Indian River Lagoon Section

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STUDY GUIDE

Following review of the Indian River Lagoon (IRL) section materials, you should be able to:

- Provide a definition of an estuary and identify the various types.
- Identify and locate different components of the Indian River Lagoon system.
- Identify and define watersheds.
- Identify the primary forces driving circulation and mixing in the IRL and their effects on salinity and water quality.
- Identify the primary factors affecting water quality in the IRL and their impacts on the resources of the Lagoon.
- Explain point and non-point sources of pollution and be able to provide examples of both sources. ID and describe muck sediments.
- Provide a definition of biodiversity and discuss its importance in the IRL.
- Identify and characterize the major habitats found in the IRL, explain their importance and discuss how man's activities have affected these habitats.
- Identify the seagrass species found in the IRL and describe their significance and role in the IRL.
- Identify the mangrove species found in the IRL and describe their significance and role in the IRL.
- Discuss the status and trends of fisheries in the IRL.
- Identify the wildlife resources (including threatened and endangered species) of the IRL and discuss how these man's activities have affected these species.

INTRODUCTION

GEOGRAPHICAL LOCATION

The Indian River Lagoon is located on the east coast of Florida, stretching from Ponce deLeon Inlet near Daytona Beach to Jupiter Inlet north of West Palm Beach. The Indian River Lagoon region, which comprises more than a third of Florida's east coast, includes three major waterbodies: Mosquito Lagoon, Banana River and the Indian River. This combination of water bodies results in a long, narrow lagoon system approximately 156 miles in length.

NOT A RIVER BUT A LAGOON

The Indian River Lagoon is an estuary: an area where salt water from the sea meets and mixes with freshwater running off the land. Unlike a typical riverine estuary with a river flowing from headwaters to a mouth, the Indian River Lagoon is a lagoonal estuary with several small freshwater tributaries and a limited connection to the ocean through broadly spaced inlets. The Indian River Lagoon has no "headwaters" or "mouth" and, as a result, circulation or movement within this brackish water body is driven more by the wind than by oceanic tides.

FISHERY FACTS

The Lagoon is a cradle of the ocean, serving as a spawning ground for numerous oceanic and Lagoonal fish species. The Indian River Lagoon accounts for more than $300 million in fishery revenues each year, providing more than 50 percent of the Florida east coast commercial fish landings and 90 percent of Florida clam landings.

MORE THAN JUST FISH

The Lagoon region supports a world-renowned $2.1 billion citrus industry. It is estimated that the Lagoon generates more than $300 million in boat and marine sales annually.

TALK ABOUT VARIETY.....

More species inhabit the Indian River Lagoon region than any other estuary in North America. There are more than 2,200 different animal species and at least 2,100 species of plants found in the Lagoon region. Also included are

300 species of fish and 310 bird species, the most diverse bird population found anywhere in North America.

ANIMALS

Thirty-six rare, threatened, or endangered species are found in the Indian River lagoon region. One of these species is the West Indian Manatee. More than one-third of the nation's manatee population lives in or migrates through the Indian River Lagoon.

In addition, the ocean beaches in the Lagoon region provide one of the densest sea turtle nesting areas found in the Western Hemisphere. The region is the only location in the world where you can find the Atlantic salt marsh snake.

IF YOU LIKE PARKS....

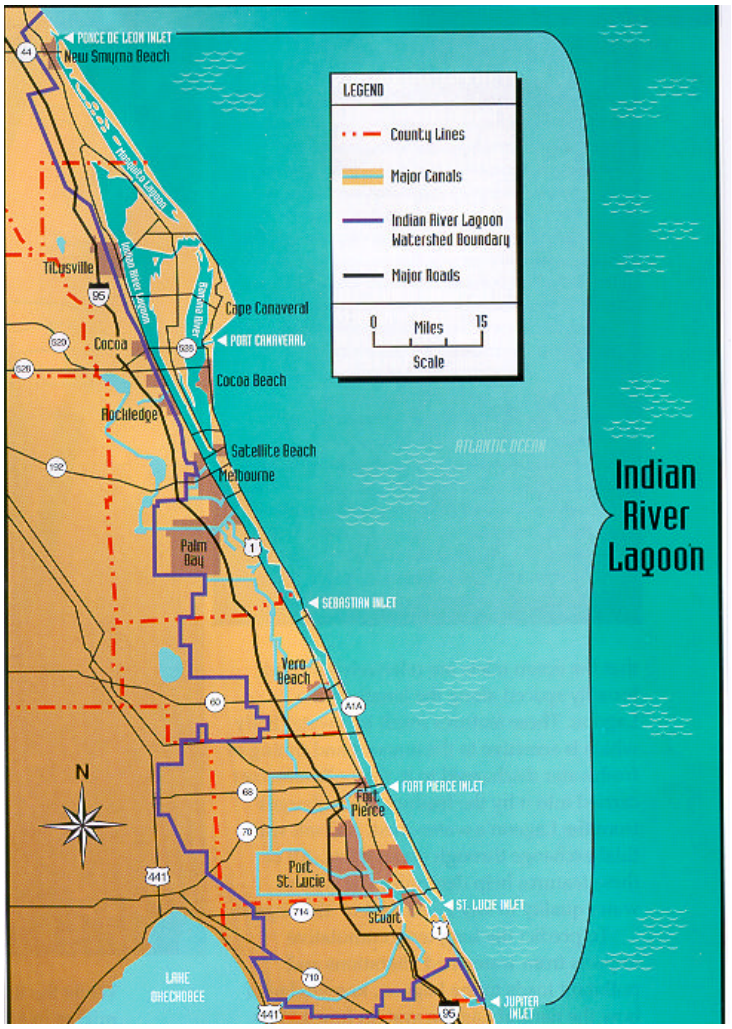
The Indian River lagoon region has five state parks, four federal wildlife refuges and a national seashore. More people visit Sebastian Inlet State Park than any other state park in Florida.

GEOGRAPHIC FEATURES

(scan in Map of IRL)

The Indian River Lagoon is located on the east coast of Florida, stretching from Ponce deLeon Inlet near Daytona Beach to Jupiter Inlet north of West Palm Beach. It extends 156 miles through six coastal counties and includes part of a seventh county within its watershed. It is the location of such well-known institutions as Kennedy Space Center, Cape Canaveral, the Indian River citrus industry and Pelican Island National Wildlife Refuge.

The Indian River Lagoon system is composed of three major waterbodies: Mosquito Lagoon, Banana River and the Indian River. The Lagoon varies in width from one-half mile to five miles and has an average depth of three feet. Several tributaries drain the land surrounding the Lagoon. These tributaries include Eau Gallie River, Crane Creek, Turkey Creek, Sebastian River, Taylor Creek and the St. Lucie River. The Indian River Lagoon is connected to the Atlantic Ocean at seven points. These are Ponce deLeon Inlet near Daytona Beach, Sebastian Inlet, Fort Pierce Inlet, St. Lucie Inlet near Stuart and Jupiter Inlet. In addition, there is a limited connection at



Port Canaveral where navigation locks allow boaters to travel between oceanic waters in the port and the Atlantic Ocean and the Banana River.

Nearly 1 million people live and work in the Indian River Lagoon region, attracted here by the mild climate and the resources of the Lagoon. The Indian River Lagoon produces $300 million in fishery revenues, includes a world-renowned $2.1 billion citrus industry, and generates more than $300 million in boat and marine sales annually. The Lagoon region contains five state parks and recreation areas, four wildlife refuges and a national seashore.

PHYSICAL FEATURES

Although the word “river” appears in its name, the Indian River Lagoon is not a river in any sense of the term. A river, by definition, has headwaters and flows to a mouth. The Indian River Lagoon has no headwaters, has no mouth, and when it does “flow,” it often flows in many directions. The direction of this “flow” is dependent on winds, tides, and several other factors.

The Indian River Lagoon is an estuary - a body of water where freshwater draining from the land meets and mixes with the ocean’s salt water. The main freshwater sources for the Indian River lagoon are direct rainfall onto the Lagoon and runoff from lands within the watershed of the Lagoon.

Runoff is carried by creeks, rivers, canals and ditches to the Lagoon. Ocean waters enter the Lagoon through ocean inlets.

The Indian River lagoon is a special kind of estuary called a lagoon - a body of water separated from the ocean by a barrier island, with limited exchange of waters through inlets. The Indian River Lagoon is unique among Florida estuaries because of this limited exchange of water with the ocean. The location of the Lagoon, its shallowness, variations in the amounts of freshwater discharged to the system, and the few widely-spaced ocean inlets combine to reduce exchange with the ocean. As the result of this limited exchange of waters, however, the Indian River Lagoon is sensitive to the amount and timing of freshwater discharges, pollutant loadings associated with freshwater discharges and salt water exchange through inlets.

The Indian River Lagoon system is a complex, dynamic and variable system. This system is composed of several smaller segments, each of which is slightly different from other segments. The various segments which compose the Indian River Lagoon system are influenced by the locations of inlets which connect the Indian River Lagoon as well as by the location, size and volume of freshwater tributaries. As a result, each segment has individual characteristics that contribute to the unique nature of the Indian River Lagoon.

WATERSHEDS

The watershed (or drainage basin) is the area of land from which water drains to a receiving surface water body. Historically, the Lagoon had a long, narrow watershed. Most of the drainage basin (with a few exceptions, such as the St. Lucie River) was limited to the area east of the Atlantic Coastal Ridge. This area, which is roughly east of present-day U.S. Highway 1, totaled approximately 572,000 acres.

For more than a century, projects have been undertaken in Florida to develop or reclaim lands for agricultural or urban development. Development or reclamation in many cases involved projects designed to control flood waters by or lower the water table by draining these waters to waterbodies that ultimately flowed to the ocean. In the portion of the Indian River

Lagoon from Melbourne south, several large drainage systems associated with water control districts or federal flood control projects were constructed which extended the drainage basin of the Lagoon westward to include extensive areas which historically drained to the St. Johns River or Lake Okeechobee. The extended, present-day watershed of the Indian River Lagoon now includes more than 1.4 million acres, an increase of 146 percent over the historic drainage basin acreage. As a result of this extended and enlarged drainage basin, substantially more fresh water now flows into the Indian River Lagoon.

Changes to the watershed and increased freshwater discharges have meant the Lagoon's ecosystems have had to adapt to changes. These adaptations have had a price: over time seagrass distributions have changed, resulting in losses in several areas, and certain fish populations have declined. Changes may also occur quickly and dramatically, such as algae blooms, fish kills, or shellfish harvesting area closures

CIRCULATION AND MIXING

Circulation and mixing in the Indian River Lagoon system are quite complex. While the tidal currents which drive circulation and mixing in a typical estuary are important in the Indian River Lagoon, there are several additional factors which are unique to this system.

Within a given segment of the Indian River Lagoon, circulation and mixing are primarily influenced by the distance from the segment to an ocean inlet. Other influences include freshwater discharges, wind-generated currents and evaporation processes. With increased distance from an ocean inlet, these other factors increase in importance.

In the vicinity of ocean inlets, tidal currents dominate and control mixing and circulation. Where tributaries discharge to the Lagoon, freshwater flows drive these processes. In those portions of the Lagoon that are not near an inlet or a tributary, wind-driven currents provide the primary energy for circulation or mixing.

Evaporation also plays a role in circulation in the Indian River Lagoon system. When evaporation exceeds the amount of fresh water entering the Lagoon from rainfall or runoff, more salt water will enter the Lagoon from the

ocean. In addition to raising salinity through evaporation, this process also contributes to mixing and circulation in certain areas of the Lagoon.

During the warmer months of the year, evaporation in the Banana River, Mosquito Lagoon and the northern Indian River normally exceeds the inflow of fresh water. These areas have a relatively small watershed with few streams or other drainage flowing to the Lagoon.

In contrast, in the southern portion of the Indian River Lagoon region evaporation never exceeds freshwater inflows during a normal year. This is due to the large, extended watershed and extensive drainage systems in this area, which deliver large amounts of fresh water to the Lagoon.

The circulation and mixing processes in the Indian River Lagoon are further complicated by factors such as seasonal influences, structures such as causeways which may affect water movement and alterations to the Lagoon's shoreline and bottom as the result of dredging and filling projects.

SALINITY

The distribution of salinity in the Indian River Lagoon is another example of the complexity of the Lagoon system. In general, high salinity ocean water is carried into the Lagoon by tides and currents through ocean inlets. This saline ocean water mixes with fresh water entering the Lagoon from runoff and rainfall. The result is a distribution of salinities, which range from fresh water to high-salinity ocean water.

Previously, it was mentioned that the Banana River, Mosquito Lagoon and the northern Indian River Lagoon have a limited inflow of fresh water. Combining this limited inflow of fresh water with evaporative losses results in higher salinities for the northern portion of the Lagoon system. Even in these areas salinity is highly dependent on runoff and rainfall. In drought years salinities may approach oceanic levels. In rainy years, salinities may approach fresh water.

In contrast, fresher waters are found in the portion of the Indian River Lagoon from Melbourne to Vero Beach. This is the result of large amounts of fresh water entering the Lagoon from the Eau Gallie River, Crane Creek, Turkey Creek and Indian River Farms Water Control District canals in the

Vero Beach area, particularly in the wet season. Another contributing factor is the fact that Sebastian Inlet, the only connection to the ocean in the central portion of the Lagoon system, is relatively small. The resulting lower, but highly variable, salinity levels in this area may be a factor in determining the type and extent of certain biological resources in the area such as seagrasses, clams and oysters.

In the southern portion of the Lagoon, mixing of fresh water and ocean water is controlled by slightly different factors. Because this area has more ocean inlets it is more directly interconnected with the ocean and tidal currents dominate in driving circulation. The southern portion of the Lagoon shows high salinities and demonstrates a greater influence by ocean water, even though the area's extensive drainage system carries and discharges a larger quantity of fresh water to this segment of the Lagoon than any other portion of the Lagoon system.

As can be seen from the distribution of salinities and ocean tides, mixing differs within various segments of the Indian River Lagoon system. These differences are very important to ecosystems established within each part of the Indian River Lagoon. Although tolerant of seasonal changes that change patterns of salinity distribution, long-term changes in salinity can result in ecosystem changes.

WATER AND SEDIMENT QUALITY

Water and sediment quality in the Indian River Lagoon has changed during the last century. Much of this change has occurred in the last 50 years. Long-term residents of the Lagoon region tell of clear waters, extensive wetlands and seagrass beds, as well as an abundance of fish and wildlife. These conditions are present today, but only in the less developed portions of the Indian River lagoon region.

Most of the Lagoon meets the minimum water quality standards set by state and federal environmental agencies. In fact, much of the Lagoon system has been designated as Aquatic Preserves and/or Outstanding Florida Water. However, water quality in many areas of the Lagoon is not sufficient to support healthy seagrass beds or permit the unrestricted harvest of shellfish. Reduced water quality, as the result of increased discharges of

nutrients, suspended matter, freshwater and other pollutants, has contributed to the reduced abundance of fish and wildlife throughout much of the Lagoon. Many of the Lagoon's tributaries and deeper areas contain significant deposits of muck or ooze which, in turn, often contain elevated levels of metals or other contaminants

Water and sediment quality of any water body is directly related to activities that occur in the watershed. In estuaries, water and sediment quality is also affected by their connection to the ocean. Water and sediment quality may also affected by the physical configuration of the water body and watershed, as well as alterations to this configuration caused by natural phenomena or man's activities. All these factors combine to affect water and sediment quality in the Indian River Lagoon.

The geographic setting and shape of the Indian River Lagoon affect the water and sediment quality of the Lagoon. They also cause the Lagoon to be different from most of the bays and estuaries in Florida. The long, narrow, shape and shallow waters result in a sluggish circulation pattern in many areas. The circulation that does occur is primarily wind-driven since the tidal exchange with the ocean is through six widely separated inlets with restricted tidal flushing. As the result of limited circulation and tidal flushing, the Indian River Lagoon is particularly sensitive to influxes of pollutants or other materials resulting from activities in the watershed.

The primary types of pollutants affecting the Indian River Lagoon and their impact on water quality are as follows:

- Sediment entering the Lagoon can influence water clarity, which also affects the ability of light to penetrate the water column. Reduced light penetration interrupts photosynthesis and can affect the health or productivity of bottom-growing seagrasses. Discharges of sediments can also smother seagrass beds or certain organisms.

- Decomposing organic matter feeds oxygen-demanding decay processes. Oxygen is consumed through these processes which may result in lower oxygen levels which, in turn, may cause fish kills or stress other oxygen-dependent organisms.

- Nutrients contained in runoff from lawn fertilizers, agricultural operations and domestic wastewater discharges may cause algae blooms. Algae blooms can reduce water clarity and produce additional decomposing organic matter.

- Heavy metals such as lead, zinc, copper; chromium and cadmium are often found in stormwater discharges and may occur in point source discharges. These metals can be toxic to plankton larvae, fish and other organisms, affecting their viability and ability to reproduce.

- Viruses and bacteria can cause the closure of shellfish harvesting areas and may result in restrictions on swimming and other watersports.

- Excessive amounts of fresh water may cause salinities to vary widely. When large amounts of freshwater are discharged to an estuary, it can cause a rapid and dramatic change in salinity. Many fish species that inhabit the Indian River Lagoon have evolved to tolerate wide ranges of salinity. To survive salinity extremes typically, they must slowly acclimate to these changes. Therefore, these fish are less tolerant to rapid changes of salinity.

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POINT SOURCE/NON-POINT SOURCE POLLUTANT LOADINGS

On the average, the Indian River Lagoon Region receives approximately 50 inches of rain each year. Roofs highways, parking lots and other impervious surfaces now cover areas that once were covered with native vegetation. These impenetrable surfaces prevent stormwater from soaking into the ground as it once did. Now, large volumes of stormwater run off into creeks, streams, canals and ditches which ultimately discharge to the Indian River lagoon. Uses of land from which the runoff originates and flows through determine the pollutant load picked up in the runoff and carried to the receiving surface water. Pollutant loads include sediments, decomposed organic matter, nutrients, heavy metals, viruses and bacteria, as well as other pollutants.

Stormwater is considered a non-point source of pollution. Non-point source pollution is generated over a wide area with no single readily identifiable source of pollution. Although stormwater may be discharged through a single pipe or canal, it is still considered a non-point source of pollution.

Point source pollution, on the other hand, is generally the product of a process. For example, until a few years ago, almost all point source discharges in the Indian River Lagoon region were domestic wastewater treatment plants. In addition to the domestic wastewater treatment plants there are approximately 30 point source discharges to the Indian River Lagoon, which are classified as industrial. These are primarily cooling water discharges from power generation plants and discharges of reject water or brine from reverse osmosis drinking water treatment plants.

Recognizing the impacts of discharges from the domestic wastewater treatment plants on the Lagoon, the Florida Legislature passed the Indian River Lagoon Act (Chapter 90 - 262, Laws of Florida) in 1990, requiring these plants to cease discharging their effluent to the Lagoon. To allow time for wastewater treatment plants to upgrade their facilities, this legislation took effect in 1996. Presently, most domestic wastewater treatment plants are in compliance with the act. Those who are not in compliance are actively working on projects that will bring them into compliance.

While implementation of the Indian River Lagoon Act will significantly reduce the amount of pollutants discharged to the Lagoon, non-point sources contribute substantial pollutant loadings to the Lagoon. In the early 1990s, it was estimated that non-point source pollution constituted more than 60 percent of the pollutant loadings to the Indian River Lagoon. With the elimination of domestic wastewater treatment plant discharges, the importance of non-point source loadings increases even further. Even with current laws, pollutant loadings to the Lagoon will not be reduced much, if at all, in the future. It is estimated that by the year 2010 increases in non-point source loadings resulting from anticipated increased development in the watershed will nearly equal the reductions resulting from the law eliminating domestic wastewater discharges if no action is taken to address existing loadings as well as future loadings. Armed with knowledge about the Lagoon's workings and its probable future pollutant loadings, we can begin to predict where its capacity to assimilate pollutants will be overloaded and

how appropriate management efforts can protect the Lagoon's resources for future generations.

SEDIMENT QUALITY

Most sediments in the Indian River Lagoon are sands, silts and shell fragments. However, about 10 percent of the bottom are covered with a loose, black, organic-rich mud commonly referred to as "muck" or "ooze." This muck may harm fish, shellfish, and seagrasses by affecting respiration, light penetration or simply smothering these resources. Not only does muck cover important bottom habitat, it can also be stirred up by storms and boats, decreasing water clarity. Elevated concentrations of copper, lead, zinc and other pollutants have been found in muck deposits in several locations in the Lagoon.

Major muck deposits are generally found in deeper areas of the Lagoon, especially in areas that have been dredged. These areas include the Intracoastal Waterway and other channels, as well as borrow pits where the fill for causeways and other development was mined from the bottom of the Lagoon.

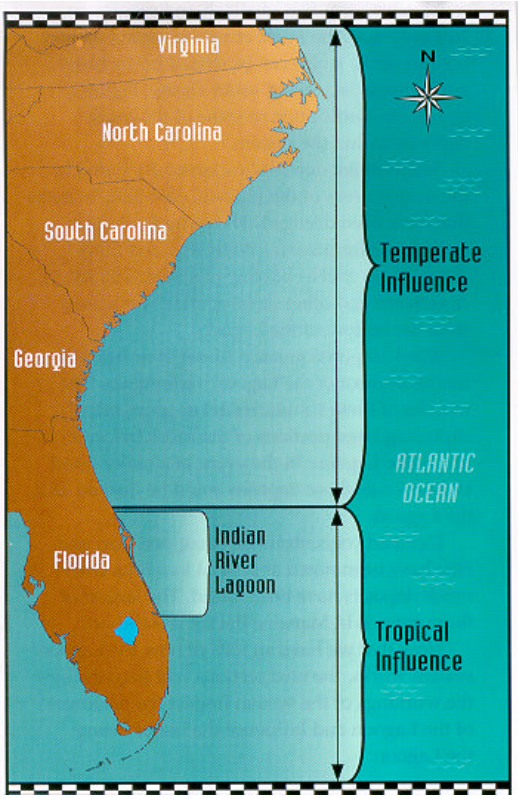
Muck deposits are also found at or near the mouth of most of the Lagoon's tributaries. The mouths of these tributaries act as traps, often capturing large portions of the muck before it reaches the Lagoon. In the event of a major storm or hurricane, these deposits could be flushed into the Lagoon.

LIVING RESOURCES

Within the Indian River Lagoon region a broad variety of natural community types, watershed and drainage features, connections to the Atlantic Ocean and complex hydrodynamics have combined to create a complex landscape unique among Florida's estuaries. The overlapping boundaries of two biotic provinces, the temperate Carolinian province and the sub-tropical Caribbean province, also occur within the region. Biological diversity is high as a variety of species associated with both these provinces as well as species unique to the area, are found in the Indian River lagoon region. More than 75 of the species found in the region are listed as rare, threatened, endangered or species of special concern by state or federal agencies or private

organizations. This has resulted in the Indian River Lagoon being labeled as the most diverse estuary in North America.

BIODIVERSITY



Maintaining biological diversity (the existence of many types of plants and animals) is a key part of maintaining the health of the earth's ecological systems and its future resources. The same could be said for the Indian River Lagoon.

Besides the 2,100 species of plants, the Lagoon is home to more than 2,200 species of animals - the most in any North American estuary. All seven species of seagrass found in Florida are found in the Lagoon including Johnson's seagrass (*Halophila johnsonii*), which is found nowhere else in the world.

Why does the Indian River Lagoon contain such biological diversity? There are several reasons but perhaps the primary causes are the unique combination of its north-south orientation along the Atlantic coast and the Lagoon's long, narrow configuration.

The Lagoon is located in the zone where the tropical and temperate climates meet. As a result, the tropical species of plants and animals which cannot tolerate much cold weather, along with species that thrive in cooler climates are both found in the Lagoon region. The mean annual temperature differs between the northern and southern ends of the Lagoon region by as much as it does between the northern end of the Lagoon region and North Carolina, 500 miles to the north.

The Lagoon region's habitats range from ocean inlets, which are like the open sea, to the dry upland oak scrub ridges. Many of these habitats are so specialized and unique that they have limited tolerance to change. As a

result, changes in the Lagoon region have resulted in the loss of a great deal of these specialized habitats as well as the species that depend on them.

Many of these areas are critical habitats for the 36 species of animals classified by state or federal agencies as threatened or endangered that are found within the Lagoon's watershed. The Merritt Island National Wildlife Refuge, located in the northern section of the Lagoon, contains more species of threatened and endangered animals than any other national wildlife refuge in the continental U.S.

(scan in tropical/temperate zone graphic map)

HABITATS AND COMMUNITIES

Habitats, (the environments in which plants and animals live) result from physical conditions as well as the effects of the plants and animals themselves. Communities are assemblages of plants or animals that live in these habitats.

Complex interactions occur between habitats and the surrounding environment so that the actions that affect one habitat can ultimately affect other, even distant, habitats. When we affect one part of this complex system, we may be affecting all parts of the system.

The major habitats of the Indian River Lagoon and its associated tidal zone can be described as:

- Seagrass habitats,
- Open water habitats,
- Mangrove and salt marsh habitats, and,
- Spoil island and shoal habitats.

Seagrass Habitats

Seagrasses are a particularly valuable component of an estuarine ecosystem, providing important habitat for many species. These include threatened and endangered species; species of recreational and commercial importance as well as many other species which, while not having great individual value, are vital components of the Indian River Lagoon ecosystem. All these species are part of a complex food web whose common and perhaps most important element is seagrass.

Seagrasses are plants that grow and complete their life cycles entirely underwater. Seagrasses are higher plants that have roots, leaves, flowers, pollen and seeds. In comparison, algae are simpler plants that have none of these characteristics. Approximately 52 species of seagrass have been identified worldwide of which seven are found in Florida. Of all the estuarine areas in Florida, the only estuary where all seven species are present is the Indian River Lagoon. One species, *Halophila johnsonii*, is found nowhere else in the world.

The seven species of seagrass found in the Indian River Lagoon include: (The *predominate species are bolded*)

- **Shoal grass**, *Halodule wrightii*;
- **Turtle grass**, *Thalassia testudinum*;
- **Manatee grass**, *Syringodium filiforme*;
- **Johnson's seagrass**, *Halophila johnsonii*;
- Star grass, *Halophila engelmanni*;
- Paddle grass, *Halophila decipiens*; and
- Widgeon grass, *Ruppia maritima*.

Seagrasses, along with the microscopic algae that often cover their leaves, convert solar energy into plant tissue. In terms of biomass production, the seagrass community is one of the most productive ecosystems on earth. The complexity of the structure of the seagrass community, its biodiversity and productivity have been compared to rain forests.

The plant tissue produced by seagrass forms the basis of the food webs for many of the animals in the Indian River Lagoon. The Lagoon is known as a "seagrass-based ecosystem" rather than a "phytoplankton based ecosystem," meaning that these rooted plants, rather than free-floating algae provide most of the food for animals in the system.

Seagrasses are sensitive to water quality conditions, particularly those parameters that affect water clarity. Waters which are turbid or cloudy as the result of high amounts of suspended solids or algae do not allow needed sunlight to reach bottom-growing seagrass. As a result, seagrasses serve as a good "barometer" of the condition of a

water body. In areas of good water quality with low concentrations of suspended solids or algae-producing nutrients, seagrasses can form dense “beds” or “meadows.”

In many Florida estuaries and coastal areas the acreage of seagrasses has declined. These losses have been primarily attributed to development within the watershed and resulting impacts to water quality. These impacts are generally the result of discharges of stormwater or fresh water drainage from urban industrial and agricultural areas, and discharges of wastewater from domestic and industrial sources. In addition, there have been direct losses of seagrass acreage to dredge and fill projects.

(Scan in Seagrass coverage graphic)

Open Water Habitats

Open water habitats include all of the submerged portions of the Indian River Lagoon which are not covered by seagrasses, encompassing both the water column and the bottom of the Lagoon.

Bottom types may be rocky, sandy or muddy. Most animals that live on the bottom or in the sediments are invertebrates (having no backbone). The animals include mollusks (such as clams), tiny polychaete worms, amphipod crustaceans, sponges, bryozoans, oysters and blue crabs.

Open water habitats comprise about 65 percent of the area of the Lagoon. Although most of the productivity of the Lagoon is based on seagrasses and other larger plants, smaller free-floating microscopic plants known as phytoplankton also play an important role. Phytoplankton forms one of the key bases of the food web. Small, free-floating animal species of plankton known as zooplankton feed on these algae. The phytoplankton and zooplankton are, in turn, eaten by larval forms of important fish species such as the spotted seatrout or by other fish species such as the bay anchovy or black mullet. The anchovy and the mullet, in turn, are primary food sources for significant species such as the red drum (redfish) and tarpon, along with a number of other species important to the ecology and economy of the Indian River Lagoon region.

However, in this delicate environment, too much phytoplankton can kill both seagrasses (due to shading) and fish (due to a lack of oxygen consumed by dying or decaying phytoplankton). When high levels of nutrients, such as those associated with stormwater run-off and other pollution, are combined with high summer temperatures and light, an overabundance or "blooms" of algae may occur. Algae blooms can upset the delicate balance of the Lagoon, causing fish kills, odors, decreased water clarity and other problems.

Mangrove Forests and Salt Marshes

Two important habitats adjacent to the open waters of the Indian River lagoon are mangrove forests and salt marshes. The sediments supporting these habitats are often covered by water at high tide but are exposed at low tide. Mangrove forests and salt marshes are home to a large number of plants and animals, several of which could not survive elsewhere. For example, the salt marshes of Mosquito Lagoon are the only habitat of the threatened Atlantic salt marsh snake. The salt marshes of Merritt Island were once the prime habitat for the dusky seaside sparrow, prior to their impoundment for mosquito control. Losses of this prime habitat contributed to the extinction of this species.

Large numbers of wading birds forage for small fish and insects in these wetlands. The mangrove forests also provide roosting and nesting areas for many of these birds, and 80 percent or more of the recreational and sport fish species spend at least part of their lives in tidal wetlands.

Mangrove forests and salt marshes also play an important role in the protection of water quality. The tidal wetlands along the shore serve as a filter, removing sediments, nutrients and other pollutants from runoff before it reaches the open waters of the Lagoon. These same wetlands buffer the impacts of waves from storms or boats, helping protect the shoreline from erosion.

Mangroves are tropical species that have adapted to a saltwater environment. Worldwide, there are 50 species of mangrove. Three

mangrove species are found in Florida, all of which are found in the Indian River Lagoon. These species are:

- Red mangrove, *Rhizophora mangle*;
- Black mangrove, *Avicienna germinans*; and,
- White mangrove, *Laguncularia racemosa*.

Red mangroves are often found in water or adjacent to the waters edge and are readily identified by their tangled, reddish, support roots called **"prop roots**." **Black mangroves** are found at a slightly higher elevation than red mangroves and can be identified by numerous finger-like projects from the root system known as **pneumatophores**. The **white mangrove** normally occupies the highest elevations further upland than either the red or black mangroves. The white mangrove has **no visible aerial root structures** such as prop roots or pneumatophores.

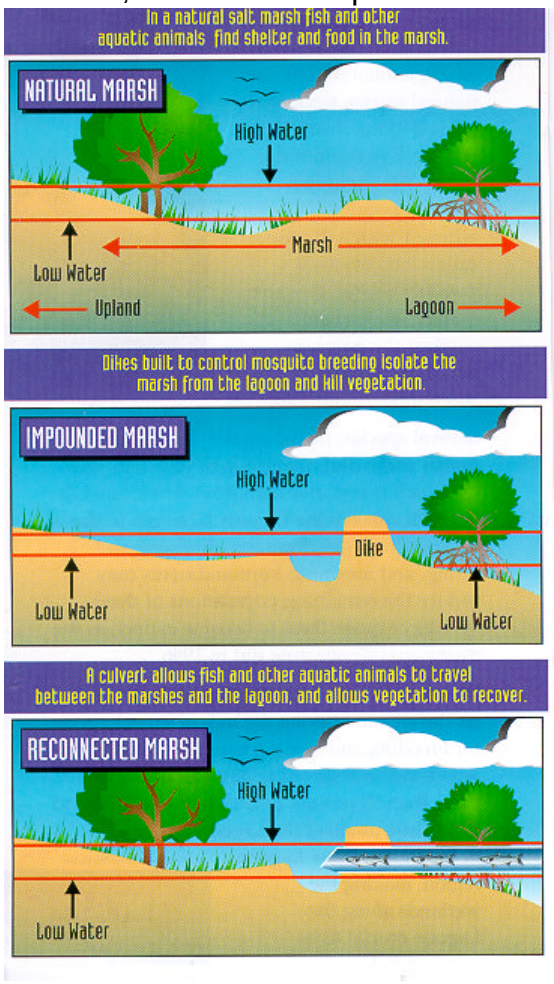
Salt marshes are dominated by non-woody plant species such as grasses or rushes. Common species found in Indian River Lagoon salt marshes include:

- Smooth cordgrass, *Spartina alterniflora*;
- Saltmeadow cordgrass (or salt hay), *Spartina patens*;
- Black rush (or needle rush), *Juncus roemerianus*;
- Saltwort, *Batis maritima*;
- Glasswort (or pickleweed), *Salicornia* sp.;
- Saltgrass, *Distichlis spicata*; and,
- Sea-oxeye daisy, *Borrichia frutescens*.

Most salt marshes in the Indian River Lagoon occur from Merritt Island north, where periodic winter freezes limit the spread of mangroves. Many of the salt marshes of the Indian River Lagoon differ from those elsewhere in Florida because a natural berm restricts flooding to only the highest tides, limiting vegetation to those species capable of tolerating high salinities as the result of evaporation.

Mosquito Control Impoundments

Since 1950, more than 75 percent of Lagoon's mangrove forests and salt marshes bordering the Lagoon have been destroyed, altered, or functionally isolated. More than 40,000 acres of these wetlands have been impounded for mosquito control.



Salt marsh mosquitoes that breed in these marshes need alternating wet and dry soils to reproduce. Building an impoundment and flooding the wetlands during the mosquito breeding season interrupts this reproductive cycle. Many mosquito impoundments were constructed in the 1940s, 1950s and 1960s. An impoundment is created by digging a ditch around the edge of a wetland and using the dredged material to create a dike along the ditch. The impoundment is then flooded, which prevents mosquitoes from laying their eggs. Artesian wells or pumps are used to maintain water levels in the impoundment, replacing water lost to seepage or evaporation.

Flooding for mosquito control has resulted in the loss of much of the original wetland vegetation and a change to a different vegetative community. This, in turn changed the habitat, so that many species that were adapted to the pre-impoundment conditions could no longer survive in the impoundments. On the other hand, some species, particularly

waterfowl, have benefited from impoundment and flooding of the marshes, which has created sheltered, shallow-water habitat for these species. However, dikes isolated the wetlands from the Lagoon, cutting off the exchange of water between the Lagoon and the wetlands and their associated benefits to water quality; the export of detritus and food materials from the wetlands to the Lagoon, matter which forms the basis of the food chain; and, the movement of fish, crabs and other aquatic species between the Lagoon and the wetlands, which are vital habitat to many species in certain portions of their life cycle.

In recent years, agencies have begun to implement improved impoundment management strategies to increase the hydrologic connection between impoundments and the Lagoon, restoring the vital link between the wetlands and the Lagoon. Approximately 70 percent of the impoundments in the Lagoon now have at least some type of open connection to the Lagoon.

Additional impoundment reconnection projects are scheduled for coming years, however many impoundments are privately owned. Many owners have been reluctant to allow reconnection of these impoundments. To address this problem many privately owned impoundments are targeted for acquisition through various environmental land acquisition programs.

(scan in natural marsh/impoundment graphic)

Spoil Island and Shoal Habitats

These little-appreciated habitats in the Indian River Lagoon are man-made islands created by depositing dredged bottom material. Most of the 200-plus spoil islands in the Lagoon were created in the 1950s from the dredging of the Intracoastal Waterway.

When these islands were constructed, many environmental impacts resulted. One impact was the destruction of seagrass beds by filling and the large areas of turbid water created as the islands were constructed. Over the years, many of the islands have stabilized and seagrasses have colonized portions of the shallow submerged areas of these islands.

Mangroves have often become established in the intertidal areas along with some native trees or shrubs on the upland portions on many islands, providing roosting and nesting sites for wading birds. Typically, the spoil islands have a mangrove fringe with the interior comprised of mainly exotic plant species such as Australian Pine and Brazilian Pepper. Bare, sandy areas and sand spits provide alternative nesting sites for terns and many other shorebirds whose nesting sites on the barrier island beaches are often disturbed by humans.

While old spoil islands have become a valuable habitat in the Lagoon, creating new islands would likely have a far greater negative impact to the resources of the Indian River Lagoon than the benefits that would be gained from the artificial creation of habitat.

FISH AND WILDLIFE

FISHERIES

The fisheries of the Indian River Lagoon have played an important role in the human use and development of the region throughout recorded history. The remains of fish and shellfish found in Ais and Timacuan Indian shell mounds and camp sites show that these early settlers depended heavily on fishery resources for food.

The commercial fisheries industry in the Indian River Lagoon region began about 1865. Many commercial fishermen took advantage of the long docks at places such as Cobb's store and landing in Fort Pierce. At many of these locations, large racks were used to dry miles of nets. Mule-drawn carts hauled the catch from the piers on rail lines running to shore, where it was then processed and transported to market.

Today, fisheries-related employment represents only a fraction of the regional total, but the value of the fishery resource is measured in other terms as well. Sport fishing and abundant fresh fish in local restaurants and markets attract visitors and residents alike, contributing millions of dollars to local economies. Many people employed in related fields such as boat construction and sales, bait and tackle, and restaurants, all of which depend on the fishing industry.

Fishery resources were extremely abundant in the 1800s and early 1900s, as can be seen in photographs from that era showing large catches of snook, redfish, spotted seatrout and even sawfish. Today, with the exception of the sawfish, these species are still present, but many older fishermen will tell you that today's fish are fewer and smaller.

Catch data collected over the past 30 years show that catches of some species such as snook and spotted seatrout have declined severely. In recent years, the snook has been declared a gamefish and has been listed as a species of special concern by the state, so it is no longer sold commercially. Reports of more and bigger snook caught by anglers have appeared in recent magazines and newspapers, which may indicate that this species is responding to improved management techniques.

The spotted seatrout is one of the most popular species of gamefish in the Indian River Lagoon. It is also an important commercial species. Declines of important species like the spotted seatrout hurt both recreational and commercial fishermen. Since 1953 the recorded seatrout commercial catch has declined more than 50 percent in the region. Sport fishermen have also caught fewer seatrout. According to the National Marine Fisheries Service, the average time to catch a seatrout has increased from two hours to four hours since 1980. Because the seatrout depends on the Lagoon exclusively throughout its life, factors within the Lagoon are obviously related to its decline.
(scan in commercial catch of spotted seatrout by year)
Overfishing has been cited by some as a cause of declining fish populations. Another major factor is the loss of productive habitat. Seatrout use seagrass beds during significant portions of their lives. Seagrass beds have decreased by more than 90 percent in some portions of the Lagoon. Other changes in habitat have included the isolation of productive mangrove and salt marsh habitats for mosquito control, and filling of productive areas of the Lagoon for coastal development.

WILDLIFE

The Indian River Lagoon contains more than 2,200 species of animals. This number includes nearly 700 species of fish, 68 species of reptiles and amphibians, 370 bird species and 29 mammal species. Among the birds - perhaps the most readily noticed wildlife - more than 125 species breed in the Lagoon region, while another 175 species winter here.

The estuary is located along the Atlantic flyway, the route used by millions of birds that migrate between eastern North America and the Caribbean. Some get as far as the Lagoon, then decide to forego the rest of the trip south. More than 200,000 ducks and other waterfowl have been counted at the Merritt Island National Wildlife Refuge alone. Wading birds and shore birds are also abundant year-round in the region as well. The Lagoon is also home to more than 50 communal nesting areas (or rookeries); most of them located on spoil islands or in the mangrove forests.

One of the major rookeries is the Pelican Island National Wildlife Refuge, established in 1903 by President Theodore Roosevelt in response to a severe decline in brown pelicans in the United States, particularly in central and southern Florida, in the early 1900s. Many of the breeding birds were located at Pelican Island, which was virtually the only remaining significant nesting site in South and East Florida, possibly saving the pelican population in this area.

When brown pelican populations dipped again in the 1960s and 1970s, reportedly because of the use of DDT, the Lagoon was affected only slightly because less DDT was used for mosquito control here. Mangrove forests and salt marshes were either ditched and drained, or impounded and flooded, to control mosquito breeding. This approach was developed as a less expensive yet highly effective alternative to pesticides.

Although ditching, draining and impounding marshes instead of using DDT may have aided the brown pelican, it disturbed the fragile ecology of the Indian River Lagoon system. Changes in the salt marsh habitat helped make the dusky seaside sparrow extinct and expelled the Smyrna seaside sparrow from Indian River Lagoon marshes. These changes also resulted in changes in feeding and nesting patterns for many other species, and use of wetlands by fish and wildlife was restricted.

Among marine mammals, the manatee (also known as the sea cow) and the Atlantic bottlenose dolphin are found in the Lagoon year-round. Some use the Lagoon seasonally or as a migratory route to other feeding grounds or refuge areas.

The manatee is a large plant-eating mammal, which swims slowly through shallow waters, grazing on seagrasses and other plant life. The Indian River lagoon is used by at least one-third of the U.S. manatee population, of which some are permanent residents of the Lagoon and some are migratory. As an example of manatee use of the Indian River Lagoon system, as many as 300 manatees have been counted in surveys in the northern end of the Banana River alone.

Manatees are quite susceptible to injury from watercraft using the Lagoon. Much of the manatee population has prop scars or other evidence of encounters with watercraft. Collisions with watercraft are the leading human-related cause of manatee mortality.

The fish-eating Atlantic bottlenose dolphin is found most commonly in the central and southern portions of the Lagoon system. As many as 300 of the dolphins live permanently in the Lagoon, with others moving between the Lagoon and the Atlantic Ocean.

Many other species of wildlife depend on the Lagoon at various times in their life cycle. All of these species contribute to the biodiversity of the Lagoon but their continued existence requires adequate amounts of suitable habitats. Many species have become threatened or endangered and will require special attention if they are to remain part of the Indian River Lagoon system.

APPENDIX

GLOSSARY

algae - aquatic non-flowering plants that lack roots and use light energy to convert carbon dioxide and inorganic nutrients, such as nitrogen and phosphorous, into organic matter by photosynthesis.

amphipod crustaceans - a group of aquatic arthropods, these invertebrate animals, including those commonly referred to as “sand fleas,” have a hard exoskeleton. These crustaceans are a key part of the Lagoon food web.

assimilative capacity - the amount of pollution the waters of a water body can receive without resulting in detrimental change or impact.

bathymetry - the physical shape of a basin which contains water, with special attention to the contours of depth.; bathymetric maps of water bodies are analogous to topographic maps of mountains.

berm - a raised area that impounds water and prevents drainage

bio-accumulation - the process by which a contaminant accumulates in the tissue of an individual organism. For example, certain chemicals in food eaten by a fish tend to accumulate in its liver and other tissues.

borrow pits - an area where natural sediments have been removed, usually for construction material, leaving a pit.

brackish water - a mixture of fresh water and saline water.

bryozoan - a tiny moss-like invertebrate that forms permanently attached colonies and reproduces by budding. It is a sensitive indicator of water quality and pollution

causeway - a filled-in area of the Lagoon on which a roadway or railroad is constructed, and leading to or from bridges.

clam landings - the amount of clams harvested from the Lagoon.

contaminant - a pollutant to a water body. A substance which is not normally present in the environment or is present in unnatural concentrations that can, in sufficient concentrations, adversely affect the environment.

community - a group of organisms that live together.

detritus - free, disintegrating dead organic tissue (mostly of plant origin) and the associated microorganisms engaged in the decomposition of the material.

dissolved oxygen - the oxygen content of the water.

ecosystem - a community of living organisms interacting with one another and their physical environment.

effluent - the outflow of water, with or without pollutants, often from a pipe.

estuary - a semi-enclosed water body which has free connection to the open sea and within which seawater is measurably diluted with fresh water.

eutrophication - the process of nutrient enrichment in a water body.

exotic species - any introduced plant or animal species that is not native to the area and that may be considered a nuisance.

emergent wetland - fresh water or salt water wetland that is dominated by plants that grow partly above and partly below the water.

food web - a group of interrelated food chains in a particular community, describing the flow of food from the original producer to the ultimate consumer.

habitat - the place where an organism naturally lives or grows.

hydrologic connections - the interaction of waters flowing from one water body to another water body.

impoundment - a body of water which is physically confined.

intertidal - sediment surface between mean low water and mean high water.

lagoon - a shallow body of water which is separated from the sea by a sandbar, barrier beach or coral reef where salt water from the sea and fresh surface water runoff from the land meet and mix.

loading - the total amount of material entering a system from all sources.

mangrove - an ecological grouping for woody plants that inhabit marine intertidal shorelines, principally along tropical shores.

mean high water - the average maximum tidal elevation above mean sea level reached by the rising tide and is the average of all high tides of each tidal day over the National Tidal data Epoch (19 years).

mitigation - attempting to offset wetlands or other habitat losses through restoration, creation, or enhancement of wetlands or other habitat at other locations.

muck - the loose-grained, black, organic-rich mud that washes into the Lagoon and settles on the bottom in pockets.

non-point source - the source for pollution which is generated over a wide area with no single identifiable source. Stormwater runoff and septic tank seepage are examples of non-point sources.

nutrient - any substance required by organisms for normal growth and maintenance. Excessive amounts of nutrients, primarily nitrogen and phosphorous, may result in excessive growth of algae, leading to oxygen depletion and water quality degradation.

nutrient loading - the amount of nutrients such as nitrogen or phosphorous that enters the Lagoon from point and non-point sources.

pathogen - an agent, such as a virus bacteria or fungus that can cause disease in humans.

photosynthesis - the process by which a plant converts carbon dioxide and water to carbohydrates. The process requires sunlight and the chlorophyll in plant cells. Oxygen is released as a by-product of this process. This process is the source of most of the oxygen in the air.

phytoplankton - small organisms that float or drift in the Lagoon. Phytoplankton consists of plants or plant-like organisms such as algae. Phytoplankton serves as an important food source for many species found in the Indian River Lagoon.

plankton - algae and microscopic floating aquatic plants (phytoplankton) and animals (zooplankton)

plant community - all of the plant populations occurring in a shared habitat or environment and being recognizable as being differentiated from adjacent communities.

point source - a source of pollution which is generally the product of some process such as manufacturing or the treatment of domestic wastewater, whose discharge location can be identified.

pollution - the impurities that are added to the environment by man or by natural sources that affect biological processes.

polychaete worms - segmented worms that are an important part of the Lagoon's food webs. They are the most abundant benthic (bottom-dwelling) invertebrates found in the Lagoon.

propagule - generally, the dispersible "offspring" of a plant (e.g., seeds, fruits, vegetative units). Mangrove offspring are called propagules because seeds are never formed in these plants.

resource - a substance or product required by an organism for normal maintenance, growth and reproduction. If the resource is scarce

relative to demand, it is referred to as a limiting resource. Non-renewable resources (such as space) occur in fixed amounts and can be fully utilized; renewable resources (such as food) are produced at a fixed rate, with which the rate of exploitation attains an equilibrium.

runoff - the part of precipitation that travels overland and appears in streams and other water bodies.

salinity - the dissolved inorganic salts in seawater expressed in grams of salt per kilogram of seawater (or ppt).

salt-tolerant - having the physiology necessary to cope with the stresses resulting from exposure to fluctuating levels of salts in the growing medium.

septic tank - a domestic wastewater treatment system commonly used in areas not served by central sewer systems.

shellfish - an aquatic animal, such as a mollusk (clam, oyster, or snail) or crustacean (crab or shrimp) which has a shell-like exoskeleton.

species of special concern - a designation used by the State of Florida to identify species which are on the verge of becoming threatened.

standard - a standard is an acknowledged basis for comparing or measuring criterion; a degree or level requirement.

stormwater runoff - water from rainfall that does not infiltrate the land surface and flows to a surface water body.

submerged aquatic vegetation - plants which grow and complete their life cycles entirely underwater.

substrate - the base or substance on or into which an organism is attached or rooted.

taxonomy - the classification of organisms using Latin terminology.

turbidity - a measure of cloudiness of the water which is caused by solids or colloidal particles suspended in the water column.

wastewater - water contaminated with the byproducts of domestic, commercial, agricultural or industrial uses.

wastewater discharges - treated waters which are released from a wastewater treatment plant.

water quality parameters - constituents found in surface waters that characterize the quality of the water.

water column - a vertical section of the water from the water surface to the bottom sediments.

watershed - the land area which drains to a common surface water body.

wetlands - areas which are permanently saturated or permanently or periodically inundated by surface or groundwater sufficient to support vegetation typically adapted for life in saturated soil conditions (e.g., estuaries, rivers, swamps, marshes, and bogs).

REFERENCES

Barnett, M.R., and D.W. Crewz (eds.). An Introduction to Planting and Maintaining Selected Coastal Plants in Florida. Florida Sea Grant Report Number 97. Florida Sea Grant. Gainesville, Florida.

Florida Department of Environmental Protection. Florida's Mangroves. Florida Department of Environmental Protection. St. Petersburg, Florida.

The Underwater World of Florida's Seagrasses. Florida Department of Environmental Protection. St. Petersburg, Florida.

Indian River Lagoon National Estuary Program. 1996. Indian River Lagoon Comprehensive Conservation and Management Plan. Indian River Lagoon National Estuary Program. Melbourne, Florida.

St. Johns River Water Management District and South Florida Water Management District. 1994. Surface Water Improvement and Management (SWIM) Plan for the Indian River Lagoon. Palatka and West Palm Beach, Florida.

Steward, J. and J. vanArman (eds.). 1987. Indian River Lagoon Joint Reconnaissance Report. St. Johns River Water Management District and South Florida Water Management District. Palatka and West Palm Beach, Florida.

Woodward-Clyde Consultants. 1994a. Status and Trends of the Indian River Lagoon. Woodward-Clyde Consultants. Tampa, Florida.

1994b. Uses of the Indian River Lagoon. Woodward-Clyde Consultants. Tampa, Florida

1994c. Non-Governmental and Governmental Programs for the Indian River Lagoon. Woodward-Clyde Consultants. Tampa, Florida.

1994d. Loadings assessment of the Indian River Lagoon. Woodward-Clyde Consultants. Tampa, Florida.

1994e. Physical Features of the Indian River Lagoon. Woodward-Clyde Consultants. Tampa, Florida.

1994f. Preliminary Water and Sediment Quality Assessment of the Indian River Lagoon. Woodward-Clyde Consultants. Tampa, Florida.

1994g. Historical Imagery and Seagrass Assessment: Indian River Lagoon. Woodward-Clyde Consultants. Tampa, Florida.

1994h. Biological Resources of the Indian River Lagoon. Volume 1 & 2. Woodward-Clyde Consultants. Tampa, Florida.

1994i. Indian River Lagoon: A Fragile Balance of Man and Nature. Woodward-Clyde Consultants. Tampa, Florida.

IRL-1 Indian River Lagoon Marsh Habitat (Merritt Island National Wildlife Refuge.)

IRL-2 Indian River Lagoon Mangrove Swamp (Sebastian Inlet)

IRL-3 Spoil Islands of the Indian River Lagoon (Duck Point, Wabasso)

IRL-4 Manatee with propeller scar

IRL-5 Submerged Aquatic Vegetation (seagrass)

IRL-6 Red Mangrove Swamp in St. Lucie County; note the prop roots.

IRL-7 There are resident populations of Atlantic Bottlenose Dolphin in the Indian River Lagoon.

IRL-8 It's easy to count Manatees while they take advantage of the warm water discharge of a local power plant on a cool day.