FINAL TECHNICAL REPORT
VOLUME 2 OF 2

BIOLOGICAL RESOURCES OF THE INDIAN RIVER LAGOON

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM MELBOURNE, FLORIDA

Prepared By:
Woodward-Clyde Consultants
Marshall McCully & Associates, Inc.
Natural Systems Analysts, Inc.

Prepared For:
Indian River Lagoon National Estuary Program
1900 South Harbor City Boulevard - Suite 109
Melbourne, Florida 32901-4749
July 1994

Woodward-Clyde

Woodward-Clyde Consultants
9950 Princess Palm Avenue, Suite 232
Tampa, Florida 33619

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U.S. CUSTOMARY CONVERSION TABLES

TO CONVERT FROM	TO	MUTLIPLY BY
LENGTH		
centimeters	inches	0.3937
inches	centimeters	2.5400
feet	meters	0.3048
meters	feet	3.2808
kilometers	meters feet miles	1.0×10^3 $3.280\ 84 \times 10^3$ 0.621 37
miles	kilometers	1.609 34
AREA		
acres	hectares square feet square kilometers (km^2) square miles	0.404 69 4.356×10^4 .00404 .00156
hectares	square meters acres	1.0×10^4 2.471
square kilometers	hectares acres square miles (mi^2)	100.0 274.105 38 0.3861
square miles	hectares square kilometers (km^2) square feet acres	258.998 81 2.589 99 $2.787\ 84 \times 10^7$ 640.0
VOLUME		
liters	cubic feet gallons	0.035 31 0.264 17
gallons	liters cubic feet	3.785 41 0.133 68
cubic feet	cubic meters (m^3) gallons (gal) acre-feet (acre-ft)	$28.316\ 85 \times 10^{-3}$ 7.480 52 $22.956\ 84 \times 10^{-6}$
cubic yards	cubic meters cubic feet	0.764 55 27.0

INTERNATIONAL SYSTEM (SI METRIC)/
U.S. CUSTOMARY CONVERSION TABLES, Continued

TO CONVERT FROM	TO	MUTLIPLY BY
VOLUME		
cubic meters	gallons cubic feet cubic yards acre-feet	264.1721 35.314 67 1.307 95 8.107×10^{-4}
acre-feet	cubic feet gallons	43.560×10^{3} 325.8514×10^{3}
TEMPERATURE		
	degrees Celsius (C) (t_c)	$t_c = (t_f - 32)/1.8 =$ $t_k - 273.15$
	degrees Fahrenheit (F)	$t_f = t_c/1.8 + 32$
VELOCITY		
kilometers per hour	meters per second miles per hour	0.277 78 0.621 47
miles per hour	kilometers per hour meters per second	1.609 34 0.447 04
FORCE		
kilograms	pounds (lbs)	2.2046
MASS		
pounds (avdp)	kilograms	0.453 59
VOLUME PER UNIT TIME FLOW		
cubic feet per second	cubic meters per second (m^3/s) gallons per minute (gal/min) acre-feet per day (acre-ft/d) cubic feet per minute (ft^3/min)	0.028 32 448.831 17 1.983 47 60.0
gallons per minute	cubic meters per second cubic feet per second (ft^3/s) acre-feet per day	0.631×10^{-4} 2.228×10^{-3} 4.4192×10^{-3}
acre-feet per day	cubic meters per second cubic feet per second	0.014 28 0.504 17

6.0 WILDLIFE RESOURCES

6.1 BENTHIC INVERTEBRATES AND FOULING COMMUNITIES

6.1.1 Status and Distribution

Much research has been done on the benthic community of the Indian River Lagoon. Virnstein and Campbell (1987) report that close to 700 species of benthic invertebrates have been reported in these studies; over 400 species of mollusks alone are known from the Lagoon (Mikkelsen, et al., 1994). Sixteen species of sipunculan worms have also been reported from the Lagoon (Rice, et al., 1983, 1994) from numerous habitats. At least 70 species of fouling organisms (sessile filter feeding animals such as barnacles, limpets, bryozoans, and sea squirts or tunicates that adhere to hard substrates) have been reported from the Lagoon (Mook, 1983). Twenty-eight species of foraminifera have been reported by Buzas and Kropf (1975).

It is not possible to cover all of the several hundred pieces of literature on the benthic communities for this report. Much of the research has centered on very specific locations or topics or utilized short-term observations and are not well-suited to presenting an overview of the conditions of the Lagoon or describing trends or characteristics that can be extrapolated to other parts of the Lagoon. Research in the last 5 to 10 years seems to have concentrated on biochemical, taxonomic, and anatomical aspects with less emphasis on ecological studies and distributional patterns than occurred in the previous 10 years. Another difficulty in extrapolating benthic data or comparing data from different studies lies in species identification differences. Unlike in many groups of larger organisms, taxonomic identification of many benthic invertebrates, particularly the infaunal species, is difficult and standardization of taxonomic criteria and level of identification varies greatly among different studies.

The known information on macroinvertebrate and fouling communities has been rather thoroughly summarized by Virnstein and Campbell (1987). Reports on these communities include Gore, 1972; Clark, et al., 1975; Gore, et al., 1975, 1976; Grizzle, 1974, 1979;

Mook, 1976, 1977, 1980, 1983; Young, 1975; Young and Young, 1974, 1977, 1978; Young, et al., 1974, 1976; Zimmerman, et al., 1979; Mikkelsen, 1981; Nelson, et al., 1982; Howard, 1985; Reish and Hallisey, 1983; Stoner, 1980, 1983; Howard and Short, 1986; Virnstein, 1987, 1990; and Virnstein, et al., 1983.

A general finding of many of the studies (Nelson, et al., 1982; Virnstein, et al., 1983, 1984; Virnstein, 1990) has been high variability within stations over time and among similar stations. For example, Virnstein, et al. (1983) found over 6,000 Atlantic modulus and horn snails (*Cerithium muscarum*) at a station only 1.2 miles (2 km) from another similar seagrass bed station where these species were efectively absent. The invertebrate community composition at any location may also vary over short time periods. Howard (1985) found that over 50% of the individuals in snail and shrimp populations within small areas of seagrass beds could move out of sampling areas within a few hours.

Studies by Young and Young (1977) and by Nelson, et al. (1982) have indicated little relationship of species number and diversity to latitudinal gradients in the Lagoon, although Young, et al. (1976) found that an abundance gradient of amphipods from 1,331 organisms per square ft in stations near Haulover Canal and Banana River in the north to 373 ft^2 at St. Lucie Inlet, while Virnstein, et al. (1984) found little latitudinal variation in density or biomass.

6.1.2 Ecological Patterns

Benthic species can generally be split into two groups - the epifauna, which includes species living on top of the substrate, and the infauna, which comprises the species living underneath the surface.

Polychaete (segmented) worms comprise the largest component of the Indian River Lagoon complex infaunal benthic community. Gastropods, oligochaete worms, amphipods, and bivalve molluscs are also major components of this community. Amphipods are the most abundant group within the epifaunal community, with other crustaceans and gastropods also being important groups (Grizzle, 1979; Virnstein, 1987).

Unpublished data from Brevard County covers stations throughout the county over the periods from 1973 -1985 and 1988 - 1989 (White, 1993). These data indicated that polychaetes numerically accounted for 34% of the total benthic community, crustaceans 35%, molluscs 23%, and echinoderms 1%. The dominant crustaceans were the amphipods (31%) and the isopods (5%). The most abundant of the sipunculan worms, *Phascolian cryptus*, inhabits abandoned gastropod shells in densities up to 364 ft^{-2} (3,856 m^{-2}) on sand bottom areas and seagrass beds throughout the Lagoon, with higher densities in seagrass beds although considerable variation has again been found over time (Rice, et al., 1983).

Different studies have reported different polychaete species as being the most abundant. Data from Brevard County (White, 1993) indicate that *Streblospio benedicti*, *Mediomastus* sp., and *Prionspio cerifera* were the most abundant polychaetes in 1989. *S. benedicti* was also identified as one of the more abundant polychaetes in a study by Young (1975) near Ft. Pierce and St. Lucie Inlet, but Young found *Polydora ligni*, and *Exogene dispar* to be more abundant and *Clymenella mucosa* to be generally dominant.

Much invertebrate community research has centered on the infaunal and epifaunal amphipod crustaceans, which appear to be one of the most significant components associated with the seagrass habitat (Young and Young, 1977; Nelson, 1980; Nelson, et al., 1982; Virnstein, et al., 1984). The most common species of amphipods that have been described for the Indian River Lagoon include *Grandidierella bonnieroides* and *Cymadusa compta* throughout the Lagoon complex; *Ampelisca abdita*, *Corophium lacustre*, and *C. ellisi* in the northern portion of the complex; and *Ampithoe longimana* in the southern portion (Nelson, et al., 1982).

Trends in occurrence and abundance appear to exist for some individual species and groups within the Lagoon. For example, tubeworms, which are burrowing polychaete worms, (Sabellariidae Family) are largely restricted to areas with substantial current action and actively changing sand substrates (Kirtley, 1974; Eckelbarger, 1976). Consequently they are most abundant near the inlets where large masses of worm tubes can become cemented together to form hard "worm reefs" which may change the contours and substrate characteristics of the Lagoon in the vicinity of the inlets. The northern limit of the dominant sabellariid worm, *Phragmatopoma lapidosa*, has been reported as Cape Canaveral (Gore, et al., 1975).

A latitudinal pattern for the three dominant species of foraminifera has been reported for the Lagoon (Buzas and Kropf, 1975). Of these, *Ammonia beccarii* is most abundant in the most southern portion, *Elphidium incertum* between Ft. Pierce and Sebastian Inlets, and *Quinqueloculina semimula* primarily north from the Sebastian Inlet area.

Various studies have shown that substantial variation occurs within the benthic community, both spatially and temporally, although the dominant groups generally remain amphipods, polychaetes, or bivalve molluscs. Seasonal differences have been demonstrated by the Brevard County data and by Nelson, et al. (1982); Virnstein, et al. (1983); and others. Population density may vary by 2 to 60 times between seasons, with the lowest densities occurring either in late summer, when water temperatures are highest, or in winter when temperatures are lowest.

Spatial variations are also apparent. Virnstein, et al. (1983) reported benthic populations to be 3 times as abundant within seagrass beds as in bare sand areas adjacent to the beds. Other studies (Stoner, 1980) have shown similar ratios in abundance between vegetated and unvegetated bottom habitats. Greater species diversity appears to occur near the inlets, as well as in areas in the Banana River and in the Indian River near Haulover Canal (Virnstein, 1987; Nelson, et al., 1982). Nelson (1993) has observed that population density varies greatly among years and that different sites within the complex peak at different times with no apparent causal linkage among different areas of the Lagoon complex.

Of the 72 species of hard substrate fouling organisms reported by Mook (1983), there were 23 Ascidians, 19 bryozoans, and 8 crustaceans. Again considerable variatiability is found in seasonal and spatial patterns. Some species such as the barnacles (*Balanus* spp.) are prevalent throughout the year, while others are most abundant in either summer or winter. Fouling organisms also appear to show a pattern of decreasing species diversity with increasing distance from the inlets (Mook, 1983). Several studies have also indicated that predation is important in determining community patterns in fouling organisms (Mook, 1977; 1981).

The benthic community also forms a critical link in the food chain, converting plant and detrital material into concentrated energy forms available to higher level consumers. Some evidence suggests that population levels of groups such as the amphipods are closely tied to the population levels of predators such as pinfish and mojarro or to the degree to which available cover protects the invertebrates from predation (Stoner, 1982; Nelson, et al., 1982; Virnstein, et al., 1984), illustrating the importance of the benthos in the food chains of the Lagoon. Various species have also been found to have different and well defined responses to water quality conditions. Thus, they can be used as indicators of the water quality and ecological health of a system. However, such data can easily be misinterpreted due to the wide range of temporal and spatial variation that occurs naturally and has not yet been well explained within the Lagoon.

6.2 AMPHIBIANS AND REPTILES

Amphibians and reptiles have colonized many of the biotic communities within and adjacent to the Indian River Lagoon. These animals are distributed throughout the Lagoon and are found in salt marshes, mangroves, mosquito impoundments, spoil islands and the adjacent upland and freshwater systems. Lagoonal ecosystems are among the most variable ecosystems known, in which constant changes in temperature, salt concentrations, and water levels create a challenging environment for these species to survive.

Amphibians and reptiles have perhaps the widest range of adaptive abilities of vertebrate wildlife that inhabit the Lagoon. They have evolved specific physiological and morphological adaptations enabling them to survive these changing conditions. These adaptations include a variety of reproductive strategies, such as being either egg-laying (oviparous) or live-bearing (viviparous); being capable of phenotypic (visible characteristic) changes that provide protection from predators; and having instinctive behaviors such as burying themselves beneath the substrate during times of cold weather. In addition, many reptiles have evolved euryhaline (wide salinity range) body systems, which allow them to acclimate to a wide variety of salt concentrations.

6.2.1 Status and Distribution

Undoubtedly, turtles, frogs, and possibly snakes were a food source for early native Americans exploring the Lagoon. However, as man began to settle in greater density adjacent to the Lagoon, impacts to amphibian and reptile species increased. The taking of amphibians and reptiles for commercial purposes began in the late 1800s. Two species, the green sea turtle and the diamondback terrapin, were routinely taken and shipped on ice to markets in New York (True, 1887). Additionally, species, particularly snakes viewed as undesirable, were killed routinely by the general public, undoubtedly decreasing the population of both poisonous and non-poisonous snakes. This practice continues today. Increased urbanization from 1950 to 1970 also has caused habitat loss which has in turn decreased diversity and overall populations of amphibians and reptiles within the Lagoon system.

Information regarding the historical record of species observations and collections is sparse. Odum, et al. (1982) described 24 species of amphibians and reptiles that inhabitant mangrove communities, and Neill (1958) reported 10 species of reptiles and amphibians which inhabit the Merritt Island area. Siegel (1989) described many of the aquatic turtle species inhabiting the Lagoon. Most species accounts of amphibians and reptiles within the entire Lagoon system have been obtained from data involving observations and collections on the KSC and the MINWR (Edward E. Clark Engineers-Scientists, Inc., 1986, 1991). Additionally, several species have been observed on the numerous spoil islands within the Lagoon as part of a 1990 investigation by the Florida Department of Natural Resources (1990a).

Fifty-two reptile and 16 amphibian species are known to inhabit the KSC and MINWR portions of the Indian River Lagoon system (Edward E. Clark Engineers-Scientists, Inc., 1991; Provancha, et al., 1992). Table 6-1 shows these species and 28 species reported to inhabit the Hobe Sound National Wildlife Refuge (HSNWR) at the southern end of the Lagoon (US FWS, 1992). Many of these species occur in both areas, but some regional differences in species composition are also apparent.

Amphibians or reptiles are present in all of the habitat associations of the Indian River Lagoon region (Edward E. Clark Engineers-Scientists, Inc, 1991), but they are most common in the freshwater wetlands and savannas, upland hammocks, and pine flatwoods. In terms of species numbers, they are least well represented in the harsh environments along the beaches and in the open water zones of the ocean and estuary. The lower habitat diversity in HSNWR as compared to KSC and MINWR may be a main factor in the reduced species diversity at HSNWR. A greater intensity of study at MINWR may also account for these differences.

TABLE 6-1

REPTILE AND AMPHIBIAN SPECIES RECORDED WITHIN AND ADJACENT TO INDIAN RIVER LAGOON

COMMON NAME	SCIENTIFIC NAME	PRESENCE AT MINWR	PRESENCE AT HSNWR
Eastern spadefoot	*Scaphiopus h. holbrooki*	●	
Oak toad	*Bufo quercicus*	●	
Southern toad	*Bufo terrestris*	●	
Eastern narrowmouth toad	*Gastrophryne carolinensis*	●	
Greenhouse frog	*Eleutherodactylus p. planirostris*	●	
Florida cricket frog	*Acris gryllus*	●	
Green treefrog	*Hyla cinerea*	●	
Pine woods treefrog	*Hyla femoralis*	●	
Barking treefrog	*Hyla gratiosa*	●	●
Squirrel treefrog	*Hyla squirella*	●	●
Cuban treefrog	*Hyla septentrionalis*	●	●
Little grass frog	*Limnaoedus ocularis*	●	
Florida chorus frog	*Pseudacris nigrita verrucosa*	●	
Pig frog	*Rana grylio*	●	
Southern leopard frog	*Rana pipiens sphenocephala*	●	
Eastern lesser siren	*Siren intermedia intermedia*	●	
Greater siren	*Siren lacertina*	●	
Two-toed amphiuma	*Amphiuma means*	●	
Green anole	*Anolis carolinensis*	●	●
Brown anole	*Anolis sagrei*		●
Six-lined racerunner	*Cnemidophorus s. sexlineatus*	●	●
Ground skink	*Scincella lateralis*	●	●
Southeastern five-lined skink	*Eumeces inexpectatus*	●	●
Peninsula mole skink	*Eumeces egregius onocrepis*	●	
Indo-Pacific gecko	*Hemidactylus garnoti*		●
Eastern slender glass lizard	*Ophisaurus attenuatus longicaudus*	●	
Eastern glass lizard	*Ophisaurus ventralis*	●	

TABLE 6-1

REPTILE AND AMPHIBIAN SPECIES RECORDED WITHIN AND ADJACENT TO INDIAN RIVER LAGOON, Continued

COMMON NAME	SCIENTIFIC NAME	PRESENCE AT MINWR	PRESENCE AT HSNWR
Island glass lizard	*Ophisaurus compressus*	●	
Florida scrub lizard	*Sceloporus woodi*		●
American alligator	*Alligator mississippiensis*	●	●
Atlantic loggerhead	*Caretta caretta*	●	●
Atlantic green turtle	*Chelonia mydas*	●	●
Atlantic ridley	*Lepidochelys kempii*	●	
Atlantic leatherback	*Dermochelys coriacea*	●	●
Atlantic hawksbill	*Eretmochelys i. imbricata*		●
Florida snapping turtle	*Chelydra serpentina osceola*	●	
Striped mud turtle	*Kinosternon baurii*	●	
Florida mud turtle	*Kinosternon subrubrum steindachneri*	●	
Florida cooter	*Pseudemys floridana floridana*	●	
Florida chicken turtle	*Deirochelys reticularia chrysea*	●	
Florida box turtle	*Terrapene carolina bauri*	●	●
Florida softshell turtle	*Apalone ferox*	●	
Diamond-backed terrapin	*Malaclemys terrapin*	●	
Gopher tortoise	*Gopherus polyphemus*	●	●
Florida scarlet snake	*Cemophora coccinea coccinea*	●	
Southern black racer	*Coluber obsoleta priapus*	●	●
Southern ringneck	*Diadophis punctatus*	●	●
Eastern indigo snake	*Drymarchon corais souperi*	●	●
Corn snake	*Elaphe guttata guttata*	●	●
Yellow rat snake	*Elaphe obsoleta quadrivittata*	●	●
Eastern mud snake	*Farancia abacura reinwardti*	●	
Eastern hognose snake	*Heterodon platyrhinos*	●	
Florida kingsnake	*Lampropeltis getulus floridana*	●	
Scarlet kingsnake	*Lampropeltis triangulum elapsoides*	●	●

TABLE 6-1

REPTILE AND AMPHIBIAN SPECIES RECORDED WITHIN AND ADJACENT TO INDIAN RIVER LAGOON, Continued

COMMON NAME	SCIENTIFIC NAME	PRESENCE AT MINWR	PRESENCE AT HSNWR
Eastern coachwhip	*Masticophis flagellum flagellum*	●	●
Florida green water snake	*Natrix cyclopion floridana*	●	
Banded water snake	*Natrix fasciata fasciata*	●	
Florida water snake	*Natrix fasciata pictiventris*	●	
Mangrove water snake	*Natrix fasciata compressicauda*	●	
Salt marsh snake	*Nerodia clarkii compreeicaunda*	●	
Atlantic salt marsh snake	*Nerodia clarkii taeniata*	●	
Pinewoods snake	*Rhadinaea flavilata*	●	
Rough green snake	*Opheodrys aestivus*	●	●
Florida pine snake	*Pituophis melanoleucus mugitus*	●	●
Florida brown snake	*Storeria dekayi victa*	●	
Eastern garter snake	*Thamnophis sirtalis*	●	
Peninsula ribbon snake	*Thamnophis sauriyus sackeni*	●	
Eastern coral snake	*Micrurus fulvius fulvius*	●	●
Florida cottonmouth	*Agkistrodon piscivorus conanti*	●	
Eastern diamondback rattlesnake	*Crotalus adamanteus*	●	●
Dusky pigmy rattlesnake	*Sistrurus miliarius barbouri*	●	●

Sources: Edward C. Clark Engineers - Scientists, Inc., 1991
Ehrhart and Witherington, 1992
McDiarnid, 1978
U.S. FWS, 1992

6.3 AVIFAUNA

Avifaunal richness is synonymous with the Indian River Lagoon system. The geography and physiography of the system provides a wide array of habitats for wading birds and wetland-dependent avian species. These habitats include open water, mangroves, salt marshes, spoil islands, and mosquito impoundments, which attract and sustain numerous avian species. The Lagoon not only provides permanent habitats for resident species but also serves as a migratory stopover for species utilizing the Eastern Flyway. Large numbers of avian species also winter along the open water communities distributed throughout the Lagoon. Over 200,000 waterfowl have been reported to utilize the wetlands, Lagoon, and impoundments at MINWR as wintering habitat (Edward E. Clark Engineers-Scientists, Inc., 1991).

6.3.1 Status and Distribution

There are currently reported 367 species of birds (Table 6-2) that use the Indian River Lagoon or adjacent uplands and coastal areas at some point in their life cycle (Kale, 1988). Of these, about 125 species breed in the region, another 172 species overwinter in the area, and 70 are transient visitors to the area, largely stopping during spring and fall migrations (Kale, 1988; Edward E. Clark Engineers-Scientists, Inc., 1991). The number of transient species is important because resting sites during migration may be a very critical factor for the survival of migrating birds. Based on these numbers, the Indian River Lagoon system possibly supports more avian species than any other estuarine location in the United States.

Avifaunal species also use the upland and freshwater habitats adjacent to the Lagoon. These adjacent areas are important because, while many species such as the wood stork use the open water of the Lagoon for foraging, they return to adjacent areas within the watershed to roost and to nest.

Numerous rookeries are found scattered along the Lagoon. The natural and man-made spoil islands harbor thousands of birds each year. The bare sands of some spoil islands are valuable nesting sites for several species of shore birds, such as the least tern, which nest on the ground. Tree covered islands provide some of the primary rookeries for wading birds. The presence of three National Wildlife Refuges (Pelican Island, Merritt Island, Hobe Sound) and the newly designated Archie Carr Refuge along the Brevard and Indian River

TABLE 6-2

SUMMARY OF THE STATUS OF BIRD SPECIES RECORDED WITHIN AND ADJACENT TO INDIAN RIVER LAGOON

CATEGORY	NUMBER OF SPECIES
Breeding Species	
Water Birds	41
Land Birds	84
Nonpasserine	36
Passerine	48
Total Breeding Species	125
Wintering and Migrant Species	
Water Birds	78
Land Birds	94
Nonpasserine	15
Passerine	79
Total Wintering and Migrant Species	172
Irregular and Accidental Species	70
Total Species	367

Source: Table from Kale (1988)

County coasts) are important resources for maintaining breeding populations of many species. They thus may have helped to maintain a high diversity of avian species in the region. One well known rookery, Pelican Island, in northern Indian River County, became the first National Wildlife Refuge in the United States in 1903.

6.3.2 Historical Perspective

Herbert W. Kale II, on staff at the Florida Audubon Society, investigated the available and obscure references pertinent to avian history within the Lagoon. In the Indian River Monograph (Kale, 1988), he has provided valuable dates and occurrences outlining the history of avifauna within the Indian River Lagoon region. Highlights that have been extracted from that report are:

1562 to 1916 Period

- The earliest available record indicates the presence of wild turkeys being killed at the mouth of the St. Lucie River in 1775.
- In 1850 Dr. Harry Bryan noted and observed the presence of roseate spoonbills breeding on Pelican Island.
- Charles J. Maynard spent time collecting in the Mosquito Lagoon near Haulover Canal and discovered the dusky seaside sparrow in 1872.
- Well known ornithologist Frank Chapman visited Pelican Island from 1889 to 1914 and initiated protection for pelicans which led to the designation of Pelican Island National Wildlife Refuge, America's first refuge in 1903.
- In 1913 the last Carolina Parakeet was collected from the mouth of the Sebastian River, in Brevard County.

1916 to 1970 Period

- W. W. Worthington collected birds from Titusville to Sebastian Inlet. Many of the birds are in collections including the Smithsonian, American Museum of Natural History, and numerous universities.

- From 1906 until 1970 Rupert J. Longstreet of Daytona Beach studied the northern Indian River Lagoon and Mosquito Lagoon. His observations were published in "Ornithology of the Mosquitoes".

- The 1950s brought noted naturalist and birder, Allan D. Cruickshank, to the Lagoon. His studies were published posthumously in "Birds of Brevard County" and increased the popularity of bird watching in Brevard and surrounding counties.

- The development of the Canaveral Space Center, later renamed the Kennedy Space Center, placed 60,000 acres into public ownership in the late 1950s and early 1960s.

- Merritt Island National Wildlife Refuge designated in 1963.

- A Lagoon-wide study was initiated by the Fish and Wildlife Service in 1967 to determine the impacts on birds by the mosquito impoundments. In this study, Provost (1967) found that 7 species were adversely affected by the impoundments, and 22 species benefitted from the creation of these structures.

1970 to 1992 Period

- Local National Audubon Society Chapters (Halifax River Audubon, Southeast Audubon, Indian River Audubon, Pelican Island Audubon, St. Lucie Audubon, and martin County Audubon) were organized within the Lagoon, leading to the popular "Christmas Counts" that are conducted every year and provide valuable avian population data.

- Implementation of the Endangered Species Act of 1973

- Colonial waterbird study initiated within the Lagoon, from 1976 to 1978. This study was updated and expanded in 1986, leading to the publication of " Florida Atlas of Breeding Sites for Herons and their Allies" by the Florida Game and Fresh Water Fish Commission.

- The development of a statewide breeding bird atlas by Florida Audubon Society, under the direction of Herbert W. Kale II and Wes Biggs.

- The last known dusky seaside sparrow dies in captivity at Disney World in 1987.

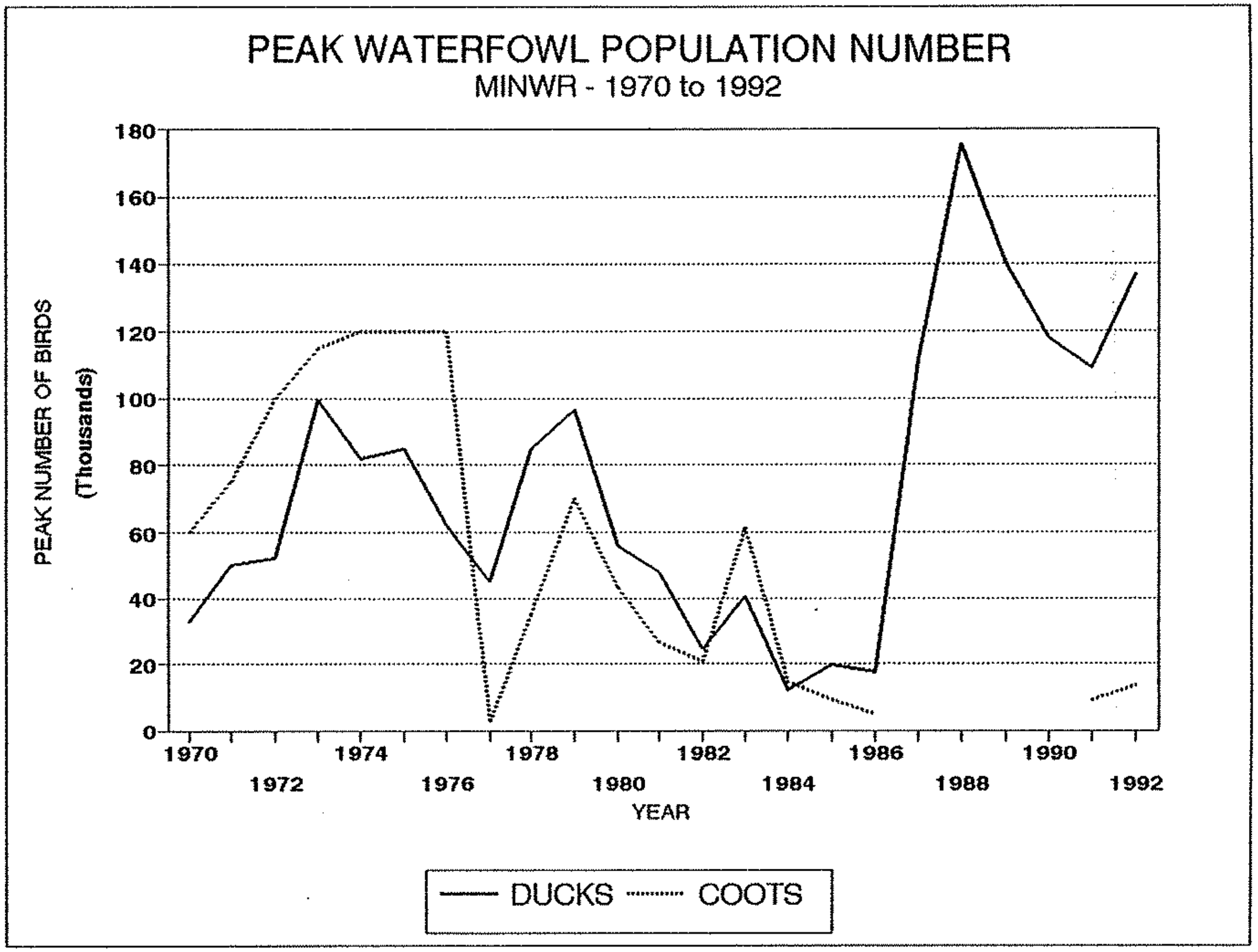
6.3.3 Waterfowl and Wading Birds

The Indian River Lagoon provides many types of habitats for migratory and resident waterfowl (ducks and coots) and wading birds. Of the 367 bird species in the region, 119 are waterbirds (Kale, 1988). The shallow waters of the Lagoon and numerous marshes and mosquito control impoundments provide foraging and roosting areas for these species.

Much of the habitat for waterfowl and wading birds is within MINWR. The proximity of KSC and MINWR to the eastern flyway provides migratory waterfowl an ideal winter habitat. The MINWR has kept records of mid-winter counts of ducks and coots since 1970. Over 200,000 waterfowl have been known to utilize MINWR habitat for overwintering (Edward E. Clark Engineers-Scientists, Inc., 1991). Figure 6-1 shows the peak overwintering waterfowl populations at MINWR for the period from 1970 to 1992. There are quantifiable differences between many of the years. No definitive studies have been conducted to explain these fluctuations.

6.3.4 Rookeries

Nesting of many wading and shore birds occurs in communal nesting sites known as rookeries, in which hundreds of birds may nest simultaneously. These species are collectively referred to as colonial nesting water birds (Osborn and Custer, 1978). Rookery



Source: Data from MINWR, 1993

• Woodward–Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysis	DRAWING NO.: DATE:	FIGURE 6-1 PEAK SEASONAL NUMBERS OF WATERFOWL OCCURRING IN THE MERRITT ISLAND NATIONAL WILDLIFE REFUGE

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locations generally have specific characteristics which make them attractive for nesting and which usually persist for many years. Presence of suitable nesting substrates, isolation,protection from predators, and proximity to feeding areas are often the main requirements for rookery areas (Wiese, 1977).

Numerous rookeries scattered throughout the Lagoon provide sites for communal nesting and rearing of young wading birds. These rookeries are vital to the continued existence of many avian species found in the Lagoon. The FGFWFC non-game program has developed an atlas documenting the location, status and species of birds utilizing these rookeries. The document "Florida Atlas of Breeding Sites for Herons and their Allies" (Nesbitt, et al., 1991), is an update to a 1978-1979 study. Figure 6-2 shows the location of these important rookeries.

6.3.4.1 Pelican Island National Wildlife Refuge

One of the oldest documented rookeries is on the Pelican Island National Wildlife Refuge, located about 6 miles (9.6 km) south of Sebastian Inlet. This refuge was established in 1903 during Theodore Roosevelt's presidency as the first National Wildlife Refuge. Protection for nesting pelicans was important at this time due to impacts from habitat losses, recreational shooting, and hunting for plumage. Nesting birds in the refuge were still subject to harassment, since most passing boats carried passengers with guns who would use the birds for targets as they passed. By 1910, the National Audubon Society hired a warden to help protect the estimated 3,000 to 10,000 breeding pelicans and the island (Kale, 1988; Whitmore, 1993).

For a period of time after the establishment of the refuge, it was reported to be the only significant brown pelican nesting site along the entire east coast of Florida (Kale, 1988; Whitmore, 1993). It is believed that several nesting colonies of pelicans relocated from south Florida to use this island (Whitmore, 1993). In the 1920s and 1930s, the refuge was unique in that it maintained a population of pelicans that nested in the fall as well as a population that nested during the normal spring period. As many as 75% of the approximately 10,000 nesting birds in 1910 were fall nesters (Whitmore, 1993). It is thought that these birds were from a south Florida population and that the fall nesting was in response to the change in latitude (D. Whitmore, 1993). With time, fewer and fewer birds nested in the fall.

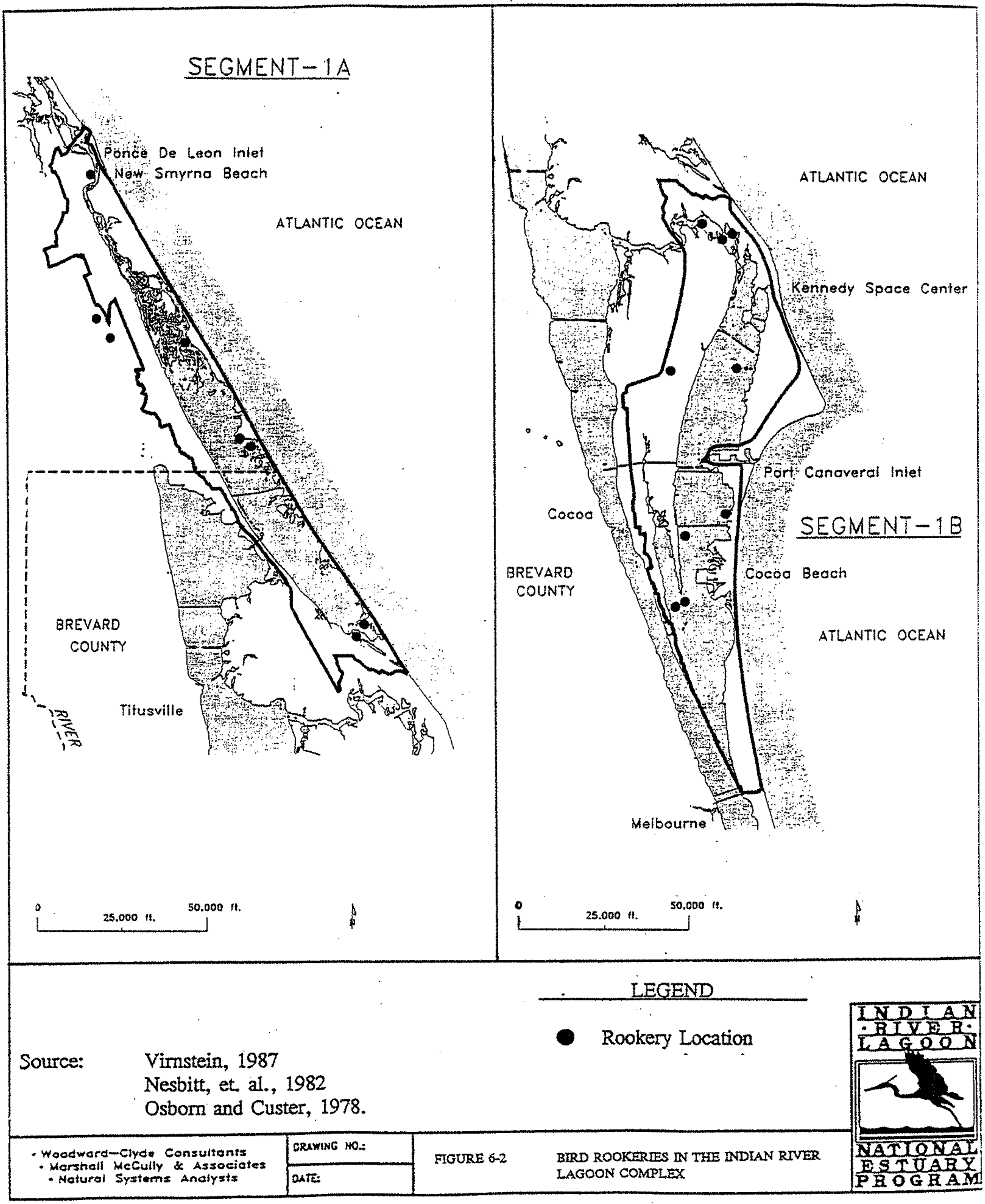
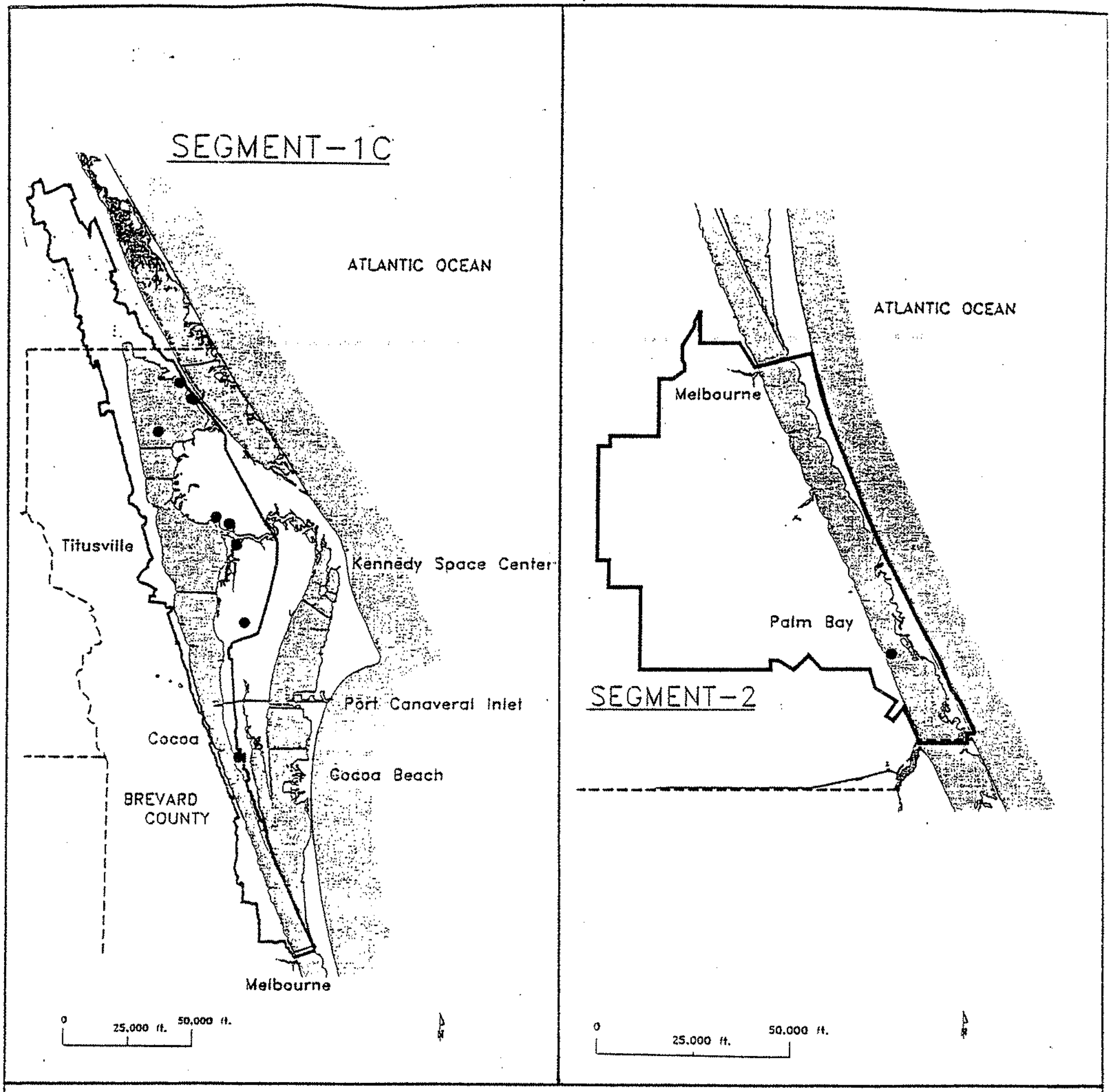


FIGURE 6-2 BIRD ROOKERIES IN THE INDIAN RIVER LAGOON COMPLEX



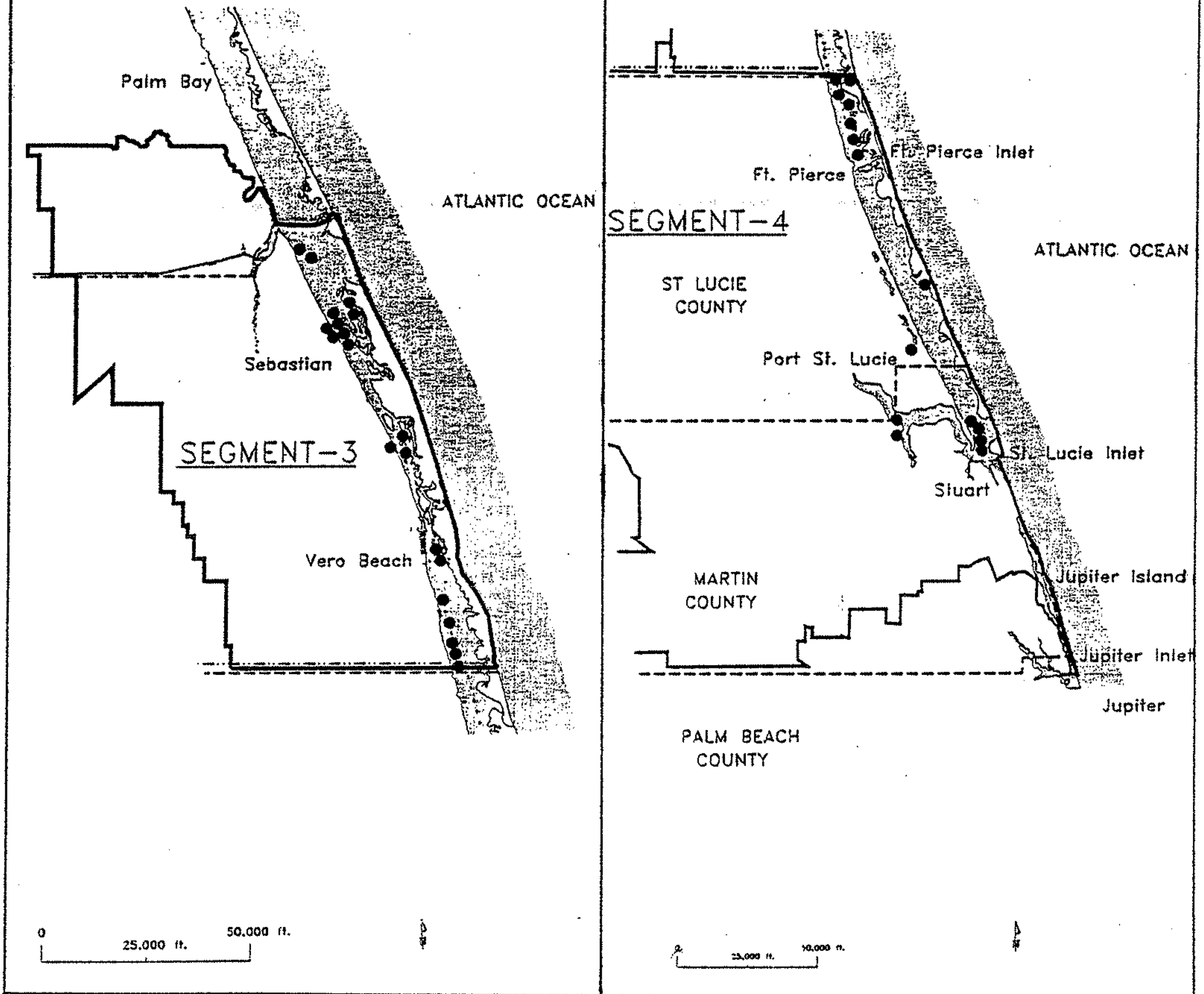
Source: Virnstein, 1987
Nesbitt, et. al., 1982
Osborn and Custer, 1978.

LEGEND

● Rookery Location

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM

• Woodward-Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.: DATE:	FIGURE 6-2	BIRD ROOKERIES IN THE INDIAN RIVER LAGOON COMPLEX



Source: Virnstein, 1987
Nesbitt, et. al., 1982
Osborn and Custer, 1978.

LEGEND

● Rookery Location

- Woodward-Clyde Consultants
- Marshall McCully & Associates
- Natural Systems Analysts

DRAWING NO.:

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FIGURE 6-2 BIRD ROOKERIES IN THE INDIAN RIVER LAGOON COMPLEX

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Nesting habitats of birds utilizing Pelican Island have also been unusual. Early pictures show hundreds of pelicans nesting on bare ground rather than in trees. The vegetation of the island has undergone numerous changes in the last 100 years due to freezes, hurricanes, and the effects of the birds themselves. Severe freezes in 1895 and 1898 killed most of the mangroves, thus forcing the birds to nest on the ground (Whitmore, 1993). The relative isolation of the island and lack of predators made this possible. There have also been shifts in utilization by different species groups, with various wading birds utilizing the island as well as pelicans at various times.

The refuge remained the only significant pelican nesting site until the establishment of the Merritt Island National Wildlife refuge near Cape Canaveral in 1963, when numerous pelicans began to utilize the habitats being created at that site. For a brief period, pelicans entirely abandoned Pelican Island, leaving it to wading birds for nesting. Although pelicans have since returned to the island, the overall pelican population has grown significantly and many additional nesting sites are now being used throughout the Lagoon system. However, there may have been no residual population for re-establishment if Pelican Island had not been protected as a breeding ground for a critical period of history.

6.3.5 Impacts to Avian Species

Avian populations endemic to the Indian River Lagoon system have no doubt fluctuated greatly throughout time since periodic natural occurrences combined with man's influence have affected the bird life within the Lagoon. Typical natural occurrences are the periodic freezes which have killed vegetation such as mangroves and thereby adversely affected avian species which utilize the mangrove forests as rookeries. An example of this effect is the 1982 abandonment by woodstorks of the Bird Island rookery in Mosquito Lagoon after a frost damaged the vegetation in 1981 (Provancha, et al., 1992).

Man is also responsible for creating both adverse and beneficial effects on avian populations within the Lagoon. As man settled within the region, destruction and alteration of avian habitat was the primary factor for loss of bird species. Other impacts created by man's influence included the hunting of birds for sport and plumage. In the first major avian decline recorded, the plume trade of the 1920s devastated many populations of herons and other wading birds (Kale, 1988). The enactment of conservation laws in the 1920s probably saved many species from extinction. Although newly implemented laws have protected wading species from being hunted for game or plumage, continued development along the Lagoon has impacted avian habitat and continues as a major factor in the decline of numerous species.

Urbanization of the Lagoon has been both beneficial and detrimental to avian species utilizing the Lagoon. Many avian species such as passerines (i.e. warblers, sparrows, chickadees, wrens, thrushes, and swallows) were able to survive and adapt to the development and creation of houses which provided new breeding and foraging areas. From the late 1950s through the early 1970s, the creation of mosquito impoundments altered tens of thousands of acres of habitat. However, the creation of these impoundments also benefitted many bird species in two ways. The first was a reduction in the use of pesticides containing chlorinated hydrocarbons (i.e. DDT), which therefore buffered the Lagoon region from the tremendous loss of bird life seen elsewhere in the country. Secondly, over time these impoundments helped to increase species diversity, because they increased previously limited habitat types such as open water foraging grounds (Provost, 1969). Provost (1967, 1969) reported that several wading birds appeared to benefit from impoundment of mosquito impoundments in the MINWR because they provided increased shallow open water feeding areas.

Swain, et al., (1992) have also studied the effects of impoundment management strategies on bird populations. Their study also showed that populations of wading birds increased significantly when water levels were low, especially at times when water levels were decreasing and prey density was increasing (Swain, et al., 1992). The most dense fish populations were observed in the impoundments that were drawn down in comparison to those that were maintained in permanent high water conditions or those which were open to the Lagoon and exposed to natural tidal cycles. As many as 2,500 wading birds from 13 species were observed in the six study impoundments at one time. White ibis was the most abundant species (29%), followed by great egrets (18%), snowy egrets (17%), and roseate spoonbills (14%). The visual feeders, especially the great egrets and snowy egrets, showed positive responses to declining water levels, while the tacto-locating white ibis did not. The wood storks responded like the visual feeding species, even through they are grope feeders.

Certain species such as the dusky seaside sparrow, snail kite, and wood storks have suffered because of habitat loss and the inability to adapt to new conditions. This inability to adapt to the loss of the tidally influenced salt marshes led to the extinction of the dusky seaside sparrow in 1987.

6.4 MAMMALS

At least 25 mammal species are known from the Merritt Island area (Table 6-3) and 17 species have been reported from HSNWR in Martin County (Edward E. Clark Engineers-Scientists, Inc., 1991; US FWS, 1992). Almost all of the species at HSNWR are also present at MINWR in Brevard County, but several species are recorded only from the MINWR area. This indicates that the mammalian fauna at HSNWR may not have the tropical or south Florida exhibited by several other biological groups, although the region has also been less well studied.

Most of the mammal species in Table 6-3 are wide-ranging species that occur in a wide range of habitats. Most of these are most common in the upland habitat areas, but they also occur in freshwater wetlands and coastal mangrove forests and salt marshes. Although most of these species adapt well to disturbed habitats, several of the species such as the Florida mouse (*Peromyscus floridanus*), southeastern beach mouse (*Peromyscus polionotus niveiventris*), and bottlenose dolphin (*Tursiops truncatus*) have restrictive habitat requirements. Each of these is a federally protected species that is covered in more detail in Section 7.0.

Other than the manatee, mammals probably represent the least studied group of wildlife that occurs along the Lagoon. The ecological requirements and effects of mammal populations in the habitats associated with the Lagoon have not been well studied.

TABLE 6-3

MAMMAL SPECIES RECORDED WITHIN AND ADJACENT TO INDIAN RIVER LAGOON

COMMON NAME	SCIENTIFIC NAME	PRESENCE AT MINWR	PRESENCE AT HSNWR
Virginia opossum	*Didelphis marsupialis*	●	●
Least shrew	*Cryptotis parva*	●	
Eastern mole	*Scalopus aquaticus*	●	
Nine-banded armadillo	*Dasypus novemcinctus*	●	●
Marsh rabbit	*Sylvilagus palustris*	●	●
Eastern cottontail	*Sylvilagus floridanus*	●	●
Gray squirrel	*Sciurus carolinensis*	●	●
Marsh rice rat	*Oryzomys palustris*	●	
Eastern wood rat	*Neotoma floridana*	●	●
Cotton rat	*Sigmodon hispidus*	●	
Cotton mouse	*Peromyscus gossypinus*	●	●
Southeastern Beach mouse	*Peromyscus polionotis*	●	●
Florida mouse	*Peromyscus floridanus*	●	●
Golden mouse	*Ochrotomys nuttalli*	●	
Round-tailed muskrat	*Neofiber alleni*	●	
Black rat	*Rattus rattus*	●	
Gray fox	*Urocyan cinereoargenteus*	●	●
Raccoon	*Procyon lotor*	●	●
Eastern spotted skunk	*Spilogale putorius*	●	●
River otter	*Lutra canadensis*	●	●
Bobcat	*Felis rufus*	●	●
Feral cat	*Felis catus*	●	
White-tailed deer	*Odocoileus virginianus*	●	●
Wild boar	*Sus scrofa*	●	●
Eastern pipistrelle	*Pipistrellus subflavus*	●	
Black bear	*Ursus americanus*	●	

TABLE 6-3

MAMMAL SPECIES RECORDED WITHIN
AND ADJACENT TO INDIAN RIVER LAGOON, Continued

COMMON NAME	SCIENTIFIC NAME	PRESENCE AT MINWR	PRESENCE AT HSNWR
Florida manatee	*Trichechus manatus latirostris*	●	●
Bottlenose dolphin	*Tursiops truncatus*	●	●
Hooded seal	*Crystophora cristata*		●[1]

Sources: Edward E. Clark Scientists - Engineers, Inc., 1991
Layne, 1978
Provancha, et al., 1992
U.S. FWS, 1993

1 = Accidental occurrence only October, 1984

7.0
THREATENED AND ENDANGERED WILDLIFE SPECIES

The Endangered Species Conservation Act was first passed in 1969 and superseded by the Endangered Species Act of 1973. The 1973 Act established categories for threatened as well as endangered species, and allowed for the protection of populations and sub-species as well as individual species. This latter provision is important for the Indian River Lagoon system, because many of the animals in peril in the region are sub-species of more wide-ranging species. It has been pointed out that the Indian River Lagoon has a very high degree of biodiversity. Much of that biodiversity is a result of the development of new species or populations at the outer edges of species ranges that overlap in the sub-tropical and temperate zones within the Indian River Lagoon region.

Following the Endangered Species Act of 1973, the Florida Audubon Society and the Florida Defenders of the Environment jointly founded the Florida Committee on Rare and Endangered Plants and Animals (FCREPA). This committee selected well known scientists and lay persons to develop information on and to classify species of Florida as endangered, threatened, of special concern, or rare. The FGFWFC developed this list in 1987 to be backed by the Florida Wildlife Code, Chapter 39, Florida Statutes.

Endangered, Threatened, and Special Concern Species of the Indian River Lagoon region are listed in Table 7-1 (Complied from "Official Lists of Endangered and Potentially Endangered Fauna and Flora in Florida", 1991 (FGFWFC, 1991). Also shown are species under review for potential listing by the USFWS. The following accounts cover those species listed as Endangered, Threatened, or of Special Concern by the USFWS or FGFWFC, as well as a few unlisted species of special interest to the region. Unless noted, the status of each species discussed below is listed according to its federal status as reported in the FGFWFC list.

TABLE 7-1

ENDANGERED, THREATENED, AND SPECIAL CONCERN ANIMAL SPECIES RECORDED WITHIN THE INDIAN RIVER LAGOON SYSTEM

COMMON NAME	SCIENTIFIC NAME	USFWS STATUS	FGFWFC STATUS
Shortnose sturgeon	*Acipenser brevirostrum*	E	E
Common snook	*Centropomus undecimalis*		SSC
Mangrove rivulus	*Rivulus marmoratus*		SSC
Gopher frog	*Rana areolata*	C2	SSC
American alligator	*Alligator misissippiensis*	T	SSC
Atlantic loggerhead turtle	*Caretta caretta*	T	T
Atlantic green turtle	*Chelonia mydas myda*	E	E
Atlantic ridley turtle	*Lepidochelys kempii*	E	E
Leatherback turtle	*Dermochelys coriacea*	E	E
Atlantic hawksbill turtle	*Eretomochelys imbricata imbricata*	E	E
Gopher tortoise	*Gopherus polyphemus*	C2	SSC
Island glass lizard	*Ophiosaurus compressus*	C2	
Florida scrub lizard	*Sceloporus woodi*	C2	SSC
Atlantic salt marsh snake	*Nerodia clarkii taeniata*	T	T
Eastern indigo snake	*Drymarchon corais couperi*	T	T
Florida pine snake	*Pituophis melanoleucus mugitus*	C2	SSC
Bachman's sparrow	*Aimophila aestivalis*	C2	
Roseate spoonbill	*Ajaia ajaja*		SSC
Dusky seaside sparrow	*Ammodramus maritimus nigriscens*	Ex	
Smyrna seaside sparrow	*Ammodramus maritimus pelonotus*		
Florida scrub jay	*Aphelocoma c. coerulescens*	T	T
Limpkin	*Aramus guarauna*		SSC
Burrowing owl	*Athene cunicularia*		SSC
Piping plover	*Charadrius melodus*	T	T
Kirtland's warbler	*Dendroica kirtlandii*	E	
Little blue heron	*Egretta caerulea*		SSC

TABLE 7-1

ENDANGERED, THREATENED, AND SPECIAL CONCERN ANIMAL SPECIES RECORDED WITHIN THE INDIAN RIVER LAGOON SYSTEM, Continued

COMMON NAME	SCIENTIFIC NAME	USFWS STATUS	FGFWFC STATUS
Reddish egret	*Egretta rufescens*	C2	SSC
Snowy egret	*Egretta thula*		SSC
Tricolored heron	*Egretta tricolor*		SSC
Arctic peregrine falcon	*Falco peregrinus tundrius*	T	E
Southeastern American kestrel	*Falco sparverius paulus*	C2	T
Florida sandhill crane	*Grus canadensis pratensis*		T
American oystercatcher	*Haematopus palliatus*		SSC
Bald eagle	*Haliaeetus leucocephalus*	E	T
Wood stork	*Mycteria americana*	E	E
Eastern brown pelican	*Pelecanus occidentalis*		SSC
Red-cockaded woodpecker	*Picoides borealis*	E	T
Snail kite	*Rostrhamus socialbilis plumbeus*	E	E
Least tern	*Sterna antillarum*		T
Roseate tern	*Sterna dougallii*	T	T
Bachman's warbler	*Vermivora bachmanii*	E	E
Florida long-tailed weasel	*Mustela frenata peninsulae*	C2	
Florida mink	*Mustela vision lutensis*	C2	
Round-tailed muskrat	*Neofiber alleni*	C2	
Florida mouse	*Peromyscus floridanus*	C2	SSC
Southeastern beach mouse	*Peromyscus polionotus niveiventris*	T	T
Florida manatee	*Trichechus manatus latirostris*	E	E
Florida black bear	*Ursus americanus floridanus*	C2	T

Sources: Edward C. Clark Engineers - Scientists, Inc., 1991; FGFWFC, 1992; Provancha, et al., 1992

Status:
E = Endangered
SSC = Species of Special Concern
Ex = Extinct
T = Threatened
C2 = Candidate for Listing, with some evidence for vulnerability

7.1 THREATENED AND ENDANGERED AMPHIBIANS AND REPTILES WITHIN THE INDIAN RIVER LAGOON REGION

Several species of amphibians and reptiles are listed as endangered and threatened by state and federal agencies. The following species descriptions are derived primarily from species accounts associated with KSC (Edward E. Clark Engineers-Scientists, Inc., 1991; Provancha, et al., 1992) and the FDNR Spoil Island study conducted in 1990 (FDNR, 1990a).

7.1.1 Endangered

No amphibian or reptile species endemic to the Indian River Lagoon are listed as endangered with the exception of the marine turtles which are discussed in more detail in Section 7.1.4.1.

7.1.2 Threatened

Atlantic Salt Marsh Snake *(Nerodia fasciata taeniata)*

The Atlantic salt marsh snake is not commonly known, but it is of great interest among biologists and conservationists because of its uniqueness to the Indian River Lagoon complex. This small water snake, generally less than two feet long, is found only within the mosquito control impoundments and associated ditches and salt marshes along the Mosquito Lagoon in southern Volusia County. Although individuals have been observed feeding during the day, this snake is largely nocturnal. The Atlantic salt marsh snake feeds primarily on small fishes within impoundment ponds and ditches. There is also evidence that they use existing fiddler crab burrows and await the crabs as prey. Researchers have noted the docile behavior of the species, since many times when they are encountered they appear dead, even while being handled. The species is viviparous, and bears several young once per year.

The Volusia County Mosquito Control District is conducting research on this species and establishing population estimates and distributions (Goode, 1993). The continued research being conducted on the Atlantic salt marsh snake will provide valuable information which will assist in the preservation of the species.

The future of this species depends largely upon preservation of its habitat. Loss of habitat may also cause this species to move into adjacent habitats of the more wide-ranging southern water snake (*N. fasciata*). This would promote hybridization and also eventual loss of the Atlantic salt marsh snake as a species (McDiarmid, 1978). The prevention of future alterations to the mosquito impoundments and of dredging and filling of salt marshes is needed to ensure the survival of this species. Several conservation groups have recommended that this region of Volusia County from its southern border with Brevard County north to the Bulow State Park area be classified as significant habitat, acquired, and placed into public lands for preservation.

<u>Eastern Indigo Snake *(Drymarchon corais couperi)*</u>

This species is usually found in upland habitats including oak scrub, sandhills, mesic and xeric hammocks, maritime forests, and pine flatwoods. It is most common in mesic hammocks, xeric hammocks, scrub, and maritime forest. These communities occur on dry upland soils where the water table is sufficiently deep for gopher tortoise burrows. The major concentrations of these habitats along the Lagoon are in KSC and MINWR, in scattered areas of the barrier islands, and on scrubs near Titusville and Ft. Pierce.

Although the indigo snake has been observed in mangrove communities within the Lagoon, its distribution and occurrence in this habitat is largely limited by its commensal relationship with the gopher tortoise (*Gopherus polyphemus*), whose burrows it uses as refuge from cold, dessication, and preditors. Gopher tortoise burrows are limited to dry upland communities such as oak scrub and maritime forest where the water table is deep enough to allow dry burrows. Thus the occurrence of the eastern indigo snake in mangrove habitats is largely limited to stands which adjoin dry upland communities and is occasional in nature. However, indigo snakes have been noted using the burrows of land crabs which are associated with mangrove systems and coastal wetlands as shelter.

7.1.3 Species of Special Concern

American Alligator *(Alligator mississippiensis)*

The alligator was once listed by the FWS and FGFWFC as endangered because of its declining population throughout the southeastern United States. The Florida populations have recovered, and the species has been re-designated by FGFWFC as a species of special concern. Although the FGFFC allows licenses for limited hunting of these animals for commercial purposes, FWS still classifies the American alligator as threatened because of its similarity of appearance to the endangered crocadile.

The species is commonly found in the open water and mosquito impoundments within the Lagoon, and also is found in freshwater wetland systems adjacent to the Lagoon.

Gopher Tortoise (*Gopherus polyphemus*)

Within the Indian River Lagoon region, the gopher tortoise is limited to upland habitats adjacent to the Lagoon, probably in greatest abundance at Cape Canaveral and Merritt Island on the MINWR and KSC. It also is found sparsely along the coastal ridges east of the Lagoon, including habitats on HSNWR, Jonathan Dickinson State Park, and the Savannas State Reserve. Prime habitats are the arid oak and sand pine scrubs and the oak hammocks. Gopher tortoises are unique in the fact that their burrows also serve as habitat for an estimated 300 commensal species including eastern indigo snakes, gopher frogs, numerous insects, and small mammals. The decline of the species is attributed to the loss of valuable upland habitats that are also prime areas for development (McDiarmid, 1978).

Gopher Frog (*Rana areolata*)

This species is a commensal of the gopher tortoise. It lives in conjunction with the gopher tortoise in its burrow, with no apparent effect on the tortoise. It is recognized by its large head and mouth, and a creamy white to brown color (McDiarmid, 1978). It occurs in coastal xeric habitats and interior scrub habitats from south Georgia to mid-Florida.

Its habitat utilization and distribution is similar to the eastern indigo snake in that it is also limited by its dependence upon the burrows of the gopher tortoise. The species is limited to the dry upland habitats such as sandhills, sand pine scrub, and oak scrub. However, during breeding (wet) season, it migrates to shallow grassy wetlands adjacent to these areas to breed (McDiarmid, 1978). Some of these wetlands may be adjacent to the Lagoon. Population pressures have been similar to those of the gopher tortoise.

Florida Pine Snake (*Pituophis melanoleucus mugitus*)

The Florida pine snake is up to 90 in. (230 cm) in length and usually has a gray color with tan to reddish to black blotches. It occurs throughout the southeastern coastal plain from South Carolina to Dade County in south Florida in dry sandy habitats of drier pine forests, oak hammocks, and scrubs (Conant, 1975). Food consists of small mammals and birds eggs. Its status is poorly known in this region.

Striped Mud Turtle (*Kinosternon bauri*)

The striped mud turtle is found throughout peninsular Florida and southern Georgia in marshes, cypress domes, and other freshwater wetlands where it feeds on plant materials and small animals (Ashton and Ashton, 1991). It generally nests in sandpiles or decaying vegetation along the shores of wetlands between March and October. Although it may occur throughout the region, it presence in the vicinity of the Lagoon is slight because of its dependence on freshwater wetlands.

Florida Scrub Lizard (*Sceloporus woodi*)

The Florida scrub lizard is apparently restricted to four distinct areas of Florida which contain fire-maintained scrub or coastal beach and dune habitats (Conant, 1975; Ashton and Ashton, 1991). One of these areas is a narrow band along the east coast of Florida from approximately Brevard County south. The endemic habitat of the Florida scrub lizard includes the sand pine scrubs along the Atlantic Coastal Ridge west of the Lagoon as well as the dunes and xeric oak hammocks on Hutchinson and Jupiter Islands.

The Florida scrub lizard is about 5 in (12 cm) long with rough scales. The background color is pale or grey-brown with a brown or black stripe along each side of the body (McDiarmid, 1978). Males may have pale blue spots or bands on the throat or sides of the belly.

Scrub lizards tend to be less arboreal and more ground-dwelling than many other lizards. Mating occurs from the end of March to late June with eggs laid in the soil or in gopher tortoise burrows. Insects comprise about 85% of their diet (McDiarmid, 1978). Loss of scrub habitat to development is thought to be the greatest threat to this species.

7.1.4 Marine Turtles

Marine turtles or sea turtles are commonly found within the Indian River Lagoon complex. These turtles are long-lived, often not reaching sexual maturity until more than 20 years old (Ehrhart and Witherington, 1992). During their lives, they travel long distances between coastal and open ocean waters. Of the seven species of marine turtles found worldwide, five have been documented to use the Indian River Lagoon complex. The five species that have been found within the Lagoon complex are the green turtle (*Chelonia mydas*), loggerhead sea turtle (*Caretta caretta*), hawksbill turtle (*Eretmochelys imbricata*), Atlantic ridley turtle (*Lepidochelys kempii*), and the leatherback turtle (*Dermochelys coriacea*).

Population and distribution studies of marine turtles within the Indian River Lagoon system have been conducted over the past twenty years. These studies have indicated that the green turtle and the loggerhead turtle and are the most prevalent species and are the only two species which play a significant role in the ecology of the Indian River Lagoon (Ehrhart, 1988). The other three species have been documented only as incidental observations.

7.1.4.1 Marine Turtle Descriptions and Ecological Requirements

Green Turtle (*Chelonia mydas*)

These herbivorous marine turtles were often referred to as "soup turtles" by those who consumed the gel-like substance adhered to the underside of the carapace (upper shell plate). Hatchlings are black to gray above with the underside plastron (lower shell plate) an off-white. Hatchlings weigh approximately 1 oz (30 g). Juvenile and sub adults are brownish-green with radiating light and dark streaks from each scute. Adults retain a somewhat dark green color and can weigh 220-389 lb (104-177 kg) and are 35-46 in (0.88 to 1.17 m) in length (Ehrhart and Witherington, 1992).

The green turtle is found throughout tropical and subtropical areas worldwide. Nesting occurs in widely scattered sites throughout the Caribbean and Florida. Although nesting may once have been common throughout Florida, it is now concentrated along the east central coast of Florida from Jupiter Inlet to Volusia County and in scattered sites on the upper peninsula and panhandle along the Gulf coast. The area between Cape Canaveral and Palm Beach is considered to be the major nesting area in Florida for this species. Hatchlings emerge from beach clutches, enter the ocean, and apparently congregate around sargassum rafts. Juveniles are thought to enter the Indian River Lagoon complex at ages of 1 to 2 years when they are believed to use the shallow Lagoon waters as a developmental habitat until they are about 5 years old (Ehrhart, 1988).

Adult green turtles graze primarily on turtle grass and other seagrasses, but will occasionally eat crabs, jellyfish, and other marine invertebrates. Juveniles are reported to feed mainly on small invertebrates (Ashton and Ashton, 1991). The species is a diurnal feeder and sleeps under ledges or other protected areas at night (Ashton and Ashton, 1991).

Although destruction of nests and disruption of the beachfront nesting habitat has been a major cause of this species decline, it may also be subject to significant stresses that are more severe than for other turtle species. In particular, the green turtle is the most sought after food species because of the quality of the meat and its use for soups. It also is the only species in which the disease papillomatosis has been found (Ehrhart, 1988).

<u>Loggerhead Sea Turtle (*Caretta caretta*)</u>

Juvenile and sub-adult loggerheads are the most common marine turtles found within the Indian River Lagoon complex (Ehrhart, 1988). The adults are easily identified by their massive head and elongated carapace. The carapace is reddish-brown in color with the underside plastron a creamy yellow. Adults can weigh 400 lb (180 kg) and be 2.3-4.1 ft (70-125 cm) in length (Ehrhart and Witherington, 1992).

The range of this species includes the Gulf of Mexico and the Atlantic Ocean from southern Canada to Argentina. It nests along ocean beaches throughout Florida between April and August, although the most important nesting habitat in the United States is the Indian River Lagoon region between Cape Canaveral and Palm Beach (Ashton and Ashton, 1991). Destruction of habitat including losses of eggs and nests is presently the greatest threat to this species, although there is some use of its meat on Caribbean islands. Disruption of hatchling turtle migration from the beaches also results in losses of young loggerheads.

This species is omnivorous. Although it does eat turtle grass and algae, it primarily uses its massive jaws to crush mollusks and crustaceans (Ashton and Ashton, 1991). Juveniles inhabit the Indian River Lagoon complex throughout the year, feeding on crabs and mollusks, usually in shallow hard bottom areas where these mollusks are most abundant.

Atlantic Ridley Turtle (*Lepidochelys kempii*)

The most endangered species of marine turtles is the Atlantic ridley turtle. Only three accounts of observation of this species have been documented in the Lagoon. Ehrhart live captured three individuals from the Banana River and the Mosquito Lagoon between 1976 and 1981 (Ehrhart, 1983). Additionally, two instances of capture occurred near Sebastian Inlet between 1989 and 1993 (Ehrhart, 1993). These sporadic captures and observations indicate *L. kempii* is apparently a transient species in the Indian River Lagoon complex.

The Atlantic ridley turtle is thought to be primarily a Gulf of Mexico resident, although individuals have been recovered from the Atlantic Ocean. Adults nest almost exclusively at Rancho Nuevo, Mexico, and only rarely has nesting occurred in Texas or Florida. This nesting specificity has not been explained. Adults are similar to the loggerhead in appearance but differ in having a broad carapace which at times is wider than it is long (Layne, 1978).

A tremendous decline of nesting females has reduced the population from 40,000 in 1947 to an estimated less than 600 today. This has been largely attributed to illegal egg taking and shrimp trawl net mortality.

Atlantic Leatherback Turtle (*Dermochelys coriacea*)

This, the largest of all turtle species, can weigh over 1,300 lb (590 kg). The carapace differs from other marine turtles by its leathery or rubbery texture, black color, and 12 longitudinal ridges along the dorsal surface. It is also the only marine turtle without scutes (plates on the carapace) or claws.

This species has the greatest range of the marine turtles, extending worldwide with the Atlantic population spreading from Nova Scotia to French Guiana (McDiarmid, 1978). It rarely occurs in shallow waters (McDiarmid, 1978). Major nesting areas are in the Caribbean, but nesting has been reported on the east coast of Florida from Miami to Flagler County. Most nesting activity has occurred in Martin and Palm Beach counties and on Hutchinson Island in St. Lucie County. Two records have also been made of nesting in Georgia (FDNR, 1990a) and also in the Florida panhandle (Mullen, 1994).

Utilization of the Indian River Lagoon by this species appears to be low. The only two recorded incidences (Ehrhart and Redfoot, 1994) in the Lagoon were entanglement in crab traps near Sebastian Inlet, which indicate that the species may use the Indian River Lagoon on an incidental basis, most likely entering during incoming tides.

The principal food of this species is jellyfish (McDiarmid, 1978).

Atlantic Hawksbill Turtle (*Eretmochelys imbricata imbricata*)

This is one of the smaller marine turtles, with mature females weighing about 100 lb (45 kg). It is distinguished by a sharply pointed beak-like mouth and by a radiating pattern of red, yellow, brown, or black colors on the scutes of plates of the carapace which are used for "tortoiseshell" jewelry.

The hawksbill turtle is a circumtropical species that is widely distributed throughout the Caribbean and western Atlantic. It has been observed very rarely in Florida with only a few documented nestings, one on Jupiter Island and others in Brevard and Volusia counties. It does occur within the Indian River Lagoon and live specimens have been captured near Sebastian Inlet (Ehrhart and Redfoot, 1994). Capture data and beach strandings data indicate that the majority of hawksbill turtles occurring in Florida waters are of immature or juvenile age classes (Ehrhart, 1993).

It has omnivorous feeding habits (McDiarmid, 1978), although recent studies have indicated that demosponges are its main food throughout the Caribbean where it appears to occur primarily along tropical reefs (McDiarmid, 1978). Data on feeding habits in Florida is scarce, but it appears that the same patterns may hold.

This species is second to the Atlantic ridley turtle in degree of endangerment. Continued exploitation of tortoiseshell for jewelry, in addition to widespread consumption of its eggs and meat, has threatened its survival.

7.1.4.2 Historical Perspective

The green turtle and the loggerhead turtle were important commodities during the early settlement of the Indian River Lagoon system. Prehistoric population levels of marine turtles are impossible to quantify, but skeletal remains of marine turtles have been discovered in Indian middens such as the Junerman Archaeological site at Canova Beach (Wing, 1963). These discoveries imply that early settlers and native Indians most likely captured sea turtles within the Lagoon as a food source by the use of nets, harpoons and by hand-capture (Wing, 1977).

Additional evidence documenting the presence of marine turtles within the Indian River Lagoon did not arise until the mid-1800's. The commercialization and establishment of a "turtle fishery" developed just prior to the Civil War. These early catches were sold or traded to government and merchant ships (True, 1887). After the Civil War, a more established trade was created with markets in the north. The capture of these turtles was accomplished by the use of gill nets laid out on shallow seagrass flats (Brice, 1896; Wilcox, 1896). Turtles were live-captured primarily in the winter months from November to March, when the likelihood of shark and sawfish captures was minimal. The most desirable species was the green turtle, since it is apparent that loggerhead flesh was oily, tough, and not suitable for market (True, 1887).

In 1878, commercialization of this turtle fishery reached a peak with a Connecticut ship fishing near Sebastian inlet and taking turtles to the Savannah market (Brice, 1896). Brice (1896), True (1887), and Wilcox (1896) mention the following capture rates during these periods:

- 1878 - 8 fishermen captured 1600 green turtles
- 1878 to 1890 - 16 fishermen captured 1400 green turtles
- 1891 - 1 fisherman with eight nets captured 2500 green turtles

These large numbers of turtles removed from the Lagoon undoubtedly had an impact on the population, as evidenced by the fact that the same fisherman who claimed to have captured 2500 turtles in 1891 was able to capture only 60 turtles in 1895 (Wilcox, 1896).

The great freeze of 1894-1895 also contributed to the decline of turtle captures. Wilcox (1896) noted "hundreds of turtles were found floating in a stunned condition". The combination of exploitation of the turtles as evidenced by large capture rates, and the "freeze of 1894-1895" lead to the demise of the commercial fishery for marine turtles within the Indian River Lagoon complex. From 1916 to 1970, limited netting of marine turtles continued within the Lagoon system. The lack of literature suggests that the turtle fishery as a viable enterprise in the Indian River Lagoon had apparently ended.

In 1975, L.M. Ehrhart, from the University of Central Florida, began to investigate marine turtle populations within the Indian River Lagoon complex. These investigations resurrected information of turtle populations that had been silent for almost 75 years. Utilizing the same methods of capture used by his predecessors, Ehrhart began a systematic study of the ecology and distribution of marine turtles within the Indian River Lagoon.

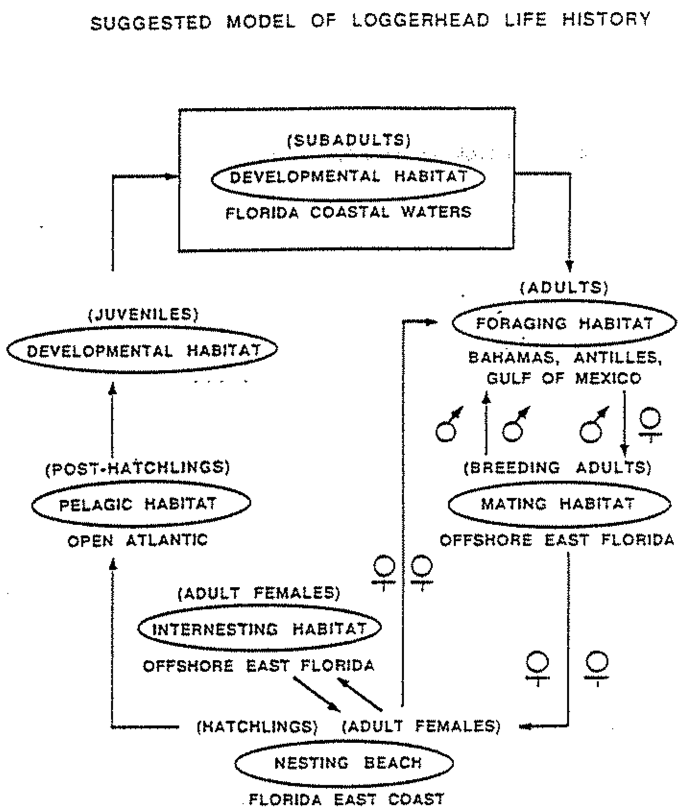
Ehrhart and his students (Mendonca, Witherington, and Redfoot) have and/or are involved in such studies as mark-recapture, radio tracking, and recording the occurrence of papillomatosis. Ehrhart has documented the capture of approximately 1200 - 1300 marine turtles from the Indian River Lagoon system since 1982, primarily from near Sebastian Inlet and several sites in Mosquito Lagoon.

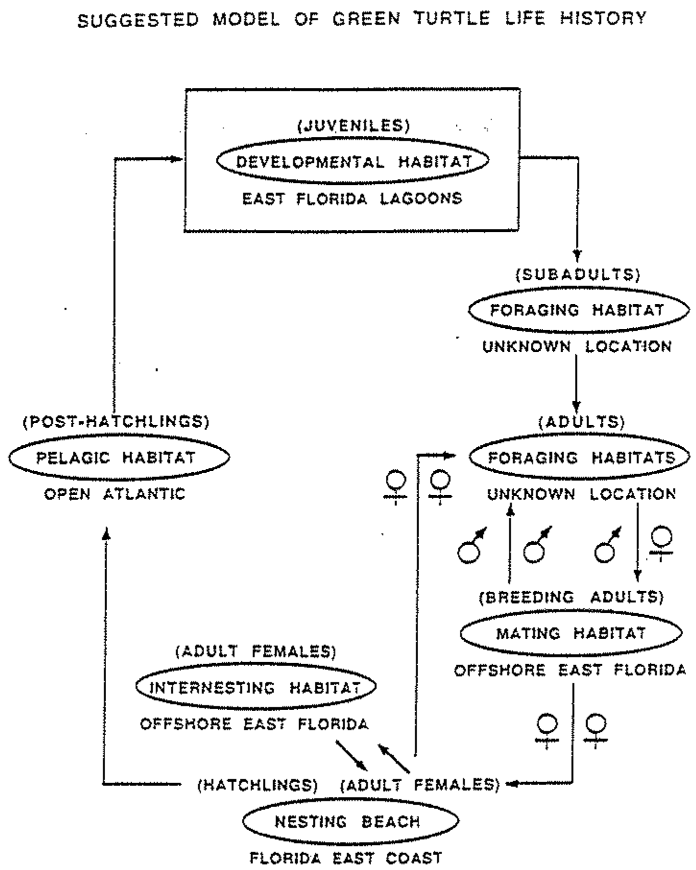
7.1.4.3 Role of Indian River Lagoon in Marine Turtle Biogeography and Life Cycles

The studies conducted by Ehrhart and others have provided valuable morphometric and age class data for marine turtles inhabiting the Lagoon. Ehrhart and numerous others have also collected morphometric data from nesting adult sea turtles on adjacent beaches. The availability of data from adults on nearby beaches and juveniles from the Lagoon allows speculation into age structure based on the size of these lagoonal turtles. Almost all of Ehrhart's captures within the Lagoon have been of green turtles and loggerhead turtles. Almost all have been identified as in the sub-adult or juvenile age and size class. It is evident that neither the green turtle nor the loggerhead turtle population captured within the Lagoon includes adults. This age distribution differs from the populations that nest on the adjacent ocean-front beaches.

The general absence of adult size class animals within the Lagoon leads to the conclusion that immature individuals of these species use the Lagoon as a developmental habitat at certain life history stages (Ehrhart, 1988). Most of the green turtles captured in the Lagoon have been juveniles or "dinner plate " size. This implies that the green turtles spend about one year in an unknown pelagic offshore location before returning to the Lagoon as juveniles. By contrast, almost all of the loggerhead turtles in the Lagoon have been much larger, and apparently are about 4 to 5 years old when they return to the Lagoon as sub-adults (Ehrhart, 1988). Thus the ecology and life cycles of these two principal species may be different when they are in the Lagoon. Figure 7-1 shows suggested models of the life history of the two species.

Recent information indicates that the green sea turtles occur in the Lagoon most often in January and February and least often in summer, while the occurrence of the loggerhead turtle is more constant throughout the year (Ehrhart and Redfoot, 1994). There may be some evidence that the green sea turtle population level has been increasing in the Lagoon over the past decade, while that of the loggerhead has remained relatively stable (Ehrhart and Redfoot, 1994).





Source: Ehrhart, 1988

• Woodward–Clyde Consultants
• Marshall McCully & Associates
• Natural Systems Analysts

DRAWING NO.:

DATE:

FIGURE 7-1 POSSIBLE LIFE HISTORY MODELS OF INDIAN RIVER LAGOON LOGGERHEAD AND GREEN TURTLES

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM

7.1.4.4 Papillomatosis

Papillomatosis (or fibropapilloma) is a debilitating disease of marine turtles which is characterized by multi-lobed, tumorous, integumentary (on skin or shell) growths. Despite the extensive documented history of marine turtles within the Indian River Lagoon, the occurrence of these growths afflicting a large portion of the Lagoon's green turtle population is a recent discovery. These disfiguring and highly noticeable growths were evidently not present on green turtles captured in the Indian River Lagoon nearly 100 years ago, as none of the literature suggests that this problem existed.

Modern day evidence of this disease was first discussed by Smith and Coates (1938) who observed these growths in 3 of 200 green turtles in the Florida Keys. The identical condition was documented in the Indian River Lagoon for the first time in 1982 (Ehrhart, et al., 1986), with the capture of an afflicted turtle near Sebastian Inlet, Florida.

Papillomatosis has apparently spread throughout the Lagoon since 1982. Examination of 183 green turtles stunned or killed during the freezes of 1977 and 1981 revealed no presence of papillomatosis. However, 28% of 145 green turtles observed in Mosquito Lagoon after the freeze of 1985 had papillomatosis growths (Ehrhart, et al., 1986), establishing the 1981 to 1985 period as the time frame of the incidence of the disease in the Lagoon complex. Ehrhart and Redfoot (1994) report that from 40% to 60% of the green sea turtles in the Indian River Lagoon exhibited symptoms in the period between 1982 and 1992.

The presence of papillomatosis in other sea turtle populations in the Cayman Islands, Virgin Islands and Hawaii has brought concern and additional research to determine the cause of this dehabilitating disease. The disease causes secondary infections and probably weakens the overall immune system of the animal. Blindness and entanglement in nets are commonly associated with these growths. There is speculation that reduced water quality may be a factor in the prevalence of the disease. Dr. Elliot Jacobson, University of Florida Veterinary College, is leading the clinical investigations to determine the epidemiology of the disease. Biopsies removed from afflicted turtles have been studied intensively. At the present time, they have not yet provided a definitive cause for papillomatosis.

7.1.4.5 Other Stresses

Sea turtles within the Lagoon are susceptible to temperatures below freezing for an extended (>24 hours) time. The Lagoon has undoubtedly experienced numerous cold events which lead to the cold stunning of these turtles. Freezes occurring in 1977 and 1981 killed or stunned 183 green turtles. Other freezes in 1983, 1985, and 1989 also resulted in turtle losses.

Marine turtle mortality within the Lagoon also is associated with human uses of the system such as recreational boating and commercial fishing. Marine turtles found dead are reported to the Sea Turtle Stranding and Salvage Network (STSSN) operated by the National Marine Fisheries Service in Miami. These reports include morphometric data and cause of death, if known. Boat propeller and boat collision injuries are known to have been present in over 10% of stranded sea turtles on the Gulf and Atlantic coasts of the United States in both 1991 and 1992 (Teas, 1993). Althoough these injuries may not necessarily have been the cause of death, they were the most common type of damage found on dead turtles, and were about four times as common as cold or stun-related symptoms and twice as common as external tumors (Teas, 1993). Other human-associated impacts include entanglement with crab traps and/or fishing buoys and monofilament line, and oil and tar effects. The entanglement and subsequent drowning of turtles in gill nets has been documented along the Atlantic coast. There is speculation that incidental accidental capture by inshore commercial netting within the Lagoon may also be occurring.

Of the 1,742 marine turtle strandings reported in 1992 on the Atlantic and Gulf coasts of the United States (including Puerto Rico and the Virgin Islands), 515 were on the Atlantic coast of Florida (Teas, 1993), indicating the importance of the indian River Lagoon region in the natural history and population dynamics of this group of species.

7.2 THREATENED AND ENDANGERED BIRD SPECIES WITHIN THE INDIAN RIVER LAGOON REGION

7.2.1 Endangered Species

Wood Stork (*Mycteria americana*)

These true native north American storks are the largest of the wading birds utilizing the Indian River Lagoon system. Adults range from 35 - 45 in. (88 - 114 cm) and have a wingspan of 60 - 65 in. (152 - 165 cm). The body is white with a black tail and wing tips. Nesting occurs from February to April, and 2 to 4 eggs are generally lain.

Wood storks utilize the freshwater systems adjacent to the Indian River Lagoon for foraging as well as the mangrove forests and open water mosquito impoundments. Small fish are the most common food. Wood storks use a specialized form of feeding called "grope-feeding" or tacto-location rather than visual feeding. In this method, the bird probes in water up to 10 in (25 cm) deep with its bill partially open (Kale, 1978). When a fish touches the bill, the bill snaps shut. Nesting occurs in rookeries, several of which are in the mangrove forests along the Indian River Lagoon. They have generally adapted to urbanization of the Lagoon since it is a common sight to observe wood storks foraging in retention ponds and other man-made water structures.

This wetlands-dependent species has increased in numbers as a breeding bird in the Indian River Lagoon region in recent years. Surveys of peninsular Florida colonies in 1976-78 and 1986 to 1989 (Nesbitt, et al., 1982, 1993) found nesting sites in western St. Lucie County, at Pelican Island in Indian River County, at Moore Creek and Grants Farm Island in Brevard County, and at Turnbull Slough in Volusia County. The hard freezes that occurred in the winters of 1983-84, 1984-85, and 1990-91 killed the majority of the mangroves on which wood storks were nesting throughout the Lagoon. It is believed that the storks have abandoned these mangrove nesting areas and have not returned as of 1993 (Kale, 1993).

Wood storks are the most endangered of the wading birds of Florida. This status is probably due to loss of both foraging and nesting habitat. Repeated nesting failures in south Florida due to overdrainage as well as freeze damage to rookeries in central Florida have been partially responsible for this status (Kale, 1988). Its specialized groping feeding technique apparently contributes to the severity of loss of prime foraging habitat since this technique requires much higher densities of fishes for successful foraging than are needed for methods of the other wading birds (Kale, 1978).

The Florida population of this species is believed to have declined by 93% between 1930 and 1988 (Kale, 1988) to a population of about 4,000 to 5,000 birds. In recent years, the Indian River Lagoon population is believed to have grown slightly. Since its feeding success is dependent upon suitable water levels and high fish densities, it is possible that some mosquito impoundment management strategies may enhance the suitability of these impoundments as wood stork forage areas. Recent studies by Swain, et al. (1992) in St. Lucie County have indicated that these impoundments can attract large numbers of wood storks to feed.

Snail Kite (*Rostrhamus socialbilis plumbeus*)

Formerly known as the Everglades kite, the snail kite is dependent upon the freshwater apple snail (*Pomacea paludosa*) as its sole food supply. The decline of this species has been attributed to drainage of freshwater marshes and the resultant decline of its food supply (Kale, 1988). Because of this freshwater foraging requirement, the snail kite is not found within the marine or brackish water areas of the Indian River Lagoon complex. In the Indian River Lagoon system, its occurrence is limited to some of the low marshy areas of the extended watershed in St. lucie and Martin counties. Drainage of these areas for flood control and agriculture has limited its occurrence in the region.

Peregrine Falcon (*Falco peregrinus*)

This species is a migratory visitor to the Indian River Lagoon region, passing through the state on migrations to the northern United States and Canada where it breeds. There are three recognized subspecies, and most of the birds seen in the Indian River Lagoon region are from the arctic population (*F. p. tundrius*) (Kale, 1978; Kale, 1988). The overwintering population normally arrives in September or October and departs between March and May (Kale, 1978).

The number of peregrine falcons migrating through the region appears to be increasing, and the number that are staying to overwinter along the Lagoon also appears to be increasing (Kale, 1988). This species tends to be found along the coastline of the Lagoon where it feeds on small waterfowl and shorebirds. Overwintering birds appear to be concentrated near the various inlets and wildlife refuges.

Peregrine falcons appear to co-exist with human populations, as long as a dependable food supply is available. The cause of the decline of this species was the concentration of pesticides in the food chain due to the use of DDT from the 1940s to the 1960s. Populations have increased since this time, but the effects of the pesticides still linger in the very reduced population of this species (Kale, 1978).

Red-cockaded Woodpecker (*Picoides borealis*)

This woodpecker is one of the most habitat specific of the woodpeckers. It is restricted to mature stands of pine forests. Therefore, its presence within the Lagoon region is limited to the adjacent upland pine forests west of the Indian River. It nests in cavities in pines that are at least 40 years old and are surrounded by sparse understory and shrub cover (Kale, 1978).

The birds maintain family units (clans or colonies) of up to 10 birds with nesting cavities in several closely spaced trees. As of 1988, approximately 10 colonies were known to exist in the watershed area (Kale, 1988). The clan members tend to work as a unit, with several unmated birds acting as helpers to mated pairs. Reproductive rate is generally low, with only one or two fledglings per year. The low reproductive rate, combined with a high habitat specificity, has severely limited this species' ability to maintain sustained populations in the face of clearing of old age pine forests and flatwoods in the region.

Bachman's Warbler (*Vermivora bachmani*)
Kirtland's Warbler (*Dendroica kirtlandii*)

Both of these species are very rare migratory visitors to the Lagoon during migrations between breeding grounds and wintering grounds in the Bahamas and near Cuba (Kale, 1978). No more than ten records of the occurrence of either species in the state have been recorded, so the ecological function of these species in the Lagoon system is very low. Bachman's Warbler has not been reported in many years and may be extinct (Kale, 1978).

Dusky Seaside Sparrow (*Ammodramus maritimus nigrescens*)

This species is extinct as of June 1987. Although extensive efforts were initiated to stop the decline of the dusky seaside sparrow, all efforts failed. The bird was only found in a 10-square mile area of Brevard County where it was once abundant in the vast cordgrass marshes of northern Merritt Island and in the St. John River marshes west of the Indian River Lagoon between State Roads 520 and 46 (Trost 1968). Habitat modification due to drainage of the St. Johns River freshwater marshes and impoundment of the salt marshes along the Indian River Lagoon was responsible for the loss of this species, which could not adapt to the altered conditions.

Southern Bald Eagle (*Haliaeetus leucocephalus leucocephalus*)

Although listed as an endangered species on the federal list, the southern bald eagle is considered as threatened in the state of Florida by the Florida Game and Fresh Water Fish Commission (FGFWFC, 1991). This is largely due to the fact that Florida has the highest population of bald eagles within the continental United States. At present about 400 nests have been documented in Florida by the FGFWFC (Kale, 1988). In 1986, about 65 of these nests were within the Indian River Lagoon watershed, but only 19 were in the immediate vicinity of the Lagoon (i.e., east of Interstate I-95). Eighty percent of the nests in the region are in Volusia and Brevard counties (Kale, 1988).

Southern bald eagles mate for life, but will re-mate if one of the pair dies. Nesting generally occurs in tall pine or cypress trees, but mangroves have also been used in coastal locations. Nests often are located within a line of sight of a large body of water, but can be in many habitat types. Nesting occurs from about October through late spring, and the young require up to 10 weeks before they are able to leave the nest (Kale, 1978).

Eagles are not specific in feeding habits. They eat virtually any vertebrate small enough to carry, including mammals, birds, and fish. They also will feed on carrion if present. Because of the fish and birds in the diet, southern bald eagles are susceptible to the effects of DDT, which was a main cause of the population decline. Loss of nesting habitat and killing of birds continue to be major threats to the population. Eagles are also very sensitive to noise and disturbance around the nest tree, and this is a major cause of reproductive failure. The FGFWFC and FWS have set guidelines with buffer zones or management areas around nest trees to minimize this disruption of nesting.

7.2.2 Threatened Species

Southeastern American Kestrel (*Falco sparverius paulus*)

This small falcon is a race of the American kestrel. While the American kestrel is migratory and only overwinters in Florida, the southeastern American kestrel breeds and resides year-round in the southeast. It is found throughout Florida and is occasionally present in uplands adjacent to the Lagoon. The kestrel feeds primarily on large insects such as grasshoppers, but small mammals and reptiles are also key parts of its diet (Kale, 1978). It feeds in open fields and nests in old woodpecker cavities in dead trees, usually surrounded by open areas.

The populations are in decline statewide, largely due to lack of cavities for nesting sites and lack of dead trees for perching (Kale, 1988). This species has been considered for federal listing, but has not been officially listed. It is listed by the FGFWFC as Threatened.

Florida Sandhill Crane (*Grus canadensis pratensis*)

In a pattern similar to that of the American kestrel and southeastern American kestrel, this subspecies differs from the greater sandhill crane by being a year-round resident of Florida and breeding in the state. It is a ground-nesting species in wet prairies and marshes. Foraging occurs in wet prairies and pastures where it feeds on insects and other small invertebrates. It occurs primarily along the marshes and prairies west of I-95, and rarely occurs eastward to the Indian River Lagoon and barrier islands. A Florida sandhill crane was observed in the MINWR in 1988 for a short time (Edward E. Clark Engineers-Scientists, Inc., 1991).

This species is not on the federal list, but is listed as Threatened by the FGFWFC. The primary reason for the threatened status of this species is loss of its specific habitats by drainage and filling, and conversion of prairies and pastures into urban and other agricultural uses. It has a low reproductive rate and does not appear to be responsive to relocation, if its home territory has been disturbed.

Piping Plover (*Charadrius melodus*)

This small 7 in. (17 cm) shorebird is pale gray above and white below, enabling it to blend in with the sands of beaches, sand flats, and spoil areas. The individuals seen in the Indian River Lagoon system are generally members of the Atlantic coast population (Edward E. Clark Engineers-Scientists, Inc., 1991).

A migratory species that does not breed near the Indian River Lagoon, it does overwinter along this coast between late summer and the following May. The piping plover feeds on insects and small marine invertebrates on the sandy beaches, spoil islands, and mud flats (Kale, 1978) where it can often be seen in company with semipalmated plovers (*Charadrius semipalmatus*) foraging along mud flats near inlets.

Least Tern (*Sterna antillarum*)

The least tern is listed by the FGFWFC as Threatened, but is not on the federal list. It is the smallest of the terns that occur in this region, being 8.5 - 9.5 in. (22 - 24 cm) long. Adults have a predominantly white forehead and underside, with a black cap and gray on the back and tops of wings. Young are generally pale gray with some black. Considerable variation may be encountered due to age and state of the breeding plumage (Kale, 1978).

This is a migratory summer resident which breeds in Florida between late April and September on open beach or sandy nest sites such as newly deposited spoil material associated with dredging of inlets along the Lagoon (Kale, 1978). It has even been known to nest on roofs, parking lots, and land being cleared for construction. Nests consist of shallow depressions in the sand, with 2 to 3 eggs that hatch within 14 to 21 days. Since the least tern nests on vegetation-free beach areas close to the shore, the nests are often washed out by storm tides and waves. Nesting site locations are usually in highly vulnerable locations that may be changed from year to year. Suitable nest locations may attract colonies of several hundred pairs.

It has been reported that KSC is the nesting location of half of the remaining least terns in Florida (Edward E. Clark Engineers-Scientists, Inc., 1991). The FGFWFC is currently conducting nesting site studies to determine the population size and nesting locations of the least tern within the Indian River Lagoon region. Current data is in the process of being published, but has not been released (Hovis, 1993).

Nests and eggs are inconspicuous on the open beaches and may be inadvertently destroyed before they are seen. Beaches that are heavily used by people often can not be used for nesting because of this. Loss of natural nesting habitat is the primary reason for the decline of this species. It has been estimated that 60% to 80% of least tern nesting now occurs on man-made or disturbed sites (Kale, 1978). Spoil deposition areas can be ideal nesting sites if free of vegetation. Spoil islands offer additional protection, since predators such as dogs, cats, and raccoons are a major cause of nesting failure.

Least terns feed on small bait fish, flying low over the open water along the shore and diving on their prey.

Florida Scrub Jay (*Aphelocoma coerulescens coerulescens*)

The Florida scrub jay is similar in appearance to the common blue jay (*Cyanocitta cristata*), but is slightly smaller 12 in. (30 cm) and lacks the crest and bright blue and white plumage of the blue jay. Its plumage has a more subdued blue-gray cast. A permanent resident of the region, the scrub jay nests from March to June, producing two to five eggs per season. Occasionally they may breed and raise more than one clutch per season if the first clutch is lost (Kale, 1978). Scrub jays are omnivorous and feed predominantly on invertebrates and small lizards and frogs, but utilize other foods such as saw palmetto berries and fruits. They are relatively tame and will feed on handouts at parks and picnic areas.

Like the red-cockaded woodpecker, this species lives in small family units or clans. The birds are monogamous, but young birds often remain with the parents for several years and participate in raising the young. The length of time they remain with the original clan seems to be partly a function of the amount of nesting and foraging area available for establishing new territories (Woolfenden and Fitzpatrick, 1984). The species is highly territorial, and a clan will remain in and defend a specific area, usually consisting of 3 to 50 ac (1 to 20 ha (1 to 20 ha).

This unique species has an extremely specific habitat requirement, needing dry sandy oak scrub habitats with a low canopy layer of shrubby oaks and interspersed open areas. Under natural conditions such areas are maintained by fire. The main reason for the status of this species is decline of the very specific habitat. Restriction of fire has allowed dense undergrowth and tall canopy trees to develop in many previously suitable habitats (Kale, 1978). These well-drained habitats are also very suitable for development, and many territories have been turned into residential communities. Other threats include predation by domestic animals and effects of pesticides.

The primary concentration of the Florida scrub jay in the Indian River Lagoon system is in the MINWR and on natural upland areas within KSC and the Cape Canaveral Air Force Station (CCAFS) at Cape Canaveral. The MINWR and CCAFS populations are believed to be among the three largest population centers (which together account for 80% of the state population) in the state (Edward E. Clark Engineers-Scientists, Inc., 1991). An estimate of the scrub jay population for this area in 1987 was 6,000-10,000 birds (Cox, 1987). However, recent more detailed investigations have placed the number between 1,400 and 3,600 birds (Breininger, 1989). Breininger, et al. (1991) have estimated remaining habitat in KSC and MINWR to be about 4,800 ac (1,950 ha).

Elsewhere in Volusia and Brevard County, small numbers of jays occur at scattered sites along the coast east of the Lagoon (Cox, 1987). It has been estimated that 77% of all Brevard County scrub habitat of the scrub jay has been lost through development (Snodgrass, et al., 1993), with the remaining 11,375 ac (4,605 ha) in patches that are highly fragmented. Approximately 69 groups of scrub jays were identified in Brevard County by Snodgrass, et al. (1993). Most locations, which utilized about 70% of the potentially available scrub habitat, were within 6 miles (10 km) of the Lagoon along the ridge and island paralleling the Lagoon.

7.2.3 Species of Special Concern

Eastern Brown Pelican (*Pelecanus occidentalis carolinensis*)

The brown pelican is a species associated with Florida in the minds of Florida residents and tourists alike, and it occurs commonly throughout the Indian River Lagoon. The species was listed as endangered because of declining populations throughout the U.S. during the 1960s and 1970s. In those years, the population had decreased severely because of reproductive failures caused by DDT and other chlorinated hydrocarbon pesticides. Following the banning of DDT, the species recovered to a large extent. However, the brown pelican is still considered to be at peril for several reasons. The severe population loss may have led to a large reduction of its gene pool of the species and a loss of resiliency for future stresses. Pesticide poisoning has remained as a potential threat (Kale, 1978). The species has also been impacted by a few fishermen who think the bird competes with them for fish, and many birds die after becoming accidently entangled in fishing lines and nets. Coastal oil spills also have a potential for adversely affecting this species.

The brown pelican's historic range includes most of the Pacific coast of North and South America, as well as the Atlantic coasts from about North Carolina to Guyana (Kale, 1978). In the 1950s and 1960s, populations declined so severely that they virtually disappeared in Texas and Louisiana, and nestlings from Florida were introduced to these states to rebuild the populations (Kale, 1978).

The brown pelican is a non-migratory resident of Florida, usually nesting in mangrove trees in colonies from 10 to 1500 pairs. Females usually lay 3 eggs between February and April in the Indian River Lagoon region. The eggs incubate for 30 days before hatching, and the new-born young fledge at 11 to 12 weeks. Immature birds have white bellies and brown backs, changing to black bellies and gray backs as the birds mature (Kale, 1978). Pelicans are fish-eaters, soaring over the ocean and estuary and diving for small bait fish such as sardines, mullets, and menhaden.

At one time, Pelican Island was virtually the only Florida rookery for this species, with thousands of birds nesting there (Packard, 1910). Nesting colonies are presently widespread throughout the Lagoon, and most rookeries are found on the islands scattered throughout the Lagoon.

Reddish Egret (*Egretta refescens*)

The reddish egret occurs almost exclusively in coastal habitats. While it is not an abundant species in the Lagoon area, KSC is known to be one of the major nesting centers in the state (Edward E. Clark Scientists-Engineers, Inc., 1991). It can often be observed feeding in the mosquito impoundments at MINWR along Black Point Wildlife Drive (USFWS, n.d.). This species breeds along the Gulf coast, the Caribbean, and the coasts of Florida as far north as Tampa and Cape Canaveral.

The reddish egret is smaller than the great egrets, but larger than the little blue heron, reaching a body length of about 30 in (75 cm). Adult coloration varies, but it has a dark phase with a characteristic deep reddish brown on the head and neck. Reddish egrets nest individually on stick platforms, usually in red mangroves, about 4 ft (1.2 m) above ground. Clutch size is 2 to 5 eggs. Small fish are believed to be the main food of this species (Kale, 1978).

The main reason for the decline of the reddish egret appears to have been the plume-hunting trade of the 1800s. It was almost extirpated by the turn of the century, but the population has had a slow recovery since the 1930s. The number of reddish egrets in Florida at about 1975 was estimated to be 300 (Kale, 1978). The reproductive rate appears to be very low, partially accounting for the slow recovery of this species.

Snowy Egret (*Egretta thula*)

The snowy egret is a small 24 in. (60 cm) white egret with a black bill and legs and yellow feet. It is common in both brackish and freshwater wetlands, but is more common in coastal areas than inland sites (Kale, 1978). Like most other wading birds, it nests in colonial rookeries, often in association with the tricolored heron and great egret. Nests are in mangroves or other shrubby trees along the coast (Kale, 1978). It feeds on small fish, terrestrial and aquatic invertebrates, and occasionally on plant tissue in ditches, fresh and brackish marshes, and ponds.

It has remained a relatively common species, but the population has declined considerably (possibly by 90%) since the 1930s (Kale, 1978) due to the plume-hunting of that period. A breeding population of about 430 nesting pairs was reported in six of the rookeries near KSC in 1986 (Edward E. Clark Engineers-Scientists, Inc., 1991). In the 1970s, 1,900 pairs were reported from Merritt Island and 780 pairs from near Vero Beach (Kale, 1978)

Little Blue Heron (*Egretta caerulea*)

The little blue heron is also a small 24 in. (60 cm) wading bird with purple-maroon on the head and neck and slate-blue on the rest of the body. It breeds from New England through the Gulf of Mexico and Central America. Although little blue herons nest in colonial rookeries, they tend to be less gregarious than the other egrets and herons. Nesting occurs in freshwater wetlands in trees such as cypress and willows, and in mangroves in salt water wetlands. The largest colonies appear to be in coastal locations and on islands (Kale, 1978). Nesting occurs between February and September. Freshwater wetlands appear to be preferred for foraging. They feed on small fish, crustaceans, insects, frogs, and lizards.

Population levels have undergone declines, primarily in response to the decreases in wetland habitats, but little is known about overall population number (Kale, 1988).

Tricolored Heron (*Egretta tricolor*)

The tricolored heron is similar in size to the reddish egret and little blue heron with a dark slate-blue on the head, neck, wings, and upper body. It has a purple chest and a white belly, thus acquiring its name. Nesting occurs from February to July in colonial rookeries throughout the Atlantic coast from New England to Brazil, usually in estuarine areas (Kale, 1978). Nesting occurs in mangroves or shrubby trees in coastal wetlands and islands. Small fishes are the primary foods of this wading bird, but crustaceans and aquatic insects are also a part of its diet (Kale, 1978). Coastal salt marshes, mangrove forests, and mosquito impoundments are the primary feeding habitats of the tricolored heron.

The decline of this species has generally been in proportion to the loss of wetlands in coastal areas of Florida (Kale, 1978; Kale, 1988), but it remains a relatively common wading bird. The 1970s apparently was a period of severe population decline (Kale, 1978). In the mid

1970s, 985 nests were reported in the Indian River Lagoon near Vero Beach and 650 nests were reported at Merritt Island (Kale, 1978). Approximately 50 mating pairs were reported in two rookeries at KSC in 1986 (Edward E. Clark Engineers-Scientists, Inc., 1991).

<u>Roseate Spoonbill (*Ajaia ajaja*)</u>

Once an abundant species seen throughout the Lagoon, the roseate spoonbill also was almost extirpated by the plume trade of the early 1900s. Since that time the species has made a comeback, with KSC and MINWR being the primary centers of abundance. The first modern documentation of nesting on the east coast of Florida occurred in April 1987 on Merritt Island where three young were produced (Smith and Breininger, 1988). Nesting has continued in small numbers at the KSC since that first occurence. Roseate spoonbills also can be found amid the mangrove and salt marsh islands throughout Mosquito Lagoon as far north as New Smyrna Beach, in the mangrove islands of the Thousand Islands in the Banana River, along the Indian River Lagoon near Sebastian Inlet, and along the Indian River Lagoon from Ft. Pierce Inlet south. The mosquito impoundments throughout St. Lucie County have also been extensively utilized by this species.

Roseate spoonbills are usually seen in small groups in salt marshes and mangrove forests, where they feed on small fish and invertebrates such as shrimp. Nests are located in thickets of red and black mangroves, usually on isolated islands. Nesting occurs in November and December, mostly in south Florida. There appear to be two separate migration patterns from the south to areas as far north as Cape Canaveral. The migration patterns differ for adult breeding birds and for the juvenile/sub-adult birds.

<u>Limpkin (*Aramus guarauna*)</u>

The limpkin is a medium-sized water bird with brownish coloration. Its range extends from Georgia through the Caribbean. It has forage habits similar to the snail kite, including a preference for the apple snail. Therefore, this species is also essentially limited to the freshwater wetlands west of the Lagoon. It is rarely seen along the Lagoon itself.

<u>American Oystercatcher (*Haematopus palliatus*)</u>

This easily identified species, with its bright orange bill, is commonly seen foraging on mud flats and beaches adjacent to the Lagoon. It is one of the larger (16 in.) 40 cm of the shorebirds. Its chief food is oysters and clams, although it also will eat crustaceans and marine worms (Kale, 1978). Breeding occurs only on sandy shores where nests consist of shallow depressions in the sand (Kale, 1978).

A few members of this species have become permanent breeders within the Lagoon region, but it remains primarily a migratory species. Spoil islands have been documented as nesting areas in KSC (Edward E. Clark Engineers-Scientists, Inc., 1991). Disturbance of the sandy beach nesting habitat has been reported as the main reason for this species' decline (Kale, 1978).

<u>Florida Burrowing Owl (*Athena cunicularia floridana*)</u>

This is a unique species of owl because it nests in burrows in dry sandy habitats, such as the sandhills and dry upland pastures west of the Lagoon system. The species does not use the Lagoon or its coastal habitat, but is part of the fauna found within the watershed boundaries of the Lagoon. A single individual was reported from KSC in 1976 (Edward E. Clark Engineers-Scientists, Inc., 1991). The range extends from Florida to the Caribbean. Forage consists of small reptiles, amphibians, and mammals, although it has been documented to eat crayfish and snails (Kale, 1978).

7.2.4 Other Ancillary Species

<u>Smyrna Seaside Sparrow (*Ammodramus maritimus pelonota*)</u>

Currently, this second subspecies of seaside sparrow does not appear on either state or federal lists, although it is under federal review (FGFWFC, 1991). Its range was originally reported as being from New Smyrna Beach to Amelia Island in northeastern Florida, in coastal salt marshes similar to those inhabited by the dusky seaside sparrow. However, it has not been observed south of the mouth of the St. Johns River since the mid-1970s and probably no longer occurs in the Indian River Lagoon region (Kale, 1978). The explanation for its disappearance has been given as the displacement of salt marshes by black mangrove dominated high marshes or salt flats (Kale, 1978).

Magnificent Frigate Bird (*Fregata magnificens*)

A tropical species endemic to south Florida, the magnificent frigate bird is a casual visitor to the Indian River Lagoon complex, but is not known to nest along the mainland Florida coast. Several individuals have been reported to roost irregularly at Pelican Island and to have appeared occasionally at other waterbird roosting sites in the region (Kale, 1988). The species has also been observed on the spoil islands in the southern extent of the Lagoon (FDNR, 1990a). The species is most common in summer when wind conditions are generally most calm, since it spends much of its time feeding on fish in the ocean and soaring above the ocean.

Other Wading Species

- Great Egret (*Casmerodius albus*)
- Black-crowned Night-Heron (*Nycticorax nycticorax*)
- Yellow-crowned Night-Heron (*Nycticorax violacea*)
- Eastern Least Bittern (*Ixobrychus e. exilis*)
- White Ibis (*Eudocimus albus*)
- Glossy Ibis (*Plegadis falcinellus*)

All of the long-legged waders listed above are common inhabitants of wetlands throughout the Indian River Lagoon region, especially in mosquito control impoundments. With the extensive drainage of freshwater wetlands associated with the Lagoon, the impoundments along the Lagoon have become important forage and nesting sites for the survival of these coastal wading populations. Spoil islands also provide additional nesting sites for these species.

Other Shore Birds

- Royal Tern (*Sterna maxima*)
- Sandwich Tern (*Sterna sandvicensis*)

- Caspian Tern (*Sterna caspia*)
- Black Skimmer (*Rynchops niger*)

These four species are relatively common throughout the region, especially near inlets. Royal and sandwich terns nest on spoil islands in the Banana River, in one of the few colony sites for these species on the east coast of Florida (Nesbitt, 1993). Black skimmers nest on spoil islands and sand spits throughout the region, but, as with the least tern, nesting site availability is becoming scarce.

7.3 THREATENED AND ENDANGERED MAMMAL SPECIES WITHIN THE INDIAN RIVER LAGOON REGION

7.3.1 Endangered Species

7.3.1.1 Florida Manatee (*Trichechus manatus latirostris*)

The Florida manatee is a subspecies of the West Indian manatee (*Trichechus manatus*), and is one of only two living genera and four living species of the mammalian order Sirenia. This order of large aquatic herbivores, often referred to as "sea cows", is distributed throughout the tropics and subtropics, and has been described throughout early maritime history.

Species Description

The Florida manatee is gray-brownish and fusiform, with paddle-like forelimbs and a spatulate, horizontal flattened tail. Hind limbs are absent. These mammals are thick-skinned 0.2 to 0.6 in. (8 to 16 mm) and have hair sparsely distributed over their bodies, with true nails on their forelimbs and very small eyes with protective membranes. The massive bones are solid with no marrow cavity. Their teeth consist of 24 to 32 molars at the rear, which move forward and are replaced as the front teeth wear. Manatees have a bristled cleft upper lip that is used for grasping food. Two axillary mammae are found at the base of the flippers. Adults commonly weigh from 800 to 2,000 lbs (360 to 900 kg) and are from 9.5 to 11.6 ft (2.8 to 3.5 m) in length; new borne calves are 3.3 to 5.0 ft (1.0 to 1.5 m) in length and weigh 44 to 66 lb (20 to 30 kg) (Odell, 1982). Adults may weigh up to 3,500 lbs (1600 kg) and be 13 ft (4 m) in length (Van Meter, 1989). Differentiation between sexes is slight, with males having a more anterior genital opening.

Florida manatees may live to be well over 25 years, and generally begin to reproduce at 7 to 9 years (Layne, 1978). Usually one young is born after a gestation period of 13 months. Calves remain with the mother for up to 2 years, and the normal interval between births is probably 2 to 5 years (Van Meter, 1989). Thus the reproductive rate of the species is low. Upon the loss of a calf, females may go into estrus and mate again within a substantially shorter period (Odell and Reynolds, 1979).

Florida manatees herbivores, feeding primarily on submerged aquatic vegetation such as seagrasses. Manatees are opportunistic and will feed on other vegetation such as floating and emergent vegetation, mangrove leaves and smooth cordgrass. About 5 to 8 hours per day is spent feeding, and anywhere from 2 to 12 hours are spent resting (Bengsten, 1983; Van Meter, 1989).

With a low metabolic rate manatees lose body heat rapidly, making them susceptible to the effects of hypothermia in water temperatures below 64°F (18°C) and rapid declines in temperature. Manatees can occur in a wide range of water types, from fresh to saline waters and from clear to muddy water. Water depths from 3 to 16 ft (1 to 5 m) are preferred, and manatees are seldom found in depths greater than 20 ft (6m) (Van Meter, 1989).

Historical Perspective

Prehistoric evidence of manatees associated with the Indian River Lagoon has been documented by remains found in Indian middens along the Lagoon (Cumbaa, 1980). Skeletal remains of this species were also found at the well-known Windover Archeological Research Project near Titusville (Atkins and Doran, 1988). These slow moving, shallow water inhabitants were easy prey as a food source for the Timucuan Indians in the north part of the Indian River region and the Tequesta Indians that settled along the southern portion of the Lagoon (Swanton, 1922, 1946).

Other than undocumented sightings of manatees by crews of ocean going vessels along the Atlantic coastline, the first documented evidence of manatees within the Indian River Lagoon was "the St. Lucie River having large numbers of manatees aggregating," (Canova, 1885). Maynard (1872) also noted the presence of manatees occurring in large numbers near the inlets of the Indian River Lagoon.

The first documentation of manatee live-capture was by Le Baron in 1888, who noted the capture of these animals by the use of ropes and mesh nets (Beeler, et al., 1988). It appears that manatee skeletons and bones were in great demand by museums worldwide at that time. The first evidence of "freeze killed" manatees occurred in 1895 when Bangs noted "a hard freeze in 1894 killed at least three manatees". In 1895 another freeze killed manatees near the Sebastian Inlet area of the Lagoon (Bangs, 1895).

Most of the historical accounts have been from the southern portion of the Lagoon. In 1884, True stated that populations of manatees were common throughout the Indian River, but absent in the Mosquito Lagoon. More recent surveys by NASA contractors at Kennedy Space Center and the Brevard County Natural Resources Management Department have indicated that more manatees may be present in Mosquito Lagoon, the northern Indian River Lagoon proper (Turnbull Creek area), and Banana River than previously thought (Provancha and Provancha, 1988; Provancha and Hall, 1991; Clinger, 1994).

Accounts of manatees began to increase after 1916, as scientists began to investigate the habits of these creatures. The first description of migratory habits of manatees was suggested in 1918 by Nelson. He found that manatees left areas of the Lagoon around December 1, and returned in the early spring around mid-March. Nelson also documented that shooting and netting of manatees had continued, placing the manatee in danger of extinction by 1918.

Additional information collected during this time period was limited to research indicating that manatees were utilizing the ICWW as a migratory pathway, most probably moving to the south during colder months to seek possible warm water refuges found in the interior of the Lagoon. The first apparent manatee mortality involving a boat was documented near Eau Gallie, Florida in March, 1963.

Conservation efforts for manatees began in 1893 when a state law was enacted protecting manatees, followed in 1907 by a prohibition on the killing of manatees, punishable by a $500 fine and a three month prison term (Van Meter, 1989). Since 1970, increased research efforts and awareness of manatees have created an abundance of significant laws and regulations that provide increased protection for these animals. Important milestone events have included:

- The Federal Marine Mammal Protection Act enacted in 1972.

- The Endangered Species Act passed in 1973.

- The Florida Manatee Sanctuary Act of 1978, which created 20 manatee sanctuaries with seasonal or year round boat regulations and speed zones.

- Initiation of the Save-The-Manatee Club of Florida in 1981, with a present day membership of 35,000.

- Boat Speed Regulations and Manatee Protection Zones implemented starting in 1990 by the state of Florida in Brevard County under Florida Administrative Code Section 62N-22.006 FAC, Indian River County (62N-22.007), St. Lucie County (62N-22.008), Volusia County (62N-22.012), Martin County (62N-22.024) and Palm Beach County (62N-22.009).

- Fish and Wildlife Service production of "West Indian Manatee Recovery Plan" in 1980 and revision in 1989.

- Establishment of the manatee license plate and Save the Manateee trust fund by the Florida Legislature in 1989.

Distribution and Habitat Use

The Florida manatee is found throughout the coastal and inland waterways of the state, and is the only Sirenian to inhabit temperate regions (Irvine, 1983). Florida manatees are migratory and often travel to northern waters during the summer months, as documented by Zoodsma (1992). Zoodsma's research involved radio tagging four manatees in Brevard County and then tracking them to southeastern Georgia for one or more years of her three year study. Tagged manatees have been known to travel over 500 miles (Powell and Waldren, 1981).

The range of this species varies seasonally. During the summer months this species is widely dispersed throughout the Lagoon, and there is some evidence that manatees travel in and out of the various inlets. Manatees have been documented as migrating between the Banana River and south Florida through the Indian River Lagoon and the ICWW, as well as along the Atlantic coast (Packard, 1981).

The historical winter range is believed to have been centered in south Florida with a few individuals overwintering in natural warm water springs in central Florida. On the east coast, small numbers of manatees have been reported to reside year-round in the Hobe Sound and Jupiter Inlet areas (Packard, 1981). Moore (1951) concluded that Sebastian Inlet was the approximate northern boundary of the winter range. Manatees that remained north of central Florida in the winter often did not survive low temperatures or sudden freezes (Moore, 1951). The minimum sustainable water temperature is believed to be about 66°F (19°C) with minimum values of about 52°F (13°C) (Hartman, 1979).

Over the past 30 years, operation of numerous power plants and other dischargers of warmed water have allowed manatees to congregate in winter around these artificial warm water sources and thus extend their winter range to the north (Van Meter, 1989). Air temperatures of 50°F to 59°F (10°C to 15°C) and water temperatures below 68°F (20°C) stimulate the formation of manatee aggregations in warm water sources (Hartman, 1979).

Documented warm water refuges within the Indian River Lagoon include the discharge canals of the Florida Power and Light (FPL) and Orlando Utilities Commission (OUC) power plants at Frontenac and Delespine south of Titusville (Van Meter, 1989), the H.D. King Municipal Electric Station at Ft. Pierce, and the Vero Beach Municipal Power Plant (Beeler, et al., 1988).

Manatees generally remain in the thermal discharge areas in winter. However, forage is limited near the power plants, so they must move away from these warm water refugia to feed. Bengston (1983) found that manatees typically cannot travel more than 6 miles (9.6 km) from the refugia to obtain food. Shane (1981) has reported that manatees may move from the Brevard County warm water refugia on the west side of the Lagoon to the grass beds on the east side of the Lagoon to forage in winter. However, during particularly cold weather, the manatees' need to remain near the warm water refugia may override the need for food.

Seagrasses have been found to be major constituents of the diet of the manatee in several studies (Hartman, 1979; Packard; 1981; Zieman, 1982). Provancha and Hall (1991) found that manatee grass and shoal grass were both significantly more abundant in areas with high manatee densities than in areas with lower peak manatee densities. Conversely, *Caulerpa prolifera* and other macroalgae have been found to be poorly represented in the diet of manatees (Hartman, 1971; Lipkin, 1975; Beck, 1989), indicating that SAV community areas with algal dominance over seagrasses may be less capable of supporting the manatee population.

The carrying capacity or amount of seagrass needed to support the manatee population has not been well established. Various researchers have estimated the amount of fresh (wet weight) biomass needed to support an adult manatee to be between 66 and 77 lbs (30 and 35 kg) per day (Heinsohn, et al., 1977; Bengston, 1983; Etheridge, et al., 1985). Provancha and Hall (1991) have related these masses to typical average seagrass biomasses of the Banana River and estimated that an average seagrass forage area of 490 ft^2 (46 m^2) may be required per manatee per day. Carrying capacity will vary seasonally depending on the standing crop biomass, nutritional value, and the density of a seagrass bed.

Various researchers have indicated contradictory observations on the feeding behavior of manatees in seagrass beds. Some researchers have described manatee feeding behavior as "rooting", in which the roots and rhizomes of seagrasses are uprooted and damaged (Packard, 1981; Zieman, 1982), while others have observed primarily grazing or "cropping" of the leaf blades only (Provancha and Hall, 1991). The predominant feeding method may affect the carrying capacity of seagrass beds and seagrass rate of regrowth following manatee grazing. Much is still unknown about the effects of manatee grazing, regowth potential, and the carrying capacity of the food resources in the Indian River Lagoon complex. Provancha and Hall (1991) have found that above-ground cover of manatee grass beds in a relatively small area can be reduced by 90%. These intense feeding events were observed in spring when grassbeds may recover from grazing quickly. As a result of manatee grazing, manatees may have large effects on seagrass abundance and ecology in some areas.

Mortality and Stresses

Since 1983, between 80 and 206 manatee deaths have been recorded each year in Florida. Over 33% of these deaths have been directly attributed to human related causes, of which over 25% were a result of collisions with watercraft. (FDNR, 1992). Undetermined causes accounted for 32% of deaths. Another 24% of deaths were losses of dependent calves which may have occurred as a result of the deaths of the mothers or separation from the mothers.

Kinnaird (1983) performed a statistical analysis of manatee deaths in Brevard County and found that mortality density was positively correlated with boat density and with boat slip density and negatively correlated with salinity. Higher boat traffic and non-linear patterns of boat traffic, as well as density of larger (>24 ft [7.3 m]) boats were characteristic of higher mortality zones.

Non-linear traffic (which does not follow specific channels) appeared to be a significant factor in manatee mortality (Kinnaird, 1983). Although larger boats may increase mortality in channel areas, smaller boats tend to have greater non-linear motion patterns outside of the channels, and thus have as great an impact as larger boats (Kinnaird, 1983).

Beeler, et al. (1988) report a study that indicates a positive relationship of boat registration numbers and boat use indices to manatee mortality rates from 1974 to 1985 in the area between Sebastian Inlet and St. Lucie Inlet. This study also indicated that the number of applications for new boat slips in this region increased by 600% between 1983 and 1986, implying that boating impacts were anticipated to increase.

Additional impacts linked to man include entanglement by and ingestion of fishing gear, fishing nets and crab traps; entrapment in floodgates and canal locks; and poaching and vandalism. Natural occurrences also contribute to manatee mortality, with cold-related deaths accounting for a significant portion of these mortalities. Loss of habitat such as grassbeds and declines in flow of natural warm water artesian springs have also been considered to be significant threats to the manatee (Van Meter, 1989). Habitat loss in the Indian River Lagoon complex may be less than in many other parts of the state, but any loss of habitat is still very critical for manatees. The greater loss of habitat in other regions may result in an increasing importance of the Indian River Lagoon complex as habitat for manatees. An analysis of changes in seagrass bed extent has been included in the companion Technical Report volume "Analysis of Historical Imagery". This analysis indicates that the loss of seagrass beds is less than in several other areas of the state, but may be significant in some areas of the Lagoon.

Pollution and water quality degradation have also been implicated as health concerns for the manatee. Actual effects have not been documented, but studies have shown elevated tissue levels of copper and cadmium, presumably from aquatic herbicide use (Van Meter, 1989). Lead, mercury, and organochlorine residues in manatee tissues have generally been found to be below levels of pathogenic significance, although levels resulting in long-term chronic effects are unknown (O'Shea, et al., 1984; Van Meter, 1989). High copper or cadmium levels were not indicated to be a problem in the Indian River Lagoon (Van Meter, 1989).

Table 7-2 presents manatee mortality data from the five counties of the Indian River complex for the period from 1975 through 1992. This data shows the distribution of mortality throughout the region. The number of deaths are grouped by size class of the animals. The size class might also be considered as an indication of the number of deaths by age as well since the <4.8 ft (150 cm) group largely represents calves and the >7 ft (220 cm) class is composed of adults, usually over 4 to 5 years of age. Indirectly it may also indicate a similar population distribution, although there may be a disproportionate level of mortality in some areas.

Brevard County, in which there is the greatest year-round manatee use, had by far the greatest number of deaths with 63% of the regional total. Volusia and Martin counties had moderate levels (14% and 12% respectively), while Indian River and St. Lucie counties had low levels (5% and 6%). Mortality appears to have been relatively evenly distributed among the size classes. This pattern indicates a possibly greater than expected rate of mortality among an adult population with long lifespans and no natural predators. Such a loss of

TABLE 7-2

SUMMARY OF FLORIDA MANATEE DEATHS IN THE INDIAN RIVER LAGOON COMPLEX BY COUNTY FROM 1975 TO 1992

COUNTY	NUMBER OF DEATHS BY SIZE CLASS (LENGTH)				
	< 1.5M (< 5FT)	1.5 TO 2.2M (5 TO 7 FT)	2.2 TO 2.7M (7 TO 9 FT)	> 2.7 M (> 9 FT)	ALL SIZES TOTAL
Volusia	40 (21)[1]	14 (12)	11 (9)	23 (11)	88 (14)
Brevard	118 (62)	78 (66)	86 (67)	125 (61)	407 (63)
Indian River	15 (8)	1 (1)	6 (5)	11 (5)	33 (5)
St. Lucie	7 (4)	10 (8)	11 (9)	10 (5)	38 (6)
Martin	10 (5)	15 (13)	13 (10)	37 (18)	75 (12)
Regional Total	**190 (100)**	**118 (100)**	**127 (40)**	**206 (100)**	**641 (100)**

Source: FDEP, 1993

1 = ( ) is the percent of Regional Total

reproductive age animals in populations of endangered species of limited size has been a concern to some biologists.

Population Levels and Trends

Winter aerial surveys have indicated a minimum Florida manatee population as high as 1,856 (FDNR, 1992). The winter population of the Indian River Lagoon complex may represent only a small portion of this total state population, since many manatees migrate to more southern locations during the winter. Nearly 100 manatees were reported at the two plants south of Titusville in the relatively warm winter of 1979-80, but only 56 manatees were counted at these plants in the very cold winter of 1980-81. On February 20, 1993, 273 animals were counted using the FPL and OUC power plants (Reynolds, 1993). Summer populations near the plants drop to a range of 5 to 30 individuals.

Up to 39 manatees have been counted during winter surveys in a 10 mile (16 km) portion of the Lagoon surrounding the Vero Beach Municipal Power Plant between 1977 and 1979, and up to 32 individuals have been noted near the Ft. Pierce power plant during various surveys between 1976 and 1986 (Beeler, et al., 1988). Between 0 and 5 manatees were noted at the Vero Beach plant during the winter of 1989-90 (Reynolds, 1990). In January of 1990, 84 manatees were observed at the Fort Pierce power plant, while 0 to 43 were noted on various days in December, 1989 (Reynolds, 1990). The variability of numbers observed near these power plants has led Beeler, et al. (1988) to suggest that the Vero Beach and Ft. Pierce plants function as important stop-over points and refugia from sudden cold periods during seasonal migrations.

The complex as a whole appears to contain a much higher portion of the statewide population during the spring and summer months when manatees move north, but the animals appear to be scattered over a wider area. Warm season population numbers observed in the Brevard County portion of the Indian River and the Bananna River have been as high as 245 in the spring and 100 to 150 in summer (Shane, 1981; Provancha and Provancha, 1985). A total of 366 manatees was observed in the northern Bananna River in the spring of 1994, possibly signifying an increasing use of this part of the system (Provancha, 1995).

During the spring and summer, the largest concentrations of manatees occur in the Banana River, possibly because of an abundance of seagrasses and restriction of boating traffic in the northern end (Beeler, et al., 1988; Provancha and Hall, 1991). Mosquito Lagoon has apparently had the lowest usage by manatees of any segment in the northern part of the complex (Beeler, et al., 1988).

Fewer studies and observations have been made in the region centered around Sebastian Inlet from about Turkey Creek south to Vero Beach. However, available data have appeared to indicate that this area is not utilized by manatees to the same extent as areas to the north and south, although it may be an important travel corridor with substantial numbers of manatees using the Sebastian River system and nearby waters. This area corresponds to Segments 2 and 3 of the Lagoon complex. These segments have been identified in the companion Technical Report "Analysis of Historical Imagery" and in Section 4.0 of this report as areas with reduced seagrass abundance, which may correlate to lower use by manatees.

Manatees have also been known to enter freshwater tributaries of the Indian River Lagoon. These tributaries include Turkey Creek, Eau Gallie River, Sebastian River, Sebastian Canal, the Main Canal and other canals at Vero Beach, Taylor Creek, and the St. Lucie River (Beeler, et al., 1988). It is suspected that the freshwater flows may be attracting the manatees to these areas. Discharges from wastewater treatment plants have also attracted manatee aggregations.

The FDEP has been conducting additional surveys of manatee population and distribution, but this data has not been released. Therefore, there is not yet enough data to accurately identify population trends for the Lagoon. Available survey data shows wide variability between years and seasons, and does not cover all areas simultaneously. Available data does indicate that collisions with watercraft may be the single largest human-related cause of mortality within the Lagoon, and that it is positively correlated with the amount and density of boat traffic. Therefore, watercraft-related manatee mortality is expected to increase as boat traffic increases in the Lagoon complex.

7.3.2 Threatened Species

Southeastern Beach Mouse (*Peromyscus polionotus niveiventris*)

This mouse is a pale gray-brown subspecies of the oldfield mouse. The historical range of this subspecies extended from Ponce De Leon Inlet in Volusia County to Broward County. The population has become fragmented with only a few scattered remnant centers remaining between Sebastian Inlet and St. Lucie Inlet (Edward E. Clark Engineers-Scientists, Inc., 1991). Substantial populations have been reported as remaining within KSC (Edward E. Clark Engineers-Scientists, Inc., 1991). Foods of the southeastern beach mouse include beach grasses and sea oats. Burrows in the sand are used for nesting.

The species is restricted to the sand dunes and scrubs adjoining Atlantic beaches and therefore does not actually occur within the Indian River Lagoon watershed. However, in some areas, there is a narrow and changeable boundary between the oceanic beach and the Lagoon habitats so this species has been included in this discussion. Disturbance of beach and dune habitats, loss of habitat for development, and possible predation by house cats and other animals have been identified as threats to this species (Layne, 1978; Edward E. Clark Engineers-Scientists, Inc., 1991).

7.3.3 Species of Special Concern

Florida Mouse (*Peromyscus floridanus*)

In the Indian River Lagoon system, this rather large (7.5 in [19 cm]) gray mouse is restricted to the xeric dry sandy habitats such as the sand pine and oak scrubs. It utilizes the burrows of gopher tortoises for shelter and therefore its range and habitat are similar to that of the gopher tortoise (Layne, 1978).

In a similar manner to the gopher tortoise and gopher frog, the greatest threat to this species is loss of habitat since the well-drained scrub habitats are very well suited for urban development and for citrus production. The Florida mouse is common in the scrubs within KSC and MINWR (Edward E. Clark Engineers-Scientists, Inc., 1991), and is known to occur in locations such as Jonathan Dickinson State Park and the Savannas State Reserve (FDNR, n.d.).

7.3.4 Other Ancillary Species - Cetaceans (Whales and Dolphins)

The only cetacean resident of the Indian River Lagoon complex is the Atlantic bottlenose dolphin (*Tursiops truncatus*). Although not listed as threatened on the USFWS or FGFWFC, the Atlantic bottlenose dolphin is a protected species under the Marine Mammal Protection Act of 1972. It is a common inhabitant of the Indian River Lagoon complex. These dolphins are frequently seen throughout the Lagoon, feeding on small fish in the shallows of the system. Other cetacean species have used the Lagoon historically, but today only the bottlenose dolphin is found residing in Lagoonal water.

Species Description

Like all cetaceans, bottlenose dolphins bear live young called calves, after a 12 to 16 month gestation period. The young wean after about one year, and reach maturity at 10 to 15 years (Layne, 1978). Life span is long, probably about 30 to 35 years. The average weight of adult dolphins is about 400 lb (180 kg).

The primary foods of estuarine bottlenose dolphins are mullets, spotted seatrout, silver perch, Atlantic croaker, oyster, toad fish, pinfish, and pigfish, with spotted seatrout, silver perch, and mullets generally considered to be the primary food sources (Wells, 1992; Barros and Odell, 1994). Many other species of fish also are eaten when available. On the west coast of Florida, dolphin abundance appears to mirror mullet abundance (Edwards, 1987). Dolphins have been shown to consume about 3% to 5% of their body weight in fish each day (Wells, 1992), so an average adult may eat about 20 lbs (9 kg) of fish daily. Based on this daily intake and the estimated total Indian River Lagoon complex population (in a following section), the total annual consumption of fish within the Indian River Lagoon complex may be over 2.2 million pounds (1,000,000 kg).

Historical Perspective

A juvenile gray whale (*Eschrichtius robustus*) skull was found at Hobe Sound National Wildlife Refuge in January 1983. The remains found on the beach provided evidence that the whale may have bred and calved in the Indian River Lagoon waters (Odell, 1983). Skeletal remains found in Indian middens in Brevard County also include Atlantic bottlenose dolphin, Cuvier's beaked whale (*Ziphus caurostris*) and pygmy sperm whale (*Kogia breviceps*) (Cumbaa, 1980).

A summary of historical data is as follows:

- Larson (1970) reviewed historical literature and found evidence of whale hunting along the Lagoon by Tequesta Indians.
- A skull of the Atlantic bottlenose dolphin *Tursiops truncatus* was found in South Melbourne Beach in 1948 (Layne, 1965).
- The Miami Seaquarium live-captured a *Tursiops truncatus* in the ICWW south of New Smyrna Beach in 1960 (Ehrhart, 1988).
- Leatherwood, et al. (1985) reviewed studies of *Tursiops truncatus* within the Indian River Lagoon and the Banana River system.
- The Marine Mammal Protection Act of 1972 required population studies prior to live collection (Odell, et al., 1979).
- A carcass salvage and natural history study in 1973 provided valuable mortality data.
- Large scale population and distribution studies began late in the 1970s (Leatherwood, et al., 1985).
- Systematic aerial surveys of *Tursiops truncatus* were conducted from August 1977 to November 1980.

- A mark-recapture study began in April 1977 with 36 dolphins marked and released between April 1977 and March 1979 (Leatherwood, et al., 1985).

The paucity of historical data regarding cetaceans in the Indian River Lagoon is evidenced by these summaries. Skeletal remains discovered in Indian middens are evidence that dolphins were hunted for food in prehistoric times. Although not documented, this practice probably continued in historic and modern times. Additionally, numerous dolphins were collected for research prior to the enactment of the Marine Mammal Protection Act of 1972. This legislative act provided needed protection for marine mammals nationwide. The Protection Act also required scientific studies to be conducted prior to the collection or removal of these species (Odell, et al., 1979). Researchers conducting these studies found the Indian River Lagoon system to be an ideal study area for bottlenose dolphins. The warm, protected waters within a closed system allowed easy access to the species. The level of study effort since has been substantial with over 4,000 dolphin observations between 1980 and 1988 (Beeler, et al., 1988).

Leatherwood, et al. (1985) captured, marked and released 36 dolphins between April 1977 and March 1979. During these captures dolphins were photographed, and other data such as blood samples and morphometrics were collected. This study was initiated to obtain data on daily and seasonal movements. In 1980, an additional 49 dolphins were captured and 13 previously marked animals were re-captured (Leatherwood, et al., 1985).

Current research is also limited. However, a non-profit organization, the Treasure Coast Dolphin Project (TCDP), is conducting research in the southern portion of the Lagoon complex. This research focuses on population dynamics between Vero Beach and Jupiter.

<u>Distribution and Habitat Use</u>

Bottlenose dolphins are believed to occur in distinct populations or communities with specific home ranges that can remain stable for at least 22 years (Wells, 1992). Extensive data on habitat use in the Indian River Lagoon complex is not available at this time. However, extensive studies in Sarasota area have indicated that estuarine dolphin populations tend to occur in proximity to extensive seagrass beds during the summer (Wells, 1992), presumably because these areas harbor the largest populations of the pinfish, pigfish, and mullet that make up a large portion of the dolphin's diet. In winter, dolphins were shown to spend a greater part of the time in deeper water and offshore in the Gulf, again presumably because of the movement of mullet and other fishes to deeper waters (Irvine, et al., 1979). Similar patterns may also occur in the Indian River Lagoon complex. There is evidence in the Indian River Lagoon system (Scott, 1984: Beeler, et al., 1988) that the resident dolphin population rarely passes through the inlets to the Atlantic, but that transient dolphins from the Atlantic population may enter the Lagoon during the summer months, accounting for the seasonal increase in numbers.

Other factors affecting habitat use and distribution of bottlenose dolphins include response to predators (generally large sharks which are not a major factor in the Indian River Lagoon complex), and use of specific areas for rearing of calves (Wells, 1992). In the Sarasota region, shallow waters appear to be utilized by females with young calves. Possible reasons for this include protection from predators and rough water conditions, reduction of the potential for separation of calf from mother, and increased accessibility to food supplies for the mother (Wells, 1992). Females appear to be more consistent in use of specific areas and home ranges than males who tend to travel over larger areas (Wells, 1992).

<u>Stresses and Mortality</u>

Since 1978, mortality data has been collected for dolphins stranded in the Lagoon system as part of the southeastern Marine Mammal Stranding Network (MMSN). A total of 293 stranded animals have been recovered and investigated, at a rate of about 20 per year for the Indian River Lagoon region. Woody and Odell (1993) have determined from analysis of this data that mortality increased during the calving season (spring/summer) and that the sex ratio was approximately 1:1.

Most mortality is considered to be from natural causes, although some dolphins are shot illegally or drowned in commercial fishing nets (Leatherwood et al., 1985). Evidence of entanglement has been found in about 8% to 12% of dolphins examined by the MMSN between 1985 and 1992 (Wells, 1992). Mortality data also suggests that extreme low temperatures may also be responsible for death in this species.

More recent research has suggested that a fungal skin disease "Lobo Mycosis" is a dehabilitating disease that may be contributing to the mortality rate. This disease creates lesions which often lead to bacterial infections. Approximately 12% of the dolphin population in the southern portion of the Lagoon has been determined by the TCDP to be afflicted with this disease. There has been some suggestion that the high incidence of the disease may be a result of suppression of the dolphin's immune system by chemical or biological agents within the Lagoon. However, no research has been conducted on etiology or causes. More information is needed to determine the causes and significance of this disease.

Heavy metal and organochlorine pollutants have also been suspected of affecting dolphin health and abundance in other parts of the world (Wells, 1992), although no specific correlations have been established. King (1987) found that PCB and dieldrin concentrations in 10 dolphins collected from the Indian River Lagoon complex between Ft. Pierce Inlet and Ponce de Leon Inlet were relatively high in comparison with average global levels in other dolphins, but that DDT concentrations were within the low range. The low range for DDT and its metabolites may be a reflection of the use of mosquito impoundments for mosquito control in this region rather than extensive use of DDT. Because of the long life span and the position of this species at the top of the marine food chain, it is reasonable that such contaminants would become concentrated in the tissue of dolphins. In addition, it has been reported that up to 80% of the contaminant residue in body tissue of a female may be transferred to the first-born offspring (Wells, 1992), thus affecting early survival.

Collection of dolphins for scientific and other purposes was a significant source of population loss prior to the Marine Mammal Protection Act of 1972. Between 1968 and 1972, 950 bottlenose dolphin were taken from Florida waters under state and federal permits (Beeler, et al., 1988).

Distribution and Population Trends

Leatherwood's study did not include extensive monitoring in the Indian River Lagoon south of Sebastian Inlet and had no reports of observations in that area. Leatherwood's herd monitoring studies did indicate that approximately 260 individuals may range between the Banana River and Indian River Lagoon north of Sebastian Inlet (Leatherwood, et al., 1985).

Shane (1981) counted up to 101 dolphins in the Banana River in 1980 and 30 dolphins in Mosquito Lagoon in 1979 (Shane, 1981). It has been noted that most animals remained within 5 km of their capture site (Beeler, et al., 1988).

The Treasure Coast Dolphin Project has identified a distinct resident bottlenose dolphin population in the portion of Indian River Lagoon south of Ft. Pierce that is believed to consist of about 25 individuals. Data from these studies indicate that the total resident population throughout the Lagoon complex may be in the vicinity of 300 individuals. However, this is an estimate based on very limited data as compared to that available for other estuary areas. It also does not include any estimates for population in Mosquito Lagoon. Bottlenose dolphins do utilize Mosquito Lagoon, and individuals from the northern Indian River Lagoon population have been sighted in Mosquito Lagoon (Odell and Asper, 1990; Provancha, et al., 1992). The population in this segment is believed to be small, but still has not been accounted for. Twelve dolphin strandings were reported for Mosquito Lagoon in the period from 1977 to 1990 (Provancha, et al., 1992).

Today, the bottlenose population appears to be stable throughout the Lagoon. However, the level of available historical and current information on bottlenose dolphins in the Indian River Lagoon complex is insufficient to establish any population trends at this time. Additional research and synthesis of all available information remains a need to determine the current and projected future status of this species.

7.4 THREATENED AND ENDANGERED FISH SPECIES WITHIN THE INDIAN RIVER LAGOON REGION

7.4.1 Endangered Species

Shortnose Sturgeon (*Acipenser brevirostrum*)

Sturgeon are large, very primitive fishes that were widely distributed in early geological history. They are characterized by bony plates on the head, 5 rows of bony scutes on the body, and four barbels near the mouth (McClane, 1965). They are slow growing, not reaching sexual maturity until about 12 years, with a life span of up to 75 years.

The shortnose sturgeon is a bottom feeder that has been reported from the mouths of tributaries and scattered widely throughout the northern portion of the Lagoon. The north end of the complex is reportedly at the southern range limit of this species (Robison, 1992). However, almost no data is available on the current status of this species.

7.4.2 Threatened Species

<u>Common Snook (*Centropomus undecimalis*)</u>

The common snook is unique in that it is both a sport fish and a threatened (state list) species. Its life cycle has been described in detail in the fisheries resources section of this report. Commercial fishing pressure was a major stress to the population until it was prohibited. Strict recreational bag and size limits have also led to a recovery of population size in recent years.

7.4.3 Species of Special Concern

<u>Mangrove Rivulus (*Rivulus marmoratus*)</u>

The mangrove rivulus is a small killifish species that occurs in the mangrove marshes and mangrove forest fringes of the Lagoon. It is tropical in nature, occurring in Cuba and a few other Caribbean locations and on the Florida coast as far north as the Vero Beach area (Taylor, 1990). There is little available information on its ocurrence in the Lagoon, since the number of specimens collected may be less than 100. This species has several unique factors, including the fact that the entire population appears to be composed of hermaphroditic clones, each capable of self-fertilization (Harrington, 1961; Taylor, 1990, 1994). Because of the isolated nature of the species and this clone effect, genetic diversity is low.

The mangrove rivulus appears to be restricted to the mangrove or salt marsh habitats where virtually all other fish species may be excluded. During low water periods in the mangrove habitats, the mangrove rivulus may shelter in abandoned burrows of the great land crab (*Cardisoma guanhumi*), where the water table maintains moist conditions. It is thought to move to mosquito ditches and stagnant pools in place of land crab burrows in south and southwest Florida (Taylor, et al., 1994). The mangrove rivulus may also be able to survive in an emersed state in damp terrestrial habitats for short periods (Taylor, 1990).

7.5 FINDINGS AND RECOMMENDATIONS ON THREATENED AND ENDANGERED SPECIES

The Indian River Lagoon system has an exceptionally large number of threatened and endangered species, as exemplified by MINWR which has the largest number of any of the national wildlife refuges.

The Lagoon region contains some of the largest concentrations in the state of many of these species. One half of the nesting least tern population of the state is thought to nest in KSC, which also has one of the three largest concentrations of scrub jays in the state. The barrier island along the Lagoon and KSC are the primary habitat of the southeastern beach mouse. The beaches of this island complex are the primary nesting grounds of the green turtle and the loggerhead turtle, both of which spend part of their lives in the Lagoon.

Several other species are endemic to very specific salt marsh habitats of the complex. The dusky seaside sparrow was restricted to the marshes of this region before it became extinct in 1977. The smyrna seaside sparrow has similar restricted requirements and is believed to have been eliminated from the complex. Only the Atlantic salt marsh snake still remains in the marshes of Mosquito Lagoon.

The Lagoon's resources have played critical roles in the survival of many species. For several years, Pelican Island was virtually the only nesting location of pelicans in the southeastern United States and may have been the key to the survival of this species during the DDT crisis and earlier periods of decline. The beaches of the region are critical for the survival of at least two species of marine turtles in the United States.

Reasons for endangerment of these species generally fall into one of several varieties. Probably the main reason has been loss of habitat. This has especially affected species of the salt marshes in the northern section of the complex and species of the xeric scrub communities. Other reasons include disturbance of nesting or breeding habitat, particularly on the beaches, and physical damage to the animals. Collisions with boats are the largest cause of manatee mortality, accounting for a quarter of all documented manatee deaths.

Diseases and contaminant accumulation appear to be present in a substantial number of species living or feeding within the waters of the Lagoon. Papillomatosis is a disease of unknown origins which has appeared in the Lagoon in the last ten years and now affects a substantial proportion of the marine turtle population of the Lagoon. Lobo mycosis is a fungal infection affecting about 10% of the bottlenose dolphin population of the Lagoon. There have been some indications that these diseases are connected in some way to water quality, but no definitive answers have yet appeared.

Indian River Lagoon appears to have suffered less than many coastal areas from the DDT and organochlorine pesticide effects that affected many bird species. Concentrations of organochlorine compounds and toxic metals within the tissues of such species as manatees, bottlenose dolphins, and pelicans in the Lagoon system appear to be relatively low and within safe limits, but very little is actually known about long-term chronic effects in these species.

8.0
RECOMMENDATIONS AND PRIORITY ISSUES

This inventory and analysis provides information on several problems or priority issues pertaining to the biological resources of the Lagoon that have been expressed by the SWIM and IRLNEP programs. The Lagoon-wide estimation of the extent and distribution of key resources, and evaluation of the functions, requirements, and trends of key resources has identified several data gaps and resulted in several recommendations for information needs and further management and research action. This section provides recommendations for addressing specific problems relating to biological resources.

Adjacent Upland and Wetland Communities

- Habitat loss and fragmentation due to development remains the key factor affecting these resources, with primary impacts along the coasts and in scrub habitats. Public acquisition programs may be the best means of protecting these resources and should be encouraged. Funding and local agency coordination are main needs which should be developed.

- Habitat degradation along margins of freshwater tributaries has occurred, with greater water quality degradation than in the Lagoon. It may be possible to combine habitat preservation and land acquisition along tributaries with water quality best management practices or retrofitting controls to enhance both habitat and water quality of the tributaries and the Lagoon.

- Exotic species are abundant in many areas, especially in the southern portions of the region. Of these, Brazilian pepper may be the primary plant species threat due to its agressive invasion and presence at the edge of the intertidal habitat. Minimizing soil and natural cover disturbance along the fringes of the Lagoon wetlands would reduce potential for further invasion, if complete eradication is beyond the means of available resources.

Mosquito Impoundments and Intertidal Wetlands

- Recent advances in promoting RIM management and reconnection of impounded wetlands appear to have had a positive impact on Lagoon resources and the present successful programs should be continued. The RIM actions have resulted in demonstrated water quality and fishery utilization improvements.

- The effect of impoundments on nutrient and energy cycling in particular, including the roles of plants, benthic organisms, and blue and fiddler crabs is not as well documented. RIM may be less effective in restoring these functions and the overall degree of impact should be investigated in greater detail.

- MINWR is the managing agency for the largest block of impoundments in the Lagoon, and should remain a key member of regional management plans and groups. MINWR should be kept informed of developments and new information relating to impoundments.

- A large percentage of non-MINWR impoundments are privately owned, reducing effectiveness of management programs. Efforts and funding to promote public acquisition of these areas should be encouraged.

- Block management, including the use of drawdowns and water level control for specific species, appears to have potential for enhancing populations of certain target species. Research and regional coordination for this approach should be continued.

Subtidal and Marine Communities

- SAV mapping studies indicate that substantial changes in seagrass coverage have occurred in portions of the Lagoon; however, the available data is not sufficient to indicate whether the changes represent long-term trends, short-term responses to weather or other natural factors, or short-term responses to specific perturbations. Periodic mapping, mapping of historical conditions, and permanent transect studies should be maintained to provide data on which to make these determinations.

- Seagrasses have shown the ability to recolonize areas in which they had been absent, indicating that positive responses to management actions are possible. It is recommended that programs to encourage, monitor, and protect potential seagrass bed areas be a part of other water quality enhancement programs such as discharge point controls or re-diversion projects. Natural recolonization may be possible, given adequate site protection and appropriate physical conditions.

- Data on the distribution of individual seagrass species in the Lagoon is limited. Since the responses of individual species may be a more sensitive indicator of specific conditions or environmental changes than is overall SAV cover, more research on individual species should be encouraged.

- Salinity may be a factor controlling distribution of some seagrass species. Although more data should be developed on this subject, it appears that reduction of salinity variation and raising of minimum salinity levels in areas such as in Segment 2 from Turkey Creek to Sebastian River and in the St. Lucie Estuary may result in increased seagrass ocurrence in these areas.

- Light penetration is an important factor controlling seagrass abundance and distribution. Available data indicates correlations occur between water clarity and depth of occurence, and between depth of occurrence and areal coverage in the Lagoon. Relatively simple techniques for modelling seagrass response and depth of occurrence as functions of light penetration have been demonstrated and can form an important management tool for monitoring of Lagoon quality and for predicting seagrass response to changes in water quality. These methods can also be extended to predictions of density and relative cover of species in beds, given sufficient data on individual species response. Research and application of these techniques should continue.

- Light penetration in the Lagoon is a function of several factors acting in combination. These factors differ throughout the Lagoon so that there are different combinations and different seagrass responses throughout the Lagoon. Chlorophyll *a*, suspended solids, and color conditions in different parts of the Lagoon should be characterized.

- Attached and drift algae appear to be a major, and possibly increasing, component of the SAV community, but little is known about their ecology, functions, or importance to other species. This data gap should be addressed.

- Phytoplankton levels within the Indian River Lagoon complex appear to be within the "healthy" range that has been indicated as compatible with sufficient light penetration for seagrass growth in other estuaries, and on an average basis this level currently appears to be stable. Data is not extensive however, and effects on seagrasses will depend on other components such as suspended solids.

- Phytoplankton dynamics have not been well studied in the Lagoon. Very limited data suggests that both N and P may be limiting nutrients seasonally or under different conditions. The establishment of the SWIM water quality monitoring network affords an opportunity to study nutrient and phytoplankton dynamics on a Lagoon-wide basis to provide a better understanding.

- The effect of epiphytic algae on seagrass growth and survival is currently being studied, but the effects are not well known. Since these effects may also depend on nutrient effects on epiphyte growth, and on other factors controlling light intensity for seagrasses, determination of effects on seagrasses may be a very complicated process requiring prior completion of other studies.

- The direct role of epiphytes, icthyoplankton and other zooplankton, and benthic invertebrates in the food chain is another important aspect which is not well known and deserves further study.

Fish, Shellfish, and Fisheries Resources

- RIM management and reconnection of mosquito impoundments to the Lagoon appears to be having a beneficial effect on fish populations, allowing movement of transient fish between impoundments and Lagoon. However, quantification of these effects will be a very difficult process.

- Quantitative information on fish populations and trends is extremely hard to produce. Landings data generally are not sufficiently specific to identify trends in the Lagoon, and other means of surveying adults are difficult to quantify or extrapolate to different situations. Monitoring of juvenile fish and icthyoplankton populations may provide the most effective means of identifying trends in fisheries resources in the Lagoon. Consideration should be given to a long-term commitment to expanding existing programs to cover the entire complex and developing a network for more rapid and complete dissemination of results.

- The hard clam and oyster industry in the Lagoon currently is almost entirely confined to the Mosquito Lagoon and Brevard County Indian River Lagoon areas. Oyster landings have shown a steady drop while hard clams dropped between about 1984 and 1990, but have shown some recent recovery. Declines in hard clam and oyster populations in other parts of the complex have largely been attributed to variation in the salinity regime and low minimum salinity levels, particularly in Bodies E and F, Segments 2 and 3 between Melbourne and Sebastian, and in the St. Lucie Estuary. Efforts to control salinity variation and raise levels through freshwater peak source reduction in these areas are underway or have been proposed, but the large volumes of freshwater as compared to pre-development conditions coupled with the hydrodynamics of these sections of the Lagoon complex (from Loadings Assessment and Physical Features Technical Reports) may inhibit the effectiveness of these measures unless alterations also occur in the exchange of waters through the controlling inlets. Although it may be possible to re-establish commercially viable populations in some of these areas, it is possible that large population variations may continue.

- Mariculture of hard clams and perhaps oysters is a viable process in the Lagoon. Increased application of intensive cultivation on leased tracts offers an advantage of concentrating resources in small regions of the Lagoon which can be intensively managed to maintain water quality. However, this concentration may increase localized impacts of mariculture on the Lagoon, and may also make the resource more vulnerable to localized catastrophic impacts. An analysis of the relative values and problems should be conducted.

Wildlife Resources and Endangered Species

- Although much research has been done on benthic invertebrates, it is difficult to describe Lagoon-wide patterns and influences due to a high variability within samples and the site-specific nature of many studies. There appears to be a large volume of additional data that has not been compiled and samples that have not been analysed due to lack of resources. Completion of these studies could be a valuable addition to the data base for the Lagoon. Additional funding would have to be made available to various researchers to complete these studies.

- The green sea turtle, loggerhead turtle, and Atlantic salt marsh snake are the only threatened or endangered reptile or amphibian species that utilize subtidal or intertidal habitats of the Lagoon on a regular basis. Management plans for Mosquito Lagoon impoundments should consider potential impacts on the Atlantic salt marsh snake. Papillomatosis appears to be spreading and may pose a threat to green sea turtles. Research should be continued with the intent of determining whether pollution in the Lagoon has any relation to the disease.

- Wading bird populations appear to be relatively stable in the region. Block management of mosquito impoundments can be used to enhance forage potential for these species. Impoundments should be identified that can be managed for wading bird forage, particularly under conditions of drought or excessive rainfall that affect unmanaged forage habitat.

- The wood stork currently appears to be the most vulnerable wading bird in the region due to specialized feeding habits. Impoundment drawdown management has shown some potential for enhancing forage potential, and additional management research should be conducted.

- Nesting or rookery habitat appears to be a limiting factor for wading and shore birds in the Lagoon and efforts to preserve and enhance such areas need to be strengthened. Spoil islands and impoundments may offer good potential for active enhancement efforts.

- Boating has the largest impact on manatees of any human-related action in the Lagoon. Projected increases in boat density on the Lagoon by the year 2010 indicate that this will continue to be a major impact, and additional management efforts should be considered.

- Recent studies have begun to provide a reliable estimate of the manatee population of the Lagoon complex. However, the carrying capacity of the Lagoon, especially the food resource provided by SAV beds has not been determined. Information on the existing population and potential population limits could be of value in determining the level of management needed for manatees in the Lagoon.

9.0
SUMMARY AND CONCLUSIONS

The Indian River Lagoon complex and its watershed has been endowed with a great diversity of biological resources and habitats. Historically, the Lagoon complex has had an abundance of highly productive shallow waters containing seagrass and algal beds which harbor many organisms and form the base for much of the Lagoon food web. Salt marsh and mangrove forests bordered much of the Indian River Lagoon, Banana River, and Mosquito Lagoon. These salt water wetlands also made an important contribution to the food base of the system and provided habitat for a multitude of organisms. The geomorphology of the region contributed to a high diversity of habitats in close proximity to the Lagoon complex, including xeric scrubs, freshwater wetlands, and coastal beaches and dunes.

Substantial changes have occurred within the past 50 to 100 years. Large portions of the adjacent habitats have been lost through conversion to other land uses. Close to 90% of the salt marshes and mangrove forests have been altered by ditching and diking for mosquito control. Responsive changes have occurred in many of the biological resources of the region. Several species have disappeared from the salt marsh habitats, and fish utilization of these areas has decreased. The habitat changes and decreases in fish populations have led to decreases in wading bird populations in the region.

Seagrass meadows have been shown to harbor the greatest diversity and abundance of fishes and invertebrates of the submerged habitats within the Lagoon. Manatee grass and shoal grass comprise the vast majority of the seagrass biomass. Distribution of these and the other seagrass species throughout the Lagoon appears to be primarily a function of gradients of certain environmental parameters along the axis of the Lagoon. The north-south temperature gradient, availability of suitable shallow water substrates, and salinity are the primary factors determining seagrass composition and abundance throughout the Lagoon. Abundance is generally high except for portions of the Indian River Lagoon from Vero Beach to Melbourne and in the Cocoa area. Much of this area is characterized by salinities that are lower than the rest of the Lagoon as well as a smaller percentage of suitable shallow water substrates. Manatee grass appears to have decreased in abundance in this region in response to the reduced salinity.

In addition to these factors, seagrasses are also influenced by light penetration and availability. Water color, suspended and dissolved solids concentration, and chlorophyll *a* concentration in the water all influence light penetration. In general, the light penetration is greatest near the inlets and decreases with increasing distance, indicating that color and suspended solids (mostly organic particles) are the main factors influencing light penetration in the Lagoon. Phytoplankton population levels and the corresponding chlorophyll *a* levels in the water column appear to be similar to levels reached in the 1970s and within the normal levels for estuary systems in Florida. This level is below levels found to have significantly reduced light penetration in other estuaries.

In conjunction with the "Analysis of Historical Imagery" Technical Report, this report indicates that although seagrass abundance has remained fairly steady in the complex as a whole, it has declined in some areas of the Lagoon and that this decline appears to be related to a decrease in depth of occurrence, implying decreasing light availability. However, additional light availability data needs to be collected before this trend can be confirmed and causes and management options can be fully defined.

The phytoplankton and zooplankton communities of the Lagoon appear to be in a normal balance that indicates good condition of the ecosystem. However, there is a lack of information on the plankton component of the ecosystem and on the relationship of this component to water quality, productivity, and seagrass dynamics. Thus, this is a research topic that requires additional study. In the portions of the Lagoon that have been examined, increased nutrients do not appear to have led to a significant increase in phytoplankton populations, at least on a regional scale.

Fisheries resources also show a geographical pattern from south to north, with the fauna at the south reflecting a more tropical origin. Temperature and salinity also play a major role in influencing distribution of fishes in the Lagoon. Seagrass meadows support the most diverse and abundant fish communities. Patterns of fish movement into salt marsh creeks and mangrove forests have been upset by impoundment for mosquito control. New techniques of impoundment management, including RIM management and flow-through systems, have been shown to increase fish and wading bird utilization of these impoundments.

Blue crabs have always been the main harvested shellfish resource of the Lagoon. Oysters for many years were the second largest resource, but have been surpassed by hard clams since the 1970s. Almost all of the commercial shellfish industry is confined to the north half of the Lagoon complex, with Brevard County being the dominant center. The hard clam is well suited to this portion of the Lagoon, being relatively tolerant of salinity fluctuations and adapting to the hard sandy bottoms of much of the Lagoon. Major freshwater storm influxes, bacterial and copper contamination, and deposition of mucks and silts appear to be the major threats to the hard clam industry.

Birds, especially waterfowl and wading birds, are the most obvious component of the wildlife resources of the Lagoon region. The northern part of the Lagoon around MINWR is a major waterfowl wintering and migratory location, with thousands of birds present in winter. Numerous rookeries for wading birds are present along the Lagoon complex, and many spoil islands offer nesting habitat for wading birds and shorebirds.

The Lagoon and the surrounding region is a significant resource for threatened and endangered species. It has the only known habitat for the Atlantic salt marsh snake, which is dependent on the salt marsh habitat in Volusia County. It is home to some of the largest concentrations of listed species in the state, including the Florida scrub jay, least tern, roseate spoonbill, and brown pelican. For several years, the Lagoon contained one of the only significant brown pelican breeding populations in the United States.

Several threatened or endangered marine species occur in waters of the Indian River Lagoon complex. These are the green turtle, loggerhead turtle, Florida manatee, and the protected but not endangered bottlenose dolphin. Each has been reasonably well studied, and estimates of population size and dynamics are beginning to develop. However, studies have not been undertaken for a sufficient period of time to develop firm conclusions about population trends. However, there appear to be sufficient causes for concern about the future of these species. The green turtle and the bottlenose dolphin both suffer from diseases whose severity and causes are not well understood, but which may be connected to water quality conditions. Human-related causes account for the majority of Florida manatee deaths, with boats and barges collisions the single largest documented cause of known manatee mortality.

For all of these resources, there will be greater competition for available resources as the human population of the region grows. Some actions which have already been initiated, such as the new impoundment management programs, have been shown to have positive effects for the majority of the biological resources of the system. Other programs, such as water quality management programs, may have significant benefits but may require much greater efforts for a significant impact on the Lagoon ecosystem. Management options which may benefit several species may also severely damage the prospects of other species. Thus all aspects of options need to be carefully evaluated. Finally, much additional information on many resources needs to be acquired on such aspects as seagrass light responses, plankton dynamics and nutrient responses, juvenile fisheries populations, manatee and bottlenose dolphin populations and movements, and causes and effects of papillomatosis and lobo mycosis diseases on green turtles and bottlenose dolphins.

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Appendix A

APPENDIX A
FISHES REPORTED TO OCCUR IN INDIAN RIVER LAGOON, FLORIDA

Family RHINCODONTIDAE - carpet sharks

Ginglymostoma cirratum (Bonnaterre 1788) - nurse shark

Family CARCHARHINIDAE - requiem sharks

Carcharhinus leucas (Valenciennes 1841) - bull shark
Carcharhinus limbatus (Valenciennes 1841) - blacktip shark
Carcharhinus plumbeus (Nardo 1827) - sandbar shark
Mustelus canis (Mitchill 1815) - smooth dogfish
Negaprion brevirostris (Poey 1868) - lemon shark

Family SPHYRNIDAE - hammerhead sharks

Sphyrna lewini (Griffith & Smith 1834) - scalloped hammerhead
Sphyrna mokarran (Ruppell 1837) - great hammerhead
Sphyrna tiburo (Linnaeus 1758) - bonnethead

Family PRISTIDAE - sawfishes

Pristis pectinata Latham 1794 - smalltooth sawfish
Pristis pristis Linnaeus 1758 - largetooth sawfish

Family TORPEDINIDAE - electric rays

Narcine brasiliensis (Olfers 1831) - lesser electric ray

Family RHINOBATIDAE - guitarfishes

Rhinobatos lentiginosus (Garman 1880) - Atlantic guitarfish

Family DASYATIDAE - stingrays

Dasyatis americana Hildebrand & Schroeder 1928 - southern stingray
Dasyatis centroura (Mitchill 1815) - roughtail stingray
Dasyatis sabina (Lesueur 1824) - Atlantic stingray
Dasyatis say (Lesueur 1817) - bluntnose stingray
Gymnura micrura (Schneider 1801) - smooth butterfly ray

Family MYLIOBATIDAE - eagle rays

Aetobatis narinari (Euphrasen 1790) - spotted eagle ray
Myliobatis freminvillei Lesueur 1824 - bullnose ray
Rhinoptera bonasus (Mitchill 1815) - cownose ray

Family ACIPENSERIDAE - sturgeons

Acipenser brevirostrum Lesueur 1818 - shortnose sturgeon

Family LEPISOSTEIDAE - gars

Lepisosteus osseus (Linneaus 1758) - longnose gar
Lepisosteus platyrhincus DeKay 1842 - Florida gar
Lepisosteus spatula Lacepede 1803 - alligator gar

Family AMIIDAE - bowfins

Amia calva Linnaeus 1766 - bowfin

Family ELOPIDAE - tarpons

Elops saurus Linnaeus 1766 - ladyfish
Megalops atlanticus Valenciennes 1847 - tarpon

Family ALBULIDAE - bonefishes

Albula vulpes (Linnaeus 1758) - bonefish

Family ANGUILLIDAE - freshwater eels

Anguilla rostrata (Lesueur 1817) - American eel

Family MURAENIDAE - morays

Gymnothorax funebris Ranzani 1839 - green moray
Gymnothorax moringa (Cuvier 1829) - spotted moray
Gymnothorax vicinus (Castelnau 1855) - purplemouth moray
Muraena retifera Goode & Bean 1882 - reticulate moray

Family OPHICHTHIDAE - snake eels

Ahlia egmontis (Jordan 1884) - key worm eel
Bascanichthys bascanium (Jordan 1884) - sooty eel
Bascanichthys scuticaris (Goode & Bean 1880) - whip eel
Callechelys springeri (Ginsburg 1951) - ridgefin eel
Myrichthys breviceps (Richardson 1845) - sharptail eel
Myrichthys ocellatus (Lesueur 1825) - goldspotted eel
Myrophis punctatus Lutken 1851 - speckled worm eel
Ophichthus gomesi (Castelnau 1855) - shrimp eel

Family CONGRIDAE - conger eels

Ariosoma balearicum (Delaroche 1809) - bandtooth conger

Family CLUPEIDAE - herrings

Alosa sapidissima (Wilson 1811) - American shad
Brevoortia smithi Hildebrand 1941 - yellowfin menhaden
Brevoortia tyrannus (Latrobe 1802) - Atlantic menhaden
Dorosoma cepedianum (Lesueur 1818) - gizzard shad
Dorosoma petenense (Gunther 1867) - threadfin shad
Harengula clupeola (Cuvier 1829) - false pilchard
Harengula humeralis (Cuvier 1829) - redear sardine
Harengula jaguana Poey 1865 - scaled sardine
Jenkinsia sp. [listed by Gilmore 1977]
Opisthonema oglinum (Lesueur 1817) - Atlantic thread herring
Sardinella aurita Valenciennes 1847 - Spanish sardine

Family ENGRAULIDAE - anchovies

Anchoa cubana (Poey 1868) - Cuban anchovy
Anchoa hepsetus (Linnaeus 1758) - striped anchovy
Anchoa lamprotaenia Hildebrand 1943 - bigeye anchovy
Anchoa lyolepis (Evermann & Marsh 1900) - dusky anchovy
Anchoa mitchilli (Valenciennes 1848) - bay anchovy
Anchoa nasuta Hildebrand & Carvalho 1948 - longnose anchovy

Family CYPRINIDAE - carps and minnows

Notemigonus crysoleucas (Mitchill 1814) - golden shiner
Notropis maculatus (Hay 1881) - taillight shiner
Notropis petersoni Fowler 1942 - coastal shiner

Family CATOSTOMIDAE - suckers

Erimyzon sucetta (Lacepede 1803) - lake chubsucker

Family ICTALURIDAE - bullhead catfishes

Ameiurus catus (Linnaeus 1758) - white catfish
Ameiurus natalis (Lesueur 1819) - yellow bullhead
Ameiurus nebulosus (Lesueur 1819) - brown bullhead
Ictalurus punctatus (Rafinesque 1818) - channel catfish
Noturus gyrinus (Mitchill 1817) - tadpole madtom

Family CLARIIDAE - labyrinth catfishes (Introduced, I)

Claris batrachus (Linnaeus 1758) - walking catfish (I)

Family ARIIDAE - sea catfishes

Arius felis (Linnaeus 1766) - hardhead catfish
Bagre marinus (Mitchill 1815) - gafftopsail catfish

Family ESOCIDAE - pikes

Esox americanus Gmelin 1788 - grass pickerel

Family SYNODONTIDAE - lizardfishes

Synodus foetens (Linnaeus 1766) - inshore lizardfish
Trachinocephalus myops (Forster 1801) - snakefish

Family APHREDODERIDAE - pirate perches

Aphredoderus sayanus (Gilliams 1824) - pirate perch

Family OPHIDIIDAE - cusk-eels

Ophidion marginatum (DeKay 1842) - striped cusk-eel

Family BYTHITIDAE - viviparous brotulas

Ogilbia cayorum Evermann & Kendall 1897 - key brotula

Family BATRACHOIDIDAE - toadfishes

Opsanus tau (Linnaeus 1766) - oyster toadfish

Family ANTENNARIIDAE - frogfishes

Antennarius pauciradiatus Schultz 1957 - dwarf frogfish
Antennarius striatus (Shaw & Nodder 1794) - striated frogfish
Histrio histrio (Linnaeus 1758) - sargassumfish

Family GOBIESOCIDAE - clingfishes

Gobiesox strumosus Cope 1870 - skilletfish

Family EXOCOETIDAE - flyingfishes

Cypselurus melanurus (Valenciennes 1847) - Atlantic flyingfish
Hyporhamphus unifasciatus (Ranzani 1842) - silverstripe halfbeak

Family BELONIDAE - needlefishes

Strongylura marina (Walbaum 1792) - Atlantic needlefish
Strongylura notata (Poey 1860) - redfin needlefish
Strongylura timucu (Walbaum 1792) - timucu
Tylosurus acus (Lacepede 1803) - agujon
Tylosurus crocodilus (Peron & Lesueur 1821) - houndfish

Family APLOCHEILIDAE - rivulins

Rivulus marmoratus Poey 1880 - mangrove rivulus

Family CYPRINODONTIDAE - killifishes

Cyprinodon variegatus Lacepede 1803 - sheepshead minnow
Floridichthys carpio (Gunther 1866) - goldspotted killifish
Fundulus chrysotus (Gunther 1866) - golden topminnow
Fundulus cingulatus Valenciennes 1846 - banded topminnow
Fundulus confluentis Goode & Bean 1879 - marsh killifish
Fundulus grandis Baird & Girard 1853 - gulf killifish
Fundulus heteroclitus (Linnaeus 1766) - mummichog
Fundulus lineolatus (Agassiz 1854) - lined topminnow
Fundulus majalis (Walbaum 1792) - striped killifish
Fundulus seminolis Girard 1859 - Seminole killifish
Jordanella floridae Goode & Bean 1879 - flagfish

Family CYPRINODONTIDAE - killifishes, Continued

Leptolucania ommata (Jordan 1884) - pygmy killifish
Lucania goodei Jordan 1880 - bluefin killifish
Lucania parva (Baird & Girard 1855) - rainwater killifish

Family POECILIIDAE - livebearers

Gambusia affinis (Baird & Girard 1853) - mosquitofish
Heterandria formosa Agassiz 1855 - least killifish
Poecilia latipinna (Lesueur 1821) - sailfin molly

Family ATHERINIDAE - silversides

Hypoatherina harringtonensis (Goode 1877) - reef silverside
Labidesthes sicculus (Cope 1865) - brook silverside
Membras martinica (Valenciennes 1835) - rough silverside
Menidia beryllina (Cope 1866) - inland silverside
Menidia peninsulae (Goode & Bean 1879) - tidewater silverside

Family FISTULARIIDAE - cornetfishes

Fistularia tabacaria Linnaeus 1758 - bluespotted cornetfish

Family SYNGNATHIDAE - pipefishes

Bryx dunckeri (Metzelaar 1919) - pugnose pipefish
Hippocampus erectus Perry 1810 - lined seahorse
Hippocampus reidi Ginsburg 1933 - longsnout seahorse
Hippocampus zosterae Jordan & Gilbert 1882 - dwarf pipefish
Microphis brachyurus (Bleeker 1853) - opossum pipefish
Syngnathus floridae (Jordan & Gilbert 1882) - dusky pipefish
Syngnathus fuscus Storer 1839 - northern pipefish
Syngnathus louisianae Gunther 1870 - chain pipefish
Syngnathus scovelli (Evermann & Kendall 1896) - gulf pipefish

Family SCORPAENIDAE - scorpionfishes

Scorpaena brasiliensis Cuvier 1829 - barbfish
Scorpaena dispar Longley & Hildebrand 1940 - hunchback scorpionfish
Scorpaena grandicornis Cuvier 1829 - plumed scorpionfish
Scorpaena plumieri Bloch 1789 - spotted scorpionfish

Family TRIGLIDAE - searobins

Bellator brachychir (Regan 1914) - shortfin searobin
Prionotus evolans (Linnaeus 1766) - striped searobin
Prionotus rubio Jordan 1886 - blackwing searobin
Prionotus scitulus Jordan & Gilbert 1882 - leopard searobin
Prionotus tribulus Cuvier 1829 - bighead searobin

Family CENTROPOMIDAE - snooks

Centropomus parallelus Poey 1860 - fat snook
Centropomus pectinatus Poey 1860 - tarpon snook
Centropomus undecimalis (Bloch 1792) - common snook

Family PERCICHTHYIDAE - temperate basses

Morone saxatilis (Walbaum 1792) - striped bass

Family SERRANIDAE - sea basses

Centropristis ocyurus (Jordan & Evermann 1887) - bank sea bass
Centropristis philadelphica (Linnaeus 1758) - rock sea bass
Centropristis striata (Linnaeus 1758) - black sea bass
Diplectrum bivittatum (Valenciennes 1828) - dwarf sand perch
Diplectrum formosum (Linnaeus 1766) - sand perch
Epinephelus itajara (Lichtenstein 1822) - jewfish
Epinephelus morio (Valenciennes 1828) - red grouper
Epinephelus nigritus (Holbrook 1855) - warsaw grouper
Epinephelus striatus (Bloch 1792) - Nassau grouper
Hypoplectrus unicolor (Walbaum 1792) - butter hamlet
Mycteroperca bonaci (Poey 1860) - black grouper
Mycteroperca microlepis (Goode & Bean 1879) - gag
Mycteroperca phenax Jordan & Swain 1884 - scamp
Serranus baldwini (Evermann & Marsh 1900) - lantern bass
Serranus subligarius (Cope 1870) - belted sandfish
Rypticus maculatus Holbrook 1855 - whitespotted soapfish
Rypticus saponaceus (Schneider 1801) - greater soapfish

Family CENTRARCHIDAE - sunfishes

Elassoma evergladei Jordan 1884 - Everglades pygmy sunfish
Enneacanthus gloriosus (Holbrook 1855) - bluespotted sunfish
Enneacanthus obesus (Girard 1854) - banded sunfish
Lepomis gulosus (Cuvier 1829) - warmouth

Family CENTRARCHIDAE - sunfishes, Continued

Lepomis macrochirus Rafinesque 1819 - bluegill
Lepomis marginatus (Holbrook 1855) - dollar sunfish
Lepomis microlophus (Gunther 1859) - redear sunfish
Lepomis punctatus (Valenciennes 1831) - spotted sunfish
Micropterus salmoides (Lacepede 1802) - largemouth bass
Pomoxis nigromaculatus (Lesueur 1829) - black crappie

Family PERCIDAE - perches

Etheostoma fusiforme (Girard 1854) - swamp darter

Family APOGONIDAE - cardinalfishes

Apogon binotatus (Poey 1867) - barred cardinalfish
Apogon maculatus (Poey 1860) - flamefish
Apogon pseudomaculatus Longley 1932 - twospot cardinalfish
Astrapogon puncticulatus (Poey 1887) - blackfin cardinalfish
Astrapogon stellatus (Cope 1869) - conchfish
Phaeoptyx conklini (Silvester 1916) - freckled cardinalfish
Phaeoptyx pigmentaria (Poey 1860) - dusky cardinalfish

Family POMATOMIDAE - bluefishes

Pomatomus saltatrix (Linnaeus 1766) - bluefish

Family ECHENEIDAE - remoras

Echeneis naucrates Linnaeus 1758 - sharksucker
Echeneis neucratoides Zuieuw 1789 - whitefin sharksucker

Family CARANGIDAE - jacks

Alectis ciliaris (Bloch 1787) - African pompano
Caranx bartholomaei Cuvier 1833 - yellow jack
Caranx crysos (Mitchill 1815) - blue runner
Caranx hippos (Linnaeus 1766) - crevalle jack
Caranx latus Agassiz 1831 - horse-eye jack
Caranx ruber (Bloch 1793) - bar jack
Chloroscombrus chrysurus (Linnaeus 1766) - Atlantic bumper
Oligoplites saurus (Schneider 1801) - leatherjack
Selar crumenophthalmus (Bloch 1793) - bigeye scad
Selene setapinnis (Mitchill 1815) - Atlantic moonfish

Family CARANGIDAE - jacks, Continued

Selene vomer (Linnaeus 1758) - lookdown
Trachinotus carolinus (Linnaeus 1766) - Florida pompano
Trachinotus falcatus (Linnaeus 1758) - permit

Family CORYPHAENIDAE - dolphins

Coryphaena hippurus Linnaeus 1758 - dolphin

Family LUTJANIDAE - snappers

Lutjanus analis (Cuvier 1828) mutton snapper
Lutjanus apodus (Walbaum 1892) - schoolmaster
Lutjanus cyanopterus (Cuvier 1828) - cubera snapper
Lutjanus griseus (Linnaeus 1758) - gray snapper
Lutjanus jocu (Schneider 1801) - dog snapper
Lutjanus mahogoni (Cuvier 1828) - mahogany snapper
Lutjanus synagris (Linnaeus 1758) - lane snapper
Ocyurus chrysurus (Bloch 1791) - yellowtail snapper

Family LOBOTIDAE - tripletails

Lobotes surinamensis (Bloch 1790) - tripletail

Family GERREIDAE - mojarras

Diapterus auratus Ranzani 1840 - Irish pompano
Diapterus plumieri (Cuvier 1830) - striped mojarra
Eucinostomus argenteus Baird & Girard 1855 - spotfin mojarra
Eucinostomus gula (Quoy & Gaimard 1824) - silver jenny
Eucinostomus havana (Nichols 1912) - slender mojarra
Eucinostomus lefroyi (Goode 1874) - mottled mojarra
Eucinostomus jonesi (Gunther 1878) - slender mojarra
Gerres cinereus (Walbaum 1792) - yellowfin mojarra

Family HAEMULIDAE - grunts

Anisotremus surinamensis (Bloch 1790) - black margate
Anisotremus virginicus (Linnaeus 1758) - porkfish
Haemulon album Cuvier 1830 - margate
Haemulon aurolineatum Cuvier 1830 - tomtate
Haemulon carbonarium Poey 1860 - caesar grunt
Haemulon chrysargyreum Gunther 1859 - smallmouth grunt

Family HAEMULIDAE - grunts, Continued

Haemulon flavolineatum (Desmarest 1823) - French grunt
Haemulon macrostomum Gunther 1859 - Spanish grunt
Haemulon melanurum (Linnaeus 1758) - cottonwick
Haemulon parra (Desmarest 1823) - sailors choice
Haemulon plumieri (Lacepede 1801) - white grunt
Haemulon sciurus (Shaw 1803) - bluestriped grunt
Orthopristis chrysoptera (Linnaeus 1766) - pigfish
Pomadasys croco (Cuvier 1830) - burro grunt

Family SPARIDAE - porgies

Archosargus probatocephalus (Walbaum 1792) - sheepshead
Archosargus rhomboidalis (Linnaeus 1758) - sea bream
Calamus arctifrons Goode & Bean 1882 - grass porgy
Calamus bajonado (Schneider 1801) - jolthead porgy
Diplodus argenteus (Valenciennes 1830) - silver porgy
Diplodus holbrooki (Bean 1878) - spottail pinfish
Lagodon rhomboides (Linnaeus 1766) - pinfish
Stenotomus chrysops (Linnaeus 1766) - scup

Family SCIAENIDAE - drums

Bairdiella chrysoura (Lacepede 1802) - silver perch
Cynoscion nebulosus (Cuvier 1830) - spotted seatrout
Cynoscion nothus (Holbrook 1855) - silver seatrout
Cynoscion regalis (Bloch & Schneider 1801) - weakfish
Equetus acuminatus (Schneider 1801) - high-hat
Equetus umbrosus Jordan & Eigenmann 1889 - cubbyu
Leiostomus xanthurus Lacepede 1802 - spot
Menticirrhus americanus (Linnaeus 1758) - southern kingfish
Menticirrhus littoralis (Holbrook 1855) - gulf kingfish
Menticirrhus saxatilis (Bloch & Schneider 1801) - northern kingfish
Micropogonias undulatus (Linnaeus 1766) - Atlantic croaker
Pogonias cromis (Linnaeus 1766) - black drum
Sciaenops ocellatus (Linnaeus 1766) - red drum
Stellifer lanceolatus (Holbrook 1855) - star drum
Umbrina coroides Cuvier 1830 - sand drum

Family MULLIDAE - goatfishes

Pseudupeneus maculatus (Bloch 1793) - spotted goatfish

Family KYPHOSIDAE - sea chubs

Kyphosus incisor (Cuvier 1831) - yellow chub
Kyphosus sectatrix (Linnaeus 1758) - Bermuda chub

Family EPHIPPIDAE - spadefishes

Chaetodipterus faber (Broussonet 1782) - Atlantic spadefish

Family CHAETODONTIDAE - butterflyfishes

Chaetodon capistratus Linnaeus 1758 - foureye butterflyfish
Chaetodon ocellatus Bloch 1787 - spotfin butterflyfish

Family POMACANTHIDAE - angelfishes

Holacanthus bermudensis Goode 1876 - blue angelfish
Holacanthus ciliaris (Linnaeus 1758) - queen angelfish
Holacanthus tricolor (Bloch 1795) - rock beauty
Pomacanthus arcuatus (Linnaeus 1758) - gray angelfish
Pomacanthus paru ((Bloch 1787) - French angelfish

Family CICHLIDAE - cichlids (I)

Cichlasoma octofasciatum (Regan 1903) - Jack Dempsey (I)
Hemichromis bimaculatus Gill 1862 - African jewelfish (I)
Tilapia mariae (Boulenger 1899) - spotted tilapia (I)
Tilapia melanotheron (Ruppell 1852) - blackchin tilapia (I)
Tilapia mossambica (Peters 1852) - Mozambique tilapia (I)

Family POMACENTRIDAE - damselfishes

Abudefduf saxatilis (Linnaeus 1758) - sergeant major
Abudefduf taurus (Muller & Troschel 1848) - night sergeant
Pomacentrus fuscus Cuvier 1830 - dusky damselfish
Pomacentrus leucostictus Muller & Troschel 1848 - beaugregory
Pomacentrus partitus Poey 1868 - bicolor damselfish
Pomacentrus variabilis Castelnau 1855 - cocoa damselfish

Family MUGILIDAE - mullets

Agonostomus monticola (Bancroft 1836) - mountain mullet
Mugil cephalus Linnaeus 1758 - striped mullet
Mugil curema Valenciennes 1836 - white mullet
Mugil gaimardianus Desmarest 1831 - redeye mullet
Mugil gyrans (Jordan & Gilbert 1884) - fantail mullet

Family SPHYRAENIDAE - barracudas

Sphyraena barracuda (Walbaum 1792) - great barracuda
Sphyraena borealis DeKay 1842 - northern sennet
Sphyraena guachancho Cuvier 1829 - guaguanche

Family LABRIDAE - wrasses

Bodianus rufus (Linnaeus 1758) - Spanish hogfish
Doratonotus megalepis Gunther 1862 - dwarf wrasse
Halichoeres bivittatus (Bloch 1791) - slippery dick
Halichoeres maculipinna (Muller & Troschel 1848) - clown wrasse
Halichoeres poeyi (Steindachner 1867) - blackear wrasse
Halichoeres radiatus (Linnaeus 1758) - puddingwife
Hemipteronotus novacula (Linnaeus 1758) - pearly razorfish
Lachnolaimus maximus (Walbaum 1792) - hogfish
Thalassoma bifasciatum (Bloch 1791) - bluehead

Family SCARIDAE - parrotfishes

Cryptotomus roseus Cope 1871 - bluelip parrotfish
Nicholsina usta (Valenciennes 1839) - emerald parrotfish
Scarus coeruleus (Bloch 1786) - blue parrotfish
Scarus croicensis Bloch 1790 - striped parrotfish
Scarus guacamaia Cuvier 1829 - rainbow parrotfish
Scarus taeniopterus Desmarest 1831 - princess parrotfish
Sparisoma chrysopterum (Bloch & Schneider 1801) - redtail parrotfish
Sparisoma radians (Valenciennes 1839) - bucktooth parrotfish
Sparisoma rubripinne (Valenciennes 1839) - redfin parrotfish

Family OPISTHOGNATHIDAE - jawfishes

Opisthognathus sp. [listed by Gilmore 1977]

Family URANOSCOPIDAE - stargazers

Astroscopus y-graecum (Cuvier 1829) - southern stargazer

Family DACTYLOSCOPIDAE - sand stargazers

Dactyloscopus crossotus Starks 1913 - bigeye stargazer
Dactyloscopus tridigitatus Gill 1859 - sand stargazer
Gillellus greyae Kanazawa 1952 - arrow stargazer
Gillellus healae Dawson 1982 - warteye stargazer
Paragillellus rubrocinctus (Longley 1934) - saddle stargazer

Family CLINIDAE - clinids

Labrisomus gobio (Valenciennes 1836) - palehead blenny
Labrisomus nuchipinnis (Quoy & Gaimard 1824) - hairy blenny
Malacoctenus macropus (Poey 1868) - rosy blenny
Malacoctenus triangulatus Springer 1959 - saddled blenny
Paraclinus fasciatus (Steindachner 1876) - banded blenny
Paraclinus nigripinnis (Steindachner 1876) - blackfin blenny
Starksia ocellata (Steindachner 1876) - checkered blenny

Family BLENNIIDAE - combtooth blennies

Chasmodes bosquianus (Lacepede 1800) - striped blenny
Chasmodes saburrae Jordan & Gilbert 1882 - Florida blenny
Entomacrodus nigricans Gill 1859 - pearl blenny
Hypleurochilus aequipinnis (Gunther 1861) - oyster blenny
Hypleurochilus bermudensis Beebe & Tee Van 1933 - barred blenny
Hypleurochilus geminatus (Wood 1825) - crested blenny
Hypsoblennius hentz (Lesueur 1825) - feather blenny
Lupinoblennius nicholsi (Tavolga 1954) - highfin blenny
Parablennius marmoreus (Poey 1876) - seaweed blenny
Scartella cristata (Linnaeus 1758) - molly miller

Family CALLIONYMIDAE - dragonets

Diplogrammus pauciradiatus (Gill 1865) - spotted dragonet

Family ELEOTRIDAE - sleepers

Dormitator maculatus (Bloch 1785) - fat sleeper
Eleotris pisonis (Gmelin 1788) - spinycheek sleeper

Family ELEOTRIDAE - sleepers, Continued

Erotelis smaragdus (Valenciennes 1837) - emerald sleeper
Gobiomorus dormitor Lacepede 1800 - bigmouth sleeper

Family GOBIIDAE - gobies

Awaous tajasica (Lichtenstein 1822) - river goby
Bathygobius curacao (Metzelaar 1919) - notchtongue goby
Bathygobius soporator (Valenciennes 1837) - frillfin goby
Coryphopterus glaucofrenum Gill 1863 - bridled goby
Evorthodus lyricus (Girard 1858) - lyre goby
Gobioides broussoneti Lacepede 1800 - violet goby
Gobionellus boleosoma (Jordan & Gilbert 1882) - darter goby
Gobionellus oceanicus (Pallas 1770) - highfin goby
Gobionellus pseudofasciatus Gilbert & Randall 1979 - slashcheek goby
Gobionellus shufeldti (Jordan & Eigenmann 1886) - freshwater goby
Gobionellus stigmaturus (Goode & Bean 1882) - spottail goby
Gobiosoma bosc (Lacepede 1800) - naked goby
Gobiosoma ginsburgi Hildebrand & Schroeder 1928 - seaboard goby
Gobiosoma macrodon Beebe & Tee Van 1928 - tiger goby
Gobiosoma robustum Ginsburg 1933 - code goby
Lophogobius cyprinoides (Pallas 1770) - crested goby
Microgobius gulosus (Girard 1858) - clown goby
Microgobius microlepis Longley & Hildebrand 1940 - banner goby
Microgobius thalassinus (Jordan & Gilbert 1883) - green goby

Family MICRODESMIDAE - wormfishes

Cerdale floridana Longley 1934 - pugjaw wormfish

Family ACANTHURIDAE - surgeonfishes

Acanthurus bahianus Castelnau 1855 - ocean surgeon
Acanthurus chirurgus (Bloch 1787) - doctorfish
Acanthurus coeruleus Schneider 1801 - blue tang

Family TRICHIURIDAE - snake mackerels

Trichiurus lepturus Linnaeus 1758 - Atlantic cutlassfish

Family SCOMBRIDAE - mackerels

Euthynnus alletteratus (Rafinesque 1810) - little tunny
Scomberomorus cavalla (Cuvier 1829) - king mackerel
Scomberomorus maculatus (Mitchill 1815) - Spanish mackerel

Family STROMATEIDAE - butterfishes

Nomeus gronovii (Gmelin 1788) - man-of-war fish
Peprilus alepidotus (Linnaeus 1766) - harvestfish
Peprilus triacanthus (Peck 1804) - butterfish
Psenes cyanophrys Valenciennes 1833 - freckled driftfish

Family BOTHIDAE - lefteye flounders

Bothus ocellatus (Agassiz 1831) - eyed flounder
Bothus robinsi Topp & Hoff 1972 - twospot flounder
Citharichthys arctifrons Goode 1880 - Gulf Stream flounder
Citharichthys arenaceus Evermann & Marsh 1900 - sand whiff
Citharichthys macrops Dresel 1885 - spotted whiff
Citharichthys spilopterus Gunther 1862 - bay whiff
Etropus crossotus Jordan & Gilbert 1882 - fringed flounder
Paralichthys albigutta Jordan & Gilbert 1882 - gulf flounder
Paralichthys dentatus (Linnaeus 1766) - summer flounder
Paralichthys lethostigma Jordan & Gilbert 1884 - southern flounder
Paralichthys squamilentus Jordan & Gilbert 1882 - broad flounder
Syacium micrurum Ranzani 1840 - channel flounder

Family SOLEIDAE - soles

Achirus lineatus (Linnaeus 1758) - lined sole
Symphurus plagiusa (Linnaeus 1766) - blackcheek tonguefish
Trinectes maculatus (Bloch & Schneider 1801) - hogchoker

Family BALISTIDAE - leatherjackets

Aluterus heudeloti Hollard 1855 - dotterel filefish
Aluterus schoepfi (Walbaum 1792) - orange filefish
Aluterus scriptus (Osbeck 1765) - scrawled filefish
Balistes capriscus Gmelin 1789 - gray triggerfish
Canthidermis sufflamen (Mitchill 1818) - ocean triggerfish
Monacanthus ciliatus (Mitchill 1818) - fringed filefish
Monacanthus hispidus (Linnaeus 1766) - planehead filefish

Family OSTRACIIDAE - boxfishes

Lactophrys quadricornis (Linnaeus 1758) - scrawled cowfish
Lactophrys trigonus (Linnaeus 1758) - trunkfish
Lactophrys triqueter (Linnaeus 1758) - smooth trunkfish

Family TETRAODONTIDAE - puffers

Chilomycterus antennatus (Cuvier 1818) - bridled burrfish
Chilomycterus schoepfi (Walbaum 1792) - striped burrfish
Diodon histrix Linnaeus 1758 - porcupinefish
Diodon holocanthus Linnaeus 1758 - balloonfish
Lagocephalus laevigatus (Linnaeus 1766) - smooth puffer
Sphoeroides maculatus (Bloch & Schneider 1801) - northern puffer
Sphoeroides nephelus (Goode & Bean 1882) - southern puffer
Sphoeroides spengleri (Bloch 1782) - bandtail puffer
Sphoeroides testudineus (Linnaeus 1758) - checkered puffer