during this period (Fig. 5) and manatee use of the bay is minimal (Table 3). The arrival of manatees in Kings Bay during October is apparently not a direct response to adverse temperature, since Gulf water is still moderately warm (Fig. 5). Perhaps fall migrations are initiated by the October cooling trend in the Gulf, as well as changes in air temperature, photoperiod or barometric pressure (Shane, 1981). The observed seasonal variation in manatee use of Kings Bay compares favorably with trends reported by Hartman (1979) and Powell (1981) for this site and is similar to patterns found at other winter refugia in Florida (Rose and McCutcheon, 1980; Powell and Waldron, 1981).

Although the seasonal pattern of manatee occurrence in Kings Bay was observed consistently during the 4-year survey period (Fig. 15) and dates back to at least the late 1960's (Hartman, 1979; Powell, 1981), the actual number of manatees using the bay appears to be increasing.

Winter manatee counts in Kings Bay (Table 3) were over twice as high as the maximum aerial count (40) reported by Hartman (1979) for the winters of 1967-1968 and 1968-1969. Both average and maximum manatee counts have increased annually from November 1977-October 1981, although only the fourth-year increase was statistically significant (Table 4). The increasing number of manatees using Kings Bay may reflect intrinsic population growth and/or winter migrations from farther south along the Gulf coast (Powell and Rathbun, 1983). The virtual elimination of human predation and the increased abundance of exotic aquatic vegetation in Kings Bay may be responsible for growth of the northwestern Florida manatee population (Powell and Rathbun, 1983).

The spatial distribution of manatees in Kings Bay is influenced by several factors, the most important being the location of artesian springs. The largest and earliest winter aggregations form in the warm-water area around the Main Spring between Banana Island and Sunset Shores (Fig. 1). Although November aggregations may be relatively diffuse (Fig. 16), clustering around the Main Spring intensifies with the onset of colder weather (Figs. 17-19). Smaller groups develop at Magnolia Spring later in the winter (Figs. 18-19), possibly in response to human disturbance at the Main Spring (Hartman, 1979). Water temperatures at the 2 aggregation sites remain above 20 C even during the coldest winter periods (Fig. 4). The relatively low use of Tarpon Spring (Fig. 1) throughout the winter may relate to its smaller size and limited discharge. Several fairly large springs, however, are not frequently used by manatees, suggesting that spring size and water temperature are not the only factors influencing winter aggregations in Kings Bay. Warm-water sites at Catfish Corner Spring, American Legion Spring and Three Sisters Spring (Fig. 1) are associated with cul-de-sacs and relatively narrow, shallow or weed-choked passes (Fig. 2). Manatees generally avoid such situations (Hartman, 1979), especially in the presence of humans. Manatee use of specific sites may also be dictated by tradition (Bengtson, 1981; Powell and Rathbun, 1983), which may partially explain the consistent location of winter aggregations and avoidance of other potentially suitable areas. During the transition months of March (Fig. 20) and October (Fig. 27), aggregations are generally poorly defined and manatees may be dispersed throughout the bay. Manatee dependence on springs during these months is variable, however, and relatively large aggregations may form in response to sudden periods of cold weather. Ironically, the springs remain colder than surrounding bay waters during spring and summer and are largely avoided by the few animals using Kings Bay during this period (Figs. 21-26).

Manatee aggregations at winter refugia can be seriously disrupted by human disturbance. Animals driven away from warm-water areas in Kings Bay during cold winter periods could suffer prolonged exposure to unsuitable (<20 C) or critically low (≤ 16 C) water temperatures (Fig. 4). The establishment of no-entry zones at winter aggregation sites allows manatees to escape from swimmers and boaters while remaining in sufficiently warm water (≥ 20 C). Although most wintering manatees group around the Main Spring during early morning hours (Fig. 29), sanctuaries at Banana Island

and Sunset Shores provide alternate aggregation sites during periods of increased human activity (Fig. 28). Despite the apparent effectiveness of no-entry zones during the first winter of implementation (15 Nov 80-31 Mar 81), additional restrictions may become necessary as human use of Kings Bay escalates.

Although manatees require unlimited access to warm-water sites while wintering in Kings Bay, they commonly leave the refugia and temporarily disperse to other sections of the bay (Fig. 33). While warm areas adjacent to springs are preferred for resting (Fig. 31) and social interactions (Fig. 32), many important feeding sites are in colder water north of Banana Island (Fig. 30). Manatees in Kings Bay and at other aggregation sites in Florida have been known to feed in water as cold as 15-16 C (Hartman, 1979; Powell and Waldron, 1981; Shane, 1981). Considering their large body size and corresponding thermal inertia, it is unlikely that manatees are stressed by brief exposure to cold water, as long as warmer areas are readily accessible (Irvine, 1983). A daily cycle of manatee dispersal to northern feeding sites in Kings Bay (Fig. 34) coincides with hourly increases in air temperature, water temperature and human activity (Fig. 3). It is difficult to determine which factors, if any, are influencing the observed movements, since manatees may respond to all of them (Hartman, 1979; Irvine, 1983). Since 20-30 animals that actually seek human contact follow the same pattern (pers. observ.), however, human disturbance is probably not the sole contributing factor. Dispersed manatees return to the Main Spring during early morning hours, apparently in response to cold predawn temperatures (Hartman, 1979).

The location of manatee feeding sites in Kings Bay (Fig. 30) is influenced primarily by submerged vegetation abundance and water depth, but does not suggest a preference for specific plant species. Hartman (1979) indicated that manatees probably feed on submerged aquatic plants nonselectively in proportion to their abundance. Although manatees in Kings Bay appear to feed extensively on *Hydrilla*, this may merely reflect the great abundance of the plant (Tables 1-2, Fig. 6) rather than an actual preference for it. Manatees frequently feed where *Hydrilla* forms extensive floating mats in water deeper than 1 m. Large mats of vegetation may partially buffer manatees from human disturbance and animals often bottom rest in such areas. *Hydrilla* was already well established in Kings Bay by the late 1960's (Hartman, 1979) and is now the most widespread and abundant submerged aquatic plant (Tables 1-2, Fig. 6). *Myriophyllum*, however, which Hartman (1979) ranked equal in frequency to *Ceratophyllum*, appears to have decreased both in distribution and abundance (Tables 1-2, Fig. 10). Changes in plant species composition, as well as variation in vegetation abundance throughout Kings Bay (Fig. 14), may be the result of aquatic weed control activities, manatee feeding pressure and changes in water chemistry. These same factors, in addition to changes in day length and water temperature, may also contribute to seasonal variation in the aquatic vegetation of Kings Bay (Fig. 13).

CONCLUSIONS

1) Kings Bay is an important winter refugium for manatees occurring along the northern Gulf coast of peninsular Florida.

2) Manatee use of Kings Bay is highest from November through February, moderate during October and March, and lowest from April through September.

3) The number of manatees using Kings Bay as a winter refuge appears to have doubled since the late 1960's, and continues to increase.

4) Wintering manatees require unlimited access to warm-water areas at the Main Spring and Magnolia Spring, and feed on submerged aquatic vegetation throughout Kings Bay.

5) Implementation of no-entry zones at warm-water aggregation sites in Kings Bay reduces human disturbance and allows wintering manatees to avoid unsuitably low temperatures.

6) Planners, developers and resource managers can minimize conflicts with manatees by understanding their seasonal and spatial distribution in Kings Bay.

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THE MANATEE POPULATION IN CRYSTAL RIVER, CITRUS COUNTRY, FLORIDA

James A. Powell

West Indian manatees (Trichechus manatus) return annually to the headwaters of Crystal River, Citrus County, Florida (Hartman, 1971). The warm springs in Kings Bay form a natural refuge for manatees that return each year at the onset of winter cold spells (Hartman, 1971; Layne, 1965; Moore, 1951, 1956).

Crystal River is located on the central west coast of Florida approximately 120 km north of Tampa. It empties into the Gulf of Mexico, 8 km from its source in Kings Bay. The "main" spring, located at the southern terminus of the bay, is the focus of manatee aggregations (Fig. 1). Although the Homosassa River, 10 km south, is also spring-fed, it is used by only a few manatees.

The National Fish and Wildlife Laboratory (NFWL) has been monitoring the status of manatees at Crystal River extensively since 1976. This research continues and supplements the studies of Hartman (1971), thus compiling long-term information on manatee habitat use, reproduction, and population status. These data should help provide the necessary foundation for sound conservation and management decisions.

METHODS

Between October 1977 and March 1978, either an aerial or surface survey (or both) was conducted each week and supplemented by several hours of underwater observations. All aerial and surface sightings were recorded on a study area map which was superimposed with a grid system for later analysis of distribution data. In previous years (1967-1977) data were gathered during occasional aerial and surface surveys.

Weather permitting, aerial reconnaissance flights were made in a single engine, high-wing aircraft at an altitude of 150-200 m and an airspeed of 120-160 km per hour. The Kings Bay complex was subdivided into five zones and each was circled repeatedly until consistent counts were obtained. On the last circuit, photographs were taken for later comparison with the observer's records. The average flight time over Kings Bay was 55 min. From Kings Bay, the survey continued down the Crystal River to the Gulf of Mexico, after which the Withlacoochee River (15 km to the north) and the Homosassa River (10 km to the south), as well as intermediate areas, were surveyed. Twenty-two aerial surveys were conducted, averaging 1.8 h each.

Nine surface surveys were conducted in a 5 m Boston Whaler with a 70-hp outboard motor. A standard route in Kings Bay was followed through known areas of manatee use. Observation stops were made at five locations in the southern portion of Kings Bay where manatees were usually aggregated. At each stop, observations were made for 5 min. 180° forward of the beam and then repeated for 5 min. 180° aft. The positions of any animals observed surfacing were plotted on grid sheets identical to those used for aerial surveys. The survey was then continued in other parts of the bay at idle speed, but without stops

[a] From: R. L. Brownell, Jr. and K. Ralls (eds.). 1981. The West Indian Manatee in Florida. Procedings of a workshop held in Orlando, Florida. 27-29 March 1978. pp 33-40.

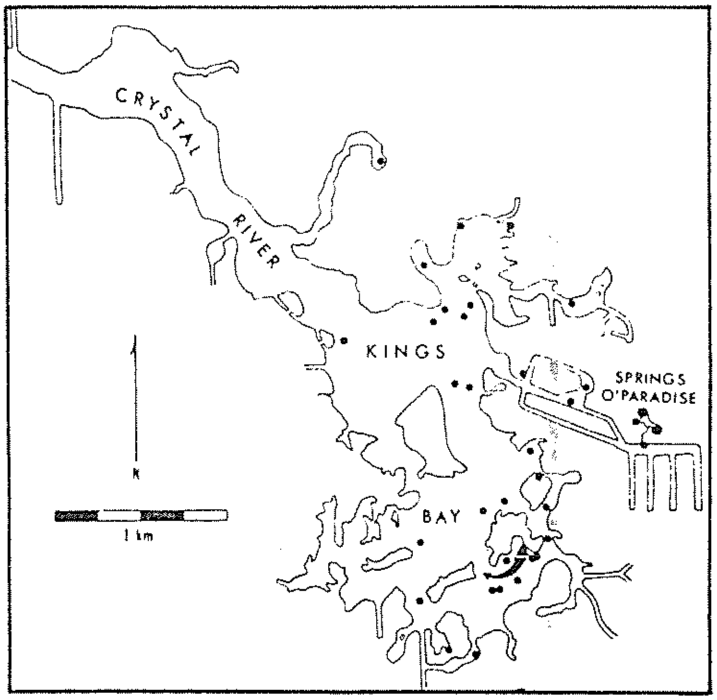

Figure 1. Kings Bay and the upper reaches of the Crystal River showing the locations of the main spring (solid triangle) and other major springs (solid circles). Arrow indicates course of main spring run (from Hartman, 1971).

except to count or identify manatees. Boat surveys were conducted immediately after five of the flight surveys to compare the data obtained with the two methods. The boat surveys averaged 1.2 h each.

Individual manatees were observed underwater by snorkeling. An average of 2 to 3 h were spent in the water per survey day for a total of 104 h from 1 October 1977 through 1 February 1978. A mask, snorkel, and fins were used rather than SCUBA, which appeared to disturb the animals. Most manatees were identifiable by morphological peculiarities, scar patterns caused by boat propellers or barnacles, and other minor markings (Hartman, 1971; Moore, 1956). Photographs and sketches of each animal encountered helped facilitate reidentification. A sighting log for each identified animal was maintained. Date, sighting locations, and, when possible, the identity of accompanying manatees were noted.

RESULTS AND DISCUSSION

The arrival of manatees in Crystal River is related to the seasonal temperature decrease in the air and waters along the Gulf of Mexico coast.

There can be a substantial difference in temperature between the gulf and the main spring. In mid-winter, the Gulf of Mexico surface temperature may decrease to 10°C; the mean is approximately 16°C. The main spring remains a constant 23.5°C throughout the year (pers. obs.).

Table 1. Number of manatees observed during aerial and surface surveys conducted at Crystal River, Citrus County, Florida, from 7 September 1977 to 7 March 1978. Blanks indicate that no survey was conducted on that date.

DATE	AERIAL SURVEY Adults	Calves	BOAT SURVEY Adults	Calves*	TEMPERATURE °C Air**	Gulf***
7 Sept.	5	0			22	30
5 Oct.	8	0			20	25
14 Oct.	10	2			9	22
9 Nov.	29	1	9	1	21	23
11 Nov.	34	5			6	18
17 Nov	49	2			16	17
24 Nov.			14	1	17	20
25 Nov.			14	1	16	21
27 Nov.			22	0	13	17
28 Nov.			29	1	18	17
29 Nov.	49	3	32	3	18	18
7 Dec.	45	4	24	1	1	14
22 Dec.	51	2			2	13
29 Dec.	37	0			3	10
3 Jan.	59	3	49	3	4	12
12 Jan.	67	5			4	10
21 Jan.	55	3	34	2	6	11
7 Feb.	48	3			5	11
25 Feb.	61	3			6	10
2 Mar.	55	4			15	14
7 Mar.	50	4			14	16

* Calves identified from the air were 2/3 the length of adults or 2m long.
** Air temperatures taken at 0800 h at Sanitary Disposal Plant at Kings Bay.
*** Gulf water temperatures taken at 2400 h at Florida Power Plant 4 km north of the mouth of Crystal River.

Information from Blue Spring, Volusia County, indicates that the manatees first appear when the temperature in the neighboring St. Johns River approaches 21-22°C (Powell and Waldron, this volume). The first significant change in the number of animals present in Crystal River also occurs when gulf temperatures approach 21-22°C. An almost four-fold increase of animals occurred between 14 October and 17 November 1977 when the mean gulf temperature dropped from 22 to 18°C (Table 1). The number of manatees counted in Crystal River increased as the season progressed and stabilized near mid-January. They are usually gone by late March or early April. Manatees only occasionally visit Crystal River from May to October, probably because the water temperature is then below that of the Gulf of Mexico (Irvine and Campbell, 1978).

Table 2. Largest reported winter manatee aggregations from 8 years of aerial surveys at Crystal River, Citrus County, Florida.

Season	Largest Winter Aggregation
1967-1968*	38
1968-1969*	44
1969-1970	No observations
1970-1971	No observations
1971-1972	No observations
1972-1973**	45
1973-1974**	44
1974-1975	47
~~1975~~-1976	~~51~~
1976-1977	37
1977-1978	72

* Hartman (1971)
** Hartman (pers. comm.)

During extremely cold weather, the manatees congregate within 100 m of the main spring. Data were collected on manatees in Kings Bay on 64 days. They were seen in the main spring (n=9) only when the previous night's air temperature was less then 5.5°C. During such cold weather, up to a 5°C decrease in the water temperature occurs beyond the upwelling and flume of the spring (pers. obs.). Manatees thus appear to utilize the warmest water available during severe cold.

The manatees usually rest along the slopes of the main spring unless divers are present. At the first arrival of divers, the majority usually move at least 100 m away to quieter but cooler areas. They apparently leave because of harassment by some of the divers. However, a few individual manatees do remain near divers and occasionally seek attention from them. Aggregations of manatees were observed at the spring while divers were present only during the three periods of extremely cold weather (less than 1°C).

Some individual manatees frequent natural warm water springs throughout the winter season, whereas others are transients and remain in the vicinity only a few hours to several days or weeks (Hartman, 1971; Powell and Waldron, this volume). In 1977-78 in Crystal River, six individuals were resighted on at least 29 of 36 water observation days, whereas 12 were only sighted on 3 or fewer days. Two of these 12 transients were later seen in the Homosassa River within 1 month of the original sighting, and one of them then returned to Crystal River within 4 weeks.

Until 1977-78, there had been no significant change in the ~~maximum~~ size of the winter aggregation size the past 8 years of study (Table 2). The increase for the winter of 1977-78 may be due to either better techniques and greater frequency of surveys or an increase in the number of manatees using the area.

Table 3. Sex composition of individually known manatees during five selected years in Crystal River, Citrus County, Florida.

WINTER	ADULTS Males	ADULTS Females	CALVES	UNIDENTIFIED SEX	TOTAL
1967-68*	25	25			50
1968-69*	23	25			48
1972-73**	16	18	4	23	61
1976-77	19	20	10	5	54
1977-78	33	43	10	12	98

* Calves included in adult count (Hartman, 1971)
** Hartman (pers. comm.)

In 1977-78 approximately 88 adult manatees were individually identified in Crystal River. The sex ratio of the Crystal River animals has remained at approximately one to one since 1967 (Table 3). Calves composed 12.0% of the identified manatee population in 1967-68, 22.9% in 1968-69, 18.5% in 1976-77, and 10.2% in 1977-78. The age classes used in this study were adults and calves. Calves were those individuals still suckling and in attendance with their mothers. Several calves were within Hartman's (1971) juvenile category (greater than 2.4 m). Therefore, I consider that category described by Hartman (1971) and Moore (1956) too arbitrary to be useful.

Table 4. The number of known manatees resighted in Crystal River, Citrus County, Florida, during four selected winters.

	1968-1969 *	1972-1973 **	1976-1977	1977-1978
Number of individuals resighted from any previous study period	35	16	6	21
Number of new individually identified manatees (calves in parentheses)	13(11)	45(4)	48(10)	77(10)
Total number of identified manatees	48	61	54	98
Percent of total that returned	72.9%	26.2%	11.1%	21.4%

* Hartman (1971)
** Hartman (pers. commn.)

Some manatees used Crystal River for several consecutive years (Table 4). Twenty-one animals (21.4%) from the winter of 1977-78 were positively identified from previous years. Six of these also had been seen in 1972-73, and five of them were first seen in 1967-69. Hartman (1974) resighted 35 animals in 1968-69 that he originally identified in 1967-68; 16 of these were seen again in 1972-73. The lower percantage return in 1976-77 shown in Table 4 is probably due to less frequent surveys and the use of sketches of scars in 1976-77 instead of more accurate photographs.

One female (Piety), first seen in the winter of 1972-73 and estimated to be 3 to 4 years old at that time (Hartman, pers. comm.), was resighted in all subsequent years. In January 1977 she was pregnant. In October 1977, she was observed in Crystal River with a calf approximately 1.5 m in length (a first year calf), indicating that she first conceived when she was 7 or 8 years old. This agrees with Odell's (1977) estimate, based on reproductive organ weights and body lengths, that females reach sexual maturity at an age of 7 to 8 years, but is greater than the 3 to 5 years estimated by Hartman (1971).

Table 5. Reproductive data on an individually known female manatee (Sadie) in Crystal River, Citrus County, Florida.

YEAR	SEASON	REPRODUCTIVE STATUS
1967	Fall (Oct)	New calf
1968-69	Fall and Winter	Same calf
1969-70	Fall and Winter	No observations
1970-71	Fall and Winter	No observations
1971-72	Fall and Winter	No observations
1972	Fall (Oct)	New Calf
1973-74	Fall and Winter	Same Calf
1974-75	Fall and Winter	No observations
1975-76	Fall and Winter	No observations
1976-77	Fall and Winter	Pregnant
1977	Fall (Oct)	New calf

Another female (Sadie) was first sighted in 1967 and has been seen several times in the intervening years with calves (Table 5). Calving data from this female are inconclusive due to the two periods of no observations. They suggest either a 5- or possibly 2.5-year calving interval. If she gave birth during the two periods of no observations and either successfully raised the calf (in the 3-year period from 1969-70 through 1971-72) or lost a neonate (in the 2-year period from 1974-75 and 1975-76), then she had a calving interval of 2.5 years. If she gave birth only the three times indicated in Table 5, she calved approximately every 5 years.

Continued long term study of known animals is necessary to confirm the calving interval estimates. Crystal River provides a unique opportunity for such studies. It is one of the few areas in the world where manatees consistently gather in significant numbers and where satisfactory conditions exist for observing them. The programs underway will continue to develop baseline biological data of scientific value and use for management planning.

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STATUS OF MANATEES IN FLORIDA IN RELATION TO CERTAIN ENVIRONMENTAL CONTAMINANTS [1]

THOMAS J. O'SHEA[2], Patuxent Wildlife Research Center, Laurel, MD 20811

JOHN F. MOORE, Patuxent Wildlife Research Center, Laurel, MD 20811

HOWARD I. KOCHMAN, Denver Wildlife Research Center, Gainesville Field Station, Gainesville, FL 32601

Abstract: The status of the endangered West Indian manatee (*Trichechus manatus*) in relation to organochlorine pesticides, polychlorinated biphenyls, mercury, lead, cadmium, copper, iron and selenium was investigated in Florida from 1977-1981. Concentrations of organochlorines in blubber, mercury in muscle and liver, lead in liver, and lead and cadmium in kidneys did not indicate serious exposure to these contaminants. Of all metals examined, only cadmium in kidneys showed a positive correlation with relative age. No significant relationship existed between liver iron and copper; liver selenium concentrations were low. Copper concentrations in livers of these aquatic herbivores were significantly elevated in areas of high herbicidal copper usage after adjustment for significant age-related

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[1]Submitted to Journal of Wildlife Management

[2]Present address: Denver Wildlife Research Center, Gainesville Field Station, Gainesville, FL 32601.

effects, with upper values (to 1,200 ppm dry weight) exceeding all previously reported concentrations in livers of any species of wild mammals from free-ranging populations. Concentrations known to occur in aquatic plants as a result of herbicide application exceed those which produce harmful effects in feeding studies of many domestic mammals, and liver copper concentrations comparable to those associated with toxic effects in some domestic species were found in manatees from areas of high copper herbicide use. It is recommended that the use of copper herbicides for control of aquatic plants be carefully managed in areas of intensive use by manatees.

Key words: contaminants, copper, endangered species, Florida, heavy metals, herbicides, organochlorine pesticides, *Trichechus manatus*, West Indian manatee.

The impact of environmental contaminants on West Indian manatees in Florida has not been previously assessed, although a considerable proportion of the dead manatees recovered each year as part of a carcass salvage program have been reported to die of unknown causes (Beck et al. 1981; Irvine et al. 1981). This report presents results of a survey of tissues from salvaged manatee carcasses for residues of organochlorine pesticides and metabolites, polychlorinated biphenyls (PCBs), mercury, lead, cadmium, and copper. Organochlorine compounds have caused significant mortality and contributed to population declines of other endangered mammals and birds (see, for example, Blus et al. 1974, 1979; Cromartie et al. 1975; Clark et al. 1978), and have been reported in alarmingly high concentrations in tissues of other marine mammals (LeBouef and Bonnell 1971; O'Shea et al. 1980). Certain other marine mammals have also been shown to accumulate elevated concentrations of mercury (Heppleston and French 1973; Anas 1974). Manatees are herbivores and may therefore be exposed to lead and cadmium through ingestion of aquatic vegetation, which can contain elevated concentrations of these toxic heavy metals in polluted environments (Mayes et al. 1977; Cooley and Martin 1979; Welsh and Denny 1980). The significance of exposure to copper-based aquatic herbicides is also examined because of the large-scale application of these chemicals for control of vegetation in important manatee habitat in Florida. Residue concentrations of selenium and iron in livers are considered because of potential interrelationships with mercury and copper, respectively.

Tissue samples were obtained from manatee carcasses salvaged under authority of Federal Fish and Wildlife Permits PRT2-3058 and PRT9-25-C. C. A. Beck, R. K. Bonde and D. K. Odell assisted in collecting specimens. Helpful suggestions on the manuscript were provided by R. L. Brownell, Jr., D. R. Clark, Jr., G. B. Rathbun, and L. Sileo.

METHODS

Tissue samples were obtained from dead manatees stranded throughout Florida from October 1977 through January 1981. Samples were excised from the same topographical locations in each animal with stainless steel dissecting tools rinsed in acetone and hexane. Areas sampled were the caudal tip of the right lobe of the liver, the caudal third of the entire right kidney, and blubber and muscle from the mid-ventral body wall. Tissues were preserved frozen in glass jars (previously rinsed in acetone, hexane, and dilute nitric acid) lined with teflon lids. Metal residues were quantitated by atomic absorption spectrophotometry and organochlorines by gas chromatography or combined gas chromatography-mass spectrometry. The limits of sensitivity were 0.02 ppm for mercury and 0.1 ppm for other metals and organochlorines. A detailed description of chemical methodology has been reported elsewhere (Haseltine et al. 1981). Organochlorines capable of being detected following these procedures included PCBs, p,p'-DDE, p,p'-DDT, p,p'-TDE, dieldrin, heptachlor epoxide, oxychlordane, *cis*-chlordane, *trans*-nonachlor, *cis*-nonachlor, endrin, hexachlorobenzene, mirex, and toxaphene. Organochlorines are expressed on the basis of wet weight of blubber; metal residue concentrations are reported on a dry weight basis. Metal concentrations from other studies discussed in the text are also expressed on a dry weight basis.

Statistical analyses were performed using SAS software (Helwig and Council 1979). Metal residue concentrations in tissues of wild mammals are usually reported in the literature as arithmetic means, ranges, and standard deviations. We display these summary statistics for comparative purposes. All statistical analyses, however, are based on logarithmic (base 10) transformations of original data to reduce heterogeneity of variances and deviations from normality. A constant of 1 was added to variables including not detected values prior to transformation. Analysis of covariance (ANCOVA) was employed for each metal to examine sexual and geographic differences in metal concentrations using total length as the covariate. Regression slopes were compared among sexes and locations by testing the significance of the factor x covariate interaction. When homogeneity of regression slopes appeared tenable, group differences were tested after adjusting for the covariate, and within-groups regression was evaluated after adjusting for group effects. Linear contrasts among adjusted means were compared to a Bonferroni *post hoc* criterion of $P \leq 0.017$ in order to maintain an experiment-wise error rate of $P \leq 0.06$.

Total length was used in these analyses as a measure of relative age. More accurate aging techniques have not been developed for this species. Unpublished data indicate that total body lengths of neonates and early juveniles in their first year range from about 100 to 175 cm. Sexual maturity occurs at 5 or more years of age, with all manatees greater than 275 cm considered as adults; dependent calves in their second year and subadults are intermediate in size. Maximum longevity is unknown but an individual currently in captivity has survived over 33 years.

Our interest in determining geographic trends in liver copper concentrations stemmed from concern for possible high exposure of manatees to copper as an aquatic herbicide in Crystal River, Citrus County, Florida. Each winter up to 120 manatees from Florida's northwest coast aggregate in the headwaters of the 11 km long Crystal River. The constant, relatively warm temperatures of the spring-fed river provide a thermal refuge (Hartman 1979), and the manatees feed extensively on the aquatic vegetation in the area throughout the winter. In the late 1970's weed control agencies applied large amounts of copper herbicides directly into Crystal River during months when manatees were most abundant and dependent on the area. In the annual period ending 1 November 1979, for example, over 6 metric tons of elemental copper were introduced into this system. In order to determine if copper was being accumulated by manatees under such conditions, we employed ANCOVA on the liver copper data of manatees classified as being from regions of probable high, moderate, or low exposure to copper herbicides using body length as the covariate. Carcasses recovered from the annual range of the Crystal River population (Citrus, Dixie, and Levy Counties) were classified as being from regions of possible high exposure. Other counties where carcasses were recovered were considered regions of possible moderate exposure (Brevard and Dade Counties), or low exposure (Broward, Collier, Hillsborough, Lee, Martin, Monroe, and Palm Beach Counties). Copper herbicide usage was estimated by interviewing weed control authorities and obtaining summaries or logs of chemicals used during an annual period beginning in autumn. Approximate annual amounts (in kg of elemental copper as the active ingredient) used by respondent agencies in the county of carcass recovery varied from none to 200 in counties of the low group, 600 to 4,000 in counties of the moderate group, and 8,800 or more in the high group. These amounts are considered to be indices of relative copper use rather than absolute quantities and have not been calculated on the basis of area of manatee habitat treated. They are reliable relative indices in that different regions of Florida have programs emphasizing control of certain weed species that call for copper herbicides whereas others do not. Thirty-nine manatees with length data could be classified according to these groups. Satisfactory usage data were not obtained for other areas from which the remaining manatee carcasses were obtained.

RESULTS

Metals

Copper concentrations in livers of manatees were extremely variable (Table 1). Significant effects due to herbicide usage area (P = 0.0005) and a significant negative correlation with size (P = 0.02) were apparent (Fig. 1). There was no evidence of sexual variation (P = 0.90) or of sex x area interaction (P = 0.51). Regression slopes did not differ significantly among the 3 treatment areas (P = 0.71). Copper residue concentrations in livers of manatees from high copper herbicide usage areas were greater than medium (P = 0.01) or low (P = 0.0001) usage areas. Copper concentrations in manatees from medium and low usage areas did not differ significantly (P = 0.04, H_0 accepted based on a Bonferroni critical value of 0.017). Back-transformed adjusted means of liver copper concentrations in manatees from high, medium and low usage areas were 322, 64, and 24 ppm, respectively. The partial correlation coefficient for log copper concentration with total body length adjusted for treatment effects was -0.39 (P = 0.02). The six highest individual copper residue concentrations (600, 650, 670, 850, 850, and 1,200 ppm) were found in manatees from the northwest coast of Florida, five from the Crystal River population in the Citrus-Levy-Dixie County region (Fig. 1).

Iron concentrations in livers were less variable than copper (Table 1), and showed no significant effects due to sex (P = 0.21) or regression with size (P = 0.80). The partial correlation between liver iron concentrations and liver copper concentrations (adjusting for total length) was not significant (P = 0.44).

Table 1. Metal residue concentrations (ppm dry weight) in tissues of West Indian manatees from Florida.

Tissue and metal	N	N detected	range	$\bar{X}$	SD	CV(%)
Kidney						
Cadmium	38	36	ND[a]- 190	25.7	42.6	166
Lead	20	20	3.3-7.1	5.2	1.0	20
Liver						
Copper	54	54	4.4-1,200	175	255	146
Iron	35	35	460-8,200	1,920	1,450	75
Lead	19	19	1.8-4.4	2.7	0.6	22
Mercury	19	1	ND -0.2	0.23		
Selenium	19	11	ND -1.1	0.42	0.4	98
Muscle						
Mercury	27	0				

[a]ND = not detected, entered in computations as zero.

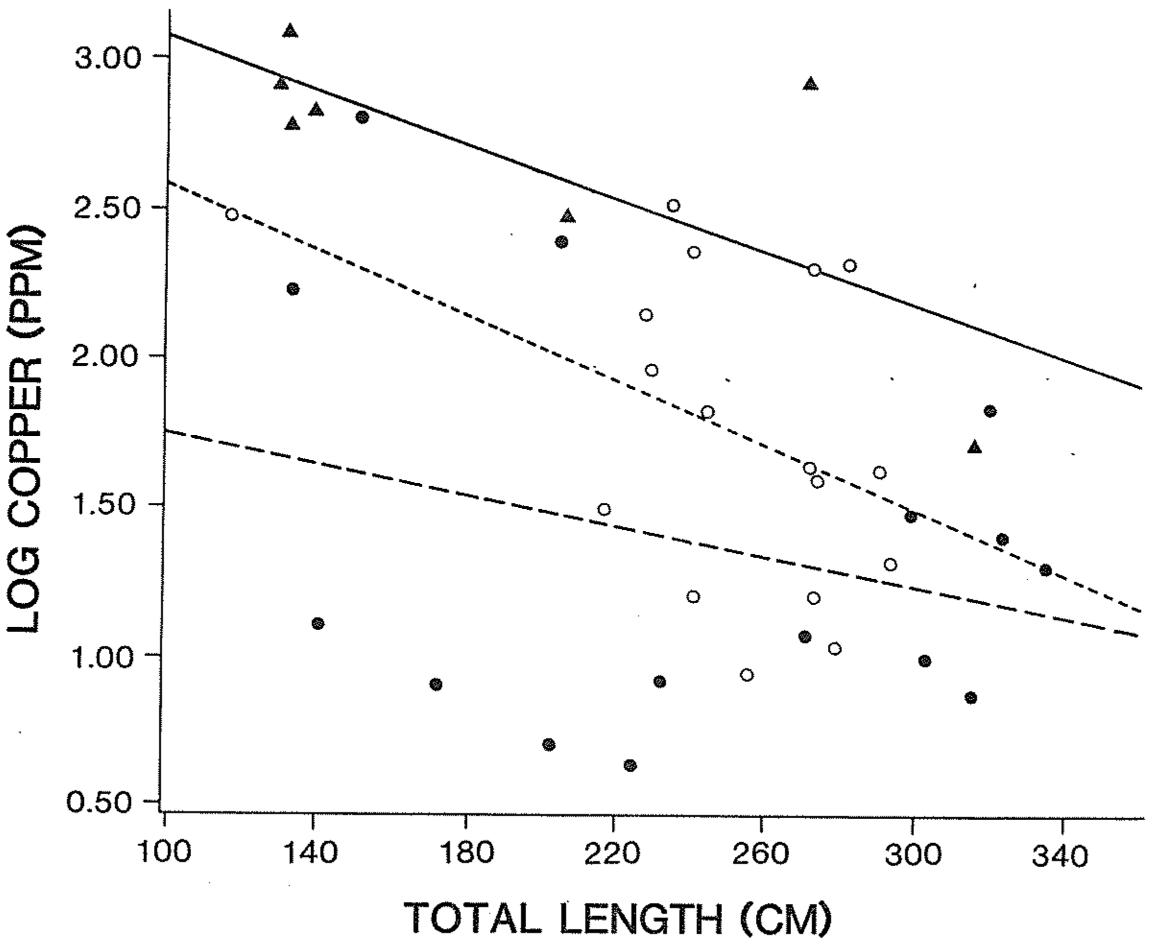

Figure 1. Copper concentrations (ppm dry weight) in livers in relation to total body length of manatees found in high (squares), medium (diamonds), and low (triangles) copper herbicide usage areas. Regression equations for the high, medium, and low usage areas are log Y = 3.51 - 0.004X, log Y = 3.12 - 0.005X, and log Y = 1.99 - 0.002X, respectively. Slopes of regression lines for high (solid), medium (dashed), and low (finely dashed) usage areas are not significantly different (P = 0.71).

Cadmium concentrations in kidneys also showed much variation (Table 1), with no significant effects due to sex ($P = 0.59$). A significant positive regression ($P<0.0001$) with body length (relative age) existed (Fig. 2), which explained 58% of the variation in the pooled sample of males and females. Lead residue concentrations in livers were not excessive (Table 1) and showed no effects due to sex ($P = 0.20$) or regression with body length ($P = 0.40$). Lead concentrations in kidneys were significantly greater than in livers ($P<0.0001$, paired t-test). Lead in kidneys also showed no effects due to sex ($P = 0.98$) or regression with body length ($P = 0.19$). Mercury concentrations in tissues were consistently low, generally below the limits of detection in both liver and muscle samples (Table 1). Selenium concentrations in livers were also low (Table 1).

Organochlorines

Results of analyses of blubber samples from 26 manatees indicate that these animals are relatively free from contamination with organochlorines. Only five of the samples contained detectable residue concentrations of the metabolites of DDT (summed here as DDTR). These five averaged 0.19 ± 0.06 ppm DDTR (range 0.14 - 0.28). Dieldrin was detected in 4 of 26 samples, averaging 0.26 ± 0.10 ppm in these four (range 0.12 - 0.36). PCBs were detected in a greater number of samples: 13 of 26 individuals possessed an average concentration of 1.4 ± 1.1 ppm, ranging from 0.50 to 4.6 ppm. All of the manatees with detectable PCB residues were recovered from locations in relatively urbanized areas of northeastern Florida, primarily the lower St. Johns River and Brevard County. No other organochlorines were detected.

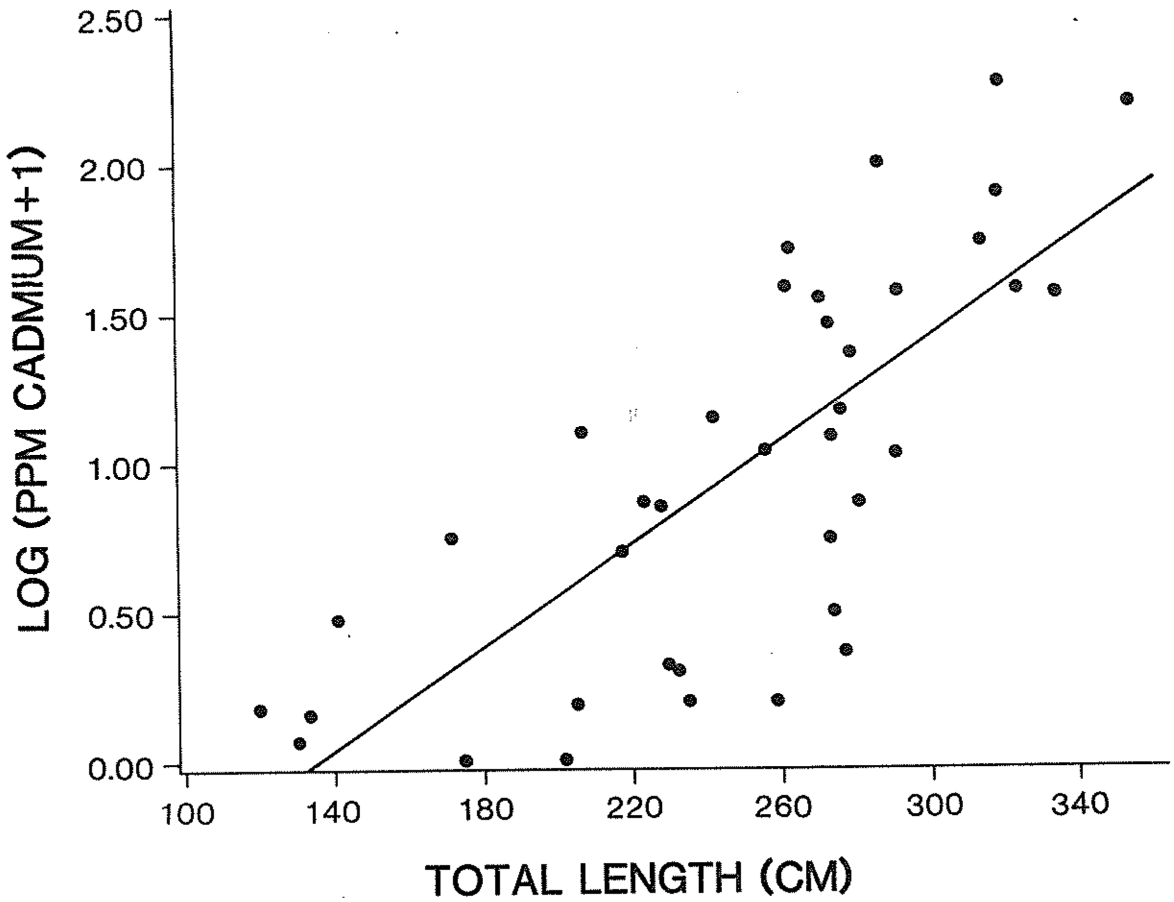

Figure 2. Cadmium concentrations (ppm dry weight) in manatee kidneys in relation to total length. The line is described by the regression equation $\log_{10}(Y + 1) = -1.17 + 0.0086X$ ($r = 0.76$, $P < 0.0001$).

DISCUSSION

Our data indicate that West Indian manatees accumulate copper in livers in areas where high amounts of copper-based aquatic herbicides are used. We have had no field reports suggestive of copper poisoning in these areas, and autolysis has prevented meaningful histopathological examination of specimens from the most heavily contaminated individuals. Interpretation of residue concentrations in tissues of manatees is difficult lacking such information and in the absence of diagnostic laboratory toxicity studies, which would be impractical and undesirable to undertake. In order to evaluate the potential seriousness of copper contamination of manatees and its management implications we alternatively rely on the literature. We compare the liver copper status of manatees with other wild mammals. We also examine the possible degree of dietary exposure to copper following herbicide application in relation to results of feeding experiments with domestic mammals, and compare concentrations of copper in manatee livers with those in livers of other mammals where harmful effects have been noted.

Copper concentrations in liver tissue have been reported for at least 35 other species of wild mammals, representing 8 orders (Table 2). With few exceptions, copper concentrations generally show narrower ranges and relatively low variation in comparison with our findings, and maxima are well below those of manatees in Florida. Results of ANCOVA show that sex had no effect on the wide variation seen in our study (this is in accord with most studies of vertebrates; Underwood 1977:58), and body size (relative age) showed only a weak negative correlation with copper concentration (a

Table 2. Copper concentrations in livers of wild mammals from free-ranging populations in areas without known significant exposure to anthropogenic sources of copper. Values listed are in ppm dry weight except where noted.

Groups and species	$\bar{X}$	SD	Range	N	Source
Marsupials					
Bettongia penicillata	27.0		21-33	2	Beck 1956
Macropus agilis	17.0	0.4	14-21	35	Beck 1956
M. giganteus	19.3	0.7	15-26	17	Beck 1956
M. irma	19.0			1	Beck 1956
M. robustus	14.2	0.6	13-17	9	Beck 1956
M. rufus	14.2	0.6	13-17	13	Beck 1956
Petrogale sp.	23.0			1	Beck 1956
Setonyx brachyurus	13.1	0.7	8-18	20	Beck 1956
Thylogale sp.	18.5		15-22	2	Beck 1956
Lagomorphs					
Lepus capensis	15.0			10	Wójcik 1980
Oryctolagus cuniculus	15.8	0.6	14-19	7	Beck 1956
Rodents					
Apodemus sylvatious[a]	6.8	5.7	2.6-18.1	6	Jefferies and French 1976
Clethrionomys glareolus[a]	5.3			1	Jefferies and French 1976
Microtus agrestis			8-33	9	Beardsley et al. 1978
M. pennsylvanicus[a]	5.0			48	Anderson et al. 1982
Ondatra zibethicus	11.7			30	Radvanyi and Shaw 1981
Peromyscus maniculatus	46.3	93.3	18-622	45	Stelter 1980

Table 2. (Continued)

Group and species	$\bar{X}$	SD	Range	N	Source
Cetaceans					
Delphinapterus leucas[a]	20.4			1	Harms et al. 1978
Globicephala macrorhynchus	21.0			1	Denton et al. 1980
Hyperoodon ampullatus[a]	2.8			1	Harms et al. 1978
Lagenorhynchus albirostris[a]	6.4			1	Andersen and Rebsdorff 1976
Megaptera novaeangliae	21.0	0.9	12-38	37	Beck 1956
Phocoena phocoena[a]	4.5		2.6-8.3	4	Andersen and Rebsdorff 1976
P. phocoena[a]	8.3	6.0	4-15	3	Harms et al. 1978
Carnivores					
Vulpes vulpes	32.0		23-44	3	Beck 1956
Pinnipeds					
Halichoerus grypus[a]	25.8		6-48	10	Holden 1975
Hydrurga leptonyx	95.0		84-105	2	Beck 1956
Leptonychotes weddelli	38.0		24-46	3	Beck 1956
L. weddelli	17.0			1	Denton et al. 1980
Mirounga leonina	66.0	6.0	34-90	10	Beck 1956
Phoca hispida[a]	2.1			1	Harms et al. 1978
P. vitulina[a]			2-20	8	Duinker et al. 1979
P. vitulina[a]			2.6-17	70	Harms et al. 1978
P. vitulina[a]	13.7		9-23	9	Holden 1975
Sirenians					
Dugong dugon			9.1-608	42	Denton et al. 1980
Trichechus manatus	175	255	4.1-1,200	54	This study

Table 2. (Continued)

Group and species	$\bar{X}$	SD	Range	N	Source
Artiodactyls					
Antilocapra americana	26.9	12.8		20	Munshower and Neuman 1979
Cervus elaphus	36.1	40.8	3.0-209	37	Cowie 1976
C. elaphus[b]	132			83	Reid et al. 1980
Odocoileus hemonius	46.3	29.1		29	Munshower and Neuman 1979
O. hemonius	73.4	47.3	19-227	18	Stelter 1980
O. virginianus	109	69		190	Woolf et al. 1982

[a] Concentrations expressed on a wet weight basis; liver tissue is typically 70 to 80% water.

[b] Back transformed mean of natural logarithm of copper concentration.

marked age difference is seen in most mammals studied; Underwood 1977:58-59). An excessive or deficient intake of iron may also influence liver copper levels, resulting in an inverse relationship between concentrations of the two elements (Kirchgessner et al. 1979), but our study did not reveal such an association in manatees; interactions with other elements were not investigated. Our results suggest instead that differences in individual exposure to excessive dietary copper and a poor ability to maintain copper homeostasis have resulted in the wide variation and unusually high concentrations of copper in livers of manatees in Florida.

Beck (1956) has hypothesized that copper concentrations in livers of vertebrates become excessive only in species with an inherent inability to regulate copper storage, and this is generally accepted to be the case given a balance of other critical elements such as iron, zinc, and molybdenum (Venugopal and Luckey 1978:27-28). The most marine of the sirenians, the dugong (Dugong dugon), also shows a wide range of liver copper concentrations (Denton et al. 1980), although the highest value found is half of the highest (1,200 ppm) found in Florida manatees (Table 2). Unlike manatees, dugongs of coastal Australia possess high concentrations of iron in livers (to 82,000 ppm), and are considered to be facing an opposite problem of possible copper deficiency due to a natural diet of seagrasses excessively high in iron and low in copper, as well as due to possible interactions with other trace elements in the diet (Denton et al. 1980). Copper concentrations of aquatic plants in comparison with terrestrial species are in general slightly lower and iron much higher (Denton et al. 1980). Extending the findings of Denton et al. (1980) regarding reduced availability of copper in the natural diet to other sirenians suggests that selection pressure for regulating upper limits of copper storage in livers of manatees may be relaxed, and that manatees may be inefficient at maintaining copper homeostasis in the face of dietary excess. This could lead to toxic effects. Oke (1967), for example, attributed the death of a captive dugong to exposure to copper sulfate added to its tank as an algicide, but did not substantiate this claim with toxicological or pathological evidence.

The amount of copper in the diet required to overload the storage ability of the liver and subsequently produce toxic effects has been determined for a number of domestic and laboratory mammals, as have been associated liver copper loads. Diets of 10-15 ppm copper over periods of exposure ranging from a few weeks to several months cause severe toxic effects and death in domestic sheep (Venugopal and Luckey 1978:29). Biochemical evidence of liver damage in sheep is associated with an accumulation of 500 ppm or more copper in livers (Thompson and Todd 1970) and death generally occurs at liver copper concentrations of 2,500 ppm or more (Gopinath and Howell 1975). Liver copper concentrations as low as 500 ppm have been associated with death of sheep in some cases (Sivertsen et al. 1978). White rats fed 250 ppm copper for 8 weeks had 163 ppm in liver and showed minor toxicological effects (Elliot and Bowland 1972). Calves of domestic cows developed jaundice and the subsequent hemolytic crisis after 20 weeks exposure at dietary concentrations of 20 to 125 ppm (Venugopal and Luckey 1978:29), and death occurred at 12 weeks on a diet of 115 ppm copper in milk substitute, with liver copper concentrations of 1,400 ppm or more (Shand and Lewis 1957). Adult cattle killed by chronic copper poisoning had minimum concentrations of 1,250 ppm in livers (Stogdale 1978). Harmful effects have been reported in pigs following exposure to concentrations as low as 130 ppm (Buntain 1961), with concentrations in livers as low as 330 ppm reported in pigs with chronic copper poisoning (Hatch et al. 1979). Female mink fed copper at 100 ppm for approximately 10 months showed increased kit mortality and decreased body weights of kits by 4 weeks of age (Aulerich et al. 1982). Ponies, in contrast, are the least sensitive domestic mammals studied, with no harmful effects after six months at 791 ppm and liver copper concentrations averaging up to 3,870 ppm (Smith et al. 1975). The liver copper loads associated with harmful effects in most of these feeding studies were comparable to those found in some Florida manatees.

Manatees may be exposed to excessive herbicidal copper under certain conditions. Following treatment for weed control, copper occurs in aquatic plants at concentrations in excess of levels capable of producing toxic effects in mammals as exemplified by the studies cited above. Laboratory and field studies have measured up to 5,000 ppm copper for 2-3 weeks prior to plant death and disintegration in species commonly eaten by manatees in Florida, in most cases following application at rates recommended for weed control (Sutton et al. 1970, 1971; Sutton and Blackburn 1971; McIntosh 1975). Concentrations of hundreds of ppm can occur in plants surviving such exposure (Sutton and Blackburn 1971). Based on the knowledge that copper can reach toxic concentrations in aquatic plants following herbicide usage, the finding of unusually high liver copper loads in manatees from areas of high copper herbicide use, and the linking of comparable levels in livers and diets of domestic mammals to toxic effects, we recommend that the use of copper-based aquatic herbicides be carefully managed in areas used intensively by manatees.

With the exception of copper, our findings indicate that manatees are not excessively contaminated by the substances studied. Organochlorine pollutant concentrations are low, as previously reported in a sample of 1 manatee from Florida (Forrester et al. 1975). Low concentrations of organochlorines and mercury have been reported in 2 dugongs from Sulawesi Island (Miyazaki et al. 1979), and low mercury concentrations in 2 dugongs from Australia (Denton and Breck 1981). Studies completed thus far indicate that among all marine mammals the herbivorous sirenians are probably the least subject to organochlorine and mercury contamination, owing to their unique food habits and the well-known finding of decreased exposure to these substances at lower positions in food chains. Lead was present in each of the individuals sampled, but not at concentrations suggestive of harmful exposure (Buck et al. 1973:196). Cadmium concentrations in kidneys increased with relative age, a well-established finding for other mammals, but were not indicative of serious contamination.

The status of manatees in relation to many of the contaminants examined in the present study is not discouraging. The use of copper herbicides has a potential for harm, but given information on seasonal movement patterns and habitat use responsible agencies can conceive of application schemes wherein exposure can be minimized. Recent aquatic plant control efforts at Crystal River, for example, have focused on a more restricted use of herbicides and the use of alternative compounds during winter when manatees are most abundant. Future studies should continue to monitor the copper status of manatees in Florida, and detailed clinical observations should be made on moribund manatees found in areas of suspected copper contamination. The maintenance of a carcass salvage program should provide an alarm system in the event that future mortality occurs due to unforeseen environmental contaminants or as a result of a change in the level of exposure to the chemicals examined in the present study.

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A REVIEW OF THREE AQUATIC HERBICIDES IN RELATION TO THEIR POTENTIAL HAZARDS TO THE ENDANGERED WEST INDIAN MANATEE (*Trichechus manatus*)

Thomas J. O'Shea

Wildlife Biologist

U.S. Fish and Wildlife Service

Denver Wildlife Research Center
Gainesville, Florida

UNITED STATES GOVERNMENT

memorandum

DATE: 16 June 1983

REPLY TO ATTN OF: Biologist, Sirenia Project

SUBJECT: Review of herbicides included in Compendium for Crystal River Management Plan

TO: Jane M. Packard, Florida Cooperative Fish and Wildlife Research Unit

I am pleased that the subject manuscript may be of help in future management of manatees in northwestern Florida. There are no introductory comments on the manuscript to define its scope and purpose. As a result I have drafted this memo to accompany the review.

This review was written with no intent to evaluate all potential aquatic herbicides or to imply endorsement of any particular product. In 1978 I was employed as a research zoologist in the Environmental Contaminant Evaluation (ECE) program at Patuxent Wildlife Research Center. At that time the Sirenia Project leader informally asked for my evaluation of the three aquatic herbicides used most heavily at Crystal River in relation to their potential hazards to manatees. The subject document was prepared as an informal report.

In that report I tried to evaluate the herbicides on a few key points: residue concentrations reached in aquatic plants, duration of exposure to contaminated plants by feeding manatees before plant death, concentrations shown to produce toxic effects in mammalian feeding studies, and potential for diagnostic residue concentrations to be found in manatee tissues.

The situation at Kings Bay was and is unique: large numbers of manatees dependent on an intentionally chemically treated supply of aquatic plants as food during a long and critical phase of their annual cycle. To my knowledge label precautions do not consider concentrations reached in aquatic plants, or consider aquatic plants as livestock forage. Restrictions for feeding of livestock, drinking, watering and swimming found on herbicide labels, on the other hand, were not discussed in the subject review.

For future consideration I suggest that as new chemicals are proposed as weed control agents in important manatee habitats Service ECE specialists consider the specific points noted above and in the subject review <u>as well as</u> label precautions.

Thomas J. O'Shea

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OPTIONAL FORM NO. 10
(REV. 7-76)
GSA FPMR (41 CFR) 101-11.6
5010-112

B. Land acquisition (Section 5)
C. Cooperation with the states (Section 6)
D. Interagency cooperation and review (Section 7)

The general law for the identification and protection of endangered and threatened species and their habitat.

Regulations: 50 C.F.R. §§14.13; 14.18; 17 (Subparts A,B,C,D,I,J); 17.95(a); 17.100-108; 18.3; 23 (Subparts A,C); 81; 217-222; 225; 424; 450(1982)

D. ENVIRONMENTAL PESTICIDE CONTROL ACT (7 U.S.C. §§136-136w-4(1979)

Contains the provisions for control and distribution of pesticides and herbicides and certification of applicators.

Regulations: 40 C.F.R. §§162-164; 167; 171-172; 173(1982)

E. FISH AND WILDLIFE COORDINATION ACT (16 U.S.C. §§661-667(1978))

Provides for protection of fish and wildlife within the governmental permitting systems as well as acquisition of important lands to protect specific resources.

Regulations: 43 C.F.R. §24(1982); 50 C.F.R. §§25-33; 70; 71

F. LAND AND WATER CONSERVATION FUND (16 U.S.C. §§460d-460l-5(1982)

The major land acquisition statute. Provides for purchase of lands to protect endangered species and is fed by other acts giving similar authority. Includes numerous statutes authorizing land acquisition.

Regulations: 50 C.F.R. §36(1982); 36 C.F.R. §327(1982)

G. MARINE MAMMAL PROTECTION ACT OF 1972 (16 U.S.C. §§1361-1384(1972) (Pub.L.No.92-522)

A. Restrictions on taking (Section 101)
B. Regulations on taking (Section 103)
C. Permits (Section 104)
D. Enforcement (Section 107)
E. Cooperation with states (Section 109)
F. Establishment of the Marine Mammal Commission (Section 201)

Creates the Marine Mammal Commission and gives general authority over research, capture, licensing and some other implied protection for marine mammals.

Regulations: 50 C.F.R. §18; 216(1982)

H. MARINE PROTECTION, RESEARCH AND SANCTUARIES ACT OF 1972 (16 U.S.C. §§1431-1434(1972))

Provides, among other things, for establishment and acquisition of marine sanctuaries along the coast of the United States including measures for protection, once established.

Regulations: 15 C.F.R. §§24,29,922(1982); 33 C.F.R. §§320-327 (1982); 40 C.F.R. §§220-225,227-229(1982); 50 C.F.R. §§12-14,17,18,82,216,219(1982)

I. MIGRATORY WATERFOWL ACT (16 U.S.C. §§715-718d, et seq.)

Various enactments since the turn of the century that provide for the purchase of wetlands for the purpose of protecting wildlife. Acquisition is directed toward waterfowl habitat.

J. NATIONAL ENVIRONMENTAL POLICY ACT OF 1969 (42 U.S.C. §§4321-4332(1969))

Requires that prior to any major federal action which significantly effects the quality of the human environment an environmental impact statement be prepared.

Regulations: 40 C.F.R. §§1500-1508(1982)

K. NATIONAL FLOOD INSURANCE ACT (42 U.S.C. §4001(1973))

Establishes the National Flood Insurance Program which includes restrictions on insurance for certain barrier islands.

Regulations: 12 C.F.R. §339; 40 C.F.R. §60(1982)

L. NATIONAL WILD AND SCENIC RIVERS ACT (16 U.S.C. §§1271-1287, et seq.)

Allows for designation and purchase of lands adjacent to special wild and scenic rivers throughout the country.

Regulations: 43 C.F.R. §§8000,8350(1982); 50 C.F.R. §251 (1982)

M. NATIONAL WILDERNESS PRESERVATION ACT (16 U.S.C. §§1131-1136, et seq.)

Permits federal lands to be placed in a category which protects them from man's activities. Applies to lands in excess of 5,000 acres and special lands.

Regulations: 36 C.F.R. §§251-261; 43 C.F.R. §§19,3500,3510,3520; 50 C.F.R. §35(1982)

N. NATIONAL WILDLIFE REFUGE ACT (16 U.S.C §668dd-ee(1978)

Provides for the management of the national wildlife refuge system and includes authority for land purchases.

Aqua-k (endothall)

Under aerobic conditions endothall residues disappear from aquatic systems fairly rapidly. Sikka and Rice (1973) applied the compound to a New York pond at 2 ppm and monitored residues at a level of sensitivity of .01 ppm. Endothall was undetectable in water at 36 days and in sediments at 44 days. Disappearance is due to microbial degradation (Sikka and Saxena, 1973).

Endothall concentrations following application reach levels 12 times higher in plant tissues than those in water (Thomas, 1968). At external concentrations of .1 and 5.0 ppm Potamogeton and Elodea tissues reached levels of 10 and 20 ppm (Thomas, 1968). Complete death of aquatic plants occurs in about eight days (Yeo, 1970). Endothall is metabolized in plant tissues (Thomas, 1968; Freed et al., 1961).

Mammalian toxicity data are limited. The acute oral LD50 for rats is 38 mg/kg (WSSA, 1974), a very low amount for an organic herbicide. However, chronic toxicity is slight. Keckemet (1969) reported no harmful effects in dogs fed disodium endothall at 1000 ppm for four months. Lindaberry (1961) cites unpublished data which show that survival and weights of rats were unaffected during a two year exposure to dietary concentrations of 100, 300 and 1,000 ppm.

Endothall is rapidly excreted. Rats given an oral dose of 5 mg/kg eliminated from 95 to 99 per cent of the administered dose within two days (Soo et al., 1967). By 72 hours post-exposure endothall had completely disappeared from all tissues. The compound was not observed in fat or in the milk of lactating females (Soo et al., 1967).

There are no indications that endothall would jeopardize manatees when used for aquatic weed control at recommended rates (1.0-5.0 ppm). It is not persistent in the aquatic environment and it is degraded in sediments. It would be available to manatees in food plants for several days, but at concentrations far below those which produce harmful effects in laboratory animals. Endothall should be rapidly excreted by manatees and residues should not accumulate in their tissues.

Diquat

Diquat rapidly dissipates from water following application for aquatic weed control. Only trace levels have been detected 12 days after treatments at concentrations ranging from .1 to 2.5 ppm (Grzenda et al., 1966; Yeo, 1967). Loss from the water column is not due to degradation, however, but to adsorption by sediments (Simsiman and Chesters, 1975) and plants (Davies and Seaman, 1968; Newman and Way, 1966). Susceptible aquatic macrophytes die at about four days following treatment (Newman and Way, 1966). At the time of death maximum accumulations of 25 ppm have been noted in plant tissues, a concentration 50 times that of the surrounding water (Newman and Way, 1966). Diquat is not metabolized by plants.

Diquat from decomposing plants or water is tightly adsorbed by sediments and is unavailable for microbial degradation (Simsiman and Chesters, 1975). This results in comparatively long persistence. Newman and Way (1966) found 36 percent of the unchanged herbicide in the top two meters of sediments 5 1/2 months after application, and Beasley (1966; cited in Simsiman et al., 1976) has reported persistence of diquat in sediments for as long as four years. Persistence in the system alone should not, however, pose any threat to manatees: diquat is not available in the adsorbed form, and in addition the chemical is not translocated in aquatic plants (Funderburk and Lawrence, 1963). Movements from roots to leafy parts would not occur even in the absence of sediment adsorbtion.

The toxicity of diquat to mammals varies with species. Overall, however, diquat is one of the most lethal of the organic herbicides. Acute oral LD50 values (mg chemical/kg body weight) for rats, dogs, mice and cattle are 400, 200, 170 and 30, respectively (Howe and Wright, 1965). In studies of chronic toxicity, rats fed 250 ppm for eight weeks showed no ill effects (Litchfield et al., 1973). Dogs fed 70 ppm for three years were not affected, although cataracts were produced at greater dosages (unpublished data cited by Howe and Wright, 1965). Cataracts were also produced in rats during lifespan experiments at doses greater than 7.5 ppm (unpublished data cited by Howe and Wright, 1965). Sheep and cattle exposed to 20 ppm in drinking water for one month were unaffected (Howe and Wright, 1965). Bus et al. (1975) gave pregnant rats direct intravenous injections of diquat at 15 mg/kg and found no teratogenesis, although 57% of the embryos died or were resorbed. Pathological symptoms are such that at high doses diquat affects the gastrointestinal tract and conjunctivae (Kay, 1973). Respiratory and nervous symptoms are apparently also shown in cattle (Howe and Wright, 1965).

Residues of diquat do not accumulate in tissues of mammals. Litchfield et al. (1973) fed rats diquat at 250 ppm for eight weeks. Highest residues found were 1.2 ppm in kidneys and .2 ppm in lungs. All other tissues contained less than .1 ppm. After one week on a normal diet diquat was no longer detectable (Litchfield et al., 1973). Stevens and Walley (1966) dosed the calf of a domestic cow at 10 mg/kg (one-third the LD50) and at

24 hours could detect just .03 ppm unchanged herbicide in kidneys and less than .01 ppm in liver and muscle. The total amount of combined diquat and unknown metabolites in these tissues were .7, .2 and .01 ppm, respectively. Adult cows excreted less than .02 percent of the administered dose through lactation (Stevens and Walley, 1966). Apparently diquat is broken down through microbial action in the gut (Simsiman et al., 1976) and is rapidly excreted (Litchfield et al., 1973).

In summary, diquat is persistent in aquatic ecosystems because adsorption renders it inaccessible to microbial degradation. Although persistent, it would not be available to manatees in food except at the time of application. Diquat on plants would then be available for just a few days prior to plant death. Concentrations under these circumstances do not appear to approach levels toxic to other animals, given normal application rates of 2.5 ppm or less. Plant tissues disintegrate long before chronic effects would be produced in laboratory animals. Ingested diquat is excreted or broken down rapidly; residues should not be detectable in manatee tissues.

Komeen (copper salts)

Copper, being a natural element, persists in aquatic ecosystems. There is no evidence, however, that copper is biomagnified. Copper rapidly precipitates from the water column, particularly in the high carbonate waters (NAS, 1977) typical of some manatee wintering areas. Copper is also adsorbed in sediments. However, significant positive correlations have been found between copper in sediments and in roots of some aquatic macrophytes (Hutchinson, et al. 1975). Due to its high toxicity to fish and aquatic invertebrates, copper is usually applied for control of water weeds at concentrations of 1.0 ppm or less. Kills can occur even at these levels (NAS, 1977).

Aquatic vegetation takes up very high amounts of copper during weed control operations. In experiments with hydrilla (Hydrilla verticillata), a plant sometimes eaten by manatees, tissues contained 4,400 ppm after immersion in water at 1.0 ppm for eight days (Sutton et al., 1970). At this time plants had not lost integrity and weights were identical to controls, although some injury was apparently visible (Sutton et al., 1970). In the same study copper sulfate was applied at 1.0 ppm to pools containing pond water, hydrosoil and experimental populations of hydrilla and southern naiad (Najas guadalupensis). By three days copper concentrations in hydrilla reached 3,000 ppm; levels of 1,200 ppm were present in plants at 21 days after treatment. Southern naiad contained 1,300 ppm at three days and 1,050 ppm by 21 days (Sutton et al., 1970). After three weeks at these levels the plants presumably retained much of their integrity.

Some aquatic plants are not susceptible to simple applications of copper but nevertheless accumulate residues in tissues. This is true of parrotfeather (Myriophyllum brasiliense), a manatee food plant. Two weeks after treatment at concentrations ranging from .25 to 1.00 ppm root tissues contained from 70-170 ppm, with no effect on the condition of the plant (Sutton and Blackburn, 1971). Hydrilla is also resistant to applications of copper. Sutton et al. (1971) report that after a two week exposure at 1.0 ppm this species showed no evidence of harmful effects, despite whole plant residues of 980 ppm. Plant concentrations averaged 360 ppm after a two week exposure at .5 ppm.

Copper and diquat are usually applied simultaneously because diquat enhances the uptake and toxicity of copper in resistant plants (Sutton et al., 1970). Copper residues in hydrilla averaged 5,300 ppm 8 days following application of 1.0 ppm copper and .1 ppm diquat. Concentrations over 6,000 ppm occurred at 1.5 ppm diquat and 1.0 ppm copper (Sutton et al., 1970).

In mammals the toxicity of copper varies with species. In cases of poisoning due to chronic dietary exposure, copper accumulates in livers, producing some damage but no overt signs of toxicity. At some point from a few weeks to a year following the initiation of exposure the storage or excretory capacity of the liver may be exceeded. In a matter of one to a few days following this point gross liver damage occurs, large amounts of copper are released into the bloodstream, hemolysis of erythrocytes takes place and death ensues (for reviews see Hill, 1977; Todd, 1969; Venugopal and Luckey, 1978). The latter events are termed the hemolytic crisis. Additional damage asrociated with chronic copper poisoning includes a number of biochemical lesions associated with liver and kidney damage (MacPherson and Hemingway, 1969; Thompson and Todd, 1970) and pathological changes in the brain (Doherty et al., 1969). The liver is the major organ of accumulation of copper residues.

The degree of exposure required to produce the acute phase of the syndrome in mammals varies with species. Sheep, which are especially sensitive, wil undergo the hemolytic crisis after exposures varying from a few weeks to several months on diets containing only 10-15 ppm copper (Venugopal and Luckey, 1978 and references therein). At the time of death liver copper levels reach an average of 2,500 ppm dry weight, in comparison with control values of about 125 ppm (Gopinath and Howell, 1975). Thompson and Todd (1970) indicate that passive accumulation of up to 500 ppm (dry weight) liver copper can occur in sheep before biochemical evidence of liver damage is detectable. They also state that normal liver levels are about 50 ppm.

Other species of mammals are less sensitive to copper than sheep. Calves of domestic cows develop jaundice and the subsequent hemolytic crisis after about 20 weeks exposure at 20 to 125 ppm (Venugopal and Luckey, 1978). Harmful effects occur in pigs following exposure to dietary levels of 500-750 ppm copper (Venugopal and Luckey, 1978; duration of exposure unspecified), or as low as 250 ppm for seven weeks in the face of dietary imbalances of other nutrients (Gipp et al., 1974). Liver levels in the latter study were 6,080 ppm at seven weeks. Suttle and Mills (1966) added 750 ppm copper to the diet of pigs and observed severe toxic effects at four weeks, although the animals subsequently recovered. Smith et al. (1975) found no harmful effects in ponies fed up to 790 ppm copper for six months, when liver concentrations at the high dosage averaged 3,870 ppm dry weight. White rats accumulate less copper in liver than other species. Animals fed 250 ppm for eight weeks had 163 ppm in liver, and also showed reduced weight gains and food conversion (Elliot and Bowland, 1972). Dogs are much more susceptible to injections of copper than rats, and have much higher natural concentrations in the liver (Goresky, et al., 1968). Feeding studies have not been conducted on dogs.

It is possible for manatees to be exposed to harmful levels of copper in localized areas as a result of application for aquatic weed control. The sensitivity of manatees to copper is a matter for conjecture: they could be as susceptible as sheep or as tolerant as ponies. Nevertheless, laboratory experiments have shown that copper concentrations reach thousands of parts per million in manatee food plants for weeks prior to plant death. Some aquatic macrophytes are not susceptible to copper, yet accumulate residues of hundreds of parts per million in tissues. These would be available to foraging manatees. Even susceptible plant species would probably show elevated but non-lethal residues at the fringes of treated areas, although a demonstration of this has not been attempted. Finally, there is a potential for elevated copper in new, untreated growths of plants as copper residues increase in sediments.

This information indicates that copper residues in manatee food plants reach levels which are toxic to some other species of mammals, and that these concentrations are available for comparatively lengthy periods of time. Repeated applications during winter months also prolong the potential for chronic exposure. Although inferences from the literature do not constitute proof of harm to manatees, it is prudent to suggest that less toxic and less persistent alternative herbicides be used for control of aquatic weeds in areas of high manatee population density.

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ANNOTATED LIST OF LAWS AND REGULATIONS RELEVANT TO PROTECTION OF WEST INDIAN MANATEES AND THEIR HABITAT

David Gluckman, Esq. and Richard Hamann, Esq.

This list presents the relevant laws and regulations on the federal, state, regional and local levels in alphabetical order by area of jurisdiction. The major acts are listed separately though some may be sections of chapters which contain numerous different provisions. Conversely, those sections of acts which are commonly referred to as portions of a major act are included as a part of that act. Unfamiliar citations are explained in the glossary.

I. FEDERAL LAWS AND REGULATIONS

A. CLEAN WATER ACT OF 1977, 33 U.S.C.§1251(1977)
(Pub. L. 92-500, Pub.L. 95-217)

A. Sewage grants (Section 201)
B. Nonpoint runoff (Sections 208 - 303(3)
C. Effluent limitations (Section 301)
D. Oil or hazardous substance discharge into coastal waters (Section 311)
E. Marine sanitation devices (Section 312)
F. Thermal discharges (Section 316)
G. National Pollution Discharge Elimination System (Section 402) 40 C.F.R. §§112-125(1983)
H. Dredge and fill (Section 404) 33 C.F.R.§209.320(1983) 40 C.F.R.§230(1982), 33 C.F.R.§320(1982)

The general Federal water pollution control statute. Contains most of the restrictions on discharges of pollutants into the waters of the United States and dredging and filling of submerged lands and wetlands. Administered by the Environmental Protection Agency with assistance of the Corps of Engineers and the Coast Guard.

Regulations: 40 C.F.R §§133,221,230,231,320,323,325-327,401,409, 413(1982)

B. COASTAL ZONE MANAGEMENT ACT OF 1972 (16 U.S.C, §§1451-1464(1972))

This act is designed to help states cope with the problems of a developing coastal zone. It contains grant programs for planning and land purchase.

Regulations: 15 C.F.R. §§920,921,923,925,926-928,930(1982)

C. ENDANGERED SPECIES ACT OF 1973 (16 U.S.C. §§1531-1543(1973))
(Pub.L. No. 93-205)

A. Listing of species and designation of critical habitat (Section 4)

Regulations: 43 C.F.R. §17; 50 C.F.R. §§26,36(1982)

O. RIVER AND HARBOR ACT OF 1899 (33 U.S.C. §401, et seq.)

The earliest pollution control act though it was originally passed to protect navigable waters for navigation purposes.

Regulations: 32 C.F.R. §300(1982)

II. FLORIDA CONSTITUTION OF 1968 (as revised,1979)

A. HOME RULE FOR CITIES AND COUNTIES (Article VIII, Sections 1,2)

Permits counties and cities to pass their own laws. This power is limited only by those powers reserved to the state.

B. GAME AND FRESHWATER FISH COMMISSION (Article IV, Section 9)

Establishes the Game and Freshwater Fish Commission and its authority over freshwater fish and wildlife within the state.

C. NATURAL RESOURCES PROTECTION (Article II, Section 7)

Sets out the public policy of the state to "conserve and protect its natural resources...."

D. SOVEREIGNTY SUBMERGED LANDS (Article X, Section 11)

Establishes the public trust doctrine for the ownership of state lands.

III. FLORIDA STATUTES

A. ADMINISTRATIVE PROCEDURES ACT (Fla.Stat. Ch.120(1981))

Sets out the procedures for agency rulemaking and challenges to agency actions. The act is administered by the Department of Administration and the Division of Administrative Hearings (DOAH).

Rules: 9 Fla. Admin. Code 28

B. AIR AND WATER POLLUTION CONTROL ACT (Fla.Stat. Ch.403(1981))

A. Water Quality Standards (Fla.Stat. §403.061(1981))

Rules: 7 Fla. Admin. Code 17-3, 17-4(1982)

B. Sewage Disposal (Fla.Stat. §403.086(1981))

Rules: 7 Fla. Admin. Code 17-6(1982)

C. Permits (Fla. Stat. §§403.087, 403.088(1981))

Rules: 7 Fla. Admin. Code 17-4(1982)

D. Water Pollution Control (Fla. Stat. §§403.1821-403.1833 (1981))

Rules: 7 Fla. Admin. Code 17-3, 17-4(1982)

E. Power Plant Siting (Fla. Stat.§§403.51-403.539(1981))

Rules: 7 Fla. Admin. Code 17-17(1982)

F. Hazardous Waste Act (Fla. Stat. §§403.723-729(1981))

Rules: 7 Fla. Admin. Code 17-7 (1982)

The general pollution control statute for the state. It is under the jurisdiction of the Department of Environmental Regulation and deals with all aspects of dredge and fill and water quality control.

Rules: 7 Fla. Admin. Code 17-3,17-4,17-6,17-17,17-22, 17-23,17-24,17-25(1982)

C. AQUATIC PLANT IMPORTATION (Fla.Stat. §403.271(1981))

Provides for control of the importation of aquatic weeds. The program is administered by the Department of Natural Resources.

Rules: 7 Fla. Admin. Code 16C-19 (1982)

D. AQUATIC PRESERVE ACT of 1975 (Fla.Stat. §§258.35-258.46(1981))

Gives special protection to state submerged lands which have been designated as aquatic preserves by the legislature. It prohibits activities such as mining, that are destructive to fish and wildlife values. The program is administered by the Department of Natural Resources.

Rules: 7 Fla. Admin. Code 16Q-20(1982)

E. AQUATIC WEED CONTROL ACT (Fla.Stat. §372.925(1981)

Divides the aquatic weed control program between the Department of Natural Resources and the Game and Freshwater

Fish Commission. The Department of Natural Resources permits application of chemicals while the Game and Freshwater Fish Commission is responsible for biological controls.

Rules: 7 Fla. Admin. Code 16C-20(1982)

F. BEACH AND SHORE PRESERVATION ACT (Fla.Stat. §§161.011-161.212(1981))

Provides some protection for beaches and shore areas throughout the state and is administered by the Department of Natural Resources.

Rules: 7 Fla. Admin. Code 16B-23,24.041,25,26,33(1982)

G. BOAT REGISTRATION AND SAFETY LAW (Fla.Stat. §§327.01-327.72(1981)

Contains the safety and registration requirements powers of the Florida Marine Patrol in the Department of Natural Resources and Wildlife Officers of the Game and Freshwater Fish Commission.

H. COASTAL MANAGEMENT ACT OF 1978 (Fla.Stat. §§380.19-380.25(1981)

Contains Florida's Coastal Zone Management authority (along with Section 380.22, F.S.). Provides a conduit for federal funding in the Department of Environmental Regulation.

Rules: 7 Fla. Admin. Code 17-24 (1982)

I. COMPREHENSIVE PLANNING ACT OF 1972 (Fla.Stat. §§23.011-23.0191(1981))

Contains the requirements for the state comprehensive plan and planning process including the ten year site plan for public utilities.

Rules: 8 Fla. Admin. Code 22-8(1982); 9 Fla. Admin. Code 27E,27F(1982)

J. CONSERVATION AND RECREATION LANDS TRUST FUND (Fla.Stat. §§253.023-253.124(1981))

The major land purchase act for state land purchases for environmentally endangered and recreational lands (CARL). The program is administered by the Department of Natural Resources with the help of an interagency advisory committee.

Rules: 7 Fla. Admin. Code 16Q-2(1982)

K. ENDANGERED AND THREATENED SPECIES ACT OF 1977 (Fla. Stat. §372.072(1981))

Provides for protection of all endangered and threatened species including law enforcement responsibility and educational programs. Major responsibility is in the Game and Freshwater Fish Commission with additional law enforcement authority in the Department of Natural Resources.

Rules: 11 Fla. Admin. Code 39-3,39-4(1982)

L. GAME AND FRESHWATER FISH COMMISSION (Fla.Stat.Ch.372(1981))

The legislative authority for the GFFC. It contains law enforcement and regulatory powers of the commission along with other specific acts on endangered species and aquatic weed control.

Rules: 7 Fla. Admin. Code 16D,16E(1982); 11 Fla. Admin. Code 39(1982)

M. FLORIDA ENVIRONMENTAL EDUCATION ACT (Fla.Stat. §229.8055(1981))

Provides for the development and dissemination of information about the outdoor environment to public schools throughout the state. This act is administered by the Commissioner of Education.

Rules: 3 Fla. Admin. Code 6A-10.21(1982)

N. LAND CONSERVATION ACT OF 1972 (Fla. Stat.Ch. 259(1981))

The old environmentally endangered lands act which was partly superceded by the Conservation and Recreation Lands Trust Fund (Section 253.023, F.S.). It is administered by the Department of Natural Resources.

Rules: 7 Fla. Admin. Code 16D, 16Q (1982)

O. LAND SALES ACT (Fla. Stat. Ch. 498(1981))

Regulates the sales of subdivided lands in the state. It is administered by the Department of Business Regulations.

Rules: 4 Fla. Admin. Code 7D(1892)

P. LAND AND WATER MANAGEMENT ACT (Fla. Stat. §§380.012-380.10(1981)

1. Development of Regional Impact (Fla.Stat. §380.06(1981))

Requires an extensive planning and approval process by local government for large developments with the ability of the state to override for issues of regional or statewide impact. This program is administered by the Department of Community Affairs and the Regional Planning Councils.

Rules: 4 Fla. Admin. Code 9B(1892); 9 Fla. Admin. Code 27F-1 (Part II), 27F-2(1982)

2. Areas of Critical State Concern (Fla.Stat. §380.05(1981))

Permits the state to declare portions of the state as critical areas after a period of substantial study. The state may then apply development restrictions if local governments refuse to adequately control development. This program is administered by the Department of Community Affairs.

Rules: 9 Fla. Admin. Code 27F-3,27F-5,27F-8(1982)

Q. LOCAL GOVERNMENT COMPREHENSIVE PLANNING ACT OF 1975 (Fla. Stat. §§163.3161-163.3211(1981))

Requires all local governments to develop a comprehensive land plan for lands within their jurisdiction. All future development must conform to the plan. The Department of Community Affairs has oversight authority but few enforcement powers.

Rules: 4 Fla. Admin. Code 9B-4,9B-5(1982)

R. MANATEE SANCTUARY ACT OF 1978 (Fla.Stat. §370.12(2),(1981))

Establishes areas throughout the state (including the Crystal River area) that are sanctuaries for manatees. It provides for the posting of special speed limits for motor boats and makes it unlawful to molest or injure manatees.

Rules: 7 Fla. Admin. Code 16N-22(1982)

S. ARTHROPOD CONTROL ACT (Fla. Stat. Ch. 388(1981))

Establishes districts for control of arthropods. It also requires control activities on all state lands and provides for mosquito spray programs.

Rules: 5 Fla. Admin. Code 10D-54 (1982)

T. NONINDIGENOUS AQUATIC PLANT CONTROL ACT (Fla.Stat. §372.932(1981))

Gives the Department of Natural Resources the authority to set up a program for aquatic weed control.

Rules: 7 Fla. Admin. Code 16C-20(1982)

U. OUTDOOR RECREATION AND CONSERVATION ACT OF 1963 (Fla.Stat. §§375.011-375.315(1981))

An early land acquisition statute, permitting the Department of Natural Resources to acquire lands for conservation and recreation purposes.

Rules: 7 Fla. Admin. Code. 16D-5,16D-10,16D-11(1982)

V. STATE WILDERNESS ACT (Fla.Stat. §§258.17-258.332(1981))

Allows the Department of Natural Resources to purchase and accept lands for inclusion in the state wilderness system. These lands are protected from development and are restricted to wilderness compatible uses.

W. PESTICIDE APPLICATION ACT of 1974 (Fla.Stat. §§487.151-487.166(1981))

Requires permits for applying pesticides and herbicides. It is administered by the Department of Agriculture.

Rules: 3 Fla. Admin. Code 5E-9(1982)

X. POLLUTANT SPILL PREVENTION AND CONTROL ACT (Fla.Stat.Ch.376(1981))

Provides for cleaning up spills of oil and other hazardous wastes in coastal waters. It is administered by the Department of Natural Resources.

Rule: 7 Fla. Admin. Code 16N-16(1982)

Y. SAVE OUR RIVERS (Fla.Stat. §§201.15,373.59(1981))

This program, administered by the water management districts, provides for documentary stamp taxes to be deposited into the Water Management Lands Trust Fund to purchase river floodplains.

Rules: 7 Fla. Admin. Code 17-42(1982); 11 Fla.Admin. Code 40C-9, 40E-7(1982)

Z. INDIVIDUAL SEWAGE DISPOSAL SYSTEMS (Fla.Stat. §381.272(1981))

Requires the Department of Health and Rehabilitative Services to control the installation and use of septic tanks and small package plants.

Rules: 5 Fla. Admin. Code 10D-6(1982)

AA. SOVEREIGN STATE LAWS (Fla.Stat.Ch.253(1981))

Provides for protection and use of state owned submerged lands. The land management agency is the Trustees of the Internal Improvement Trust Fund which is staffed by the Division of State Lands of the Department of Natural Resources.

Rules: 7 Fla. Admin. Code 16Q-21(1982)

BB. SPEARFISHING REGULATION (Fla.Stat. §370.172(1981))

Allows the Department of Natural Resources to control spearfishing in oceans and the salt water areas of all tributaries.

Rules: 7 Fla. Admin. Code 16N-21.01(1982)

CC. STATE MARINE MAMMAL DESIGNATION (Fla.Stat. §15.038(1981))

Names the manatee as the state marine mammal.

DD. WATER RESOURCES ACT OF 1972 (Fla. Stat. Ch.373(1981))

Establishes the five water management districts in the state and provides for control of water quantity, flood control and some areas of water quality. The Department of Environmental Regulation has oversight authority.

Rule: 11 Fla. Admin. Code 40B,40C(1982); 7 Fla Admin. Code 17 (1982)

LEGAL REVIEW REGARDING CONSTRUCTION
OF MARINAS AND DOCKS AND DREDGE AND FILL
IN MANATEE HABITAT AND ADJACENT WETLANDS

Richard Hamann, Esq.

I. INTRODUCTION

Dredging, filling and construction in manatee habitat or in adjacent wetlands has several potential effects on manatees.[1] Where the purpose is to construct a marina or docks, the activity will increase the level of boat traffic and thus may increase the probability of collisions with manatees. The construction of marinas and docks can also displace aquatic and wetlands vegetation, degrade water quality, obstruct manatee pathways and otherwise interfere with the animals' essential habitat needs. The destruction of adjacent wetland vegetation tends to interfere with surface fresh water inflow and degrade water quality.

The Research and Management Plan for the Crystal River Subpopulation of Manatees (Manatee Management Plan) may provide for planning decisions in the following areas:

1. Number of boats. An upper limit on the number of boats that should be permitted to use Crystal River may be established.

2. Location of marinas and docks. If additional boat traffic is allowable, locations where additional marinas and docks should or should not be located may be specified or mapped. Such locations would be identified considering the likely routes of boat traffic that would be generated (compared with manatee traveling, feeding and aggregating areas) and the location of habitat that should not be disturbed (e.g. feeding, resting, breeding areas).

3. Performance standards for the design of docks and marinas. Marinas that are sited in good locations must also be properly designed and constructed to avoid adverse effects on the manatees. A set of performance standards for evaluating the design and construction of docks and marinas may also be developed. Performance standards may also apply to dock and marina siting if more specific direction is not available.

4. Wetland development restrictions. Performance standards for land use in adjacent wetlands may be developed but provide for the preservation of natural vegetation and surface water flows. Limitations on dredging, filling or clearing wetlands connected to the Crystal River are probably needed.

This section of the report will discuss alternative means by which the recommendations of the Manatee Management Plan can be implemented by local, state and federal agencies.

II. LOCAL PLANS AND REGULATIONS

Local governments in Florida have extensive powers, delegated by the state, to regulate private action as necessary to protect the public health, safety and general welfare.[2] Local governments in Florida have adopted a wide array of special zoning, subdivision regulations and permitting standards designed to protect the natural resources of the state.[3] Although regulation must be reasonably related to the attainment of some valid objective, the preservation of an endangered species such as the manatee would clearly be a valid objective. The general reasonableness and constitutional validity of regulation depends on the specific facts and circumstances at issue. The information in the Manatee Management Plan and the expertise of the wildlife management agencies would be of invaluable assistance to local governments seeking to uphold the validity of regulatory measures intended to protect the Crystal River manatee population.

Basic guidance for the exercise of local land use regulatory authority is provided by the Local Government Comprehensive Planning Act of 1975 (LGCPA) (Figure 1).[4] The LGCPA contains two essential mandates:

1. Every local government in Florida must adopt a local comprehensive plan (LCP) to guide the future growth and development of the community. The plan must contain specified elements and must be updated every five years.

2. Local land development regulations and land development permits must be consistent with the adopted plan.

The LCP must contain certain specified elements. These include elements detailing future land use, housing, utilities, transportation, recreation and conservation. All elements of the plan must be coordinated with each other and with the plans of neighboring local governments and the state. Two elements of particular significance to manatees are the conservation and coastal zone elements. The conservation element must provide for:

> the conservation, development, utilization, and protection of natural resources in the area, including, as the situation may be, air, water, estuarine marshes, soils, beaches, shores, flood plains, rivers, lakes, harbors, forests, fisheries and wildlife, minerals, and other natural and environmental resources.[5]

A coastal zone protection element is required that sets out policies for:

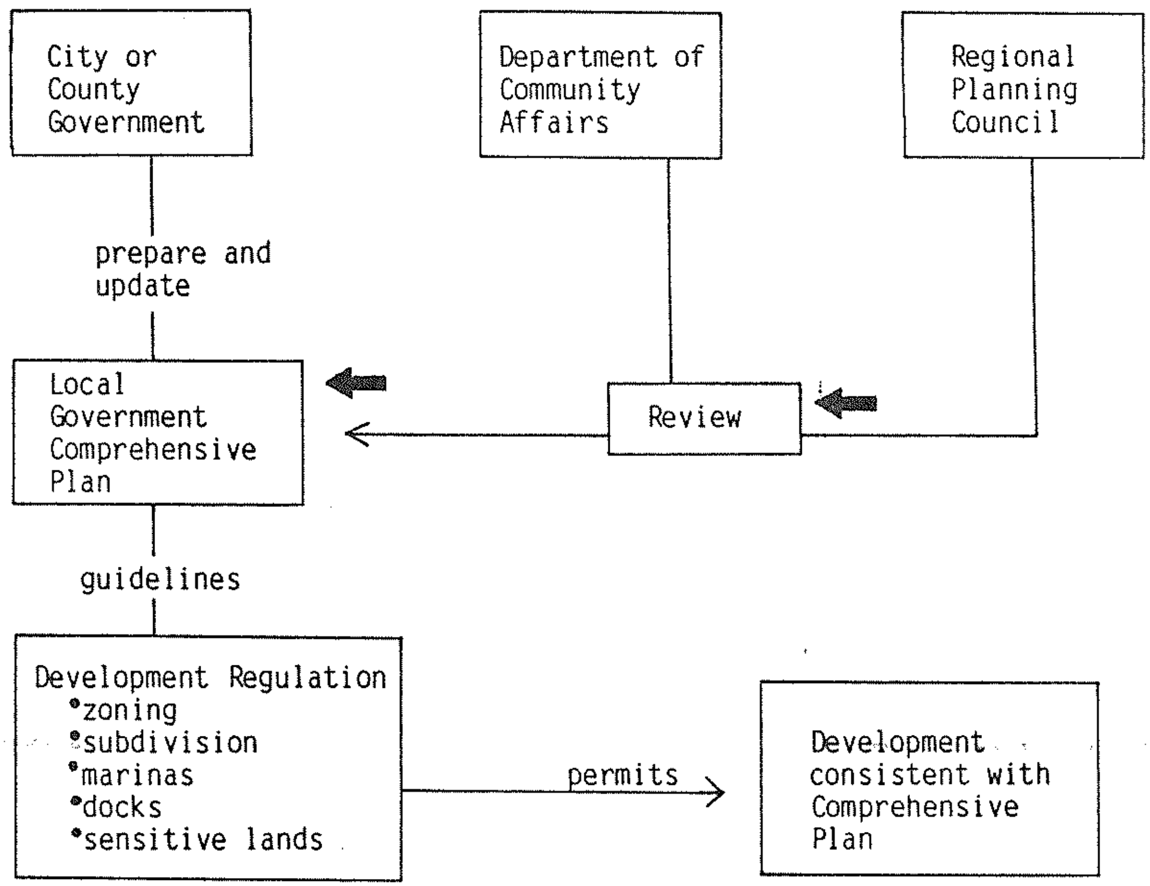

Figure 1. Process for setting development guidelines under the Local Government Comprehensive Planning Act. Heavy areas indicate steps where Manatee Management Plan could be used.

1. Maintenance, restoration, and enhancement of the overall quality of the coastal zone environment, including, but not limited to, its amenities and aesthetic values.
2. Continued existence of optimum populations of all species of wildlife.
3. The orderly and balanced utilization and preservation, consistent with sound conservation principles, of all living and nonliving coastal zone resources.
4. Avoidance of irreversible and irretrievable commitments of coastal zone resources.
5. Ecological planning principles and assumptions to be used in the determination of suitability and extent of permitted development.
6. Proposed management and regulatory techniques.[6]

The current local comprehensive plans of Citrus County[7] and the City of Crystal River[8] address the requirements of the LGCPA in an extremely vague and ambiguous manner.[9] The mandatory five year review of LCP's, however, provides local governments in the area an opportunity to improve their comprehensive planning. The recommendations of the management plan could be incorporated into the local comprehensive plans of Citrus County and Crystal River as part of that process. The LCP of Citrus County must be revised by July, 1984.

The plans should be made as specific as possible. Areas of aquatic or wetlands vegetation that should not be disturbed and areas where no docks should be constructed might be specifically mapped, for example. If immediate action is necessary, a moratorium on the construction of docks, marinas and other waterfront development could be imposed by local governments to maintain the status quo pending completion of the process for amending and implementing the plans.[10]

Local land development regulations could then be adopted to implement the plan. Existing regulations seem inadequate. The south shore of Crystal River and Dixie Bay are zoned by the county as General Commercial, General Agriculture, Single Family Residential and Single Family (Mobile Homes) Residential. The north shore is zoned Light Industrial, General Industrial, General Commercial and Single Family Residential.[11] Most of the city's waterfront is zoned Single Family, except for Multiple Family and various categories of commercial zoning along Kings Bay.[12] Both city and county zoning thus allow relatively high density residential, industrial and commercial development of the most sensitive wetlands adjacent to the Crystal River. Although approval by the Zoning Board of Adjustment is required for filling within the county's jurisdiction, there are no standards for denial or approval.

Citrus County currently allows small boat docks in residential areas as a permitted use,[13] i.e. no special approval or permit is necessary to construct boat docks that serve single family or duplex units. Similarly, marinas serving hotels, motels or similar uses where the docking and servicing of boats is incidental to the principal land use are not required to be specially permitted. Marinas are defined as businesses that store and service pleasure boats.[14] This type of marina is permitted in most districts as a special exception i.e., by approval of the Zoning Board of Adjustment.[15] However, as with filling, there are no standards for the Board of Adjustment to use in determining whether to allow a marina.[16]

This system could be improved in several respects. All docks and marinas, as well as dredging, filling or clearing of wetlands for other purposes, should be subject to permitting. General performance standards, based on the recommendations of the Manatee Management Plan, might govern the issuance of a permit.[17] For example, permits might be denied for developments that would disturb aquatic vegetation, obstruct manatee travel routes, generate excessive boat traffic, degrade water quality or alter the quantity or timing of surface runoff.

If sufficient information is available, very specific restrictions might be imposed on docks and marinas, instead of general standards. The number of docks and their size might be specified, for example. Docks might be prohibited in certain specified, mapped areas. Other sites might be designated for development as marinas and zoned for that use exclusively, provided additional marina development is warranted.

Specific restrictions might also be imposed on other types of development adjacent to Crystal River, particularly in connected wetlands. These lands could be rezoned to reduce allowable density and exclude inconsistent uses. The percentage of any site that could be altered (e.g. - 5%) might be specified. Construction in specified wetlands might be prohibited. Clustering of buildings in adjacent wetlands could be required, instead. Setbacks may also be used to preserve wetland vegetation.

The burden on private property owners of stringent land use restrictions may be mitigated somewhat by the use of transferrable development rights (TDR's).[18] TDR's have been used to protect historic buildings and preserve environmentally sensitive areas in jurisdictions throughout the country. The ownership of property includes many separable rights, like a bundle of sticks. One of those rights, i.e. one of the sticks--is the right of development. This right can be severed from a parcel of land--separated from the bundle--and used on another piece of land. Transferable Development Rights ordinances restrict the use of sensitive lands but allow the right to develop those lands to be transferred to other, less sensitive lands, thereby increasing their allowable density. The Supreme Court of the United States has specifically approved the use of TDR's as a means of mitigating the burdensome effects of land use regulation.[19]

An example of how TDR's work is in Dade County, which uses them as part of a program to protect the East Everglades.[20] In Dade County, TDR's are called Severable Use Rights (SUR). Sensitive wetlands in the East Everglades have been stringently regulated in order to protect the natural resources of the area and the water supply of Dade County. Allowable density was reduced to one unit per 40 acres in much of the area. SUR's were allocated to mitigate the effect on property values and to redirect development from sensitive areas. The number of SUR's allocated to a parcel depended on its location and ranged from 1 SUR/5 acres to 1 SUR/40 acres. The owners of very wet lands were allowed entitled to no SUR's. SUR's may be sold or transferred by the owner to increase the allowable density on lands slated for development in less sensitive locations within Dade County. Limitations on the transfer of SUR's serve to protect existing zones from noticeable increases in density. Similar ordinances could be used to protect wetlands adjacent to manatee habitat. The TDR concept might also be used by local governments to limit the number and location of docks, while at the same time preserving riparian rights of access of existing lot owners. A TDR ordinance might be used to redirect the location of docks in the Crystal River area as follows:

1. The owner of each parcel of record as of a certain date could be allocated the right to build one boat slip.

2. The construction of docks in specified highly sensitive locations could be prohibited.

3. The construction of docks in more suitable locations (e.g. existing dredged channels) could be allowed provided a sufficient number of dock rights was acquired.

4. The owners of dock rights would only be allowed to exercise their rights in suitable locations. They could either sell those rights to a marina developer or purchase additional land in a suitable location to build their own docks. Rights of access could be preserved if the dock rights were sold to a marina developer by reserving the right to rent a slip at a rate lower than that charged to other people.

III. STATE OVERSIGHT OF LOCAL USE REGULATION

Other than requiring local comprehensive plans to be prepared and implemented, the state exercises no oversight of local planning pursuant to the LGCPA; plans are reviewed by the Department of Community Affairs (DCA), but the substance of the plans is not controlled. However, a related statute, the Environmental Land and Water Management Act,[21] gives the Governor and Cabinet substantive authority over certain local land-use decisions. Twin procedures were established: the process for designating and administering Areas of Critical State Concern (ACSC) and the process for reviewing Developments of Regional Impact (DRI).

A. Areas of Critical State Concern

The Governor and Cabinet (sitting as the Administration Commission) are empowered to designate, as an Area of Critical State Concern, an area "containing or having a significant impact upon, environmental or natural resources of regional or statewide importance. . ."[22] Before designation, a Resource Planning and Management Committee must be given the opportunity to voluntarily resolve the resource management problems of the area (Figure 2).[23] The rule designating an area must contain "principles for guiding development," which apply to all subsequent land development in the area.[24] Local governments are then required to adopt new land development regulations consistent with the principles in order for the designation to be lifted.

The Manatee Management Plan would be useful in the designation process, if that was necessary, at several stages. The Department of Community Affairs (DCA), local government officials and members of the public would know what actions had to be taken to preserve the manatees. It could provide the basis for discussion of a Resource Planning and Management Committee and, if that effort failed, it could provide the technical basis for

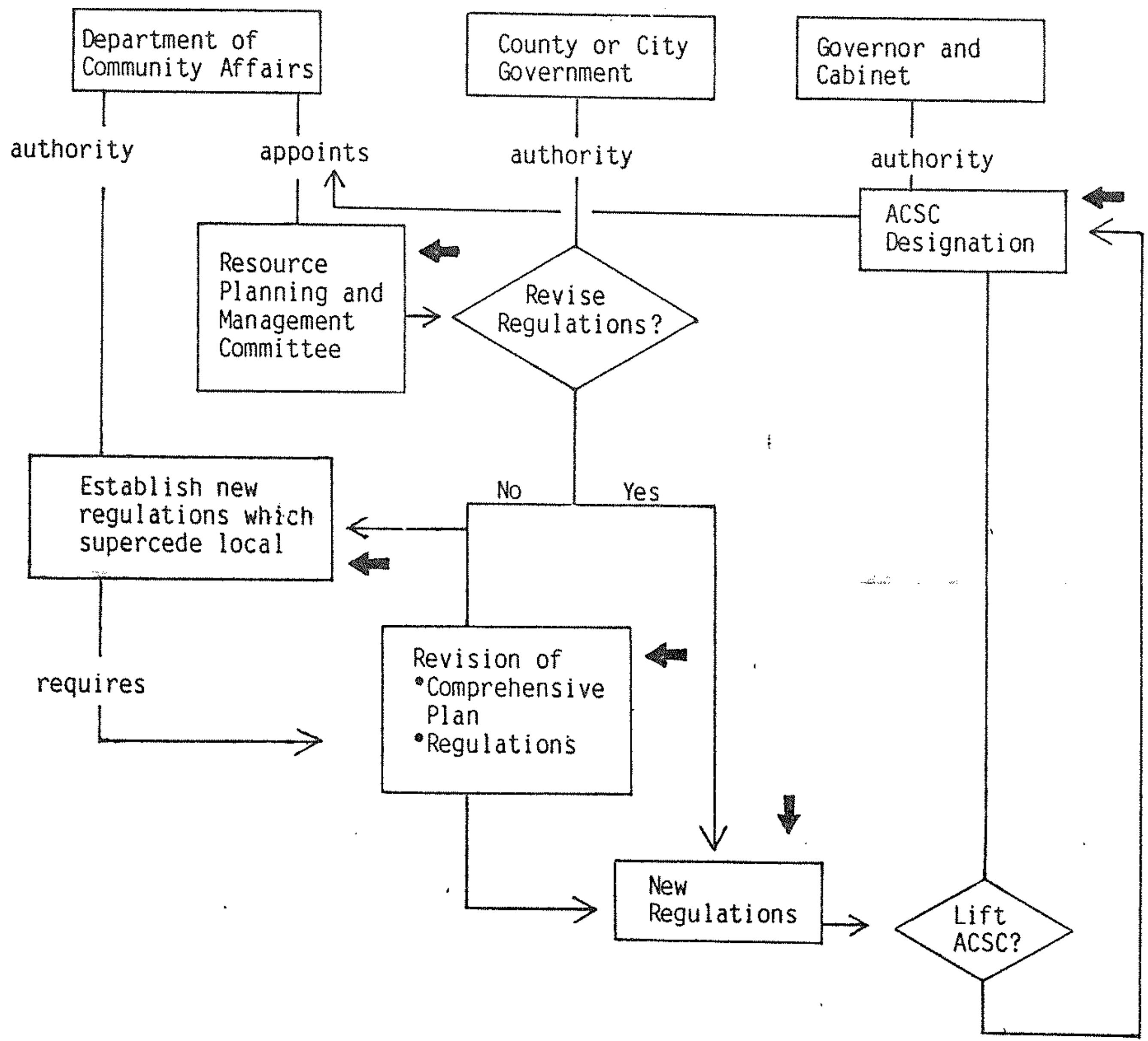

Figure 2. Revision of development regulations in Areas of Critical State Concern (ACSC). Heavy arrows indicate steps where Manatee Management Plan could be used.

the DCA to recommend designation. Elements of the plan could be incorporated into the principles for guiding development.

B. Developments of Regional Impact

A Development of Regional Impact (DRI) is defined by statute as "any development which, because of its character, magnitude or location, would have a substantial effect on the citizens of more than one county."[25] Manatees are recognized as a biological resource of national importance that move seasonally across county boundaries. Any development substantially affecting manatees would therefore appear to meet this definition and should be subject to DRI review.

The Governor and Cabinet have adopted rules for identifying developments that are presumed to be DRI's.[26] Marinas of 100 slips or more and residential developments in Citrus County of 750 dwelling units are currently presumed to be DRI's according to this rule.[27] This rule could be changed by the Governor and Cabinet (with concurrence by the Legislature) to classify as presumed DRI's other developments within sensitive habitat of the Crystal River manatee population (Figure 3). The guidelines could adopt lower thresholds or use other descriptive criteria. They could apply within a specifically mapped area or could apply more generally to the critical habitat of other endangered species. The Manatee Management Plan could provide the technical basis for changing the administrative guidelines.

Without such a rule change, development that does not meet the administrative thresholds can only be treated as a DRI if the

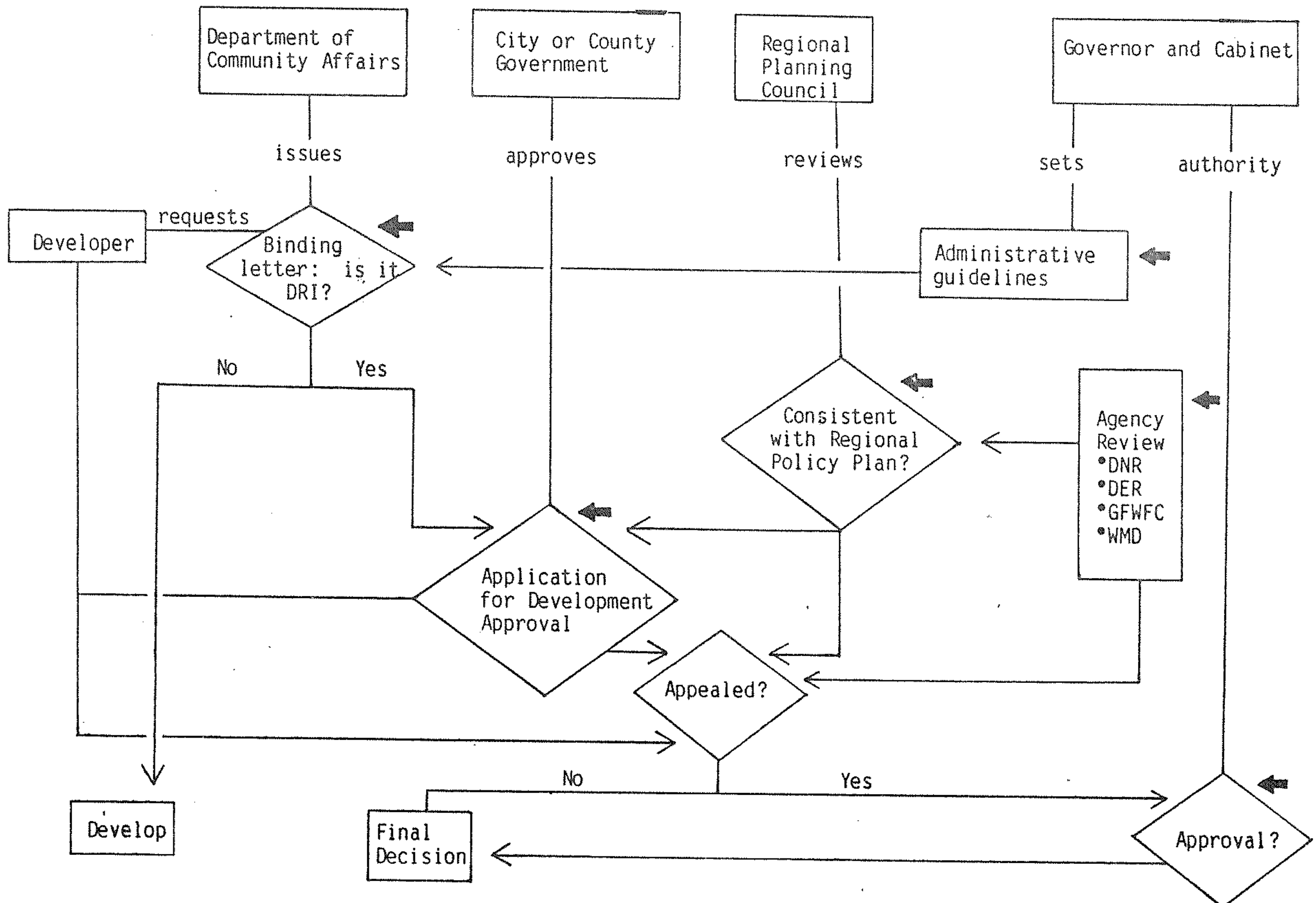

Figure 3. Permitting process for Developments of Regional Impact (DRI). Heavy arrows indicate steps at which Manatee Management Plan could be used.

Department of Community Affairs finds that it meets the statutory criteria. The DCA must have sufficient evidence to overcome the presumption created by the guidelines in order to make such a determination. Information contained in the Manatee Management Plan could be used as the basis for the necessary evidence.

The Manatee Management Plan could also be used in the review of developments that are found to be DRI's. An Application for Development Approval (ADA) is submitted by the developer to the local government and the Regional Planning Council (RPC). Citrus County is in the Withlacoochee Regional Planning Council. The RPC reviews the ADA and submits a report to the local government. As part of the review, the RPC considers, among other things, "the extent to which the development will have a favorable or unfavorable impact on the environment and natural resources of the region."[28] Regional policies, adopted by rule of the RPC, may also serve as the basis for review.[29] The Withlacoochee Regional Planning Council could adopt elements of the Manatee Management Plan as a basis for reviewing DRI's affecting the Crystal River manatee subpopulation.[30] Other appropriate agencies may also be requested by the RPC to review the ADA, and their reports are to be incorporated into the regional planning council's report. The Department of Natural Resources (DNR) would appear to be the appropriate state agency to review impacts on the manatee population, and the Manatee Management Plan could provide a valuable basis for making such assessments.

Authority to approve or disapprove the DRI is vested in the local government, which considers whether the development is consistent with the state land development plan, local land development regulations and the report and recommendations of the RPC. The development order of the local government may be appealed by either the developer, the RPC or the DCA to the Governor and Cabinet, sitting as the Land and Water Adjudicatory Commission.[31] Information in the Manatee Management Plan could be used by those agencies as the basis for an appeal, or in the case of the Governor and Cabinet, as the basis for a decision regarding whether to approve or disapprove the local government's development order.

C. Exemptions

Two major weaknesses of the Environmental Land and Water Management Act must be noted. It does not apply to "the use of any land for the purpose of growing plants, crops, trees, and other agricultural or forestry products; raising livestock; or for other agricultural purposes."[32] It also does not apply to most existing platted lands (i.e. subdivisions), which are "vested" under the statute.[33] These and other deficiencies of the Act are being reviewed by a special committee appointed by the Governor.

IV. SOVEREIGNTY SUBMERGED LANDS MANAGEMENT

Lands below mean high water are generally owned by the state, unless they have been sold or given away.[34] Title to sovereignty submerged lands is vested in the Governor and Cabinet sitting as the Trustees of the Internal Improvement Trust Fund (Trustees).[35] A public trust in submerged lands protects the people's many interests in those important lands and waters.

A. Leasing Policies

All activities on sovereignty submerged lands such as the construction of docks, channels, seawalls or similar structures must be approved by the Trustees [36] (Fig. 4). Two forms of approval are of particular significance: the consent of use and the lease.[37] A consent of use may authorize relatively minor projects such as the construction of a single dock or channel, the construction of a dock that preempts no more than 1,000 square feet of sovereignty lands, or the construction of a seawall within three feet of mean high water.[38] A lease must be obtained for larger projects or for revenue generating/income related activities.[39] Most private, individual docks would likely qualify for a consent of use, whereas marinas would require a lease. The significance of the distinction is that a fee must be paid for a lease; more extensive information must be submitted in the application; and the Trustees must specifically approve issuance of a lease. A consent of use is granted by a letter from the Director of the Division of State Lands. The same general policies apply to the issuance of both consents of use and leases.

Certain activities are granted a consent of use by the rule and can be conducted on sovereignty submerged lands without further review or specific approval, provided that they are not located in an Aquatic Preserve[40] or a Manatee Sanctuary.[41] In abridged form, these are:

1. installation of overhead transmission lines;
2. installation of aids to navigation;

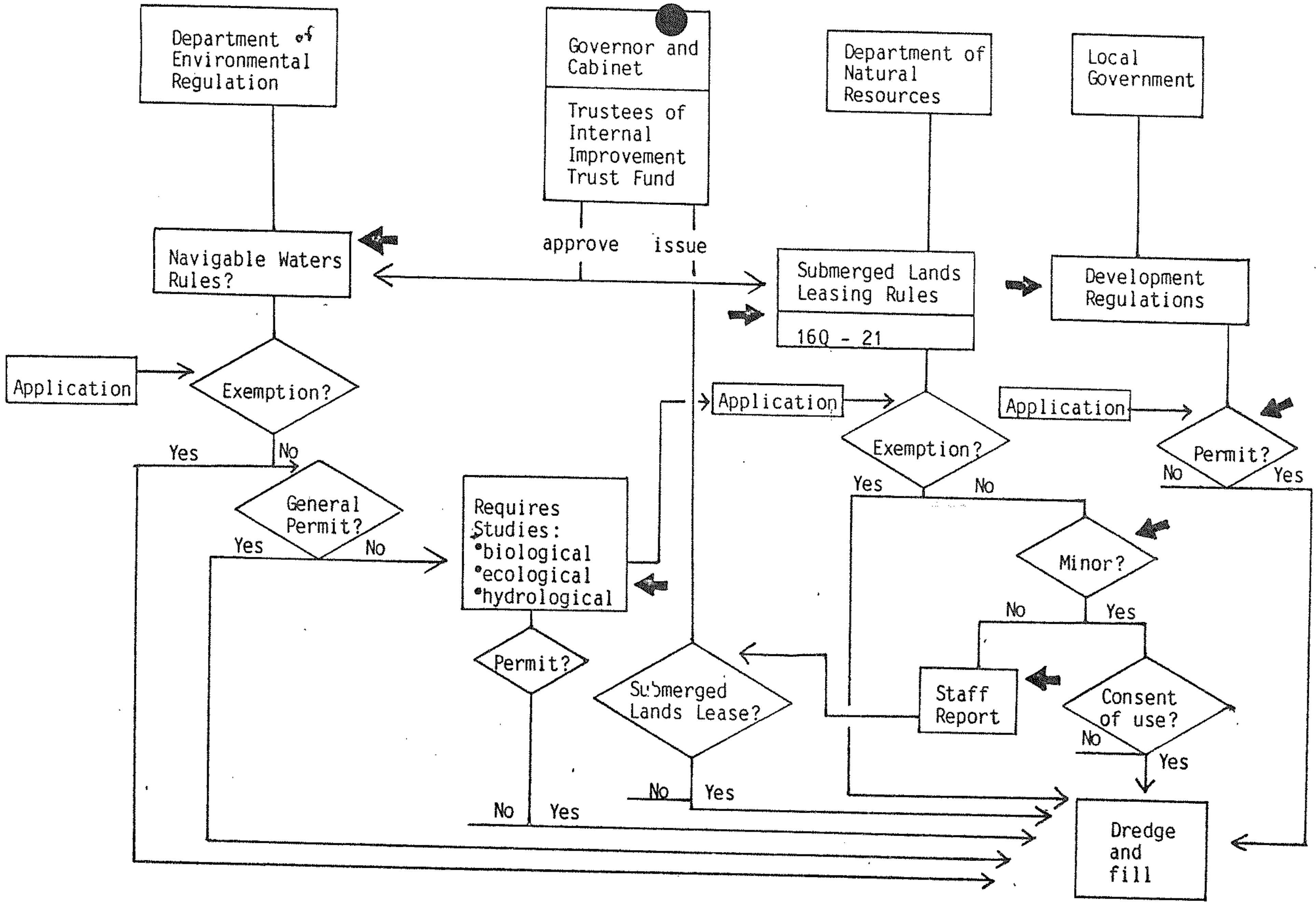

Figure 4. State and local permitting process for dredge and fill on sovereign submerged lands and navigable waters (Chapter 253). Heavy arrows indicate steps where Manatee Management Plan could be used.

3. installation and repair of mooring pilings and dolphins;
4. installation and repair of private docks less than 1,000 square feet;
5. installation of boat ramps on artificial bodies of water;
6. the construction of seawalls and private docks in artificially created waterways;
7. the replacement or repair of existing docks to the same configuration;
8. restoration of seawalls;
9. maintenance of existing mosquito control structures, dikes and irrigation and drainage ditches;
10. repair or replacement of stormwater discharge pipes;
11. dredging or filling approved pursuant to the Florida Electrical Power Plant Siting Act;
12. the deposition of up to 25 cubic yards of material every six months in the transitional zone of a submerged land, subject to suspension for cause;
13. artificial waterways behind control structures permitted by a water management district, except those to be used for residential purposes or directly connected to works of the district or constructed in waters of the state;
14. artificial waterways that are normally dry;
15. artificial waters for commercial forestry operations; and
16. the installation of subaqueous transmission and distribution lines.[42]

If the exempted activities should be individually reviewed, there are three options:

1. Expand the Manatee Sanctuary;

2. Establish an Aquatic Preserve;

3. Amend the legislation to alter or abolish the exemption.

As title-holder of sovereignty submerged lands, the Trustees have the broadest possible discretion to restrict use of those lands. The public trust doctrine, in fact, imposes an affirmative duty on the Trustees to protect the public interests in submerged lands. Criteria for review of proposals to use sovereignty submerged lands have been adopted by rule.[43] In general, activities must be "not contrary to the public interest" and water-dependent. The objective of management is "maintenance of essentially natural conditions, propagation of fish and wildlife, and traditional recreational uses such as fishing, boating, and swimming." The rule further states:

> (b) Activities which would result in significant adverse impacts to sovereignty lands and associated resources shall not be approved unless there is no reasonable alternative and adequate mitigation is proposed.
> (i) Activities on sovereignty lands shall be designed to minimize or eliminate adverse impacts on fish and wildlife habitat. Special attention and consideration shall be given to endangered and threatened species habitat.

An activity that is harmful to manatees could be denied on the basis of these criteria, although the criteria could be made more specifically protective of manatees. Information in the Manatee Management Plan could be submitted on an ad hoc basis by the staff of DNR, DER, the Game and Fresh Water Fish Commission, or the U. S. Fish and Wildlife Service in response to specific applications. The rules provide for consideration of such reports. A better alternative would be to incorporate specific requirements for the protection of the Crystal River sub-population of manatees into the State Lands Management Plan, thereby providing stable guidance in the management of the manatee habitat. The State Lands Management Plan is currently fairly general--not site-specific--but it specifically envisions "parcel-specific management evaluations and recommendations."[44]

B. Aquatic Preserve Management

An alternative means of implementing site-specific habitat protection for sovereignty submerged lands would be for the Trustees and the Legislature to create an aquatic preserve encompassing Crystal River. There is an existing aquatic preserve, but it appears to be too small. The Florida Aquatic Preserve Act[45] provides for the management of exceptional designated sovereignty submerged lands in essentially their natural condition. The Act established a number of preserves (including the St. Martins Marsh Aquatic preserve in Citrus County), but the Trustees are authorized to establish additional areas, subject to confirmation by the Legislature.[46] Preserves generally include only publicly owned uplands, submerged lands and waters, but privately owned lands and waters may be included by agreement of the landowner.

The Aquatic Preserve Act excludes from aquatic preserve boundaries:

> Any publicly owned and maintained navigation channel or other public works project authorized by the United States Congress designed to improve or maintain commerce and navigation.

It is unclear whether this exclusion is limited to existing projects (such as the Suwannee Pass and Crystal River nagivation channels) or whether it also applied to proposed projects (such as the Big Bend barge channel, extending the Intercoastal Waterway to connect with the Cross Florida Barge Canal).

Standards for managing aquatic preserves are established by statute and regulations adopted by the Trustees (Figure 5).[47] They are very similar to the standards for management of submerged lands. Authorization by the Trustees is required for dredging, filling, the construction of docks and similar activities in aquatic preserves. The applicant is required to affirmatively demonstrate compliance with the management criteria.[48] These criteria generally limit activities to water dependent uses such as marinas and docks that are designed to minimize habitat destruction. One significant aspect of the management criteria is that they specifically include consideration of cumulative impacts. As defined in the rule, these include indirect effects upon the preserve that may reasonably be expected to result from the activity.[49] The effect of boating generated by the construction of docks and marinas could thus be considered. The cumulative effect of constructing relatively minor structures could also be considered. Information supplied by the Manatee Management Plan would be useful in identifying such impacts.

Additional criteria for reviewing proposals to conduct activities in aquatic preserves may be incorporated in a resource inventory and management plan developed for each preserve. These plans may be developed by either the Division of State Lands or

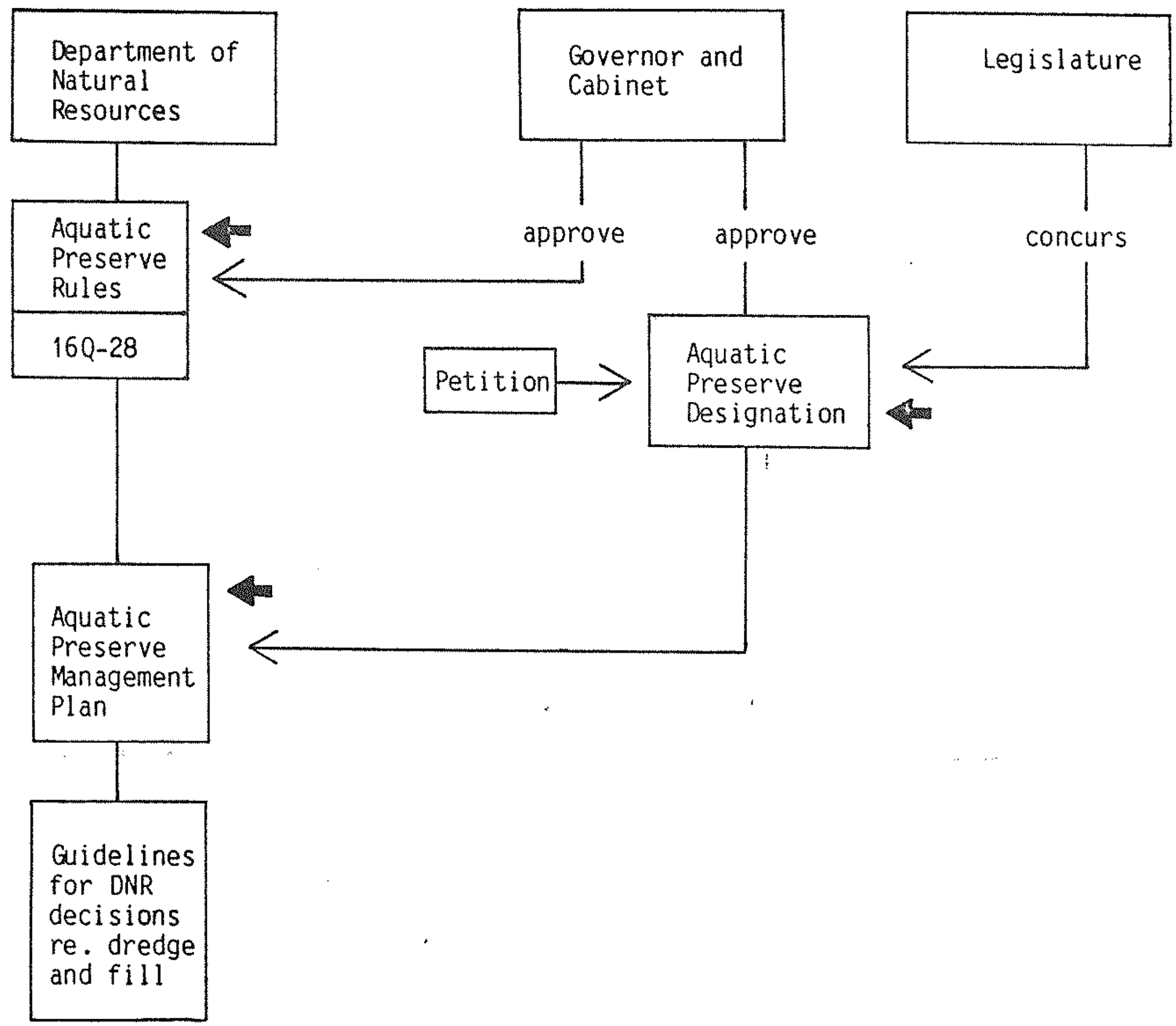

Figure 5. Designation and function of state Aquatic Preserves. Heavy arrows indicate steps where Manatee Management Plan could be used.

other persons working under agreement with the Division. Information and recommendations developed for the Manatee Management Plan could be incorporated into a resource inventory and management plan for an aquatic preserve and implemented through permitting by the Trustees.

C. Riparian Rights

One major problem in the statutes and regulations for both general submerged lands and aquatic preserve management is that they fail to adequately address the conflict between allowing boat owners and riparian land owners free exercise of their traditional activities and the protection of an endangered resource such as the manatee. The objective appears to be to protect natural resources and recreation from activities such as major dredging and filling projects that are inconsistent with both of those public interests. For example, Section 253.034(1)(a), Florida Statutes states that submerged lands "shall be managed primarily for the maintenance of essentially natural conditions, the propagation of fish and wildlife, and public recreation. . ." The Aquatic Preserve Act explicitly recognizes riparian rights, stating:

> Neither the establishment nor the management of the aquatic preserves under the provisions of this act shall operate to infringe upon the traditional riparian rights of upland property owners adjacent to or within the preserves.[41] Reasonable improvement for ingress and egress, mosquito control, shore protection, public utility expansion, surface water drainage, installation and maintenance of oil and gas transportation facilities, and similar purposes may be permitted by the trustees. . . .[50]

A logical and harmonious interpretation of the two sentences is that although the riparian rights of property owners are preserved, improvements are subject to reasonable regulation by the Trustees, which is authorized but not required to permit them. In addition, the application of other laws and regulations is not affected. Nevertheless, the status of riparian rights is sufficiently ambiguous and the exercise of those rights is so potentially damaging to manatees, that the issue should be clarified by the Legislature. There is no apparent reason for treating riparian rights differently then other rights appurtenant to real property ownership.

V. DREDGE AND FILL REGULATION

Several additional state and federal agencies have jurisdiction over the construction of docks and marinas in the Crystal River area and dredging or filling in adjacent wetlands. The Florida Department of Environmental Regulation (DER) regulates such activities under authority of two statutes: Chapters 253 and 403, Florida Statutes. The U.S. Army Corps of Engineers (Corps) has authority under the River and Harbor Act of 1899 and Section 404 of the Clean Water Act of 1977. The Environmental Protection Agency (EPA) has an important role in administering Section 404. The Fish and Wildlife Service and the National Marine Fisheries Service participate in the review of Corps permits as required by the Fish and Wildlife Coordination Act. The requirements of the Endangered Species Act (ESA) and the National Environmental Policy Act (NEPA) also apply to Corps decisions.

A. Chapter 253

The Department of Environmental Regulation (DER) regulates dredging and filling of navigable waters under Chapter 253, Florida Statutes, (Figure 6).[51] Jurisdiction extends to the line of mean high water on tidal waters and the ordinary high water mark of fresh water bodies.[52] Jurisdiction is not affected by whether the land is privately owned.

Somewhat different criteria apply depending on whether the land is being dredged or filled and the purpose of the work. A biological survey and an ecological study must be conducted by DER or under its supervision to determine the value of the affected submerged lands and the potential impacts of the proposed work. DER may also require an hydrographic survey. In order for a permit to be granted for dredging, the studies must show the work:

> will not interfere with the conservation of fish, marine and other wildlife, or other natural resources to such an extent as to be contrary to the public interest and will not result in the destruction of oyster beds, clam beds, or marine productivity, including, but not limited to, destruction of natural marine habitats, grass flats suitable as nursery or feeding grounds for marine life, and established marine soils suitable for producing plant growth of a type useful as nursery or feeding grounds for marine life or natural shoreline processes to such an extent as to be contrary to the public interests.[53]

With regard to applications to fill land, DER may only issue a permit if it finds the proposed work does not violate other statutes or restrictions and:

> . . . that no harmful obstruction to or alteration of the natural flow of the navigable water within such area will arise . . . that no harmful or increased erosion, shoaling of channels or stagnant areas of water will be created . . . and that no material injury or monetary damage to adjoining land will accrue. . . .[54]

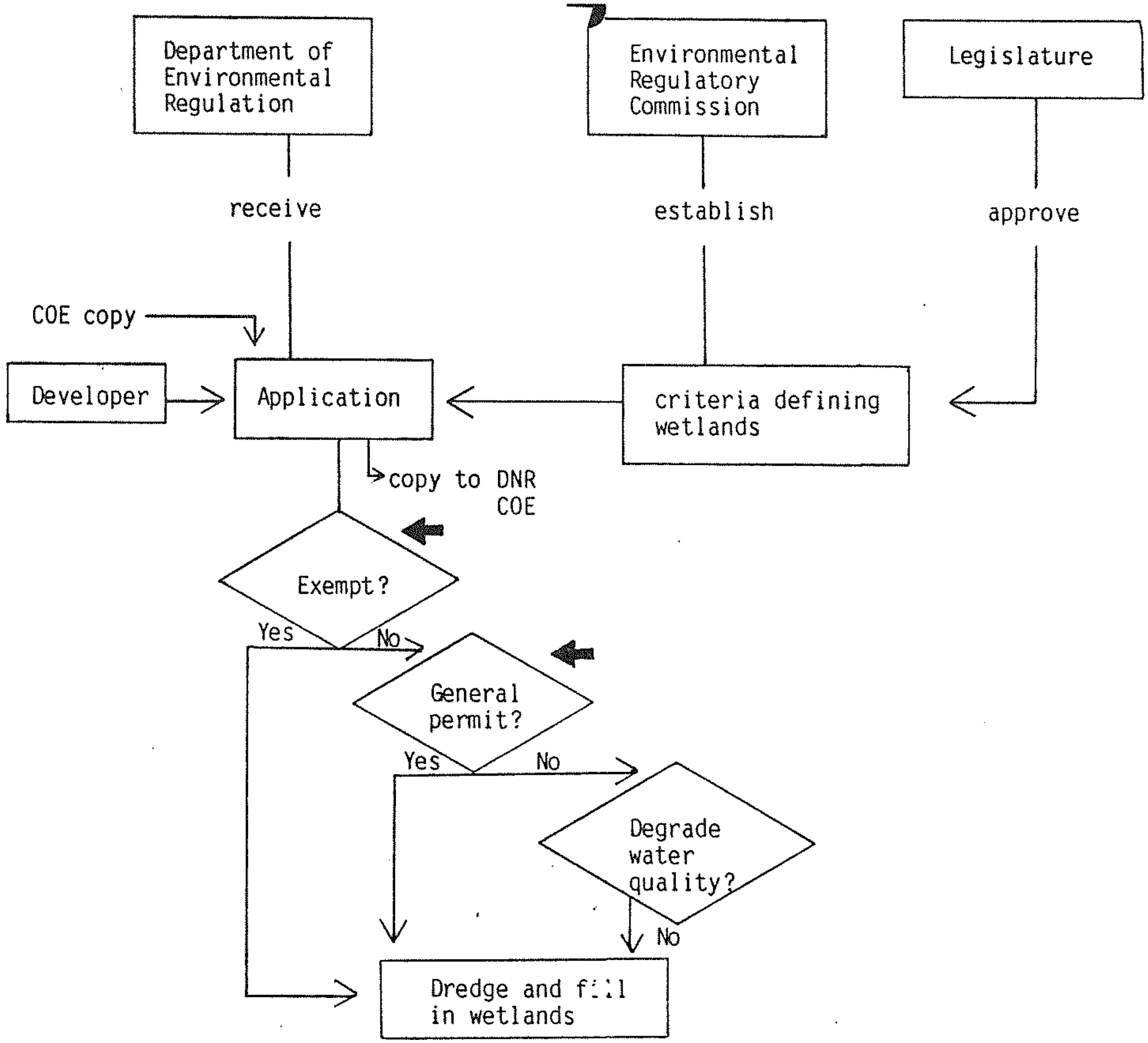

Figure 6. State permitting process for dredge and fill in wetlands under the Air and Water Pollution Control Act (Chapter 403). Heavy arrows indicate steps where Manatee Management Plan could be used.

In addition, DER is directed to consider:

> whether the granting of such permit and the construction to be done pursuant thereto would interfere with the conservation of fish, marine and other wildlife, or other natural resources to such an extent as to be contrary to the public interest and whether the destruction of oyster beds, clam beds, or marine productivity, including but not limited to, destruction of natural marine habitats, grass flats suitable as nursery or feeding grounds for marine life, including established marine soils suitable for producing plant growth of a type useful as nursery or feeding grounds for marine life, will result therefrom to such an extent as to be contrary to the public interest. The department shall also consider any other factors affecting the public interests.[55]

Manatees are an endangered species of wildlife. Congress has declared the loss of manatees would be contrary to the public interest. The Florida Legislature has declared the manatee Florida's official state marine mammal[56] and has declared the entire state a refuge and sanctuary for manatees.[57] Any dredging or filling that would "interfere with the conservation" of manatees and their habitat should thus be considered contrary to the public interest and unable to receive a permit under Chapter 253.

Local governments are also entitled to play an important role in the evaluation of Chapter 253 permits.[58] Until recently, the approval of local governments was required for Chapter 253 permits, but the Legislature amended the statute in 1981. DER is required to send copies of each application to the governing body of the local government where the project is located. The local government may request copies of the biological and hydrographic surveys. When they are received, the local government has 30 days to comment or object to the proposed development. If a majority of the local governing body objects by resolution or other formal action, the permit cannot be issued by DER. Comments or objections, however, may be based only on the following factors:

> --the results of the surveys, if requested, or the local governments own environmental studies, whether the activity conforms to an adopted local government comprehensive plan, or;
>
> --whether the activity is consistent with public access for fishing, recreation or other public interest activities, or;
>
> --whether the activity conforms to applicable ordinances or development regulations.

The time limits specified by the statute must be strictly followed and special procedures should probably be established in each local government for administration of the review and comment process to ensure timely participation.

B. Chapter 403

DER regulates the effects of dredge and fill projects on water quality under authority of Chapter 403, Florida Statutes. A project requiring a Chapter 253 permit is virtually always subject to regulation under Chapter 403. However, the converse is not true: Chapter 403 jurisdiction includes additional waterbodies and adjacent wetlands that are not covered by Chapter 253. As a result, dredging or filling in many wetlands is only regulated on water quality grounds. Effects on fish and wildlife or other important values are not considered by DER except to the extent they would be influenced by degraded water quality or might contribute to the maintenance of water quality.

Permits are required under Chapter 403 for the construction or installation of various structures such as docks or moorings and for dredging or filling in waters subject to regulation.[59] A long list of activities is exempt from permitting, although they are required to meet state water quality standards.[60]

Areas subject to jurisdiction under Chapter 403 are defined by reference to a specific list of descriptive criteria for "waters of the state"[61] and a list of wetlands vegetative indicators.[62] The waters of the state subject to permitting jurisdiction include all of the navigable and tidal waters subject to Chapter 253 and their "natural tributaries." Waters of the state also include artificially created waterbodies connected to them. However, natural tributaries do not include:

> intermittent natural water courses which act as tributaries only following the occurrence of rainfall and which normally do not contain contiguous areas of standing water.[63]

In addition, although natural lakes are considered waters of the state, the term does not include lakes that:

a. are owned entirely by one person; or

b. become dry each year and are without standing water; or

c. are no more than 10 acres of water area at a maximum average depth of 2 feet existing throughout the year.[64]

The landward extent of submerged lands is defined by reference to a list of vegetative species.[65] Lands contiguous to waters of the state on which a combination of the listed species constitutes the dominant plant community are considered submerged lands subject to Chapter 403 jurisdiction. In addition, this jurisdiction may include a "transitional zone" consisting of the first 50 feet landward of submerged lands or 1/4 of the distance between submerged and upland lands, whichever is greater.[66] Jurisdiction does not extend to this transition zone, however, unless specified transitional species constitute the dominant plant community. These lists may not include all species indicative of important wetlands in the Crystal River area.

The review of applications for Chapter 403 permits is limited by DER to consideration of water quality impacts. To receive a Chapter 403 permit, the applicant has to provide "reasonable assurance" the project will meet state water quality standards.[67] Biological impacts and other factors of concern are considered only to the extent they are related to water quality.[68] For example, the destruction of wetland vegetation may be considered, but only to the extent that loss of wetland vegetation would affect water quality through loss of its biological filtering capabilities or its function of binding soil and thus reducing turbidity. The effect of degraded water quality on biological processes may also be considered.[69]

Crystal River has been designated an Outstanding Florida Water (OFW), which is the state's highest water quality classification. Crystal River was classified as an OFW after DER found that it had "exceptional recreational and ecological significance".[70] It is DER policy "to afford the highest protection to Outstanding Florida Waters".[71] To receive a dredge and fill permit for activities in Crystal River or for adjacent activities that discharge into Crystal River and would signifgicantly degrade water quality (alone or in conjunction with other stationary installations), the applicant must affirmatively demonstrate:

(a) "the proposed activity . . . is clearly in the public interest; and,

(b) "the existing ambient water quality . . . will not be lowered".[72] Activities that are currently permitted, however, and activities that are exempt from permitting by statute or rule do not have to meet the OFW water quality standards. Water quality can be degraded by such activities regardless of the OFW designation.

The processing of both Chapter 253 and Chapter 403 permit applications is coordinated by DER with review by the Corps of Engineers pursuant to a Memorandum of Understanding executed in 1976. This memorandum provides for the use of a joint application form. Two copies of an application must be submitted to either DER or the Corps, which will forward one copy to the other agency. Although their decisions are made independently, the two agencies may use joint public notices and cooperate with each other in their review of the project. DER also forwards a copy of the application to the Department of Natural Resources.

Short form applications, which may be submitted for projects below specified thresholds, are processed by a District Office.[73] Standard form applications are processed by the Tallahassee office of DER, using field inspection reports provided by the District Office. The District Office for Citrus County is located in Tampa.

The application is first evaluated for completeness. DER must request any additional information required to evaluate the project within 30 days of receipt of the application or lose the right to deny the permit for lack of sufficient information to evaluate the impacts.[74] During the completeness evaluation, DER also determines whether a hydrographic survey is needed in the case of a Ch. 253 permit.[75] Once a completed application has been received, the agency has 90 days to evaluate it.[76] If no formal action is taken, the permit is deemed issued by default. Standard conditions, however, may be incorporated into the permit and water quality standards are supposed to be met.

C. Exemptions and General Permits

Numerous activities have been exempted from regulation under both Chapters 253 and 403 by the Legislature.[77] These activities are listed below in abbreviated form. There are detailed conditons or exceptions to the listed exemptions that have been omitted because of their complexity and length.

1. installation of overhead transmission lines;

2. installation of aids to navigation;

3. installation and repair of mooring pilings and dolphins;

4. installation and repair of private docks less than 1,000 square feet (reduced to 500 square feet in an OFW);

5. maintenance of existing channels, canals and intake and discharge structures;

6. installation of boat ramps on artificial bodies of water;

7. the construction of seawalls and private docks in artificially created waterways;

8. the replacement or repair of existing docks to the same configuration;

9. restoration of seawalls;

10. maintenance of existing dikes and irrigation and drainage ditches;

11. repair or replacement of stormwater discharge pipes;

12. construction and maintenance of swales;

13. dredging or filling approved pursuant to the Florida Electrical Power Plant Siting Act;

14. the deposition of up to 25 cubic yards of material every six months in the transitional zone of a submerged land, subject to suspension for cause;

15. artificial waterways behind control structures permitted by a water management district, except those to be used for residential purposes or directly connected to works of the district or constructed in waters of the state;

16. artificial waterways that are normally dry;

17. artificial waterways for commercial forestry operations; and

18. the installation of subaqueous transmission and distribution lines.

General permits are permits that are issued by rule. One does not have to apply for a general permit to use it (although notice of intent to use a general permit may be required). Compliance with specified conditions is all that may be required.

DER is authorized to issue general permits under Chapter 253 and 403 "for projects, or categories of projects, which have, either singly or cumulatively, a minimal adverse environmental effect."[78] Nine general permits have been issued thus far.[79] General permits that may be of particular significance to the Crystal River manatee population include permits allowing the installation or maintenance of boat ramps, the installation of rip rap on existing sea walls, and the installation of headwalls and culverts for permitted stormwater discharge systems. Complex conditions apply to these general permits. Although permittees are required to notify DER 30 days prior to beginning work, enforcement of the conditions is difficult.

Review of the general permits indicates they may allow activities that are inconsistent with preservation of the Crystal River manatee subpopulation. DER could modify the permits to limit their applicability within certain waters. A precedent for such action is the exclusion of the Biscayne Bay Aquatic Preserve from general permitting.[80]

D. The River and Harbor Act of 1899

The River and Harbor Act of 1899[81] gives the U.S. Army Corps of Engineers (Corps) jurisdiction to require permits for the construction of marinas or docks and for most other dredging, filling or construction activities in traditional navigable waters (Figure 7). Jurisdiction of the Corps under the River and Harbor Act is essentially coterminous with that of DER under Chapter 253. The criteria for issuance of permits are incorporated in the public interest review standards discussed below with regard to Section 404 permits.

E. The Clean Water Act of 1977, Section 404

The Clean Water Act[82] was enacted to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters."[83] The discharge of any pollutant from a point source to waters of the United States is prohibited without a permit.[84]

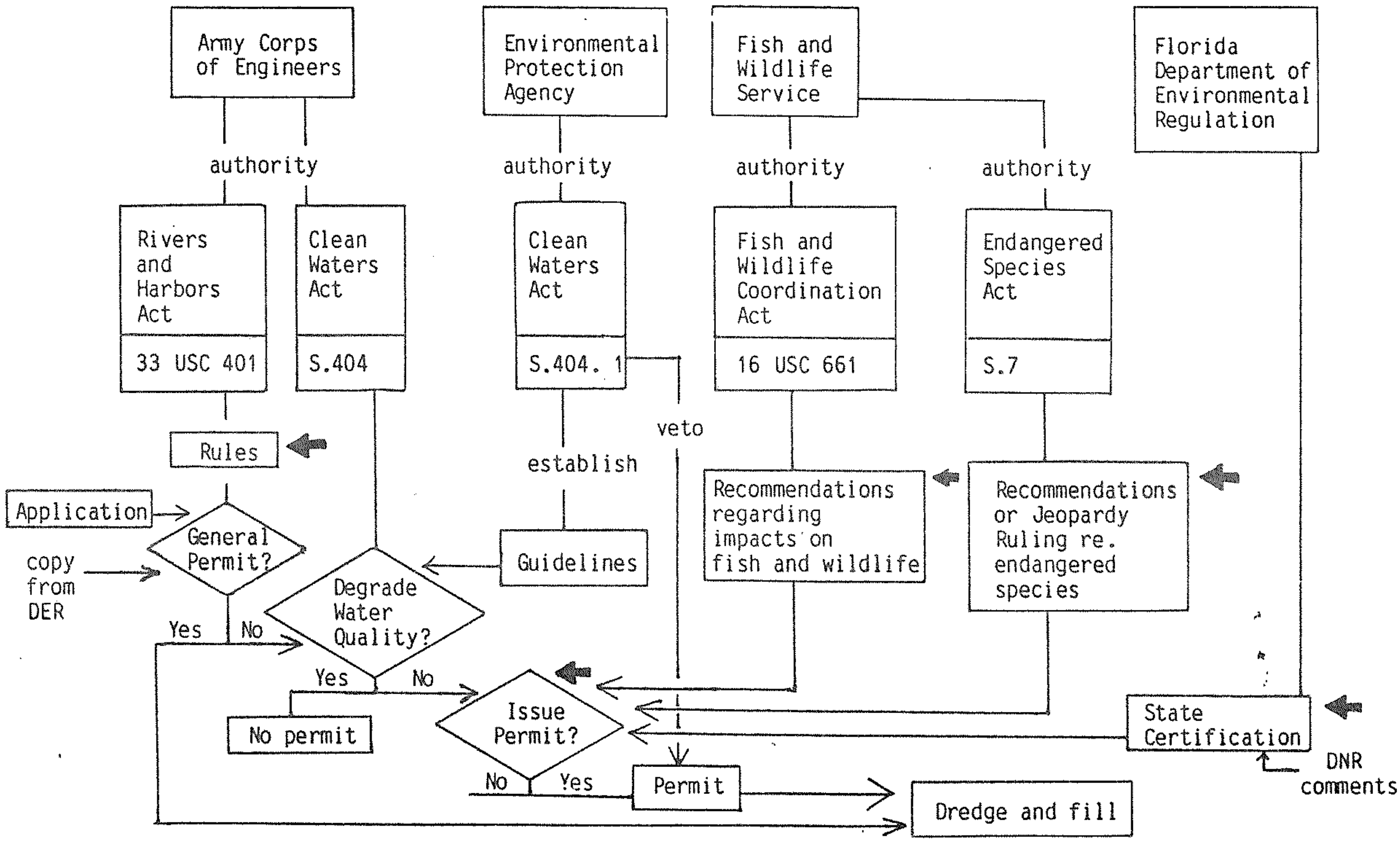

Figure 7. Federal permitting process for dredge and fill in navigable waters. Heavy arrows indicate steps where Manatee Management Plan could be used.

Although most permitting is conducted by EPA and the states,[85] the Corps is authorized to permit the discharge of dredged or fill material using guidelines adopted by EPA.[86]

The Section 404 permitting program was not fully implemented until 1977.[87] The Reagan Administration has indicated an intent to substantially reduce the program, and substantial changes appear to be imminent that would alter the substance of this section.[88] Significant revisions of the regulatory program adopted July 22, 1982 are incorporated.[89]

The jurisdiction of the Corps under Section 404 is not limited to traditional, navigable waters, but extends to all waters of the United States, including adjacent wetlands, to the extent authorized by the Commerce Clause.[79] Wetlands are defined as:

> those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas.[91]

Three factors are thus used to identify wetlands: frequency and duration of inundation, characteristics of vegetation, and soil characteristics. Wetlands may be distinguished from uplands by the existence of plants that are tolerant of inundation and saturated soils.[92]

The discharge of dredged or fill material within the Corps' jurisdiction without a permit is generally illegal. The courts have broadly interpreted the terms "discharge" and "dredged or fill material." Material that is dripping from a dredge bucket that is excavating a wetland, for example, may constitutue a discharge.[93] The clearing of bottomland hardwood trees and removal of their roots by plowing has been held to be a discharge of dredged or fill material.[94] The Corps, however, follows a more limited interpretation.

In substantially abbreviated form, the activities listed below are exempted from regulation by Congress.[90] Exemptions do not apply where the discharge is intended to convert an area of navigable waters to a new use or where the flow, circulation or reach of navigable waters may be impaired:

a. normal farming, silviculture and ranching activities;

b. maintenance and emergency reconstruction of dams, dikes, etc;

c. construction or maintenance of farm ponds or irrigation ditches or maintenance of drainage ditches;

d. construction of temporary sedimentation basins on a construction site above navigable waters;

e. the construction or maintenance of farm, forest or mining roads in accordance with certain best management practices;

f. activities controlled by an approved Section 208 program.

The Clean Water Act authorizes the Corps to issue general permits on a state, regional or nationwide basis for categories of activities that are "similar in nature, will cause only minimal adverse environmental effects when performed separately, and will have only minimal cumulative adverse effects on the environment."[96]

Nationwide permits have been issued authorizing all activities in certain classes of waters: lakes, streams and adjacent wetlands that do not drain to navigable waters or are above the "headwaters," defined as the point on a stream at which the average rate of flow is 5 CFS.[97]

Nationwide permits have also been issued authorizing such activities as the bulkheading of less than 500 feet of shoreline,[98] the construction of "minor" road crossings,[99] the discharge or dredging of ten cubic yards or less of fill,[100] non-commercial, single boat mooring buoys,[101] aids to navigation,[102] structures constructed in artificial, residential canals,[103] restoration of previously authorized structures or fill,[104] the discharge of concrete into tightly sealed forms or cells.[105]

State program general permits may be issued to authorize activities that are approved by a state regulatory program.[106] When a state program permit was proposed in Florida, it was opposed by the Department of Environmental Regulation and environmental groups. Nevertheless, it was issued.[107] The District Engineer in Jacksonville has also issued a number of more limited general permits--sometimes restricted to individual counties. None have been issued specifically for Citrus County, but several may apply.

Activities conducted pursuant to general permits are supposed to be conducted in accordance with certain conditions. One condition of particular relevance to the Crystal River manatees is

> the activity will not jeopardize a threatened or endangered species as identified under the Endangered Species Act or destroy or adversely modify the critical habitat of such species.[108]

Enforcement of these conditions appears to be nonexistent.[109] A Division Engineers (located in Atlanta) has discretionary authority to require individual permits,[110] but there is no provision for the permittee to give notice to the Corps before commencing work. The Division Engineer thus depends on notification by local, regional and state officials or private individuals of the need to assert discretionary authority.

Division Engineers are also authorized to "modify nationwide permits by adding conditions applicable to certain activities or specific geographic areas."[111] These conditions could be made applicable to the Crystal River area and could include conditions or limitations on the exercise of certain general permits based on the recommendations and data of the Manatee Management Plan. In view of the apparent failure to enforce general conditions, specific conditions that are more easily monitored might be considered. General permits could be made inapplicable in manatee habitat, for example.

Permit applications for individual permits are reviewed using comprehensive criteria. A discharge must be in the public interest to be permitted. The Corps' Public Interest Review is conducted by balancing a broad range of factors, including: economics, aesthetics, historic values, fish and wildlife, flood damage prevention, water quality and energy needs.[112]

The unnecessary alteration or destruction of valuable wetlands is discouraged as contrary to the public interest. The

District Engineer is to consider whether the proposed activity is dependent on being located in or in close proximity to the proposed site and whether practicable alternative sites are available. The criteria also recognize that the cumulative effects of numerous minor changes can have significant effects.

The review of permit applications must also consider and apply guidelines developed by EPA pursuant to Section 404(b) of the Act.[113] These guidelines are currently highly protective of water quality, aquatic vegetation, wetlands, endangered species and wildlife and include the following provisions:

-No discharge is permitted if there is a practicable alternative which would have less adverse impact.

-If the proposed activity does not require access or proximity to or siting within a wetlands or other aquatic site of high value, practicable alternatives are presumed to be available. Residential development is not usually considered to be "water-dependent;"[114] marinas are.[115]

-No discharge is to be permitted that will cause or contribute to significant degradation of the waters of the United States. Such degradation might include significant adverse effects on water quality, aquatic life, recreation, aesthetics, or the capacity of a wetland to assimilate nutrients or reduce wave energy.

No discharge is to be allowed that would jeopardize an endangered species or result in likelihood of the destruction or adverse modification of a critical habitat.

The guidelines recognize that potential impacts on endangered species include:

> (1) Covering or otherwise directly killing species;
> (2) The impairment or destruction of habitat to which these species are limited. Elements of the aquatic habitat which are particularly crucial to the continued survival of some threatened or endangered species include adequate good quality water, spawning and maturation areas, nesting areas, protective cover, adequate and reliable food supply, and resting areas for migratory species. Each of these elements can be adversely affected by changes in either the normal water conditions for clarity, chemical content, nutrient balance, dissolved oxygen, pH, temperature, salinity, current patterns, circulation and fluctuation or the physical removal of habitat; and
> (3) Facilitating incompatible activities.[116]

Further, regarding compliance with the Endangered Species Act, the guidelines state that "conclusions of the Secretary (of the Interior) concerning the impact(s) of the discharge on threatened and endangered species and their habitat shall be considered final."[117] The guidelines also force consideration of other impacts on wildlife habitat.[118]

Special aquatic sites are given special attention.[119] These are defined as "areas designated under State and Federal Laws or local ordinances to be managed principally for the preservation and use of fish and wildlife resources."[120]

Among the recognized threats to such areas are discharges of dredged or fill material that would "disrupt the breeding, spawning, migratory movements or other critical life requirements of resident or transient fish and wildlife resources"[121] or "create unplanned, easy and incompatible human access to remote aquatic areas."[122]

The guidelines give direction on how to avoid, eliminate or mitigate the effect of a discharge on the values described above.[123] These include "avoiding sites having unique habitat or other values, including habitat of threatened or endangered species."[124]

These guidelines are administered by the Corps, with consultation by EPA. EPA is also entitled to veto permits that would "have an unacceptable adverse effect on . . . wildlife."[125] This may be done on an individual ad hoc basis or categorically by prohibiting specified discharges in discrete areas such as the Crystal River.

Under the Fish and Wildlife Coordination Act,[126] consultation with game and fish management agencies is required and their comments must be given full consideration. Manatees are more specifically protected under the Endangered Species Act of 1973.[127] They may not be jeopardized and their critical habitat must be preserved. This act is administered by the Department of Interior, which has designated Crystal River as critical habitat for the manatee.[128] Finally, the provisions of the National Environmental Policy Act (NEPA), [129] requiring the preparation of an Environmental Impact Study (EIS) for major federal actions significantly affecting the quality of the environment. The issuance of a Corps permit is subject to all of these laws. The Manatee Management Plan could be used as a basis for evaluating and acting in compliance with all of the standards and guidelines described above.

NOTES

1. Research/Management Plan for the Crystal River Subpopulation of Manatees: South Big Bend, Florida. Volume II. Technical Plan. Florida Cooperative Fish and Wildlife Research Unit (Manatee Management Plan).

2. For an extensive discussion of local regulatory powers in Florida, see Comer, Hubbel and Hamann, A Model Flood Management Ordinance 34-95 (1982) (Available from the Southwest Florida Water Management District).

3. For examples, see Florida Department of Community Affairs and the Center for Governmental Responsibility, Local Options for Floodplain and Wetlands Management: Conference Materials (September 16-17, 1982).

4. Fla. Stat. §§163.3161-.3211 (1981).

5. Id., §163.3177(6)(d).

6. Id., §163.3177(6)(g).

7. Citrus County Comprehensive Plan (adopted by Ord. No. 79-03, July 24, 1979).

8. City of Crystal River Comprehensive Plan (September, 1979).

9. White-Sullivan Group, et al, Evaluation Report: Citrus County Comprehensive Plan and Zoning Ordinance (August 23, 1983).

10. See generally, Juergensmeyer and Wadley, Florida Land Use Restrictions, Ch 20.

11. Citrus County Zoning Ordinance No. 80-05 (November 19, 1980).

12. Manatee Management Plan, Vol. II, IV-87, Fig. 62.

13. Citrus County Zoning Ordinance, §§1250, 2153, 2203, etc.

14. Id., §1250.

15. See, e.g., Id., §2304.

16. Id., §5471.

17. For discussion of the use of performance standards, see Thurow, Toner & Early, Performance Controls for Sensitive Lands, American Society of Planning Officials (1975); L. Kendig, Performance Zoning (1980).

18. See generally, Williams, Transfer of Development Rights (1980) (unpublished seminar paper on file with author).

19. Penn Central Transportation Co. v. City of New York, 438 U.S.

104, 99 S.Ct. 2646 (1978); See also, City of Hollywood v. Hollywood, Inc., 8 FLW 1181 (Fla. 4th DCA, 1983).

20. See Conference Materials, supra note 3 at II.5-6.

21. Fla. Stat. §§380.012-.12(1981).

22. Id., §380.05(1)(a).

23. Id., §380.045. Representatives of affected local governments, state and regional agencies and citizens serve on the committee, which must meet over at least six months. The Department of Community Affairs staffs these committees and recommends to the Governor and Cabinet whether designation is needed.

24. For examples of such principles see 9 FAC Rule 27 F-3 to -13.

25. Fla. Stat. §380.06(1)(1981).

26. 9 FAC 27 F-2.

27. Assuming the population of the country is between 50,000-100,000.

28. Fla. Stat. §380.06(1)(a)(1981).

29. Id., §§380.06(11)(a)6; 160.07 (1981).

30. 9 FAC 29E-2,8,9.

31. Fla. Stat. §380.07(2)(1981).

32. Id., §380.04(e).

33. Id., §§380.05(18), .06(12).

34. Article X, Section II, Florida Constitution.

35. Fla. Stat. Ch. 253 (1981).

36. Id., §§253.00-.02,.03,.034,.12(1981).

37. 7 FAC 16 Q-21.

38. Id., 16Q-21.05(a).

39. Id., 16Q-21.05(b).

40. Fla. Stat. §258.35 et.sq. (1981).

41. Id., §370.12(2)(1981).

42. Fla. Stat. §403.813(2)(a),(b),(c),(d),(e),(g),(h),(i),(k) (supp. 1982). ((f) and (j) are not permitted).

43. 7 FAC 16Q-21.04.

44. Conceptual State Lands Management Plan, 1 (March 17, 1981).

45. Fla. Stat. §§258.35-.46 (1981).

46. Id., §258.41.

47. 7 FAC 16Q-20.

48. Id., 16Q-20.04-.06.

49. Id., 16Q-20.06(3).

50. Fla. Stat. §258.44 (1981).

51. Fla. Stat. §§253.123-.1245 (1982 Supp.). A case upholding denial of a Ch. 253 dredge and fill permit in Crystal River is Yonge v. Askew, 293 So.2d 395 (Fla. 1st DCA, 1974).

52. See generally, Maloney, The Ordinary High Water Mark: Attempts at Settling an Unsettled Boundary 13 Land and Water L. Rev. 465-99 (1978); Maloney and Ausness, The Use and Legal Significance of the Mean High Water Line in Coastal Boundary Mapping, 53 N.C.L. Rev. 185-273 (1974).

53. Fla. Stat. §253.123(3)(d)(1982 Supp.).

54. Id., §253.124(2).

55. Id.

56. Id., §15.038(1).

57. Id., §370.12(2)(b).

58. Id., §253.1245 (1982 Supp.).

59. 7 FAC 17-4.28(2).

60. Id., 17-4.28, 17-4.04(10).

61. Id., 17.4.28(2).

62. Id., 17-4.02(17),(19).

63. Id., 17-4.28(2)(g).

64. Id., 17-4.28(2)(d).

65. Id., 17-4.02(17). DER is in the process of adopting a new list incorporating a somewhat different methodology.

66. Id., 17.4.02(19).

67. Fla. Stat. §403.088(3)(b)(1981); 7 FAC Rule 17-4.28(3).

68. See e.g., Whitehurst & Sons v. D.E.R., No. 76-1919 (Recommended Order) (May 17, 1977).

69. Dept. of Pollution Control v. Universal Adams, Inc., 44 Fla. Supp. 165 (1974); Farrugia v. Frederick, 344 So. 2d 921 (Fla. 1st DCA, 1977).

70. 7 FAC 17-3.041 (1982 Supp.) Note: The OFW rule is being revised.

71. Id.

72. Id., 17-4.242.

73. Fla. Stat. §403.8131(1)(1981).

74. Id., §120.60(2)(1981).

75. Id., §253.123(d), .124(3).

76. Id., §120.60(2).

77. Id., §403.813(2)(1982 Supp.).

78. Id., §403.814 (1982 Supp.).

79. 7 FAC 17-4.51 - .63.

80. Id., 17-4.53(4).

81. 33 USC §§401 et. seq.; 33 CFR 320, 321, 325.

82. The Clean Water Act of 1977 substantially amended and renamed the Federal Water Pollution Control Act Amendments of 1972, codified at 33 USC §1344 et. seq.

83. 33 USC §1251.

84. 33 USC §1311(a).

85. 33 USC §1342.

86. 33 USC §1344. A published decision regarding Corps permitting in Crystal River is U.S. v. Weisman, 489 F. Supp. 1331 (M.D.Fla. 1980).

87. 42 Fed. Reg. 37122-64 (July 9, 1977).

88. A good source of information regarding recent developments is the National Wetlands Newsletter, published by the Environmental Law Institute, Suite 600, 1346 Connecticut Avenue., N.W., Washington, D.C. 20036.

89. 47 Fed. Reg. 31794-31833 (July 22, 1982).

90. NRDC v. Calloway, 392 F. Supp. 685 (D.D.C. 1975); U.S. v. Holland, 373 F. Supp. 665 (M.D. Fla. 1974).

91. 40 CFR §230.3(t).

92. Avoyelles Sportsmen's League, Inc. v. Alexander, 13 ELR 20942 (5th Cir. 1983).

93. Weizman v. Corps of Engineers, 526 F.2ds 1302, 1306 (5th Cir. 1976).

94. Avoyelles Sportsmen's League, Inc. v. Alexander, 13 ELR 20942 (5th Cir. 1983).

95. 33 USC §1344(f)(i).

96. _Id_. §1344(c); 33 CFR 330.

97. 33 CFR §333.4.

98. _Id_., §330.5(a)(13).

99. _Id_., §330.5(a)(14).

100. _Id_., §330.5(a)(18),(19).

101. _Id_., §330.5(a)(10).

102. _Id_., §330.5(a)(1).

103. _Id_., §330.5(a)(2).

104. _Id_., §330.5(a)(3).

105. _Id_., §330.5(a)(25).

106. RGL 81-10.

107. SAJ-49 (June 15, 1983).

108. 33 CFR §330.5(b)(3).

109. For example, on August 16, 1982, the Jacksonville District Office of the Corps authorized construction of a multi-family pier in King's Bay Antiquian Shores, Inc. under a general permit.

110. _Id_., §330.7.

111. _Id_., §330.7(a).

112. 33 CFR §320.4(a).

113. 33 USC §1344(b); 40 CFR 230.

114. See e.g., Deltona Corp. v. Alexander, 504 F. Supp. 1280 (M.D. Fla. 1981).

115. DNR, Blue Ribbon Marina Committee, Final Report, January, 1983; Maloney, Canter and Hamann, Legal Aspects of Recreational Marina Siting in Florida, Florida Sea Grant College, Report No. 36, November, 1980.

116. 40 CFR §230.30(b).

117. Id., §230.30(c).

118. 40 CFR §230.32.

119. Id., §230.40.

120. Id., §230.40(a).

121. Id., §230.40(b)(1).

122. Id., §230.40(b)(2).

123. Id., §230.70.

124. Id., §230.74(c).

125. 33 CFR §1344(c).

126. 16 USC §742 et seq.

127. 16 USC §668 et seq.

128. 50 CFR §§17.66, 402.02.

129. 42 USC §4321 et seq.

REVIEW OF LAWS AND EDUCATIONAL PROGRAMS PREVENTING HARM TO MANATEES DUE TO WATERBORNE ACTIVITIES

David Gluckman, Esq.

I. INTRODUCTION

The harm to manatees due to human activities has been direct and intentional, as well as incidental or unintentional due to collisions with boats, contact with swimmers and entanglements with fishing gear.[1] Both federal and state governments have enacted laws which prohibit intentional physical harm to manatees (without a permit) and allow for the passage of regulations which assist in preventing incidental damage as well. This report will describe these laws and their accompanying regulations along with others which provide funding for educational programs regarding manatee protection.

II. INTENTIONAL HARM TO MANATEES

State and federal laws prohibit the "taking" of manatees (or any endangered species) without a permit from the proper authorities. A "taking" is defined differently in the various acts but it generally means that it is against the law to harm, bother or harass manatees, or to capture animals for display or other purposes.

A. Federal Law

The Endangered Species Act (ESA) defines the word "take" with to mean "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct."[2] Permits may be granted to "take" endangered species for scientific or educational reasons, or other purposes that will benefit the species. Under the Marine Mammal Protection Act (MMPA), "The term 'take' means to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal."[3] Permits may be issued to qualified individuals for activities of scientific or educational merit.

Violators for ESA or MMPA may be subject to civil fines not to exceed $10,000 for each offense or $20,000 and/or one year in jail for criminal offenses.[4]

B. State Laws

The Florida Manatee Sanctuary Act (FMSA) provides for similar restrictions.

> ...,(I)t shall be for any person at any time, by any means, or in any manner intentionally or negligently, to annoy, molest, harass, or disturb or attempt to molest, harass, or disturb any manatee; injure or harm any manatee; capture or collect or attempt to capture or collect any manatee; pursue, hunt, wound, or kill or attempt to hunt, wound or kill any manatee; or possess, literally or constructively, any manatee or part of any manatee.[5]

III. INCIDENTAL HARM TO MANATEES

A. Total or Partial Exclusion of Waterborne Activities

Boats and/or swimmers are exluded from open water areas only in a few portions of the study area. The federal sanctuaries of Kings Bay exclude all waterborne activites while the Manatee Springs State Park excludes boats from certain areas.

1. Federal Restrictions

The Federal government, under the provisions of ESA and MMPA (Fig.1), has provided substantial protection for manatees within "manatee sanctuaries" in Kings Bay.[6] These three small areas in Kings Bay are roped off from November 15 to March 31 and all boating and other "waterborne activity" is prohibited within the areas.[7] "Waterborne" activities are defined to include "swimming, diving (including skin and scuba diving), snorkeling, water skiing, surfing, fishing, the use of water vehicles, and dredging and filling operations".[8]

The area is policed by the Fish and Wildlife Service (FWS) with assistance from the Florida Marine Patrol of the Department of Natural Resources (DNR).

2. State Restrictions

Under the State Parks Act (Fig.2), the DNR is given the authority to adopt regulations and prepare a management plan to control activities in parks[9]. Under this plan , waterborne activities may be excluded from specified areas within the parks. The state has used this power by excluding boats from the spring run at Manatee Springs State Park.

The DNR is empowered by law to control the safety of boats on the state's waters[10]. Though this law does not mention protection of manatees as a reason for excluding boats from certain ares, if DNR were to determine that collisions with manatees were a safety problem, exclusions of boats from high hazard areas would be proper[11].

The state may also be able to exclude waterborne activities from portions of designated Areas of Critical State Concern[12]. However, it

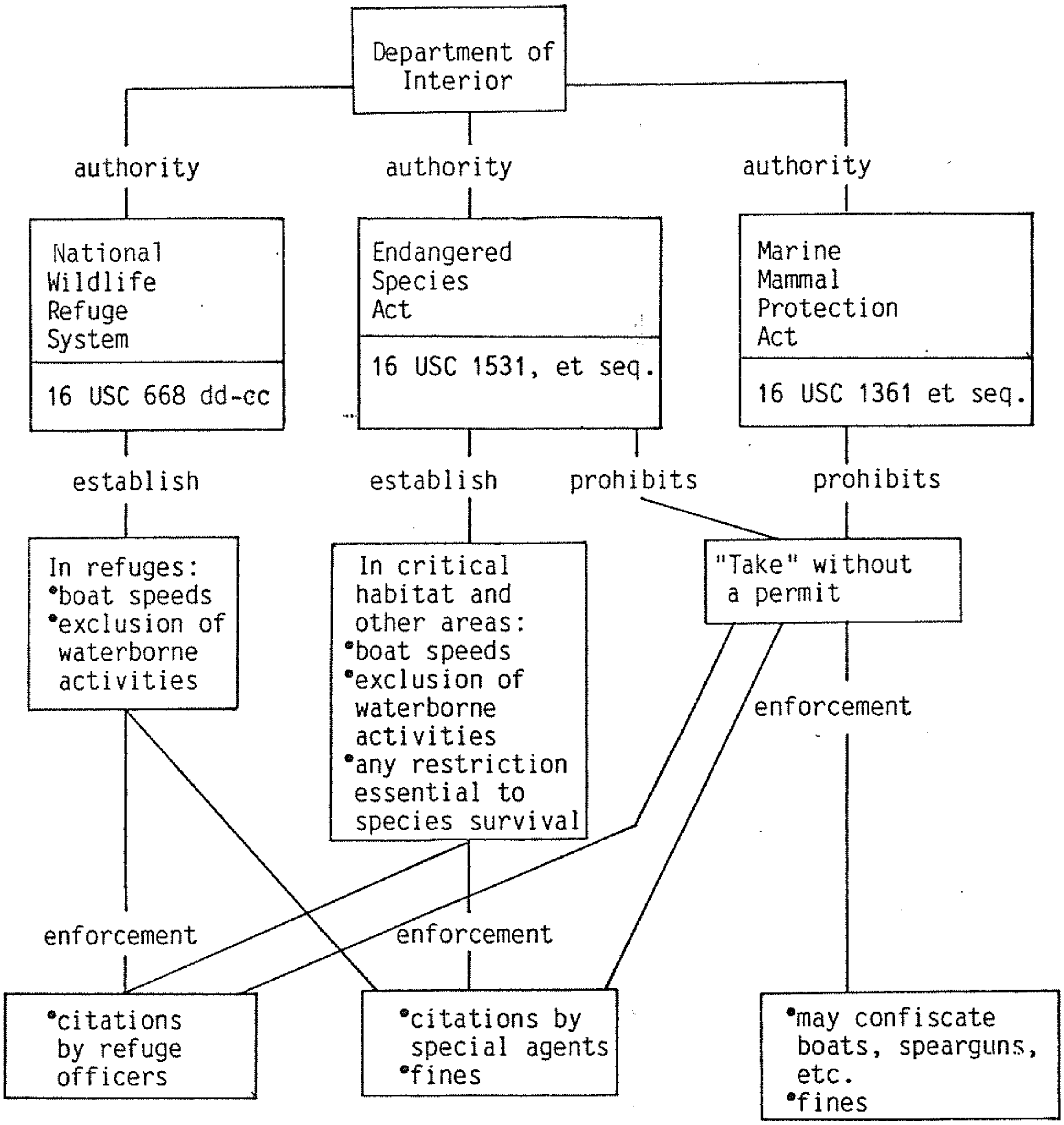

Figure 1. Federal programs to protect manatees from human waterborne activites.

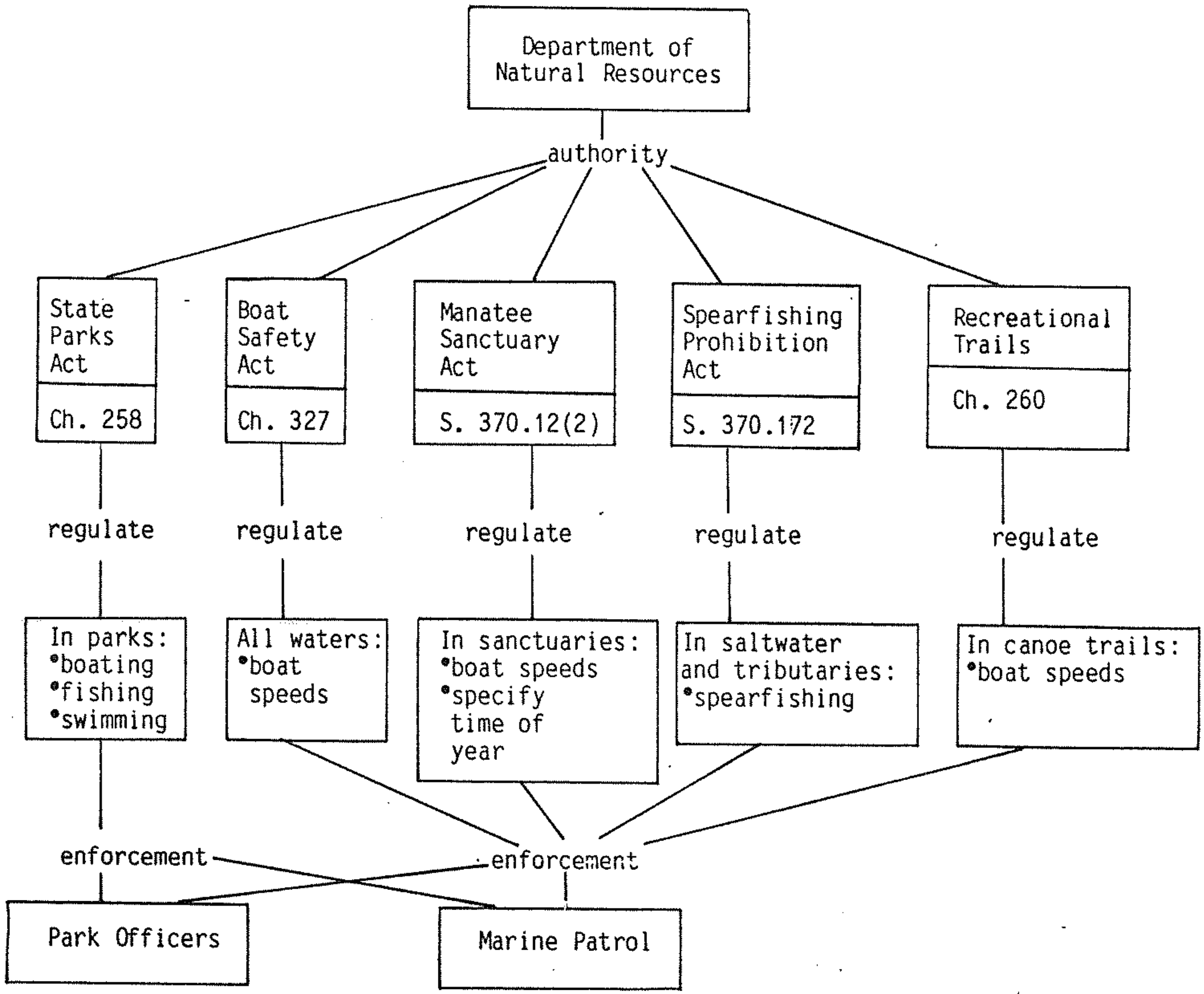

Figure 2. Department of Natural Resources' authority to control waterborne activities for protection of manatees.

should be noted that the state may not exclude traditional boating, swimming and fishing activities in state designated Aquatic Preserves[13].

3. Local Restrictions

Although the authority of city and county governments to exclude waterborne activities from designated areas is not expressly provided, local governments have such authority within their areas of jurisdiction (Fig.3) as long as they are not preempted by state or federal regulations[14].

4. Evaluation and Recommendations

The designated locations within the study area which exclude waterborne activities to protect manatees are minimal. Unfortunately, uncertain legal rights surround the issue of excluding waterborne activities from the nation's waters because of the general "riparian" and "navigation" rights which accrue to the adjacent landowners and the citizens of this country. There are many legal decisions which deal with these issues but they are usually unclear and often conflicting. For this reason, the exclusion of boats from open public waters may be difficult to achieve and should only be undertaken when a clear and convincing public need exists.

If it is necessary to restrict waterborne activities from certain areas, it is recommended that the Secretary of Interior designate additional sanctuaries. This approach has worked in the past and a clear designation mechanism exists[15].

Should a connection be shown between boat collisions with manatees and a clear danger to the boating public, it is further recommended that DNR establish exclusion zones under the powers granted in the boating safety act[16].

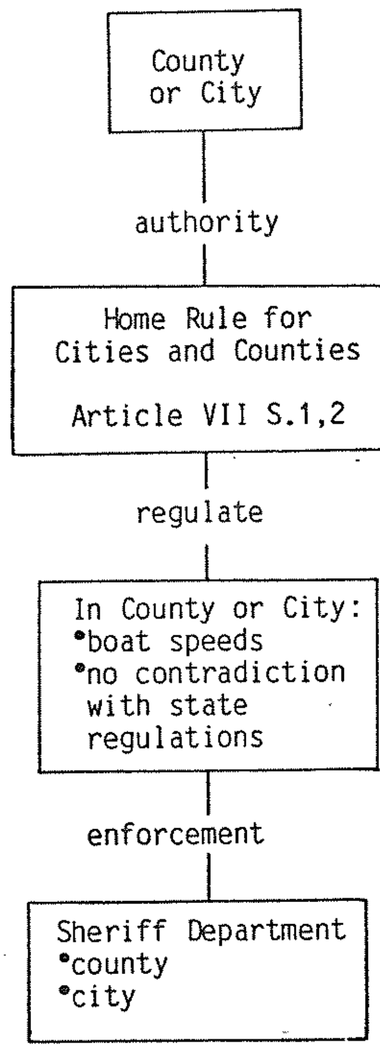

Figure 3. Authority of local governments to regulate boat speeds to protect manatees.

B. Boating Speed Restrictions

The federal government has the authority to restrict boat speeds in all waterways that contain manatees. However, this authority has only been exercised in National Wildlife Refuges. The state government can restrict boat speeds in legislatively designated Manatee Sanctuaries to protect manatees and in other public waters for the safety of the boating public. Local governments can adopt speed restrictions in the public interest by ordinance as long as they are not preempted by state or federal law.

1. Federal Restrictions

The provisions of ESA and the MMPA give the Secretary of Interior general authority to enact regulations protecting manatees from the occurrence of a "taking"[17]. This is the same authority the Secretary used in enacting the regulations that provide for the federal manatee sanctuaries in Kings Bay. Using this rationale, if excess boat speeds would injure manatees, this activity would be considered a "taking" and could be regulated by the Secretary.

ESA permits the Secretary of Interior to designate certain lands and waters as "critical habitat" for manatees[18]. In this case, however, designation did not give any additional specific protection to manatees except to act as a "notice" to all federal agencies that an endangered species is present and the provisions of section 7 may apply[19].

The federal government also has specific power to regulate activities that may harm manatees within the National Wildlife Refuge system. This power comes directly from the ability of the government to manage its lands and wildlife20.

At the present time, the only boat speed limits established by the federal government within the study are in the Chassahowitzka National Wildlife Refuge[21]. The state boat speed regulations describe below have also been adopted by the federal government and may be enforced by any federal officer[22].

2. State Restrictions

The Florida Legislature has designated the whole state as a manatee sanctuary and established speed restriction zones in various water bodies which are often used by manatees[23]. Pursuant to this act, DNR established winter speed limits within most of Kings Bay and the Homosassa River (November 15 to March 31), and summer speed limits in the Withlachoochee River (March 1 through September 30)[24]. The 1983 legislature increased the power of DNR to allow the establishment of speed restrictions in these zones at any time during the year that manatees are present (Chapter 83-81, Laws of Florida). DNR also has the power to set speed limits for boats in any of the state's waters if it is required for the safety of the boating public[25]. However, at the present time, no speed limits have been established for the purposes of boating safety to avoid collisions with manatees.

Speed restrictions for boats may be enforced by DNR's Marine Patrol, the Game and Fresh Water Fish Commission's (GFC) Wildlife Officers[26] (Fig.4), the local sheriff or any appropriate federal officer, usually the FWS and/or Coast Guard[27]. Violations of the state rules are second degree misdemeanors with prison terms up to sixty days and fines up to $500[28].

3. Local Restrictions

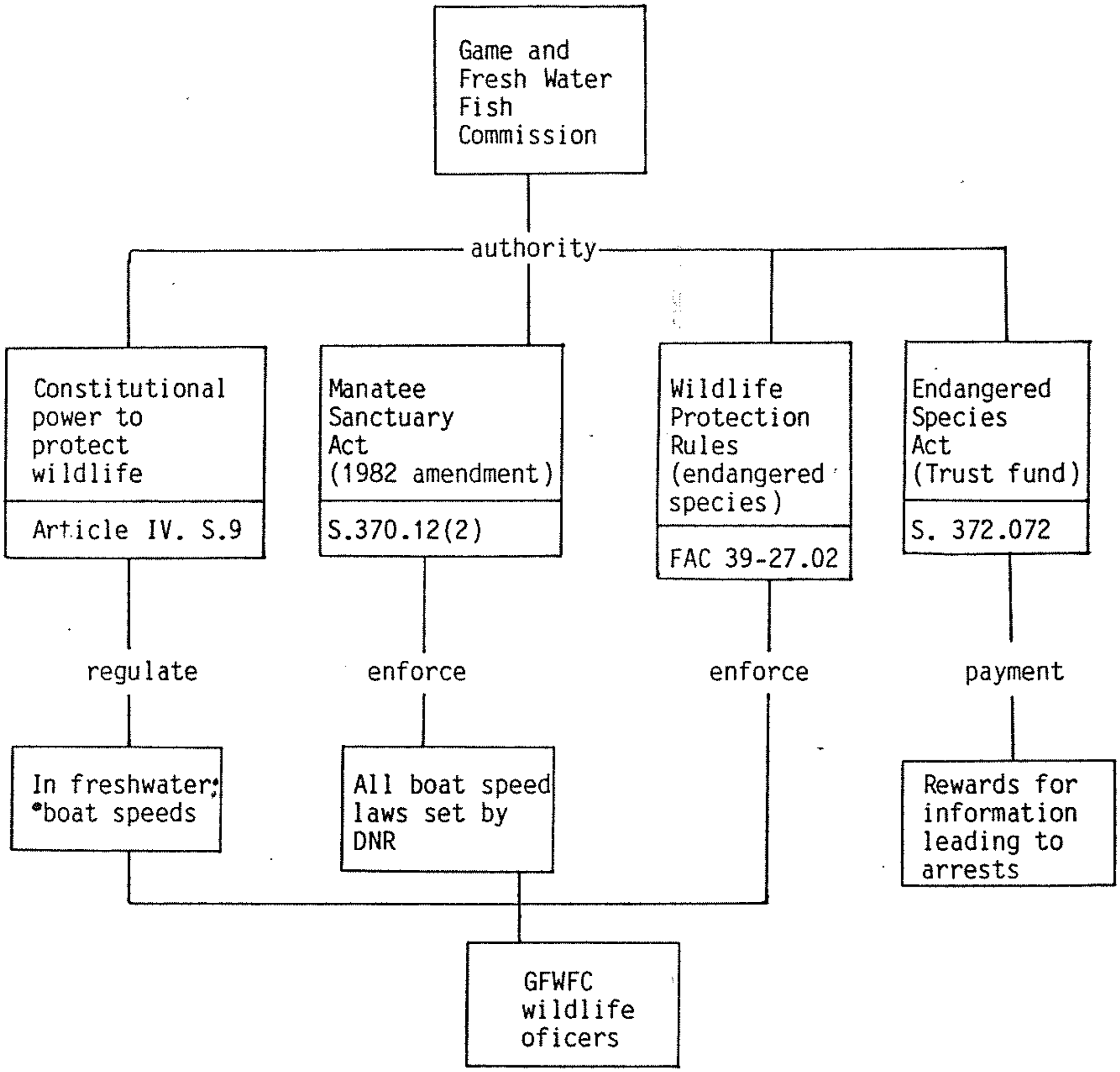

Figure 4. Control of boat speeds by Game and Fresh Water Fish Commission.

Currently, no local ordinances controlling boat speeds have been adopted. Regulation of boat speeds near marinas is under consideration by Crystal River City Council and the Citrus County Commission.

4. Evaluation and Recommendations

The speed restrictions have been enforced relatively well in some areas and poorly in others. The main reason for the uneven enforcement seems to be lack of personnel and a difficulty in posting the appropriate signs. These signs have not been placed in some areas or have been dismantled by weather or vandals. In addition, many areas frequently used by manatees have not been designated for speed restrictions either by the legislature or DNR and have no protection at the present time.

In order to correct these problems the following recommendations should be considered. First, seek additional funds to pay for proper placement of signs in legislatively designated areas. Second, seek increased enforcement personnel or expand the volunteer "Manatee Watch" to aid in public education. Third, designate additional locations within the study area where speed restrictions should be imposed and request appropriate legislation to accomplish this end. Alternatively, request the Secretary of Interior to designate additional manatee protection areas with appropriate speed restrictions as permitted by ESA and the MMPA.

C. Hazardous Fishing Gear

Federal and state laws permit the regulation of fishing gear that is hazardous to manatees but few regulations have been issued for that purpose to date.

1. Federal Regulations

There are no federal regulations regarding the use of fishing gear that may be hazardous to manatees. However, the Secretary of Interior may regulate hazardous gear under provisions of ESA and the MMPA if the use of the gear could constitute a "taking"[29].

2. State Regulations

Although the state DNR and GFC have the power to control all aspects of fishing, they have not chosen to regulate specific gear to protect manatees within the study area. The authority of DNR to control the taking of saltwater fish carries with it the ability to adopt rules that would restrict the types of lines and nets that are used in areas frequented by manatees[30]. The 1983 legislature established the Marine Fisheries Commission within the DNR, which will have broad powers over saltwater fishing, including potentially dangerous equipment[31]. It is too early to determine the impact of this Commission on manatee protection but it should be carefully monitored. A similar power resides in the GFC for freshwaters[32].

Spearfishing is controlled in saltwater by DNR[33] and in freshwater by GFC[34]. At the present time, no taking of fish is allowed by speargun in fresh water within the state. However, non-game fish species may be taken with a bow, gig or snatch hook from the surface[35]. There are numerous restrictions imposed on spearfishing in saltwater by the State which have an impact on the study area[36]. Recent conversations with Marine Patrol personnel indicate there is little spearfishing in the study area at the present time.

3. Local Regulations

Regulation of fishing activities by local governments is prohibited under state statute[37].

4. Evaluation and Recommendations

It is recommended that DNR (through the Marine Fisheries Commission) and GFC work together to adopt requirements for biodegradable nets and lines used in waters frequented by manatees. The Marine Fisheries Commission should also develop regulations which would prevent entanglements with crab, shrimp and baitfish traps, such as requiring line sleeves.

There is sufficient laws available to control spearfishing within the study area if it should prove necessary. Criminal penalties and confiscation of gear and boats are adequate deterrents for most violators, though inadequate enforcement due to lack of personnell effort may sometimes be a problem[38].

If additional controls are needed, it is recommended that the Marine Fisheries Commission request the Governor and Cabinet to enact rules prohibiting spearfishing in the problem areas.

IV. EDUCATION

Education of the public about the problems encountered by manatees within the study area may be more important than the recommended legal changes at any level of government. Where there is resistance to restrictions and bureaucracy, regulations may actually encourage criminal acts. As is true with most areas of the law, when people know about the problems to be avoided, they will go out of their way to make certain that the anticipated harm will not occur. This should be particularly true with manatees where a great deal of public acceptance and concern has been generated over the last few years. This section of the report will discuss the opportunities for support of educational programs on governmental levels which could assist in manatee protection (Fig. 5).

A. Federal Programs

There does not appear to be any educational program on the federal level that is specifically directed to manatees or environmental studies[39]. However, section 6 of ESA provides for financial assistance to the states for programs for the conservation of endangered species and DNR has used these federal funds for informational and educational programs for manatee protection. There is no reason to believe that any additional funds could not be used for similar purposes if the state-federal cooperative agreement included the description of a program using these funds for the purposes specified[40]. It should be noted that these funds are given on a federal to state match[41].

B. State Programs

The Florida Legislature passed the Environmental Education Act in 1970 for the purpose of increasing the environmental awareness and problem solving through the creation of the office of Energy and Environmental Education in the Department of Education. A major portion of the program is providing small mini-grants for public school teachers, schools or school systems. These grants range from $2,000 to $10,000

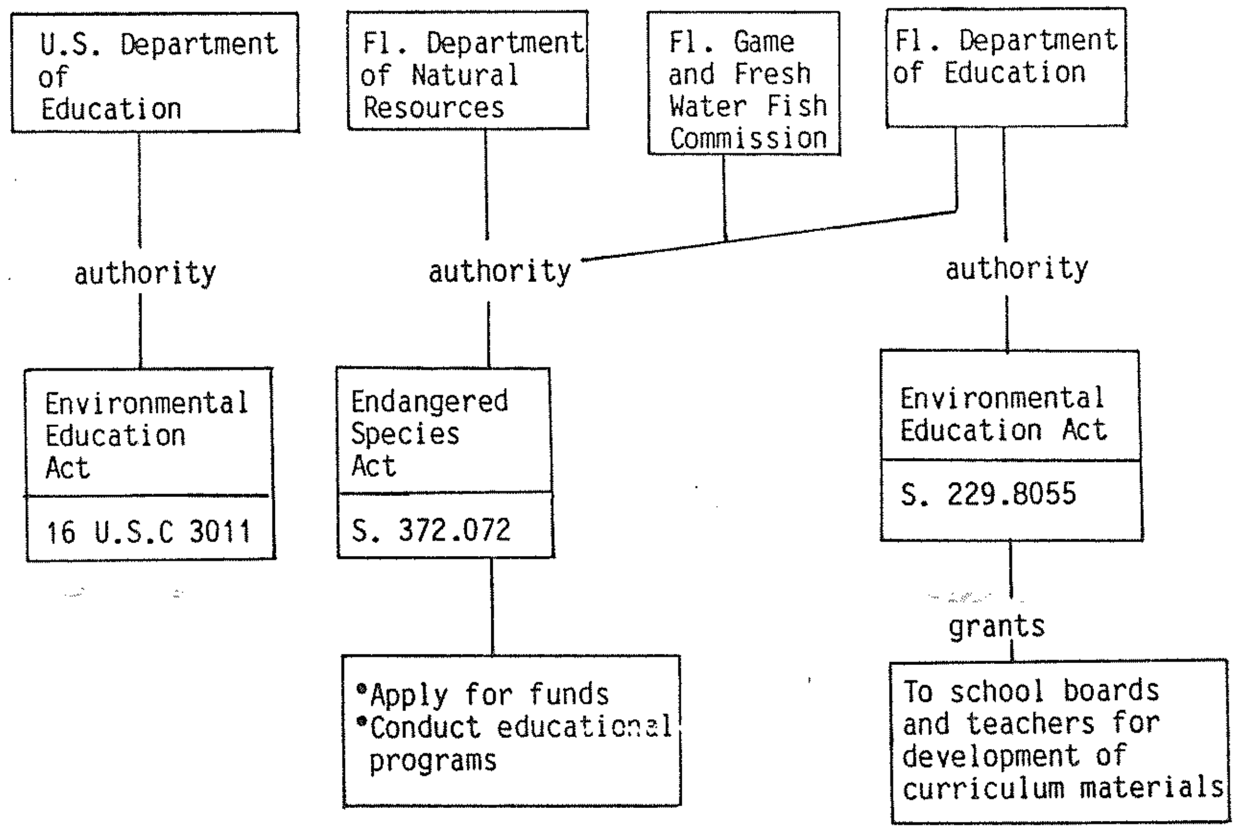

Figure 5. Federal and state programs relevant to public education regarding manatees.

depending on the size and impact of the project and are available to all systems through the state. Grants for manatee awareness information have been given in the past but this should not restrict the compilation and dissemination of new information[42].

Information on the mini-grant program is available from the Florida Department of Education. Objectives are as follows:

> The concept of the state mini-grant program is to apply seed money to ideas, people, and programs that will enable them to take the first steps in implementing an environmental education program or activity in their school or county that will serve as a county or state model.

In reviewing grants priority consideration is given to:

1) interdisciplinary environmental education applications;
2) programs addressing urban environmental education materials, activities and teacher training;
3) projects that would clearly serve as district or state environmental education models;
4) direct active involvement of students, teachers, and community members in the environmental education project;
5) projects where alternative funding sources were not reasonably available;
6) individual school proposal submissions.[43]

C. County Programs

Each county in Florida is a separate school district controlled by its own school board [44]. The school board has the power to establish programs for teaching the subjects specified and allowed by state law[45]. Environmental education is one of the allowed subjects and manatee awareness could be considered a valid subject for any teaching program[46]. One example of an educational program which includes information about manatees is conducted by the Citrus County Marine Science Center.

D. Evaluation and Recommendations

The manatee awareness programs conducted through the county school system may be enhanced by funds from the state mini-grant program. Application for funds to develop materials may come from a teacher, school, or school district. In order to educate the public outside the school system, a joint state and federal program is recommended. The DNR (in cooperation with any other state or local agency) should propose an amendment to the cooperative agreement with the Department of Interior, specifying the need for educational funds and designating a source of matching funds "in kind" contributions. Though it is outside the purview of this report, consideration should also be given to private programs such as the one sponsored by Florida Power and Light Company and Florida Audubon Society. As the availability of government funds decrease, the private sector will play a more important role in the process.

NOTES

1. Packard, J.M. 1983. Proposed Research/Management Plan for Crystal River Manatees. Volume II. Technical Plan. Gainesville, Fl. 235pp.
2. MMPA - PL 97-58, §104; ESA - 16 USC 1539.
3. MMPA - PL 97-58, §3(12).
4. ESA 16 USC 1540 (a)(1) Civil Penalties
   1540 (b)(1) Criminal Penalties.
5. Florida Manatee Sanctuary Act, §370.12 (2)(d),F.S.
6. 50 CFR 17.108.
7. 50 CFR 17.104(a).
8. 50 CFR 17.102.
9. §258.07(2), F.S.
10. Chapter 327, F.S.
11. §327.04 and §327.02(14), F.S.
12. §380.05, F.S.
13. §258.43(1), F.S.
14. Article VIII, Sections 1, 2, Florida Constitution, 1968.
15. 50 CFR 17.104 - 108.
16. Chapter 327, F.S.
17. See MMPA §3, 101(a), 102(a)(2), 104, 105, 112(a), (16 USC §1371 (a), 1372 (a)(2), 1374, 1375 and 1382(a)). ESA §§4(d) and (f), 9(a)(1)(G) and 11(a)(1),(16 USC §1533(d) and (f), 1538(a)(1)(G), and 1540(a)(1)).
18. 16 USC §1533.
19. 16 USC §1336.
20. 16 USC §668 dd-ee.
21. 50 CFR §26.
22. 50 CFR §17.104(c).
23. §370.12(2)(f)7, F.S.
24. §370.12(2)(h),F.S.

25. Chapter 327, F.S.

26. §370.12(2)(j), F.S.

27. 50 CFR §17.102

28. §370.021(1), F.S.

29. See Note Number 17.

30. §370.10 and 370.021(1), F.S.

31. See: SC/CS/HB 194,224,244,285,442, 1983 Florida Legislative Session. Chapter 83-134, Laws of Florida.

32. Article IV, Section 9, Florida Constitution, 1968.

33. §370.172, F.S.

34. See Note Number 32.

35. §39-23.02(3), F.A.C.

36. See the Local Marine Patrol Office in Crystal River for these restrictions.

37. Section 370.10, F.S.

38. Section 370.12(3), F.S.

39. 16 USC, §3011-3018 (Repealed 1978).
    34 CFR §758 (still existing but based on repealed law).

40. 16 USC §1535 (d)(1),(2).

41. 16 USC §1535 (d)(2)(i).

42. §229,8055, F.S.

43. 1978-1979 Pinellas County School Board, Anderson Environmental Education Center - Sawgrass Lake.

44. §230.01, F.S.

45. §230.031, F.S.

46. §229.8055, F.S.

GLOSSARY

F.S.	-	Florida Statutes, 1982.
F.A.C.	-	Florida Administrative Code.
USC	-	United States Code.
CFR	-	Code of Federal Regulations.

LEGAL REVIEW REGARDING WATER QUALITY AND AQUATIC WEED CONTROL IN MANATEE HABITAT

David Gluckman, Esq.

I. INTRODUCTION

The direct impact of water pollution discharges on the manatee population of the Crystal River area is not clearly understood at the present time. However, it has been postulated that wastes from numerous sources being discharged into the waters of the area are, or have the potential to, cause harm if they are not reduced or stopped in the future.

The purpose of this section of the report is to give a brief description of the efforts on the federal, state, and local levels to control these problems with recommendations for changes which will help protect and preserve the manatee populations of the study area. This section will also analyze the state and local aquatic weed control programs on all governmental levels, setting forth the provisions of present law or any needed changes that will allow alteration of these programs should they be found to be causing harm to the manatees in the study area.

II. WATER QUALITY LAWS

A. Limitations and Standards

Before reviewing the specific permitting processes[1] the reader must understand how the types of standards are established. The U. S. Environmental Protection Agency (EPA) sets technology based "effluent limits" which are to control the amounts of pollutants discharged from the end of the pipe of an industrial or sewage facility [2] (Figure 1). The Florida Department of Environmental Regulation (DER),through its Environmental Regulation Commission (ERC), sets "water quality standards" that control the actual conditions of the body of water receiving the pollution from the end of the pipe[3]. The EPA then adopts the state water quality standards as their own and is required to enforce them in their separate permitting processes. DER has adopted the federal effluent limits (and one or two more stringent standards of its own) as well as its water quality standards and also enforces both[4].

If the discharge from the pipe meets the effluent limit standard but will cause the water quality standards to be exceeded the state can impose a more stringent requirement of treatment at the end of the pipe called "water quality based effluent limits". This standard is determined by running a computer model of the water body receiving the discharge and using that information to determine the new standards. The water pollution control programs that are described below use all three standards as the basis for granting or denying permits.

B. Sewage Treatment Facilities

1. Individual Sewage Disposal Facilities

Septic tanks and small package plants under 5,000 gallons are regulated by the Florida Department of Health and Rehabilitative Services through their county health departments[5]. (Figure 2) Septic tanks are allowed throughout the state if soil conditions are acceptable and no more than a certain number are located per acre of deve-

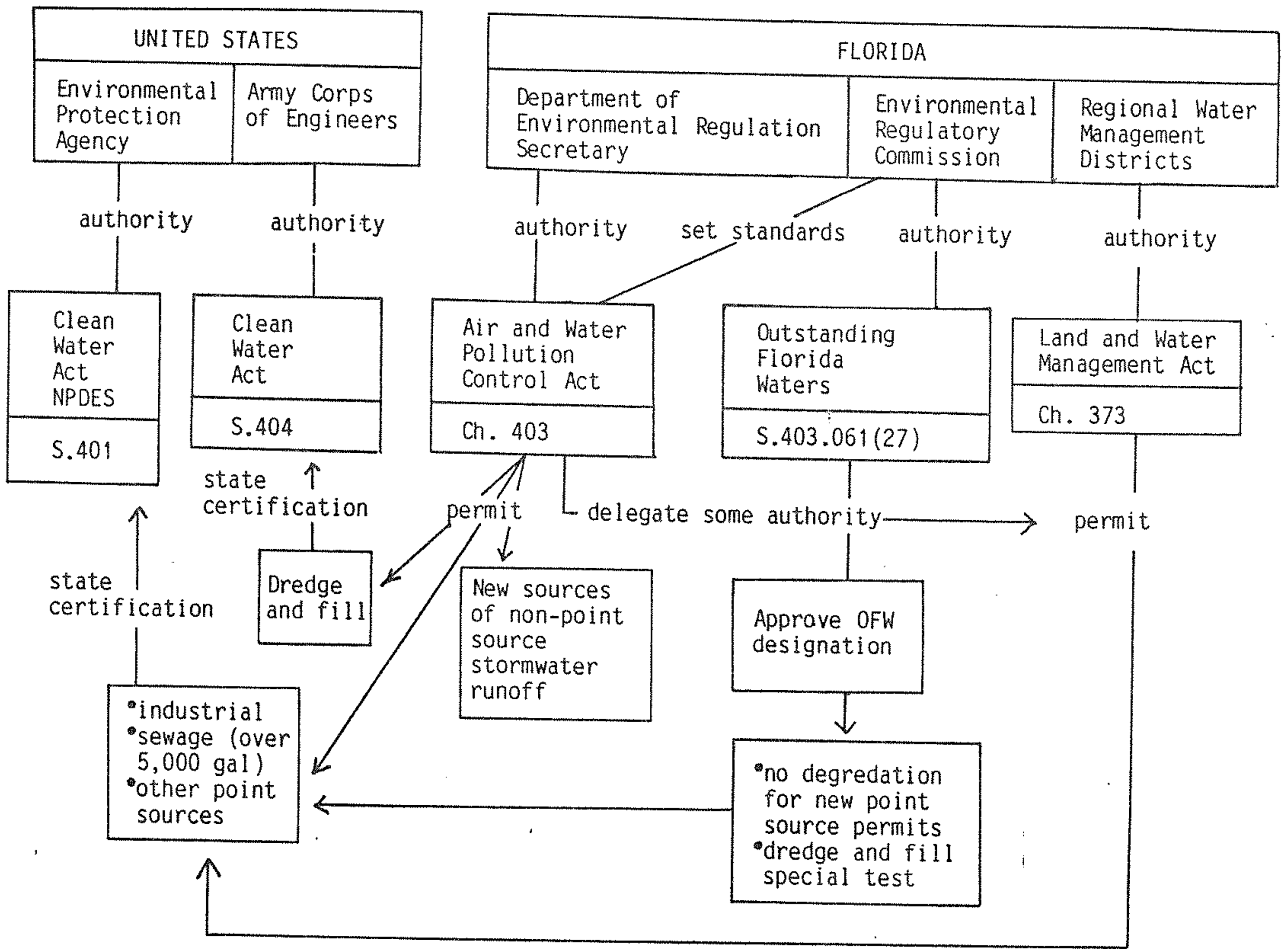

Figure 1. State of Florida water quality permitting process.

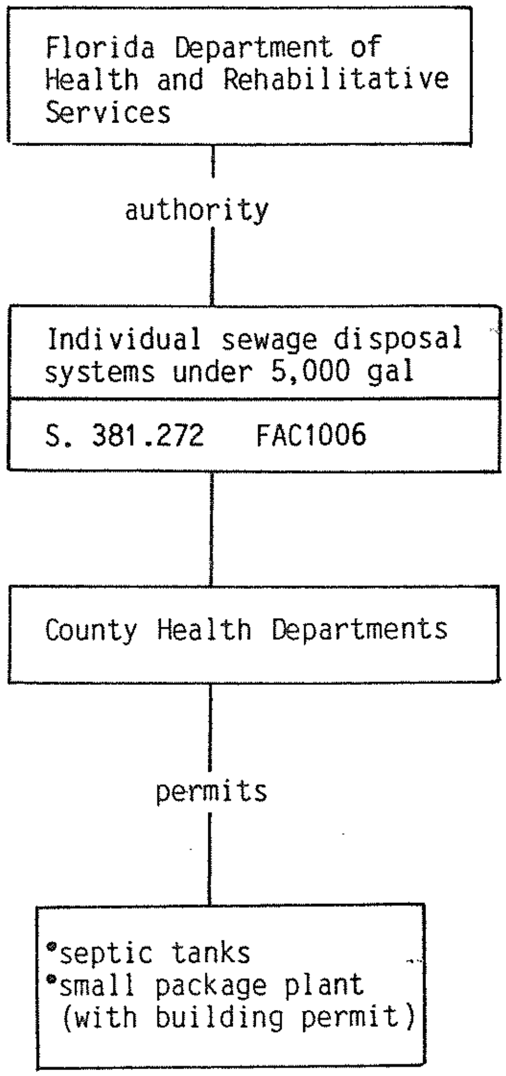

Figure 2. Individual sewage disposal systems less than 5,000 gal.

loped property. The county health departments issue septic tank permits at the same time as building permits. Though the local health departments have full authority to require that problems which have been brought to their attention be corrected, there are no established programs to check on the operation of septic tanks after they are installed. Small package plants are covered by the same regulations and handled in a similar manner.

The program that allows for the installation of individual sewage treatment facilities has probably been more poorly run than any other environmental program on the state or local levels. Permits are rarely denied, even if soil conditions or water proximity indicates that problems will arise in the future. There are no inspection programs for existing systems and few restrictions have been established that will cure their impact on adjacent water bodies[6].

One of the reasons for the lax enforcement has been that is was assumed that most of these small systems would be incorporated into large regional systems as soon as they were constructed (required by Section 381.272, F.S.). Unfortunately, many areas grew too fast and there were not enough regional systems to go around. In addition to this problem, the federal grant program which provided money to construct new regional systems has been severely reduced. For these reasons, it appears that future clean up in this area will be slow. Another difficulty is that little research has been done to find damage that might be occurring from these small sources. Without such information enforcement is not possible. The following recommendations should be followed if problems are discovered. First, the local health departments should be notified and requested to help stop problems from individual systems that are not properly functioning. Second, existing small systems should be connected to properly functioning central sewage systems when they become available. Third, local health departments should be closely monitored to assure that permits for new septic tanks and package plants are denied if soil conditions are not appropriate for teating the wastes received. Fourth, more emphasis should be given to alternative sewage disposal methods in areas where small systems will not operate properly. The "clivus multrum" and similar waterless disposal systems are available in Florida, and, if required, could help alleviate the problems caused by improperly sited small systems.

2. Large Sewage Treatment Plants

Sewage disposal facilities in excess of 5,000 gallons daily flow are controlled by the federal and state governments pursuant to provisions of the Federal Clean Water Act[7] and the Florida Air and Water Pollution Control Act[8], respectively (Figure 1). All discharges into the waters of the United States and the State of Florida must meet the effluent limits and water quality standards established by each government, including the water quality based effluent limitations established by the state. (For all practical purposes the standards on the federal and state levels can be considered the same for sewage treatment plant enforcement). The federal program is run by EPA and the state program by DER. The larger regional plants are generally owned and operated by local governments.

All sewage treatment plants are required to be operated by a properly certified operator[9] who must monitor and submit reports of the quantity and quality of its discharges to DER. If the plant is not meeting its permitted limits, the state or federal government as well as affected citizens and groups may bring enforcement actions[10]. If a plant is meeting its permitted limits but damage is occuring to the animals in the water the permit can be modified to require more stringent limits[11]. (Numerous additional remedies are also available[12].)

At the present time, few changes in the law appear to be needed in this area. The legal framework is available to correct harm to manatees if any is discovered. However, the administration of the sewage treatment programs on the state and federal levels is often controlled by political rather than environmental considerations. Though sewage hookups should be prohibited after a plant exceeds its treatment capacity, this usually only occurs after extensive negotiations and the addition of sewage far in excess of what should be allowed. Overloaded plants (which violate state and federal standards) are often permitted to be operated for many years before remedial action is taken.

The following recommendations should be considered in this area. First, appropriate research should be conducted to determine if discharges from sewage plants within the study area are causing damage to the manatee populations. Second, if harm is discovered notify the appropriate federal, state and local authorities. Third, if no action is taken, request that no additional hookups be allowed until the problems are corrected. Fourth, prior to the completion of the studies suggested in the first recommendation, all plants should be checked to make certain they are meeting the present federal and state standards. If they are not, immediate moratoria on hookups should be requested until standards are met.

The remedies provided by the National Environmental Policy Act[29] and Section 7 of the Endangered Species Act[30] apply to the federal involvement in this program (Figure 3). See Section   of this report for an explanation of these acts.

C. Stormwater Discharge

The impact of stormwater disharges is controlled by the DER[13] and EPA through its National Pollution Discharge Elimination System (NPDES) permitting and certification program[14](Figure 3). The state system requires permits for all new and existing discharges from pipes, or discrete structures and for all new sources which cause sheet flow to reach the state's surface waters, whether from a pipe or over the ground. The federal system requires permits only for discharges from pipes or discrete structures.

The state permitting process for new projects may be delegated to any of the water management districts, though none have accepted this delegation in the study area. There are also numerous exemptions to the process for certain small projects that are allowed by state rule[15].

Because of the magnitude and expense of correcting this problem in Florida there has been little real control on either the state or federal levels. Many existing sources have no permits at the present time nor is there much hope that permits will be sought or issued in the near future. Even if permits are issued, there are few realistic limitations that can be placed on the discharges that will reduce their impacts without the expenditure of more money than is presently available.

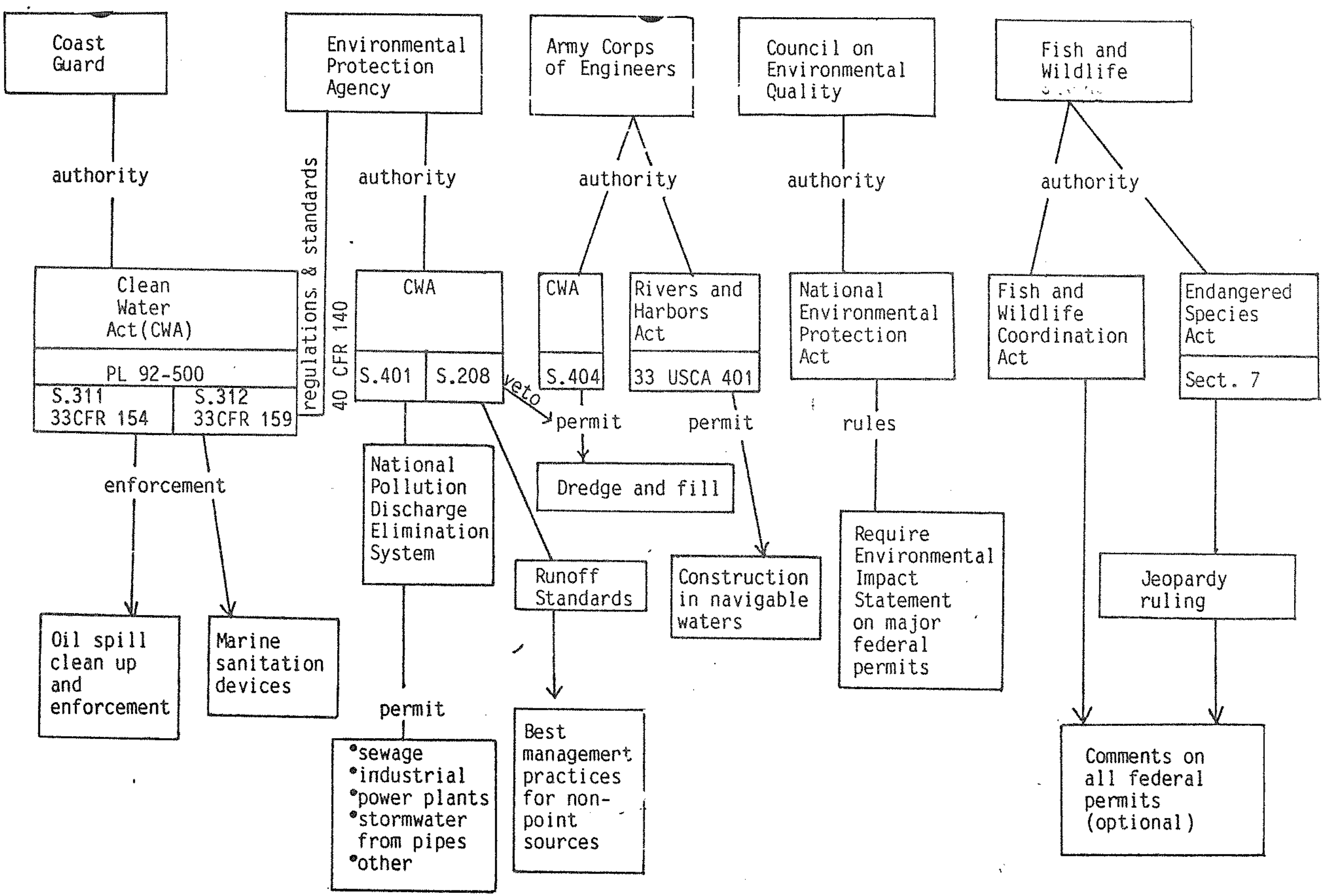

Figure 3. Federal laws regarding water quality

If stormwater discharges are adversely affecting the manatee populations of the study area, the following procedures may help to limit the problems. First, obtain the location and ownership of the source or sources of the discharges and request copies of any permits previously issued. Second, notify the state or federal agencies of the damage occurring and request that the permitting process be initiated for sources without permits and that a review be conducted of those previously issued. Third, participate in the permitting or review process to assure that the agency's response will, in fact, assist in the resolution of the problem[16]. Particular emphasis should be given to locating new sources which are proposed for construction which will add to the present problems. These are often times easy to correct prior to construction but very difficult after a project is completed.

D. Additional Water Quality Controls

There are other programs on the state and federal levels that appear to be of only minor concern in dealing with potential harm to the manatee populations in the study area. These are shown in detail on the accompanying figures but will receive only brief mention here in the text.

Discharges from industrial facilities are treated similarly to sewage treatment plants by both the state and federal agencies[17]. Oil spill control is covered by the federal government under the Clean Water Act[18] with jurisdiction in the EPA and the Coast Guard for various functions (Figure 3). The state oil or chemical spill prevention and cleanup program is administered by the Department of Natural Resources[19](Figure 4). The chemical spraying of mosquitoes is done by the local

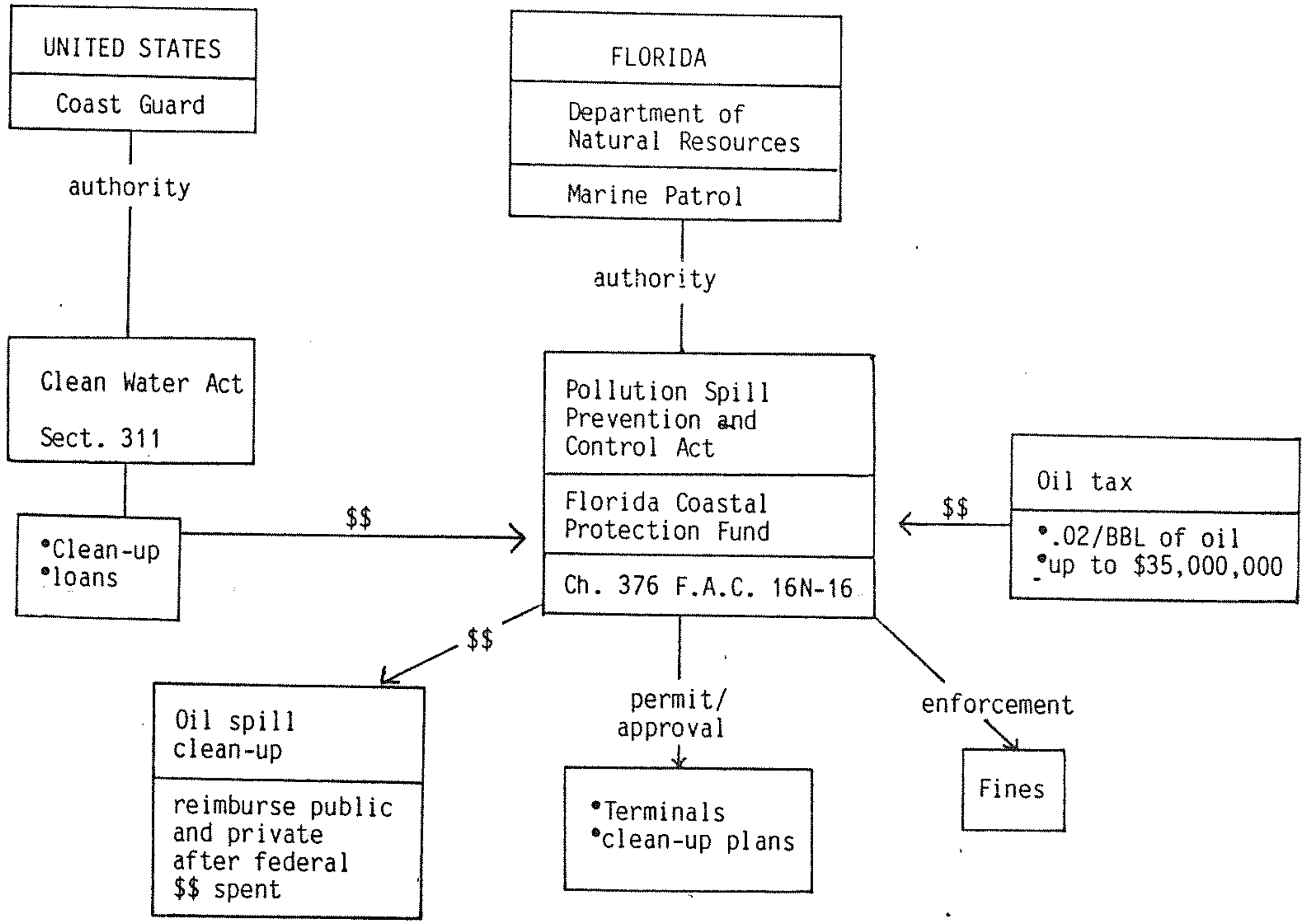

Figure 4. Oil spill prevention and clean-up by the state of Florida.

governments[20] while certification of applicators and chemicals is done by the State Department of Agriculture and Consumer Affairs[21] and the U.S. Environmental Protection Agency[22]. (Figure 5). Standards for radiation from nuclear power plants are established by EPA and monitored by the U.S. Nuclear Regulatory Commission with some of its functions delegated to the Florida Department of Health and Rehabilitative Services[23]. Siting of power plants is pursuant to the Florida Power Plant Siting Act under the authority of the Governor and Cabinet with staffing by DER and input from various parties[24] (Figure 6).

Should a problem arise under one of these programs it is suggested that the appropriate agency be contacted.

III. AQUATIC WEED CONTROL

Because the manatee population of the study area depends on aquatic vegetation for its food supply, the programs which control the growth and spread of these weeds are very important. Federal, state, regional and local agencies all play a part in the process (Figure 7). This section of the report reviews the aquatic weed program and makes recommendations for changes in those areas with potential impacts on manatees in the South Big Bend region.

A. Federal Programs

The U. S. Environmental Protection Agency (EPA) administers that portion of the program which requires the certification of applicators and the registration of chemicals which are to be used for aquatic weed control[25]. Once a chemical is registered it may only be used for the purposes and in the manner specified on the label. If injury occurs to

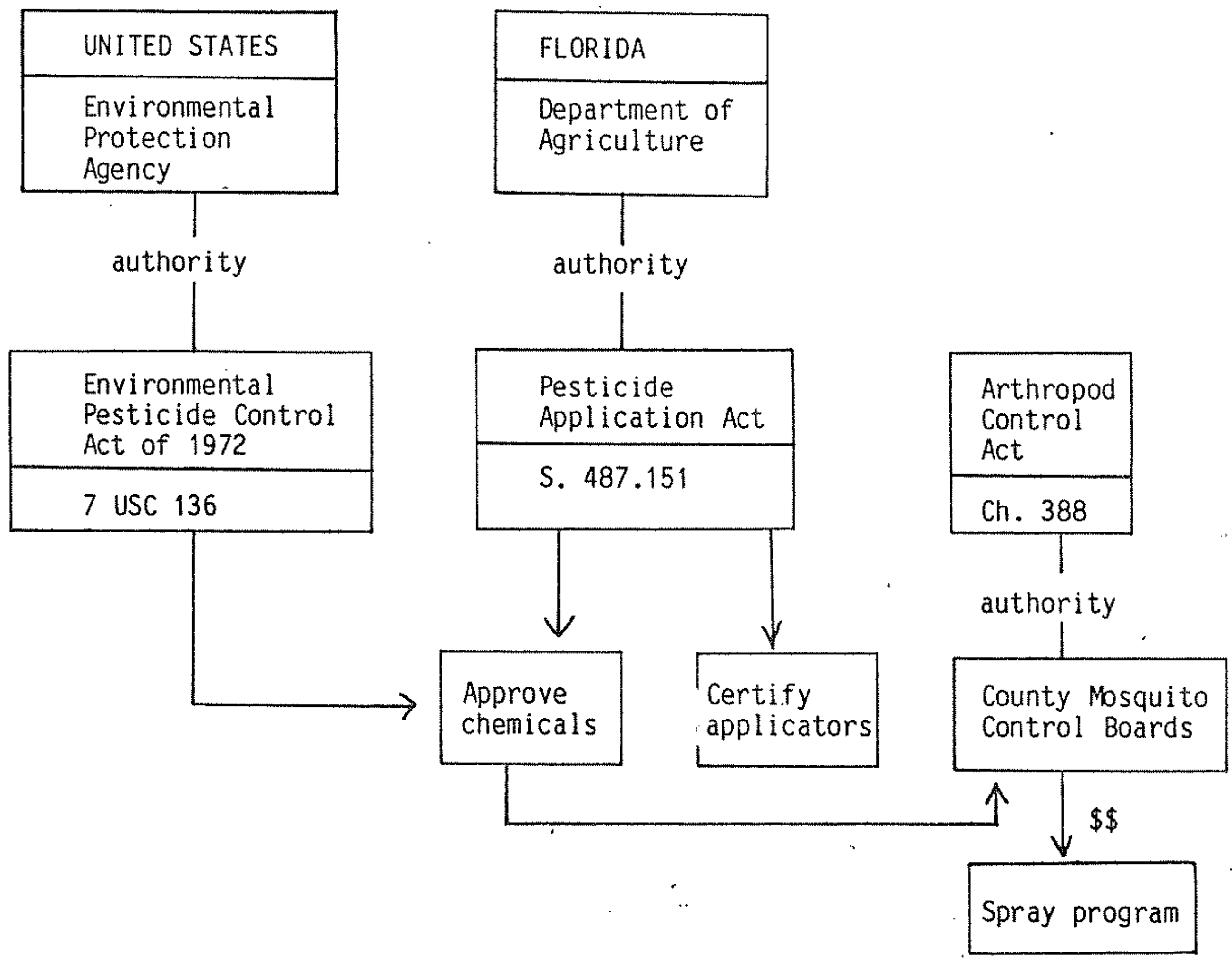

Figure 5. Permitting process for use of pesticides in arthropod control.

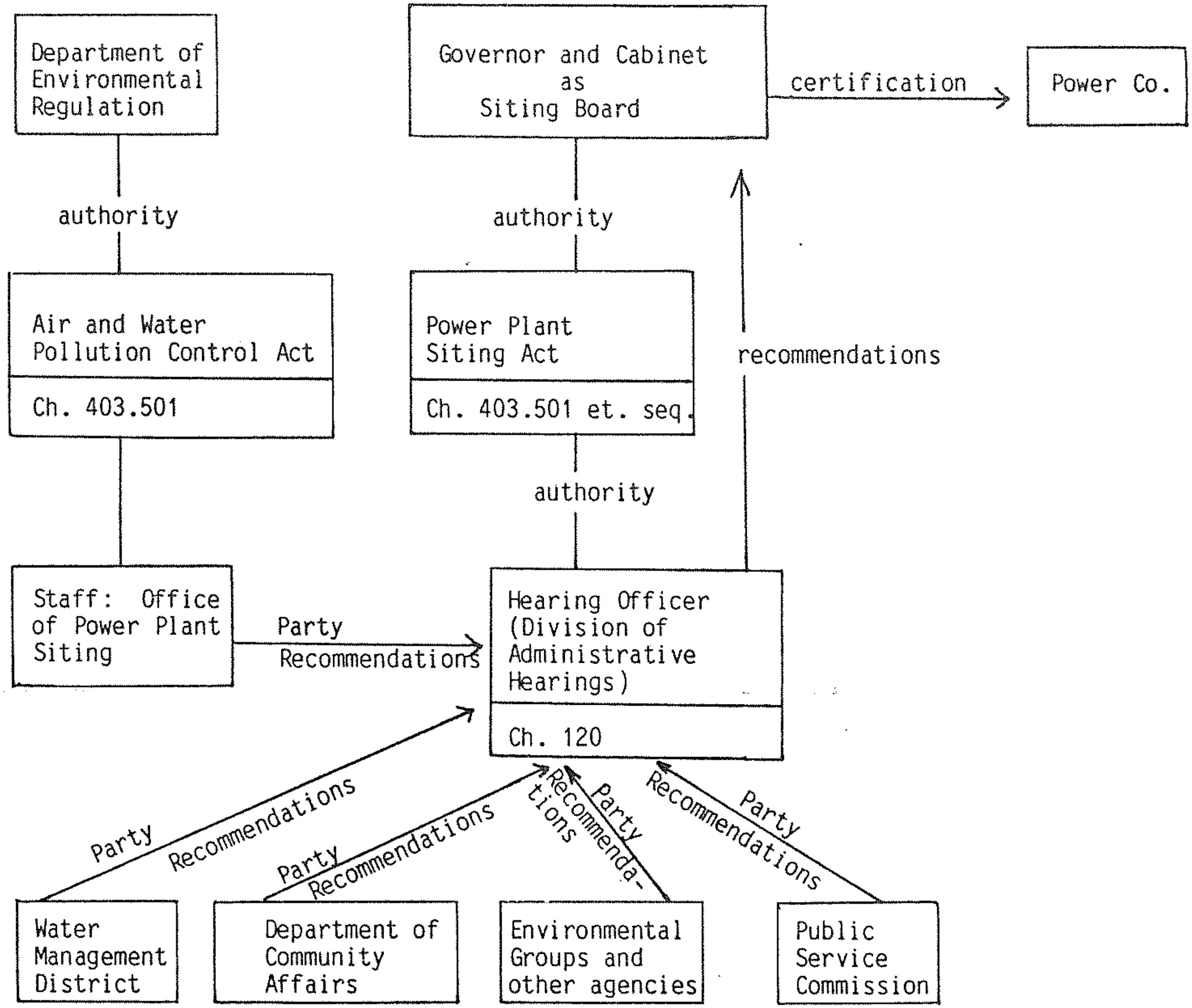

Figure 6. Florida certification of power plant siting.

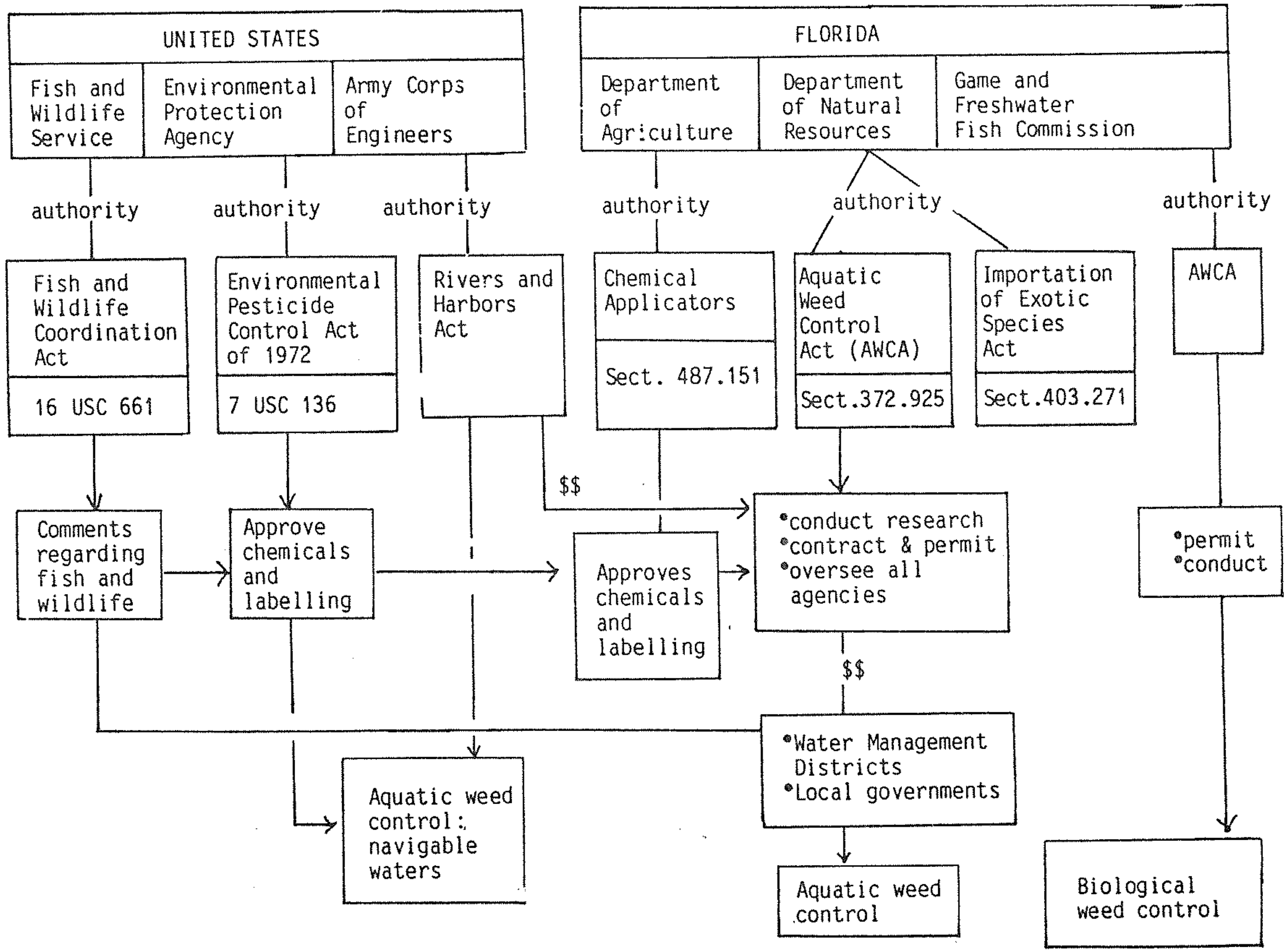

Figure 7. State and Federal laws regarding aquatic weed control.

any endangered species designated under the Endangered Species Act[26] a special "fast track" deregistration is available[27].

The U. S. Army Corps of Engineers (COE) is charged with the responsibility of maintaining the waters of the United States free for navigation[28]. This responsibility includes chemical or biological control of aquatic weeds either through its own programs or through grants to the state for that purpose. The COE applicators are certified by EPA or the state program and use the chemicals registered at EPA. At the present time, they do not directly treat weeds anywhere within the study area although they do provide funding through the state program for such treatment.

Both the National Environmental Policy Act of 1969[29] and Section 7 of the Endangered Species Act[30] apply to the grants and the application of chemicals under this program. (See pp 310-320 for an explanation of these acts.)

B. State Programs

The Florida Department of Agriculture and Consumer Services (DACS) carries out the same functional role as the EPA in certifying applicators and registering chemicals for use within the state[31]. It is very active in the certification role, having received delegation of this program from EPA, but does very little other than accept the EPA registrations for chemical use.

The aquatic weed control program is split between the Department of Natural Resources (DNR) and the Game and Freshwater Fish Commission (GFC)[32]. The GFC licenses and conducts research on biological controls and some chemical applications in conjunction with their research activities. The DNR is responsible for licensing the importation of exotic plants[33], permitting the application of chemicals for the control of aquatic weeds[34], research into aquatic weed control[35] and grants to various regional and local entities for their spray programs[36]. DNR also exercises general oversight authority over the programs.

C. Regional Programs

The Suwanne River Water Management District and the Southwest Florida Water Management District are the two regional agencies within the study area that conduct chemical spraying activities. These water management districts (WMD) receive most of their funds from DNR either as direct grants or pass-throughs of COE monies[37].

D. Local Programs

Many counties in the state have their own weed control programs on a minor scale and a number receive funds for these programs from DNR. Citrus County is the only county in the study area that carries out an extensive program. Most governmental spraying done in Citrus County is done by the county program with COE support. Treatment in Kings Bay is reviewed by DNR, COE and FWS (under Section 7 of the Endangered Species Act) and work done there is performed pursuant to an specific treatment program approved by the U.S. Fish and Wildlife Service.

E. Evaluation and Recommendations

Because there is no hard data on the impact of these spray programs on manatees within the study area, it is difficult to evaluate the present situation. These difficulties may be increased if any damage is discovered because the basic goal of weed control is the elimination and control of aquatic vegetation, a purpose which may be diametrically opposed to preservation of manatee populations. Though protection of wildlife is required if problems are found[38] this requirement has not been tested for manatees.

Problems with the spray programs have been reported from time to time (overspraying or spraying barking dogs on the banks or pouring chemicals directly into the waters) but these have been mainly personality problems and not legal problems with the programs. Enforcement of the controls required by the labels has not been extensive and monitoring of spraying impacts on fish and wildlife is practically non-existant. Because criminal penalties are the only remedies readily available under the present law, the state is slow to take enforcement actions unless actual damage occurs such as large fish kills[39].

The following recommendations should be following to give maximum protection to the manatee population in the study area. First, the Fish and Wildlife Service should request a section 7 review of all areas of heavy manatee use that are presently being chemically sprayed for the control of aquatic weeds. Second, if problems are found, the county and the DNR should be notified of the problem, its probably cause and location. Third, the applicators should be notified to stop or modify applications or the DNR should be asked to make this request. Fourth, if the applicator refuses to stop, either legal or administrative proceedings should be started to enjoin the spraying and to revoke the applicator's permit and/or certification.

If the infraction is serious enough criminal charges may be brought although this remedy is rarely effective because local law enforcement does not like to use criminal penalties against county employees for this type of violation. It is suggested that additional legislation be sought which allows DNR to impose substantial civil penalties for violations of the aquatic weed control acts to avoid criminal penalties except in extreme cases.

After the immediate problem is resolved it is suggested that DNR is requested to modify their permits in the areas where problems are discovered. The most effective means of dealing with long term problems is within the DNR permitting and grant programs. It is also important to request that EPA and the state DACS change the registration and labeling of the treatment chemicals to reflect the new knowledge. The "fast track" deregistration provisions of the federal law can be used for this purpose if necessary[40].

NOTES

1. PL 92-500 and Chapter 403, F.S.
2. §301, PL 92-500
3. §403.061 (10), 17-3 F.A.C.
4. 17-3, 17-4, 17-6 F.A.C.
5. §381.272 F.S., 10D-6 F.A.C.(1983)
6. 10D-6 F.A.C.
7. §401, PL 92-500 (NPDES)
8. Chapter 403 F.S., 17-3,4,6,F.A.C.
9. 17-16. 19 F.A.C.
10.

Federal	- Enforcement	Section 309, PL 92-500
	Citizens suits	Section 505, Pl 92-500
State	- Enforcement	Section 403.121-161 F.S.
	Citizens suits	Section 403.412 F.S.

11. §403.088 F.S., 17-4 F.A.C.
12. Chapter 120 F.S.
13. §403.087 F.S., 17-25 F.A.C.
14. §402, PL 92-500
15. §17-25.03 F.A.C.
16. §120.56 F.A.C.
17. Chapter 403 F.S., 17-3,4,6 F.A.C.
18. §311, PL 92-500
19. Chapter 376 F.S.
20. Chapter 388 F.S.
21. §487.151 F.S.
22. 7 USC 136-1361

23. 42 USC 584-5849, 40 CFR 190
24. 403.501-539 F.S., 17-17 F.A.C.
25. 7 USC 136-1361, 40 CFR 162,164,167
26. 16 USC 1531, et seq.
27. 7 USC 136 (1)
28. 33 USC 610
29. 42 USC 4321 et seq.
30. 6 USC 1531 et seq.
31. §487.151 F.S.
32. §372.925, 39 F.A.C.
33. §403.271 F.S., 16C-19 F.A.C.
34. §372.925 F.S., §372.932 F.S, 16C-50, 16C-20 F.A.C.
35. §372.925 (2) F.S.
36. §372.925 (2) F.S., 16C-50 F.A.C.
37. §372.932 (5), §373.086 F.S.
38. §372.932 (4), F.S.
39. §370.021 (1) F.S.
40. 7 USC 136 (1)

REVIEW OF LAND ACQUISITION PROGRAMS SUITABLE FOR PROTECTION OF MANATEE HABITAT

David Gluckman, Esq.

I. INTRODUCTION

This section of the report will describe and evaluate the various land acquisition programs on the federal, state and local levels that may be used to purchase manatee habitat. It will also include recommendations for legal changes in some of the programs and some specific suggestions for habitat acquisitions within Taylor, Levy, Citrus and Hernando Counties.

II. FEDERAL HABITAT ACQUISITION

A. Introduction

The federal laws contain two major land acquisition trust funds and numerous statutes which give authority to use those funds for the purchase of lands to protect wildlife habitat or water systems[1]. These laws also contain a separate source of funding for coastal protection that may also be used for the same purpose. This section of the report will discuss these laws and evaluate how they may be used to protect manatee habitat within the study area.

B. Land and Water Conservation Fund (LWCF)[2] (Figure 1).

The LWCF was originally established to fund the purchase of outdoor recreation lands throughout the United States[3]. Since its passage, it has been amended numerous times to allow for the purchase of lands for

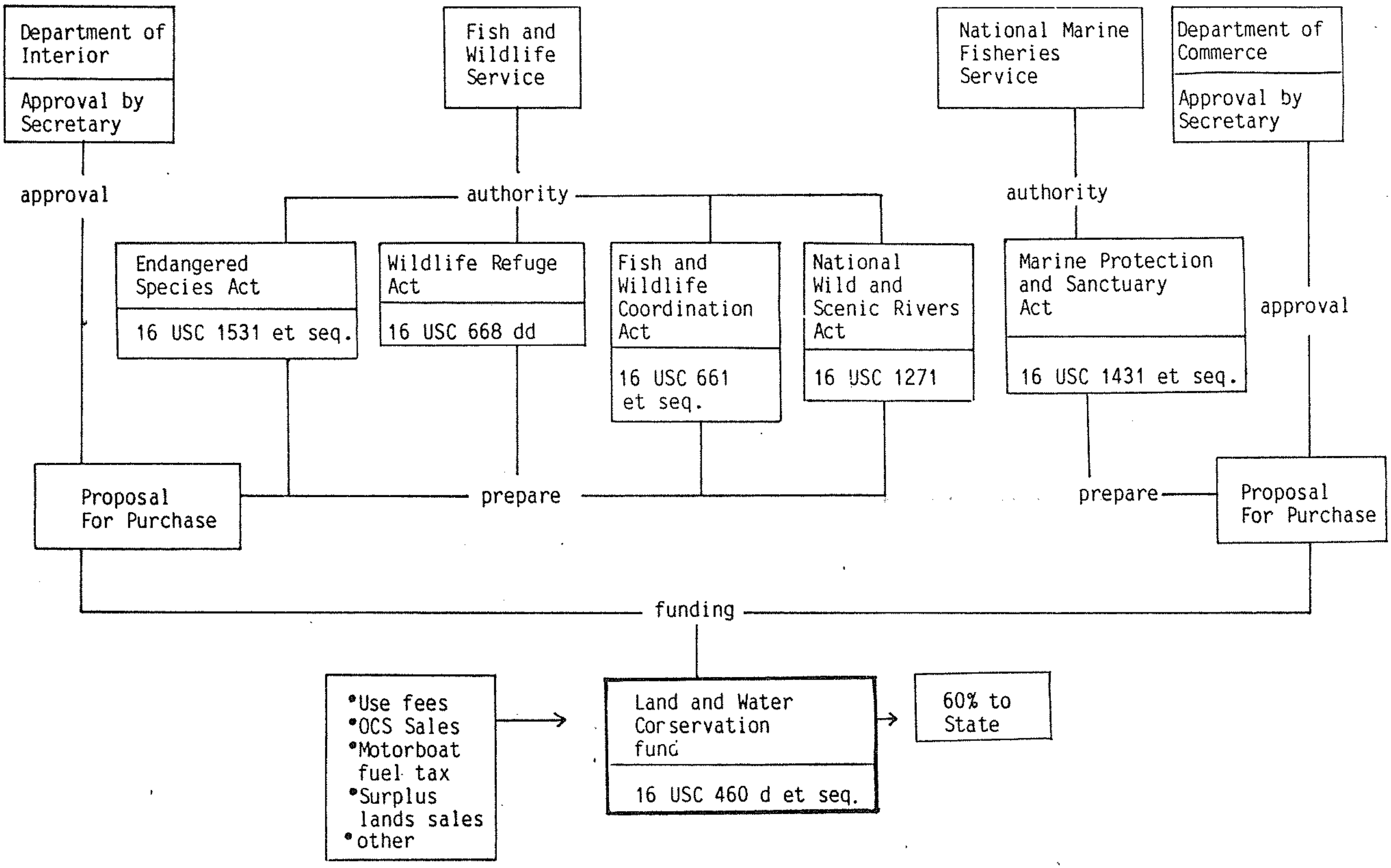

Figure 1. Income and disbursement of the Federal Land and Water Conservation Fund.

wildlife needs as well[4]. It receives funds from the sale of surplus federal lands[5], taxes on motorboat fuels[6], recreational fees[7], sales of OUter Continental Shelf mineral rights and general appropriations, among other sources[8].

At least forty percent of the fund must be spent for federal purposes and the remainder transferred to the states pursuant to a formula established in the LWCF[9]. No state can receive more than ten percent of the total fund in any one year[10] and all funds given to a state for its purchase program must be matched with a fifty percent state contribution[11]. The monies paid to the state from the fund must comply with the state adopted Outdoor Recreation Plan[12]. In Florida these funds are paid into the Land Acquisition Trust Fund which will be described below.

The LWCF is managed by the Secretary of the Department of Interior (DOI) with the assistance of the other agencies that receive money from it. The Fish and Wildlife Service (FWS), within the DOI, is responsible for land acquisition from that portion of the fund which can be specifically allocated for purchases which protect wildlife, including manatees[13]. Other agencies such as the Department of Agriculture and Department of Commerce also have access to the LWCF for purchased of land which they will have legal responsibility to manage.

The type of land that can be purchased varies with the authority under each specific statute that uses the LWCF for funding. Because there are always more projects for purchase than money available, a priority system is established by the agencies who use the fund. There is usually substantial competition not only for types of land to be purchased but also the locations of specific parcels to assure the fairest geographic distribution.

There are five federal acts that authorize the use of monies from the LWCF as their major source of land acquisition funding that may be used as authority for habitat acquisition for manatee protection. These acts are briefly described in the following sections.

Endangered Species Act (ESA)[14]. ESA was enacted in 1972 to protect and conserve endangered and threatened species and the ecosystems upon which they depend for survival. It provides for the identification of the species and the designation of the habitat which is considered critical to their conservation[15]. Section 5 of the act specifically allows the Secretary of DOI to acquire "lands, waters, or interest therein," with funds from the LWCF for the purpose of implementing a program to "conserve...wildlife...including those which are listed as endangered species..."[16]. It is important to note that the act does not require that lands purchased from the LWCF under the provision of section 5 be designated as "critical habitat". However, recent communications with staff members in the FWS knowledgable about the land acquisition program noted that lands within "critical habitat" designations were given higher priority for acquisition than those that were not listed.

National Wildlife Refuge Act (NWRA)[17]. This act is administered by the FWS for the purpose of consolidating all refuge lands and protecting fish and wildlife for the benefit of present and future generations[18]. It specifically provides for the purchase of lands from the LWCF to conserve species that are threatened with extinction[19]. Priority of purchase is given to lands that are adjacent to existing refuges. All lands acquired for the protection of wildlife are included within the National Wildlife Refuge System.

Fish and Wildlife Coordination Act (FWCA)[20]. The FWCA gives the FWS the authority to comment on federal actions which affect the management and conservation of fish and wildlife throughout the country. It also provides for the purchase of lands necessary to conserve wildlife, using funds from the LWCF, though later enactments seem to prohibit the use of funds allocated to this act from being used to protect marine mammals[21]. These provisions do not necessarily preclude the use of this act for the purpose of land acquisition for manatee protection (particularly if other wildlife is also protected by a specific purchase); however, care should be taken when using this act to obtain a more extensive ruling on this point.

National Wild and Scenic Rivers Act (NWSRA)[22]. The NWSRA was passed to protect rivers which have been relatively undisturbed by man's influence and which provide outdoor recreational opportunities. In order to further this purpose the National Forest Service is allowed to purchase lands (not to exceed 100 acres per mile) on both side of undeveloped rivers. The lands to be purchased are designated by Congress, with state approval, and the funds for purchase are allocated from the LWCF[23].

Marine Protection, Research and Sanctuaries Act (MPRSA)[24]. This act is administered by the Secretary of Commerce though the National Oceanic and Atmospheric Administration's Office of Coastal Zone Management. Though its major purpose is to set aside and protect marine areas of unique importance, it also provides for the designation and acquisition of lands and waters for their "conservation, recreational, ecological or aesthetic values..." within tidal waters of the United States[25]. The funding for purchases made pursuant to this act comes from the LWCF. (Note that the MPRSA is separate from the Coastal Zone Management Act (see C below) which also provides for the purchase and establishment of estuarine sanctuaries but with a different funding source).

C. Migratory Bird Conservation Fund (MBCF)[26] (Figure 2).

The main purpose of the MBCF is the acquisition of lands and waters to protect and preserve waterfowl populations and their important wetland habitats. It is funded from receipts from the annual duck stamps sold to hunters and from legislative appropriations. The act is administered by the Migratory Bird Conservation Commission (Secretaries of DOI, Agriculture, Transportation, two Senators and Representatives, and State Wildlife Administrators) and is staffed by the FWS[27]. The MBCF is a source of funding for two major acts which may be used for the purpose of land acquisition to protect manatee habitat.

Migratory Loan Act(s) (MBA)[28]. The enactments of Congress in this area are not subject to simple categorization because of the number of acts passed over many years with few substantive distinctions. The Migratory Bird Hunting Stamp Act of March 16, 1934 is representative[29]. Each act provides for the acquisition of lands to protect waterfowl hunting and habitat.

Wetlands Loan Act (WLA)[30]. The WLA was established to provide a source of funding for the MBCF to be repaid from duck stamp monies. It has been renewed a number of times and is still available for purchase of wetlands. The WLA is often considered part of the MBA, which has lead to some confusion about how to cite this act. It is listed separately here for information purposes only.

D. Coastal Zone Management Act (CZMA)[31] (Figure 3).

The CZMA is a comprehensive statute originally passed to help the states protect their coastal zones from the adverse effects of energy-

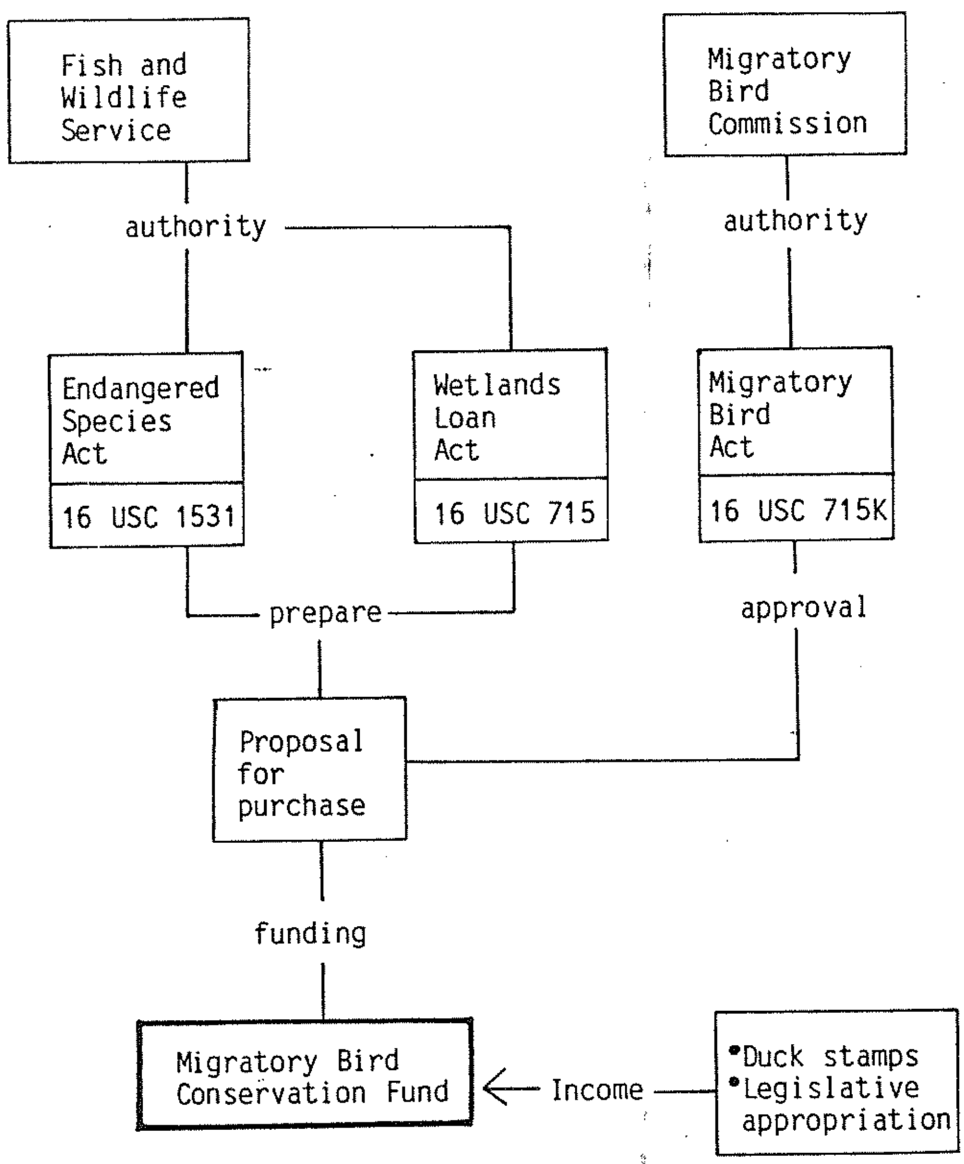

Figure 2. Income and disbursement of the Migratory Bird Conservation Fund.

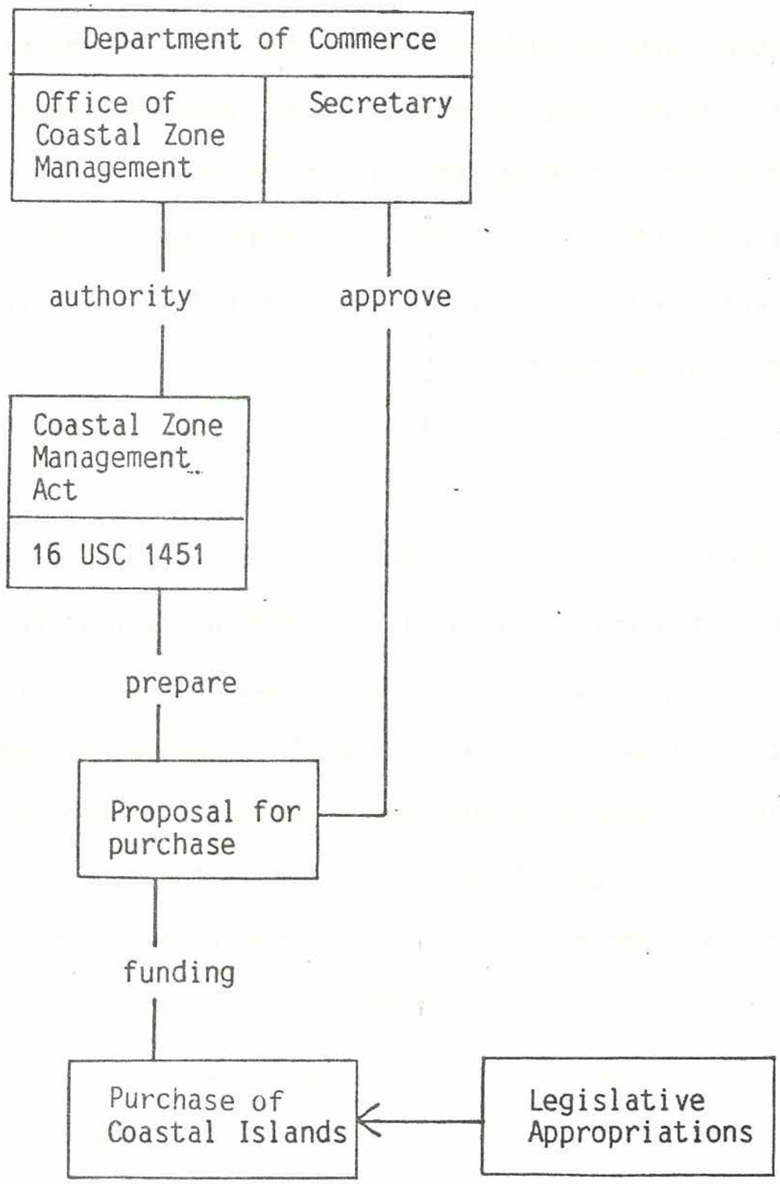

Figure 3. Coastal Zone Management land acquisition process.

related exploration and development. It contains provisions for the establishment and purchase of estuarine sanctuaries and coastal islands[32] and is funded by general appropriations. Estuarine sanctuaries have been established throughout the country (two in Florida) but no islands in Florida have been acquired to date through this program.

A state may have as many as three sanctuaries and there is not limit on the number of islands purchased[33]. The lands within sanctuaries and the islands are purchased with grant monies that are funded on a fifty-fifty matching basis with the state.

E. Evaluation

The land acquisition process on the federal level has been in place for many years and operates relatively well. It does not suffer from the many problems presently existing in the state system which will be discussed below. It operates slowly (approximately three years from submission of proposed purchase to actual purchase) but has been relatively successful in buying the parcels which are listed for acquisition. The federal government has the ability to use the power of eminent domain to acquire lands under the LWCF and MBCF and may acquire less than fee interest if that is appropriate. The government must pay full fair market value for the land and relocation costs for moving the seller[34].

Because of the legal structure of the LWCF and the MBCF it is necessary for the lands sought to be purchased to fit within the proper statutory framework. Since most manatee habitat is water area with adjacent wetlands, all of the acts cited above will give varying authority for the acquisition of important parcels. Though ESA, NWRA and FWCA contain language which specifically provides for purchase of lands to protect endangered species such as the manatee, the other acts are also available if the purpose for the purchase is included within the purview of those acts.

The MPRSA provides for land purchase for marine sanctuaries in tidal waters which would cover a large portion of the manatee's summer range within the study area. The NWSRA could be used for the purchase of portions of the four important river systems in the area which are extensively used by manatees, though this act has been poorly used in the past[35]. The CZMA could also be used to establish a new estuarine sanctuary and/or to buy the islands which are adjacent to manatee habitat. Similar use could be made of the MBCF to purchase the water and wetland areas that are also important waterfowl habitat since most of the manatee habitat in the study area serves as wintering grounds for migratory waterfowl and the endangered American bald eagle.

It should be noted that the act which is used for authorization for purchase of lands may be important in establishing the priorities for purchase under each fund. Each agency establishes its management objectives which determine how the funds are divided among the many applications for purchase. The general policy is stated below.

> "Policy for Use of the Federal Portion of the Land and Water Conservation Fund.
>
> The Federal portion of the Land and Water Conservation Fund will be used to acquire lands, waters, and interests therein necessary to achieve the natural, cultural, wildlife, and recreation management objectives of the National Park Service, Fish and Wildlife Service, Bureau of Land Management, and Forest Service. The fund will be used in accord with management objectives for each

currently authorized area based on agency missions and Congressional mandates. The agencies using the Federal portion of the LWCF will, to the extent consistent with statutory authorities:

-Identify what land or interests in land need to be in Federal ownership to achieve management unit purposes consistent with public objectives in the unit.

-Use to the maximum extent practical cost-effective alternatives to direct Federal purchase of private lands and, when acquisition is necessary acquire or retain only the minimum interests to meet management objectives.

-Cooperate with landowners, other Federal agencies, State and local governments, and the private sector to manage land for public use or protect it for resource conservation.

-Formulate, or revise as necessary, plans for land acquisition and resource use or protection to assume that soci-cultural impacts are considered and that the most outstanding areas are adequately managed[36].

III. STATE LAND ACQUISITION PROGRAMS (Figure 4)

The laws establishing the state land acquisition programs provide for a series of trust funds that are a part of the organic authority to purchase lands for various purposes. In contrast to the federal system, there is no need under the state land purchase programs to find separate legal authority to acquire land. The following is a description and evaluation of the state programs.

A. Conservation and Recreation Lands Trust Fund (CARL)[37].

The CARL fund is the continuation and expansion of an earlier landmark program in Florida that was called the Environmentally Endangered Lands program. This acquisition program was originally

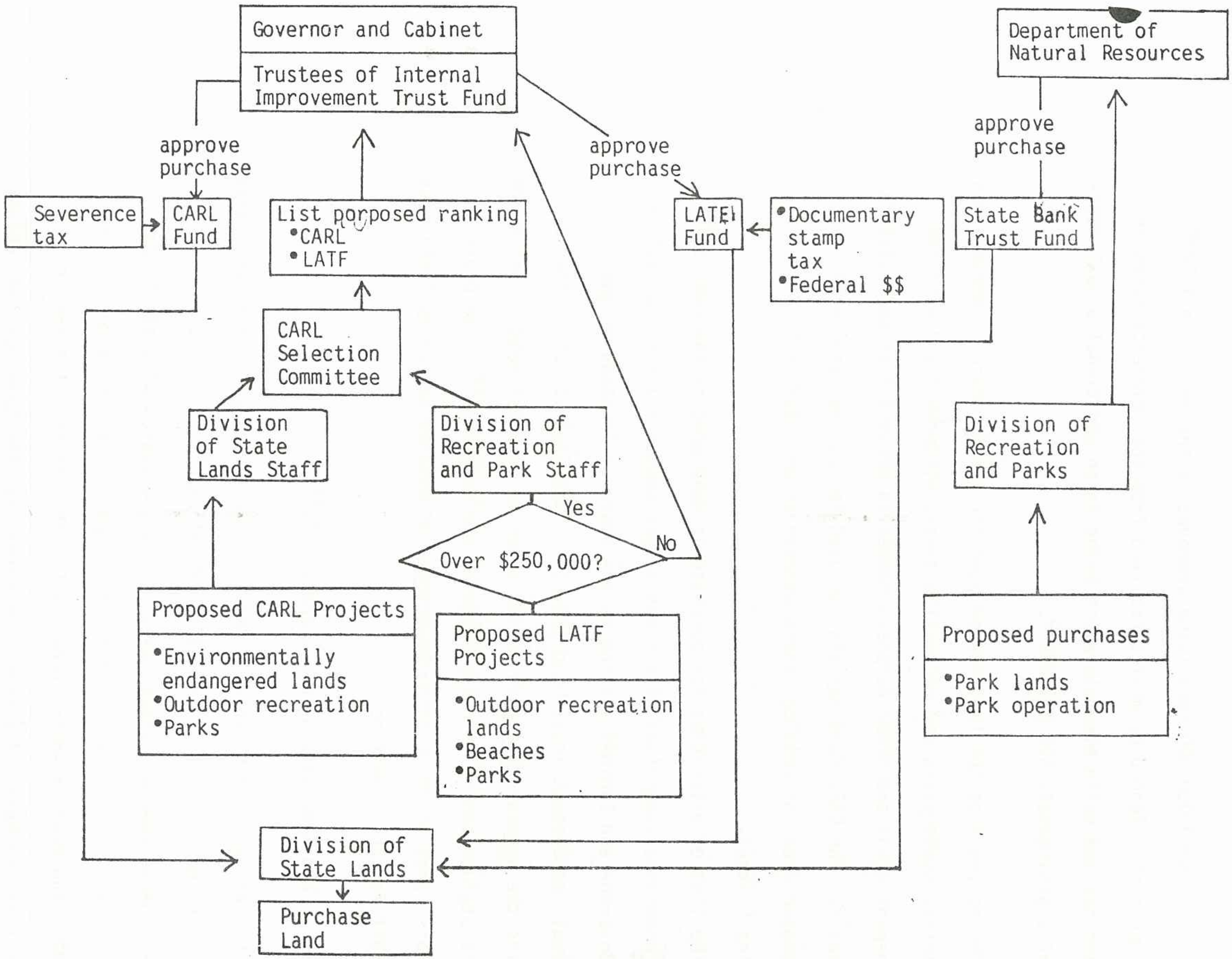

Figure 4. State land acquisition programs.

funded by a $200,000,000 bond issue approved by the voters in 1972[38]. It is presently funded by monies received from the severence taxes on oil and gas and solid minerals which bring in an additional annual revenue of approximately $20,000,000[39].

The monies from the fund may be used for the purchase of marshes and estuaries, state parks and recreation areas, wilderness and wildlife management areas and other purposes needed to protect fish and wildlife habitat[40]. The CARL fund may also be used to acquire lands within designated Areas of Critical State Concern as provided in §.380.05, Florida Statues.

The list of priorities for purchase is developed by the CARL selection committee (comprised of various agency personnel) for approval of the Governor and Cabinet sitting as the Board of Trustees of the Internal Improvement Trust Fund (TIIF)[41]. the list is established by ranking the proposed projects in the order of greatest need as set forth in the statute and rules established by the committee[42]. The Division of State Lands of the Florida Department of Natural Resources (DNR) acts as staff for the committee.

B. Land Acquisition Trust Fund (LATF)[43].

The LATF was established in 1963 to take advantage of the funds that were being made available from the Federal LWCF[44]. It receives its funds from documentary stamp taxes, sales and leases of state lands, legislative appropriations and the fifty percent matching monies from LWCF[45]. The fund is administered by DNR through the Division of Recreation and Parks. (It should be noted that the Governor and Cabinet are the head of DNR and the Board of the TIIF).

The law also allows DNR to issue bonds pledging the full faith and credit of the state to be paid from the fund[46]. Approximately $50,000,000 of these bonds have been authorized for sale at the present time. The receipts of the bond sales are earmarked by DNR for the purchase of recreational beaches in what has been called the "Save our Coasts" program.

Though the major emphasis of the LATF is the purchase of outdoor recreation lands, any "Land, water areas, and related resources...includ(ing), but not limited to, parks and recreation areas, wildlife preserves..., wetlands, floodways..., beaches , water access sites, boating and navigational channels, submerged lands..." can be purchased through the fund[47]. The federal matching monies can only be spent for lands which are included in the Comprehensive Outdoor Recreation and Conservation plan which is established pursuant to this chapter[48]. When using state funds for land purchase, however, DNR is only required to "consider" the recommendations of the Outdoor Recreation Advisory Committee which developed the plan's purchase priorities[49].

The Division of Recreation and Parks of DNR acts as staff to the Outdoor Recreation Commission for securing the list of properties to be purchased from this fund. The Division of State Lands of DNR is responsible for the actual purchase of the lands[50].

C. State Park Trust Fund (SPTF)[51].

The SPTF was established to assist in the acquisition and operation of the state park system. It is administered by the Division of Recreation and Parks of DNR and receives its funding from park user fees and legislative appropriations[52]. The monies from the SPTF may be expended for administration, improvement, maintenance and acquisition of parklands[53].

D. Water Resources Restoration and Preservation Trust Fund (WRRPTF)[54].

The WRRPTF was established by the legislature to assist in the restoration and preservation of water bodies throughout the state[55]. It is funded from legislative appropriations and monies received from the Pollution Recovery Fund[56]. The WRRPTF is administered by the Florida Department of Environmental Regulation (DER) which may use the funds for any water restoration or preservation project (Figure 5).

E. Water Management Lands Trust Fund (WMLTF)[57] (Figure 6)

The WMLTF was established by the legislature to fund the "Save Our Rivers" program in 1981[58]. It receives its funding from documentary stamp taxes and will terminate in 1992[59]. The WMLTF is established within DER for use by the five water management districts for the acquisition of lands "necessary for water management, water supply, and the conservation and protection of water resources...."[60].

The two water management disticts within the study area (Suwannee River Water Management District (SRWMD) and the Southwest Florida Water Management District (SWFWMD) are required to acquire lands identified in their five-year land acquisition plan[61]. The SWRMD receives ten percent of the WMLTF and the SWFWMD receives twenty five percent[62].

F. Evaluation

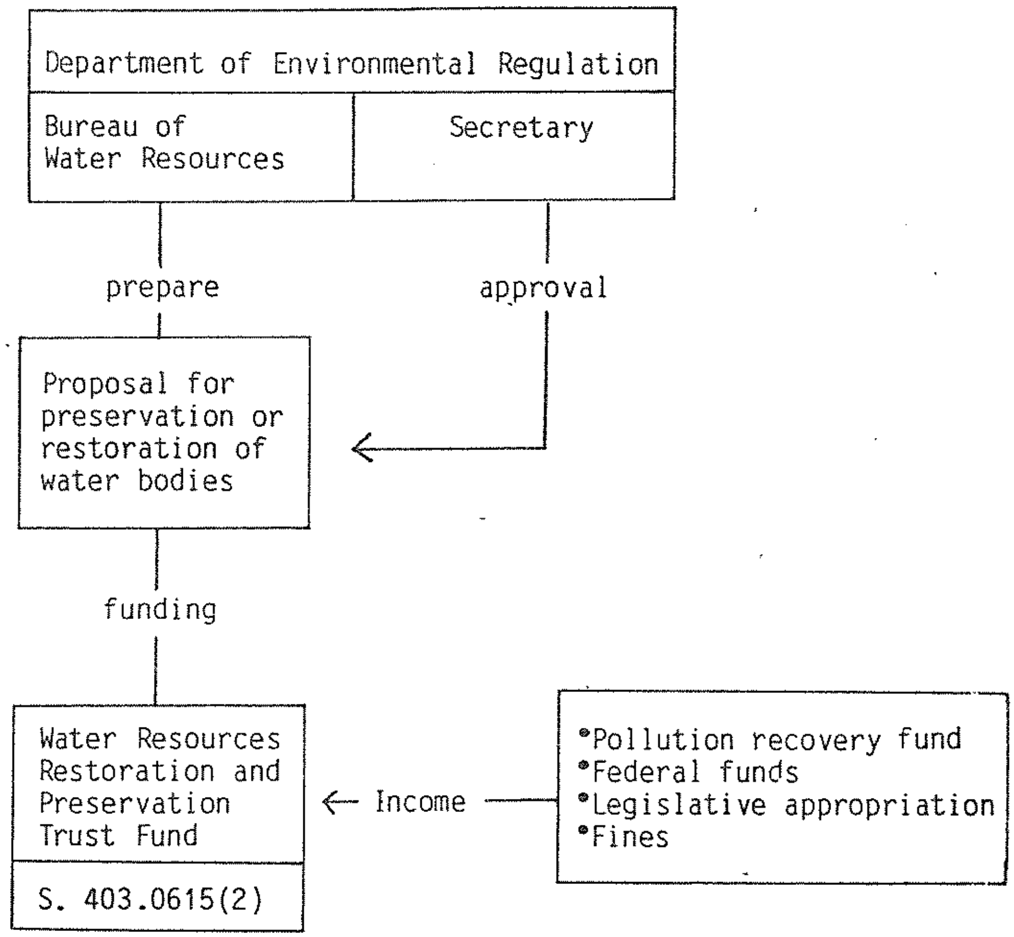

Figure 5. Income and disbursement of the Water Resources Restoration and Preservation Trust Fund

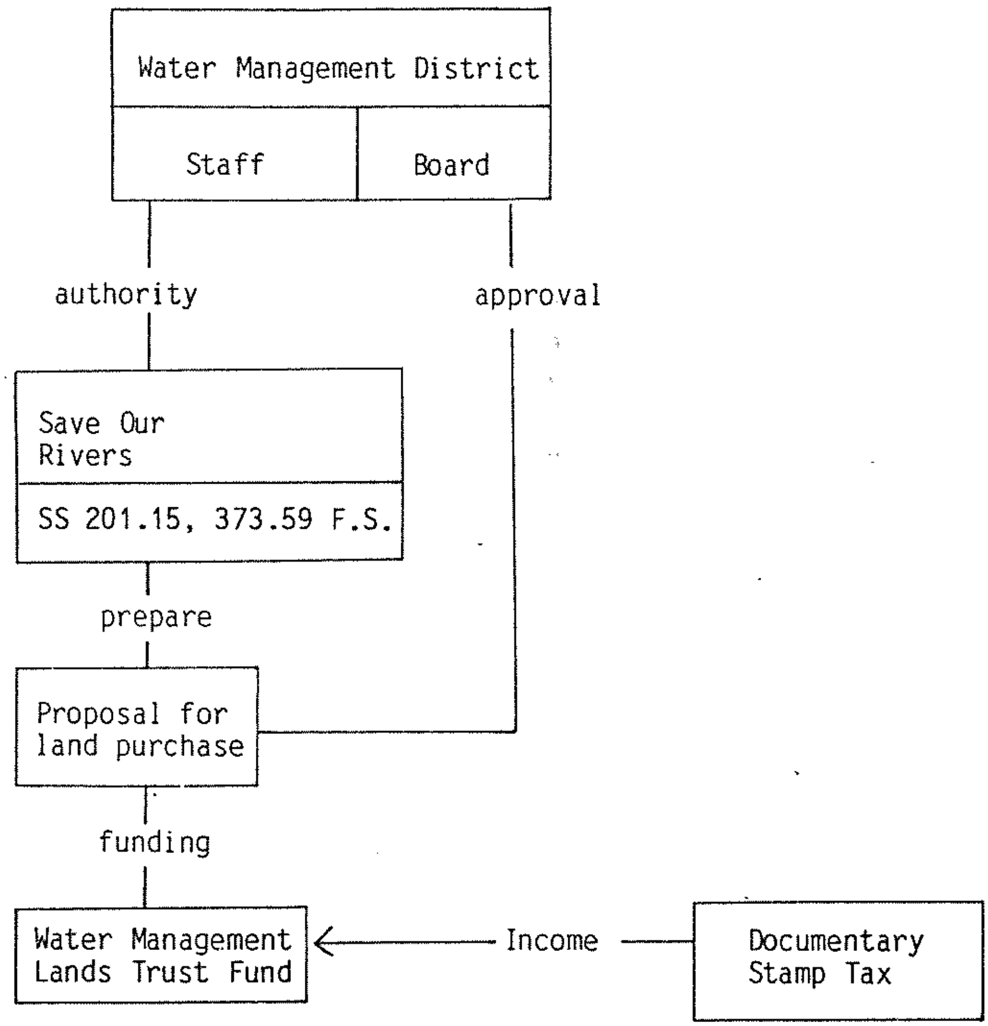

Figure 6. Income and disbursement of the Water Water Management Lands Trust Fund.

Land is generally acquired faster under the state programs than their federal counterparts with the average purchase taking less than two years. The state can acquire less than fee interest but past experience in this area has been less than satisfactory[63]. Unfortunately, all of the state programs suffer from three problems which result in higher than necessary costs and an inability to buy some lands which the state desires to buy. First, all negotiations for land acquisition are open to public inspection and copying. This means that all appraisals and negotiation correspondence is available to the prospective seller and the press at all times. Second, the state does not have the power of eminent domain to acquire lands from any of the above mentioned trust funds (except a limited capacity which should not be applicable to lands needed for the protection of manatee habitat). Third, the Division of State Lands of DNR is a relatively new division which lacks experienced personnel in the land acquisition field. This has led to numerous time delays and complaints from public interest groups and prospective sellers that has caused a lack of full confidence in the programs.

Even with these faults the programs seem to have worked well enough to acquire numerous important parcels of land and future purchases are anticipated that will continue this trend. There are some specific problems with each program that are also important which are mentioned below.

A major problem with the CARL trust fund is the large amount of unnecessary information that is needed before a parcel can be considered for listing on the acquisition list. Full appraisals, sales histories and surveys are generally required even before the project may be considered for listing. This results in unnecessary expenditures from the fund and delays in consideration and purchase of important parcels.

The LATF was used for many years without much public scrutiny until the DNR decided to issue $200,000,000 worth of bonds to purchase beaches throughout the state. It was then discovered that the fund had no selection process or method of prioritizing its purchases. A hasty set of policy guidelines was established but the priorities can be altered by the Governor and Cabinet for any reason. This has resulted in purchase priorities subject to heavy political pressures and a loss of confidence in the beach-purchase program. Priorities for the purchase of other outdoor recreation lands are established by the Division Director of the Division of Recreation and Parks and are not integrated into the other state purchasing programs. This has further eroded confidence in the LATF program and is slowing future purchases.

The SPTF is a small fund used mainly to operate the state park system with little money available for acquisition of sizable parcels. It is however, usable for the purchase of park inholdings or minor expansions.

The WRRPTF has few dollars and is of little use for acquiring lands for the purpose of wildlife protection. However, it may be used to acquire or clean up areas which are degraded as a result of pollution discharges such as some portions of Kings Bay.

The WMTF may be useful for the acquisition of the river floodplains within the study area but the program has not been in existance long enough to know how effective it will be in protecting manatee habitat. The SWFWMD has been purchasing land for many years and has an experienced staff for this purpose. The SRWMD is a relatively new district with little experience in land acquisition.

IV. LOCAL LAND ACQUISITION

Local governments, through their home rule powers, can acquire land for any valid governmental purpose[64]. At the present time, none of the cities and counties within the study area have established a comprehensive program for the purchase of lands within their boundaries. Most local governments purchase park and recreational lands and occasionally lands for environmental education purposes. These often include lands for nature studies and interpretive centers[65]. It should also be noted that local governments who are willing to contribute funds or lands to assist in purchases under the federal or state programs will often speed the acquisition of lands in their areas.

There is no method available to evaluate land acquisition programs on the local level because of the lack of legal controls or guidelines. Each local goverment can be as effective as it desires, being restricted only by the amount of funds available and the desires of its governing authority.

V. PRIVATE LAND ACQUISITIONS

There are a few private non-profit organizations which have been established since the early 1950's to acquire land for the purpose of preserving wildlife values and habitat. The two most active in Florida are The Nature Conservancy (TNC) and the Trust for Public Lands (TPL). These organizations buy land to protect it from harmful development and usually donate or sell the land to a public entity for the same purpose or maintain it in a preserve status. The monies received from any sales go into a revolving fund to operate the organizations and to purchase additional lands.

TNC and TPL are private tax-exempt organizations which operate with few legal restrictions on the types of lands purchased or the methods of financing and acquisition. Their records are confidential except to their members and they can generally negotiate and purchase lands as any private person. These organizations are available to assist governmental agencies with purchases and have a long history of support for this activity[66].

The private land acquisition programs are the best operated, most flexible and fastest programs available for the purchase of important habitat. They are able to educate sellers about innovative land sales options and take advantage of appropriate tax benefits. They are also better able to receive donations of land not generally obtainable by government negotiators. They are able to take advantage of quick "bargain" sales and can buy very rapidly to prevent land from being developed because a seller couldn't afford to wait the two or three years it would take for the government to act.

The major weakness in the private programs is their lack of funding. Since their monies come from private contributions and a percentage of some land sales, there are not guarantees that a private land acquisition organization will have funds available when needed for a specific purchase. They are also severely limited to the size of a parcel they can purchase and the total amount of land they can buy, for the same reason.

VI. RECOMMENDED LEGAL CHANGES

A. Federal Programs

A major change recommended in the federal programs is to allow the government to negotiate for puchase of lands or an interest in lands for less than appraised value. There is little reason for the government to pay more than a private person for land if a seller is not required to sell for the negotiated price. Acquisition on this basis could result in a substantial cost savings to the taxpayers. It is also suggested that relocation costs be part of the negotiation process rather than a mandatory requirement of all purchases.

B. State Programs

There are many changes needed in the state land acquisition programs. The state should be given the power of eminent domain to acquire environmentally endangered or outdoor recreation lands when the private negotiation process fails. All appraisals and negotiation correspondence should be confidential until a point in the process where disclosure will minimize adverse impacts on the proposed purchase. The CARL selection process should be liberalized to allow consideration of projects prior to expending large sums of money on appraisals and surveys. The LATF projects should come under the CARL selection committee process so they can be prioritized on the basis of land needs and the process can be stabilized outside the political arena as much as possible. Each of these points is being considered in legislation presently pending before the 1983 session of the Florida Legislature with a good chance of passage.

C. There are no recommended changes for local land acquisition programs. The power to exercise local discretion in land purchases is available and may be used by any local government as part of their home rule powers.

VII. PROGRAM-SPECIFIC RECOMMENDATIONS

There are various categories of land management on the federal and state levels that offer good protection for lands which may be acquired within the study area. A knowledge of the management options which are available for each category can also assist in choosing the habitat acquisition program most suitable for specific parcels of land. The information contained below should be generally helpful in this area.

A. National Wildlife Refuges

There are four National Wildlife Refuges within the study area. The regulations controlling the use of the lands and waters presently located within these refuges provide the best long-term legal protection presently available for manatees on the federal level. The purchase of lands to increase the size of these refuges or the creation of new refuges should receive the highest priority for habitat acquisition. Examples of the types of acquisition suggested are as follows.

1. The lands on the Crystal River should be acquired for inclusion into the Chassahowitzka National Wildlife Refuge or as a part of a new Refuge for the Crystal River/Kings Bay area.

2. The purchase of lands for inclusion into the Lower Suwannee River National Wildlife Refuge should be completed and additional lands

connecting the Refuge to the Manatee Springs State Park should be considered.

Monies for these purchases should be sought from either the LWCF or the MBCF depending on the reasons used to justify the purchases. Specific purchases which will only protect manatees should be sought from the LWCF. Purchases to preserve waterfowl or waterfowl habitat as a primary purpose should be sought from the MBCF.

B. National Wild and Scenic Rivers

Portions of the four major river systems within the study area may be available for purchase under the NWSR program though this program has been used infrequently in the past and few dollars are presently available for their purchase.

C. Marine and Estuarine Sanctuaries and Islands

The estuarine systems at the mouths of the Crystal, Suwannee, Withlacoochee and Hommasassa rivers are suitable for inclusion within the estuarine sanctuary program in the CZMA or the marine sanctuary program of the MPRSA. Purchase of the island systems may also be available under the CZMA.

D. State Reserves and Preserves

There is one State Preserve and one Reserve presently existing within the study area. Though these are only management classifications within the DNR without express legal status, they are very helpful in assuring that habitat acquired by the state will be maintained essentially in its natural condition[67]. Purchases under the CARL trust fund or the LATF may be managed as State Reserves or Preserves for manatee protection. Three parcels have been proposed for acquisition from the CARL fund within the study area[68]. One portion of the Crystal River parcel has recently been acquired. It is suggested that the state be encouraged to purchase the other parcels as well.

E. State Parks

The Manatee Springs State Park is the only state park of significance to the manatees within the study area. If additional lands are needed to protect the manatee population that uses this park consideration should be given to using the SPTF as a partial funding source; however, funds from the LATF and the CARL trust fund should also be used for this purpose.

VII. CONCLUSION

There are three federal funds and five state funds that could be used for land acquisition to protect manatee habitat. Although local governments have the right to acquire such lands, none in the management area have an active land acquisition program. Private land acquisition programs can generally move more rapidly and effectively than governmental programs but are limited in the funding they have available. A recommended procedure is to identify the land which should be purchased, evaluate which acquisition program is most suited to the particular property, ascertain which fund has monies available for purchase and submit a request for purchase to the appropriate agency. Recommended legal changes in state and federal programs are described.

NOTES

1. 16 USC 4601-9(b)
2. 16 USC 4601-4 - 4601-11
3. 16 USC 4601-4 (1964)
4. 16 USC 4601-7
5. 16 USC 4601-5(a)
6. 16 USC 4601-5(b)
7. 16 USC 4601-5 a
8. 16 USC 4601-5(c)
9. 16 USC 4601-7,8
10. 16 USC 4601-8(b)(3)
11. 16 USC 4601-8(c)
12. 16 USC 4601-8(d)
13. Statement, Walter B. McAllester, Chief, Division of Realty, FWS, June 14, 1982, Workshop on Public Lands Acquisition, Senate Committee on Energy, Natural Resources Subcommittees on Public Lands and Reserved Waters.
14. 16 USC 1531, et seq.
15. 16 USC 1533(3), 1532(5)
16. 16 USC 1534(b)
17. 16 USC 668dd-ee
18. Id.
19. 16 USC 668dd (a)(1)
20. 16 USC 661, et seq.
21. 16 USC 2901-29011
22. 16 USC 1271, et seq.
23. 16 USC 1277(a)
24. 16 USC 1431, et seq.
25. 16 USC 1432(a)

26. 16 USC 715

27. See note 13.

28. 16 USC 715k

29. 16 USC 718d

30. 16 USC 715k-3-k-5

31. 16 USC 1451, et seq.

32. 16 USC 1461(2)

33. 15 CFR 921

34. Uniform Relocation Assistance and Real Property Acquisition Policy Act of 1970.

35. GAO Report CED - 78-79, May 22 (Suwannee, Withlacoochee, Crystal and Hommosassa Rivers).

36. Federal Register, March 18, 1982 (Vol. 47, Not 53, pp11777-8).

37. Chapter 259, §253.023 F.S.

38. Article VII, Section 11(a), Florida Constitution 1968

39. §253.023(2) F.S.

40. §253.023(3) F.S.

41. §259.035 F.S.

42. Id., 16 Q-3 FAC

43. Chapter 375 F.S.

44. Id.

45. §375.041 F.S.

46. §375.051 F.S.

47. §375.031(5) F.S.

48. §375.021 F.S.

49. §375.031 (2) F.S.

50. §375.031(3) F.S.

51. §258.034 F.S.

52. Id.

53. *Id.*

54. §403.0615 F.S.

55. §403.0615(2) F.S.

56. §403.0615(4), 403.165 F.S.

57. §373.59 F.S.

58. Chapter 81,33, Laws of Florida

59. §373.59(10) F.S.

60. §373.59(3) F.S.

61. §373.59(2) (a), (b) F.S.

62. §373.59(b) F.S.

63. Flowage easements in South Florida purchased for 85% of the land total value of the property may now be worthless because the fee owner intends to rock mine the area. Purchase of the total fee interest at this point may cost twice the original value of land.

64. Article VIII, Section 1, 2, Florida Constitution 1968

65. Personal Communication, Richard Tillis, Florida Department of Education, March 1983.

66. See Note 13.

67. Cedar Key Scrub Reserve, Waccassa Bay State Preserve

68. Crystal River, Chassahowitzka Swamp, Cedar Key Addition

LEGAL REVIEW REGARDING WATER
DEMANDS INFLUENCING FLOW OF
SPRINGS THAT ARE WINTER REFUGES FOR MANATEES

Richard Hamann, Esq.

I. INTRODUCTION

Crystal River is vital manatee habitat because the Floridan Aquifer discharges relatively warm water through numerous springs. The manatees are able to move out of colder Gulf waters during the winter into this natural warm water refuge. The size of the area that is habitable to them depends on the rate of discharge and the resulting thermal gradient. Maintaining a sufficient flow of warm spring water to create the thermal conditions needed by manatees is therefore essential to the maintenance of manatee habitat. Fresh water flow may also be related to manatee food sources.

The rate of spring discharge is primarily a function of hydrostatic pressures within the aquifer system. These pressures can be reduced by: (1) pumping water for consumption by residential, agricultural or industrial users and (2) reducing recharge by paving over recharge areas or draining surface waters away before they can infiltrate the ground water system. Florida water law provides the mechanism for addressing these potential threats to the manatee. However, effective regulation should be based on sound technical information. With regard to Crystal River, three components appear to be needed:

(1) a hydrologic model capable of predicting the effects of pumping and reduced recharge on spring discharge;

(2) a model capable of predicting the effects of reduced spring discharge on thermal conditions in Crystal River; and,

(3) a basis for predicting the tolerance of manatees to altered thermal conditions.

II. WATER RESOURCES ACT

The Florida Water Resources Act of 1972, codified as Chapter 373, Florida Statutes, authorized comprehensive management of the state's water resources by DER and five regional water management districts.[1] Citrus County is in the Southwest Florida Water Management District (SWFWMD),[2] which is administered by an Executive Director and a nine member Governing Board of gubernatorial appointees. Decisions of the Governing Board may be appealed to the Governor and Cabinet.

DER and SWFWMD have extensive authority. They can (1) conduct studies and collect data regarding water resources[3] ;(2) build and maintain water management structures[4] ;(3) purchase lands for water management purposes[5] ;(4) regulate the construction of wells[6] ;(5) regulate the consumptive use of water[7] ;(6) set minimum flows and levels[8] ;(7) regulate the construction and operation of surface water management systems[9] ;(8) restrict use of water during water shortages and emergencies[10] ;(9) control artificial groundwater recharge[11] and, (10) levy ad valorem taxes to finance water management functions.[12]

Authority to conduct water resources studies is contained in several sections of the FWRA. A State Water Use Plan is supposed to be based on studies that determine, among other things "existing and contemplated needs and uses of water for protection and procreation of fish and wildlife..."[13] In developing the plan, DER and the District are directed to "give careful consideration to the ...protection and procreation of fish and wildlife."[14] The plan may "prohibit or restrict other future uses on certain designated bodies of water which may be inconsistent with these objectives."[15] A State Water Policy, which is to be used in developing regional plans, has been adopted by DER.[16]

The agencies are required by statute to establish minimum flows and levels.[17] The minimum flow of a watercourse, such as Crystal River, is to be "the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area." Manatees may be considered an integral part of the Crystal River ecosystem. Minimum groundwater levels are to be set at the level "at which further withdrawals would be significantly harmful to the water resources of the area." The State Water Policy specifically provides for the consideration of wildlife habitat in setting minimum flows and levels.[18] Minimum flows and levels are to be established using the "best information available" and may reflect seasonal variations. The protection of "nonconsumptive uses" by setting minimum flows and levels is specifically authorized. DER and the Southwest Florida Water Management District are thus well authorized, and in fact may be required, to set minimum flows and levels, using the best available information, sufficient to maintain the warm water habitat of manatees.

Both consumptive use of water, and interference with groundwater recharge can be regulated by the District to maintain minimum flows and levels. The District currently regulates large users of water.[19] In order to obtain a permit, the applicant must demonstrate the proposed use is a "reasonable beneficial use" that is consistent with the public interest and will not interfere with a legal existing use of water.[20] A use that would be detrimental to manatee habitat is arguably not in the public interest. However, in the absence of sufficient technical data, it would not be possible to determine whether a use would interfere with manatee habitat. One solution might be for the District to require the applicant for a major withdrawal to fund studies to establish whether its use would meet the statutory criteria.

An application can also be denied if it would cause minimum flows and levels to be violated. However, no specific minimum flows and levels have been established for the Crystal River, and the general rule for defining minimum flows and level seem inadequate. The minimum flow, for example, is determined as follows:

> For each month, the five (5) lowest monthly mean discharges for the proceeding twenty (20) years shall be averaged. Minimum rates of flow shall be established as seventy percent (70%) of these values for the four (4) wettest months and ninety (90%) of these values of the remaining eight (8) months.[21]

If better information is available, the Governing Board can impose another method for determining minimum flows. Minimum flows and levels are apparently not used to evaluate permit applications in the Crystal River area due to a lack of technical data. The potential for salt water intrusion, reflected by increasing chloride levels in wells, is the primary limiting factor. New wells are thus required to be located east of U.S. 19.

The regulation of surface water management systems is also authorized by the FWRA.[22] The construction of impervious surfaces, such as parking lots, and of drainage works, may be permitted by the District. These types of works may interfere with recharge of the ground water systems that supply Crystal River. Reasonable conditions can be imposed on permits to insure the works will not be harmful to the water resources or inconsistent with the overall objectives of the District.

The Southwest Florida Water Management District has implemented a rather limited surface water management permitting program,[23] choosing to regulate only the very largest projects.[24] Violation of minimum flows or levels is grounds for denial of a permit.[25] However, in the absence of adequate hydrologic models, it would be technically challenging to show causal relationships. The relevance of cumulative effects is not clear.

III. RECOMMENDATIONS

The information needed to establish minimum flows and levels for the Crystal River ground and surface water system should be determined through appropriate studies. The Southwest Florida Water Managmeent District is authorized to conduct such studies, but may be reluctant to commit the necessary funds. A cooperative effort among the SWFWMD, USGS, USF&WS and other interested agencies may be most realistic. Until such studies are completed, an interim rule should be adopted that limits the effect of withdrawals on flows and levels. The minimum flow of Crystal River, for example, could be set at 95% of the flow that would occur in the absence of consumptive use. The cumulative effect of all withdrawals should be considered in determining whether minimum flows are being maintained. Consideration should also be given to whether drainage activities affecting groundwater recharge are sufficiently regulated. These recommendations could be adopted by the District Governing Board on its own initiative or in response to a petition filed under the Administrative Procedures Act.[26] Ultimate responsibility rests with the Governor and Cabinet, who are authorized to review and rescind or modify rules and orders of water management districts.[27]

NOTES

1 See generally, F. Maloney, S. Plager, R. Ausness, B. Canter, Florida Water Law - 1980; Hamann, Common Law Water Rights and the Florida Water Resources Act of 1972, in Continuing Legal Education, The Florida Bar, Environmental Regulation and Litigation in Florida (1981).

2 5060 U.S. 41 South, Brooksville, Fla., 33512, (904)796-7211.

3 Fla. Stat. §§373.036, .083(3)(1981).

4 Id., §373.086.

5 Id., §373.139(1981), §373.59(1982 Supp.)

6 Id., §§373.303-.342.

7 Id., §§373.203-.249.

8 Id., §373.042.

9 Id., §§373.403-.443.

10 Id., §373.246.

11 Id., §373.106.

12 Florida Constitution, Art. VII, §9(b); Fla. Stat. §373.0697, .503.(1981). The SWFWMD may levy up to 1.0 mill.

13 Fla. Stat. §373.036(1)(1981).

14 Id., §373.036(7).

15 Id.

16 7 Fla. Admin. Code 17-40.

17 Fla. Stat. §373.042 (1981).

18 7 Fla. Admin. Code 17-40.08(1)(b).

19 11 Fla. Admin. Code 40 D-2.

20 Id., 40 D-2.301.

21 Id., 40 D-1.601.

22 Fla. Stat. §§373.413, .416 (1981).

23 11 Fla. Admin. Code 40 D-4.

24 Id., 40 D-4.041.

25 Id., 40 D-4.301.

26 Fla. Stat. §120.54(5)(1981).

27 Id. §373.114

PROTECTION AFFORDED MANATEES AND THEIR HABITAT BY THE ENDANGERED SPECIES ACT AND THE MARINE MAMMAL PROTECTION ACT

Richard Hamann, Esq.

I. THE ENDANGERED SPECIES ACT

The Endangered Species Act (ESA)[1] affords considerable legal protection to manatees and their habitat. Manatees have been listed as endangered[2] pursuant to the ESA and the Crystal River has been designated as critical habitat.[3] Private persons, as well as government agencies, are thus prohibited from harming individual manatees or taking actions that indirectly could lead to extinction of the species.

A. Section 7(a)(2) of the Endangered Species Act states;

> Each Federal agency shall . . . insure that any action authorized, funded, or carried out by such agency . . . is not likely to jeopardize the continued existence of any endangered species . . . or result in the destruction or adverse modification of [critical] habitat. . . [4]

The mandate is very clear. Congress does not want federal agencies to conduct activities, fund activities or permit activities adversely affecting manatees or their habitat. As the Supreme Court of the United States has said, "this language admits of no exception."[5] Examples of affected federal activities are: permitting by the Corps of Engineers of construction by private parties of docks, marinas, dredging or the discharge of fill; permitting by EPA of sewage discharges; funding by EPA of sewage treatment facilities; federal loans or guarantees; and, the construction of a federally funded navigation channel.

Whether the effects are "direct" or "indirect", "primary" or "secondary" is not relevant.[6] For example, in <u>Riverside Irrigation District</u>

v. Andrews[7], revocation by the Corps of Engineers of a nationwide general permit to construct a dam was upheld because operation of the reservoir would adversely modify critical habitat of the whooping crane on the Platte River. All possible ramifications of the agency action must be considered.[8]

To determine whether their actions comply with Section 7, federal agencies are required to consult with the U.S. Fish and Wildlife Service.[9] The Secretary of Interior, in turn, is required to provide a written opinion "detailing how the agency action affects the species or its critical habitat."[10] If the action is found to jeopardize the species or adversely modify critical habitat, the Secretary is required to suggest "reasonable and prudent alternatives"[11] that would avoid the violation.[12] Responsibility for determining a course of action consistent with ESA rests with the agency receiving the consultation.

B. Section 9

Section 9 of ESA also provides substantive protection by prohibiting any person from "taking" an endangered species.[13] Unlike section 7, taking is prohibited regardless of whether it is funded or authorized by a federal agency. Purely private actions may not take endangered species.

Two respected commentators have noted:

> Although this prohibition might appear to be simply a hunting law forbidding the intentional killing of a listed species, such a narrow interpretation is unwarranted. Section 9 is an important land use control.
>
> The fundamental issue is whether habitat modification that indirectly kills endangered species is a "taking" within the meaning of the Act. An

> answer depends on three critical questions: whether the section requires intent to harm or to violate the Act as an element of the offense; whether negligent conduct or indirectly caused harm are violations; and whether future foreseeable takings may be enjoined. Persuasive evidence in the statute and its legislative history, administrative interpretations, several judicial decisions, and analogous, parallel precedent support the startling conclusions that any conduct that will forseeably harm a species directly or indirectly by adversely affecting its habitat is a violation and that such conduct can be enjoined.[14]

There is no requirement in the Act that taking be intentional to be illegal. The term "take" is defined broadly in the statute as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in such conduct."[15] The Fish and Wildlife Service has defined "harm" as

> ...an act which actually kills or injures wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering.

To "harass" an endangered species means to engage in

> ...an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding or sheltering.

These provisions have been interpreted to enjoin an otherwise valid state program, with no federal connection, that was harming an endangered species. A federal district court ordered the State of Hawaii to eliminate feral goat and sheep herds that it was maintaining for hunters because of their destructive effects on the native forest habitat of a small honeycreeper, the palila[18]. This precedent supports judicial intervention to protect endangered species. and their habitat from a wide range of state and private actions and omissions.

C. Conservation Plans

Although takings are generally prohibited, amendments to section 10(a) enacted in 1982 authorize the Secretary to permit takings that are incidental to an otherwise lawful activity[19]. The applicant for such a permit must submit a conservation plan specifying: the impacts of the taking; steps the applicant will take to minimize or mitigate the impacts; funding for the program; analysis of alternatives; and, other information specified by the Secretary. The Secretary is required to approve a plan only after finding: the taking will be incidental; the impacts will be minimized and mitigated to the maximum extend practicable; adequate funding will be provided; the taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild; and, adequate assurances have been provided that the plat will be implemented.

This new mechanism provides an opportunity for developers in the Crystal River area to use their creativity and entreprenurial abilities to enhance the possibilities for survival of the manatee while attaining their development objectives. The process is based on the San Bruno

Mountain Conservation Plan, a plan created to accomodate limited development in habitat of the endangered Mission Blue Butterfly[20].

Unless government agencies, development interests, and concerned citizens works together to devise such a plan, much of the development that appears imminent in the Crystal River area may be foreclosed for violating the Endangered Species Act. Federal permits and federal funding for projects adversely affecting manatees or their habitat are prohibited by Section 7. Any action, public or private, that creates the likelihood of harm to manatees is prohibited by Section 9. Where survival of the manatee conflicts with human activity, Congress has declared the manatee shall take precedence.

II. THE MARINE MAMMAL PROTECTION ACT

Manatees are also protected under the Marine Mammal Protection Act (MMPA)[21], as which makes it unlawful for any person or vessel to take a manatee[22]. Implementing regulations define "take" as:

> ...to harrass, hunt, capture, collect, or kill, or attempt to harass, hunt, capture, collect, or kill any marine mammal, including, without limitation, any of the following: The collection of dead animals or parts thereof; the restraint or detention of a marine mammal, no matter how temporary; tagging a marine mammal; or the negligent or intentional operation of an aircraft or vessel, or the doing of any other negligent or intentional act which results in the disturbing or molesting of a marine mammal.[23]

The language is similar to the prohibition of taking in Section 9 of the Endangered Species Act. It could be similarly interpreted to prohibit development in the Crystal River that is likely to adversely affect manatees.

NOTES

1. P.L. 92-205, codified at 16 U.S.C.A. §§1531 *et seq*.
2. 50 CFR 17.11.
3. *Id*., 17.66. Portions of Crystal River are also regulated under ESA as manatee protection areas. *Id*. 17.100-.108.
4. 16 U.S.C.A. §1536 (a)(2)(1982 Supp.)
5. TVA v. Hill, 437 U.S. 153,173,98 S. Ct. 2279,2291,57 L.Ed. 2d 117 (1978). Subsequent to *Hill*, it should be noted, Congress created a limited exception. An Endangered Species Committee may authorize otherwise illegal federal actions, subject to stringent criteria. 16 U.S.C.A. §1536(e)-(p) (1982 Supp.) There are other limited exceptions for scientific research, captive breeding, etc. *Id*. §1539.
6. Riverside Irrigation District v. Andrews, 13 ECR 21091, 21093 (D.Colo 1883).
7. *Id*.
8. North Slope Borough v. Andrews, 642 F.2d 589 (D.C. Cir 1980).
9. 16 U.S.C.A. §1536 (a)-(c) (1982 Supp.)
10. *Id*., (b)(3)(A).
11. *Id*.
12. Regulations implementing this procedure are found at 50 CFR Part 402.
13. 16 U.S.C.A. §1538 (a)(1)(B)(1974).
14. Coggins and Russell, *Beyond Shooting Snail Darters in Pork Barrels: Endangered Species and Land Use in America*, 70 Georgetown L.J. 1433-1525, 1470(1982).
15. 16 U.S.C.A. §1533(19)(1974).

16. 50 CFR 17.3.

17. Id.

18. Palila v. Hawaii Department of Land and Natural Resources, 471 F. Supp. 985 (D. Hawaii 1979), aff'd, 639 F.2d 495 (9th cir. 1981).

19. 16 U.S.C.A. §1539 (a)(1)(B)(1982 Supp.).

20. Bossellman, New Mechanisms for Dissolving Disputes in Federal Environmental Law, Urban Land 34-5 (July 1983).

21. P.L. 92-522, codified at 16 U.S.C.A. §§1361-1407(1974); 50 C.F.R. Part 18.

22. Id., §1372; 50 C.F.R. 18.11. The prohibition is subject to certain exemptions for regulated fishing, native subsistence, scientific research and other limited practices not generally applicable to manatees. Id., Part 18, Subparts C,D,H.

23. 50 C.F.R. 18.3.

IMPACT OF THE NATIONAL ENVIRONMENTAL POLICY ACT ON PRESERVATION AND PROTECTION OF MANATEES

David Gluckman

I. INTRODUCTION

The National Environmental Policy Act (NEPA)(1) was passed in 1970 as the first major legislation on the federal level that recognized the growing concern for protection of the environment in the late 60's (2). The act created a preplanning study requirement for federal agencies prior to taking actions that might have an adverse impact on the environment. This article will briefly discuss how NEPA is implemented, evaluate its successes and limitations, and make recommendations for the preservation and protection of manatees within the study area using the provisions of this act.

II. IMPLEMENTATION OF NEPA

NEPA requires that an environmental impact statement (EIS) "be prepared and included with every recommendation or report on propc als for legislation and other major federal actions significantly affecting the quality of the human environment...;"

(3).

An EIS is a document that contains the results of a study of the environmental effects of an action. The document must be prepared before any major federal action is undertaken (4). The EIS must be made available for public review before finalization (5).

Every federal agency that conducts any major federal activity must prepare an EIS prior to the activity, if the activity will significantly affect the quality of the human environment. A "major federal action" is any project or activity "entirely or partly financed, assisted, conducted, regulated, or approved by a federal agency (6)". The "human environment" includes the "natural and physical environment" and the "relationship of people to the environment (7)".

NEPA requires a study of the activity's impact on manatees, as an endangered species, along with other animals and plants that may be affected (8). The EIS must be prepared by the primary acting agency though the agency may contract out protions of the study from other agencies or private contractors (9).

III. EVALUATION AND RECOMMENDATIONS

The most positive benefit of NEPA is that it requires studies of environmental impacts prior to action. Its greatest weakness is that the agency doesn't have to stop the proposed action as a result of harm discovered by the environmental study.

It is important to note, however, that if possible harm to manatees is discovered in an EIS, other laws such as the Endanged Species Act and the Marine Mammal Protection Act could be used to prevent the harm (10).

It is recommmended that careful attention be paid to all proposed "major federal actions" within the study area to make certain that a proper EIS is prepared that includes the potential impact on manatees and their important habitat. If possible harm is discovered, the approriate agencies should be notified to take actions under other organic statutes.

NOTES

1. 42 USC 4321, et seq; PL 91-190.
2. Gluckman, David. Workshop Proceedings on Environmental Impact Statements, Florida Technicological University, Orlando, FL, 1973. Pg. 30.
3. 42 USC 102 (c).
4. 40 CFR 1507.
5. 40 CFR 1503.
6. 40 CFR 1508.18.
7. 40 CFR 1508.14.
8. See 40 CFR 6.
9. 40 CFR 1505.
10. Endangered Species Act - 16 USC 1531, et seq.
    Marine Mammal Protection Act - 16 USC 1431, et seq.

INTERVIEWS WITH CITRUS COUNTY RESIDENTS REGARDING MANATEE PROTECTION

Catherine Puckett
117 Newins-Ziegler Hall
University of Florida
Gainesville, FL 32611

INTRODUCTION

Residents of eastern Citrus County, Florida, were interviewed during development of a proposed research/management plan for Crystal River manatees (Packard 1983). The purpose of these interviews was to gain information on the perceptions of local interest groups regarding existing regulations protecting manatees and the potential need for additional regulations. In addition, the value of manatees to the local Crystal River community was described by the information obtained during this survey.

The presence of manatees in Crystal River directly affects businesses supplying goods and services to tourists that come to the area to view manatees; examples of such businesses are dive shops, marinas, motels, hotels, restaurants and service stations. Other businesses such as commercial fishing and guiding services may not be directly affected by manatees, but are indirectly affected by speed regulations protecting manatees in the waterways that are pathways to fishing areas in Gulf waters. Regulations concerning manatees are of interest to business people who are directly and those who are indirectly involved with manatees and who perceive that such regulations could affect their livelihoods.

METHODS

Interviews were conducted on an informal basis, with the goal of documenting the variety of opinions expressed rather than quantitatively determining the relative frequency of such opinions. Thus, this survey provides preliminary information such as would be needed to design a questionnaire for an opinion poll, but cannot be interpreted as describing which attitudes are most prevalent.

The interest groups that were contacted for interviews included operators (owners or managers) of dive shops, marinas, shrimp boats, fishing boats, seafood businesses, and fishing guides on Crystal and Homosassa rivers (Table 1). Businesses were identified from a phone book and by asking interviewees for contacts. No leaders representing existing business organizations were identified, so individuals were contacted. During an initial phone call, the purpose of the interview was described and an appointment for a personal interview was made. Interviews were conducted by phone when it was not possible to make an appointment. It was not possible to contact all shrimpers in the Crystal River area, so only those present at the docks at the same time as the interviewer were questioned.

A prepared list of questions were asked during each interview, including the following. How is your business affected by manatees or by regulations protecting manatees? Are existing regulations necessary? Are existing regulations effective? What additional regulations, if any, are needed? What are potential regulations that might have an adverse effect on your business? What additional regulations do you feel you could live with? Interviewees were encouraged to talk about whatever they felt was important, and were not limited to answering the prepared questions. To encourage candid discussion, interviewees were assured that their comments would be anonymous.

Table 1. Businesses contacted for interviews.

BUSINESS NAME	SERVICE
Berry's Scuba	dive shop
Brown's Crab House	seafood
Cedar Key Seafood	seafood
Crystal Lodge Dive Center	dive shop, marina
Crystal River Seafood	seafood
Homosassa Seafood	seafood
Knox's Bait House	marina
Pete's Pier	marina
Plantation Inn Marina	dive shop, marina
Port Paradise Marina	dive shop, marina
Seasweet Crabmeat Co.	seafood
Talley's Pro Dive	dive shop

Because this survey deals with opinions and attitudes rather than facts, the interviewer tried to avoid pointing out what to her, were inconsistencies in statements or contradictions to established facts. The perceptions of the interviewee were recorded as the basis of information upon which opinions and attitudes are formed. Although the interviewer recognized that such perceptions might be based on a limited set of information, the perceptions of interviewees nonetheless were considered quite valid by the individuals interviewed.

Several additional sources of information were used to identify public attitudes toward manatees. Articles in a local newspaper (Citrus County Chronicle) were monitored from October 1982 through March 1983. The number of businesses directly or indirectly potentially benefiting from tourism associated with manatees were tallied from addresses listed in the phone book and verified with local residents. The director of the Citrus County Marine Science Center was interviewed regarding educational programs about manatees. During the period that this study was conducted, The Nature Conservancy was involved in a public awareness campaign to raise funds to purchase islands in Kings Bay, lands that needed to be protected to maintain the manatee sanctuary. Public support for purchase of the Kings Bay islands was documented by statistics provided by The Nature Conservancy and its members.

RESULTS

Public awareness of manatees in the area of Crystal and Homosassa rivers is high, and there are several indications of the value of manatees to this community (Table 2). Five dive shops located adjacent to or on Kings Bay are affected most directly by the presence of manatees. Three of the marinas located on Crystal River are associated with these dive shops, and three

Table 2. Indications of the value of manatees and their habitat to the local community.

Item	Estimated Number
Businesses directly or indirectly benefiting from tourism associated with manatees[1]	
Dive shops (Crystal River)	5
Motels, hotels, campgrounds on Crystal River	6
Restaurants in Crystal River	27
Service stations in Crystal River	13
Marinas in Crystal River	6
Fish and seafood (wholesale and retail) in Crystal River, Homosassa, and Chassahowiztka	10
Educational programs: students attending the Citrus County Marine Science Center per year (fourth grade through college)[2]	8,000 to 10,000
Divers renting equipment from dive shops[3]	
Per weekend in manatee season (October-March)	580 to 800
Per week (Mon-Fri) in season	420 to 390
Publicity (Citrus County Chronicle: Oct. 82-Mar. 83)	
Newspaper articles related to manatees	40
Editorials related to manatees	6
Support for purchase of the Kings Bay Manatee Sanctuary by the Nature Conservancy	
Local donors (Citrus County)	270
Non-local donors	2,726
Businesses donating goods for auction	79
Local artists donating goods for auction	12

[1]Estimated from businesses listed in the phonebook and verified with local residents.
[2]Personal communication from Pat Purcell.
[3]Estimates from individual dive shops were added together.

other marinas serve primarily the interests of fishermen and boaters. Ten businesses dealing with wholesale and retail seafood are located on Crystal, Homosassa and Chassahowitzka rivers. Businesses indirectly associated with tourists attracted to manatee areas include six motels, hotels and campgrounds in Crystal River, twenty-seven restaurants in Crystal River and thirteen service stations in Crystal river.

Publicity regarding manatees was frequent during the winter 1982/83. In five months (October through March), forty newspaper articles and six editorials related to manatees were published in the Citrus County Chronicle. Support for purchase of the Kings Bay islands included a large number of non-local sources (2,726 donors) as well as Citrus County residents (270 donors). Additional fund raising activities within the community included donations of a percentage of sales by three local businesses, sales of $20,000 worth of T-shirts and other manatee-related items, a skateathon, and an auction of goods donated by seventy-nine businesses and twelve local artists.

A large number of students learn about manatees via the programs of the Citrus County Marine Science Center. Programs include students from fourth grade through college age. About 8,000 to 10,000 students attend educational programs at the science center each year. During the manatee season, students are taken on boat trips and supervised dives to view manatees.

Dive shop operators indicated different attitudes toward manatee issues than individuals associated with commercial fishing. Thus, the attitudes and opinions of the two groups are reported separately below.

Dive Shops

Operators of dive shops indicated that increasing numbers of tourists are visiting the area recently, possibly due to the high profile that manatees have received in the news media during the last few years. They say that more non-divers, such as retirees and families with small children, are now coming to see the manatees. One dive shop owner said, "A lot of people just rent boats to see manatees. When the manatees surface next to their boats, they let people scratch their backs." Another dive shop owner said, "This year we have had more people than ever, interested in seeing manatees." While conducting interviews in the dive shops, the author frequently heard visitors ask about manatees, request literature about them, or enthusiastically describe "the manatee experience."

a. Effects on business

Divers come to Kings Bay throughout the year to dive in its numerous springs and to teach or to take diving classes. The opportunity to view manatees is an additional attraction during the winter season.

Manatee season, according to dive shop operators, generally lasts from Oct. 5 to March 31, with highest numbers of divers present around Thanksgiving, Christmas, and the first week of January. In late fall and winter, some operators felt most dive shop business was manatee-oriented, whereas business during the other six months of the year was related to exploration of the natural springs in Kings Bay.

All dive shop operators said that a large number of divers who come to Crystal River are from out-of-state. Almost all dive shops advertise primarily out-of-state and even abroad. For example, one owner advertises in

Germany, England, Austria, Switzerland and Canada. An Ohio diving instructor visiting Kings Bay said that one dive shop in Columbus, Ohio brings forty divers a month to Crystal River between the end of November and the end of March.

In addition to attracting out-of-state divers, Crystal River's springs are also used for diving instruction classes by "every dive shop in a 100-mile radius." In the winter this business falls off, but in the summer these dive shops regularly bring divers to Kings Bay. This business, said one dive shop owner, helps support the dive shops year-round. Forth-one dive shops and instructors around the state rent equipment and boats from one shop alone. The operator of this shop said that at least two other Crystal River dive shops probably receive an equal number of in-state dive shops and instructors using their facilities. In addition, the number of divers using Kings Bay probably increases when the springs of the Suwannee River backflood with dark river water.

One dive shop operator said that most weekend divers are not in the spring to see manatees, but to take classes. He believes that less than 25 percent of the weekend divers are there for the manatees, and that most of the divers in Crystal River go to the Main Spring boil and do not explore the rest of the area.

Each dive shop operator was asked to give an upper and lower estimate of the number of customers served per week during the manatee season. Estimates for each dive shop were added to obtain an upper and lower estimate of the total number of divers using Kings Bay per week. About 820 to 1190 dive shop customers are in Kings Bay each week during the manatee season. Dive shops generally receive twice as many customers on weekends (about 580 to 800 people) than during the week (about 240 to 390 people). Several operators felt that some divers avoid crowded weekends and choose to come on weekdays.

Most dive shop operators considered manatees as important for the success of their business. They perceived additional regulation of boating and diving activities in Kings Bay as a potential threat to their livelihoods. Some remarks that reflect the attitudes of several dive shop operators are as follows: "If Kings Bay is closed down, it would effectively put us out of business." "About 40 percent of our business year-round is boat rental, so if Kings Bay is closed off, it would kill us." "Manatees are the only thing keeping us going." "There's a 50-50 chance that a person coming into our dive shop wants to play with manatees. The whole survival of Crystal River depends on manatees. Restaurants, gas stations, dive shops, hotels. If you couldn't play with manatees, you are cutting off 50 percent of our business."

b. Existing regulations

Dive shop operators were asked a series of more specific questions about the need for and effectiveness of existing regulations. These regulations include manatee sanctuaries that exclude people and boats during the winter, slow boat speed zones in effect during the winter, and a law prohibiting harassment or injury to manatees.

Dive shop operators differed in their responses to the question "Do you have any problems with the sanctuaries or the regulations associated with them?" Three of the five dive shop operators said the restrictions on diving due to the sanctuaries in Kings Bay posed no problems to them, although one of the three added that he hardly ever sees manatees in the sanctuaries. These three operators felt comfortable about being able to co-exist with the sanctuaries. Said one: "It doesn't bother me, it doesn't bother the other divers." Likewise, another owner said, "I can live with the sanctuary."

However, a fourth dive shop operator called the sanctuaries "ridiculous." He feels that the sanctuary on the south side of Banana Island is too shallow for manatees to inhabit and that the two sanctuaries are so close together that boats are funneled into one narrow channel. This, he feels, is potentially more dangerous for the manatees than if there were no sanctuaries at all. It's all just a bad way for (the) federal government to spend money," he said.

The same owner said he thinks the fines imposed on divers trespassing into the sanctuaries are hurting his business. Divers, he said, are "harassed unnecessarily" by law enforcement officers and are required to go to Jacksonville to pay fines. He thought divers should be warned once that they would be fined if they repeat a violation.

Another operator said that divers should be allowed to snorkel but not to scuba dive in the sanctuaries.

All dive shop operators said that the manatee sanctuaries are not clearly marked. At present, the sanctuaries are encircled by bright orange balls marked "No Entry." These interviewees said that divers can easily see the balls from the water's surface, but when underwater, divers can unknowingly swim into the sanctuary. Said one operator: "The only problem I have is that when you surface in the Main spring, you might find yourself in the manatee sanctuary."

Another said, "It was better when you had the buoys out. The balls are not in a straight line. It is clearer for divers if (they) are in a straight line." Another dive shop operator suggested that "a rope or something" is needed in the sanctuaries to prevent divers from entering the sanctuaries unknowingly. Likewise, another operator said, "It would help if we had something on the bottom."

In addition, all dive shop operators said that the "NO ENTRY" message marked on the balls is unclear, especially to newcomers to the bay. " A lot of people are mad. The (restricted) areas are not properly marked. People think (the signs) mean no boats, not them. They think swimming is OK."

Dive shop operators were asked whether they felt the presence of many divers in Kings Bay adversely affects the manatees. All dive shop operators believed the presence of divers does not bother manatees because, "manatees like people."

For example, one dive shop operator said, "Manatees like people there (in the springs). They don't go away from divers. I don't think that there could be too many divers in the spring." He believes that in the long-term, divers help manatees because, "The more people exposed to them, the more people will protect them." When asked if he perceived the high number of divers as a problem to manatees, he replied, "No way is it a problem. No regulations are needed for divers."

Another dive shop operator said that he has never witnessed any problems between divers and manatees except when a manatee rams into a diver and the diver is "forced" to push the animal away.

A third dive shop operator said, "I really don't think divers pose threats to manatees. Most divers are conservation-oriented. We give divers a map with the sanctuary areas marked. We verbally point out the sanctuaries--and say they are not allowed (in the sanctuaries). We verbally tell them, 'Don't chase, hang on, or ride (the manatees).' I don't think divers bother manatees. If manatees don't want you around, they can split. This year, manatees have approached the divers a lot more." In his opinion, "Fish and Wildlife Service and the Florida Marine Patrol have all been very cooperative with us. I don't really see any problem (with the number of divers)." He calls the Marine Patrol if he observes any "hassling" of manatees.

Dive shop operators expressed some confusion regarding the regulations protecting manatees from harassment. They were asked how they defined harassment.

One dive shop operator defined harassment as playing with tags, chasing manatees or riding manatees. "If a diver does harass (a manatee), fine him," he said. "Put a restriction that he could no longer come here." Another dive shop operator said that other than killing manatees, not many human activities could be considered harassment. However, a dive shop instructor turned the question around and asked the interviewer, "How do you define harassment? It needs to be defined." He tells divers that a crowd of people on a manatee is not pleasant for the animal and asks divers how they would like a bunch of people crowding in on them.

On dive shop operator said that he tells the Coast Guard to fine people who touch manatees--his shop personnel, he said, make it clear that divers are not to touch manatees. Instead, they should let the animals come up to them.

Several dive shop operators suggested that the slow and idle speed laws do not adequately cover the period of time when manatees are in Crystal River. Currently, the speed regulations are in effect from November 15 to March 15th. One interviewee said, "Speed laws need to be moved up in Crystal River around the 15th of October, not the 15th of November." In addition, this person said the Marine Patrol should be given authority to post more boat speed signs. He said he believes that speed laws are not adequately enforced.

A dive shop instructor said, "When they slapped slow and idle speed, (in the river and bay), it's the best thing they did." Another interviewee said, "Idle speed, slow speed, no problem." This owner said he asks the Marine Patrol that if its officers see one of his boats speeding, to stop the boat and fine the boat's driver.

The operator of another shop agreed that the slow speed limit poses no problems. He noted that the boats at his shop only have 8-15 horsepower capacity.

Another owner said that he thinks idle speed should be enforced year-round. "Not just for the manatees' (sake), but for divers also."

c. Need for additional regulations

When asked if any more regulations are needed, one dive shop operator said flatly, "We don't need any more regulations. We don't even need the ones we've got." Another dive shop operator said that no more regulations are necessary because the ones in effect should do the job of protecting manatees.

However, a dive shop instructor said, "It is a fine set of regulations." Several of the dive shop operators indicated that they would be willing to cooperate with governmental agencies to protect manatees. Said one: "There should be something so that industry, manatees and people can live together." He noted that he is willing to work in any possible way with the U.S. Fish and Wildlife Service (FWS) in doing so.

Without exception, dive shop operators believe that education is the key to "good" human-manatee interaction and protection. All complained of the lack of state and federal information they can distribute to divers, swimmers and boaters. Although most dive shops do have a short booklet on diving regulations published by the state, few have much other literature.

One dive shop operator said that 80 percent of the divers that come into his shop ask for manatee literature. But, he said, "the only thing we have is rules and regulations for diving."

Another operator said, "Literature helps--it's a good thing." He said that his dive shop plans to help increase manatee awareness by having some of its staff give talks to middle school students.

A third dive shop operator said that he doesn't get any literature. In addition, he noted, literature is "vitally" needed at marinas for fishermen, water-skiers, and other boaters. "They are not up on regulations as are divers," he said. He suggested that information booths about manatees be set up in the Florida Visitor centers. "I don't think you need to restrict people as much as educate them."

One dive shop has a guideboat that is used primarily for educational purposes. Several times each week, a guide takes 4th-graders from around Florida to see manatees and to learn about their environment . The operator of this dive shop also would like more manatee literature. "Divers are always asking for it. 200 (brochures by the Audubon Society) are gone in a week." The state, said a diving instructor, needs a new brochure on diving rules and regulations, one that gives a "real" definition of harassment.

d. Additional comments

One dive shop owner said that the most important factor that would protect manatees is to "quit destroying their food supply by spraying chemicals." In his opinion, spraying should be halted because the entire state of Florida is a manatee sanctuary, and he also believes federal laws state that any activity that harms manatees should be halted. He believes spraying hurts manatee habitat and, eventually, the animals themselves.

Another dive shop operator agreed, saying he is in favor of mechanical harvesting of aquatic plants. "You can't dump chemicals in water without having some long-term effect."

A few dive shop operators criticized the activities of government agencies that protect manatees. For example, one dive shop operator told that after seeing a manatee with a tightly bound rope around its flipper, he called the FWS in Jacksonville to report the manatee's plight. He said that the officer replied that he would "get back to him," but "Never did. (This) happened several times. When you report something, you don't hear anything about it." Another operator said he thinks that state and local governmental agencies should be the law enforcers for the area, not federal agencies.

Several dive shop operators expressed opinions that the FWS violated its own regulations. Few interviewees knew exactly what scientists were studying in regard to manatees, and several questioned why they had never seen the results of any of FWS studies.

Commercial Fishing

To determine if commercial fishermen and fishing guides have any problems with current regulations or perceive any future problems, the author interviewed the operators (managers, producers and owners), of commercial docking facilities and fish houses, and some commercial fishermen.

As many as 125 large fishing vessels are reportedly docked in Crystal River (Table 3). This estimate is based on the number of boats estimated by each dock operator to be at their respective docks.

Dock operators were asked to estimate the size of boats used in each fishery. Although some boats are used for several fisheries, the estimates were based on the purpose for which is the boat is primarily used during the

Table 3. Estimated number of fishing boats docked on Kings Bay.[1]

BOAT USE (Boat Size)	Dock A	Dock B	Dock C	Dock D	Dock E	TOTAL
	ESTIMATED NUMBER OF BOATS AT EACH DOCK					
Shrimp (28-44')	9	12-14	4	1	0	26-28
Grouper (not specified)	2	0	1	0	0	3
Commercial fishing (18-24')	10-30	4	10	0	0	24-44
Stone Crab (20-37')	15	10-18	5	0	0	30-38
Blue Crab	0	3	0	0	0	3
Guideboats (22-24')	0	6-7	0	8	10	24-25
TOTAL	36-56	26-36	20	9	10	112-125

[1] Estimates were made in March 1983. Docking patterns have changes since then.

year. Dock operators estimated that shrimp boats average 28-44' in length, commercial fishing boats, 18-24 feet; stone crab boats, 20-37 feet; blue crab boats, 20-26 feet, and fishing guideboats, 22-24 feet.

These same boats may be used for other purposes during off-seasons for each fishery. For example, because the taking of stone crabs is seasonal, stone crab fishermen usually switch to catching some other desirable species during the off-season.

Fishing boats follow the same path to the Gulf as manatees. All large boat operators interviewed said they follow the channel markers to navigate into the Gulf. The fishermen rarely remain near the mouth of Crystal River, but instead travel well into the Gulf.

Shrimp boats usually leave the docks in the afternoon (usually late afternoon) and arrive back at the docks before 10:00 a.m. Shrimpers may stay in the Gulf for three for four days at a time.

Although shrimping is a year-round industry, shrimp fishermen said that the peak shrimp season lasts from mid-August to December, which is also the time that manatees start arriving in Crystal River to take refuge from the cold. June and July are the slowest months for shrimping, and several shrimpers said they switch to some other "species" during these months. All fishermen interviewed said their boats are used year-round. If the shrimping is not good, they may try crabbing or grouper fishing.

One fishing guide was represented in this informal survey. There are approximately twenty one fishing guides in the Fishing Guide Association at Crystal River. Most of the fishing, this guide said, is done in the Gulf--on the bars and grass flats.

The guide said that they don't lead many fishing trips in the river itself except in the fall and winter. In the winter, fishing guides do lead tours in Crystal Bay, in Crystal River, in Salt River, in the Cross Florida Barge Canal and near the Florida Power hot water discharge. However, in the summer, most of the fishing is trout-fishing in the grass flats. Most of the fishing guides, he said, pick up their customers about 8 a.m., and return to their docks around 4 p.m. Most of their business is from out-of-state, and most of their customers are not divers.

The boats average from 22 to 24 feet in length and run about 80-150 horsepower.

a. Existing regulations

Most of the commercial fishermen and/or seafood store operators said that they have no problem with the slow and/or idle speed restrictions. The operator of one seafood house said, "No, I don't think they (fishermen) have any problems with boat speed. Haven't heard of any problem." Likewise, another operator said that the idle speed does not bother the crabbers. A producer at a seafood house said, "As set up now, I don't think we have a problem. Speed limit doesn't pose a problem as it is now."

The shrimpers that were interviewed all indicated that they don't have any problems with speed restrictions. However, on the Homosassa River, one manager of a seafood house said that he occasionally hears complaints that the restricted speed limit extends too far down that river. "Where it used to be, by marker 75, was ideal," this manager said.

Many of the operators and shrimpers interviewed said they have a real problem trying to get their large boats out of the bay in the winter when high tides don't raise the river's water level as much as it does the rest of the year. Dredging, said two fish house operators, is "a dire need." "(There are) days in winter when boats can't get out. Some areas that are filling in need deepening. Marker #5 is one of the worst," one operator said. Two shrimpers I interviewed also mentioned the need for dredging.

Although these fishermen and operators occasionally see manatees around their docks, none reported having seen manatees in the deeper Gulf waters where the fishermen fished. Two of these shrimpers had been shrimping the Gulf near Crystal River for the last 15 years. All shrimpers said they can co-exist comfortably with existing regulations. One owner of seafood plant, said the manatee sanctuary doesn't affect the crabbers at all. "Divers are no problem."

The owners of two seafood plants reported that they get a substantial amount of business from diving parties and tourists. Said one operator: "I would say that if we had any more restrictions on boats getting in and out or where they go, it would affect the generation of business. A lot of stuff is sold to tourists. Winter is the peak season for business. Our business wouldn't survive without this (tourist) business."

The same operator noted that Crystal River is "just an avenue of reaching the Gulf for us." He said, "They can close more of the Bay and not affect commercial fishermen but I'm not advocating this at any means because it will affect friends and neighboring businesses. (It) could affect (us) indirectly if tourists don't (come)."

However, the operator of one pier, where 300 boats are docked, mostly small pleasure boats, said he personally doesn't like speed zones and would like to "go as fast as his boat can go." This manager said, the "manatees have been here for hundreds of years with men. I don't see why you have to slow down for them." What would he like to happen? "Me being able to do whatever I want to do. The h--- with the manatees." However, this manager was giving his own opinion and was not speaking for fishermen in general; no commercial fishing boats are docked at the pier where he works. Although this manager said the sanctuaries don't bother him, he maintains that they don't do any good, because, "Manatees can't read." A similar attitude was expressed by a sport fisherman who was listening to the author conduct an interview. He said that if many more regulations were imposed to protect manatees, there wouldn't be any manatees left to protect.

Although his story was not validated, one interviewee said that he had recently seen four boatloads of divers inside the sanctuary markers. One time, he said, he saw two boatloads of divers stop near the pier, herd four manatees in a circle, and then proceed to stand on the animals and to sit on their backs. In his opinion, "Divers are doing more damage than boats are. Manatees are naturally curious animals but (they) don't like divers sitting on them, poking them." This person maintains that manatees leave Kings Bay after divers are present for an hour or two. "Divers molest those manatees to no end," he said.

The fishing guide interviewed said "Our main problem is not the manatee, it is the speed limit--(we) now have to run to idle speed all over the bay." The guide said that the speed limit is not hurting business but that it takes guides 15-20 minutes extra on each trip to or from the Gulf. This, he said, costs them money, because their props are being ruined by the excessive length of time running at idle speed.

b. Additional comments

All the seafood house operators and shrimpers interviewed said they would like to see more mechanical harvesting and less chemical control of waterplants. Some said they would like chemical control discontinued. However, their concerns were related to the effects of plant control on fish, not on manatees.

The operator of one seafood house said, "They should stop poisoning the weeds." Instead, he suggested that the county use mechanical harvesting and find some use for the weeds. He said, "For a month after they poison the river, there's no crabs or fish in the bay. This is one important thing to be done. Poisoning is (a) bad situation." For example, he said, weeds die and settle down in the river, making the river even siltier. "twelve years ago, this place was full of fish. Compared (to then), we don't have any fish at all." Another person in the same shop said that boats have a lot of problems with dead weeds. For example, motors' propellers often get caught in them. The other co-owner said, "Dead weeds are just as much a problem as live ones."

However, the operator of another seafood house said that although spraying for hydrilla doesn't seem to affect crabs, he believes that the county ought to engage in a control program consisting of both spraying and mechanical harvesting. Another seafood operator said, "I think that the control we do have is a little less than satisfactory because they could do more for us."

Two shrimpers said that after chemicals are sprayed in the river, they don't see fish for days. Said one: "I think chemicals are affecting everything in the river." Both said they believe that mechanical harvesting does more good than chemicals. One shrimper said that he sees fish in the weeds before spraying but not after spraying. In addition, both shrimpers believe that when mechanical harvesting is conducted, it keeps the weeds away "three times longer than chemicals."

Again, the lack of knowledge of what FWS is "really" doing in Crystal River came up in an interview. One person said he once asked a FWS scientist what he was studying and the scientist replied that he was seeing if there was enough grass for the manatees to eat. "Wastin' money. (It would) help if (we) know what FWS is doing down here."

DISCUSSION

Information from an informal survey of this type must be used and interpreted with great care. Due to its subjective style, biases of the interviewer may have affected comments that were recorded and reported, although every efforts was made to avoid such bias. However, the range of opinions and attitudes reported in this selected group of interviews may provide insight relevant to public relations of agencies involved in manatee protection, and to design of a more comprehensive survey of public opinion.

Two generalizations were apparent to me after completing these interviews. First, there are many different perceptions regarding the effects of human activities on manatees, and many factors would need to be considered in an objective evaluation of such effects. Second, the resistance to additional regulations is strong and a positive alternative would be an enhanced public education campaign to improve enforcement of existing regulations.

In general, dive shop operators perceived that there was no problem for manatees due to their interactions with divers. However, opinions of dive shop operators regarding effects of divers on manatees were not shared by several residents who live across from the Main Spring and view the activities from their homes. These residents felt that the number of people and boats in the area south of Banana Island disturbed the manatees. The boats using the area are not all from the dive shops, but include fishermen and sight-seers as well as swimmers and divers.

One resident recorded the number of boats present in the area south of Banana Island and Warden Key during February 21, 1983 through March 28, 1983. Observations were made on the hour, although not for every hour of each day. No distinction was made regarding the type of boat (e.g. skiff, yacht, sailboat, platform pontoon, canoe etc.) in tallying these data. The data for weekend days (Saturday and Sunday) was summarized separately from the data for weekdays (Monday through Friday) (Table 4).

According to these observations, boats were more abundant on weekends than on weekdays, verifying the pattern of activity reported by the dive shop operators (Table 4). For example, at noon an average of 21 boats were observed on weekend days compared to an average of 8 boats on week days. As many as 34 boats were observed on one weekend day; a density that might disturb manatees. Boat density was lower in mornings and evenings. Observed boats were most abundant between 10 a.m. and 3 p.m. on both weekends and weekdays.

To evaluate the effects of boats, snorkelers and SCUBA divers on manatees, the hourly change throughout each day should be considered as well as differences between weekdays and weekends. The number of manatees that tolerate, compared to those that avoid, human interaction would also need to be determined. The perceptions of some dive shop operators appear to be based on those animals with which they have had contact, which may be a small part of the total group.

Dive shop operators and instructors need to be somehow involved in an objective study of the effects of human interactions on manatees, to give them the opportunity to evaluate the validity of the study and its recommendations. Several individuals held a low opinion of the credibility and purpose of government research, indicating that better public relations are needed.

Table 4. Number of boats observed south of Banana Island and Warden Key, Kings Bay, February 21, 1983 through March 28, 1983.

TIME	WEEKEND			WEEKDAY		
	n	X ± S.D.	min-max	n	X ± S.D.	min-max
7:00 a.m.	9	1 ± 1	0-4	23	1 ± 2	0-10
8:00	9	3 ± 2	1-7	23	1 ± 1	0-5
9:00	9	8 ± 3	2-13	22	2 ± 2	0-9
10:00	9	14 ± 6	8-28	20	5 ± 3	1-13
11:00	7	17 ± 8	11-34	15	6 ± 5	0-15
12:00	7	21 ± 6	11-28	18	8 ± 5	1-15
1:00 p.m.	8	19 ± 7	10-31	19	7 ± 4	0-14
2:00	7	16 ± 6	6-25	18	7 ± 6	1-21
3:00	6	14 ± 11	3-28	19	6 ± 4	0-14
4:00	7	9 ± 5	2-17	20	5 ± 4	1-13
5:00	7	5 ± 4	1-12	16	4 ± 4	0-13
6:00	5	3 ± 2	1-4	8	1 ± 2	0-5
7:00	3	2 ± 2	1-4	4	2 ± 2	1-5
8:00	2	1 ± 1	1-2	2	1 ± 1	1-2

Both dive shop operators and members of the commercial fishing industry were concerned about the possible addition of more extensive regulations in Crystal River. They felt their businesses would be adversely affected by any action that reduced tourism, and expressed unwillingness over having personal rights restricted on the waterways.

Several dive shop operators felt that existing regulations were adequate, but that more information and public education was needed to explain rules to visitors. They were willing to cooperate with an enhanced program of public education, anticipating that it would reduce the need for additional regulations.

However, public education should extend beyond the dive shops. People who bring their own boats and launch at boat ramps may not receive any information on manatee protection in Crystal River. Such visitors may come from a wide area outside Citrus County. For example, the point of origin was recorded from the license plates of ninety seven cars parked at boat ramps on Crystal River during one winter day (Tabb, pers. comm.). Most of the cars (85%) were from outside Citrus County, and 21% were from outside the state of Florida.

The existing educational program at the Citrus County Marine Science Center enhances manatee awareness among students, but does not reach the general public. Considering the apparent value of manatees to the local community, a public education program that reaches many types of visitors to the area would be warranted.

RECOMMENDATIONS

1. The effects of human activities on manatees in Crystal River should be studied in more detail. Such research should be done in a manner that involves the local dive shops so that they understand the purpose and results of the study.
2. A public education program regarding manatee protection should be developed to reduce the need for additional regulation of human activities in Crystal River.
3. If additional regulations are made regarding human activities on Crystal River, the socioeconomic effects on local businesses should be considered.

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